

World Resources Company
EPA ID No. AZD 980 735 500
Attachment 9
Draft Permit

ATTACHMENT 9
GROUNDWATER DETECTION MONITORING PROGRAM

9. GROUNDWATER DETECTION MONITORING PROGRAM

9.1 Introduction

This document represents the groundwater detection monitoring program (DMP) for World Resources Company (WRC) located in Tolleson, Arizona. WRC operates a hazardous waste management unit (HWMU) that processes waste streams from industrial enterprises and produces metal concentrates sold to manufacturers of precious and non-ferrous metals. The WRC facility is located at 8113 West Sherman Street in Tolleson, Maricopa County, in the northwest quarter of Section 9 in Township 1 North, Range 1 East of the Salt and Gila rivers baseline and meridian.

This DMP includes information on the initial phase of groundwater detection monitoring at the WRC site, as well as the ongoing DMP, or long-term monitoring program, which will be instituted at the conclusion of the initial phase. The initial phase of groundwater monitoring was designed to document background conditions for a broad range of constituents while verifying that hazardous constituents from the facility have not entered the groundwater system. Based on the analytical data obtained from the initial groundwater monitoring phase, the ongoing DMP was designed to focus on those parameters and waste constituents that were deemed to be early warning indicators of a release from the facility. The selected parameters for the ongoing DMP are in accordance with Code of Federal Regulations Title 40 (40 CFR) § 264.98(h), and have been approved by the Arizona Department of Environmental Quality (ADEQ).

The monitoring network for the ongoing DMP includes those monitoring wells most appropriately located downgradient of the point of compliance (POC), in conformance with 40 CFR § 264.97 and as required by 40 CFR § 264.98(b), and the monitoring well most appropriately located upgradient of the facility, in conformance with 40 CFR § 264.97(a)(1) and 40 CFR § 264.97(g). The groundwater monitoring program presented in this document meets the requirements of Arizona Administrative Code (A.A.C.) R18-8-264.A, I, and J, which incorporates and modifies the 40 CFR § 264, Subpart F (Releases from Solid Waste Management Units).

9.2 Hydrogeologic Conditions and Existing Monitoring Well Network

The WRC facility (Site) is located within the western portion of the Salt River Valley (SRV) sub-basin of the Phoenix Active Management Area (AMA), as defined by the Arizona Department of Water Resources (ADWR). The principal water-bearing aquifer units in the western SRV sub-basin consist of, in descending order: the upper alluvial unit (UAU), middle alluvial unit (MAU), and lower alluvial unit (LAU) (ADWR, 1993). Few wells are screened in the LAU in the vicinity of the Site, and little is known regarding the vertical limits and physical properties of the unit. All of the WRC monitoring wells are, or were, screened in the uppermost portion of the UAU.

Most of the production wells in the western SRV sub-basin are screened in the UAU and MAU and have yields ranging from several hundred to a few thousand gallons per minute (gpm) of water (Ross, 1978). Most of the production wells located in the vicinity of the Site are owned by Roosevelt Irrigation District (RID) and produce water for crop irrigation. The nearest municipal drinking water supply well (owned by the City of Tolleson) is located approximately three-quarters of a mile upgradient of the Site. Land use in the area has historically been primarily agriculture with light industry and warehousing moving in over the last few years.

From 1993 through 2003, 11 monitoring wells (MW-1 through MW-11) have been installed at the Site. Monitoring well locations are shown on Figure DMP-01. Lithologic information specific to the WRC site has been obtained from the borehole information from these 11 monitoring wells. The depth of the wells ranges from 70 to 150 feet. A summary of the soil types (defined in terms of the Uniform Soil Classification System) encountered in the soil borings of monitoring wells MW-1 through MW-8 is shown on Figure DMP-02. (No soil borings were collected during the installation of monitoring wells MW-9, MW-10, and MW-11, and hence, there are no soil borings listed for those wells on Figure DMP-02.) Soil types encountered at the Site are typical of alluvial/fluvial sedimentary deposits, composed primarily of sandy silt, silty sand, clay, and well graded sand. The upper 50 to 70 feet of sediments across the Site appear to be finer-grained silts and clays, while deeper sediments appear to be coarser grained well-graded sands.

All 11 monitoring wells at the WRC facility were screened in the UAU, as recommended by ADEQ. Well construction diagrams for the network of 11 wells are provided in Attachment 9-A of this DMP. The construction of these wells conforms to the requirements of 40 CFR § 264.97(c).

The well installations were documented in the following reports.

- *Monitor Well Installation, World Resources Company Facility, 8113 West Sherman Street, Phoenix, Arizona* (Western Technologies, Inc. 1993);
- *Monitor Well Installation Report* (Dames & Moore, 1997a);
- *Monitor Well MW-8 Installation Report* (Dames & Moore, 1997b); and
- *Monitoring Installation Technical Memorandum – Wells MW-9, MW-10, and MW-11* (Malcolm Pirnie, 2004).

The abandonment of six of the monitoring wells was due to drought conditions in the SRV, which caused the water table to recede to below the screened sections of these six monitoring wells.

WRC will expand the current groundwater network to cover groundwater passing underneath the eastern portion of the property. Within 90 days of permit issuance, WRC will submit a permit modification request for the Director's approval and work plan for the installation of the additional groundwater monitoring. Information submitted for the Director's approval will include the proposed well location, well construction details, and proposed monitoring frequency. Installation of the new well will be required within 12 months of permit issuance. Initial monitoring frequency will be quarterly for at least two years.

In December 2007, depth to groundwater beneath the Site ranged from approximately 84 to 95 feet below ground surface (bgs). Direction of groundwater flow in December 2007 beneath the Site was north, as shown on Figure DMP-01. Historic and current groundwater level measurements are included in the quarterly (or semi-annual) monitoring reports (dated 1997 through 2008) submitted to ADEQ.

Historically, and in general, water level measurements performed at WRC indicate that the groundwater flow direction in the UAU is generally toward the north during the summer months and shifts slightly toward the northwest during the winter months. The most probable explanation for the variation in groundwater flow direction is the presence of the large, agricultural pumping well owned by RID (55-607227) located northeast of the Site. The RID well is turned on in early April and turned off the second week of September each year (RID personal communication, 1999). This usage approximately corresponds to the time when the groundwater gradient is aligned in a more northerly direction. All pumping wells within a mile radius of the Site are indicated in Figure DMP-03. Table 9-1 lists the cadastral location, ADWR registration number, depth, reported use, and owner for each of the wells shown on Figure DMP-03.

A storm water retention basin located on the south side of the Site currently collects run-off from the entire property, excluding the HWMU area, which has a separate collection system. The retention basin is intended to temporarily retain surface run-off during storm events. Most of the impounded storm water will either

evaporate or percolate slowly through pore spaces above the water table during wetting of the vadose zone. Small amounts of storm water may reach the aquifer but will not be of sufficient quantity to have an effect on the direction of groundwater flow at the Site.

Table 9-1. Wells Located Within 1-Mile Radius

Cadastral Location	ADWR Registration No.	Well Depth (feet)	Well Use	Owner
A-01-01 02CCC	55-607728	910	Irrigation	Salt River Project
A-01-01 10 AAA	55-518899	560	Public Supply	City of Tolleson
A-01-01 10 ACC	55-621646	353	Domestic, Stock	E&V Investments, LLC
A-01-01 10 BBB	55-618806	585	Industrial	Esmark, Inc.
A-01-01 10 CBA	55-500078	603	Industrial	Sun Land Beef Company
A-01-01 10 CCC	55-608436	662	Irrigation	Salt River Project
A-01-01 10 DDD	55-617700	150	Irrigation	Salt River Project
A-01-01 11	55-636351	276	Domestic	W.C. Norris
A-01-01 11AA	55-638111	210	Domestic	E. Hutchison
A-01-01 11ACB	55-607227	790	Irrigation	Roosevelt Irrigation District
A-01-01 11ADC	55-607624	410	Industrial	Westside Mining Company
A-01-01 11ADD	55-617112	800	Irrigation	Salt River Project
A-01-01 11BCC	55-626594	388	Public Supply	City of Phoenix (Well 196)
A-01-01 11CCB	55-608362	800	Irrigation	Salt River Project
A-01-01 12BBB	55-607206	622	Irrigation	Roosevelt Irrigation District
A-01-01 12CBB	55-638600	280	Domestic	J. H. Evans
A-01-01 14B	55-636746	200	Domestic	C. Veen and N. Viss
A-01-01 14BAB	55-618655	400	Domestic	B & T Enterprises
A-01-01 14BAB	55-507637	400	Domestic	B & T Enterprises
A-01-01 15AAA	55-626415	420	Domestic, stock	L. Homrighausen - Bell
A-01-01 15AAD	55-626416	450	Irrigation	L. Homrighausen - Bell
A-01-01 15BAA	55-626512		Domestic	D. Layton
A-01-01 15DAA	55-626511	500	Irrigation	L. R. Layton

9.3 Initial Phase of the Detection Monitoring Program

9.3.1 Monitoring Well Network for the Initial Phase of the DMP

WRC initially began collecting quarterly groundwater samples from monitoring wells MW-1 through MW-5 in February 1997 with the intent of using the information obtained for the initial phase of the DMP. Quarterly sampling of these five wells was performed mid-month in January, April, July, and October. However, as discussed in Section 2.0, one by one each of those monitoring wells went dry by spring 2001 (monitoring well MW-1 went dry in October 1997). Subsequently, and with ADEQ's approval, new monitoring wells (MW-6 through MW-11) were installed.

Although groundwater monitoring at WRC began in 1997, the set of water quality used to calculate a detection of a release from the facility consisted of semi-annual (June and December) sampling data collected from monitoring wells MW-9, MW-10, and MW-11 for the period of September 2003 through December 2007. However, for discussion purposes herein, and in actuality, the initial phase of groundwater monitoring at WRC began in February 1997 and ended in December 2007, and included 11 monitoring wells.

The POC, as defined in 40 CFR § 264.95, is shown on the Site Plan (Figure DMP-01). Locations of the monitoring wells are also shown on Figure DMP-01. During the initial phase of the DMP, quarterly (from February 1997 through December 2003) and semi-annual (from June 2004 through December 2007) groundwater samples were collected from the monitoring wells to assess background concentrations of useful monitoring parameters and to assess whether hazardous constituents were detected in groundwater downgradient of the HWMU.

The baseline groundwater quality data obtained during the initial phase of the DMP was used to:

- Estimate background concentrations of useful monitoring parameters;
- Assess natural spatial variability in average concentrations of monitoring parameters within groundwater beneath the facility;
- Assess natural temporal variability in concentrations of monitoring parameters within groundwater sampled from upgradient and downgradient monitoring wells; and
- Verify that statistical tests anticipated for use in the ongoing DMP met the statistical performance standards of 40 CFR § 264.97(i).

Based on the data obtained from February 1997 through December 2007, no hazardous constituents have been detected in the groundwater that indicates a release from the facility.

9.3.2 Analytical Program for the Initial Phase of the DMP

Table 9-2 lists the 17 chemicals of interest that were selected for, and analyzed during, the initial phase of the DMP. The applicable groundwater screening levels and standards for the chemicals of interest are also shown in Table 9-2. During the initial phase of the DMP, unfiltered groundwater samples were analyzed for total concentrations of the metals listed on Table 9-2, and filtered groundwater samples were analyzed for dissolved concentrations of these metals. Hexavalent chromium was not analyzed because the federal primary maximum contaminant level (MCL) for chromium is based on total chromium.

Table 9-2. List of Chemicals of Interest, Analytical Methods, Reporting Limits, and Screening Levels (Concentrations in mg/L)					
Analyte	SW-846 Analytical Method ^a	Reporting Limit	AWQS ^b	RCRA Concentration Limit ^c	Federal Primary MCL ^d
Antimony	6020B	0.002	0.006	NP	0.006
Arsenic	6020B	0.003	0.05	0.05	0.01 ^e
Barium	6010B	0.01	2.0	1.0	2.0
Beryllium	6020B	0.0005	0.004	NP	0.004
Cadmium	6020B	0.002	0.005	0.010	0.005
Chromium	6020B	0.005	0.10	0.05	0.10
Copper	6020B	0.01	NP	NP	TT
Cyanide, total	SM4500-CN CE	0.01	0.20	NP	0.20
Lead	6020B	0.001	0.05	0.05	TT
Manganese	6010B	0.01	NP	NP	NP
Mercury	7470A	0.0002	0.002	0.002	0.002
Nickel	6020B	0.01	0.10	NP	NP
Selenium	6010B	0.002	0.05	0.01	0.05

Table 9-2. List of Chemicals of Interest, Analytical Methods, Reporting Limits, and Screening Levels (Concentrations in mg/L)

Analyte	SW-846 Analytical Method ^a	Reporting Limit	AWQS ^b	RCRA Concentration Limit ^c	Federal Primary MCL ^d
Silver	6010B	0.001	NP	50	NP
Thallium	6020B	0.0005	0.002	NP	0.002
Tin	6010B	0.05	NP	NP	NP
Zinc	6010B	0.05	NP	NP	NP

^a The listed analytical method may be substituted using another, updated SW-846 method as long as the laboratory reporting limit was at or below the Arizona Aquifer Water Quality Standard (AWQS) and the data was generated out of the 6010/6020/7000 series.

^b AWQS= Aquifer Water Quality Standard, as designated in A.A.C. R18-11-406.

^c Resource Conservation and Recovery Act (RCRA) of 1976, as amended maximum concentration of constituents for groundwater protection as found in 40 CFR § 264.94.

^d US Environmental Protection Agency (USEPA) Safe Drinking Water Act (SDWA) primary Maximum Contaminant Level (MCL).

^e The MCL for arsenic applies only to community water systems.

mg/L = milligrams per liter

NP None published

TT Treatment technology-based MCL

Of the 17 analytes listed on Table 9-2, copper, chromium, lead, nickel, and zinc are the predominant metals present in the materials handled on the Site. The other metals listed may be present in the materials handled on site in trace quantities.

Groundwater samples were also analyzed for halogenated and aromatic volatile organic compounds (VOCs) using United States Environmental Protection Agency (USEPA) Test Method 601/602 during two of the sampling rounds (Fourth Quarter 1997 and Second Quarter 1998). During the April 1999 sampling round, groundwater samples were analyzed for total petroleum hydrocarbons (TPH) using USEPA Test Method 418.1AZ.

Table 9-3 lists the general chemistry analytes selected for the initial phase of the DMP. These parameters were selected for the purpose of characterizing the general chemistry of the groundwater. Table 9-3 lists the associated laboratory analytical methods for each analyte. The analyses listed on Table 9-3 were performed only on unfiltered groundwater samples.

Table 9-3. List of General Chemistry Analytes, Analytical Methods, Reporting Limits, and Screening Levels (Concentrations in mg/L)

Analyte	Analytical Method ^a	Reporting Limit	AWQS
Alkalinity	SM 2320B	20	NS
Calcium	SW6010B	1.0	NS
Chloride	EPA300	2.5	NS
Fluoride	EPA300	0.5	4.0
Iron	SW6010B	0.10	NS
Magnesium	SW6010B	1.0	NS
Nitrate (as N)	EPA353.2	0.50	10.0
Nitrite (as N)	SM 4500- NO2 B	0.02	1.0
Phosphorus, total	EPA365.3	0.05	NS

Table 9-3. List of General Chemistry Analytes, Analytical Methods, Reporting Limits, and Screening Levels (Concentrations in mg/L)

Analyte	Analytical Method ^a	Reporting Limit	AWQS
Potassium	SW6010B	2.0	NS
Sodium	SW6010B	2.0	NS
Sulfate	EPA300	3.0	NS
Total dissolved solids	SM2540 C	10	NS
Turbidity	EPA180.1	0.10 NTU	5

^a The listed analytical method may be substituted using another, updated SW-846 method as long as the laboratory reporting limit was at or below the Aquifer Water Quality Standard (AWQS) and the data was generated out of the 300 or 6010/7000 series.

mg/L = milligrams per liter

NS No established standard

NTU = Nephelometric turbidity units

In addition to the parameters listed in Tables 9-2 and 9-3, groundwater samples were analyzed for pH, specific conductance, and temperature using field instruments prior to sampling.

9.3.3 Sampling Procedures for the Initial Phase of the DMP

The DMP sampling and analysis procedures described below comply with 40 CFR § 264.97(d) and (e) in that they were designed to ensure that monitoring results provided a reliable indication of groundwater quality below the Site and were appropriate to accurately measure hazardous constituents in groundwater samples.

