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December 21, 2007

Received
DEC 2007
Division of
Radiation Control

Mr. Dane Finerfrock
Executive Secretary
Utah Radiation Control Board
State of Utah Department of Environmental Quality
168 North 1950 West
Salt Lake City, UT 84114-4850

Dear Mr. Finerfrock:

Re: White Mesa Mill Preliminary Contamination Investigation Report
State of Utah Notice of Violation and Groundwater Corrective Action Order
(UDEQ Docket No. UGO-20-01, the Order)

Pleases find enclosed two copies of the Preliminary Contamination Investigation Report pertaining to the above-caption Order.

If you should have any question regarding this report please contact me.

Yours very truly,

Steven D. Landau
Denison Mines (USA) Corp.
Manger, Environmental Affairs

Cc Ron Hochstien
David Frydenlund
David Turk

PRELIMINARY CONTAMINATION INVESTIGATION REPORT
WHITE MESA URANIUM MILL
NEAR BLANDING, UTAH

Received
DEC 2007
Division of
Radiation Control

Prepared for:

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November 20, 2007

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1. INTRODUCTION

During May of 1999, International Uranium (USA) Corporation (now Denison Mines (USA) Corp. (DUSA)), collected samples from perched zone groundwater monitoring wells at the White Mesa Uranium Mill (the site) which were split for duplicate analyses by the Utah Department of Environmental Quality (UDEQ). The analysis of these samples revealed the presence of chloroform in well MW-4. In response to the discovery of chloroform, on August 23, 1999, the UDEQ issued a Notice of Violation and Order (Docket UGW20-01) that required DUSA to:

> Submit within (30) days of receipt of this Order a plan and timetable for conduction a Groundwater Contamination Investigation and submittal of a report for Executive Secretary approval, pursuant to the provisions of UAC R317-6-6.15(D).

As a result of the discovery of chloroform and the issuance of the Order, DUSA has installed 25 additional perched zone and temporary perched zone monitoring wells (Figure 1), established a sampling network, equipped 4 of the wells with pumps to recover water impacted by chloroform, and recovered approximately 23 gallons of chloroform from the perched zone. In addition to these monitoring and remediation efforts, DUSA has completed investigatory activities that include the following:

- Completing historical research and providing to UDEQ an explanation for the occurrence of chloroform in groundwater at the Mill site
- Filing with UDEQ the results of routine investigation samples
- Submitting to UDEQ technical information about the site hydrology and geology
- Providing UDEQ with lithologic information derived from well drilling programs
- Compiling and transmitting to UDEQ the results of well hydraulic tests
- Preparing and transmitting to UDEQ graphical presentations which depict the extent and direction of movement of chloroform in the perched zone
- Providing to UDEQ schedules for the installation of new and re-completed wells and future reports required by UDEQ

The purpose of this report is to summarize the current status of the chloroform investigation. The summary is in the form of a Preliminary Investigation Report responsive to the requirements of UAC R317-6-6.15(D). Specific reporting components of UAC R317-6-6.15(D) are incorporated in Section headings followed by DUSA information responding to the specific requirements. This preliminary report is to be followed by a final report that will incorporate the additional information derived from testing and sampling of temporary perched monitoring wells TW4-23, TW4-24, and TW4-25, installed in May 2007.

2. POLLUTANT CHARACTERIZATION

The occurrence, characteristics, extent, migration, and expected fate of chloroform in the perched water zone at the site are discussed in the following Sections.

2.1 The Amount, Form, Concentration, Toxicity, Environmental Fate and Transport, and Other Significant Characteristics of Substances Present, for Both Ground Water Contaminants and any Contributing Surficial Contaminants

The substance of concern at the White Mesa site is chloroform which was released from a temporary sampling plant laboratory operation that was active prior to the construction of the White Mesa Mill. Chloroform was likely released as a liquid in laboratory waste received initially by a sanitary septic system leach field referred to as the abandoned scale house leach field. After routing of laboratory waste to the scale house leach field was discontinued, and prior to the construction of tailings cell #1, wastes were routed to another leach field referred to as the former office leach field. Subsequently, laboratory wastes were transported directly to the tailings cells for disposal. Use of the leach fields for disposal of laboratory wastes ceased more than 25 years ago.

The total amount of chloroform released is unknown. However, the results of a DUSA investigation into laboratory activities which utilized the substance have been provided to UDEQ. Analytical procedures included the use of small quantities (40-50 milliliters) of reagent grade chloroform for each laboratory test. DUSA's investigation did not indicate that chloroform was used in larger scale tests or in the milling process at the site.

The toxicological character of chloroform is well known and is commonly reported on Material Safety Data Sheets (MSDS). A copy of a chloroform MSDS is included under Appendix A.

Chloroform is a common byproduct resulting from chlorination of water for purposes of disinfection, and is one of the trihalomethanes (THM) regulated under the U.S. Environmental Protection Agency (USEPA) Stage 1 Disinfectants/Disinfection Byproducts Rule for water delivery systems. The USEPA standard for total THM (the sum of chloroform, bromoform, bromodichloromethane, and dibromochloromethane) is 80 micrograms per liter (µg/L). Chloroform, a volatile compound with a solubility of approximately 8,000,000 µg/L (nearly 1%), is a central nervous system depressant and is considered a carcinogen.

Chloroform has been transported to perched groundwater in the vicinity of both the former office and the abandoned scale house leach fields. Once reaching perched groundwater, dissolved chloroform has been transported downgradient of the abandoned scale house leach field to the vicinity of the discovery point at well MW-4, and downgradient of the former office leach field into the vicinity of temporary well TW4-20 (Figure 1). An interim remedial action, that consists of pumping chloroform laden perched water, has been ongoing since 2003. Pumped water is disposed in the tailings cells. Chloroform remaining in the subsurface that is not directly removed by pumping is expected to be remediated in-situ by natural attenuation processes that include biodegradation. These processes are described in more detail in Section 2.3.3.

2.2 The Areal and Vertical Extent of the Contaminant Concentration, Distribution and Chemical Make-up

At the request of the Executive Secretary, the extent and concentration of chloroform in perched water is reported to UDEQ on a quarterly basis in the form of written reports. The areal extent of chloroform as of the first quarter of 2007 is shown in Figure 2. With respect to perched groundwater flow, the detected chloroform is located primarily cross-gradient or upgradient of the tailings cells. Once sufficient data have been collected from new temporary wells TW4-23, TW4-24 and TW4-25 (Figure 1) that were installed in May, 2007, the areal extent of chloroform will be re-assessed and reported in the final Contamination Investigation Report for the site. Based on the initial sampling of these wells in June, 2007, the boundary of the chloroform plume would be nearly the same as depicted in Figure 2 should these data be included in the contouring. Chloroform was detected at a concentration of approximately 3 µg/L in TW4-24, and was not detected in TW4-23 and TW4-25.

Chloroform was first detected in monitoring well MW-4 during groundwater split sampling on May 11, 1999. The results of the sampling and analyses indicated chloroform concentrations of 4,520 and 4,700 µg/L. Subsequent investigation has included the installation of 25 perched zone and temporary perched zone monitoring wells to delineate and monitor the chloroform (Figure 1). Chloroform concentrations in the perched zone have ranged from non-detect to a maximum of 61,000 µg/L at well TW4-20 in the second quarter, 2006. The chloroform concentration at TW4-20 has fluctuated, and was 4,400 µg/L as of the first quarter of 2007. TW4-20 is located immediately downgradient of the former office leach field source area. Chloroform concentrations at TW4-6 (the most downgradient temporary well prior to installation of TW4-23 in May, 2007), were non-detect for approximately 5 years, became detectable in the second quarter of 2005, and have been slowly increasing but have not exceeded the proposed corrective action concentration limit of 70 µg/L as of the first quarter of 2007.

Compounds associated with the chloroform include carbon tetrachloride (TCM) methylene chloride (DCM), chloromethane (CM), and nitrate. TCM, DCM, and CM have been detected sporadically in chloroform investigation wells at low concentrations (typically a few µg/L). Nitrate concentrations in chloroform investigation wells range from non-detect to the low milligrams per liter (mg/L) range (typically < 10 mg/L, but have exceeded 10 mg/L at some locations near source areas). As discussed in Appendix B, the presence of low concentrations of DCM and CM, which are degradation products of chloroform, suggest that natural in-situ biodegradation of chloroform is slowly occurring. TCM was likely present at trace concentrations in the chloroform delivered to the site for use in analytical procedures, and later disposed to the leach fields along with the chloroform.

Although chloroform can exist as a dense, non-aqueous phase liquid (DNAPL), the solubility of the substance is relatively high for a chlorinated solvent (approximately 8,000,000 µg/L or nearly 1%). Having been released in relatively small quantities over time to sanitary septic systems more than 25 years ago, and subsequently mixing into perched groundwater, it is unlikely that the substance exists as a separate phase in the perched zone. The maximum concentration detected (61,000 µg/L at TW4-20), is more than two orders of magnitude lower than the solubility of chloroform. Furthermore, a sampling program was conducted in 2002 to detect the presence of potential DNAPL. The sampling program consisted of placing passive diffusion bags (PDBs) at the base of MW-4 and several of the temporary chloroform investigation wells, then collecting and analyzing the bags for chloroform.

The sampling program did not detect any DNAPL, nor did it indicate significant stratification of chloroform concentrations with depth in the perched zone. Chloroform concentrations from the PDBs were similar to the results obtained from typical purging and sampling of the tested wells (personal communication with Mr. Harold Roberts, DUSA). Had DNAPL been present, significantly higher chloroform concentrations would have been detected in the PDB samples because the PDBs were placed near the bottoms of the wells where any DNAPL would be expected to collect. The results of the PDB sampling program were similar to those of the multi-depth sampling of MW-4 reported in International Uranium (USA) Corporation (IUSA) and HGC, 2000, and IUSA and HGC, 2001. The chloroform concentration in a sample collected from the upper 2 feet (ft) of the water column (6,200 µg/L) was similar to the chloroform concentration in a sample collected near the base of the well (5,820 µg/L).

Furthermore, as will be discussed in Section 3, a soil gas survey conducted in 1999 detected only very low concentrations of chloroform in the leach field source areas (HGC, 1999). The magnitude of the detected concentrations (<1 µg/L gas) indicated that DNAPL does not exist in the vadose zone in these areas, and that the residual chloroform concentrations are too low to represent a continuing source to perched groundwater.

2.3 The Extent to which Contaminant Substances Have Migrated and are Expected to Migrate

The current extent of contaminant migration is discussed in Section 2.2 above. This information will be re-assessed once sufficient data have been collected from the new perched zone wells TW4-23, TW4-24, and TW4-25. As a result of interim remedial actions (described in Section 2.1 above), and natural attenuation processes, perched zone chloroform concentrations appear to be decreasing on average, and the areal extent of the chloroform plume appears to be relatively stable at the present time.

2.3.1 Chloroform Concentration Trends

Appendix C contains graphs of chloroform concentrations over time at the chloroform investigation wells (from DUSA, 2007). The chloroform investigation wells include MW-4, MW-26 (TW4-15), MW-32 (TW4-17), and the TW4-series wells. As indicated, within the last few years, chloroform concentrations at most of the wells have been decreasing. Concentrations at some of the wells, for example TW4-20, have fluctuated substantially, even though concentrations at this well have been on a general downward trend during the last few quarters. Historically, the highest chloroform concentrations have been detected near MW-4 and TW4-19. The highest detected concentration was 61,000 µg/L at TW4-20 in the second quarter of 2006. As of the first quarter of 2007, the chloroform concentration at TW4-20 was 4,400 µg/L. TW4-20 is located immediately downgradient of TW4-19 and the former office leach field source area. The highest detected concentration near MW-4 was 6,300 µg/L during the second quarter of 2001. As of the first quarter of 2007, the chloroform concentration at MW4 was 2,900 µg/L. MW-4 is located downgradient of the abandoned scale house leach field source area. MW-4, MW-26 (TW4-15), TW4-19, and TW4-20 are all pumping chloroform laden water as part of the interim remedial action for the site.

The general reduction in chloroform concentrations within the plume over the 2 year period ending with the first quarter, 2007, is illustrated in Tables 1, 2, and 3. Table 1 compares chloroform concentrations from the first quarter, 2007 with concentrations from the second quarter of 2005. Table 2 compares concentrations from the first quarter, 2007 with concentrations from the second quarter, 2006. Table 3 compares average concentrations over the four quarters from second quarter, 2006 to first quarter, 2007 with average concentrations over the four quarters from second quarter, 2005 to first quarter, 2006. Only wells with consistently detectable concentrations are included in these Tables.

Between the second quarter, 2005 and first quarter, 2007 (Table 1), 11 wells decreased in concentration, 4 increased, and 1 remained the same. Between the second quarter, 2006, and the first quarter, 2007, 11 wells decreased in concentration, and 5 increased. Using the averages (Table 3), 10 wells decreased in concentration, and 6 increased. These comparisons indicate that despite short term fluctuations, chloroform concentrations within most of the plume area are decreasing. This decrease is attributed to mass removal by pumping and natural attenuation.

2.3.2 Chloroform Mass Removal Rates

The interim action, which has included pumping of MW-4, MW-26 (TW4-15), TW4-19, and TW4-20 (Figure 1), has resulted in substantial removal of chloroform mass from the perched zone. Chloroform mass removal rates and the cumulative mass removed can be estimated using the cumulative pumped volumes for each well and the average chloroform concentrations over the pumping period. Based on DUSA, 2007, during the first quarter of 2007, the approximate total volumes of water pumped were 81,230 gallons from MW-4; 54,400 gallons from MW-26; 605,400 gallons from TW4-19; and 163,520 gallons from TW4-20. Since the start of pumping, the total approximate volumes of water pumped were 1,307,110 gallons from MW-4; 930,510 gallons from MW-26; 6,768,986 gallons from TW4-19; and 642,290 gallons from TW4-20.

Using first quarter, 2007, chloroform concentrations, and the first quarter pumped volumes, chloroform mass removal rates were approximately 0.15 lbs/day (pounds per day), and the total chloroform removed within the quarter was approximately 13.6 lbs or 1.1 gallons. Since pumping began, using the total pumped volumes and average chloroform concentrations of 3,370 µg/L for MW-4, 1,660 µg/L for MW-26, 2,660 µg/L for TW4-19, and 16,240 µg/L for TW4-20, an estimated 283 lbs, or 23 gallons of chloroform have been removed by pumping from the perched zone. Average chloroform concentrations used in the above calculations are the averages of all chloroform analytical results for each well during each well's pumping period.

The total amount of dissolved chloroform estimated to remain in the plume is approximately 650 lbs or 52 gallons. This estimate is based on the first quarter, 2007 saturated thicknesses (Figure 10), and the average chloroform concentrations from the second quarter of

2006 to the first quarter of 2007. Average chloroform concentrations were used because of the large fluctuations in concentrations measured at pumping well TW4-20. The total amount estimated to have been removed by pumping is approximately 44% of the estimated amount remaining. Assuming that no natural attenuation of chloroform has occurred, the total amount that entered the perched zone can be approximated as the sum of the estimated amounts pumped and remaining, or approximately 75 gallons. The total removed by pumping would then be approximately 30% of the initial amount. The actual percentage of the initial amount removed by pumping may be somewhat less than 30% because natural attenuation of chloroform, in particular biodegradation of chloroform as discussed in Appendix B, has likely been a significant mass removal mechanism. Accounting for loss of chloroform to natural attenuation would increase the estimate of the initial chloroform mass in the perched zone.

DUSA reported that as much as 50 to 100 gallons of chloroform per year were used in the laboratory operation that disposed waste to the abandoned scale house and former office leach fields between 1977 and mid 1980. This would imply that a maximum of 175 to 350 gallons may have been disposed as waste between 1977 and mid 1980. The actual amount disposed to the leach fields would be less than the amount used because of loss of product by volatilization, consumption in analytical processes, and other factors that would use up chloroform before disposal to the leach fields could occur. The difference between the above estimate of 75 gallons initially disposed (which is low because it does not account for natural attenuation), and the actual amount disposed (that would be less than the maximum of approximately 175 to 350 gallons estimated to have been used in the laboratory operation between 1977 and mid 1980), is within a range that is likely consistent with natural attenuation since 1980.

Regardless of the mass reduction contributed by natural attenuation, and the actual total mass of chloroform initially released to the perched zone, the amount of chloroform removed by pumping has been significant.

2.3.3 Expected Future Chloroform Migration

The extent of future migration of the chloroform will depend on factors that include 1) the rate of future mass removal by pumping, 2) perched zone hydraulic gradients, 3) perched zone permeabilities downgradient of the chloroform, 4) retardation by sorption, and 5) natural attenuation.

Pumping of MW-4, MW-26 (TW4-15), TW4-19, and TW4-20, directly removes chloroform mass from the perched zone, and reduces the magnitude of the hydraulic gradients in the downgradient portions of the plume. As a result of this pumping, chloroform concentrations are reduced within the plume and the rate of downgradient migration is slowed.

Figure 3 is a map showing the plume boundary, the estimated combined capture zones of MW-26 (TW4-15), TW4-19, and TW4-20, and the estimated capture zone for MW-4 for the first quarter, 2007 (from DUSA, 2007). As shown, hydraulic capture of approximately ? to ¾ of the plume has been achieved. A portion of the southern half of the plume is currently outside the estimated capture zone. Although the extent of the capture zone is expected to increase over time, including expansion to the south, it is unlikely that complete hydraulic capture of the plume is achievable with the current pumping scheme. However, pumping in the southern (downgradient) extremity of the plume is impractical due to low permeability and low saturated thickness (HGC, 2005), as discussed below.

The estimated range in perched zone permeabilities over much of the area of the chloroform plume is one to two orders of magnitude greater than estimates for areas downgradient of the chloroform plume and the tailings cells, as will be discussed in Section 3. This reduction in permeability to the south and southwest is interpreted as a "pinching out" of a coarser-grained, higher permeability zone identified during installation of many of the temporary wells (HGC, 2005). The pinching out of this zone is important in limiting the rate of downgradient migration of chloroform, in stabilizing the plume boundaries, and in allowing natural attenuation to be more effective in limiting plume migration. The combination of relatively high permeability and relatively large saturated thickness in the upgradient portions of the plume that make the productivity of the perched zone high and allow relatively high chloroform mass removal rates via interim pumping, is absent at downgradient wells such as TW4-4 and TW4-6. The combination of relatively low permeability and small saturated thickness near these downgradient wells makes pumping at these wells impractical.

Because low permeability conditions to the south and southwest, and flattening hydraulic gradients resulting from upgradient pumping will reduce rates of downgradient migration, natural attenuation will likely be effective in treating that portion of the plume that will remain outside hydraulic capture (Appendix B). Natural attenuation processes include physical and biological mechanisms. Physical mechanisms that will reduce chloroform concentrations include processes that remove chloroform mass such as volatilization from the water table and abiotic reductive dechlorination, and processes such as hydrodynamic dispersion that rely on mixing with recharge and waters outside the plume. Furthermore, retardation of the plume by sorption onto natural organic carbon in the subsurface will act to slow the rate of downgradient migration. Sorption onto organic carbon and mass loss by volatilization will act to retard the migration of chloroform with respect to more conservative constituents such as nitrate which does not sorb and is not volatile. In addition to these physical mechanisms, biologically mediated decomposition of chloroform is also expected to reduce chloroform mass and concentrations within the plume (Appendix B).

As a result of ongoing chloroform mass removal by pumping, and natural attenuation processes, the chloroform plume at present appears to be relatively stable. Figure 4 compares the extents of the chloroform plume in the first quarters of 2006 and 2007. Over this period, the plume boundary has expanded slightly in some areas and contracted slightly in others, but has not shown a net expansion in area. Although the plume appears to have stabilized, continued monitoring is needed to verify this condition. The additional data that will be obtained from new perched wells TW4-23, TW4-24, and TW4-25 will be important in assessing plume stability. Inclusion of data obtained from the initial sampling of these wells in June 2007, however, would result in little change in the areal extent of the plume as defined by the first quarter, 2007 data (Section 2.2), suggesting that the apparent stability of the plume will likely be supported by future data collected from these wells.

3. FACILITY CHARACTERIZATION

The hydrogeology of the White Mesa Mill and the media of occurrence of chloroform is discussed in the following sections.

3.1 Contaminant Substance Mixtures Present and Media of Occurrence

The contaminant of concern is chloroform which is dissolved in perched groundwater beneath the site primarily in areas hydraulically cross-gradient or upgradient of the tailings cells. Perched groundwater is a relatively shallow groundwater zone that is hosted primarily by the Burro Canyon Formation (predominantly sandstone) and is separated from the underlying regional aquifer by more than 1,000 ft of low permeability materials. While chloroform represents the primary constituent of concern, chloride, nitrogen (nitrate + nitrite as N), TCM, DCM and CM are analyzed on a quarterly basis as a means of monitoring the status of the contaminant plume and any degradation products from chloroform. As discussed in Section 2 above, and Appendix B, the presence of low concentrations of chloroform degradation products DCM and CM indicate that slow in-situ natural biodegradation of chloroform is occurring in the perched groundwater.

3.2 Hydrogeologic Conditions Underlying, Upgradient, and Downgradient of the Facility

Titan, 1994 provides a detailed description of site hydrogeology based on information available at that time. A brief summary of site hydrogeology that is based on Titan, 1994, and that includes the results of more recent site investigations, is provided below.

3.2.1 Geologic Setting

The site is located within the Blanding Basin of the Colorado Plateau physiographic province. Typical of large portions of the Colorado Plateau province, the rocks underlying the site are relatively undeformed. The average elevation of the site is approximately 5,600 ft above mean sea level (amsl).

The site is underlain by unconsolidated alluvium and indurated sedimentary rocks consisting primarily of sandstone and shale. The indurated rocks are relatively flat lying with dips generally less than 3 degrees. The alluvial materials consist mostly of aeolian silts and fine-grained aeolian sands with a thickness varying from a few feet to as much as 25 to 30 ft across the site. In places, the alluvium is underlain by fine grained materials that have been interpreted as erosional remnants of the Mancos Shale. The alluvium (and Mancos, where present) is underlain by the Dakota Sandstone and Burro Canyon Formation, which are sandstones having a total thickness ranging from approximately 100 to 140 ft. Beneath the Burro Canyon Formation lies the Morrison Formation, consisting, in descending order, of the Brushy Basin Member, the Westwater Canyon Member, the Recapture Member, and the Salt Wash Member. The Brushy Basin and Recapture Members of the Morrison Formation, classified as shales, are very fine-grained and have a very low permeability. The Brushy Basin Member is primarily composed of bentonitic mudstones, siltstones, and claystones. The Westwater Canyon and Salt Wash Members also have a low average vertical permeability due to the presence of interbedded shales.

Beneath the Morrison Formation lie the Summerville Formation, an argillaceous sandstone with interbedded shales, and the Entrada Sandstone. Beneath the Entrada lies the Navajo Sandstone. The Navajo and Entrada Sandstones constitute the primary aquifer in the area of the site. The Entrada and Navajo Sandstones are separated from the Burro Canyon Formation by approximately 1,000 to 1,100 ft of materials having a low average vertical permeability. Groundwater within this system is under artesian pressure in the vicinity of the site, is of generally good quality, and is used as a secondary source of water at the site.

3.2.2 Hydrogeologic Setting

The site is located within a region that has a dry to arid continental climate. Recharge to aquifers occurs primarily along the mountain fronts (for example, the Henry, Abajo, and La Sal Mountains), and along the flanks of folds such as Comb Ridge Monocline.

Although the water quality and productivity of the Navajo/Entrada aquifer are generally good, the depth of the aquifer (approximately 1,200 ft below land surface [ft bls]) makes access difficult. The Navajo/Entrada aquifer is capable of yielding significant quantities of water to wells (hundreds of gallons per minute [gpm]). Water in wells completed across these units at the site rises approximately 800 ft above the base of the overlying Summerville Formation.

Perched groundwater in the Dakota Sandstone and Burro Canyon Formation is used on a limited basis to the north (upgradient) of the site because it is more easily accessible. Water quality of the Dakota Sandstone and Burro Canyon Formation is generally poor due to high total dissolved solids (TDS) and is used primarily for stock watering and irrigation. The saturated thickness of the perched water zone generally increases to the north of the site, increasing the yield of the perched zone to wells installed north of the site.

3.2.3 Perched Zone Hydrogeology

Perched groundwater beneath the site occurs primarily within the Burro Canyon Formation, but locally rises into the Dakota northeast of the tailings cells where saturated thicknesses are greater. Perched groundwater at the site has a generally low quality due to high total dissolved solids (TDS) in the range of approximately 1,200 to 5,000 mg/L, and is used primarily for stock watering and irrigation in the areas upgradient (north) of the site. Perched water is supported within the Burro Canyon Formation by the underlying, fine-grained Brushy Basin Member of the Morrison Formation. Figure 5 is a contour map showing the approximate elevation of the contact of the Burro Canyon Formation with the Brushy Basin Member, which essentially forms the base of the perched water zone at the site. Contact elevations are based on perched monitoring well lithologic logs and surveyed land surface elevations. As indicated, the contact generally dips to the south/southwest beneath the site.

Groundwater within the perched zone generally flows south to southwest beneath the site. Beneath the tailings cells at the site, perched water flow is generally southwest to south-southwest. East of the tailings cells, perched water flow is more southerly.

3.2.3.1 Lithologic and Hydraulic Properties

Although the Dakota Sandstone and Burro Canyon Formations are often described as a single unit due to their similarity, previous investigators at the site have distinguished between them. The Dakota Sandstone is a relatively-hard to hard, generally fine-to-medium grained sandstone cemented by kaolinite clays. The Dakota Sandstone locally contains discontinuous interbeds of siltstone, shale, and conglomeratic materials. Porosity is primarily intergranular. The underlying Burro Canyon Formation hosts most of the perched groundwater at the site. The Burro Canyon Formation is similar to the Dakota Sandstone but is generally more poorly sorted, contains more conglomeratic materials, and becomes argillaceous near its contact with the underlying Brushy Basin Member. The permeability of the Dakota Sandstone and Burro Canyon Formation at the site is generally low.

No significant joints or fractures within the Dakota Sandstone or Burro Canyon Formation have been documented in any wells or borings installed across the site. This was the conclusion of Knight Piésold, 1998, and HGC, 2001, and is consistent with findings provided in HGC, 2005. Any fractures observed in cores collected from site borings are typically cemented, showing no open space.

3.2.3.1.1 Dakota

Based on samples collected during installation of wells MW-16 (no longer used) and MW-17, located immediately downgradient of the tailings cells at the site, porosities of the Dakota Sandstone range from 13.4% to 26%, averaging 20%, and water saturations range from 3.7% to 27.2%, averaging 13.5%. The average volumetric water content is approximately 3%. The permeability of the Dakota Sandstone based on packer tests in borings installed at the site ranges from 2.71 x 10^{-6} centimeters per second (cm/s) to 9.12 x 10^{-4} cm/s, with a geometric average of 3.89 x 10^{-5} cm/s (Titan, 1994).

3.2.3.1.2 Burro Canyon

The average porosity of the Burro Canyon Formation is similar to that of the Dakota Sandstone. Based on samples collected from the Burro Canyon Formation at MW-16 (no longer used), located immediately downgradient of the tailings cells at the site, Titan, 1994, reported that porosity ranges from 2% to 29.1%, averaging 18.3%, and water saturations of unsaturated materials range from 0.6% to 77.2%, averaging 23.4%. Titan, 1994, reported that the hydraulic conductivity of the Burro Canyon Formation ranges from 1.9 x 10^{-7} to 1.6 x 10^{-3} cm/s, with a geometric mean of 1.1 x 10^{-5} cm/s, based on the results of 12 pumping/recovery tests performed in monitoring wells and 30 packer tests performed in borings prior to 1994.

Hydraulic testing of wells MW-01, MW-03, MW-05, MW-17, MW-18, MW-19, MW-20, and MW-22 during the week of July 8, 2002, and newly installed wells MW-23, MW-25, MW-27, MW-28, MW-29, MW-30, MW-31, MW-32, TW4-20, TW4-21, and TW4-22 during June 2005, yielded average perched zone permeabilities ranging from approximately 2 x 10^{-7} cm/s to 5 x 10^{-4} cm/s, similar to the range reported by previous investigators at the site (Hydro Geo Chem, Inc [HGC], 2002; HGC, 2005). Downgradient (south to southwest) of the tailings cells, average perched zone permeabilities based on tests at MW-3, MW-5, MW-17, MW-20, MW-22, and MW-25 ranged from approximately 4 x 10^{-7} to 1 x 10^{-4} cm/s Permeability estimates from these tests were based on pumping/recovery and slug tests analyzed using several different methodologies. Permeability estimates from these tests are summarized in Table 4.

25 perched zone and temporary perched zone monitoring wells have been installed at the site to investigate elevated concentrations of chloroform initially discovered at well MW-4 in 1999. Some of the coarser grained and conglomeratic zones encountered within the perched zone during installation of these wells are believed to be continuous with or at least associated with a relatively thin, relatively continuous zone of higher permeability (IUSA and HGC, 2001).

The higher permeability zone defined by these wells is generally located east to northeast of the tailings cells at the site, and is hydraulically cross-gradient or upgradient of the tailings cells with respect to perched groundwater flow. Based on analyses of pumping tests at MW-4 and drilling logs from nearby temporary wells, the permeability of this relatively thin coarser-grained zone was estimated to be as high as 2.5 x 10^{-3} cm/s or 7 ft/day. Relatively high average permeabilities estimated at MW-11, located on the southeastern margin of the downgradient edge of tailings cell #3, and at MW-14, located on the downgradient edge of tailings cell #4, of 1.4 x 10^{-3} cm/s and 7.5 x 10^{-4} cm/s, respectively (UMETCO, 1993), may indicate that this zone extends beneath the southeastern margin of the cells. However, this zone of higher permeability within the perched water zone does not appear to exist downgradient (south-southwest) of the tailings cells. At depths beneath the perched water table, the zone is not evident in lithologic logs of the southernmost temporary wells TW4-4 and TW4-6 (located east [cross-gradient] of cell #3), nor is it evident in wells MW-3, MW-5, MW-12, MW-15, MW-16 (no longer used), MW-17, MW-20, MW-21, or MW-22, located south to southwest (downgradient) of the tailings cells, based on the lithologic logs or hydraulic testing of the wells. The apparent absence of the zone south of TW4-4 and south-southwest of the tailings cells indicates that it "pinches out" (HGC, 2005).

To test the potential existence and continuity of this higher permeability zone, and to refine hydraulic parameter estimates, long term pumping of MW-4 and TW4-19 began in April 2003. MW-26 (TW4-15) was added to the pumping network in August 2003, and TW4-20 was added in August 2005. These wells were selected for pumping because they were 1) located in areas of the perched zone having relatively high transmissivity, and could therefore sustain relatively high pumping rates, and 2) because the wells were also located in perched water having relatively high chloroform concentrations, which resulted in significant rates of chloroform mass removal. This long term pumping has constituted an interim action to mitigate chloroform in the perched zone (HGC, 2004).

Analysis of drawdown data collected from wells that responded measurably to pumping between the start of pumping (April 2003) and November 2003, indicated average permeabilities ranging from 4 x 10^{-5} to 5 x 10^{-4} cm/s in the area east to northeast of the tailings cells, assuming the perched zone is unconfined (HGC, 2004). Table 5 summarizes the results of the testing.

Figure 6 shows the approximate area where detectable drawdowns were measured during the 7 months of pumping. This area is interpreted to coincide roughly with the zone of higher permeability. Wells located immediately outside this zone that did not respond measurably to pumping are interpreted to be completed in lower permeability materials (for example, TW4-4 and TW4-6).

3.2.3.2 Perched Groundwater Flow

Perched groundwater flow at the site has historically been to the south/southwest. Figures 7 through 10 are perched groundwater elevation contour maps for the years 1990, 1994, 2002, and the first quarter of 2007, respectively. The 1990, 1994, and 2002 maps were hand contoured because of sparse data. As groundwater elevations indicate, the perched groundwater gradient changes from generally southwesterly in the western portion of the site, to generally southerly in the eastern portion of the site. The most significant changes between the 2002 and 2007 water levels result from pumping of wells MW-4, TW4-19, TW4-20, and MW-26 (TW4-15). These wells are pumped to reduce chloroform mass in the perched zone east and northeast of the tailings cells. (Chloroform occurrence in the perched zone was discussed in Section 2.)

In general, perched groundwater elevations have not changed significantly over most of the site since monitoring began, except in the vicinity of the wildlife ponds and the pumping wells. For example, relatively large increases in water levels occurred between 1994 and 2002 at MW-4 and MW-19, located in the east and northeast portions of the site, as shown by comparing

Figures 9 and 10. These water level increases in the northeastern and eastern portions of the site are likely the result of seepage from wildlife ponds located near the piezometers shown in Figures 9 and 10, which were installed in 2001 for the purpose of investigating these changes. Increasing water levels affect many of the chloroform investigation wells as shown in the hydrographs provided in Appendix D (from DUSA, 2007).

The increases in water levels in the northeastern portion of the site have resulted in locally steepening groundwater gradients over portions of the site. Conversely, pumping of wells MW-4, TW4-19, TW4-20, and MW-26 (TW4-15) has depressed the perched water table locally and reduced average hydraulic gradients to the south and southwest of these wells. Perched zone hydraulic gradients currently range from a maximum of approximately 0.05 ft/ft east of tailings cell #2 to approximately 0.01 ft/ft downgradient of cell #3, between cell #3 and MW-20.

Perched water discharges in springs and seeps along Westwater Creek Canyon and Cottonwood Canyon to the west-southwest of the site, and along Corral Canyon to the east of the site, where the Burro Canyon Formation outcrops. The discharge point located most directly downgradient of the tailings cells is Ruin Spring. This feature is located approximately 10,000 ft south-southwest of the tailings cells at the site and is depicted on the USGS 7.5-minute quad sheet for Black Mesa (Figure 11).

The average hydraulic gradient between the downgradient edge of tailings cell #3 and Ruin Spring is approximately 0.12 ft/ft assuming the following:

1) The elevation of Ruin Spring, based on the USGS topographic map for Black Mesa, is approximately 5,390 ft amsl.

2) The distance between the downgradient edge of tailings cell #3 and Ruin Spring is approximately 10,000 ft.

3) The average groundwater elevation at the downgradient edge of tailings cell #3 is approximately 5,510 ft amsl.

3.2.3.3 Saturated Thickness

The saturated thickness of the perched zone as of the first quarter of 2007 ranges from approximately 93 ft in the northeastern portion of the site to less than 5 ft in the southwest portion of the site (Figure 12), and depths to water range from approximately 14 ft in the northeastern portion of the site (adjacent to the wildlife ponds) to approximately 114 ft at the southwest margin of tailings cell #3 (Figure 13). The relatively large saturated thicknesses in the northeastern portion of the site are likely related to seepage from wildlife ponds located near the piezometers shown in Figure 10.

Although sustainable yields of as much as about 4 gpm have been achieved in wells intercepting the larger saturated thicknesses and higher permeability zones in the northeast portion of the site, perched zone well yields are typically low (<0.5 gpm) due to the generally low permeability of the perched zone. Sufficient productivity can generally be obtained only in areas where the saturated thickness is greater, which is the primary reason that the perched zone has been used on a limited basis as a water supply to the north (upgradient) of the site, but not downgradient of the site.

3.2.3.4 Perched Groundwater Travel Times

Average rates of movement of a conservative solute in perched groundwater (equivalent to interstitial or pore velocity) have been calculated for the area of the perched zone downgradient of the tailings cells, and beneath and immediately upgradient of the tailings cells (HGC, 2005 and HGC, 2007).

The calculated rate of movement downgradient of the tailings cells was based on an effective porosity of 0.18, an average hydraulic gradient of 0.012 ft/ft, and geometric averages of permeabilities estimated from hydraulic tests at wells located south and southwest of the cells. The geometric averages were based on slug tests performed at MW-3, MW-5, MW-17, MW-20, MW-22, and MW-25 (HGC, 2002; HGC, 2005), and pump tests performed by Peel Environmental (UMETCO, 1993) at MW-11, MW-12, MW-14, and MW-15. Two averages were calculated; one using permeabilities estimated from HGC slug test data analyzed using the Bouwer-Rice solution (Bouwer and Rice, 1976) and the other using permeabilities estimated from the same data using the KGS solution (Hyder, 1994). Included in each average were the results of the pump tests reported in UMETCO, 1993, for MW-11, MW-12, MW-14, and MW-15. The geometric averages thus calculated were 2.3×10^{-5} and 4.3×10^{-5} cm/s. Assuming the average permeability ranges from 2.3×10^{-5} to 4.3×10^{-5} cm/s (0.064 ft/day to 0.120 ft/day), the calculated average rate of movement ranges from 0.0043 ft/day to 0.0080 ft/day (or 1.6 ft/year to 2.9 ft/year).

Beneath and immediately upgradient of the tailings cells, using hydraulic gradients in the vicinity of each well, the estimated permeability at each well, and an effective porosity of 0.18, the estimated pore velocities ranged from 49.5 ft/year at TW4-21, to 0.010 ft/year at MW-23 (HGC, 2005), and have a geometric average of approximately 4.5 ft/year. Wells with relatively high calculated pore velocities, such as TW4-21, likely penetrate the relatively thin, coarser-grained, higher permeability zone discussed in Section 3.2.3.1.2, that is interpreted to "pinch out" to the south and southwest, and does not appear to be present south of TW4-4 or south or southwest of the tailings cells.

3.3 Surface Waters in the Area

There are no surface water pathways in the immediate vicinity of the chloroform occurrence. Ruin Spring, located approximately 2.2 miles southwest and downgradient of the chloroform occurrence, is the nearest surface discharge point for perched water (Figure 11). Chloroform has not been detected in samples collected from the spring.

Seepage of water from the two wildlife ponds on the White Mesa property, one upgradient, and one downgradient of the detected chloroform, has resulted in groundwater mounds in the area of piezometers P-1 and P-4 that have locally affected the generally south to southwest direction of perched groundwater flow, as shown in Figure 10, and as discussed in Section 3.2.

3.4 Climatologic and Meteorologic Conditions in the Area of the Facility

The climate of southeastern Utah is classified as dry to arid continental. Although varying somewhat with elevation and terrain, the climate in the vicinity of the site can be considered as semi-arid. Titan, 1994 reported average annual precipitation for the site of less than 11.8 inches, and average annual evapotranspiration of approximately 61.5 inches.

