NAVAL FACILITIES ENGINEERING COMMAND
Washington, DC 20374-5065

NFESC Technical Report
TR-2120-ENV

PERFORMANCE COMPARISON: DIRECT-PUSH WELLS VERSUS DRILLED WELLS

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January 2001

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REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-018

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
January 2001

3. REPORT TYPE AND DATES COVERED
Final; Jun 1999 - Sep 2000

4. TITLE AND SUBTITLE
PERFORMANCE COMPARISON: DIRECT-PUSH WELLS VERSUS DRILLED WELLS

5. FUNDING NUMBERS

6. AUTHOR(S)
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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESSE(S)
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1100 23rd Ave.
Port Hueneme, CA 93043-4370

8. PERFORMING ORGANIZATION REPORT NUMBER
TR-2120-ENV

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESSES
Naval Facilities Engineering Command
Southwest Division

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

A comparison between ground water monitoring alternatives (direct-push installed monitoring wells and hollow stem auger drilled monitoring wells) was conducted on the leading edge of a methyl-tertiary butyl ether (MTBE) plume located at Naval Base Ventura County (NBVC) Port Hueneme, California. The purpose of this effort was to determine whether representative chemical and water table data could be generated using properly designed direct-push monitoring wells. An advisory committee comprised of experts from industry, government regulatory entities, and academia assisted with the project design and review of the work plan and all reporting efforts. Field efforts included piezocone measurements, collection of core samples, pre-installation collection of water samples from selected depths, installation of customized monitoring well test cells, and sampling of the wells in triplicate. Laboratory efforts included chemical analysis of water samples (for MTBE and various inorganic materials and parameters), determination of permeability for selected core samples, and determination of grain size distribution for selected samples. No significant performance differences were observed between the direct-push wells and drilled wells. Within experimental error, the performance was comparable for the hydrogeologic setting of Port Hueneme, California. More specifically, the chemical variability among the different well types was less than that displayed by spatial heterogeneities associated with well screen depth differences and temporal variability. Although a comprehensive hydraulic evaluation was not conducted, water level values also appeared to yield comparable results for the different well designs. Since the study duration was limited to approximately 6 months, a longer observation period will be required to evaluate the long-term (greater than 1 year) performance of direct-push wells.

14. SUBJECT TERMS
Ground water monitoring, direct-push monitoring wells, piezocone, ANOVA, MTBE, geochemical parameters

15. NUMBER OF PAGES

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	
Unclassified	Unclassified	Unclassified	UL

EXECUTIVE SUMMARY

A comparison between ground water monitoring alternatives (direct-push installed monitoring wells and hollow stem auger drilled monitoring wells) was conducted on the leading edge of a methyl-tertiary butyl ether (MTBE) plume located at Naval Base Ventura County (NBVC) Port Hueneme, California. The purpose of this effort was to determine whether representative chemical and water table data could be generated using properly designed direct-push monitoring wells. An advisory committee comprised of experts from industry, government regulatory entities, and academia assisted with the project design and review of the work plan and all reporting efforts.

Field efforts included piezocone measurements, collection of core samples, pre-installation collection of water samples from selected depths, installation of customized monitoring well test cells, and sampling of the wells in triplicate. Laboratory efforts included chemical analysis of water samples (for MTBE and various inorganic materials and parameters), determination of permeability for selected core samples, and determination of grain size distribution for selected samples.

From February 8 to February 14, 2000, a total of 32 wells were installed in two cells. Twelve wells were installed in Cell A, while a total of twenty wells were installed in Cell B. Specific well screen design (sand filter pack and slot size) was determined using several criteria. To evaluate performance of wells adhering to the ASTM specifications (ASTM D5092), grain size distribution curves (Appendix C) were used to determine filter pack grain size and corresponding slot size recommendations (Appendix D). For Cell A, each of the wells was designed using ASTM specifications. For Cell B, two additional well designs were also employed to account for the most common well installation designs used by drillers and direct-push device operators.

An extensive statistical effort was conducted to compare the performance of the different well designs for the Port Hueneme hydrogeologic regime. Analysis of variance (ANOVA) was selected as the best technique for analyzing data consisting of categorical factor predictors and a continuously varying response variable.

In summary, no significant performance differences were observed between the direct-push wells and hollow stem auger drilled wells. Within experimental error, the performance was comparable for the hydrogeologic setting of Port Hueneme, California. More specifically, the chemical variability among the different well types was less than that displayed by spatial heterogeneities associated with well screen depth differences and temporal variability. Although a comprehensive hydraulic evaluation was not conducted, water level values also appeared to yield comparable results for the different well designs. Since the study duration was limited to approximately 6 months, a longer observation period may be required to evaluate the long-term and seasonal (greater than 1 year) performance of direct-push wells.

LIST OF ACRONYMS

ANOVA	Analysis of Variance
ASTM	American Society of Testing and Materials
CPT	Cone Penetrometer Test
DF	Degrees of Freedom
EC	Electrical Conductivity
EPA	Environmental Protection Agency
ft	feet
GW	Ground Water
in.	inch
mg/l	milligrams per liter
mS/cm	Millisiemens per Centimeter
MSL	Mean Sea Level
MTBE	Methyl Tertiary Butyl Ether
NA	Not Applicable
ND	Not Detected
NBVC	Naval Base Ventura County
NFESC	Naval Facilities Engineering Service Center
NTU	Nephelometric Turbidity Units
O_2	Oxygen
ppb	parts per billion
PTFE	Polytetrafluoroethylene
PVC	Polyvinyl Chloride
Sch.	Schedule
T.D.S.	Total Dissolved Solids
µg/l	micrograms per liter
uMHOs/cm	micromhos per centimeter

CONTENTS

LIST OF FIGURES

LIST OF TABLES

Page

INTRODUCTION

A comparison between ground water monitoring alternatives (direct-push installed monitoring wells and hollow stem auger drilled monitoring wells) was conducted on the leading edge of a methyl-tertiary butyl ether (MTBE) plume located at Naval Base Ventura County (NBVC) Port Hueneme, California. The purpose of this effort was to determine whether representative chemical and water table data could be generated using properly designed direct-push monitoring wells. Successful implementation will result in the following:

1. Long-term cost savings for Naval Facilities Engineering Command Southwestern Division remediation projects; and
2. Determination of site-specific design criteria for future installation restoration site work at NBVC Port Hueneme.

The comparison consisted of performance evaluation of selected direct-push microwell designs and conventional hollow stem auger drilled wells with respect to sample representativeness (chemical), limited hydrogeologic observations (potentiometric), and long term installation and monitoring costs. In addition, steps taken to properly design, construct, and sample direct-push monitoring wells yielded site-specific design criteria required for future work at NBVC Port Hueneme.

The main regulatory concerns regarding the use of direct-push microwells for long-term ground water monitoring include the following:

1. Filter pack materials are either not used or are not based on grain size distribution of the formation in contact with the well screen section;
2. Minimum annular sealing requirements based on drilled well specifications exist; and
3. Annular sealing may not be complete for pre-packaged well screen devices and tremmied filter pack applications under certain geologic conditions.

Pre-packaged well screen materials have recently become available for direct-push applications. This recent development is significant in that it allows for filter pack design based on grain size distribution of the screened formation in accordance with the American Society of Testing and Materials (ASTM) Standard Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers (ASTM D5092). This development offers an alternative to highly uncertain tremmie filter pack installation methods. Under certain conditions, there is no guarantee that annular sealing is complete for direct-push wells. However, recently developed annular sealing devices can potentially reduce the chance for vertical cross-contamination within porous aquifer media. Vertical cross contamination is a concern for coarse, unconsolidated, water-saturated sandy materials that can be mobilized during well development.

The State of California Department of Water Resources (1981) requires the following:

"An oversized hole, at least 4 inches (100 millimeters) greater than the diameter of the conductor casing, shall be drilled to the depth specified … and the annular space … filled with sealing material."

The purpose of the 2-inch (5.08-cm) increase in annular sealing radius is to ensure that formation particles are inhibited from entering the well. However, since the design theory of sand pack gradation is based on mechanical retention of the formation particles, a pack thickness of only two or three grain diameters is required to retain and control the formation materials (Driscoll, 1986). Since it is impractical to tremmie a sand pack in a drilled well annulus only a fraction of an inch thick and expect the material to completely surround the well screen, the 2-inch (5.08-cm) requirement has been used as a minimum criteria. Current designs for pre-packaged direct-push well screens allow for the use of "thin" filter packs. Therefore, the 2-inch (5.08-cm) requirement may not be necessary for direct-push pre-packed wells.

On August 11, 1999, an advisory committee comprised of experts from industry, government regulatory entities, and academia was assembled to determine how best to compare the performance of direct-push and drilled monitoring wells. Of particular concern was the comparison of chemical data (e.g., concentration of contaminant of concern and monitored natural attenuation indicator parameters) and hydrogeologic data (potentiometric surface measurement) for the different types of wells. Detailed discussions related to direct-push well construction, experimental design, well configuration plans, statistical analysis, and sampling approaches were considered during the generation of the project work plan. In addition, data collected under the scope of this effort was targeted at enabling engineers to select an optimal remediation design for eventual MTBE plume control and containment.

The study was conducted within an MTBE plume located at NBVC Port Hueneme, California (Figure 1). According to NBVC personnel, gasoline was released from the underground storage tanks (USTs) and fuel distribution lines at the Navy Exchange (NEX) automobile service station in 1984. A large source zone and associated dissolved contaminant plume have resulted in MTBE concentrations as high as 35,000 µg/l in the shallow, unconfined sand and silt aquifer.

One of the two evaluation cells (Cell A) was installed downgradient of the plume in the direction of migration along Track 13 just west of the Daewoo lot. The other cell (Cell B) was installed in a moderately contaminated portion of the plume between the Daewoo lot and Building 401 (Figure 2). The cells were constructed in areas covered by asphalt. The two test locations consisted of footprints approximately 10 feet by 10 feet (3.048 m by 3.048 m).

Although the site soil was not homogeneous, this effort did not address large ranges of hydrogeologic conditions. The "semi-perched" aquifer zone consisted of fluvial-deltaic sediments approximately 25 feet (4.6 m) thick in the vicinity of the site. The uppermost silty sands graded into more sand and silty sand at depths ranging from approximately 6.0 to 25 feet (1.8 to 4.6 m) below ground surface (bgs), depending upon the location within the plume footprint. The unconfined water table ranged from 5 to 12 feet (1.5 to 3.7 m) bgs, depending on the location along the plume, the distance from the coastline, and the most recent climatic conditions. The saturated aquifer thickness ranged from approximately 15 to 20 feet (4.6 to 6.1 m). Anticipated ground water elevations in the two evaluation cells typically ranged between 5 and 7 feet (1.5 to 2.1 m) bgs. Tidal, climatic, and barometric factors could have contributed to the water table elevation in the vicinity of the proposed evaluation cells. Mean hydraulic conductivity in the most permeable zones in the cells ranged from 6.3 x 10^{-4} to 6.4 x 10^{-2} cm/s, and tended to be higher in the deeper portions of the aquifer where the sand units tended to be relatively more coarse. The average linear ground water velocity in the unconfined aquifer ranged from approximately 0.5 to 1.5 feet (0.15 to 0.46 m) per day.

DESCRIPTION OF FIELD AND LABORATORY EFFORTS

Field efforts included piezocone measurements, collection of core samples, pre-installation collection of water samples from selected depths, installation of customized monitoring well test cells, and sampling of the wells in triplicate. Laboratory efforts included chemical analysis of water samples, determination of permeability for selected core samples, and determination of grain size distribution for selected samples. These efforts are described in more detail below.

Piezocone Pushes

On 13 October 1999, a total of ten piezocone pushes were advanced in and adjacent to Cells A and B. Piezocone push locations are presented in Figure 3. Four pushes were advanced in each cell to depths of 25 feet (7.63 m) below ground surface (bgs) at locations corresponding to proposed well cluster locations. Piezocone logs and raw output are presented in Appendix A.

The piezocone consisted of a cone penetrometer test (CPT) probe equipped with sensors to determine soil type and generate lithologic logs in accordance with ASTM Standard D3441 and Robertson and Campanella (1986). The piezocone used for this effort housed a set of load cells to determine sleeve friction and resistance to vertical force. In addition, a pressure transducer was used to determine pore pressure, which can help with soil type and hydrologic determinations. The CPT equipment was mounted on a 20-ton (18,143-kg) truck that was elevated and leveled during operation. The CPT method used involved hydraulically pushing the piezocone into the ground while continuously recording the soil responses of tip resistance, sleeve friction, and induced pore pressure for each depth. While the data generated was continuous (recording measurements approximately every centimeter), the output software limited the soil type resolution to one soil classification estimate approximately every 0.3 foot (9.1 cm). This information was used to generate a detailed conceptual stratigraphic model for the two cells, to help determine optimal well screen depths for each well cluster, and to determine depths for collecting water samples. Pushes were filled with pelletized bentonite poured from the surface to approximately a 1-foot depth and topped off with asphalt.

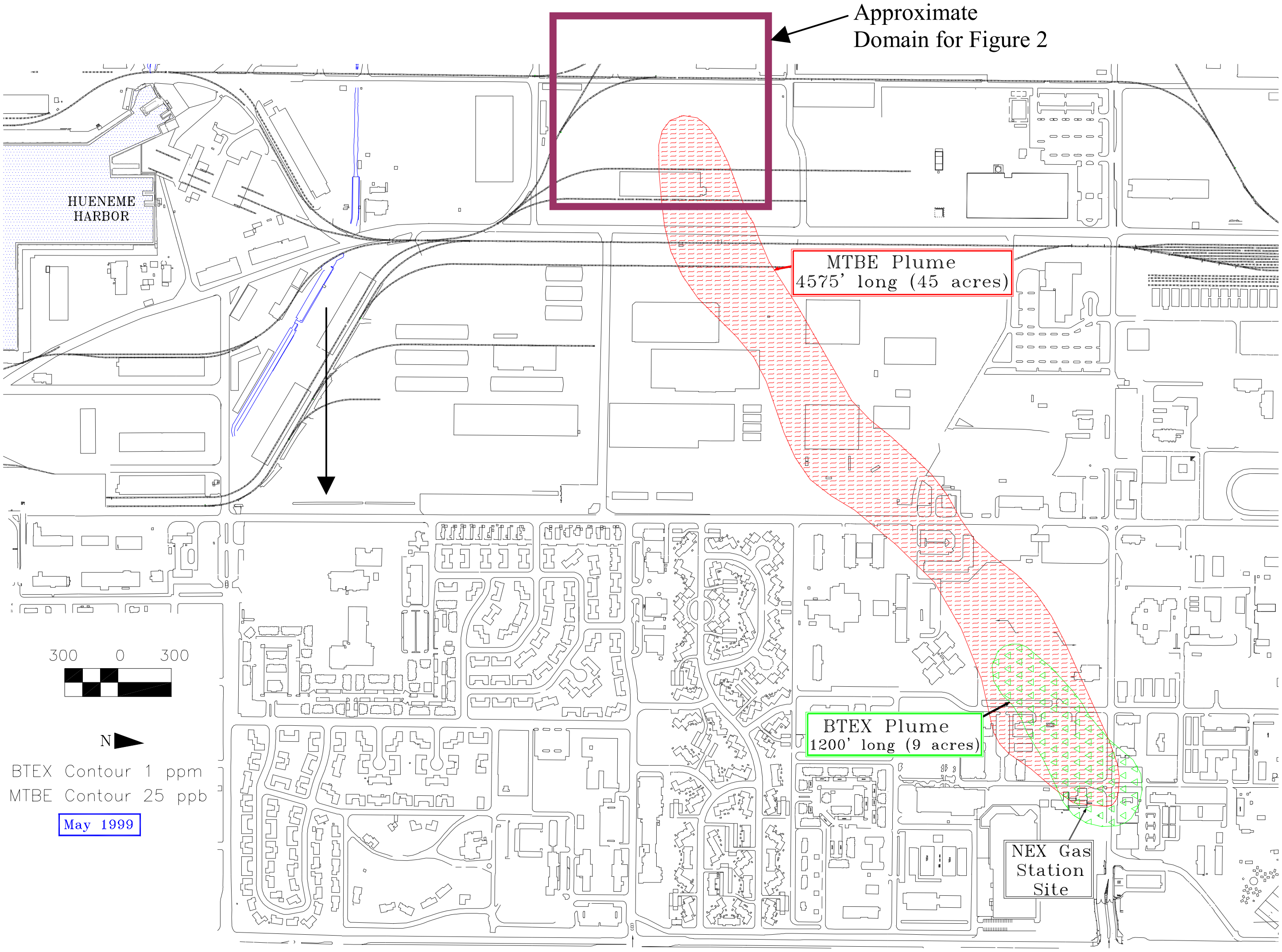

Figure 1. NBVC Port Hueneme MTBE plume map as of May 1999.

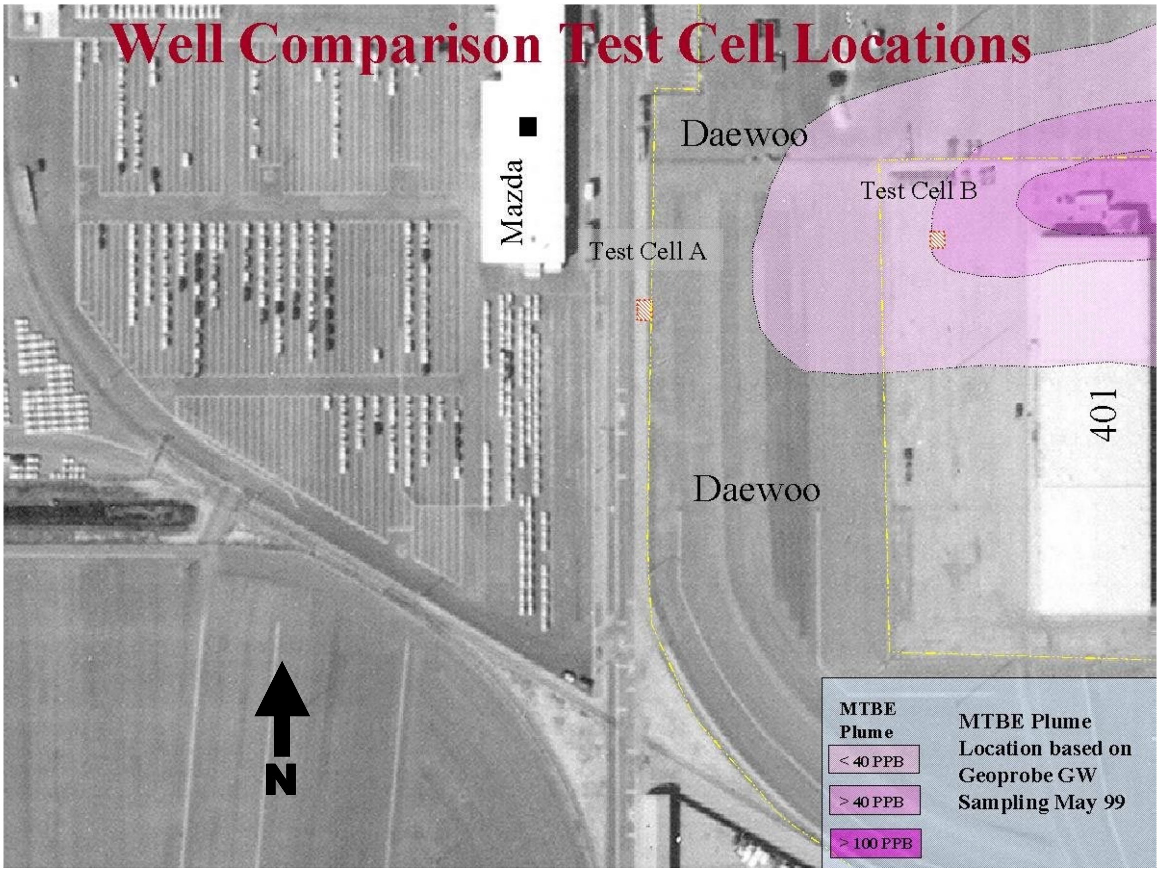

Figure 2. Locations of Evaluation Cells A and B as of May 1999.

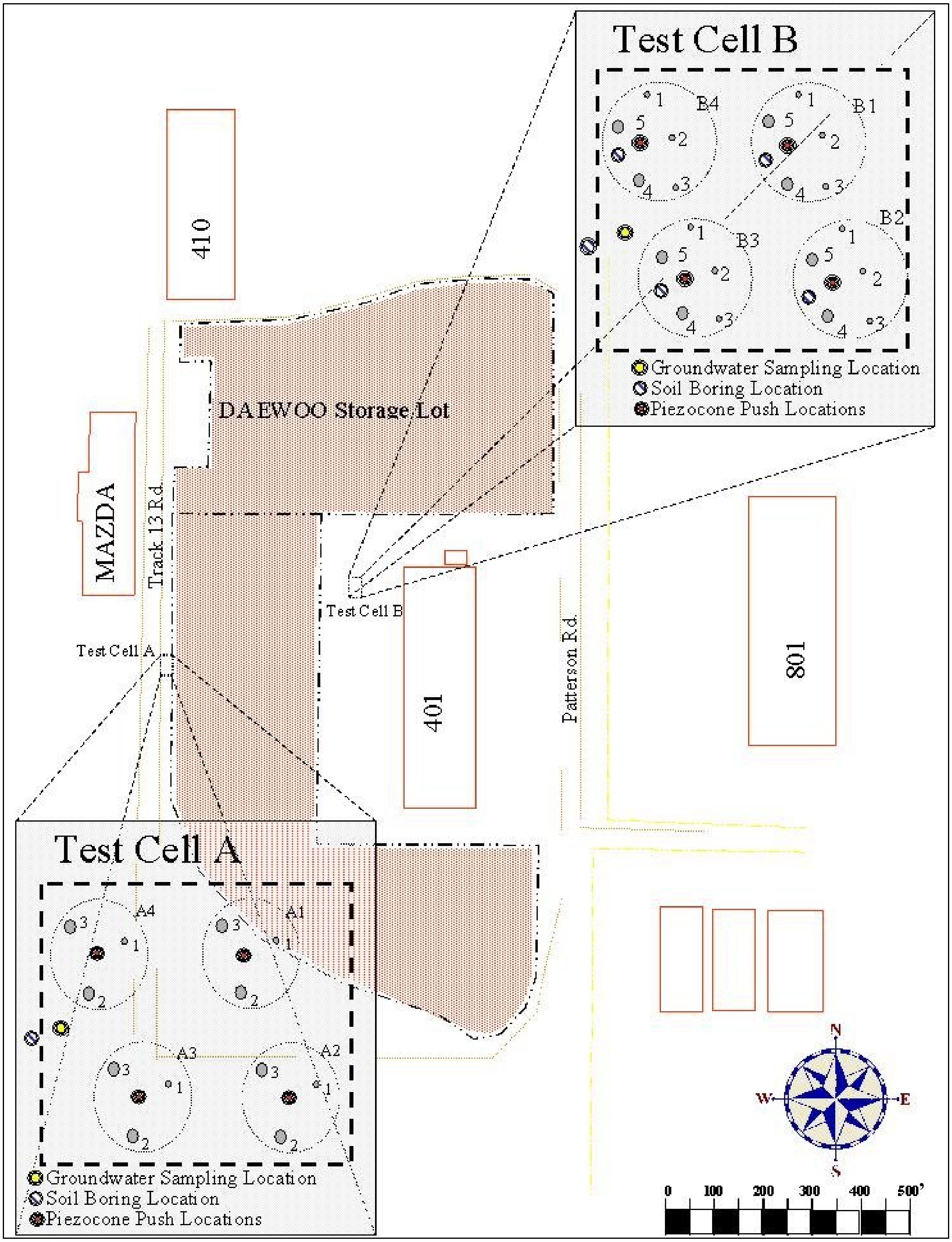

Figure 3. Piezocone push, soil boring, and direct-push water sampling locations.

The field strategy included identification of the most permeable zones within the shallow (7- to 12-foot (2.13- to 3.66-m) bgs) and deep (12- to 20-foot (3.66- to 6.10-m) bgs) zones for each cell. Piezocone data was used to identify candidate soil sample collection areas. As indicated in CPTA1 (which refers to the piezocone push in Cell A, Cluster 1), CPTA2, CPTA3, and CPTA4, a relatively finer zone of silt and clay exist in Cell A from approximately 12 to 15 feet (3.66 to 4.57 m) bgs (Appendix A). This finer zone ranges from approximately 0.3 foot (0.09 m) to approximately 2 feet (0.61 m) in depth and serves to split the shallow and deep zones that consist of medium to coarse sand. This data agrees with the observation of distinct shallow and deep migration paths within the uppermost water-bearing zone along several portions of the plume. The relatively finer layer was not identified in the Cell B piezocone data or the subsequent core samples.

Core Samples

On October 14, 1999, four continuous soil cores were collected from boring locations within Cell B approximately 3 feet downgradient from the corresponding piezocone push locations. A Precision Super Duty Vibracore Direct-Push Rig with 3.5-inch (8.89-cm) diameter core barrels was used to collect 2-5/8-inch (6.6-cm) diameter core samples in butyrate liners in accordance with ASTM D6282. The system advances a cutting tool in 3-foot (0.91-m) sections. Sections were advanced from 7 to 22 feet (2.13 to 6.71 m) bgs. The original purpose of using the large diameter barrel system was to recover relatively undisturbed samples from potential migration pathways (as identified in the piezocone tests) that were to be used for permeability testing. Due to poor recovery and jammed butyrate liners in sandy zones (as interpreted by the piezocone data), the field crew had to abandon the goal of retrieving undisturbed samples. A new approach in collecting samples in specific coarse-grained zones was required. Several different approaches were attempted to recover sand to gravel samples from depths ranging from 7 to 22 feet (2.13 to 6.71 m) bgs. Fifty percent or less was recovered from these zones for the majority of the 3-foot (0.91-m) sections. Of the materials recovered, it was assumed that they represented the top of the 3-foot (0.91-m) stroke down to maximum depth of recovery for that section. In other words, for the 1.5 feet (0.45 m) of recovery for the 7- to 10-foot (2.13- to 3.05-m) section of B2 (boring number 2 of Cell B), it was assumed that this represented soil collected from 7 to 8.5 feet (2.13 to 2.44 m) bgs. Due to the poor recovery rates, no cores were collected from Cell A during the first phase of soil sample collection.

On October 28, 1999, the Precision Super Duty Vibracore Direct-Push Rig was remobilized to the site. However, this second phase was different in that a slurp piston sampler, equipped with three core catchers, was used to try to increase percent sample recovery below depths of 10 feet (3.05 m) bgs. In addition, for several sections, aluminum liners were used. The first core was advanced in an area adjacent to piezocone push B5, approximately 50 feet (15.24 m) south of Cell B. Except for depths ranging from 11.5 to 13 feet (3.51 to 3.96 m) bgs, 15 to 16 feet (4.57 to 4.88 m) bgs, and 17.5 to 19 feet (5.33 to 5.79 m) bgs, recovery was good (generally greater than 70 percent), even in the coarse grained zones. Therefore, the device was advanced approximately 10 feet (3.05 m) downgradient from Cell B (core B7; see Image 14, Appendix I). Except for depths ranging from 6.5 to 7 feet (1.98 to 2.13 m) bgs, 9 to 10 feet (2.74 to 3.05 m) bgs, and 12 to 13 feet (3.66 to 3.96 m) bgs, recovery was good (generally greater than 75 percent). The device was then advanced approximately 5 feet (1.52 m) downgradient from Cell A (core A5; see Image 13, Appendix I). Except for depths ranging from 9.2 to 10 feet (2.80 to 3.05 m) bgs, 11.5 to 13 feet (3.51 to 3.96 m) bgs, 15 to 16 feet (4.57 to 4.8 m) bgs, and 20 to 22 feet (6.10 to 6.71 m) bgs, recovery was good (generally greater than 75 percent). Cores were backfilled with pelletized bentonite poured from the surface to approximately a 1-foot depth and topped off with asphalt.

Figure 3 displays locations for each boring. Selected soil samples were correlated to the piezocone results and analyzed for permeability and grain size distribution. Samples were selected based on their potential for being located at candidate screen depths for the 2-foot (0.61-m) screen clusters.

Figures 4 and 5 display cone penetrometer (CPT) soil classification logs, boring logs, and grain size distribution and average permeability values for specific samples. The two CPT logs are from the downgradient portion of the cell, approximately 3 feet (0.91 m) from the boring location. Grain size distribution and permeability tests were conducted on selected samples recovered during coring.

Direct-Push Water Samples

On 10 November 1999, a total of eight ground water samples were collected from specific locations and depths to determine potential solute pathways and corresponding candidate well screen depths. The specific locations were based on the following:

1. Corresponding piezocone and boring lithologic data indicative of coarse grained materials.
2. Whether soil samples from corresponding depths were successfully recovered.

While piezocone and boring log information indicated that several zones could serve as potential solute pathways, it was important to select depths for which samples were collected so that permeability and grain size distribution tests could be conducted. Permeability tests on samples recovered for these depths allow for evaluation of theories related to preferential pathways. Grain size distribution tests on samples recovered for these depths allow for determination of filter pack requirements for each well cluster.

Water samples were collected in accordance with ASTM D6001. Figure 3 displays locations for direct-push ground water collection activities. Water samples adjacent to Cell A were collected 32 inches (0.81 m) downgradient from the cell. Water samples adjacent to Cell B were collected 44 inches (1.12 m) downgradient from the cell. Table 1 lists the samples collected, collection depths and times, and analytical results for each sample. A 2-inch (5.08-cm) screen section was used as the direct-push sampling interface. A minimum of 2 liters were slowly removed (at approximately 150 ml/min) from each sampling point before two 40-ml VOA vials were completely filled. The samples were delivered on ice to CAPCO Analytical Services, Ventura, California following final collection, and subsequently analyzed using Environmental Protection Agency (EPA) Method 8020. The push holes were gravity filled with granulated bentonite (Enviroplug #8) and cold patched at the surface.

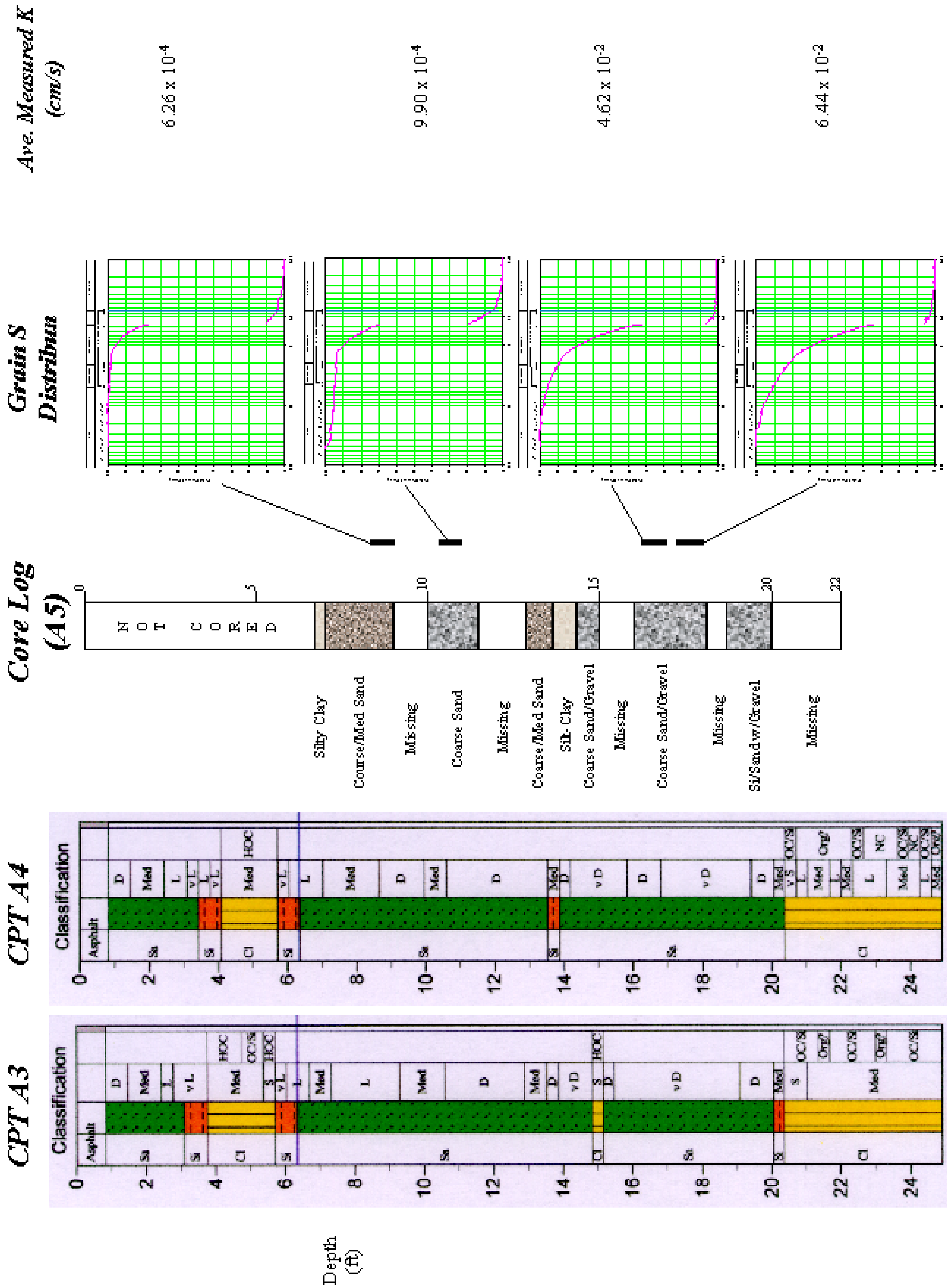

Figure 4. Soil classification logs, boring logs, grain size distribution and average permeability values for Evaluation Cell A.

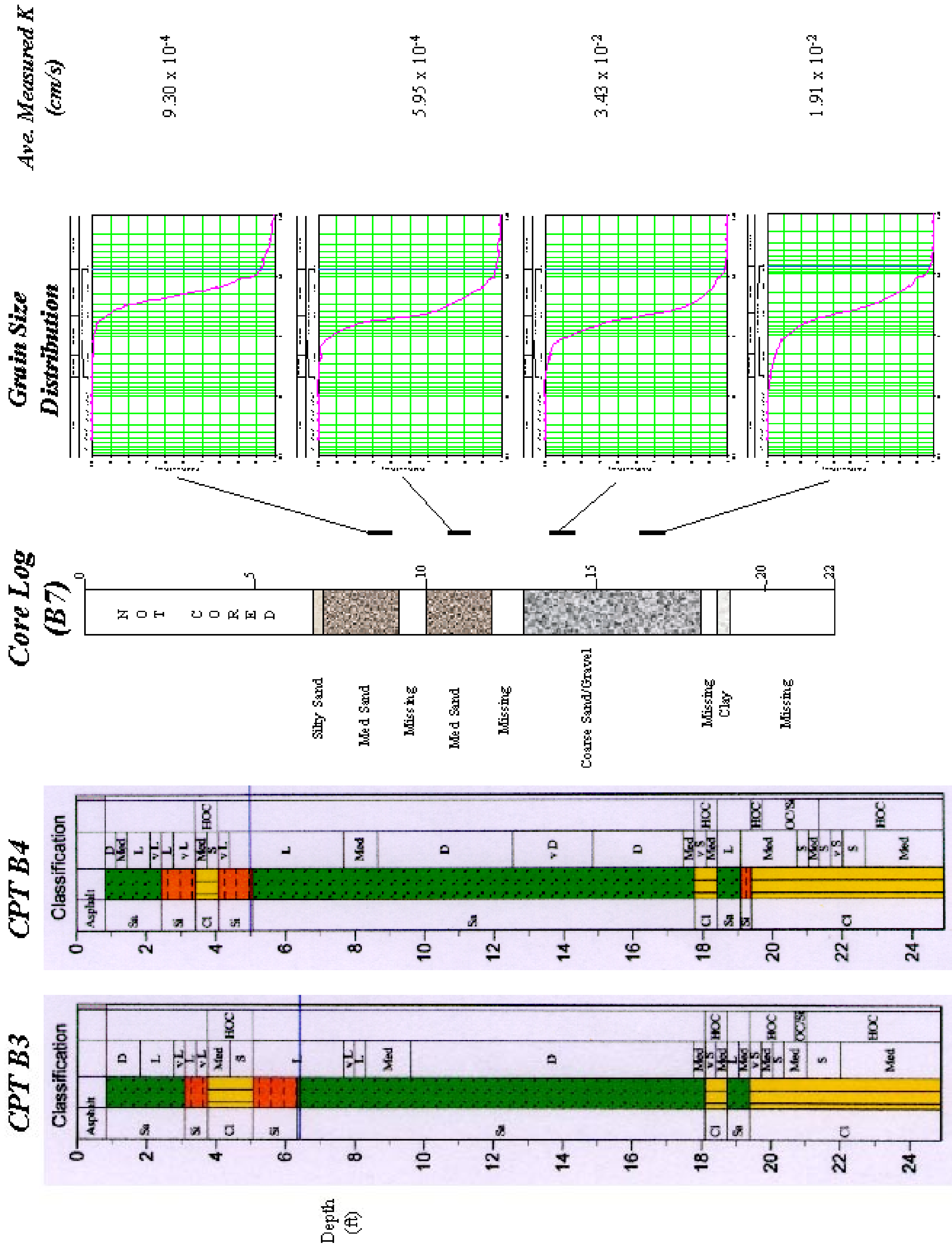

Figure 5. Soil classification logs, boring logs, grain size distribution and average permeability values for Evaluation Cell B.

Table 1. Direct-Push Ground Water Sample Results
(BQL = below practical quantitation limit of 5 µg/l)

Sample Name	Depth (ft. bgs)	Depth (m bgs.)	Time Sampled	MTBE Concentration (µg/l)
A-9	9	2.74	11:25	BQL
A-11	11	3.35	11:30	BQL
A-17	17	5.18	11:50	BQL
A-18	18	5.49	12:00	BQL
B-9	9	2.74	13:00	BQL
B-11	11	3.35	13:08	80
B-14	14	4.27	13:30	95
B-16	16	4.89	13:40	BQL

These findings indicated that the MTBE plume had not reached Cell A as of November 10, 1999. In addition, Cell B data implied preferred migration at depths of 11 and 14 feet (3.35 and 3.96 m). This observation was critical to the well comparison tests, since improper depth placement for well screens can impact concentrations (and interpretations) used in the study. Although wells in each of the clusters consisted of common screen depths and filter pack materials, preferential pathways on scales finer than intra-cluster well separation distances can lead to differences not attributable to well construction and emplacement techniques. This observation may become even more critical when comparing wells at a leading edge of a plume that can exhibit concentrations at or near instrumentation detection capabilities.

Permeability Tests for Selected Samples

Permeability tests were conducted for eight selected samples to help determine appropriate depths for screening wells in each cluster. Zones of highest permeability are the most probable pathways for solute migration. Candidate testing depths were selected based on piezocone soil classification results and recovered core samples. A modified version of ASTM D2434, Standard Test Method for Permeability of Granular Soils (Constant Head), was conducted for each of the eight samples. Modifications included the following:

1. Samples were not pre-sieved to remove selected clast ranges.
2. Only large pebbles were removed.
3. Samples were not weighed, since this was done when grain size distribution tests were conducted.

Once the test cells were filled to appropriate levels (minimum of 2 cm above the upper manometer per ASTM D2434), the soils were lightly tamped with a standard 100-g sliding weight (four blows equally distributed about the top of the soil for each sample).

Appendix B presents the laboratory data for the permeability tests. Table 2 summarizes the permeability test results.

Table 2. Permeability Results

Soil Core	Depth Range (ft)	Depth Range (m)	Average k (cm/s)
A5	8.3 – 9.3	2.53 – 2.83	6.26×10^{-4}
A5	10.3 – 11.3	3.14 – 3.44	9.90×10^{-4}
A5	16.2 – 17.2	4.94 – 5.24	4.62×10^{-2}
A5	17.2 – 18.2	5.24 – 5.55	6.44×10^{-2}
B7	8.3 – 9.3	2.53 – 2.83	9.30×10^{-4}
B7	10.5 – 11.5	3.20 – 3.51	5.95×10^{-3}
B7	13.5 – 14.5	4.11 – 4.42	3.43×10^{-3}
B7	16.0 – 17.0	4.88 – 5.18	1.91×10^{-3}

The Cell B MTBE water concentrations measured during the direct-push ground water sampling event supported the conceptual model whereby permeability is related to concentration when hydraulically continuous layers are present. This suggested that migration pathways may be identified using the sequence of events employed (i.e., penetrometer soil classification tests, soil sample collection, and evaluation of the vertical distribution of permeability for candidate zones).

Although the 13.5- to 14.5-foot (4.11- to 4.42-m) sample displayed a relatively higher permeability than the sample collected from 16 to 17 feet (4.88 to 5.18 m) bgs for Cell B, it was decided to use the 16- to 17-foot (4.88- to 5.18-m) depth as the screen depth range determinant for the deeper Cell B clusters. This was done for several reasons. The most important reason was based on the desire to have vertical separation for the 2-foot (0.6-m) screen length clusters. This would serve to avoid redundancy in the comparison test. Since the permeability differences between the two samples in question (B7, 13.5 to 14.5 feet (4.11 to 4.42 m); B7, 16 to 17 feet (4.88 to 5.18 m)) proved to be relatively small (less than a fifth of an order of magnitude), it was believed that bias would be relatively small. One concern with this approach stems from the observation that the preliminary direct-push ground water sampling event showed more MTBE at the 14-foot (4.27-m) depth (95 ppb) than at the 16-foot (4.89-m) depth (bgs). However, one important factor to be considered was that these samples were collected over a small vertical depth range (<6 inches (15.2 cm)) while the well screens were either 2 or 5 feet (0.61 or 1.52 m) in length.

Cell A had not initially been located in part of the plume area, therefore selection of screen depth placement was based solely on permeability results for selected samples. If the most permeable zones were not hydraulically connected to upgradient zones containing measurable levels of MTBE, the criteria used could lead to erroneous screen placement depths. Provided the cell was placed in the proper location to intercept the migrating plume, it could have been useful to collect additional depth discreet direct-push ground water samples from an area within or adjacent to Cell A once the plume reached that area. This would have helped determine whether the screens were placed in optimal depths.

Grain Size Distribution of Selected Samples

ASTM D422, Standard Test Method for Particle-Size Analysis of Soils, was conducted for each of the eight soil samples analyzed for permeability. Appendix C presents the laboratory results from these efforts. ASTM D5092, Standard Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers, was used to determine appropriate well construction design specifications for each of the well clusters.

Well Construction and Installation

From February 8 to February 14, 2000, a total of 32 wells were installed in the two cells. Twelve wells were installed in Cell A, while a total of twenty wells were installed in Cell B. Prior to installing the wells for Cell A, an asphalt cap was fabricated to prohibit runoff from entering the wells. Figures 6 and 7 display the configuration for each of the evaluation cells. The drilled wells were installed using a Mobile B-61 hollow stem auger drill rig. All push wells were installed using a Precision SD-1 direct-push rig. Drilled well filter packs were installed using a tremmie method and sealed in accordance with ASTM D5092. All push wells with filter packs consist of pre-pack filter packs and expandable bentonite seals. The pre-pack jackets are comprised of inner and outer cylinders of 65-mesh stainless steel filled with sand and fit over the PVC screened sections. The 3/4-inch (1.91-cm) jackets have a 1.4-inch (3.56) outer diameter. The 2-inch (5.08-cm) jackets have a 2.8-inch (7.11-cm) outer diameter. All wells were completed to the surface and protected with traffic boxes and keyed-alike (one key fits all) locks.

Well screen depth ranges for each of the clusters in each cell were determined using several factors. Since short screen lengths are expected to yield more comparable and representative solute concentration data on a localized scale, each well was constructed with either a 2- or 5-foot (0.61- or 1.52-m) screen length and included a 6-inch (1.27-cm) sediment sump. With one exception, the center of each screen for each cluster was set at the most permeable depth. The one exception included the deep clusters for Cell B. Although the 13.5- to 14.5-foot (4.11- to 4.42-m) zone displayed relatively higher permeability, the screens were set to encompass the 16- to 17-foot (4.89- to 5.18-m) depth range. This was done so that the 5-foot (1.52-m) screen lengths for the shallow and deep clusters would not overlap. Although the direct-push screening samples showed non-detectable levels for the 16-foot (4.89-m) depth, the differences in permeability between the 14-foot (4.27om) and 16-foot (4.89-m) zones were considered negligible when recognizing that the screens span 2- or 5-foot (0.61- or 1.52-m) depth ranges. Well clusters (consisting of five wells each for Cell B, and three wells each for Cell A) were grouped by screen length and depth range.

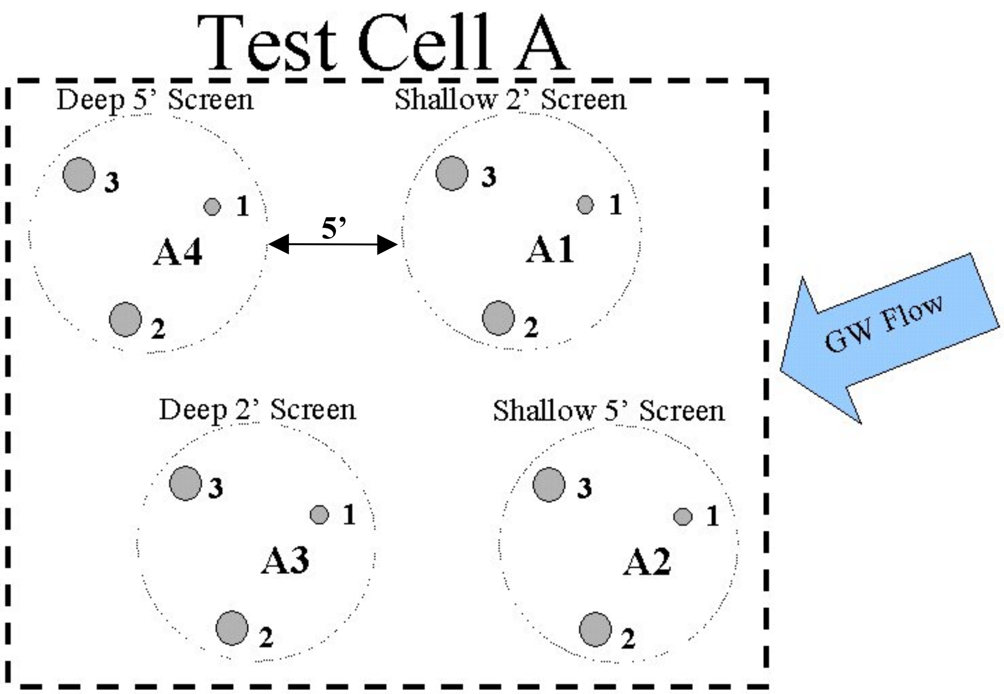

Figure 6. Configuration for Evaluation Cell A

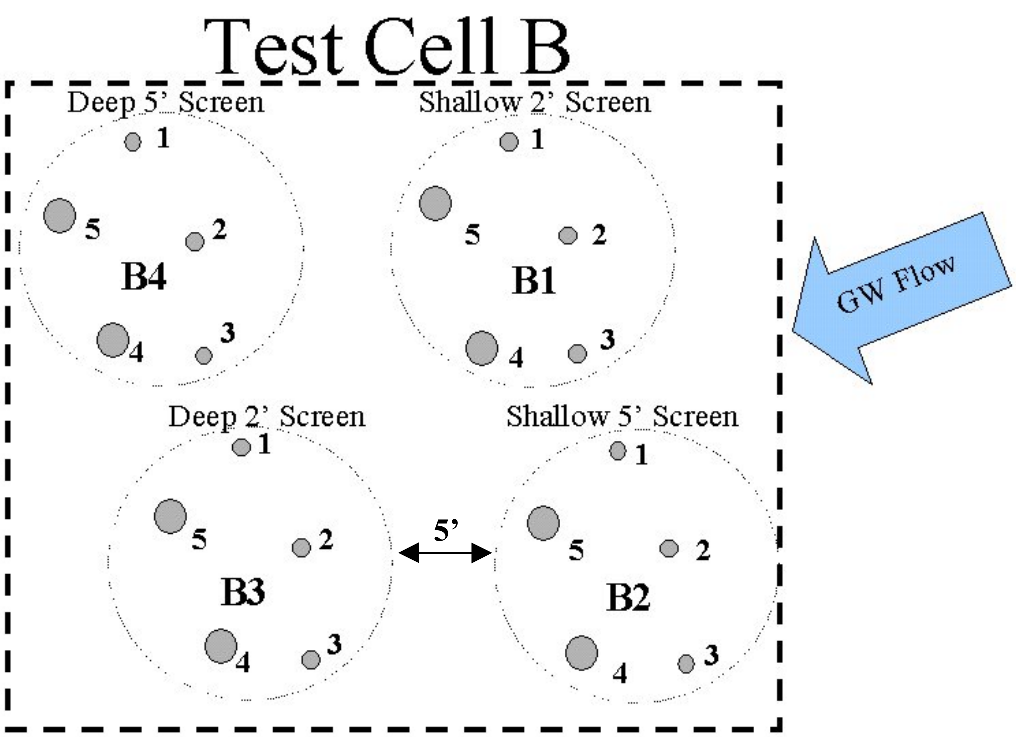

Figure 7. Configuration for Evaluation Cell B

Specific well screen design (filter pack and slot size) was determined using several criteria. To evaluate performance of wells adhering to the ASTM specifications (ASTM D5092), grain size distribution curves (Appendix C) were used to determine filter pack grain size and corresponding slot size recommendations (Appendix D). For Cell A, each of the wells was designed using ASTM specifications. For Cell B, two additional well designs were also employed. To evaluate the performance of wells most commonly installed by drillers, a generic ("conventional") well design consisting of 20 to 40 sand pack mesh surrounding 0.010-inch (0.25-mm) slotted schedule 40 PVC pipe was used as one of the alternatives in each of the well clusters in Cell B. To evaluate performance of non-pack wells that are often installed by direct-push equipment operators, an additional set of wells consisting of 0.010-inch (0.25-mm) slotted schedule 40 PVC pipe was installed without a filter pack in each of the clusters in Cell B.

For Cell A, four clusters were installed, each consisting of the following three types of wells:

1. 3/4-Inch Diameter Pushed Wells – ASTM Specifications (#1 wells)
2. 2-Inch Diameter Pushed Wells – ASTM Specifications (#2 wells)
3. 2-Inch Diameter Drilled Wells – ASTM Specifications (#3 wells)

For Cell B, four clusters were installed (Figure 9), each consisting of the following five types of wells:

1. 3/4-Inch Diameter Pushed Wells – No Filter Pack (#1 wells)
2. 3/4-Inch Diameter Pushed Wells – ASTM Specifications (#2 wells)
3. 3/4-Inch Diameter Pushed Wells – "Conventional" (0.010 slot; 20-40 sand) (#3 wells)
4. 2-Inch Diameter Pushed Wells – ASTM Specifications (#4 wells)
5. 2-Inch Diameter Drilled Wells – ASTM Specifications (#5 wells)

Table 3 presents well construction details. A nomenclature for each cluster was established to preserve relationships between wells, emplacement methods, and evaluation cells. The first two symbols in each well name refer to the cluster they belong to. For instance, each A1 well belongs to the A1 cluster. The "p" and "d" refer to emplacement method (pushed versus drilled, respectively), "pcv" refers to pushed conventional, and "pnp" refers to pushed no pack designs. Although small diameter push wells consist of 3/4-inch inner diameter riser pipes, a "1" is used in the name to signify "1-inch wells" (a common name for these types of wells).

Appendix E presents well construction logs. Figures 6 through 9 display configuration for Cell A, configuration for Cell B, a side view for a Cell B cluster, and the layout for Cell B.

Table 3. Well Construction Details

Cell (Cluster #)	Well Names	Inner Diameter (in.)	Emplacement Method	Screen Depth Range (ft)	Filter Pack Mesh	Slot Size (in.)
A (1)	A1p1 (A1-1)	3/4	Pushed	9.5 - 11.5	20 to 40	0.010
A (1)	A1p (A1-2)	2	Pushed	9.5 - 11.5	20 to 40	0.010
A (1)	A1d (A1-3)	2	Drilled	9.5 - 11.5	20 to 40	0.010
A (2)	A2p1 (A2-1)	3/4	Pushed	7 – 12	20 to 40	0.010
A (2)	A2p (A2-2)	2	Pushed	7 – 12	20 to 40	0.010
A (2)	A2d (A2-3)	2	Drilled	7 – 12	20 to 40	0.010
A (3)	A3p1 (A3-1)	3/4	Pushed	17 – 19	10 to 20	0.030
A (3)	A3p (A3-2)	2	Pushed	17 – 19	10 to 20	0.030
A (3)	A3d (A3-3)	2	Drilled	17 – 19	10 to 20	0.030
A (4)	A4p1 (A4-1)	3/4	Pushed	14 – 19	10 to 20	0.030
A (4)	A4p (A4-2)	2	Pushed	14 – 19	10 to 20	0.030
A (4)	A4d (A4-3)	2	Drilled	14 – 19	10 to 20	0.030
B (1)	B1pnp (B1-1)	3/4	Pushed	10 – 12	No pack	0.010
B (1)	B1p1 (B1-2)	3/4	Pushed	10 – 12	10 to 20	0.020
B (1)	B1pcv (B1-3)	3/4	Pushed	10 –12	20 to 40	0.010
B (1)	B1p (B1-4)	2	Pushed	10 – 12	10 to 20	0.020
B (1)	B1d (B1-5)	2	Drilled	10 – 12	10 to 20	0.020
B (2)	B2pnp (B2-1)	3/4	Pushed	7 – 12	No pack	0.010
B (2)	B2p1 (B2-2)	3/4	Pushed	7 – 12	10 to 20	0.020
B (2)	B2pcv (B2-3)	3/4	Pushed	7 – 12	20 to 40	0.010
B (2)	B2p (B2-4)	2	Pushed	7 – 12	10 to 20	0.020
B (2)	B2d (B2-5)	2	Drilled	7 – 12	10 to 20	0.020
B (3)	B3pnp (B3-1)	3/4	Pushed	16 – 18	No pack	0.010
B (3)	B3p1 (B3-2)	3/4	Pushed	16 – 18	10 to 20	0.020
B (3)	B3pcv (B3-3)	3/4	Pushed	16 – 18	20 to 40	0.010
B (3)	B3p (B3-4)	2	Pushed	16 – 18	10 to 20	0.020
B (3)	B3d (B3-5)	2	Drilled	16 – 18	10 to 20	0.020
B (4)	B4pnp (B4-1)	3/4	Pushed	12.5 - 17.5	No pack	0.010
B (4)	B4p1 (B4-2)	3/4	Pushed	12.5 - 17.5	10 to 20	0.020
B (4)	B4pcv (B4-3)	3/4	Pushed	12.5 - 17.5	20 to 40	0.010
B (4)	B4p (B4-4)	2	Pushed	12.5 - 17.5	10 to 20	0.020
B (4)	B4d (B4-5)	2	Drilled	12.5 - 17.5	10 to 20	0.020

Well Development

Appendix F presents well development logs. All wells were developed in accordance with ASTM D5521. Development for the drilled wells consisted of bailing with a 7.0-foot (2.13-m) stainless steel bailer. For all the pushed wells (3/4-inch and 2-inch diameter), a small diaphragm pump was used to develop the wells. During bailing, field personnel tracked cumulative volume removed, turbidity, temperature, conductivity, pH, dissolved oxygen, and logged critical observations. As can be seen in Appendix F, the wells varied greatly with respect to the volumes required to reduce turbidity. In addition, some wells (A1-1, A1-2, and A2-1) were pumped dry and did not produce significant water volumes at development pumping rates of approximately 1 gpm. Also, in some wells (A2-3, A3-3, A4-3, each drilled designs) turbidity did not decrease throughout the development period.

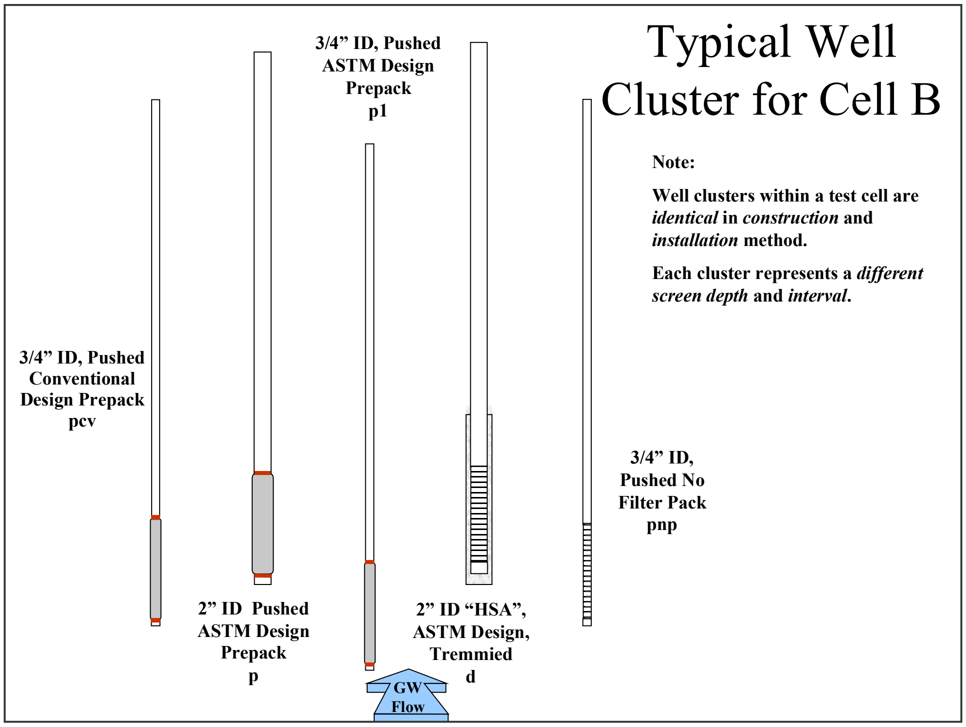

Figure 8. Side view for typical Cell B Well B cluster.

Cluster	Screen Length	Screen Interval
B1	2 ft.	10 to 12 ft.
B2	5 ft.	7 to 12 ft.
B3	2 ft.	16 to 18 ft.
B4	5 ft	12.5 to 17.5 ft.

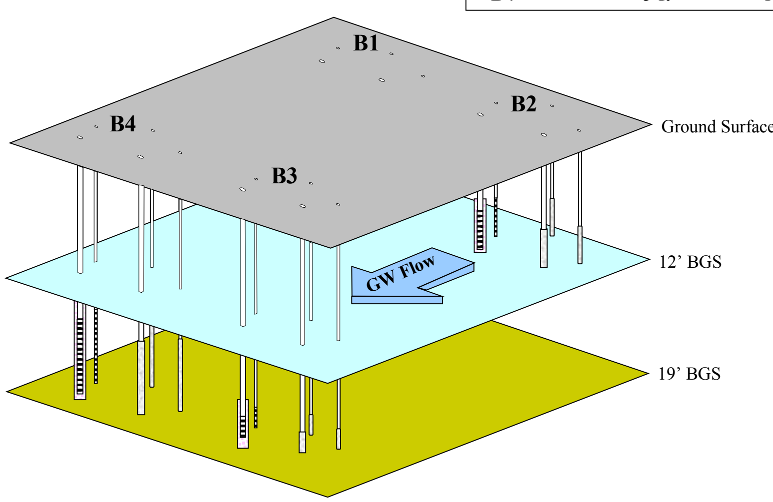

Figure 9. Cell B layout.

Sampling and Analytical Logistics

Pre-Sampling. The test cell locations were checked at least one day before each sampling event. The cells were checked for obstructions (parked vehicles, stored materials, etc.) and a pallet with an empty wastewater drum was placed in an appropriate location adjacent to each cell. The field crew reviewed the field implementation plan to ensure that the types of samples, numbers of samples, and sampling randomization logistics were understood and that all field logistics were addressed accordingly. Laboratory personnel were contacted and times were established for sample courier pickup times and places. Labels for the sample bottles were printed to include the well identifier and date and time sampled. The Hydrolab™ was calibrated and the battery was charged.

The morning of the sampling event a canopy was deployed at the first sampling location to protect the samples and workers from solar exposure. A small gasoline generator (750-watt Honda) was set up approximately 75 feet down wind of the test cell. The traffic box covers were removed, and the sample pump and Hydrolab™ were set up. The monitoring wells included dedicated 1/4-inch (0.64-cm) Teflon sample tubes in the wells. The sample tube was pulled up 1 or 2.5 feet (depending on well screen length) to position the end of the sample tube at the center of the screen interval. Sample tubing was held in place by a clothespin attached to the well head. The peristaltic pump was placed adjacent to the well so that the sample tube could be inserted directly into the influent end of the flexible pump tubing (*Masterflex* 6402-15, Norprene). The effluent end of the pump tubing was plumbed with 1/4-inch polytubing and Norprene connectors to transport the effluent ground water through the Hydrolab flow-through cell and then into the wastewater drum. A new piece of pump tubing was used for every well sampled to avoid cross contamination.