The DMP sampling procedures described in this section involve the following elements:

- Prior to each sample collection event, the depth to water in each monitoring well was measured for the purpose of calculating groundwater elevations and flow direction, as required by 40 CFR §§ 264.97(f) and 264.98(e);
- A minimum of three well volumes of water was purged from each monitoring well using a portable submersible pump. (None of the monitoring wells have dedicated pumps.) The flow rate of the pump was controlled to minimize turbulent flow within the monitoring well. Purge water was placed in labeled containers pending receipt of the laboratory analyses;
- Monitoring wells were purged with a single non-dedicated pump prior to sample collection, and groundwater samples were collected using disposable polyethylene bailers. Non-dedicated equipment was decontaminated before being used at the Site and after use in each monitoring well;
- Both filtered and unfiltered groundwater samples were collected for metals analysis to evaluate both dissolved and total metal concentrations. Other analyses were performed on unfiltered groundwater samples;
- Quality Control (QC) samples were collected as described below and in the Quality Assurance Plan (QAP); and
- All groundwater samples were collected under the direction of an independent groundwater professional.

A detailed description of the sampling procedures used during the initial phase of the DMP is presented in the following sections.

9.3.3.1 Field Equipment

A variety of equipment was used to obtain water levels, purge monitoring wells, collect samples, and measure field parameters. Depth to water was measured using a Solinst Model 101 electronic water level meter, or equivalent. The monitoring wells were purged using a Grundfos Redi-Flo 2 Pumping System that included a 2-inch submersible, variable speed, stainless steel pump. The pump was used only at the WRC facility for groundwater sampling events. Teflon® tubing was not required for the non-dedicated pump because samples were collected from the monitoring wells using 1.66- by 36-inch disposable polyethylene bailers equipped with a bottom-emptying device. Field data was measured using a portable pH/temperature/conductivity meter calibrated and operated according to the manufacturer's recommended specifications. Groundwater samples collected for dissolved metals analysis were filtered in the field at the time of sample collection using disposable 0.45-micron filter capsules.

9.3.3.2 Water Level Measurement

Each quarterly or semi-annual DMP sampling event began by measuring the depth to water to the nearest 0.01 foot in each monitoring well. The depth to water was measured in each of the monitoring wells before water from any single well was purged so that the evacuation of one monitoring well did not affect the water levels in nearby wells. In conjunction with previously-measured monitoring well depths and well head elevations, these depth-to-water measurements were used to calculate groundwater elevations, and flow rate and direction annually, as required by 40 CFR §§ 264.97(f) and 264.98(e) and to calculate the minimum volume of water to be purged from each monitoring well. The total depth of the monitoring well also was measured each sampling event.

9.3.3.3 Monitoring Well Purging

Purging was performed with a variable speed submersible pump. A single non-dedicated pump was used for all of the monitoring wells during the initial phase of the DMP. Dedicated pumps eventually may be used in the monitoring wells selected for long-term monitoring. If a dedicated pump is installed in the future, the pump will be installed near the middle of the water column and the depth to the top of the pump will be measured and recorded as the pump is installed.

Monitoring wells that contained less than 4 feet of water before purging were considered to be "dry" because these monitoring wells could not be purged with the submersible pump prior to sampling. Therefore, monitoring wells with less than 4 feet of standing water before purging were not sampled.

During purging, the pH, temperature, and conductivity were measured at least once for every well volume of groundwater removed. If possible, the monitoring wells were purged until at least three well volumes of water were removed, and the pH, temperature, and conductivity stabilized. Parameter stabilization was determined by comparing successive readings to one another. When three successive parameter measurements were within 10 percent of one another and the required volume was purged from the monitoring well, the well purging was complete.

The purge rate for each monitoring well was adjusted to maximize the volume removed without drying out the well and to minimize turbulent flow into the monitoring well, as follows:

- The height of the water column in the monitoring well was calculated before purging began.
- The depth to water was monitored during purging using the Solinst meter.
- The location/level of the top of the pump was noted when installing the pump.
- The pump began pumping at a rate of approximately 2 gpm. Water levels in the monitoring well were measured during pumping. If water levels dropped less than 1 foot and appeared to stabilize, a higher pumping rate was applied. If water levels continued to drop, the pumping rate was lowered.

- If the minimum flow rate of the pump continued to de-water the monitoring well, the pump was lowered and the minimum flow rate was maintained until the water level was lowered to the level of the top of the pump. The pump then was turned off and purging was considered complete. The pumping rates used at each monitoring well was recorded and used in future sampling events with similar static water levels.
- For monitoring wells that did not pump dry, the pumping was stopped when at least three well volumes of water had been removed, and the temperature, pH, and conductivity had stabilized.
- Upon completion of purging, the pump was removed at a slow and controlled rate. Sediment stirred up by removing the pump was allowed to settle for up to 24 hours before samples were collected. The sampling team judged the appropriate amount of time between purging and sampling on the basis of the observed rates of drawdown and recovery, the observed turbidity of the purge water, and historical observations of sediment accumulation in the monitoring well. Ideally, the monitoring well was sampled after the water level had recovered to at least 80 percent of the starting height and the sampled water was non-turbid.
- For monitoring wells that pumped dry, the well was sampled when water levels recovered to at least 80 percent of the starting level.

9.3.3.4 Groundwater Sample Collection Procedure for Monitoring Wells without a Dedicated Pump

For monitoring wells purged with the single non-dedicated pump, groundwater samples were collected using disposable polyethylene bailers. The bailer was attached to a nylon (or equivalent) rope for delivery into and from the monitoring well. The rope and bailer were discarded after the groundwater sample was collected from each monitoring well and a new length of rope was used for each disposable bailer at each well.

If monitoring well water appeared clear and non-turbid, a sample was collected immediately after the well had sufficiently recovered. Groundwater samples were retrieved from the purged monitoring well by lowering the bailer into the water and withdrawing the filled bailer from the monitoring well at a slow and controlled rate. The rope was gathered at the surface to prevent it from touching the ground by holding it or by coiling it into a clean bucket. A bottom-emptying device was attached to the bailer upon removal and the water was transferred into the required sample bottles and preserved as outlined on Table 9-4. This process was repeated until a sufficient amount of groundwater was obtained from the monitoring well to fill the set of sample containers.

Table 9-4. Sampling Plan Summary for Initial Phase of Detection Monitoring Program

Sample Container	Preservation ^a	Sample Type/Frequency	Analytical Method	Analyte	Recommended Maximum Holding Time
TOTAL METALS					
(1) 1-liter polyethylene bottle	HNO ₃ ; 4°C ±2°C	1. One groundwater sample from each of the seven wells per quarterly or semi-annual event. 2. One duplicate groundwater sample per quarterly or semi-annual event. 3. One field equipment blank per quarterly or semi-annual event when non-dedicated equipment is used.	6010A	Barium	6 months except 28 days for mercury
			6010A	Calcium	
			6010A	Copper	
			6010A	Iron	
			6010A	Magnesium	
			6010A	Manganese	
			6010A	Nickel	
			6010A	Potassium	
			6010A	Sodium	
			6010A	Tin	
			6010A	Zinc	

Table 9-4. Sampling Plan Summary for Initial Phase of Detection Monitoring Program

Sample Container	Preservation ^a	Sample Type/Frequency	Analytical Method	Analyte	Recommended Maximum Holding Time
			7041 7060A 7091 7131A 7191 7421 7471A 7740 7761 7841	Antimony Arsenic Beryllium Cadmium Chromium Lead Mercury Selenium Silver Thallium	
DISSOLVED METALS					
(1) 1-liter polyethylene bottle	Filtered in field before placed in container with HNO ₃ ; 4°C ±2°C	1. One groundwater sample from each of the seven wells per quarterly or semi-annual event. 2. One duplicate groundwater sample per quarterly or semi-annual event.	Same methods as above	Same metals as above	6 months except 28 days for mercury
TOTAL CYANIDE					
(1) 1-liter polyethylene bottle	NaOH; 4°C ±2°C	1. One groundwater sample from each of the seven wells per quarterly or semi-annual event. 2. One duplicate groundwater sample per quarterly or semi-annual event.	9010A	Cyanide	14 days
NITRATE, PHOSPHATE					
(1) 0.5-liter polyethylene bottle	H ₂ SO ₄ ; 4°C ±2°C	1. One groundwater sample from each of the seven wells per quarterly or semi-annual event. 2. One duplicate groundwater sample per quarterly or semi-annual event.	353.2 365.3	Nitrate ^b Phosphate	28 days 28 days
GENERAL CHEMISTRY					
(1) 1-liter polyethylene bottle	4°C ±2°C	1. One groundwater sample from each of the seven wells per quarterly or semi-annual event. 2. One duplicate groundwater sample per quarterly or semi-annual event.	9038 SM 2320B 325.2 340.2 354.1 160.1 180.1	Sulfate Alkalinity Chloride Fluoride Nitrite TDS Turbidity	28 days 14 days 28 days 28 days 48 hours 7 days 48 hours

^aUpon collection, samples will be maintained with sufficient coolant to chill the samples to 4°C ±2°C until received by the analytical laboratory. While in the laboratory, samples will be stored and maintained at 4°C ±2°C.

^bTest Method 353.2 provides concentration of nitrate plus nitrite; nitrate concentration will be calculated by subtracting the Test Method 354.1 nitrite result.

As shown on Table 9-4, each groundwater sample consisted of four 1-liter bottles and one 0.5-liter bottle. These bottles were equipped by the analytical laboratory with various preservatives. The bailed groundwater analyzed for dissolved metals was field-filtered using the filtration system described in Section 9.3.3.1. The filtering was performed on an unpreserved sample before the groundwater was transferred into one of the

1-liter bottles containing nitric acid preservative. The other four bottles listed on Table 9-4 were filled with unfiltered groundwater transferred directly from the bailer.

The sampling plan summary shown on Table 9-4 indicates that one duplicate groundwater sample was collected for each sampling event. The duplicate sample was collected from one of the recently installed monitoring wells positioned downgradient of the POC that met the requirements of 40 CFR § 264.97(a)(2). The primary/duplicate sample pair was collected by filling approximately one-quarter of a sample bottle with groundwater from the bailer, alternating between the two bottles designated for the same analyses until the bottles were full, and filtering as necessary for the pair of bottles identified for dissolved metals analysis. The duplicate sample was submitted to the laboratory blind and assigned a fictitious name so that the laboratory did not recognize it as a QC sample. The sample was called MW-1X, where "X" was the monitoring well number. For example, a duplicate of MW-6 would have been labeled MW-16.

9.3.3.5 Procedures for Decontaminating the Non-Dedicated Pump

The non-dedicated pump was decontaminated before and after it was installed in each monitoring well for purging. The outside of the pump and discharge lines were rinsed thoroughly with purified water, and purified water was run through the inside of the pump and discharge line. The pump hose had a check valve to prevent the discharge of any water in the hose from entering the monitoring well.

To monitor for cross-contamination of samples from inadequate cleaning of the non-dedicated purging pump, one field equipment blank was collected during each quarterly (or semi-annual) sampling event when the non-dedicated pump was used. The field equipment blank was prepared in the field by running purified water through the cleaned pump discharge line and through an unused disposable sampling bailer. As shown on Table 9-4, the water was then collected in a 1-liter bottle containing nitric acid preservative and submitted as a sample for total metals analysis. The field equipment blank was submitted to the laboratory blind by being given a fictitious name so that the laboratory did not recognize it as a blank. The field equipment blank was collected at the end of sampling and was called MW-7F.

9.3.3.6 Groundwater Sample Collection Procedure for Monitoring Wells with a Dedicated Pump

None of the WRC monitoring wells are equipped with a dedicated pump.

9.3.3.7 Sample Containers, Preservation, and Holding Times

The sample containers, filtration and/or preservation requirements, and recommended maximum holding times vary per analyte, and a matrix containing this information is presented in Table 9-4. Before each quarterly (or semi-annual) field sampling event, the appropriate containers were obtained from the laboratory for the planned suite of analyses. The sample containers were clean, unused, bottleware obtained from the laboratory, who obtained them from I-Chem, Eagle Picher, or other equivalent source. The laboratory affixed labels to the sample containers indicating the nature of the preservative added to the container by the laboratory, or indicating that the proper preservation was added.

9.3.3.8 Sample Handling, Storage, Shipment, and Custody

For each sample submitted to the laboratory for analysis, an entry was made on a chain-of-custody form supplied by the laboratory. The information recorded on the chain-of-custody form included: the sampling date and time, monitoring well number, matrix type, requested analyses and methods, preservatives, and the sampler's name. The chain-of-custody form accompanied the samples from the time of collection until they were received by the laboratory. Each party in possession of the samples (except professional courier services) signed the chain-of-custody form signifying receipt. One of the copies of the chain-of-custody form was retained by the field crew for future reference. The remaining copies of the chain-of-custody form were

placed in a plastic bag and maintained with the samples inside the cooler during sample delivery. A copy of the completed chain-of-custody form also was provided by the laboratory along with the laboratory analytical report.

After being filled, sample containers were wiped with paper towels and securely packed in a chilled cooler in preparation for delivery to the laboratory. Upon collection, the samples were stored with sufficient coolant to chill the samples to 4 degrees Celsius ($^{\circ}\text{C}$) $\pm 2^{\circ}\text{C}$ until received by the analytical laboratory. After the samples, ice, and chain-of-custody forms were packed in the coolers, custody seals were placed on the lid of each cooler. Sampling team members maintained custody of the samples until they were relinquished to laboratory personnel or a professional courier service. Sealed coolers were delivered to the laboratory by the sampling team or a professional courier service. Custody seals provided assurance that the samples were not tampered with during transportation to the laboratory.

Upon receipt, the laboratory inspected the condition of the sample containers and reported the information on the chain-of-custody form. The laboratory immediately notified WRC or consultant Project Manager if conditions or problems were identified that required immediate resolution. Such conditions included: container breakage, missing or improper chain-of-custody forms, exceeded holding times, missing or improper sample labeling, compromised custody seals, or frozen water samples. While in the laboratory, samples were stored and maintained at $4^{\circ}\text{C} \pm 2^{\circ}\text{C}$.

9.3.3.9 Documentation

In the field, the labels affixed to the sample containers were marked with the monitoring well number, initials of the person who collected the sample, date and time of sample collection, and the category of analytes requested for the container (e.g., total metals, dissolved metals, total cyanide, nitrate/phosphate, or general chemistry; see Table 9-4). The labels had already been marked by the laboratory with the preservative placed in the container or that appropriate preservation had been placed in the container.

Three types of forms were used to document field activities: a chain-of-custody form (discussed above), a daily field report, and a groundwater sampling data sheet. The daily field report was used to describe general activities and conditions, weather conditions, visitors, start and stop times, and other information not recorded on the groundwater sampling data sheet. The groundwater sampling data sheet was used to record well-specific information including:

- Depth to water;
- Calculated total height of water in the monitoring well and volume to be purged;
- Equipment used for purging and the time purging started;
- Purge rate, adjustments to the purge rate, and the time and gallons purged when each adjustment is made;
- Periodic measurements of temperature, pH, and conductivity, and the time and number of gallons purged when the measurements were made;
- Visual observations of turbidity and the time and number of gallons purged when the observations were made;
- Ending purge time and the total gallons purged;
- Equipment used for sampling and the time of sample collection; and
- The number and size of sample containers filled, and the fictitious sample identification applied to blind duplicate groundwater samples.

9.3.3.10 Disposal of Purge Water

Purge water produced from each monitoring well was stored on Site behind the WRC laboratory in 55-gallon drums until the results of the laboratory analyses were evaluated. Unless the evaluation indicated that hazardous constituents had been released to groundwater from the facility, the contained water was treated on Site. The containers were reused during the next sampling event. All purge water, whether clean or contaminated, was processed through the on-site wastewater treatment plant. Used bailers and personal protective equipment (PPE) were decontaminated and discarded as non-hazardous waste.

9.4 Quality Assurance Plan (QAP) for the DMP

This section discusses the QAP procedures and specifications that were employed during the initial phase of the DMP, and which will be employed for the ongoing phase of the DMP. The purpose of this QAP is to designate and document the specifications and methods that were (and will be) employed to establish technical accuracy and precision, statistical validity, and documentary evidence of data generated during the initial phase of groundwater monitoring at WRC. This QAP serves as the quality-controlling document for the work conducted to assure that the data obtained is of sufficient quality to meet intended usages and Applicable or Relevant and Appropriate Requirements (ARARs) within the project.