Site specific information provided by DUSA indicates the normal annual precipitation is approximately 13.4 in (34 cm). Most precipitation is in the form of rain with snowfall accounting for about 29% of the annual total. There are two separate rainfall seasons; the first in late summer and early autumn (August to October), and the second during the winter months (December to March). The mean annual relative humidity is about 44% and is typically highest in January and lowest in July. The average annual Class A pan evaporation rate is 68 inches (172.7 cm) (National Oceanic and Atmospheric Administration and U.S. Department of Commerce, 1977), with the largest evaporation rate typically occurring in July. This evaporation rate is not appropriate for determining water balance requirements for the tailings management system and must be reduced by the Class A pan coefficient. Values of pan coefficients range from 60% to 81%. Water balance calculations at the site used to obtain the lake evaporation rate are based on an average value of 70%. Using this coefficient, the annual lake evaporation rate is 47.6 inches (120.4cm), and the net evaporation rate is 34.2 inches (86.8 cm) per year.

The weather in the area of the site is typified by warm summers and cold winters. The mean annual temperature in Blanding (located approximately 5 miles north of the site) is about 50°F (10°C). January is usually the coldest month and July is usually the warmest month.

Winds are typically light to moderate year round, although occasional stronger winds may occur in the late winter and spring. The winds are predominantly from the north to north-east (approximately 30% of the time) and from the south to south-west (about 25% of the time). Winds are generally less than 15 mph; wind speeds greater than 25 mph occur less than one percent of the time.

3.5 Type, Location and Description of Possible Sources of the Pollution at the Facility

Investigation of potential source areas for the chloroform included a soil gas survey conducted in September 1999 (HGC, 1999). Detectable chloroform concentrations were measured in two suspected source areas; 1) the abandoned scale house leach field located approximately 1,100 ft north (upgradient) of MW-4, and 2) the former office leach field, located immediately southeast of the office building and north-east of tailings cell #2 (Figure 14). Prior to Mill operations, these leach fields accepted sanitary wastes as well as laboratory wastes containing chloroform at quantities sufficient to have resulted in the measured groundwater concentrations. The abandoned scale house leach field is reported to have accepted laboratory waste from 1977 to 1979, and the former office leach field from 1979 to mid 1980. After 1980, laboratory wastes were disposed in the tailings cells.

Discussions of the results of the soil gas survey and the identification of the abandoned scale house leach field as the most likely source of the chloroform detected at MW-4 are provided in IUSA and HGC, 2000. The former office leach field is considered the most likely source of the chloroform detected immediately northeast and upgradient of tailings cell #2.

In general, the leach-field origin of the chloroform is supported by the following factors:

1) The leach fields are within and upgradient of the chloroform contamination,

2) Based on records of chloroform used in the laboratory, sufficient chloroform was disposed in the leach fields to result in the measured groundwater concentrations,

3) Elevated nitrate is associated with the chloroform, and

4) The leach fields were designed to infiltrate water rapidly, which would reduce travel times to the perched water through the vadose zone.

An additional conclusion based on the low soil gas chloroform concentrations detected (<1 µg/L gas) was that a significant residual vadose zone source does not exist in either source area (HGC, 1999). The association of nitrate with the chloroform is discussed in IUSA and HGC, 2001.

3.6 Groundwater Withdrawals, Pumpage Rates, and Usage within a 2-Mile Radius

Perched groundwater in the vicinity of the site is used on a limited basis primarily for irrigation, stock watering, and domestic purposes. A search by Titan, 1994, and a recent search of the water rights database accessible from the Utah Geological Survey website, did not indicate any users of perched water downgradient (south to southwest) of the site. Users of perched water are primarily located upgradient of the site where saturated thicknesses and well productivities are higher. Wells installed for industrial uses, for example wells that were installed to supply the White Mesa Mill with fresh water, are typically completed in the deep regional Navajo/Entrada aquifer. Brief descriptions of the perched zone and regional Navajo/Entrada aquifer are provided in Sections 3.2.2 and 3.2.3.

Titan, 1994, listed users of groundwater within a 5 mile radius of the White Mesa Mill. Several of the users listed in Titan, 1994, are located within 2 to 2 ½ miles of the chloroform occurrence. These users (all within Township 37 South, Range 22 East) are as follows:

Owner	**Section**	**Depth (ft)**	**Use**	**Yield (gpm)**
Plateau Resources	15	740	industrial	6.75
Plateau Resources	15	135	industrial	6.75
Lyman	15	135	stock	6.75
Holt and McLaws	15	195	stock	3.15
Perkins	21	150	industrial	6.75
Energy Fuels Nuclear	21	1,600	industrial	270
Energy Fuels Nuclear	22	1,820	industrial	500
Utah Launch Complex	27	650	industrial	6.75

Wells installed by Energy Fuels Nuclear were used for fresh water supply at the White Mesa Mill and are completed in the deep regional (Navajo/Entrada) aquifer. These wells are now used as an alternate water supply for the site, as discussed in Section 3.2.1.

A recent search for wells in the area using the water rights database accessible from the Utah Geological Survey website, indicated additional wells, most having been installed since the search by Titan, 1994. The following are the additional wells identified within a 2 to 2 ½ mile radius, including comments regarding their status:

Owner	Section	Depth (ft)	Use	Yield (gpm)	Comment
Nielson	15	125	domestic	5	lapsed
Lyman	21	160	unknown	10	provisional
Lyman	21	180	unknown	10	provisional
Rafferty	22	160	Ir, St, D	7	
Perkins	22	140	unknown	7	
Laws	22	75	Ir, St, D	6.5	capped
Bayles	22	120	Ir, St, D	6	lapsed
Energy Fuels Nuclear	27	1,800	industrial	120	
Hawkins	32	240	stock	12	

(Note: Ir, St, D indicates use is irrigation, stock, or domestic)

Again, the 1,800 foot deep well installed by Energy Fuels Nuclear is completed in the deep Navajo/Entrada aquifer, and is not screened in the perched zone.

On-site perched groundwater withdrawal is limited to those waters pumped for chloroform recovery from wells MW-4, MW-26 (TW4-15), TW4-19, and TW4-20. The approximate average pumping rates of these wells during the first quarter of 2007 were 0.63 gpm for MW-4; 0.42 gpm for MW-26; 4.6 gpm for TW4-19; and 1.3 gpm for TW4-20.

Overall, perched water use near the chloroform occurrence is very limited. Identified offsite users are located upgradient or cross-gradient of the chloroform and are not threatened by the potential for contamination of their water supply by the on-site chloroform. Remedial pumping of the perched zone to remove chloroform laden water is also not likely to ever impact the existing user's available supply, especially considering the recharge by the wildlife ponds that occurs immediately upgradient of the on-site pumping wells.

4. DATA REPORTING

4.1 Data Packages Including Quality Assurance and Quality Control Reports

Data packages, including quality assurance and quality control reports are provided to the Executive Secretary on a quarterly basis. For example, the first quarter, 2007 report (DUSA, 2007), submitted to UDEQ on May 31, 2007, has been referenced in this document. The elements of proposed future reporting are provided in the Preliminary Corrective Action Plan (HGC, 2007b).

4.2 A Description of the Data used in the Quarterly Reports

Routine analytical parameters for the chloroform investigation wells include the following:

- Chloroform
- Chloromethane
- Carbon tetrachloride
- Methylene chloride
- Chloride
- Nitrogen, Nitrate + Nitrite as N

In addition, water levels for all of the chloroform investigation wells are measured and reported. Contour maps showing water levels, chloroform concentrations, and estimated capture zones for pumping wells MW-4, MW-26 (TW4-15), TW4-19, and TW4-20 are presented. Proposed collection and use of data in future reports is described in HGC, 2007b.

4.3 A Description of any Data Gaps Encountered, How Those Gaps Affect the Analysis and Any Plans to Fill Those Gaps

The investigation and monitoring program has been ongoing since the time of chloroform discovery in 1999. Accordingly, any data gaps identified as part of this ongoing process that have indicated additional monitoring to be necessary, have been filled as part of an interactive process with the UDEQ. For example, the proposed location and installation of new wells TW4-23, TW4-24 and TW4-25 is an example of filling a data gap. It is not anticipated that significant gaps will remain once data from the above wells are obtained. Based on the initial sampling of TW4-23, TW4-24, and TW4-25, no significant changes to water level contours or to the chloroform plume boundary are expected to occur when these data are incorporated. However, this decision will ultimately be based on more than these initial data, and will be discussed in the Final Contamination Investigation Report.

5. ENDANGERMENT ASSESSMENT

The goal of the chloroform investigation, interim action, and proposed corrective action program (HGC, 2007b) is to continue remedial efforts by means of pumping and natural attenuation until the Corrective Action Concentration Limit (70 µg/L) has been met. As discussed in Section 2.3.2, the extent of the chloroform plume appears relatively stable at the present time, and concentrations within the plume are generally decreasing. The low permeability of the perched zone downgradient of the chloroform plume, the consequent low transport velocities and large travel times, and the large distance to the nearest discharge point (Ruin Spring), indicate that, even in the absence of remedial action, the chloroform plume would migrate slowly and potentially not reach the nearest discharge point for thousands of years. Considering the expected concentration reductions due to pumping and natural attenuation, it is unlikely that detectable chloroform concentrations would ever reach the discharge point, or even the area south and southwest of the tailings cells, as discussed in Appendix B. Therefore, the preparation of an Endangerment Assessment is not warranted at this time. This aspect of the Contamination Investigation requirements will, however, be re-visited as an element of the Final Contamination Investigation Report.

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7. LIMITATIONS STATEMENT

The opinions and recommendations presented in this report are based upon the scope of services and information obtained through the performance of the services, as agreed upon by HGC and the party for whom this report was originally prepared. Results of any investigations, tests, or findings presented in this report apply solely to conditions existing at the time HGC's investigative work was performed and are inherently based on and limited to the available data and the extent of the investigation activities. No representation, warranty, or guarantee, express or implied, is intended or given. HGC makes no representation as to the accuracy or completeness of any information provided by other parties not under contract to HGC to the extent that HGC relied upon that information. This report is expressly for the sole and exclusive use of the party for whom this report was originally prepared and for the particular purpose that it was intended. Reuse of this report, or any portion thereof, for other than its intended purpose, or if modified, or if used by third parties, shall be at the sole risk of the user.

TABLES

TABLE 1
Comparison of 2nd Quarter 2005 and 1st Quarter 2007 Chloroform Concentrations

Well	Q2 2005 Chloroform (µg/L)	Q1 2007 Chloroform (µg/L)	Change
MW-4	3170	2300	-870
TW4-1	3080	1900	-1180
TW4-2	3750	2900	-850
TW4-4	2400	2200	-200
TW4-5	113	33	-80
TW4-6	2.5	46	43
TW4-7	2700	1100	-1600
TW4-10	62.4	500	438
TW4-11	3590	3500	-90
TW4-15	442	570	128
TW4-16	212	8.7	-203
TW4-18	29.8	9.2	-21
TW4-19	1200	1200	0
TW4-20	39000	4400	-34600
TW4-21	192	160	-32
TW4-22	340	440	100

TABLE 2
Comparison of 2nd Quarter 2006 and 1st Quarter 2007 Chloroform Concentrations

Well	Q2 2006 Chloroform (µg/L)	Q1 2007 Chloroform (µg/L)	Change
MW-4	3000	2300	-700
TW4-1	2200	1900	-300
TW4-2	3200	2900	-300
TW4-4	2600	2200	-400
TW4-5	51	33	-18
TW4-6	19	46	27
TW4-7	2200	1100	-1100
TW4-10	300	500	200
TW4-11	4300	3500	-800
TW4-15	830	570	-260
TW4-16	13	8.7	-4
TW4-18	12	9.2	-3
TW4-19	1100	1200	100
TW4-20	61000	4400	-56600
TW4-21	130	160	30
TW4-22	390*	440	50

Notes:

** Q1 2006 Concentration*

TABLE 3
Comparison of Average Chloroform Concentrations Between 1st Quarter 2007 and 2nd Quarter 2006 and Between 1st Quarter 2006 and 2nd Quarter 2005

Well	Average Concentrations Q2, Q3, Q4, 2005 and Q1 2006	Average Concentrations Q2, Q3, Q4, 2006 and Q1 2007	Change
MW-4	3192	2738	-455
TW4-1	2770	2305	-465
TW4-2	3738	3410	-328
TW4-4	2825	2505	-320
TW4-5	81	46	-35
TW4-6	15	30	15
TW4-7	2550	2060	-490
TW4-10	166	439	273
TW4-11	4198	3885	-313
TW4-15	876	963	88
TW4-16	88	10	-77
TW4-18	24	11	-13
TW4-19	1650	1118	-533
TW4-20	17750	20425	2675
TW4-21	119	134	15
TW4-22	335	558	223

TABLE 4
Hydraulic Test Analysis Results
Single Well Tests

Well ID	Interpretation Method	Type	Hydraulic Conductivity (cm/sec)	Storativity	Specific Storage (1/foot)	Saturated Thickness (feet)	Skin
MW-01	WHIP	pump/recovery	7.7×10^{-7}	0.0082	--	20	none
	AQTESOLV (Moench, Leaky)	pump/recovery	7.7×10^{-7}	0.0082	--	20	none
	AQTESOLV (Moench, Unconfined)	pump/recovery	8.9×10^{-7}	0.01	--	40	none
MW-03	WHIP	slug	4.3×10^{-5}	0.01	--	5.2	none
	AQTESOLV (KGS, Unconfined)	slug	4.0×10^{-7}	0.098	1.92×10^{-2}	5.2	--
	AQTESOLV (Bouwer-Rice, Unconfined)	slug	1.5×10^{-5}	--	--	5.2	--
MW-05	WHIP	slug	1.1×10^{-5}	0.1	--	10	none
	AQTESOLV (KGS, Unconfined)	slug	3.5×10^{-6}	0.044	4.4×10^{-3}	10	--
	AQTESOLV (Bouwer-Rice, Unconfined)	slug	3.9×10^{-6}	--	--	10	--
	AQTESOLV (Bouwer-Rice, unconfined)	slug	2.4×10^{-5}	--	--	10	--
MW-17	WHIP	slug	2.9×10^{-5}	0.01	--	18	none
	AQTESOLV (KGS, Unconfined)	slug	2.6×10^{-5}	0.0031	1.71×10^{-4}	18	--
	AQTESOLV (Bouwer-Rice, Unconfined)	slug	2.7×10^{-5}	--	--	18	--
MW-18	WHIP	slug	4.4×10^{-4}	2.2×10^{-5}	--	45	none
	WHIP	slug	5.3×10^{-4}	0.02	--	45	6.54
	AQTESOLV (KGS, Unconfined)	slug	2.9×10^{-4}	2.7×10^{-5}	4.6×10^{-7}	58	--
	AQTESOLV (Bouwer-Rice, Unconfined)	slug	2.4×10^{-4}	--	--	58	--

TABLE 4
Hydraulic Test Analysis Results
Single Well Tests

Well ID	Interpretation Method	Type	Hydraulic Conductivity (cm/sec)	Storativity	Specific Storage (1/foot)	Saturated Thickness (feet)	Skin
MW-19	WHIP	slug	7.1×10^{-6}	0.032	--	47	none
	WHIP	slug	1.7×10^{-5}	0.027	--	47	2.24
	AQTESOLV (Moench, Leaky)	slug	1.7×10^{-5}	0.027	--	47	2.24
	AQTESOLV (KGS, Unconfined)	slug	1.7×10^{-5}	1.2×10^{-4}	1.44×10^{-6}	80	none
	AQTESOLV (KGS, Confined)	slug	1.6×10^{-5}	1.5×10^{-4}	3.24×10^{-6}	47	none
	AQTESOLV (Bouwer-Rice, Unconfined)	slug	1.3×10^{-5}	--	--	80	--
	AQTESOLV (Bouwer-Rice, Confined)	slug	1.2×10^{-5}	--	--	47	--
MW-20	WHIP	slug	8.2×10^{-6}	0.02	--	12	none
	AQTESOLV (Bouwer-Rice, Unconfined)	slug	9.3×10^{-6}	--	--	12	--
	AQTESOLV (Bouwer-Rice, Unconfined)	slug	5.9×10^{-6}	--	--	12	--
MW-22	WHIP	slug	4.2×10^{-6}	0.014	--	51	none
	AQTESOLV (KGS, Unconfined)	slug	1.0×10^{-6}	0.10	2.0×10^{-3}	51	--
	AQTESOLV (Bouwer-Rice, Unconfined)	slug	7.9×10^{-6}	--	--	51	--
	AQTESOLV (Bouwer-Rice, Unconfined)	slug	4.4×10^{-6}	--	--	51	--
MW-23	AQTESOLV (KGS, Unconfined)	slug	3.2×10^{-8}	--	1×10^{-1}	12	--
	AQTESOLV (Bouwer-Rice, Unconfined)	slug	1.6×10^{-6}	--	--	12	--
MW-23b[1]	AQTESOLV (KGS, Unconfined)	slug	2.3×10^{-7}	--	2.3×10^{-3}	12	--
	AQTESOLV (Bouwer-Rice, Unconfined)	slug	2.5×10^{-7}	--	--	12	--
MW-25	AQTESOLV (KGS, Unconfined)	slug	1.1×10^{-4}	--	3.0×10^{-4}	33	--
	AQTESOLV (Bouwer-Rice, Unconfined)	slug	7.4×10^{-5}	--	--	33	--

TABLE 4
Hydraulic Test Analysis Results
Single Well Tests

Well ID	Interpretation Method	Type	Hydraulic Conductivity (cm/sec)	Storativity	Specific Storage (1/foot)	Saturated Thickness (feet)	Skin
MW-27	AQTESOLV (KGS, Unconfined)	slug	8.2×10^{-5}	--	5.3×10^{-4}	36	--
	AQTESOLV (Bouwer-Rice, Unconfined)	slug	3.6×10^{-5}	--	--	36	--
MW-28	AQTESOLV (KGS, Unconfined)	slug	1.7×10^{-6}	--	2.0×10^{-2}	23	--
	AQTESOLV (Bouwer-Rice, Unconfined)	slug	1.7×10^{-6}	--	--	23	--
MW-29	AQTESOLV (KGS, Unconfined)	slug	1.1×10^{-4}	--	1.9×10^{-4}	18	--
	AQTESOLV (Bouwer-Rice, Unconfined)	slug	9.3×10^{-5}	--	--	18	--
MW-30	AQTESOLV (KGS, Unconfined)	slug	1.0×10^{-4}	--	2.9×10^{-4}	24	--
	AQTESOLV (Bouwer-Rice, Unconfined)	slug	6.4×10^{-5}	--	--	24	--
MW-31	AQTESOLV (KGS, Unconfined)	slug	7.1×10^{-5}	--	2.5×10^{-5}	53	--
	AQTESOLV (Bouwer-Rice, Unconfined)	slug	6.9×10^{-5}	--	--	53	--
MW-32	AQTESOLV (KGS, Unconfined)	slug	3.0×10^{-5}	--	8.8×10^{-5}	46	--
	AQTESOLV (Bouwer-Rice, Unconfined)	slug	2.6×10^{-5}	--	--	46	--
TW4-20	AQTESOLV (KGS, Unconfined)	slug	5.9×10^{-5}	--	1.6×10^{-5}	43	--
	AQTESOLV (Bouwer-Rice, Unconfined)	slug	4.2×10^{-5}	--	--	43	--
TW4-21	AQTESOLV (KGS, Unconfined)	slug	1.9×10^{-4}	--	1.1×10^{-4}	63	--
	AQTESOLV (Bouwer-Rice, Unconfined)	slug	3.2×10^{-5}	--	--	63	--
TW4-22	AQTESOLV (KGS, Unconfined)	slug	1.3×10^{-4}	--	6.8×10^{-6}	55	--
	AQTESOLV (Bouwer-Rice, Unconfined)	slug	1.1×10^{-4}	--	--	55	--

Notes:

cm/sec = Centimeters per second

^{1} = overnight test

TABLE 5
Estimated Perched Zone Hydraulic Properties Based on Analysis of Observation Wells Near MW-4 and TW4-19

Observation Well	Theis Solution (Confined or Unconfined)	Transmissivity (ft^2/day)	Storage Coefficient	Water Bearing Zone Thickness (feet)	Average Hydraulic Conductivity (ft/day)	Average Hydraulic Conductivity (cm/sec)
TW4-1	Unconfined	8.9	0.023	39	0.23	$8.2x10^{-5}$
	Confined	8.4	0.023	24	0.35	$1.3x10^{-4}$
TW4-2	Unconfined	4.6	0.0065	39	0.12	$4.3x10^{-5}$
	Confined	3.8	0.0063	24	0.16	$5.7x10^{-5}$
TW4-7	Unconfined	4.7	0.011	39	0.12	$4.3x10^{-5}$
	Confined	3.3	0.011	24	0.14	$5.0x10^{-5}$
TW4-8	Unconfined	4.5	0.010	39	0.12	$4.3x10^{-5}$
	Confined	3.9	0.010	24	0.16	$5.7x10^{-5}$
MW-4A	Unconfined	5.8	0.019	39	0.15	$5.4x10^{-5}$
	Confined	3.5	0.019	24	0.15	$5.4x10^{-5}$
MW-4A (early time)	Unconfined	12.4	0.0029	39	0.32	$1.1x10^{-4}$
	Confined	9.1	0.0031	24	0.38	$1.4x10^{-4}$

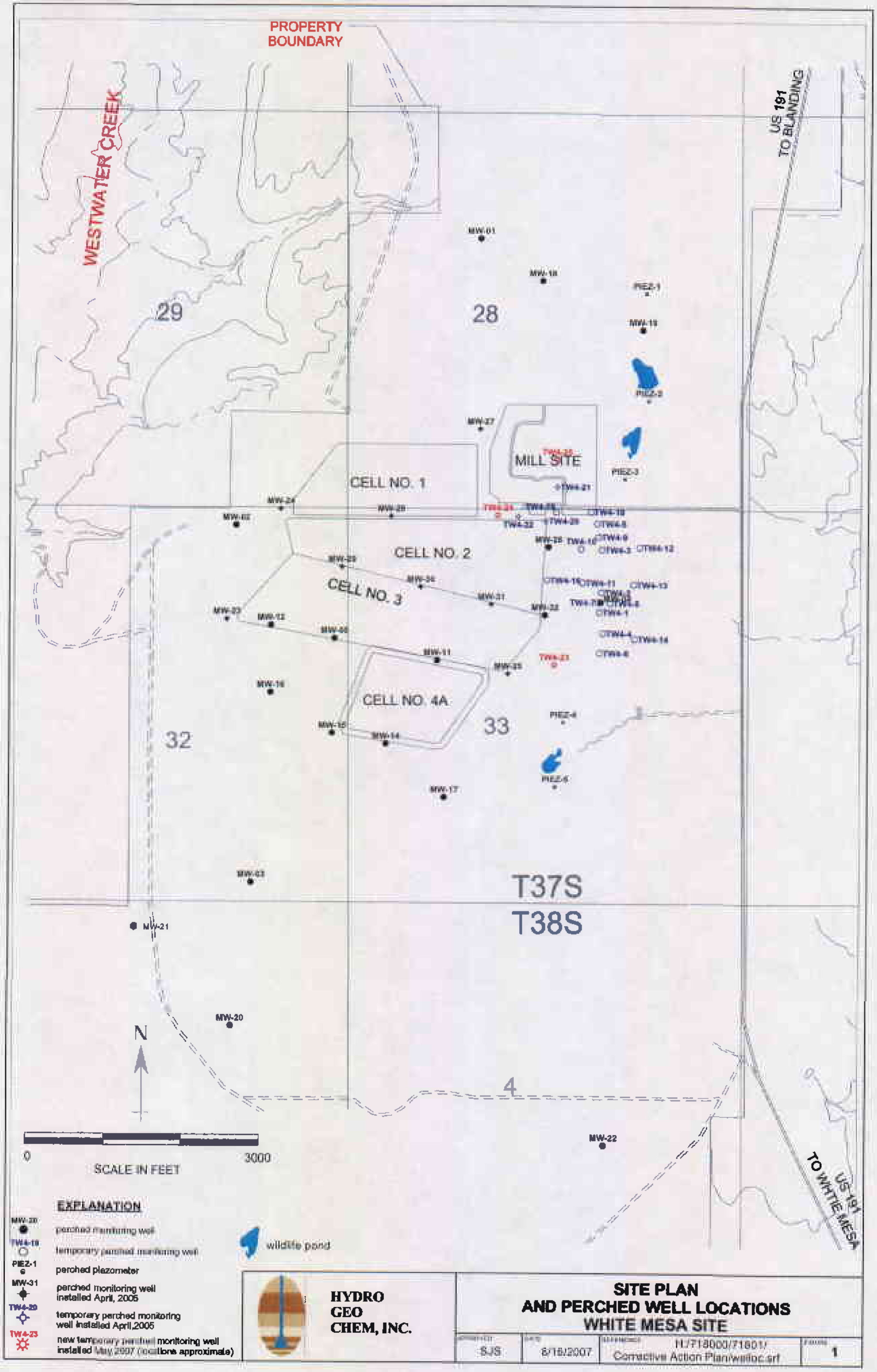
TABLE 5
Estimated Perched Zone Hydraulic Properties Based on Analysis of Observation Wells Near MW-4 and TW4-19

Observation Well	Theis Solution (Confined or Unconfined)	Transmissivity (ft^2/day)	Storage Coefficient	Water Bearing Zone Thickness (feet)	Average Hydraulic Conductivity (ft/day)	Average Hydraulic Conductivity (cm/sec)
TW4-5	Unconfined	89	0.0043	67	1.3	$4.6\text{x}10^{-4}$
	Confined	87	0.0043	31	2.8	$1.0\text{x}10^{-3}$
TW4-9	Unconfined	72	0.0043	67	1.1	$3.9\text{x}10^{-4}$
	Confined	71	0.0043	31	2.3	$8.2\text{x}10^{-4}$
TW4-10	Unconfined	48	0.0077	67	0.72	$2.6\text{x}10^{-4}$
	Confined	46	0.0076	31	1.5	$5.4\text{x}10^{-4}$
TW4-15	Unconfined	15	0.0037	67	0.22	$7.9\text{x}10^{-5}$
	Confined	12	0.0037	31	0.39	$1.4\text{x}10^{-4}$
TW4-16	Unconfined	19	0.0036	67	0.28	$1.0\text{x}10^{-4}$
	Confined	18	0.0035	31	0.58	$2.1\text{x}10^{-4}$
TW4-18	Unconfined	76	0.0046	67	1.1	$3.9\text{x}10^{-4}$
	Confined	74	0.0046	31	2.4	$8.6\text{x}10^{-4}$
TW4-19	Unconfined	44	0.12	67	0.66	$2.4\text{x}10^{-4}$
	Confined	39	0.12	31	1.3	$4.6\text{x}10^{-4}$

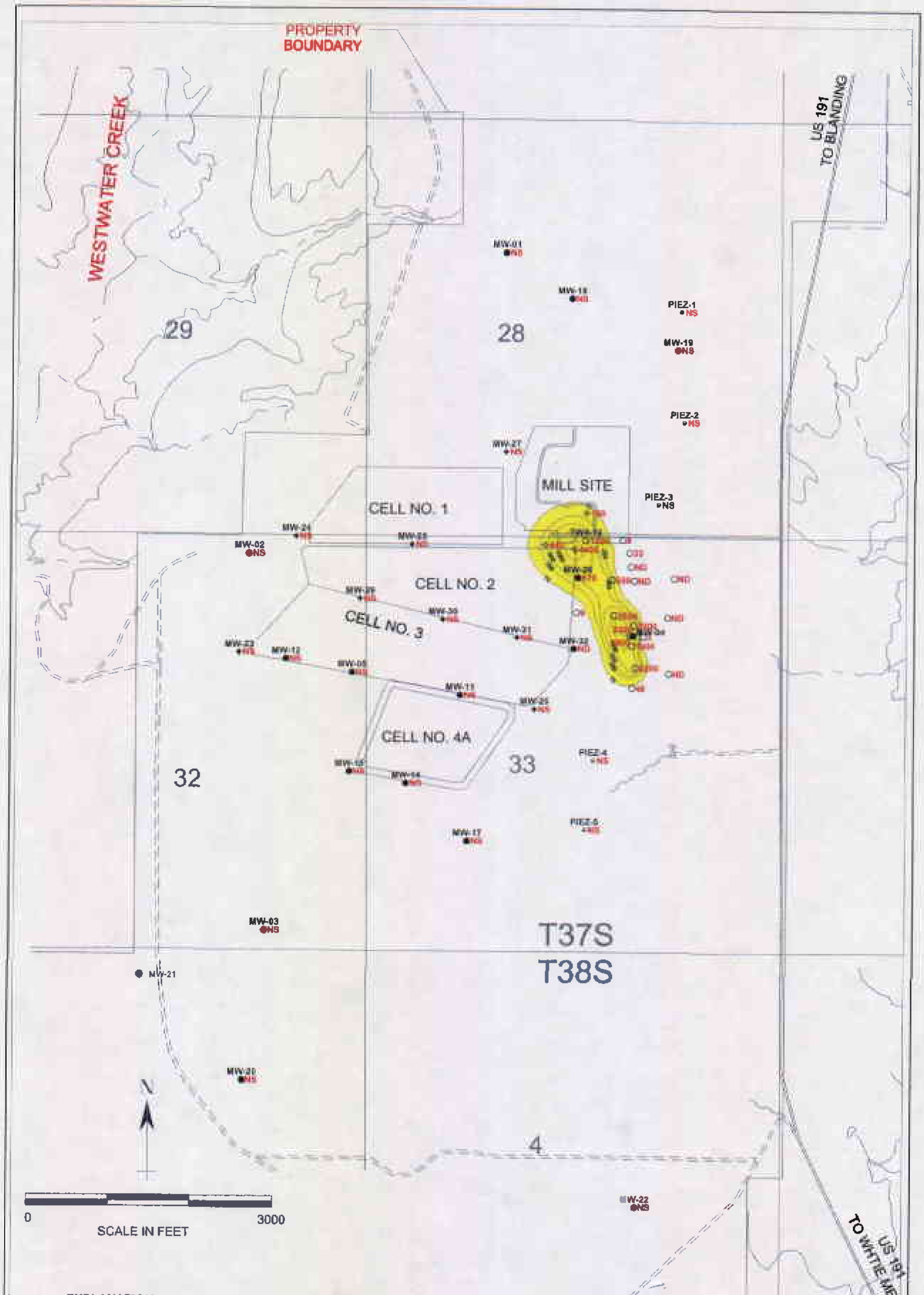
Notes:

cm/sec = Centimeters per second
ft/day = Feet per day
ft^2/day = Feet squared per day

FIGURES



SITE PLAN
AND PERCHED WELL LOCATIONS
WHITE MESA SITE



EXPLANATION

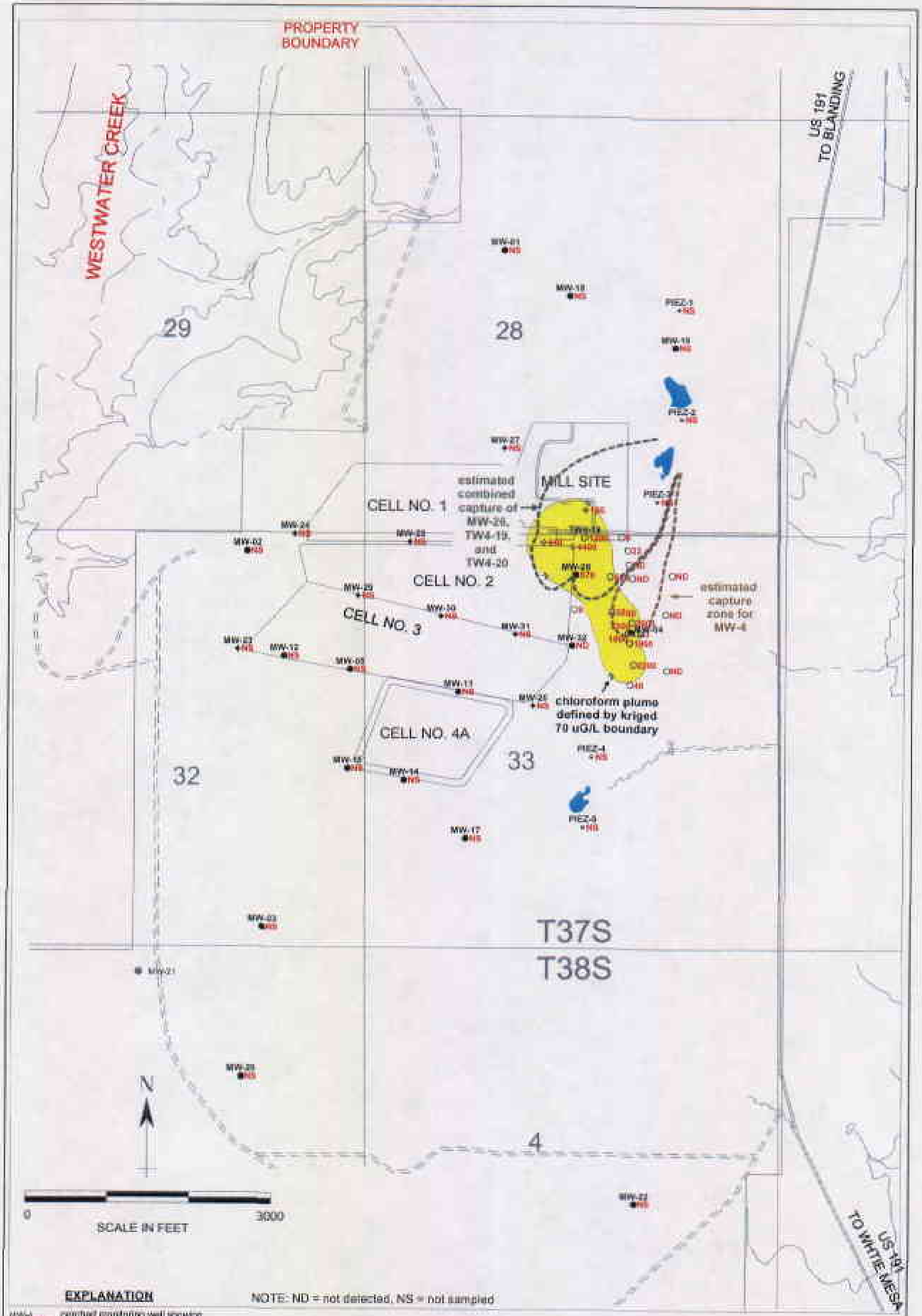
NOTE: ND = not detected, NS = not sampled

MW-4 ● 2300	perched monitoring well showing concentration in uG/l
○ 2200	temporary perched monitoring well showing concentration in uG/l
PIEZ-1 ● NS	perched piezometer (not sampled)
MW-32 ✦ ND	perched monitoring well installed April, 2005 showing concentration in uG/l
✧ 160	temporary perched monitoring well installed April, 2005 showing concentration in uG/l

HYDRO GEO CHEM, INC.

KRIGED 1st QUARTER 2007 CHLOROFORM (ug/L) WHITE MESA SITE

SJS	9/19/2007	H:/718000/71801/CIR/chl0307.srf	2



EXPLANATION

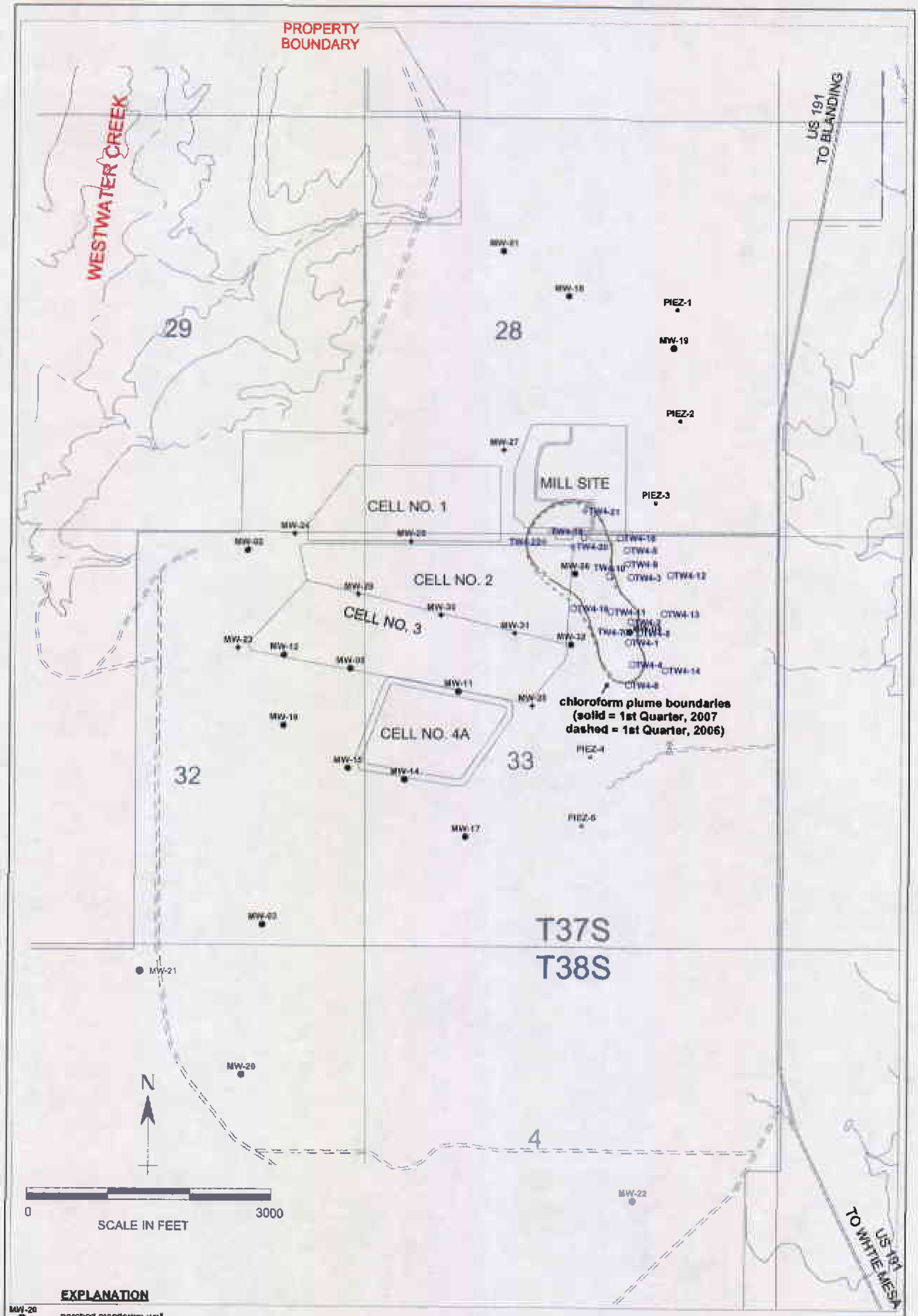
NOTE: ND = not detected, NS = not sampled

MW-4 ● 2300	perched monitoring well showing concentration in uG/l
○ 2200	temporary perched monitoring well showing concentration in uG/l
PIEZ-1 • NS	perched piezometer (not sampled)
MW-32 ◆ ND	perched monitoring well installed April, 2005 showing concentration in uG/l
✧ 100	temporary perched monitoring well installed April, 2005 showing concentration in uG/l

HYDRO GEO CHEM, INC.