Before pumping was initiated, the depth to ground water was measured using a Solinst water level meter with a 1/4-inch (0.64-cm) cable. The water level meter was decontaminated upon retrieval. The sampling pump was started and set at half speed (Pump Drive: Cole-Palmer, *Masterflex*; Console Drive Mod. # 7520-40; Pump Head: *Masterflex* Easy-Load Mod. # 7518-62). Once flow was established, the water was diverted into a graduated cylinder and timed for 1 minute. The flow rate was set to range between 460 to 480 mil per minute, since it was easy to attain and maintain and was close to conditions categorized as "low flow." This rate calibration procedure was performed at the beginning and end of the sampling of a test cell or workday, whichever came first. Samples were collected in random order according to the Environmental Security Technology Certification Program (ESTCP) Long-Term Monitoring Project team recommendations. Table 4 displays the sampling order for rounds 1 and 2.

Table 4. Sampling Event Order for Rounds 1 and 2

Round 1 Sampling Order			Round 2 Sampling Order		
Well ID	Date	Time	Well ID	Date	Time
B1-5	3/22/00	10:05	A1-2	5/16/00	10:50
B2 -5	3/22/00	10:20	A1-3	5/16/00	11:10
B1-4	3/22/00	11:00	A1-1	5/16/00	11:30
B2 -4	3/22/00	11:23	A2 -2	5/16/00	13:20
B1-2	3/22/00	13:20	A2 -3	5/16/00	13:45
B2 -2	3/22/00	13:40	A2 -1	5/16/00	14:11
B1-3	3/22/00	14:05	A3 -2	5/16/00	14:30
B2 -3	3/22/00	14:20	A3 -3	5/16/00	14:50
B1-1	3/22/00	14:50	A3 -1	5/16/00	15:10
B2 -1	3/22/00	15:10	A4 -2	5/16/00	15:30
B3 -5	3/23/00	10:40	A4 -3	5/16/00	15:40
B4 -5	3/23/00	11:05	A4 -1	5/16/00	16:10
B3 -4	3/23/00	11:25	B1-4	5/17/00	10:00
B4 -4	3/23/00	13:45	B1-5	5/17/00	10:20
B3 -2	3/23/00	14:05	B1-3	5/17/00	10:40
B4 -2	3/23/00	14:35	B1-1	5/17/00	11:00
B3 -3	3/23/00	14:50	B1-2	5/17/00	11:20
B4 -3	3/23/00	15:10	B2 -4	5/17/00	13:40
B3 -1	3/23/00	15:25	B2 -5	5/17/00	14:00
B4 -1	3/23/00	15:45	B2 -3	5/17/00	14:20
A1-3	3/24/00	10:06	B2 -1	5/17/00	14:40
A2 -3	3/24/00	10:42	B2 -2	5/17/00	15:00
A1-2	3/24/00	11:00	B3 -4	5/17/00	15:20
A2 -2	3/24/00	11:18	B3 -5	5/17/00	15:40
A1-1	3/24/00	11:35	B3 -3	5/17/00	16:00
A2 -1	3/24/00	11:55	B3 -1	5/18/00	9:15
A3 -3	3/24/00	12:15	B3 -2	5/18/00	9:40
A4 -3	3/24/00	12:42	B4 -3	5/18/00	10:15
A3 -2	3/24/00	13:00	B4 -4	5/18/00	10:35
A4 -2	3/24/00	13:12	B4 -5	5/18/00	10:45
A3 -1	3/24/00	13:20	B4 -1	5/18/00	11:10
A4 -1	3/24/00	13:25	B4 -2	5/18/00	11:30

Sampling. The effluent from the pump was run through the Hydrolab flow-through cell at the established flow rate. The well was purged for a minimum of 5 minutes while simultaneously monitoring for stabilization of dissolved oxygen, specific conductance, temperature, and pH in accordance with ASTM D5463. If stabilization was not observed within 5 minutes, pumping and monitoring continued until stabilization was achieved. The field team noted that 10-minute purge times are about the average duration. Once stabilization occurred and readings were noted in the field logbook, the pump was turned off. The depth to ground water was checked for water table drawdown before sampling. If the drawdown was greater than 0.5 feet, pumping would continue at a reduced rate to allow the well to recover. For low-flow sampling, drawdown must be minimal (Puls and Barcelona, 1996). To date, drawdown has been negligible in all the wells during purging.

To initiate the sampling procedure, the polytubing was pulled from the effluent end of the pump tube. The Hydrolab flow-through cell has a check valve to prevent the back flow of wastewater. Initially the geo-chemical sample bottle was filled directly from the pump tube (at the established flow rate), then the pump speed was turned down to less than 100 mil per minute and the turbidity sample bottle filled. Turbidity was measured using a *Hach* Portable Turbidity Meter. Finally, a set of three 40-ml VOA sample bottles was filled for the MTBE analysis. After the parameters were measured and noted in the logbook, the 40-ml VOA bottles were put on ice and the old pump tube was discarded. The procedure was repeated for the next well in the sampling sequence. Trip blanks and matrix spike duplicates were transported with the samples to the lab when applicable (e.g., most MTBE analyses were conducted in a field laboratory facility).

Post Sampling. Samples were stored at 4^{o}C and delivered to CAPCO within 48 hours for analysis. Sampling tubes were tucked in their wells with caps placed on the well heads and lids on the well boxes. The area was policed for refuse generated by the sampling event (used paper products) and arrangements were made for the pickup and proper disposal of the wastewater. Following field activities, field notes were entered into an electronic format for group review. Following receipt of laboratory analyses, analytical results were entered into an electronic format for data processing and management.

Analytical Logistics. For each well, several analytical measurements were used. Geochemical parameters such as dissolved oxygen, pH, specific conductance, temperature, and turbidity were measured in the field. General minerals and MTBE were analyzed using the laboratory methods listed in Table 5. For several sampling rounds (rounds 1, 2, and 4), a field laboratory was used for MTBE analyses, with detection capabilities as low as 2 to 5 ppb. For round 3, the AFRL Laboratory (located at Tyndall AFB) was used to analyze MTBE, with detection capabilities as low as 2 to 5 ppb. Typically, single samples were processed for general minerals for each well, while MTBE was measured in triplicate for each well. In addition, a few additional samples were collected (approximately 10 percent) and analyzed for MTBE to assess quality control.

Table 5. List of Laboratory Methods

Analyte/Parameter	EPA Method
MTBE	8260
Color	110.1
Specific Conductance	120.1
Hardness ($CaCO_3$)	130.2
Odor	140.1
PH	150.1
Total Dissolved Solids	160.1
Turbidity	180.1
Metals (via Inductively Coupled Plasma)	200.7
Ions	300
Alkalinity	310.1
Fluoride	340.1
Surfactants	425.1

ANALYTICAL RESULTS

Appendix G presents analytical results for Sampling Round 1 (conducted from 3/21/00 to 3/24/00), Sampling Round 2 (conducted from 5/16/00 to 5/18/00), Sampling Round 3 (conducted from 7/11/00 to 7/12/00), and Sampling Round 4 (conducted from 8/3/00 to 8/4/00), and the field data collected during sampling. Each of the 32 wells were sampled in triplicate and analyzed for MTBE using a field laboratory. Three additional confirmation samples were collected each round and analyzed for MTBE using a conventional laboratory. Three of the round 3 samples were separated into matrix spikes and matrix spike duplicates to evaluate solute recovery efficiencies. Each well was sampled and analyzed for a suite of inorganic parameters as well. Turbidity, dissolved oxygen, specific conductance, pH, and temperature were each monitored during sampling in accordance with ASTM D5463.

Statistical evaluation of the geochemical parameters and MTBE results are presented in the Statistical Analyses section. Outside consultation was procured for detailed statistical assessment and assistance regarding the determination of similarities and differences for each of the well clusters and cells.

WATER LEVELS

Ground water level elevation measurements (relative to mean sea level) conducted in the field during Sample Rounds 1 through 4 are presented in Appendix H. In addition, a round of measurements was taken on 9/5/00 during a short time interval (less than 1 hour) in order to avoid potential problems associated with tidal influence. This data is also presented in Appendix H.

INSTALLATION COSTS

Although this project consists of several research components, potentially leading to higher costs, well installation and development were tracked. These findings are summarized in Table 6. For the 24 direct-push wells (8 2-inch wells and 16 3/4-inch wells), four days of installation were required to install approximately 385 feet of materials. Installation of pre-pack wells requires more time than the non-pack wells. Therefore, for non-pack devices, the same number of wells could be installed in approximately 2 days. Eight rotary drilled hollow stem auger wells (for a total of 129 feet) were installed in 2 days. The largest differences in the well installation efforts are associated with the generation of solid and liquid waste. Solid soil cutting waste is not generated for direct-push wells, except when required to set wellhead traffic protection boxes. However, this small amount of material is generally considered not hazardous. For this project, liquid waste generation was 3 to 4 times higher for drilled wells. However, the liquid waste comparisons must be interpreted with caution, since high turbidity associated with augured wells was not simply due to the fact that more annular space disruption occurred. The sand pack material selection (based on ASTM standards applied to boring sample grain size distribution) may have also contributed to the level of turbidity (which was used to determine development end points).

Table 6. Cost and IDW Comparisons for Direct-Push and Rotary Installed Wells

	Direct-Push Wells	Rotary Installed Wells
Well Diameter	2” and ¾”	2”
Maximum Well Depth	20’ (6.1m)	20’ (6.1m)
Average No. Installations/Day	6	4
Average Cost (Equipment and Labor)	\$20/ft	\$23/ft
Average Well Material Costs	\$3/ft*	\$6/ft
Solid Waste Generated	0 drums	6 drums (for 8-2” wells) 0.75 drums/well
Decon Rinseate Generated	0.5 drums/day (5 total for 24 wells) ~0.2 drum per ¾” well (16) ~0.3 drum per 2” well (8)	2 drums/day (8 total for 8 wells) ~1 drum/well
Average Development Water Volume	21 gal/well (~10 gal/well per ¾” well) (~15 gal/well per 2” well)	45 gal/well

*Stainless steel prepack screens (2”) cost \$28/ft; Prepack schedule 40 PVC screens (3/4”) cost \$10/ft.

Several costs are not accounted for in Table 6. For instance, additional costs of approximately $4,200 for consumables (e.g., bentonite, sand, and grout), approximately $2,900 for mobilization, approximately $1,400 for subsistence, approximately $2,000 for surveying, approximately $2,400 for generation of boring logs, and approximately $2,400 for well development were also incurred. These costs were difficult to separate between drilled and pushed well activities, since these items are generally required regardless of the method of installation. In addition, several items (e.g., consumables, surveying activities, and generation of boring logs) are paid for on a sliding cost scale, whereby the greater the number of units, the lower the per unit cost.

These general costs may be used to estimate anticipated costs when using different well designs. The least expensive alternative is to employ direct-push wells without annular sand pack. The most expensive approach would consist of using conventional drilling installation methods.

STATISTICAL ANALYSES

Consultation from an outside contractor (Dr. Michaelsen, Department of Geography, University of California at Santa Barbara) was obtained to help reach specific conclusions. Determination of the significance of the comparison results can be a complex matter, since many variables can affect the outcome. A partial list of these variables includes: (1) how well these sample collection devices represent options to be considered by potential users; (2) similarities between the test site and sites where these devices might potentially be used; (3) how repeatable and consistent the installation methods are; and (4) how uncontrollable variables (i.e., climate, tidal influence, soil and flow heterogeneities (both magnitude and direction), etc.) might influence the chemical concentration and water level results.

Specific conclusions regarding how adequate direct-push installed wells compare to drilled wells were determined by observing four rounds of ground water sampling and monitoring data. In particular, MTBE concentration, specific geochemical parameters, and water level measurements were used to try to identify data trends and to determine whether significant differences between drilled and pushed wells exist. In addition, since several push well designs were used (each with different installation and cost attributes), it allowed for a determination of the performance comparisons among these designs as well.

The following sections discuss the statistical treatment used for the data and specific observations related to the main question: “How does the performance of hollow stem auger drilled wells compare to the performance of direct-push installed wells?" Statistics can be an imprecise gauge of significance, since budgetary constraints impact the size of the data set, and outside influences (e.g., impact of climate) are often not quantifiable. However, where possible, the engineers focused on the main question in an attempt to describe the nature of the comparative qualities of the data set.

MTBE Concentration Data

The primary objective of this sample alternative comparison was to identify and evaluate the statistical significance of any consistent variations in measured MTBE concentrations in Cells A and B associated with any of the four major design variables: well type, depth zone, screen length, and sampling date. Well type was the primary variable of interest, but the other three variables could potentially be important sources of variability, so their impacts needed to be considered and accounted for in the analyses.

Statistical Methods. Well type was clearly a categorical factor, while date, screen length, and screen depth were treated as either continuous variables or categorical factors. The date variable has only four different levels, so it was easily converted into a factor. Screen length and depth zone had two different levels and were also be converted into factors. Screen length was either 2 feet or 5 feet; depth zone was either shallow (7 to 12 feet) or deep (12.5 to 18 feet in Cell B, 14 to 19 feet in Cell A). Screen length and depth zone was also combined into a single four-level factor referred to as a screen depth range with the following levels: Cell A - 7 to 12 feet, 9.5 to 11.5 feet, 14 to 19 feet, 17 to 19 feet; Cell B – 7 to 12 feet, 10 to 12 feet, 12.5 to 17.5 feet, 16 to 18 feet. The first specification had the advantage of treating screen length separately, while the second provided the ability to resolve depth-related variations in more detail. Results were presented for both specifications. In either case, all the predictors were factors, which simplified the analyses considerably.

Analysis of variance (ANOVA) was determined to be the best technique for analyzing data consisting of categorical factor predictors and a continuously varying response variable. The basic method was to partition the variability (as measured by the sum of squares) into components associated with each factor and a residual error sum of squares. The total degrees of freedom of the sample was also partitioned between factor and error components. Statistical tests based on ratios of mean squares (sums of squares divided by associated degrees of freedom) were used to estimate the probabilities that the relationship between each factor and the response could have occurred by chance. It is necessary to assume that the errors were Gaussian, had equal variance, and were uncorrelated in order for the ANOVA results to be valid. These assumptions could not be tested directly, but model residuals were examined to qualitatively evaluate their validity. By partitioning the variability into components associated with each factor, analysis of variance provided a more complete model of variability than tests like the two-sample Wilcoxon test which could make a single comparison between differences associated with well design and differences associated with everything else analyzed together.

The results of ANOVA tests indicate whether or not a factor has a significant impact on the value of the response variable, but the tests do not provide direct information on how the response varies with different levels of the factor. It is mathematically impossible to independently estimate means for each level of each factor; statisticians typically define a reduced set of orthogonal linear combinations of response values for different factor levels known as contrasts to be evaluated. The choice of contrasts was arbitrary, and it did not affect the results of the overall ANOVA tests. The designed contrasts with the specific issues made interpretation of the results easier. For this comparison, well type issues required consideration of differences between each of the direct-push well designs and the standard hollow stem auger drilled well design. The standard drilled well was treated as the default case for the ANOVA test. There were five well types in Cell B and four contrasts were defined as differences between one of the push well designs and the drilled well. Similarly, two contrasts were defined for Cell A differentiating between each push well design and the drilled well. These contrasts do not permit testing differences between different pushed well designs. Depth zone and screen length were binary factors, and a simple difference contrast was appropriate. Sampling date and the combined four-level depth range factor were ordinal, and contrasts based on orthogonal polynomials were chosen for ordinal factors because they could be used to separate temporal or depth-related variations into linear, quadratic, and higher components. Tables 7 through 11 present the specific coefficients for each set of contrasts.

Table 7. Contrasts for Well Type Factor

	Contrast 1 (Cell B only)	Contrast 2	Contrast 3 (Cell B only)	Contrast 4
Push ¾" No pack	1.000	0.000	0.000	0.000
Push ¾" ASTM Spec.	0.000	1.000	0.000	0.000
Push ¾" Conventional	0.000	0.000	1.000	0.000
Push 2" ASTM Spec.	0.000	0.000	0.000	1.000
Drill 2" ASTM Spec.	0.000	0.000	0.000	0.000

Table 8. Contrasts for Date Factor

	Linear	Quadratic	Cubic
March	-0.671	0.500	-0.224
May	-0.224	-0.500	0.671
July	0.224	-0.500	-0.671
August	0.671	0.500	0.224

Table 9. Contrasts for Screen Depth Range Factor

	Linear	Quadratic	Cubic
7'–12'	-0.671	0.500	-0.224
10'–12'	-0.224	-0.500	0.671
12.5'–17.5'	0.224	-0.500	-0.671
16'–18'	0.671	0.500	0.224

Table 10. Contrast for Depth Zone Factor

	Contrast
Shallow	1.000
Deep	-1.000

Table 11. Contrast for Screen Length Factor

	Contrast
2-foot	1.000
5-foot	-1.000

Four different configurations of models were used. They were distinguished from each other based on how the screen length and depth zone factors were specified and which types of effects were included. The first two models tested only the main effects for each factor. Main effects were variations in the response for different levels of a factor that were consistent across all levels of the other factors in the model. The main effect for the well type variable, for example, measured the strength of variations in MTBE concentrations for different well types over all screen lengths, depth zones, and sample dates. This main effect gave the most direct and straightforward evaluation of the differences in performance between the different well designs. Similarly, the main effect for the sample date factor measured the magnitude of temporal changes in MTBE concentrations over all well types, depth zones, and screen depths in Cell B. The main effect for screen depth range measured concentration variations with depth that were consistent for all well types and over all sample dates. (The sample design did not permit clear distinctions between screen depth range and horizontal location (or x and y position) since screen depth was the same for all five wells in each cluster. This factor was referred to as "horizontal location" with equal statistical justification. This was considered significant based on the geologic evidence.)

The second set of models included interactions between pairs of factors. Interactions provided detailed analysis of the impacts the factors had on MTBE variations, but they were correspondingly more difficult to interpret. In addition, these models used more degrees of freedom. This reduced the pool available for estimating error magnitudes. Interactions between well type and screen length measured MTBE concentration variations for different well types that also differed for different screen lengths but were consistent over the three sample dates and depth zones. This set of interactions pointed to diverging performances for different well types as a function of screen length. Interactions between well type and depth zone captured variations in well type performance that was specific to either the shallow or deep zone. Another potentially interesting interaction was the one between sample date and screen depth that measured concentration variations as a function of both date and depth but not well type. It identified depth-dependent temporal variations. The interaction between sample date and well type measured changes in MTBE concentrations by well type on different dates that were common to the four screen depths.

A complete analysis of variance model included three-way interactions between all combinations of three factors and a four-way interaction between all four factors. These terms measured concentration variations that were specific to each individual well type, sample date and screen length or well type, screen length and depth zone, etc. The errors consisted mainly in the case of three-way interactions and in the case of four-way interactions of variations between different lab results from the same samples. This error term was a useful baseline measure of what was termed pure noise, but it did not appear to be an appropriate error term for comparisons between different well types, dates, depth zones, and screen lengths. Three-way and four-way interactions were not evaluated in this analysis.

The response variable in all cases was MTBE concentrations. Values in Cell B were great enough so their distribution was reasonably symmetrical, and concentrations in ppb (μg/l) was analyzed directly. Concentrations in Cell A were lower and about 15 percent were non-detects (less than 5 μg/l). As a result, the distribution of concentrations was highly skewed, and a log transformation was deemed necessary before standard analysis of variance methods was applied. Laboratory MTBE analyses indicating non-detects were replaced by 2.5 μg/l (one-half the minimum detect level), and a log transform was applied, so all the results were in units of $\log_{10}$ (μg/l).

Results for Main Effects Models

1. Cell B - Single Four-Level Depth Range Factor. The ANOVA results for main effects only are shown in Table 12. The depth range factor had a strong, unambiguous impact. The sample date factor was also significant, while well type was insignificant. About 59 percent of the total sum of squares was identified by the model (31.4 percent by depth range and 27.7 percent by sample date).

Table 12. ANOVA Results for Cell B Main Effects Model with Combined Four-Level Screen Depth Range Factor

Source	Sum of Sq	DF	Mean Sq	F Value	Prob(F)
Total	602,673.5	237	2542.93		
Well Type	3,156.3	4	789.09	0.736	0.568
Sample Date	166,775.4	3	55,591.82	51.873	0.000
Depth Range	189,466.5	3	63,155.51	58.930	0.000
Error	243,275.1	227	1,071.70		

None of the coefficients for the well type contrasts were as large as their standard errors. The boxplot in Figure 10 represents the statistical evidence of little difference between concentrations for different well types.

The quadratic and cubic sample date contrasts were both large and significant. Taken together, these two contrasts captured the fact that the July concentrations were much higher than those for the other three dates. This trend was evident in the boxplot shown in Figure 11.

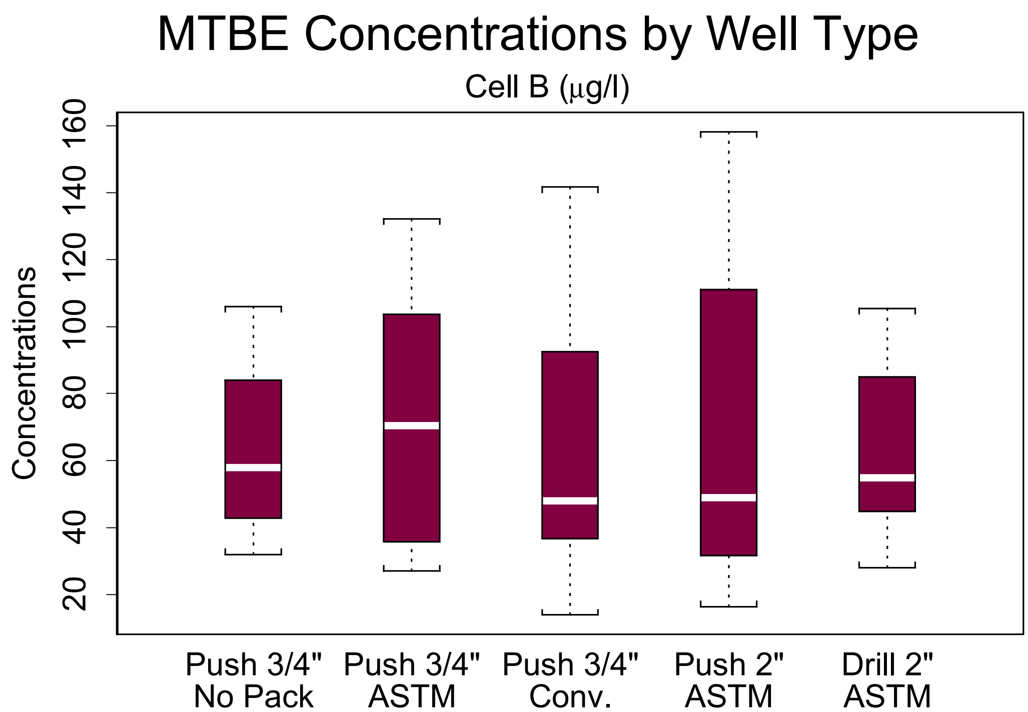

Figure 10. Boxplot of MTBE concentrations based on well type for the four analytical rounds.

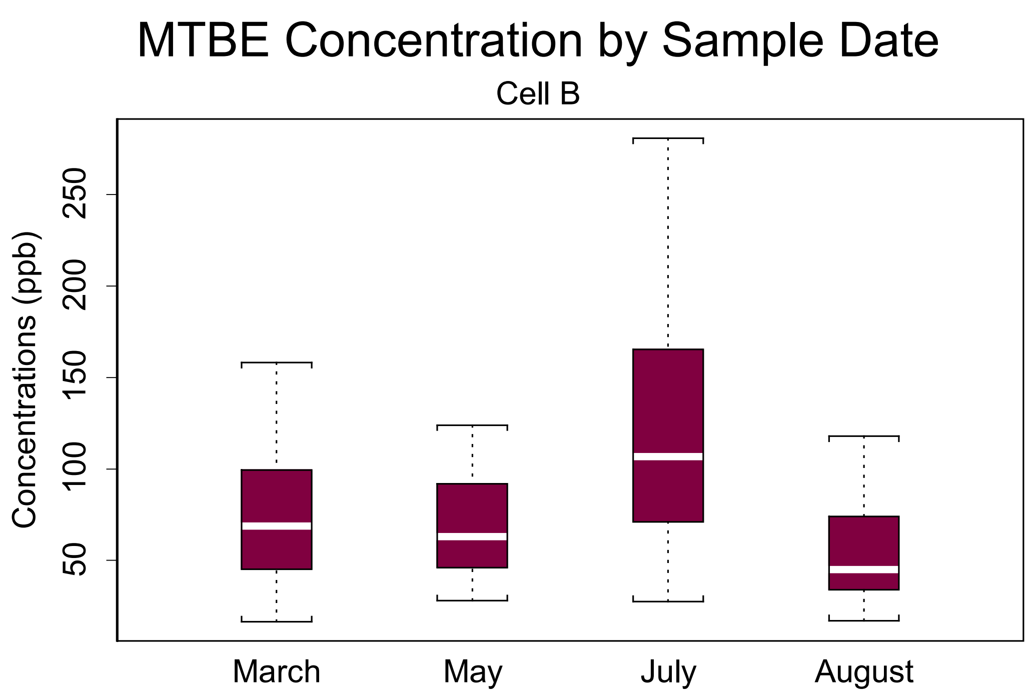

Figure 11. Boxplot of MTBE concentrations for the four analytical rounds.

Both the quadratic and cubic contrasts for the screen depth factor were large and significant. Combined together they captured a variation in concentration with depth that first increases from 57 µg/l in the 7- to 12-foot level to 90 µg/l in the 10- to 12-foot level to 122 µg/l in the 12.5 to 17.5-foot level and then decreases sharply to 55 µg/l in the 16- to 18-foot level. The boxplot in Figure 12 indicates the changes for this factor.

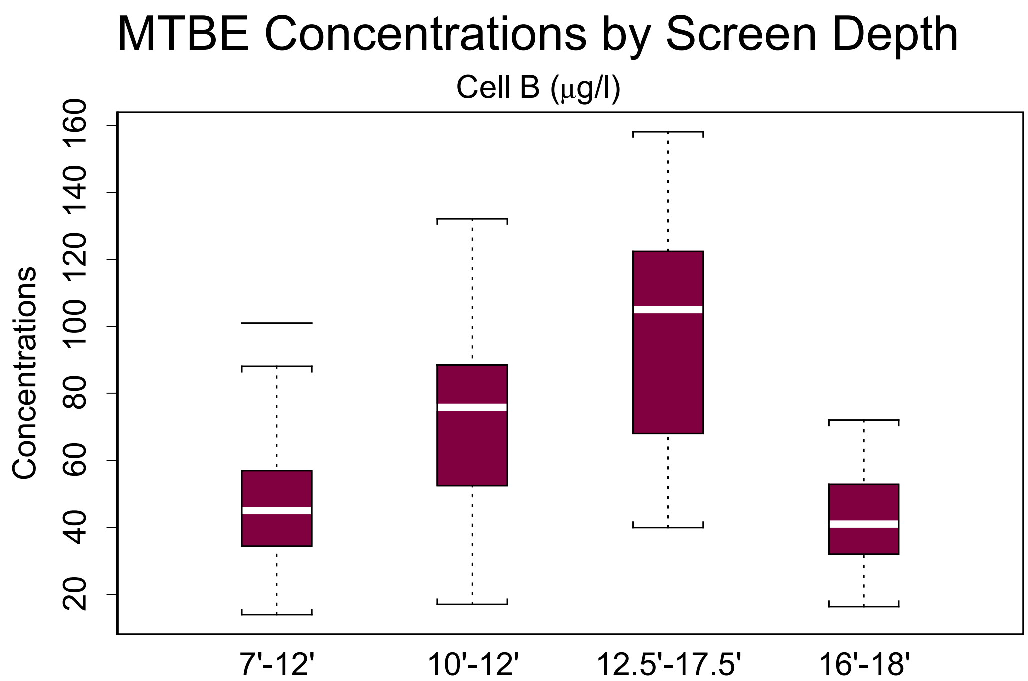

Figure 12. Boxplot of MTBE concentrations based on screen depth for the four analytical rounds.

2. Cell B - Separate Screen Length and Depth Zone Factors. As indicated in the ANOVA summary (Table 13), separating depth range into two separate factors did not change the sums of squares associated with the sample date and well type factors. The coefficients for the contrasts were also the same. The F values and probabilities did change, however, because the two separate depth zone and screen length factors did not capture the variability as the combined depth range factor. (The remaining variation was indicated by a sizeable interaction between depth zone and screen length.) The larger error mean square reduced the F values for well type and sample date, but sample date was still statistically significant at the 0.01 level while well type was not.

Table 13. ANOVA Results for Cell B Main Effects Model with
Separate Depth Zone and Screen Length Factors

Source	Sum of Sq	DF	Mean Sq	F Value	Prob(F)
Total	602,673.5	237	2,542.93		
Well Type	3,156.3	4	789.09	0.450	0.772
Sample Date	166,775.4	3	55,591.82	31.710	0.000
Depth Zone	14,902.5	1	14,902.49	8.501	0.004
Screen Length	18,130.2	1	18,130.33	10.342	0.001
Error	399,709.0	228	1,753.11		

The depth zone factor accounts for about 2.5 percent of the total sum of squares and was significant at the 0.01 level. The contrast indicates that concentrations in the deep zone are about 15 µg/l higher than in the shallow layer (88.4 µg/l compared to 73.0 µg/l). It is not easy to identify this difference in the boxplot (Figure 13). The screen length main effect accounts for about 3.0 percent of the sum of squares. It reflects higher concentrations in the 5-foot screened wells averaging 89.4 µg/l compared to an average of 72.0 µg/l in the 2-foot screened wells (see Figure 14). Note that the combined explanatory power of the two separate factors (5.5 percent) is much less than that of the single four-level depth range factor (31.4 percent).

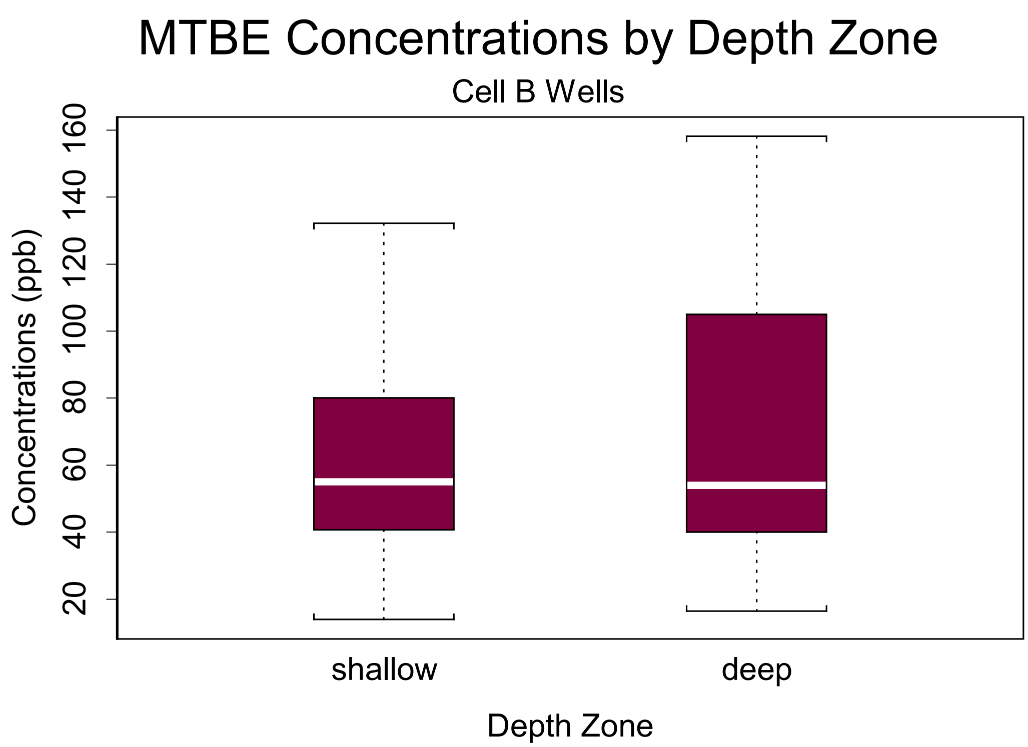

Figure 13. Boxplot of MTBE concentrations based on screen depth zone
for the four analytical rounds

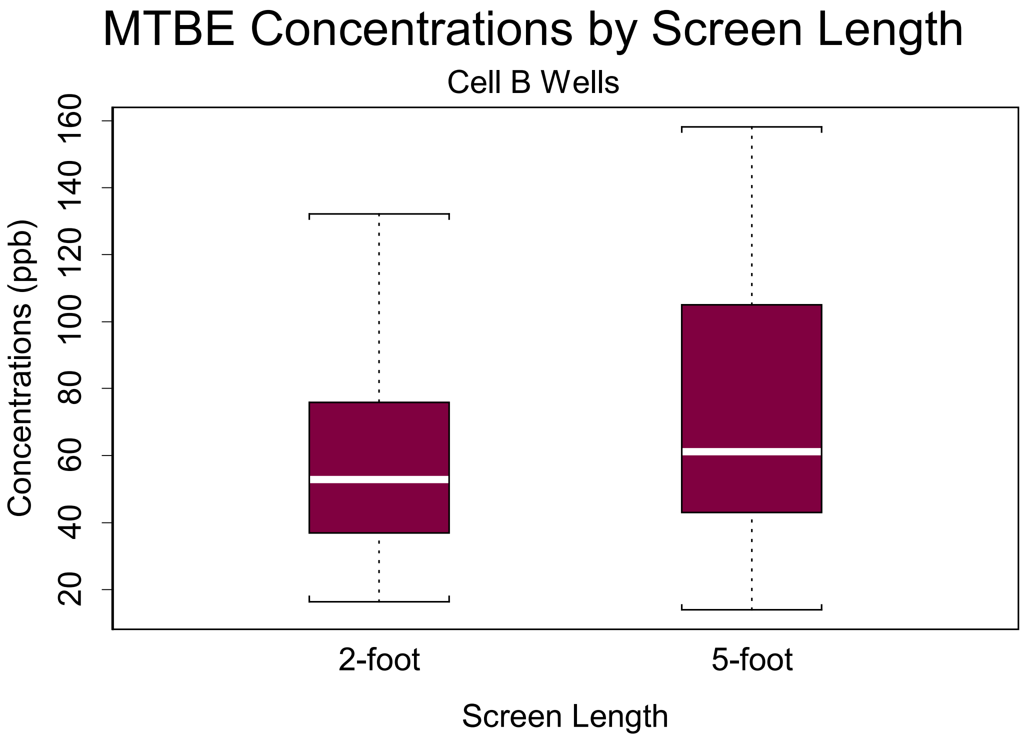

Figure 14. Boxplot of MTBE concentrations based on screen length for the four analytical rounds.

3. Cell A - Single Four-Level Depth Range Factor. The ANOVA summary table for this main effects model is presented in Table 14. The results were similar to those for Cell B in that sample date and screen depth range were significant effects, while well type was marginal or insignificant. About 58 percent of the total sum of squares was explained by the main effects, with screen depth picking up 43 percent and sample date 12 percent.

Table 14. ANOVA Results for Cell A Main Effects Model with Combined Four-Level Screen Depth Range Factor

Source	Sum of Sq	DF	Mean Sq	F Ratio	Prob(F)
Total	16.237	143	0.114		
Well Type	0.386	2	0.193	3.799	0.025
Sample Date	1.971	3	0.657	12.907	0.000
Depth Range	7.009	3	2.336	45.901	0.000
Error	6.872	135	0.051		

The largest contrast for the well type main effect was the one that distinguished the pushed 3/4-inch wells from the drilled 2-inch wells. The value of -0.110 with a standard error of 0.046 was significant at the 0.05 level (p-value of 0.018). The inverse transformed value (10 raised to the -0.11 power) for this contrast coefficient of 0.78

implies that the pushed well concentrations were typically about 78 percent of the drilled well concentrations over all dates and depths. It is difficult to identify this effect from interpretation of the boxplot (Figure 15).

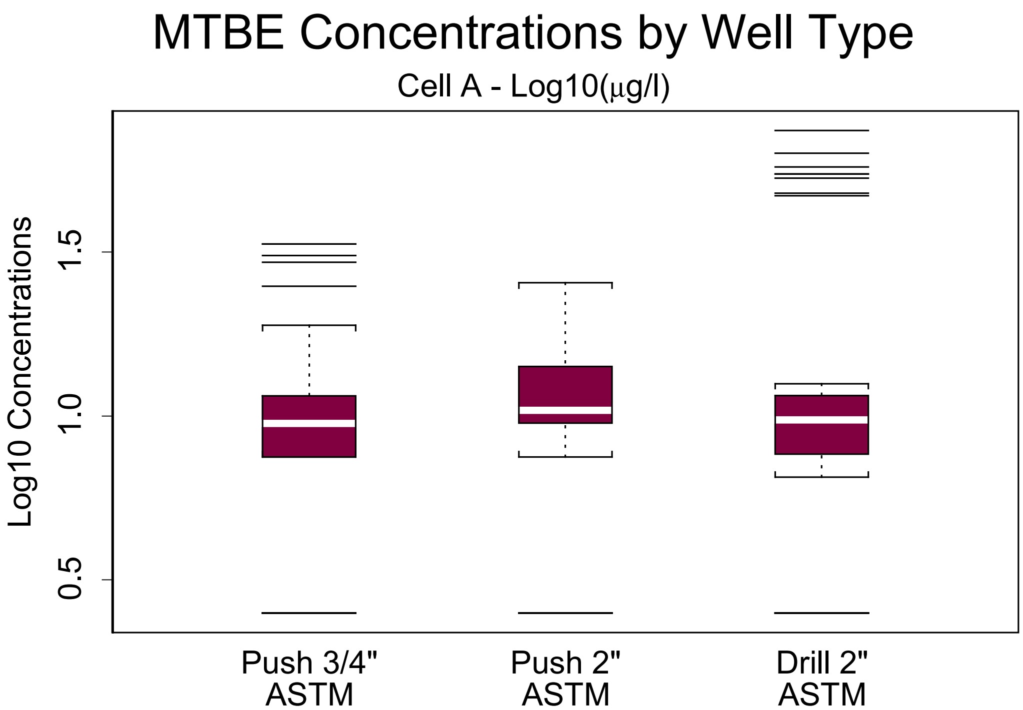

Figure 15. Boxplot of variations in log of concentration with well type based on the four analytical rounds.

The largest contrast for the date factor was the quadratic trend. It had a negative value, implying a concave downward shape that captured much of the increase from March through July followed by the decrease in August (see Figure 16). The typical concentrations for May were 1.25 times those for March, July 1.65 times March, and August 0.76 times March. This is a similar but much less pronounced temporal pattern than the very high July average concentrations from Cell B.

The trends over screen depth range were also different for Cell A than for Cell B. In this case, there was a general linear increase in concentration with increasing depth (Figure 17). The linear contrast captured this pattern quite well and was the only significant contrast for this factor. Concentrations increased consistently downward with the 9.5- to 11.5-foot depth range being approximately 1.5 times higher than the 7- to12-foot depth range, the 14- to 19-foot range 2.9 times higher, and the 17- to 19-foot range 6.8 times higher.

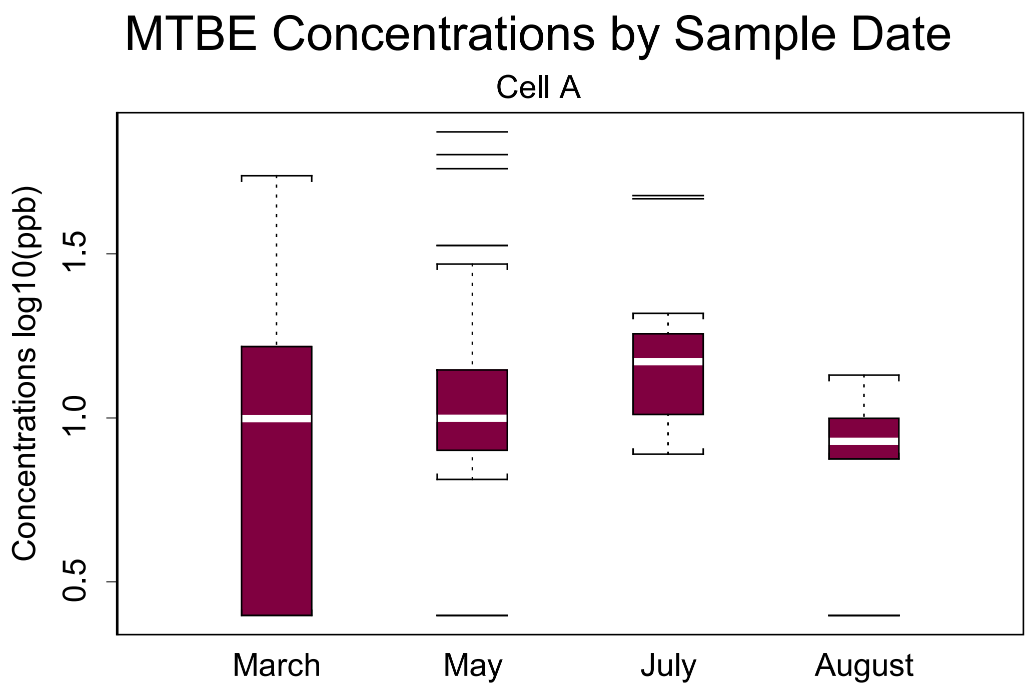

Figure 16. Boxplot of variations in log of concentration with sample date based on the four analytical rounds.

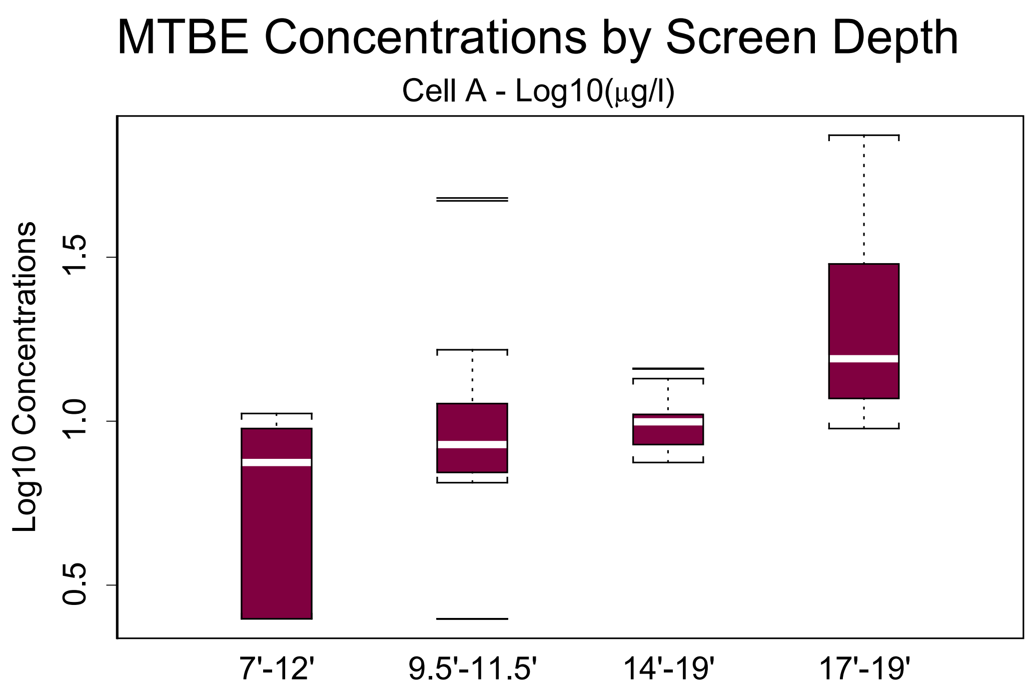

Figure 17. Boxplot of variations in log of concentration with screen depth based on the four analytical rounds.

4. Cell A - Separate Screen Length and Depth Zone Factors. The ANOVA results for this main effects model are presented in Table 15. The sums of squares and contrast coefficients for the well type and sample date factors were unchanged by the separate specifications of depth zone and screen length factors. In this case, the F values and probabilities were almost identical. In contrast to Cell B, here the two separate factors captured almost all of the sum of squares indicated by the combined screen depth range factor, using one less degree of freedom in the process. In both Cell A and Cell B the combined main effects and pairwise interactions between the depth zone and screen length factors were identical to the main effect of the combined screen depth range factor. In Cell B the main effects were less significant because there were not strong concentration variations between depth zones that were consistent over both screen lengths or variations between screen lengths consistent over both depth zones. In Cell A the main effects are strong. The depth zone factor explains about 32.0 percent of the sum of squares, and the contrast indicates that concentrations in the deep wells were generally about double those in the shallow wells (average of 14 µg/l versus 6.5 µg/l). This difference is presented in the boxplot (Figure 18). The screen length factor explained about 10.7 percent of the sum of squares. As indicated in the boxplot (Figure 19) concentrations were generally higher for 2-foot screened wells than for 5-foot screened wells by a factor of about 1.7.

Table 15. ANOVA Results for Cell A Main Effects Model with Separate Depth Zone and Screen Length Factors

Source	Sum of Sq	DF	Mean Sq	F Ratio	Prob(F)
Total	16.237	143	0.114		
Well Type	0.386	2	0.193	3.772	0.025
Sample Date	1.971	3	0.657	12.851	0.000
Depth Zone	5.192	1	5.192	101.574	0.000
Screen Length	1.737	1	1.737	33.971	0.000
Error	6.952	136	0.051		

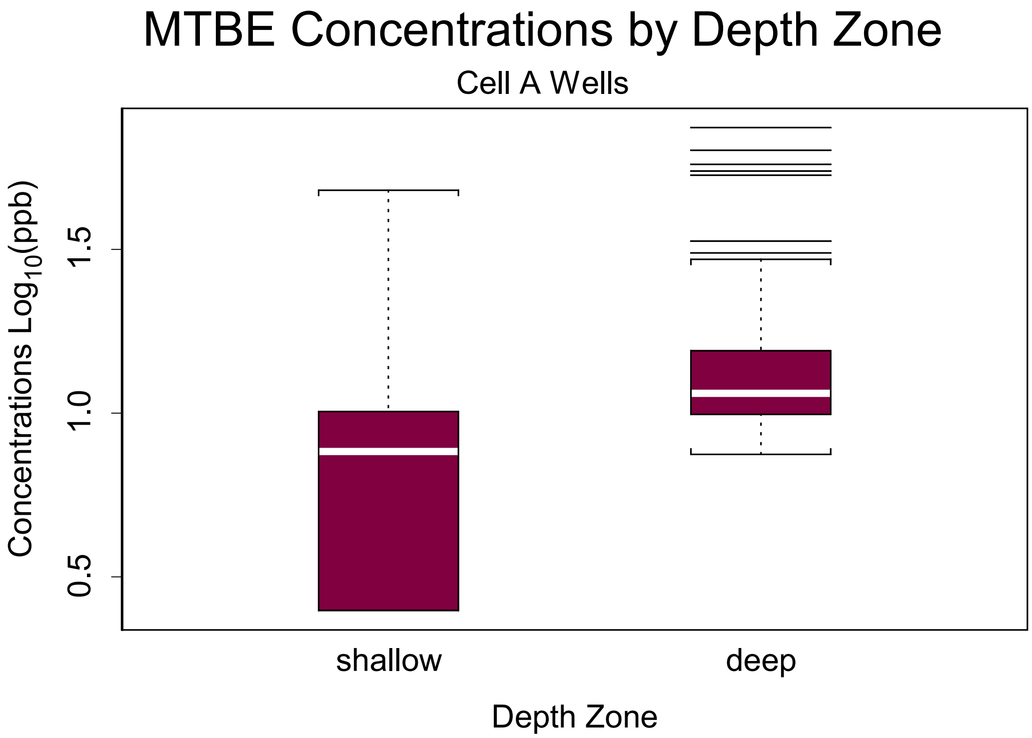

Figure 18. Boxplot of variations in log of concentration with depth zone based on the four analytical rounds.

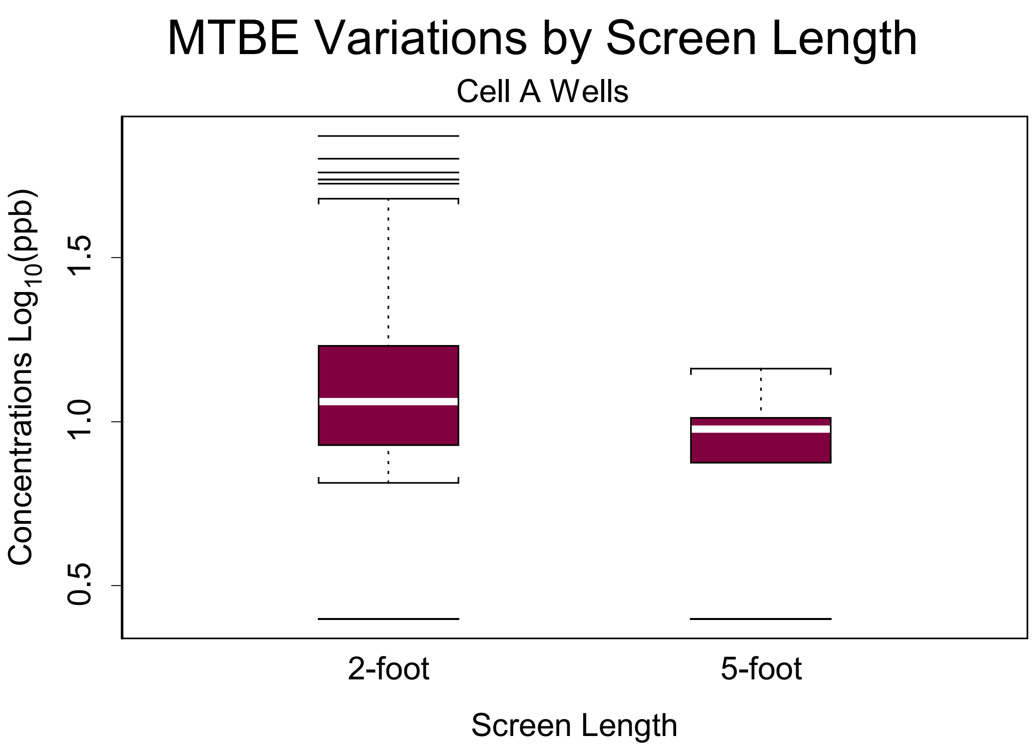

Figure 19. Boxplot of variations in log of concentration with screen length based on the four analytical rounds.

Results for Pairwise Contrasts Models

1. Cell B - Single Four-Level Depth Range Factor. Table 16 presents the ANOVA summary for the model including pairwise contrasts between the three factors. The magnitudes of the sums of squares for the main effects were the same as in the previous model, but their F values were increased substantially due to the much smaller error sum of squares. All of the main effects and interactions were now significant at the 0.001 level or greater. The magnitudes of the contrasts for the main effects were the same, as were the differences in means for the main effects. Slightly more than 90 percent of the sum of squares was captured by the model.

Table 16. ANOVA Results for Cell B Pairwise Interactions Model with Combined Four-Level Screen Depth Range Factor

Source	Sum of Sq	DF	Mean Sq	F Value	Prob(F)
Total	602,673.5	237	2,542.97		
Well Type	3,156.3	4	789.09	2.57	0.039
Sample Date	166,775.4	3	55,591.82	181.36	0.000
Depth Range	189,466.5	3	63,155.51	206.03	0.000
Date:Type	6,424.0	12	535.34	1.75	0.060
Date:Depth	58,793.4	9	6,532.59	21.31	0.000
Type:Depth	118,591.1	12	9,882.59	32.24	0.000
Error	59,466.7	194	306.53		

While the well type main effect was statistically significant, the contrasts were still the same, and only the Push 3/4-inch ASTM filter pack design contrast was significant. This well type had a slightly higher average concentration than the drilled wells. The interaction term for well type and screen depth range was the largest of any of the interactions and the third largest term in the model, after the sample date and depth range main effects. There were a total of 12 contrasts for this effect, so interpreting significant differences was difficult. This effect captured differences in concentrations between different well types that were consistent over all four dates but change as a function of screen depth range. Table 17 indicates differences between means of the pushed well types and the drilled wells over the range of screen depths after the main effects were removed. At all screen depths, the differences between Push No Pack and Drill were small. None of the contrasts involving this well type were significant. Contrasts for differences in the other three push well types and drilled wells were significant for various depth ranges. The concentration patterns in the 12.5- to 17.5-foot range were substantially higher than for the drilled wells. The screen depth range that indicated the highest concentrations overall was a major point. The screen depth ranges with the lowest concentrations did not show comparable negative differences, however, no trend over the range of different concentrations was observed.

Table 17. Interactions Between Well Type and Depth Range in Cell B. (Differences between the different pushed well types and drilled wells as a function of screen depth range after main effects were removed. Units are μg/l.)

	Push ¾" No Pack	Push ¾" ASTM Spec	Push ¾" Conv. Spec	Push 2" ASTM Spec
7' – 12'	0.22	3.37	-15.67	10.88
10' – 12'	-4.66	-13.93	-38.13	-48.69
12.5' – 17.5'	1.89	41.37	57.01	58.78
16' – 18'	2.55	-24.07	-3.21	-20.97

The interaction term between sample date and screen depth range was as large as the depth/well type one. Means for the different depth ranges and dates (not shown) did not indicate any depth or temporal trends.

2. Cell B - Separate Screen Length and Depth Zone Factors. The ANOVA results for this interaction model are presented in Table 18. As is usual with the interaction models, all interaction terms are statistically significant (probability is either much greater than 0.05, or it is extremely low). Seventy-one percent of the sum of squares was captured by the six interaction terms.

Table 18. ANOVA Results for Cell B Pairwise Interactions Model with Separate Depth Zone and Screen Length Factors

Source	Sum of Sq	DF	Mean Sq	F Value	Prob(F)
Total	602,673.5	237	2,543.0		
Well Type	3,156.3	4	789.1	1.595	0.177
Sample Date	166,775.4	3	55,591.8	112.380	0.000
Depth Zone	14,902.5	1	14,902.5	30.126	0.000
Screen Length	18,130.2	1	18,130.2	36.651	0.000
Type:Date	6,293.5	12	524.5	1.060	0.396
Date:Depth	30,611.3	3	10,203.8	20.627	0.000
Date:Screen	1,184.3	3	394.8	0.798	0.496
Type:Depth	46,548.8	4	11,637.2	23.525	0.000
Type:Screen	62,167.9	4	15,542.0	31.418	0.000
Depth:Screen	153,473.3	1	153,473.3	310.250	0.000
Error	99,429.9	201	494.7		

The largest interaction term, and the second largest term overall, was the interaction between depth zone and screen length. Most of the depth-related variations in concentrations identified using the single depth range factor were accounted for in this interaction term. As noted above, concentrations were low in the 7- to 12-foot depth range, higher in the 10- to 12-foot range, higher still in the 12.5- to 17.5-foot range, and then lower in the 16- to 18-foot range. As a result of this trend, average concentrations in the shallow depth zone were much higher in the 2-foot screened wells than in the 5-foot screened wells (90 μg/l versus 56 μg/l), while the relationship was reversed in the deep depth zone (56 µg/l for 2-foot screened wells versus 122 µg/l for 5-foot screened wells). It is not evident these relationships would produce a sharp difference, but vertical variations in stratigraphy and associated vertical concentration gradients were more apparent causes than screen length. It should be noted that the deeper 2-foot screen wells (Cluster B3) were installed into the 16- to 18-foot screen depths even though permeability and pre-installation water sampling data indicated the screen intervals should be approximately 13 to 15 feet. This was done to vertically separate the shallow 2-foot screen clusters (B1 and B3). This may have impacted the concentration results by rendering lower values for B3 than would otherwise be observed had they been screened from 13 to 15 feet.

The next two largest interaction terms involved well type interacting with screen length and depth zone. In both cases the contrasts distinguishing Push 3/4-inch No Pack wells from drilled wells were insignificant, while the those distinguishing the other three push well designs from drilled wells were significant.

The screen length main effect implies a tendency over all well types for concentrations in 5-foot screened wells to be higher by about 15 µg/l. This pattern was reversed in the drilled wells with concentrations in 2-foot screened wells averaging about 14 µg/l higher. The pushed 3/4-inch wells with no packing followed this pattern with 2-foot screened wells having concentrations averaging about 13 µg/l higher, resulting in an insignificant contrast with the drilled wells. The 5-foot screened wells for the other three well types all showed substantially higher concentrations than the 2-foot screened wells. The pushed 2-inch wells were particularly anomalous with concentrations for 5-foot screened wells averaging 55 µg/l higher than those for 2-foot screened wells.

The interaction between depth zone and well type was not as large but followed a similar pattern. Overall, deep zone well concentrations averaged about 9µg/l higher than shallow zone well concentrations, but the drilled well and pushed 3/4-inch no packed well differences were reversed - shallow well concentrations were 14 µg/l higher than deep well concentrations for drilled wells and 9 µg/l higher for pushed 3/4-inch no packed wells. The small difference between these two concentrations indicated no significant contrast. Deep well concentrations were higher for the other three pushed well types, with the pushed 2-inch well showing a strong contrast with the drilled well results (deep well concentrations were 24 µg/l higher for the pushed 2-inch design). The largest contrast for this interaction was between the drilled well results and the pushed 3/4-inch conventional packing wells which had deep well concentrations 40 µg/l higher than those for shallow wells.

3. Cell A - Single Four-Level Depth Range Factor. The ANOVA summary table for the model including pairwise interactions (Table 19) showed all effects as significant at the 0.05 level and was attributable to the reduction in error sum of squares. The interactions captured less of the total sum of squares for Cell A than for Cell B - 26 percent compared to 36 percent - and the date/depth interaction was the most important.

Table 19. ANOVA Results for Cell A Pairwise Interactions Model with Combined Four-Level Screen Depth Range Factor

Source	Sum of Sq	DF	Mean Sq	F Ratio	Prob(F)
Total	16.237	143	0.114		
Well Type	0.386	2	0.193	6.141	0.003
Sample Date	1.971	3	0.657	20.924	0.000
Depth Range	7.009	3	2.336	74.419	0.000
Type:Date	0.402	6	0.067	2.134	0.055
Date:Depth	2.315	9	0.257	8.194	0.000
Type:Depth	0.575	6	0.096	3.054	0.008
Error	3.579	114	0.031		

Table 20 indicates the means for different dates and depth ranges with the main effects removed. These values show patterns that were unique to each date and depth but common to all three well types. The most significant patterns reflected a tendency toward increasing concentrations over time in the shallowest depth range and decreasing concentrations in the deepest depth range. The main depth effect showed overall increasing concentrations with depth, and the main date effect showed increases from March through July followed by a decrease in August. The interactions modified these patterns so that the increase over time was relatively significant at the shallow depth, which started with low concentrations, rising from about 2.8 μg/l (primarily non-detects) to about 9.5 μg/l in July. At the other extreme, concentrations started relatively high at the deepest depth and decreased counter to the general trend, dropping from about 30 μg/l in March to about 11 μg/l in August. The 2-foot screened wells with screens covering the bottom of the shallow layer (9.5 to 11.5 feet) showed very similar trends as those of the 7- to 12-foot screened wells notwithstanding somewhat higher concentrations on each date. The deeper 5-foot screened wells (14 to 19 feet) did not show the same trends as the deepest 2-foot screened wells. There did not appear to be any consistent effects over time associated with screen length.

Table 20. Mean Averages for Each Depth Range and Date after Main Effects were Removed, Showing Effects for Pairwise Date/Depth Range Interactions in Cell A. (Averages for each depth range and date after main effects were removed. Units are $\log_{10}$ μg/l.)

	7’ – 12’	9.5’ – 11.5’	14’ – 19’	17’ – 19’
March	-0.217	0.012	-0.003	0.207
May	-0.058	-0.006	-0.071	0.135
July	0.093	0.118	0.024	-0.235
August	0.181	-0.125	0.050	-0.107

The interaction term between well type and screen depth range was statistically significant overall, but the only individual contrast that was significant displayed a variation with depth range in the concentrations in the pushed 2-inch wells compared to the drilled wells. The pushed wells showed slightly higher concentrations in the shallowest layer and lower concentrations in the deepest layer. The pushed 2-inch and drilled 2-inch wells did not show any main effect difference averaged over all screen depths, but the pushed well concentrations were about 20 percent higher in the 7- to 12-foot wells and 30 percent lower in the 16- to 18-foot wells. The decreasing trend was fairly consistent over the intermediate depths. Averages for each depth range and date after main effects were removed. Units are µg/l.

4. Cell A - Separate Screen Length and Depth Zone Factors. The ANOVA summary for this model is shown in Table 21. The interaction terms are generally less important in Cell A than in Cell B. The only terms that were significant at the 0.01 level involve sample date interacting with depth zone and with screen length. These two interactions capture the same depth-related temporal trends noted above, with increased concentrations through July in the shallow zone (and 5-foot screened wells) and decreased concentrations over time in the deep zone (and 2-foot screened wells that were in the lower sections of each depth zone).

Table 21. ANOVA Results for Cell A Pairwise Interactions Model with Separate Depth Zone and Screen Length Factors

Source	Sum of Sq	DF	Mean Sq	F Ratio	Prob(F)
Total	16.237	143	0.114		
Well Type	0.386	2	0.193	5.843	0.004
Sample Date	1.971	3	0.657	19.909	0.000
Depth Zone	5.192	1	5.192	157.353	0.000
Screen Length	1.737	1	1.737	52.627	0.000
Type:Date	0.402	6	0.067	2.030	0.067
Date:Depth	0.842	3	0.281	8.501	0.000
Date:Screen	1.190	3	0.397	12.026	0.000
Type:Depth	0.263	2	0.131	3.984	0.021
Type:Screen	0.248	2	0.124	3.760	0.026
Depth:Screen	0.080	1	0.080	2.436	0.121
Error	3.927	119	0.033		

Residual Diagnostics. Two sets of diagnostics plots were presented as guides for identifying possible problems with the assumptions that the model residuals were normally distributed and independent. Normal quantile-quantile plots were used to identify potential deviations from a normal distribution. All the points should plot along a straight line if they are normally distributed. The variogram plots the average squared difference between observations as a function of their separation distance. In the presence of spatial autocorrelation, the magnitude of the variogram estimates would increase with increasing distance. Results for the residuals from the pairwise interaction models for both cells are presented below.