This QAP contains general and specific details regarding field sampling, laboratory, and analytical procedures that apply to this sampling program. This QAP provides field and laboratory personnel with instructions regarding activities to be performed before, during, and after these field investigations. Field sampling procedures for the initial phase of the DMP are discussed in Section 9.3.3.

Guidelines followed in the preparation of this QAP are described in *USEPA Region IX Guidance for Preparing Quality Assurance Project Plans for Superfund Remedial Projects* (USEPA, 1989a); *USEPA Requirements for Quality Assurance Plans for Environmental Data Operations* (USEPA, 1993); *USEPA Guidance for the Data Quality Objectives Process*, (USEPA, 1994); *USEPA Guidance for the Data Quality Assessment Process: Practical Methods for Data Analysis* (USEPA 1996); *USEPA Requirements for Quality Assurance Project Plans*, (USEPA, 1999); and *Arizona Department of Environmental Quality (ADEQ) Superfund Program Section Quality Assurance Program Plan* (ADEQ, 2000).

Other documents that have been referenced in this DMP include *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846* (USEPA, 1994b) and *Methods for Chemical Analysis of Water and Wastes* (USEPA, 1983).

Total metals, dissolved metals, and general groundwater chemistry parameters were the target compounds for the initial phase of the DMP program. It was intended that data collected through implementation of the QAP will satisfy the requirements of A.A.C. R18-8-264.A, I, and J, which incorporates and modifies 40 CFR § 264, Subpart F (Releases from Solid Waste Management Units).

9.4.1 Data Quality Objectives

Data Quality Objectives (DQOs) have been specified for each data collection activity and the work was conducted and documented in a manner whereby data collected are sufficient and of adequate quality for its intended use (USEPA, 1993, 1994, and 1999; and ADEQ, 2000). DQOs specify the data type, quality, quantity, and uses needed to make decisions, and are the basis for designing data collection activities. The DQOs have been incorporated into the data collection activities presented above. The DQOs for the project are discussed in the following sections.

9.4.1.1 Data Categories

The two general categories of data are defined as: (1) screening data and (2) definitive data. Field screening methods include water chemistry screening, such as measuring the groundwater temperature, pH, and

conductivity. Results from field screening methods were recorded on the groundwater sampling data sheets discussed in Section 9.3.3.9. Field screening methods were used to direct field activities and provide general information regarding field conditions.

Definitive data are generated using rigorous analytical methods, such as approved USEPA or American Society of Testing and Materials (ASTM) reference methods. Definitive data are analyte specific, and both identification and quantification are confirmed. These methods have standardized QC and documentation requirements. Definitive data are not restricted in their use unless quality problems require data qualification.

The definitive data was generated by a laboratory certified by the Arizona Department of Health Services (ADHS) Office of Laboratory Licensure and Certification for the analyses to be performed.

9.4.1.2 Precision, Accuracy, Representativeness, Comparability, and Completeness

The basis for assessing the elements of data quality is discussed in the following subsections. In accordance with general QC methods described in USEPA SW-846 (1994b), the laboratory was responsible for generating acceptable limits of accuracy and precision for use during analysis. In the absence of laboratory-specific precision and accuracy limits, the QC limits listed in this section were met.

Precision

Precision measures the reproducibility of repetitive measurements. It is strictly defined as the degree of mutual agreement among independent measurements as the result of repeated application of the sample process under similar conditions.

Analytical precision is a measurement of the variability associated with duplicate or replicate analyses of the same sample in the laboratory, and is assessed by analysis of laboratory QC samples, such as duplicate control samples ([DCS] or laboratory control sample duplicate [LCSD]), matrix spike duplicates (MSD), or sample duplicates. If the recoveries of analytes in the specified control samples are comparable within established control limits, then precision is within limits.

Total precision is a measurement of the variability associated with the entire sampling and analytical process. It is assessed by analysis of duplicate field samples, and measures variability introduced by both the laboratory and field operations. Field duplicate samples are analyzed to assess field and analytical precision. A field duplicate sample was collected from one monitoring well per sampling event.

Duplicate results were assessed using the relative percent difference (RPD) between duplicate measurements. If the RPD for laboratory QC samples exceeded 30 percent, the data were qualified. If the RPD between primary and duplicate field samples exceeded 50 percent, the data were qualified.

The RPD was calculated as follows:

$$RPD = (100)(X_1 - X_2) / (X_1 + X_2)$$

where: X_1 is the larger of the two observed values; and
 X_2 is the smaller of the two observed values.

Accuracy

Accuracy is a statistical measurement of correctness and includes components of random error (variability due to imprecision) and systematic error. It reflects the total error associated with a measurement. A measurement is accurate when the value reported does not differ from the true value or known concentration of the spike or standard.

Accuracy of laboratory analyses was assessed by LCS, matrix spikes, and initial and continuing calibrations of instruments. Laboratory accuracy was expressed as the percent recovery (%R). If the percent recovery was assessed to be outside of acceptance criteria, the data were qualified. The calculation for percent recovery is:

$$\%R = (100) (X_s - X) / T$$

where: X_s is the measured value of the spiked sample;
 X is the measured value of the unspiked sample; and
 T is the true value of the spike solution added.

Field accuracy was assessed through the analysis of field equipment blanks for sampling events that employed non-dedicated equipment. Analysis of field equipment blanks monitored errors associated with the sampling process, field contamination, sample preservation, and sample handling. The accuracy DQO for field equipment blanks was that all values were less than the reporting limit for each analyte. If contamination was reported in the field equipment blanks, the data were qualified.

Representativeness

Representativeness is the degree to which data accurately and precisely represent selected characteristics of the media sampled. Representativeness of data collection is addressed by careful preparation of sampling and analysis programs. This QAP, together with the sample collection procedures described above, addresses representativeness by specifying sufficient and proper numbers and locations of samples; incorporating appropriate sampling methodologies; specifying proper sample collection techniques and decontamination procedures; selecting appropriate laboratory methods to prepare and analyze the samples; and establishing proper field and laboratory Quality Assurance (QA) and QC procedures.

Completeness

Completeness is the amount of valid data obtained compared to the amount that was expected under “ideal” conditions. The number of valid results divided by the number of possible results, expressed as a percentage, assesses the completeness of the data set. The objective for completeness is to recover at least 90 percent of the planned data to support field efforts. The formula for calculation of completeness is as follows:

$$\% \text{ completeness} = (100)(\text{number of valid results} / \text{number of possible results})$$

Comparability

Comparability is an expression of confidence with which one data set can be compared to another. The objective of comparability is to ensure that data developed during the DMP are comparable to previously obtained DMP data and adequately address applicable criteria or standards established by the USEPA and ADEQ. This QAP addresses comparability by specifying field and laboratory methods that are consistent with the current standards of practice as approved by the USEPA and ADEQ.

Sensitivity

Sensitivity is a measure of the analytical detection or quantification limits and is a function of the sample matrix, the ability of an instrument or system to respond to an analyte, and the ability of the analyst to verify the identification of the compound. Sensitivity is achieved by the use of appropriate laboratory reporting limits as defined in Tables 9-3 and 9-4. Sensitivity can be affected by matrix interferences or blank contamination, as discussed above in this section.

9.4.2 Quality Control Elements

This section presents QC requirements relevant to analysis of environmental samples that were followed during project analytical activities. The purpose of the QC program is to produce data of known quality that satisfy the project objectives and that meet or exceed the requirements of the standard methods of analysis. This program provides a mechanism for ongoing control and evaluation of data quality measurements.

9.4.2.1 Quality Control Procedures

The chemical data collected for this effort were used to monitor for a release of contaminants to the groundwater. As such, it was critical that the chemical data be of the highest confidence and quality. Consequently, strict QA/QC procedures were adhered to. These procedures included:

- Adherence to strict protocols for field sampling and decontamination procedures;
- Collection and laboratory analysis of appropriate field equipment blanks to monitor for cross-contamination of samples in the field;
- Collection and laboratory analysis of matrix spike, MSD, and blind split samples to evaluate analytical precision and accuracy; and
- Attainment of completeness goals.

Equipment Decontamination

The non-dedicated purge pump was decontaminated before and after use in each monitoring well. A description of the specific methodologies followed for decontamination of the purge pump is presented in Section 9.3.3.5. After purging, groundwater samples were collected using disposable bailers, not with non-dedicated equipment that must be decontaminated.

Standard Materials

Standard material used to calibrate equipment and to prepare samples were traceable to National Institute of Standards and Technology (NIST), USEPA, or other equivalent sources. The standard materials were current at the time of calibration. The expiration date was established by the manufacturer or was based on chemical stability, the possibility of contamination, and environmental and storage conditions. Standard materials were labeled with expiration dates, and referenced primary standard sources if applicable. Expired standard materials were discarded.

Supplies

Supplies were inspected prior to their use in the field or laboratory. The descriptions of methods for sample collection and analysis were used as a guide for establishing the acceptance criteria for related materials. A current inventory and appropriate storage system for these materials protected their integrity prior to use. Efficiency and purity of supplies were monitored through the use of standard materials and blank samples.

Holding Time Compliance

Sample preparation and analysis were completed within the required method holding times. Holding time begins at the time of sample collection. If holding times were exceeded, and the analyses were performed, the associated results were qualified. The following definitions of extraction and analysis compliance were used to assess holding times:

- Preparation or extraction completion: completion of the sample preparation process as described in the applicable method, prior to any necessary extract cleanup; and

- Analysis completion: completion of all analytical runs, including dilutions, second-column confirmations, and any required re-analyses.

9.4.2.2 Quality Assurance and Quality Control Samples

QA and QC samples were collected as part of the overall QA/QC program. The purpose of this QA/QC program is to produce data of known quality that satisfy the project objectives and that meet or exceed the requirements of the standard methods of analysis. This program provides a mechanism for ongoing control and evaluation of data quality measurements through the use of QC materials.

Laboratory Reagent Blanks

A laboratory reagent blank is deionized, distilled water that is extracted by the laboratory and analyzed as a sample. Analysis of the reagent blank indicates potential sources of contamination from laboratory procedures (e.g., contaminated reagents, improperly cleaned laboratory equipment, or persistent contamination due to presence of certain compounds in the ambient laboratory air). A reagent blank was analyzed at least once each day for each method utilized by the laboratory for that day.

Field Equipment Blanks

A field equipment blank is a sample that is prepared in the field by pouring deionized, distilled water over and through the cleaned non-dedicated purge pump and over an unused disposable sampling bailer. The water is then collected and analyzed as a sample. Field equipment blanks are typically “blind” (given a fictitious name so that the laboratory will not recognize it as a blank). The field equipment blank gives an indication of contamination from field procedures (e.g., improperly cleaned sampling equipment, cross-contamination). When a pump was used in more than one monitoring well per sampling event, one field equipment blank was collected for the sampling event. The field equipment blanks were analyzed for total concentrations of the laboratory analytes listed on Table 9-2 that were the same analytes requested for the associated primary samples.

Matrix Spike Samples

Matrix spikes are performed by the analytical laboratory in order to evaluate the efficiency of the sample extraction and analysis procedures, and are necessary because matrix interference (that is, interference from the sample matrix) may have an impact on the accuracy and precision of the extraction analysis. The matrix spike is prepared by the addition of known quantities of target compounds to a sample. The sample is extracted and analyzed. The results of the analysis are compared with the known additions and a matrix spike recovery is calculated giving an evaluation of the accuracy of the extraction and analysis procedures. Typically, matrix spikes are performed in duplicate in order to evaluate the precision of the procedures as well as the accuracy. Matrix spike recoveries are reviewed to check that they are within acceptable range. However, the acceptable ranges vary widely with both sample matrix and analytical method. Matrix spikes and MSDs were analyzed by the laboratory at a frequency of at least 1 per 20, or 5 percent.

Duplicate Spike Samples

Precision objectives (represented by agreement between matrix spike and MSD recoveries) and accuracy objectives (represented by matrix spike recovery results) are established by the laboratory. It is important to note that these objectives are to be viewed as goals, not as criteria.

Field Duplicate Samples

Field duplicate samples are collected and analyzed to evaluate sampling and analytical precision. Field duplicates are collected and analyzed in the same manner as the primary samples. Agreement between duplicate sample results indicates representative and consistent sampling and analytical precision. One field duplicate was collected during each sampling event. The duplicate sample was collected from a downgradient

monitoring well. The specific monitoring well location selected for duplicate sampling was chosen at random prior to each sampling event. The duplicate sample was analyzed for dissolved and total concentrations of the laboratory analytes listed on Table 9-2 requested for the associated primary sample. The precision goal for field duplicate analyses was plus or minus 50-percent RPD.

9.4.3 Field Sampling and Handling Procedures

Collection of environmental samples of high integrity is important to the quality of chemical data to be generated, and the defensibility of data is dependent on the use of well-defined, accepted sampling and handling procedures. Section 9.3.3 above presents a full description of the strict procedures that were followed regarding monitoring well purging; sample collection; sample containers, preservation, and holding times; sample handling and storage; and sample custody.

9.4.3.1 Analytical Procedures

The analytical methods used for this project are primarily USEPA Test Methods and are listed in Tables 9-3 and 9-4. Specific analytical method procedures are detailed in *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (USEPA, 1998) and *Methods for Chemical Analysis of Water and Wastes* (USEPA, 1984).

9.4.3.2 Data Reporting

Data measured by field instruments were recorded on groundwater sampling data sheets. Units of measure for field analyses were identified on the field forms. The field data were reviewed by the Project Manager to evaluate completeness of the field records and appropriateness of the field methods employed. Field records were retained in the project files.

The laboratory data report was consistent with previous USEPA Level III documentation and, at a minimum, included the following data and summary forms:

- Narrative, cross reference, chain of custody, and method references;
- Analytical results;
- Blank results;
- LCS recoveries and applicable QC limits;
- Sample spike recoveries and applicable QC limits;
- Duplicate sample results or duplicate spike recoveries and applicable QC limits; and
- Method of Standard Additions (as required).

The data were subject to validation to assess for bias and review for completeness, representativeness, and acceptable levels of precision and accuracy. Supporting documentation, including associated raw data, was made available upon request if a more comprehensive data review was warranted.

9.4.3.3 Data Validation

Data were evaluated through the process of validation. Data validation is the procedure of reviewing data against a known set of criteria to verify data validity prior to its use.

Data validation criteria are derived from the *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (USEPA, 1994a). The Functional Guidelines provide general data validation protocols that can be applied to data generated for this investigation.

The laboratory data were reviewed for compliance with the applicable method and the quality of the data reported. The following summarizes the areas of data validation:

- Completeness of data;

- Holding times;
- Blanks;
- Laboratory control samples;
- Matrix spike/MSD;
- Field duplicates; and
- Compound identification and quantification.

The application of data validation criteria is a function of project specific DQOs. The Project Manager assessed if the data quality objectives were met. Results of the data validation review were documented and summarized in a Data Validation Memorandum, which was prepared and included as an attachment to the quarterly (or semi-annual) groundwater monitoring report. Quarterly (or semi-annual) groundwater monitoring reports were completed within 4 weeks of obtaining laboratory analytical results.

The data validation procedures were designed to review each data set and identify biases inherent to the data, including assessment of laboratory performance, overall precision and accuracy, representativeness, and completeness. Data validation flags were applied to those sample results that fall outside of specified tolerance limits, and, therefore, did not meet the program's QA objectives. An explanation of the data flags is as follows:

- U** The analyte was analyzed for, but was not detected above the reported sample quantification limit.
- J** The analyte was **positively** identified; the associated numerical value is the approximate concentration of the analyte in the sample.
- N** The analysis **indicates** the presence of an analyte for which there is presumptive evidence to make a "tentative identification."
- NJ** The analysis **indicates** the presence of an analyte that has been "tentatively identified" and the associated numerical value represents its approximate concentration.
- UJ** The analyte was not detected above the reported sample quantification limit. However, the reported **quantification** limit is approximate and may or may not represent the actual limit of quantification necessary to accurately and precisely measure the analyte in the sample.
- R** The sample **results** are rejected due to serious deficiencies in the ability to analyze the sample and meet QC criteria. The presence or absence of the analyte cannot be verified.

WRC relies on the laboratory limits established by the ADHS-certified laboratory conducting the analyses. In the event that a sample result fell outside of the laboratory limits, WRC contacts the laboratory and requests that the sample in question be re-analyzed and re-extracted/digested. If the re-analysis also falls outside of the laboratory limits, WRC will contact the laboratory and discuss the options available (re-sampling, re-analyzing, etc.).