1st QUARTER 2007 CHLOROFORM PLUME SHOWING ESTIMATED CAPTURE ZONES WHITE MESA SITE

APPROVED	DATE	REFERENCE	FIGURE
SJS	9/19/2007	H/718000/71801/CIR/chl0307cz.srf	3



EXPLANATION

MW-20 ●	perched monitoring well
TW4-19 ○	temporary perched monitoring well
PIEZ-1 •	perched piezometer
MW-31 ●	perched monitoring well installed April, 2005
TW4-20 ✧	temporary perched monitoring well installed April,2005

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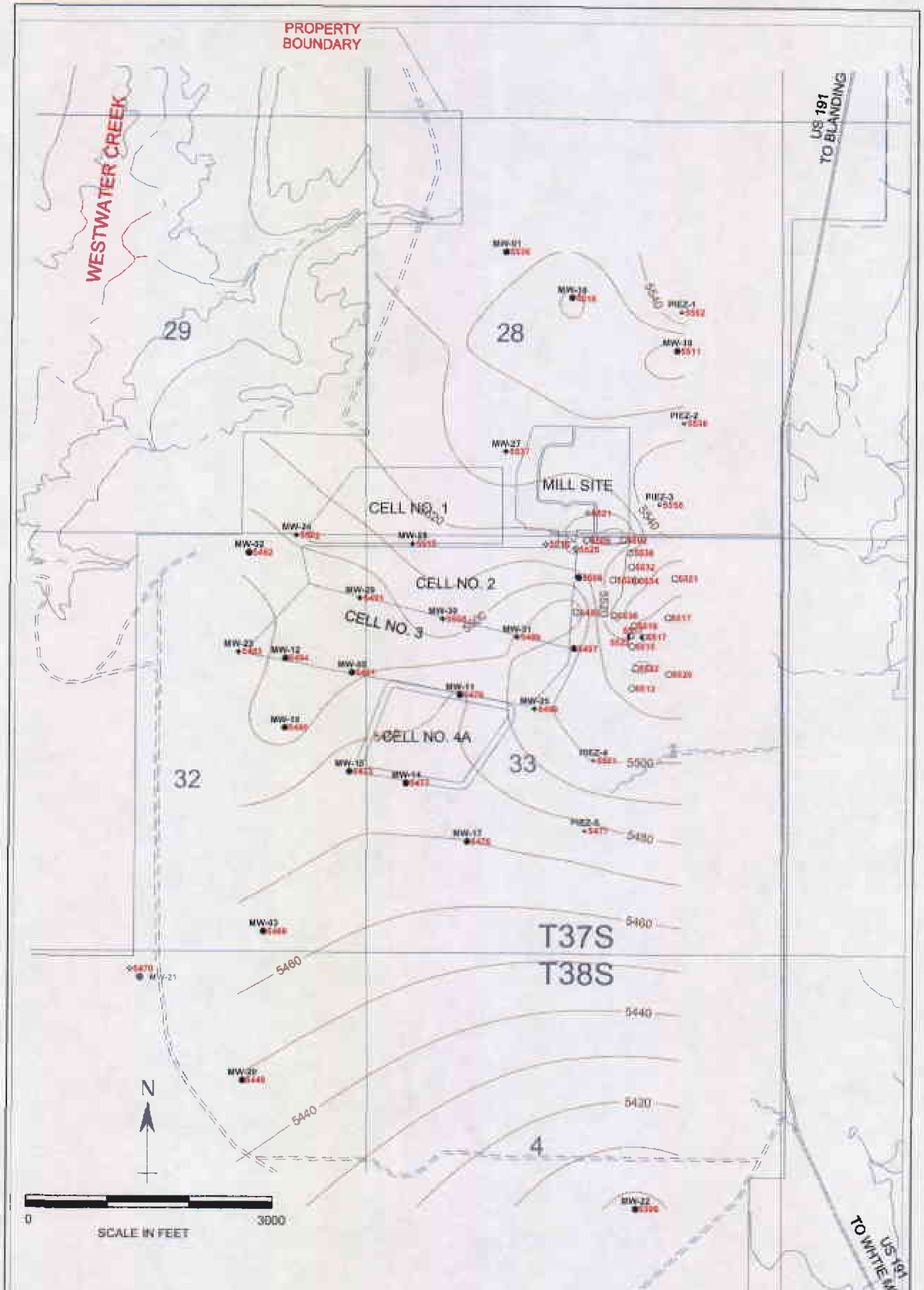
COMPARISON OF KRIGED 1st QUARTER 2007 AND 1st QUARTER 2006 CHLOROFORM PLUMES
WHITE MESA SITE

APPROVED	DATE	REFERENCE	FIGURE
SJS	9/19/2007	H:/718000/71801/ClR/chlcomp.srf	4



EXPLANATION

MW-20 ● 5449	perched monitoring well showing elevation in feet amsl
○ 5481	temporary perched monitoring well showing elevation in feet amsl
PIEZ-1 ● 5552	*perched piezometer showing* elevation in feet amsl
MW-31 ✦ 5489	perched monitoring well installed April,2005 showing elevation in feet amsl
✧ 5528	temporary perched monitoring well installed April,2005 showing elevation in feet amsl

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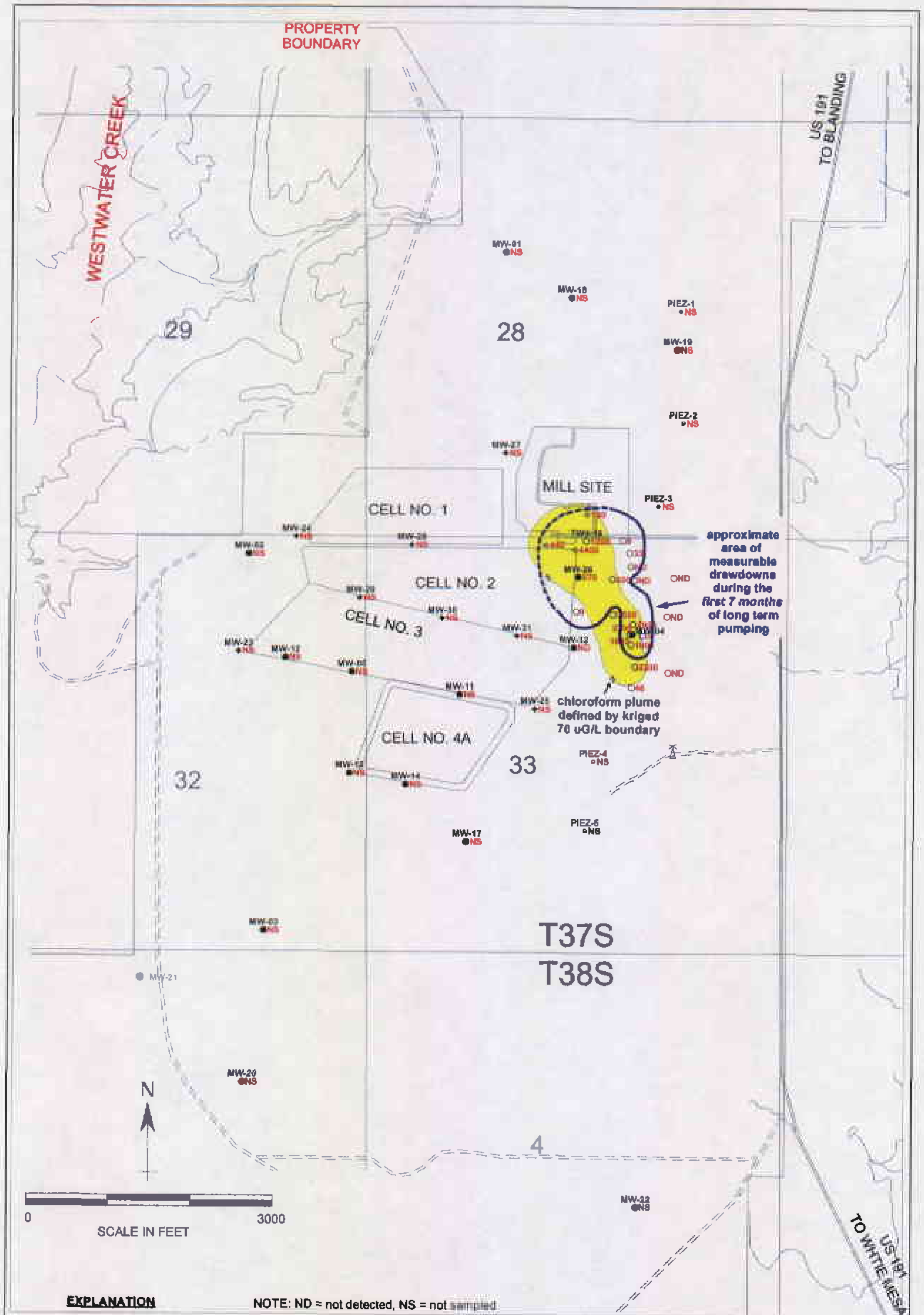
KRIGED BRUSHY BASIN CONTACT ELEVATIONS
WHITE MESA SITE

APPROVED	DATE	REFERENCE	FIGURE
SJS	9/19/2007	H:/718000/71801/CIR/bbel0705.srf	5



EXPLANATION

NOTE: ND = not detected, NS = not sampled

MW-4 ● 2300	perched monitoring well showing concentration in uG/l
○ 2200	temporary perched monitoring well showing concentration in uG/l
PIEZ-1 ● NS	perched piezometer (not sampled)
MW-32 ◆ ND	perched monitoring well installed April, 2005 showing concentration in uG/l
◇ 160	temporary perched monitoring well installed April, 2005 showing concentration in uG/l

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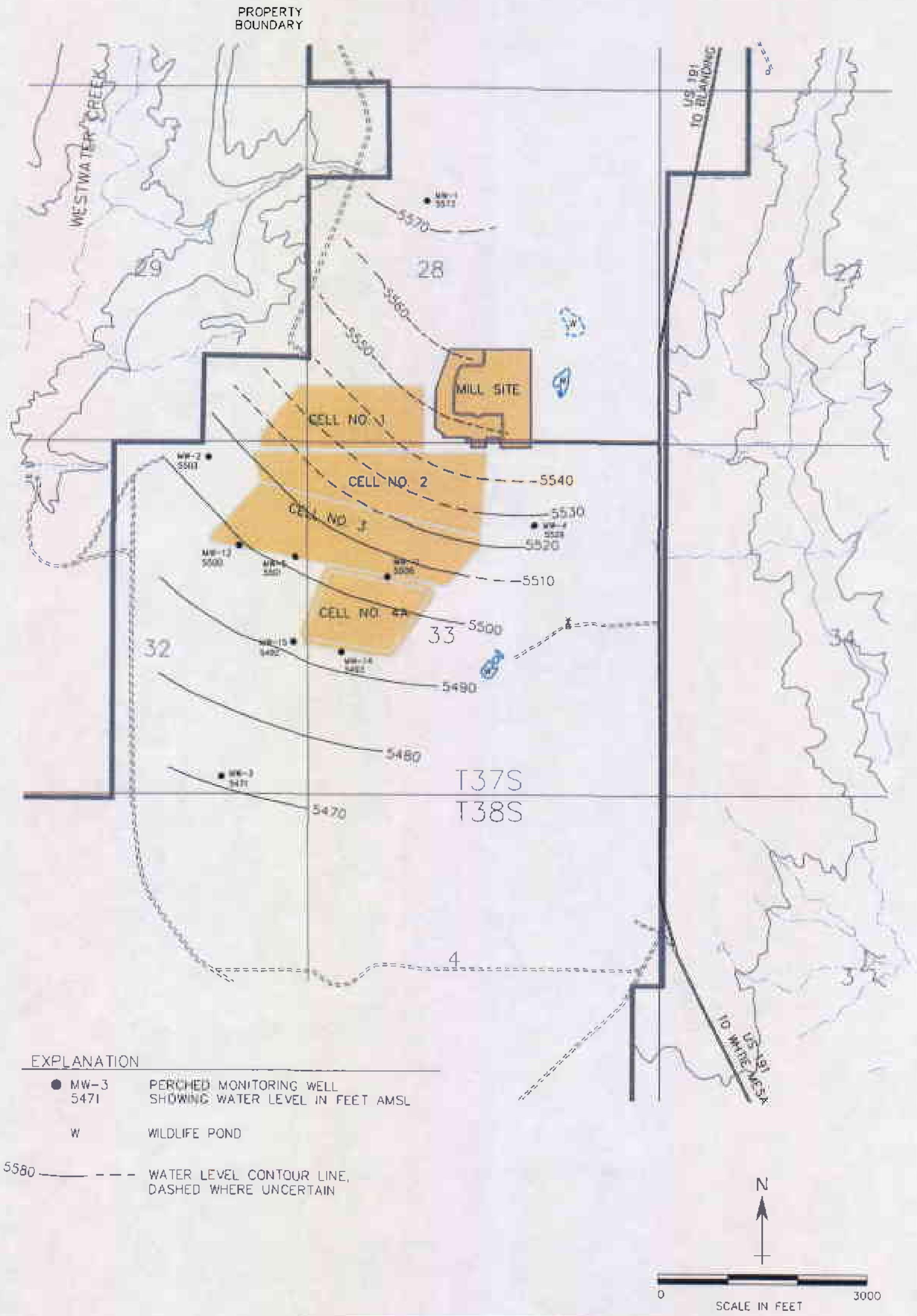
1st QUARTER 2007 CHLOROFORM PLUME SHOWING AREA RESPONDING TO THE FIRST 7 MONTHS OF LONG TERM PUMPING WHITE MESA SITE

SJS	9/19/2007	H:/718000/71801/CIR/chldwn.srf	6



EXPLANATION

● MW-3 5471 PERCHED MONITORING WELL SHOWING WATER LEVEL IN FEET AMSL

W WILDLIFE POND

5580 ——— - - - WATER LEVEL CONTOUR LINE, DASHED WHERE UNCERTAIN

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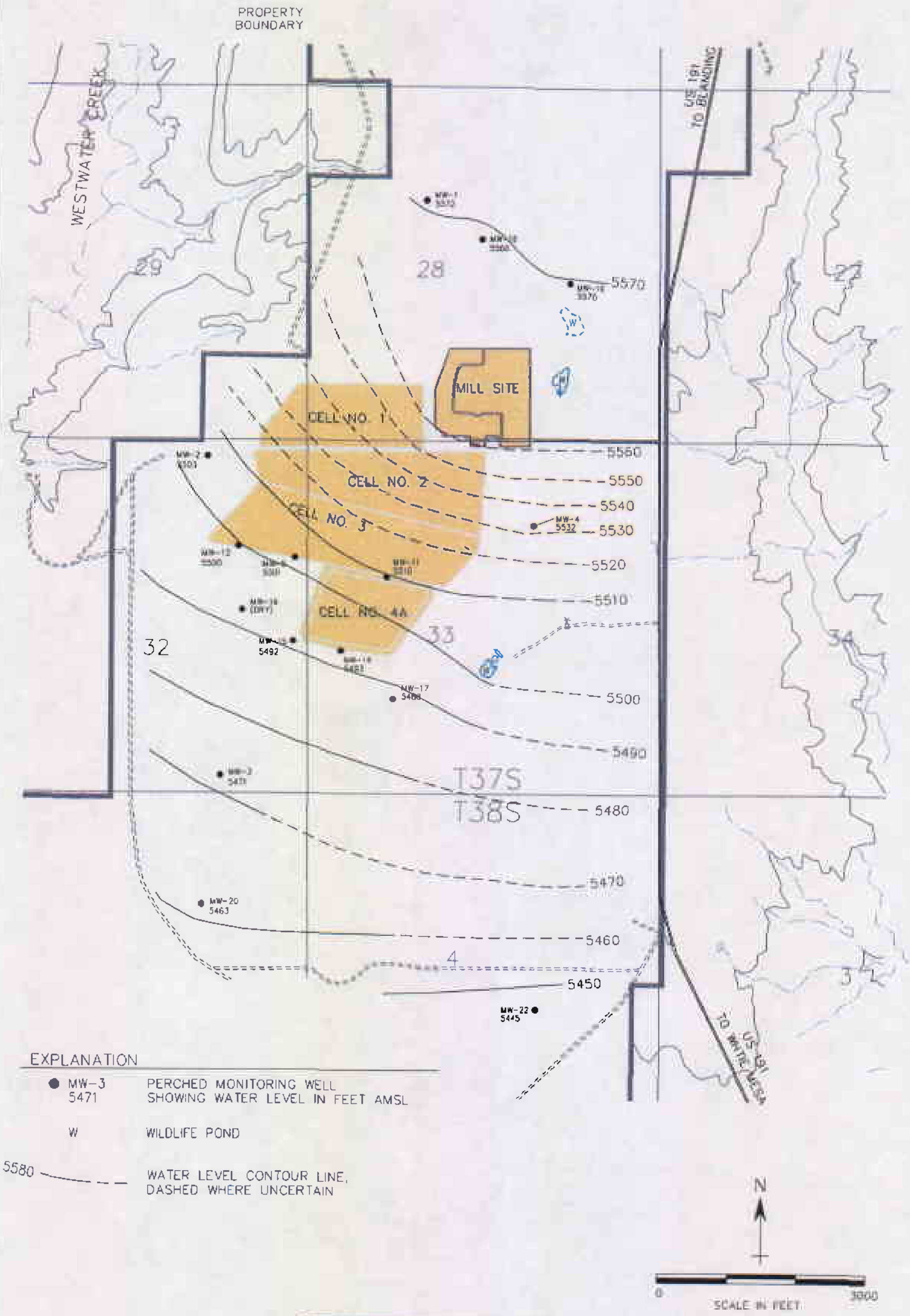
PERCHED WATER LEVELS
AUGUST 1990

Approved:	Date:	Author:	Date:	File Name:	Figure:
SS	06/22/07			71800096A	7



EXPLANATION

● MW-3 5471	PERCHED MONITORING WELL SHOWING WATER LEVEL IN FEET AMSL
W	WILDLIFE POND
5580 — —	WATER LEVEL CONTOUR LINE, DASHED WHERE UNCERTAIN

HYDRO
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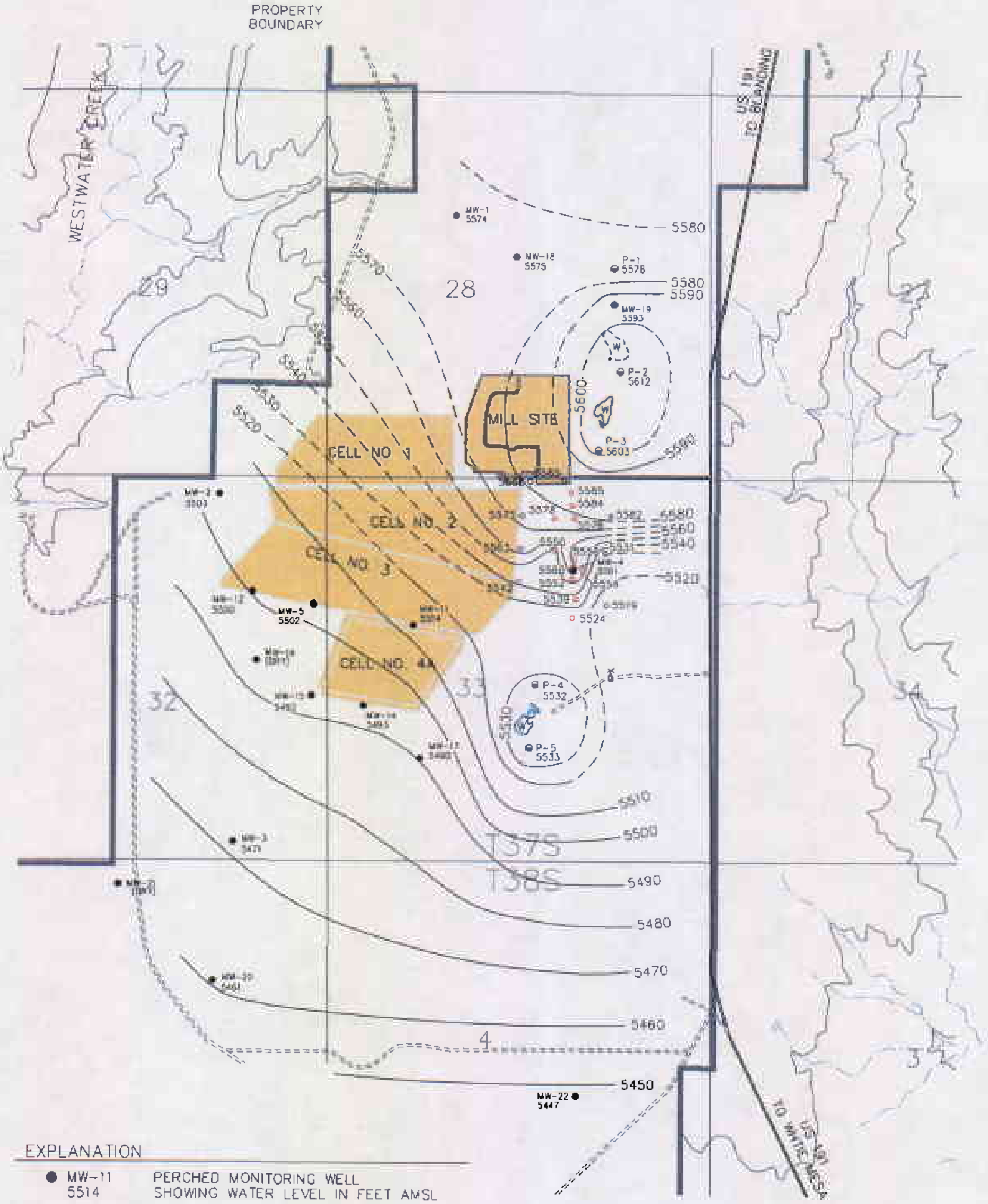
CHEM, INC.

PERCHED WATER LEVELS
AUGUST 1994

Approved	Date	Revised	Date	Reference	Figure
SS	01/30/03			71800097A	8



EXPLANATION

● MW-11 5514	PERCHED MONITORING WELL SHOWING WATER LEVEL IN FEET AMSL
○ 5524	TEMPORARY PERCHED MONITORING WELL SHOWING WATER LEVEL IN FEET AMSL
P-5 5533	PIEZOMETER SHOWING WATER LEVEL IN FEET AMSL
5580 ——— – – –	WATER LEVEL CONTOUR LINE, DASHED WHERE UNCERTAIN
W	WILDLIFE POND

NOTE: WATER LEVELS FOR PIEZOMETERS
ARE FROM AUGUST, 2002

HYDRO
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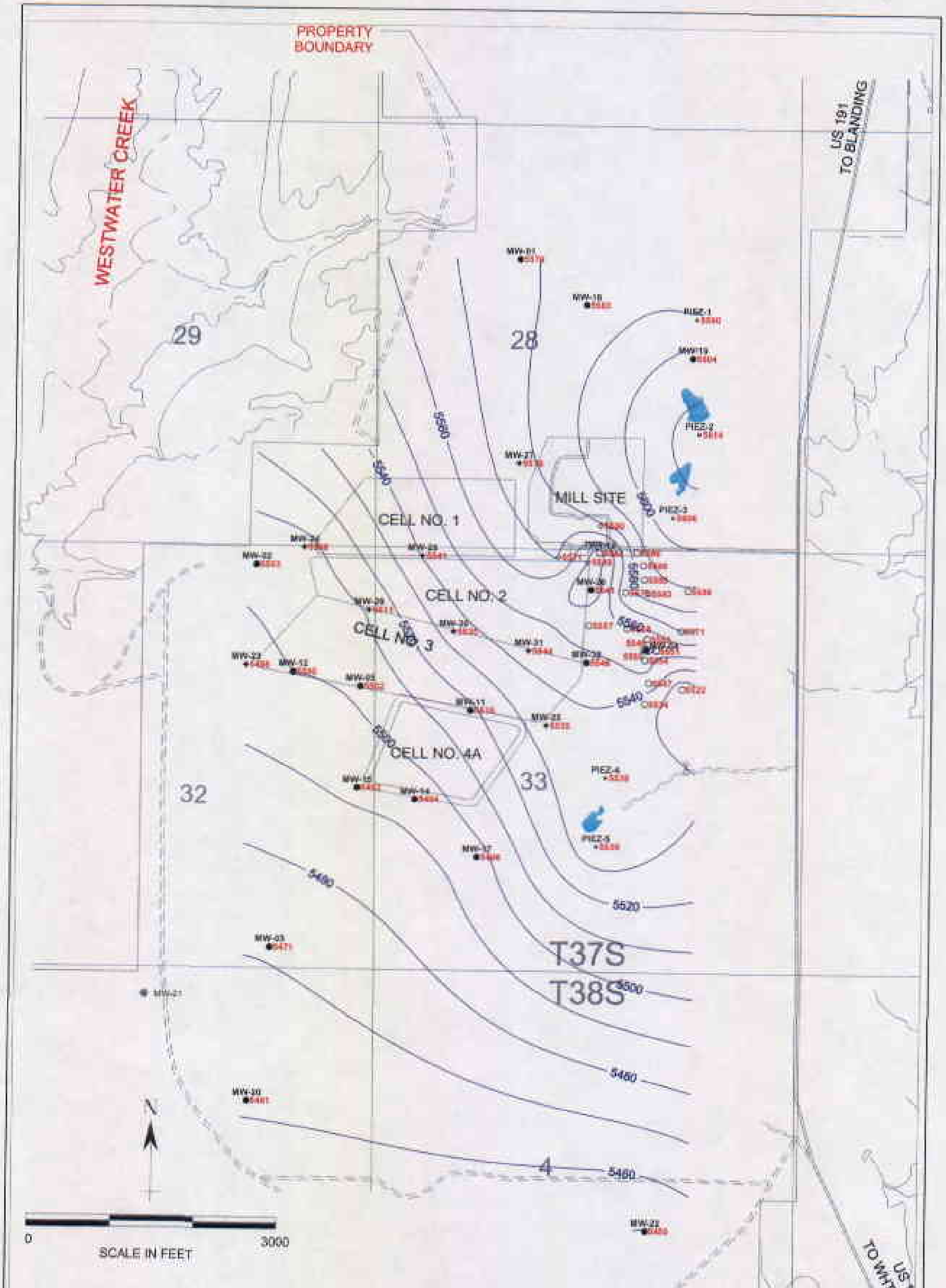
PERCHED WATER LEVELS
SEPTEMBER 2002

Approved	Date	Revised	Date	Reference	Figure
SS	06/22/07			71800098A	9



EXPLANATION

MW-20 ● 5461 perched monitoring well showing elevation in feet amsl

○ 5551 temporary perched monitoring well showing elevation in feet amsl

PIEZ-1 • 5590 perched piezometer showing elevation in feet amsl

MW-31 ◆ 5544 perched monitoring well installed April, 2005 showing elevation in feet amsl

⌖ 5571 temporary perched monitoring well installed April, 2005 showing elevation in feet amsl

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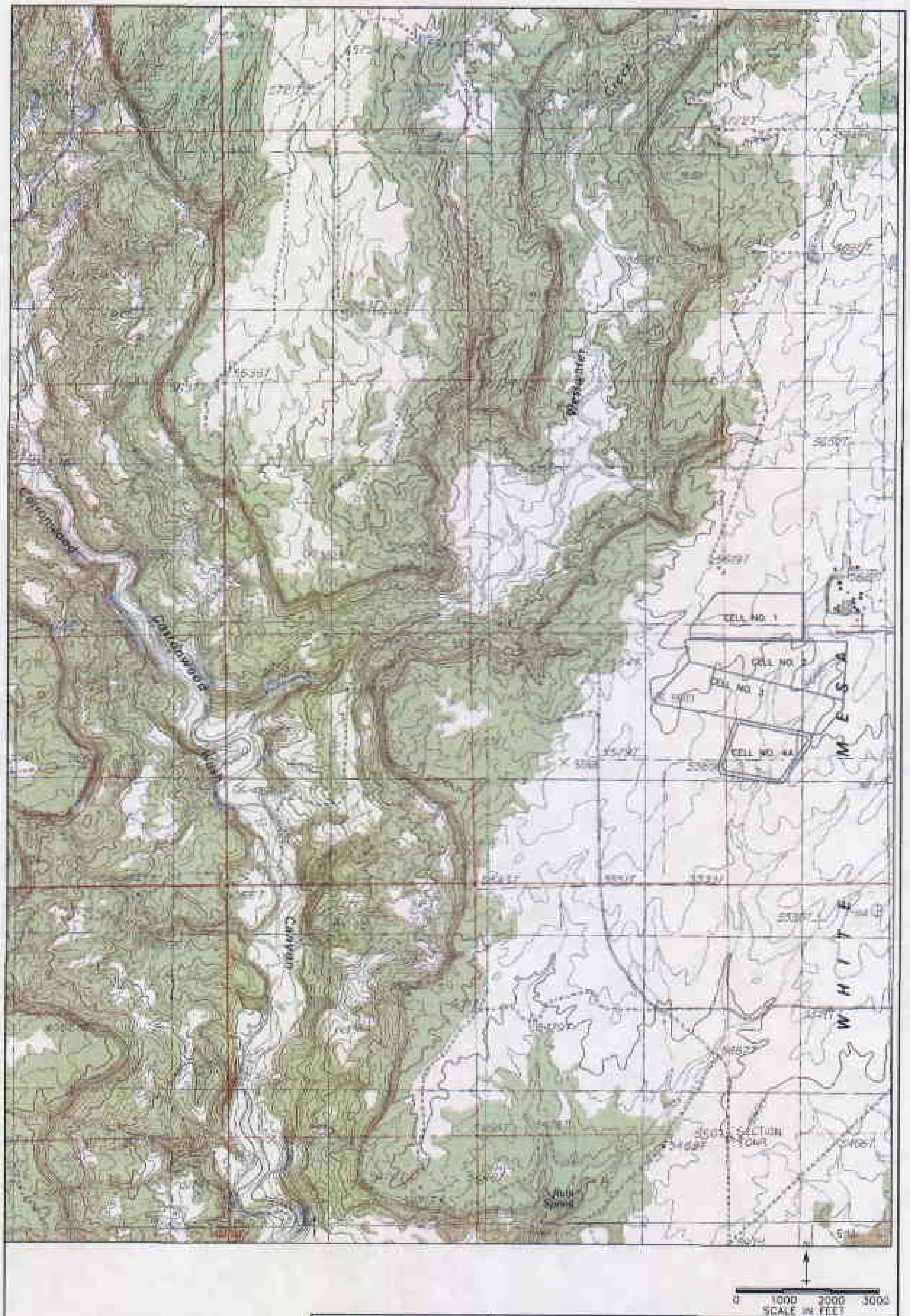
KRIGED 1st QUARTER 2007 WATER LEVELS
WHITE MESA SITE

APPROVED	DATE	REFERENCE	FIGURE
SJS	9/19/2007	H:/718000/71801/CIR/wl0307.srf	10



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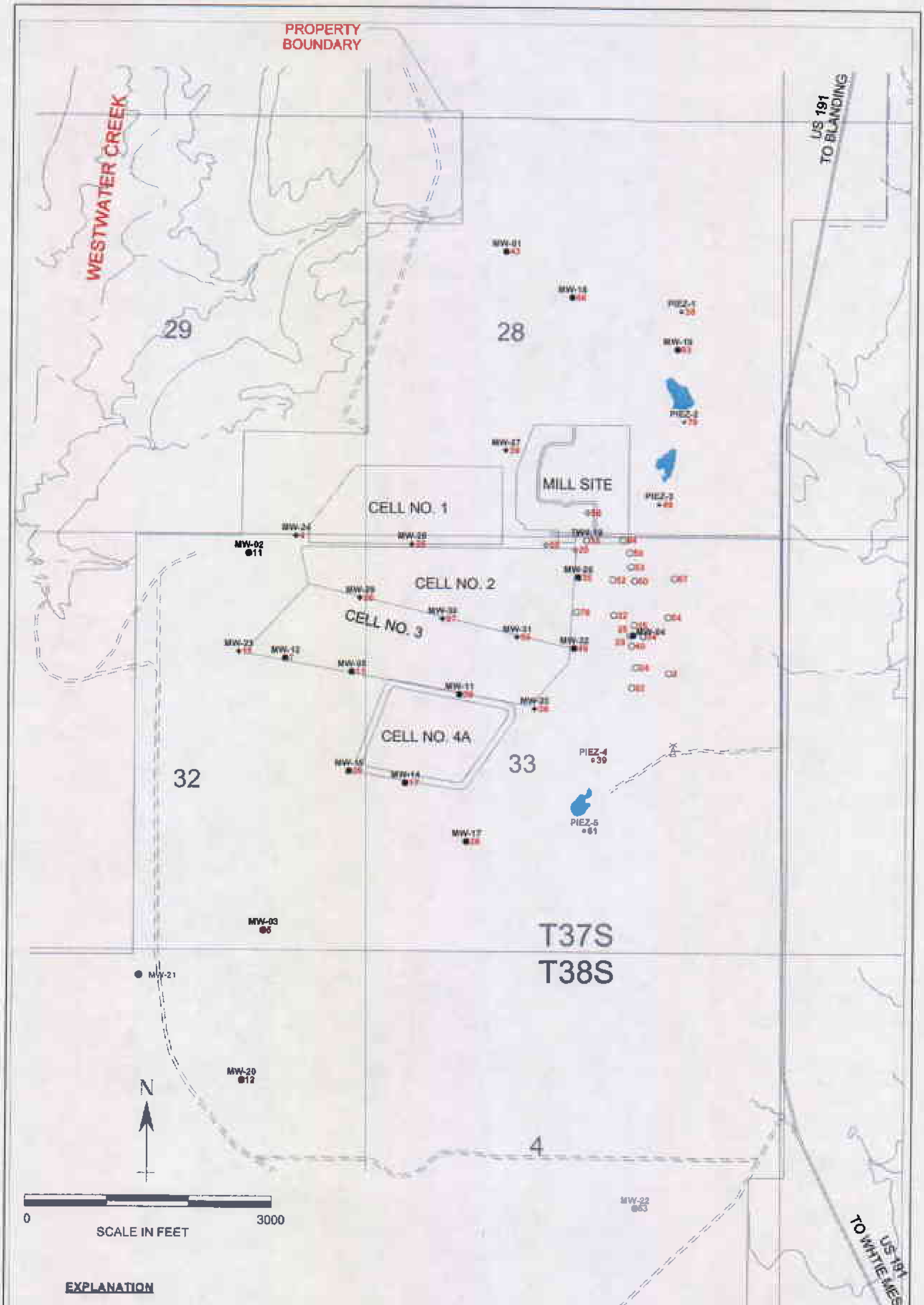
PORTION OF USGS BLACK MESA 7.5' SHEET SHOWING APPROXIMATE LOCATION OF TAILING CELLS IN RELATION TO NEARBY CANYONS AND RUIN SPRING

Approved	Date	Revised	Date	Reference:	Figure:
SS	06/22/07			71800099A	11



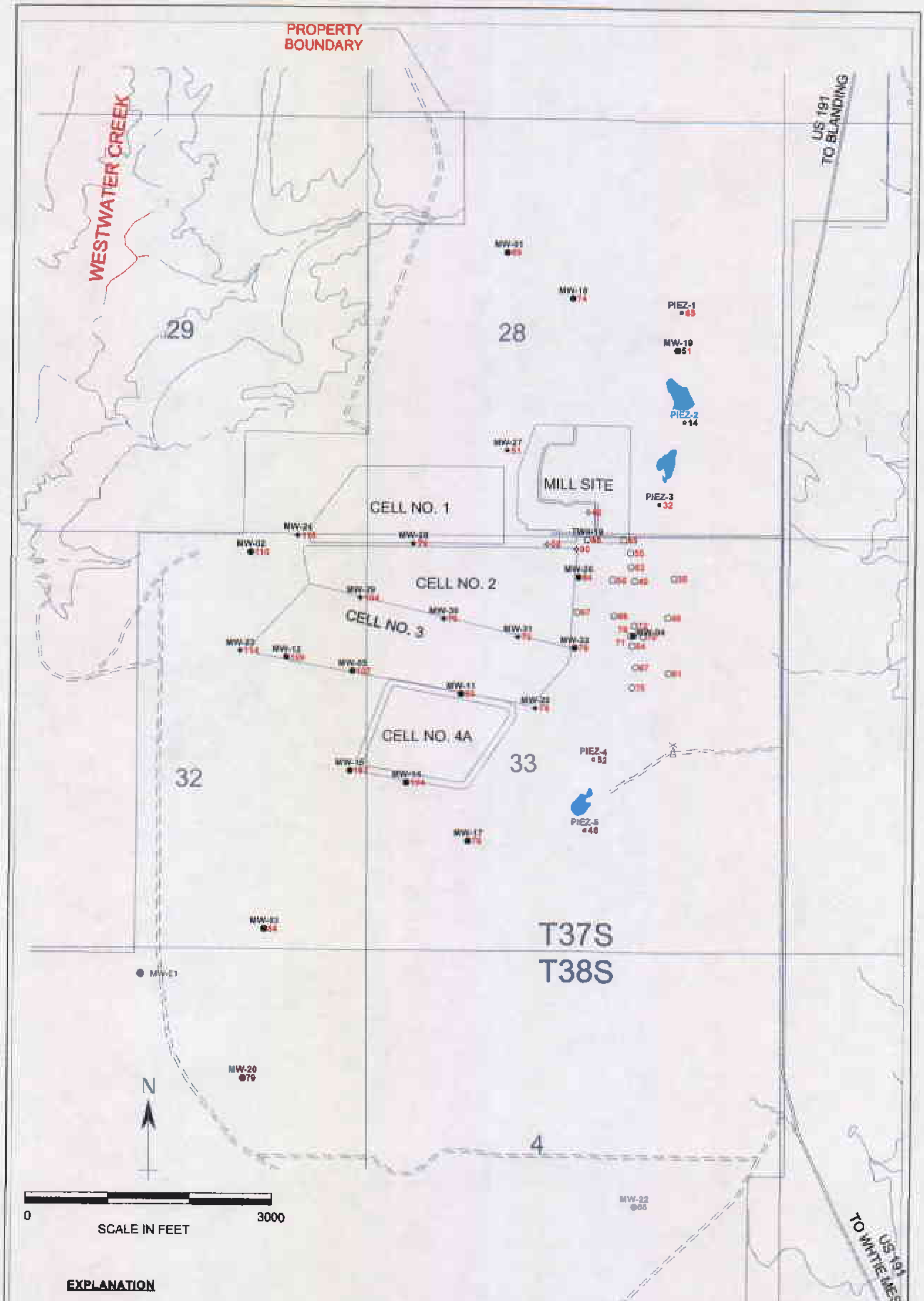
EXPLANATION

MW-20 ● 12	perched monitoring well showing saturated thickness in feet
○ 22	temporary perched monitoring well showing saturated thickness in feet
PIEZ-1 ● 38	perched piezometer showing saturated thickness in feet
MW-31 ✦ 55	perched monitoring well installed April, 2005 showing saturated thickness in feet
✧ 55	temporary perched monitoring well installed April, 2005 saturated thickness in feet

HYDRO GEO CHEM, INC.