The quantile-quantile plot of the Cell B residuals (Figure 20) shows several of the largest residuals above the line, indicating that the upper tail of the distribution stretches out. The lower tail would be considered normal, and the deviation in the upper tail is not significant enough to invalidate the general results, although the precision of significance tests may have been compromised. The quantile-quantile plot of the A-cell residuals (Figure 21) has a truncated lower tail that indicates a remnant of the non-detects. The upper tail trend is similar to that in Cell B, so the distribution was of concern.

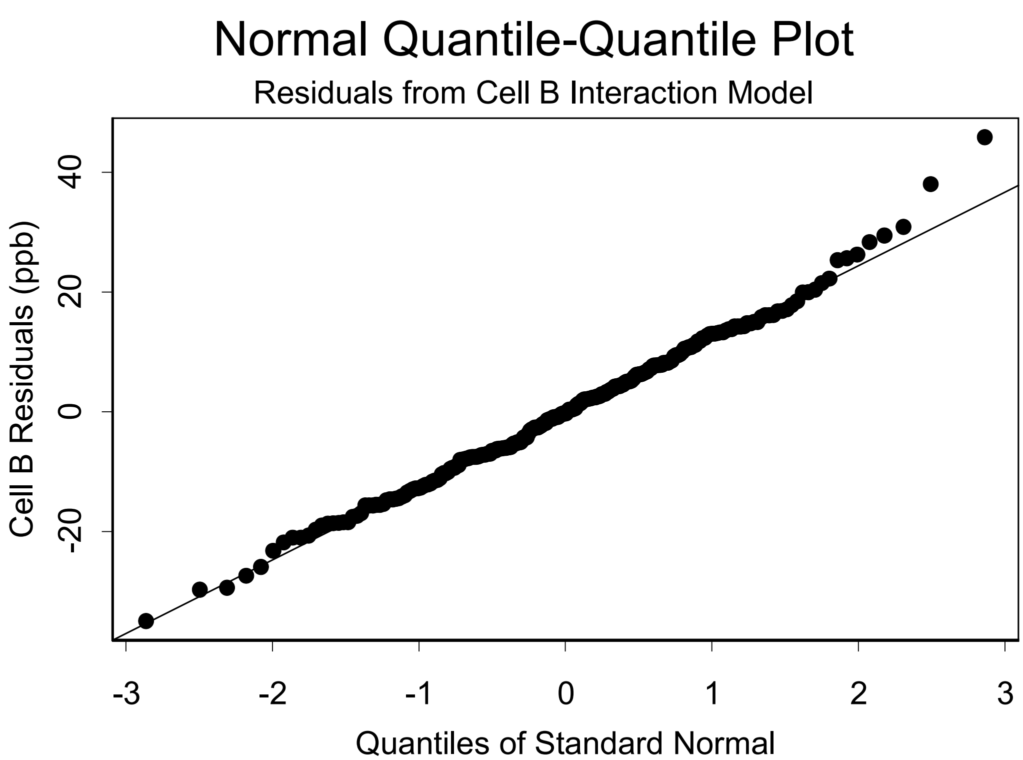

Figure 20. Quantile-quantile plot of residuals for Cell B.

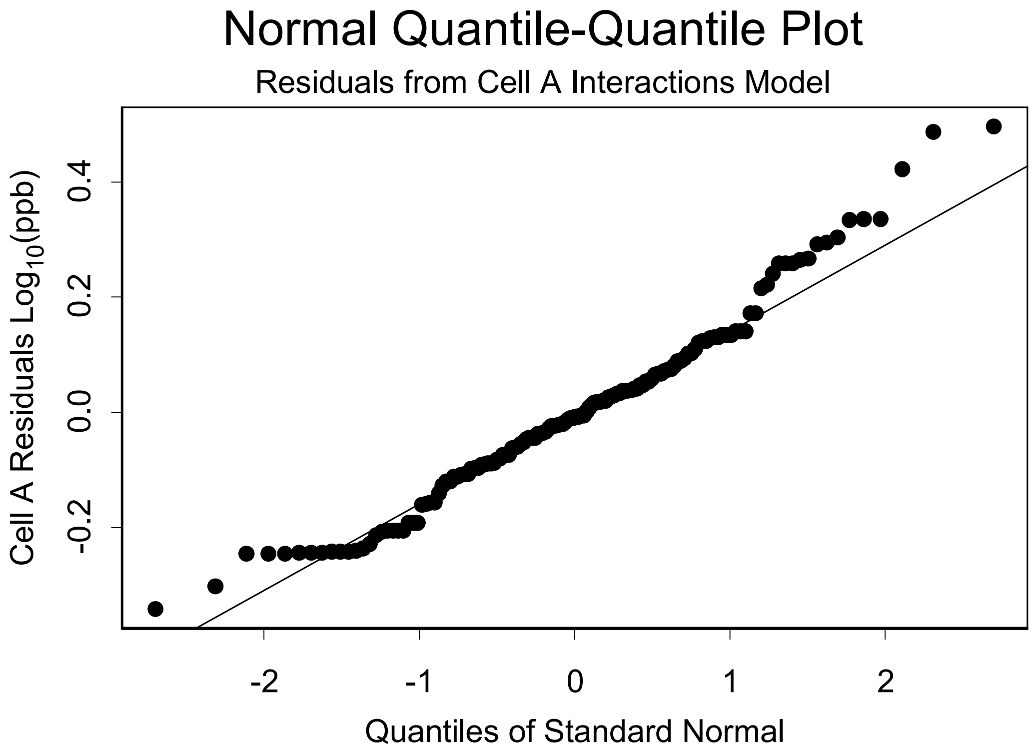

Figure 21. Quantile-quantile plot of residuals for Cell A.

Both variogram plots (Figures 22 and 23) indicate slight evidence of spatial autocorrelation. In Cell B there was possibly some correlation in the shortest distances, but it was present in a single estimate, and the scatter of the estimates was large.

MTBE Concentration Data Summary. Interpretation of the Cell B main effects model was straightforward. There was a relationship with screen depth range that reflects increasing concentrations down to the 12.5- to 17.5-foot level, with lower concentrations in the layer below. The wells with different screen depth ranges were also in different sub-clusters and horizontal locations, so a trend could not be attributed to depth variations with absolute certainty. There were no discernible relationships between the horizontal variations in concentrations and the direction of ground water flow, however, depth appears to be the important factor. The trend was not linear, splitting the depth range factor into separate depth zone and screen length factors did not provide good results in the main effects model. The other main effect was the sharp increase in concentrations in July at all levels.

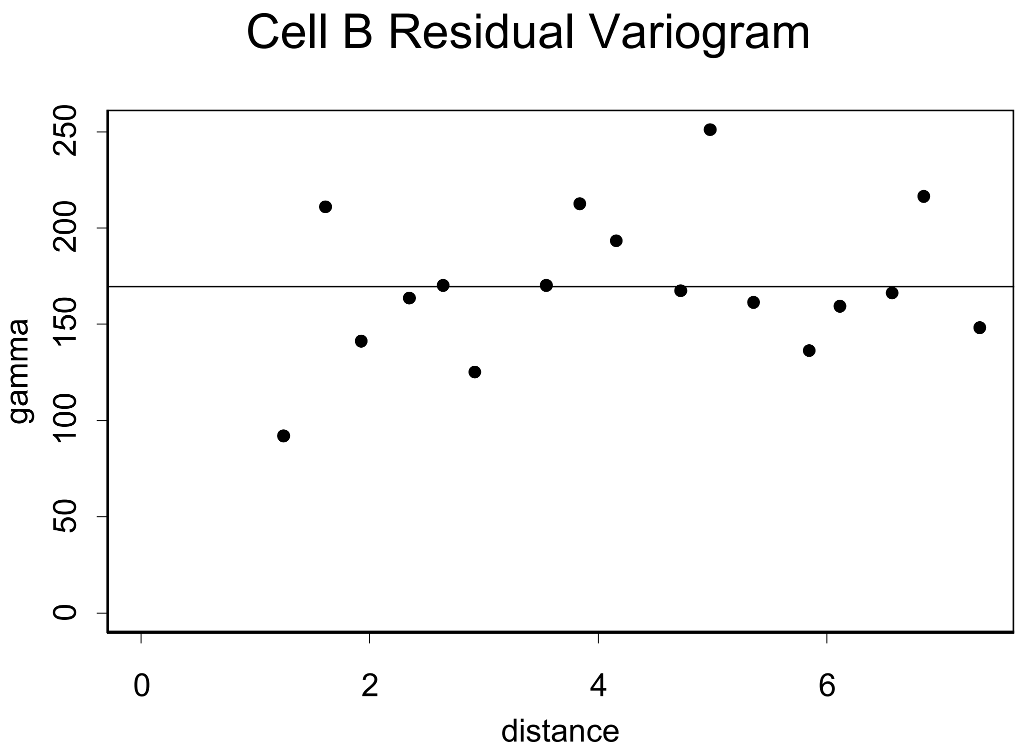

Figure 22. Variogram plot of residuals for Cell B.

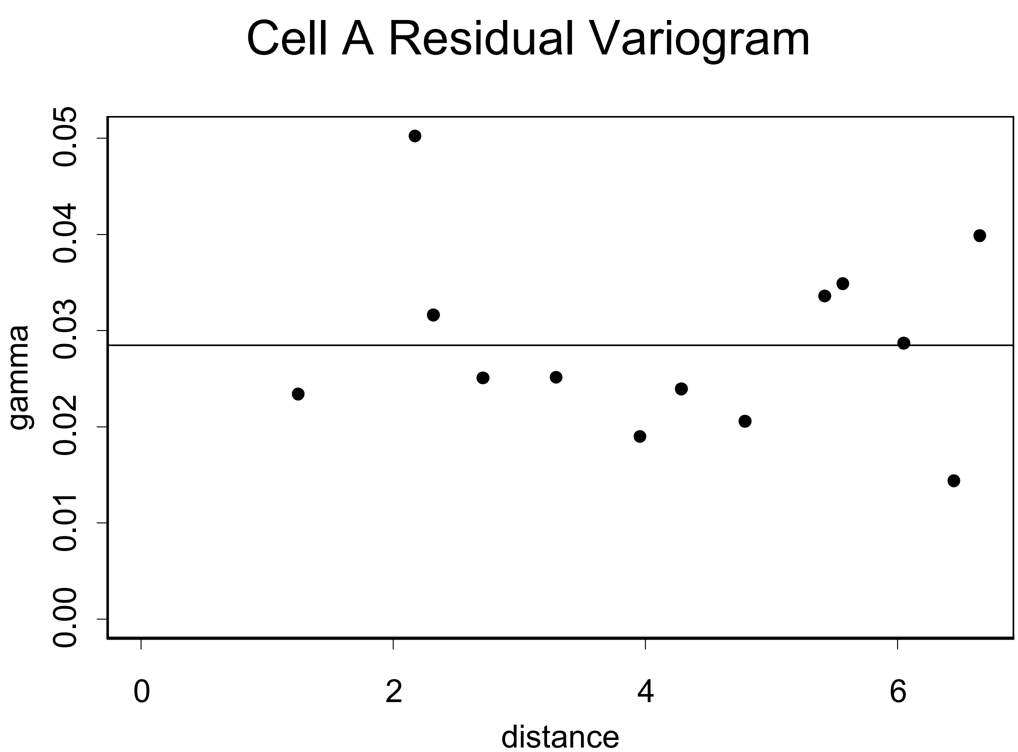

Figure 23. Variogram plot of residuals for Cell A.

The interaction terms were more difficult to interpret. There were interactions between well type, depth zone, and screen length that involved differences between pushed wells and drilled wells that were unique to specific depth zones and screen lengths. There were no significant differences between pushed wells without packing and drilled wells at any depth zone or screen length. The other three pushed well types showed a tendency toward higher concentrations than the drilled wells in the 5-foot screened wells and lower concentrations in the 2-foot screened wells. The pushed 2-inch wells showed the largest difference. The pushed 3/4-inch conventional packing and pushed 2-inch wells also typically had higher concentrations in the deep zones than the drilled wells and lower concentrations in the shallow zones. The sample date/screen depth interactions showed a slight indication of decreasing concentrations over time in the shallowest layer and increasing concentrations over time (or less rapidly decreasing concentrations) in the deepest layer.

The analysis of Cell A concentrations showed that screen depth range was the most important factor, followed by sample date. The depth trend was characterized by linearly increased concentrations with increasing depth, while the temporal trend was quadratic with rising concentrations from March to July and falling concentrations in August. The depth trend was linear, it did get incorporated when the depth range factor was split into separate depth zone and screen length factors. The deep zone wells had higher concentrations than the shallow zone wells, and the 2-foot screened wells, which were at the bottom of each depth zone, had higher concentrations than the 5-foot screened wells. There was some indication in the interaction between the depth range and date factors such that concentrations had been increased over time in the shallowest layers and decreased over time in the deepest layer. Both individually and through their interactions, these two factors captured consistent variations that were considerably larger than any associated with differences in well type. The results for Cell A were similar to those for Cell B, although the specific temporal and depth-related trends were different in the two cells. In both cases the variations related to temporal and vertical concentration trends were considerably larger than those related to well design.

Geochemical Data

In this section, variations in concentrations of the following elements - boron, calcium, iron, magnesium, manganese, potassium, and sodium - will be analyzed. The predictors in all cases will be sampling date, well type, depth zone and screen length. Results are presented only for the factor specification that splits depth range into two separate binary factors - depth zone (shallow or deep) and screen length (2-foot or 5-foot). Only main effects models are presented. Pairwise interaction models were examined but indicated very few significant terms, and those that were significant were not consistent from one cell to the other.

Boron Concentrations. Table 22 presents the ANOVA results for main effects models of boron concentrations in Cell A and Cell B. Sampling date and depth zone were significant factors in both Cell A and Cell B, while well type was not significant in either cell. Evaluation of sample date contrasts indicates that in both sets of wells the significance of sample date was produced by higher average boron concentrations in May than on the other three dates, which all had similar averages (Table 23). Both cells had very similar variations in boron concentrations with depth, as well, with concentrations in the shallow wells averaging about 0.33 mg/l higher than those in the deep wells. The Cell B wells with 5-foot screens had average concentrations about 0.21 mg/l higher than the 2-foot screen wells, but the Cell A wells did not indicate the same pattern.

Table 22. ANOVA Results for Main Effects Models of Boron Concentrations

Source	Sum of Sq	DF	Mean Sq	F Value	Prob(F)
Cell A Wells					
Total	23.52	47	0.501		
Sample Date	16.65	3	5.549	41.59	0.000
Well Type	0.02	2	0.008	0.06	0.944
Depth Zone	1.14	1	1.135	10.76	0.002
Screen Length	0.09	1	0.092	0.69	0.412
Error	5.34	40	0.133		
Cell B Wells					
Total	51.35	57	0.650		
Sample Date	36.06	3	12.020	70.61	0.000
Well Type	0.29	4	0.072	0.43	0.789
Depth Zone	2.24	1	2.244	13.19	0.001
Screen Length	0.84	1	0.840	4.94	0.030
Error	11.92	70	0.170		

Table 23. Average Boron Concentrations by Date (mg/l)

	March	May	July	August
Cell A	2.33	3.57	2.56	1.98
Cell B	2.10	3.69	2.22	2.10

Calcium Concentrations. Depth zone was the only factor that indicated consistently significant impacts on calcium concentrations in both Cell A and Cell B wells (Table 24). The shallow zone wells had higher average calcium concentrations in both cases (540 mg/l versus 477 mg/l in Cell A and 478 mg/l versus 432 mg/l in Cell B).

Table 24. ANOVA Summaries of Main Effects Models of Calcium Concentrations

Source	Sum of Sq	DF	Mean Sq	F Value	Prob(F)
Cell A Wells					
Total	289267	47	6154.6		
Sample Date	53800	3	17933.3	3.93	0.015
Well Type	4054	2	2027.1	0.44	0.644
Depth Zone	48133	1	48133.3	10.54	0.002
Screen Length	675	1	675.0	0.15	0.703
Error	182604	40	4565.1		
Cell B Wells					
Total	352200	79	4458.2		
Sample Date	13990	3	4663.3	1.17	0.327
Well Type	1750	4	437.5	0.11	0.979
Depth Zone	41405	1	41405.0	10.40	0.002
Screen Length	16245	1	16245.0	4.08	0.047
Error	278810	70	3983.0		

Iron Concentrations. The ANOVA analyses of iron concentrations (not shown) indicated that depth zone was the only factor that produces significant differences in concentrations in both cells. Deep zone wells had higher average concentrations in both cases (7.25 mg/l versus in 5.79 mg/l in Cell A and 9.68 mg/l versus 5.92 mg/l in Cell B). Well type did not produce any significant differences of any kind in either cell.

Magnesium Concentrations. The ANOVA summaries for magnesium concentrations in Table 25 indicated that sample date was the only factor that was significant in both sets of wells. The temporal trends were comparable in both, as well, with average concentrations rising fairly consistently over time from 147 mg/l in March to 205 mg/l in August in Cell A and from 146 mg/l to 198 mg/l in Cell B. The depth factor was also highly significant in Cell A with shallow wells exhibiting higher average concentrations - 192 mg/l versus 164 mg/l. Cell B concentrations varied in the same direction but by concentrations that were too small to be significant.

Manganese Concentrations. Analysis of variance summaries for manganese concentrations (not shown) indicated that date was the only significant factor in Cell A, while depth zone was the only significant factor in Cell B. The significant temporal variation in Cell A was characterized by concentrations that were nearly constant for March – July concentrations averaging about 2.5 mg/l and drop to about 1.8 mg/l in August. The Cell B wells indicated the same trend, but the drop from 2.5 mg/l to 2.1 mg/l was not significant at the 0.05 level. The depth-related trend in Cell B consisted of concentrations averaging 2.7 mg/l in the shallow zone and 2.1 mg/l in the deep zone. The Cell A wells indicated a decrease in concentrations moving from the shallow zone to the deep zone, but it was not large enough to be statistically significant. Well type did not show any significant effects in either cell.

Table 25. ANOVA Summaries for Magnesium Concentrations

Source	Sum of Sq	DF	Mean Sq	F Value	Prob(F)
Cell A Wells					
Total	53931.2	47	1147.47		
Sample Date	28522.9	3	9507.64	29.89	0.000
Well Type	1662.5	2	831.25	2.61	0.086
Depth Zone	9918.8	1	9918.75	31.18	0.000
Screen Length	1102.1	1	1102.08	3.46	0.070
Error	12725.0	40	318.12		
Cell B Wells					
Total	150426.7	79	1904.14		
Sample Date	27715.9	3	9238.65	5.47	0.002
Well Type	1280.7	4	320.19	0.19	0.943
Depth Zone	2916.1	1	2916.11	1.73	0.193
Screen Length	374.1	1	374.11	0.22	0.639
Error	118139.8	70	1687.71		

Potassium Concentrations. Table 26 indicates that sample date and depth zone both had effects on potassium concentrations in Cell A and Cell B. Screen length was also significant in Cell B, and well type showed no indications of having a significant impact on concentrations. The temporal trends were consistent between Cell A and Cell B (Table 27), and showed fairly similar concentrations in March and May, followed by an increase in July and a decrease in August. The depth-related trends were also similar, with lower concentrations in the shallower zones - 5.90 mg/l versus 9.66 mg/l in Cell A and 7.68 mg/l versus 11.43 mg/l in Cell B.

Table 26. ANOVA Summaries for Potassium Concentrations

Source	Sum of Sq	DF	Mean Sq	F Value	Prob(F)
Cell A Wells					
Total	510.77	47	10.867		
Sample Date	88.68	3	29.561	5.06	0.005
Well Type	18.73	2	9.367	1.60	0.213
Depth Zone	169.50	1	169.500	29.04	0.000
Screen Length	0.37	1	0.368	0.06	0.803
Error	233.48	40	5.837		
Cell B Wells					
Total	790.28	79	10.004		
Sample Date	100.15	3	33.382	8.36	0.000
Well Type	29.12	4	7.280	1.82	0.134
Depth Zone	282.00	1	282.001	70.61	0.000
Screen Length	99.46	1	99.458	24.90	0.000
Error	279.56	70	3.994		

Table 27. Average Potassium Concentrations by Date (mg/l)

	March	May	July	August
Cell A	8.22	8.06	9.28	5.58
Cell B	9.72	8.79	11.03	8.40

Sodium Concentrations. The ANOVA results for sodium concentrations (not shown) indicated sample date as the only significant effect in both Cell A and Cell B. Sample date was significant in each cell at the 0.001 level, while none of the other three factors was significant at even the 0.10 level in either cell. The temporal trend was generally similar in the two cells and consists of relatively low concentrations in March of about 287 mg/l in each cell, increasing to a constant level in May – August of 346 mg/l in Cell A and 339 mg/l in Cell B.

Geochemical Data Summary. The most striking trend of the statistical analyses of the seven elements above was that there were no strong concentration differences between them by well type. There were significant temporal variations in many cases that were shared between Cell A and Cell B. There were no consistent patterns among the temporal trends for the different elements, however. In a number of instances depth zone was also a significant factor with common trends for both cells. Depth-related trends differ for different elements. Overall, however, it appears that there were spatial and temporal variations in chemical concentrations that were much larger than any related to well type.

Water Level Data

Appendix H presents ground water level data collected during Sample Rounds 1 through 4. Due to the large number of wells, the field sampling activities for each round generally spanned the course of 2 days. As a result, several measurements could have been collected during different times within the water level fluctuation cycle. This was assumed to be most prevalent within the Cell A wells, where tidal influence was a concern. As a result, an additional ground water monitoring event was performed on September 5, 2000, over a brief time span (i.e., less than 1-hour duration for the entire set of data). It was also important to note that wells in Cluster A1 had recharge problems during their development.

Figure 24 presents the distribution of water levels for Cell A. With one exception (Cluster A1), the variability among the inter-cluster and intra-cluster wells was relatively small (ranging less than three one hundredths of a foot). While the water level elevation ranged from 2.95 to 3.54 feet above mean sea level (MSL) for Cell A, the cell mean value of 3.27 feet (including a Cluster A1 mean value of 3.26 feet), and standard deviation of 0.13 (dominated by the variability of Cluster A1) implied that the water level values were very similar for each of the well types in each cluster. For the purpose of determining direction of flow, water levels in the different well designs were believed to be close enough to obtain similar results, depending on the spread of the potentiometric surface measurement points and the assumptions used in the statistical contouring package.

Figure 25 displays the distribution of ground water levels for Cell B. The small range of values within each cluster demonstrated similarity among the different well types. Ranges smaller than one tenth of a foot in each cluster indicated that the wells perform comparably with respect to water level. It is believed that the ranges in water level measurements displayed by the different well types is so small that the impacts to flow analyses based on potentiometric surface mapping is negligible.

In summary, although the data set is small, it appears that each of these well designs would yield similar results when used to determine flow gradients, potentiometric surface maps, flownets, and the hydraulic components associated with volumetric flux determinations. Hydraulic conductivity measurements based on pumping and slug tests were not performed during this investigation, since skin effects associated with the areas impacted by well installation methods are not easy to quantify. Therefore, hydraulic performance was only based on water level data.

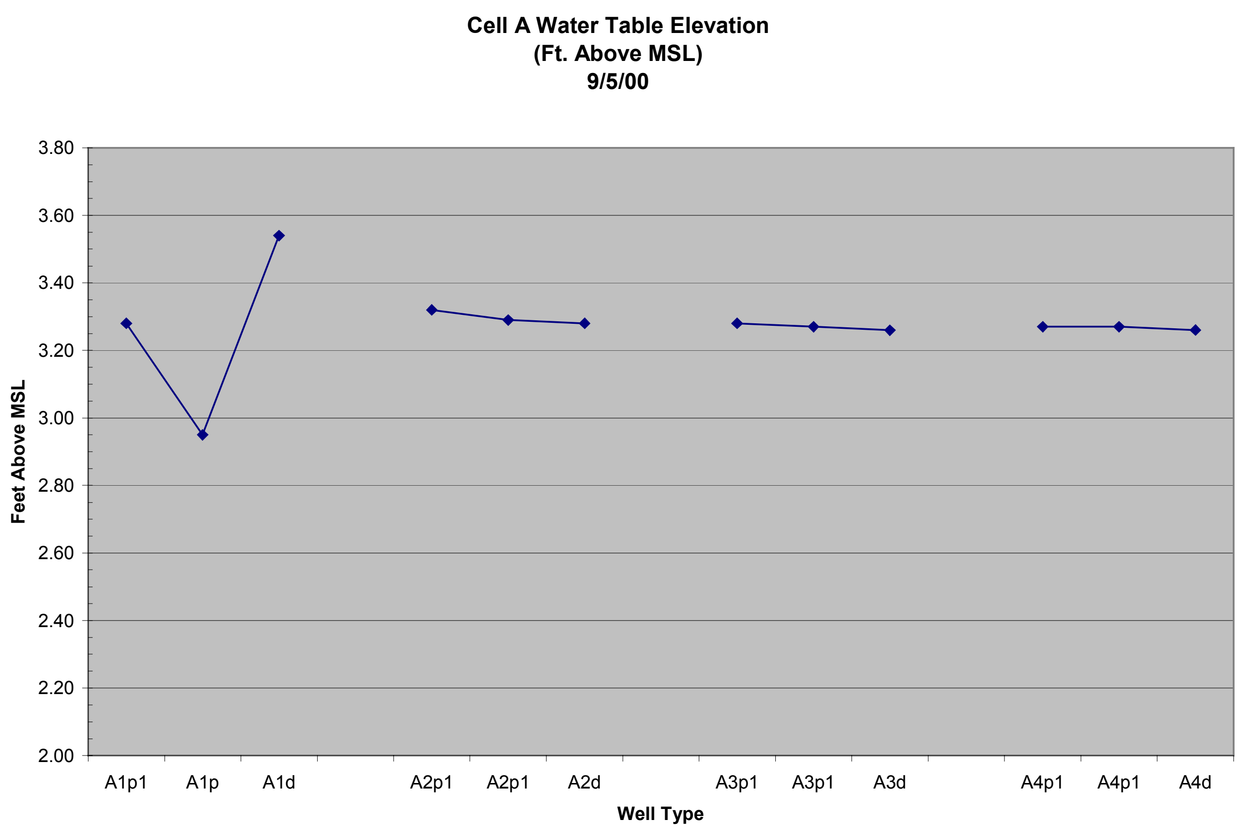

Figure 24. Cell A ground water level distribution.

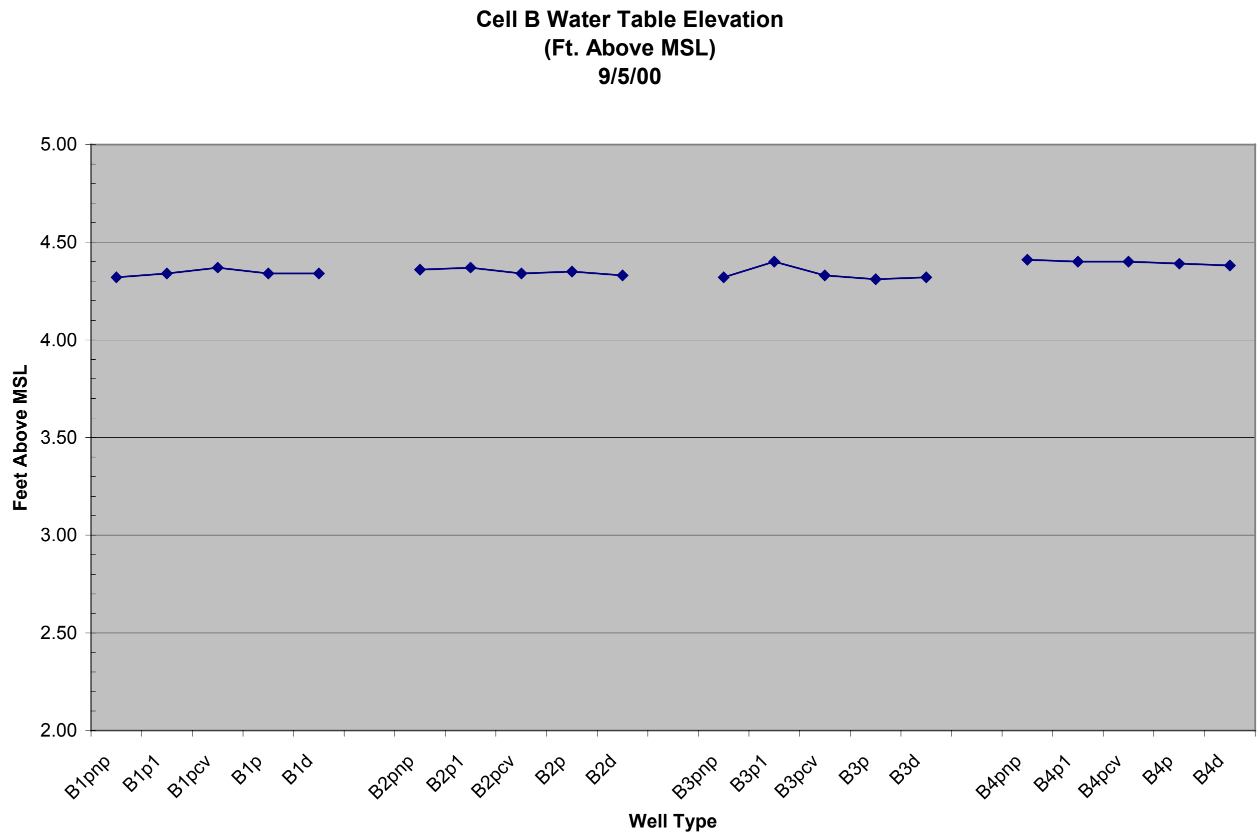

Figure 25. Cell B ground water level distribution.

SUMMARY AND CONCLUSIONS

A comparison between direct-push installed monitoring wells and hollow stem auger drilled monitoring wells was conducted on the leading edge of a methyl-tertiary butyl ether (MTBE) plume located at Naval Base Ventura County (NBVC) Port Hueneme, California. The purpose of this effort was to determine whether representative chemical and water table data could be generated using properly designed direct-push monitoring wells.

On August 11, 1999, an advisory committee comprised of experts from industry, government regulatory entities, and academia was assembled to determine how best to compare the performance of direct-push and drilled monitoring wells. Of particular concern was the comparison of chemical data (e.g., concentration of contaminant of concern and monitored natural attenuation indicator parameters) and hydrogeologic data (potentiometric surface measurement) for the different types of wells. Detailed discussions related to direct-push well construction, experimental design, well configuration plans, statistical analysis, and sampling approaches were considered during the generation of the work plan.

Field efforts included piezocone measurements, collection of core samples, pre-installation collection of water samples from selected depths, installation of customized monitoring well test cells, and sampling of the wells in triplicate. Laboratory efforts included chemical analysis of water samples, determination of permeability for selected core samples, and determination of grain size distribution for selected samples.

From February 8 to February 14, 2000, a total of 32 wells were installed in two cells. Twelve wells were installed in Cell A, while a total of twenty wells were installed in Cell B. Well screen depth ranges for each of the clusters in each cell were determined using several factors. Since short screen lengths were expected to yield more comparable and representative solute concentration data on a localized scale, each well was constructed with either a 2-foot or 5-foot (0.61- or 1.52-m) screen length. With one exception, the center of each screen for each cluster was set at the most permeable depth of that portion of the aquifer. The one exception included the deep clusters for Cell B. Although the 13.5- to 14.5-foot (4.11- to 4.42-m) zone displayed relatively higher permeability, the screens were set to encompass the 16- to 17-foot (4.89- to 5.18-m) depth range. This was done so that the 5-foot (1.52-m) screen lengths for the shallow and deep clusters would not overlap vertically. Although the direct-push ground water samples showed non-detectable MTBE levels for the 16-foot (4.89-m) depth, the differences in permeability between the 14-foot (4.27-m) and 16-foot (4.89-m) zones were considered negligible when recognizing that the screens span 2- or 5-foot (0.61- or 1.52-m) depth ranges. Well clusters (consisting of five wells each for Cell B, and three wells each for Cell A) were grouped by screen length and depth range.

Specific well screen design (sand filter pack and slot size) was determined using several criteria. To evaluate performance of wells according to the ASTM specifications (ASTM D5092), grain size distribution curves (Appendix C) were used to determine filter pack grain size and corresponding slot size recommendations (Appendix D). For Cell A, each of the wells was designed using ASTM specifications. For Cell B, two additional well designs were also employed to account for the most common well installation designs used by drillers and direct-push device operators. To evaluate performance of wells which are most commonly installed by drillers who do not have access to site-specific grain size distribution data, a generic ("conventional") well design consisting of 20 to 40 sand pack mesh surrounding 0.010-inch (0.25-mm) slotted schedule 40 PVC pipe was used as one of the alternatives in each of the well clusters in Cell B. To evaluate performance of non-pack wells that are most commonly installed by direct-push equipment operators, an additional set of wells consisting of 0.010-inch (0.25-mm) slotted schedule 40 PVC pipe was installed without a filter pack in each of the clusters in Cell B.

Water samples were collected in a pre-specified random order using a low-flow sampling procedure. Triplicate samples were analyzed for MTBE. Additional samples were analyzed for specific inorganic and geochemical parameters. Water levels were collected and sampling parameters were monitored during each sampling event. An additional water level survey was conducted on September 5, 2000, within a short time period (less than 1 hour) to minimize potential impacts due to water level fluctuations that can occur during sampling rounds.

An extensive statistical effort was conducted to compare the performance of the different well designs for the Port Hueneme hydrogeologic regime. Analysis of variance (ANOVA) was selected as the best technique for analyzing data consisting of categorical factor predictors and a continuously varying response variable. The results of ANOVA tests indicate whether or not a factor has a significant impact on the value of the response variable, but they do not provide direct information on how the response varies with different levels of the factor. For this comparison, well type issues required consideration of differences between each of the direct-push well designs and the standard drilled well design. The standard drilled well was treated as the default case for the ANOVA test. Four different configurations of models were presented. They were distinguished from each other based on how the screen length and depth zone factors were specified and which types of effects were included.

Both individually and through their interactions, depth range and date factors capture consistent variations that are considerably larger than any associated with differences in well type. In this regard, the results for Cell A are similar to those for Cell B, although the specific temporal and depth-related trends are different in the two cells. In both cases the variations related to temporal and vertical concentration trends are considerably larger than those related to well design.

The most striking result of the statistical analyses of the seven inorganic geochemical elements evaluated was that there were no strong systematic variations observed which were based on well type. There were significant temporal variations in many cases that were shared between Cell A and Cell B. However, there were no clear, consistent patterns among the temporal trends for the different elements. In a number of instances depth zone was also a significant factor with common trends for both cells. Once again, depth-related trends varied for different elements. Indications are that spatial and temporal variations in chemical concentrations are much larger than variations related to well type.

The data generated during the water level monitoring event of September 5, 2000, indicated that the variability among the inter-cluster and intra-cluster wells was relatively small (inter-cluster means ranging less than 0.05 foot for Cell A and less than 0.07 foot for Cell B). Cluster A1 may have had hydraulic problems (based on the observed well development low recovery rates and the range in the September 5th water level elevation). However, the mean water level for the cluster was extremely close (3.26 feet above MSL) to the mean levels in the other three clusters in Cell A (which ranged from 3.27 to 3.30 feet above MSL). Although the data set was small, it appears that each of these well designs would yield similar results when used to determine flow gradients, potentiometric surface maps, flownets, and the hydraulic components associated with volumetric flux determinations.

Several experimental design issues may have had significant impact on the results and conclusions. For instance, there may have been problems associated with the way replicates were collected, since samples were collected consecutively (three replicates at a time) prior to moving on to the next well in the queue. The impact of sampling from one well on the neighboring wells may be of concern, which was why a low flow sampling approach was used. Flow heterogeneities may have controlled the concentration distribution as much as the mechanisms associated with proximity. In general, excellent repeatability within the replicates was observed (as indicated by low variability). Some clusters displayed a significant amount of MTBE concentration variability. However, as noted above, the well design variability was not as significant as the variability observed with depth. The observed heterogeneous nature of the MTBE distribution may have been due to either "real" spatial heterogeneities or impacts of sampling from neighboring wells. Tests to quantify these factors were not conducted. However, impacts from lithologic heterogeneities are minimized the closer the well screens are set to a centralized position where uncertainty is minimal (e.g., a sampling or piezocone measurement log). There probably exists an optimal separation distance that balances the spatial lithologic heterogeneities with the potential impacts due to sampling, however the analyses did not attempt to address this. With respect to sampling impacts on adjacent wells (specifically, impacts on wells located downgradient from those being sampled at any given time), the site configuration was designed so that the clusters straddle a line oriented perpendicular to the observed direction of ground water flow. One potential future approach to minimizing inter-cluster and intra-cluster impact would be to sample from the most downgradient wells initially, and then proceed to the wells located upgradient. Inter-cluster impact should be minimal since wells are screened at different depths, with those most downgradient screened through the deeper portions of the aquifer. In addition, low-flow sampling procedures were used to reduce potential impacts due to proximity.

Installation of drilled wells requires more time, and therefore more expense, than for direct-push wells. However, the largest cost differences in the well installation efforts are associated with the generation of solid and liquid waste. Solid soil cutting waste is not generated for direct-push wells, except when required to set wellhead traffic protection boxes. However, this relatively small amount of material is generally not hazardous unless situated at the location of a surface contaminant release. For this project, liquid waste generation during well installation and development was 3 to 4 times higher for drilled wells.

When planning for use of direct-push wells, a significant cost advantage can be realized when coupling monitoring well installation activities with site characterization activities associated with solute plume delineation. Since many direct-push monitoring well installation devices can be used to deploy direct-sensing probes, expedited site characterization activities can be augmented with direct-push wells without an additional mobilization requirement. This approach significantly reduces the time and labor associated with report review, contracting, and permitting activities often required when plume delineation field efforts are limited to field screening and reporting activities. In addition, the plume delineation field screening data can be best utilized to determine appropriate ground water monitoring locations while the investigators remain in the field.

In summary, no significant performance differences were observed between the direct-push wells and hollow stem auger drilled wells. Within experimental error, the performance was comparable for the hydrogeologic setting of Port Hueneme, California. More specifically, the chemical variability among the different well types was less than that displayed by spatial heterogeneities associated with well screen depth differences and temporal variability. Similar representative solute concentration results are anticipated for direct-push wells installed and screened in soils with hydraulic conductivity ranging from 10^{-1} to 10^{-4} cm/s. Although a comprehensive hydraulic evaluation was not conducted, water level values also yielded comparable results for the different well designs. Since the study duration was limited to approximately 6 months, a longer observation period may be required to evaluate the long-term (greater than 1 year) performance of direct-push wells.

ACKNOWLEDGEMENTS

The authors would like to thank Sonya Murphy (Naval Facilities Engineering Command Southwestern Division) for her support and assistance with program management. We would also like to express our gratitude to Captain Lisa Ackert (Tyndall Air Force Base), Erica Becvar (Applied Research Associates), Dr. Mike Barcelona (University of Michigan), Jeff Farrar (U.S. Bureau of Reclamation), Steve Farrington (Applied Research Associates), Dr. Paul Johnson (Arizona State University), Dr. Randall Ross (U.S. EPA), and Rick Young (Tyndall Air Force Base) for their constructive review of the project design and results. We are indebted to Dorothy Cannon (Naval Facilities Engineering Service Center) for her field efforts and contractual support. In addition, we are also greatly indebted to Cristin Bruce of Arizona State University for conducting most of the MTBE analyses. ***This project was funded through the Naval Facilities Engineering Command Southwestern Division.***

REFERENCES

American Society for Testing and Materials. ASTM D422: Standard Method for Particle-Size Analyses of Soils.

American Society for Testing and Materials. ASTM D2434: Standard Test Method for permeability of Granular Soils (Constant Head).

American Society for Testing and Materials. ASTM D3441: Standard Test Method for Deep, Quasi-Static, Cone and Friction-Cone Penetration Tests of Soil.

American Society for Testing and Materials. ASTM D5092: Standard Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers.

American Society for Testing and Materials. ASTM D5463: Standard Guide for Use of Test Kits to Measure Inorganic Constituents in Water.

American Society for Testing and Materials. ASTM D5521: Standard Guide for Development of Ground Water Monitoring Wells in Granular Aquifers.

American Society for Testing and Materials. ASTM D6001: Standard Guide for Direct-Push Water Sampling for Geoenvironmental Investigations.

American Society for Testing and Materials. ASTM D6282: Standard Guide for Direct Push Soil Sampling for Environmental Site Characterization.

Driscoll, F.G. (1986). Groundwater and Wells. Johnson Filtration Systems, Inc., St. Paul, MN, 5512, 1986.

Puls, Robert W., and Michael J. Barcelona (1996). Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures, EPA/540/S-95/504, April 1996, 12 p.

Robertson, P.K., and R.G. Campanella (1986). Guidelines for the Use, Interpretation, and Application of the CPT and CPTU. University of British Columbia Soil Mechanics Series No. 105.

State of California (1981). California Department of Water Resources Bulletin 74-81: Water Well Standards: State of California, December 1981, 92 p.

APPENDIX A

Piezocone Data Logs

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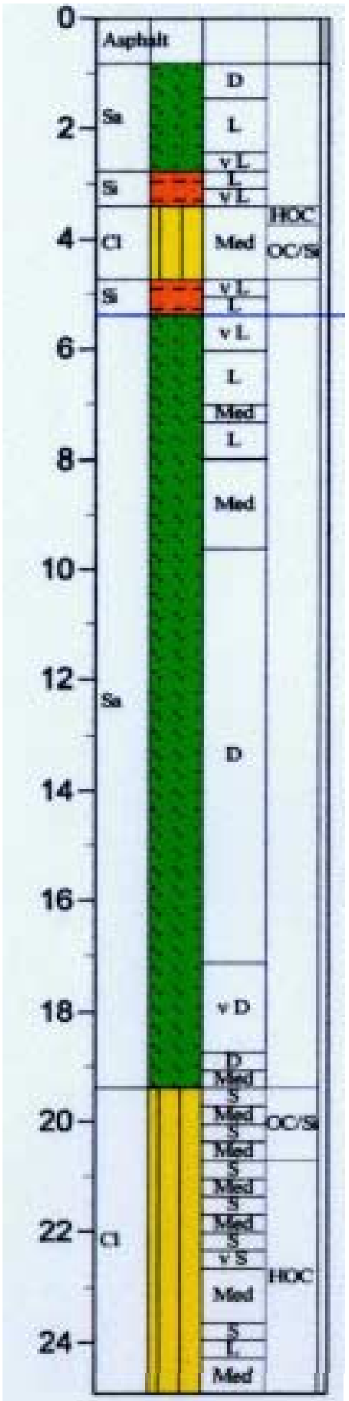

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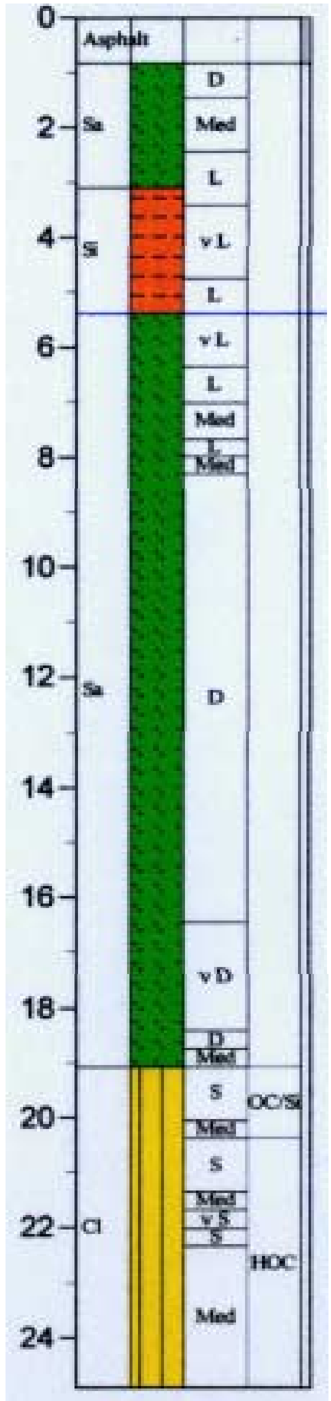

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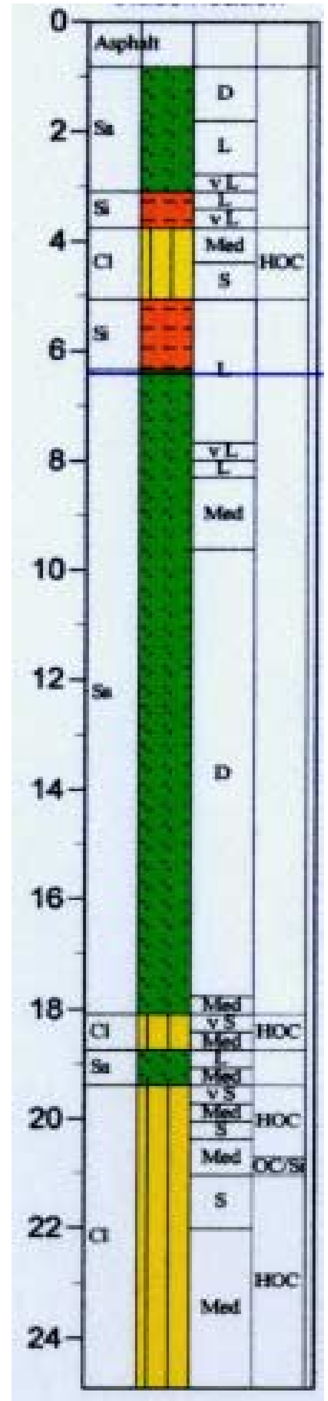

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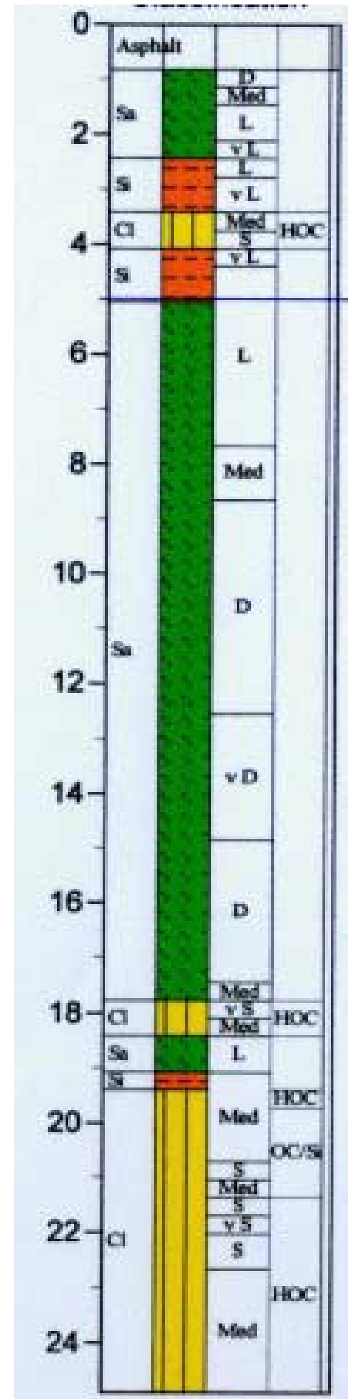

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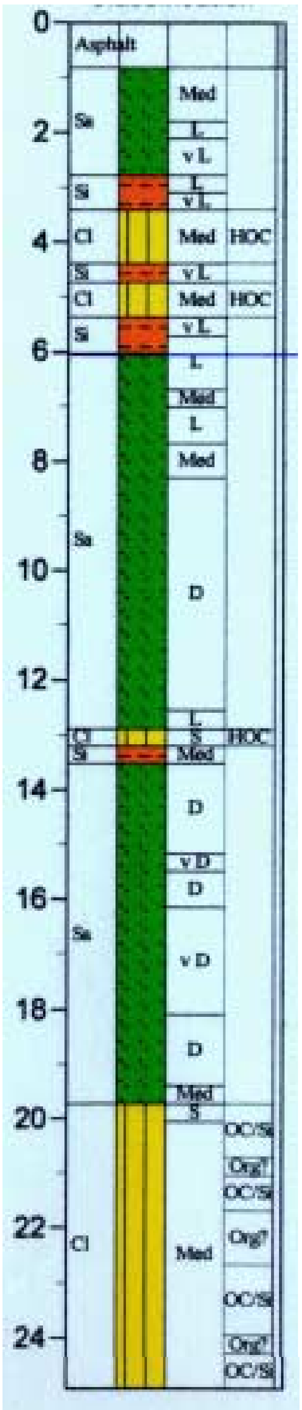

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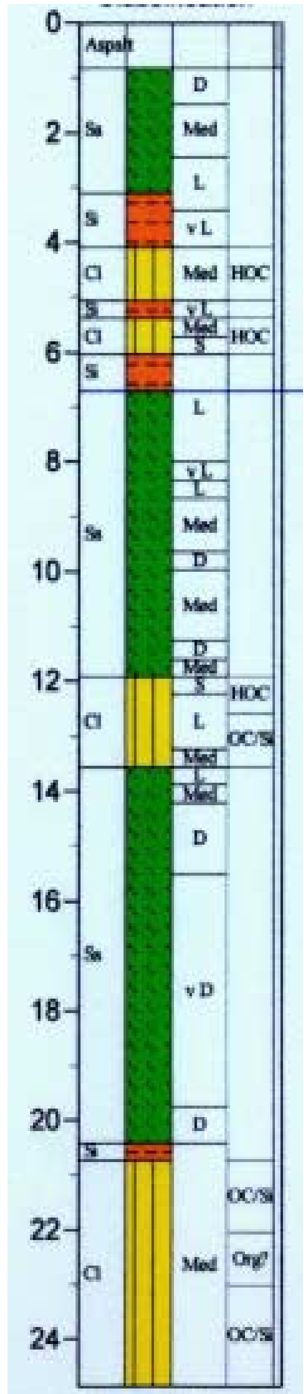

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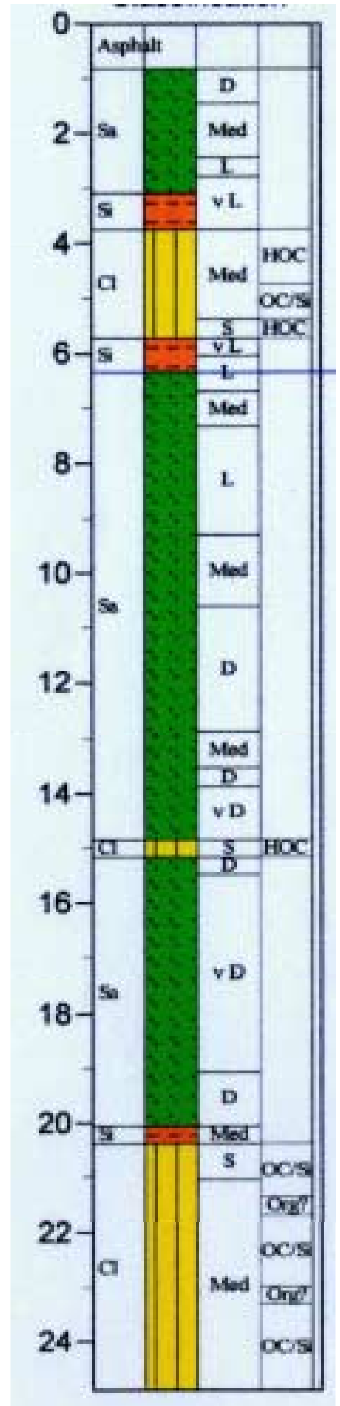
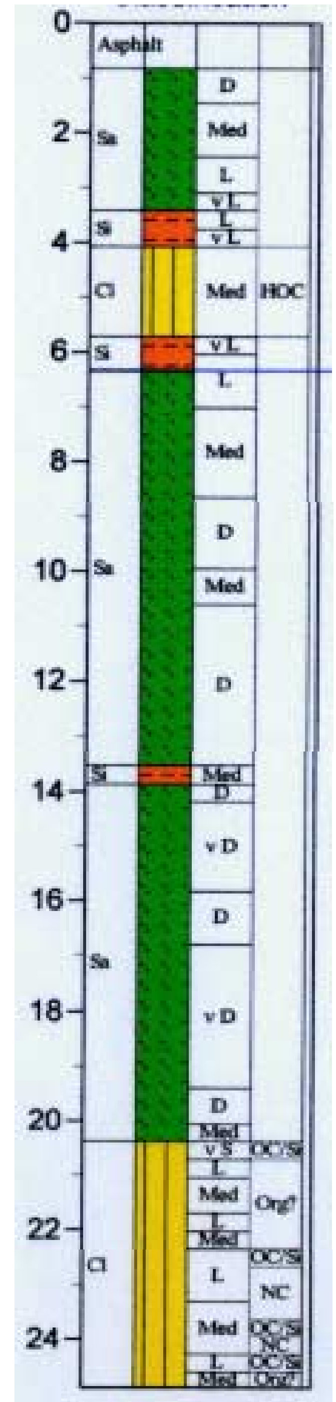


CPTA4



APPENDIX B

Permeability Test Laboratory Data

PERMEABILITY TESTS FOR WELL COMPARISON STUDY								
Sample:	**A5, 8.3-9.3'**							
		man rdgs						
Test #	**Ave H1-H2 (cm)**	**Head (cm)**	**Q (ml or cc)**	**t (secs)**	**Q/At**	**H/L**	**T (degrees C)**	**k (cm/s)**
1	13.2	27.2	5	60	0.00182749	3.569554	16.1	0.00051196
		26.9	15	180	0.00182749	3.530184	16.1	0.00051767
		26.7	26	300	0.00190058	3.503937	16.1	0.00054241
3	13.2	21.5	5	60	0.00182749	2.821522	16.4	0.00064769
		21.4	16	180	0.00194932	2.808399	16.4	0.0006941
		21.4	27	300	0.00197368	2.808399	16.4	0.00070278
4	13.2	21.4	5	60	0.00182749	2.808399	16.6	0.00065072
		21.4	16	180	0.00194932	2.808399	16.6	0.0006941
		21.5	26	300	0.00190058	2.821522	16.6	0.0006736
							k ave	**0.00062612**
Notes:	Test #2 invalid due to bubbles in upper manometer							
	Test #3: Cell raised 2" and equilibrated for 5 minutes						NEED STATS	
	Test #4: Cell raised 3/4" and let equilibrate for 5 minutes							
	Test conducted 12/22/99							

PERMEABILITY TESTS FOR WELL COMPARISON STUDY								
Sample:	**A5, 10.3-11.3'**							
		man rdgs						
Test #	**Ave H1-H2 (cm)**	**Head (cm)**	**Q (ml or cc)**	**t (secs)**	**Q/At**	**H/L**	**T (degrees C)**	**k (cm/s)**
1	12.1	27	10	60	0.003655	3.54330709	17.7	0.00103151
		27.4	29	180	0.0035331	3.59580052	17.7	0.00098257
		27.8	49	300	0.0035819	3.64829396	17.7	0.00098179
2	12.1	25.8	9	60	0.0032895	3.38582677	17.5	0.00097154
		26	28	180	0.0034113	3.41207349	17.5	0.00099978
		25.9	46	300	0.0033626	3.39895013	17.5	0.0009893
3	12.1	25.4	9	60	0.0032895	3.33333333	17.5	0.00098684
		25.7	27	180	0.0032895	3.37270341	17.5	0.00097532
		25.8	46	300	0.0033626	3.38582677	17.5	0.00099313
							k ave	**0.0009902**
Notes:								
	Test #2: Cell raised 2" and equilibrated for 5 minutes						NEED STATS	
	Test #3: Cell raised 3/4" and let equilibrate for 5 minutes							
	Test conducted 12/22/99							

PERMEABILITY TESTS FOR WELL COMPARISON STUDY								
Sample: **A5, 16.2-17.2'**								
		man rdgs						
Test #	**Ave H1-H2 (cm)**	**Head (cm)**	**Q (ml or cc)**	**t (secs)**	**Q/At**	**H/L**	**T (degrees C)**	**k (cm/s)**
1	11.9	3.6	67	60	0.024488	0.472441	17.6	0.051833577
		4.1	198	180	0.024123	0.538058	17.6	0.044833119
		3	368	300	0.026901	0.393701	17.6	0.068327485
2	11.9	6.5	96	60	0.035088	0.853018	17.6	0.041133603
		6.2	286	180	0.034844	0.813648	17.6	0.042824467
		5.9	474	300	0.034649	0.774278	17.6	0.044750223
3	11.9	6.4	104	60	0.038012	0.839895	18	0.045257675
		7.4	321	180	0.039108	0.971129	18	0.040270863
		7.7	502	300	0.036696	1.010499	18	0.03631465
							k ave	**0.04617174**
Notes:								
	Test #2: Cell raised 2" and equilibrated for 5 minutes						NEED STATS	
	Test #3: Cell raised 3/4" and let equilibrate for 5 minutes							
	Test conducted 12/22/99							

PERMEABILITY TESTS FOR WELL COMPARISON STUDY								
Sample: **A5, 17.2-18.2'**								
		man rdgs						
Test #	**Ave H1-H2 (cm)**	**Head (cm)**	**Q (ml or cc)**	**t (secs)**	**Q/At**	**H/L**	**T (degree**	**k (cm/s)**
1	12.1	8.7	185	60	0.067617	1.141732	18.8	0.05922313
		8.7	370	120	0.067617	1.141732	18.8	0.05922313
		8.4	546	180	0.06652	1.102362	18.8	0.06034357
2	12.1	7.3	182	60	0.06652	0.958005	18.8	0.06943643
		7.4	359	120	0.065607	0.971129	18.8	0.0675572
		7	505	180	0.061525	0.918635	18.8	0.06697473
3	12.1	6.8	165	60	0.060307	0.892388	19.1	0.06757933
		6.9	320	120	0.05848	0.905512	19.1	0.06458174
		7	487	180	0.059332	0.918635	19.1	0.06458751
							k ave	**0.06438964**
Notes:								
	Test #2: Cell raised 2" and equilibrated for 5 minutes						NEED STATS	
	Test #3: Cell raised 3/4" and let equilibrate for 5 minutes							
	Test conducted 12/22/99							

PERMEABILITY TESTS FOR WELL COMPARISON STUDY								
Sample: B7, 8.3-9.3'								
		man rdgs						
Test #	**Ave H1-H2 (cm)**	**Head (cm)**	**Q (ml or cc)**	**t (secs)**	**Q/At**	**H/L**	**T (degrees C)**	**k (cm/s)**
1	11.8	17.7	6	60	0.002193	2.322835	17.6	0.0009441
		17.6	18	180	0.002193	2.309711	17.6	0.00094946
		17.6	29	300	0.00212	2.309711	17.6	0.00091781
2	11.8	17.6	6	60	0.002193	2.309711	17.6	0.00094946
		17.6	17	180	0.002071	2.309711	17.6	0.00089671
		17.6	29	300	0.00212	2.309711	17.6	0.00091781
3	11.8	17.4	6	60	0.002193	2.283465	17.6	0.00096038
		17.4	17	180	0.002071	2.283465	17.6	0.00090702
		17.4	29	300	0.00212	2.283465	17.6	0.00092836
							k ave	**0.00093012**
Notes:								
	Test #2: Cell raised 2" and equilibrated for 5 minutes						NEED STATS	
	Test #3: Cell raised 3/4" and let equilibrate for 5 minutes							
	Test conducted 12/28/99							

PERMEABILITY TESTS FOR WELL COMPARISON STUDY								
Sample: B7, 10.5-11.5'								
		man rdgs						
Test #	**Ave H1-H2 (cm)**	**Head (cm)**	**Q (ml or cc)**	**t (secs)**	**Q/At**	**H/L**	**T (degrees C)**	**k (cm/s)**
1	12.4	12.2	29	60	0.010599	1.60105	18.8	0.00662
		12.3	82	180	0.00999	1.614173	18.8	0.006189
		12.3	131	300	0.009576	1.614173	18.8	0.005932
2	12.4	13.3	28	60	0.010234	1.745407	18.7	0.005863
		13.3	79	180	0.009625	1.745407	18.7	0.005514
		13.3	129	300	0.00943	1.745407	18.7	0.005403
3	12.4	19.3	44	60	0.016082	2.532808	18.6	0.006349
		19.2	122	180	0.014864	2.519685	18.6	0.005899
		19.2	199	300	0.014547	2.519685	18.6	0.005773
							k ave	**0.005949**
Notes:								
	Test #2: Cell raised 2" and equilibrated for 5 minutes						NEED STATS	
	Test #3: Cell raised 3/4" and let equilibrate for 5 minutes							
	Test conducted 12/28/99							