9.4.3.4 Preventive Maintenance

Procedures specific to the calibration, use, and maintenance of field equipment are prescribed in the manufacturer's specifications. Scheduled maintenance was performed by trained personnel. The analytical laboratory was responsible for their own equipment calibration and maintenance as described in their Laboratory QA Manual. Subcontractors, if any, were responsible for maintenance of equipment needed to carry out subcontracted duties.

9.4.3.5 Corrective Action

Data validation and verification was performed on the groundwater samples to determine the compliance of the analytical data with the established method performance criteria. Validation of the data package included

a review of the holding time requirements, sample preparation, initial and continuing calibration data, review and recalculation of the laboratory QC sample data, review of the equipment performance, reconciliation of the raw data with the reduced results, identification of data anomalies, and qualification of data to identify data usability limitations. In the event, that any data were identified as non-compliant, the contract laboratory was contacted to request that the sample in question be re-analyzed and re-extracted/digested. Contingency actions for non-compliant data may have included, but were not limited to, re-analyzing again and/or re-sampling the well.

Data validation and verification was also performed to determine whether the data quality is sufficient to support the data quality objectives. Corrective actions were initiated whenever data quality indicators suggested that DQOs had not been met. Corrective actions began with identifying the source of the problem. Potential problem sources included failure to adhere to method procedures, improper data reduction, equipment malfunctions, or systemic contamination. The first level of responsibility for identifying the problems and initiating corrective action lies with the analyst/field personnel. The second level of responsibility lies with any person reviewing the data. Corrective actions may have included more intensive staff training, equipment repair followed by a more intensive preventive maintenance program, or removal of the source of systemic contamination. Once resolved, the corrective action procedure was fully documented, and if DQOs were not met, the samples in question were recollected and/or reanalyzed utilizing a properly functioning system.

9.5 Data Analysis for the Initial Phase of the DMP

9.5.1 2001 Data Analysis

In 2001, WRC conducted a data analysis of existing groundwater quality data to assess whether hazardous constituents were detected in the groundwater downgradient of the HWMU. The 2001 data analysis was performed on groundwater quality data obtained from wells MW-5, MW-6, MW-7, and MW-8 during the eight quarters between January 1999 and December 2000. However, all four of these monitor wells began to go dry beginning in 2001. Wells MW-5 and MW-8 were officially abandoned in September 2006; monitor wells MW-6 and MW-7 are still in “active” status but are occasionally dry. Hence, after considering that half the wells used in the 2001 data analysis were no longer part of the groundwater monitoring network, WRC decided to conduct a second data analysis in 2008, incorporating groundwater quality data from the three new wells (MW-9, MW-10, and MW-11). The following section discusses the details, methodology, and results of the second data analysis. For informational purposes, the data, methodology, calculations, and results of the 2001 analysis are provided in Part III, Appendix G, of the permit application.

9.5.2 2008 Data Analysis

WRC began groundwater monitoring of their HWMU in February 1997, and has continued through the present. Based on discussions with ADEQ and having accumulated over 8 years of groundwater monitoring data, WRC officially completed the initial phase of the DMP in December 2007. In March 2008, WRC evaluated all of the data (from monitor wells MW-1 through MW-11, from February 1997 through December 2007) to assess whether hazardous constituents were detected in the groundwater downgradient of the HWMU and to calculate concentration limits, as defined in 40 CFR § 264.94.

During the March 2008 data review, a decision was made to exclude groundwater quality data obtained from monitor well MW-5 from statistical analysis due to the erratic and anomalous occurrences of metals reported in this well just prior to it going dry in 2001. All other groundwater quality data from the other 10 monitor wells were used in the 2008 statistical analysis. Each monitoring parameter was compared to standards, then reviewed to determine if it could be considered as statistically significant evidence of contamination per 40 CFR § 264.98(f). The conclusion of the data evaluation was that there was no evidence of contamination,

statistically significant or otherwise, in the aquifer beneath the WRC facility. The data, methodology, calculations, and results of the 2008 data analysis are provided in Part III, Appendix G-B of the permit application. The statistical methods used in the calculations met the statistical performance standards of 40 CFR § 264.97(i).

Specifically, the groundwater quality data obtained during the initial phase of the DMP were used to:

- Calculate background concentrations of useful indicator parameters;
- Assess the natural spatial variability in average concentrations of indicator parameters in the groundwater beneath the facility; and
- Assess the natural temporal variability in concentrations of indicator parameters in groundwater sampled from upgradient and downgradient monitoring wells.

Based on discussions and agreement with ADEQ in 2007, the following parameters of concern were selected to be monitored in the ongoing phase of the DMP and were used in the data analysis.

- Chloride
- Sulfate
- Sodium
- Magnesium
- Copper
- Nickel
- Zinc
- pH (field)

Concentration limits were calculated for seven of the above constituents; concentration limits were not calculated for field pH values because the pH is measured and recorded in the field using a hand-held field meter. The accuracy of readings (pH, specific conductance, etc.) obtained from a field meter are only as reliable as the equipment itself, and therefore, due to the inconsistency of field equipment, no concentration limits were calculated for pH. However, WRC will test for and record pH at each of the ongoing DMP monitoring wells prior to sample collection.

Table 9-5 below provides the results of the 2008 data analysis and the calculated concentration limits for each parameter of concern.

Table 9-5. Calculated Concentration Limits for Chemicals of Concern (Concentrations in mg/L)							
Analyte	Number of Sampling Events	Number of Detects	Number of Non-Detects	Mean	Standard Deviation	Calculated Concentration Limit	AWQS
Chloride	88	82	6	373	104	828	NS
Sulfate	88	79	9	191	34	341	NS
Sodium	88	88	0	420	43	609	NS
Magnesium	88	87	1	32	7.3	64	NS
Copper	88	2	86	n/a	n/a	0.80	NS
Nickel	82	0	82	n/a	n/a	0.08	0.10
Zinc	88	3	85	0.058	0.014	0.12	NS

mg/L = milligrams per liter

n/a = Due to high number of nondetects, the calculated Background Concentration Limit was set at 80 percent of a numeric standard, i.e. either the Arizona Aquifer Water Quality Standard (AWQS) or the federal secondary Maximum Contaminant Level.

NS = No numeric AWQS.

The concentration limit was set equal to 95 percent of the Chebyshev upper prediction limit (UPL) for those constituents with a sufficient number of detected values (i.e., chloride, magnesium, sodium, sulfate, and zinc). The mean and standard deviation, which are required for calculation of the Chebyshev UPLs, were determined using the Kaplan-Meier method for censored data if nondetects were present in the data. Otherwise, arithmetic values for the mean and standard deviation were calculated.

Due to the low number of actual detections of copper and nickel in the groundwater monitoring wells, an alternative method was used to establish the background concentration limit for these parameters. For those two constituents, the background concentration limits were set at 80 percent of an applicable numeric water quality standard. The background concentration limit for copper was set equal to 80 percent of the federal secondary maximum contaminant level for copper, which is 1.0 milligrams per liter (mg/L). The background concentration limit for nickel was set equal to 80 percent of the Aquifer Water Quality Standard (AWQS), which is 0.10 mg/L. Although the number of detections of zinc was also very low, there is no numeric standard, federal or state, established for that metal, and hence, the background concentration limit for zinc was determined using the Kaplan-Meier method.

Details of the 2008 statistical analysis are provided in Part III, Appendix G.

Based on the evaluation of groundwater quality data collected from the WRC monitoring wells over the period of February 1997 through December 2007, there was no evidence of contamination, statistically significant or otherwise, in the aquifer beneath the WRC facility.

9.6 Ongoing Detection Monitoring Program

This section has been developed in accordance with 40 CFR § 264.98(h) for long-term (ongoing) monitoring at the WRC facility. Based upon the results of the initial phase of the DMP, it is no longer appropriate to continue to monitor groundwater to establish background conditions, to test for analytes that can be evaluated using indicator parameters, or to sample monitoring wells located generally cross-gradient of the HWMU. This ongoing DMP is designed to yield groundwater samples that are representative of the quality of groundwater upgradient of the HWMU and groundwater passing through the POC, and will allow for the detection of groundwater contamination if hazardous constituents should migrate from the facility into the uppermost aquifer. The ongoing DMP sampling plan ensures, with reasonable confidence, that if a contaminant release to groundwater from the facility occurs, then it will be detected.

This ongoing DMP is focused on targeting indicator parameters, waste constituents, or reaction products as defined in 40 CFR § 264.93(a) and (b), required by 40 CFR § 264.98(a). The ongoing DMP includes those monitoring wells most appropriately located at and downgradient of the POC, in conformance with 40 CFR §§ 264.97(a)(2) and 264.97(g), and as required by § 264.98(b), and the monitoring well most appropriately located upgradient of the facility, in conformance with 40 CFR §§ 264.97(a)(1) and 264.97(g). The ongoing DMP takes into account rates and directions of groundwater flow beneath the facility, and the mobility of the contaminants. The elements of the ongoing DMP are further discussed below.

9.6.1 Ongoing DMP Monitoring Well Network

The ongoing DMP will include sampling of monitoring wells MW-9, MW-10, and MW-11, as well as, any future monitoring well(s) agreed upon between WRC and ADEQ. Monitoring well MW-11 meets the requirements of 40 CFR § 264.97(a)(1) for ongoing monitoring of background water quality, and monitoring wells MW-9 and MW-10 meet the requirements of 40 CFR § 264.97(a)(2) for ongoing monitoring of groundwater quality passing the POC. The POC, as defined in 40 CFR § 264.95, is shown on the Site Plan (Figure DMP-01) as are the locations of the monitoring wells listed above. As discussed in Section 9.2,

monitoring wells MW-1 through MW-5 and MW-8 have been abandoned in accordance with ADWR procedures because the groundwater level declined to a depth below the bottom of the monitor well. Monitoring wells MW-6 and MW-7 have been dry since June 2006 and will most likely be abandoned in the future. Table 9-6 lists the monitoring wells (as of the date of this DMP document) that will be used in the ongoing DMP.

Well ID	ADWR Registration Number	Well Construction Date
MW-9	55-597959	5-10-2003
MW-10	55-599992	9-08-2003
MW-11	55-200947	11-24-2003

Ongoing DMP groundwater sampling will occur annually (in April) since analysis of monitoring data to date do not show either any temporal variations or any evidence of a release (*Permit Applicants' Guidance Manual for Hazardous Waste Land Treatment, Storage, and Disposal Facilities*, USEPA, 1984).

9.6.2 Ongoing DMP Analytical Program

The primary objective of a well-designed groundwater monitoring program should be to identify a few, but key, indicator metals that occur most predominantly in the waste streams, and then incorporate this selected subset of metals into the routine ongoing groundwater monitoring program. Should any one of these key indicator metals be detected in a concentration that indicates a statistically significant increase above background, a contingency plan requirement would then be triggered that may require monitoring on a more frequent basis, and/or for a longer, more inclusive list of metals known to occur in the waste streams.

In April 2007, WRC conducted an evaluation of waste constituents received at the facility for the purpose of identifying reasonable indicator parameters for the ongoing DMP monitoring.

Based on that evaluation, and subsequent discussions with ADEQ, the following parameters will be analyzed during the ongoing DMP:

Analyte	Analytical Method ^a
pH	(field measured)
Chloride	EPA300
Magnesium	SW6010B
Sodium	SW6010B
Sulfate	EPA300
Copper	SW6010B
Nickel	SW6010B
Zinc	SW6010B

^aThe listed analytical method may be substituted using another, updated SW-846 method as long as the laboratory reporting limit is at or below the AWQS and the data is generated out of the 300 or 6010/6020 series.

For the trace metals, only the dissolved fraction will be analyzed and used for comparison to the concentration limits. This approach is consistent with current ADEQ policy which states that “Unless inconsistent with the purpose of the investigation, analysis of metals in groundwater samples for comparison with AWQS should be collected using a dissolved metals approach.” (*Monitoring Groundwater for Metals to Determine Compliance with Aquifer Water Quality Standards*, ADEQ Memo 0121.000, May 9, 1997).

9.6.3 Sampling Procedures for the Ongoing DMP

Table 9-8 presents the sample containers, filtration and/or preservation requirements, and recommended maximum holding times for the ongoing DMP. As shown on this table, each groundwater sample will consist of two 1-liter bottles containing nitric acid preservative. The sampling procedures for the ongoing DMP have been modified from those used in the initial phase of the DMP. The changes include the use of low-flow purging and sampling as described below, and an annual sampling schedule.

Table 9-8. Sampling Plan Summary: Ongoing DMP					
Sample Container	Preservation ^a	Sample Type/Frequency	Analytical Method	Analyte	Recommended Maximum Holding Time
DISSOLVED METALS					
(1) 1-liter polyethylene bottle	Filtered in field before placed in container with HNO ₃ ; 4°C ±2°C	1. One groundwater sample from the compliance wells and one from the upgradient well per annual event. 2. One duplicate groundwater sample per annual event. 3. One field equipment blank per annual event when non-dedicated equipment is used.	6020B 6020B 6010B 6010B	Copper Nickel Magnesium Sodium Zinc	6 months for metals

Table 9-8. Sampling Plan Summary: Ongoing DMP

Sample Container	Preservation ^a	Sample Type/Frequency	Analytical Method	Analyte	Recommended Maximum Holding Time
GENERAL CHEMISTRY					
(1) 1-liter polyethylene bottle	4°C ±2°C	1. One groundwater sample from the compliance wells and one from the upgradient well per annual event.	150.1	pH ^b Chloride Sulfate	Immediately
			300		28 days
		2. One duplicate groundwater sample per annual event.	300		28 days

^aUpon collection, samples will be maintained with sufficient coolant to chill the samples to 4°C ±2°C until received by the analytical laboratory. While in the laboratory, samples will be stored and maintained at 4°C ±2°C.

^bpH will be measured in the field at the time of sample collection.

9.6.4 Revised Groundwater Sample Collection Procedure for monitoring Wells Exhibiting Excessive Turbidity

Following correspondence with ADEQ (Internal Memo RIHU00, 330, dated October 4, 2000), WRC initiated purging and sampling in January 2001 using low-flow techniques (see ADEQ Superfund Program Section QAPP, SOP No. 3, sec. 10.2, May 22, 2000). Accordingly, purging and sampling will be conducted utilizing a 2-inch submersible pump. Prior to purging, depth to groundwater will be measured and then subtracted from the total depth of the monitoring well to assure that sufficient water is present to enable sampling. Water quality parameters, including pH, temperature, specific conductance, and turbidity, are measured throughout the purging. Once the water quality parameters are stabilized, the pump is turned down to a flow of less than or equal to 1 gpm and then samples are collected.

Groundwater samples will be collected directly from the discharge tubing attached to the pump. Samples will be collected in the appropriate laboratory-supplied containers and placed on wet ice in a cooler. The laboratory will be instructed to filter the samples for dissolved metals prior to analyzing the samples.

Two field QA/QC samples, a blind duplicate and an equipment blank, will be collected during each sampling event. The duplicate sample will be collected from one of the downgradient monitoring wells and assigned an arbitrary identification not related to the original sample. The equipment blank sample is collected by pouring deionized water over the sampling apparatus into the corresponding containers.

9.6.5 Ongoing DMP Quality Assurance Plan

The QAP for the ongoing DMP will be the same as presented and described above in Section 9.4.

9.6.6 Ongoing DMP Data Evaluation

9.6.6.1 Review of Annual Monitoring Data

Upon receipt of the analytical data from each annual ongoing DMP monitoring, WRC will review the laboratory analytical data for quality assurance/quality control criteria and compare the analytical results to the concentration limits calculated from the initial phase of the DMP and listed in Table 9-5.

If any parameters are detected at concentrations above the calculated concentration limits listed in Table 9-5, WRC will implement the steps outlined in Section 9.7.

9.6.6.2 Data Validation and Verification

Upon receipt of final laboratory analytical results for the annual monitoring event, WRC will perform data validation and verification on the laboratory data to determine the compliance of the analytical data with the established method performance criteria and to determine whether the data quality is sufficient to support the data quality objectives. Validation of the data package will include review of the holding time requirements, sample preparation, initial and continuing calibration data, laboratory QC sample data, equipment performance, identification of data anomalies, and overall usability of data.

In the event that any data are identified as non-compliant (e.g., exceedance of a holding time), WRC will contact the contract laboratory and request that the sample in question be re-extracted/digested and re-analyzed. Contingency actions for non-compliant data may include, but are not limited to, re-analyzing the sample and/or re-sampling the well.

9.6.6.3 Graphical Analysis Groundwater Quality

To continue to monitor the quality of groundwater upgradient of the HWMU, the background quality graphical trend will be updated following each monitoring event for monitoring well MW-11 for the duration of the DMP. After each annual DMP sampling round, the analytical data from monitoring well MW-11 will be graphed as a time series, one series per analyte.

