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Remediation System Evaluation (RSE) Vineland Chemical Company Superfund Site

Vineland, New Jersey

REMEDIATION SYSTEM EVALUATION

VINELAND CHEMICAL COMPANY SUPERFUND SITE
VINELAND, NEW JERSEY

Report of the Remediation System Evaluation
Site Visit Conducted at the Vineland Chemical Company Superfund Site
April 27-28, 2010

Final Report
March 11, 2011

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NOTICE

Work described herein was performed by GeoTrans, Inc. (GeoTrans) for the U.S. Environmental Protection Agency (U.S. E.P.A) and the U.S. Army Corps of Engineers Environmental and Munitions Center of Expertise in Omaha, Nebraska and Philadelphia District. Work conducted by GeoTrans, including preparation of this report, was performed under Work Assignment #1-58 of EPA contract EP-W-07-078 with Tetra Tech EM, Inc., Chicago, Illinois. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

PREFACE

This report was prepared as part of a project conducted by the United States Environmental Protection Agency Office of Superfund Remediation and Technology Innovation (U.S. EPA OSRTI) in support of the "*Action Plan for Ground Water Remedy Optimization*" (OSWER 9283.1-25, August 25, 2004). The objective of this project is to conduct Remediation System Evaluations (RSEs) at selected pump and treat (P&T) systems that are jointly funded by EPA and the associated State agency. The project contacts are as follows:

Organization	Key Contact	Contact Information
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1.0 INTRODUCTION

1.1 PURPOSE

During fiscal years 2000 and 2001 independent reviews called Remediation System Evaluations (RSEs) were conducted at 20 operating Fund-lead pump and treat (P&T) sites (i.e., those sites with P&T systems funded and managed by Superfund and the States). Due to the opportunities for system optimization that arose from those RSEs, EPA Office of Superfund Remediation and Technology Innovation (OSRTI) has incorporated RSEs into a larger post-construction complete strategy for Fund-lead remedies as documented in *OSWER Directive No. 9283.1-25, Action Plan for Ground Water Remedy Optimization*. A strong interest in sustainability has also developed in the private sector and within Federal, State, and Municipal governments. Consistent with this interest, OSRTI has developed a Green Remediation Primer (http://cluin.org/greenremediation/) and now as a pilot effort considers green remediation during independent evaluations.

The RSE process involves a team of expert hydrogeologists and engineers that are independent of the site, conducting a third-party evaluation of the operating remedy. It is a broad evaluation that considers the goals of the remedy, site conceptual model, available site data, performance considerations, protectiveness, cost-effectiveness, closure strategy, and sustainability. The evaluation includes reviewing site documents, potentially visiting the site for one day, and compiling a report that includes recommendations in the following categories:

- Protectiveness
- Cost-effectiveness
- Technical improvement
- Site closure
- Sustainability

The recommendations are intended to help the site team identify opportunities for improvements. In many cases, further analysis of a recommendation, beyond that provided in this report, may be needed prior to implementation of the recommendation. Note that the recommendations are based on an independent evaluation, and represent the opinions of the evaluation team. These recommendations do not constitute requirements for future action, but rather are provided for consideration by the Region and other site stakeholders.

The Vineland Chemical Company Superfund Site was selected by EPA OSRTI based on recommendations from the EPA Remedial Project Manager for the site and from the U.S. Army Corps of Engineers (USACE) Philadelphia District that provides oversight of remedial activities on behalf of EPA. The site is located in Vineland, New Jersey and consists of several operable units. This RSE specifically addresses Operable Unit 2 (OU2), which manages migration of the groundwater contaminant plume. The OU2 remedy is in the seventh year of a Long-Term Remedial Action (LTRA). In 2014, the responsibility for the OU2 remedy will be transferred to the State of New Jersey Department of Environmental Protection (NJDEP).

1.2 TEAM COMPOSITION

The RSE team consists of the following individuals:

Name	Affiliation	Phone	Email
Dave Becker	USACE – Omaha	402-697-2655	Dave.J.Becker@usace.army.mil
Lily Sehayek	USACE - Philadelphia	215-656-6463	Lily.Sehayek@usace.army.mil
Doug Sutton	GeoTrans, Inc.	732-409-0344	dsutton@geotransinc.com

In addition, the following individuals from EPA OSRTI participated in the RSE site visit.

- Kate Garufi
- Kirby Biggs

1.3 DOCUMENTS REVIEWED

The RSE team largely relied on data in electronic form provided by the USACE Philadelphia District and Sevenson Environmental, the operating contractor. These data included a data base of sampling results (contaminant concentrations and geochemical parameters) for groundwater, surface water, and process monitoring. Other electronic data provided to the RSE team included flow rates and meter readings, operations costs, and as-built drawings. The Philadelphia District also provided several PowerPoint files with figures of contaminant extent, hydrogeological setting, water levels, and other parameters.

Other documentation included:

- Record of Decision for the Vineland Chemical Superfund Site, 1989
- Explanation of Significant Differences, Vineland Chemical Superfund Site, 2001
- NAD Groundwater Center of Excellence Memo dated 2-21-2010, Impacts from turning off Vineland Superfund Site recovery wells
- Operations Manual, Vineland Chemical Company Superfund Site, OU-2 Groundwater Treatment Plant SCADA Upgrade
- Classification Exception Area and Well Restriction Area Report for Vineland Chemical
- Company Superfund Site, USACE Philadelphia District, May 2007
- An analysis of lighting options by Veteran Energy Technology, December 2009

1.4 PERSONS CONTACTED

The following individuals associated with the site were present for the visit:

Name	Affiliation	Phone	Email
Ron Naman	EPA – RPM	212-637-4375	Naman.ronald@epa.gov
Laura Bittner	USACE		
Mark Chamberlain	USACE		
Eric Charlier	USACE		
Steve Creighton	USACE		
Steve Gillespie	Sevenson		
Tom O’Neill	NJDEP		
Ken Quirk	USACE		
Dan Sirkis	USACE		
Glen Stevens	USACE		
Chad Van Sciver	NJDEP		
Charles Van Winkle	Sevenson		
Rich Vona	USACE		

1.5 Basic Site Information and Scope of Review

1.5.1 Location

The Vineland Chemical Superfund Site is located in the northwestern portion of Vineland, in Cumberland County, south central New Jersey, in an area of mixed industrial, low-density residential and agricultural properties. The site is bordered immediately to the north by other industrial properties and the Blackwater Branch, a perennial stream that flows westward to the Maurice River. See Attachment A for figures that illustrate the site location.

1.5.2 Site History, Potential Sources, and RSE Scope

The text in this section has been extracted from the 1989 Record of Decision (ROD) and the 2001 Explanation of Significant Difference (ESD). The Vineland Chemical Company operated from 1949 to 1994 and produced arsenical herbicides and fungicides. There were twelve buildings and five abandoned chicken coops on the plant site. Some of these structures were used by the Vineland Chemical Company for various manufacturing purposes.

As early as 1966, the New Jersey Department of Health observed untreated wastewater being discharged into unlined lagoons at the Vineland site. This wastewater was contaminated with arsenic at concentrations up to 67,000 parts per billion (ppb). Waste salts containing 1-2 percent arsenic were stored outside in uncovered piles. Precipitation dissolved some of these salts and carried them into the groundwater and eventually into nearby surface water bodies. Contaminated sediment was mapped 1.5 miles downstream in Blackwater Branch to its confluence with the Maurice River and then 7.5 miles downstream to Union Lake.

In 1988, EPA conducted a Remedial Investigation and Feasibility Study (RI/FS) to determine the nature and extent of the contamination and to develop remedial alternatives to address the contamination. The ROD was signed in 1989 and called for *in-situ* soil flushing of contaminated site soils, management of migration for contaminated groundwater through groundwater extraction and treatment with either re-injection or discharge to surface water of the treated water. Contaminated sediment along the Blackwater Branch was to be excavated and treated by *ex-situ* soil washing following establishment of control of contaminated groundwater through the extraction system. If natural processes do not allow attainment of action levels, additional excavation/dredging of sediment in the Maurice River would be conducted. Contaminated sediments near the shore of Union Lake were to be dredged and removed. The groundwater extraction and treatment system was constructed and first started operation in 2000.

An ESD was signed in 2001 that modified the remedy for on-site soils to be *ex-situ* soil washing. Excavation and treatment of soils on the Vineland Chemical Site began in 2003 and was completed in 2007. The Blackwater Branch west of the site is currently undergoing remediation. A portion of the stream north of the site has been remediated and restored.

1.5.3 HYDROGEOLOGIC SETTING

The text in this section is extracted from the *Classification Exception Area and Well Restriction Area Report (CEA Report).* The site is located in the Atlantic Coastal Plain physiographic province, which consists of a seaward-dipping wedge of unconsolidated sediments (sand, silt, clay, and gravel) that range in age from Cretaceous to Quaternary. Locally the site is situated on a relatively level plain that slopes slightly from the southeast toward the northwest with topographic elevations that range from 65 to 75 feet above mean sea level.

Groundwater levels vary seasonally at the site with an average of approximately 10 feet below ground surface (bgs), and a typical minimum and maximum of between 4 and 19 feet bgs. Shallow groundwater at the site occurs within the Kirkwood-Cohansey aquifer system. Three distinct hydrogeologic units have been identified during previous investigations (including split-spoon sampling and borehole geophysical logging) completed at the site: 1) Shallow Cohansey upper sand (0 to 70 feet bgs); 2) Banded Zone (35 to 70 feet bgs); and 3) Middle Cohansey sand (60 to 125 feet bgs). The shallow and middle Cohansey aquifers generally consist of fine to coarse grained sand with little fine material (i.e., clay). The Banded Zone, which is situated between the shallow and middle aquifer zones, consists of alternating layers of sand, silt, and clay, and has an average thickness of about 10 to 25 feet. It is likely that this unit acts as a leaky, semi-confining layer and may impede shallow contamination from migrating vertically to the deeper aquifer zones.

Under non-pumping conditions, groundwater flow in the shallow Cohansey aquifer at the site is toward the west – northwest (see Attachment A). Attachment A also includes figures depicting the shallow Cohansey aquifer groundwater elevations measured in 2003 at the site shallow monitoring wells and mid-depth monitoring wells. The groundwater elevations of the extraction wells are not included in this water elevation contouring. The direction and gradient of flow are consistent with both previous and recent groundwater elevation monitoring.

Groundwater modeling of the site indicates that the hydraulic conductivity at the site ranges from 350 to 700 feet per day. The hydraulic gradient ranges from approximately 0.0017 to 0.002 feet per foot.

1.5.4 POTENTIAL RECEPTORS

The text in this section is extracted from the *CEA Report.* Previous investigations included well inventory searches in the site vicinity to identify potential water users that may affect water levels at the site. The only public well identified within a 1-mile radius of the site is owned by the Vineland Water Authority (VWA). This well is located along Mill Road, approximately 9/10 of a mile south of the site. The VWA has also indicated that this supply well is only used as a backup water supply source and that there are no other VWA or industrial supply wells near the site. In addition, all residential, commercial, and industrial properties in the area (and identified during the survey) are connected to the public water supply system operated by the VWA.

The NJDEP Bureau of Water Allocation (BWA) database was also reviewed for potential supply wells in the area. One well identified from this search was an irrigation well with a capacity of 400 gpm, that is reportedly located at the intersection of Garden and Mill Roads, approximately 1 mile north of the site. However, a visual search by the site team of this area did not reveal the location of this well.

Blackwater Branch and surface water downstream of the Blackwater Branch, including the Maurice River and Union Lake, are the primary potential receptors of groundwater contamination. The objectives of the Record of Decision, as discussed in Section 3.0 of this report are focused on protecting and restoring Blackwater Branch.

1.5.5 DESCRIPTION OF GROUNDWATER PLUME

Groundwater contaminated by both organic and inorganic arsenic is generally limited to the Shallow Cohansey aquifer. Approximately eight monitoring wells are currently sampled in the deeper Middle Cohansey aquifer (below the Banded Zone aquitard) and arsenic has not been detected since 2006.

The Shallow Cohansey aquifer has been subdivided into shallow and “mid-depth” portions. Well pairs consisting of shallow and mid-depth wells have generally been installed (in some cases including a deeper Middle Cohansey aquifer monitoring well) at the site. Arsenic concentrations above the current maximum contaminant level (10 ug/L) are more wide spread in the shallow portion of the Shallow Cohansey and concentrations range from non-detect to approximately 3000 ug/L. Higher concentrations are currently found in the mid-depth wells (to over 8000 ug/L). There are apparently two overlapping arsenic plumes; one in the northern portion of the site and another in the southern portion. The plumes extend from the former locations of production and storage of product under North Mill Road toward the west-northwest toward Blackwater Branch. The plumes (of total arsenic concentration) are shown in figures included in Attachment A.

Note that anomalously high concentrations greater than 2000 ug/L of arsenic have been found north of the Blackwater Branch west of North Mill Road (MW-54S). This location near Blackwater Branch would be expected to be a discharge point for groundwater migrating from the north to surface water, so discovery of the contamination across the stream from the site was unexpected. The high concentrations in MW-54S are along the projected extension of the axis of the northern plume if extended across the stream. Note that there are records of an irrigation well with a 400 gpm capacity north of the site along North Mill Road (near its intersection with Garden Road), though this well could not be located (USACE, 2007). It is not clear if the pumping of that well could pull the plume under the stream. There are also anecdotal reports of waste disposal (presumably by Vineland Chemical Company staff) in the area across Blackwater Branch. Recent direct-push sampling has apparently defined the northern and western limits of the high concentrations north of Blackwater Branch, as reported by USACE Philadelphia District staff during the site visit.

The speciation of arsenic is periodically done and arsenic is generally found in the arsenate form, though arsenite concentrations can be higher. Organic arsenic compounds, are not as common. Refer to Section 4.2.3 for additional discussion of the speciation of arsenic reaching the treatment plant.

2.0 SYSTEM DESCRIPTION

The groundwater extraction and treatment system consists of 16 extraction wells; extraction piping; a treatment plant including oxidation, flocculation, and separation processes; and piping for discharge of the treated water to Blackwater Branch. In addition, a monitoring well network has been established consisting of at least 127 permanent monitoring wells sampled at some point. Each component is discussed in more detail below.

2.1 EXTRACTION SYSTEM

The extraction system consists of 16 wells screened in the Shallow Cohansey aquifer (see Attachment A for locations). Information about the wells is provided in table below. Most of the wells are set at the mid-depth portion of the aquifer just above the Banded Zone. Extraction wells RW02A and 02B were purposely set at shallower depth in areas of high concentrations in the shallowest portions of the aquifer. The wells are 8-inch diameter stainless steel casing and wire-wrapped screen fitted with submersible pumps and pitless adapters. A 1/2-inch "acid" pipe for the addition of chemicals to control bacterial growth and minimize fouling is set within the borehole, but outside the well screen. A 2-inch piezometer is installed adjacent to the 8-inch casing. The top of each well piezometer pair is encased in a 2-foot steel casing. Controls for each well are located at each well head.

Extraction well construction and pump information.

Extraction Well	Top of Casing Elev. (ft msl)	Elev. Ground Surface (ft msl)	Depth to Top Screen (ft)	Depth to Bottom of Screen (ft)	Pump Size (HP)	Yield (GPM)	Approx. Pumping Rate (GPM)
RW01	78.23	76.28	53	73	7.5	160	0
RW02	78.5	76.97	54	74	7.5	160	65
RW02A	-	76.71	25	45	5	124	95
RW02B	-	74.43	25	45	5	125	65
RW03	72.66	70.62	37	57	5	115	65
RW04	75.19	73.39	41	61	2	100	55
RW05	74.25	72.56	37	57	2	138	65
RW06	74.59	72.93	29	49	5	105	40
RW07	74.16	72.37	24	44	2	90	70
RW08	66.69	64.76	12	32	5	145	65
RW09	76.78	75.04	20	40	7.5	20	0
RW09A	-	66.11	19	39	7.5	150	60
RW10	71.83	70.14	21	41	7.5	50	35
RW11	74.74	73.1	30	50	7.5	50	0
RW12	72.47	70.73	29	49	7.5	107	75
RW13	71.3	69.46	29	49	7.5	63	0

The extraction wells are connected to the treatment plant via buried double-walled high-density polyethylene (HDPE) piping. Separate piping was provided for extraction wells 1 through 10 to allow separate transport of groundwater contaminated by inorganic or organic forms of arsenic from any well. Other extraction wells discharge through a common header. As discussed below, the treatment plant was originally designed to allow separate treatment of these two forms of arsenic. Extraction wells 9A, and 11 through 13 can only be directed to the inorganic treatment train. Extraction wells 2A and 2B are piped to the equalization tank. The collection headers originally ran from extraction well RW01 on the northeast side of the system westward to RW08, southward to south of RW13 then eastward to the treatment plant. At the site visit, it was learned that an additional header was installed from near RW03 to the treatment plant to provide additional groundwater transport capacity.