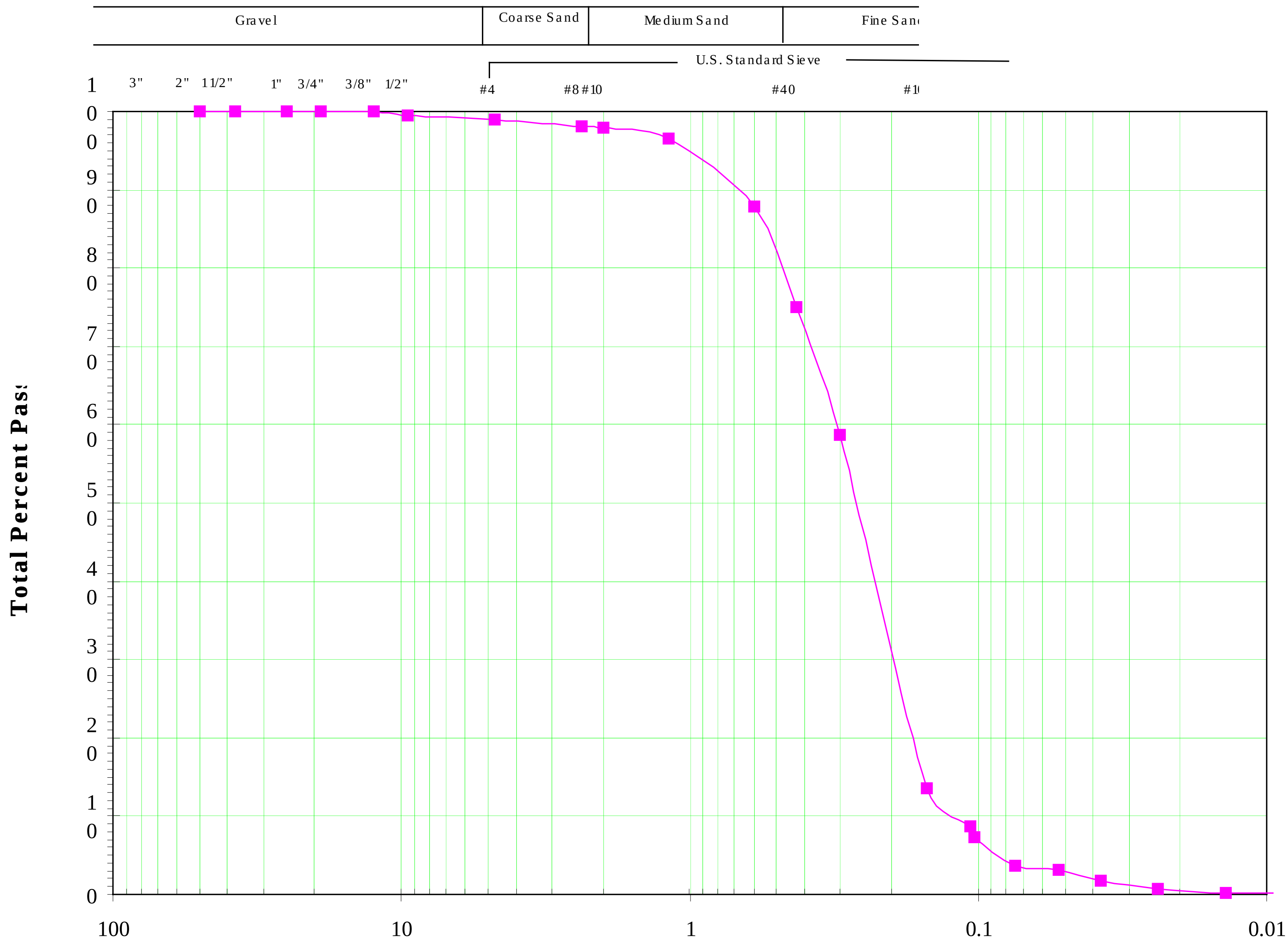
PERMEABILITY TESTS FOR WELL COMPARISON STUDY								
Sample: B7, 13.5-14.5'								
		man rdgs						
Test #	**Ave H1-H2 (cm)**	**Head (cm)**	**Q (ml or cc)**	**t (secs)**	**Q/At**	**H/L**	**T (degrees C)**	**k (cm/s)**
1	12	33.6	47	60	0.017178	4.409449	17.7	0.0038958
		33.6	135	180	0.016447	4.409449	17.7	0.00373
		33.7	221	300	0.016155	4.422572	17.7	0.0036528
2	12	33.5	43	60	0.015716	4.396325	17.8	0.0035749
		33.5	121	180	0.014742	4.396325	17.8	0.0033532
		33.5	198	300	0.014474	4.396325	17.8	0.0032922
3	12	33.3	39	60	0.014254	4.370079	17.7	0.0032618
		33.3	111	180	0.013523	4.370079	17.7	0.0030945
		33	180	300	0.013158	4.330709	17.7	0.0030383
							k ave	**0.0034326**
Notes:								
	Test #2: Cell raised 2" and equilibrated for 5 minutes						NEED STATS	
	Test #3: Cell raised 3/4" and let equilibrate for 5 minutes							
	Test conducted 12/29/99							

PERMEABILITY TESTS FOR WELL COMPARISON STUDY								
Sample: B7, 16.0-17.0'								
		man rdgs						
Test #	**Ave H1-H2 (cm)**	**Head (cm)**	**Q (ml or cc)**	**t (secs)**	**Q/At**	**H/L**	**T (degrees C)**	**k (cm/s)**
1	12.2	21.6	16	60	0.005848	2.834646	17.8	0.00206303
		21.6	46	180	0.005604	2.834646	17.8	0.00197707
		22	76	300	0.005556	2.887139	17.8	0.00192424
2	12.2	21.3	15	60	0.005482	2.795276	17.8	0.00196133
		21.5	44	180	0.005361	2.821522	17.8	0.0018999
		21.6	72	300	0.005263	2.834646	17.8	0.00185673
3	12.2	21.7	15	60	0.005482	2.847769	17.7	0.00192518
		21.8	42	180	0.005117	2.860892	17.7	0.00178859
		21.8	70	300	0.005117	2.860892	17.7	0.00178859
							k ave	**0.00190941**
Notes:								
	Test #2: Cell raised 2" and equilibrated for 5 minutes						NEED STATS	
	Test #3: Cell raised 3/4" and let equilibrate for 5 minutes							
	Test conducted 12/29/99							

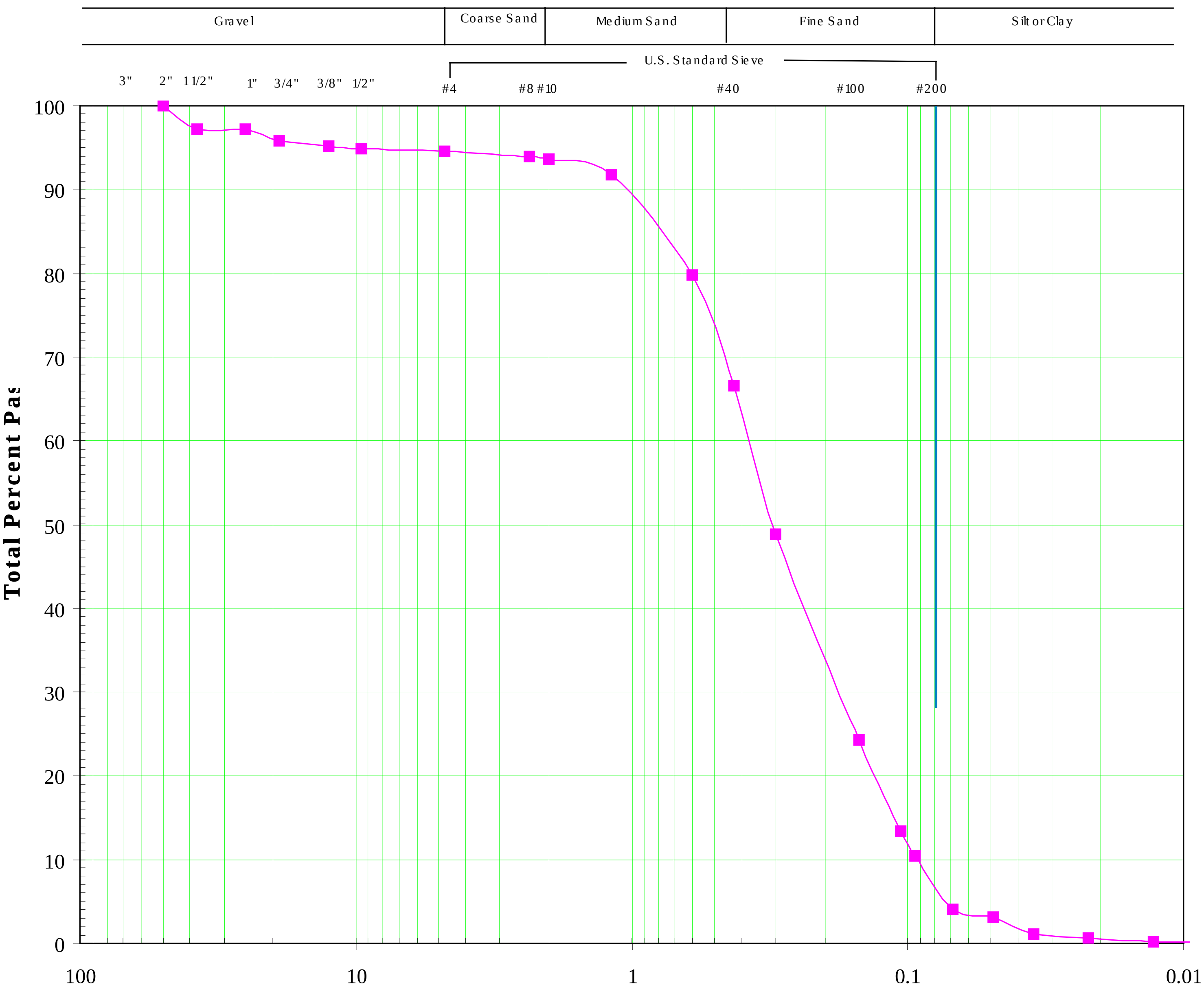
APPENDIX C

Grain Size Distribution Curves

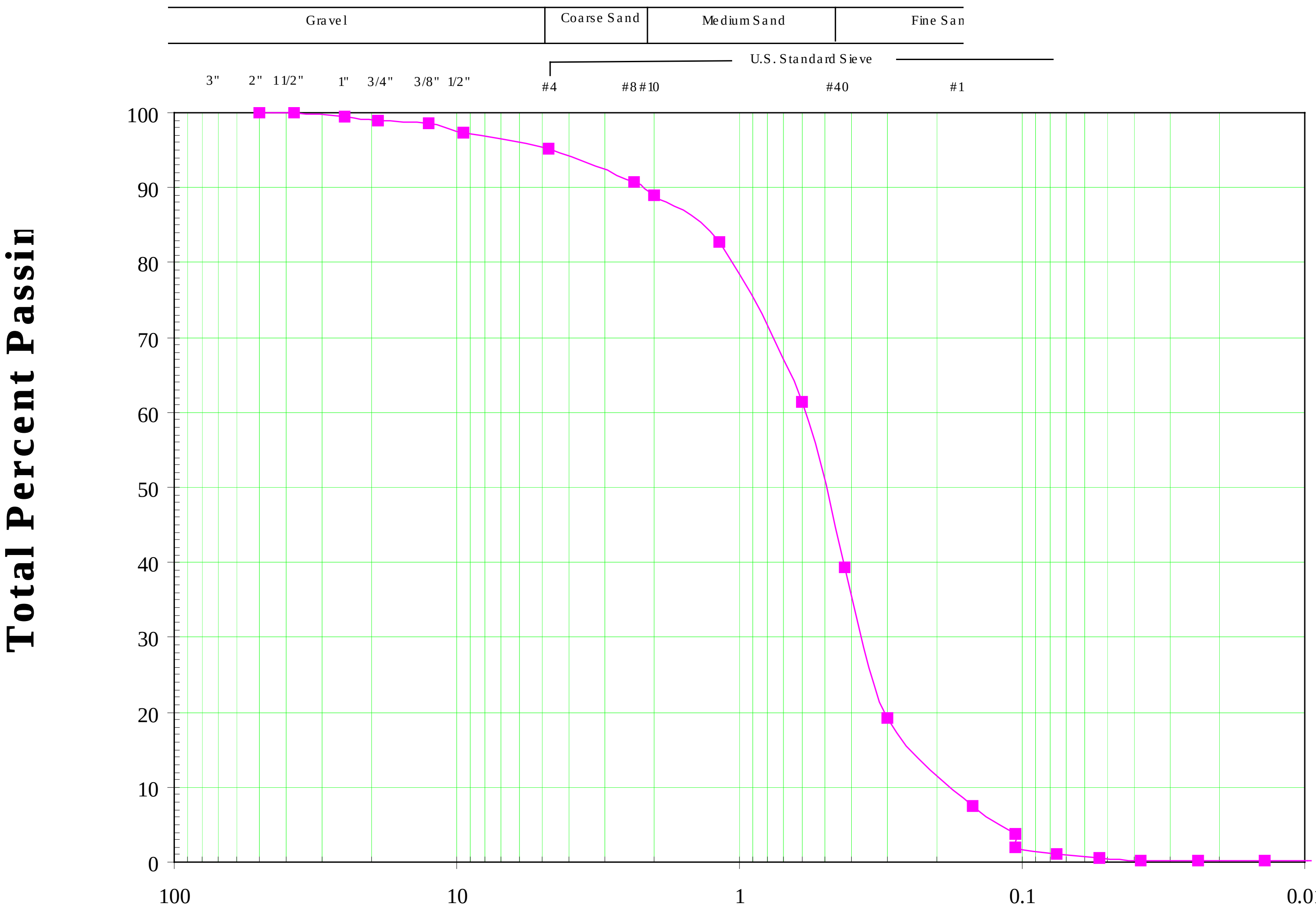
GRAIN SIZE DISTRIBUTION CURVES



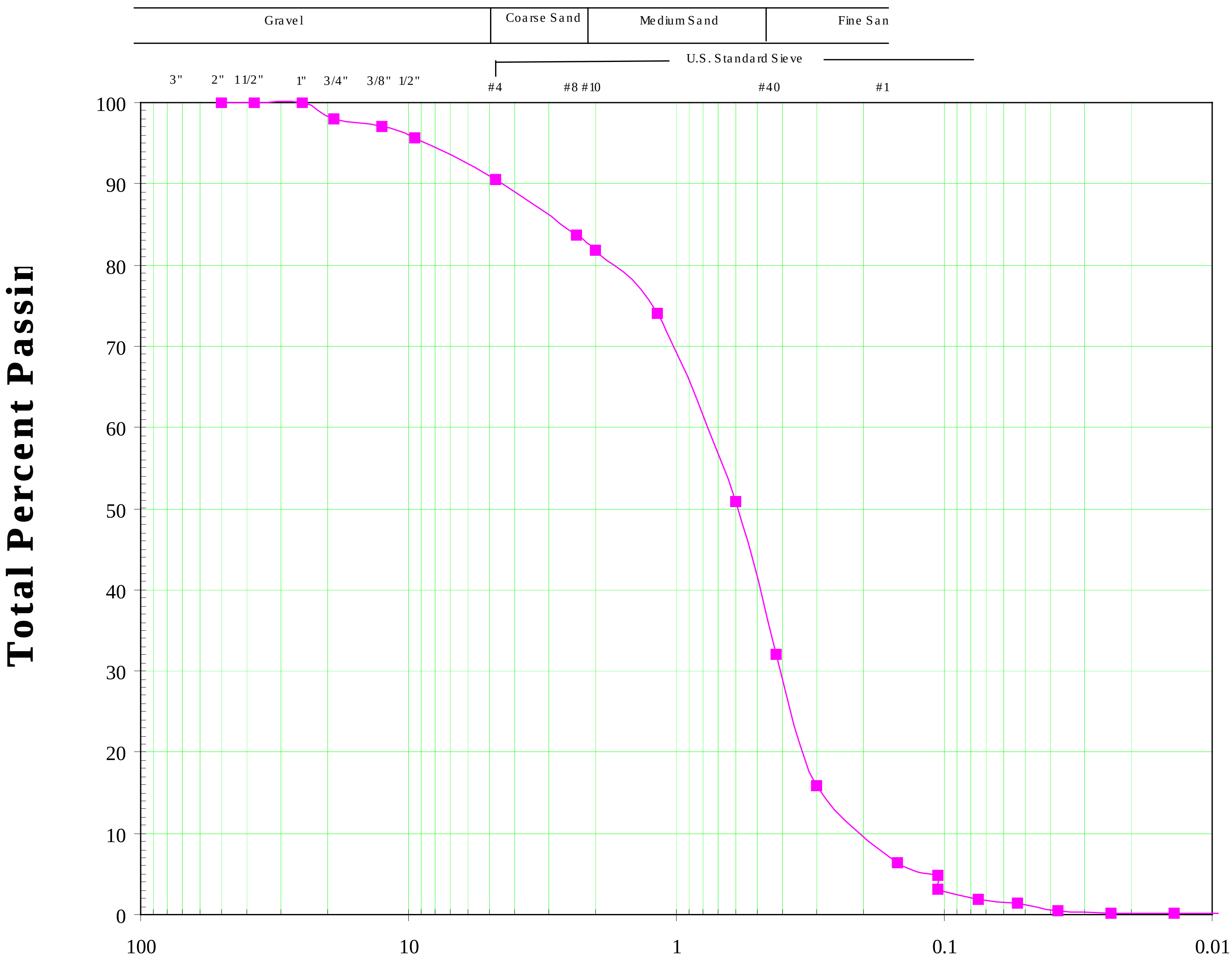
A5 at 8.3 to 9.3’



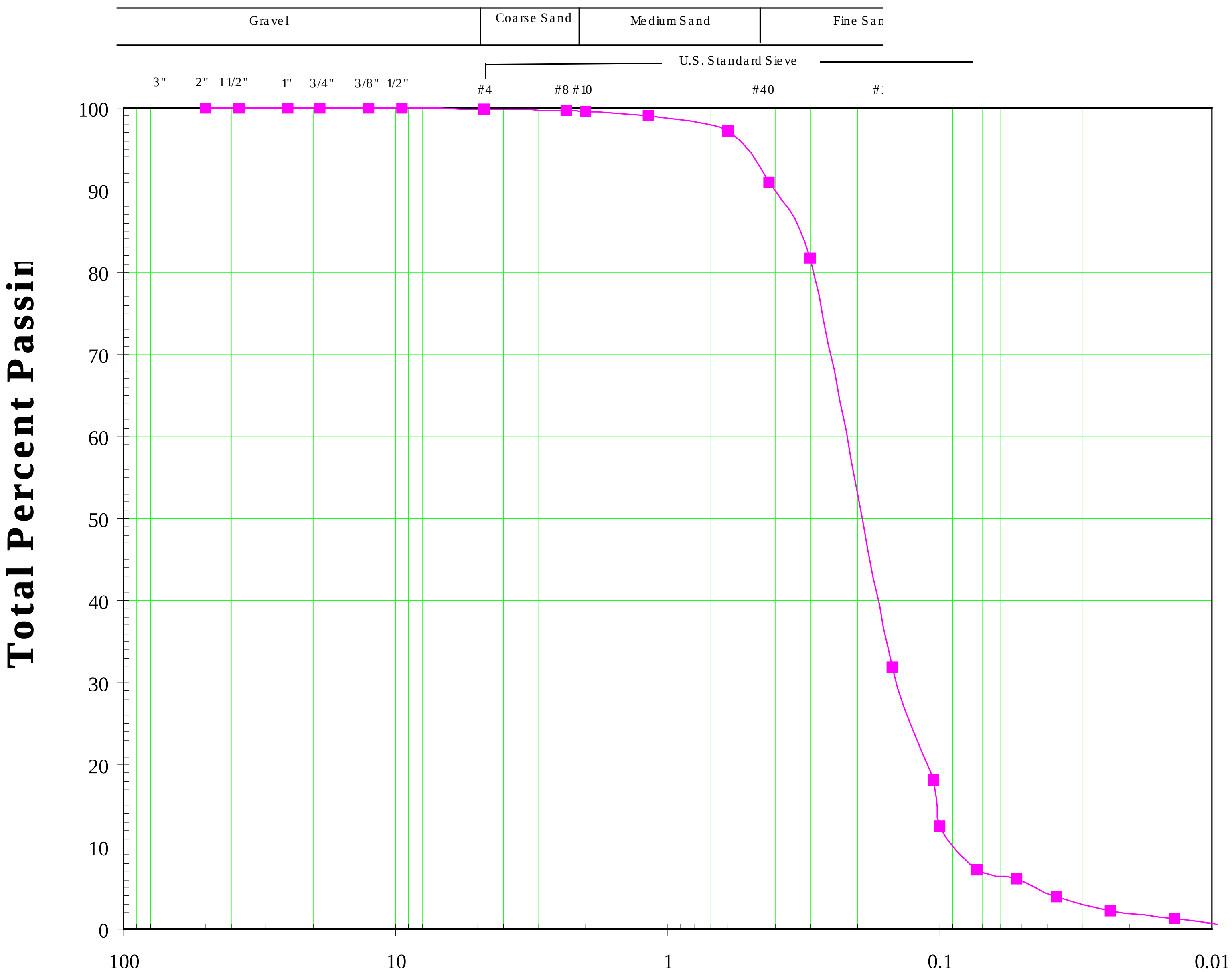
A5 at 10.3 to 11.3’



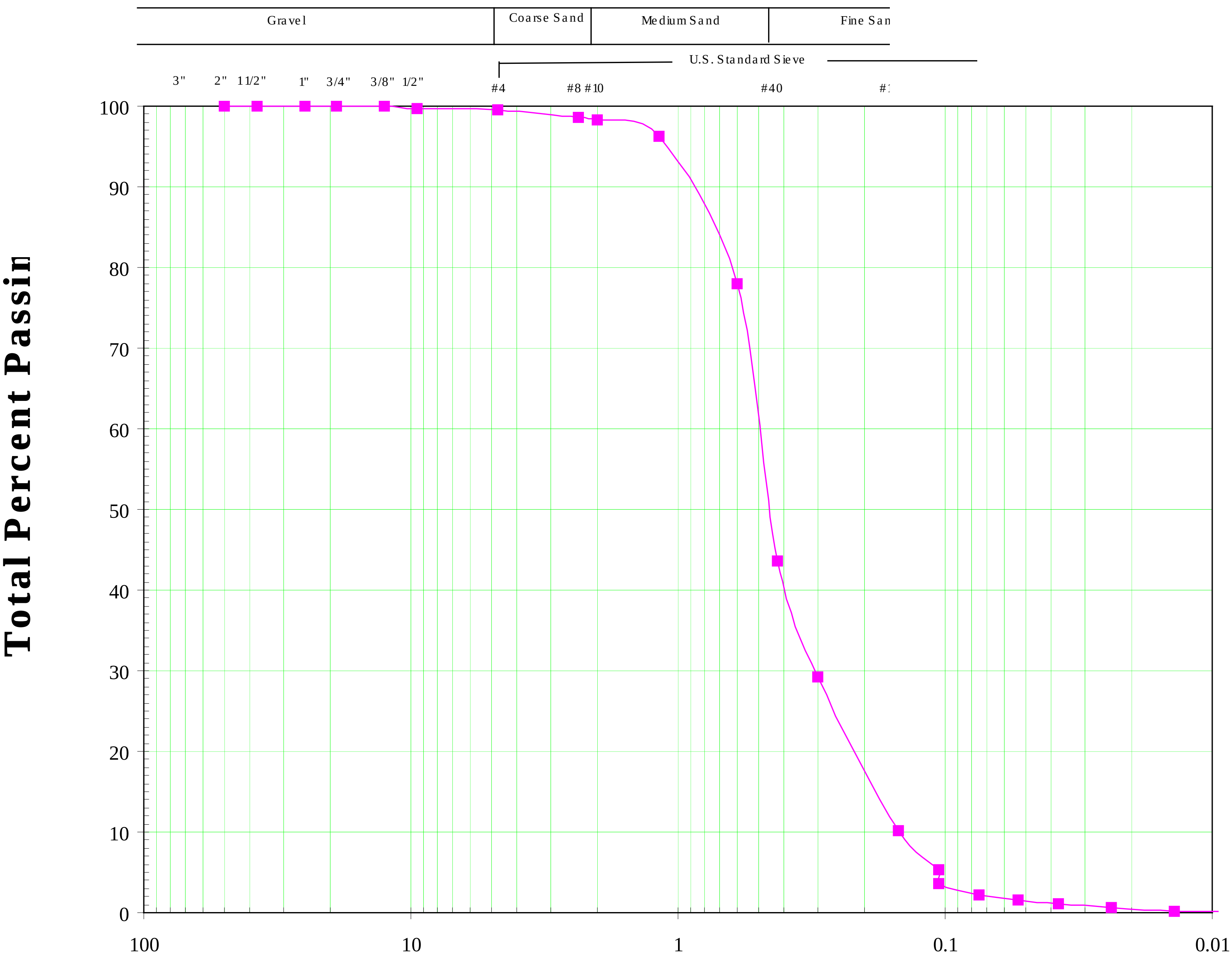
A5 at 16.2 to 17.2’



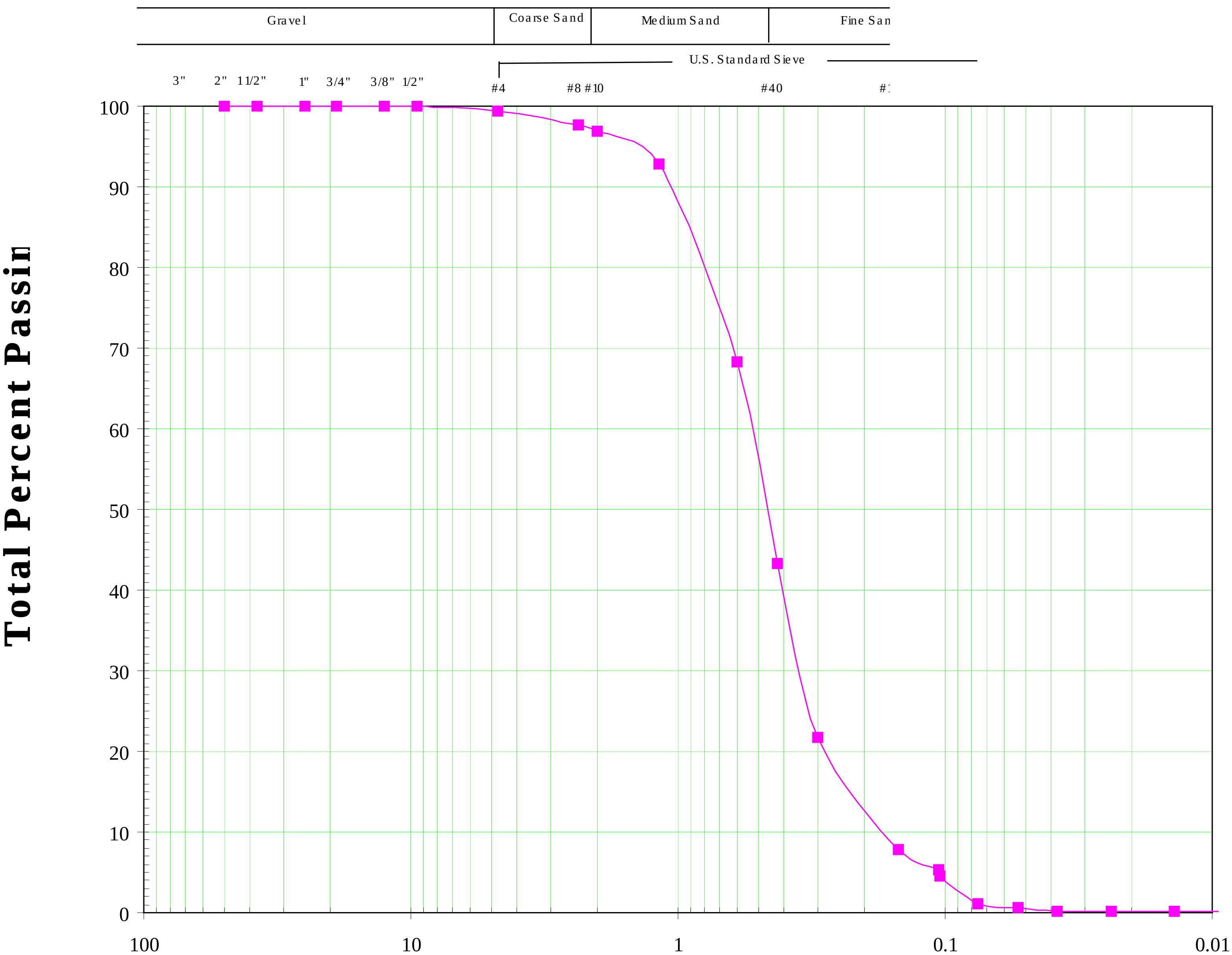
A5 at 17.2 to 18.2’


Gravel
Coarse Sand
Medium Sand
Fine San
U.S. Standard Sieve
3"
2"
1 1/2"
1"
3/4"
3/8"
1/2"
#4
#8
#10
#40
Total Percent Passin
100
90
80
70
60
50
40
30
20
10
0
100
10
1
0.1
0.01

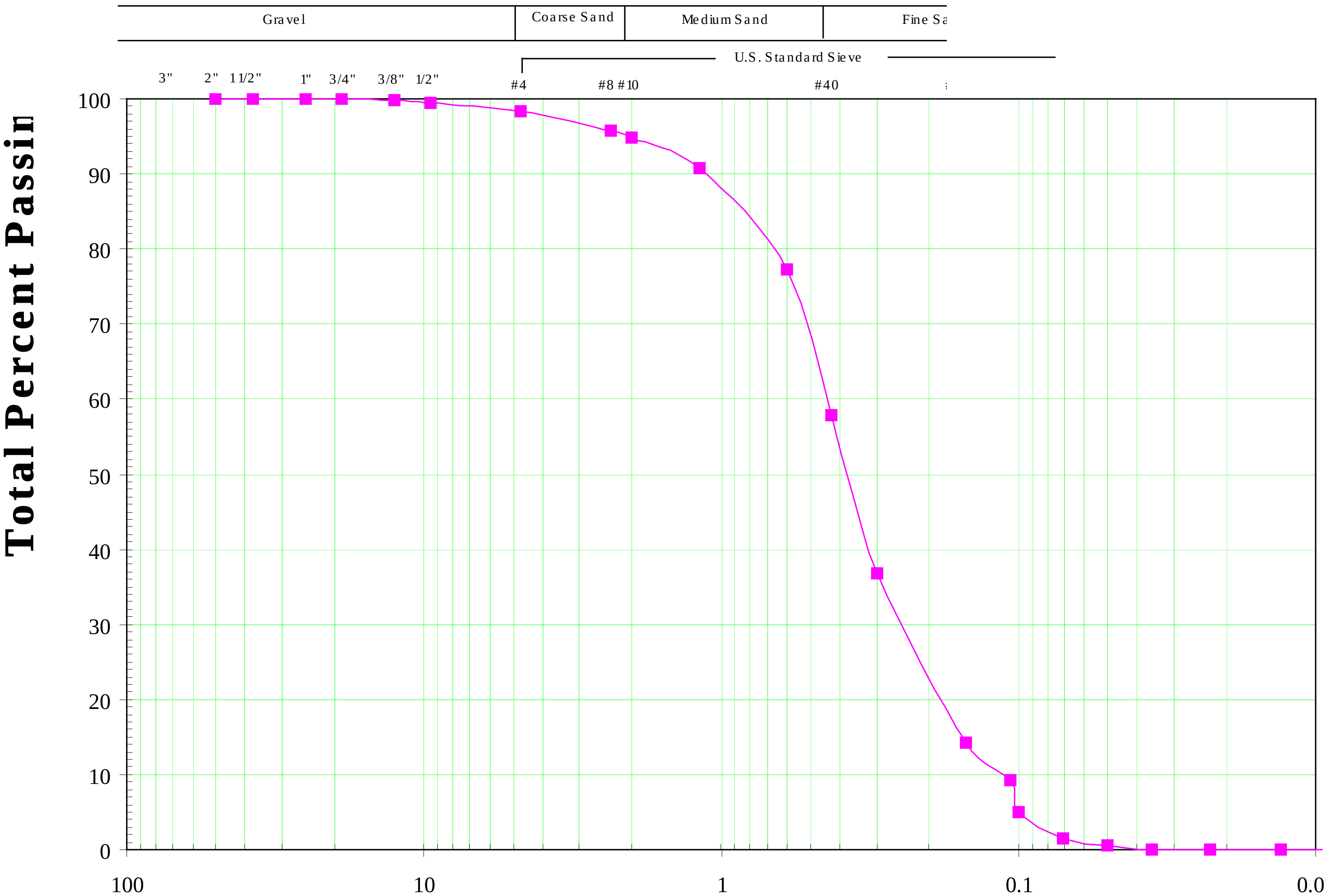
B7 at 8.3 to 9.3’



B7 at 10.5 to 11.5’



B7 at 13.5 to 14.5'



B7 at 16.0 to 17.0’

APPENDIX D

Filter Pack Design Worksheet

FILTER PACK SPECIFICATIONS - WELL COMPARISON STUDY										
						Recom. *	**Recom. ***	**Recom. ***	**2' screen**	**5' screen**
Sample	**Perm. (cm/s)**	**D-30 (mm)**	**D-30 x 4**	**D-30 x 6**	**D-30 x 10**	**Sand Pack Mesh**	**Slot Number**	**Opening (mm/in)**	**depth range**	**depth range**
A5, 10.3-11.3	0.00099	0.18	0.72	1.08	1.8	20 to 40	10	0.25/.010	9.5 to 11.5'	7 to 12'
A5, 17.2-18.2	0.0644	0.41	1.64	2.46	4.1	10 to 20	30	0.75/.030	17 to 19'	14 to 19'
B7, 10.5-11.5	0.00595	0.31	1.24	1.86	3.1	10 to 20	20	0.50/.020	10 to 12'	7 to 12'
B7, 16-17	0.00191	0.24	0.96	1.44	2.4	10 to 20	20	0.50/.020	16 to 18'	12.5 to 17.5'
These first four entries are the selected screen zones for the well comparison study.										
The four entries below are the extra samples analyzed in the permeability comparison.										
A5, 8.3-9.3	0.000626	0.195	0.78	1.17	1.95	20 to 40	10	0.25/.010		
A5, 16.2-17.2	0.0462	0.38	1.52	2.28	3.8	10 to 20	30	0.75/.030		
B7, 8.3-9.3	0.00093	0.18	0.72	1.08	1.8	10 to 20	20	0.50/.020		
B7, 13.5-14.5	0.00343	0.35	1.4	2.1	3.5	10 to 20	30	0.75/.030		
Notes:	1) Multiplied D-30 by 4, 6 and 10 to determine the control point for the filter pack grain size distribution.									
	2) * Since the material has relatively uniform gradation and contains some fine sand particles,									
	a factor between 4 and 6 for the finer of the two samples is used to determine the filter pack design.									
	3) PVC screen materials will be used for all wells.									
Generated by Mark Kram on 01/31/00										

WELL RECOMMENDATIONS

Cell	ID	Descriptor	Screen Length (ft)	Diameter (in)	Depth Range (ft)	Sand Pack Mesh	Slot Number	Completed
B	1d	shallow drilled, cluster 1	2	2	10 to 12	10 to 20	20	2/9/00
	1p	shallow pushed, cluster 1	2	2	10 to 12	10 to 20	20	2/10/00
	1p1	shallow pushed, cluster 1	2	0.75 in	10 to 12	10 to 20	20	2/10/00
	1pcv	shallow pushed, cluster 1	2	0.75 in	10 to 12	20 to 40	10	2/11/00
	1pnp	shallow pushed, cluster 1	2	0.75 in	10 to 12	no pack	10	2/12/00
B	2d	shallow drilled, cluster 2	5	2	7 to 12	10 to 20	20	2/9/00
	2p	shallow pushed, cluster 2	5	2	7 to 12	10 to 20	20	2/10/00
	2p1	shallow pushed, cluster 2	5	0.75 in	7 to 12	10 to 20	20	2/11/00
	2pcv	shallow pushed, cluster 2	5	0.75 in	7 to 12	20 to 40	10	2/11/00
	2pnp	shallow pushed, cluster 2	5	0.75 in	7 to 12	no pack	10	2/12/00
B	3d	deep drilled, cluster 3	2	2	16 to 18	10 to 20	20	2/9/00
	3p	deep pushed, cluster 3	2	2	16 to 18	10 to 20	20	2/12/00
	3p1	deep pushed, cluster 3	2	0.75 in	16 to 18	10 to 20	20	2/12/00
	3pcv	shallow pushed, cluster 3	2	0.75 in	16 to 18	20 to 40	10	2/11/00
	3pnp	shallow pushed, cluster 3	2	0.75 in	16 to 18	no pack	10	2/12/00
B	4d	deep drilled, cluster 4	5	2	12.5 to 17.5	10 to 20	20	2/9/00
	4p	deep pushed, cluster 4	5	2	12.5 to 17.5	10 to 20	20	2/11/00
	4p1	deep pushed, cluster 4	5	0.75 in	12.5 to 17.5	10 to 20	20	2/11/00
	4pcv	shallow pushed, cluster 4	5	0.75 in	12.5 to 17.5	20 to 40	10	2/11/00
	4pnp	shallow pushed, cluster 4	5	0.75 in	12.5 to 17.5	no pack	10	2/12/00

d - drilled
p - pushed 2" well
p1 - pushed 1" well
pcv - conventional slot & filter
pnp - no filter pack

APPENDIX E

Well Construction Logs

PRECISION

WELL CONSTRUCTION DETAILS

BORING DESIGNATION: A-1-D

INSTALLATION
DATE: Feb. 8, 2000 BY: THF Drilling/ Precision Sampling

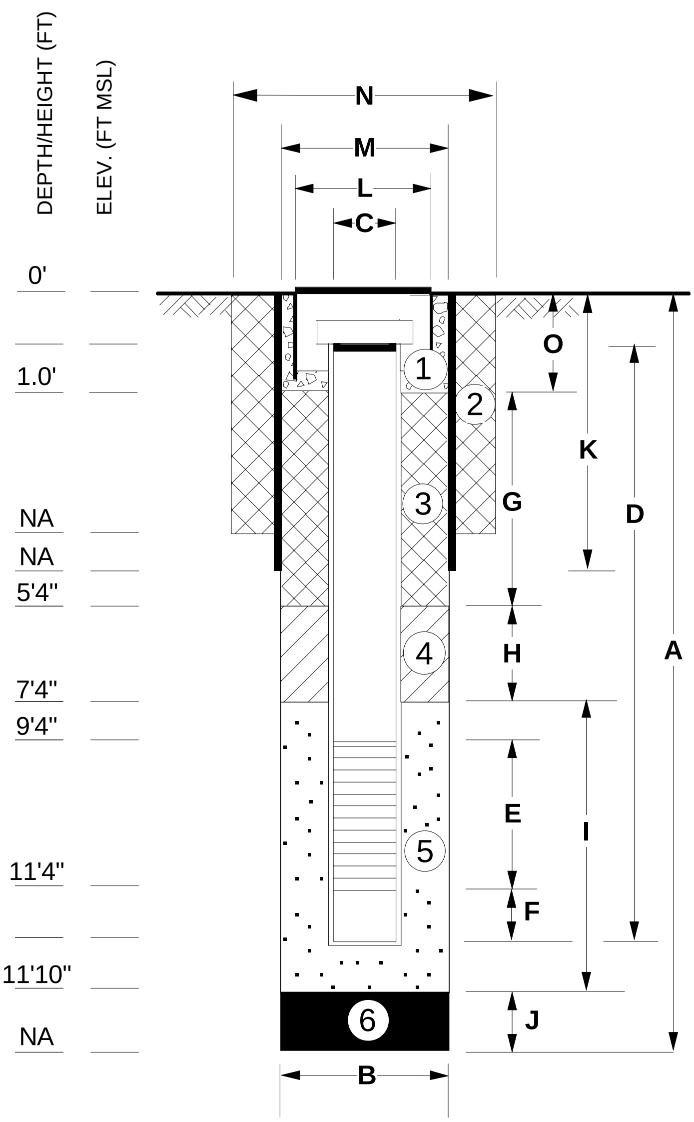
WELL DESIGNATION
A-1-D

DIMENSIONS

A	Total Depth of Boring (ft.)	11'10"
B	Borehole Diameter (in.)	8.0"
C	Well Casing Diameter (in.)	2.0"
D	Well Casing Length (ft.)	9' 4"
E	Well Casing Slotted Interval (ft.)	2.0'
F	Well Casing End Cap or Sump (ft.)	6.0"
G	Annular Seal Interval (ft.)	5'4"
H	Annular Seal Interval (ft.)	2.0'
I	Sand Pack Interval (ft.)	4'6"
J	Bottom Material Interval (ft.)	NA
K	Conductor Casing Interval (ft.)	NA
L	Protective Cover Diameter (in.)	7.0"
M	Conductor Casing Diameter (in.)	NA
N	Upper Borehole Diameter (in.)	NA
O	Monument Footing Interval (ft.)	1.0'
	Well Centralizer Depth(s) (ft.)	NA

MATERIALS DATA

Monument Footing	1	Rapid set concrete 3/8" rock
Annular Seal	2	NA
Annular Seal	3	Enviroplug medium
Annular Seal	4	Enviroplug medium
Sand Pack	5	#1/20 RMC Lonestar
Bottom Material	6	Native
Conductor Casing		---
Slotted Casing		Sch. 40 PVC
Well Casing		Sch. 40 PVC
Well Centralizers		---
Protective Cover		Morrison Dubuque 418xA



SECTION VIEW (not to scale)

CLIENT ACKNOWLEDGEMENT

NOTES:

#1/20 RMC Lonestar sand is equal to ASTM 20 to 40. Boring advanced an additional 6.0" to accommodate sump, so that the well is set exactly at 11'4" bgs (below ground surface).

m:\tmpl\welldetails\ccflush-psi.dsf 2/29/00

PRECISION

WELL CONSTRUCTION DETAILS

BORING DESIGNATION: A -1-p

INSTALLATION
DATE: Feb. 14, 2000 BY: Mark Kram

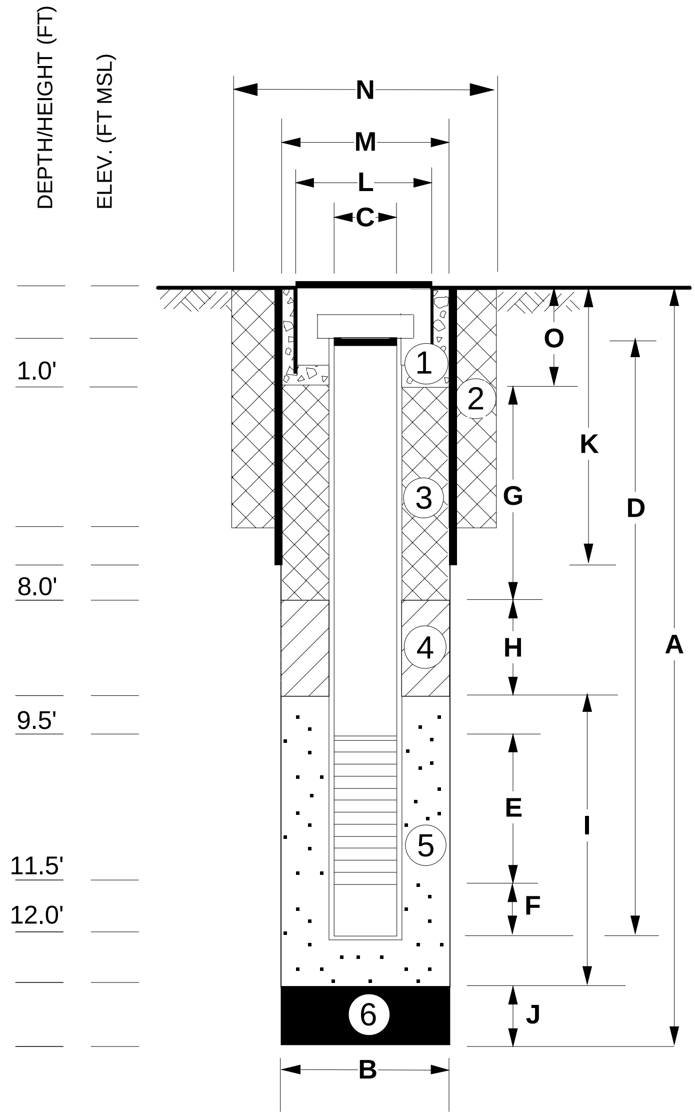
WELL DESIGNATION
A-1-p

DIMENSIONS

A	Total Depth of Boring (ft.)	12.0'
B	Borehole Diameter (in.)	3.50"
C	Well Casing Diameter (in.)	2.0"
D	Well Casing Length (ft.)	9.5'
E	Well Casing Slotted Interval (ft.)	2.0'
F	Well Casing End Cap or Sump (ft.)	6.0"
G	Annular Seal Interval (ft.)	7.0'
H	Annular Seal Interval (ft.)	1.50'
I	Sand Pack Interval (ft.)	2.5'
J	Bottom Material Interval (ft.)	NA
K	Conductor Casing Interval (ft.)	NA
L	Protective Cover Diameter (in.)	7.0"
M	Conductor Casing Diameter (in.)	NA
N	Upper Borehole Diameter (in.)	10.0"
O	Monument Footing Interval (ft.)	1.0'
	Well Centralizer Depth(s) (ft.)	NA

MATERIALS DATA

Monument Footing	1	Rapid set concrete 3/8" rock
Annular Seal	2	NA
Annular Seal	3	Volclay Grout
Annular Seal	4	Enviroplug 1/4" pellets
Sand Pack	5	20 to 40 ASTM pre-pack
Bottom Material	6	Native
Conductor Casing		NA
Slotted Casing	2.0"	0.010" slotted screen
Well Casing	2.0"	Blank Sch. 40 PVC
Well Centralizers		NA
Protective Cover		Morrison Dubuque 418xA



SECTION VIEW (not to scale)

CLIENT ACKNOWLEDGEMENT

NOTES:

Sand pack consists of 20 to 40 ASTM sand. Boring advanced an additional 6.0" to accommodate sump, so that the well is set exactly at 11.5' bgs (below ground surface).

WELL CONSTRUCTION DETAILS

PRECISION

BORING DESIGNATION: A -1-p-1

INSTALLATION
DATE: Feb. 14, 2000 BY: Mark Kram

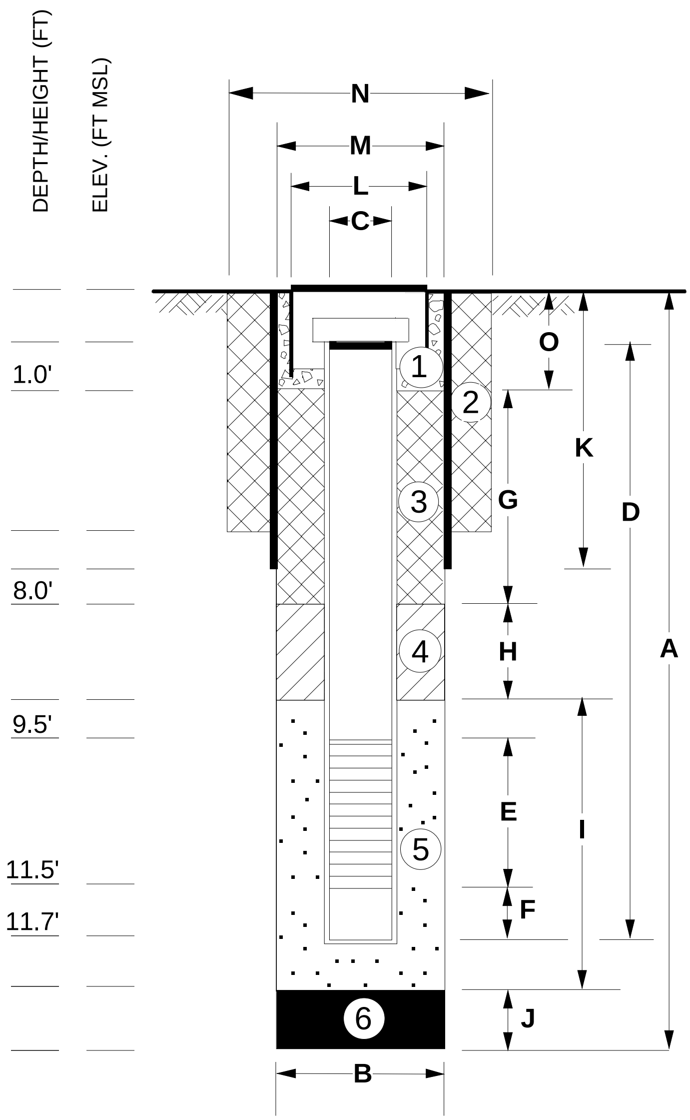
WELL DESIGNATION
A-1-p-1

DIMENSIONS

A	Total Depth of Boring (ft.)	11.7'
B	Borehole Diameter (in.)	2.5"
C	Well Casing Diameter (in.)	0.75"
D	Well Casing Length (ft.)	9.5'
E	Well Casing Slotted Interval (ft.)	2.0'
F	Well Casing End Cap or Sump (ft.)	0.2"
G	Annular Seal Interval (ft.)	7.0'
H	Annular Seal Interval (ft.)	1.5'
I	Sand Pack Interval (ft.)	2.2'
J	Bottom Material Interval (ft.)	NA
K	Conductor Casing Interval (ft.)	NA
L	Protective Cover Diameter (in.)	7.0"
M	Conductor Casing Diameter (in.)	NA
N	Upper Borehole Diameter (in.)	10.0"
O	Monument Footing Interval (ft.)	1.0'
	Well Centralizer Depth(s) (ft.)	NA

MATERIALS DATA

Monument Footing	1	Rapid set concrete 3/8" rock
Annular Seal	2	NA
Annular Seal	3	Volclay Grout
Annular Seal	4	Enviroplug 1/4" pellets
Sand Pack	5	20 to 40 ASTM pre-pack
Bottom Material	6	Native
Conductor Casing		NA
Slotted Casing	2.0"	0.010" slotted screen
Well Casing		Blank Sch. 40 PVC
Well Centralizers		NA
Protective Cover		Morrison Dubuque 418xA



SECTION VIEW (not to scale)

CLIENT ACKNOWLEDGEMENT

NOTES:

Sand pack consists of 20 to 40 ASTM sand. Rubber washers are set at top of filter pack and screen.

PRECISION

WELL CONSTRUCTION DETAILS

BORING DESIGNATION: A-2-D

INSTALLATION
DATE: Feb. 8, 2000 BY: THF Drilling

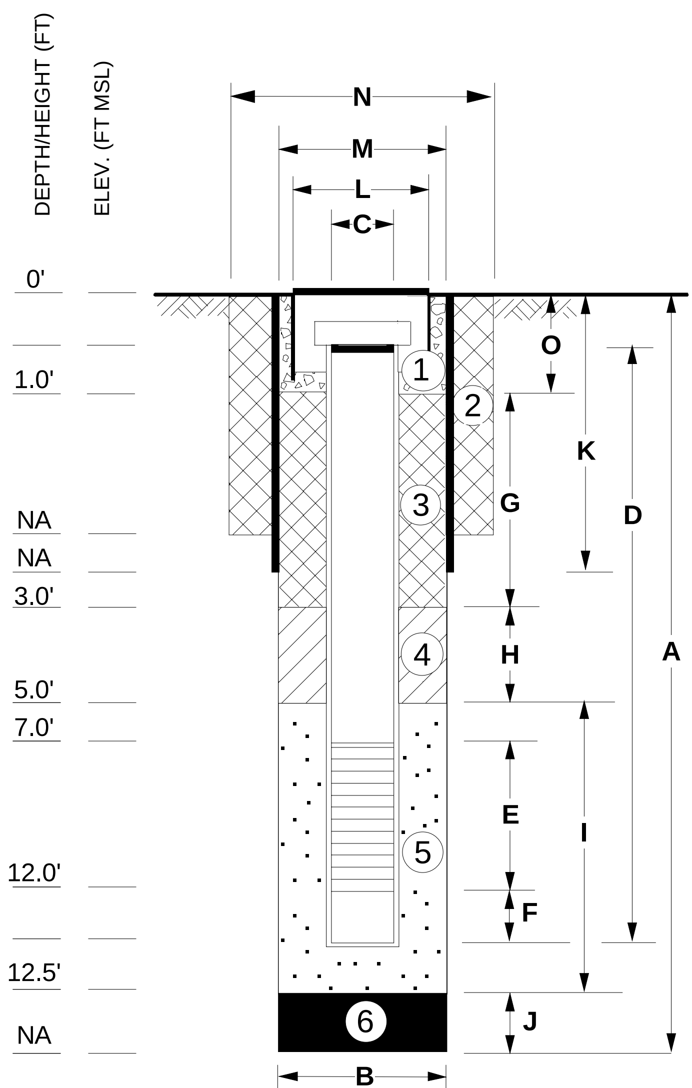
WELL DESIGNATION
A-2-D

DIMENSIONS

A	Total Depth of Boring (ft.)	12.5'
B	Borehole Diameter (in.)	8.0"
C	Well Casing Diameter (in.)	2.0"
D	Well Casing Length (ft.)	7.5'
E	Well Casing Slotted Interval (ft.)	5.0'
F	Well Casing End Cap or Sump (ft.)	6.0"
G	Annular Seal Interval (ft.)	3.0'
H	Annular Seal Interval (ft.)	2.0'
I	Sand Pack Interval (ft.)	7.5'
J	Bottom Material Interval (ft.)	NA
K	Conductor Casing Interval (ft.)	NA
L	Protective Cover Diameter (in.)	7.0"
M	Conductor Casing Diameter (in.)	NA
N	Upper Borehole Diameter (in.)	NA
O	Monument Footing Interval (ft.)	1.0'
	Well Centralizer Depth(s) (ft.)	NA

MATERIALS DATA

Monument Footing	1	Rapid set concrete 3/8" rock
Annular Seal	2	NA
Annular Seal	3	Enviroplug medium
Annular Seal	4	Enviroplug medium
Sand Pack	5	#1/20 RMC Lonestar
Bottom Material	6	Native
Conductor Casing		NA
Slotted Casing		Sch. 40 PVC, 2.0"
Well Casing		Sch. 40 PVC, 2.0"
Well Centralizers		NA
Protective Cover		Morrison Dubuque 418xA



SECTION VIEW (not to scale)

CLIENT ACKNOWLEDGEMENT

NOTES:

#1/20 RMC Lonestar sand is equal to ASTM 20 to 40. Boring advanced an additional 6.0" to accommodate sump, so that the well is set exactly at 12.0' bgs (below ground surface).

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WELL CONSTRUCTION DETAILS

PRECISION

BORING DESIGNATION: A-2-p

INSTALLATION

DATE: Feb. 14, 2000 BY: Mark Kram

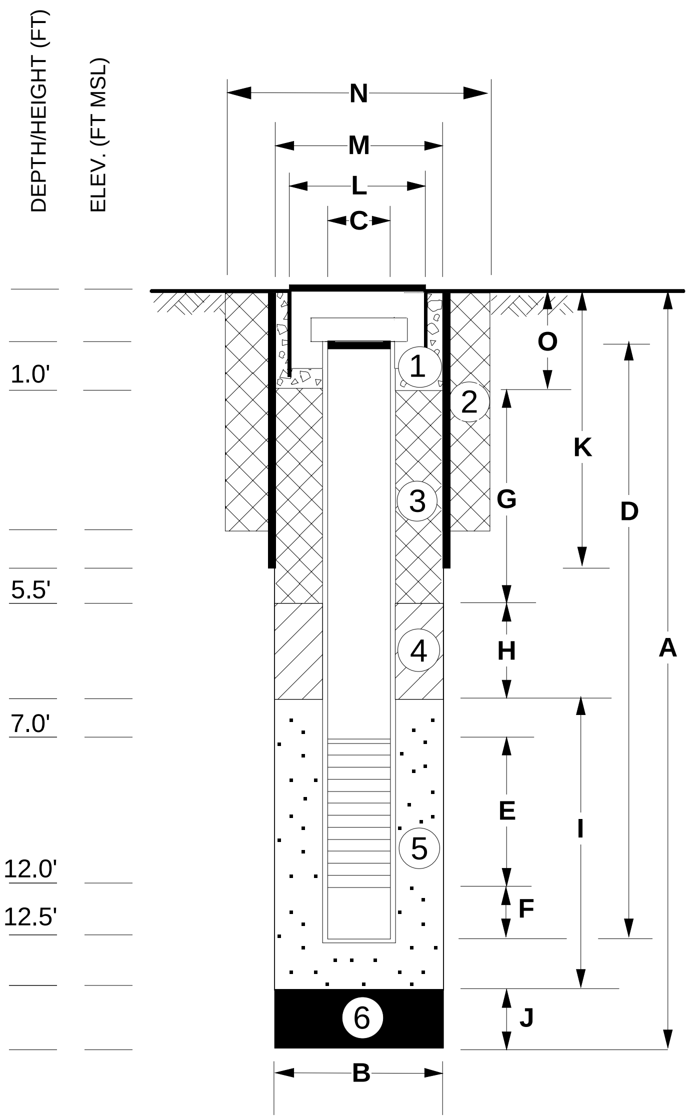
DIMENSIONS

A	Total Depth of Boring (ft.)	12.5'
B	Borehole Diameter (in.)	3.50"
C	Well Casing Diameter (in.)	2.00"
D	Well Casing Length (ft.)	7.00'
E	Well Casing Slotted Interval (ft.)	5.00'
F	Well Casing End Cap or Sump (ft.)	6.0"
G	Annular Seal Interval (ft.)	4.5'
H	Annular Seal Interval (ft.)	1.50'
I	Sand Pack Interval (ft.)	5.50'
J	Bottom Material Interval (ft.)	NA
K	Conductor Casing Interval (ft.)	NA
L	Protective Cover Diameter (in.)	7.0"
M	Conductor Casing Diameter (in.)	NA
N	Upper Borehole Diameter (in.)	10.0"
O	Monument Footing Interval (ft.)	1.0'
	Well Centralizer Depth(s) (ft.)	NA

MATERIALS DATA

Monument Footing	1	Rapid set concrete 3/8" rock
Annular Seal	2	NA
Annular Seal	3	Volclay Grout
Annular Seal	4	Enviroplug 1/4" pellets
Sand Pack	5	20 to 40 ASTM pre-pack
Bottom Material	6	Native
Conductor Casing		NA
Slotted Casing	2.0"	0.010" slotted screen
Well Casing	2.0"	Blank Sch. 40 PVC
Well Centralizers		NA
Protective Cover		Morrison Dubuque 418xA

WELL DESIGNATION
A-2-p



SECTION VIEW (not to scale)

CLIENT ACKNOWLEDGEMENT

NOTES:

Sand pack consists of 20 to 40 ASTM sand. Boring advanced an additional 6.0" to accommodate sump, so that the well is set exactly at 12.0' bgs (below ground surface).

PRECISION

WELL CONSTRUCTION DETAILS

BORING DESIGNATION: A-2-p-1

INSTALLATION
DATE: Feb. 12, 2000 BY: Mark Kram

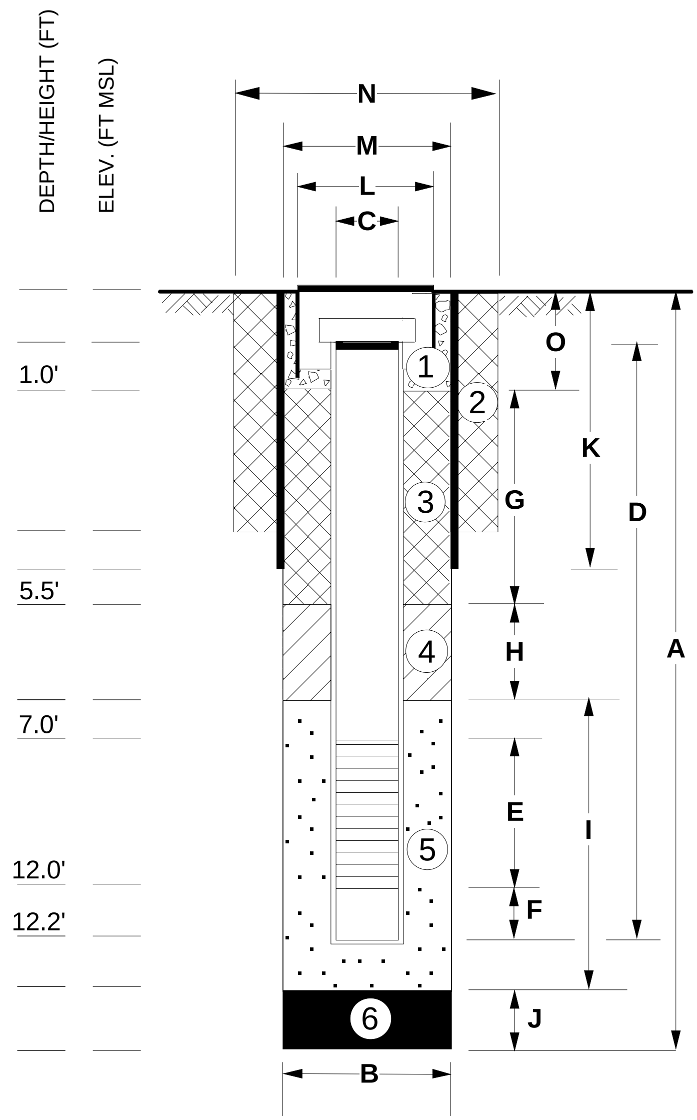
DIMENSIONS

A	Total Depth of Boring (ft.)	12.2'
B	Borehole Diameter (in.)	2.50"
C	Well Casing Diameter (in.)	0.75"'
D	Well Casing Length (ft.)	7.0'
E	Well Casing Slotted Interval (ft.)	5.0'
F	Well Casing End Cap or Sump (ft.)	0.2"
G	Annular Seal Interval (ft.)	4.5'
H	Annular Seal Interval (ft.)	1.5'
I	Sand Pack Interval (ft.)	5.2'
J	Bottom Material Interval (ft.)	NA
K	Conductor Casing Interval (ft.)	NA
L	Protective Cover Diameter (in.)	7.0"
M	Conductor Casing Diameter (in.)	NA
N	Upper Borehole Diameter (in.)	10.0"
O	Monument Footing Interval (ft.)	1.0'
	Well Centralizer Depth(s) (ft.)	NA

MATERIALS DATA

Monument Footing	1	Rapid set concrete 3/8" rock
Annular Seal	2	NA
Annular Seal	3	Volclay Grout
Annular Seal	4	Enviroplug 1/4" pellets
Sand Pack	5	20 to 40 ASTM pre-pack
Bottom Material	6	Native
Conductor Casing		NA
Slotted Casing	2.0"	0.010" slotted screen
Well Casing	2.0"	Blank Sch. 40 PVC
Well Centralizers		NA
Protective Cover		Morrison Dubuque 418xA

WELL DESIGNATION
A-2-p-1



SECTION VIEW (not to scale)

CLIENT ACKNOWLEDGEMENT

NOTES:

Sand pack consists of 20 to 40 ASTM sand. Rubber washers are set above filter pack and screen.