To continue to monitor the quality of groundwater in the POC monitoring well(s), the water quality graphical trend will be updated following each monitoring event for the duration of the DMP.

The applicability of this procedure will be re-evaluated after every four rounds of annual groundwater monitoring for the duration of the DMP.

9.6.7 Annual Monitoring Reports

A report documenting and summarizing groundwater sampling activities will be prepared and submitted to ADEQ after each annual monitoring event. Each report will contain the following information:

- Description of groundwater sampling activities and a summary of the analytical results;
- Updated groundwater elevation contour map;
- Updated groundwater elevation hydrograph;
- Groundwater quality data table;
- Water sample collection records;
- Analytical laboratory report; and
- Data validation memorandum.

The annual report will be submitted within 90 days of the receipt of final laboratory analytical data for the monitoring event.

9.6.7.1 Groundwater Flow Maps

In accordance with 40 CFR § 264.99(e), WRC will prepare a map, using the groundwater level measurements from the annual monitoring event, that shows the direction of groundwater flow in the uppermost aquifer. This map will be included in the annual report submitted to ADEQ.

9.7 Response to Groundwater Contamination Incident

Beginning with the first ongoing monitoring event (April 2008), WRC will evaluate the laboratory analytical results and compare the data to the calculated concentration limits listed in Table 9-5 to determine whether there is statistically significant evidence of a release. If the review of the analytical data identifies an exceedance of a concentration limit, as listed in Table 9-5, WRC will re-sample the monitoring well in question for the parameter(s) in question within 30 days of receipt of the final analytical results.

If the subsequent sample (verification sample) confirms the exceedance of the concentration limit, WRC will, pursuant to 40 CFR § 264.99(h):

- Notify ADEQ of the finding in writing within 7 days of receiving the final laboratory analytical data from the verification sample(s). The notification will indicate which parameters have shown statistically significant evidence of contamination.
- Within 14 days of receiving the final laboratory analytical data from the verification sample(s), collect groundwater samples from the upgradient and POC monitoring wells included in the ongoing DMP and submit the water samples for analyses of all inorganic constituents listed in Appendix IX to 40 CFR § 264.
- Upon receipt of the analytical results from Step 2 above, assess which of the chemicals are present and in what concentrations.
- If any Part 264, Appendix IX analyte is detected at a concentration above the calculated applicable concentration limit listed in Table 9-5 or a numeric AWQS, WRC will re-sample the monitoring well in question for the parameter(s) in question within 30 days. If the results of the second sampling confirm the initial results, then these constituents will form the basis for compliance monitoring.
- Within 90 days of receiving the final laboratory analytical data from the verification sample(s), WRC will submit to ADEQ an application for a permit modification to establish a compliance-monitoring program meeting the requirements of 40 CFR § 264.99. The application will include the following information:
 - For each POC well, the reported concentration of any 40 CFR § 264, Appendix IX analyte detected in the groundwater above the concentration limit and/or AWQS.
 - Proposed changes to the groundwater monitoring system at the facility necessary to meet the requirements of 40 CFR §264.99.
 - Proposed additions or changes to the monitoring frequency, sampling and analysis procedures or methods, or statistical methods used at the facility necessary to meet the requirements of 40 CFR § 264.99.
 - For each hazardous constituent detected at the POC, a proposed concentration limit under 40 CFR § 264.94(a)(1) or (2), or a notice of intent to seek an alternate concentration limit under 40 CFR § 264.94(b).
- Within 180 days of receiving the final laboratory analytical data from the verification sample(s), WRC will submit to ADEQ:
 - The data necessary to justify an alternate concentration limit sought under 40 CFR § 264.94(b); and
 - An engineering feasibility plan for a corrective action program necessary to meet the requirement of 40 CFR § 264.100, if necessary.
- WRC may demonstrate that a source other than a regulated unit caused the contamination or that a detection is an artifact caused by an error in sampling, analysis, statistical evaluation, or natural variation in the groundwater. WRC may make a demonstration in addition to, or in lieu of, submitting a permit modification application; however, WRC is not relieved of the requirement to submit a permit modification application within 90 days for detection monitoring unless the demonstration successfully shows that a source other than a regulated unit caused the increase, or that the increase resulted from error in sampling, analysis, or evaluation. In making this demonstration, WRC will do the following:

- Within 7 days of establishing statistically significant evidence of contamination at the POC, notify ADEQ in writing that WRC intends to make a demonstration that a source other than a regulated unit caused the contamination or that the detection is an error;
 - Within 90 days of establishing statistically significant evidence of contamination at the POC, WRC will submit a report to ADEQ that demonstrates that a source other than a regulated unit caused the contamination or that the contamination resulted from error in sampling, analysis, or evaluation;
 - Within 90 days of establishing statistically significant evidence of contamination at the POC, WRC will submit to ADEQ an application for a permit modification to make appropriate changes to the ongoing DMP;
 - Continue to monitor in accordance with the ongoing DMP.
- Any corrective action will include a discussion and demonstration of financial responsibility pursuant to 40 CFR § 264.90(a)(2).

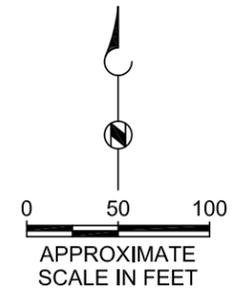
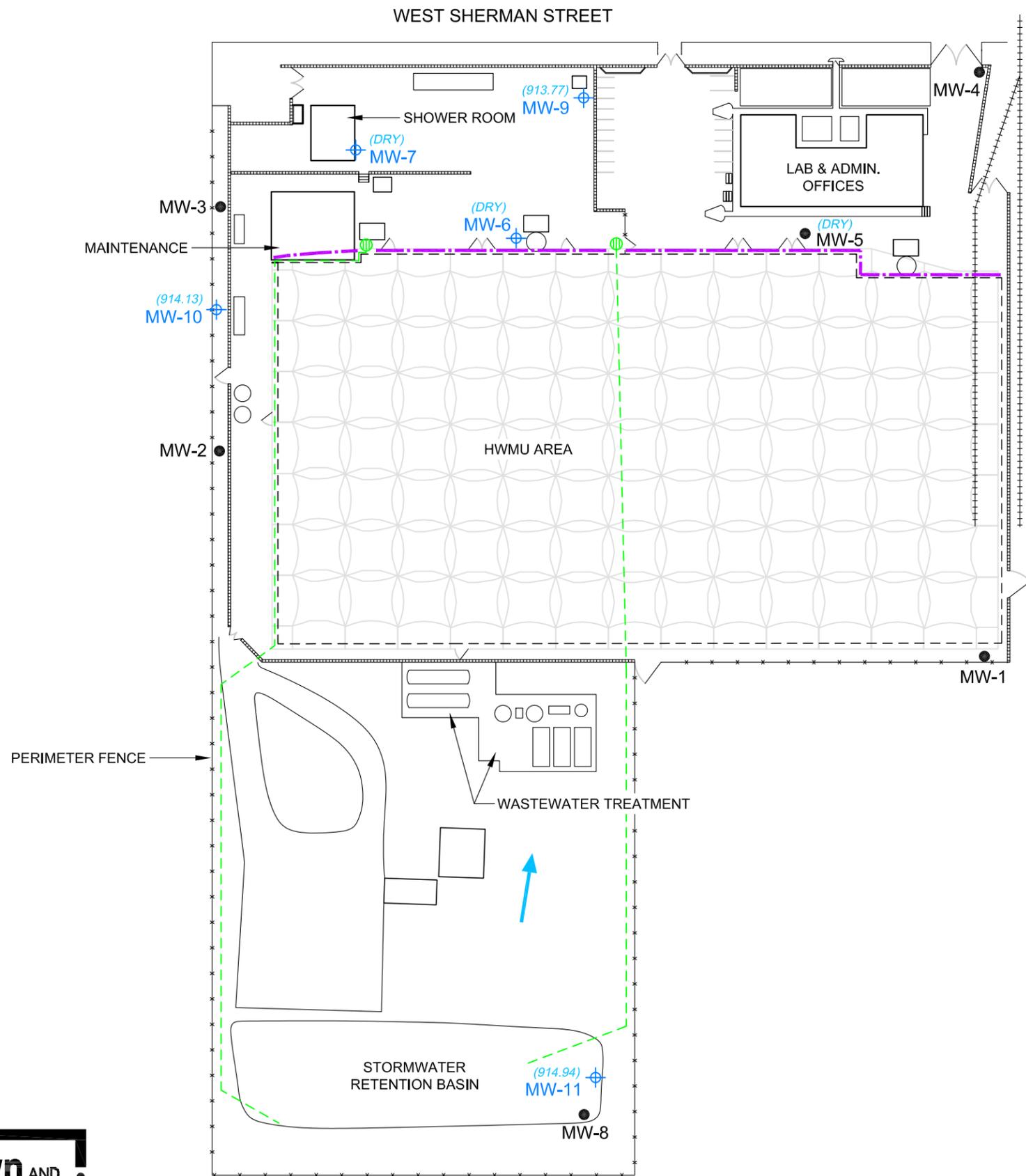
FIGURES

DMP-01 Monitoring Well Locations

DMP-02 Summary of Soil Types

DMP-03 Pumping Wells Within One-Mile Radius

F-H01 Hydrographs of Water Levels



EXPLANATION

(914.94) MW-11 EXISTING MONITOR WELL WITH GROUNDWATER ELEVATION
 BASED ON DATA COLLECTED DECEMBER 4, 2007

- MW-1 ABANDONED MONITOR WELL
- GROUNDWATER FLOW DIRECTION BASED ON DECEMBER 4, 2007 WATER LEVELS
- POINT OF COMPLIANCE AS DEFINED IN 40 CFR PART 264.95
- DRAIN ENTRANCE
- STORMWATER DRAINAGE

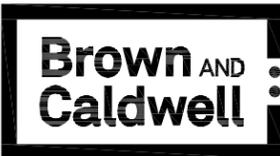
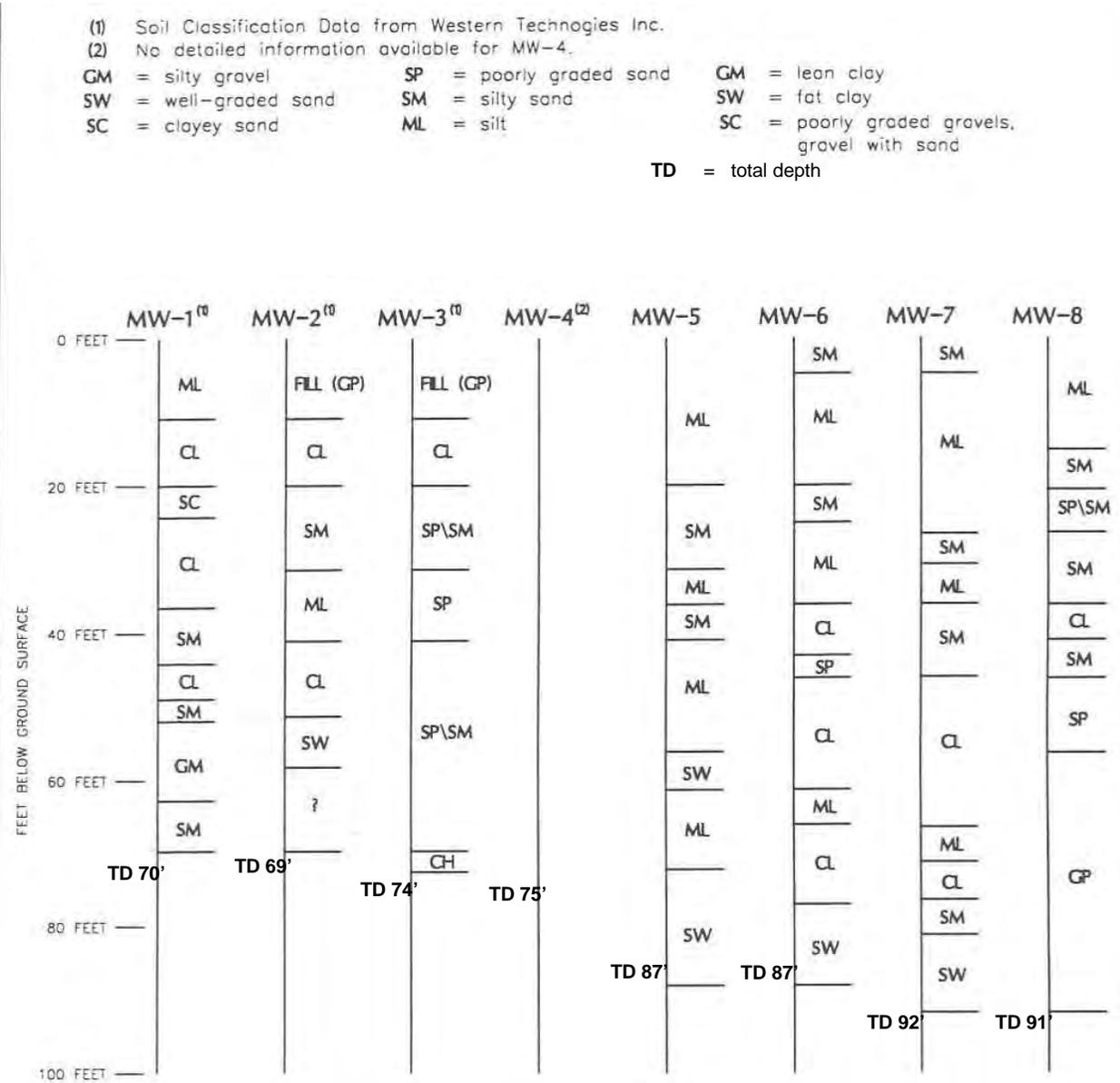
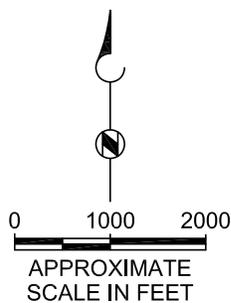
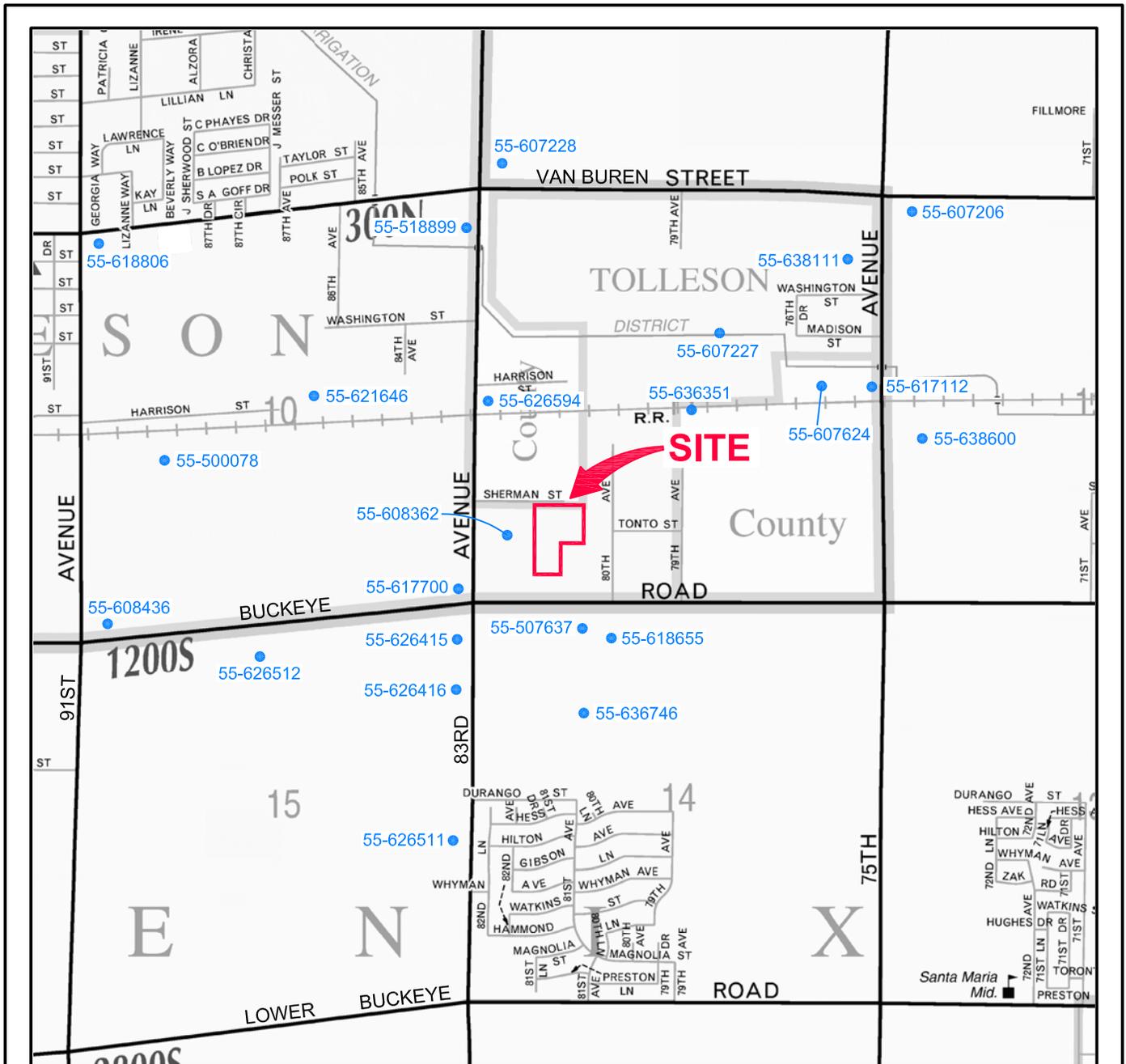