2.2 TREATMENT SYSTEM

The treatment facility consists of a 150-foot by 100-foot process building, external treatment components in a containment area, a 30-foot by 60-foot chemical storage area, a 40-foot by 50-foot solids handling building, and administrative building. The treatment system as originally designed is depicted in Figure 2-1. The processes include the following:

- addition of hydrogen peroxide to oxidize As(III) to As(V)
- ferric chloride addition as a coagulant
- sodium hydroxide addition to maintain pH ~6.5
- coagulation of iron and adsorption of arsenic to coagulated iron
- polymer addition and potassium permanganate to assist with flocculation
- solids separation with dissolved air flotation (DAF)
- additional sodium hydroxide and potassium permanganate for additional pH adjustment and floc formation
- sand filtration
- discharge to surface water
- solids thickening
- solids dewatering with a centrifuge
- off-site disposal of solids as hazardous waste

The treatment system as currently operated is depicted in Figure 2-2. It is apparent that the site team has significantly optimized the system. System optimization by the site team has resulted in many improvements to the treatment plant, including the following:

- addition of an equalization tank
- elimination of all potassium permanganate addition
- elimination of both organic treatment trains (all treatment completed by the inorganic treatment train)
- elimination of pH adjustment after the DAF
- addition of polymer to the solids to aid in dewatering
- upgrade to all system controls

As of the time of the RSE site visit, the plant operated 12 hours per day, 7 days per week. The plant was staffed by a full-time plant supervisor, three full-time operators, and a maintenance technician that shares time with other projects. A full-time chemist position and a full-time maintenance position were cut just prior to the RSE site visit. In addition, one operator has left as of July 2010 and will not be replaced, resulting in total operations staffing of 3.5 full-time equivalent employees. The OU2 remedy is also staffed by the following part-time positions: project manager, project engineer, sampling crew, administrator, and cost-estimator.

The treatment system, individual components, and staffing are discussed in more detail in Section 4.5 of this report.

2.3 MONITORING PROGRAM

Groundwater Monitoring

There are approximately 51 monitoring wells screened in the shallow portion of the Shallow Cohansey aquifer, 67 mid-depth monitoring wells in the same aquifer, and 9 monitoring wells in the Middle Cohansey that have been sampled in the last few years. In 2009, a total of 80 monitoring wells were sampled for total arsenic; 34 shallow, 40 mid-depth, and 6 deep. These wells are generally shown on Figure 2 of the CEA Report (see Attachment A). Most wells are sampled annually, and 11 shallow wells appear to be sampled on a semi-annual ("bi-annual" in project electronic records) basis, though the intervals appear to have varied. Optimization of the monitoring program has been periodically conducted. The monitoring program therefore involves approximately 90 monitoring well samples per year. These samples are analyzed for total arsenic but rarely for arsenic speciation. Sampling is done using low-flow techniques and purging adequacy is based on turbidity and oxidation/reduction potential (ORP) values. The arsenic detection limit is 9 ppb. Water levels are measured annually. Extraction wells are sampled monthly for arsenic. Data generated from the analyses are managed via a Microsoft Access data base.

Process Monitoring

Treatment plant process monitoring involves both on-site and off-site analysis.

Samples from the following locations at the indicated frequencies are analyzed off-site in a certified laboratory.

- Each extraction well monthly for total arsenic
- Speciation of arsenic in influent and effluent quarterly
- Influent weekly (before oxidation tank) for total arsenic
- Effluent weekly for arsenic
- Effluent bi-weekly for potassium, iron, manganese, sodium, conductivity, alkalinity, pH, total dissolved solids, total suspended solids, and chloride
- After each DAF unit monthly for total arsenic
- Sludge thickener overflow monthly for total arsenic
- Dewatered solids once pear year for total arsenic

Samples from the following locations at the indicated frequencies are analyzed for total arsenic on-site by the plant operators using a graphite furnace.

- Equalization tank effluent each morning
- Filter feed tank every two hours during the day
- Plant effluent every two hours during the day

The effluent is analyzed for total arsenic hourly with a real-time arsenic autosampler and analyzer.

In addition to the above water quality analyses, the following parameters are measured automatically using meters and are used to control plant operations:

- oxidation-reduction potential (ORP) is measured in the oxidation tank
- pH is measured in the coagulation tank and the filter feed tank
- turbidity is measured after each of the DAFs, prior to filtration, and after filtration

3.0 SYSTEM OBJECTIVES, PERFORMANCE, AND CLOSURE CRITERIA

3.1 CURRENT SYSTEM OBJECTIVES AND CLOSURE CRITERIA

The 1989 Record of Decision (ROD) discusses remediation alternatives at four operable units. Only two of the operable units are considered herein, plant site soils control and plant site groundwater management and migration. The following Remedial Action Objectives for contaminated soils and groundwater at the Vineland Chemical plant site were identified in the 1989 ROD:

- Prevent current or future exposure to the contaminated site soils
- Reduce soil arsenic migration into the groundwater
- Eliminate contaminated groundwater flowing into the stream to remediate stream water quality

The cleanup goals include the following:

- The plant site soil cleanup objective is 20 mg/kg.
- The plant site groundwater cleanup objective is 0.05 mg/l.

According to the ROD, the groundwater cleanup goal "*will be achieved to the maximum extent that is technically practicable.*" The ROD calls for the design of a groundwater remediation system that includes "*a combination of pumping and treatment with subsequent natural attenuation of the aquifer to reach the cleanup goal.*" According to the ROD, the end point for pump and treat is when "*resumption of groundwater flow to the Blackwater Branch would not cause violation of arsenic instream standard in that body, 0.05 mg/L.*" The ROD also allows for "*an application for an Alternate Concentration Limit (ACL)…in accordance with appropriate New Jersey regulations, if, for example pumping and treatment appears to reach a point where it is no more effective than natural attenuation. The need for an ACL and its value would be determined during the early years of the remedial action on the aquifer.*" Pumping followed by natural flushing was evaluated in the RI/FS. The alternatives considered specified operation of the pumping and treatment system "*until the maximum groundwater arsenic concentration is 0.35 mg/l*." At this concentration, based on the RI/FS information, groundwater flowing to the Blackwater Branch would not cause the in stream standard of 0.05 mg/l to be violated. The RI/FS estimated that *"approximately 10 years would be required for natural flushing to reduce the arsenic concentration to 0.05 mg/l after achieving the 0.35 mg/l level."*

3.2 TREATMENT PLANT OPERATION STANDARDS

The NPDES equivalency permit, dated September 23, 1997, for surface water discharge lists the standards for discharging treated water to Blackwater Branch. The parameters, criteria, and sampling frequency are as follows:

- Flow (continuous monitoring)
- Total Arsenic < 0.05 mg/l (sample two times per month)
- Total Dissolved Solids < 500 mg/l (sample two times per month)
- Total Suspended Solids < 40 mg/l (sample two times per month)
- pH between 6.5 and 8.5 (sample weekly)

With the exception of flow, which is monitored continuously, the site team collects and analyzes samples for these parameters on a weekly basis, which is more conservative than the required frequency.

Additional treatment plant effluent parameters monitored on a weekly basis include:

- Total metals (Iron, Manganese, Sodium, Potassium)
- Conductivity
- Alkalinity
- Chloride

Despite the above criteria, the site team has made the internal decision to treat water to under 0.02 mg/l in an effort to come closer to achieving the current Federal Maximum Contaminant Level (MCL) for arsenic.

4.0 FINDINGS

4.1 GENERAL FINDINGS

Several overall site improvements have resulted directly from operation of the pump and treat system. The most important of these include a general decrease in the maximum arsenic plume concentrations and a dramatic reduction in surface water contamination in Blackwater Branch. Protection of Blackwater Branch is a primary objective of the groundwater program and has allowed excavation for floodplain sediment remediation (Operable Unit 3) to proceed. The groundwater treatment plant operation also supported source removal (Operable Unit 1) in treating effluent from the soil washing plant.

The observations provided below are not intended to imply a deficiency in the work of the system designers, system operators, or site managers but are offered as constructive suggestions in the best interest of the EPA and the public. These observations have the benefit of being formulated based upon operational data unavailable to the original designers. Furthermore, it is likely that site conditions and general knowledge of groundwater remediation have changed over time.

4.2 SUBSURFACE PERFORMANCE AND RESPONSE

4.2.1 PLUME CAPTURE

The extraction system performance was evaluated based on several lines of evidence, including analysis of the piezometric surface contour maps, concentration contours and trend analysis, groundwater flux estimates compared to pumping rates, and review of model results. This is generally in accordance with EPA guidance in assessing capture zones for groundwater extraction systems (EPA, 2008).

Piezometric surface maps were constructed by the RSE team based on water levels measurements taken in 2010 for shallow, mid-depth, and deep wells (see Figures 4-1 and 4-2). *Note that questions have been raised regarding the comparability of surveyed reference elevations for a number of the monitoring wells, particularly those near the vicinity of Blackwater Branch west of North Mill Road. The impact of this is not yet entirely clear.* General flow directions are to the northwest. Clear indications of composite cones of depression are apparent in the shallow and mid-depth contour maps. The pumping of the northeastern extraction wells – RW02, 02A, 02B, 03, 04, 06, and 07 – have induced a northeasterly gradient adjacent to the northern arsenic plume, and contours parallel Blackwater Branch in this area. Pumping of the western wells – RW08, 09, 09A, 10, and 12 – have created a westerly gradient for the western portion of the site, particularly along the western extent of the southern arsenic plume. A groundwater divide has been established between these two “lines” of wells, and the northern arsenic plume sits atop this divide. It appears that contaminant migration could occur northward toward the stream outside of the capture of extraction wells RW07 and 08, but other lines of evidence are needed to more fully assess this possibility. Capture appears reasonably complete to the east and south of MW31S/M. There is a lack of water level information between the extraction wells and Blackwater Branch to the northeast that could be addressed by additional monitoring points and/or including the water level of Blackwater Branch. Potentiometric surface contours prepared by the site team using 2003 data and contouring software (see Attachment A) indicate substantial flow from Blackwater Branch to the extraction wells, which might be consistent with the RSE team potentiometric contours if water elevation information from Blackwater Branch was included. Site ground water model interpretations of the system capture zone are illustrated in Attachment A.

The natural flux of groundwater under non-pumping conditions was estimated based on historical pre-pumping groundwater contours provided by USACE Philadelphia District (PowerPoint slides on model development reportedly from 2004), model calibrated hydraulic conductivities (K) of 350 to 700 ft/day, an estimated conservative maximum saturated thickness of 60 feet (erring on the side of a larger natural flux), and a plume width of 1200 feet. The gradients estimated from the contours were 0.0017 to 0.002 and 0.002 was used in the calculation. Flux was calculated to approximately 260 gpm with K = 350 ft/day and 520 gpm with K = 700 ft/day. Total pumping for the extraction system is approximately 700 – 800 gpm. This exceeds the natural flux, so there is circumstantial evidence that at least most of the plume is likely to be captured. Note that any water pumped beyond the natural flux through the contaminated part of the aquifer is extracted from clean zones to the southwest or from Blackwater Branch. It is likely the extraction system is drawing a significant amount of water from the stream, particularly with the eastern extraction wells. Though the site groundwater model provides a more robust tool to assess capture, these calculations are a reasonable check on the model results.

The concentrations trends were computed for the wells using both qualitative and quantitative (Mann-Kendall) analysis. Trends for wells near and downgradient of the extraction well lines were examined for indications of contaminant “breakthrough.” Most of the applicable wells display stable or decreasing trends, with a few exceptions. Some wells displayed an increase during and following excavation activities on-site, with recent declines following completion of that work. This is a common observation at sites undergoing large-scale disturbance. However, MW38S appears to have an ongoing increasing trend, as does MW40S. MW53S has qualitative evidence of recently increasing concentrations. These exceptions are important because these are in areas in or downgradient of broader gaps in the extraction system (MW40S is the larger gap between RW07 and 08; MW38S is between RW02 and 03. Note that contamination moving through these gaps may still be captured as some flow lines enter the extraction wells from the “downgradient” side of the capture zone. Still, this analysis does raise some questions about the adequacy of the capture in these areas.

Modeling analysis included simple analytical modeling done using a capture zone width formula and assessment of numerical modeling of capture zones conducted by USACE Philadelphia District. Based on the other lines of evidence, the capture zone widths of RW07 and 08 and RW02 and 03 were computed using the following equation:

Width = Pumping rate / (saturated thickness × gradient × K)

For RW07 and 08, the relatively small saturated thicknesses in this area and the observed flow rates would suggest broad capture zones 620-720 feet wide, if the K values are near the modeled 400 feet/day. However, these wells are close to an area of modeled higher K values, 700 - 1000 feet/day. If the K values are doubled, the capture zone widths are cut in half 310 - 360 feet, slightly less than the distance between these two wells. In the case of RW02 and 03, the capture zone widths, assuming saturated thicknesses in this area of 45 - 60 feet and K values near 400 ft/day, are 220-320 feet, less than the spacing between these two wells. Capture zone analysis conducted using the site numerical groundwater model do not show such gaps in the reach of the extraction wells, though the model capture zones open more toward the east than the southeast. Based on this analysis, there is a chance that minor gaps exist between a few of the extraction wells.

4.2.2 GROUNDWATER CONTAMINANT CONCENTRATION TRENDS

Of the 115 monitoring locations for groundwater and surface water that are analyzed for total arsenic, more than half of them have reached the “non-detect” level during the remediation or were measured as non-detects prior to the remediation. A summary of trends analyses of total arsenic concentration in groundwater measured between 2000 and 2010 is provided in Table 4-1. Plots of total arsenic concentrations in groundwater versus time are shown in Attachment B. Table 4-1 shows that of the wells shown, more than a third of the monitoring locations show decreasing trends. This includes wells where the decreasing trend was interrupted by a period of increasing arsenic concentrations during or after excavation of contaminated soils (see Attachment B).

Six wells: MW53S, MW54S, MW38S, MW-28S, MW35S and MW40S, which are all screened in the upper 20 feet of the aquifer (shallow zone), show increases in total arsenic concentrations with time. Four wells have total arsenic values close to or larger than 0.35 mg/l. Locations of these wells are shown in Figures in Attachment A. Two of the wells, MW28S and MW38S, are in the heart of the plume in the area downgradient of the former process buildings. Well MW35S is in the area of the southern arsenic plume. Well MW54S is on the opposite side of Blackwater Branch northwest of the site. The reason for the arsenic increases within the zone of influence of the groundwater recovery system may be due to redistribution of the arsenic plume (i.e. change in migration pathway) from impacted soils towards the monitoring wells. For the one well, MW54S located along the north bank of the Blackwater Branch, it is possible that the recent land excavation and disturbance related to floodplain remediation in the area has contributed to the arsenic increases. However, the source of arsenic in this area is unclear. A recent Hydropunch™ investigation in this area followed with installation of monitoring and sampling did not show a widespread plume. The most recent arsenic value at MW54S is much lower than the previous several years so additional monitoring as well as evaluation of additional data gathered as part of the data gap analysis will be necessary to determine if any future action is necessary along the north bank of the Backwater Branch.

There are several wells in Table 4-1 that show a relatively stable trend since the operation of the groundwater treatment plant began. Many of these locations are downgradient of the former process buildings within the main arsenic plume. Two of the locations with high arsenic concentrations, MW25M and MW31M, are at a significant distance downgradient of the former process buildings and near Mill Road (see figures in Attachment A). It is unclear why the concentrations at these wells continue to be so high and also unclear whether the current remediation method will be able to reduce these concentrations to levels specified in the ROD. Well EW21M is another location with a relatively stable, high arsenic trend. Wells surrounding EW21M show non-detects or very low concentrations for arsenic. The explanation for the continued high arsenic concentrations at this well is unknown. One potential explanation is that these locations are along the migration path where the kinetics controlling the mass transfer rate from groundwater to the soil were fast, but the kinetics controlling the desorption of arsenic from the soil to groundwater are relatively slow. Under such conditions, arsenic desorption is the rate-limiting step for aquifer restoration, and concentrations can remain elevated despite flushing the area with many pore volumes of clean water.

The causes of the stable trends in the damaged wells MW37S, MW30S, MW49S, MW48S, MW36S, and EW15S, prior to July 2002 (ranging from 10, 1, 5, 1, 1, to 0.8 mg/l, respectively) is unknown, but the treatment system had only been operating for a period of two years, and a discernible trend may not have been readily apparent in that 2-year period for a site with such extensive groundwater contamination.

The first figure in Attachment C shows the 0.35 mg/l plume in the shallow zone at the onset of the P&T system, generated using the maximum total arsenic measured in monitoring wells between 2002 and 2003 and log kriging interpolation. The second figure of Attachment C shows the 0.35 mg/l total arsenic plume generated from the maximum total arsenic measured in monitoring wells between 2008 and 2009. These figures indicate that the decrease in the extent of the 0.35 mg/l plume between 2002/2003 and 2008/2009 is limited to the isolated plume located along the southwest (at EW13S). The decrease in the strength and extent of the 0.35 mg/l plume located along the south / southeast is attributed to the removal of the six shallow wells with elevated stable concentration MW37S, MW30S, MW49S, MW-48S, MW36S and EW15S during soil excavation. The increase in concentrations to the northeast on the south bank of Blackwater Branch in the area of MW30S and MW28S is possibly due to re-distribution of the plume by the recovery system.

The extent of the arsenic plume in the middle zone remains relatively unchanged between 2002-2003 and 2008-2009 (see the third and fourth figures in Attachment C), but concentrations have decreased significantly in many wells, including many of the recovery wells. Decreases are most notable in the wells that had the highest concentrations in 2002-2003 (i.e., source area wells). Review of the concentration trends in Attachment B indicate that the most significant decreases occurred in the first few years of operation, and that the rate of decrease is slowing. It is unclear if the concentrations in these areas of significant decreases will remain low if pumping is discontinued or if they would rebound.

EPA 2002 outlines a procedure for estimating how quickly a remediation goal will be met at a site. This procedure involves plotting concentrations versus time measured in monitoring wells on a semi log paper and determining the rate constant (point decay rate) which can be used to estimate restoration time. Only two wells in the shallow zone show a monotonic decreasing trend in arsenic concentrations, and all other wells either show stable or increasing concentrations. As a result, the available results indicate that the current P&T system is unlikely to restore the aquifer within a reasonable period specified by the ROD.