PERCHED ZONE SATURATED THICKNESS
1st QUARTER 2007
WHITE MESA SITE

APPROVED	DATE	REFERENCE	FIGURE
SJS	9/19/2007	H:/718000/71802/CIR/satthck07.srf	12



EXPLANATION

MW-20 ● 79	perched monitoring well showing depth to water in feet
○ 75	temporary perched monitoring well showing depth to water in feet
PIEZ-1 ● 65	perched piezometer showing depth to water in feet
MW-31 ✦ 72	perched monitoring well installed April, 2005 showing depth to water in feet
✧ 58	temporary perched monitoring well installed April, 2005 showing depth to water in feet

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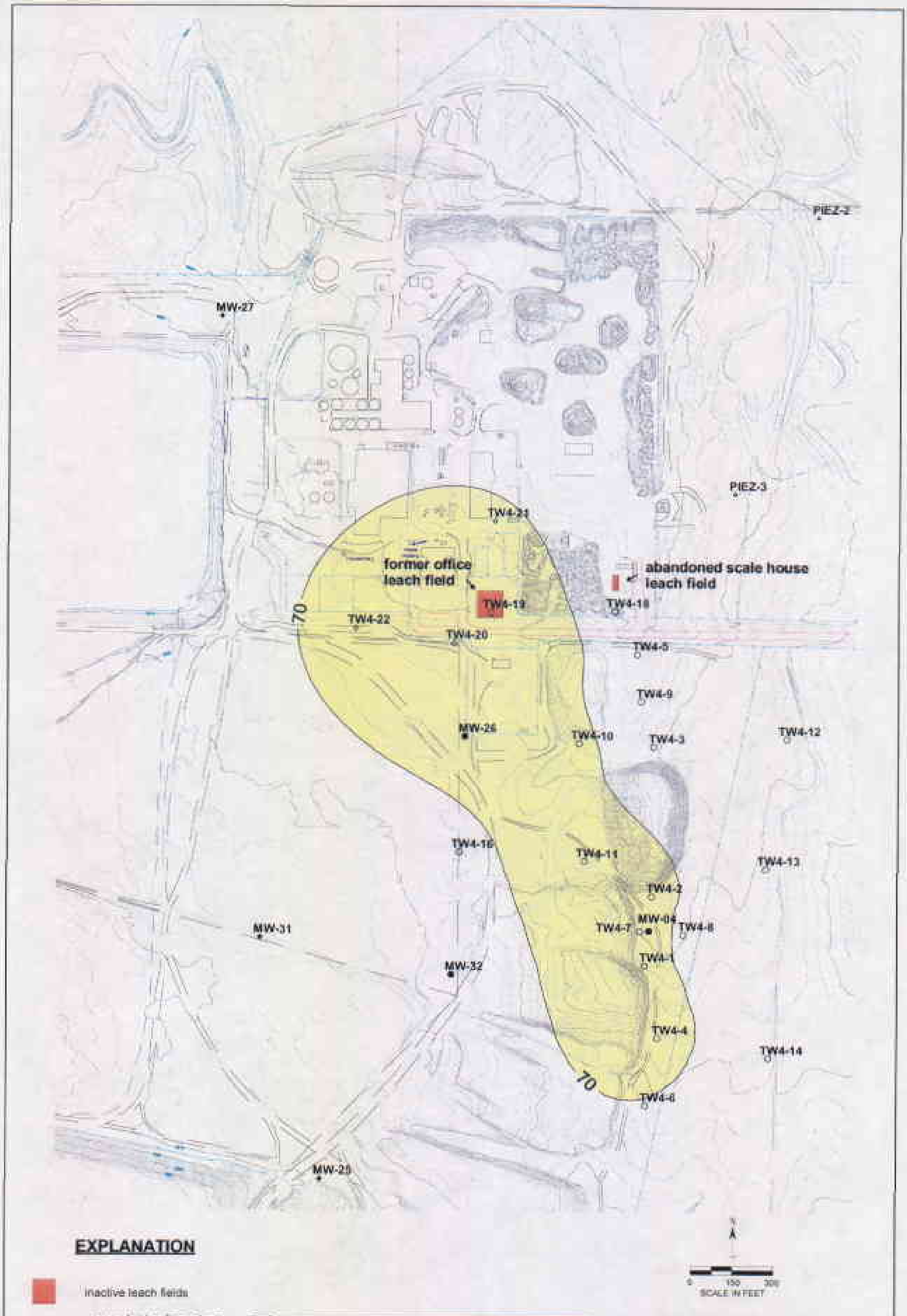
DEPTH TO PERCHED WATER
1st QUARTER 2007
WHITE MESA SITE

APPROVED	DATE	REFERENCE	FIGURE
SJS	9/19/2007	H:/718000/71801/CIR/dtw0307.srf	13



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LOCATIONS OF ABANDONED SCALE HOUSE AND FORMER OFFICE LEACH FIELDS IN RELATION TO 1st QUARTER 2007 CHLOROFORM PLUME
(detail map of northeastern portion of White Mesa Site)

APPROVED	DATE	REFERENCE	FIGURE
SJS	9/19/2007	H:/718000/71801/CIR/leach.srf	14

APPENDIX A

CHLOROFORM MSDS

Material Safety Data Sheet

1. Product and Company Identification

Product name : **Chloroform**

Chemical formula : C-H-Cl3

Synonyms : Trichloromethane; Methane Trichloride; R 20; Freon 20; Methyl Trichloride; Trichloroform; R 20 (Refrigerant); Methenyl Trichloride

Company : Specialty Gases of America, Inc
6055 Brent Dr.
Toledo, OH 43611

Telephone : 419-729-7732

Emergency : 800-424-9300

2. Composition/Information on Ingredients

Components	CAS Number	% Volume
Chloroform	67-66-3	> 99%
Stabilizers		< 0.1%

3. Hazards Identification

Emergency Overview

May cause respiratory tract irritation, skin irritation, eye irritation, liver damage, central nervous system depression, kidney damage, suspect cancer hazard (in animals).

Potential Health Effects

Inhalation	: Irritation, changes in blood pressure, nausea, vomiting, difficulty breathing, irregular heartbeat, headache, drowsiness, dizziness, disorientation, hyperactivity, loss of coordination, dilated pupils, blood disorders, heart damage, kidney damage, liver damage, convulsions, unconsciousness, coma.
Eye contact	: Irritation, visual disturbances.
Skin contact	: Irritation, changes in blood pressure, nausea, vomiting, difficulty breathing, irregular heartbeat, headache, drowsiness, dizziness, disorientation, hyperactivity, loss of coordination, dilated pupils, blood disorders, heart damage, kidney damage, liver damage, convulsions, unconsciousness, coma.
Ingestion	: Irritation, changes in blood pressure, nausea, vomiting, diarrhea, stomach pain, chest pain, difficulty breathing, muscle cramps, dilated pupils, bluish skin color, kidney damage, liver damage, unconsciousness.
Chronic Health Hazard	: None.

4. First Aid Measures

General advice	: None.
Eye contact	: Flush eyes with plenty of water for at least 15 minutes. Then get immediate medical attention.

Skin contact	: Wash skin with soap and water for at least 15 minutes while removing contaminated clothing and shoes. Get medical attention, if needed. Thoroughly clean and dry contaminated clothing and shoes before reuse.
Ingestion	: For ingestion, consider gastric lavage. Consider oxygen. Avoid epinephrine. Get medical attention immediately.
Inhalation	: If adverse effects occur, remove to uncontaminated area. Give artificial respiration if not breathing. If breathing is difficult, oxygen should be administered by qualified personnel. Get immediate medical attention.

5. Fire-Fighting Measures

Suitable extinguishing media	: Regular dry chemical, regular foam, water. Large fires: Use regular foam or flood with fine water spray.
Specific hazards	: Negligible fire hazard.
Fire fighting	: Move container from fire area if it can be done without risk. Fight large fires from a protected location or safe distance. Stay away from the ends of tanks. Dike for later disposal. Do not scatter spilled material with high-pressure water streams.

6. Accidental Release Measures

Personal precautions	: None.
Environmental precautions	: Soil release – Trap spilled material at bottom in deep water pockets, excavated holding areas or within sand bag barriers. Dike for later disposal. Absorb with sand or other non-combustible materials. Collect with absorbent into suitable container. Water release – Trap spilled material at bottom in deep water pockets, excavated holding areas or within sand bag barriers. Remove trapped material with suction hoses. Collect spilled material using mechanical equipment. Subject to California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65). Keep out of water supplies and sewers.
Methods for cleaning up	: Do not touch spilled material. Stop leak if possible without personal risk. Reduce vapors with water spray. Small spills: Absorb with sand or other non-combustible material. Collect spilled material in appropriate container for disposal. Small dry spills: Move containers away from spill to a safe area. Large spills: Dike for later disposal. Keep unnecessary people away. Isolate hazard area and deny entry. Ventilate closed spaces before entering. Notify Local Emergency Planning Committee and State Emergency Response Commission for release greater than or equal to RQ (U.S. SARA Section 304). If release occurs in the U.S. and is reportable under CERCLA Section 103, notify the National Response Center at (800) 424-8802 (USA) or (202) 426-2675 (USA).
Additional advice	: None.

7. Handling and Storage

Handling

Secure cylinder when using to protect from falling. Use suitable hand truck to move cylinders.

Storage

Store in accordance with all current regulations and standards. Notify State Emergency Response Commission for storage or use at amounts greater than or equal to TPQ (U.S. EPA SARA Section 302). SARA Section 303 requires facilities storing a material with a TPQ to participate in local emergency response planning (U.S. EPA 40 CFR 355.30). Store in a cool, dry place. Store in a well-ventilated area. Keep separated from incompatible substances.

8. Exposure Controls / Personal Protection

Exposure limits

50 ppm (240 mg/m3) OSHA ceiling
2 ppm (9.78 mg/m3) OSHA TWA (vacated by 58 FR 35338, June 30, 1993)
10 ppm ACGIH TWA
2 ppm (9.78 mg/m3) NIOSH recommended STEL 60 minute(s)

Engineering measures

Provide local exhaust or process enclosure ventilation system. Ensure compliance with applicable exposure limits.

Personal protective equipment

Respiratory protection	:	The following respirators and maximum use concentrations are drawn from NIOSH and/or OSHA. At any detectable concentration – Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode. Any supplied-air respirator with a full facepiece and operated in a pressure-demand or other positive-pressure mode in combination with a separate escape supply. Escape – Any air-purifying respirator with a full facepiece and an organic vapor canister. Any appropriate escape-type, self-contained breathing apparatus. For unknown concentrations or immediately dangerous to life or health – Any supplied-air respirator with full facepiece and operated in a pressure-demand or other positive-pressure mode in combination with a separate escape supply. Any self-contained breathing apparatus with a full facepiece.
Hand protection	:	Wear appropriate chemical resistant gloves.
Eye protection	:	Wear splash resistant safety goggles. Provide an emergency eye wash fountain and quick drench shower in the immediate work area.
Skin and body protection	:	Wear appropriate chemical resistant clothing.

9. Physical and Chemical Properties

Form	:	Liquid.
Color	:	Colorless.
Odor	:	Sweet odor and taste.
Molecular weight	:	119.38
Vapor pressure	:	160 mmHg @ 20 C
Vapor density	:	4.12 (air = 1)
Specific gravity	:	1.4832 (water = 1)
Boiling point	:	144 F (62 C)
Freezing point	:	-83 F (-64 C)
Water solubility	:	0.82% @ 20 C

10. Stability and Reactivity

Stability	:	Stable at normal temperatures and pressure.
Conditions to avoid	:	Avoid heat, flames, sparks and other sources of ignition. Containers may rupture or explode if exposed to heat.
Materials to avoid	:	Metals, combustible materials, oxidizing materials, halogens, bases.
Hazardous decomposition products	:	Thermal decomposition products: oxides of chlorine, carbon, phosgene, chlorine and halides.

11. Toxicological Information

Toxicity data : 6000 mg/m3/6 hour(s) inhalation-rat LC50; > 20 gm/kg skin-rabbit LD50; 695 mg/kg oral-rat LD50

Irritation data : 10 mg/24 hour(s) open skin-rabbit mild; 500 mg/24 hour(s) skin-rabbit mild; 148 mg eyes-rabbit; 20 mg/24 hour(s) eyes-rabbit moderate

Carcinogen status : NTP: Anticipated Human Carcinogen; IARC: Human Inadequate Evidence, Animal Sufficient Evidence, Group 2B; ACGIH: A3 – Animal Carcinogen

Acute Health Hazard

Ingestion : Moderately toxic.

Inhalation : Moderately toxic.

Skin : Not available.

12. Ecological Information

Ecotoxicity Data

Fish toxicity : 66800 ug/L 96 hour(s) LC50 (mortality) Rainbow trout, Donaldson trout (Oncorhynchus mykiss)

Invertebrate toxicity : 32000 ug/L 96 hour(s) NOEC (mortality) Pink shrimp (America) (Penaeus duorarum)

Algal toxicity : > 32000 ug/L 48 hour(s) (Population Growth) Cryptomonad (Chilomonas paramecium)

Other toxicity : 270 ug/L 7 hour(s) EC50 (Teratogenesis) Spring peeper (Hyla crucifer)

Fate and Transport

Bioconcentration : 690 Ci/mol 6 hour(s) BCF (Residue) Green algae (Selenastrum capricornutum) 13.9 Ci/mol

13. Disposal Considerations

Waste from residues / unused products : Subject to disposal regulations: U.S. EPA 40 CFR 262. Hazardous Waste Number(s): U044. Hazardous Waste Number(s): D022. Dispose of in accordance with U.S. EPA 40 CFR 262 for concentrations at or above the Regulatory level- 6.0 mg/L.

Contaminated packaging : Return cylinder to supplier.

14. Transport Information

DOT (US only)

Proper shipping name : Chloroform

Class : 6.1, Packing Group III

UN/ID No. : UN1888

Labeling : Poisonous

Further information

Cylinders should be transported in a secure upright position in a well ventilated truck.

15. Regulatory Information

OSHA Process Safety (29 CFR 1910.119) Hazard Class(es)

Not regulated.

TCSA

Material is listed in TSCA inventory.

SARA Title III Section 302 Extremely Hazardous Substances (40 CFR 355.30)
10,000 LBS TPQ

SARA Title III Section 304 Extremely Hazardous Substances (40 CFR 355.40)
10 LBS RQ

SARA Title III SARA Sections 311/312 Hazardous Categories (40 CFR 370.21)
Acute: Yes
Chronic: Yes
Fire: No
Reactive: No
Sudden Release: No

SARA Title III Section 313 (40 CFR 372.65)
Chloroform.

16. Other Information

Prepared by : Specialty Gases of America, Inc.
For additional information, please visit our website at www.americangasgroup.com.

APPENDIX B

CHLOROFORM MASS REMOVAL VIA NATURAL IN-SITU DEGRADATION

CHLOROFORM MASS REMOVAL VIA NATURAL IN-SITU DEGRADATION

In-situ breakdown of chloroform via biologically mediated and abiotic means is expected to occur within the perched zone chloroform plume at the White Mesa site. The possible degradation mechanisms include:

- reductive dechlorination (abiotic degradation)
- anaerobic reductive dechlorination (anaerobic biodegradation)
- cometabolic processes (aerobic biodegradation)

Reductive dechlorination of chloroform involves successive replacement of chloroform atoms by hydrogen. This process occurs relatively rapidly under anaerobic conditions in the presence of naturally occurring anaerobic bacteria, but can also occur, albeit slowly, without the aid of bacteria.

Degradation of chloroform can also occur under aerobic conditions by cometabolic processes. Cometabolism involves incidental biodegradation of one compound while another compound is used as a food source by the naturally occurring bacteria. Within the perched zone, naturally occurring organic carbon might be used as such a food source, allowing chloroform to be cometabolized.

Based on rates provided in HydroGeoLogic, 1999, anaerobic reductive dechlorination could reduce detected concentrations by more than three orders of magnitude within a few years, provided conditions were favorable. However, this mechanism is likely to be minimal, because the nitrate associated with the chloroform plume at the site indicates that the perched zone is aerobic. Nitrate would not be persistent under anaerobic conditions and would be expected to degrade relatively rapidly.

Abiotic reductive dechlorination is likely to be quite slow based on studies by Jeffers, et al, 1989, and Mabey and Mill, 1978, with expected half lives for chloroform of 1850 to 3650 years at neutral pH. Degradation would be more rapid at higher pH, with expected half lives of 25 to 37 years at pH 9. However, perched water at the site is generally near neutral, so the lower rates (higher half lives) would be likely for the perched zone.

Cometabolic degradation can occur relatively rapidly if sufficient organic carbon is present in the perched zone that could serve as a food source for an indigenous methanotrophic population. Under ideal conditions, this process would be expected to proceed at rates higher than anaerobic rates. However, in natural groundwater, this mechanism is not expected to be dominant.

One method of estimating the actual degradation rates of chloroform is to look for the daughter products of reductive dechlorination, methylene chloride (DCM) and chloromethane (CM). Both have been detected at the site in low concentrations (typically a few μg/L). Chloroform degrades via reductive dechlorination to DCM, then CM. DCM is commonly used in analytical laboratories and its detection in some cases may have resulted from laboratory contamination. However, assuming that detections are representative of site conditions, chloroform degradation rates can be estimated by assuming the following:

- the detected DCM is a degradation product of chloroform,
- the rate of DCM depletion is fast compared to chloroform (because, unlike chloroform, DCM can degrade relatively rapidly under aerobic conditions), and
- the concentrations of detected DCM are in pseudo steady state.

The last assumption implies that the DCM degrades about as fast as it is produced. A range of zero order aerobic degradation rate constants for DCM are provided in Aronson, et al, 1999. These range from 0.0036/day to 0.533/day, with a recommended rate of 0.0546/day. These rates are relatively large and imply fast rates of DCM degradation under aerobic conditions. The rates imply that degradation of DCM would be much faster (by orders of magnitude) than would be expected for chloroform which is expected to degrade very slowly under aerobic conditions.

DCM was detected in perched zone wells TW4-11, TW4-15, TW4-16, and TW4-20 in the first quarter of 2007 at concentrations ranging from 1.1 to 6.5 µg/L, and the same four wells in the fourth quarter of 2006, at concentrations ranging from 1.3 to 9.2 µg/L. Because DCM was detected in the same four wells during both quarters, these detections are likely representative of site conditions, and not random laboratory analytical error. Furthermore, the similarity in DCM concentrations over the two quarters suggests a pseudo steady state condition. The average DCM concentration at these four wells over the two quarters is 3.8 µg/L.

The amount of chloroform degradation implied by these DCM concentrations can be estimated by using the expected rate of DCM degradation (0.0546/day) and assuming, on a molar basis, that the amount of chloroform degraded is equal to the amount of DCM degraded. The expected amount of DCM degraded per day can be calculated using the following first order rate equation:

$$\ell n \frac{C}{C_0} = -k\Delta t$$

Where:

C = the observed concentration
C_0 = the concentration at time zero (initial concentration)
k = the rate constant (1/day)
Δt = the elapsed time (days)

Assuming that $\Delta t = 1$ day, $C_0 = 3.8$ µg/L, k = 0.0546/day, and solving for C, C = 3.60 µg/L

The implied change in DCM concentration per day is 3.8 µg/L - 3.6 µg/L, or 0.20 µg/L. On a molar basis, this implies that 0.28 µg/L chloroform was degraded to replace the 0.20 µg/L DCM that was degraded in the same day.

During the first quarter of 2007 and the third quarter of 2006, the chloroform concentrations at TW4-11, TW4-15, and TW4-16 ranged from 9 µg/L to 11,000 µg/L and averaged 2929 µg/L. A reduction of between one and two orders of magnitude would be needed to bring these chloroform concentrations to the action level of 70 µg/L. To calculate the rate of chloroform degradation implied by the daily amount of 0.28 µg/L chloroform degraded as calculated above, the same first order rate equation can be used:

$$\ell n \frac{C}{C_0} = -k\Delta t$$

Using 2929 μg/L for C_0, assuming C = 2929 – 0.28 = 2928.72 μg/L, rearranging and solving for k, k = -0.00010/day. This rate is more than an order of magnitude lower than the lowest anaerobic rate of -0.004/day reported for chloroform in HydroGeoLogic, 1999.

The calculated chloroform degradation rate of -0.00010/day can then be used in the first order rate equation after solving for Δt to calculate the time needed to reduce chloroform concentrations by one and two orders of magnitude ($C/C_0 = 0.1$, and $C/C_0 = 0.01$, respectively). By rearranging and solving for Δt,

$$\Delta t = \frac{\ell n(0.1)}{-0.00010/day}$$ = 23,025 days or 63 years for a one order of magnitude reduction,

And

$$\Delta t = \frac{\ell n(0.01)}{-0.00010/day}$$ = 46,052 days or 126 years for a two orders of magnitude reduction.

To reduce the highest concentration ever detected at the site (61,000 μg/L at TW4-20) to the action level would require three orders of magnitude reduction in concentration. Performing a similar calculation where $C/C_0 = 0.001$ yields

$$\Delta t = \frac{\ell n(0.001)}{-0.00010/day}$$ = 69,077 days or 189 years for a three orders of magnitude reduction.

These calculations assume that reductions in chloroform concentrations occur only through biological means, and do not account for additional natural attenuation mechanisms that include hydrodynamic dispersion, volatilization, and abiotic degradation. When considering the results of the above calculations in addition to 1) the other natural attenuation mechanisms that will act to reduce concentrations within the plume, 2) the chloroform mass removal by pumping, and 3) the estimated perched zone travel times of a few feet per year in the areas south and southwest of the chloroform plume, it is unlikely that chloroform concentrations exceeding the action level will ever migrate south or southwest of the tailings impoundments.

REFERENCES

Aronson, et al. 1999. Aerobic Biodegradation of Organic Chemicals in Environmental Media: A Summary of Field and Laboratory Studies. Environmental science Center, Syracuse Research Corporation, North Syracuse, NY. Submitted to U S Environmental Protection Agency.

HydroGeoLogic, Inc. 1999. Anaerobic Degradation Rates of Organic Chemicals in Groundwater: A Summary of Field and Laboratory Studies. Submitted to U. S. Environmental Protection Agency Office of Solid Waste.

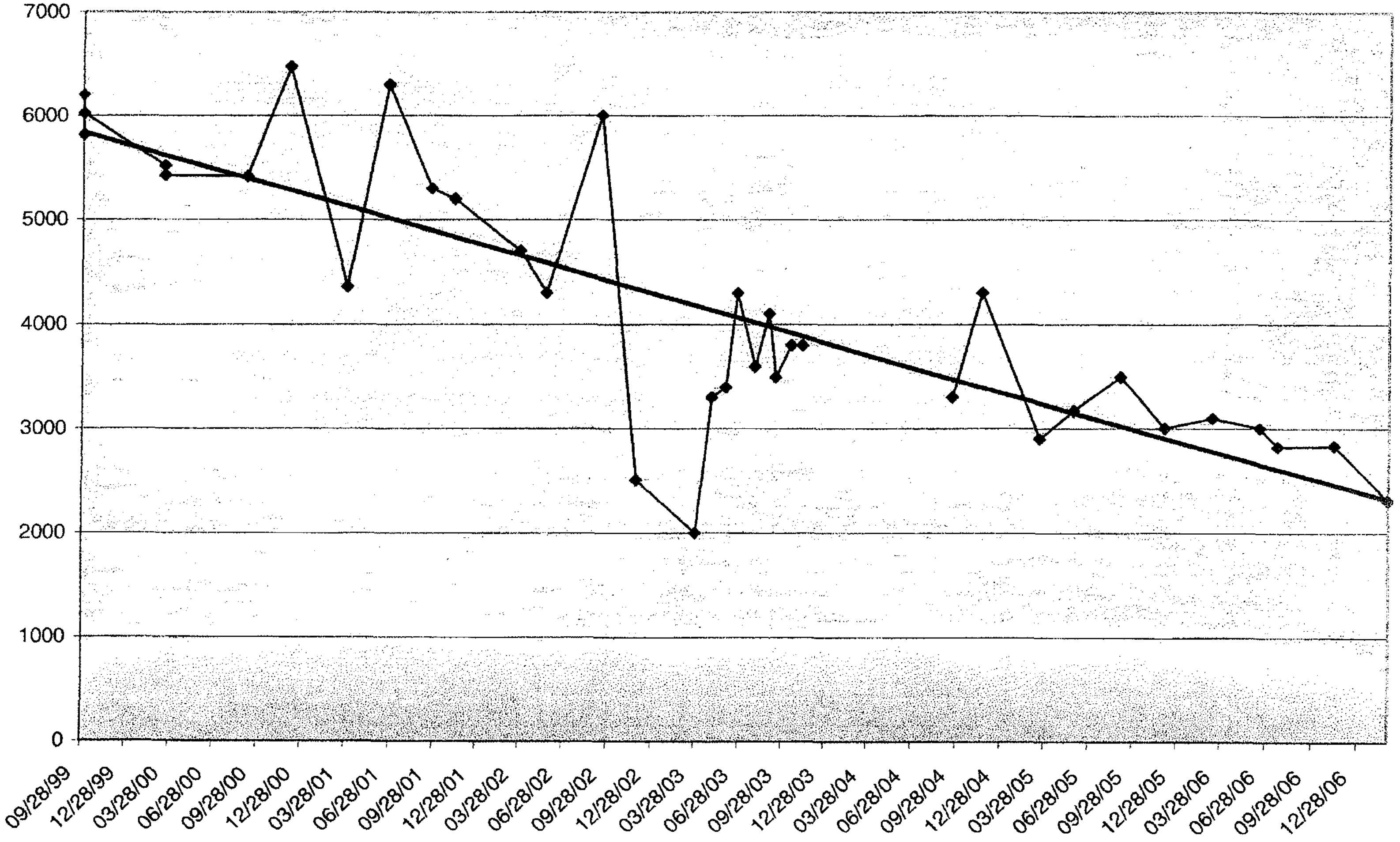
Jeffers, et al.1989. Homogeneous Hydrolysis Rate Constants for Selected Chlorinated Methanes, Ethanes, Ethenes, and Propanes. Environ. Sci. Technol., Vol 23, No. 8, pp 965-969.

Mabey, W., and T. Mill, 1989. Critical Review of Hydrolysis of Organic Compounds in Water Under Environmental Conditions. Journal of Physical and Chemical Reference Data, Vol 7, No. 2, pp 383-415.

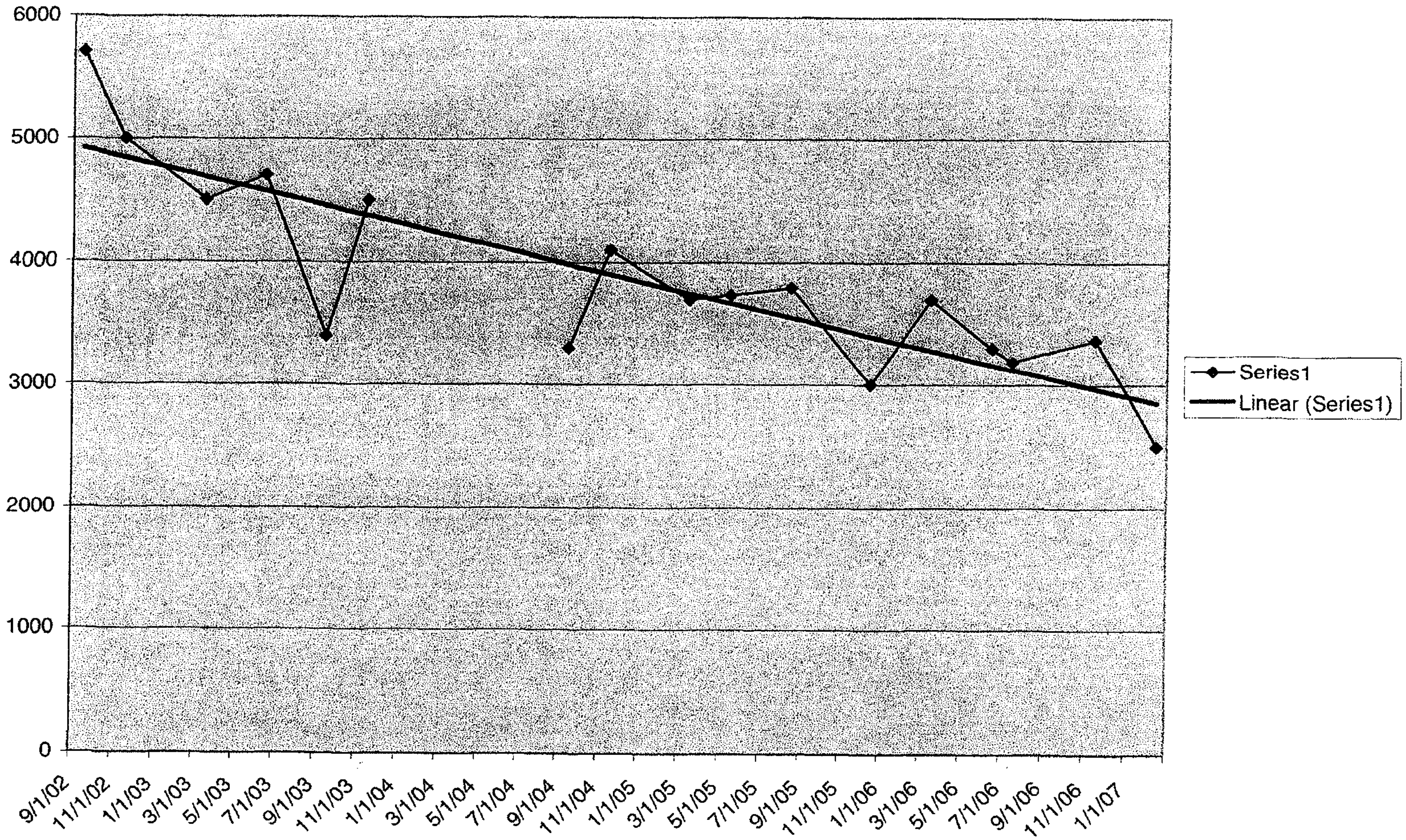
APPENDIX C

CHLOROFORM INVESTIGATION WELL CONCENTRATION GRAPHS

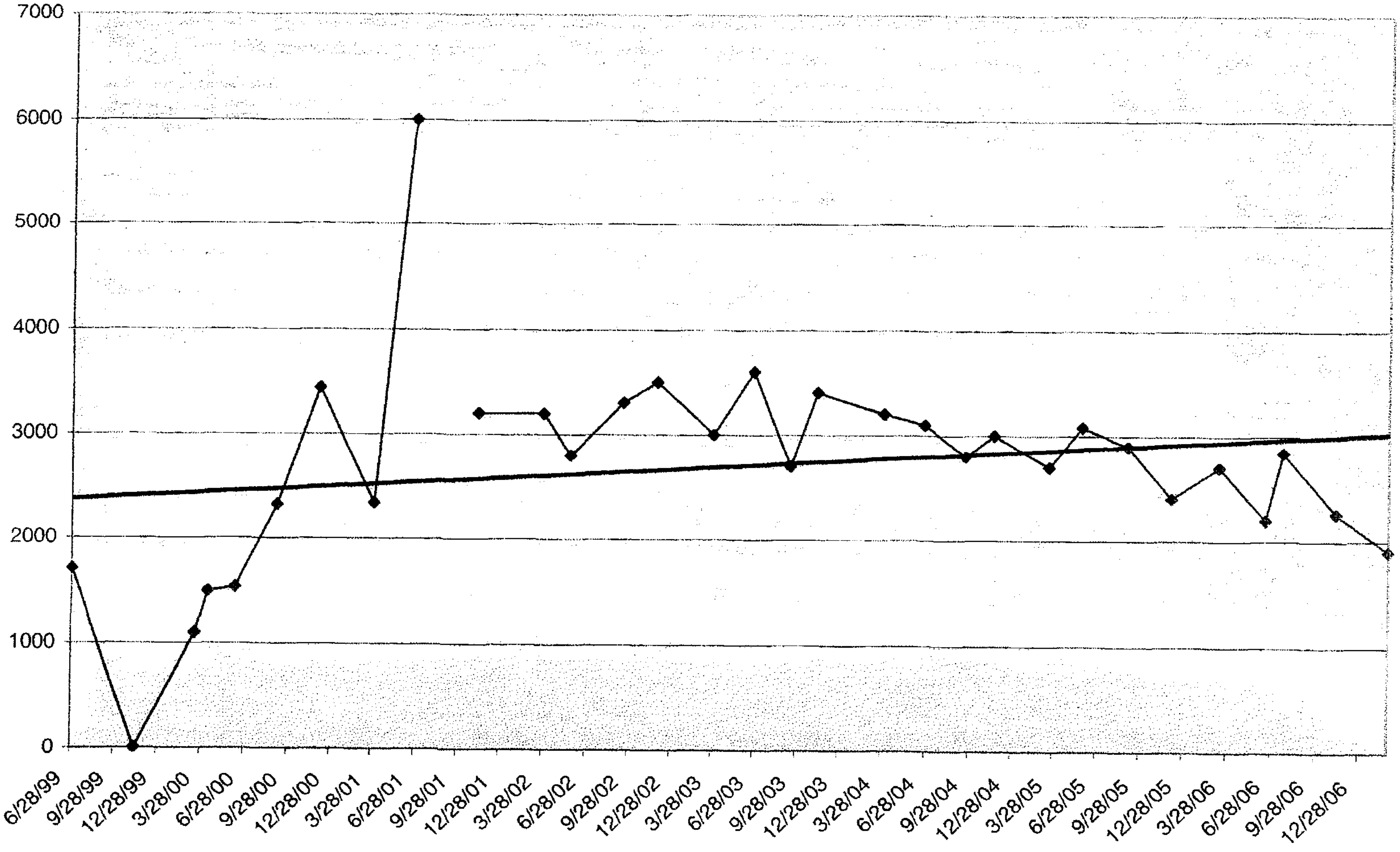
MW-4 Chloroform Values (ug/L)



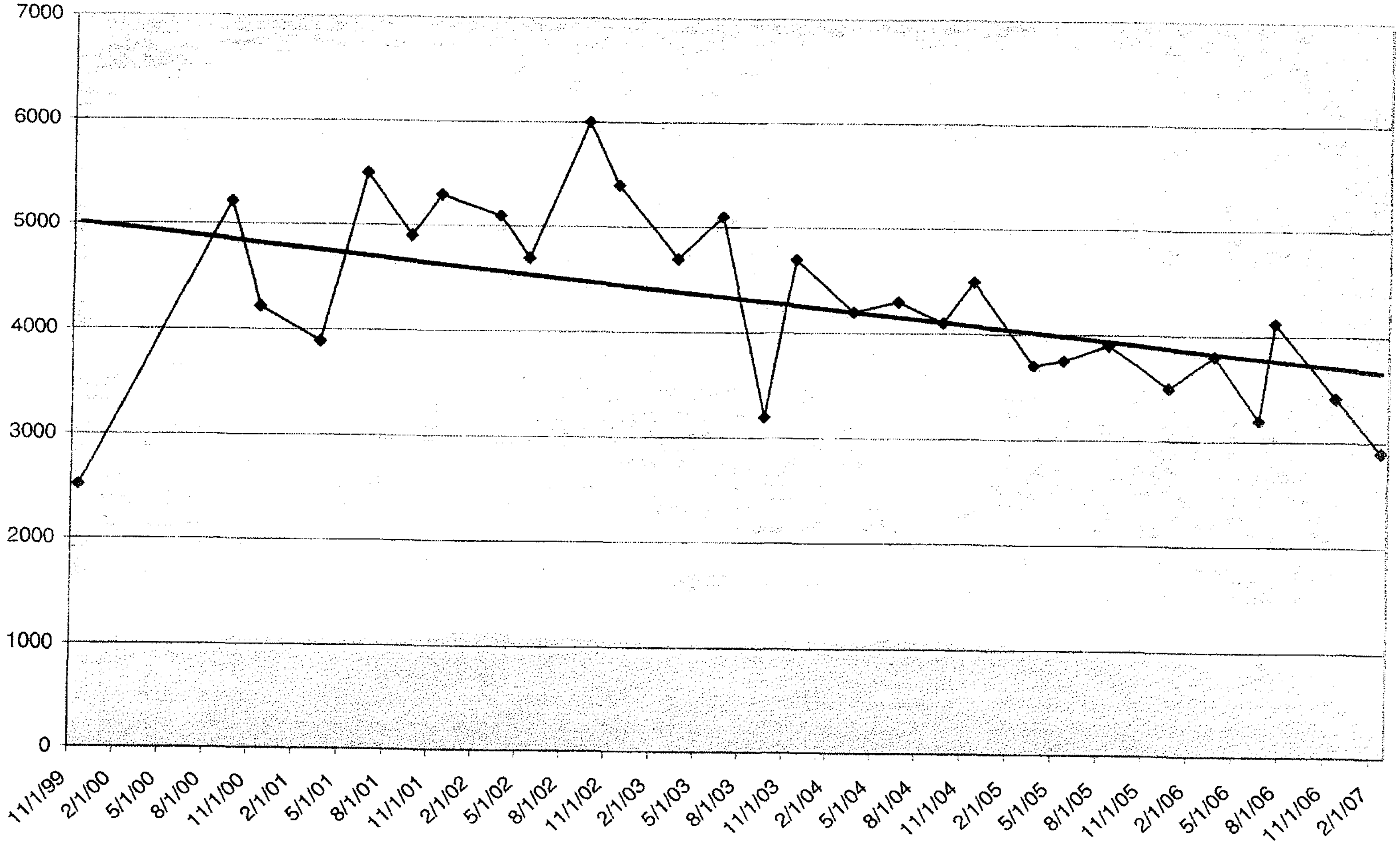
TW4-A Chloroform Values (ug/L)