PRECISION

WELL CONSTRUCTION DETAILS

BORING DESIGNATION: A-3-D

INSTALLATION
DATE: Feb. 8, 2000 BY: THF Drilling

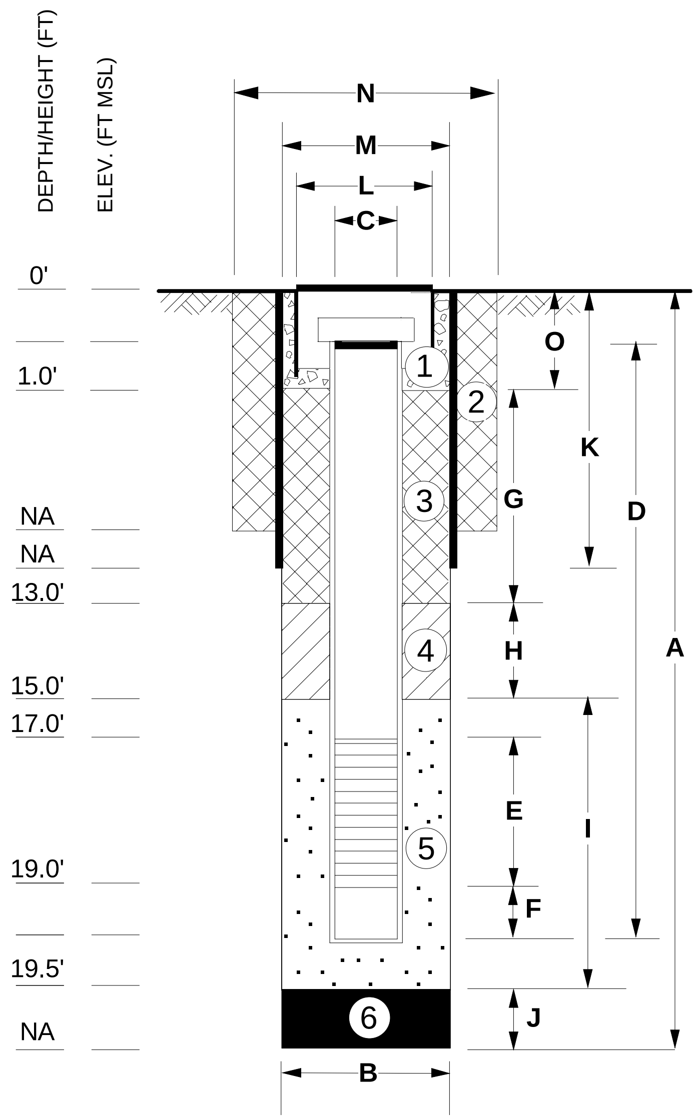
WELL DESIGNATION
A-3-D

DIMENSIONS

A	Total Depth of Boring (ft.)	19.5'
B	Borehole Diameter (in.)	8.0"
C	Well Casing Diameter (in.)	2.0"
D	Well Casing Length (ft.)	17.0'
E	Well Casing Slotted Interval (ft.)	2.0'
F	Well Casing End Cap or Sump (ft.)	6.0"
G	Annular Seal Interval (ft.)	12.0'
H	Annular Seal Interval (ft.)	2.0'
I	Sand Pack Interval (ft.)	4.5'
J	Bottom Material Interval (ft.)	NA
K	Conductor Casing Interval (ft.)	NA
L	Protective Cover Diameter (in.)	7.0"
M	Conductor Casing Diameter (in.)	NA
N	Upper Borehole Diameter (in.)	NA
O	Monument Footing Interval (ft.)	1.0'
	Well Centralizer Depth(s) (ft.)	NA

MATERIALS DATA

Monument Footing	1	Rapid set concrete 3/8" rock
Annular Seal	2	NA
Annular Seal	3	Wyo-Ben Groutwell
Annular Seal	4	Enviroplug medium
Sand Pack	5	#2/12 RMC Lonestar
Bottom Material	6	Native
Conductor Casing		NA
Slotted Casing		Sch. 40 PVC, 0.030"
Well Casing		Sch. 40 PVC threaded
Well Centralizers		NA
Protective Cover		Morrison Dubuque 418xA



SECTION VIEW (not to scale)

CLIENT ACKNOWLEDGEMENT

NOTES:

#2/12 RMC Lonestar sand is equal to ASTM 10 to 20. Boring advanced an additional 6.0" to accommodate sump, so that the well is set exactly at 19.0' bgs (below ground surface).

PRECISION

WELL CONSTRUCTION DETAILS

BORING DESIGNATION: A-3-p

INSTALLATION
DATE: Feb. 14, 2000 BY: Mark Kram

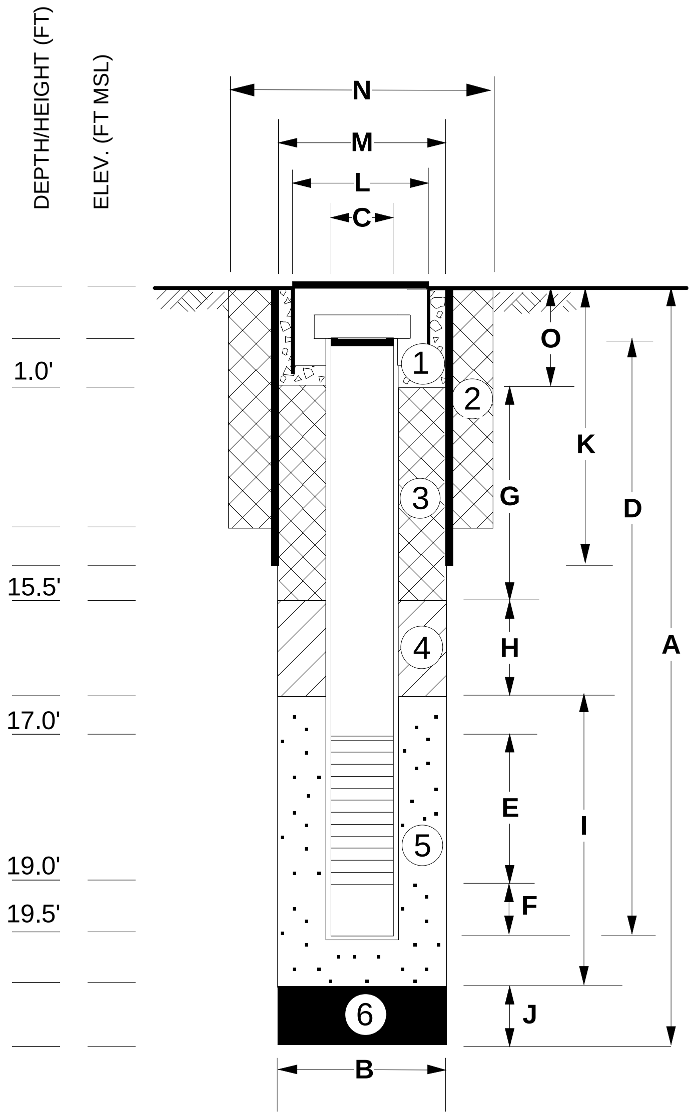
WELL DESIGNATION
A-3-p

DIMENSIONS

A	Total Depth of Boring (ft.)	19.5'
B	Borehole Diameter (in.)	3.50"
C	Well Casing Diameter (in.)	2.0"
D	Well Casing Length (ft.)	17.0'
E	Well Casing Slotted Interval (ft.)	2.0'
F	Well Casing End Cap or Sump (ft.)	6.0"
G	Annular Seal Interval (ft.)	14.5'
H	Annular Seal Interval (ft.)	1.50'
I	Sand Pack Interval (ft.)	2.50'
J	Bottom Material Interval (ft.)	NA
K	Conductor Casing Interval (ft.)	NA
L	Protective Cover Diameter (in.)	7.0"
M	Conductor Casing Diameter (in.)	NA
N	Upper Borehole Diameter (in.)	10.0"
O	Monument Footing Interval (ft.)	1.0'
	Well Centralizer Depth(s) (ft.)	NA

MATERIALS DATA

Monument Footing	1	Rapid set concrete 3/8" rock
Annular Seal	2	NA
Annular Seal	3	Volclay grout
Annular Seal	4	Enviroplug 1/4" pellets
Sand Pack	5	10 to 20 ASTM pre-pack
Bottom Material	6	Native
Conductor Casing		NA
Slotted Casing	2.0"	0.030" slotted screen
Well Casing	2.0"	Blank Sch. 40 PVC
Well Centralizers		NA
Protective Cover		Morrison Dubuque 418xA



SECTION VIEW (not to scale)

CLIENT ACKNOWLEDGEMENT

NOTES:

Sand pack consists of 10 to 20 ASTM sand. Boring advanced an additional 6.0" to accommodate sump, so that the well is set exactly at 19.0' bgs (below ground surface).

WELL CONSTRUCTION DETAILS

PRECISION

BORING DESIGNATION: A-3-p-1

INSTALLATION
DATE: Feb. 14, 2000 BY: Mark Kram

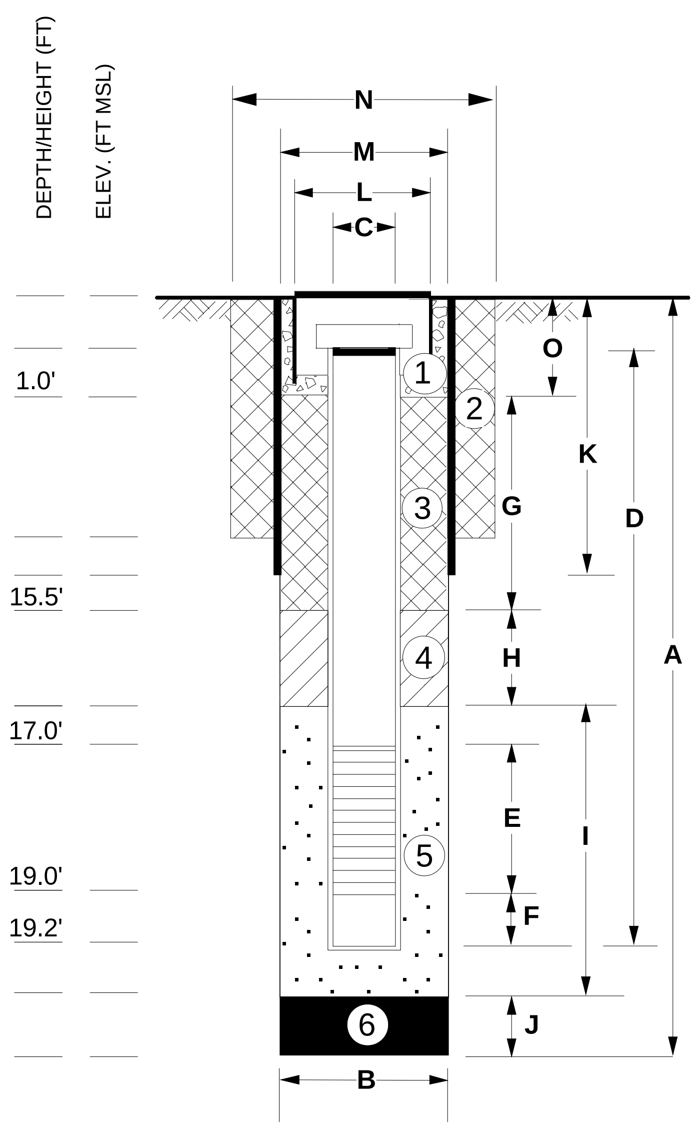
DIMENSIONS

A	Total Depth of Boring (ft.)	19.2'
B	Borehole Diameter (in.)	2.5"
C	Well Casing Diameter (in.)	0.75"
D	Well Casing Length (ft.)	17.0'
E	Well Casing Slotted Interval (ft.)	2.0'
F	Well Casing End Cap or Sump (ft.)	0.2"
G	Annular Seal Interval (ft.)	14.5'
H	Annular Seal Interval (ft.)	1.5'
I	Sand Pack Interval (ft.)	2.2'
J	Bottom Material Interval (ft.)	NA
K	Conductor Casing Interval (ft.)	NA
L	Protective Cover Diameter (in.)	7.0"
M	Conductor Casing Diameter (in.)	NA
N	Upper Borehole Diameter (in.)	10.0"
O	Monument Footing Interval (ft.)	1.0'
	Well Centralizer Depth(s) (ft.)	NA

MATERIALS DATA

Monument Footing	1	Rapid set concrete 3/8" rock
Annular Seal	2	NA
Annular Seal	3	Volclay Grout
Annular Seal	4	Enviroplug 1/4" pellets
Sand Pack	5	10 to 20 ASTM pre-pack
Bottom Material	6	Native
Conductor Casing		NA
Slotted Casing	3/4"	0.030" slotted screen
Well Casing	3/4"	Blank Sch. 40 PVC
Well Centralizers		NA
Protective Cover		Morrison Dubuque 418xA

WELL DESIGNATION
A-3-p-1



SECTION VIEW (not to scale)

CLIENT ACKNOWLEDGEMENT

NOTES:

Sand pack consists of 10 to 20 ASTM sand. Rubber washers are set above filter pack and screen.

PRECISION

WELL CONSTRUCTION DETAILS

BORING DESIGNATION: A-4-D

INSTALLATION DATE: Feb. 9, 2000 BY: THF Drilling/ Precision Sampling

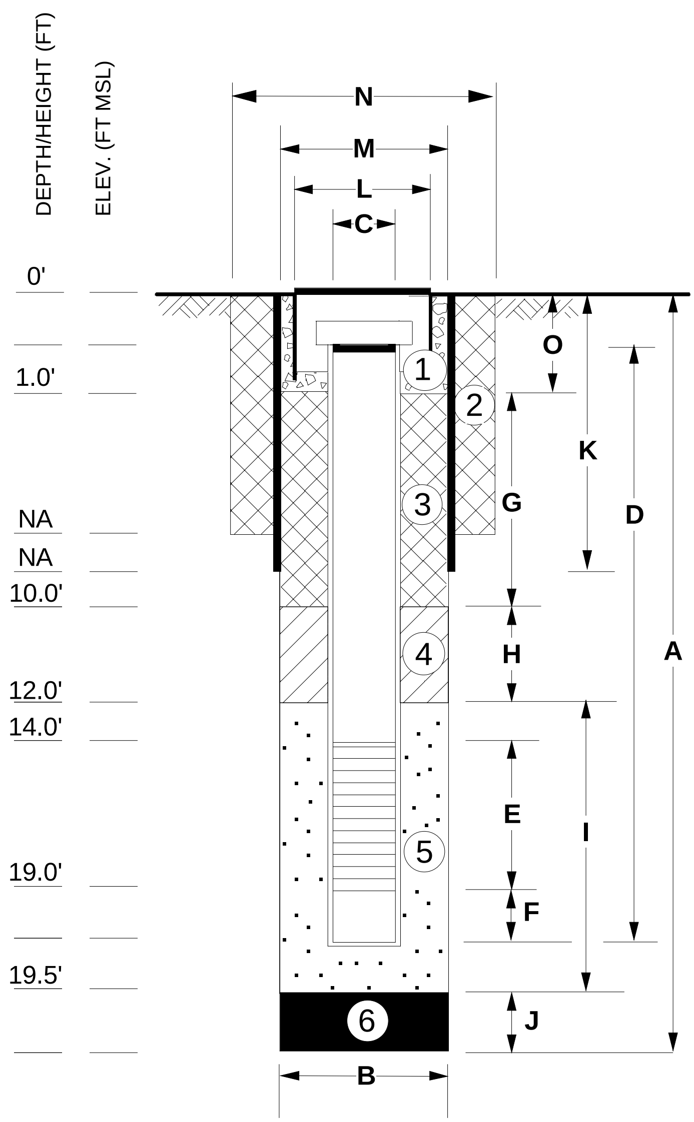
DIMENSIONS

A	Total Depth of Boring (ft.)	19.5'
B	Borehole Diameter (in.)	8.0"
C	Well Casing Diameter (in.)	2.0"
D	Well Casing Length (ft.)	15.0'
E	Well Casing Slotted Interval (ft.)	5.0'
F	Well Casing End Cap or Sump (ft.)	6.0"
G	Annular Seal Interval (ft.)	9.0'
H	Annular Seal Interval (ft.)	2.0'
I	Sand Pack Interval (ft.)	7.5'
J	Bottom Material Interval (ft.)	NA
K	Conductor Casing Interval (ft.)	NA
L	Protective Cover Diameter (in.)	10.0"
M	Conductor Casing Diameter (in.)	NA
N	Upper Borehole Diameter (in.)	NA
O	Monument Footing Interval (ft.)	1.0'
	Well Centralizer Depth(s) (ft.)	NA

MATERIALS DATA

Monument Footing	1	Rapid set concrete 3/8" rock
Annular Seal	2	NA
Annular Seal	3	Wyo-Ben Groutwell
Annular Seal	4	Enviroplug medium
Sand Pack	5	#2/12 RMC Lonestar
Bottom Material	6	Native
Conductor Casing		NA
Slotted Casing	2.0"	0.030" Sch. 40 PVC
Well Casing	2.0"	Sch. 40 PVC
Well Centralizers		NA
Protective Cover		Morrison Dubuque 418xA

WELL DESIGNATION
A-4-D



SECTION VIEW (not to scale)

CLIENT ACKNOWLEDGEMENT

NOTES:

#2/12 RMC Lonestar sand is equal to ASTM 10 to 20. Boring advanced an additional 6.0" to accommodate sump, so that the well is set exactly at 19.0' bgs (below ground surface).

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PRECISION

WELL CONSTRUCTION DETAILS

BORING DESIGNATION: A-4-p

INSTALLATION DATE: Feb. 14, 2000 BY: Mark Kram

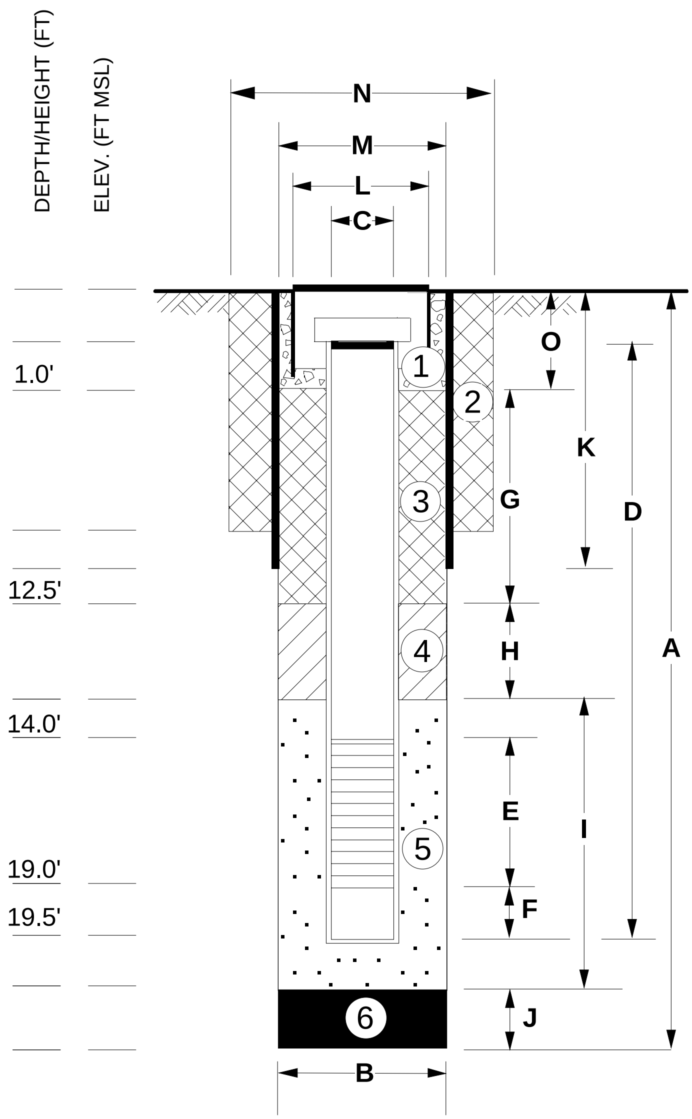
DIMENSIONS

A	Total Depth of Boring (ft.)	19.5'
B	Borehole Diameter (in.)	3.50"
C	Well Casing Diameter (in.)	2.0"
D	Well Casing Length (ft.)	14.0'
E	Well Casing Slotted Interval (ft.)	5.0'
F	Well Casing End Cap or Sump (ft.)	6.0"
G	Annular Seal Interval (ft.)	11.5'
H	Annular Seal Interval (ft.)	1.5'
I	Sand Pack Interval (ft.)	5.5'
J	Bottom Material Interval (ft.)	NA
K	Conductor Casing Interval (ft.)	NA
L	Protective Cover Diameter (in.)	7.0"
M	Conductor Casing Diameter (in.)	NA
N	Upper Borehole Diameter (in.)	10.0"
O	Monument Footing Interval (ft.)	1.0'
	Well Centralizer Depth(s) (ft.)	NA

MATERIALS DATA

Monument Footing	1	Rapid set concrete 3/8" rock
Annular Seal	2	NA
Annular Seal	3	Volclay grout
Annular Seal	4	Enviroplug 1/4" pellets
Sand Pack	5	10 to 20 ASTM pre-pack
Bottom Material	6	Native
Conductor Casing		NA
Slotted Casing	2.0"	0.030" slotted screen
Well Casing	2.0"	Blank Sch. 40 PVC
Well Centralizers		NA
Protective Cover		Morrison Dubuque 418xA

WELL DESIGNATION
A-4-p



SECTION VIEW (not to scale)

CLIENT ACKNOWLEDGEMENT

NOTES:

Sand pack consists of 10 to 20 ASTM sand. Boring advanced an additional 6.0" to accommodate sump, so that the well is set exactly at 19.0' bgs (below ground surface).

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PRECISION

WELL CONSTRUCTION DETAILS

BORING DESIGNATION: A-4-p-1

INSTALLATION

DATE: Feb. 14, 2000 BY: Mark Kram

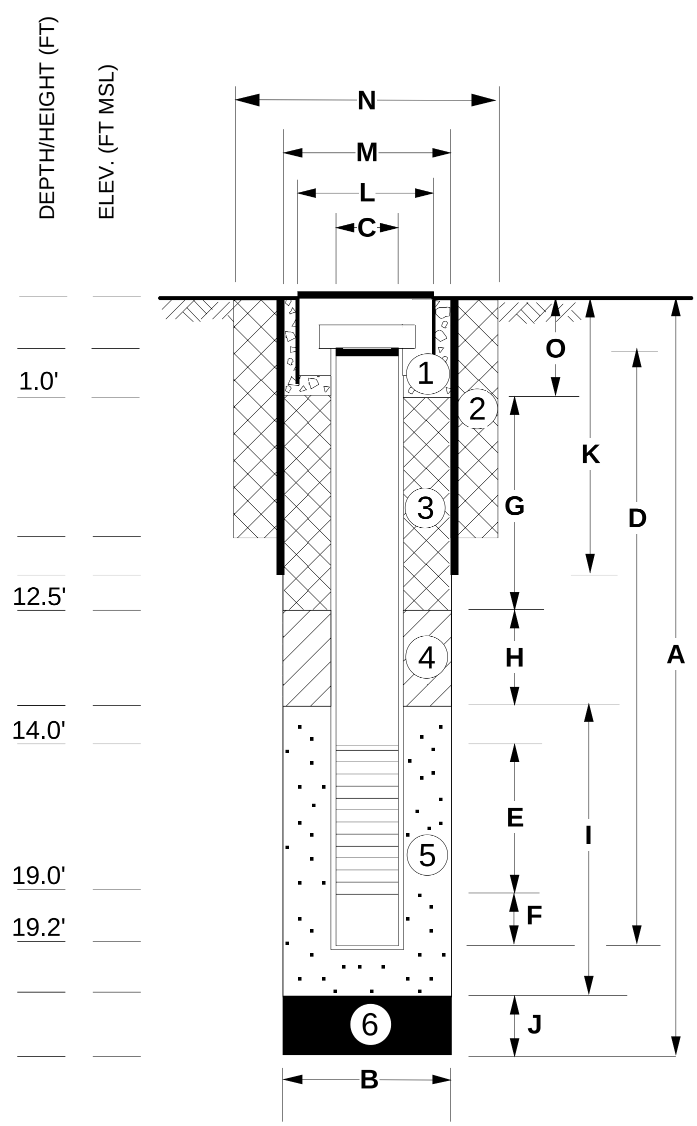
DIMENSIONS

A	Total Depth of Boring (ft.)	19.2'
B	Borehole Diameter (in.)	2.50"
C	Well Casing Diameter (in.)	3/4"
D	Well Casing Length (ft.)	14.0'
E	Well Casing Slotted Interval (ft.)	5.0'
F	Well Casing End Cap or Sump (ft.)	0.2"
G	Annular Seal Interval (ft.)	11.5'
H	Annular Seal Interval (ft.)	1.5'
I	Sand Pack Interval (ft.)	5.2'
J	Bottom Material Interval (ft.)	NA
K	Conductor Casing Interval (ft.)	NA
L	Protective Cover Diameter (in.)	7.0"
M	Conductor Casing Diameter (in.)	NA
N	Upper Borehole Diameter (in.)	10.0"
O	Monument Footing Interval (ft.)	1.0'
	Well Centralizer Depth(s) (ft.)	NA

MATERIALS DATA

Monument Footing	1	Rapid set concrete 3/8" rock
Annular Seal	2	NA
Annular Seal	3	Volclay grout
Annular Seal	4	Enviroplug 1/4" pellets
Sand Pack	5	10 to 20 ASTM pre-pack
Bottom Material	6	Native
Conductor Casing		NA
Slotted Casing	3/4"	0.030" slotted screen
Well Casing	3/4"	Blank Sch. 40 PVC
Well Centralizers		NA
Protective Cover		Morrison Dubuque 418xA

WELL DESIGNATION
A-4-p-1



SECTION VIEW (not to scale)

CLIENT ACKNOWLEDGEMENT

NOTES:

Sand pack consists of 10 to 20 ASTM sand. Rubber washers are set at top of filter pack and screen.

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WELL CONSTRUCTION DETAILS

PRECISION

BORING DESIGNATION: B-1-D

INSTALLATION
DATE: Feb. 9, 2000 BY: THF Drilling/ Precision Sampling

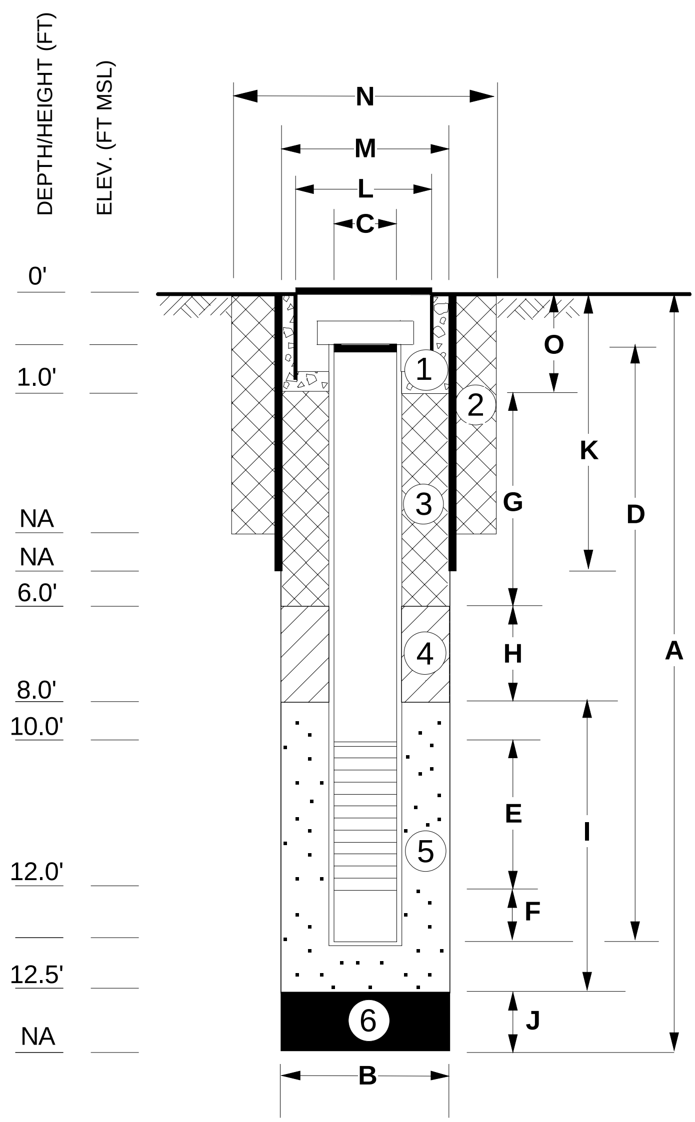
DIMENSIONS

A	Total Depth of Boring (ft.)	12.5'
B	Borehole Diameter (in.)	8.0"
C	Well Casing Diameter (in.)	2.0"
D	Well Casing Length (ft.)	10.0'
E	Well Casing Slotted Interval (ft.)	2.0'
F	Well Casing End Cap or Sump (ft.)	6.0"
G	Annular Seal Interval (ft.)	5.0'
H	Annular Seal Interval (ft.)	2.0'
I	Sand Pack Interval (ft.)	4.5'
J	Bottom Material Interval (ft.)	NA
K	Conductor Casing Interval (ft.)	NA
L	Protective Cover Diameter (in.)	7.0"
M	Conductor Casing Diameter (in.)	NA
N	Upper Borehole Diameter (in.)	10.0"
O	Monument Footing Interval (ft.)	1.0'
	Well Centralizer Depth(s) (ft.)	NA

MATERIALS DATA

Monument Footing	1	Rapid set concrete 3/8" rock
Annular Seal	2	NA
Annular Seal	3	Enviroplug medium
Annular Seal	4	Enviroplug medium
Sand Pack	5	#2/12 RMC Lonestar
Bottom Material	6	Native
Conductor Casing		NA
Slotted Casing	2.0"	0.020" Sch. 40 PVC
Well Casing	2.0"	Sch. 40 PVC
Well Centralizers		NA
Protective Cover		Morrison Dubuque 418xA

WELL DESIGNATION
B-1-D



SECTION VIEW (not to scale)

CLIENT ACKNOWLEDGEMENT

NOTES:

#2/12 RMC Lonestar sand is equal to ASTM 10 to 20. Boring advanced an additional 6.0" to accommodate sump, so that the well is set exactly at 12.0' bgs (below ground surface).

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WELL CONSTRUCTION DETAILS

PRECISION

BORING DESIGNATION: B-1-n-p

INSTALLATION
DATE: Feb. 12, 2000 BY: Mark Kram

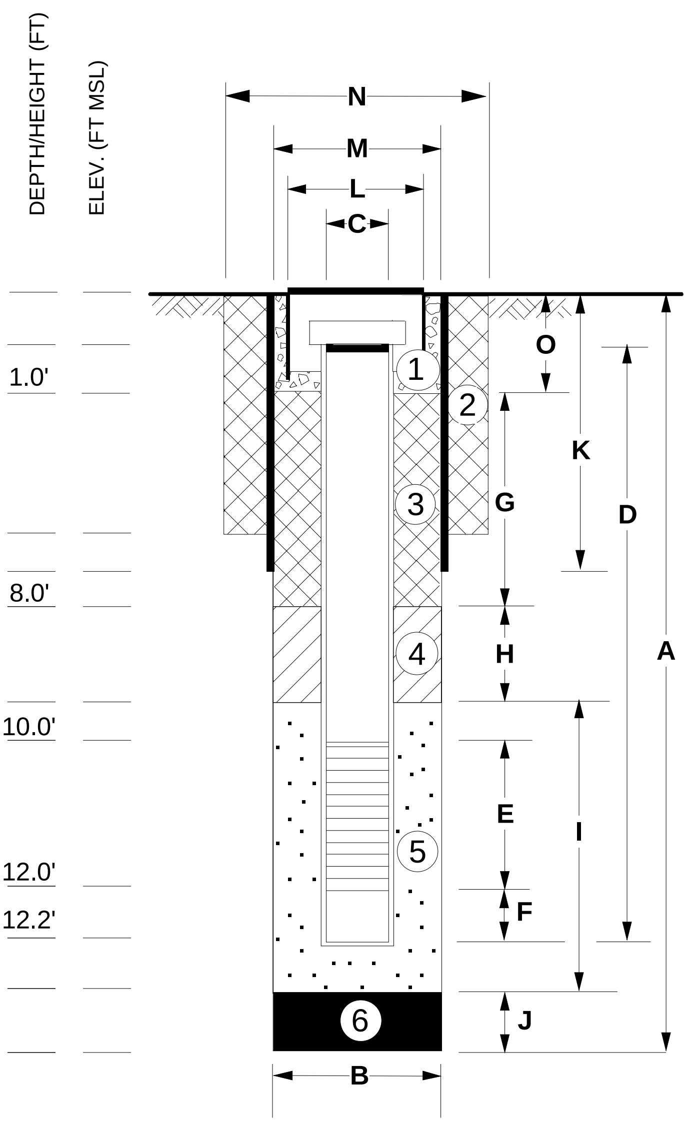
WELL DESIGNATION
B-1-n-p

DIMENSIONS

A	Total Depth of Boring (ft.)	12.2'
B	Borehole Diameter (in.)	2.50"
C	Well Casing Diameter (in.)	3/4"
D	Well Casing Length (ft.)	10.0'
E	Well Casing Slotted Interval (ft.)	2.0'
F	Well Casing End Cap or Sump (ft.)	0.2"
G	Annular Seal Interval (ft.)	7.0'
H	Annular Seal Interval (ft.)	2.0'
I	Sand Pack Interval (ft.)	2.0'
J	Bottom Material Interval (ft.)	NA
K	Conductor Casing Interval (ft.)	NA
L	Protective Cover Diameter (in.)	7.0"
M	Conductor Casing Diameter (in.)	NA
N	Upper Borehole Diameter (in.)	10.0"
O	Monument Footing Interval (ft.)	1.0'
	Well Centralizer Depth(s) (ft.)	NA

MATERIALS DATA

Monument Footing	1	Rapid set concrete 3/8" rock
Annular Seal	2	NA
Annular Seal	3	Volclay Grout
Annular Seal	4	Enviroplug 1/4" pellets
Sand Pack	5	Native formation
Bottom Material	6	Native
Conductor Casing		NA
Slotted Casing	3/4"	0.010" slotted screen
Well Casing	3/4"	Blank Sch. 40 PVC
Well Centralizers		NA
Protective Cover		Morrison Dubuque 418xA



SECTION VIEW (not to scale)

CLIENT ACKNOWLEDGEMENT

NOTES:

No sand pack: Native formation allowed to fall in around screen. Expandable annular seal and bentonite sleeve used for plug above screen.

PRECISION

WELL CONSTRUCTION DETAILS

BORING DESIGNATION: B-1-p

INSTALLATION

DATE: Feb. 10, 2000 BY: Precision Sampling, Inc.

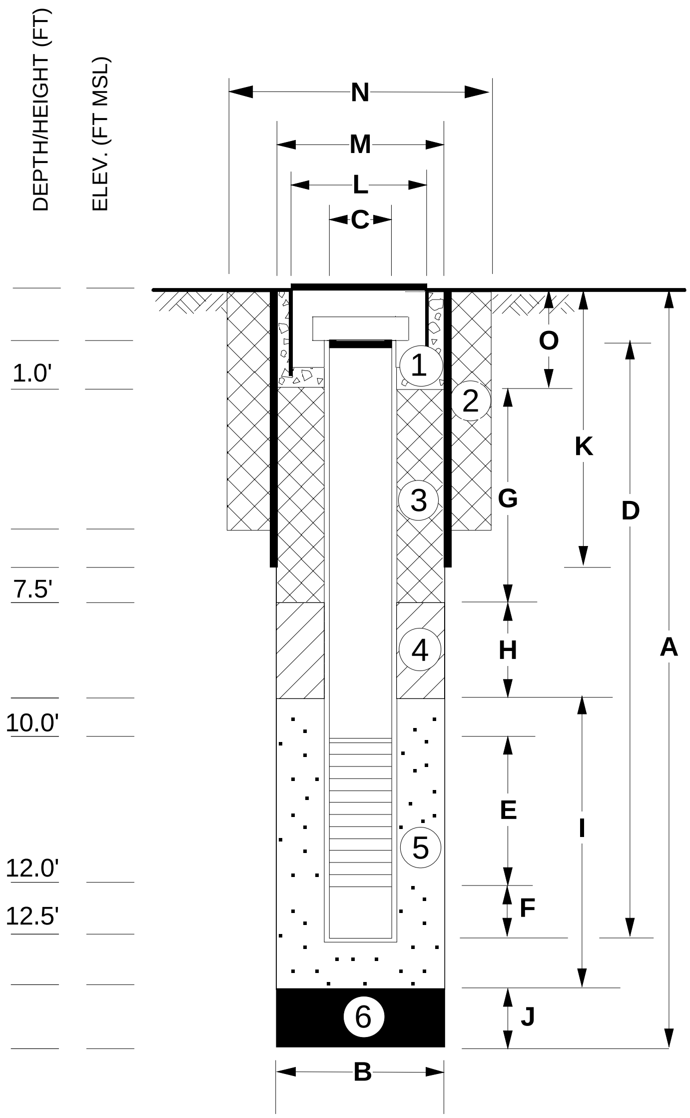
DIMENSIONS

A	Total Depth of Boring (ft.)	12.5'
B	Borehole Diameter (in.)	3.50"
C	Well Casing Diameter (in.)	2.0"
D	Well Casing Length (ft.)	10.0'
E	Well Casing Slotted Interval (ft.)	2.0'
F	Well Casing End Cap or Sump (ft.)	6.0"
G	Annular Seal Interval (ft.)	6.5'
H	Annular Seal Interval (ft.)	2.5'
I	Sand Pack Interval (ft.)	2.2'
J	Bottom Material Interval (ft.)	NA
K	Conductor Casing Interval (ft.)	NA
L	Protective Cover Diameter (in.)	7.0"
M	Conductor Casing Diameter (in.)	NA
N	Upper Borehole Diameter (in.)	10.0"
O	Monument Footing Interval (ft.)	1.0'
	Well Centralizer Depth(s) (ft.)	NA

MATERIALS DATA

Monument Footing	1	Rapid set concrete 3/8" rock
Annular Seal	2	NA
Annular Seal	3	Volclay grout
Annular Seal	4	Enviroplug 1/4" pellets
Sand Pack	5	#2/12 RMC Lonestar sand
Bottom Material	6	Native
Conductor Casing		NA
Slotted Casing	2.0"	0.020" slotted screen
Well Casing	2.0"	Blank Sch. 40 PVC
Well Centralizers		NA
Protective Cover		Morrison Dubuque 418xA

WELL DESIGNATION
B-1-p



SECTION VIEW (not to scale)

CLIENT ACKNOWLEDGEMENT

NOTES:

Sand pack consists of #2/12 RMC Lonestar sand. Boring advanced an additional 6.0" to accommodate sump, so that the well is set exactly at 12.0' bgs (below ground surface). Well ascended 6.0". Placed #2/12 sand around pre-pack well.

PRECISION

WELL CONSTRUCTION DETAILS

BORING DESIGNATION: B-1-p-1

INSTALLATION

DATE: Feb. 10, 2000 BY: Precision Sampling, Inc.

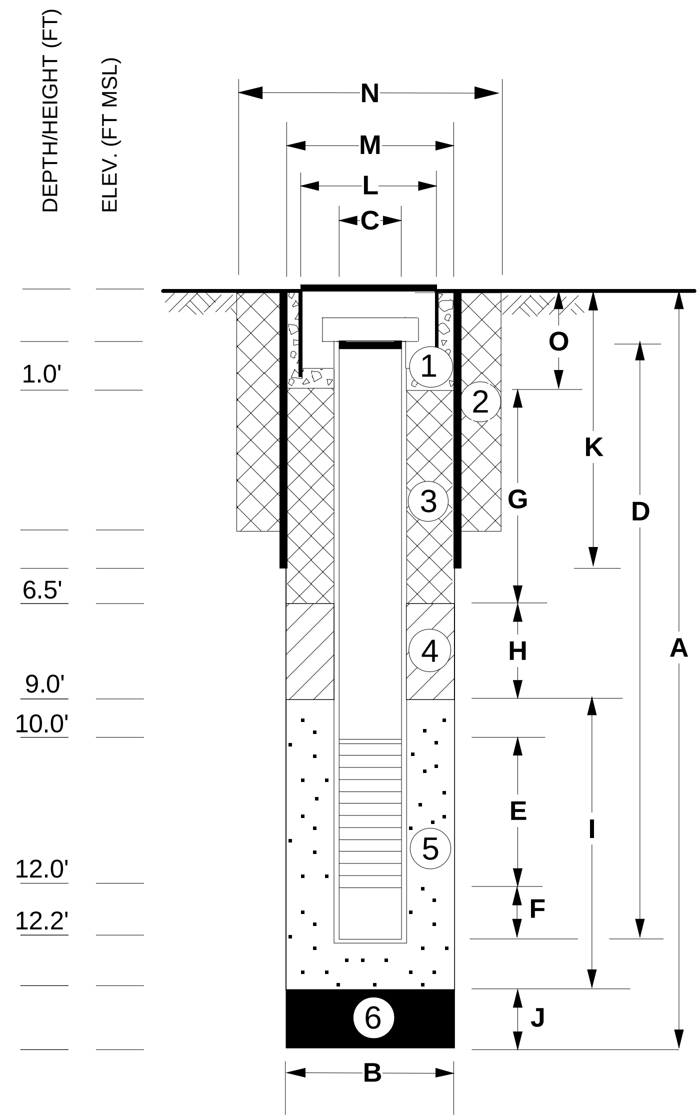
DIMENSIONS

A	Total Depth of Boring (ft.)	12.2'
B	Borehole Diameter (in.)	2.5"
C	Well Casing Diameter (in.)	3/4"
D	Well Casing Length (ft.)	10.0'
E	Well Casing Slotted Interval (ft.)	2.0'
F	Well Casing End Cap or Sump (ft.)	2.0"
G	Annular Seal Interval (ft.)	5.5'
H	Annular Seal Interval (ft.)	2.5'
I	Sand Pack Interval (ft.)	3.2'
J	Bottom Material Interval (ft.)	NA
K	Conductor Casing Interval (ft.)	NA
L	Protective Cover Diameter (in.)	7.0"
M	Conductor Casing Diameter (in.)	NA
N	Upper Borehole Diameter (in.)	10.0"
O	Monument Footing Interval (ft.)	1.0'
	Well Centralizer Depth(s) (ft.)	NA

MATERIALS DATA

Monument Footing	1	Rapid set concrete 3/8" rock
Annular Seal	2	NA
Annular Seal	3	Volclay Grout
Annular Seal	4	Enviroplug 1/4" pellets
Sand Pack	5	#2/12 RMC Lonestar sand
Bottom Material	6	Native
Conductor Casing		NA
Slotted Casing	2.0"	0.020" slotted screen
Well Casing		Blank Sch. 40 PVC
Well Centralizers		NA
Protective Cover		Morrison Dubuque 418xA

WELL DESIGNATION
B-1-p-1



SECTION VIEW (not to scale)

CLIENT ACKNOWLEDGEMENT

NOTES:

#2/12 RMC Lonestar sand is equal to ASTM 10 to 20. Rubber washer placed at 10.0' bgs (below ground surface).

WELL CONSTRUCTION DETAILS

PRECISION

BORING DESIGNATION: B-1-p-c-v

INSTALLATION
DATE: Feb. 11, 2000 BY: Precision Sampling, Inc.

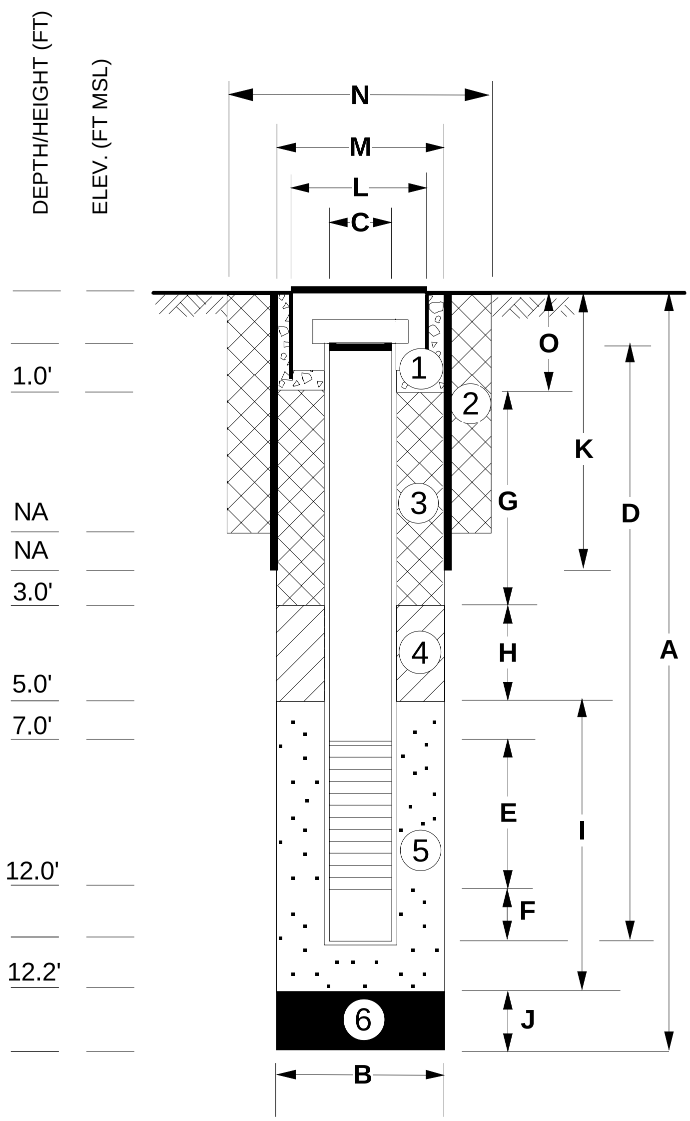
DIMENSIONS

A	Total Depth of Boring (ft.)	12.2'
B	Borehole Diameter (in.)	2.50"
C	Well Casing Diameter (in.)	0.75"
D	Well Casing Length (ft.)	7.0'
E	Well Casing Slotted Interval (ft.)	5.0'
F	Well Casing End Cap or Sump (ft.)	2.0"
G	Annular Seal Interval (ft.)	2.0'
H	Annular Seal Interval (ft.)	2.0'
I	Sand Pack Interval (ft.)	5.0' pre-pack
J	Bottom Material Interval (ft.)	NA
K	Conductor Casing Interval (ft.)	NA
L	Protective Cover Diameter (in.)	7.0"
M	Conductor Casing Diameter (in.)	NA
N	Upper Borehole Diameter (in.)	10.0"
O	Monument Footing Interval (ft.)	1.0'
	Well Centralizer Depth(s) (ft.)	NA

MATERIALS DATA

Monument Footing	1	Rapid set concrete 3/8" rock
Annular Seal	2	NA
Annular Seal	3	Volclay Grout
Annular Seal	4	Enviroplug 1/4" pellets
Sand Pack	5	#1/20 RMC Lonestar sand
Bottom Material	6	Native
Conductor Casing		NA
Slotted Casing	3/4"	0.010" slotted screen
Well Casing	3/4"	Blank Sch. 40 PVC
Well Centralizers		NA
Protective Cover		Morrison Dubuque 418xA

WELL DESIGNATION
B-1-p-c-v



SECTION VIEW (not to scale)

CLIENT ACKNOWLEDGEMENT

NOTES:

Filter pack consists of #1/20 RMC Lonestar sand instead of 20 to 40 ASTM.
Boring advanced with direct push SD-1.

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PRECISION

WELL CONSTRUCTION DETAILS

BORING DESIGNATION: B-2-D

INSTALLATION
DATE: Feb. 9, 2000 BY: THF Drilling/ Precision Sampling, Inc.

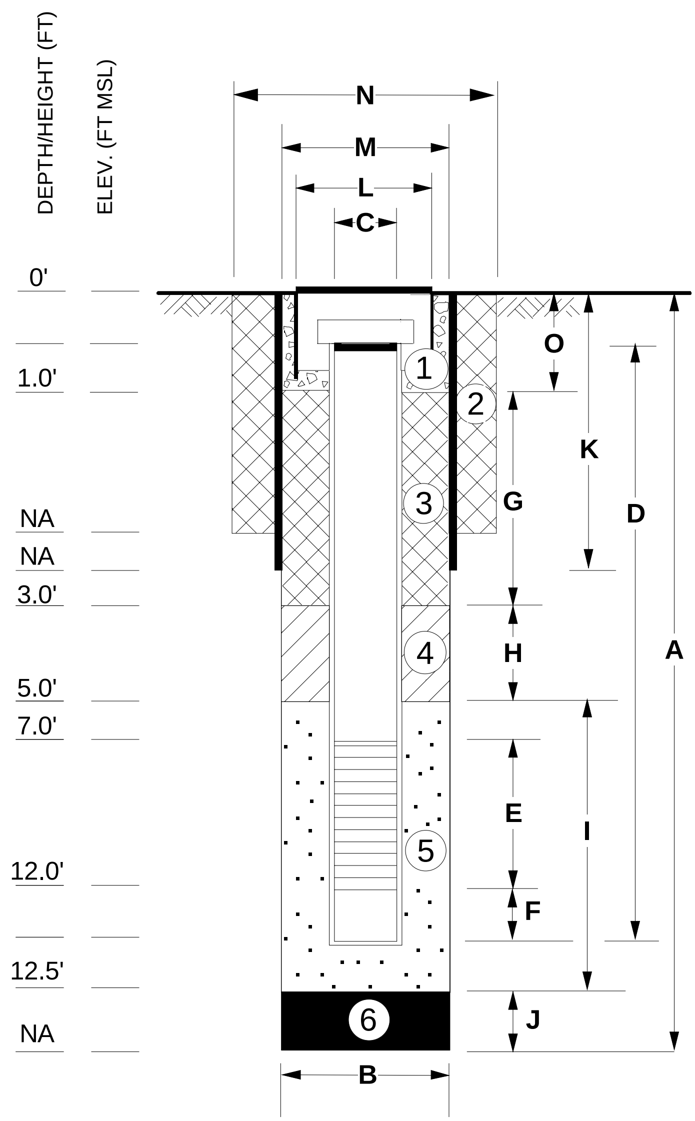
DIMENSIONS

A	Total Depth of Boring (ft.)	12.5'
B	Borehole Diameter (in.)	8.0"
C	Well Casing Diameter (in.)	2.0"
D	Well Casing Length (ft.)	7.0'
E	Well Casing Slotted Interval (ft.)	5.0'
F	Well Casing End Cap or Sump (ft.)	6.0"
G	Annular Seal Interval (ft.)	2.0'
H	Annular Seal Interval (ft.)	2.0'
I	Sand Pack Interval (ft.)	7.5'
J	Bottom Material Interval (ft.)	NA
K	Conductor Casing Interval (ft.)	NA
L	Protective Cover Diameter (in.)	7.0"
M	Conductor Casing Diameter (in.)	NA
N	Upper Borehole Diameter (in.)	10.0"
O	Monument Footing Interval (ft.)	1.0'
	Well Centralizer Depth(s) (ft.)	NA

MATERIALS DATA

Monument Footing	1	Rapid set concrete 3/8" rock
Annular Seal	2	NA
Annular Seal	3	Enviroplug medium
Annular Seal	4	Enviroplug medium
Sand Pack	5	#2/12 RMC Lonestar
Bottom Material	6	Native
Conductor Casing		NA
Slotted Casing	2.0"	Sch. 40 PVC, 0.020"
Well Casing	2.0"	Sch. 40 PVC threaded
Well Centralizers		NA
Protective Cover		Morrison Dubuque 418xA

WELL DESIGNATION
B-2-D



SECTION VIEW (not to scale)

CLIENT ACKNOWLEDGEMENT

NOTES:

Filter pack consists of #2/12 RMC Lonestar sand instead of ASTM 10 to 20. Boring advanced an additional 6.0" to accommodate sump, so that the well is set exactly at 12.0' bgs (below ground surface).

WELL CONSTRUCTION DETAILS

PRECISION

BORING DESIGNATION: B-2-n-p

INSTALLATION
DATE: Feb. 12, 2000 BY: Mark Kram

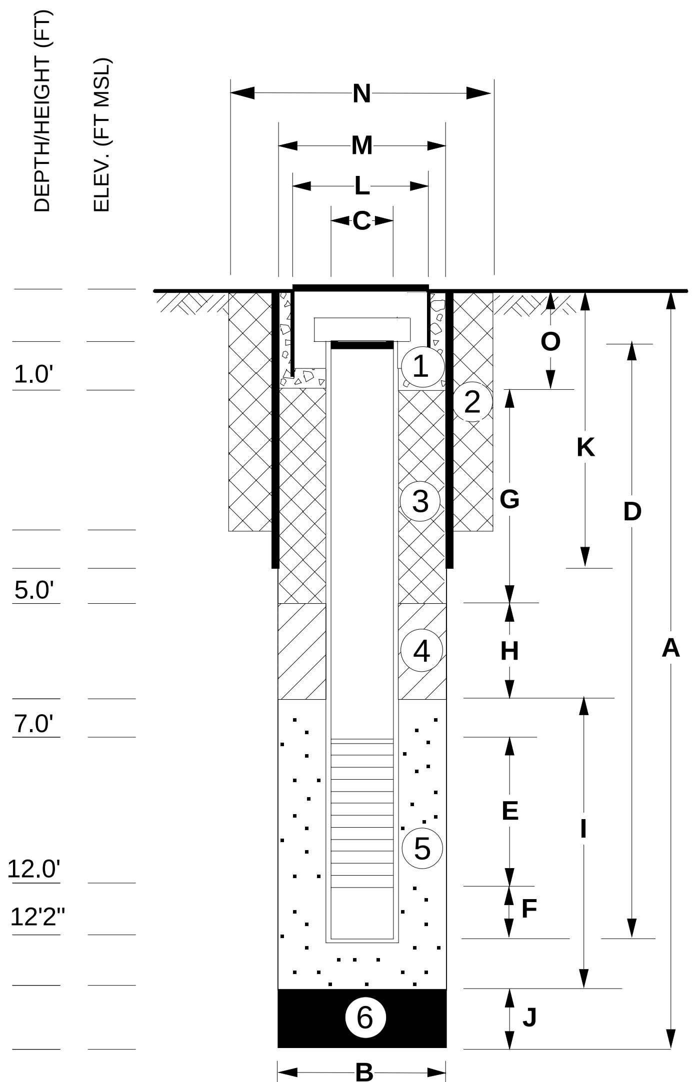
DIMENSIONS

A	Total Depth of Boring (ft.)	12'2"
B	Borehole Diameter (in.)	2.50"
C	Well Casing Diameter (in.)	3/4"
D	Well Casing Length (ft.)	12'2"
E	Well Casing Slotted Interval (ft.)	5.0'
F	Well Casing End Cap or Sump (ft.)	2.0"
G	Annular Seal Interval (ft.)	4.0'
H	Annular Seal Interval (ft.)	2.0'
I	Sand Pack Interval (ft.)	5.0'
J	Bottom Material Interval (ft.)	NA
K	Conductor Casing Interval (ft.)	NA
L	Protective Cover Diameter (in.)	7.0"
M	Conductor Casing Diameter (in.)	NA
N	Upper Borehole Diameter (in.)	10.0"
O	Monument Footing Interval (ft.)	1.0'
	Well Centralizer Depth(s) (ft.)	NA

MATERIALS DATA

Monument Footing	1	Rapid set concrete 3/8" rock
Annular Seal	2	NA
Annular Seal	3	Volclay Grout
Annular Seal	4	Enviroplug 1/4" pellets
Sand Pack	5	Native formation
Bottom Material	6	Native
Conductor Casing		NA
Slotted Casing	3/4"	0.010" slotted screen
Well Casing	3/4"	Blank Sch. 40 PVC
Well Centralizers		NA
Protective Cover		Morrison Dubuque 418xA

WELL DESIGNATION
B-2-n-p



SECTION VIEW (not to scale)

CLIENT ACKNOWLEDGEMENT

NOTES:

No sand pack: Native formation allowed to fall in around screen. Expandable annular seal and bentonite sleeve used for plug above screen. The device was modified by adding two rubber washers to the top of the foam packers.

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WELL CONSTRUCTION DETAILS

BORING DESIGNATION: B-2-p

INSTALLATION
DATE: Feb. 10, 2000 BY: Precision Sampling, Inc.

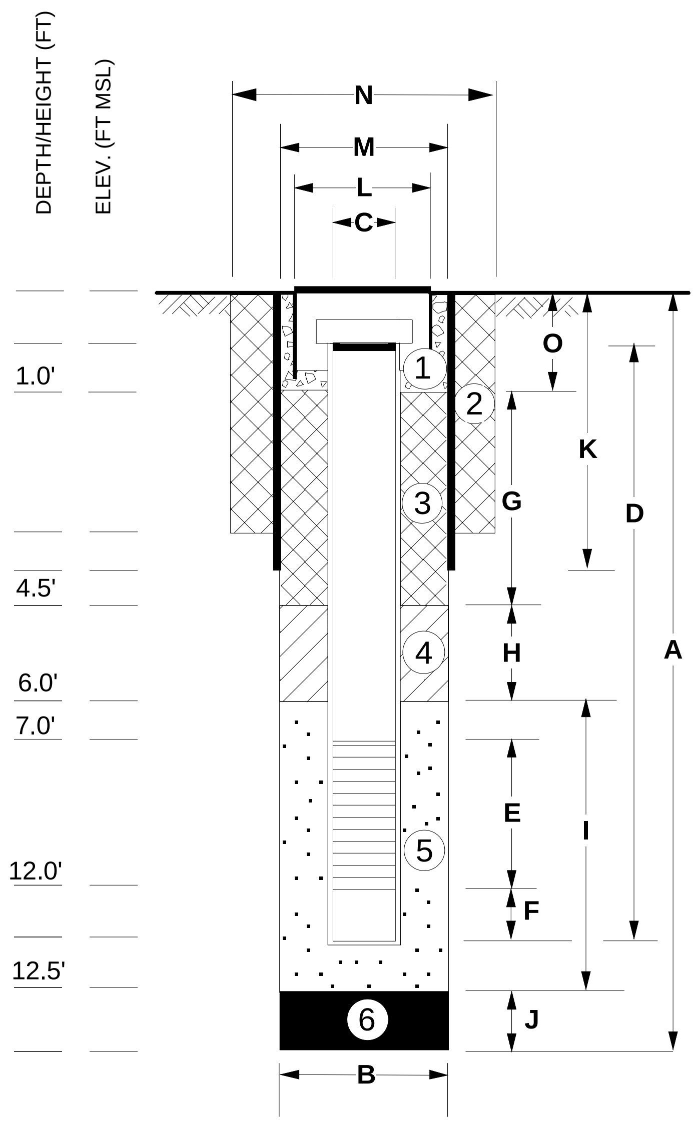
WELL DESIGNATION
B-2-p

DIMENSIONS

A	Total Depth of Boring (ft.)	12.5'
B	Borehole Diameter (in.)	3.50"
C	Well Casing Diameter (in.)	2.0"
D	Well Casing Length (ft.)	7.0'
E	Well Casing Slotted Interval (ft.)	5.0'
F	Well Casing End Cap or Sump (ft.)	6.0"
G	Annular Seal Interval (ft.)	3.5'
H	Annular Seal Interval (ft.)	2.5'
I	Sand Pack Interval (ft.)	6.5'
J	Bottom Material Interval (ft.)	NA
K	Conductor Casing Interval (ft.)	NA
L	Protective Cover Diameter (in.)	7.0"
M	Conductor Casing Diameter (in.)	NA
N	Upper Borehole Diameter (in.)	10.0"
O	Monument Footing Interval (ft.)	NA
	Well Centralizer Depth(s) (ft.)	NA

MATERIALS DATA

Monument Footing	1	Rapid set concrete 3/8" rock
Annular Seal	2	NA
Annular Seal	3	Wyo-Ben Groutwell
Annular Seal	4	Enviroplug 1/4" pellets
Sand Pack	5	#2/12 RMC Lonestar sand
Bottom Material	6	Native
Conductor Casing		NA
Slotted Casing	2.0"	0.020" slotted screen
Well Casing	2.0"	Blank Sch. 40 PVC
Well Centralizers		NA
Protective Cover		Morrison Dubuque 418xA



SECTION VIEW (not to scale)

CLIENT ACKNOWLEDGEMENT

NOTES:

#2/12 RMC Lonestar sand is equal to ASTM 10 to 20. Boring advanced an additional 6.0" to accommodate sump, so that the well is set exactly at 12.0' bgs (below ground surface).