The analysis can also be applied to the recovery wells that continue to operate, recognizing that attaining 0.35 mg/l in the recovery wells does not ensure attainment of this concentration throughout the arsenic plume required by ROD. The time needed to reach an arsenic concentration of 0.35 mg/l, 0.05 mg/l, and 0.01 mg/l for each well are estimated based on a linear regression of the arsenic concentration trends in the wells extrapolated into the future (Attachment D and Table 4-2). In addition some arsenic data were not used in the linear regression if it was determined that the data were not representative of the recent trend. For example, several of the wells show an initial increase in arsenic concentration after plant startup and then a decreasing trend that becomes milder over time. The linear regression for these wells was computed using only the last 4 or 5 years of data to be consistent with the recent data trend.

Estimated time to reach an arsenic value of 0.35 mg/l at all the recovery wells is less than a year to 20 years (see Table 4-2 and Attachment D). The longest time estimates to reach 0.35 mg/l occur at RW02b, RW06 and RW07. These are also the recovery wells with the highest arsenic concentrations and are located within the heart of the main plume. The time to reach 0.05 mg/l at all the recovery wells ranges from 3 years to 54 years. The time range to reach 0.01 mg/l is 6 years to 128 years. It must be noted that the time to reach the 0.35 mg/l in recovery wells does not represent the time to reach the 0.35 mg/l in the entire plume.

Eight surface water stations are monitored. Arsenic concentrations in all eight stations since July 2003 have been well below the NPDES criteria of 0.05 mg/l with arsenic concentrations around 0.01 mg/l in recent sampling events. Surface water concentrations prior to July 2003 concentrations were at or above the 0.05 mg/l criteria at most of these locations. The recent results indicate success of the P&T remedy in protecting Blackwater Branch.

4.2.3 SITE-SPECIFIC GEOCHEMISTRY

EPA Document *Monitored Natural Attenuation of Inorganic Contaminants in Ground Water, Volume 2*, October 2007 discusses the attenuation of arsenic in groundwater through precipitation, co-precipitation, or adsorption to various minerals, including iron oxyhydroxides. The RSE team directs the reader to this document for more information on arsenic in groundwater and relevant geochemistry. A number of factors are to be considered in assessing the natural fate of arsenic and any engineered immobilization as discussed below.

Metal Concentrations in Soil

Immobilization of arsenic is affected by the concentration of metals in aquifer soils. Available data of metal concentrations in soil and groundwater are limited to Area 5 (the source area where soil was excavated). The data, shown in Attachment E, indicate:

1) With the exception of one point plots of total versus dissolved arsenic show a near 1 to 1 relationship suggesting sound sampling protocol that ensure little trapping of suspended sediments with sorbed arsenic

2) Relatively good correlation is encountered between arsenic and iron in soil. These data may be used to develop a preliminary site specific partition coefficient. The relatively good correlation between arsenic and iron concentration and the elevated iron concentrations in soil (as high as 2%) show that iron is likely to play a dominant role in attenuation of arsenic.

3) Sulfides concentration in soil is below 13 mg/Kg and is limited in extent (most soil samples showing non-detect concentrations for sulfide. Sulfate concentration in groundwater ranges between ND and 182 mg/l with most data ranging between ~ 5 mg/l to ~15 mg/l. These data suggests ORP (Eh) value higher than those representing sulfate reducing conditions.

Columbia indicated that, based on their work regarding enhanced arsenic mobilization, iron, aluminum and arsenic were desorbed during their testing. Aluminum concentrations in soil were not tested in some areas ("Area 5") and as such additional data are needed to assess the potential of aluminum to attenuate arsenic and develop a site specific partition coefficient. Similar metals data for soil in other parts of the site are also needed.

Arsenic Speciation in Groundwater

The speciation of arsenic present in the groundwater is important for assessing its fate or for engineering its immobilization. Under conditions observed at the site (pH < 5) adsorption of arsenate to iron oxyhydroxides would be the most stable form of immobilization. Speciation of arsenic at the site shows the presence of arsenate, arsenite, MMA, and DMA. The data indicate that the fraction of organic arsenic species (MMA and DMA) is insignificant in comparison to inorganic arsenic species. Overall, in groundwater arsenate is the dominant form of arsenic although significant concentrations of arsenite are present. The ratio of arsenate to arsenite in the shallow zone ranged from values >1 to 6250 in ~ 200 samples and was less than one (i.e. where arsenite > arsenate) in ~60 samples. An additional ~70 samples were non-detect for arsenic and had a ratio of 1 (i.e., the ratio of two equal detection limits). Concentrations of organic arsenic species, particularly MMA, have declined substantially in the treatment plant influent during P&T operation. MMA concentrations in 2003 were over 0.1 mg/L but have decreased to below 0.02 mg/L, which meets current ROD and discharge standards. By contrast, the combined arsenate and arsenite concentration is approximately 0.3 mg/L.

As an aside, arsenic speciation in process water prior to chemical addition shows that overall arsenate is the dominant form of arsenic, however there are periods where arsenite is the dominant form of arsenic in process water. The RSE team believes that arsenate is likely sorbed to the iron oxide precipitate that routinely clogs the well screen and extraction piping. This hypothesis is supported by a comparison of the arsenic concentrations sampled at the extraction wells and the arsenic concentration in the treatment plant effluent. Based on extraction well sampling results and extraction well rates, the RSE team estimates that the blended arsenic concentrations in the extraction wells is approximately 0.6 mg/L whereas the actual blended influent concentration at the equalization tank is approximately 0.3 mg/L. This comparison suggests that up to 50% of the arsenic (in the form of arsenate) may be removed by precipitated iron within the extraction network. The removal of arsenate in the extraction network results in arsenite being the dominant arsenic species in the treatment plant influent during some periods.

For *in-situ* immobilization at the site, the large majority of arsenite would need to be oxidized into arsenate in order to improve the effectiveness of subsequent adsorption. Arsenite can be oxidized by oxygen, ozone, free chlorine, hypochlorite, permanganate, hydrogen peroxide and Fenton's reagent. Air oxidation of arsenic may be relatively inexpensive relative to the other options but is very slow and can take weeks for oxidation (Pierce and Moore, 1982). Chemicals like the hydrogen peroxide used in the above-ground treatment process rapidly oxidize arsenite to arsenate under wide range of conditions and would also have the ability to oxidize the organic arsenic.

pH, ORP/ Eh, Dissolved Oxygen, and Temperature in Groundwater

Spatial plots of pH, ORP, dissolved oxygen, and temperature measured between 2009 and 2010 for the shallow and middle zones indicate the following:

- There is no clear monotonic (i.e. continuous decline or continuous increase) trend in any of the measured field parameters. Pumping may be confusing any natural trend that might exist. Groundwater temperatures in many monitoring wells between the extraction network and surface water are indicative of surface water temperatures, suggesting that the extraction network is pulling surface water into the aquifer.

- DO measurements indicate aerobic conditions, ORP is positive, and the elevated values are likely representative of the ferric/ferrous ion pair rather than the H/OH ion pair. For this reason ORP cannot be related to dissolved oxygen measurements. Analysis of iron speciation in groundwater can be utilized to confirm this hypothesis and demonstrate the dominance of the iron chemistry in groundwater.

- Overall the groundwater is acidic. Arsenate adsorption to iron oxides has been shown to be effective at the pH encountered on site. However, site-specific bench scale studies are needed to determine the optimal pH range for arsenate adsorption and the recommended procedure to attain and maintain the optimal pH. Site-specific bench scale studies are also required to determine the stability of the sorbed arsenic as well as the kinetic of arsenic adsorption and factors influencing adsorption kinetics.

4.2.4 CONCEPTUAL MODEL INPUT AND DATA GAPS

Natural geochemistry at the site and historic arsenic concentration trends in groundwater, sediment, and surface water indicate the potential for arsenic to discharge to Blackwater Branch in the absence of remedial action. To date, the P&T system has been successful at mitigating arsenic discharges, and surface water concentrations are consistent with goals. However, stable but elevated concentrations remain in many areas of the plume, and it is likely that some of the extraction wells will need to continue operating for the foreseeable future. An improved understanding of the site geochemistry and potential adsorption mechanisms for arsenic could lead to alternative or complementary remedies for containing the arsenic.

This section itemizes important aspects of the conceptual model and notes some of the important data gaps in the existing site conceptual model that would need to be addressed to develop effective alternative or complementary remedies to the existing P&T system.

- Source areas – This aspect of the site conceptual model is not fully understood due to the complexity of the historic operations at the site. In the most highly contaminated areas, source excavation to a depth of three feet below the groundwater table was completed. Minor source areas may remain at other site locations and in the area below the completed source excavations. At the time of the RSE site visit, USACE was still investigating potential arsenic source areas on the opposite side of Blackwater Branch. Source area characterization needs to be completed to help distinguish those areas of the aquifer that are likely to be restored and those areas of the aquifer that will likely need either source removal or long-term source control.

- Hydrogeology and groundwater flow – This aspect of the site conceptual model is relatively well understood. A numerical model has been constructed for the site and applied in determining the Classification Exception Area and various pumping scenarios. There are some gaps in understanding of groundwater flow in some areas, and unreliable survey information for some wells complicates a full understanding of groundwater flow at the site. Collection of accurate water levels and recalibration of the model is needed to appropriately evaluate additional potential remedy alternatives. Additional groundwater / surface water studies are warranted in order to confirm that the ACL of 0.35 mg/l is protective of the Blackwater Branch and/or to develop an alternate end point for the extraction system. The ROD states, "*Additional data will be collected during design and operation of the pumping system. If these data show that a point is reached beyond which pumping and treatment is not more effective than natural attenuation, the arsenic will be allowed to flush naturally to the cleanup goal, 0.05 mg/l. The pumping and treatment maximum arsenic objective calculated in the Feasibility Study, 0.35 mg/l, will be recalculated during design*." It is the RSE team's understanding that an evaluation of natural attenuation and 0.35 mg/l objective has not been revisited since the Feasibility Study.

- Geochemistry and contaminant fate and transport – This aspect of the site conceptual model has been studied but needs further development. The site team researched arsenic adsorption as part of the soil washing remedy, but this information is not sufficiently comprehensive to apply it to site-wide contaminant fate and transport. Metals data in soil across the site and bench scale tests regarding arsenic adsorption and desorption under various potential conditions are needed to understand the potential and capacity for site soils to adsorb arsenic. Site geochemistry and arsenic adsorption would be primary mechanism for natural attenuation and for evaluating the 0.35 mg/l criteria.

- Receptors – This aspect of the site conceptual model is well understood. Blackwater Branch is the primary receptor for the site. Successfully protecting this receptor will also result in protecting other potential receptors further from the site.

4.3 MONITORING PROGRAM EFFECTIVENESS

The monitoring program was assessed through both qualitative and quantitative means. The Monitoring and Remediation Optimization System (MAROS) software (v. 2.2) was used to perform the quantitative analysis of the monitoring program. The software provides an assessment of concentration trends (as discussed above), monitoring frequency, monitoring network redundancy and monitoring network sufficiency. Qualitative analysis of the monitoring network redundancy and sufficiency was also conducted using professional judgment in consideration of the MAROS results.

Concentration trends computed by MAROS using Mann-Kendall trend analysis methods are summarized in Attachment F and displayed graphically at the end of Attachment F (for the shallow, mid-depth, and deep wells. The trends for wells in the source and up/downgradient locations are considered in a heuristic analysis by MAROS. Based on the heuristic analysis, the monitoring program should reflect a "moderate" level of effort for both the shallow and mid-depth portions of the Shallow Cohansey aquifer. According to the MAROS manual (Table A.8.1), this would roughly correlate to semi-annual to annual sampling, as is currently conducted at the site. In addition, the heuristic analysis indicates that a sampling network of approximately 30 wells would be appropriate. Given that the monitoring networks at both the shallow and mid-depth levels are only slightly larger than 30, the networks are not unreasonable. The results of the trend determination and heuristic analyses are provided in Attachment F. A qualitative review of sampling frequency supports the use of annual sampling for most wells, with semi-annual sampling near the extraction wells and Blackwater Branch. Upgradient "clean" wells could be sampled on a biennial (every two years) basis.

The MAROS analysis of potentially redundant wells indicated there are a few wells that may be excluded from the program without serious loss of information on plume configuration and extent. The wells identified include MW27S, MW51S, EW16M, and EW17M. These are all wells outside the arsenic plumes. MAROS is conservative in recommending removal of wells from the network (even when the default parameters for the analysis are modified to be more liberal). Based on the qualitative review of the data, additional wells that may be redundant include:

- EW17S (non-detect, duplicates EW14S),
- EW18S (non-detect, duplicates MW46S and EW14S),
- EW23S (non-detect, duplicates EW22S),
- MW45S (duplicates EW19S),
- EW01M (non-detect, duplicates MW32M)
- EW05M or EW06M (these provide duplicate information on plume interior)
- EW13M (duplicates MW45M)
- EW18M (non-detect, duplicates MW46M and EW14M)
- EW23M (non-detect, duplicates EW22M and MW51M)
- MW27M (non-detect, duplicates WW26M)
- EW34M (non-detect, duplicates MW33M and EW14M)

Eliminating these sampling points would represent a reduction of 15 wells.

The MAROS analysis did not indicate significant data gaps in the monitoring network. The qualitative review, however, did identify some additional gaps. Though the extent of contamination north of Blackwater Branch has been characterized by direct-push sampling, additional permanent wells should be added to allow continued monitoring of the hot spot west and northwest of MW54S/54M. In addition, there are no monitoring wells, with the exception of MW39M, between the northern plume/extraction well line and Blackwater Branch. As discussed above, it seems likely the extraction wells are inducing inflow from the stream, but additional well(s) would be useful to define the edge of the plume between the stream and existing extraction and monitoring wells. The piezometric measurements from such wells would also be useful.

The low-flow sampling methods are appropriate for inorganic constituents such as arsenic; however, alternative no-purge sampling methods such as the Hydrasleeve or Snap samplers, may reduce sampling labor costs. Such samplers also provide low-turbidity samples. A comparison study, perhaps for a representative subset of wells, would be appropriate to assess data comparability from both existing and proposed techniques.

The current data management approach is very good. There are apparently no periodic monitoring and performance reports that document and interpret the results, however. There should be one entity with the responsibility to integrate and interpret chemical and piezometric data to assess the extraction system performance.

4.4 COMPONENT PERFORMANCE

4.4.1 EXTRACTION WELLS

The extraction wells at the site face problems with biofouling and scaling that periodically reduces the specific capacity of the wells and ultimately the pumping rates. The project team has done an excellent job in attempting to address these issues with a well maintenance program and experiments with various fouling treatments and inhibitors. Currently, the wells are treated either on a continuous basis with Redux Ferremede product (RW02, 2A, 2B, 3 and 9A, per e-mail from Steve Creighton [USACE Philadelphia District] on 7/20/10) to keep iron and arsenic in solution, or treated periodically with glycolic acid and jetted. Redevelopment is conducted on a group of 3-5 wells every six months or so. The wells chosen for redevelopment depend on performance metrics including flow rates. The jetting has been found to be quite effective. Originally, well redevelopment consisted of treatment with sulfamic acid and surging.

The fouling problems have also affected the piping to the treatment plant such that the original piping header requires cleaning approximately every 6 months. The Redux product is targeted for wells that are connected to the new piping header from RW03 to the plant to provide some benefit to preventing fouling of that header. According to the project team, the Redux product added continuously to the wells has equivocal evidence of preventing or reducing fouling problems.

Though the current program is quite successful, the use of a mix of compounds including an acid (such as the glycolic acid used now), and dispersant, and a disinfectant (e.g., oxidizer) may be more effective, when used in conjunction with jetting, at delaying the decline in production. There are existing commercial products, such as the AquaClear series of compounds from Baroid (this does not necessarily represent an endorsement of this product) that can fill these roles. Some of these products have recently been incorporated into the well maintenance program.

4.4.2 EQUALIZATION TANK

The equalization tank is a cylindrical steel tank with a floating roof that the site team estimates has 300,000-gallon capacity. The equalization tank was not part of the original design but was added in anticipation of the related soil washing remedy that contributed slugs of water with higher arsenic concentrations. The equalization helped even out the spikes in arsenic concentration and helps even the flow and water quality when extraction wells are brought on and off line. Extracted water from the RW-2/2A/2B/3 area is piped directly to the tank in a new force main installed in 2007. Extracted water from all of the other recovery wells can be diverted directly to the oxidation tank or to the equalization tank using valves. All extracted water is currently pumped to the equalization tank where the water level is maintained at approximately 7 to 10 feet. The tank diameter is approximately 60 feet resulting in a residence time of approximately 3 to 4 hours for a flow rate of 750 gpm A 40-horsepower (HP) pump with a variable frequency drive (VFD) set at 20% load conveys the water from the equalization tank to the oxidation tank.

4.4.3 CHEMICAL ADDITION AND FLOCCULATION

A 50% hydrogen peroxide solution is added to the oxidation tank to maintain an ORP setpoint of approximately 320 to 350 mV. Typical hydrogen peroxide use is approximately 27 gallons per day. The tank has a volume of 10,000 providing residence time of over 12 minutes at the current flow rate and a 3 HP mixer. The peroxide oxidizes the arsenic from As^{III} to As^{V}. The operators indicate that the hydrogen peroxide feed pump has problems with off-gassing at low peroxide usage rates.

The water from the oxidation tank flows by gravity to the coagulation tank. A 37% ferric chloride solution is added as a coagulant at a rate of approximately 125 gallons per day. The ferric chloride addition is controlled by historic knowledge and visual observation. A 25% sodium hydroxide is also added at a rate of approximately 275 gallons per day to maintain a pH set point of 6.5. At this pH, the ferric hydroxide formed from the ferric chloride and hydroxide ions is $Fe(OH)_2^+$ and $Fe(OH)_3$, and the arsenate is $H_2AsO_4^-$ and $HAsO_4^{-2}$. The arsenate complexes with the ferric hydroxide. The 10,000-gallon coagulation tank has a 3 HP mixer. Process water from the coagulation tank flows by gravity to two the two-stage flocculation tanks arranged in parallel (a total of four tanks). Cationic polymer is added to the second-stage tanks at a rate of approximately 5 gallons per day (prior to polymer dilution with potable water) to facilitate flocculation. The two first-stage flocculation tanks have 5 HP mixers with VFDs set at 30 Hz, and the two second-stage flocculation tanks have 0.5 HP mixers with VFDs set at 30 Hz.