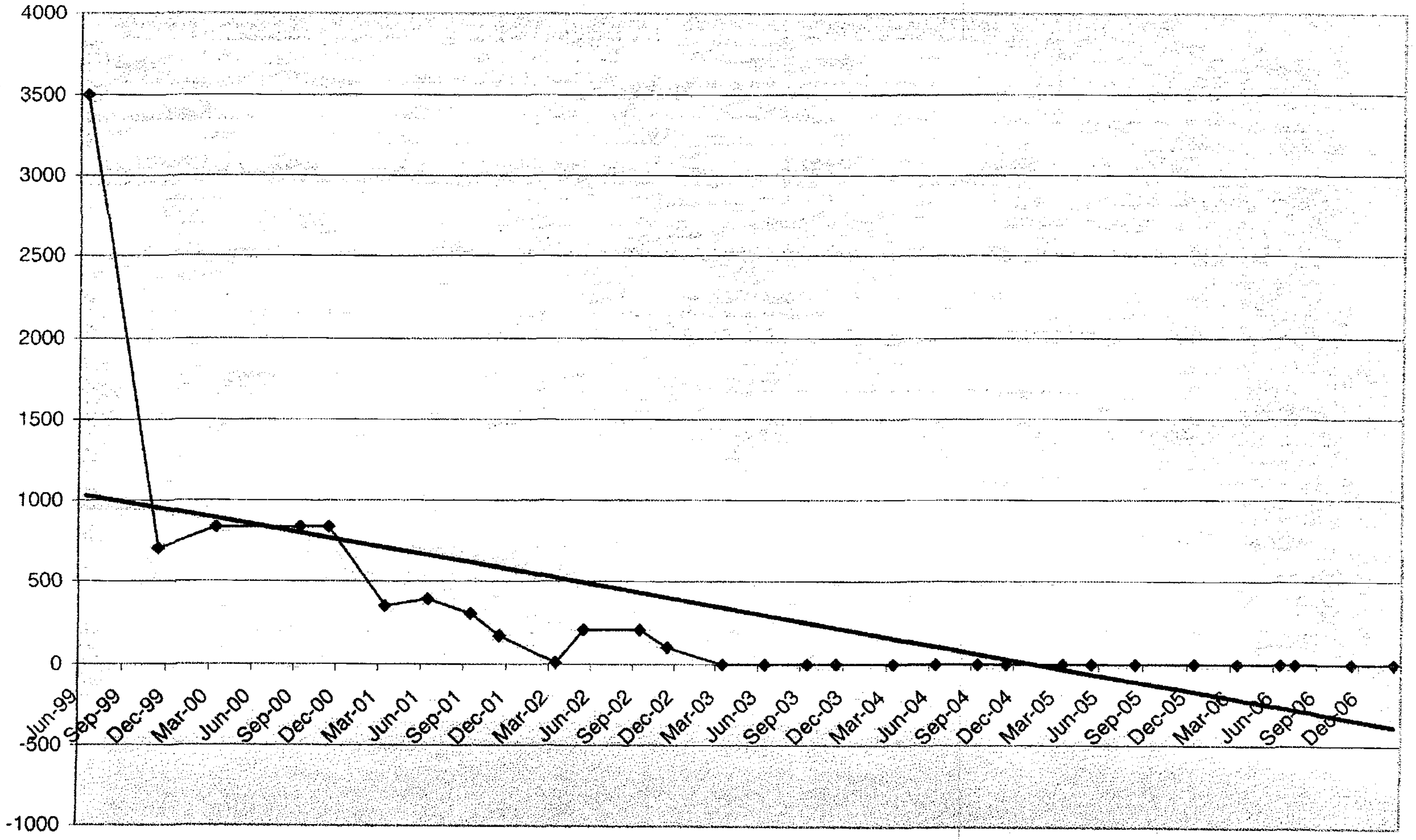
TW4-1 Clorororm Values (ug/L)



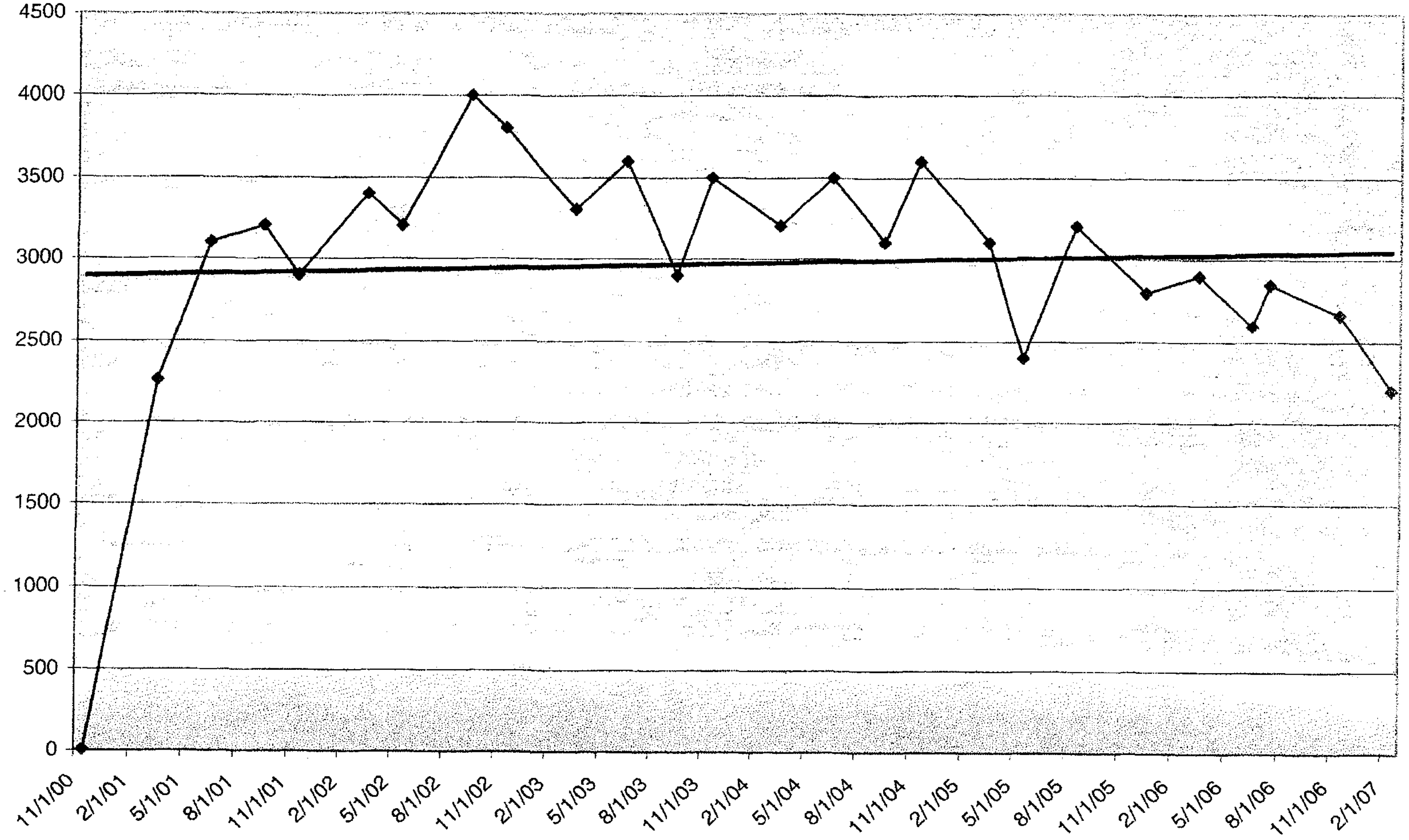
TW4-2 Chloroform Values (ug/L)



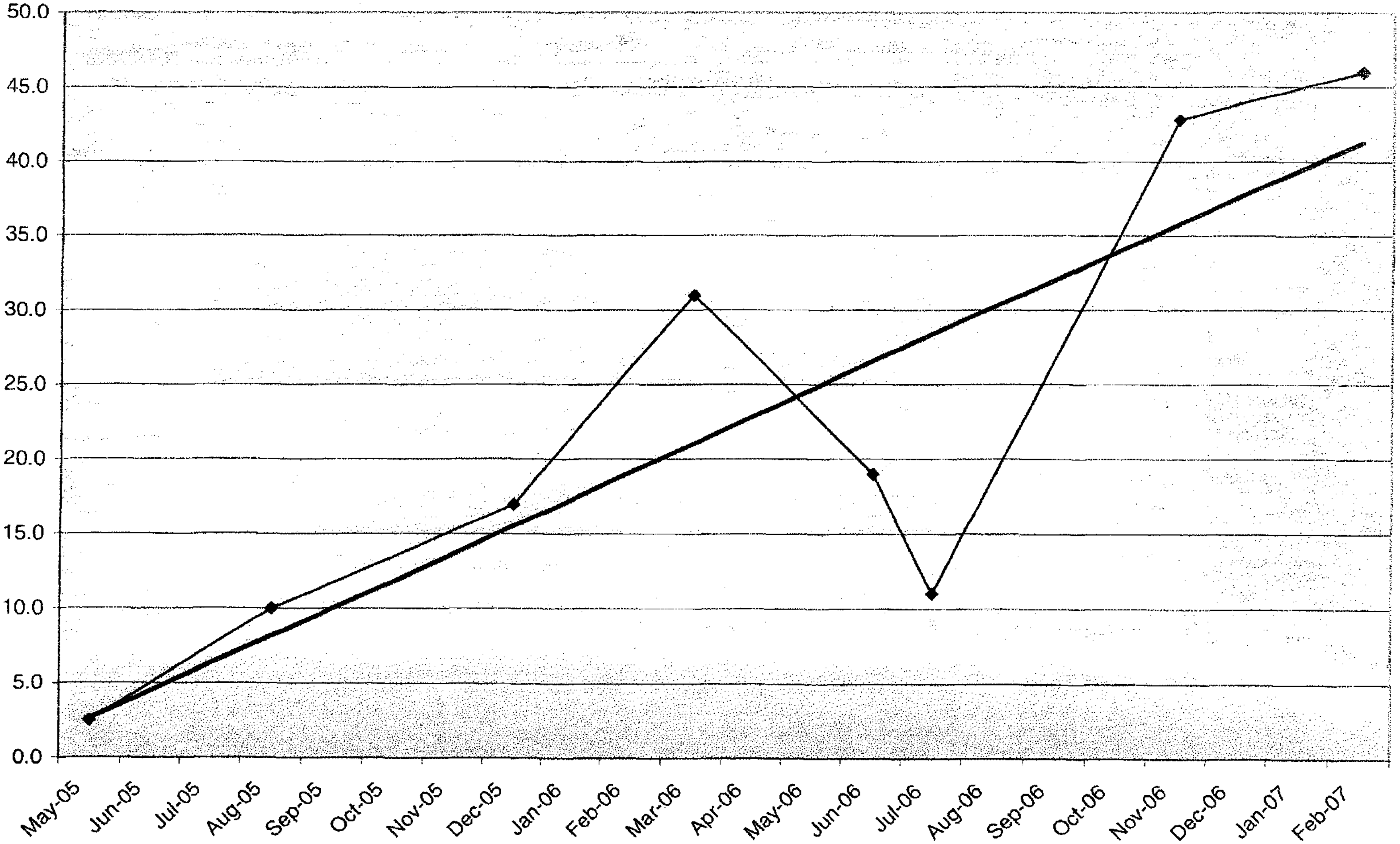
TW4-3 Chloroform Values (ug/L)



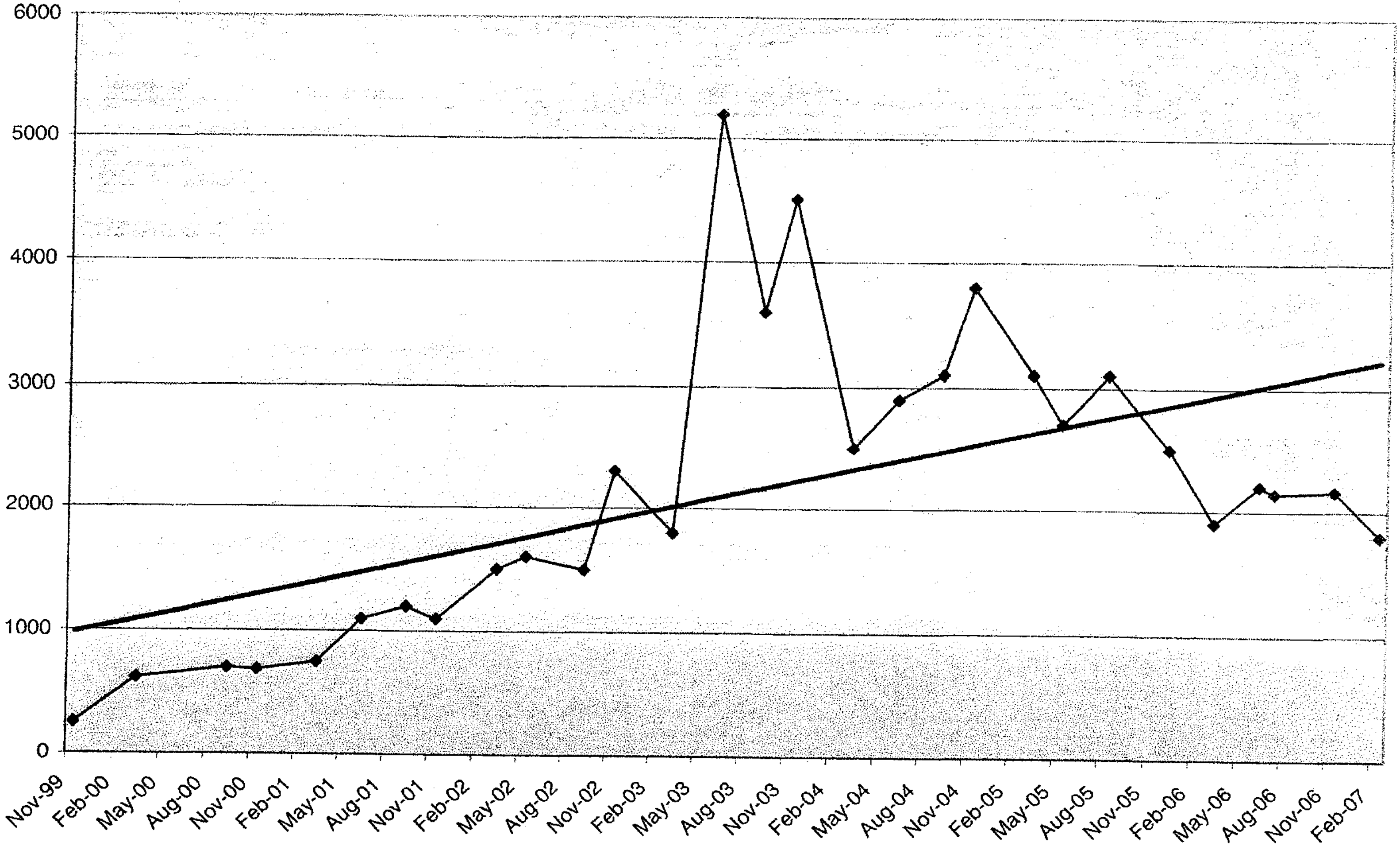
TW4-4 Chloroform Values (ug/L)



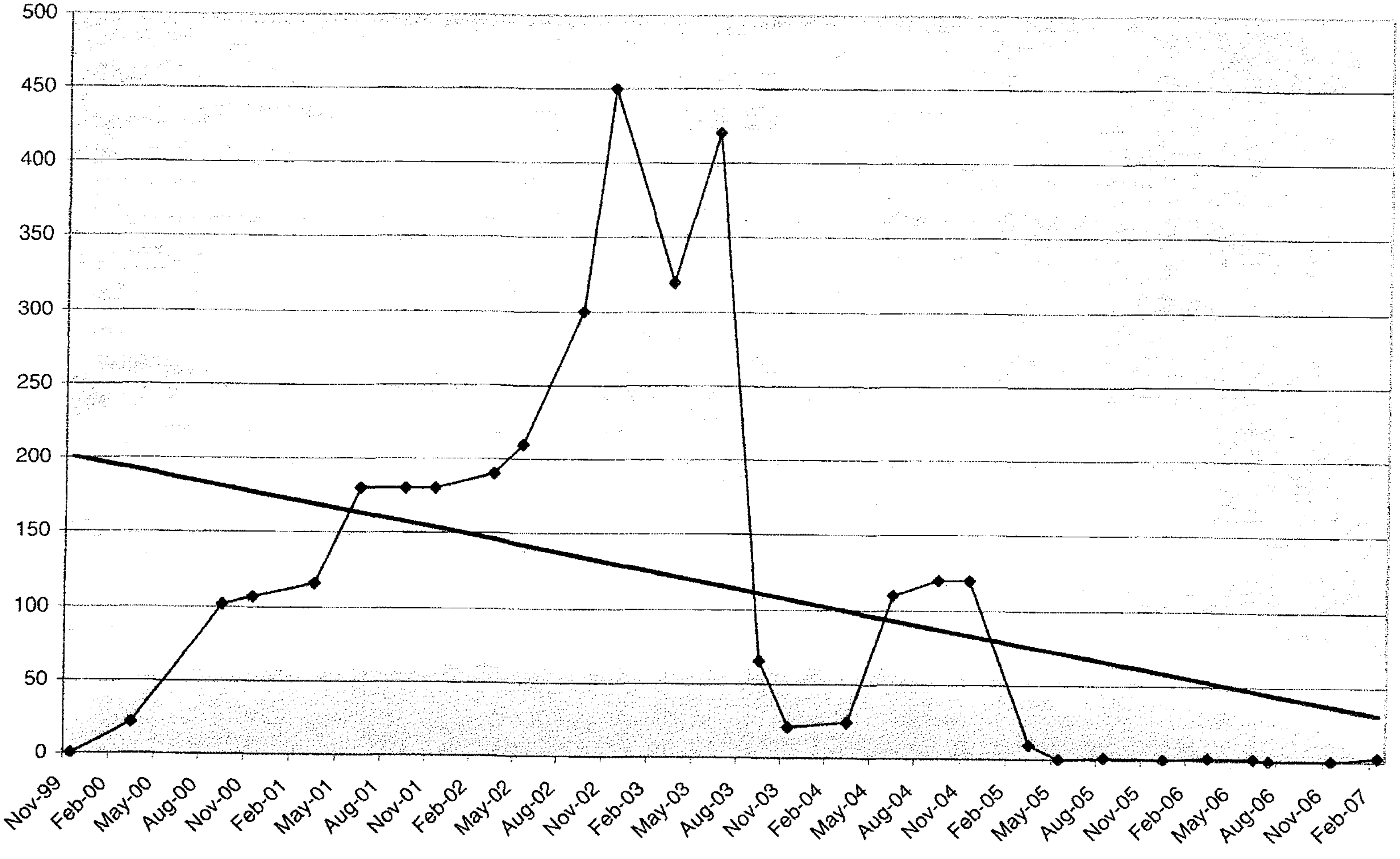
TW4-6 Chloroform Values (ug/L)



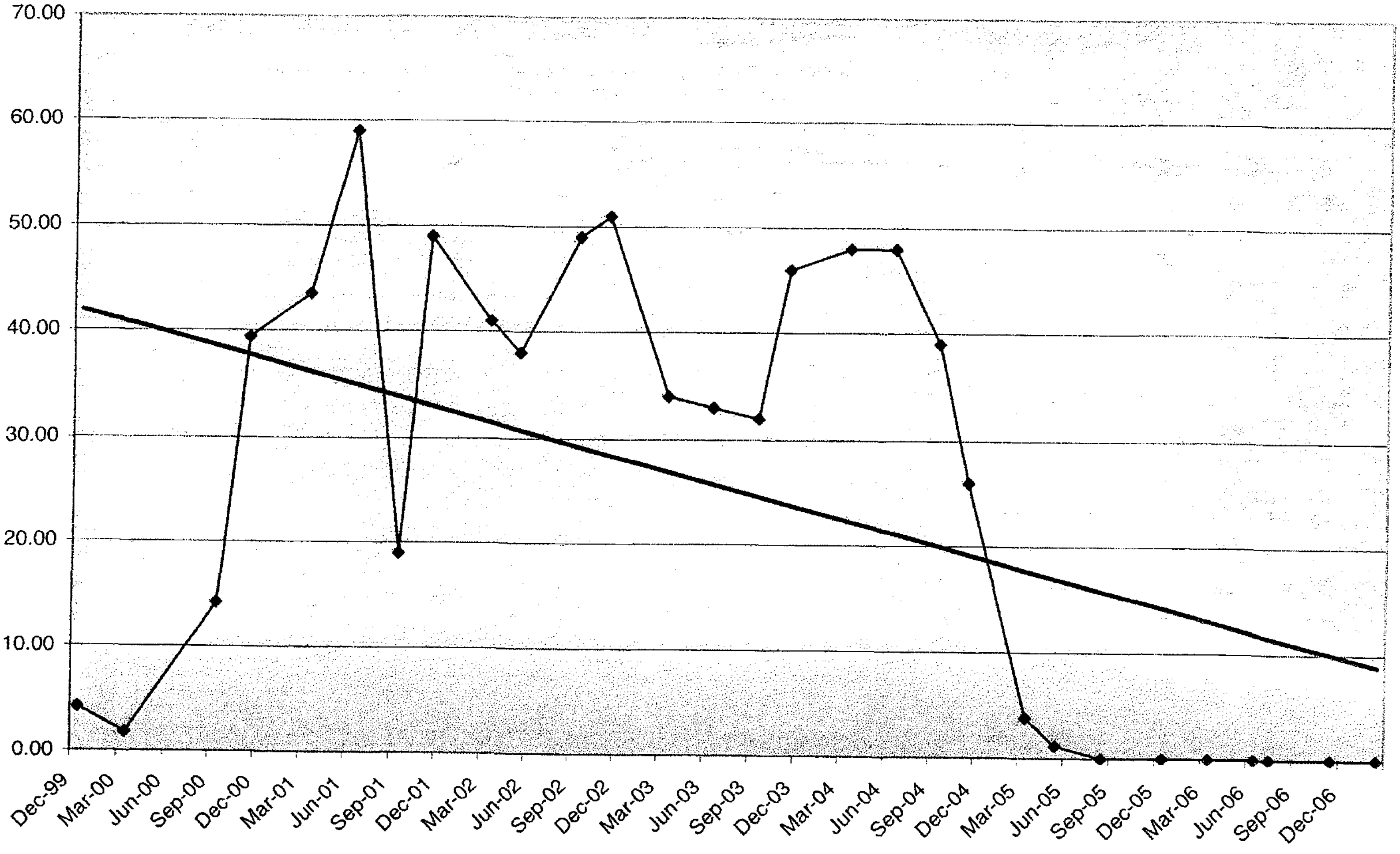
TW4-7 Chloroform Values (ug/L)



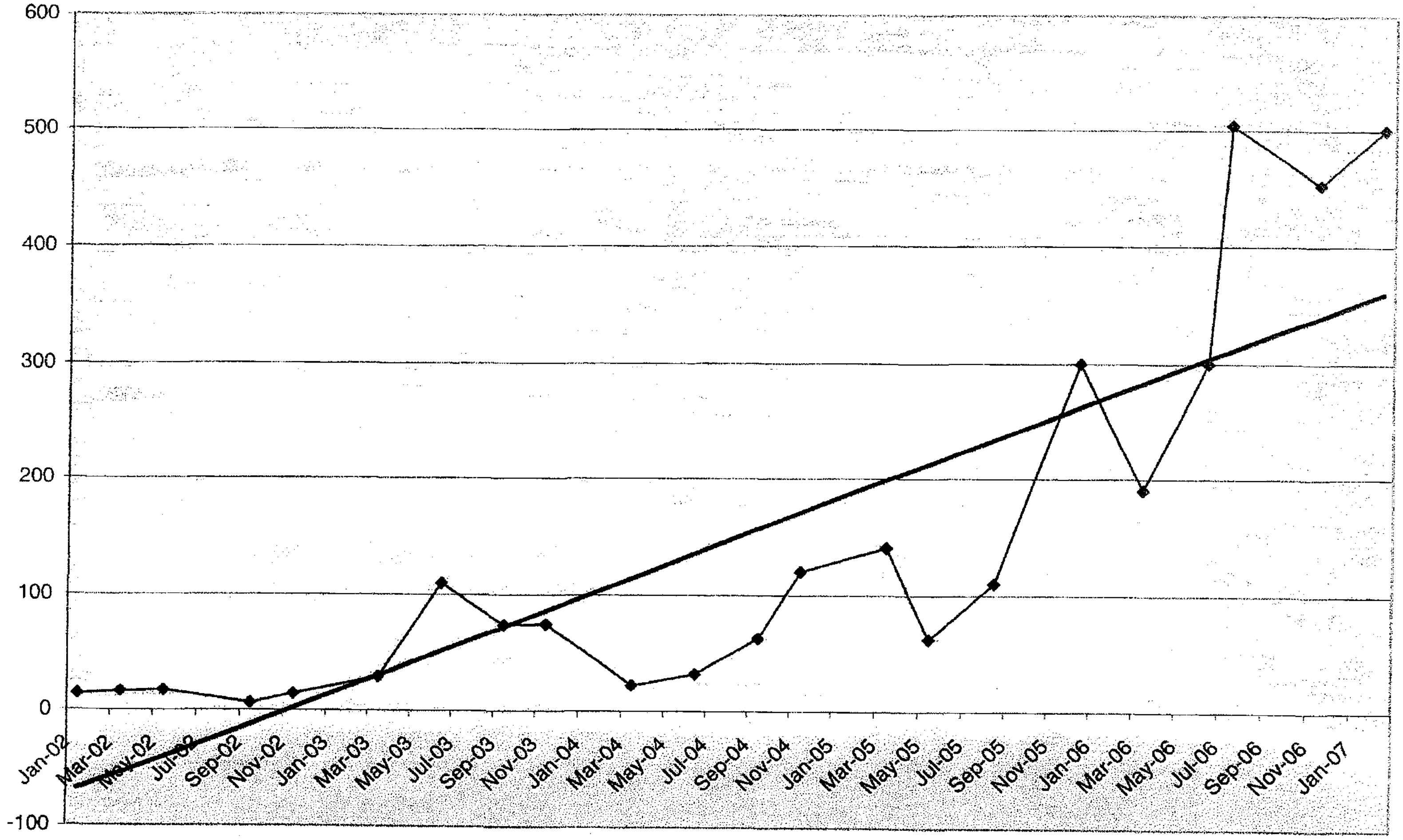
TW4-8 Chloroform Values (ug/L)



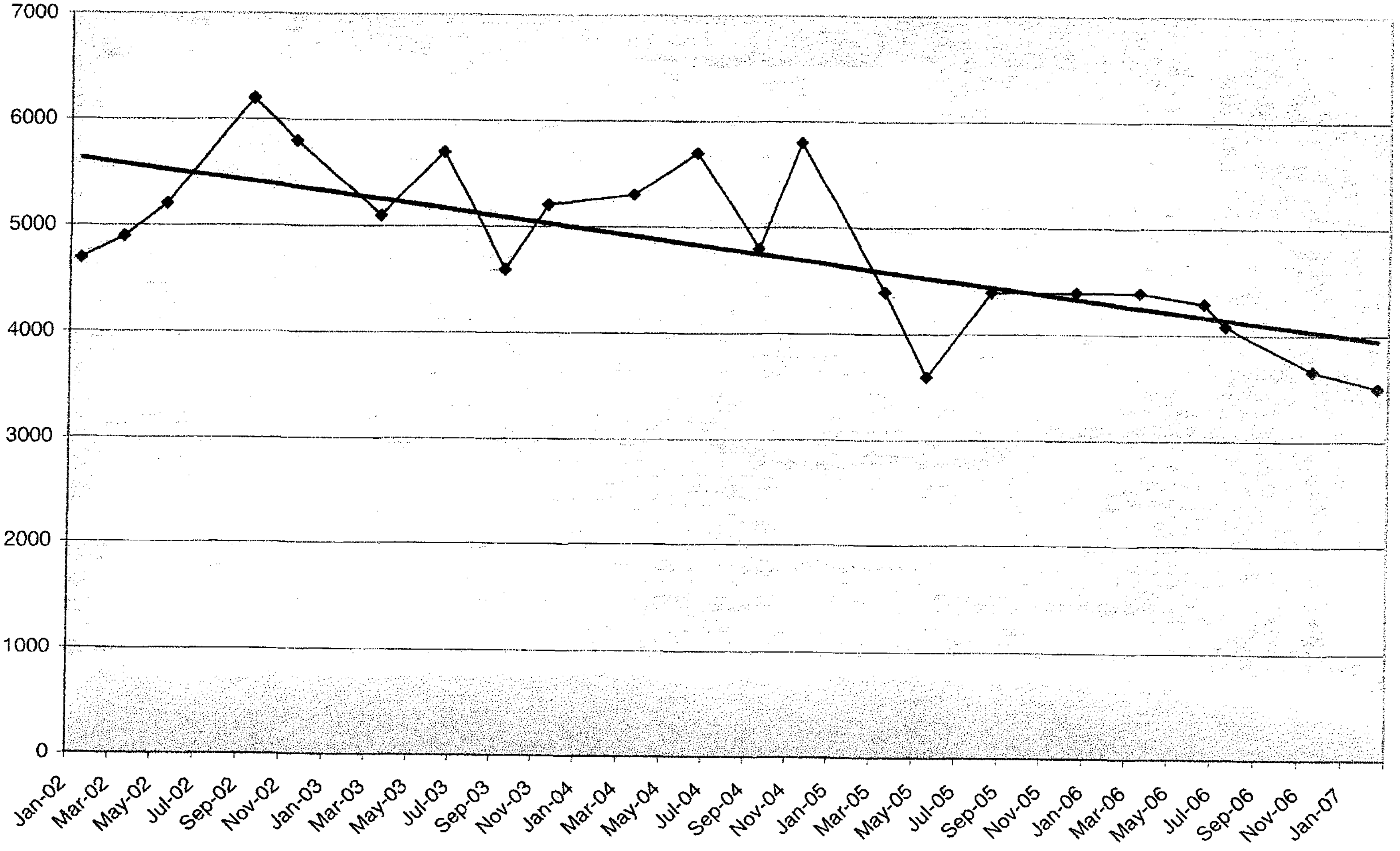
TW4-9 Chlorofrom Values (ug/L)



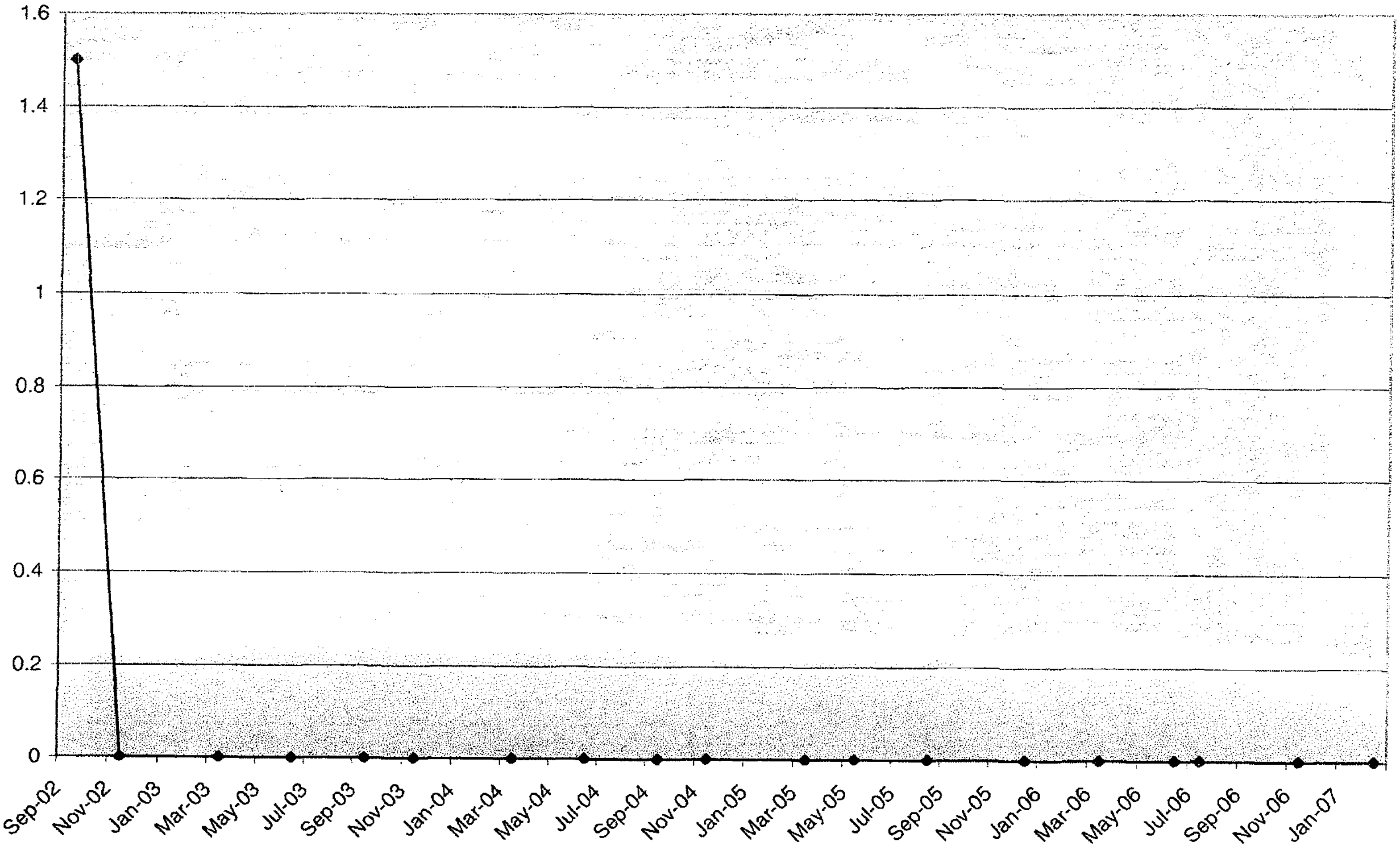
TW4-10 Chloroform Values (ug/L)

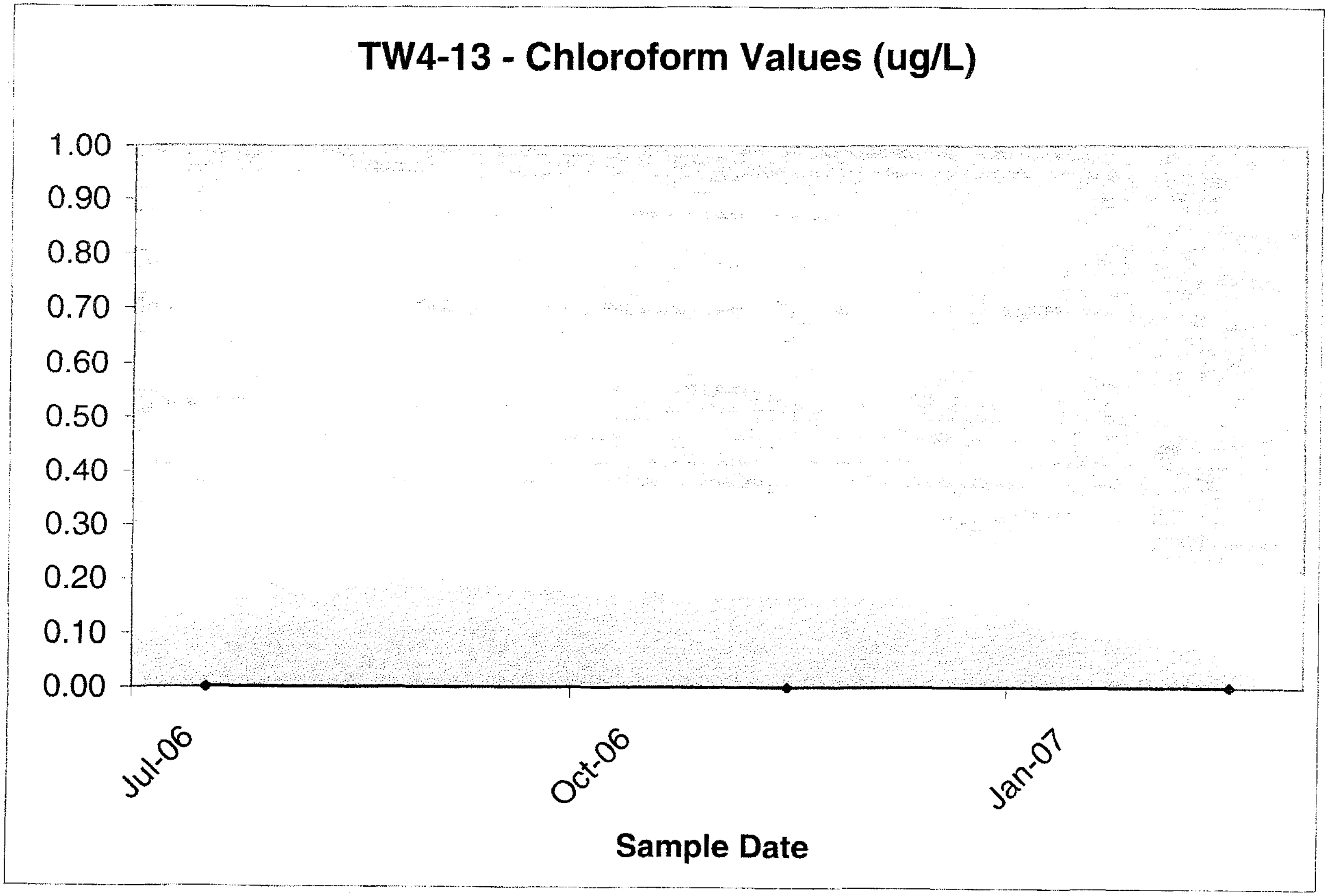


TW4-11 Chloroform Values (ug/L)