PRECISION

WELL CONSTRUCTION DETAILS

BORING DESIGNATION: B-2-p-1

INSTALLATION

DATE: Feb. 11, 2000 BY: Precision Sampling, Inc.

WELL DESIGNATION

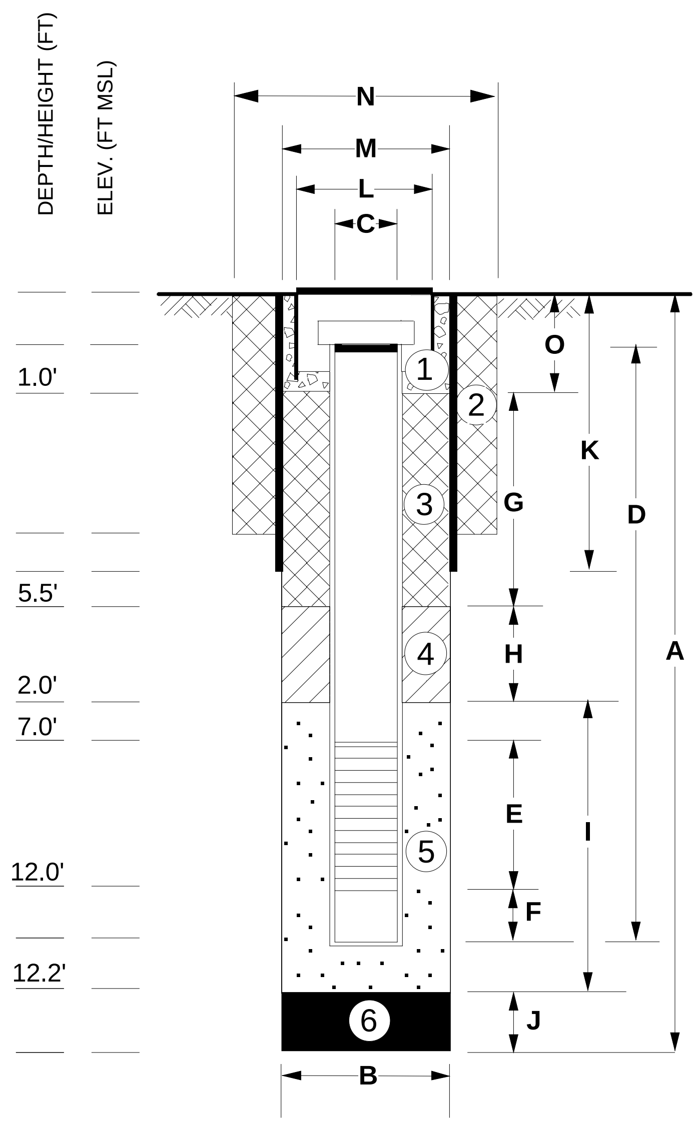
B-2-p-1

DIMENSIONS

A	Total Depth of Boring (ft.)	12.2'
B	Borehole Diameter (in.)	2.50"
C	Well Casing Diameter (in.)	0.75"
D	Well Casing Length (ft.)	7.0'
E	Well Casing Slotted Interval (ft.)	5.0'
F	Well Casing End Cap or Sump (ft.)	0.2"
G	Annular Seal Interval (ft.)	4.5'
H	Annular Seal Interval (ft.)	2.0'
I	Sand Pack Interval (ft.)	5.4'
J	Bottom Material Interval (ft.)	NA
K	Conductor Casing Interval (ft.)	NA
L	Protective Cover Diameter (in.)	7.0"
M	Conductor Casing Diameter (in.)	NA
N	Upper Borehole Diameter (in.)	10.0"
O	Monument Footing Interval (ft.)	1.0'
	Well Centralizer Depth(s) (ft.)	NA

MATERIALS DATA

Monument Footing	1	Rapid set concrete 3/8" rock
Annular Seal	2	NA
Annular Seal	3	Volclay Grout
Annular Seal	4	Enviroplug 1/4" pellets
Sand Pack	5	#2/12 RMC Lonestar sand
Bottom Material	6	Native
Conductor Casing		NA
Slotted Casing	3/4"	0.020" slotted screen
Well Casing	3/4"	Blank Sch. 40 PVC
Well Centralizers		NA
Protective Cover		Morrison Dubuque 418xA



SECTION VIEW (not to scale)

CLIENT ACKNOWLEDGEMENT

NOTES:

Filter pack consists of #2/12 RMC Lonestar sand is equal to ASTM 10 to 20.
Boring advanced with direct push SD-1.

WELL CONSTRUCTION DETAILS

PRECISION

BORING DESIGNATION: B-2-p-c-v

INSTALLATION
DATE: Feb. 11, 2000 BY: Precision Sampling, Inc.

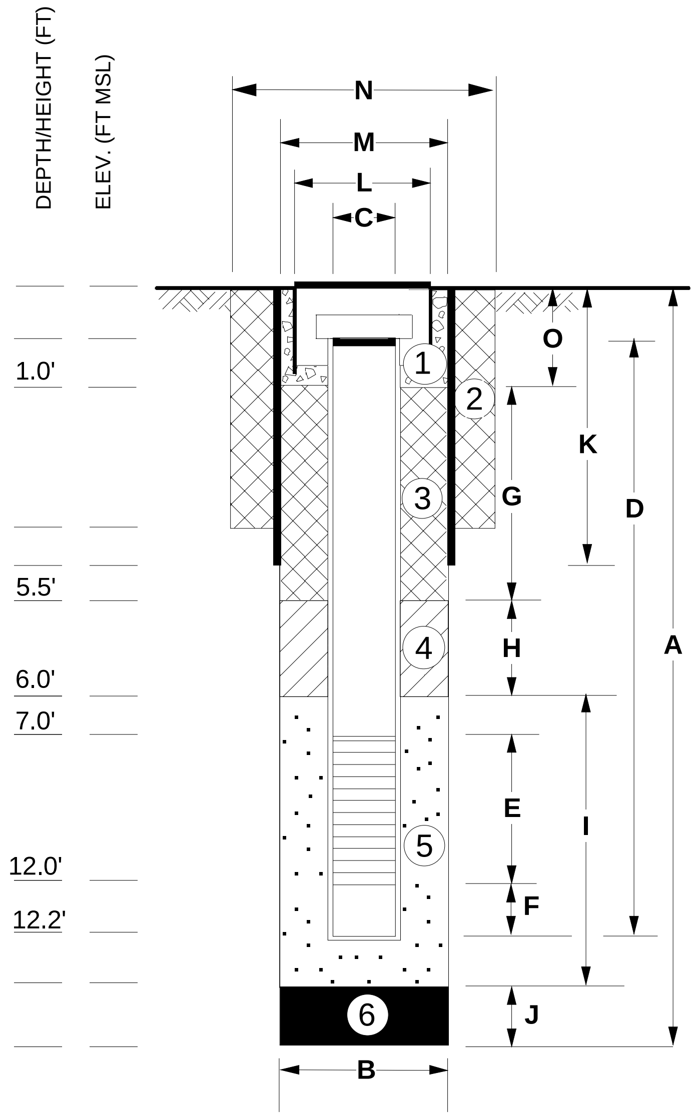
DIMENSIONS

A	Total Depth of Boring (ft.)	12.2'
B	Borehole Diameter (in.)	2.50"
C	Well Casing Diameter (in.)	0.75"
D	Well Casing Length (ft.)	7.0'
E	Well Casing Slotted Interval (ft.)	5.0'
F	Well Casing End Cap or Sump (ft.)	6.0"
G	Annular Seal Interval (ft.)	4.5'
H	Annular Seal Interval (ft.)	2.5'
I	Sand Pack Interval (ft.)	6.0'
J	Bottom Material Interval (ft.)	NA
K	Conductor Casing Interval (ft.)	NA
L	Protective Cover Diameter (in.)	7.0"
M	Conductor Casing Diameter (in.)	NA
N	Upper Borehole Diameter (in.)	10.0"
O	Monument Footing Interval (ft.)	1.0'
	Well Centralizer Depth(s) (ft.)	NA

MATERIALS DATA

Monument Footing	1	Rapid set concrete 3/8" rock
Annular Seal	2	NA
Annular Seal	3	Wyo-Ben Groutwell
Annular Seal	4	Enviroplug 1/4" pellets
Sand Pack	5	#1/20 RMC Lonestar sand
Bottom Material	6	Native
Conductor Casing		NA
Slotted Casing	3/4"	0.010" slotted screen
Well Casing	3/4"	Blank Sch. 40 PVC
Well Centralizers		NA
Protective Cover		Morrison Dubuque 418xA

WELL DESIGNATION
B-2-p-c-v



SECTION VIEW (not to scale)

CLIENT ACKNOWLEDGEMENT

NOTES:

Sand pack consists of #1/20 RMC Lonestar sand instead of 20 to 40 ASTM.
Rubber washers set at the top of the screened interval and filter pack.

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PRECISION

WELL CONSTRUCTION DETAILS

BORING DESIGNATION: B-3-D

INSTALLATION

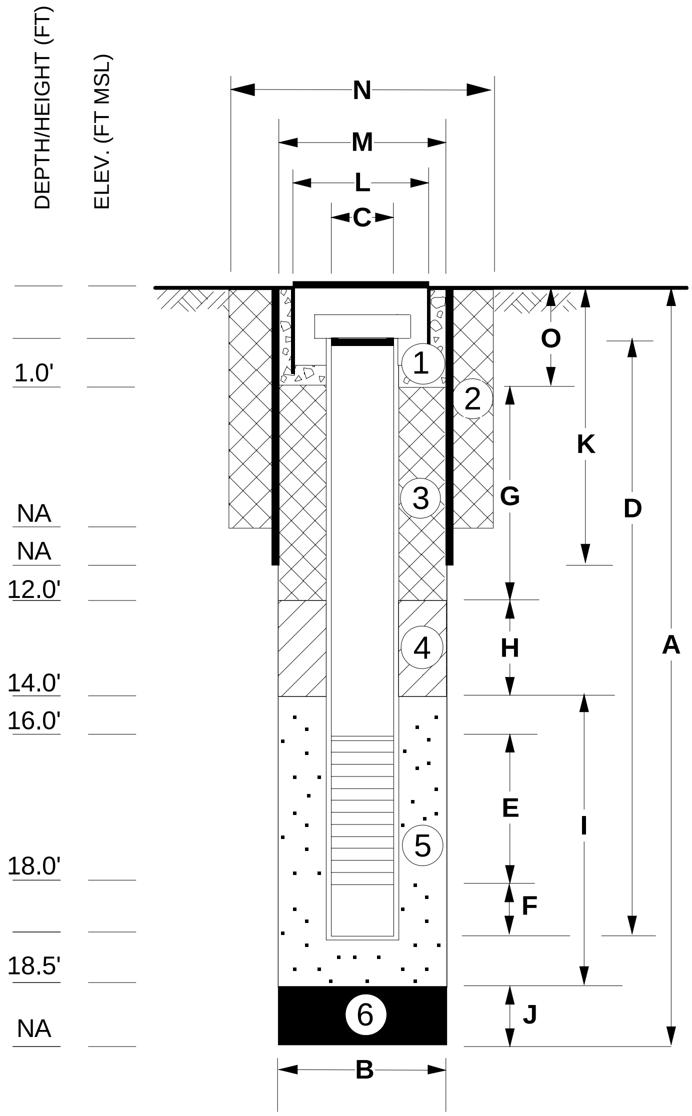
DATE: Feb. 9, 2000 BY: THF Drilling/ Precision Sampling, Inc.

DIMENSIONS

A	Total Depth of Boring (ft.)	18.5'
B	Borehole Diameter (in.)	8.0"
C	Well Casing Diameter (in.)	2.0"
D	Well Casing Length (ft.)	16.0'
E	Well Casing Slotted Interval (ft.)	2.0'
F	Well Casing End Cap or Sump (ft.)	6.0"
G	Annular Seal Interval (ft.)	11.0'
H	Annular Seal Interval (ft.)	2.0'
I	Sand Pack Interval (ft.)	4.5'
J	Bottom Material Interval (ft.)	NA
K	Conductor Casing Interval (ft.)	NA
L	Protective Cover Diameter (in.)	7.0"
M	Conductor Casing Diameter (in.)	NA
N	Upper Borehole Diameter (in.)	NA
O	Monument Footing Interval (ft.)	10.0"
	Well Centralizer Depth(s) (ft.)	NA

WELL DESIGNATION

B-3-D



SECTION VIEW (not to scale)

MATERIALS DATA

Monument Footing	1	Rapid set concrete 3/8" rock
Annular Seal	2	NA
Annular Seal	3	Wyo-Ben Groutwell
Annular Seal	4	Enviroplug medium
Sand Pack	5	#2/12 RMC Lonestar
Bottom Material	6	Native
Conductor Casing		NA
Slotted Casing	2.0"	Sch. 40 PVC, 0.020"
Well Casing	2.0"	Sch. 40 PVC threaded
Well Centralizers		NA
Protective Cover		Morrison Dubuque 418xA

CLIENT ACKNOWLEDGEMENT

NOTES:

Filter pack consists of #2/12 RMC Lonestar sand instead of ASTM 10 to 20. Boring advanced an additional 6.0" to accommodate sump, so that the well is set exactly at 18.0' bgs (below ground surface).

WELL CONSTRUCTION DETAILS

PRECISION

BORING DESIGNATION: B-3-n-p

INSTALLATION
DATE: Feb. 12, 2000 BY: Mark Kram

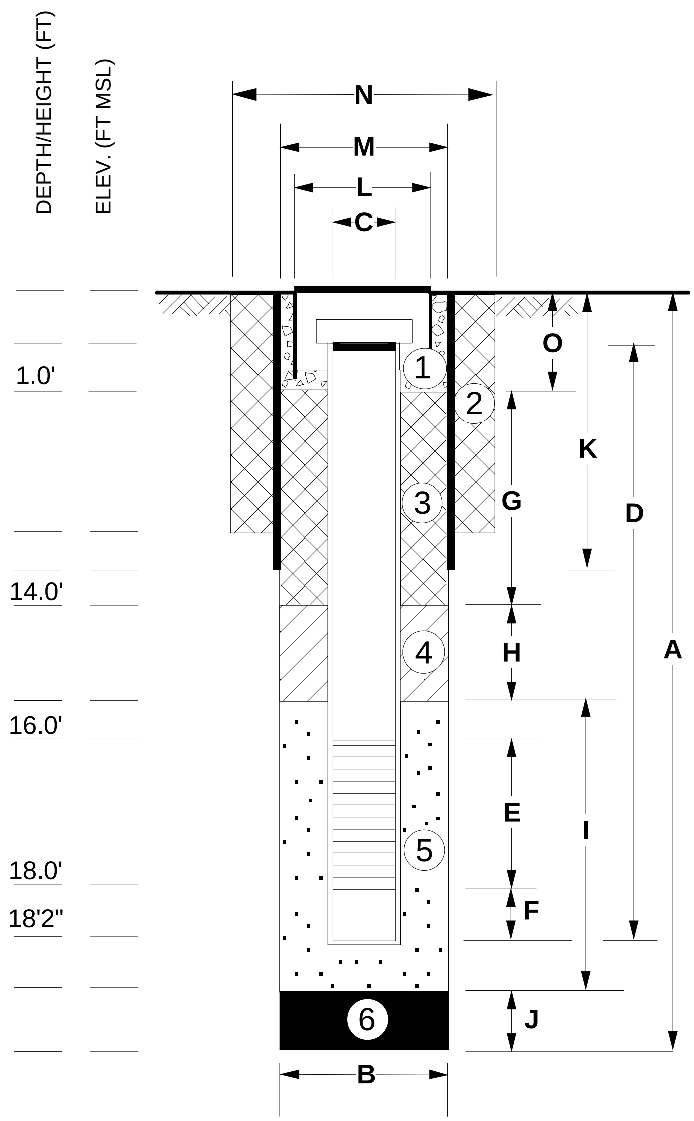
DIMENSIONS

A	Total Depth of Boring (ft.)	18'2"
B	Borehole Diameter (in.)	2.50"
C	Well Casing Diameter (in.)	3/4"
D	Well Casing Length (ft.)	16.0'
E	Well Casing Slotted Interval (ft.)	2.0'
F	Well Casing End Cap or Sump (ft.)	2.0"
G	Annular Seal Interval (ft.)	13.0'
H	Annular Seal Interval (ft.)	2.0'
I	Sand Pack Interval (ft.)	2.0'
J	Bottom Material Interval (ft.)	NA
K	Conductor Casing Interval (ft.)	NA
L	Protective Cover Diameter (in.)	7.0"
M	Conductor Casing Diameter (in.)	NA
N	Upper Borehole Diameter (in.)	10.0"
O	Monument Footing Interval (ft.)	NA
	Well Centralizer Depth(s) (ft.)	1.0'

MATERIALS DATA

Monument Footing	1	Rapid set concrete 3/8" rock
Annular Seal	2	NA
Annular Seal	3	Volclay Grout
Annular Seal	4	Enviroplug 1/4" pellets
Sand Pack	5	Native formation
Bottom Material	6	Native
Conductor Casing		NA
Slotted Casing	3/4"	0.010" slotted screen
Well Casing	3/4"	Blank Sch. 40 PVC
Well Centralizers		NA
Protective Cover		Morrison Dubuque 418xA

WELL DESIGNATION
B-3-n-p



SECTION VIEW (not to scale)

CLIENT ACKNOWLEDGEMENT

NOTES:

No sand pack: Native formation allowed to fall in around screen. Expandable annular seal and bentonite sleeve used for plug above screen. The device was modified by adding two rubber washers to the top of the foam packers.

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PRECISION

WELL CONSTRUCTION DETAILS

BORING DESIGNATION: B-3-p

INSTALLATION
DATE: Feb. 12, 2000 BY: Mark Kram

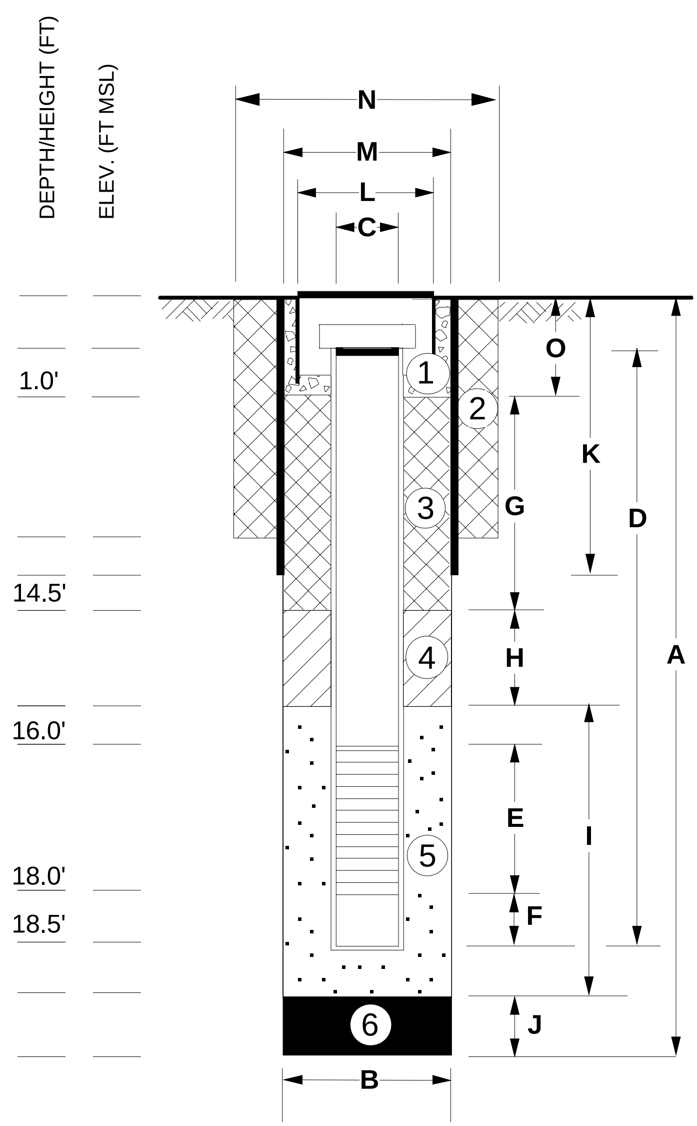
DIMENSIONS

A	Total Depth of Boring (ft.)	18.2'
B	Borehole Diameter (in.)	3.50"
C	Well Casing Diameter (in.)	2.0"
D	Well Casing Length (ft.)	16.0'
E	Well Casing Slotted Interval (ft.)	2.0'
F	Well Casing End Cap or Sump (ft.)	6.0"
G	Annular Seal Interval (ft.)	13.5'
H	Annular Seal Interval (ft.)	1.5'
I	Sand Pack Interval (ft.)	2.0'
J	Bottom Material Interval (ft.)	NA
K	Conductor Casing Interval (ft.)	NA
L	Protective Cover Diameter (in.)	7.0"
M	Conductor Casing Diameter (in.)	NA
N	Upper Borehole Diameter (in.)	10.0"
O	Monument Footing Interval (ft.)	1.0'
	Well Centralizer Depth(s) (ft.)	NA

MATERIALS DATA

Monument Footing	1	Rapid set concrete 3/8" rock
Annular Seal	2	NA
Annular Seal	3	Volclay Grout
Annular Seal	4	Enviroplug 1/4" pellets
Sand Pack	5	10 to 20 ASTM pre-pack
Bottom Material	6	Native
Conductor Casing		NA
Slotted Casing	2.0"	0.020" slotted screen
Well Casing	2.0"	Blank Sch. 40 PVC
Well Centralizers		NA
Protective Cover		Morrison Dubuque 418xA

WELL DESIGNATION
B-3-p



SECTION VIEW (not to scale)

CLIENT ACKNOWLEDGEMENT

NOTES:

Sand pack consists of ASTM 10 to 20 sand. #2/12 RMC Lonestar sand used to fill annulus adjacent to pre-pack filter.

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WELL CONSTRUCTION DETAILS

PRECISION

BORING DESIGNATION: B-3-p-1

INSTALLATION
DATE: Feb. 12, 2000 BY: Mark Kram

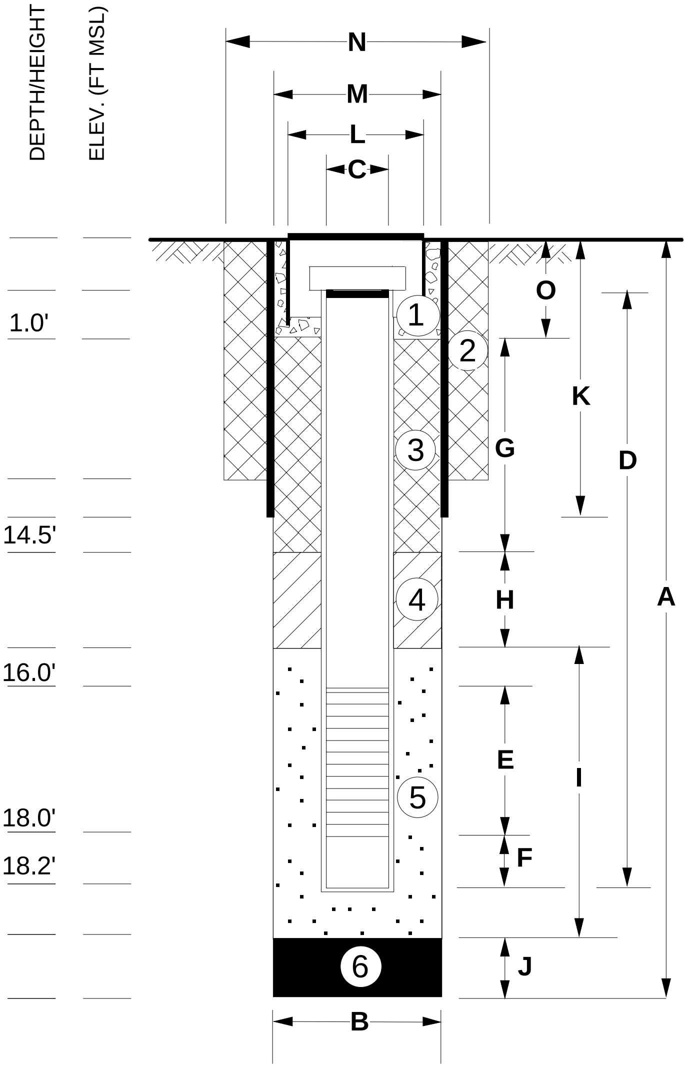
DIMENSIONS

A	Total Depth of Boring (ft.)	18.2'
B	Borehole Diameter (in.)	2.50"
C	Well Casing Diameter (in.)	3/4"
D	Well Casing Length (ft.)	16.0'
E	Well Casing Slotted Interval (ft.)	2.0'
F	Well Casing End Cap or Sump (ft.)	0.2"
G	Annular Seal Interval (ft.)	13.5'
H	Annular Seal Interval (ft.)	1.5'
I	Sand Pack Interval (ft.)	2.2'
J	Bottom Material Interval (ft.)	NA
K	Conductor Casing Interval (ft.)	NA
L	Protective Cover Diameter (in.)	7.0"
M	Conductor Casing Diameter (in.)	NA
N	Upper Borehole Diameter (in.)	10.0"
O	Monument Footing Interval (ft.)	1.0'
	Well Centralizer Depth(s) (ft.)	NA

MATERIALS DATA

Monument Footing	1	Rapid set concrete 3/8" rock
Annular Seal	2	NA
Annular Seal	3	Volclay Grout
Annular Seal	4	Enviroplug 1/4" pellets
Sand Pack	5	10 to 20 ASTM pre-pack
Bottom Material	6	Native
Conductor Casing		NA
Slotted Casing	3/4"	0.020" slotted screen
Well Casing	3/4"	Blank Sch. 40 PVC
Well Centralizers		NA
Protective Cover		Morrison Dubuque 418xA

WELL DESIGNATION
B-3-p-1



SECTION VIEW (not to scale)

CLIENT ACKNOWLEDGEMENT

NOTES:

Sand pack consists of ASTM 10 to 20 sand.
Rubber washers are set above filter pack and screen.

WELL CONSTRUCTION DETAILS

PRECISION

BORING DESIGNATION: B-3-p-c-v

INSTALLATION
DATE: Feb. 11, 2000 BY: Mark Kram

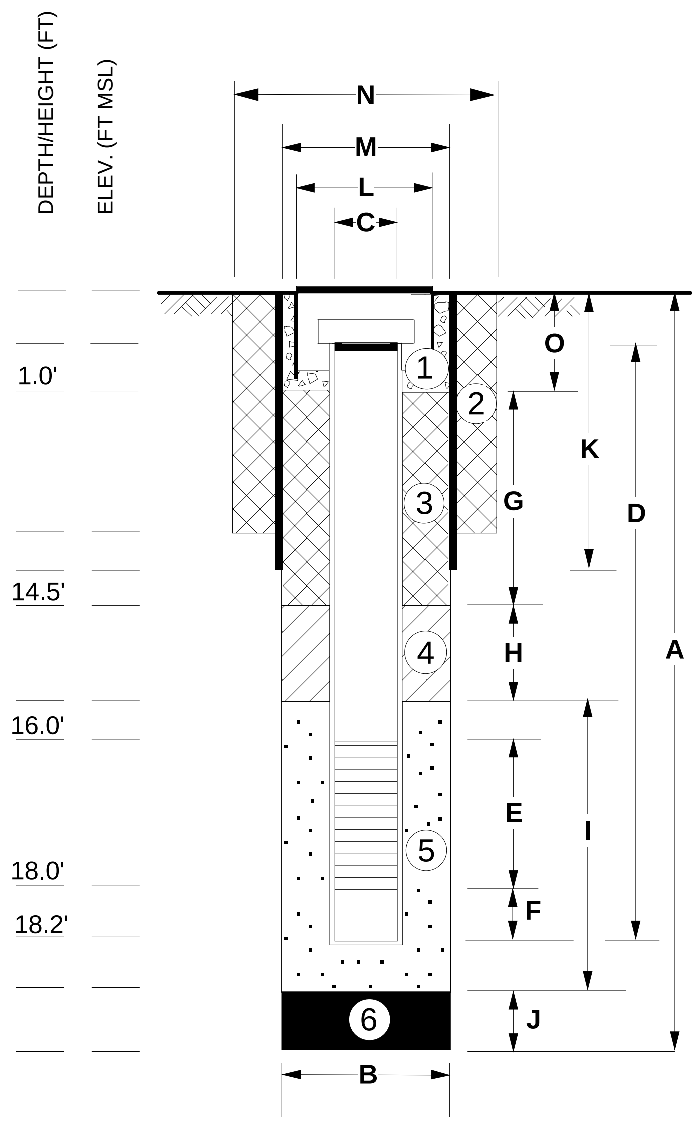
DIMENSIONS

A	Total Depth of Boring (ft.)	18.2'
B	Borehole Diameter (in.)	2.50"
C	Well Casing Diameter (in.)	0.75"
D	Well Casing Length (ft.)	16.0'
E	Well Casing Slotted Interval (ft.)	2.0'
F	Well Casing End Cap or Sump (ft.)	0.2"
G	Annular Seal Interval (ft.)	13.5'
H	Annular Seal Interval (ft.)	1.5'
I	Sand Pack Interval (ft.)	2.2'
J	Bottom Material Interval (ft.)	NA
K	Conductor Casing Interval (ft.)	NA
L	Protective Cover Diameter (in.)	7.0"
M	Conductor Casing Diameter (in.)	NA
N	Upper Borehole Diameter (in.)	10.0"
O	Monument Footing Interval (ft.)	1.0'
	Well Centralizer Depth(s) (ft.)	NA

MATERIALS DATA

Monument Footing	1	Rapid set concrete 3/8" rock
Annular Seal	2	NA
Annular Seal	3	Volclay Grout
Annular Seal	4	Enviroplug 1/4" pellets
Sand Pack	5	20 to 40 ASTM sand
Bottom Material	6	Native
Conductor Casing		NA
Slotted Casing	3/4"	0.010" slotted screen
Well Casing	3/4"	Blank Sch. 40 PVC
Well Centralizers		NA
Protective Cover		Morrison Dubuque 418xA

WELL DESIGNATION
B-3-p-c-v



SECTION VIEW (not to scale)

CLIENT ACKNOWLEDGEMENT

NOTES:

Sand pack consists of 20 to 40 ASTM sand.
Rubber washers set above screened interval and filter pack.

WELL CONSTRUCTION DETAILS

PRECISION

BORING DESIGNATION: B-4-D

INSTALLATION
DATE: Feb. 9, 2000 BY: THF Drilling/ Precision Sampling, Inc.

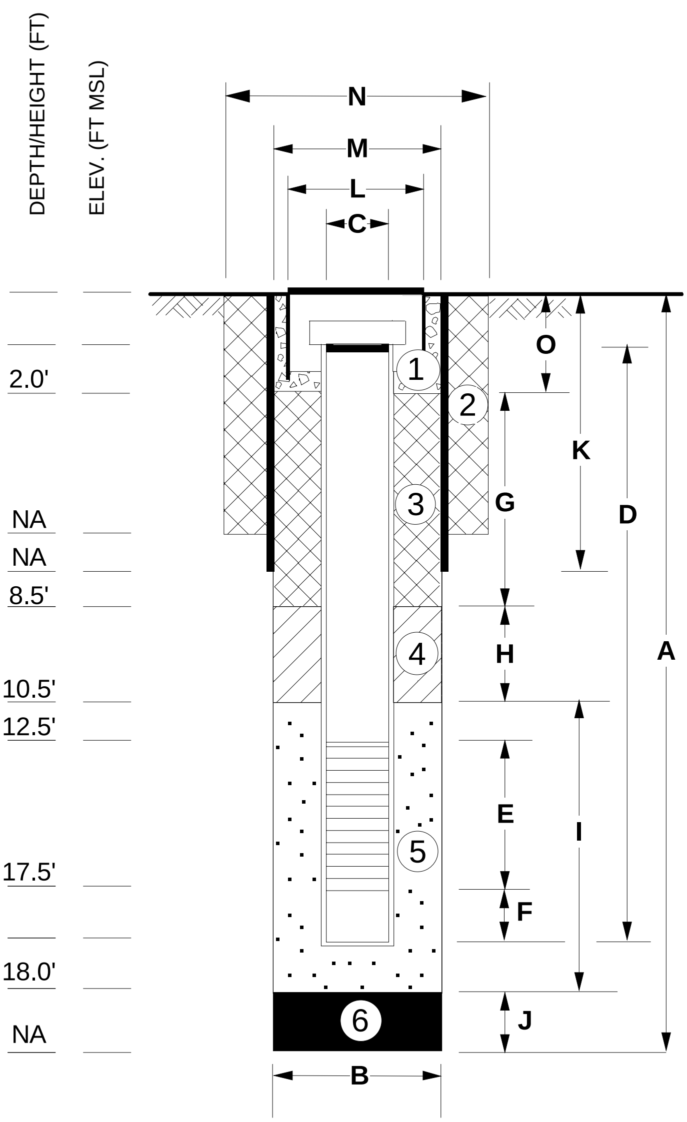
DIMENSIONS

A	Total Depth of Boring (ft.)	18.0'
B	Borehole Diameter (in.)	8.0"
C	Well Casing Diameter (in.)	2.0"
D	Well Casing Length (ft.)	12.5'
E	Well Casing Slotted Interval (ft.)	5.0'
F	Well Casing End Cap or Sump (ft.)	6.0"
G	Annular Seal Interval (ft.)	6.5'
H	Annular Seal Interval (ft.)	2.0'
I	Sand Pack Interval (ft.)	8.5'
J	Bottom Material Interval (ft.)	NA
K	Conductor Casing Interval (ft.)	NA
L	Protective Cover Diameter (in.)	7.0"
M	Conductor Casing Diameter (in.)	NA
N	Upper Borehole Diameter (in.)	NA
O	Monument Footing Interval (ft.)	10.0"
	Well Centralizer Depth(s) (ft.)	NA

MATERIALS DATA

Monument Footing	1	Rapid set concrete 3/8" rock
Annular Seal	2	NA
Annular Seal	3	Enviroplug medium
Annular Seal	4	Enviroplug medium
Sand Pack	5	#2/12 RMC Lonestar
Bottom Material	6	Native
Conductor Casing		NA
Slotted Casing	2.0"	Sch. 40 PVC, 0.020"
Well Casing	2.0"	Sch. 40 PVC threaded
Well Centralizers		NA
Protective Cover		Morrison Dubuque 418xA

WELL DESIGNATION
B-4-D



SECTION VIEW (not to scale)

CLIENT ACKNOWLEDGEMENT

NOTES:

Filter pack consists of #2/12 RMC Lonestar sand. Boring advanced an additional 6.0" to accommodate sump, so that the well is set exactly at 18.0' bgs (below ground surface).

WELL CONSTRUCTION DETAILS

PRECISION

BORING DESIGNATION: B-4-n-p

INSTALLATION
DATE: Feb. 12, 2000 BY: Mark Kram

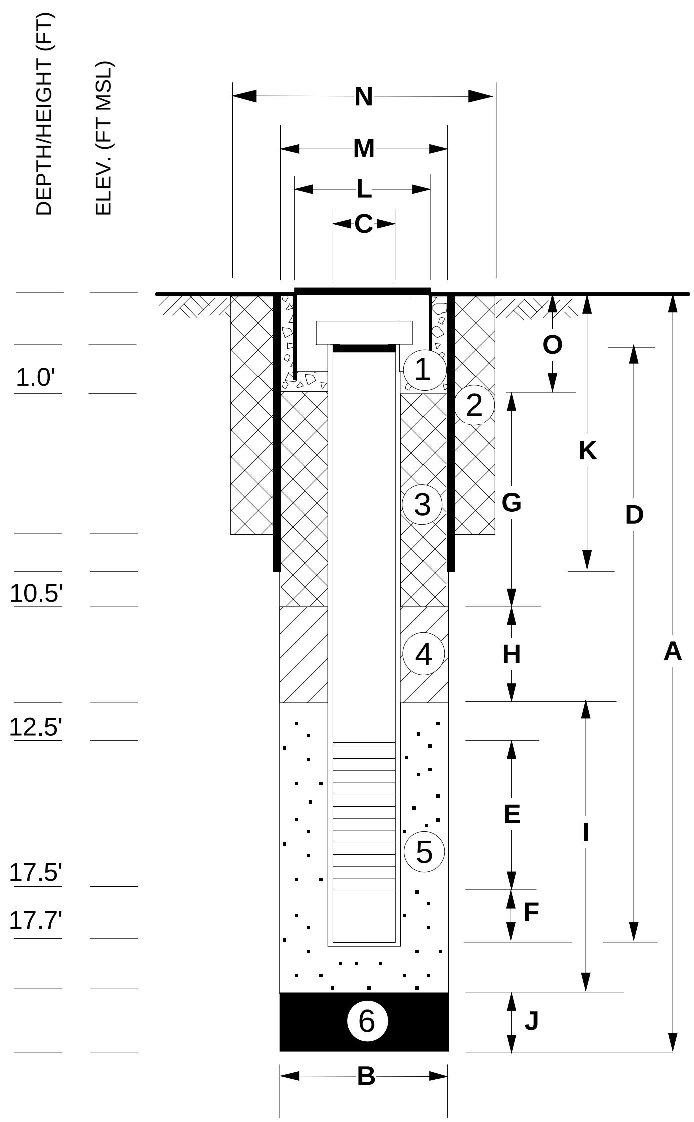
DIMENSIONS

A	Total Depth of Boring (ft.)	17.7'
B	Borehole Diameter (in.)	2.50"
C	Well Casing Diameter (in.)	3/4"
D	Well Casing Length (ft.)	12.5'
E	Well Casing Slotted Interval (ft.)	5.0'
F	Well Casing End Cap or Sump (ft.)	2.0"
G	Annular Seal Interval (ft.)	9.5'
H	Annular Seal Interval (ft.)	2.0'
I	Sand Pack Interval (ft.)	5.0'
J	Bottom Material Interval (ft.)	NA
K	Conductor Casing Interval (ft.)	NA
L	Protective Cover Diameter (in.)	7.0"
M	Conductor Casing Diameter (in.)	NA
N	Upper Borehole Diameter (in.)	10.0"
O	Monument Footing Interval (ft.)	1.0'
	Well Centralizer Depth(s) (ft.)	NA

MATERIALS DATA

Monument Footing	1	Rapid set concrete 3/8" rock
Annular Seal	2	NA
Annular Seal	3	Volclay Grout
Annular Seal	4	Enviroplug 1/4" pellets
Sand Pack	5	Native formation
Bottom Material	6	Native
Conductor Casing		NA
Slotted Casing	3/4"	0.010" slotted screen
Well Casing	3/4"	Blank Sch. 40 PVC
Well Centralizers		NA
Protective Cover		Morrison Dubuque 418xA

WELL DESIGNATION
B-4-n-p



SECTION VIEW (not to scale)

CLIENT ACKNOWLEDGEMENT

NOTES:

No sand pack: Native formation allowed to fall in around screen. Expandable annular seal and bentonite sleeve used for plug above screen. The device was modified by adding two rubber washers to the top of the foam packers.

WELL CONSTRUCTION DETAILS

PRECISION

BORING DESIGNATION: B-4-p

INSTALLATION
DATE: Feb. 11, 2000 BY: Precision Sampling, Inc.

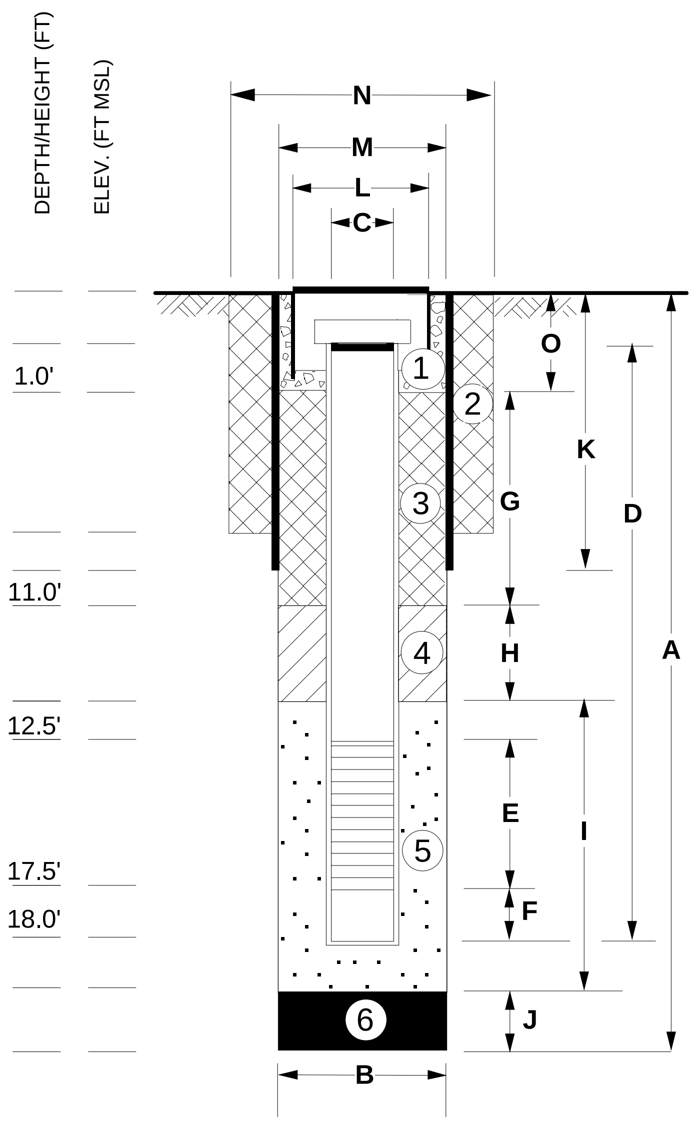
DIMENSIONS

A	Total Depth of Boring (ft.)	18.0'
B	Borehole Diameter (in.)	3.50"
C	Well Casing Diameter (in.)	2.0"
D	Well Casing Length (ft.)	12.5'
E	Well Casing Slotted Interval (ft.)	5.0'
F	Well Casing End Cap or Sump (ft.)	6.0"
G	Annular Seal Interval (ft.)	10.0'
H	Annular Seal Interval (ft.)	1.5'
I	Sand Pack Interval (ft.)	5.0'
J	Bottom Material Interval (ft.)	NA
K	Conductor Casing Interval (ft.)	NA
L	Protective Cover Diameter (in.)	7.0"
M	Conductor Casing Diameter (in.)	NA
N	Upper Borehole Diameter (in.)	10.0"
O	Monument Footing Interval (ft.)	1.0'
	Well Centralizer Depth(s) (ft.)	NA

MATERIALS DATA

Monument Footing	1	Rapid set concrete 3/8" rock
Annular Seal	2	NA
Annular Seal	3	Volclay Grout
Annular Seal	4	Enviroplug 1/4" pellets
Sand Pack	5	10 to 20 ASTM
Bottom Material	6	Native
Conductor Casing		NA
Slotted Casing		0.020" slotted screen
Well Casing		Blank Sch. 40 PVC
Well Centralizers		NA
Protective Cover		Morrison Dubuque 418xA

WELL DESIGNATION
B-4-p



SECTION VIEW (not to scale)

CLIENT ACKNOWLEDGEMENT

NOTES:

Sand pack consists of #2/12 RMC Lonestar sand which equals 10 to 20 ASTM.

WELL CONSTRUCTION DETAILS

PRECISION

BORING DESIGNATION: B-4-p-1

INSTALLATION DATE: Feb. 11, 2000 BY: Mark Kram

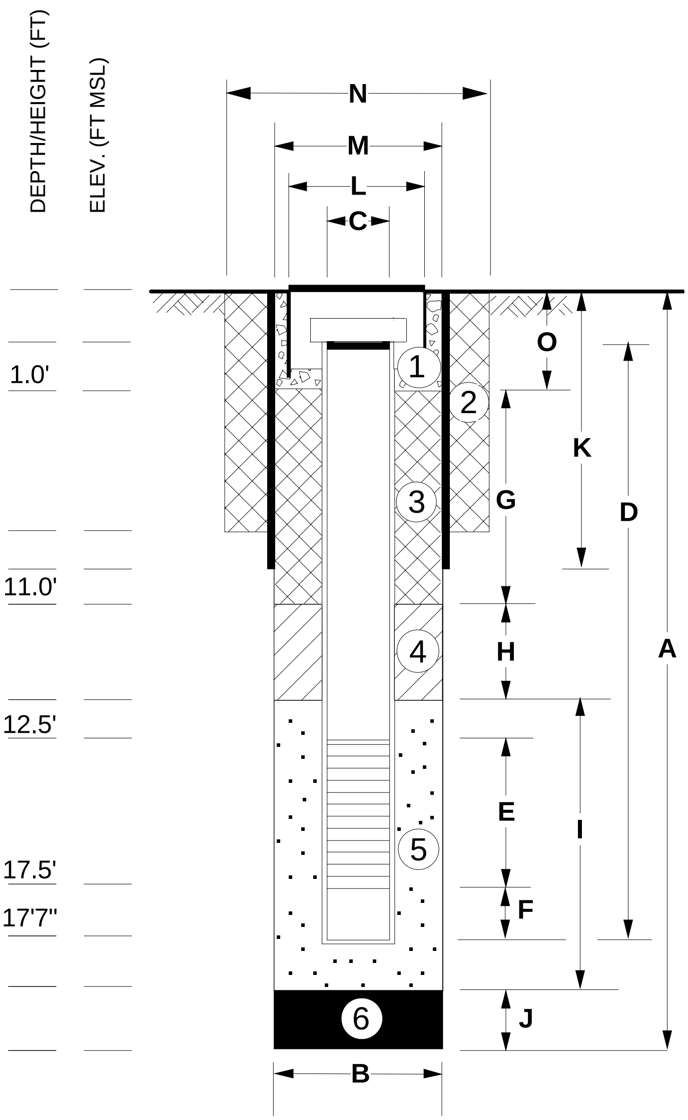
DIMENSIONS

A	Total Depth of Boring (ft.)	17'7"
B	Borehole Diameter (in.)	2.50"
C	Well Casing Diameter (in.)	0.75"
D	Well Casing Length (ft.)	12.5'
E	Well Casing Slotted Interval (ft.)	5.0'
F	Well Casing End Cap or Sump (ft.)	2.0"
G	Annular Seal Interval (ft.)	10.0'
H	Annular Seal Interval (ft.)	1.5'
I	Sand Pack Interval (ft.)	5.2'
J	Bottom Material Interval (ft.)	NA
K	Conductor Casing Interval (ft.)	NA
L	Protective Cover Diameter (in.)	7.0"
M	Conductor Casing Diameter (in.)	NA
N	Upper Borehole Diameter (in.)	10.0"
O	Monument Footing Interval (ft.)	1.0'
	Well Centralizer Depth(s) (ft.)	NA

MATERIALS DATA

Monument Footing	1		Rapid set concrete 3/8" rock
Annular Seal	2		NA
Annular Seal	3		Volclay Grout
Annular Seal	4		Enviroplug 1/4" pellets
Sand Pack	5		10 to 20 ASTM pre-pack
Bottom Material	6		Native
Conductor Casing			NA
Slotted Casing		3/4"	0.020" slotted screen
Well Casing		3/4"	Blank Sch. 40 PVC
Well Centralizers			NA
Protective Cover			Morrison Dubuque 418xA

WELL DESIGNATION
B-4-p-1



SECTION VIEW (not to scale)

CLIENT ACKNOWLEDGEMENT

NOTES:

Sand pack consists of ASTM 10 to 20 sand.
Rubber washers are set at top of filter pack and screen to prevent bentonite seal from descending into screen zone.

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WELL CONSTRUCTION DETAILS

BORING DESIGNATION: B-4-p-c-v

INSTALLATION
DATE: Feb. 11, 2000 BY: Mark Kram

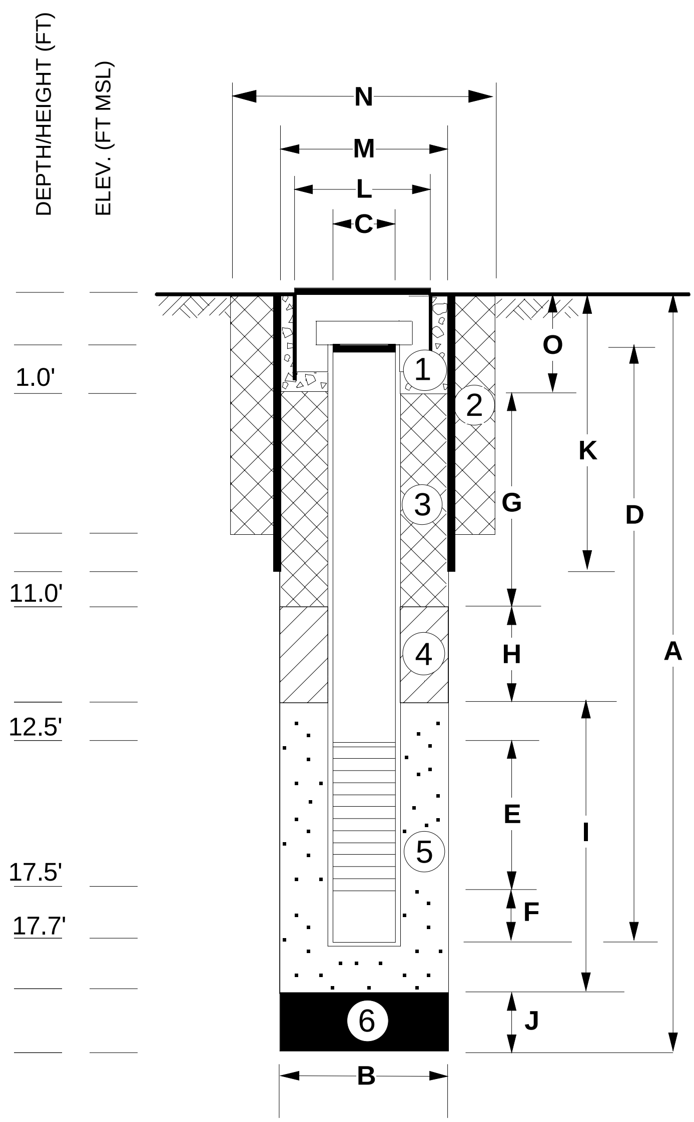
WELL DESIGNATION
B-4-p-c-v

DIMENSIONS

A	Total Depth of Boring (ft.)	17.7'
B	Borehole Diameter (in.)	2.50"
C	Well Casing Diameter (in.)	0.75"
D	Well Casing Length (ft.)	12.5'
E	Well Casing Slotted Interval (ft.)	5.0'
F	Well Casing End Cap or Sump (ft.)	0.2"
G	Annular Seal Interval (ft.)	10.0'
H	Annular Seal Interval (ft.)	1.5'
I	Sand Pack Interval (ft.)	5.2'
J	Bottom Material Interval (ft.)	NA
K	Conductor Casing Interval (ft.)	NA
L	Protective Cover Diameter (in.)	7.0"
M	Conductor Casing Diameter (in.)	NA
N	Upper Borehole Diameter (in.)	10.0"
O	Monument Footing Interval (ft.)	1.0'
	Well Centralizer Depth(s) (ft.)	NA

MATERIALS DATA

Monument Footing	1	Rapid set concrete 3/8" rock
Annular Seal	2	NA
Annular Seal	3	Volclay Grout
Annular Seal	4	Enviroplug 1/4" pellets
Sand Pack	5	20 to 40 ASTM pre-pack
Bottom Material	6	Native
Conductor Casing		NA
Slotted Casing	3/4"	0.010" slotted screen
Well Casing	3/4"	Blank Sch. 40 PVC
Well Centralizers		NA
Protective Cover		Morrison Dubuque 418xA



SECTION VIEW (not to scale)

CLIENT ACKNOWLEDGEMENT

NOTES:

Sand pack consists of 20 to 40 ASTM sand.
Rubber washers are set above screened interval and filter pack.

APPENDIX F

Well Development Logs

WELL DEVELOPMENT FORM
PRECISION SAMPLING INC.

A1-1

Project No.	Well Comparison	Date:	2/15/00
Site Location:	Port Hueneme	Well:	1P1 Cell A
Name:	Well Cluster "A"	Depth/Diameter:	11.5' / 3/4"
Development Method:	Diaphram Pump	Initial DTW:	
Total Water Removed:	0.5 Gallon	Final DTW:	
Water Contained ?	NA	Horiba U-10	

Important! Estimate of specific capacity or recharge to well:

Time	Cum. Vol. Removed	Turbidity (NTU)	Temp (C)	EC mS/cm	pH	Dissolved O_2 mg/l	Salinity %	Appearance/Comments
								Could not pull enough water to develop
								well. Water level very low.

WELL DEVELOPMENT FORM
PRECISION SAMPLING INC.

A1-2

Project No.	Well Comparison	Date:	2/15/00
Site Location:	Port Hueneme	Well:	1P Cell A
Name:	Well Cluster "A"	Depth/Diameter:	11.5' / 2.0"
Development Method:	Diaphram Pump	Initial DTW:	
Total Water Removed:	0.5 Gallon	Final DTW:	
Water Contained ?	NA	Horiba U-10	
Important! Estimate of specific capacity or recharge to well:		Very Low Recharge	

Time	Cum. Vol. Removed	Turbidity (NTU)	Temp (C)	EC mS/cm	pH	Dissolved O_2 mg/l	Salinity %	Appearance/Comments
								Could not pull enough water to develop
								well. Water level very low.

WELL DEVELOPMENT FORM
PRECISION SAMPLING INC.

A1-3

Project No.	Well Comparison	Date:	2/10/00
Site Location:	Port Hueneme	Well:	1D Cell A
Name:	Well Cluster "A"	Depth/Diameter:	11 ft.10 in. / 2.0"
Development Method:	Stainless Steel Bailer (7.0 ft.)	Initial DTW:	
Total Water Removed:	20 gallons	Final DTW:	
Water Contained ?	Drum	Horiba U-10	
Important! Estimate of specific capacity or recharge to well:		One Foot of recharge per half hour	

Time	Cum. Vol. Removed	Turbidity (NTU)	Temp (C)	EC mS/cm	pH	Dissolved O_2 mg/l	Salinity %	Appearance/Comments
1159	5 gal	999	19.0	3.56	7.19	1.88	0.17%	
Purged dry after 7.0 gallons								
1228	10 gal	999	19.4	3.60	7.10	2.70	0.18%	
1236	15 gal	834	19.6	3.60	7.04	2.28	0.18%	
1243	20 gal	750	19.7	3.59	7.03	2.53	0.18%	

WELL DEVELOPMENT FORM
PRECISION SAMPLING INC.

A2-1

Project No.	Well Comparison	Date:	2/15/00
Site Location:	Port Hueneme	Well:	2P1 Cell A
Name:	Well Cluster "A"	Depth/Diameter:	12.0' / 3/4"
Development Method:	Diaphram Pump	Initial DTW:	
Total Water Removed:	12 Gallons	Final DTW:	
Water Contained ?	Drum	Horiba U-10	
Important! Estimate of specific capacity or recharge to well:		Very Slow Recharge	

Time	Cum. Vol. Removed	Turbidity (NTU)	Temp (C)	EC mS/cm	pH	Dissolved O2 mg/l	Salinity %	Appearance/Comments
1220	5	208	20.0	3.48	7.02	3.56	0.174	Well was run dry constantly.
1225	8	105	20.0	3.58	6.93	4.44	0.18	
1230	10	280	20.0	3.60	6.93	3.88	0.18	
1235	12	250	20.0	3.60	6.93	4.17	0.18	

WELL DEVELOPMENT FORM
PRECISION SAMPLING INC.

A2-2

Project No.	**Well Comparison**	**Date:**	**2/15/00**
Site Location:	**Port Hueneme**	**Well:**	**2P Cell A**
Name:	**Well Cluster "A"**	**Depth/Diameter:**	**12.0' / 2.0"**
Development Method:	**Diaphram Pump**	**Initial DTW:**	
Total Water Removed:	**20 Gallons**	**Final DTW:**	
Water Contained ?	**Drum**	**Horiba U-10**	
Important! Estimate of specific capacity or recharge to well:		**Good Recharge**	

Time	Cum. Vol. Removed	Turbidity (NTU)	Temp (C)	EC mS/cm	pH	Dissolved O_2 mg/l	Salinity %	Appearance/Comments
1250	5	306	19.9	3.21	6.88	0.94	0.16	
1255	10	89	20.1	3.51	6.74	0.69	0.17	
1300	15	69	20.1	3.57	6.75	0.80	0.17	
1305	20	70	20.2	3.57	6.74	0.79	0.17	

WELL DEVELOPMENT FORM
PRECISION SAMPLING INC.

A2-3

Project No.	Well Comparison	Date:	February 10, 2000
Site Location:	Port Huneme	Well:	2D Cell A
Name:	Well Cluster" A"	Depth/Diameter:	12.5' / 2.0"
Development Method:	Stainless Steel Bailer (7.0 ft)	Initial DTW:	
Total Water Removed:	60 Gallons	Final DTW:	
Water Contained ?	Drum	Horiba U-10	
Important! Estimate of specific capacity or recharge to well:		Immediate	

Time	Cum. Vol. Removed	Turbidity (NTU)	Temp (C)	EC mS/cm	pH	Dissolved O_2 mg/l	Salinity %	Appearance/Comments
1311	5.0	999	19.7	3.88	7.07	2.91		
1315	10.0	999	19.9	3.60	6.98	2.46		
1319	15.0	999	19.9	3.47	6.96	2.07		
1325	20.0	999	19.5	3.44	6.91	1.02		
1331	25.0	999	19.6	3.39	6.92	1.98		
1337	30.0	999	19.8	3.36	6.90	2.61		
1341	35.0	999	19.6	3.40	6.98	3.65		
1346	40.0	999	19.4	3.27	6.90	1.78		
1351	45.0	999	19.2	3.32	6.93	2.41		
1400	50.0	999	19.6	3.32	6.96	2.35		
1405	55.0	999	19.6	3.36	7.03	2.85		
1410	60.0	999	19.1	3.25	6.96	2.48		

WELL DEVELOPMENT FORM
PRECISION SAMPLING INC.

A3-1

Project No.	Well Comparison	Date:	2/15/00
Site Location:	Port Hueneme	Well:	3P1 Cell A
Name:	Well Cluster "A"	Depth/Diameter:	19.0' / 3/4"
Development Method:	Diaphram Pump	Initial DTW:	
Total Water Removed:	25 Gallons	Final DTW:	
Water Contained ?	Drum	Horiba U-10	
Important! Estimate of specific capacity or recharge to well:		Good Recharge	

Time	Cum. Vol. Removed	Turbidity (NTU)	Temp (C)	EC mS/cm	pH	Dissolved O_2 mg/l	Salinity %	Appearance/Comments
1100	5 gal	838	20.5	3.24	6.85	0.62	0.16%	
1110	10 gal	143	20.5	3.22	6.87	0.65	0.16%	
1115	15 gal	88.0	21.0	3.23	6.82	0.69	0.16%	
1120	20 gal	76.0	21.1	3.22	6.82	0.80	0.16%	
1125	25 gal	70.0	21.2	3.22	6.82	0.81	0.16%	

WELL DEVELOPMENT FORM
PRECISION SAMPLING INC.

A3-2

Project No.	Well Comparison		Date:	2/15/00	
Site Location:	Port Hueneme		Well:	3P Cell A	
Name:	Well Cluster "A"		Depth/Diameter:	19.0' / 2.0"	
Development Method:	Diaphram Pump		Initial DTW:		
Total Water Removed:	15 Gallons		Final DTW:		
Water Contained ?	Drum		Horiba U-10		
Important! Estimate of specific capacity or recharge to well:			Good Recharge		

Time	Cum. Vol. Removed	Turbidity (NTU)	Temp (C)	EC mS/cm	pH	Dissolved O_2 mg/l	Salinity %	Appearance/Comments
1130	5 gal	588	20.0	3.14	6.90	0.98	0.15%	
1135	10 gal	295	20.0	3.23	6.81	0.69	0.16%	
1140	15 gal	127	20.0	3.23	6.83	0.76	0.16%	

WELL DEVELOPMENT FORM
PRECISION SAMPLING INC.

A3-3

Project No.	Well Comparison	Date:	2/10/00
Site Location:	Port Hueneme	Well:	3D Cell A
Name:	Well Cluster "A"	Depth/Diameter:	19.5' / 2.0"
Development Method:	Stainless Steel Bailer (7.0 ft)	Initial DTW:	
Total Water Removed:	55 Gallons	Final DTW:	
Water Contained ?	Drum	Horiba U-10	
Important! Estimate of specific capacity or recharge to well:		Immediate	

Time	Cum. Vol. Removed	Turbidity (NTU)	Temp (C)	EC mS/cm	pH	Dissolved O_2 mg/l	Salinity %	Appearance/Comments
1048	5 gal	999	19.9	3.06	7.17	1.83	0.15%	
1058	10 gal	999	20.1	3.10	7.20	2.82	0.15%	
1103	15 gal	999	20.0	3.13	7.17	1.92	0.15%	
1109	20 gal	999	20.1	3.14	7.17	2.48	0.15%	
1114	25 gal	999	20.1	3.13	7.18	2.47	0.15%	
1120	30 gal	999	20.4	3.13	7.14	1.46	0.15%	
1126	35 gal	999	20.6	3.12	7.15	1.56	0.15%	
1134	40 gal	999	20.4	3.11	7.13	1.56	0.15%	
1139	45 gal	999	20.7	3.11	7.16	1.73	0.15%	
1144	50 gal	999	20.2	3.12	7.13	1.84	0.15%	
1149	55 gal	999	20.6	3.11	7.15	2.18	0.15%	

WELL DEVELOPMENT FORM
PRECISION SAMPLING INC.