Figure DMP-01
 SITE PLAN
 WORLD RESOURCES COMPANY
 8113 WEST SHERMAN STREET
 PHOENIX, ARIZONA

Figure DMP-02

Summary of Soil Classifications for Monitoring Wells MW-1 Through MW-8





EXPLANATION

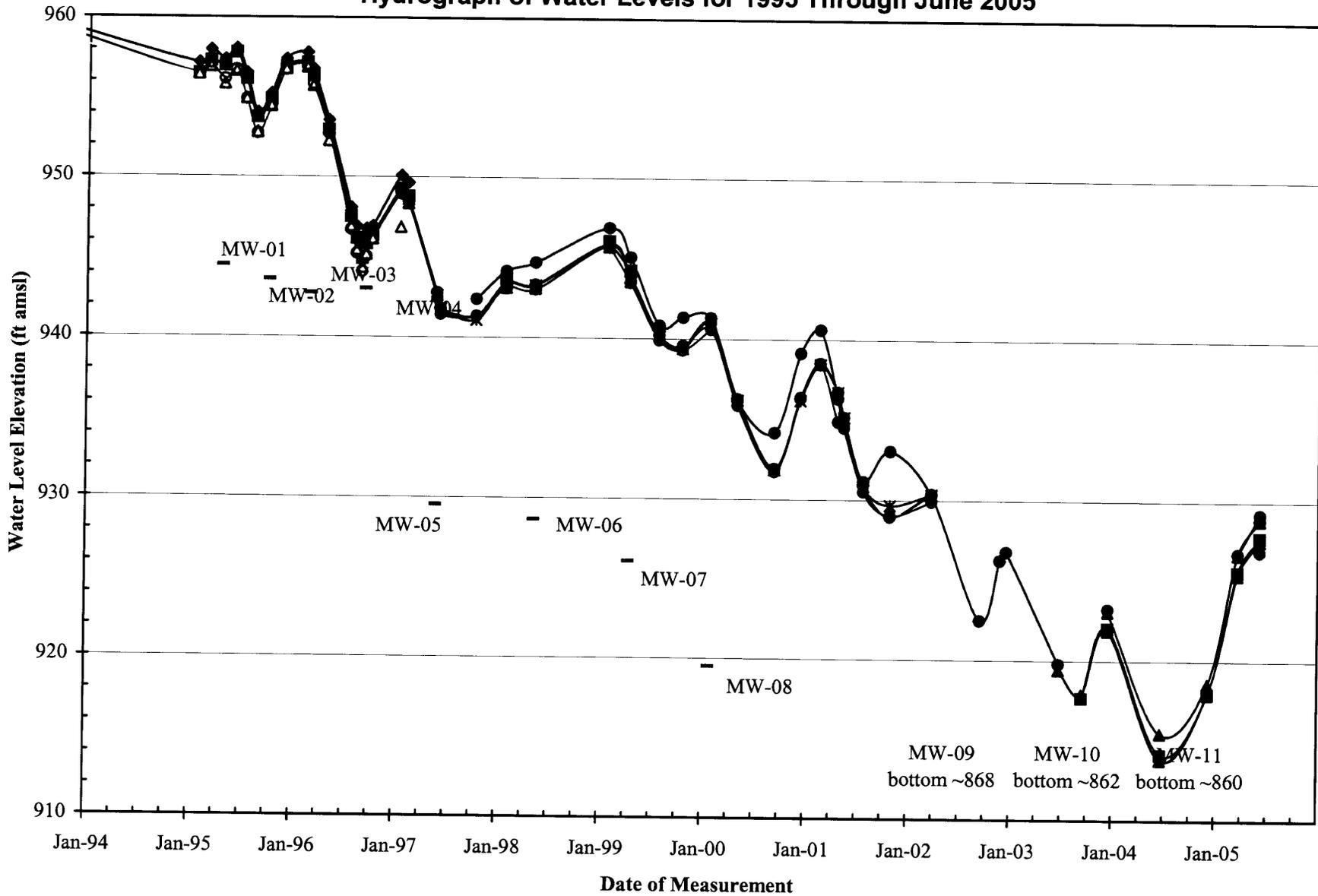
- WELL LOCATION
- 55-617700 ADWR REGISTRATION NUMBER

Figure DMP-03
APRIL 2008
**WELLS LOCATED WITHIN
1-MILE RADIUS
WORLD RESOURCES COMPANY**
8113 WEST SHERMAN STREET
TOLLESON, ARIZONA



Figure F-H01

Figure 3 World Resources Company Hydrograph of Water Levels for 1995 Through June 2005



- ◆ MW-1
- MW-1
- △ MW-3
- MW-4
- * MW-5
- MW-6
- MW-7
- MW-8
- ▲ MW-9
- MW-10
- ▲ MW-11
- bottom