Chemical addition, coagulation, and flocculation occur in the concrete containment area outside of the process building.

4.4.4 DISSOLVED AIR FLOTATION

Process water from the flocculation tank flows by gravity to two DAF units arranged in parallel located inside the process building. Compressed air is provided to DAF recirculation water. A 7.5 HP pump provides the flow and high pressure to dissolve additional air in the recirculation water. Upon discharge to the bottom of the DAF, the pressure is relieved from the recirculation water forming fine air bubbles that attach to the iron/arsenic floc and bring it to the surface. The floating solids are raked off of the DAF units and pumped to the sludge thickening tank. Process water is used either for recirculation or is discharged to the sand filter feed tank.

Treatment plant operators measure turbidity continuously to monitor DAF performance. The treatment plant operators indicate that all recent plant upsets are indicated by elevated turbidity. Excess turbidity can overwhelm the sand filters.

4.4.5 FILTRATION

Process water in the filter feed tank is pumped with a 28 HP pump with a VFD set at approximately 45 Hz through three continuously backwashing sand filters arranged in parallel in the concrete containment area outside of the process building. A fourth sand filter is currently not used. The continuous backwash requires an air scour flow rate of 3-4 cubic feet per minute at 15 to 25 psi per filter. Filtered water flows by gravity to the effluent tank. The backwashed solids are pumped to the equalization tank. The operators maintain curtains and electrical heaters around the conical bottom of the filters to help avoid freezing problems. The operators report that freezing is not an issue while the plant is running, but does become a problem during cold temperatures when the plant is down for an extended period of time.

Treatment plant operators measure turbidity continuously to monitor filter performance. The treatment plant operators indicate that all recent plant upsets are indicated by elevated turbidity.

4.4.6 SOLIDS DEWATERING

Solids from the DAF are pumped with an air-operated diaphragm pump to a 25,000-gallon solids thickening tank located outside adjacent to the solids handling building. Thickener overflow is pumped back to the equalization tank. Thickened solids are pumped with a 17.5 HP pump to the centrifuges running in the solids handling building. Anionic polymer is added at a rate of approximately 6 gallons per day (prior to dilution with potable water) to the solids stream, which is pumped to one of two centrifuges. The operators indicate the centrifuges run continuously, relatively problem free during plant operation hours. Operators indicate that at the current flow rate (approximately 800 gpm) and arsenic loading (approximately 0.3 mg/l) the centrifuge operation requires approximately 10 hours per day, 5 days per week to keep up with solids production.

The centrifuges produce approximately 10,000 pounds per week of sludge with slightly over 20% solids content. Solids are disposed of off-site as hazardous waste at the EQ facility in Bellevue, Michigan, approximately 700 miles from the site. Trucks carrying solids are weighed on the facility scale before leaving the facility.

4.4.7 SYSTEM CONTROLS

The supervisory control and data acquisition (SCADA) system was updated in 2004. The new controls are appropriate for the treatment system and offer an appropriate degree of control, operator interface, data management, and remote operation capabilities.

4.4.8 DISCHARGE OF TREATED WATER

Treated water in the effluent tank is pumped to a restored portion of Blackwater Branch by a 20 HP pump. The pump capacity is currently one of the capacity limiting factors for the treatment plant. This is because the discharge line has been moved, due activities related to realigning Blackwater Branch, to a higher elevation. The higher elevation limits the amount of flow the pump can provide. A larger pump could be used if an increase in plant capacity is necessary.

4.4.9 PROCESS AND ADMINISTRATIVE FACILITIES

The treatment plant operations and activities associated with other operable units are managed out of an administrative building that contains a reception area, conference rooms, and offices for site staff. The facility is heated by electric resistive heating.

The 150-foot by 100-foot process building houses the two DAF units associated with the inorganic (currently used) treatment train and the two DAF units associated with the two organic treatment trains (not currently used). The process building also houses the control room, electrical room, laboratory, and restrooms. The laboratory contains the graphite furnace used for on-site samples as well as other instrumentation used for analysis associated with other operable units.

4.5 COMPONENTS OR PROCESSES THAT ACCOUNT FOR MAJORITY OF ANNUAL COSTS

The annual cost for the OU2 remedy on a move-forward basis is approximately $1.8 million as presented in the following table.

Item Description	Approximate Annual Cost
Project management and engineering support	$250,000
Operator labor (assume 3.5 full-time equivalent staff)	$350,000
Utilities	
- Electricity (2009 electricity bills)	$189,000
- Potable water (2009 bills)	$13,000
- Natural gas (2009 bills)	$28,000
- Telecommunications	$4,000
- Renewable energy certificates (assumes $0.03 per kWh)	$41,000
Treatment process materials and chemicals	
- Hydrogen peroxide ($2.70 per gallon)	$27,000
- Ferric chloride (assuming $1.30 per gallon of 37% solution)	$59,000
- Sodium hydroxide (assuming $0.72 per gallon)	$72,000
- Cationic polymer (assuming $16 per gallon)	$29,000
- Anionic polymer ($17 per gallon)	$37,000
Waste disposal	$80,000
Process monitoring analysis	$20,000
Groundwater sampling, including analysis	$115,000
Well-maintenance (including well maintenance chemicals)	$365,000
Various parts/materials	$83,000
Other Costs	$1,300,000
Total	**$3,062,000**

4.5.1 UTILITIES

Electricity is provided by the Vineland Municipal Electric Utility from a coal-fired power plant at an approximate cost of approximately $0.13 to $0.15 per kilowatt-hour (kWh), depending on season. Approximately 1.35 million kWh were used during the 12-month period from February 2009 through January 2010. Natural gas is provided by South Jersey Gas at and approximate cost of $1.00 to $1.33 per therm. Approximately 31,000 therms were used during the 12-month period from February 2009 through January 2010, and approximately 90% of the natural gas is used between December and April.

Electricity usage from conventional resources is "converted" to electricity from renewable resources through the purchase of Renewable Energy Certificates at an assumed cost of $0.03 per kWh.

4.5.2 NON-UTILITY CONSUMABLES AND DISPOSAL COSTS

Chemical costs for treatment and for well maintenance are the predominant consumable costs. Treatment process chemicals cost approximately $217,000 per year, with sodium hydroxide, ferric chloride, and anionic polymer comprising almost 75% of that cost. Chemicals for well maintenance include approximately $60,000 for the sequestering agent injected around wells and approximately $3,500 for glycolic acid used for maintenance of the other wells.

Disposal costs are approximately $80,000 per year for approximately 260 tons per year for a rate of approximately $310 per ton for transport and disposal.

4.5.3 LABOR

Operator labor reductions have significantly decreased costs leading up to the RSE site visit as a result of optimization conducted by the site team. The project team estimates approximately $100,000 per full-time equivalent employee in the treatment plant.

The project management and engineering support costs are reported by the site contractor for the year 2009. The costs cover the part time administrator, part time project engineer, part time project management, and part time cost accountant. A small portion of this cost also includes office supplies and utility bills for the administrative building. The site team reports that the project management costs (not necessarily technical support costs) for 2011 are approximately $112,000. Additional cost is likely spent for engineering support.

4.5.4 CHEMICAL ANALYSIS

The total chemical analysis cost was provided by the project team, which estimates that total arsenic sample analysis costs approximately $15 per sample with a standard turn-around time and $30 per sample for an expedited turnaround time.

4.5.5 OTHER COSTS

Total expenditures for EPA for the OU2 Long-Term Remedial Action were approximately $3 million calendar year 2009 and over $4 million through the first 8 months of calendar year 2010. The $1.3 million of "other costs" in the above table were determined by subtracting the contractor costs of approximately $1.7 million from the approximate outlays by EPA of $3.0 million. Review of these other costs is outside the scope of this RSE, so the RSE team cannot comment on the use of those funds. However, the RSE team is aware of several other activities associated with the remedy that may be associated with those costs, including project administration by USACE, research on arsenic mobilization by Columbia University, modeling support provided by USACE, and additional field characterization conducted by USACE.

4.6 APPROXIMATE ENVIRONMENTAL FOOTPRINTS ASSOCIATED WITH REMEDY

4.6.1 ENERGY, AIR EMISSIONS, AND GREENHOUSE GASES

A series of spreadsheets was used to calculate the footprints for energy, air emission, greenhouse gas, and other environmental parameters for the OU2 remedy (see Attachment G). Highlights of the analysis are summarized in the following table.

	Annual Footprint			
Remedy Component	**Energy (MMbtus)**	**Greenhouse Gas (lbs CO2e)**	**Criteria Pollutant* (lbs)**	**Hazardous Air Pollutants (lbs)**
Extraction system	5,200	276,000	4,400	155
Treatment plant	17,200	1,770,000	16,200	373
Long-term monitoring	<100	5,000	<100	<1
Total	~22,400	~2,051,000	~20,600	~528

MMbtus = millions of btus
** Refers only to emissions nitrogen oxides (NOx), sulfur oxides (SOx), and particulate matter.*
Reported values include greenhouse gas, NOx, and SOx offsets from purchasing renewable energy credits

The following table provides a more detailed breakdown of air emissions by remedy component using CO2e as an indicator parameter.

Remedy Component	**Annual CO2e Emissions (lbs)**	**% of Total**
On-site emissions[1]	289,000	14%
Electricity generation[2]	555,000	27%
Transportation[3]	132,000	6%
Chemical and material production[4]	792,000	39%
Off-site services[5]	284,000	14%
Total	**2,052,000**	**100%**

[1] *predominantly natural gas combustion for building heat*
[2] *electricity generation offset by purchase of renewable energy certificates for all electrical use*
[3] *transportation for personnel, chemicals, and hazardous waste*
[4] *production of treatment materials (e.g., process chemicals) and fuels (e.g., diesel and natural gas)*
[5] *waste disposal (excluding waste transportation), laboratory analysis, electricity transmission, etc.*

Electricity generation contributes significantly to the energy and air emission footprints. Although Renewable Energy Certificates (RECs) are bundled with grid electricity from the Vineland Municipal Electric Utility to provide renewable electricity to the site, the electricity provided by this utility is from coal, which has higher net emissions than the electricity produced throughout the rest of the New Jersey area electrical grid. The emission offsets from purchasing RECs for total electricity usage are calculated from www.epa.gov/egrid plus 10% to account for resource extraction (e.g., coal mining). Of the CO2e emissions reported above, approximately 50% of them are directly tied to the extraction rate. The remaining 50% are tied to building heat, operator transportation, well maintenance, and other activities.

4.6.2 WATER RESOURCES

The groundwater extracted by the remedy would discharge to the surface water of Blackwater Branch in the absence of pumping, and extracted water is discharged to Blackwater Branch. Therefore, the remedy has little or no effect on the local water resource other than the positive effect of restoring water quality. Significant potable water is used for blending and diluting chemicals prior to addition to the treatment system. Approximately 13 million gallons of potable water are used each year for this purpose. This potable water use is directly tied to the system extraction rate.

4.6.3 LAND AND ECOSYSTEMS

The activities of the site-wide remedy have an extensive affect on local land and ecosystems due to soil excavation, sediment remediation, and realignment of Blackwater Branch. The activities of the OU2 remedy, however, have little or no direct effect on the local land and ecosystem use. The only effects of remedy activities are the presence of the treatment buildings and what influence they may have over the long-term to redevelop the property for beneficial use. The remedy's ability to achieve the remedial action objectives of preventing contaminant migration to Blackwater Branch has contributed to the restoration of large areas of the local ecosystem, including Blackwater Branch, the Maurice River, and Union Lake.

4.6.4 MATERIALS USAGE AND WASTE DISPOSAL

Materials usage at the site is extensive because of the treatment chemicals used in the process. Approximately 600,000 pounds of refined manufactured product are used as part of the remedy each year. Approximately 260 tons of waste is disposed of as hazardous waste.

4.7 RECURRING PROBLEMS OR ISSUES

Well fouling is one of the more problematic issues for the remedy. Extensive operator labor, subcontractor use, and chemical usage is required to maintain the wells.

4.8 REGULATORY COMPLIANCE

There have been five effluent releases with total arsenic values larger than 0.05 mg/l since plant startup in 2000. The releases were reported and corrective actions were taken. No harm to human health or permanent harm to the environment resulted from these isolated incidents. Since mid-2006, all effluent releases have been less than 0.025 mg/l.

4.9 SAFETY RECORD

Health and safety topics are discussed at each bi-weekly progress meeting. From October 14, 1999 to June 8, 2010, a total of 299,084 hours were worked with no recordable or reportable injuries. No health and safety issues were identified as part of the RSE investigation.

5.0 EFFECTIVENESS OF THE SYSTEM TO PROTECT HUMAN HEALTH AND THE ENVIRONMENT

5.1 GROUNDWATER

There are no current, known exposures to groundwater contamination. The classification exception area and other land-use controls should prevent groundwater use in the vicinity of the site. The groundwater extraction system is achieving its primary goal of protection of surface water quality, though there are some subtle questions about the completeness of the capture of the entire plume as discussed above. The groundwater contamination north of Blackwater Branch is currently uncontrolled, but does appear to be defined. The exact source and fate of this contamination is not known. The current extraction system is making limited progress toward attainment of cleanup goals for on-site groundwater. Though the mid-depth wells are generally displaying decreasing concentrations, shallow monitoring wells are generally stable. Projections based on these trends, as discussed previously, indicate that it may take decades to attain the site groundwater goal for arsenic, even though the goal is well above the current MCL.

5.2 SURFACE WATER

Based on the surface water sampling results, surface water quality in the vicinity of the site appears to be meeting goals for protection of ecological and human receptors. The treatment plant is more than meeting the discharge standards (50 ug/L) set in the ROD for surface water and is generally almost meeting the current arsenic MCL of 10 ug/L.

5.3 AIR

There are no apparent current risks to human or ecological receptors via air pathways. No sampling results for air impacts were reviewed for this analysis. Presumably all near-surface contaminated soils have been addressed so as to prevent unacceptable contaminated dust transport to the surrounding areas. Although there were general air permits that apply to construction activities at the site, there are no active permits associated with the treatment plant operation. Unlike a treatment system that addresses volatile organic compounds (VOCs), there are no releases of air pollutants from the system that would merit a permit.

5.4 SOIL

This analysis did not involve a detailed evaluation of the adequacy of soil remediation at the site. There are no apparent unacceptable health risks due to exposure of shallow soils remaining at the site following soil treatment. It is understood from discussions during the site visit that significantly contaminated soil extended to depths below the water table and the depths accessible to excavation techniques used in the soil remediation efforts. These soils may represent a continuing (for some time) source of arsenic contamination to groundwater.

5.5 WETLANDS AND SEDIMENTS

The remediation of sediments in and adjacent to Blackwater Branch is on-going and no evaluation of the adequacy of the work was undertaken. The restored section of Blackwater Branch east of the North Mill Road bridge appears to offer healthy habitat.

6.0 RECOMMENDATIONS

Cost estimates provided herein have levels of certainty comparable to those done for CERCLA Feasibility Studies (-30%/+50%), and these cost estimates have been prepared in a manner generally consistent with EPA 540-R-00-002, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, July, 2000. The costs presented do not include potential costs associated with community or public relations activities that may be conducted prior to field activities. The costs and sustainability impacts of these recommendations are summarized in Tables 6-1 and 6-2.

6.1 RECOMMENDATIONS TO IMPROVE EFFECTIVENESS

6.1.1 FURTHER CHARACTERIZE EXTENT OF CONTAMINATION

The groundwater contamination found near monitoring wells MW54S/M north of the Blackwater Branch is currently uncontrolled. Permanent monitoring wells are needed to allow future definition of the northern and western extent of this plume, and would be based on the recent direct-push sampling results. It is assumed that two new permanent monitoring wells would be sufficient. The source of this contamination is not known and additional characterization should be conducted to assure there is no residual soil contamination that would represent a risk to human and ecological receptors or to ground/surface water. The cost for installing the two assumed monitoring wells might be on the order of $30,000, including planning, preparation, oversight, waste disposal, and well development. Continued sampling of these wells on an annual basis might increase annual costs by approximately $1,500. The RSE team has not estimated the additional costs for source area investigation.

6.1.2 CONSIDER MODIFICATIONS TO THE GROUNDWATER EXTRACTION SYSTEM TO ASSURE CAPTURE

There are two areas that appear to have some evidence of incomplete plume capture, as discussed above; between extraction wells RW02 and 03, and between RW07 and 08. If operation of the current extraction system is to be continued, it is recommended that additional study, including both trend analysis for concentrations in monitoring points near these locations and groundwater modeling, be conducted to evaluate the conditions in these areas. Refer to Recommendation 6.4.1 for considers regarding a hydrogeological evaluation for improving understanding of groundwater flow and model calibration. Additional piezometers may be useful to better define the capture zone in both the shallow and mid-depth portions of the aquifer. If deemed necessary following the study, additional groundwater extraction wells could be installed midway in these “gaps” to increase confidence of capture in these areas. These new wells would be constructed in a similar manner to the existing extraction wells, though would not need to pump at as quite a high rate as nearby wells, provided the existing wells also continue to operate. These new wells could use the same header pipeline that serves the nearby wells. Flow rates could be allocated among new and existing wells as per the optimization study recommended in Section 6.2.3.