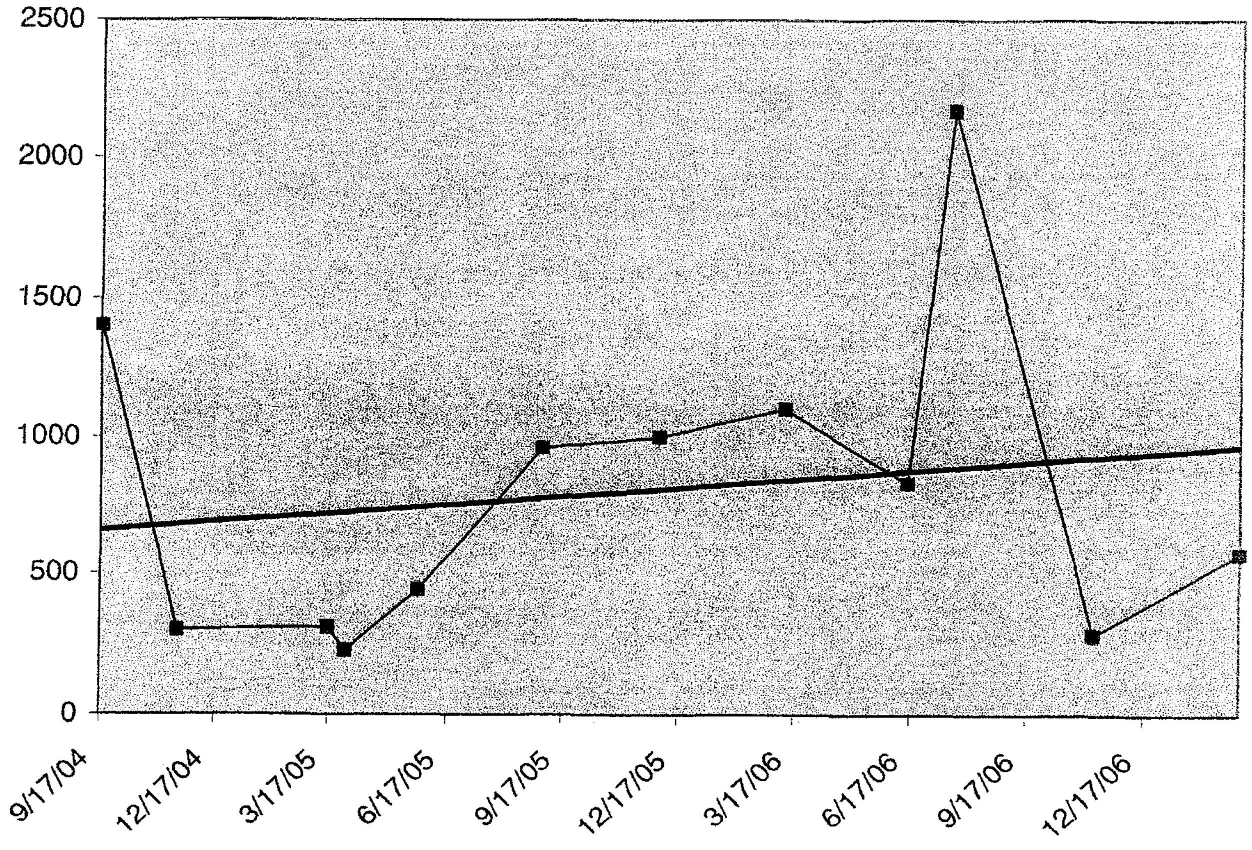


TW4-12 Chloroform Values (ug/L)

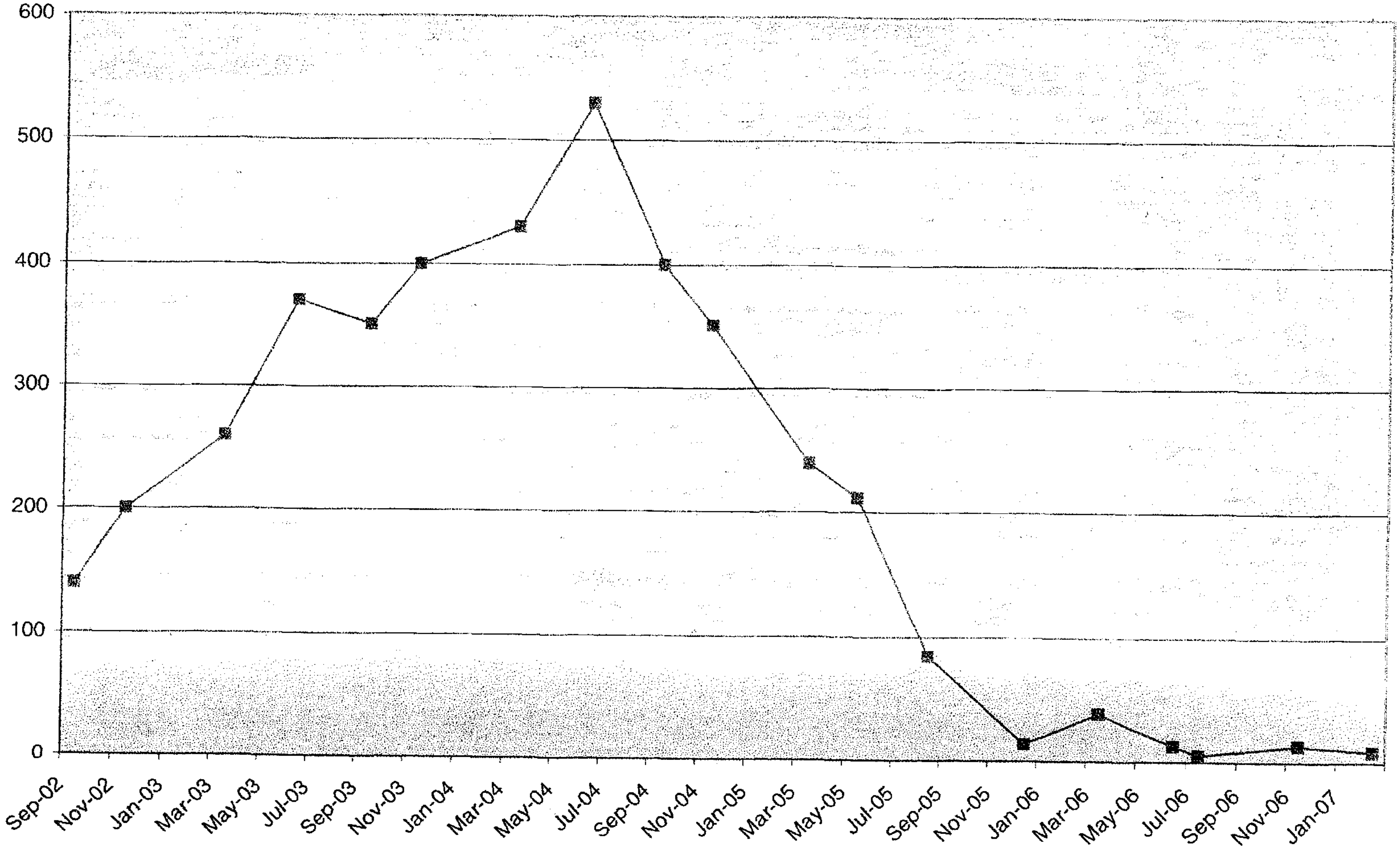



TW4-13 - Chloroform Values (ug/L)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Jul-06
Oct-06
Jan-07
Sample Date

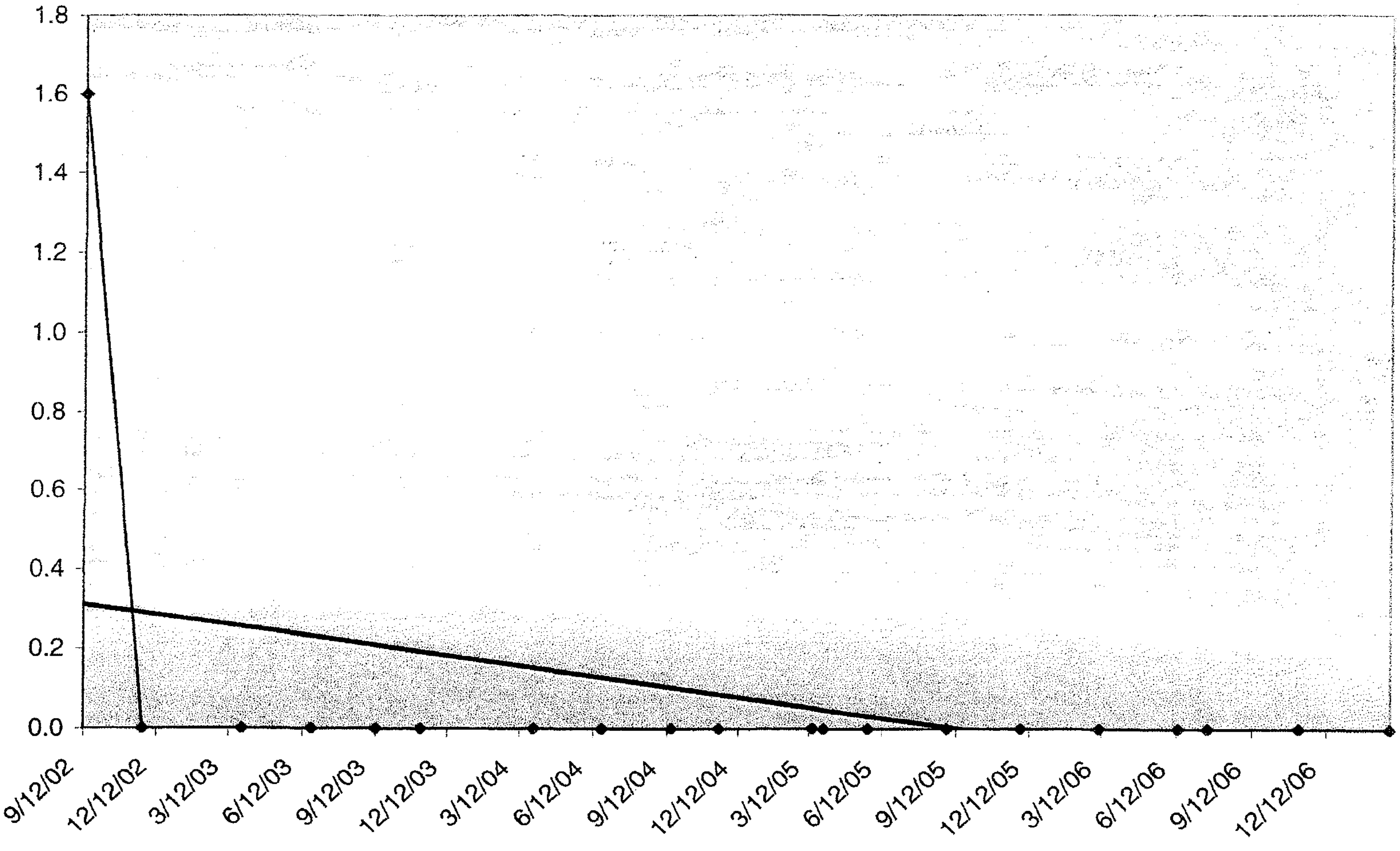
TW4-15 (MW 26) - Chloroform Values (ug/L)



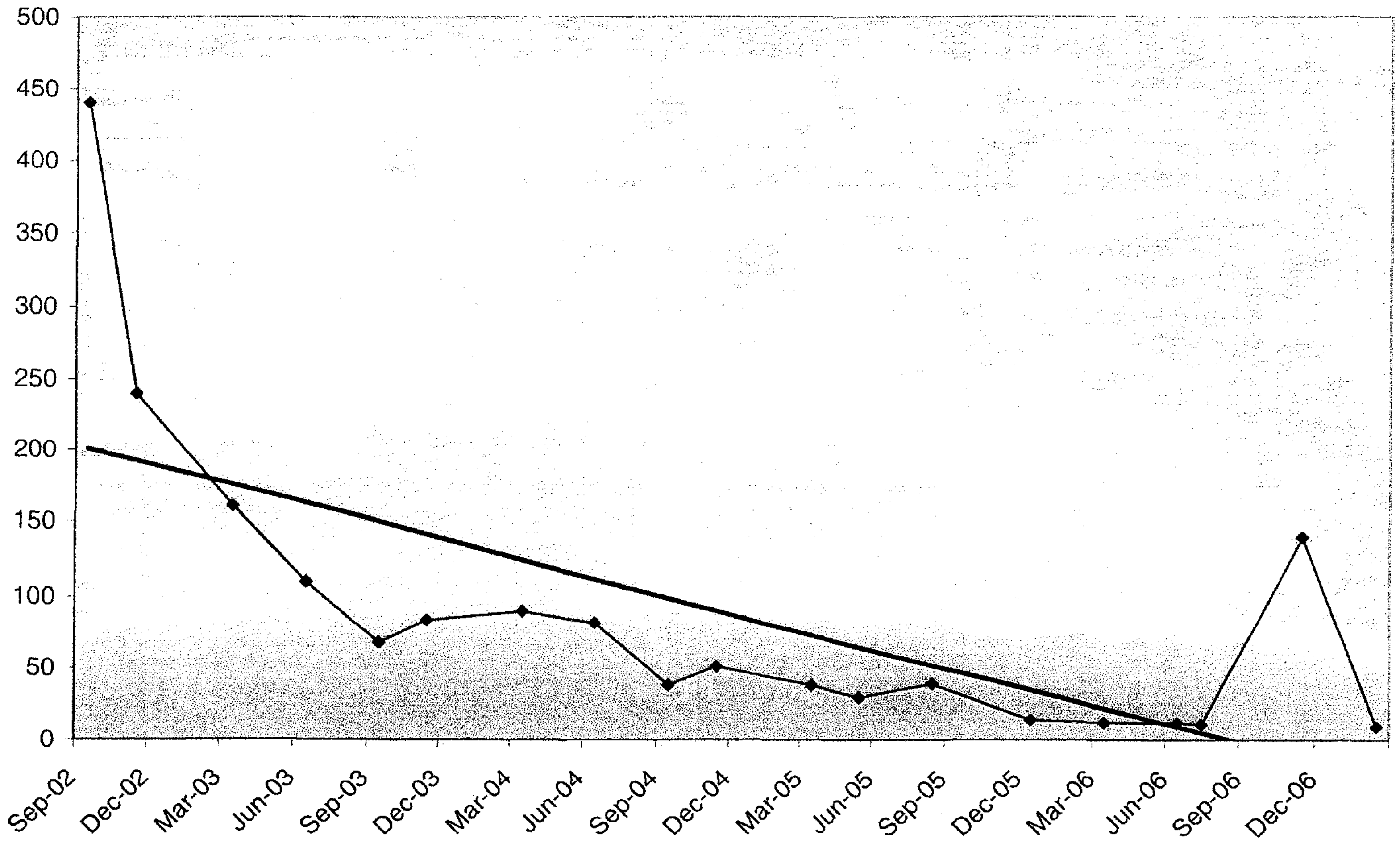
TW4-16 Chloroform Values (ug/L)



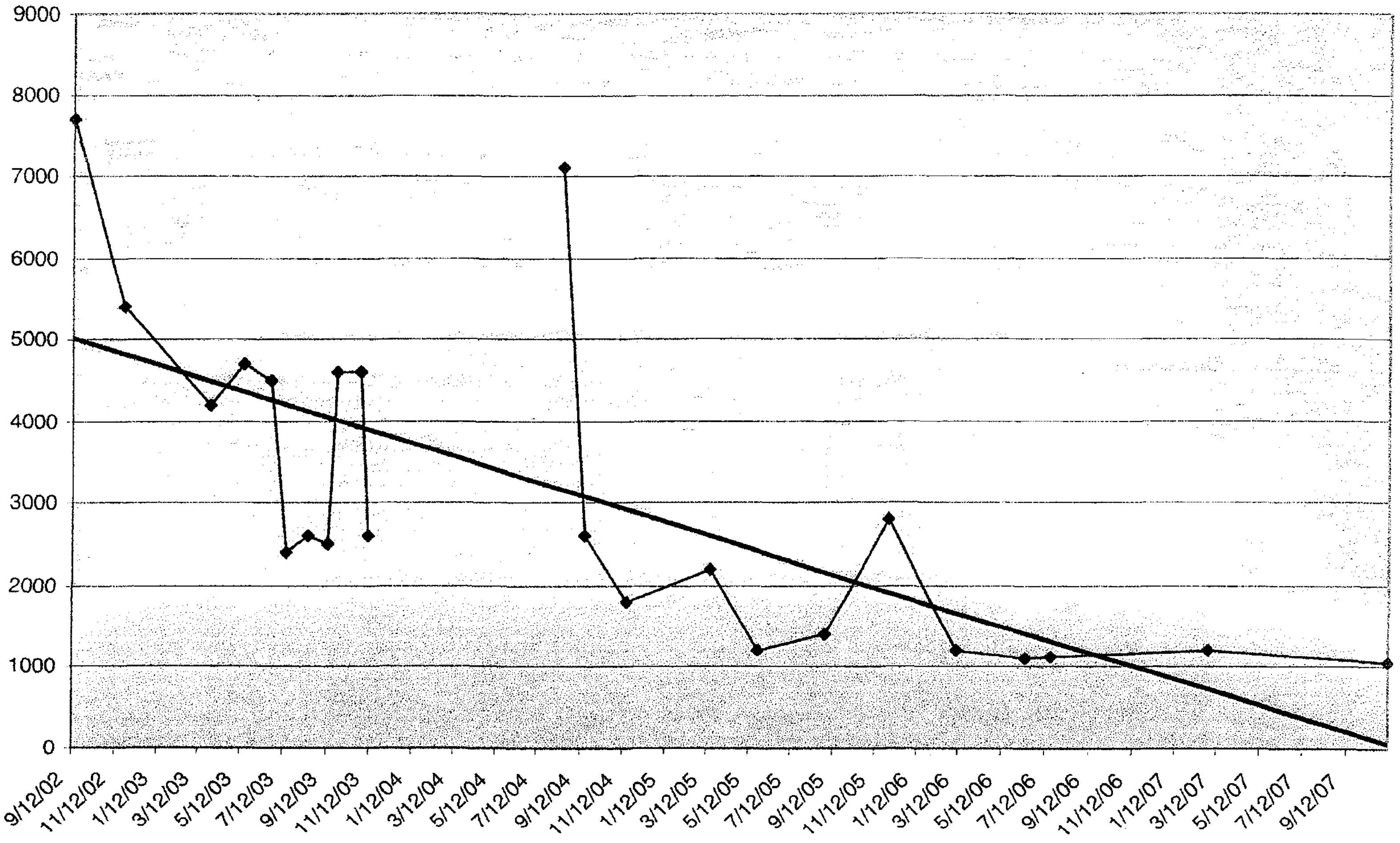
TW4-17 (MW-32) - Chloroform Values (ug/L)

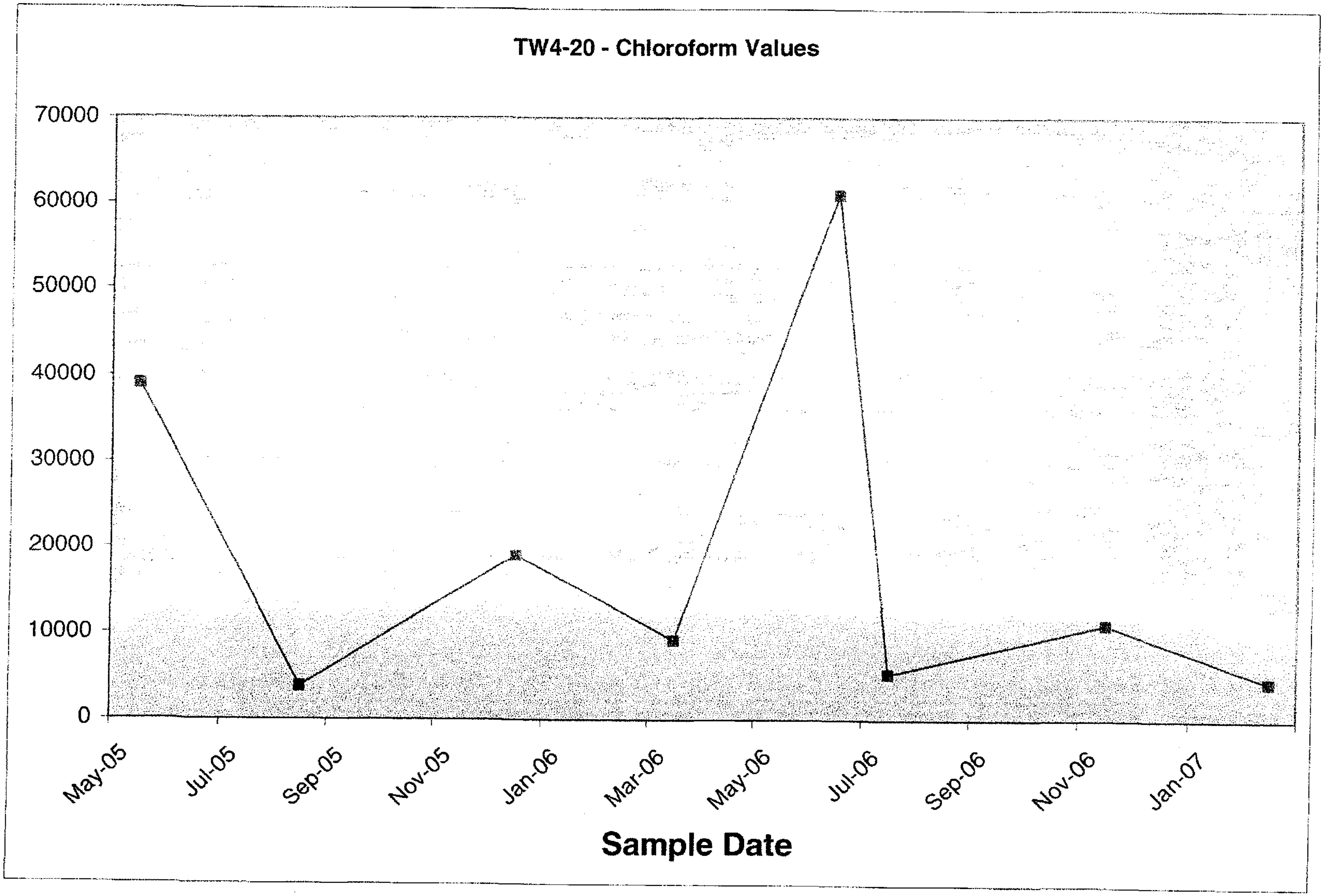


TW4-18 - Chloroform Values (ug/L)



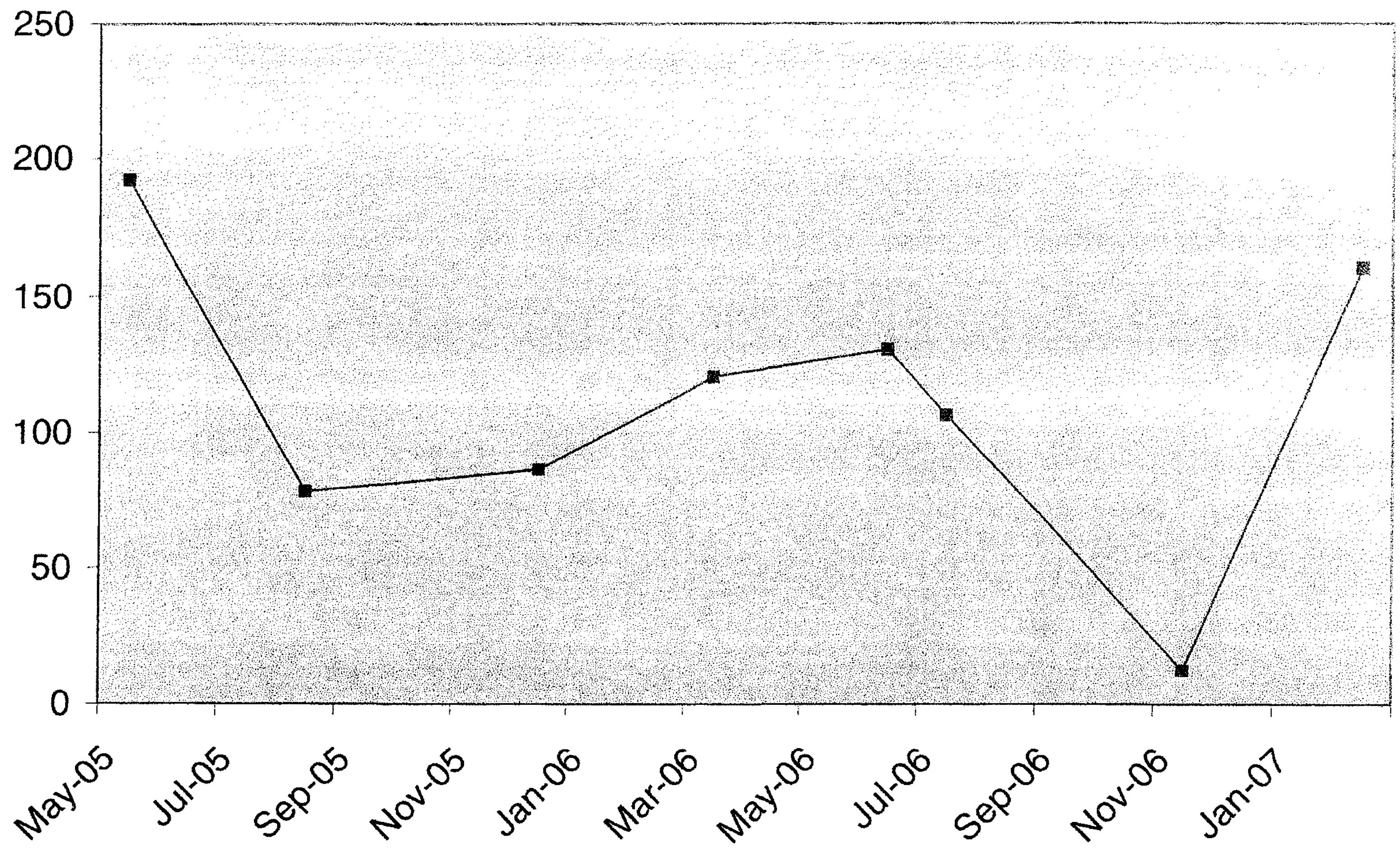
TW4-19 Chloroform Values (ug/L)



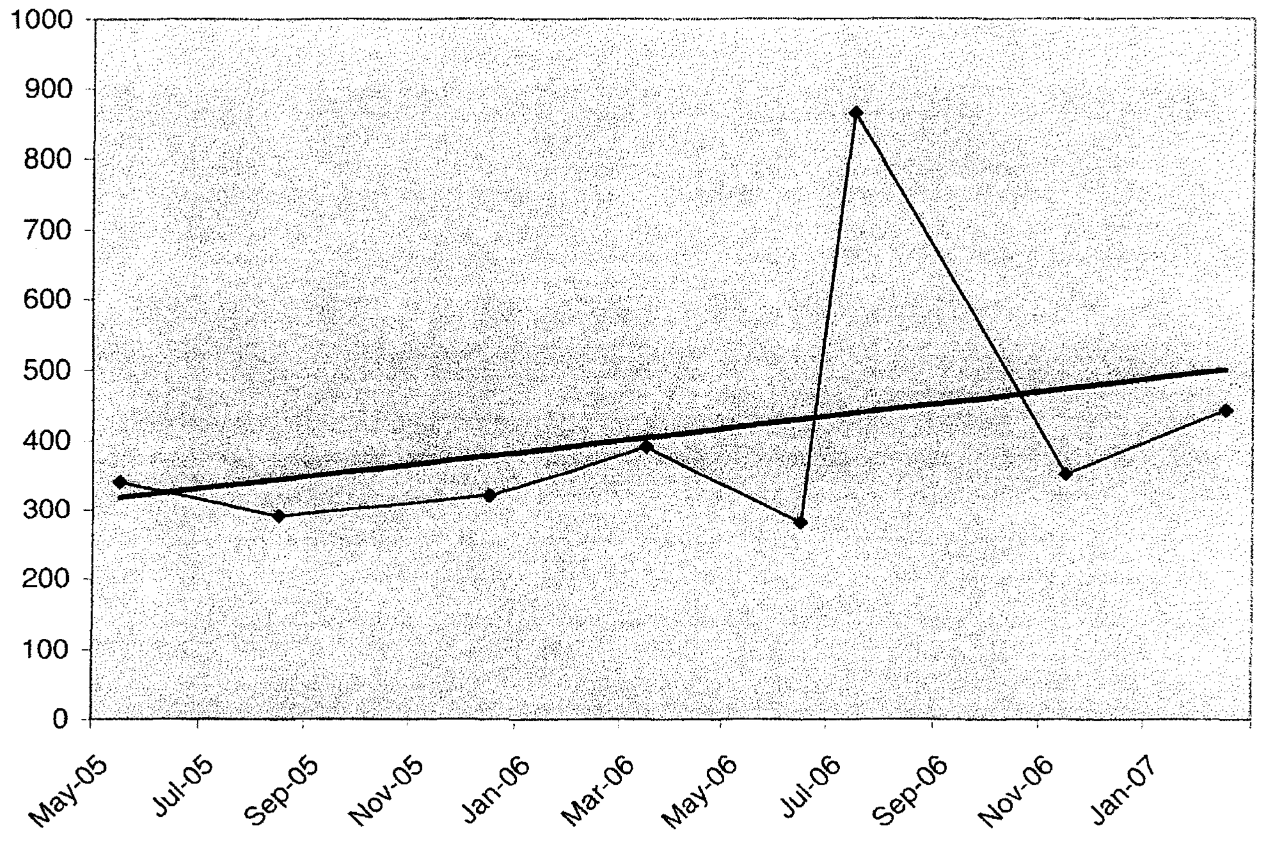


TW4-20 - Chloroform Values

TW4-21 - Chloroform Values (ug/L)



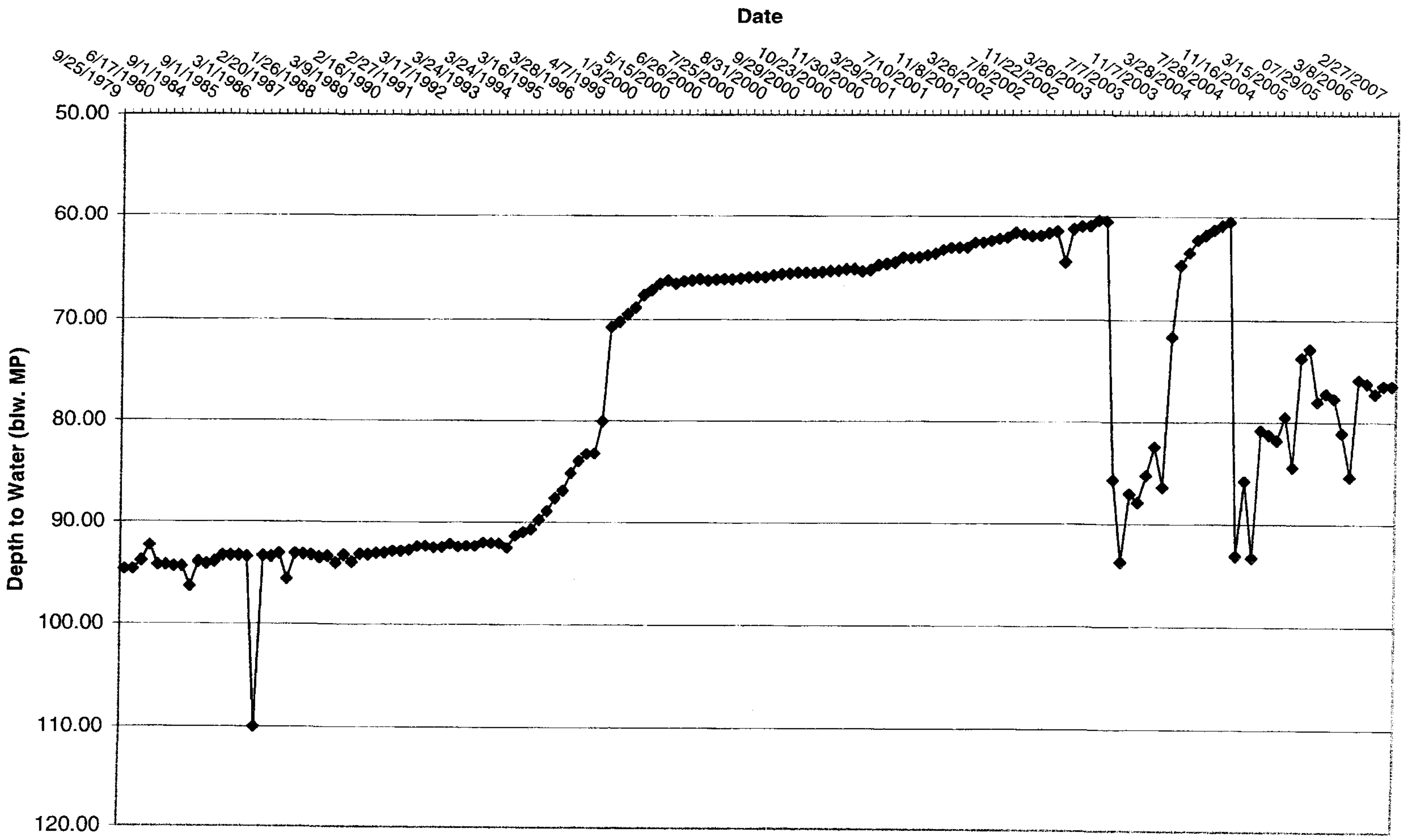
TW4-22 - Chloroform Values (ug/L)



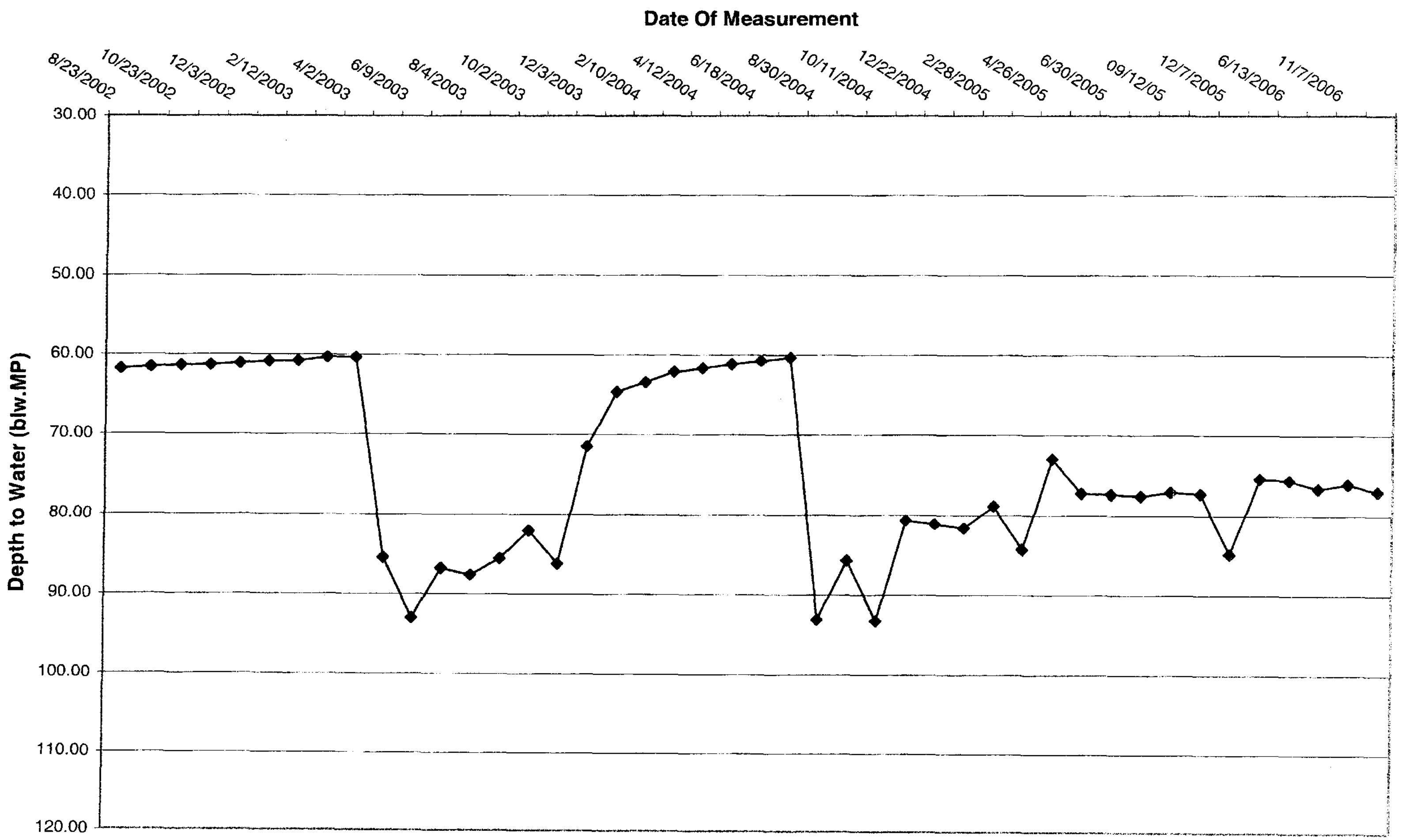
APPENDIX D

PERCHED MONITORING WELL HYDROGRAPHS

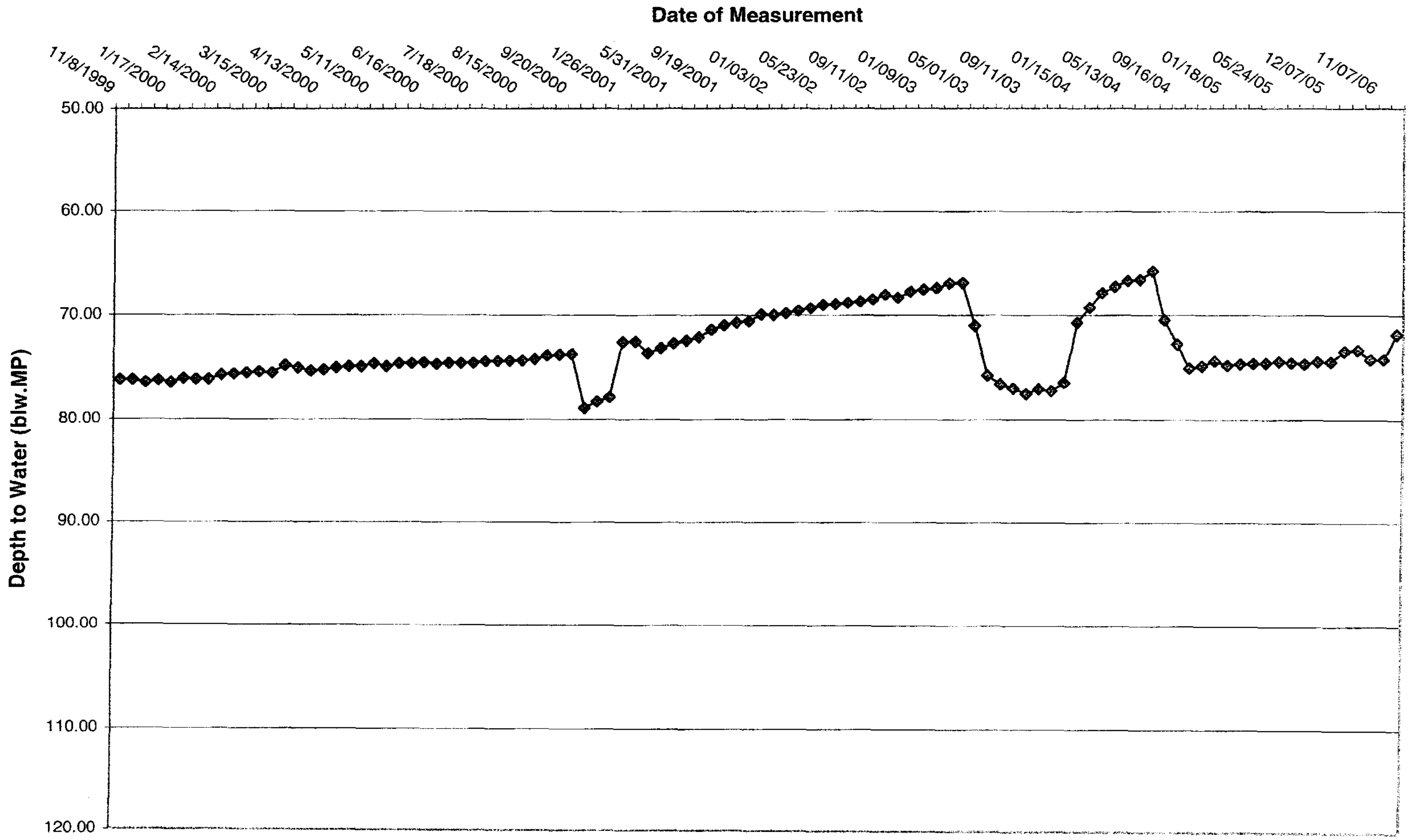
White Mesa Monitor Well 4 Depth Over Time