ATTACHMENT 9-A

Well Construction Diagrams for Monitoring Wells 9 through 11

Figure G-MW-01: Monitoring Well Construction Diagram for MW-1

May 1, 1997

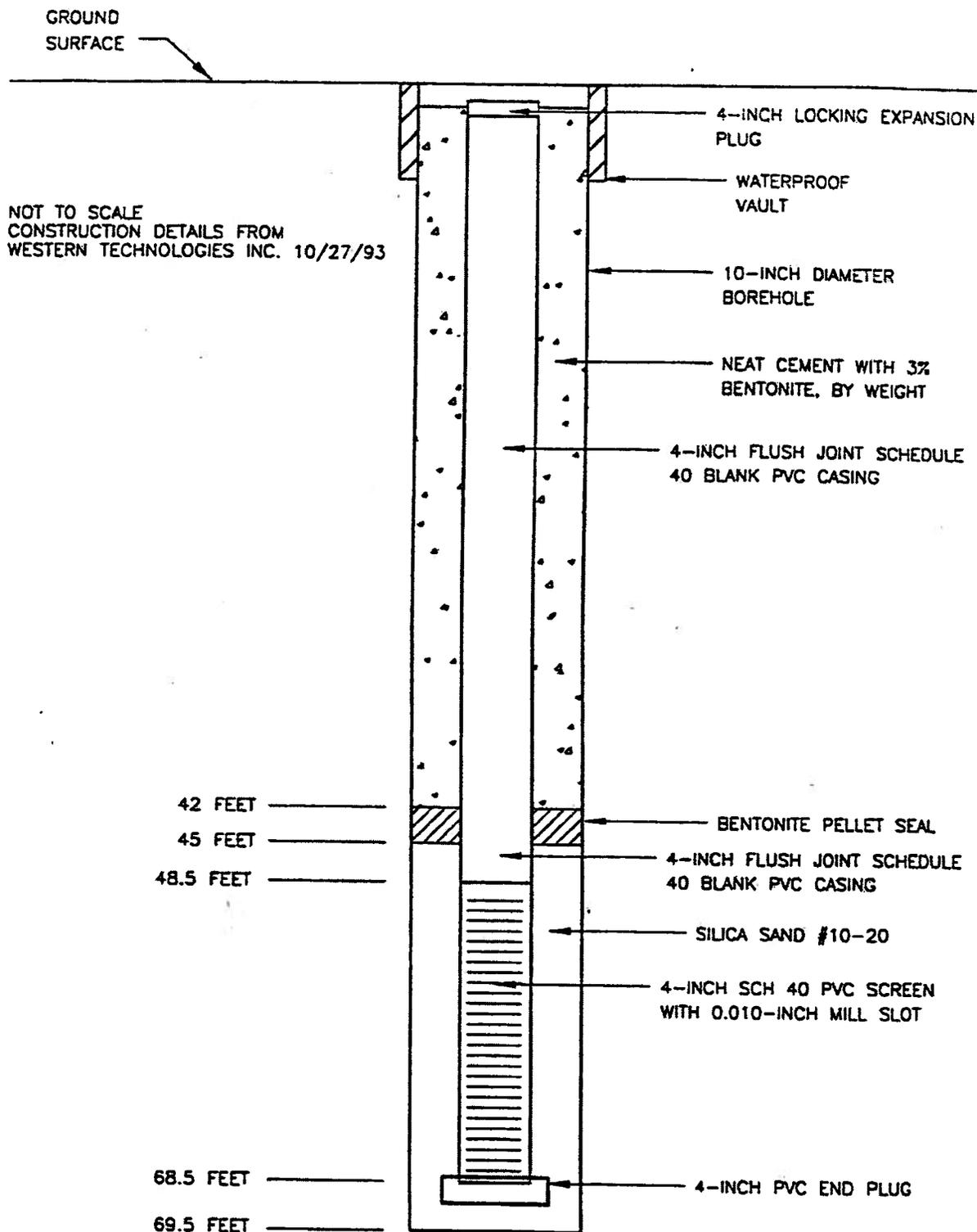


Figure G-MW-02: Monitoring Well Construction Diagram for MW-2

May 1, 1997

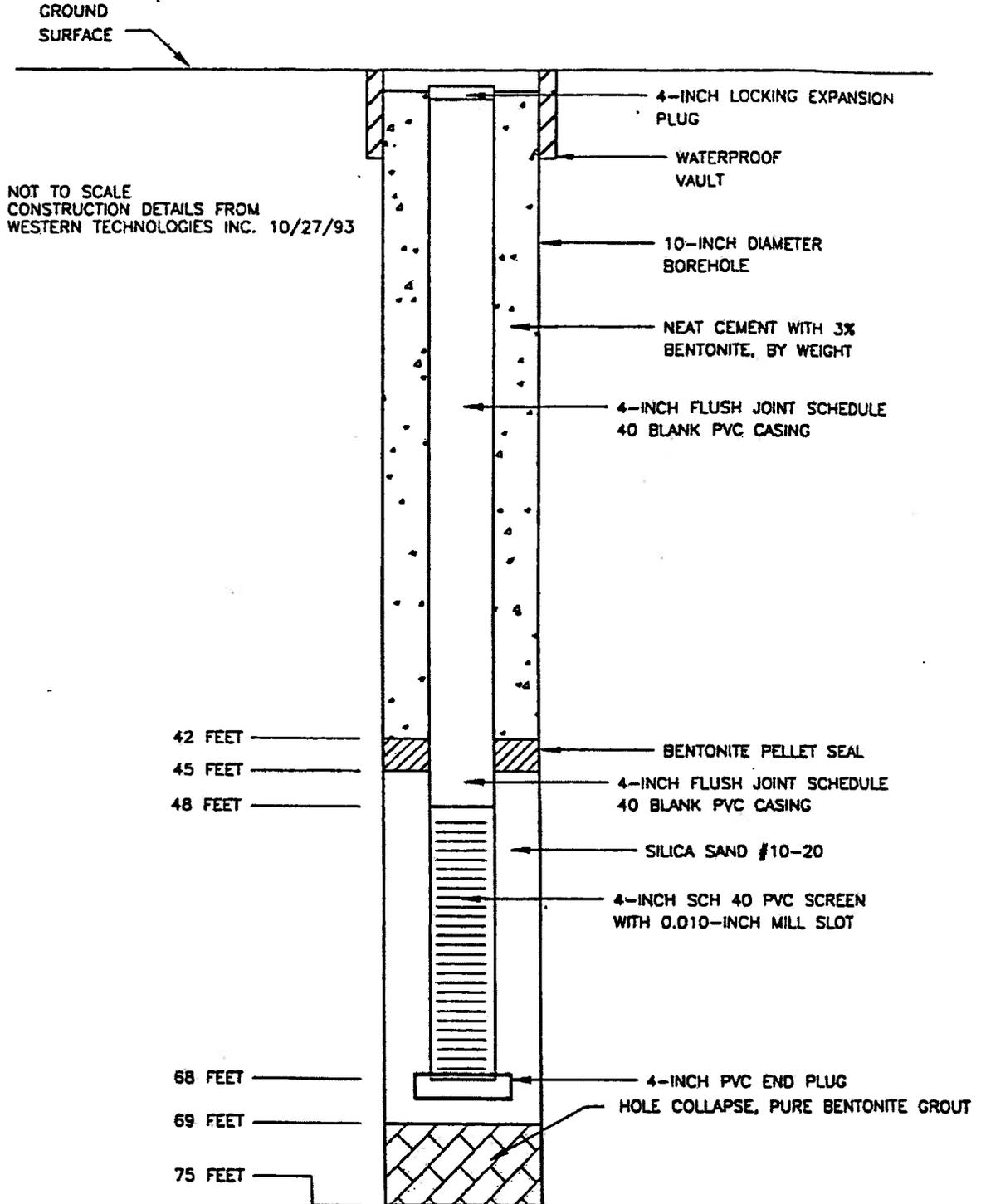


Figure G-MW-03: Monitoring Well Construction Diagram for MW-3

May 1, 1997

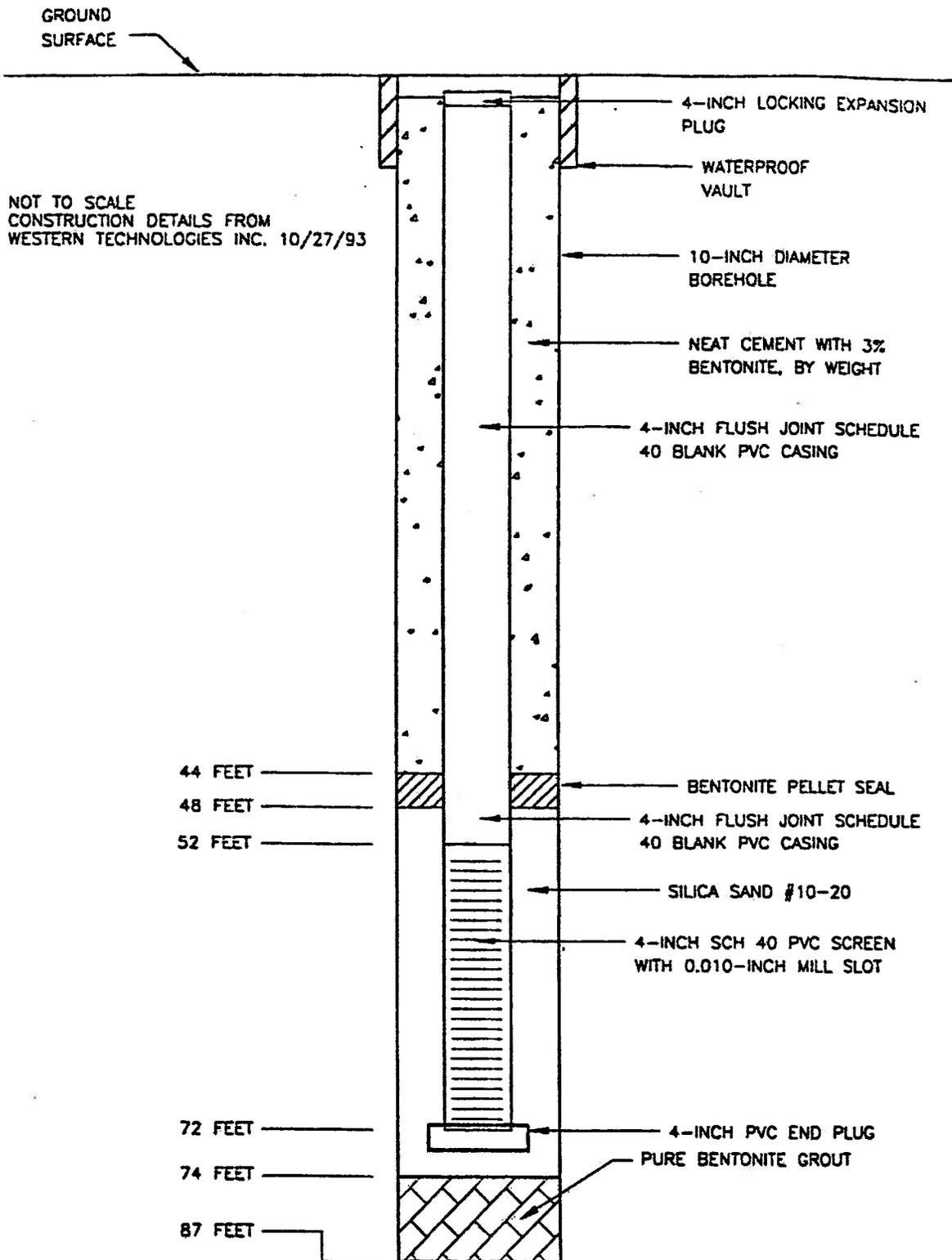


Figure G-MW-04: Monitoring Well Construction Diagram for MW-4

May 1, 1997

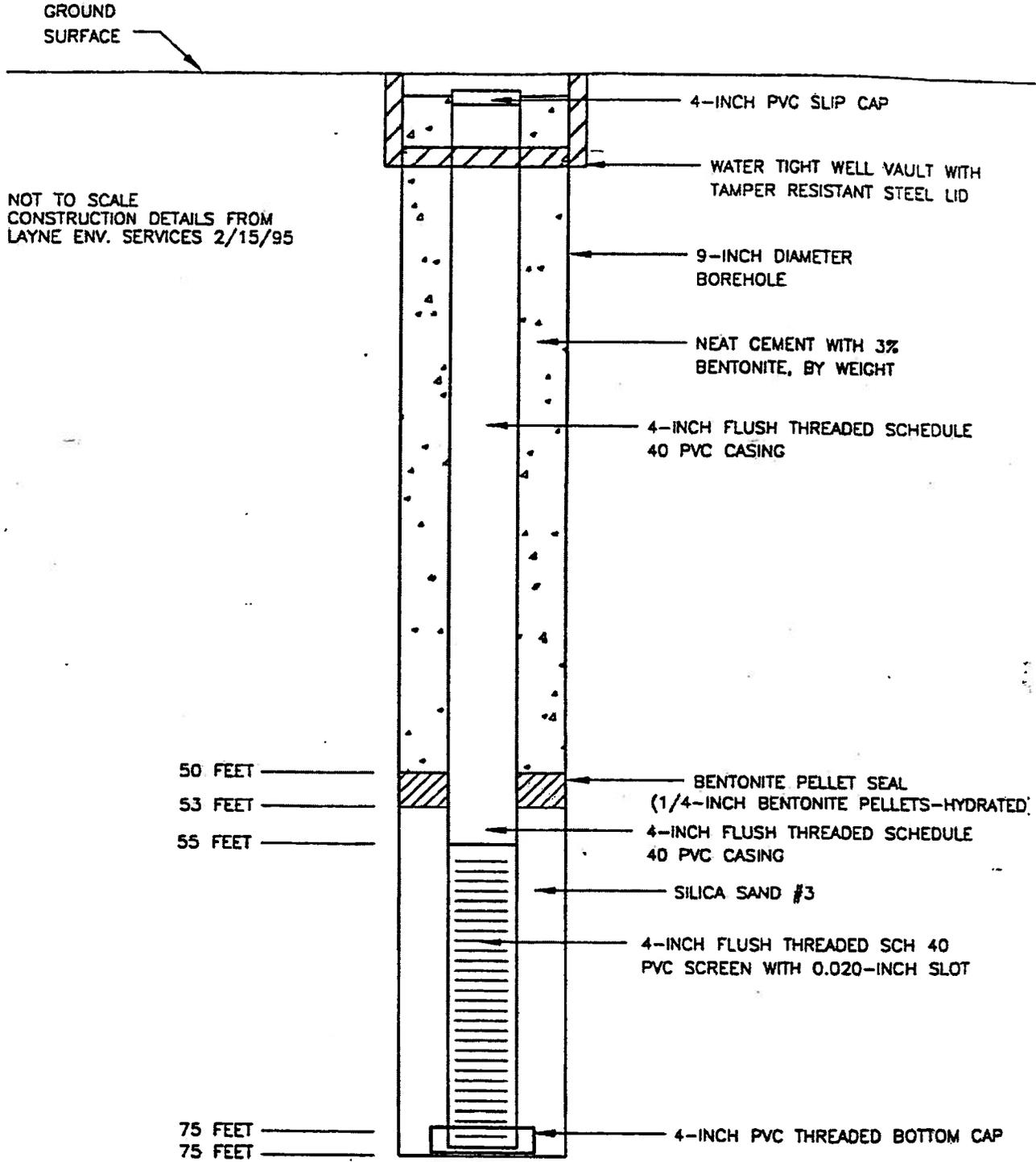


Figure G-MW-05: Monitoring Well Construction Diagram for MW-5

May 1, 1997

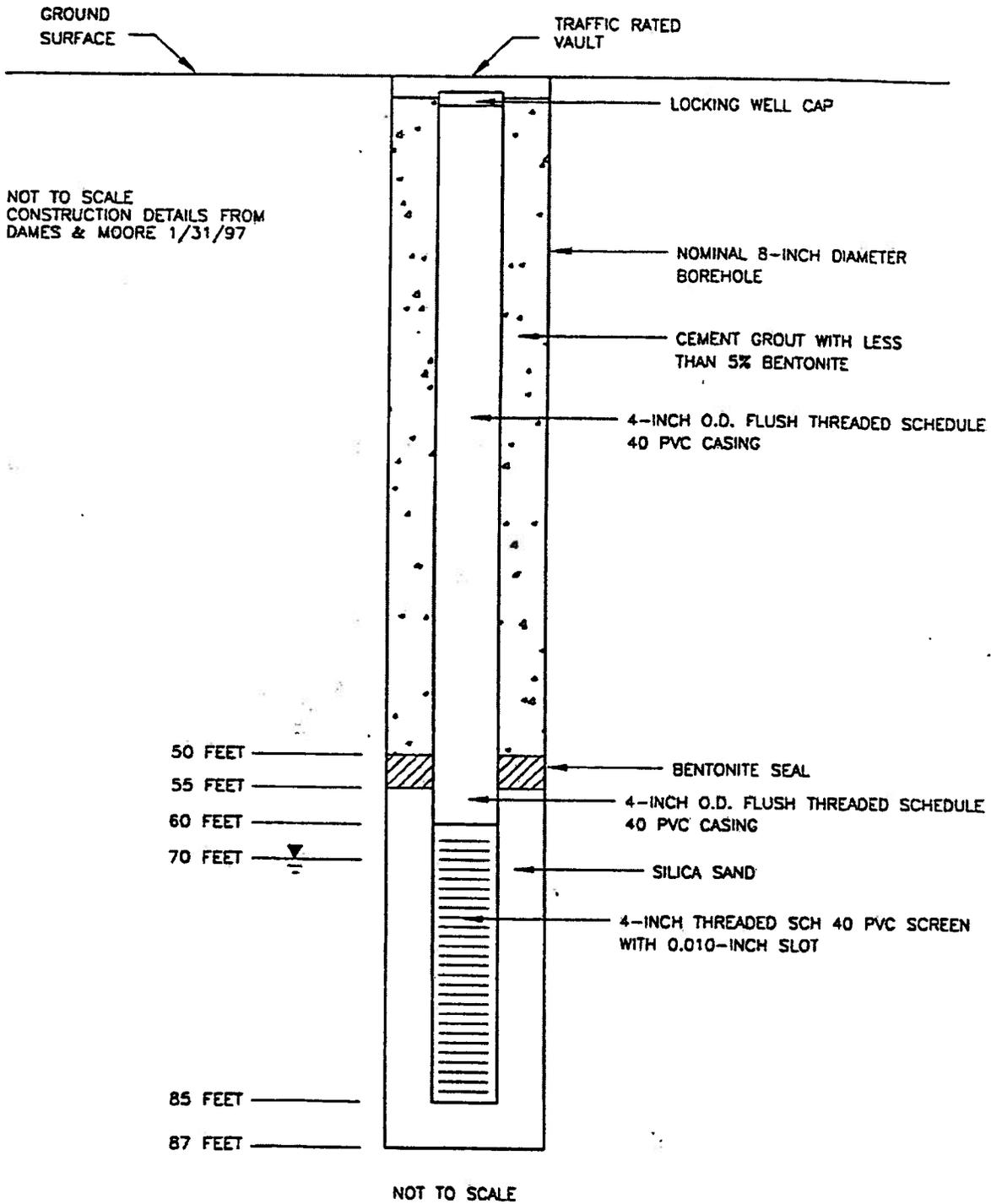


Figure G-MW-06: Monitoring Well Construction Diagram for MW-6

May 1, 1997

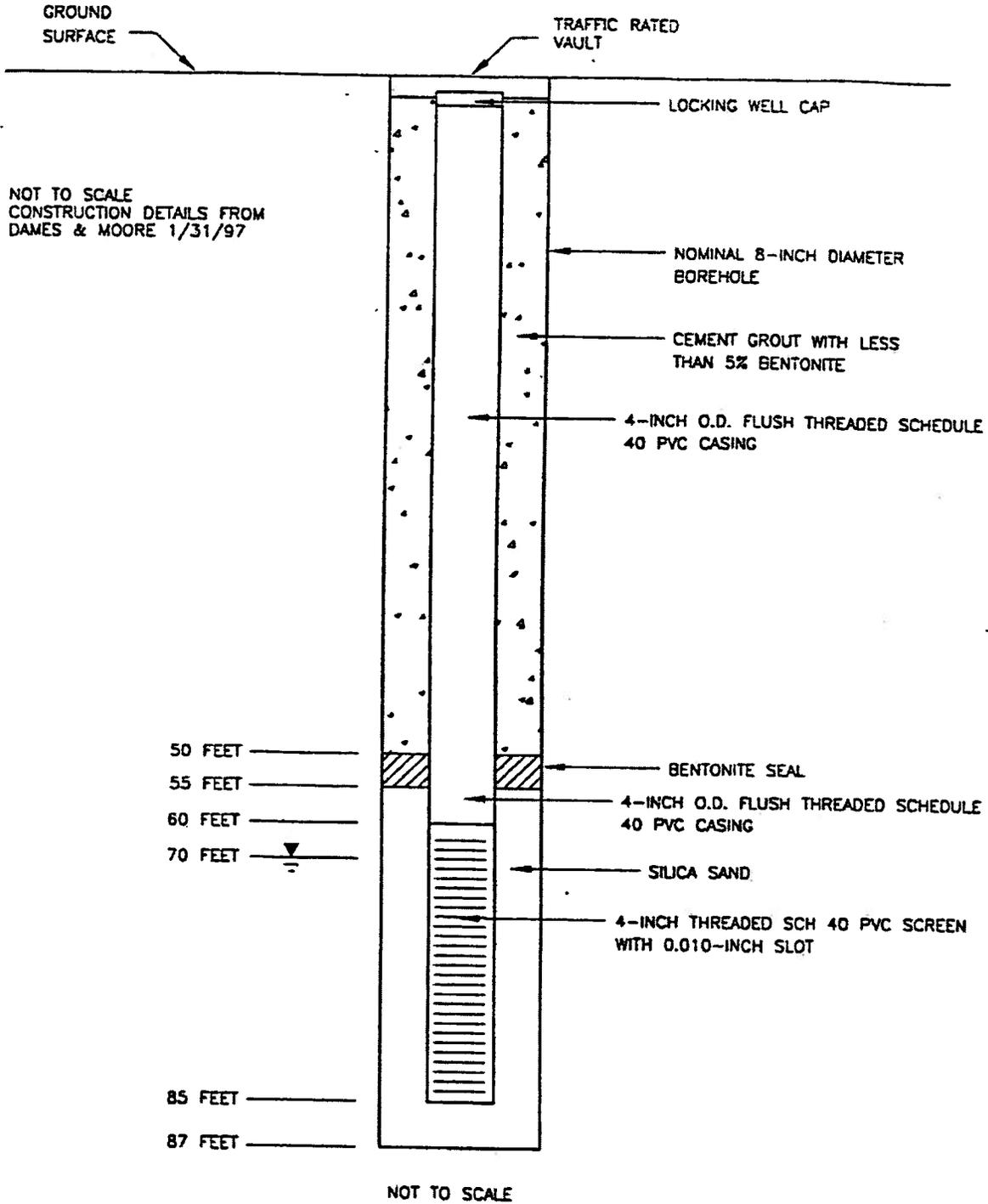


Figure G-MW-07: Monitoring Well Construction Diagram for MW-7

May 1, 1997

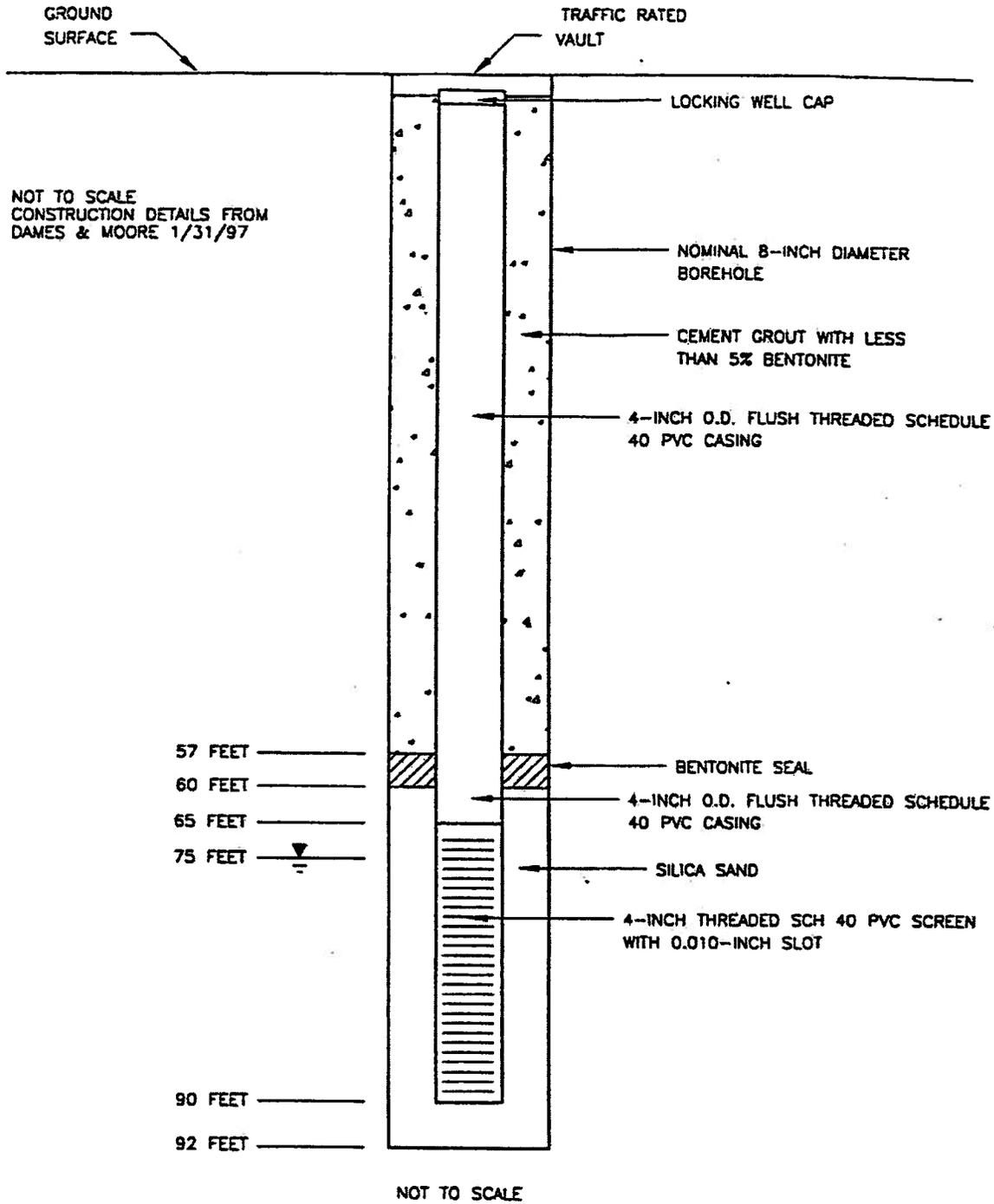