6.1.3 ADDITIONAL MONITORING OF GROUNDWATER QUALITY BETWEEN EXTRACTION WELLS AND BLACKWATER BRANCH

In order to verify that the extraction wells in the northeastern part of the site are drawing contaminated water back from Blackwater Branch (and to determine the degree of induced recharge from the stream), it is recommended that two to three additional monitoring wells be installed north and northeast of RW04/06 and MW28S/M. This would support not only the understanding of the current system performance, but also the assessment of the potential consequences of the use of treated water injection (with amendments) to help stabilize contaminants in the core of the northern arsenic plume (discussed elsewhere in this section). This recommendation might be appropriate to implement in conjunction with Recommendation 6.4.1. The cost for installing two monitoring wells might be on the order of $30,000, including planning, preparation, oversight, waste disposal, and well development. Continued sampling of these wells on an annual basis might increase annual costs by approximately $1,500.

6.2 RECOMMENDATIONS TO REDUCE COSTS

6.2.1 DISCONTINUE AUTOMATED SAMPLER AND DO NOT REPLACE THE UNIT

The treatment plant has had extensive process sampling, especially compared to other treatment plants in the Superfund program. This extensive process sampling has allowed the site team to develop a very good understanding of the system and its reliability. One component of this process sampling is the use of an autosampler that collects hourly total arsenic samples of the plant effluent. The unit has reportedly worked well for approximately 5 years but is becoming troublesome, requiring attention on a daily basis by one of the USACE staff and new parts. In 2009, approximately $4,200 was spent on parts for the autosampler. The site team is considering replacing the unit at a cost of approximately $65,000.

Very few sites within the Superfund program (regardless of complexity) have autosamplers on the plant effluent because experience with the plant and routine process sampling on a weekly or monthly basis is adequate to evaluate plant performance. In most cases in the Fund-lead program where autosamplers were in place, they are no longer used. In the case of Vineland, the autosampler has served an important purpose. It has generated off-hours alarms due to system upsets, but the site team reports that, in each instance, the turbidity meter provided adequate information for the site alarm. The autosampler has therefore played an important role in the site operators learning to control the plant and the causes of plant upsets. This additional level of sampling, however, is no longer needed. The plant performance can be evaluated visually and by ORP, pH, and turbidity data when staff are present, and the various SCADA alarms are adequate to warn of system upsets during off hours.

The RSE team recommends that the site team discontinue use of the existing autosampler and advises against replacing the unit. The RSE team estimates that implementing this recommendation will save approximately $65,000 upfront and an unspecified amount of additional savings associated with parts, reagents, and time. Discontinuing use of the autosampler should not expose EPA, USACE, or the contractor to additional liability. The permit equivalency requires sampling twice per month, and the site team already chooses to sample on a more frequent basis (weekly). In addition, as stated above, the plant operators have more than adequate experience in operating the plant to remain in compliance.

6.2.2 ELIMINATE ROUTINE ON-SITE ARSENIC SAMPLING

Arsenic samples are collected from the equalization tank each morning, from the filter feed tank every two hours while the plant is staffed, and from the plant effluent every two hours while the plant is staffed. The samples are analyzed on-site with a graphite furnace. The real-time ORP, pH, and turbidity data combined with operator experience, the new SCADA system, and the regular sampling with off-site analysis are sufficient to evaluate the plant performance. It is for these same reasons that the plant is no longer staffed 24-hours per day. Like the autosampler, the on-site graphite furnace has given the operations team the ability to troubleshoot and learn plant performance and gain confidence in the reliability of plant operation. However, after almost 10 years of plant operation and 6 years of operation with the new SCADA system, this frequency of sample collection and analysis should no longer be required. The RSE team reviewed the results of the analyzed grab samples, and the results confirm reliable operation of the treatment plant. There are instances of "spikes" in arsenic contamination, but many of them are either explained by plant modifications that were made (e.g., replacement of an air fitting on a sand filter in February 2010 and replacement of the polymer mixer on March 20, 2010) or appear spurious and uninformative.

In 2009, the site team spent approximately $5,000 on lab supplies and graphite furnace parts. More importantly, the process of collecting and analyzing the samples likely requires 2.5 to 3 hours of operator attention each day. Eliminating this frequent sampling and analysis will help the site team appropriately reduce operations staff. Implementation of this recommendation alone will not likely allow further staff reduction, but implementation of this recommendation plus other streamlining could likely help the site team reduce staff to two full time equivalent employees.

The RSE team suggests maintaining the graphite furnace but only using it occasionally when troubleshooting an issue or testing the plant under different operational parameters, such as significant adjustments to the extraction system or considering alternative chemical additions. The site team could also choose to collect and analyze a sample with the graphite furnace prior to conducting the formal discharge sampling. However, the operator experience with the site and the more aggressive voluntary target of 0.02 mg/L relative to the compliance standard of 0.05 mg/L is sufficiently conservative to be confident in plant performance prior to the formal sampling. The RSE team discussed the operation of graphite furnace instruments with a chemist who confirmed that these instruments can operate effectively when shut down and restarted on an occasional basis as long as the instrument is kept clean. The site team could discuss this further with the manufacturer if they have additional concerns about this type of operation schedule.

6.2.3 REDUCE EXTRACTION RATES TO THOSE THAT ARE NECESSARY FOR PLUME CAPTURE

The current extraction system is likely pumping more water than necessary overall than is necessary to capture the arsenic plumes. Further analysis of the potential changes in the pumping rates and locations should be conducted, preferably using automated tools compatible with the code used for the site groundwater model. New locations for pumping wells should be explored in addition to the existing wells and injection well placement options could be explored as well. Cost analyses should be conducted in conjunction with the model optimization to account for the cost of new extraction wells and necessary piping, and the cost savings for treatment based on the revised total flow rates. Assuming the existing model can be effectively linked with optimization software (e.g., MODMAN), the cost for a flow model optimization analysis would be on the order of $20,000; however, the potential savings may be several multiples of that amount saved in a single year of operation of the plant if it can be operated at a lower flow rate. Prior to use of the model for these purposes, the site team should recalibrate the model based as discussed in Recommendation 6.4.1.

The cost breakdown in Section 4.6 indicates $456,000 is spent on items that scale directly with the system flow rate, including process system electricity, chemicals, and waste disposal. Therefore, a decrease in the extraction rate will translate to direct savings. In addition, with reduced flow rates there may be potential for additional savings. The extraction rate required for plume capture is not currently known, but is estimated to be approximately 500 gpm using the current extraction well layout, but might be under 300 gpm using an optimized extraction system. As an example of the potential cost savings associated with reducing the extraction rate, the RSE team assumes a 50% reduction with extraction occurring in the same number of wells.

A 50% reduction in the extraction rate would result in a direct costs savings of approximately $228,000 per year. Modifications would likely be needed to the treatment plant, including use of one DAF, use of one or two sand filters, and replacement of chemical feed pumps. If flow is dropped below 400 gpm (or some other similar value determined by the site team), it may be appropriate to switch flow from the inorganic treatment train to one of the two organic treatment trains. Alternatively, it may make sense to divert flow from the existing inorganic treatment train through one of the smaller DAFs associated with the organic treatment train. It is noted, however, that these types of changes would require some modification prior to use. The RSE team has not estimated the costs for making these various changes. As the extraction rate decreases, the residence time in the equalization tank increases, allowing for further stabilization of the flow rate which will further facilitate plant operations. At a flow rate of 400 gpm and using the full capacity of the 300,000 gallon tank, the residence time in the equalization tank exceeds 12 hours.

6.2.4 EVALUATE GROUNDWATER MONITORING COSTS

The site team reports an annual budget of $115,000 per year for groundwater monitoring of 90 wells with low-flow sampling. Using the following reasonable assumptions, the RSE estimates that this sampling scope should cost approximately $60,000 per year.

- 90 samples collected per year
- Low-flow sampling with non-dedicated pumps and tubing
- 4 wells per 10-hour day for a two-person sampling team (site records indicate 5 to 6 wells per day)
- $80 per hour per technician
- $2,500 per week for equipment and materials
- 120 samples to be analyzed (including quality assurance samples)
- $15 per sample for analysis
- $200 per day for travel

The RSE-team estimated $60,000 per year and the budgeted $115,000 per year is a large discrepancy and merits evaluation to determine the cause of the additional expenditures. The RSE team believes that careful evaluation of the sampling budget and scope will review the inefficiencies and that the site team will be able to identify appropriate means of addressing these inefficiencies. If this is the case, savings of approximately $55,000 per year might be realized.

6.2.5 CONTINUE TO OPTIMIZE GROUNDWATER MONITORING PROGRAM

The project team has done an excellent job in periodically reassessing the monitoring program to assure that it efficiently supports site decisions. Based on the analysis conducted for this RSE, some modification to the monitoring network is recommended that may allow reductions in monitoring costs while maintaining a strong basis for evaluating remedy performance. Potentially redundant wells have been identified, including EW01M, EW05M (or 06M), EW13M, EW16M, EW17M and 17S, EW-18M and 18S, EW23M and 23S, MW27M and 27S, MW34M, MW45S, and MW51S. Cost savings due to this change would be conservatively estimated at $10,000/year, assuming annual sampling at $670/sample. This cost savings is consistent with the sampling costs estimated by the RSE team. Estimated savings based on the current sampling budget would be on the order $19,000 ($1,280 per sample). These wells should not be abandoned as they can provide valuable (and inexpensive) piezometric data.

The project team should evaluate the potential use of the Hydrasleeve or SNAP samplers in lieu of the low-flow sampling currently done. This has the potential to provide comparable data on arsenic with a significant reduction in costs. A reduction of 30 minutes per well in the sampling time would translate into a reduction of 90 person-hours/year (0.5 hours × 2 people × 90 samples), which could translate into a cost reduction of over $7,000/year assuming $80/hour and accounting for a rough cost for the samplers. A comparability study would be necessary at a select subset of wells. This would temporarily increase costs, but the long-term nature of the project would assure a large payback.

6.2.6 FOCUS BUILDING HEATING AND LIGHTING ON KEY PROCESS AREA

The process area is approximately 7,500 square feet with a 20-foot high clearance for a total of 150,000 cubic feet. However, due to past optimization by the site team, approximately half of this area is no longer used. The potassium permanganate room is no longer used and neither are the two DAFs for the organic treatment train. The site team might consider localizing or target process area heating on the parts of the system that are used in an attempt to reduce natural gas usage. The site team could hang curtains to separate the areas that require heating from areas that do not require heating. Assuming the volume to be heated is approximately 50% of the current volume but that the heat containment by the curtains is only 50% efficient, the site team might reduce natural gas usage by approximately 6,100 therms per year or approximately $6,900 per year. The RSE team does not have an accurate cost for the curtains or other partitioning that the site team may devise. The RSE team believes this would be cost-effective if effective partitioning or other focus of process area heating can be implemented for under $25,000. This recommendation should be considered after the treatment process is optimized and refined based on the recommendations from Sections 6.1 and 6.2.

6.2.7 EVALUATE CHEMICAL USAGE

Arsenic removal by oxidation and adsorption to iron is a relatively complex process, and the chemical usage from site to site will vary based on water quality. At the Vineland site, the chemical usage is higher than would be expected based on a stoichiometric analysis, and the hydrogen peroxide usage is higher than expected by the widest margin as discussed below. The ferric chloride usage is higher than typically reported, but given the low concentrations sought by the project team and the variation in the influent water quality, the ratio of ferric chloride to arsenic is not unreasonable. The sodium hydroxide use is about double what would be expected based on the ferric chloride addition but could likely be explained by other constituents in the water. The plant operators have reportedly arrived at the current chemical dosages based on experience, and have learned that reductions in the chemical usage result in increases in the effluent arsenic concentration.

Although hydrogen peroxide is the smallest contributor to chemical costs, it is the chemical that has the most potential for use reduction. Approximately 27 gallons per day of 50% hydrogen peroxide is used to oxidize constituents in the influent process water. The RSE team estimates that the actual hydrogen peroxide usage exceeds the stoichiometric hydrogen peroxide usage for influent arsenic (0.3 mg/L) and ferrous iron (2 mg/L) by 18 to 1. The extra usage may be due to other oxidant demand in the influent and/or potentially for higher concentrations needed to oxidize the organic arsenic. It may also result from the relatively short residence time in the oxidation tank (approximately 15 minutes). Aeration could effectively oxidize the ferrous iron, and potentially other constituents in the influent, which would reduce the oxidant demand for hydrogen peroxide. Therefore, the hydrogen peroxide usage could likely be reduced by the use of aeration. Hydrogen peroxide use might be further reduced by either extending the contact time of the process water with the hydrogen peroxide prior to ferric chloride addition or slightly raising the pH by adding a limited amount of neutralizing agent (e.g., sodium hydroxide) in advance of or during the oxidation stage. The RSE team suggests bench scale jar testing to evaluate the following possibilities for optimizing the oxidation stage:

- Aeration of the process water prior to the addition of hydrogen peroxide
- Additional residence time after hydrogen peroxide addition and prior to ferric chloride addition
- Aeration of the process water prior to the addition of hydrogen peroxide plus additional residence time after hydrogen peroxide addition but prior to ferric chloride addition
- Aeration and pH adjustment of the process water prior to the addition of hydrogen peroxide
- Aeration and ferric iron addition (e.g., recovered iron sludge) prior to the addition of hydrogen peroxide

If the testing suggests a significant reduction in hydrogen peroxide use, then the site team could evaluate the costs for modifying the treatment train and the potential savings resulting from the change. The site team could use some of the unused tanks in the treatment compound as part of these modifications.

The RSE team estimates that the cost for bench scale testing and documentation of the results might be on the order of $20,000. Plumbing additional tanks into the treatment train and adding a 5 HP blower and air distribution manifold might cost on the order of $30,000. An additional $10,000 might be needed for trouble shooting, sampling, and refining chemical usage once the change is in place.

Hydrogen peroxide addition currently costs approximately $27,000 per year. Assuming half of this demand ($13,000) could be accomplished by aeration, the RSE team estimates that electricity costs for blower operation would be on the order of $6,000 per year for a net savings of $7,000 per year, resulting in a payback period of 8 to 9 years. This may not be sufficiently favorable to implement, but reducing the hydrogen peroxide use by 75% would save approximately $14,000 per year for a payback period of approximately 4 years.

The site team also suggests revisiting the dosage of ferric chloride. This could be done by a series of bench scale testing and possibly with treatment plant operation. If the dosage for the treatment plant is modified, the dosages and resulting effects on arsenic treatment should be documented so that the evidence for the arsenic dosage is not anecdotal. The focus on ferric chloride is important because ferric chloride is a significant cost, it directly affects the amount of sodium hydroxide use (which is also a significant cost), and it directly affects waste disposal (which is also a significant cost).

6.2.8 CONSIDER USE OF A PLATE AND FRAME FILTER PRESS TO DEWATER SOLIDS

The current solids dewatering process has the benefit of operating without much operator attention. However, there are disadvantages as well.

- The centrifuge generates sludge with slightly over 20% solids.
- The centrifuge requires approximately $37,000 per year in anionic polymer to maintain current solids production.
- The addition of polymer requires potable water addition.
- The centrifuge requires approximately $3,500 per year in electricity usage.

A commonly used alternative for dewatering is a plate and frame filter press. The filter press might achieve dryer sludge cake and should not require the use of anionic polymer. However, operation would likely require additional labor. Assuming the filter press is capable of providing sludge with 30% solids content, the RSE team estimates that approximately 4 cubic yards of solids would be generated per week. This might translate to running a 20 cubic foot filter press once a day. This would not be a significant increase in labor, and the energy required to operate the filter press is likely similar to the energy for the centrifuge and conveyors. The site team might expect a 30% decrease in hazardous waste for a cost savings of approximately $24,000 per year in addition to a savings of approximately $37,000 per year from avoided polymer use. The RSE team therefore estimates total savings might be on the order of $60,000 per year for a relatively minor increase in labor.

The capital cost for acquiring and installing the filter press is highly dependent on the available government-owned filter presses and compressors. The site team states that the soil washing remedy, which will soon be dismantled, has plate and frame filter presses. The RSE team did not review the specifications of these filter presses to determine if they are of appropriate size for this application. If they are not, RSEs conducted at Fund-lead Superfund sites identified several filter presses that are not being used. USACE has previously maintained a list of used equipment, and this may be a starting point to identify this equipment.

Prior to investing in permanent changes, the site team should pilot dewatering with the sludge to evaluate performance and costs and determine if the change is warranted.

6.2.9 CONSIDER THE USE OF LIME FOR PH ADJUSTMENT

The site currently uses approximately 260,000 pounds of sodium hydroxide per year for pH adjustment at a cost of $72,000 per year, and the unit cost of sodium hydroxide was recently much higher suggesting future unit cost increases are likely. The same degree of pH adjustment could be achieved using approximately the same weight of lime, but lime should cost approximately $0.10 per pound (bulk) to $0.15 per pound (bagged) for an annual cost of $26,000 to $39,000 per year. This represents a potential savings of $33,000 to $46,000 per year. Capital costs would be required for acquiring a lime storage and feed system, and further costs would be required for adjusting treatment plant operations to this substitute process and troubleshooting. The RSE team estimates that it might cost $200,000 to design, procure, and implement a lime feed system based on bagged lime or up to $400,000 to design, procure, and implement and automated lime feed system. This approach therefore has a payback of approximately 6 to 10 years. However, this payback only applies at the current groundwater extraction rate, chemical usage rate, current sodium hydroxide cost, and assumed lime cost. A decrease in the extraction rate and chemical usage rate would decrease the return on investment (ROI). An increase in the sodium hydroxide cost and/or a lower estimated lime cost would make the ROI better. The site team might want to obtain lime costs from local vendors and refine the cost estimate for constructing an appropriate lime storage and feed system. If the investment based on this refined analysis appears favorable, the site team could then evaluate other factors, including potential for scaling and increased operator time.