A4-4

Project No.	Well Comparison	Date:	2/15/00
Site Location:	Port Hueneme	Well:	4P1 Cell A
Name:	Well Cluster "A"	Depth/Diameter:	19.0' / 3/4"
Development Method:	Diaphram Pump	Initial DTW:	
Total Water Removed:	25 Gallons	Final DTW:	
Water Contained ?	Drum	Horiba U-10	
Important! Estimate of specific capacity or recharge to well:		Good Recharge	

Time	Cum. Vol. Removed	Turbidity (NTU)	Temp (C)	EC mS/cm	pH	Dissolved O2 mg/l	Salinity %	Appearance/Comments
1000	5 gal	445	19.9	3.18	6.97	0.97	0.15%	
1005	10 gal	268	21	3.25	6.91	0.84	0.16%	
1010	15 gal	115	21.0	3.25	6.87	0.87	0.16%	
1015	20 gal	83	21.1	3.25	6.86	0.87	0.16%	
1020	25 gal	60	21.2	3.25	6.86	0.88	0.16%	

WELL DEVELOPMENT FORM
PRECISION SAMPLING INC.

A4-2

Project No.	Well Comparison	Date:	2/15/00
Site Location:	Port Hueneme	Well:	4P Cell A
Name:	Well Cluster "A"	Depth/Diameter:	19.0' / 2.0"
Development Method:	Diaphram Pump	Initial DTW:	
Total Water Removed:	25 Gallons	Final DTW:	
Water Contained ?	Drum	Horiba U-10	

Important! Estimate of specific capacity or recharge to well:

Time	Cum. Vol. Removed	Turbidity (NTU)	Temp (C)	EC mS/cm	pH	Dissolved O2 mg/l	Salinity %	Appearance/Comments
1025	5	515	20.7	3.19	6.93	0.80	0.15	
1030	10	305	21.2	3.23	6.85	0.63	0.16	
1035	15	218	21.2	3.25	6.85	0.79	0.16	
1040	20	176	21.0	3.24	6.88	0.83	0.16	
1045	25	150	21.1	3.22	6.88	0.79	0.16	

WELL DEVELOPMENT FORM
PRECISION SAMPLING INC.

A4-3

Project No.	Well Comparison	Date:	2/10/00
Site Location:	Port Hueneme	Well:	4D Cell A
Name:	Well Cluster "A"	Depth/Diameter:	19.5' / 2.0"
Development Method:	Stainless Steel Bailer (7.0 ft)	Initial DTW:	
Total Water Removed:	55 Gallons	Final DTW:	
Water Contained ?	Drum	Horiba U-10	
Important! Estimate of specific capacity or recharge to well:		Immediate	

Time	Cum. Vol. Removed	Turbidity (NTU)	Temp (C)	EC mS/cm	pH	Dissolved O_2 mg/l	Salinity %	Appearance/Comments
845	5 gal		19.6					
1049	55 gal	999	19.6	3.15	7.10	NR	0.15%	Did not record readings every five gallons because turbidity remained extremely high.

WELL DEVELOPMENT FORM
PRECISION SAMPLING INC.

B1-1

Project No.	Well Comparison	Date:	2/15/00
Site Location:	Port Hueneme	Well:	1PNP Cell B
Name:	Well Cluster "B"	Depth/Diameter:	12.0' / 3/4"
Development Method:	Peristaltic Pump	Initial DTW:	
Total Water Removed:	25 Gallons	Final DTW:	
Water Contained ?	Drum	Horiba U-10	
Important! Estimate of specific capacity or recharge to well:		Good Recharge	

Time	Cum. Vol. Removed	Turbidity (NTU)	Temp (C)	EC mS/cm	pH	Dissolved O2 mg/l	Salinity %	Appearance/Comments
850	5 gal	512	20.9	3.09	6.90	0.71	0.15%	
900	10 gal	70.0	20.9	3.08	6.86	0.84	0.15%	
905	15 gal	47.0	20.8	3.11	6.87	0.85	0.15%	
910	25 gal	45.0	21.0	3.10	6.88	0.75	0.15%	

WELL DEVELOPMENT FORM
PRECISION SAMPLING INC.

B1-2

Project No.	Well Comparison	Date:	2/13/00
Site Location:	Port Hueneme	Well:	1P1 Cell B
Name:	Well Cluster "B"	Depth/Diameter:	12.0' / 3/4"
Development Method:	Diaphram Pump	Initial DTW:	
Total Water Removed:	20 Gallons	Final DTW:	
Water Contained ?	NA	Horiba U-10	
Important! Estimate of specific capacity or recharge to well:		Good Recharge	

Time	Cum. Vol. Removed	Turbidity (NTU)	Temp (C)	EC mS/cm	pH	Dissolved O_2 mg/l	Salinity %	Appearance/Comments
1200	5 gal	128	19.2	3.10	7.14	3.25	0.15%	
1205	10 gal	47.0	19.6	3.13	7.04	2.76	0.15%	
1215	15 gal	22.0	19.8	3.13	7.08	2.58	0.15%	
1225	20 gal	15.0	19.6	3.12	7.06	2.86	0.15%	

Page ______ of ______

WELL DEVELOPMENT FORM
PRECISION SAMPLING INC.

B1-3

Project No.	Well Comparison	Date:	2/13/00
Site Location:	Port Hueneme	Well:	1PCV Cell B
Name:	Well Cluster "B"	Depth/Diameter:	12.0' / 3/4"
Development Method:	Peristaltic Pump	Initial DTW:	
Total Water Removed:	17 gallons	Final DTW:	
Water Contained ?	Drum	Horiba U-10	
Important! Estimate of specific capacity or recharge to well:		Very Slow Recharge.	

Time	Cum. Vol. Removed	Turbidity (NTU)	Temp (C)	EC mS/cm	pH	Dissolved O_2 mg/l	Salinity %	Appearance/Comments
1115	5	339	18.9	3.08	7.08	1.61	0.15%	
1130	10	175	18.9	3.11	7.12	1.20	0.15%	
1200	15	15.0	19.0	3.13	7.06	1.50	0.15%	
1210	17	4.00	19.2	3.14	7.02	1.58	0.15%	

Page ______ of ______

WELL DEVELOPMENT FORM
PRECISION SAMPLING INC.

B1-4

Project No.	Well Comparison	Date:	2/13/00
Site Location:	Port Hueneme	Well:	1P Cell B
Name:	Well Cluster "B"	Depth/Diameter:	12.0' / 2.0"
Development Method:	Diaphram Pump	Initial DTW:	
Total Water Removed:	30 Gallons	Final DTW:	
Water Contained ?	Drum	Horiba U-10	
Important! Estimate of specific capacity or recharge to well:		Immediate	

Time	Cum. Vol. Removed	Turbidity (NTU)	Temp (C).	EC mS/cm	pH	Dissolved O_2 mg/l	Salinity %	Appearance/Comments
1000	5 gal	999	18.9	2.93	6.90	1.36	0.14%	
1015	10 gal	5.50	19.1	3.03	7.07	1.01	0.15%	
1030	15 gal	176	19.5	2.89	7.09	1.53	0.14%	
1040	20 gal	160	19.9	2.98	7.02	1.09	0.14%	
1100	25 gal	75.0	19.5	3.05	7.05	1.15	0.15%	
1115	30 gal	6.00	19.0	3.03	7.07	1.20	0.15%	

WELL DEVELOPMENT FORM
PRECISION SAMPLING INC.

B1-5

Project No.	Well Comparison	Date:	2/15/00
Site Location:	Port Hueneme	Well:	1D Cell B
Name:	Well Cluster "B"	Depth/Diameter:	11.5' / 2.0"
Development Method:	Diaphram Pump	Initial DTW:	
Total Water Removed:	25 Gallons	Final DTW:	
Water Contained ?	Drum	Horiba U-10	
Important! Estimate of specific capacity or recharge to well:		Immediate	

Time	Cum. Vol. Removed	Turbidity (NTU)	Temp (C)	EC mS/cm	pH	Dissolved O_2 mg/l	Salinity %	Appearance/Comments
830	5.0	262	20.1	3.16	7.06	1.12	0.15%	
835	15.0	56.0	20.5	3.19	7.00	1.12	0.15%	
840	25.0	44.0	20.8	3.18	6.91	1.0	0.15%	

WELL DEVELOPMENT FORM
PRECISION SAMPLING INC.

B2-1

Project No.	Well Comparison	Date:	2/14/00
Site Location:	Port Hueneme	Well:	2PNP Cell B
Name:	Well Cluster "B"	Depth/Diameter:	12.0' / 3/4"
Development Method:	Diaphram Pump	Initial DTW:	
Total Water Removed:	25 Gallons	Final DTW:	
Water Contained ?	Drum	Horiba U-10	
Important! Estimate of specific capacity or recharge to well:		Good Recharge	

Time	Cum. Vol. Removed	Turbidity (NTU)	Temp.(C)	EC mS/cm	pH	Dissolved O_2 mg/l	Salinity %	Appearance/Comments
1500	5 gal	178	20.4	3.08	6.92	0.97	0.15%	
1505	10 gal	161	20.4	3.08	6.95	0.91	0.15%	
1510	20 gal	186	19.8	3.06	6.95	1.18	0.15%	
1520	25 gal	39.0	20.4	3.07	6.99	1.00	0.15%	

WELL DEVELOPMENT FORM
PRECISION SAMPLING INC.

B2-2

Project No.	Well Comparison	Date:	2/13/00
Site Location:	Port Hueneme	Well:	2P1 Cell B
Name:	Well Cluster "B"	Depth/Diameter:	12.0 ' / 3/4"
Development Method:	Peristaltic Pump	Initial DTW:	
Total Water Removed:	10 Gallons	Final DTW:	
Water Contained ?	Drum	Horiba U-10	
Important! Estimate of specific capacity or recharge to well:		Slow Recharge	

Time	Cum. Vol. Removed	Turbidity (NTU)	Temp (C)	EC mS/cm	pH	Dissolved O2 mg/l	Salinity %	Appearance/Comments
1400	5 gal	130	17.4	3.17	7.12	0.74	0.15%	
1430	10 gal	6.00	18.8	3.22	6.91	0.75	0.16%	

Page ______ of ______

WELL DEVELOPMENT FORM
PRECISION SAMPLING INC.

B2-3

Project No.	Well Comparison	Date:	2/11/00
Site Location:	Port Hueneme	Well:	2PCV Cell B
Name:	Well Cluster "B"	Depth/Diameter:	12.0' / 3/4"
Development Method:	Peristaltic Pump	Initial DTW:	
Total Water Removed:	10 Gallons	Final DTW:	
Water Contained ?	Drum	Horiba U-10	
Important! Estimate of specific capacity or recharge to well:		Immediate	

Time	Cum. Vol. Removed	Turbidity (NTU)	Temp (C)	EC mS/cm	pH	Dissolved O_2 mg/l	Salinity %	Appearance/Comments
1245	5 gal	21.0	18.9	3.29	7.03	0.80	0.16%	
1305	10 gal	3.00	18.6	3.25	7.08	1.46	0.16%	

WELL DEVELOPMENT FORM
PRECISION SAMPLING INC.

B2-4

Project No.	Well Comparison	Date:	2/13/00
Site Location:	Port Hueneme	Well:	2P Cell B
Name:	Well Cluster "B"	Depth/Diameter:	12.0' / 2.0"
Development Method:	Diaphram Pump	Initial DTW:	
Total Water Removed:	35 Gallons	Final DTW:	
Water Contained ?	Drum	Horiba U-10	
Important! Estimate of specific capacity or recharge to well:		Immediate	

Time	Cum. Vol. Removed	Turbidity (NTU)	Temp (C)	EC mS/cm	pH	Dissolved O2 mg/l	Salinity %	Appearance/Comments
1240	5 gal	999	18.8	2.79	7.33	4.41	0.13%	
1300	10 gal	970	18.9	3.00	7.26	4.73	0.14%	
1310	15 gal	84.0	19.3	3.02	7.19	4.63	0.15%	
1400	20 gal	100	18.7	3.02	7.31	4.59	0.15%	
1415	25 gal	25.0	19.4	3.03	7.12	4.55	0.15%	
1425	30 gal	13.0	19.2	3.00	7.09	4.89	0.14%	
1430	35 gal	6.00	19.3	3.00	7.07		0.14%	

Page ______ of ______

WELL DEVELOPMENT FORM
PRECISION SAMPLING INC.

B2-5

Project No.	Well Comparison	Date:	2/14/00
Site Location:	Port Hueneme	Well:	2D Cell B
Name:	Well Cluster "B"	Depth/Diameter:	12.0' / 2.0"
Development Method:	Diaphram Pump	Initial DTW:	
Total Water Removed:	30 Gallons	Final DTW:	
Water Contained ?	Drum	Horiba U-10	
Important! Estimate of specific capacity or recharge to well:		Immediate	

Time	Cum. Vol. Removed	Turbidity (NTU)	Temp (C)	EC mS/cm	pH	Dissolved O2 mg/l	Salinity %	Appearance/Comments
1430	5 gal	999	20.3	3.08	6.89	0.92	0.15%	
1435	10 gal	141	20.3	3.08	6.99	1.10	0.15%	
1440	15 gal	64	20.5	3.07	6.98	0.85	0.15%	
1445	20 gal	53	20.5	3.07	6.97	1.03	0.15%	
1450	30 gal	51	20.5	3.07	6.94	1.07	0.15%	

WELL DEVELOPMENT FORM
PRECISION SAMPLING INC.

B3-1

Project No.	Well Comparison	Date:	2/14/00
Site Location:	Port Hueneme	Well:	3PNP Cell B
Name:	Well Cluster "B"	Depth/Diameter:	18.0' / 3/4"
Development Method:	Diaphram Pump	Initial DTW:	
Total Water Removed:	30 Gallons	Final DTW:	
Water Contained ?	Drum	Horiba U-10	
Important! Estimate of specific capacity or recharge to well:		Immediate	

Time	Cum. Vol. Removed	Turbidity (NTU)	Temp (C)	EC mS/cm	pH	Dissolved O_2 mg/l	Salinity %	Appearance/Comments
1020	5 gal	169	21.5	3.06	7.15	0.83	0.15%	
1025	10 gal	134	21.6	3.05	7.12	0.98	0.15%	
1030	15 gal	126	21.4	3.07	7.17	0.77	0.15%	
1040	20 gal	89.0	21.5	3.07	7.15	1.05	0.15%	
1045	25 gal	50.0	21.6	3.09	7.16	0.85	0.15%	
1050	30 gal	45.0	21.3	3.05	7.11	0.97	0.15%	

WELL DEVELOPMENT FORM
PRECISION SAMPLING INC.

B3-2

Project No.	Well Comparison	Date:	2/14/00
Site Location:	Port Hueneme	Well:	3P1 Cell B
Name:	Well Cluster "B"	Depth/Diameter:	18.0' / 3/4"
Development Method:	Peristaltic Pump	Initial DTW:	
Total Water Removed:	15 Gallons	Final DTW:	
Water Contained ?	Drum	Horiba U-10	
Important! Estimate of specific capacity or recharge to well:		Immediate	

Time	Cum. Vol. Removed	Turbidity (NTU)	Temp (C)	EC mS/cm	pH	Dissolved O2 mg/l	Salinity %	Appearance/Comments
1015	5 gal	53	20.8	3.06	7.13	0.99	0.15%	
1030	7 gal	23	20.5	3.07	7.08	0.82	0.15%	
1040	10 gal	21	20.8	3.08	7.11	0.63	0.15%	
1100	13 gal	20	21.1	3.09	7.06	0.92	0.15%	
1110	15 gal	20	21.1	3.08	7.11	0.95	0.15%	

WELL DEVELOPMENT FORM
PRECISION SAMPLING INC.

B3-3

Project No.	Well Comparison	Date:	2/14/00
Site Location:	Port Hueneme	Well:	3PCV Cell B
Name:	Well Cluster "B"	Depth/Diameter:	18.0' / 3/4"
Development Method:	Peristaltic Pump	Initial DTW:	
Total Water Removed:	17 Gallons	Final DTW:	
Water Contained ?	Drum	Horiba U-10	
Important! Estimate of specific capacity or recharge to well:		Immediate	

Time	Cum. Vol. Removed	Turbidity (NTU)	Temp (C)	EC mS/cm	pH	Dissolved O_2 mg/l	Salinity %	Appearance/Comments
900	5 gal	11	19.5	3.08	6.86	0.70	0.15%	
905	7 gal	10	19.4	3.10	7.08	0.80	0.15%	
915	10 gal	9.0	20.0	3.10	7.2	1.05	0.15%	
930	12 gal	7.0	20.4	3.09	7.10	0.53	0.15%	
940	14 gal	7.0	20.5	3.09	7.09	0.50	0.15%	
955	17 gal	7.0	20.7	3.10	7.11	0.78	0.15%	

WELL DEVELOPMENT FORM
PRECISION SAMPLING INC.

B3-4

Project No.	Well Comparison	Date:	2/14/00
Site Location:	Port Hueneme	Well:	3P Cell B
Name:	Well Cluster "B"	Depth/Diameter:	18.0' / 2.0"
Development Method:	Diaphram Pump	Initial DTW:	
Total Water Removed:	25 Gallons	Final DTW:	
Water Contained ?	Drum	Horiba U-10	
Important! Estimate of specific capacity or recharge to well:		Immediate	

Time	Cum. Vol. Removed	Turbidity (NTU)	Temp (C)	EC mS/cm	pH	Dissolved O_2 mg/l	Salinity %	Appearance/Comments
925	5 gal	420	20.8	2.97	7.21	1.02	0.14%	
935	10 gal	107	21.1	3.04	7.12	0.83	0.15%	
950	15 gal	33.0	21.5	3.05	7.11	0.85	0.15%	
1000	20 gal	32.0	21.0	3.05	7.20	1.46	0.15%	
1010	25 gal	32.0	21.1	3.04	7.10	1.09	0.15%	

WELL DEVELOPMENT FORM
PRECISION SAMPLING INC.

B3-5

Project No.	Well Comparison	Date:	2/10/00
Site Location:	Port Hueneme	Well:	3D Cell B
Name:	Well Cluster "B"	Depth/Diameter:	18.5' / 2.0"
Development Method:	Stainless Steel Bailer (7.0 ft)	Initial DTW:	
Total Water Removed:	55 Gallons	Final DTW:	
Water Contained ?	Drum	Horiba U-10	
Important! Estimate of specific capacity or recharge to well:		Immediate	

Time	Cum. Vol. Removed	Turbidity (NTU)	Temp. (C)	EC mS/cm	pH	Dissolved O_2 mg/l	Salinity %	Appearance/Comments
1451	5 gal	999	20.5	2.90	7.14	1.71	0.14%	
1454	10 gal	999	20.8	2.92	7.16	2.45	0.15%	
1457	15 gal	999	20.8	2.93	7.2	2.72	0.14%	
1500	20 gal	999	20.9	2.92	7.2	2.79	0.14%	
1503	25 gal	999	20.9	2.93	7.16	2.82	0.14%	
1506	30 gal	999	21.2	2.91	7.14	3.27	0.14%	
1508	35 gal	999	21.1	2.91	7.09	2.61	0.14%	
1510	40 gal	999	21.2	2.91	7.1	3.01	0.14%	
1513	45 gal	999	21.1	2.92	7.15	3.96	0.14%	
1516	50 gal	999	21.0	2.90	7.12	3.46	0.14%	
1517	55 gal	999	21.0	2.90	7.11	3.63	0.14%	

WELL DEVELOPMENT FORM
PRECISION SAMPLING INC.

B4-1

Project No.	Well Comparison	Date:	2/14/00
Site Location:	Port Hueneme	Well:	4PNP Cell B
Name:	Well Cluster "B"	Depth/Diameter:	17.5' / 3/4"
Development Method:	Peristaltic Pump	Initial DTW:	
Total Water Removed:	10 Gallons	Final DTW:	
Water Contained ?	Drum	Horiba U-10	
Important! Estimate of specific capacity or recharge to well:		Immediate	

Time	Cum. Vol. Removed	Turbidity (NTU)	Temp (C)	EC mS/cm	pH	Dissolved O_2 mg/l	Salinity %	Appearance/Comments
1445	3 gal	999	19.9	3.03	7.04	0.80	0.15%	
1455	5 gal	49	19.9	3.05	6.98	0.80	0.15%	
1505	10 gal	39	20.0	3.07	6.99	0.81	0.15%	

WELL DEVELOPMENT FORM
PRECISION SAMPLING INC.

B4-2

Project No.	Well Comparison	Date:	2/14/00
Site Location:	Port Hueneme	Well:	4P1 Cell B
Name:	Well Cluster "B"	Depth/Diameter:	17.5' / 3/4"
Development Method:	Peristaltic Pump	Initial DTW:	
Total Water Removed:	20 Gallons	Final DTW:	
Water Contained ?	Drum	Horiba U-10	
Important! Estimate of specific capacity or recharge to well:		Immediate	

Time	Cum. Vol. Removed	Turbidity (NTU)	Temp (C)	EC mS/cm	pH	Dissolved O_2 mg/l	Salinity %	Appearance/Comments
1250	3 gal	34	18.5	3.22	7.10	1.26	0.16%	
1305	5 gal	13	18.9	3.21	7.11	1.29	0.16%	
1345	10 gal	14	20.1	3.23	7.00	0.69	0.16%	
1400	13 gal	18	19.9	3.24	6.97	0.79	0.16%	
1405	15 gal	15	19.9	3.25	6.96	0.80	0.16%	
1430	20 gal	20	19.8	3.26	6.92	0.87	0.16%	

WELL DEVELOPMENT FORM
PRECISION SAMPLING INC.

B4-3

Project No.	Well Comparison	Date:	2/14/00
Site Location:	Port Hueneme	Well:	4PCV Cell B
Name:	Well Cluster "B"	Depth/Diameter:	17.5' / 3/4"
Development Method:	Diaphram Pump	Initial DTW:	
Total Water Removed:	30 Gallons	Final DTW:	
Water Contained ?	Drum	Horiba U-10	
Important! Estimate of specific capacity or recharge to well:		Immediate	

Time	Cum. Vol. Removed	Turbidity (NTU)	Temp (C)	EC mS/cm	pH	Dissolved O_2 mg/l	Salinity %	Appearance/Comments
1355	5 gal	123	20.9	3.20	7.00	0.97	0.15%	
1400	10 gal	52	21.0	3.22	6.99	0.98	0.16%	
1405	15 gal	55	21.0	3.20	6.99	0.55	0.16%	
1410	20 gal	35	21.1	3.20	6.97	0.91	0.15%	
1415	25 gal	29	20.9	3.17	6.98	1.06	0.15%	
1420	30 gal	29	20.8	3.17	6.99	0.86	0.15%	

WELL DEVELOPMENT FORM
PRECISION SAMPLING INC.

B4-4

Project No.	Well Comparison	Date:	2/14/00
Site Location:	Port Hueneme	Well:	4P Cell B
Name:	Well Cluster "B"	Depth/Diameter:	17.5' / 2.0"
Development Method:	Diaphram Pump	Initial DTW:	
Total Water Removed:	25 Gallons	Final DTW:	
Water Contained ?	Drum	Horiba U-10	
Important! Estimate of specific capacity or recharge to well:		Immediate	

Time	Cum. Vol. Removed	Turbidity (NTU)	Temp (C)	EC mS/cm	pH	Dissolved O_2 mg/l	Salinity %	Appearance/Comments
1055	5 gal	454	21.0	3.24	7.04	1.18	0.16%	
1100	10 gal	132	21.3	3.19	7.08	1.02	0.15%	
1105	15 gal	130	21.3	3.19	7.06	0.95	0.15%	
1110	20 gal	87	21.4	3.18	7.04	0.93	0.15%	
1115	25 gal	71	21.5	3.16	7.08	1.01	0.15%	

WELL DEVELOPMENT FORM
PRECISION SAMPLING INC.

B4-5

Project No.	Well Comparison	Date:	2/10/00
Site Location:	Port Hueneme	Well:	4D Cell B
Name:	Well Cluster "B"	Depth/Diameter:	18.0" / 2.0"
Development Method:	Stainless Steel Bailer (7.0 ft)	Initial DTW:	
Total Water Removed:	55 Gallons	Final DTW:	
Water Contained ?	Drum	Horiba U-10	
Important! Estimate of specific capacity or recharge to well:		Immediate	

Time	Cum. Vol. Removed	Turbidity (NTU)	Temp (C)	EC mS/cm	pH	Dissolved O2 mg/l	Salinity %	Appearance/Comments
1526	5 gal	999	20.5	2.94	7.06	1.47	0.14%	
1529	10 gal	999	20.6	2.96	7.07	2.62	0.14%	
1531	15 gal	999	20.6	2.94	7.05	2.27	0.14%	
1535	20 gal	999	20.7	2.95	7.06	2.87	0.14%	
1538	25 gal	999	20.7	2.97	7.00	2.89	0.14%	
1541	30 gal	999	21.0	2.95	7.02	3.07	0.14%	
1544	35 gal	999	20.8	2.94	7.05	3.21	0.14%	
1547	40 gal	999	21.1	2.96	7.06	3.73	0.14%	
1549	45 gal	999	20.7	3.00	7.05	3.32	0.14%	
1550	50 gal	999	20.9	2.93	7.04	3.21	0.14%	
1554	55 gal	999	20.9	2.96	6.99	3.34	0.14%	

APPENDIX G

Analytical Results

MTBE March 00, Round 1

Well Comparison Test

3/22/00

Sampled by Dorothy Cannon

[MTBE] by Cristin Bruce

Detection limit = 0.005 mg/L

Type	Sample	Replicate (all samples reported in mg-MTBE/L-water)				Capco	Mean in mg/L	STDEV
Cluster A1 2ft Screen 9.5 to 11.5ft								
p1	A1-1	ND	ND	ND			ND	
p	A1-2	0.014	0.014	0.013			0.013	0.00068
d	A1-3	0.007	0.007	0.006	**	ND	0.007	0.00086
Cluster A2 5ft Screen 7 to 12ft								
p1	A2 -1	ND	ND	ND			ND	
p	A2 -2	ND	ND	ND			ND	
d	A2 -3	0.006	ND	ND			0.006	
Cluster A3 2ft Screen 17 to 19ft								
p1	A3 -1	0.016	0.028	0.022			0.022	0.00597
p	A3 -2	0.014	0.019	0.023			0.019	0.00451
d	A3 -3	0.052	0.052	0.051			0.052	0.00086
Cluster A4 5ft Screen 14 to 19ft								
p1	A4 -1	0.006	0.007	0.005	**		0.006	0.001
p	A4 -2	0.012	0.007	0.012			0.010	0.00259
d	A4 -3	0.007	0.007	0.006	**		0.007	0.00086

Type	Sample					Capco	Mean in mg/L	STDEV
Cluster B1 2ft Screen 10 to 12ft								
pnp	B1-1	0.100	0.100	0.091			0.097	0.0052
p1	B1-2	0.129	0.129	0.132			0.130	0.0016
pcv	B1-3	0.068	0.061	0.074			0.068	0.0065
p	B1-4	0.079	0.049	0.036		0.081	0.055	0.0222
d	B1-5	0.098	0.099	0.100			0.099	0.001
Cluster B2 5ft Screen 7 to 12ft								
pnp	B2 -1	0.076	0.063	0.078			0.072	0.0082
p1	B2 -2	0.078	0.070	0.075			0.074	0.0039
pcv	B2 -3	0.046	0.048	0.046			0.047	0.0014
p	B2 -4	0.084	0.088	0.081			0.084	0.0038
d	B2 -5	0.070	0.078	0.055			0.068	0.0119
Cluster B3 2ft Screen 16 to18ft								
pnp	B3 -1	0.045	0.048	0.048			0.047	0.0017
p1	B3 -2	0.031	0.030	0.030			0.030	0.0009
pcv	B3 -3	0.034	0.034	0.030			0.033	0.0026
p	B3 -4	0.016	0.028	0.028			0.024	0.0069
d	B3 -5	0.045	0.037	0.039			0.040	0.0039
Cluster B4 5ft Screen 12.5 to18ft								
pnp	B4 -1	0.040	0.048	0.048			0.045	0.0043
p1	B4 -2	0.119	0.125	0.122			0.122	0.003
pcv	B4 -3	0.130	0.121	0.130			0.127	0.0052
p	B4 -4	0.158	0.139	0.142		0.23	0.146	0.0104
d	B4 -5	0.052	0.051	0.049			0.051	0.0015

MTBE May 00, Round 2

Well Comparison Test
5/16/00 - 5/18/00
Sampled by Dale Lorenzana
[MTBE] by Cristin Bruce
Detection limit = 0.005 mg/L

Sample	Replicates (all samples reported in mg-MTBE/L-water)				Capco	Mean in mg/L	STDEV
Cluster A1 2ft Screen 9.5 to 11.5ft					Capco		
p1	A1 -1	0.005	0.009	0.007		0.007	0.0020
p	A1 -2	0.009	0.005	0.005		0.006	0.0023
d	A1 -3	0.004	0.006	0.006		0.005	0.0012
Cluster A2 5ft Screen 7 to 12ft							
p1	A2 -1	ND	0.006	0.005		0.006	0.0007
p	A2 -2	0.008	0.007	0.007		0.007	0.0006
d	A2 -3	ND	ND	ND			
Cluster A3 2ft Screen 17 to 19ft							
p1	A3 -1	0.031	0.027	0.031	Capco	0.030	0.0023
p	A3 -2	0.015	0.009	0.015	0.012	0.013	0.0035
d	A3 -3	0.072	0.055	0.061		0.063	0.0086
Cluster A4 5ft Screen 14 to 19ft							
p1	A4 -1	0.006	0.007	0.006		0.006	0.0006
p	A4 -2	0.012	0.011	0.008		0.010	0.0021
p	A4 -2*	0.006	0.004	0.012		0.007	0.0042
d	A4 -3	0.008	0.008	0.009		0.008	0.0006
	* Blind Sample for A4-2						
	A5 -1	0.006	0.004	0.012			

					Capco	Mean in mg/L	STDEV
Cluster B1 2ft Screen 10 to 12ft							
pnp	B1 -1	0.085	0.086	0.086		0.086	0.0006
p1	B1 -2	0.078	0.061	0.062		0.067	0.0095
pcv	B1 -3	0.092	0.052	0.077		0.074	0.0202
p	B1 -4	0.028	0.049	0.053		0.043	0.0134
d	B1 -5	0.101	0.064	0.085		0.083	0.0186
Cluster B2 5ft Screen 7 to 12ft							
pnp	B2 -1	0.032	0.051	0.046		0.043	0.0098
p1	B2 -2	0.063	0.056	0.057		0.059	0.0038
pcv	B2 -3	0.048	0.039	0.041		0.043	0.0047
pcv	B2 -3*	0.042	0.038	0.035		0.038	0.0035
p	B2 -4	0.101	0.083			0.092	0.0127
d	B2 -5	0.054	0.048	0.053		0.052	0.0032
	* B2-3 Blind						
Cluster B3 2ft Screen 16 to18ft					Capco		
pnp	B3 -1	0.062	0.063	0.068	0.061	0.064	0.0032146
p1	B3 -2	0.032	0.042	0.046		0.040	0.0072111
pcv	B3 -3	0.044	0.043	0.043		0.043	0.0005774
p	B3 -4	0.039	0.028	0.035		0.034	0.0055678
d	B3 -5	0.064	0.072	0.035		0.057	0.0194679
Cluster B4 5ft Screen 12.5 to18ft							
pnp	B4 -1	0.104	0.106	0.105		0.105	0.001
p1	B4 -2	0.124	0.123	0.116		0.121	0.0043589
pcv	B4 -3	0.095	0.093	0.105	Capco	0.098	0.0064291
p	B4 -4	0.113	0.111	0.111	0.120	0.112	0.0011547
d	B4 -5	0.092	0.085	0.089		0.089	0.0035119
	B5 -1	0.044	0.01	0.036			
	B5 -2	0.042	0.038	0.035			

MTBE July 00, Round 3

Well Comparison Test 7/11/00

Sampled by Dorothy Cannon [MTBE] by Eila Burr, AFRL Laboratory, Tyndall AFB

Detection limit = 0.005 mg/L

Type	Sample	Replicates	(mg MTBE/L water)			Mean (ug/L)	Variance (mg/L)	St. Dev. (mg/L)
Cluster A1 2ft Screen 9.5 to 11.5ft								
p1	A1-1	0.0091	0.0089	0.0086		8.9	7.3E-08	0.0003
p	A1-2	0.0077	0.0077	0.0080		7.8	2.4E-08	0.0002
d	A1-3	0.0069	0.0101	0.0091		8.7	2.6E-06	0.0016
	% Recovery		9.06%	6.17%				
	A1-3	0.007	-0.025	-0.026	*	-14.6	0.00035	0.0187
	* minus 0.035 mg/L Matrix Spike							
Cluster A2 5ft Screen 7 to 12ft								
p1	A2 -1	0.0079	0.0069	0.0071		7.3	3.1E-07	0.0006
p	A2 -2	0.0080	0.0078	0.0071		7.6	2.2E-07	0.0005
d	A2 -3	0.0066	0.0059	0.0053		5.9	4.4E-07	0.0007
Cluster A3 2ft Screen 17 to 19ft								
p1	A3 -1	0.0128	0.0129	0.0120		12.6	2.4E-07	0.0005
p	A3 -2	0.0184	0.0178	0.0170		17.7	4.5E-07	0.0007
d	A3 -3	0.0155	0.0146	0.0156		15.2	3.2E-07	0.0006
Cluster A4 5ft Screen 14 to 19ft								
p1	A4 -1	0.0123	0.0123	0.0164		13.7	5.6E-06	0.0024
p	A4 -2	0.0146	0.0153	0.0153		15.1	1.4E-07	0.0004
d	A4 -3	0.0150	0.0160	0.0158		15.6	2.7E-07	0.0005

Type	Sample					Mean (ug/L)
Cluster B1 2ft Screen 10 to 12ft						
pcv	B1 -1	0.1697	0.1722	0.1712		171.0
p1	B1 -2	0.1405	0.1486	0.1522		147.1
pnp	B1 -3	0.0939	0.0889	0.0854		89.4
p	B1 -4	0.0630	0.0805	0.0595		67.7
d	B1 -5	0.1909	0.2089	0.2065		202.1
Cluster B2 5ft Screen 7 to 12ft						
pcv	B2 -1	0.0705	0.0683	0.0812		73.3
p1	B2 -2	0.0665	0.0684	0.0688		67.9
pnp	B2 -3	0.0279	0.0289	0.0276		28.1
p	B2 -4	0.0612	0.0628	0.0615		61.8
d	B2 -5	0.0944	0.0884	0.0812		88.0
Cluster B3 2ft Screen 16 to18ft						
pcv	B3 -1	0.1116	0.1093	0.1189		113.3
p1	B3 -2	0.0657	0.0729	0.0637		67.5
pnp	B3 -3	0.1090	0.1026	0.1084		106.7
p	B3 -4	0.0714	0.0698	0.0700		70.4
d	B3-5	0.1050	0.1158	0.1045		108.5
	% Recovery		-4.66%	-4.20%		
		0.036	0.035	0.035	*	35.3
	* minus 0.035 mg/L Matrix Spike					
d	B3 -5	0.053	0.058	0.053		54.7
Cluster B4 5ft Screen 12.5 to18ft						
pcv	B4 -1	0.1119	0.1349	0.1180		121.6
p1	B4 -2	0.2049	0.2091	0.2248		212.9
pnp	B4 -3	0.2595	0.2723	0.2809		270.9
p	B4 -4	0.2651	0.2541	0.2664		261.8
d	B4 -5	0.1165	0.1262	0.1220		121.6
	% Recovery		27.77%	15.60%		
		0.059	0.091	0.087	*	79.0
	* minus 0.035 mg/L Matrix Spike					

MTBE August 00, Round 4

Well Comparison Test
5/16/00 - 5/18/00
Sampled by Dale Lorenzana
[MTBE] by Cristin Bruce
Detection limit = 0.005 mg/L

Sample	Replicates	(all samples reported in mg-MTBE/L-water)					Mean	STDEV
Cluster A1 2ft Screen 9.5 to 11.5ft						Capco	in mg/L	
p1	A1 -1	BDL (.004)	0.005	0.005			0.005	0.0000
p	A1 -2	BDL (.004)	0.005	0.005			0.005	0.0000
d	A1 -3	BDL (.004)	BDL (.004)	BDL (.003)				
Cluster A2 5ft Screen 7 to 12ft								
p1	A2 -1	BDL (.004)	BDL (.004)	BDL (.004)				
p	A2 -2	0.008	0.007	0.005			0.007	0.0015
d	A2 -3	0.005	0.005	0.005				
Cluster A3 2ft Screen 17 to 19ft								
p1	A3 -1	0.009	0.009	0.008			0.009	0.0006
p	A3 -2	0.007	0.009	0.011			0.009	0.0020
d	A3 -3	0.010	0.008	0.009			0.009	0.0010
Cluster A4 5ft Screen 14 to 19ft								
p1	A4 -1	0.006	0.005	0.006			0.006	0.0006
p	A4 -2	0.007	0.007	0.007			0.007	0.0000
d	A4 -3	0.007	0.006	0.006			0.006	0.0006
							0.005	0.0006
	A5-1	0.005	0.006	0.005		17		

							Mean	STDEV
Cluster B1 2ft Screen 10 to 12ft							in mg/L	
pnp	B1 -1	0.079	0.083	0.071			0.078	0.0061
p1	B1 -2	0.071	0.073	0.074			0.073	0.0015
pcv	B1 -3	0.024	0.018	0.017			0.020	0.0038
p	B1 -4	0.046	0.068	0.055			0.056	0.0111
d	B1 -5	0.080	0.090	0.086			0.085	0.0050
Cluster B2 5ft Screen 7 to 12ft								
pnp	B2 -1	0.040	0.038	0.040			0.039	0.0012
p1	B2 -2	0.047	0.042	0.045			0.045	0.0025
pcv	B2 -3	0.018	0.018	0.017			0.018	0.0006
p	B2 -4	0.048	0.044	0.043			0.045	0.0026
d	B2 -5	0.028	0.034	0.031			0.031	0.0030
Cluster B3 2ft Screen 16 to18ft								
pnp	B3 -1	0.038	0.037	0.039		Capco		
p1	B3 -2	0.031	0.027	0.032			0.030	0.0026458
pcv	B3 -3	0.044	0.048	0.048			0.047	0.0023094
p	B3 -4	0.025	0.024	0.025			0.025	0.0005774
d	B3 -5	0.040	0.051	0.054			0.048	0.0073711
Cluster B4 5ft Screen 12.5 to18ft								
pnp	B4 -1	0.051	0.052	0.04				
p1	B4 -2	0.104	0.102	0.097			0.101	0.0036056
pcv	B4 -3	0.105	0.118	0.113			0.112	0.0065574
p	B4 -4	0.116	0.111	0.118		Capco	0.115	0.0036056
d	B4 -5	0.043	0.044	0.049			0.045	0.0032146
	B5 -1	0.037				60		
	B5 -2	0.081	0.084			160		

Geo-Chemical

Cell A Round 1

				Cluster A1 2ft Screen 9.5 to 11.5ft			Cluster A2 5ft Screen 7 to 12ft			Cluster A3 2ft Screen 17 to 19ft			Cluster A4 5ft Screen 14 to 19ft			Cell A		
				A1-1	A1-2	A1-3	A2-1	A2-2	A2-3	A3-1	A3-2	A3-3	A4-1	A4-2	A4-3			
				p1	p	d	p1	p	d	p1	p	d	p1	p	d			
		PQL	Method	Mar-00	Mar-00	Mar-00	Mar-00	Mar-00	Mar-00	Mar-00	Mar-00	Mar-00	Mar-00	Mar-00	Mar-00	Min.	Avg.	Max.
Alkalinity (CaCO3)	mg/L	100	310.1	500	480	530	520	510	520	490	500	500	490	500	490	**480**	**503**	**530**
Bicarbonate (CaCO3	mg/L	100	310.1	500	480	530	520	510	520	490	500	500	490	500	490	**480**	**503**	**530**
Carbonate (CaCO3)	mg/L	100	310.1	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	**BQL**	**BQL**	**BQL**
Hydroxide (CaCO3)	mg/L	100	310.1	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	**BQL**	**BQL**	**BQL**
pH	S.U.	------	150.1	7.1	7.1	7.0	7.1	7.1	7.1	7.1	7.1	7.2	7.2	7.2	7.2	**7**	**7**	**7.2**
Total Hardness	mg/L	50	130.2	1730	1660	2060	1880	1800	1820	1510	1540	1520	1580	1550	1620	**1510**	**1689**	**2060**
Chloride	mg/L	50	300.0	96	100	100	98	97	100	110	100	98	260	88	92	**88**	**112**	**260**
Fluoride	mg/L	0.1	340.1	1.7	1.8	1.8	1.9	1.5	1.5	1.5	1.4	1.4	1.4	1.5	1.4	**1.4**	**2**	**1.9**
Nitrate as N	mg/L	0.1	300.0	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	**BQL**	**BQL**	**BQL**
Sulfate	mg/L	50	300.0	2340	2350	2850	2580	2510	2790	2200	1940	1930	5750	1760	1960	**1760**	**2580**	**5750**
Conductivity	uMHOs/cm	2	120.1	3340	3400	4530	4860	3460	3740	3230	3120	3250	3400	3680	3660	**3120**	**3639**	**4860**
T.D.S.	mg/L	50	160.1	3200	3190	3710	3480	3360	3400	2890	2900	2940	2950	2970	2970	**2890**	**3163**	**3710**
Boron	mg/L	0.3	200.7	2.3	2.4	2.5	2.9	2.9	2.2	2.1	2.2	2.1	2.2	2.2	2	**2.0**	**2.3**	**2.9**
Calcium	mg/L	2	200.7	480	530	640	440	470	550	470	460	420	460	490	490	**420**	**492**	**640**
Iron	mg/L	0.05	200.7	6.7	3.0	7.2	8.6	7.5	8.2	10	9.4	8.7	11	8.8	8.4	**3.0**	**8.1**	**11.0**
Magnesium	mg/L	1	200.7	140	130	150	180	180	130	130	140	140	140	150	150	**130**	**147**	**180**
Manganese	mg/L	0.1	200.7	2.6	2.3	2.1	2.8	2.9	2.4	2.4	2.3	2.7	2.8	2.9	3	**2.1**	**2.6**	**3.0**
Potassium	mg/L	4.0	200.7	6.4	6.2	4.7	6	5.6	11	10	14	8.7	8.9	10	7.1	**4.7**	**8.2**	**14.0**
Sodium	mg/L	4	200.7	270	250	270	310	320	280	280	310	290	290	310	270	**250**	**288**	**320**

PQL: Practical Quantitation Limits

BQL: Below Practical Quantitation Limits

Geo-Chemical

Cell A Round 2

				A1-1	A1-2	A1-3	A2-1	A2-2	A2-3	A3-1	A3-2	A3-3	A4-1	A4-2	A4-3		Cell A	
				p1	p	d	p1	p	d	p1	p	d	p1	p	d			
		PQL	Method	May-00	May-00	May-00	May-00	May-00	May-00	May-00	May-00	May-00	May-00	May-00	May-00	Min.	Avg.	Max.
Alkalinity (CaCO3)	mg/L	100	310.1	510	480	460	530	490	510	530	510	510	510	500	500	**460**	**503**	**530**
Bicarbonate (CaCO3	mg/L	100	310.1	510	480	460	530	490	510	530	510	510	510	500	500	**460**	**503**	**530**
Carbonate (CaCO3)	mg/L	100	310.1	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	**BQL**	**BQL**	**BQL**
Hydroxide (CaCO3)	mg/L	100	310.1	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	**BQL**	**BQL**	**BQL**
pH	S.U.	------	150.1	7.3	7.1	7.1	7.1	7.1	7.1	7.2	7.2	7.2	7.2	7.2	7.2	**7.1**	**7**	**7.3**
Total Hardness	mg/L	50	130.2	1380	1530	1570	1530	1470	1790	1530	1560	1570	1570	1530	1560	**1380**	**1549**	**1790**
Chloride	mg/L	50	300.0	63	63	60	62	61	57	72	67	69	69	65	66	**57**	**65**	**72**
Fluoride	mg/L	0.1	340.1	1.8	1.7	1.6	1.7	1.7	1.6	1.6	1.7	1.6	1.6	1.5	1.6	**1.5**	**2**	**1.8**
Nitrate as N	mg/L	0.1	300.0	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	**BQL**	**BQL**	**BQL**
Sulfate	mg/L	50	300.0	1710	1640	1900	1860	1780	1700	1530	1720	1550	1550	1470	1580	**1470**	**1666**	**1900**
Conductivity	uMHOs/cm	2	120.1	3300	3060	3520	3630	3640	3470	3100	3480	3100	3100	3410	3120	**3060**	**3328**	**3640**
T.D.S.	mg/L	50	160.1	3210	3170	3670	3417	3400	3340	2940	2900	2930	2930	2920	3020	**2900**	**3154**	**3670**
Boron	mg/L	0.3	200.7	3	4.1	4.1	3.8	3.4	3.5	3.9	4.1	3.5	3.5	3.3	2.6	**2.6**	**3.6**	**4.1**
Calcium	mg/L	2	200.7	440	380	490	640	580	510	390	440	420	420	450	380	**380**	**462**	**640**
Iron	mg/L	0.05	200.7	75	4.3	4.1	2.8	2.9	3.3	3.2	3.2	3.3	3.3	10.0	12	**2.8**	**10.6**	**75.0**
Magnesium	mg/L	1	200.7	160	160	170	200	220	180	150	150	140	140	140	140	**140**	**163**	**220**
Manganese	mg/L	0.1	200.7	1.9	3.7	3.3	2.8	2.7	2.6	2	2.6	2.3	2.3	1.7	1.3	**1.3**	**2.4**	**3.7**
Potassium	mg/L	4.0	200.7	4.3	10	9.6	6.8	7.9	6.9	6.3	7.4	5.3	5.3	17	9.9	**4.3**	**8.1**	**17.0**
Sodium	mg/L	4	200.7	300	290	330	370	380	340	270	330	310	310	330	310	**270**	**323**	**380**

PQL: Practical Quantitation Limits

BQL: Below Practical Quantitation Limits

Geo-Chemical

Cell A Round 3

				Cluster A1 2ft Screen 9.5 to 11.5ft			Cluster A2 5ft Screen 7 to 12ft			Cluster A3 2ft Screen 17 to 19ft			Cluster A4 5ft Screen 14 to 19ft			Cell A		
				A1-1	A1-2	A1-3	A2-1	A2-2	A2-3	A3-1	A3-2	A3-3	A4-1	A4-2	A4-3			
				p1	p	d	p1	p	d	p1	p	d	p1	p	d			
		PQL	Method	Jul-00	Jul-00	Jul-00	Jul-00	Jul-00	Jul-00	Jul-00	Jul-00	Jul-00	Jul-00	Jul-00	Jul-00	Min.	Avg.	Max.
Alkalinity (CaCO3)	mg/L	100	310.1	530	530	530	560	560	530	530	530	530	530	530	530	**530**	**535**	**560**
Bicarbonate (CaCO3	mg/L	100	310.1	530	530	530	560	560	530	530	530	530	530	530	530	**530**	**535**	**560**
Carbonate (CaCO3)	mg/L	100	310.1	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	**BQL**	**BQL**	**BQL**
Hydroxide (CaCO3)	mg/L	100	310.1	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	**BQL**	**BQL**	**BQL**
pH	S.U.	------	150.1	7.0	7.0	7.0	7.0	7.0	7.0	7.1	7.1	7.1	7.0	7.0	7.1	**7**	**7**	**7.1**
Total Hardness	mg/L	50	130.2	17	15	18	15	14	17	16	14	15	14	14	14	**14**	**15**	**18**
Chloride	mg/L	50	300.0	72	77	74	75	85	73	82	82	82	81	81	79	**72**	**79**	**85**
Fluoride	mg/L	0.1	340.1	1.4	1.4	1.5	1.6	1.4	1.5	1.2	1.3	1.4	1.4	1.4	1.4	**1.2**	**1**	**1.6**
Nitrate as N	mg/L	0.1	300.0	BQL	BQL	BQL	BQL	BQL	BQL	0.21	0.16	0.15	0.15	0.15	0.12	**BQL**	**BQL**	**BQL**
Sulfate	mg/L	50	300.0	1760	1750	1890	1870	1800	1860	1580	1570	1580	1610	1600	1630	**1570**	**1708**	**1890**
Conductivity	uMHOs/cm	2	120.1	3640	4440	4280	4190	4030	3950	3740	3520	3920	4080	4080	4220	**3520**	**4008**	**4440**
T.D.S.	mg/L	50	160.1	3200	3240	3450	3400	3230	3370	2900	2900	2970	2970	2870	2990	**2870**	**3124**	**3450**
Boron	mg/L	0.3	200.7	3.1	2.5	2.6	2.8	2.7	3.3	2.4	2.2	2.5	2.3	1.7	2.6	**1.7**	**2.6**	**3.3**
Calcium	mg/L	2	200.7	640	520	530	630	520	460	520	620	590	620	450	340	**340**	**537**	**640**
Iron	mg/L	0.05	200.7	6.4	6.0	4.4	6	6.7	8	6.7	7.3	8	6.2	7.0	8.4	**4.4**	**6.8**	**8.4**
Magnesium	mg/L	1	200.7	230	210	220	250	200	170	190	170	160	220	200	150	**150**	**198**	**250**
Manganese	mg/L	0.1	200.7	3.1	2.6	2.4	2.2	2.5	3.0	2.4	2.3	2.3	2.5	2.8	3.0	**2.2**	**2.6**	**3.1**
Potassium	mg/L	4.0	200.7	6.7	5.2	5.8	4.9	5.7	7.1	14	11	15	11	13	12	**4.9**	**9.3**	**15.0**
Sodium	mg/L	4	200.7	420	340	350	410	390	330	380	340	320	430	330	240	**240**	**357**	**430**

PQL: Practical Quantitation Limits

BQL: Below Practical Quantitation Limits

Geo-Chemical

Cell A Round 4

				A1-1	A1-2	A1-3	A2-1	A2-2	A2-3	A3-1	A3-2	A3-3	A4-1	A4-2	A4-3		Cell A	
				p1	p	d	p1	p	d	p1	p	d	p1	p	d			
		PQL	Method	Aug-00	Aug-00	Aug-00	Aug-00	Aug-00	Aug-00	Aug-00	Aug-00	Aug-00	Aug-00	Aug-00	Aug-00	Min.	Avg.	Max.
Alkalinity (CaCO3)	mg/L	100	310.1	600	599	599	644	644	622	577	599	599	577	599	599	**577**	**605**	**644**
Bicarbonate (CaCO3	mg/L	100	310.1	600	599	599	644	644	622	577	599	599	577	599	599	**577**	**605**	**644**
Carbonate (CaCO3)	mg/L	100	310.1	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	**BQL**	**BQL**	**BQL**
Hydroxide (CaCO3)	mg/L	100	310.1	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	**BQL**	**BQL**	**BQL**
pH	S.U.	------	150.1	7.0	7.0	7.0	7.0	7.0	7.0	7.2	7.2	7.2	7.2	7.1	7.1	**7**	**7**	**7.2**
Total Hardness	mg/L	50	130.2	1800	2200	2200	2000	1800	1900	1500	1600	1600	1600	1600	1600	**1500**	**1783**	**2200**
Chloride	mg/L	50	300.0	65	70	67	66	66	69	90	93	94	91	91	92	**65**	**80**	**94**
Fluoride	mg/L	0.1	340.1	1.4	1.4	1.5	1.4	1.5	1.2	1.2	1.2	1.3	1.4	1.2	1.4	**1.2**	**1**	**1.5**
Nitrate as N	mg/L	0.1	300.0	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	**BQL**	**BQL**	**BQL**
Sulfate	mg/L	50	300.0	1590	1550	1670	1660	1560	1670	1350	1340	1390	1420	1380	1380	**1340**	**1497**	**1670**
Conductivity	uMHOs/cm	2	120.1	4684	4468	4804	4808	4448	4748	4208	4204	4280	4252	4176	4248	**4176**	**4444**	**4808**
T.D.S.	mg/L	50	160.1	3294	3235	3440	3499	3291	3433	2939	2952	2952	2967	3017	3059	**2939**	**3173**	**3499**
Boron	mg/L	0.3	200.7	2.1	2.7	2.4	1.5	1.7	2.3	1.7	1.5	1.7	1.8	2.2	2.2	**1.5**	**2.0**	**2.7**
Calcium	mg/L	2	200.7	570	580	680	550	560	570	540	470	470	530	490	510	**470**	**543**	**680**
Iron	mg/L	0.05	200.7	4.3	5.8	3.9	5	4.4	5.5	5.3	4.9	8.6	6.3	7.5	6.6	**3.9**	**5.7**	**8.6**
Magnesium	mg/L	1	200.7	210	220	230	220	230	230	200	180	180	200	180	190	**180**	**206**	**230**
Manganese	mg/L	0.1	200.7	1.9	2.3	1.8	1.1	1.4	1.9	1.7	1.4	1.5	1.9	2.3	2.3	**1.1**	**1.8**	**2.3**
Potassium	mg/L	4.0	200.7	3.4	4.4	4.0	2.6	2.8	3.7	7.2	6.0	9.1	7.0	8.1	8.6	**2.6**	**5.6**	**9.1**
Sodium	mg/L	4	200.7	360	370	390	340	360	350	390	330	360	360	350	350	**330**	**359**	**390**

PQL: Practical Quantitation Limits

BQL: Below Practical Quantitation Limits

Geo-Chemical

Cell B Round 1

				Cluster B1 2ft Screen 10 to 12ft					Cluster B2 5ft Screen 7 to 12ft				
				B1-1	B1-2	B1-3	B1-4	B1-5	B2-1	B2-2	B2-3	B2-4	B2-5
				pnp	p1	pcv	p	d	pnp	p1	pcv	p	d
		PQL	Method	Mar-00	Mar-00	Mar-00	Mar-00	Mar-00	Mar-00	Mar-00	Mar-00	Mar-00	Mar-00
Alkalinity (CaCO3)	mg/L	100	310.1	470	470	460	470	480	450	440	440	440	450
Bicarbonate (CaCO3	mg/L	100	310.1	470	470	460	470	480	450	440	440	440	450
Carbonate (CaCO3)	mg/L	100	310.1	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
Hydroxide (CaCO3)	mg/L	100	310.1	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
pH	S.U.	------	150.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
Total Hardness	mg/L	50	130.2	1530	1480	1640	1560	1520	1540	1660	1620	1480	1560
Chloride	mg/L	50	300.0	74	71	56	64	67	65	49	56	62	52
Fluoride	mg/L	0.1	340.1	1.5	1.4	1.5	1.4	1.4	1.5	1.6	1.5	1.5	1.5
Nitrate as N	mg/L	0.1	300.0	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
Sulfate	mg/L	50	300.0	1860	1860	1790	2050	2030	2240	1920	2290	2180	1810
Conductivity	uMHOs/cm	2	120.1	3140	3400	3440	2980	3040	2760	2770	2700	2750	2830
T.D.S.	mg/L	50	160.1	2840	2800	2870	2830	2860	2780	3010	2990	2760	2810
Boron	mg/L	0.3	200.7	2.1	2.6	2.1	2.1	2.3	2.4	2.7	2.4	2.2	1.6
Calcium	mg/L	2.0	200.7	380	430	510	450	450	510	450	530	480	440
Iron	mg/L	0.05	200.7	7.8	9.8	4.6	7.6	5.4	1.2	4.9	5.1	4.0	8.7
Magnesium	mg/L	1	200.7	150	170	150	150	160	140	170	160	140	84
Manganese	mg/L	0.1	200.7	303.0	3.5	3.2	3.2	3.0	1.9	2.9	2.9	2.5	1.5
Potassium	mg/L	4.0	200.7	7.4	9.0	7.3	7.9	6.7	4.7	7.6	7.0	6.3	13.0
Sodium	mg/L	4	200.7	280	290	280	380	270	260	310	300	250	240

PQL: Practical Quantitation Limits
BQL: Below Practical Quantitation Limits

Cell B Round 1

				Cluster B3 2ft Screen 16 to18ft					Cluster B4 5ft Screen 12.5 to18ft							
				B3-1	B3-2	B3-3	B3-4	B3-5	B4-1	B4-2	B4-3	B4-4	B4-5	Cell B		
				pnp	p1	pcv	p	d	pnp	p1	pcv	p	d			
		PQL	Method	Mar-00	Mar-00	Mar-00	Mar-00	Mar-00	Mar-00	Mar-00	Mar-00	Mar-00	Mar-00	Min.	Avg.	Max.
Alkalinity (CaCO3)	mg/L	100	310.1	500	500	490	500	500	480	490	480	490	480	440	474	500
Bicarbonate (CaCO3	mg/L	100	310.1	500	500	490	500	500	480	490	480	490	480	440	474	500
Carbonate (CaCO3)	mg/L	100	310.1	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
Hydroxide (CaCO3)	mg/L	100	310.1	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
pH	S.U.	------	150.1	7.2	7.2	7.2	7.2	7.2	7.1	7.2	7.2	7.2	7.1	7.1	7.14	7.2
Total Hardness	mg/L	50	130.2	1380	1370	1360	1360	1360	1620	1460	1440	1460	1600	1360	1500	1660
Chloride	mg/L	50	300.0	75	67	76	82	88	69	70	74	70	58	49	67.25	88
Fluoride	mg/L	0.1	340.1	1.3	1.4	1.2	1.2	1.2	1.4	1.4	1.4	1.5	1.5	1.2	1.415	1.6
Nitrate as N	mg/L	0.1	300.0	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
Sulfate	mg/L	50	300.0	1700	1560	1790	2050	1880	2350	1880	1970	1840	1850	1560	1945	2350
Conductivity	uMHOs/cm	2	120.1	2740	2660	2650	2720	2860	3010	2690	2660	2570	2940	2570	2865.5	3440
T.D.S.	mg/L	50	160.1	2680	2650	2650	2660	2650	2950	2790	2780	2750	2920	2650	2801.5	3010
Boron	mg/L	0.3	200.7	1.9	2.1	2.1	1.7	2.5	2.2	2.3	2.3	2.4	0.3	0.3	2.115	2.7
Calcium	mg/L	2.0	200.7	330	410	440	430	340	480	460	480	430	450	330	444	530
Iron	mg/L	0.05	200.7	11.0	11.0	11.0	7.2	12.0	11.0	12.0	10.0	17.0	2.2	1.2	8.175	17
Magnesium	mg/L	1	200.7	120	130	130	86	170	160	160	150	160	210	84	147.5	210
Manganese	mg/L	0.1	200.7	1.8	1.9	1.8	1.4	3.3	3.0	2.7	2.9	2.8	42.0	1.4	19.56	303
Potassium	mg/L	4.0	200.7	14.0	15.0	14.0	14.0	8.7	9.6	11.0	9.4	11.0	8.2	4.7	9.59	15
Sodium	mg/L	4	200.7	280	310	290	250	300	310	320	310	290	190	190	285.5	380

PQL: Practical Quantitation Limits
BQL: Below Practical Quantitation Limits

Geo-Chemical

Cell B Round 2

				Cluster B1 2ft Screen 10 to 12ft					Cluster B2 5ft Screen 7 to 12ft				
				B1-1	B1-2	B1-3	B1-4	B1-5	B2-1	B2-2	B2-3	B2-4	B2-5
				pnp	p1	pcv	p	d	pnp	p1	pcv	p	d
		PQL	Method	May-00	May-00	May-00	May-00	May-00	May-00	May-00	May-00	May-00	May-00
Alkalinity (CaCO3)	mg/L	100	310.1	480	460	470	470	480	460	440	440	450	440
Bicarbonate (CaCO3	mg/L	100	310.1	480	460	470	470	480	460	440	440	450	440
Carbonate (CaCO3)	mg/L	100	310.1	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
Hydroxide (CaCO3)	mg/L	100	310.1	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
pH	S.U.	------	150.1	7.1	7.1	7.3	7.2	7.2	7.1	7.1	7.2	7.3	7.2
Total Hardness	mg/L	50	130.2	1530	1480	1440	1520	1480	1580	1560	1540	1250	1420
Chloride	mg/L	50	300.0	56	60	64	54	62	45	42	42	44	44
Fluoride	mg/L	0.1	340.1	1.4	1.6	1.6	1.5	1.6	1.5	1.8	1.4	1.7	1.6
Nitrate as N	mg/L	0.1	300.0	BQL	BQL	BQL	BQL	BQL	0.17	0.72	0.83	BQL	BQL
Sulfate	mg/L	50	300.0	1490	1510	1460	1510	1490	1590	1430	1410	1290	1560
Conductivity	uMHOs/cm	2	120.1	3230	2860	3060	3440	3200	2930	3240	3130	3020	3280
T.D.S.	mg/L	50	160.1	2890	2860	2810	2860	2850	2950	2960	2940	2810	2850
Boron	mg/L	0.3	200.7	3.8	4.1	4.1	3.8	3.4	3.5	3.9	4.1	3.5	4.7
Calcium	mg/L	2.0	200.7	450	430	420	730	460	500	460	470	370	440
Iron	mg/L	0.05	200.7	6.7	9.1	8.9	5.5	12.0	4.0	4.6	7.5	2.4	6.3
Magnesium	mg/L	1	200.7	200	180	170	390	190	170	170	180	140	150
Manganese	mg/L	0.1	200.7	2.4	3.7	3.3	2.8	2.6	2.5	1.9	2.6	2.3	3.1
Potassium	mg/L	4.0	200.7	5.7	10.0	9.6	6.8	7.9	6.9	6.3	7.4	5.3	8.8
Sodium	mg/L	4	200.7	340	430	310	560	360	310	330	340	290	300