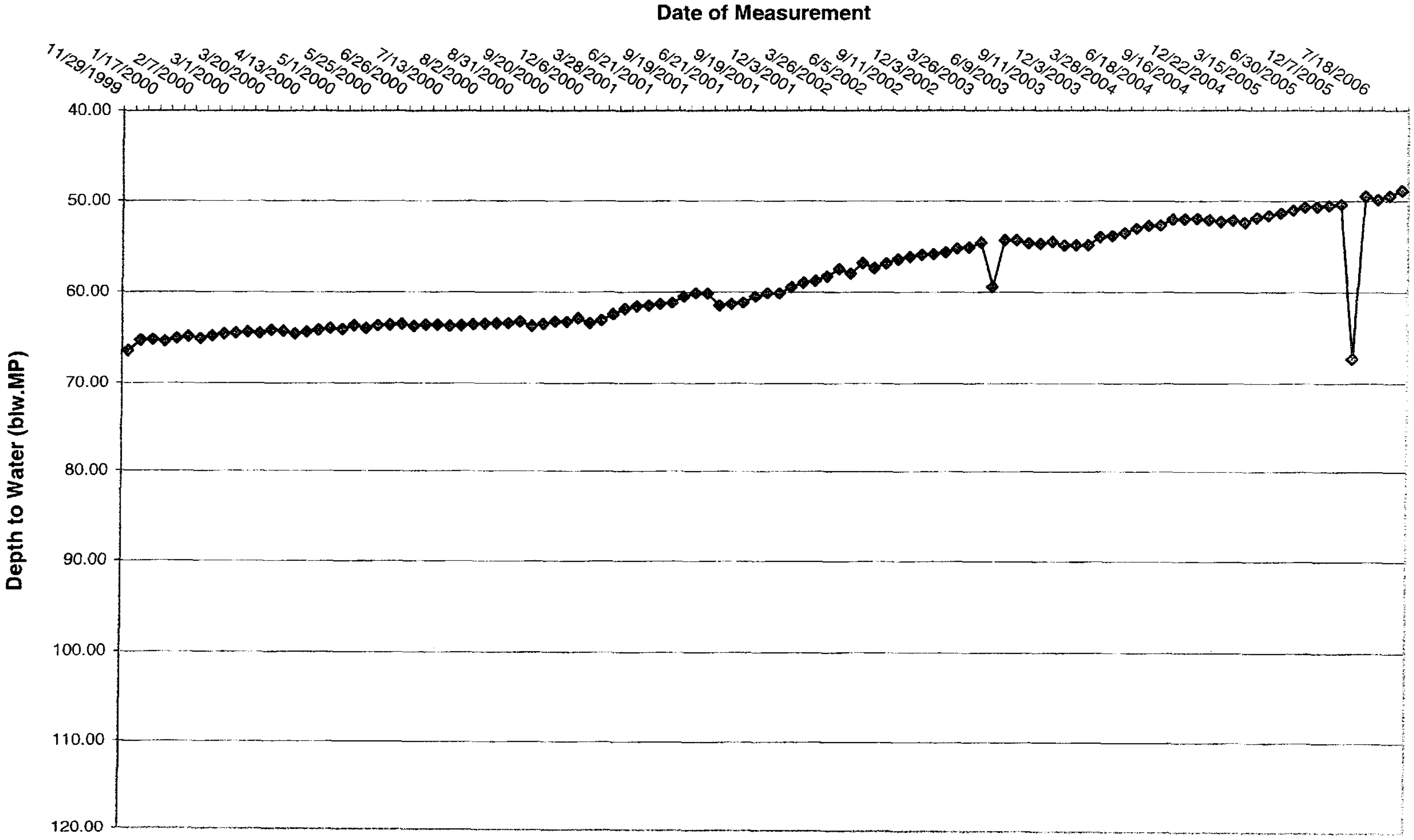
White Mesa Temporary Well (4-A) Over Time



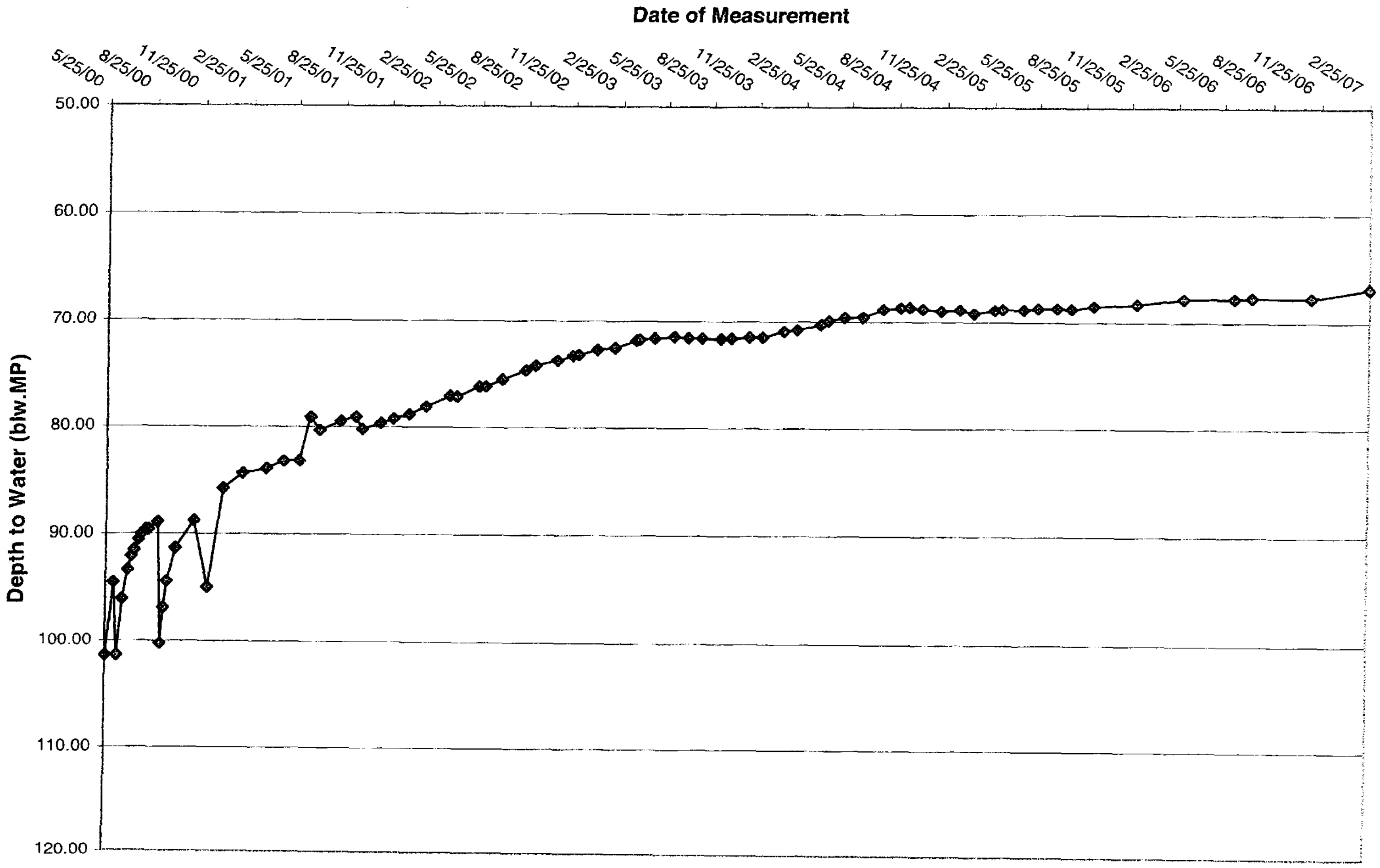
White Mesa Mill Temporary Well (4-2) Water Level Over Time



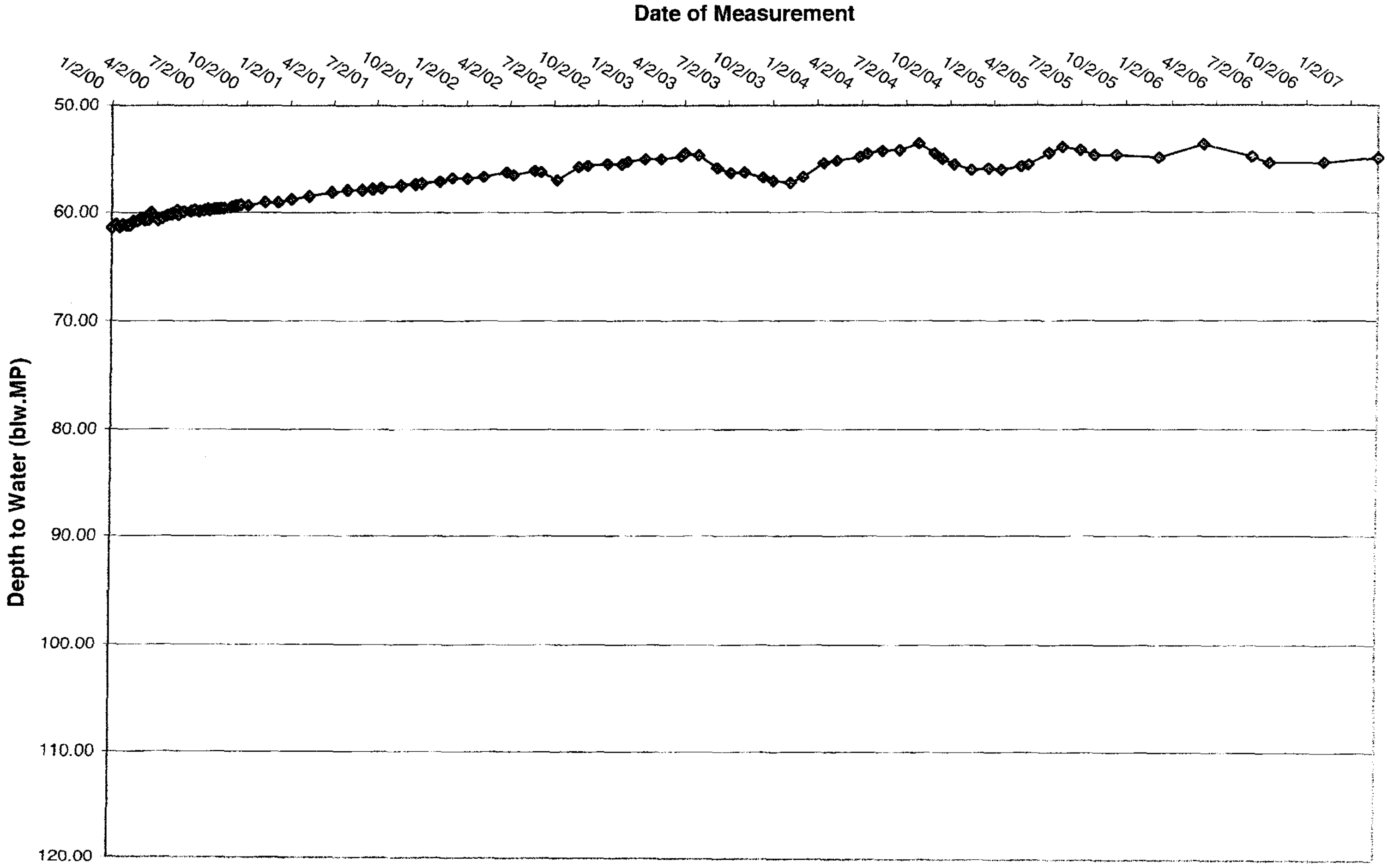
White Mesa Mill Temporary Well (4-3) Water Level Over Time



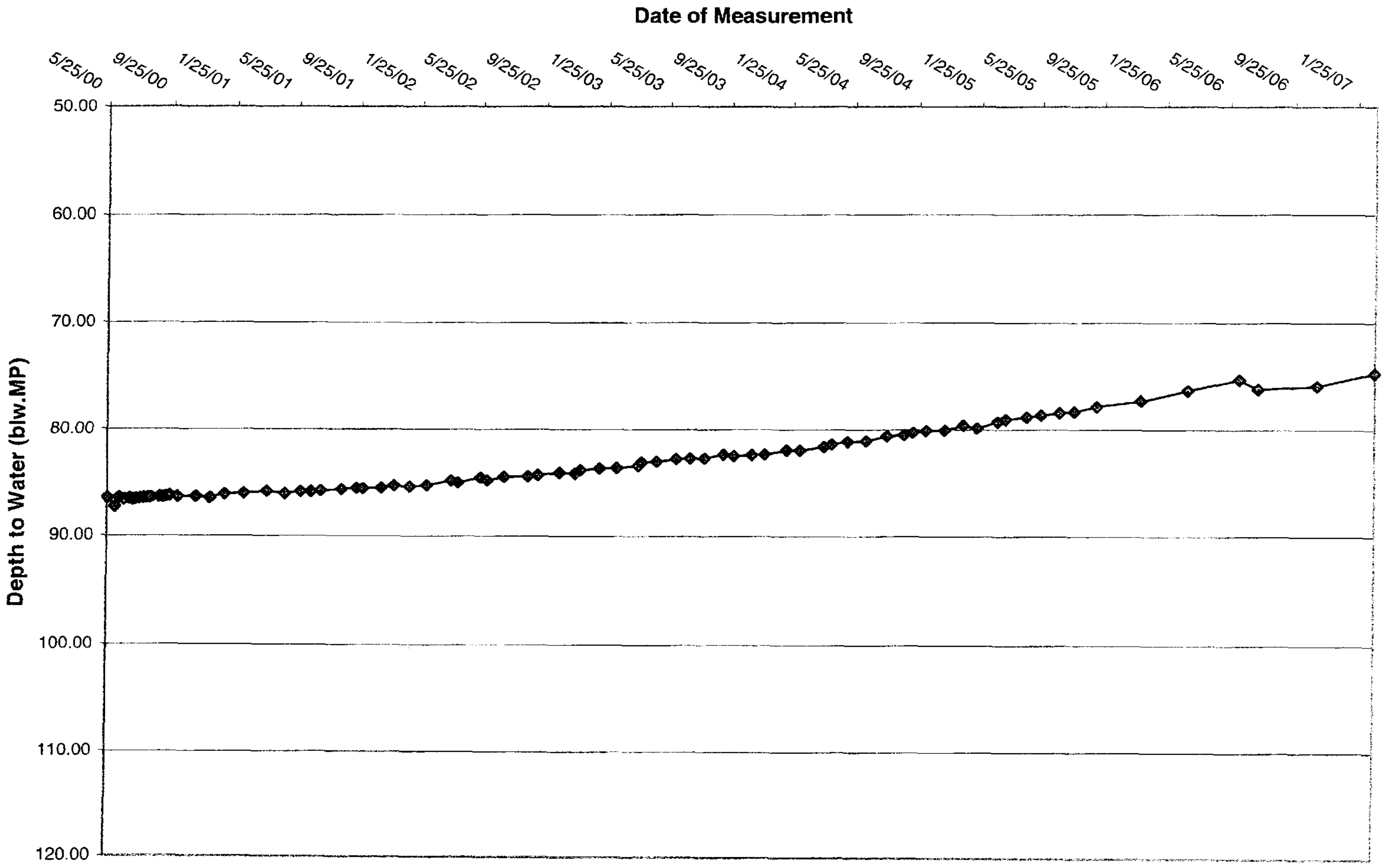
White Mesa Mill Temporary Well (4-4) Water Level Over Time



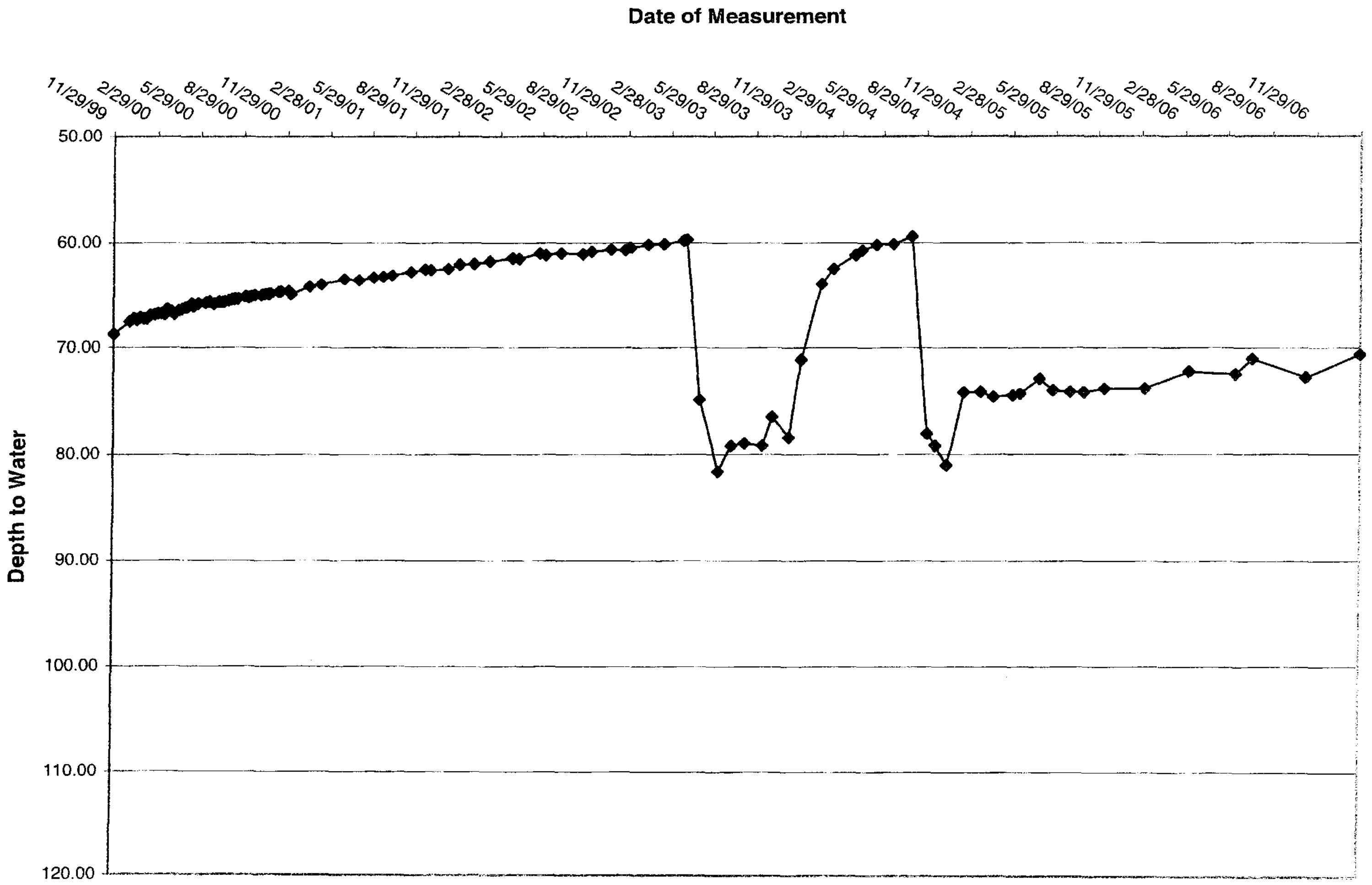
White Mesa Mill Temporary Well (4-5) Water Level Over Time



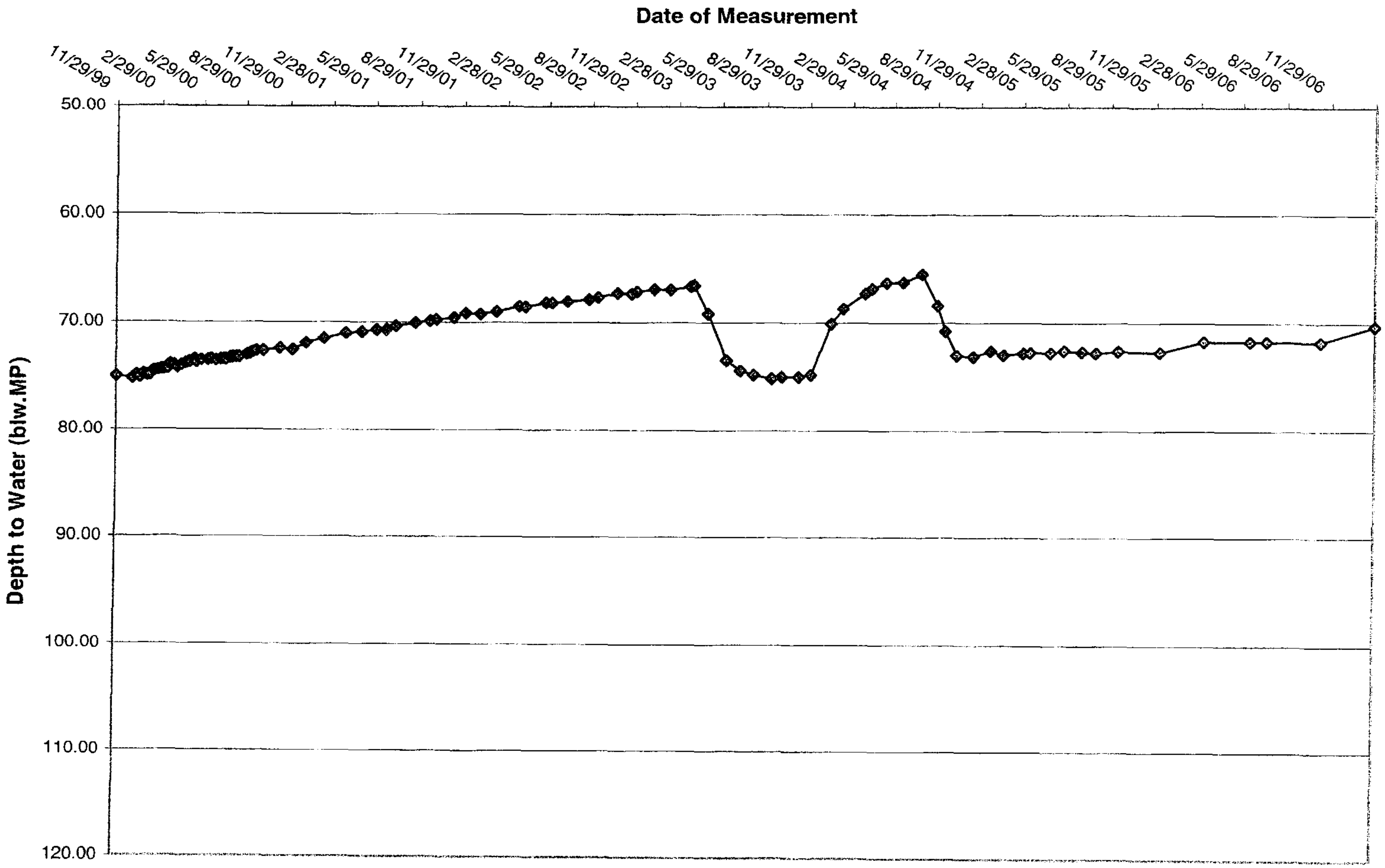
White Mesa Mill Temporary Well (4-6) Water Level Over Time



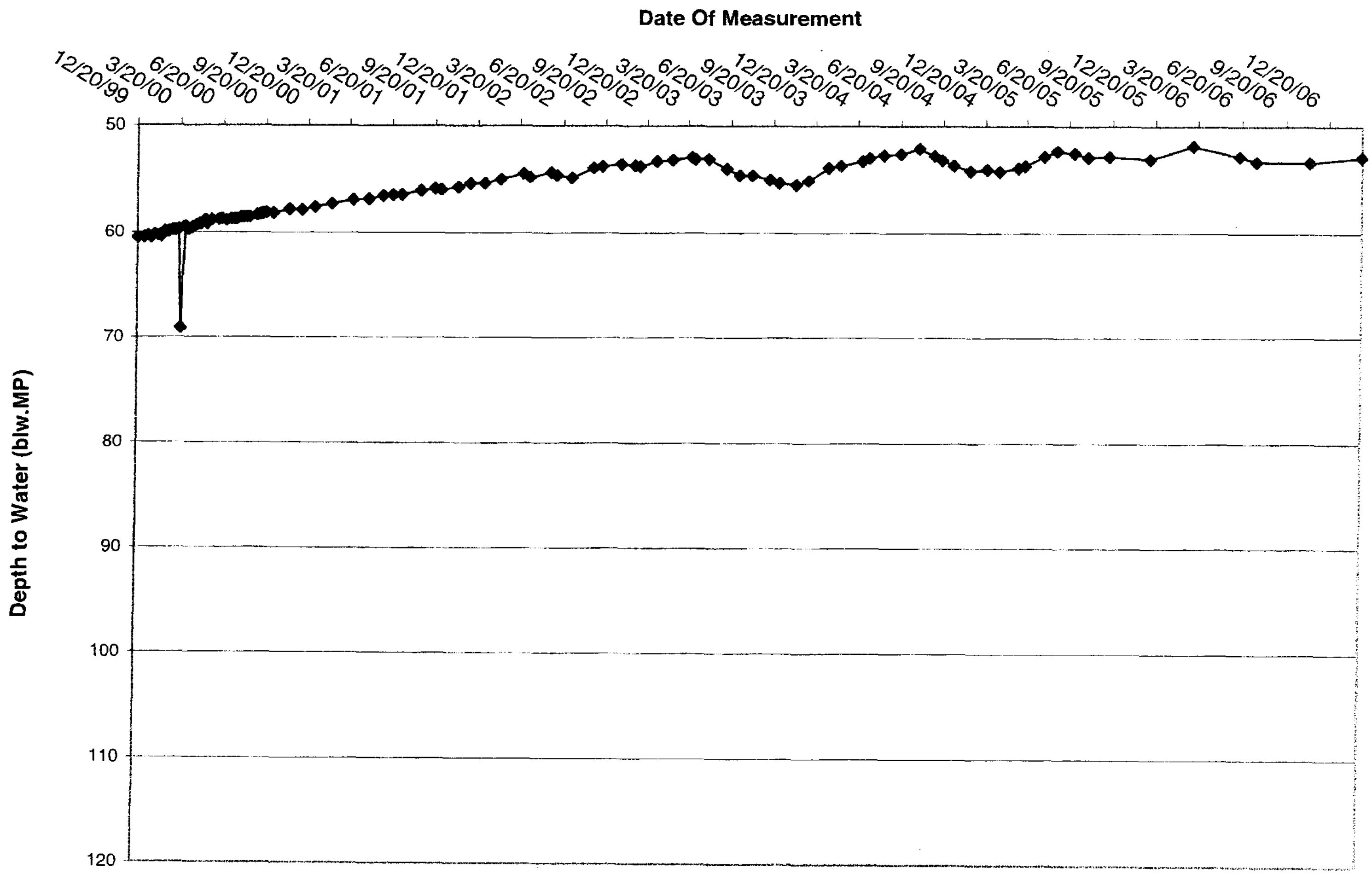
White Mesa Mill Temporary Well (4-7) Water Level Over Time



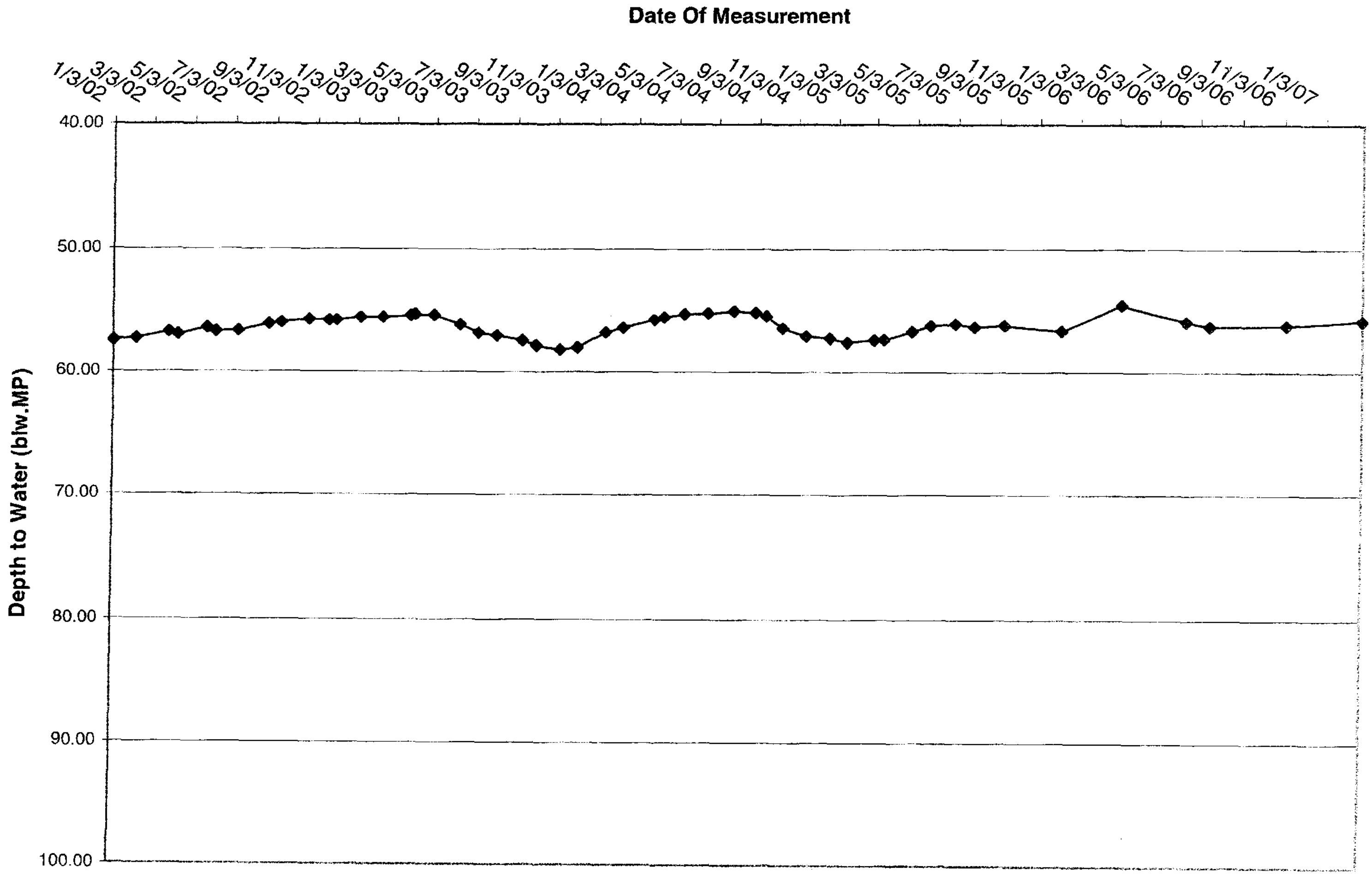
White Mesa Mill Temporary Well (4-8) Water Level Over Time



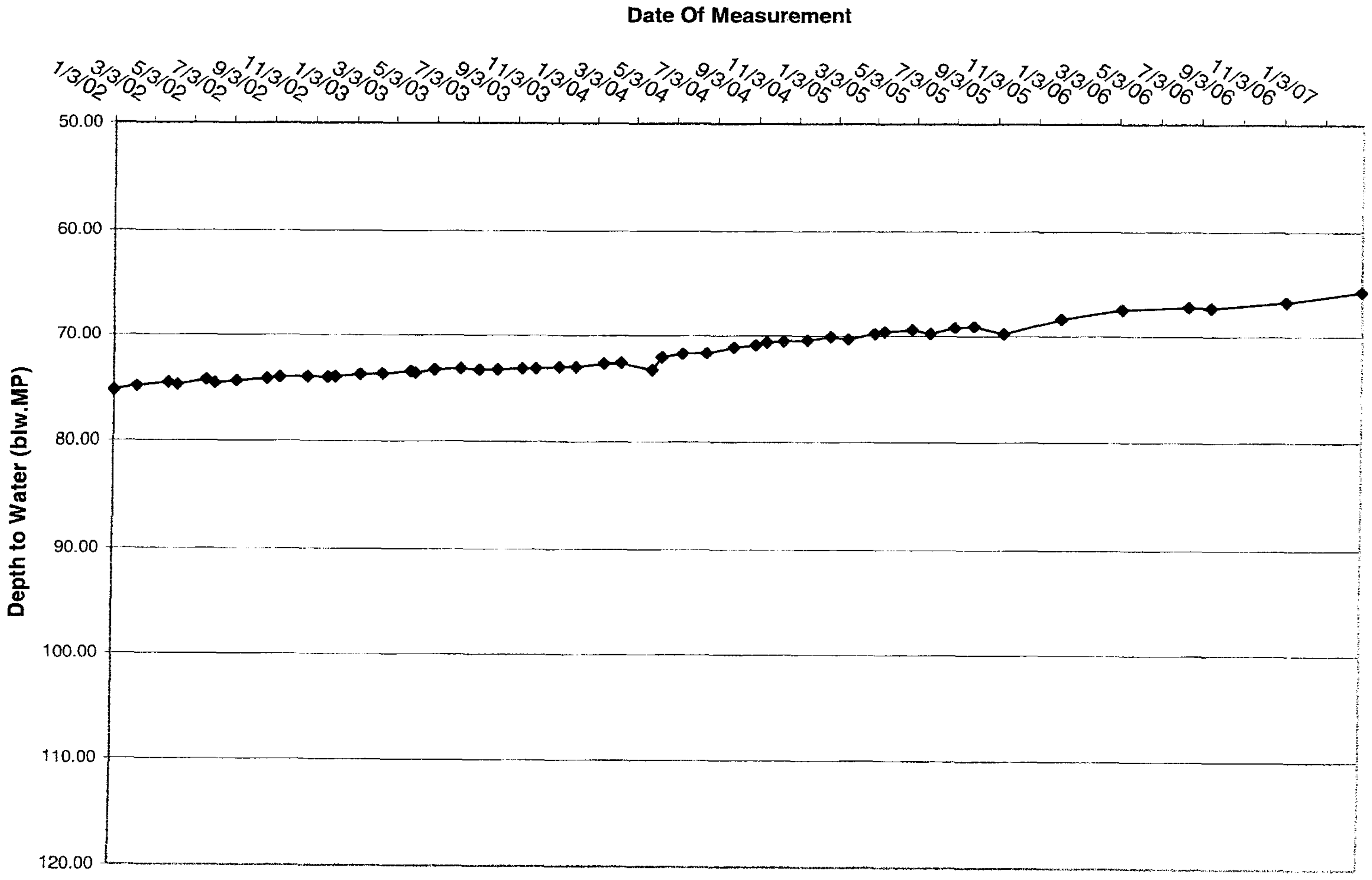
White Mesa Temporary Well (4-9) Over Time