6.2.10 CONTINUE TO STREAMLINE PLANT AND PROJECT STAFFING

The site team has done an excellent job streamlining the treatment plant and streamlining plant operations staff, and the RSE team believes that further improvements will be made due to implementation of some of the RSE recommendations and additional ideas from the site team. Further streamlining in project management, technical support, and reporting should also be feasible. As a point of comparison, the RSE team provides the following representative information from select EPA or State-lead Superfund Sites that can be compared to $250,000 per year for project management and technical support by the contractor, data evaluation provided by USACE (cost unknown), and 3.5 full-time equivalent treatment plant staff for O&M of an optimized system. This information is provided to help the Vineland site team establish a goal or target for project management, technical support, and O&M labor. Each site is different and has its own complexities, but continued optimization from the site team and from implementing the RSE recommendations can help achieve these goals.

Site Name	Relevant Site Information
Baird and McGuire (100 gpm naphthalene and arsenic removal)	$635,000 in labor in 2008 for O&M, PM, consulting, sampling, and reporting
Selma Pressure Treating (200 gpm iron co-precipitation system)	PM and technical support under 40 hours per month Operated effectively by one FTE
Groveland Wells (90 gpm metals removal, filtration, UV/OX)	$150,000 for two layers of PM, technical support, data evaluation, and reporting 1.5 FTEs for O&M
ARGO (Acid mine drainage with problematic system)	$60,000 for project management and administration 5 FTEs for O&M (includes engineering support)
Havertown PCP (product recovery, metals removal, UV/OX, and GAC)	$75,000 per year for project management, technical support, data evaluation, reporting, administration, and design upgrades 1 FTE for O&M plus 1 part-time engineer to upgrade plant
Greenwood Chemical (metals removal, UV/OX, and GAC)	$100,000 per year for PM, technical support, data evaluation, and reporting 2 FTEs for O&M
Pentawood Products (90 gpm chemical addition, DAF and GAC)	$150,000 per year for PM, technical support, data evaluation, and reporting 1.25 FTEs for O&M

One of the primary reasons for the additional operations staff is the frequent attention given to maintaining and rehabilitating the extraction system. If this and other practices can be streamlined, the plant operation staff could likely be decreased. For project management and technical support, the RSE team suggests that the site team should strive for a target PM budget of approximately $100,000 per year ($30,000 for managing plant logistics, $30,000 for preparing monthly reports, $30,000 for technical support, and $10,000 for additional meetings or communication). Additional, non-routine PM/support funding can be added for specific tests or circumstances, such as adjusting plant operations when some of the RSE recommendations are being tested or implemented (e.g., operating the plant at a reduced flow rate or using lime in place of sodium hydroxide).

6.2.11 BASED ON OUTCOME OF OTHER RECOMMENDATIONS, CONSIDER POTENTIAL FOR DELISTING WASTE SLUDGE

The potential for the sludge produced by the treatment plant to be delisted as a hazardous waste was investigated. A detailed analysis is provided as Attachment H. The ROD addressed the delisting issue for soil and sediment, but not specifically for waste generated by treatment of groundwater. The contaminated soil, groundwater, and sediment are considered K031 listed waste, and the sludge would also be considered waste under the “contained-in policy” but the sludge does not fail the toxicity characteristic leaching procedure (TCLP) test. The delisting of the sludge may require either an ESD or ROD Amendment. A ROD Amendment may open a number of issues related to the change in the MCL for arsenic and more recent NJDEP soil remediation standards. The process to delist waste (or to do a ROD Amendment) is complex and time consuming. The potential cost savings in delisting the sludge and allowing it to be disposed of in a Subtitle D facility instead of a Subtitle C facility would have to be carefully weighed relative to the time and cost for delisting and preparation of any ROD Amendment or

ESD. Cost savings would be highly dependent on the outcome of other recommendations, including optimization of the extraction system, using a plate and frame filter press, and potential use of combined heat and power (see Section 6.7). Under the current operating parameters, the RSE team believes that annual costs might decrease from approximately $80,000 per year to under $30,000 per year for a savings of more than $50,000 per year. However, if the extraction rate is decreased by 50%, this savings would likely be less than $25,000 per year, and if a plate and frame filter press is used in addition to reducing the extraction rate, the savings would be decreased to under $20,000 per year. The RSE recommends that this recommendation be considered after the other recommendations that affect waste generation are fully addressed.

6.3 RECOMMENDATIONS FOR TECHNICAL IMPROVEMENT

6.3.1 REFINE WELL REHABILITATION PRACTICES

The well rehabilitation process has been improved by the project team, but currently represents a significant investment in time and project funds. The use of the prophylactic treatments of the extraction wells by glycolic acid may want to be reconsidered. A more aggressive redevelopment treatment approach that builds on the successful use of jetting, but includes rigorous disinfection and use of dispersants with acids to break down biomass “slime” may allow longer periods between treatments and reduce costs for well maintenance. It is recommended that such changes be considered by the project team. Establishment of a clear threshold for the aggressive redevelopment based on changes in specific capacity of the well and other indicators such as BART test kits would be appropriate. Products are available to support this work (e.g., the Baroid AquaClear series). Additional information, including some on the chemicals used in well maintenance programs, is available in USACE Engineer Pamphlet EP 1110-1-27, Operation and Maintenance of Extraction and Injection Wells at HTRW Sites, Chapter 6 (see http://140.194.76.129/publications/eng-pamphlets/ep1110-1-27/toc.htm). The cessation of the continuous treatment of some of the wells with the Redux product may also be warranted in the absence of clear evidence for benefit to the well performance. No estimate is made on the potential cost savings for this recommendation due to the uncertainty on the performance of such treatment, but pilot testing for specific “problem” wells would be appropriate.

6.3.2 DISCONTINUE USE OF CURTAINS AND ELECTRICAL HEATERS FOR SAND FILTERS

The site team currently uses curtains and electrical resistive heaters around the bottoms of the sand filters to help avoid freezing while the plant is down during the winter. The plant, however, is rarely down for an extended period of time unless there is a power outage, and in these cases electricity is not available for the heaters. The RSE team suggests improving the insulation in the subject areas and discontinuing continuous electrical heating. The site team could purchase and keep radiant propane heaters on-site to prevent against freezing during power outages. Propane is a more efficient source of heat than electricity, the heaters need only be used while the plant is not operating for an extended period of time, and the heaters can work in the absence of electricity. If recommendation 6.7.1 (combined heat and power) is implemented, a reservoir of hot water plus hydronic heating elements can be used to provide the necessary heat during limited power outages. The costs and savings associated with this recommendation are likely negligible and difficult to quantify because they would be based on the number and duration of system shutdowns and power outages.

6.3.3 CONTINUE WITH PLAN TO REMOVE SOIL WASHING EQUIPMENT FROM THE SITE

The site team indicated that operations staff time is being used to exercise the equipment associated with the soil washing remedy. The site team also indicated that the equipment will not be used again for the site and that they are planning on selling or transferring the equipment to another site. This will free-up more operator time and allow the site team to optimize staffing for the treatment plant.

6.3.4 PREPARE AN ANNUAL REPORT

Groundwater data, extraction well performance, and modeling are reviewed relatively frequently at the site to determine a path forward, but the RSE team is not aware of this analysis being documented or summarized in an annual report as is done at most other Superfund sites with long-term groundwater remedies. The RSE team suggests that the data analysis, site conceptual model, and remedy performance be documented in an annual report on an annual basis. EPA document EPA-542-R05-010 *O&M Template for Groundwater Remedies* can be used as guidance for this report. The USACE also has sample contract language to require contractors to collect and report the necessary data to support performance evaluation. At many sites of reasonable complexity, the reports cost on the order of $25,000 to manage and evaluate the data, prepare tables and figures, and provide interpretive text. Along similar lines, the site team should finalize the Five-Year Review that remains in draft form.

6.4 CONSIDERATIONS FOR GAINING SITE CLOSE OUT

6.4.1 EVALUATE POTENTIAL FOR NATURAL ATTENUATION AND SUGGESTED CRITERIA FOR DISCONTINUING P&T

The ROD states that the effectiveness of natural attenuation and P&T to protect Blackwater Branch should be compared. The ROD also states the need to reevaluate the maximum arsenic criteria of 0.35 mg/l to determine if it is sufficiently protective of Blackwater Branch in the absence of pumping. The RSE team believes that the next several years is the time frame to conduct these studies and offers a suggested path forward consisting of the following elements:

- Hydrogeological analysis
- Geochemical analyses
- Fate and transport simulations
- Potential pilot testing

Hydrogeological Analysis

The site team has an existing model, but the recognizes that the model is somewhat limited due to the transient nature of the groundwater system at the site due to a relatively flat hydraulic gradient and changes in the stage of Blackwater Branch. The site team further recognizes potential anomalies in the surveyed points used for developing water levels at the site. These items need to be addressed before applied to the evaluations natural attenuation and the 0.35 mg/l criteria. The RSE team suggests the following items to address these concerns:

- Resurvey all site monitoring wells and stream gauges
- Conduct the following four synoptic rounds of water level events
    - Non-pumping conditions during low regional groundwater flow

  - Non-pumping conditions during high regional groundwater flow
  - Pumping conditions during low regional groundwater flow
  - Pumping conditions during high regional groundwater flow
    (Note: The extraction system should be discontinued for a full week or longer prior to the non-pumping water level events to give the aquifer a chance to rebound from pumping conditions.)
- Calculation of stream flow at up to five or six locations during the above four events
- Monitoring of transient water levels during system shutdown and startup
- Recalibration of the groundwater model based on the four new static water level events and stream flow calculations
- Calibration of the groundwater flow model to the transient data from the shutdown and/or restart tests

Geochemical Analyses

Site geochemistry plays a significant role in arsenic adsorption and therefore arsenic fate and transport. Furthermore, the geochemistry can be altered via chemical amendments to create more favorable conditions for arsenic immobilization and associated arsenic plume attenuation. The goals of these analyses are as follows:

- Obtain site-wide information about the magnitude and distribution of iron, aluminum, and arsenic concentrations in saturated soils and groundwater

- Obtain geochemical parameters in groundwater to assess the buffering capacity of the system and the presence of species that may compete with arsenic for adsorption sites

- Conduct bench scale testing, including complete-mix reactors and column studies to estimate partitioning coefficients for arsenic in different areas of the site and determine the rate transfer coefficient and diffusion characteristics required for fate and transport analysis

- Simulate arsenic fate and transport given existing aquifer conditions

- Conduct bench scale tests to determine the natural oxidative demand of the soil and the ability to oxidize arsenite to arsenate *in-situ*

- Conduct bench scale testing to determine the effect of chemical addition (e.g., iron, pH adjustment, and various types of oxidizing agents that may be needed to convert arsenite to arsenate in order to increase the effectiveness of immobilization) on the arsenic partitioning coefficients

- Simulate arsenic fate and transport given aquifer conditions enhanced with chemical addition

- If results of the above studies are favorable, conduct field scale pilot studies to determine performance in the field and to estimate scale-up costs

- Determine the areas of the site most suitable for arsenic immobilization, and, consequently, areas most suitable for continued P&T

To achieve these goals, this recommendation has the following components.

The site team could mobilize a direct-push rig to collect soil samples from many locations throughout the site. The RSE team suggests a broad study across the approximate 1,500-foot by 1,500-foot plume area, perhaps on an approximate 250-foot by 250-foot grid with soil samples collected from both the shallow and mid-depth zones. This would be a total of approximately 100 samples (50 from each zone). Samples from these locations and/or adjacent monitoring wells should be analyzed for the parameters outlined in Attachment I. An optimized list of samples and analyses from Attachment I could be developed at the work plan stage to limit the total number of analyses conducted but still obtain the needed information. Based on appropriate groupings, the site team should take a subset of these samples and conduct equilibrium-based and mass-transfer based jar and/or laboratory column tests (refer to Sanchez 2003) to estimate the arsenic partitioning coefficient. Similar subsets of soil samples should receive varying chemical treatments including 1) additional iron in the form of ferric chloride, additional iron in the form of ferrous chloride, and additional iron in the form of ferric oxyhydroxides, 2) pH adjustment, 3) additions of oxygen, ozone, free chlorine, hypochlorite, permanganate, and/or hydrogen peroxide in order to improve the effectiveness of adsorption by oxidizing arsenite to arsenate. The samples should then undergo testing to evaluate the changes in the arsenic partitioning coefficient and determine the rate transfer coefficient and diffusion characteristics required for fate and transport analysis. Samples with adsorbed arsenic can then undergo reasonable changes in conditions (e.g., modifications to pH and/or ORP to evaluate adsorption stability).

Fate and Transport Modeling and Simulations

Results from simulations with site groundwater model that indicate flow paths under natural and various pumping schemes should be combined with the measured partitioning coefficients to estimate time of travel for arsenic to reach surface water. For sensitive areas of the site, the contaminant transport modeling can be conducted. A site-wide transport model may or may not be necessary. However, a site-wide model that can reproduce the changes in the arsenic concentrations in the mid-depth monitoring wells between 2002/2003 and 2008/2009 will increase the confidence in the predictive capabilities of the model. The ability of the model to reproduce these conditions reasonably assumes that P&T is primarily responsible for the concentration changes the mid-depth wells and that source removal may have had some influence on concentration changes at specific shallow wells. Relatively simple transport models using MODFLOW and MT3D might be appropriate to simulate idealized “study areas” to predict the concentrations of arsenic that would discharge to surface water. The output could then be modeled using a tool such as CORMIX to evaluate surface water mixing. Results of the mixing would need to be compared to the 0.05 mg/l standard established in the ROD or any other surface water Applicable or Relevant and Appropriate Requirements (ARARs). Discussions would likely need to occur with NJDEP to determine the appropriate regulatory mixing zone for this discharge to Blackwater Branch.

These simulations, which are based on the analyses discussed above, should provide a thorough evaluation of the 0.35 mg/l criteria and the point at which natural attenuation can replace P&T in accordance with the ROD.

The above simulations can be repeated with the fate and transport parameters derived from lab testing with chemical amendments. These simulations would evaluate the effect of chemical addition on arsenic immobilization and help determine areas of the site that would be well-suited for arsenic immobilization to either reduce the extent of P&T or reduce the time frame of P&T.

Potential Pilot Testing

If any suitable areas are identified, one or more of them should be subject to field-scale pilot testing. The pilot tests should likely take the form of a recirculation cell to help isolate the study area from natural contaminant migration. The recirculation cell would likely take the form of an extraction well, an injection well, and several monitoring points between the two wells. Distances should be sufficiently small to see results in a timely manner with groundwater flow rates that are not substantially higher than natural groundwater flow rates. The test should likely begin with oxidation to determine the effectiveness of oxidizing the arsenite to arsenate. Oxidation should likely be tested with air sparging, hydrogen peroxide, and other oxidants independently. Samples should be taken to quantify the remaining arsenite concentrations and evaluate the effectiveness of the oxidation. The next step of the test will likely involve iron addition and pH adjustment. There are several possibilities for iron addition, and further evaluation is needed to determine the most appropriate means. Some possibilities include the following (in no particular order of preference):

- Inject a ferrous iron solution that can migrate through the subsurface some distance from the injection point and provide sufficient oxygen and alkalinity to allow it oxidize to ferric iron.

- Inject an acidic solution of ferric iron and let it migrate into an area with sufficient alkalinity to allow it to precipitate.

- Create a permeable barrier with a mixture of coarse sand and iron hydroxide sludge, which is a waste product from some water treatment processes and has the benefit of being relatively cheap and sustainable).

- Add nano-iron that can migrate some distance from the injection point and provide sufficient oxygen to oxidize it.

Recirculate arsenic impacted groundwater through the test area and monitor the test area’s ability to immobilize the arsenic. If arsenic immobilization is demonstrated, then test the same area with variations in ORP and pH to determine if the arsenic will remain immobilized under natural conditions.

The RSE team has not determined a full-scale cost for this recommendation, but it seems that costs would be on the order of $500,000. The RSE team estimates that likely under $100,000 of this amount is needed to update the groundwater flow model to help confirm capture of the existing system and help determine the optimized system that minimizes the extraction rate while maintaining capture. As stated in Recommendation 6.2.3, the RSE team estimates that reducing the system extraction rate by 50% could save more than $228,000 per year.

Furthermore, the RSE team estimates that significantly more than half of the $500,000 cost is required to effectively evaluate the 0.35 mg/l maximum arsenic criteria. The results of the above studies could have a number of outcomes, including (but not limited to) the following:

- Confirmation that a site-wide maximum arsenic concentration of 0.35 mg/l is protective
- Demonstration that a lower site-wide maximum arsenic concentration is protective
- Demonstration that a higher site-wide maximum arsenic concentration is protective
- Demonstration that a maximum arsenic concentration of 0.35 mg/l is appropriate within 100 feet of Blackwater Branch but that a higher maximum arsenic concentration is appropriate further from Blackwater Branch

If a lower site-wide maximum arsenic concentration is derived, then completion of this study will have helped prevent the site team from prematurely discontinuing pumping. If a higher maximum arsenic concentration is determined, then the site team may be able to reduce the operational time frame for the system. At a cost of $1.7 million per year (or even $1 million per year for an optimized system), reducing the operational time of the remedy by 5 to 10 years could save close to $10 million.

Other portions of the $500,000 involve evaluating the effectiveness of chemical addition to enhance arsenic immobilization and design a cost-effective remedy that uses enhanced arsenic immobilization to significantly reduce the operating extent of the P&T system and/or the operating life of the system. If P&T operation can be reduced to $500,000 per year for 10 years or the duration of active treatment can be reduced by 5 to 10 years, significant savings could be realized even with potential significant capital expenditure for chemical addition.

The RSE team suggests the following approximate timeline for conducting the above activities:

- Hydrogeologic analysis field work – complete within 12 month period
- Groundwater model update – complete within 6 months following completion of the hydrogeologic analysis field work
- Geochemical analysis – complete field work and laboratory analysis leading up to but not including the pilot test within a 12 month period
- Fate and transport simulations – complete within 6 months following completion of the geochemical analysis field work and groundwater model update
- Pilot testing – if study results are favorable complete pilot testing design, installation, and results in a 12 month period following the fate and transport simulations.