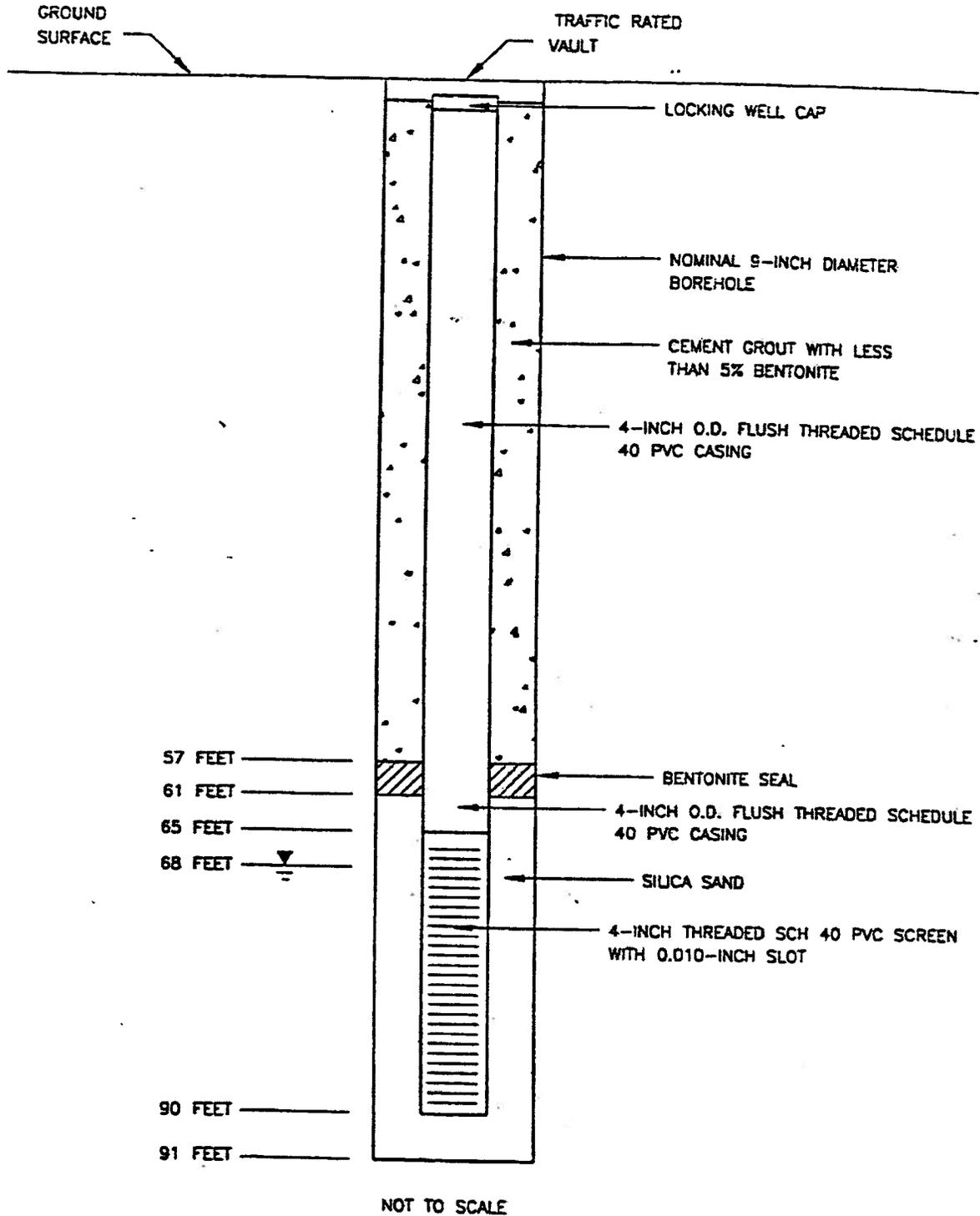


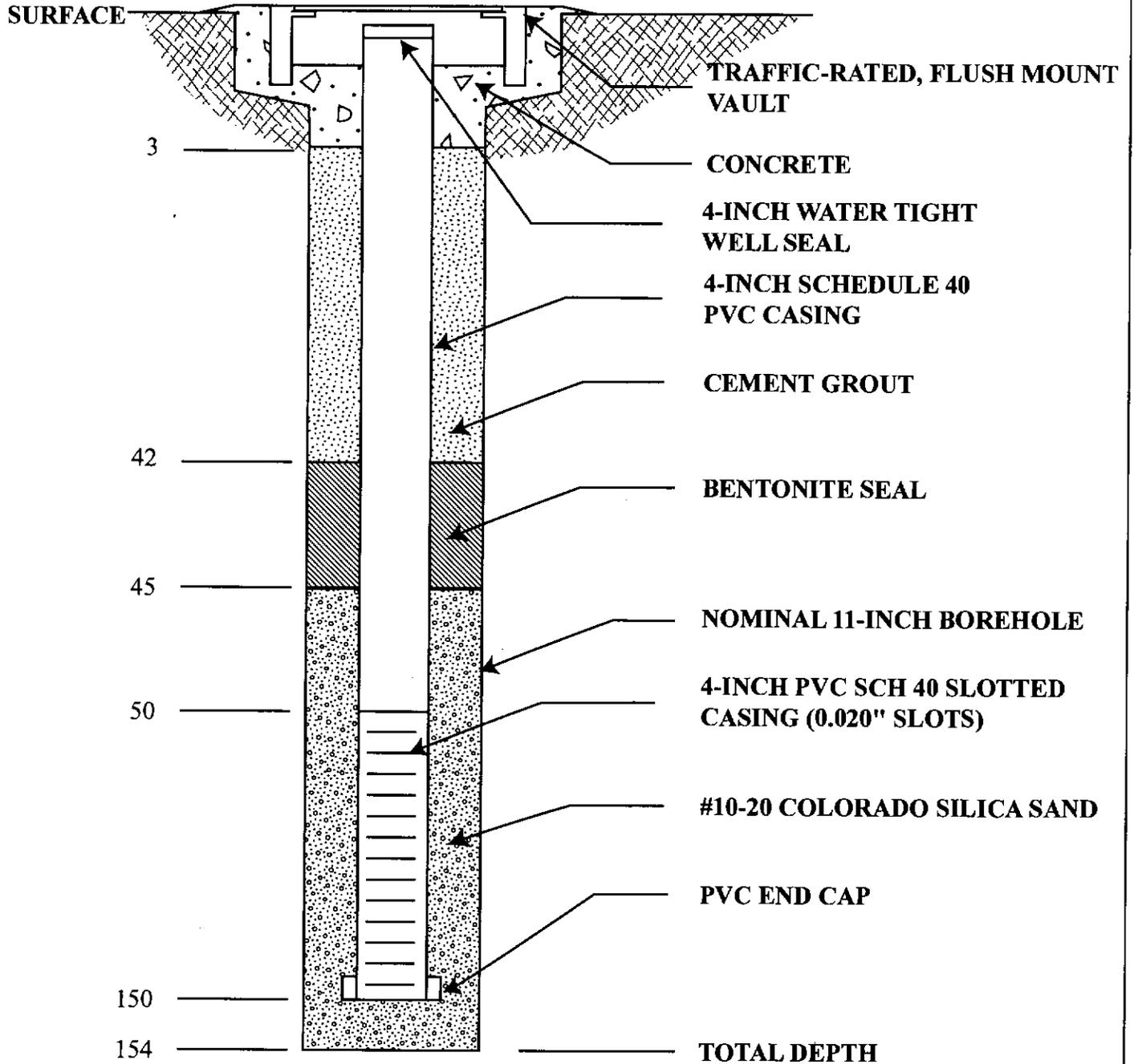
Figure G-MW-08: Monitoring Well Construction Diagram for MW-8

May 1, 1997



**ADWR WELL REGISTRATION
NUMBER 55-597959**

**DEPTH
(FT)**



NOT TO SCALE

**MALCOLM
PIRNIE**

MW-9

**AS-BUILT MONITOR
WELL COMPLETION
DIAGRAM**

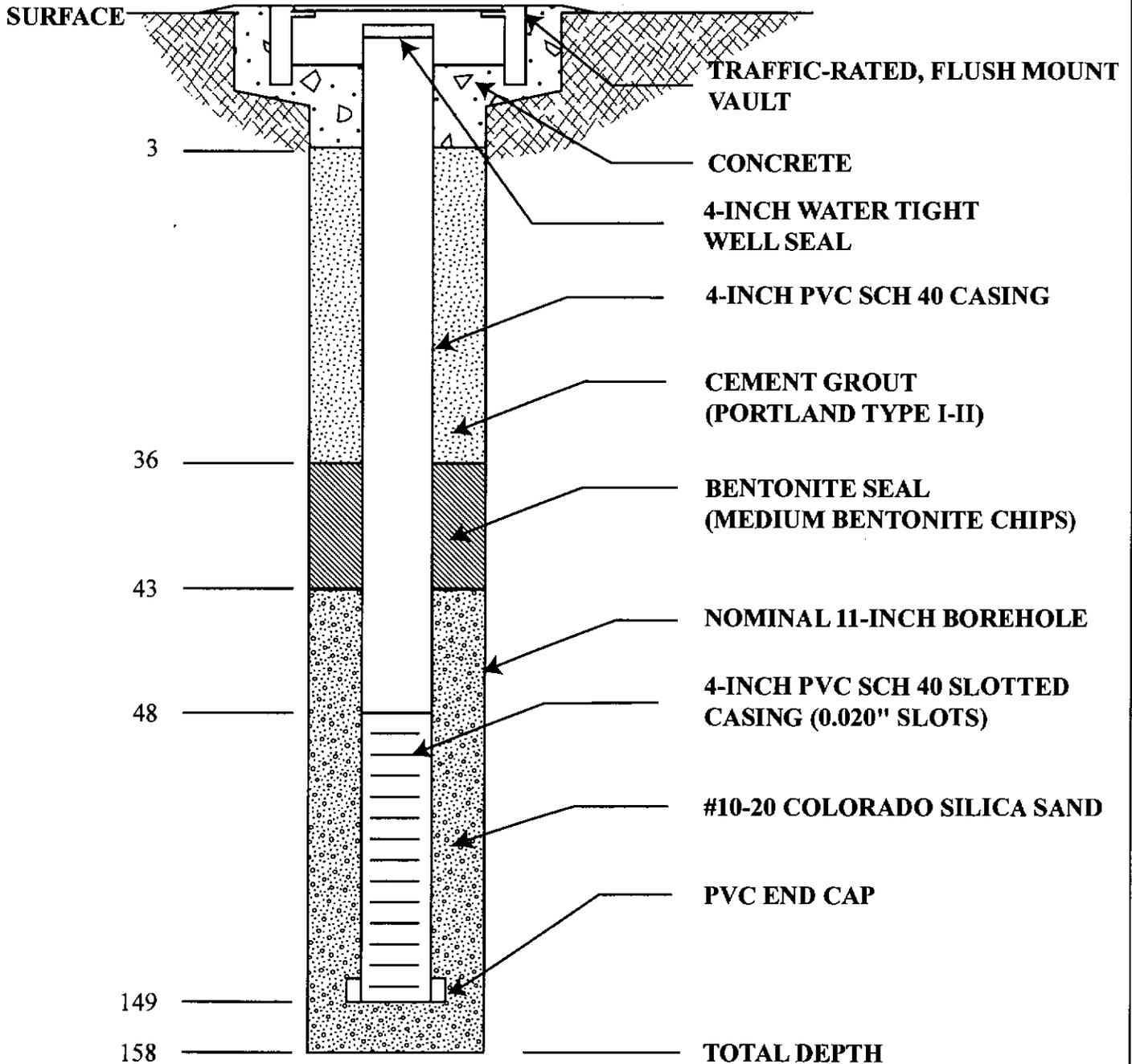
Malcolm Pirnie Inc.

Figure 1

m:\4713001\figures\MW-9-well_completion_diagram.ai

**ADWR WELL REGISTRATION
NUMBER 55-599992**

**DEPTH
(FT BGS)**



NOT TO SCALE

**MALCOLM
PIRNIE**

MW-10

**MONITOR WELL
COMPLETION DIAGRAM**

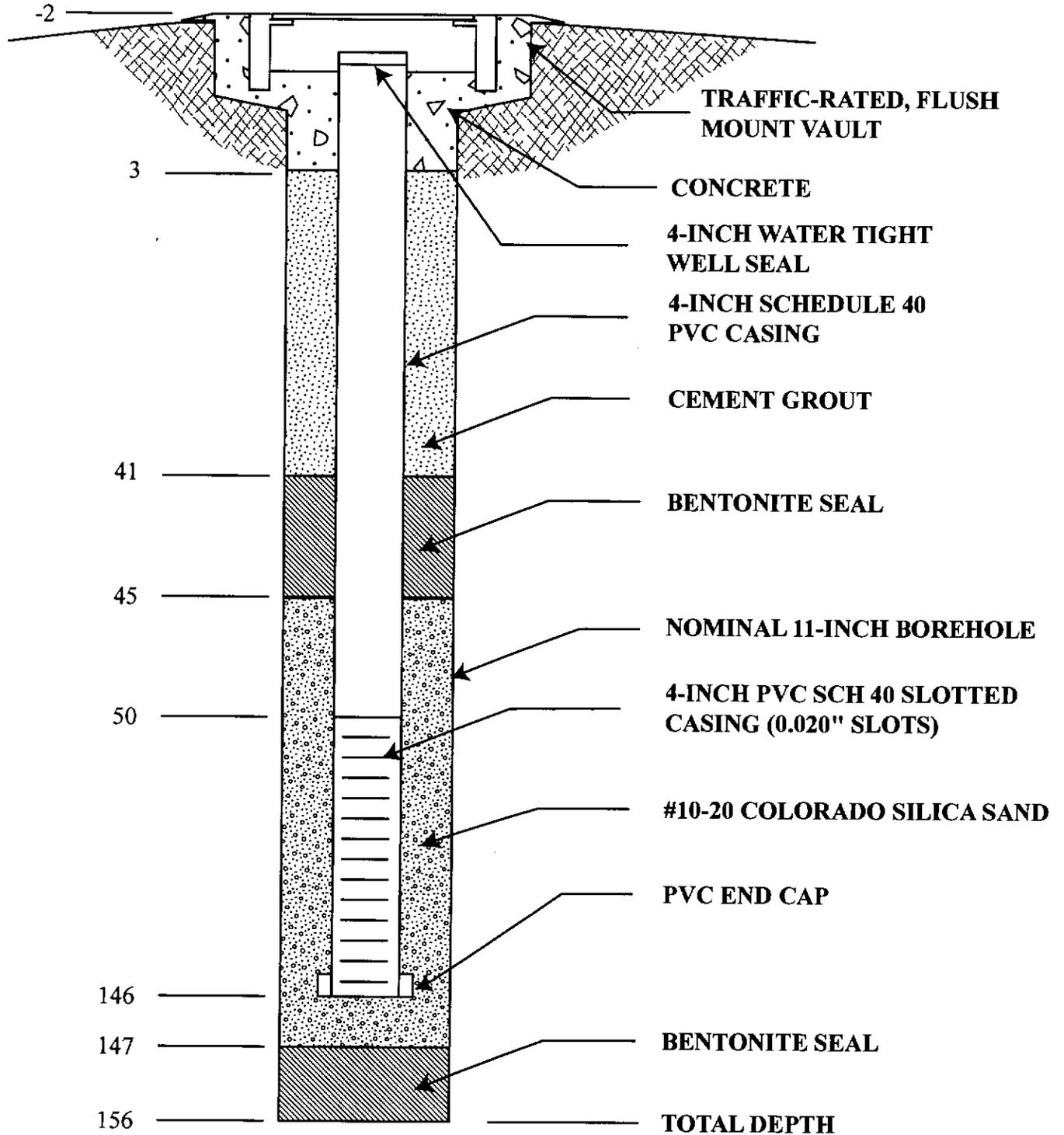
Malcolm Pirnie Inc.

Figure 2

m:\471300\figures\MW-10-well construction_diagram.ai

**ADWR WELL REGISTRATION
NUMBER 55-200947**

**DEPTH
(FT)**



NOT TO SCALE

**MALCOLM
PIRNIE**

MW-11

**MONITOR WELL
COMPLETION DIAGRAM**

Malcolm Pirnie Inc.

Figure 3

m:\4713001\figures\MW-11-well_construction_diagram.ai