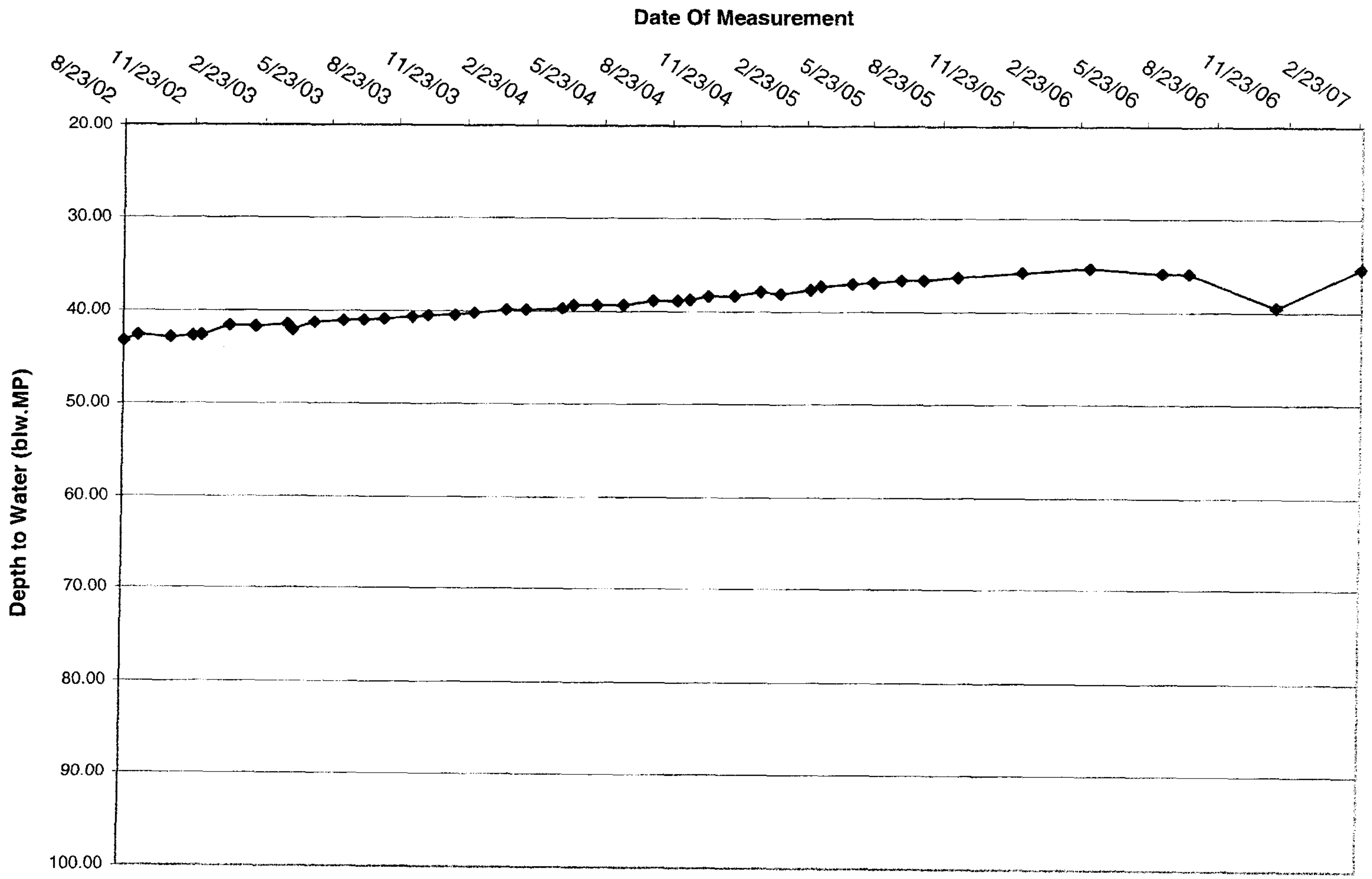
White Mesa Temporary Well (4-10) Over Time



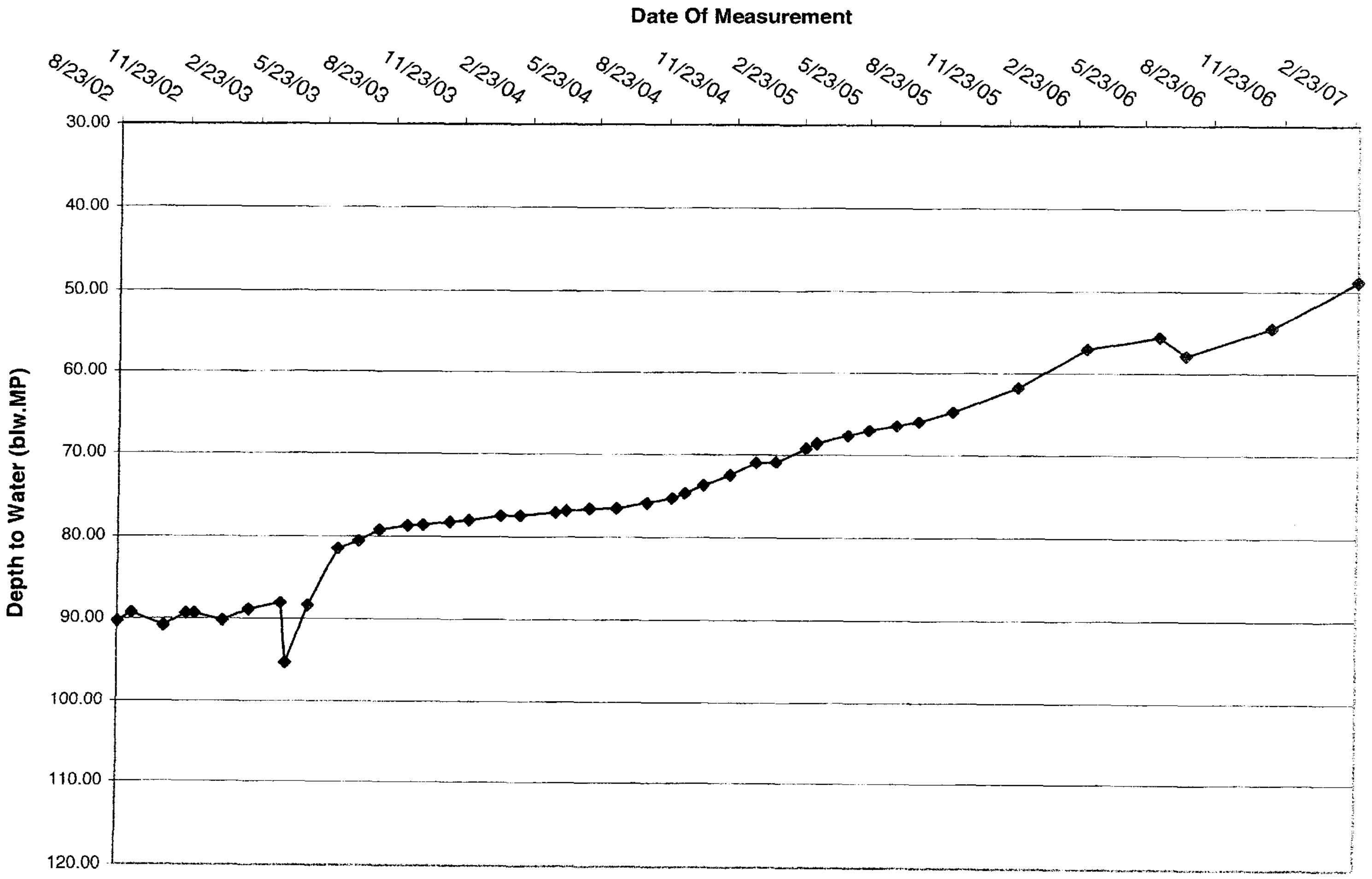
White Mesa Temporary Well (4-11) Over Time



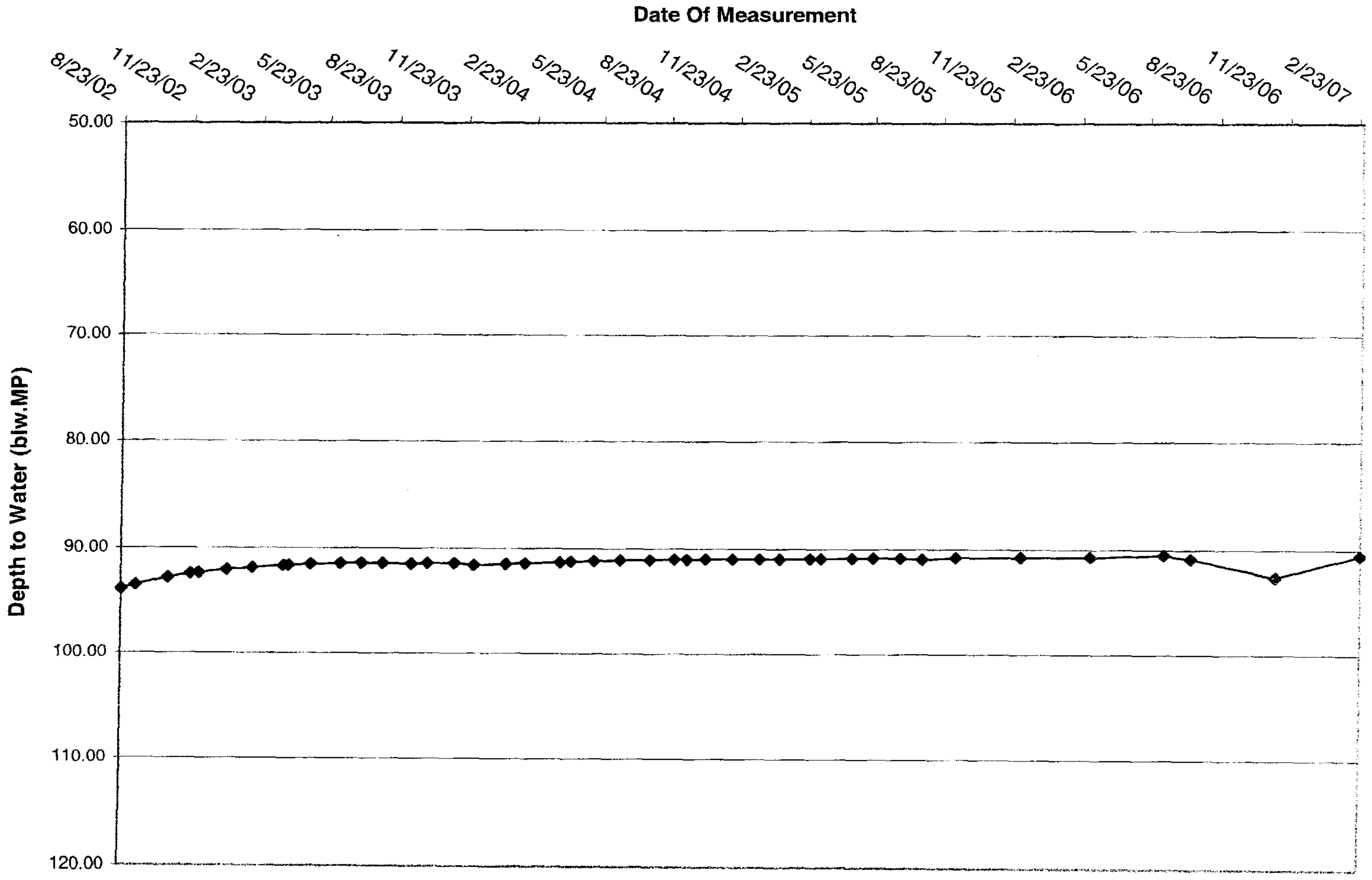
White Mesa Temporary Well (4-12) Over Time



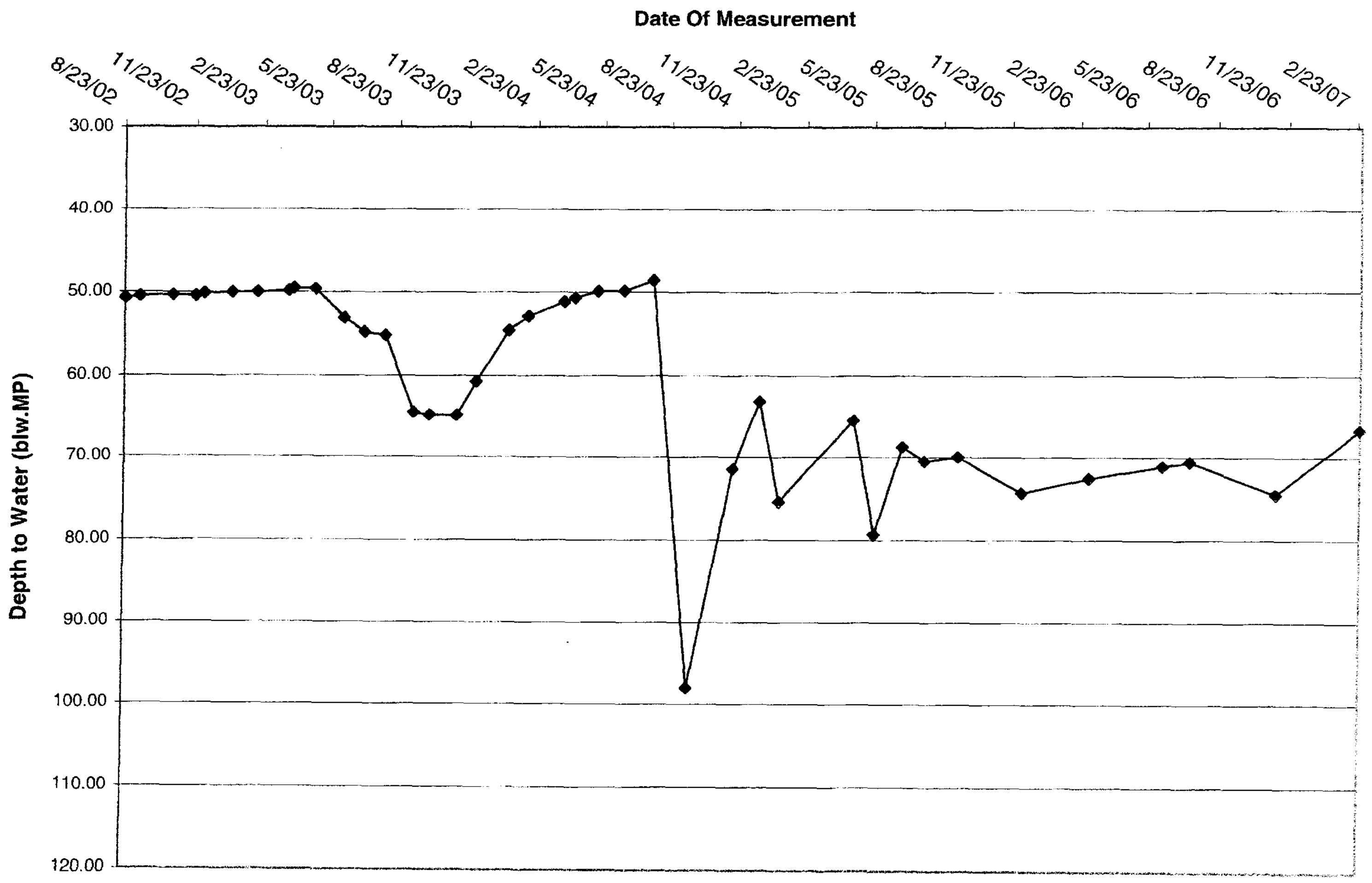
White Mesa Temporary Well (4-13) Over Time



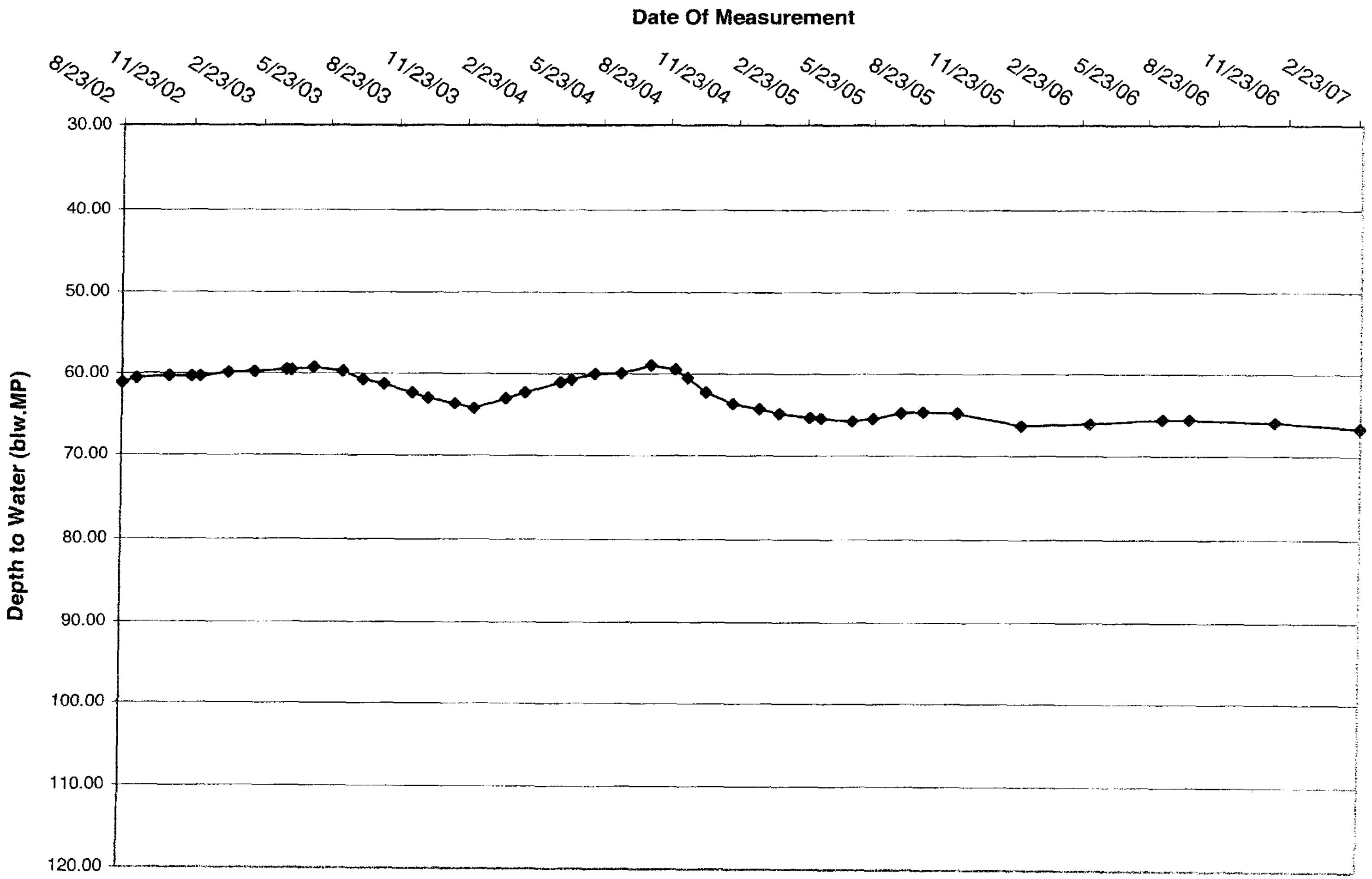
White Mesa Temporary Well (4-14) Over Time



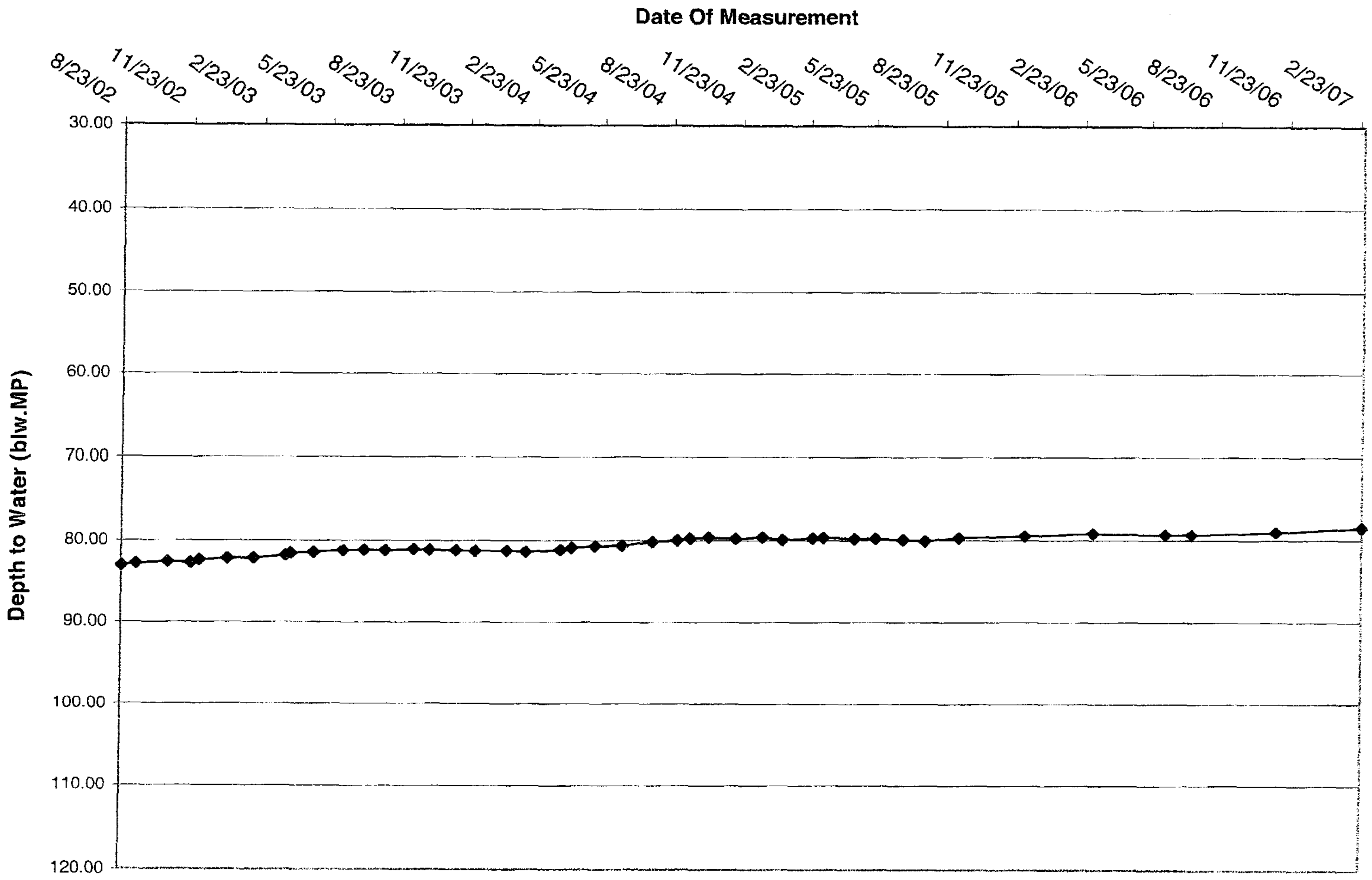
White Mesa Temporary Well (4-15) (MW-26) Over Time



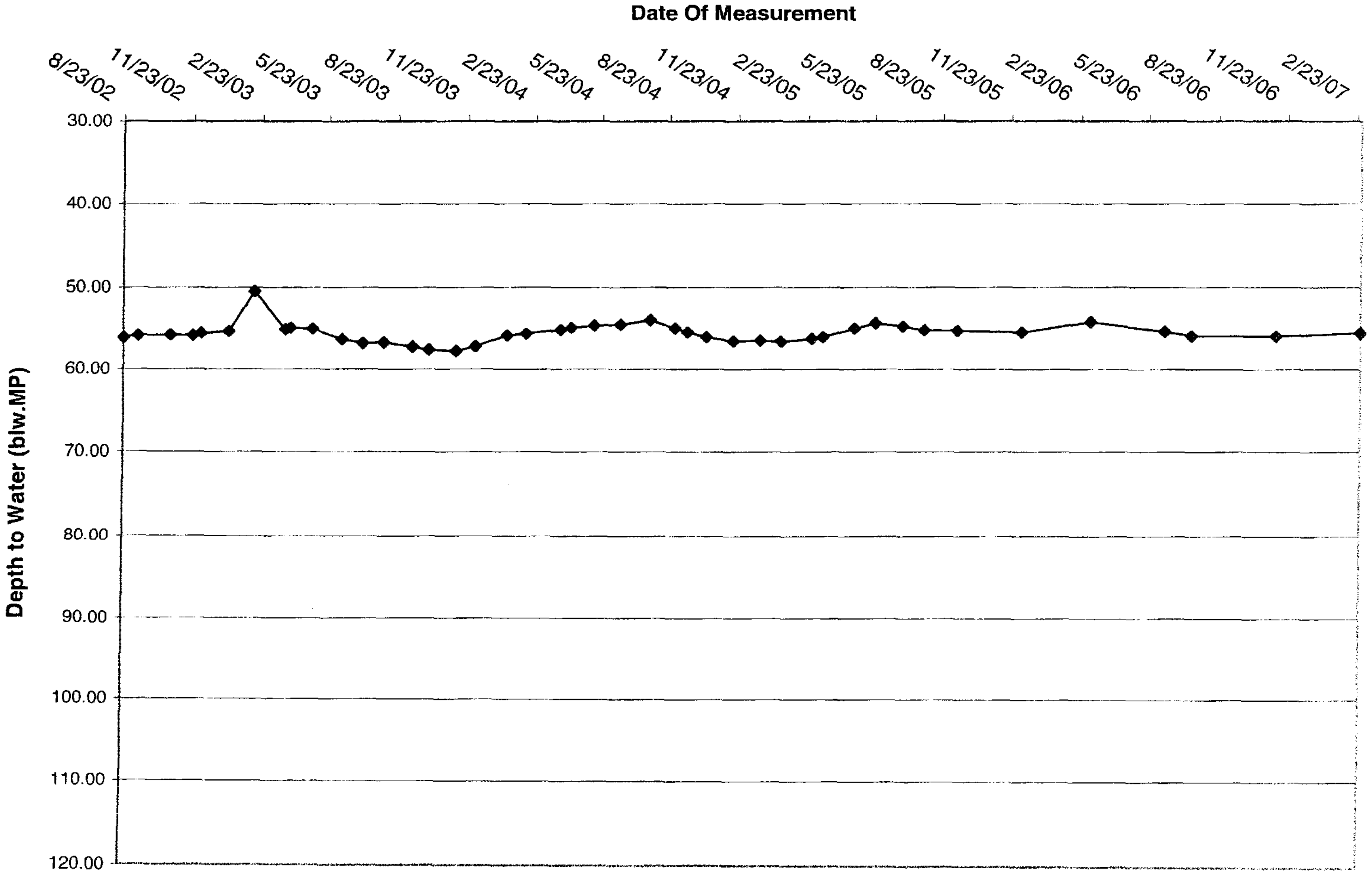
White Mesa Temporary Well (4-16) Over Time



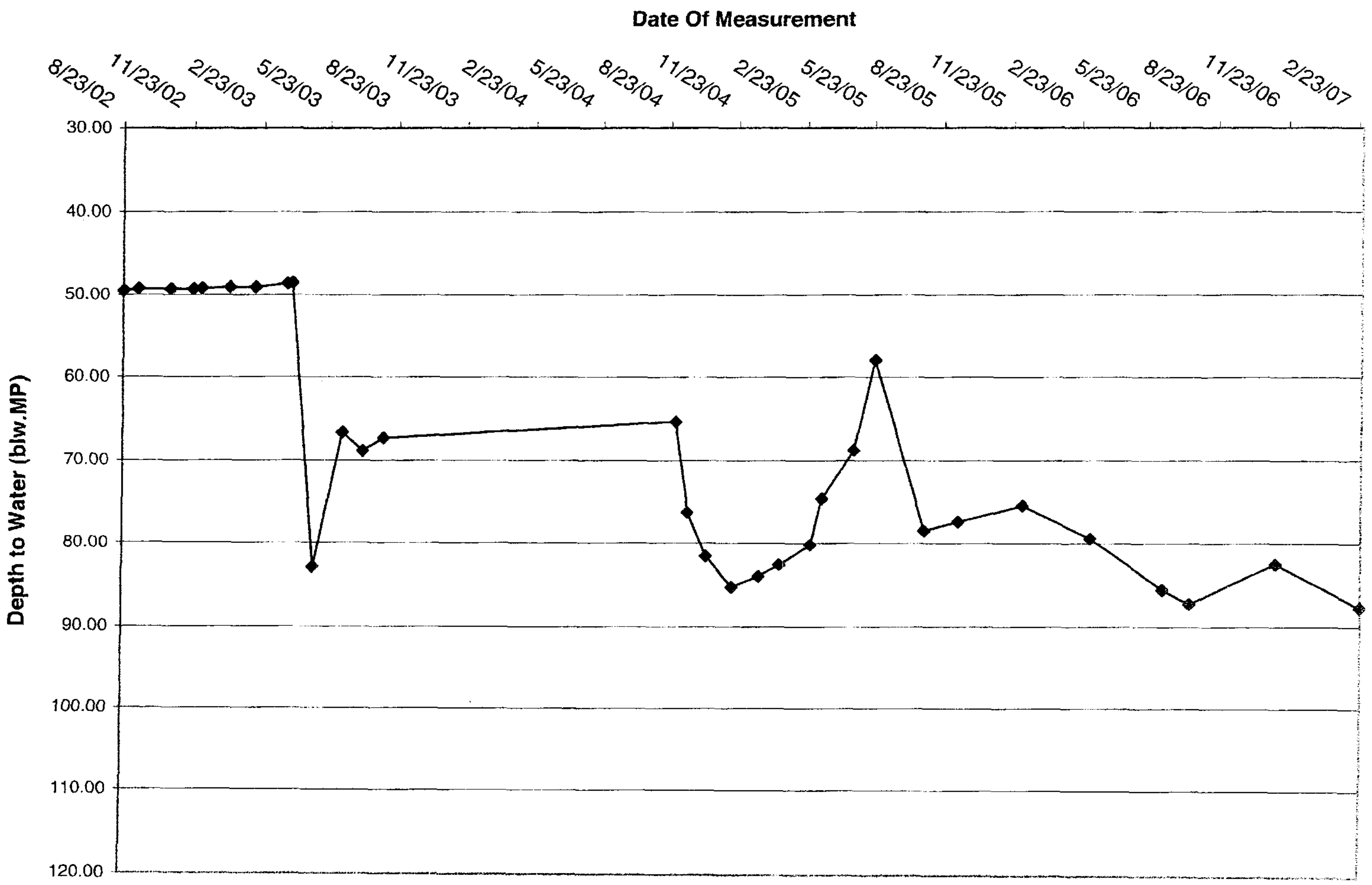
White Mesa Temporary Well (4-17) (MW-32) Over Time



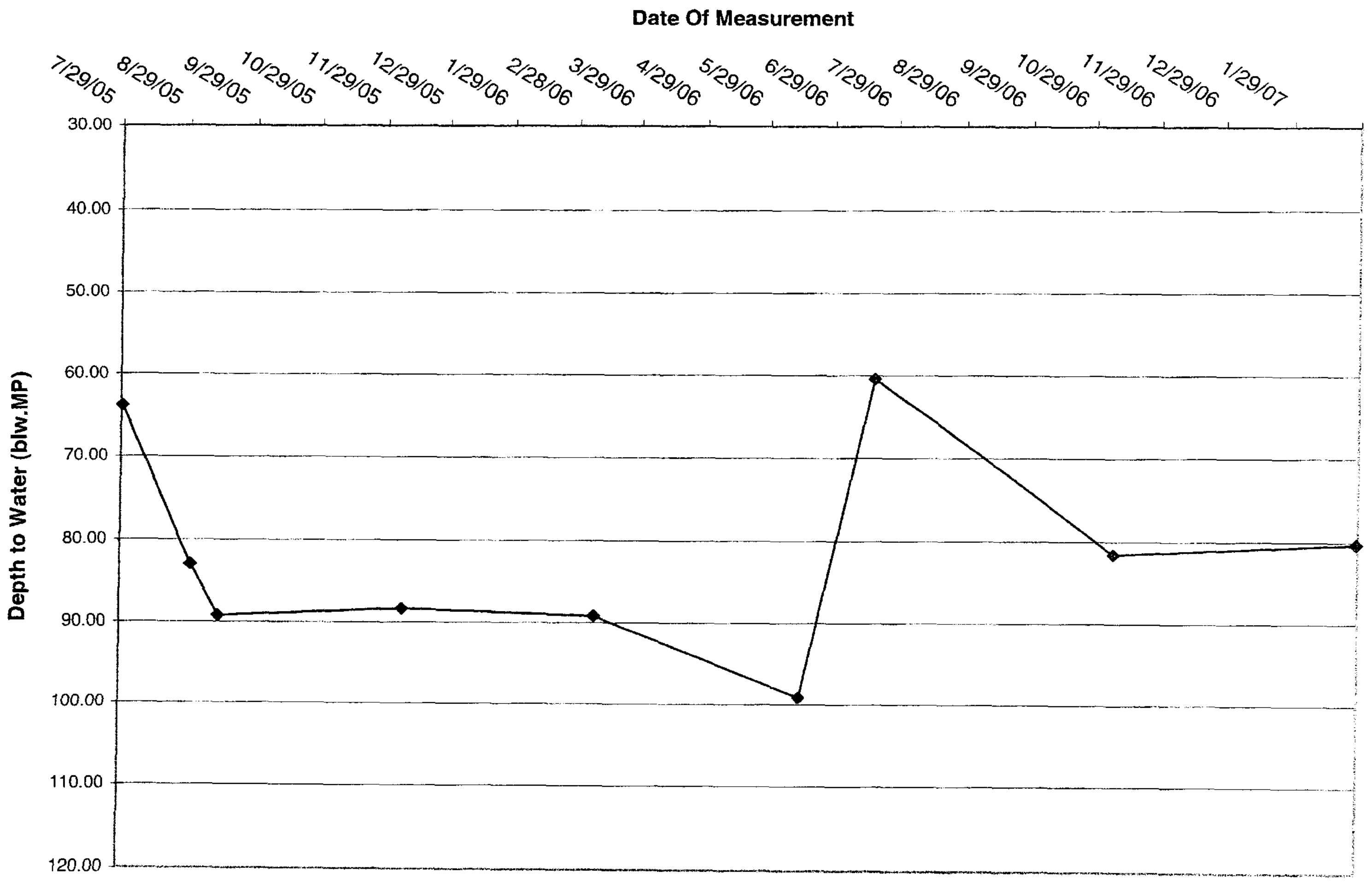
White Mesa Temporary Well (4-18) Over Time



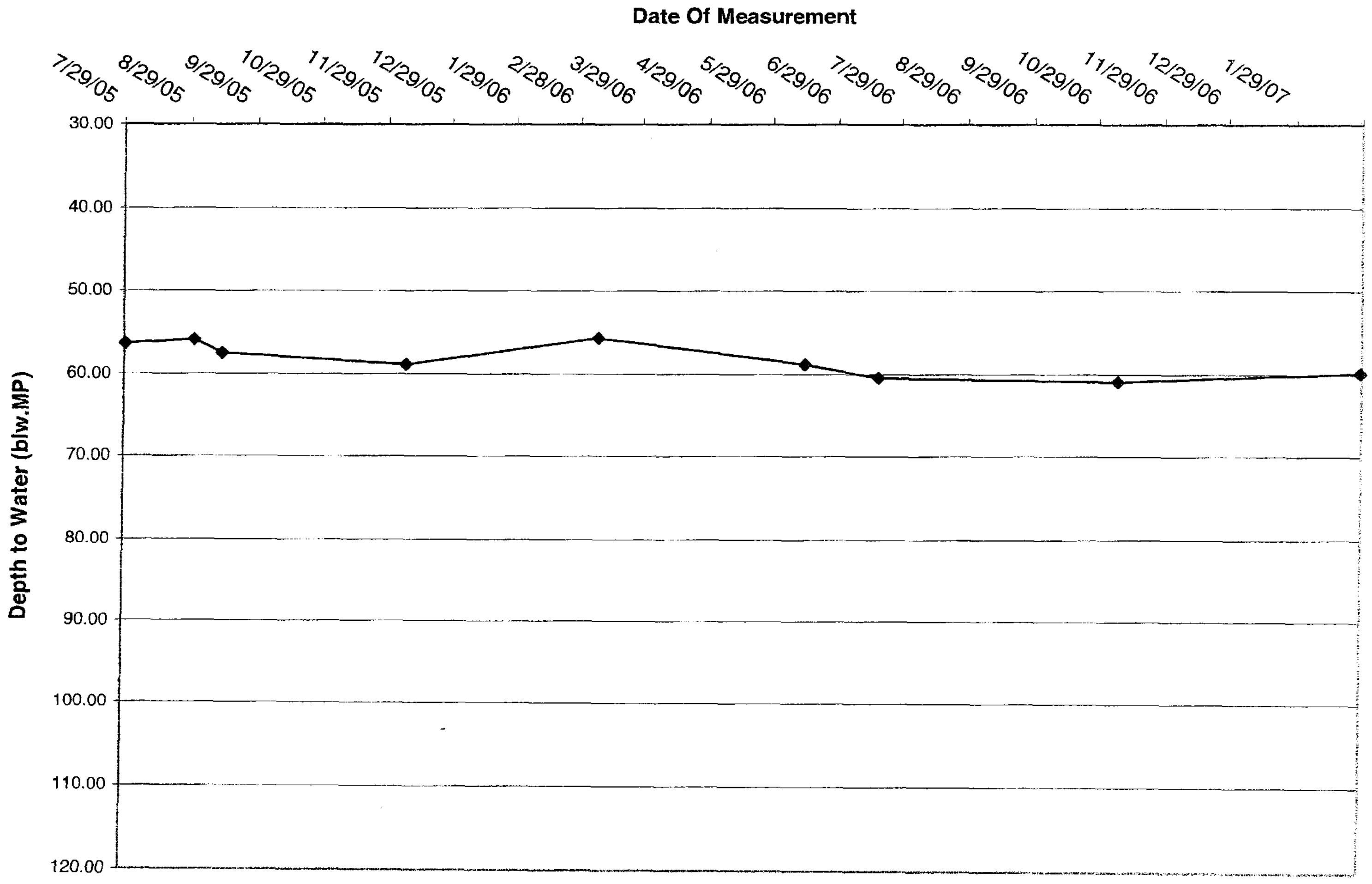
White Mesa Temporary Well (4-19) Over Time



White Mesa Temporary Well (4-20) Over Time



White Mesa Temporary Well (4-21) Over Time



White Mesa Temporary Well (4-22) Over Time