The field work for the hydgeological and geochemical analyses can be conducted simultaneously because they do not depend on each other, but the fate and transport simulations need to occur after the groundwater model has been updated. The pilot testing, if appropriate, would need to follow the simulations. Accounting for these suggested time periods and potential delays, the study should be completed within a five-year period.

6.4.2 ACTIVE *IN-SITU* TREATMENT FOR ARSENIC IMMOBILIZATION

The RSE team finds it unlikely that the evaluations in Recommendation 6.4.1 will lead to immediate discontinuation of the P&T system in favor of natural attenuation. However, the RSE team is hopeful that the above information will indicate that enhanced arsenic immobilization can play an important role in cost-effectively reducing the extent of groundwater extraction and the duration of groundwater extraction. The current groundwater extraction and treatment system could be used, following some modification, to extract and treat contaminated groundwater from portion of the plume, inject water in strategic locations to create a hydraulic barrier between the contamination and the creek, and deliver chemical amendments to the appropriate areas of the subsurface.

One possible configuration would be to inject (via wells or trenches) treated water with amendment between the northern extraction well line and Blackwater Branch. The injection would help create a hydraulic barrier to prevent contaminant flux toward the stream while ultimately creating an *in-situ* zone for treatment following cessation of active treatment. Extraction would continue from the western line. Flux of amended water would move from the injection lines westward through the core of the highest groundwater concentrations, immobilizing some of the mass. This configuration would also reduce the amount of water requiring treatment while providing control of the plume. Additional injection of amended water would occur near the source area for the southern and northern plume. Ultimately, the dissolved arsenic concentrations should diminish and active treatment could be terminated. Natural flux of upgradient groundwater will maintain stability of iron and arsenic. Figure 6-1 illustrates the possible locations of injection and extraction. The model development discussed in the previous section and the use of optimization software discussed in Recommendation 6.2.3 could help determine an optimal strategy. No costs are included with this as there is much uncertainty on the feasibility and chemistry involved.

6.5 SUGGESTED APPROACH TO IMPLEMENTING RECOMMENDATIONS

The RSE team has provided a number of recommendations that each have individual merit, but that may conflict with each other if implemented together. The RSE provides the following section for prioritizing and implementing the recommendations.

The RSE team suggests that the site team address Recommendations 6.1.1, 6.1.3, 6.2.3, 6.4.1, and 6.4.2 as part of developing a site exit strategy (see next section). Collectively, these recommendations address plume delineation and optimizing the use of geochemistry and groundwater extraction to contain the arsenic plume. Based on the results from addressing these recommendations, the site team will have an understanding of the groundwater extraction rate, the influent water quality, and the extraction (and possibly injection) wells that will be used. Recommendations 6.3.1 can then be considered for the wells that will be operating. If the results suggest that the extraction system will remain unchanged, then the site team should address Recommendation 6.1.2 to confirm the system is providing adequate capture and 6.2.5 to optimize the groundwater monitoring program. If the results suggest reduce flow rates and water quality, the site team can address the cost-effectiveness and appropriateness of Recommendations 6.2.4, 6.2.6, 6.2.7, 6.2.8, 6.2.9, 6.2.11, 6.7.1, and 6.7.2. Collectively, these recommendations involve optimization of the groundwater monitoring program and the treatment plant, but they cannot be fully considered until the site team has settled on a long-term strategy and know the parameter for treatment plant operation.

Recommendations 6.2.1, 6.2.4, 6.3.2, 6.3.3, and 6.3.4 can occur at any time without interfering with the other recommendations and should be implemented a soon as possible without detracting from the resources needed to address the other recommendations.

Recommendation 6.2.10 has two components. Treatment plant staffing should likely remain at its current level until the remedial strategy has been selected and the treatment plant modified accordingly. The project management and technical support budget should likely be reviewed and refined as soon as possible, so that routine effort (project logistics, monthly reporting, basic technical support, and basic communication) is budgeted separately from special projects and tasks.

6.6 EXIT STRATEGY

6.6.1 SUGGESTED EXIT STRATEGY

The current approach to achieving site closure involves the containment of the groundwater plumes, source mass removal at and above the water table, and efforts to maximize mass removal from the saturated zone. Ultimately, the goal is to achieve a concentration (nominally 0.35 mg/l, a value above the former and current MCL) in groundwater at the site that would prevent the exceedance of 50 ug/L in surface water. The removal of source materials from the vadose zone has certainly improved the chances for attainment of these goals, and significant progress has been made in the reduction of concentrations in the mid-depth portion of the impacted aquifer. Still, efforts to significantly reduce the concentrations and footprint of the arsenic plume in the shallowest part of the aquifer have had more limited success. Though bench-scale results have been promising, the results so far for field-scale testing of methods to increase the mobility of arsenic compounds in the aquifer have been mixed. Increasing mobility is potentially feasible, but estimates of the time to attain cleanup goals in groundwater are long, as described above.

As an alternative exit strategy, this study is proposing consideration of ways to leverage the natural geochemistry of the aquifer in ways that allow stable immobilization of the arsenic in the subsurface, all while maintaining control of the plume to prevent unacceptable impacts on the Blackwater Branch. If feasible, the immobilization of arsenic would result in reduction in dissolved arsenic concentrations and would allow cessation of active remediation at some earlier time compared to the current approach. As described above, the existing extraction and treatment system may be integrated into the effort to immobilize the arsenic.

The first steps in the new approach would be to gather data to more fully understand site hydrogeology, the geochemistry of the interactions between the arsenic and the native soils, and the ability for the aquifer to naturally attenuate the arsenic through immobilization processes. This would be followed by efforts to refine the estimate of the acceptable levels of dissolved arsenic in the aquifer that would not cause unacceptable impacts on the stream. This is consistent with the approach identified in the ROD. Contaminant transport modeling (that reflects the revised conceptual model based on the investigations) would be highly beneficial for the task of assessing a new cleanup goal. During these investigations, the current extraction and treatment system would continue to operate, although implementation of certain proposed changes meant to optimize its cost-effectiveness would proceed as appropriate.

If the investigation of the geochemistry and alternative cleanup goal for the aquifer shows that natural processes could prevent unacceptable impacts on the stream, then the active extraction and treatment could be terminated (though the extraction and treatment system could be mothballed in case unexpected impacts on surface water occurred). If the natural processes are determined to be incapable of controling the release of arsenic to the stream, either the current strategy could be continued or the implementation of efforts to engineer the processes of immobilization could be pursued. Engineered immobilization of the arsenic would have to be demonstrated on a pilot scale, and if successful could be implemented in a way that targets both the source areas (below the water table) and areas near the stream and in areas of high dissolved arsenic concentrations. It is presumed that a modified groundwater extraction and treatment system would continue to operate. Once dissolved arsenic concentrations reach the revised cleanup goals in the aquifer, active remediation would cease, but monitoring would continue for some period to assess protectiveness.

Throughout the process, periodic optimization of the monitoring program would be necessary, as has been conducted by the project team to date. The emphasis should be on collecting only the data needed to support site decisions. Specific rationale can be used to verify that sampling of each well included in the monitoring network is needed and that the frequency of sampling is still appropriate. Note that sampling frequency may need to be increased in some locations during major changes in the remedy (e.g., implementation of treated and amended groundwater injection, or cessation of pumping).

Ultimately, site groundwater concentrations may reach levels that allow unrestricted use of the site, though this may not be possible. If not, the Classification Exception Area designation and restrictions on groundwater use will have to remain in effect indefinitely. Five-year reviews would have to be done on a recurring basis. However, the level of effort required for the project will have diminished to minimal levels, including limited sampling to support the five-year reviews and periodic verification of compliance with land-use restrictions.

6.7 ADDITIONAL SUSTAINABILITY CONSIDERATIONS

6.7.1 CONSIDER COMBINED HEAT AND POWER

Electricity used by the site is generated from coal by the Vineland Municipal Electric Utility at a cost of approximately $0.14 per kWh. As discussed in Section 4.6, despite offsetting electricity usage with RECs, electricity use of 1.35 million kWh per year at the site translates to annual emissions of approximately 560,000 pounds of carbon dioxide equivalents per year, plus emissions criteria pollutants and hazardous air pollutants.

Generating electricity with natural gas results in fewer emissions than generating electricity with coal, and generating electricity on-site can be a more efficient use of energy if the waste heat is used for beneficial purposes (otherwise referred to as combined heat and power). One beneficial purpose is to use the waste heat for space heating, which eliminates the need for natural gas for heating. Another beneficial purpose would be to use the heat to evaporate some of the water from the process sludge to reduce the weight of hazardous waste produced by the remedy. Therefore, the use of combined heat and power could use energy more efficiently and could result in from substantial reductions in hazardous waste generation. Because electricity is no longer obtained from the grid, the purchase of RECs is no longer appropriate. If the site team would like to offset the carbon dioxide emissions from the natural gas combustion, carbon offsets could be purchased and/or trees could be replanted at the site to store carbon in biomass.

Once the recommendations in the above sections are considered and the site team has determined the long-term extraction rate for the site, the site team should consider the use of combined heat and power. In 2009, electricity from the grid averaged $0.14 per kWh and natural gas averaged $1.13 per therm. In addition, approximately 130 tons of waste that was 75% water was disposed of 700 miles from the site as hazardous waste at a cost of approximately $80,000. The following analysis holds for the 2009 electricity usage, natural gas usage, and waste generation and would need to be modified to account for a lower extraction rate and lower electricity use.

Item	Quantity
Capital cost for 175kW system	$385,000
Additional capital for heating applications	$100,000
Electricity generated (kWh)	1,350,000
Grid electricity avoided (kWh)	1,350,000
Natural gas required (therms)	162,189
Natural gas for heating avoided (therms)	24,400
Net natural gas used (therms)	137,789
Hazardous waste disposal generated from original process (tons)	260
Hazardous waste disposal avoided (tons) (assume 50% reduction)	130
Natural gas cost ($)	$183,274
O&M cost ($)	$27,000
Carbon offsets ($) (assumes $0.005 per pound)	$8,500
Annual costs	$218,774
Electricity cost avoided	$189,000

Item	Quantity
Natural gas cost avoided ($)	$27,600
Hazardous waste disposal cost avoided ($)	$40,000
Avoid costs for purchasing RECs ($) (assumes $0.03/kWh)	$40,500
Annual avoided costs	$297,100
Net annual savings	$78,326
Financial position after 10 years	Savings of $298,260

All combined heat and power values approximated from Technology Characterization: Reciprocating Engines, prepared for the Environmental Protection Agency, Combined Heat and Power Partnership, December 2008. The purchased carbon offsets offset carbon dioxide emissions from all natural gas usage.

As indicated in the above table, the project would result in savings of approximately $300,000 over a 10-year period. The analysis includes offset of all carbon dioxide emission from natural gas combustion, which would represent a significant reduction in the remedy's carbon footprint. It also reduces the hazardous waste generated and the diesel fuel used to transport that waste 700 miles from the site.

The 175 kW system would generate adequate heat for building heat and evaporation. The useful heat output at temperatures over 200 F is approximately 6,000 btu per kWh of electricity generated for a total of 8,100 million btus. By contrast, 24,400 therms of natural gas that is currently used for building heat is equal to 2,440 million btus, and the amount of heat needed to heat 130 tons of sludge and evaporate 65 tons of water (130,000 pounds) is approximately 700 million btus assuming a 25% heating efficiency. The site team would need to devise a custom heat exchanger to transfer the heat from the combined heat and power system to the sludge boxes and allow adequate ventilation for the resulting moisture.

6.7.2 CONSIDER ALTERNATIVES FOR IRON ADDITION

A significant portion of the O&M costs and the environmental footprint are associated with the addition of ferric chloride, the addition of sodium hydroxide, and the disposal of the solids generated by the treatment plant. One of the primary practices of green remediation is to identify opportunities for recycling and reuse to minimize use of materials and generation of waste. The site team could consider obtaining iron hydroxide sludge from other sites that would not add new pollutants to the Vineland process stream. An example would be iron hydroxide sludge from an acid mine drainage site that has high iron hydroxide sludge production. This iron hydroxide sludge could be added to the process stream in addition to or in place of ferric chloride and sodium hydroxide. If effective, using this sludge could eliminate or significantly reduce the amount of ferric chloride and sodium hydroxide that are added. Although the total amount of waste generated from Vineland might not be reduced, net waste disposal to a landfill would be reduced because the sludge from the other site would be used at Vineland prior to disposal.

There are several aspects to using sludge that require additional consideration, including composition of the sludge, its effectiveness of adsorbing arsenic, the amount to add relative to system flow rate, how to adjust existing chemical addition, the capacity of the DAF units for handling in the increased solids loading, and the properties of the sludge that would be generated. The site team might consider conducting bench scale jar tests at the treatment plant, using extracted groundwater, appropriate iron hydroxide sludge from another site, and the on-site graphite furnace for testing results. Based on the results, the site team can determine if a pilot test is appropriate. If a pilot test is conducted, the site team could consider conducting it in one (not both) of the currently operating DAF treatment trains or in one of the currently unused organic treatment trains. The bench and pilot scale testing should be focused to avoid it from becoming open-ended and expensive.

6.7.3 POSTPONE LIGHTING RETROFIT

The site team has proactively pursued energy efficiency measures including having a lighting survey done and replacing some fluorescent lighting at the site with the more efficient light-emitting diode (LED) lights. A recent lighting survey recommended further retrofit of fluorescent lights with LED lights. Although the RSE team supports the pursuit of energy efficiency measures such as the use of energy efficient LED lights, there may be substantial changes to the remedy in the next few years based on the recommendations in this report. The RSE team suggests focusing on the RSE recommendations above before pursuing further lighting retrofit. The money that would be spent on the lighting retrofit may be better spent from a green remediation perspective on pursuing reductions in the extraction rates, an *in-situ* remedy, or improvements to the treatment process. In addition, one of the recommendations suggests focusing heating and lighting on the portion of the building that is used. The RSE team believes the efforts to reduce lighting and heating need should take precedence over lighting and heating efficiency. Once the above recommendations have been considered and the site team has relative certainty on the future lighting and heating needs and funding is not constrained, then the site team can revisit the lighting retrofit.

TABLES

Table 4-1. Summary of Trend Analyses – 2000 to 2010

Mon. Loc.	Concentration Trend	Total Arsenic (mg/l)	Mon. Loc.	Concentration Trend	Total Arsenic (mg/l)
EW04M	Decreasing	**1.37**	MW37M	Decreasing - increase post excavation, then decrease	0.025
EW06M	Decreasing	0.265	MW39M	Decreasing - increase post excavation, then decrease	0.019
EW07M	Decreasing	0.275	MW41M	Decreasing - increase post excavation, then decrease	0.016
EW10M	Decreasing	0.009	MW45M	Decreasing - increase post excavation, then decrease	**0.395**
EW13M	Decreasing	0.046	EW05M	Stable - increase post excavation, then decrease	0.222
EW20M	Decreasing	**0.876**	EW07S	Stable - increase post excavation, then decrease	**1.72**
MW39S	Decreasing	**0.41**	EW08S	Stable - increase post excavation, then decrease	**1.32**
MW42M	Decreasing	0.009	EW11M	Stable - increase post excavation, then decrease	0.06
MW45S	Decreasing	0.019	EW11S	Stable - increase post excavation, then decrease	0.075
MW48M	Decreasing	0.009	EW13S	Stable - increase post excavation, then decrease	0.052
MW49M	Decreasing	0.029	EW19S	Stable - increase post excavation, then decrease	0.02
MW52M	Decreasing	0.226	MW30S	Stable - increase post excavation, then decrease	**0.545**
MW52S	Decreasing	0.242	MW31S	Stable - increase post excavation, then decrease	0.009
EW04S	Stable	**1.75**	MW33S	Stable - increase post excavation, then decrease	0.026
EW06S	Stable	0.222	MW34S	Stable - increase post excavation, then decrease	**1.17**
EW08M	Stable	0.031	MW47M	Stable - increase post excavation, then decrease	0.162
EW19M	Stable	0.028	WW24S	Stable - increase post excavation, then decrease	0.102
EW21M	Stable	**0.527**	MW28S	Increasing	**5.7**
MW28M	Stable	**9.56**	MW38S	Increasing	**3.5**
MW29S	Stable	0.016	MW40S	Increasing	0.177
MW31M	Stable	**2.93**	MW53S	Increasing	0.018
MW32S	Stable	0.016	MW54S	Increasing, then abrupt decrease recently	0.341
MW53M	Stable	0.009	MW35S	Increasing, then dropping off recently	**1.33**
MW54M	Stable	0.02	MW56D	First sample	0.011
WW25M	Stable	**1.39**	MW56S	First sample	0.045
WW25S	Stable	0.232			

Table 4-1 does not include monitoring wells with non-detect, and it does not include wells where recent measurements of arsenic are not available. Specifically the six wells with stable elevated arsenic concentrations between 2000 and 2002 are not included in the table below due to limited data set. The arsenic data sets for these six wells (MW37S, MW30S, MW49S, MW48S, MW36S, and MW15S) are available for the period extending from 2000 to 2002 and are shown in Attachment A. These six wells were damaged during the soil removal and therefore data for these wells are not available subsequent to 2002. Concentrations in these wells prior to 2002 were elevated and fairly stable ranging from 10, 1, 5, 1, 1, to 0.8 mg/l for wells MW37S, MW30S, MW49S, MW48S, MW36S, and MW15S, respectively (see attachment A).

Table 4-1 includes the trends since pumping at the groundwater treatment plant began and the most recent total arsenic concentration. Bold, highlighted values are larger than 0. 35 mg/l.