PQL: Practical Quantitation Limits

BQL: Below Practical Quantitation Limits

Cell B Round 2

				Cluster B3 2ft Screen 16 to18ft					Cluster B4 5ft Screen 12.5 to18ft							
				B3-1	B3-2	B3-3	B3-4	B3-5	B4-1	B4-2	B4-3	B4-4	B4-5		Cell B	
				pnp	p1	pcv	p	d	pnp	p1	pcv	p	d			
		PQL	Method	May-00	May-00	May-00	May-00	May-00	May-00	May-00	May-00	May-00	May-00	Min.	Avg.	Max.
Alkalinity (CaCO3)	mg/L	100	310.1	440	560	510	490	500	490	470	480	450	450	Mar-01	Apr-01	Jul-01
Bicarbonate (CaCO3	mg/L	100	310.1	440	560	510	490	500	490	470	480	450	450	440	471.5	560
Carbonate (CaCO3)	mg/L	100	310.1	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
Hydroxide (CaCO3)	mg/L	100	310.1	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
pH	S.U.	------	150.1	7.2	7.2	7.2	7.2	7.2	7.1	7.1	7.2	7.2	7.2	7.1	7.18	7.3
Total Hardness	mg/L	50	130.2	1310	1420	1330	1290	1350	1680	1420	690	530	1440	530	1363	1680
Chloride	mg/L	50	300.0	67	65	62	64	61	54	89	55	57	57	42	57.2	89
Fluoride	mg/L	0.1	340.1	1.5	1.3	1.4	1.4	1.4	1.2	1.4	1.4	1.5	1.4	1.2	1.48	1.8
Nitrate as N	mg/L	0.1	300.0	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
Sulfate	mg/L	50	300.0	1420	1420	1360	1400	1390	1550	1500	1540	1500	1560	1290	1469	1590
Conductivity	uMHOs/cm	2	120.1	3210	2980	2880	3100	3150	3370	3010	3370	3080	3220	2860	3138	3440
T.D.S.	mg/L	50	160.1	2680	2660	2680	2710	2730	2890	2820	2860	2820	2900	2660	2826.5	2960
Boron	mg/L	0.3	200.7	3.3	2.6	3.6	3.7	3.4	3.7	3.5	3.8	3.9	3.3	2.6	3.685	4.7
Calcium	mg/L	2.0	200.7	420	410	370	320	350	530	380	380	500	400	320	439.5	730
Iron	mg/L	0.05	200.7	9.3	7.0	11.0	10.0	10.0	12.0	7.5	8.7	9.6	7.6	2.4	7.985	12
Magnesium	mg/L	1	200.7	160	150	130	110	130	230	160	150	210	160	110	176.5	390
Manganese	mg/L	0.1	200.7	1.7	1.3	1.8	1.9	1.8	2.7	2.3	2.4	2.8	2.1	1.3	2.4	3.7
Potassium	mg/L	4.0	200.7	14.0	9.9	11.0	7.9	12.0	9.8	7.7	10.0	10.0	8.8	5.3	8.79	14
Sodium	mg/L	4	200.7	370	350	320	270	300	420	320	300	410	320	270	347.5	560

PQL: Practical Quantitation Limits

BQL: Below Practical Quantitation Limits

Geo-Chemical

Cell B Round 3

				Cluster B1 2ft Screen 10 to 12ft					Cluster B2 5ft Screen 7 to 12ft				
				B1-1	B1-2	B1-3	B1-4	B1-5	B2-1	B2-2	B2-3	B2-4	B2-5
				pnp	p1	pcv	p	d	pnp	p1	pcv	p	d
		PQL	Method	Jul-00	Jul-00	Jul-00	Jul-00	Jul-00	Jul-00	Jul-00	Jul-00	Jul-00	Jul-00
Alkalinity (CaCO3)	mg/L	100	310.1	510	510	490	490	510	490	490	470	470	470
Bicarbonate (CaCO3	mg/L	100	310.1	510	510	490	490	510	490	490	470	470	470
Carbonate (CaCO3)	mg/L	100	310.1	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
Hydroxide (CaCO3)	mg/L	100	310.1	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
pH	S.U.	------	150.1	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Total Hardness	mg/L	50	130.2	13	11	13	16	21	16	21	21	22	22
Chloride	mg/L	50	300.0	65	61	55	52	65	47	46	47	48	46
Fluoride	mg/L	0.1	340.1	1.3	1.3	1.2	1.3	1.2	1.4	1.3	1.3	1.3	1.3
Nitrate as N	mg/L	0.1	300.0	0.17	0.18	0.13	0.14	0.16	BQL	1.7	0.14	BQL	0.11
Sulfate	mg/L	50	300.0	1520	1530	1560	1510	1530	1830	1720	1540	1600	1510
Conductivity	uMHOs/cm	2	120.1	3750	3980	3920	4160	4120	4270	4130	3840	4000	3850
T.D.S.	mg/L	50	160.1	2810	2750	2740	2760	2790	3160	3210	2740	2830	2760
Boron	mg/L	0.3	200.7	2.2	1.9	2.2	2.3	2.6	2.8	2.8	2.6	2.2	2.4
Calcium	mg/L	2.0	200.7	310	460	430	520	540	540	530	460	500	370
Iron	mg/L	0.05	200.7	7.9	5.9	6.8	6.0	10.0	2.5	2.0	5.2	3.2	5.7
Magnesium	mg/L	1	200.7	170	190	180	220	220	210	200	180	190	40
Manganese	mg/L	0.1	200.7	2.9	2.7	3.0	3.1	3.5	2.7	2.1	3.2	2.5	2.6
Potassium	mg/L	4.0	200.7	9.0	7.4	9.6	8.2	13.0	7.1	7.0	8.9	6.8	8.1
Sodium	mg/L	4	200.7	260	350	310	390	330	330	320	310	320	300

PQL: Practical Quantitation Limits

BQL: Below Practical Quantitation Limits

Cell B Round 3

				Cluster B3 2ft Screen 16 to18ft					Cluster B4 5ft Screen 12.5 to18ft							
				B3-1	B3-2	B3-3	B3-4	B3-5	B4-1	B4-2	B4-3	B4-4	B4-5	Cell B		
				pnp	p1	pcv	p	d	pnp	p1	pcv	p	d			
		PQL	Method	Jul-00	Jul-00	Jul-00	Jul-00	Jul-00	Jul-00	Jul-00	Jul-00	Jul-00	Jul-00	Min.	Avg.	Max.
Alkalinity (CaCO3)	mg/L	100	310.1	560	560	560	530	560	530	560	530	530	560	Apr-01	Jun-01	Jul-01
Bicarbonate (CaCO3	mg/L	100	310.1	560	560	560	530	560	530	560	530	530	560	470	519	560
Carbonate (CaCO3)	mg/L	100	310.1	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
Hydroxide (CaCO3)	mg/L	100	310.1	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
pH	S.U.	------	150.1	7.2	7.2	7.3	7.2	7.1	7.0	7.1	7.1	7.0	7.0	7	7.06	7.3
Total Hardness	mg/L	50	130.2	22	22	24	22	22	24	27	24	13	13	11	19.45	27
Chloride	mg/L	50	300.0	77	77	77	74	83	63	67	72	71	66	46	62.95	83
Fluoride	mg/L	0.1	340.1	1.4	1.1	1.1	1.0	1.1	1.1	1.3	1.1	1.1	1.2	0.98	1.219	1.4
Nitrate as N	mg/L	0.1	300.0	0.21	0.2	0.2	0.18	0.21	BQL	0.19	0.18	0.19	0.19	BQL	BQL	BQL
Sulfate	mg/L	50	300.0	1460	1480	1450	1430	1450	1640	1470	1480	1500	1600	1430	1540.5	1830
Conductivity	uMHOs/cm	2	120.1	3720	3770	3840	3870	3840	4040	3940	3930	3750	4130	3720	3942.5	4270
T.D.S.	mg/L	50	160.1	2740	2690	2650	2690	2730	2960	2780	2760	3740	2950	2650	2862	3740
Boron	mg/L	0.3	200.7	1.9	2.0	1.8	1.9	2.0	2.4	2.0	1.8	2.2	2.3	1.8	2.215	2.8
Calcium	mg/L	2.0	200.7	430	380	380	440	520	440	410	430	440	540	310	453.5	540
Iron	mg/L	0.05	200.7	8.6	9.2	12.0	9.0	8.2	11.0	8.7	8.0	9.0	9.9	2	7.44	12
Magnesium	mg/L	1	200.7	160	150	140	170	230	180	170	180	190	230	40	180	230
Manganese	mg/L	0.1	200.7	1.7	1.8	1.6	1.6	1.7	3.0	2.4	2.0	2.5	2.5	1.6	2.455	3.5
Potassium	mg/L	4.0	200.7	16.0	16.0	18.0	15.0	19.0	12.0	10.0	10.0	12.0	13.0	6.8	11.305	19
Sodium	mg/L	4	200.7	340	310	300	360	370	330	310	320	300	400	260	328	400

PQL: Practical Quantitation Limits

BQL: Below Practical Quantitation Limits

Geo-Chemical

Cell B Round 4

				Cluster B1 2ft Screen 10 to 12ft					Cluster B2 5ft Screen 7 to 12ft				
				B1-1	B1-2	B1-3	B1-4	B1-5	B2-1	B2-2	B2-3	B2-4	B2-5
				pnp	p1	pcv	p	d	pnp	p1	pcv	p	d
		PQL	Method	May-00	Aug-00	Aug-00	Aug-00	Aug-00	Aug-00	Aug-00	Aug-00	Aug-00	Aug-00
Alkalinity (CaCO3)	mg/L	100	310.1	533	577	511	511	577	577	511	511	488	488
Bicarbonate (CaCO3	mg/L	100	310.1	533	577	511	511	577	577	511	511	488	488
Carbonate (CaCO3)	mg/L	100	310.1	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
Hydroxide (CaCO3)	mg/L	100	310.1	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
pH	S.U.	------	150.1	7.1	7.1	7.0	7.1	7.1	7.1	7.0	7.0	7.0	7.1
Total Hardness	mg/L	50	130.2	1500	1500	1600	1500	1500	1400	1600	1700	1500	1500
Chloride	mg/L	50	300.0	70	68	55	57	73	51	42	47	53	48
Fluoride	mg/L	0.1	340.1	1.3	1.4	1.3	1.5	1.4	1.3	1.4	1.5	1.4	1.3
Nitrate as N	mg/L	0.1	300.0	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
Sulfate	mg/L	50	300.0	1310	1300	1370	1270	1330	1320	1450	1540	1380	1360
Conductivity	uMHOs/cm	2	120.1	3944	4144	3896	4000	4116	4935	4268	4360	4116	3964
T.D.S.	mg/L	50	160.1	2775	2746	2797	2674	2837	2741	2949	3067	2812	2786
Boron	mg/L	0.3	200.7	2.1	1.9	1.6	2.0	3.2	2.3	2.7	2.1	2.5	2.2
Calcium	mg/L	2.0	200.7	490	400	460	400	540	580	550	580	480	470
Iron	mg/L	0.05	200.7	9.6	5.1	5.7	4.3	13.0	5.1	1.2	1.7	4.3	3.5
Magnesium	mg/L	1	200.7	220	180	200	180	230	220	220	240	190	180
Manganese	mg/L	0.1	200.7	2.6	2.5	2.2	2.4	3.8	2.6	2.0	1.8	2.5	2.1
Potassium	mg/L	4.0	200.7	7.3	6.1	5.4	5.8	13.0	6.9	6.2	4.6	6.4	6.1
Sodium	mg/L	4	200.7	360	300	280	280	390	320	360	370	320	280

PQL: Practical Quantitation Limits

BQL: Below Practical Quantitation Limits

Cell B Round 4

				Cluster B3 2ft Screen 16 to18ft					Cluster B4 5ft Screen 12.5 to18ft							
				B3-1	B3-2	B3-3	B3-4	B3-5	B4-1	B4-2	B4-3	B4-4	B4-5		Cell B	
				pnp	p1	pcv	p	d	pnp	p1	pcv	p	d			
		PQL	Method	Aug-00	Aug-00	Aug-00	Aug-00	Aug-00	Aug-00	Aug-00	Aug-00	Aug-00	Aug-00	Min.	Avg.	Max.
Alkalinity (CaCO3)	mg/L	100	310.1	599	577	599	599	599	577	577	599	577	577	May-01	Jul-01	Aug-01
Bicarbonate (CaCO3	mg/L	100	310.1	599	577	599	599	599	577	577	599	577	577	488	558.2	599
Carbonate (CaCO3)	mg/L	100	310.1	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
Hydroxide (CaCO3)	mg/L	100	310.1	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
pH	S.U.	------	150.1	7.2	7.2	7.2	7.2	7.2	7.1	7.1	7.1	7.1	7.1	7	7.105	7.2
Total Hardness	mg/L	50	130.2	1400	1300	1600	1400	1400	1600	1500	1400	1400	1600	1300	1495	1700
Chloride	mg/L	50	300.0	70	68	67	68	70	54	63	66	67	57	42	60.7	73
Fluoride	mg/L	0.1	340.1	1.1	1.1	1.2	1.2	1.1	1.4	1.3	1.2	1.2	1.4	1.1	1.3	1.5
Nitrate as N	mg/L	0.1	300.0	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
Sulfate	mg/L	50	300.0	1260	1240	1220	1240	1210	1460	1310	1320	1280	1410	1210	1329	1540
Conductivity	uMHOs/cm	2	120.1	3808	4012	4080	4104	4112	4372	3904	4028	4092	4268	3808	4126.15	4935
T.D.S.	mg/L	50	160.1	2686	2728	2660	2680	2716	3012	2778	2775	2795	2966	2660	2799	3067
Boron	mg/L	0.3	200.7	1.9	2.2	1.6	1.0	1.6	2.1	3.2	1.6	1.9	2.3	1	2.1	3.2
Calcium	mg/L	2.0	200.7	460	420	500	410	470	450	520	400	420	520	400	476	580
Iron	mg/L	0.05	200.7	21.0	10.0	7.3	5.0	7.4	8.7	16.0	6.7	7.9	6.4	1.2	7.495	21
Magnesium	mg/L	1	200.7	180	160	190	160	190	210	225	170	180	230	160	197.75	240
Manganese	mg/L	0.1	200.7	1.6	1.7	1.3	0.9	1.3	2.4	3.3	1.6	2.0	2.2	0.9	2.14	3.8
Potassium	mg/L	4.0	200.7	13.0	13.0	12.0	6.6	12.0	8.5	7.5	7.5	9.1	11.0	4.6	8.4	13
Sodium	mg/L	4	200.7	360	330	460	320	390	320	390	310	330	360	280	341.5	460

PQL: Practical Quantitation Limits

BQL: Below Practical Quantitation Limits

Field Data Mar 00, Round 1

Cell	Well ID Cluster	Well	Well Type	Sampling Date	Start Time	Start Depth to Water in ft.	Purge Rate ml/min.	Finish Time	Finish Depth to Water in ft.	Water Temp. C°	DO mg/L	SpC	pH	Turbidity NTU
Cluster A1 2ft Screen 9.5 to 11.5ft														
A	1	1	p1	3/24/00	11:35	6.40	480	11:55	6.42	19.80	0.13	3.364	7.37	7.3
A	1	2	p	3/24/00	11:00	6.50	480	11:16	7.17	19.66	0.93	3.309	7.46	2.3
A	1	3	d	3/24/00	10:06	6.25	480	10:40	7.67	19.61	0.35	3.741	7.35	1.6
Cluster A2 5ft Screen 7 to 12ft														
A	2	1	p1	3/24/00	11:55	6.38	460	12:00	6.33	19.45	0.15	3.590	7.39	3.0
A	2	2	p	3/24/00	11:18	6.46	480	11:30	6.46	19.57	0.16	3.347	7.38	31.0
A	2	3	d	3/24/00	10:42	6.33	480	11:00	6.33	19.74	0.13	3.501	7.38	2.4
Cluster A3 2ft Screen 17 to 19ft														
A	3	1	p1	3/24/00	13:20	6.32	480	13:25	6.39	20.78	0.10	3.169	7.47	11.3
A	3	2	p	3/24/00	13:00	6.40	480	13:10	6.40	20.66	0.11	3.153	7.49	11.9
A	3	3	d	3/24/00	12:15	6.25	480	12:25	6.29	20.93	0.12	3.225	7.58	22.4
Cluster A4 5ft Screen 14 to 19ft														
A	4	1	p1	3/24/00	13:25	6.38	480	13:35	6.33	20.52	0.10	3.214	7.48	11.3
A	4	2	p	3/24/00	13:12	6.42	480	13:19	6.42	20.66	0.09	3.223	7.47	32.1
A	4	3	d	3/24/00	12:42	6.38	460	12:58	6.40	20.76	0.12	3.225	7.47	8.3
Cluster B1 2ft Screen 10 to 12ft														
B	1	1	pnp	3/22/00	14:50	5.92	460	15:00	5.90	20.52	0.10	3.099	7.37	22.5
B	1	2	p1	3/22/00	13:20	6.00	460	13:30	5.88	20.58	0.20	3.049	7.39	4.7
B	1	3	pcv	3/22/00	14:05	5.92	460	14:15	5.92	20.45	0.11	3.073	7.40	4.0
B	1	4	p	3/22/00	11:00	6.00	460	11:20	6.02	19.91	0.43	3.066	7.39	1.3
B	1	5	d	3/22/00	10:05	6.00	460	10:18	6.00	20.50	0.62	3.070	7.35	21.9
Cluster B2 5ft Screen 7 to 12ft														
B	2	1	pnp	3/22/00	15:10	5.83	460	15:20	5.83	20.05	0.10	3.009	7.34	4.2
B	2	2	p1	3/22/00	13:40	5.88	460	13:50	5.92	20.05	0.12	3.201	7.30	4.8
B	2	3	pcv	3/22/00	14:20	5.90	460	14:30	5.91	20.20	0.19	3.150	7.34	23.8
B	2	4	p	3/22/00	11:23	6.00	460	11:33	6.02	19.99	0.32	3.022	7.38	18.4
B	2	5	d	3/22/00	10:20	5.90	460	10:54	5.90	19.91	0.16	3.008	7.37	8.2
Cluster B3 2ft Screen 16 to18ft														
B	3	1	pnp	3/23/00	15:25	5.90	435	15:45	5.90	20.93	0.11	2.998	7.56	3.87
B	3	2	p1	3/23/00	14:05	5.88	435	14:30	5.90	21.18	0.13	2.985	7.54	3.96
B	3	3	pcv	3/23/00	14:50	6.00	435	15:10	6.00	21.03	0.33	3.000	7.54	1.23
B	3	4	p	3/23/00	11:25	6.02	435	12:00	6.67	20.75	0.23	2.954	7.56	1.38
B	3	5	d	3/23/00	10:40	5.92	435	10:50	5.92	20.78	0.54	3.003	7.53	2.79
Cluster B4 5ft Screen 12.5 to18ft														
B	4	1	pnp	3/23/00	15:45	5.88	435	16:00	5.88	20.49	0.16	3.154	7.39	1.29
B	4	2	p1	3/23/00	14:35	5.88	435	14:50	5.88	20.70	0.15	3.052	7.45	8.12
B	4	3	pcv	3/23/00	15:10	5.92	435	15:25	5.92	20.42	0.13	3.029	7.46	2.15
B	4	4	p	3/23/00	13:45	5.90	435	14:05	5.90	21.52	0.24	3.004	7.45	6.73
B	4	5	d	3/23/00	11:05	5.83	435	11:20	5.83	20.45	0.74	3.153	7.42	24.6

Field Data May 00, Round 2														
						Start			Finish					
						Depth to	Purge		Depth to	Water				
	Well ID		Well	Sampling	Start	Water	Rate	Finish	Water	Temp.	DO	SpC	pH	Turbidity
Cell	Cluster	Well	Type	Date	Time	in ft.	ml/min.	Time	in ft.	C°	mg/L			NTU
Cluster A1 2ft Screen 9.5 to 11.5ft														
A	1	1	p1	5/16/00	11:30	6.53	450	11:50	6.53	20.92	0.14	3.384	7.81	42.0
A	1	2	p	5/16/00	10:50	6.62	450	11:10		20.82	0.25	3.342	7.83	3.8
A	1	3	d	5/16/00	11:10	6.53	450	11:30		20.83	0.19	3.629	7.78	12.3
Cluster A2 5ft Screen 7 to 12ft														
A	2	1	p1	5/16/00	14:11	6.45	450	14:31	6.51	21.38	0.13	3.597	7.84	3.59
A	2	2	p	5/16/00	13:20	6.56	450	13:40		21.11	0.16	3.350	7.81	45.0
A	2	3	d	5/16/00	13:45	6.40	450	14:05		21.26	0.17	3.543	7.81	4.2
Cluster A3 2ft Screen 17 to 19ft														
A	3	1	p1	5/16/00	15:10	6.51	450	15:30	6.50	20.95	0.12	3.195	7.94	1.10
A	3	2	p	5/16/00	14:30	6.53	450	14:50		21.27	0.15	3.230	7.93	2.56
A	3	3	d	5/16/00	14:50	6.43	450	15:10		21.41	0.12	3.225	7.94	13.3
Cluster A4 5ft Screen 14 to 19ft														
A	4	1	p1	5/16/00	16:10	6.48	450	16:30	6.49	21.08	0.12	3.222	7.93	3.54
A	4	2	p	5/16/00	15:30	6.54	450	15:50		21.27	0.12	3.225	7.93	8.19
A	4	3	d	5/16/00	15:40	6.52	450	16:00		21.09	0.11	3.240	7.91	2.02
Cluster B1 2ft Screen 10 to 12ft														
B	1	1	pnp	5/17/00	11:00	6.13	450	11:20	6.13	21.51	0.13	3.086	7.83	29.1
B	1	2	p1	5/17/00	11:20	6.04	450	11:40	6.05	21.16	0.1	3.059	7.87	0.96
B	1	3	pcv	5/17/00	10:40	6.12	450	11:00	6.11	21.17	0.14	2.985	7.89	1.1
B	1	4	p	5/17/00	10:00	6.14	450	10:20		20.75	0.16	3.055	7.88	1.24
B	1	5	d	5/17/00	10:20	6.14	450	10:40		21.15	0.17	3.047	7.85	88.5
Cluster B2 5ft Screen 7 to 12ft														
B	2	1	pnp	5/17/00	14:40	6.05	450	15:00	6.01	20.65	0.09	3.710	7.80	4.13
B	2	2	p1	5/17/00	15:00	6.08	450	15:20	6.07	20.7	0.08	3.121	7.81	22.0
B	2	3	pcv	5/17/00	14:20	6.02	450	14:40	6.09	20.64	0.08	7.069	7.82	6.99
B	2	4	p	5/17/00	13:40	6.17	450	14:00		20.65	0.08	2.992	7.84	1.73
B	2	5	d	5/17/00	14:00	6.03	450	14:20		20.63	0.08	3.047	7.78	22.5
Cluster B3 2ft Screen 16 to18ft														
B	3	1	pnp	5/18/00	9:15	6.08	450	9:35	6.06	21.21	0.1	3.018	8.00	3.07
B	3	2	p1	5/18/00	9:40	6.07	450	10:00	6.05	21.06	0.15	3.000	7.99	1.32
B	3	3	pcv	5/17/00	16:00	6.04	450	16:20	6.19	20.89	0.1	3.010	7.48	1.49
B	3	4	p	5/17/00	15:20	6.27	450	15:40		20.84	0.12	2.981	8.04	6.27
B	3	5	d	5/17/00	15:40	6.05	450	16:00		20.87	0.09	2.999	8.02	15.6
Cluster B4 5ft Screen 12.5 to18ft														
B	4	1	pnp	5/18/00	11:10	6.04	450	11:30	6.07	21.37	0.08	3.131	7.89	24.4
B	4	2	p1	5/18/00	11:30	6.07	450	11:50	6.09	21.27	0.07	3.061	7.88	5.61
B	4	3	pcv	5/18/00	10:15	6.11	450	10:35	6.12	21.18	0.08	3.102	7.92	2.35
B	4	4	p	5/18/00	10:35	6.09	450	10:55		21.21	0.10	3.069	7.91	1.93
B	4	5	d	5/18/00	10:45	6.00	450	11:05		20.98	0.08	3.134	7.91	25.1

Field Data July 00, Round 3

Cell	Well ID Cluster	Well	Well Type	Sampling Date	Start Time	Start Depth to Water in ft.	Purge Rate ml/min.	Finish Time	Finish Depth to Water in ft.	Water Temp. C°	DO mg/L	SpC	pH	Turbidity NTU
Cluster A1 2ft Screen 9.5 to 11.5ft														
A	1	1	p1	7/11/00	13:43	6.68	450	13:50	6.67	22.35	0.11	3.4	6.64	1.3
A	1	2	p	7/11/00	14:00	6.76	450	14:14	7.10	22.18	0.13	3.304	6.67	1.8
A	1	3	d	7/11/00	13:24	6.55	450	13:30	7.00	22.82	0.13	3.806	6.64	9.0
Cluster A2 5ft Screen 7 to 12ft														
A	2	1	p1	7/11/00	14:28	6.60	450	14:38	7.10	23.31	0.15	3.437	6.69	1.7
A	2	2	p	7/11/00	15:03	6.75	450	15:11	7.05	22.75	0.11	3.419	6.66	8.8
A	2	3	d	7/11/00	14:47	6.61	450	14:54	6.66	24.17	0.13	3.416	6.67	1.6
Cluster A3 2ft Screen 17 to 19ft														
A	3	1	p1	7/11/00	15:50	6.69	450	16:01	7.70	22.43	0.09	3.15	6.78	0.3
A	3	2	p	7/11/00	15:38	6.69	450	15:46	6.75	22.47	0.10	3.145	6.77	4.4
A	3	3	d	7/11/00	16:09	6.60	450	16:15	6.60	21.75	0.09	3.183	6.8	6.5
Cluster A4 5ft Screen 14 to 19ft														
A	4	1	p1	7/11/00	13:00	6.68	450	13:11	6.70	21.73	0.14	3.197	6.77	0.8
A	4	2	p	7/11/00	12:44	6.76	450	12:52	6.75	21.98	0.17	3.203	6.77	3.5
A	4	3	d	7/11/00	11:44	6.70	450	12:05	6.80	22.97	0.42	3.207	6.75	3.2
Cluster B1 2ft Screen 10 to 12ft														
B	1	1	pnp	7/11/00	14:28	6.27	450	14:33	6.35	22.47	0.09	2.990	6.71	12.9
B	1	2	p1	7/11/00	15:18	6.20	450	15:23	6.17	22.43	0.07	2.960	6.71	0.4
B	1	3	pcv	7/11/00	14:07	6.27	450	14:10	6.27	22.41	0.26	2.960	6.70	2.5
B	1	4	p	7/11/00	15:03	6.30	450	15:08	6.44	22.36	0.06	2.920	6.73	8.7
B	1	5	d	7/11/00	14:46	6.29	450	14:51	6.32	22.30	0.07	3.033	6.73	8.7
Cluster B2 5ft Screen 7 to 12ft														
B	2	1	pnp	7/11/00	13:00	6.24	450	13:05	6.23	22.45	0.17	2.880	6.68	1.7
B	2	2	p1	7/11/00	12:40	6.25	450	12:45	6.35	22.62	0.30	3.212	6.66	30.4
B	2	3	pcv	7/11/00	13:35	6.28	450	13:40	6.29	22.43	0.08	3.289	6.64	2.4
B	2	4	p	7/11/00	13:55	6.35	450	14:00	6.42	22.34	0.07	3.086	6.67	5.9
B	2	5	d	7/11/00	13:15	6.22	450	13:20	6.24	22.40	0.10	2.929	6.65	23.8
Cluster B3 2ft Screen 16 to18ft														
B	3	1	pnp	7/11/00	11:20	6.28	450	11:25	6.24	21.65	0.14	3.02	6.86	3.78
B	3	2	p1	7/11/00	11:00	6.30	450	11:06	6.32	21.81	0.17	3	6.87	0.86
B	3	3	pcv	7/11/00	10:45	6.28	450	10:50	6.31	21.52	0.28	3.017	6.87	0.47
B	3	4	p	7/11/00	11:35	6.35	450	11:40	6.65	22.52	0.19	2.993	6.87	1.3
B	3	5	d	7/11/00	12:15	6.24	450	12:20	6.25	21.8	0.14	3.021	6.87	??
Cluster B4 5ft Screen 12.5 to18ft														
B	4	1	pnp	7/11/00	10:30	6.24	450	10:35	6.25	21.84	0.42	3.15	6.72	2.39
B	4	2	p1	7/11/00	10:45	6.27	450	10:50	6.26	21.87	0.3	3.064	6.76	3.61
B	4	3	pcv	7/11/00	11:00	6.29	450	11:10	6.34	21.81	0.13	3.026	6.78	1.21
B	4	4	p	7/11/00	11:15	6.26	450	11:20	6.31	21.83	0.08	3.037	6.77	3.53
B	4	5	d	7/11/00	11:30	6.16	450	11:35	6.22	21.79	0.06	3.134	6.77	9.58

Field Data August 00, Round 4														
						Start			Finish					
						Depth to	Purge		Depth to	Water				
	Well ID		Well	Sampling	Start	Water	Rate	Finish	Water	Temp.	DO	SpC	pH	Turbidity
Cell	Cluster	Well	Type	Date	Time	in ft.	ml/min.	Time	in ft.	C°	mg/L			NTU
Cluster A1 2ft Screen 9.5 to 11.5ft														
A	1	1	p1	8/2/00	15:33	6.70	450	15:39	6.73	23.09	0.17	3.391	6.80	1.5
A	1	2	p	8/2/00	15:00	6.78	450	15:06	7.2	22.93	0.08	3.366	6.82	3.13
A	1	3	d	8/2/00	15:15	6.53	450	15:21	7	23.49	0.1	3.445	6.79	10.2
Cluster A2 5ft Screen 7 to 12ft														
A	2	1	p1	8/2/00	14:07	6.72	450	14:13	6.72	22.95	0.1	3.515	6.83	8.99
A	2	2	p	8/2/00	13:54	6.76	450	14:00	6.8	23.03	0.12	3.433	6.81	13.6
A	2	3	d	8/2/00	13:36	6.80	450	13:42	6.65	22.8	0.11	3.526	6.80	1.17
Cluster A3 2ft Screen 17 to 19ft														
A	3	1	p1	8/2/00	13:14	6.74	450	13:20	6.70	21.81	0.1	3.163	6.97	1.98
A	3	2	p	8/2/00	13:24	6.72	450	13:30	6.75	21.9	0.1	3.157	6.94	12.9
A	3	3	d	8/2/00	12:59	6.62	450	13:05	6.59	21.03	0.15	3.190	6.79	3.54
Cluster A4 5ft Screen 14 to 19ft														
A	4	1	p1	8/2/00	14:29	6.70	450	14:35	6.7	22.46	0.09	3.204	6.93	4.35
A	4	2	p	8/2/00	14:21	6.78	450	14:27	6.73	22.31	0.1	3.216	6.86	4.32
A	4	3	d	8/2/00	14:45	6.70	450	14:51	6.73	22.66	0.09	3.215	6.92	2.9
Cluster B1 2ft Screen 10 to 12ft														
B	1	1	pnp	8/1/00	15:06	6.30	450	15:12	6.1	23.08	0.09	2.997	6.83	7.19
B	1	2	p1	8/1/00	14:17	6.24	450	14:23	6.25	22.96	0.1	2.965	6.87	1.11
B	1	3	pcv	8/1/00	14:36	6.31	450	14:42	6.31	23.15	0.08	2.927	6.83	1.14
B	1	4	p	8/1/00	14:54	6.33	450	15:00	6.45	22.92	0.07	2.895	6.83	3.35
B	1	5	d	8/1/00	15:19	6.35	450	15:25	6.45	22.95	0.09	3.043	6.85	?
Cluster B2 5ft Screen 7 to 12ft														
B	2	1	pnp	8/1/00	13:49	6.25	450	13:55	6.29	23.1	0.08	2.865	6.79	2.08
B	2	2	p1	8/1/00	13:24	6.29	450	13:30	6.3	23.34	0.17	3.137	6.78	1.4
B	2	3	pcv	8/1/00	12:44	6.32	450	12:50	6.33	23.24	0.19	3.213	6.89	1.74
B	2	4	p	8/1/00	13:01	6.36	450	13:07	6.44	23.23	0.11	2.986	6.80	11.4
B	2	5	d	8/1/00	13:39	6.25	450	13:45	6.25	23.11	0.1	2.943	6.78	9
Cluster B3 2ft Screen 16 to18ft														
B	3	1	pnp	8/1/00	11:19	6.23	450	11:25	6.28	22.15	0.1	3.021	7.00	3.47
B	3	2	p1	8/1/00	11:30	6.27	450	11:36	6.36	22.22	0.13	3.009	7.01	2.32
B	3	3	pcv	8/1/00	10:54	6.11	450	11:00	6.42	21.96	0.14	3.022	7.01	1.55
B	3	4	p	8/1/00	11:04	6.43	450	11:10	6.72	22.2	0.11	2.995	7.03	8
B	3	5	d	8/1/00	10:39	6.26	450	10:45	6.25	22.04	0.29	3.023	7.01	4.53
Cluster B4 5ft Screen 12.5 to18ft														
B	4	1	pnp	8/1/00	11:09	6.3	450	11:15	6.24	22.47	0.14	3.192	6.84	3.54
B	4	2	p1	8/1/00	11:34	6.28	450	11:40	6.3	22.55	0.15	3.048	6.89	2.96
B	4	3	pcv	8/1/00	10:29	6.33	450	10:35	6.33	22.49	0.2	3.019	6.86	1.43
B	4	4	p	8/1/00	11:20	6.32	450	11:26	6.24	22.35	0.14	3.047	6.84	3.11
B	4	5	d	8/1/00	10:49	6.23	450	10:55	6.19	22.38	0.19	3.160	6.87	3.95

APPENDIX H

Ground Water Levels

Water Table Data Round 1

Cell	Well ID Cluster	Well	Well Type	Sampling Date	Start Time	Start Depth to Water in ft.	Water Table Elev. ft. msl	Well Head Elev. ft. msl
Cluster A1 2ft Screen 9.5 to 11.5ft								
A	1	1	p1	3/24/00	11:35	6.40	3.43	9.83
A	1	2	p	3/24/00	11:00	6.50	3.14	9.64
A	1	3	d	3/24/00	10:06	6.25	3.64	9.89
Cluster A2 5ft Screen 7 to 12ft								
A	2	1	p1	3/24/00	11:55	6.38	3.45	9.82
A	2	2	p	3/24/00	11:18	6.46	3.40	9.86
A	2	3	d	3/24/00	10:42	6.33	3.41	9.74
Cluster A3 2ft Screen 17 to 19ft								
A	3	1	p1	3/24/00	13:20	6.32	3.50	9.82
A	3	2	p	3/24/00	13:00	6.40	3.41	9.81
A	3	3	d	3/24/00	12:15	6.25	3.45	9.70
Cluster A4 5ft Screen 14 to 19ft								
A	4	1	p1	3/24/00	13:25	6.38	3.42	9.79
A	4	2	p	3/24/00	13:12	6.42	3.40	9.82
A	4	3	d	3/24/00	12:42	6.38	3.43	9.80
Cluster B1 2ft Screen 10 to 12ft								
B	1	1	pnp	3/22/00	14:50	5.92	4.64	10.56
B	1	2	p1	3/22/00	13:20	6.00	4.50	10.50
B	1	3	pcv	3/22/00	14:05	5.92	4.66	10.58
B	1	4	p	3/22/00	11:00	6.00	4.57	10.57
B	1	5	d	3/22/00	10:05	6.00	4.58	10.58
Cluster B2 5ft Screen 7 to 12ft								
B	2	1	pnp	3/22/00	15:10	5.83	4.68	10.51
B	2	2	p1	3/22/00	13:40	5.88	4.68	10.55
B	2	3	pcv	3/22/00	14:20	5.90	4.65	10.55
B	2	4	p	3/22/00	11:23	6.00	4.62	10.62
B	2	5	d	3/22/00	10:20	5.90	4.58	10.48
Cluster B3 2ft Screen 16 to18ft								
B	3	1	pnp	3/23/00	15:25	5.90	4.59	10.49
B	3	2	p1	3/23/00	14:05	5.88	4.69	10.56
B	3	3	pcv	3/23/00	14:50	6.00	4.55	10.55
B	3	4	p	3/23/00	11:25	6.02	4.58	10.60
B	3	5	d	3/23/00	10:40	5.92	4.56	10.48
Cluster B4 5ft Screen 12.5 to18ft								
B	4	1	pnp	3/23/00	15:45	5.88	4.69	10.56
B	4	2	p1	3/23/00	14:35	5.88	4.71	10.58
B	4	3	pcv	3/23/00	15:10	5.92	4.68	10.60
B	4	4	p	3/23/00	13:45	5.90	4.69	10.59
B	4	5	d	3/23/00	11:05	5.83	4.64	10.47

Water Table Data Round 2								
						Start		
						Depth to	Water Table	Well Head
	Well ID		Well	Sampling	Start	Water	Elev.	Elev.
Cell	Cluster	Well	Type	Date	Time	in ft.	ft. msl	ft. msl
Cluster A1 2ft Screen 9.5 to 11.5ft								
A	1	1	p1	5/16/00	11:30	6.53	3.30	9.83
A	1	2	p	5/16/00	10:50	6.62	3.02	9.64
A	1	3	d	5/16/00	11:10	6.53	3.36	9.89
Cluster A2 5ft Screen 7 to 12ft								
A	2	1	p1	5/16/00	14:11	6.45	3.37	9.82
A	2	2	p	5/16/00	13:20	6.56	3.30	9.86
A	2	3	d	5/16/00	13:45	6.40	3.34	9.74
Cluster A3 2ft Screen 17 to 19ft								
A	3	1	p1	5/16/00	15:10	6.51	3.31	9.82
A	3	2	p	5/16/00	14:30	6.53	3.28	9.81
A	3	3	d	5/16/00	14:50	6.43	3.27	9.70
Cluster A4 5ft Screen 14 to 19ft								
A	4	1	p1	5/16/00	16:10	6.48	3.31	9.79
A	4	2	p	5/16/00	15:30	6.54	3.28	9.82
A	4	3	d	5/16/00	15:40	6.52	3.28	9.80
Cluster B1 2ft Screen 10 to 12ft								
B	1	1	pnp	5/17/00	11:00	6.13	4.43	10.56
B	1	2	p1	5/17/00	11:20	6.04	4.46	10.50
B	1	3	pcv	5/17/00	10:40	6.12	4.46	10.58
B	1	4	p	5/17/00	10:00	6.14	4.43	10.57
B	1	5	d	5/17/00	10:20	6.14	4.44	10.58
Cluster B2 5ft Screen 7 to 12ft								
B	2	1	pnp	5/17/00	14:40	6.05	4.46	10.51
B	2	2	p1	5/17/00	15:00	6.08	4.47	10.55
B	2	3	pcv	5/17/00	14:20	6.02	4.53	10.55
B	2	4	p	5/17/00	13:40	6.17	4.45	10.62
B	2	5	d	5/17/00	14:00	6.03	4.45	10.48
Cluster B3 2ft Screen 16 to18ft								
B	3	1	pnp	5/18/00	9:15	6.08	4.41	10.49
B	3	2	p1	5/18/00	9:40	6.07	4.49	10.56
B	3	3	pcv	5/17/00	16:00	6.04	4.51	10.55
B	3	4	p	5/17/00	15:20	6.27	4.33	10.60
B	3	5	d	5/17/00	15:40	6.05	4.43	10.48
Cluster B4 5ft Screen 12.5 to18ft								
B	4	1	pnp	5/18/00	11:10	6.04	4.52	10.56
B	4	2	p1	5/18/00	11:30	6.07	4.51	10.58
B	4	3	pcv	5/18/00	10:15	6.11	4.49	10.60
B	4	4	p	5/18/00	10:35	6.09	4.50	10.59
B	4	5	d	5/18/00	10:45	6.00	4.47	10.47

Water Table Data Round 3

Cell	Well ID Cluster	Well	Well Type	Sampling Date	Start Time	Start Depth to Water in ft.	Water Table Elev. ft. msl	Well Head Elev. ft. msl
Cluster A1 2ft Screen 9.5 to 11.5ft								
A	1	1	p1	7/11/00	13:43	6.68	3.15	9.83
A	1	2	p	7/11/00	14:00	6.76	2.88	9.64
A	1	3	d	7/11/00	13:24	6.55	3.34	9.89
Cluster A2 5ft Screen 7 to 12ft								
A	2	1	p1	7/11/00	14:28	6.60	3.22	9.82
A	2	2	p	7/11/00	15:03	6.75	3.11	9.86
A	2	3	d	7/11/00	14:47	6.61	3.13	9.74
Cluster A3 2ft Screen 17 to 19ft								
A	3	1	p1	7/11/00	15:50	6.69	3.13	9.82
A	3	2	p	7/11/00	15:38	6.69	3.12	9.81
A	3	3	d	7/11/00	16:09	6.60	3.10	9.70
Cluster A4 5ft Screen 14 to 19ft								
A	4	1	p1	7/11/00	13:00	6.68	3.11	9.79
A	4	2	p	7/11/00	12:44	6.76	3.06	9.82
A	4	3	d	7/11/00	11:44	6.70	3.10	9.80
Cluster B1 2ft Screen 10 to 12ft								
B	1	1	pnp	7/11/00	14:28	6.27	4.29	10.56
B	1	2	p1	7/11/00	15:18	6.20	4.30	10.50
B	1	3	pcv	7/11/00	14:07	6.27	4.31	10.58
B	1	4	p	7/11/00	15:03	6.30	4.27	10.57
B	1	5	d	7/11/00	14:46	6.29	4.29	10.58
Cluster B2 5ft Screen 7 to 12ft								
B	2	1	pnp	7/11/00	13:00	6.24	4.27	10.51
B	2	2	p1	7/11/00	12:40	6.25	4.30	10.55
B	2	3	pcv	7/11/00	13:35	6.28	4.27	10.55
B	2	4	p	7/11/00	13:55	6.35	4.27	10.62
B	2	5	d	7/11/00	13:15	6.22	4.26	10.48
Cluster B3 2ft Screen 16 to18ft								
B	3	1	pnp	7/11/00	11:20	6.28	4.21	10.49
B	3	2	p1	7/11/00	11:00	6.30	4.26	10.56
B	3	3	pcv	7/11/00	10:45	6.28	4.27	10.55
B	3	4	p	7/11/00	11:35	6.35	4.25	10.60
B	3	5	d	7/11/00	12:15	6.24	4.24	10.48
Cluster B4 5ft Screen 12.5 to18ft								
B	4	1	pnp	7/11/00	10:30	6.24	4.32	10.56
B	4	2	p1	7/11/00	10:45	6.27	4.31	10.58
B	4	3	pcv	7/11/00	11:00	6.29	4.31	10.60
B	4	4	p	7/11/00	11:15	6.26	4.33	10.59
B	4	5	d	7/11/00	11:30	6.16	4.31	10.47

Water Table Data Round 4								
						Start		
						Depth to	Water Table	Well Head
	Well ID		Well	Sampling	Start	Water	Elev.	Elev.
Cell	Cluster	Well	Type	Date	Time	in ft.	ft. msl	ft. msl
Cluster A1 2ft Screen 9.5 to 11.5ft								
A	1	1	p1	8/2/00	15:33	6.70	3.13	9.83
A	1	2	p	8/2/00	15:00	6.78	2.86	9.64
A	1	3	d	8/2/00	15:15	6.53	3.36	9.89
Cluster A2 5ft Screen 7 to 12ft								
A	2	1	p1	8/2/00	14:07	6.72	3.10	9.82
A	2	2	p	8/2/00	13:54	6.76	3.10	9.86
A	2	3	d	8/2/00	13:36	6.80	2.94	9.74
Cluster A3 2ft Screen 17 to 19ft								
A	3	1	p1	8/2/00	13:14	6.74	3.08	9.82
A	3	2	p	8/2/00	13:24	6.72	3.09	9.81
A	3	3	d	8/2/00	12:59	6.62	3.08	9.70
Cluster A4 5ft Screen 14 to 19ft								
A	4	1	p1	8/2/00	14:29	6.70	3.09	9.79
A	4	2	p	8/2/00	14:21	6.78	3.04	9.82
A	4	3	d	8/2/00	14:45	6.70	3.10	9.80
Cluster B1 2ft Screen 10 to 12ft								
B	1	1	pnp	8/1/00	15:06	6.30	4.26	10.56
B	1	2	p1	8/1/00	14:17	6.24	4.26	10.50
B	1	3	pcv	8/1/00	14:36	6.31	4.27	10.58
B	1	4	p	8/1/00	14:54	6.33	4.24	10.57
B	1	5	d	8/1/00	15:19	6.35	4.23	10.58
Cluster B2 5ft Screen 7 to 12ft								
B	2	1	pnp	8/1/00	13:49	6.25	4.26	10.51
B	2	2	p1	8/1/00	13:24	6.29	4.26	10.55
B	2	3	pcv	8/1/00	12:44	6.32	4.23	10.55
B	2	4	p	8/1/00	13:01	6.36	4.26	10.62
B	2	5	d	8/1/00	13:39	6.25	4.23	10.48
Cluster B3 2ft Screen 16 to18ft								
B	3	1	pnp	8/1/00	11:19	6.23	4.26	10.49
B	3	2	p1	8/1/00	11:30	6.27	4.29	10.56
B	3	3	pcv	8/1/00	10:54	6.11	4.44	10.55
B	3	4	p	8/1/00	11:04	6.43	4.17	10.60
B	3	5	d	8/1/00	10:39	6.26	4.22	10.48
Cluster B4 5ft Screen 12.5 to18ft								
B	4	1	pnp	8/1/00	11:09	6.3	4.26	10.56
B	4	2	p1	8/1/00	11:34	6.28	4.30	10.58
B	4	3	pcv	8/1/00	10:29	6.33	4.27	10.60
B	4	4	p	8/1/00	11:20	6.32	4.27	10.59
B	4	5	d	8/1/00	10:49	6.23	4.24	10.47

SEPTEMBER 5 WATER LEVEL

Well ID			Well	Sampling		Start	Depth to	Water Table	Well Head	Water Table	Water Table	Water Table	Water Table
Cell	Cluster	Well	Type	Date		Time	Water in ft.	Elev. ft. msl	Elev. ft. msl	Cluster Mean ft. msl	Cluster Std. Dev.	Cell Mean ft. msl	Cell Std. Dev.
Cluster A1 2ft Screen 9.5 to 11.5ft													
A	1	1	p1	9/5/00	A1p1	10:28	6.55	3.28	9.83	3.26	0.29569128	3.27	0.127430908
A	1	2	p	9/5/00	A1p	10:29	6.69	2.95	9.64				
A	1	3	d	9/5/00	A1d	10:29	6.35	3.54	9.89				
Cluster A2 5ft Screen 7 to 12ft													
A	2	1	p1	9/5/00	A2p1	10:30	6.50	3.32	9.82	3.30	0.02081666		
A	2	2	p	9/5/00	A2p1	10:31	6.57	3.29	9.86				
A	2	3	d	9/5/00	A2d	10:32	6.46	3.28	9.74				
Cluster A3 2ft Screen 17 to 19ft													
A	3	1	p1	9/5/00	A3p1	10:33	6.54	3.28	9.82	3.27	0.01		
A	3	2	p	9/5/00	A3p1	10:34	6.54	3.27	9.81				
A	3	3	d	9/5/00	A3d	10:34	6.44	3.26	9.70				
Cluster A4 5ft Screen 14 to 19ft													
A	4	1	p1	9/5/00	A4p1	10:35	6.52	3.27	9.79	3.27	0.005773503		
A	4	2	p	9/5/00	A4p1	10:35	6.55	3.27	9.82				
A	4	3	d	9/5/00	A4d	10:36	6.54	3.26	9.80				
Cluster B1 2ft Screen 10 to 12ft													
B	1	1	pnp	9/5/00	B1pnp	10:58	6.24	4.32	10.56	4.34	0.017888544	4.36	0.031854934
B	1	2	p1	9/5/00	B1p1	10:59	6.16	4.34	10.50				
B	1	3	pcv	9/5/00	B1pcv	11:00	6.21	4.37	10.58				
B	1	4	p	9/5/00	B1p	11:01	6.23	4.34	10.57				
B	1	5	d	9/5/00	B1d	11:01	6.24	4.34	10.58				
Cluster B2 5ft Screen 7 to 12ft													
B	2	1	pnp	9/5/00	B2pnp	11:02	6.15	4.36	10.51	4.35	0.015811388		
B	2	2	p1	9/5/00	B2p1	11:03	6.18	4.37	10.55				
B	2	3	pcv	9/5/00	B2pcv	11:03	6.21	4.34	10.55				
B	2	4	p	9/5/00	B2p	11:03	6.27	4.35	10.62				
B	2	5	d	9/5/00	B2d	11:04	6.15	4.33	10.48				
Cluster B3 2ft Screen 16 to18ft													
B	3	1	pnp	9/5/00	B3pnp	11:05	6.17	4.32	10.49	4.34	0.036469165		
B	3	2	p1	9/5/00	B3p1	11:06	6.16	4.40	10.56				
B	3	3	pcv	9/5/00	B3pcv	11:06	6.22	4.33	10.55				
B	3	4	p	9/5/00	B3p	11:07	6.29	4.31	10.60				
B	3	5	d	9/5/00	B3d	11:07	6.16	4.32	10.48				
Cluster B4 5ft Screen 12.5 to17.5ft													
B	4	1	pnp	9/5/00	B4pnp	11:09	6.15	4.41	10.56	4.40	0.011401754		
B	4	2	p1	9/5/00	B4p1	11:10	6.18	4.40	10.58				
B	4	3	pcv	9/5/00	B4pcv	11:10	6.20	4.40	10.60				
B	4	4	p	9/5/00	B4p	11:11	6.20	4.39	10.59				
B	4	5	d	9/5/00	B4d	11:11	6.09	4.38	10.47				

September 5 Tides

High	Low
5:22 (3.3')	9:33 (2.8')
16:14 (4.6')	23:57 (1.0')

APPENDIX I

Images

Image 1. Preparation of piezocone probe.

Image 2. Advancement of the wireless piezocone.

Image 3. Soil sample recovered in an acrylic liner using a Vibracore.

Image 4. Permeability test cell.

Image 5. Tremmie installation of a filter pack for a 2-inch diameter well installed using a hollow stem auger drilling technique.

Image 6. Preparation of a 2-inch diameter direct-push monitoring well with a prepacked filter.

Image 7. Prepack filter for a ¾-inch direct-push well.

Image 8.   Preparation of a ¾-inch prepack direct-push well.

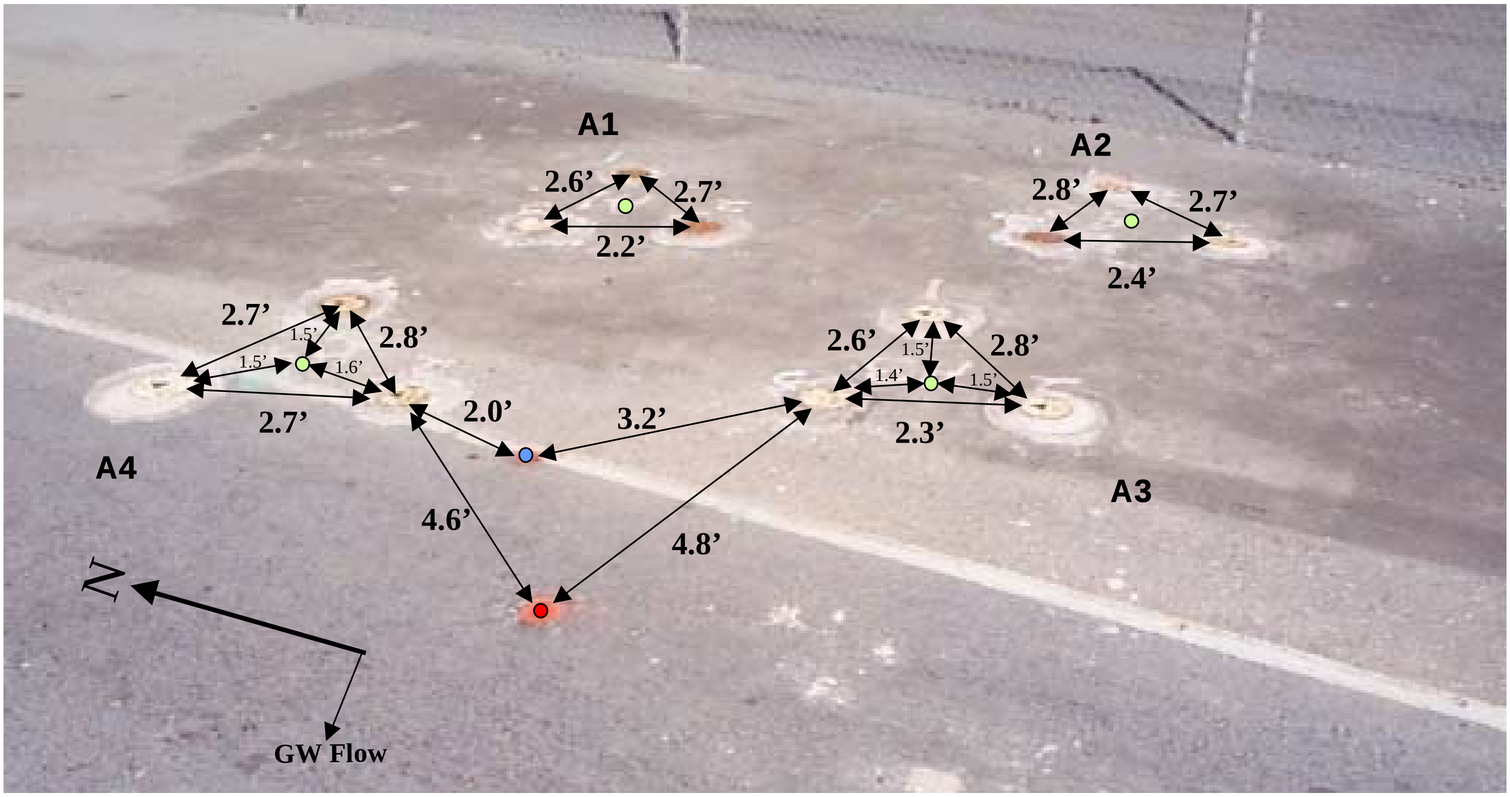
Image 9. Preparation of ¾-inch diameter direct-push well with a bentonite sleeve.

Image 10. Installation of ¾-inch direct-push no filter pack well consisting of an expandable bentonite sleeve above the screen.

Image 11. Completed wells within Cell A.

Image 12. Completed wells within Cell B.

Image 13. Cell A Well Cluster Configuration

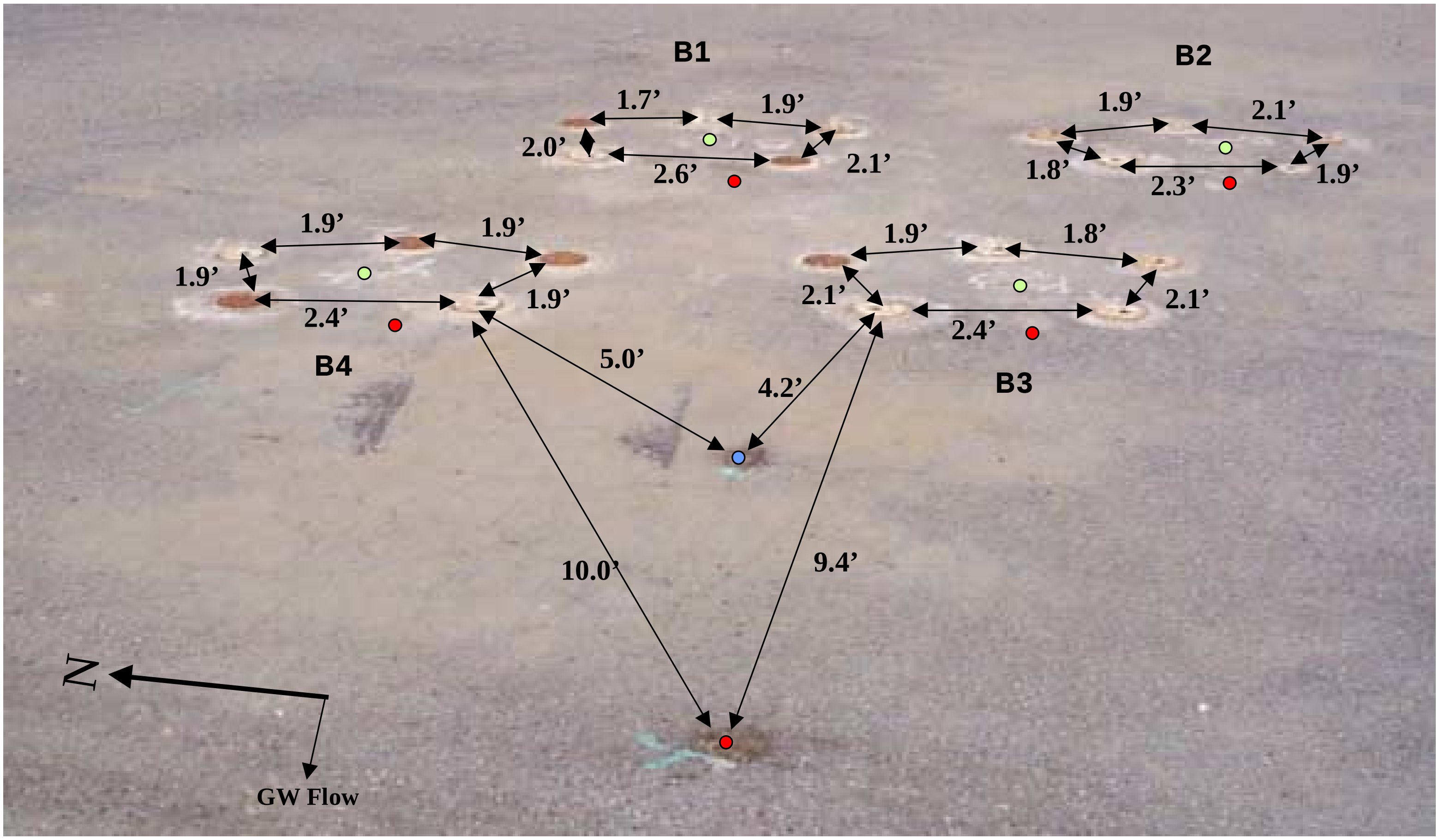


Piezocone Push

GeoProbe Water Sample

Boring

Image 14. Cell B Well Cluster Configuration



Piezocone Push

Boring

GeoProbe Water Sample

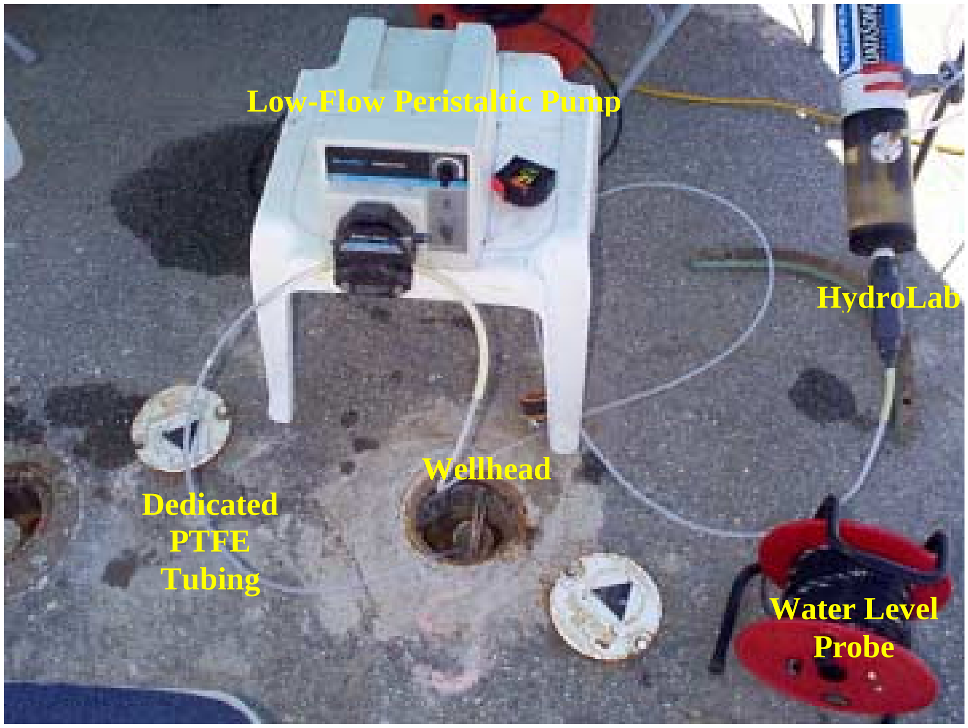


Image 15. Groundwater sampling configuration.