Table 4-2. Trend Plots in Recovery wells and Estimation of Restoration Time (EPA, 2002)

Ext. Loc.	Total Arsenic (mg/l)	Concentration Trend	Time to 0.35 mg/l (yrs)	Time to 0.05 mg/l (yrs)	Time to 0.01 mg/l (yrs)
RW01*	0.222	Initial increases, stable, pumping reduction caused large decrease, stable	-	Stable at 0.222	Stable at 0.222
RW02	**0.593**	Initial increases, decreasing	1	9	16
RW02a	**0.502**	Decreasing	< 1	3	6
RW02b	**1.22**	Mild decrease	14	36	54
RW03	**0.478**	Initial increase, decrease becoming milder over time	< 1	21	39
RW04	**0.622**	Initial increase, decrease becoming milder over time	3	12	20
RW05	0.288	Initial increase, decrease becoming milder over time	-	27	41
RW06	**1.33**	Significant decrease event in early 2001, decrease becoming milder over time	20	54	83
RW07	**0.951**	Initial increase, decrease becoming milder over time	13	41	65
RW08	**0.698**	Significant decrease event in late 2000, decrease becoming milder over time	4	21	35
RW09a	0.011	Decreasing with recent large fluctuations	-	-	<1
RW10	0.257	Decreasing	-	11	22
RW11*	0.009	Significant decrease in 2003-2004, ND for last 2 years	-	-	-
RW12	0.152	Initial increase, mild decrease	-	54	129
RW13*	0.187	Initial increase, significant decreases in 2001 and 2002, increasing	Currently below 0.35 but Increasing	Increasing	Increasing

**Recovery discontinued.*

Table 6-1. Cost Summary Table

Note: The approximate costs included in this table reflect estimates for individual recommendations given the current operating system. Implementation of some recommendations could affect or completely eliminate potential cost savings associated with other recommendations.

Recommendation	**Reason**	**Additional Capital Costs ($)**	**Estimated Change in Annual Costs ($/yr)**	**Estimated Change in Life-Cycle Costs $***	**Discounted Estimated Change in Life-Cycle Costs $****
6.1.1 FURTHER CHARACTERIZE EXTENT OF CONTAMINATION	Effectiveness	$30,000	$1,500	$75,000	$59,000
6.1.2 CONSIDER MODIFICATIONS TO THE GROUNDWATER EXTRACTION SYSTEM TO ASSURE CAPTURE	Effectiveness	Not quantified			
6.1.3 ADDITIONAL MONITORING OF GROUNDWATER QUALITY BETWEEN EXTRACTION WELLS AND BLACKWATER BRANCH	Effectiveness	$30,000	$1,500	$75,000	$59,000
6.2.1 DISCONTINUE AUTOMATED SAMPLER AND DO NOT REPLACE THE UNIT	Cost Reduction	($65,000)	Not quantified	More than ($65,000)	More than ($65,000)
6.2.2 ELIMINATE ROUTINE ON-SITE ARSENIC SAMPLING	Cost Reduction	Reduction not specifically quantified			
6.2.3 REDUCE EXTRACTION RATES TO THOSE THAT ARE NECESSARY FOR PLUME CAPTURE	Cost Reduction	Not quantified	($228,000) Assumes 50% reduction in flow	Not quantified	
6.2.4 EVALUATE GROUNDWATER MONITORING COSTS	Cost Reduction	$0	($55,000)	($1,650,000)	($1,078,000)
6.2.5 CONTINUE TO OPTIMIZE GROUNDWATER MONITORING PROGRAM	Cost Reduction	$0	($10,000)	($300,000)	($197,000)
6.2.6 FOCUS BUILDING HEATING AND LIGHTING ON KEY PROCESS AREA	Cost Reduction	<$10,000	($6,900)	($197,000)	($125,000)

Recommendation	Reason	Additional Capital Costs ($)	Estimated Change in Annual Costs ($/yr)	Estimated Change in Life-Cycle Costs $*	Discounted Estimated Change in Life-Cycle Costs $**
6.2.7 EVALUATE CHEMICAL USAGE	Cost Reduction	Requires more study. See text for details.			
6.2.8 CONSIDER USE OF A PLATE AND FRAME FILTER PRESS TO DEWATER SOLIDS	Cost Reduction	Not quantified	($60,000)	($1,800,000)	($1,176,000)
6.2.9 CONSIDER THE USE OF LIME FOR PH ADJUSTMENT	Cost Reduction	$200,000	($33,000)	($790,000)	($447,000)
6.2.10 CONTINUE TO STREAMLINE PLANT AND PROJECT STAFFING	Cost Reduction	$0	($150,000)	($4,500,000)	($2,940,000)
6.2.11 BASED ON OUTCOME OF OTHER RECOMMENDATIONS, CONSIDER POTENTIAL FOR DELISTING WASTE SLUDGE	Cost Reduction	Not quantified	($50,000)	($1,500,000)	($980,000)
6.3.1 REFINE WELL REHABILITATION PRACTICES	Technical Improvement	Not quantified			
6.3.2 DISCONTINUE USE OF CURTAINS AND ELECTRICAL HEATERS FOR SAND FILTERS	Technical Improvement	Negligible			
6.3.3 CONTINUE WITH PLAN TO REMOVE SOIL WASHING EQUIPMENT FROM THE SITE	Technical Improvement	Negligible			
6.3.4 PREPARE AN ANNUAL REPORT	Technical Improvement	$0	$25,000	$750,000	$490,000

Recommendation	**Reason**	**Additional Capital Costs ($)**	**Estimated Change in Annual Costs ($/yr)**	**Estimated Change in Life-Cycle Costs $***	**Discounted Estimated Change in Life-Cycle Costs $****
6.4.1 EVALUATE POTENTIAL FOR NATURAL ATTENUATION AND SUGGESTED CRITERIA FOR DISCONTINUING P&T	Site Closeout	~$500,000	Not quantified but potentially substantial		
6.4.2 ACTIVE *IN-SITU* TREATMENT FOR ARSENIC IMMOBILIZATION	Site Closeout	Not quantified			
6.7.1 CONSIDER COMBINED HEAT AND POWER	Sustainability	$485,000	($78,000)	($295,000) After 10 years	($178,000) After 10 years
6.7.2 CONSIDER ALTERNATIVES FOR IRON ADDITION	Sustainability	Not quantified			
6.7.3 POSTPONE LIGHTING RETROFIT	Sustainability	Not quantified			

Costs in parentheses imply cost reductions

* assumes 30 years of operation with a discount rate of 0% (i.e., no discounting)

** assumes 30 years of operation with a discount rate of 3%

FIGURES

Figure 2-1. Treatment Process as Designed

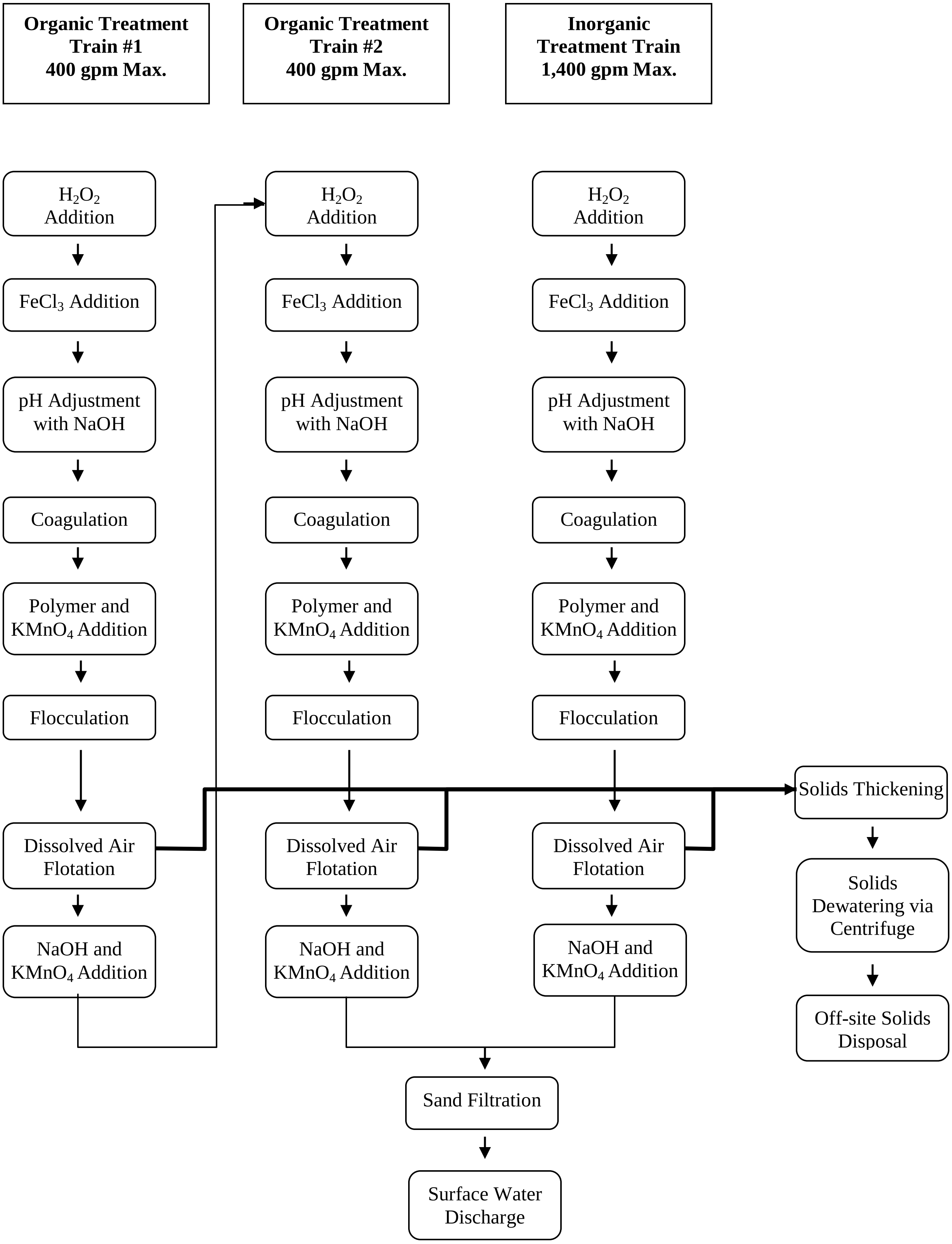
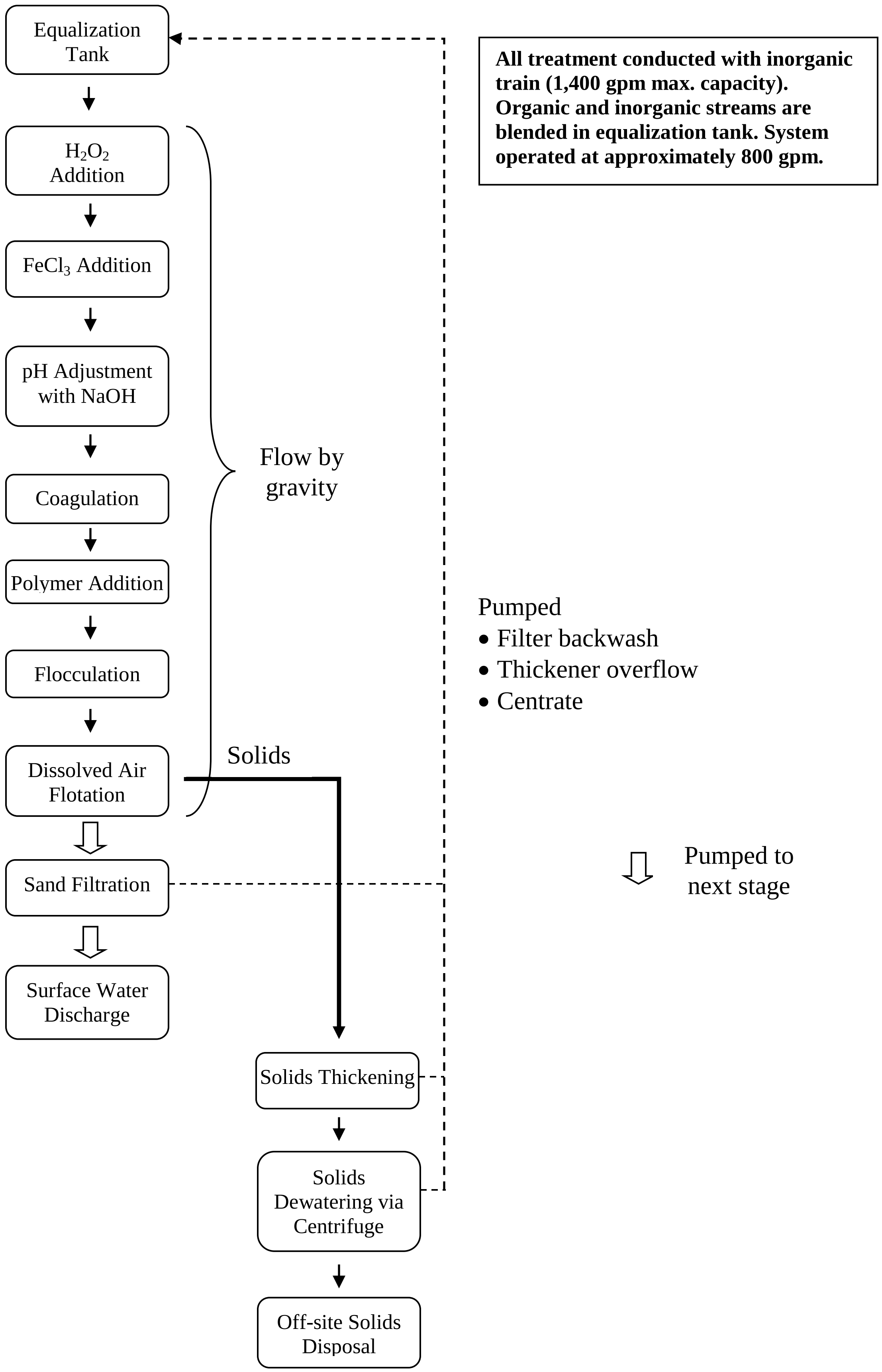
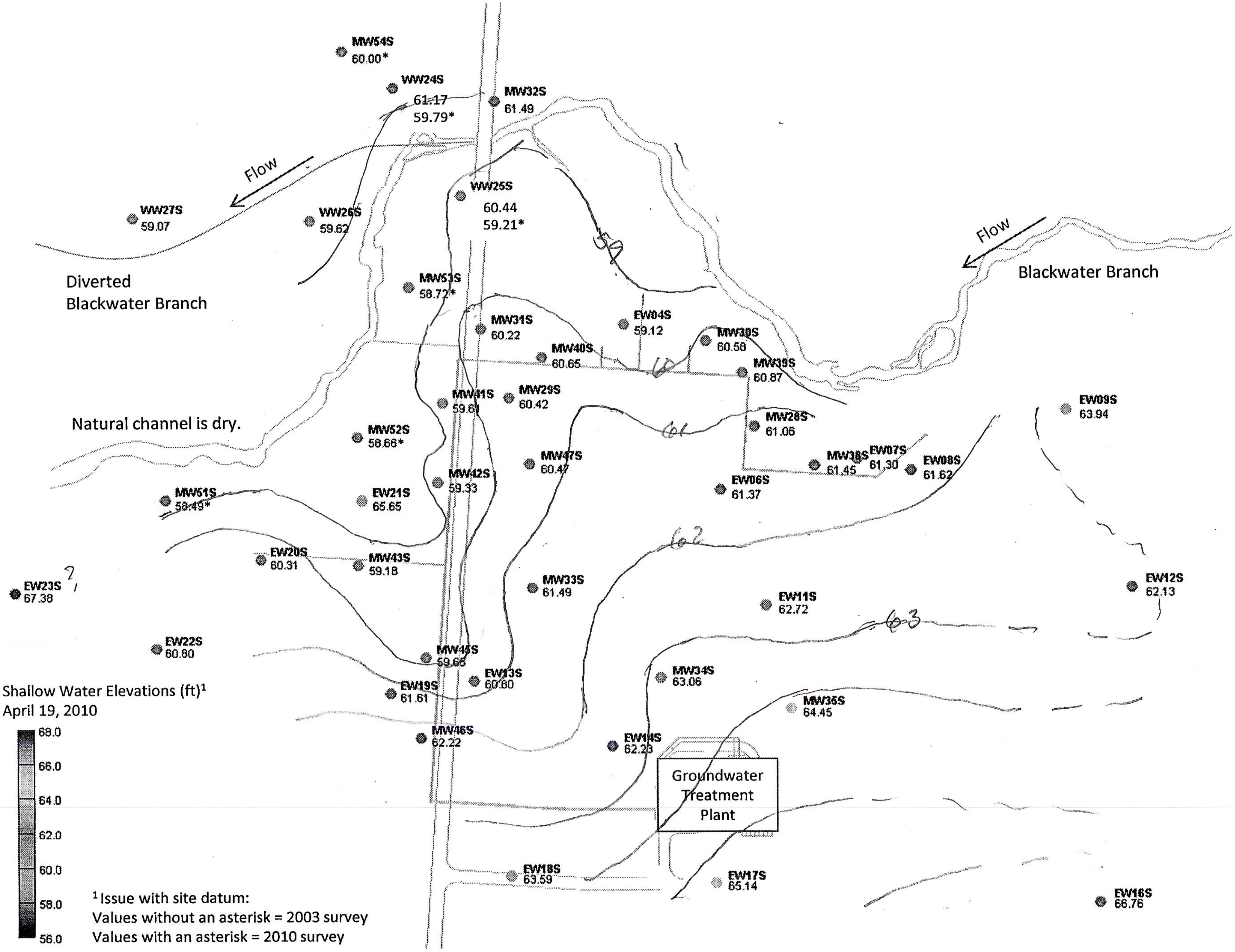


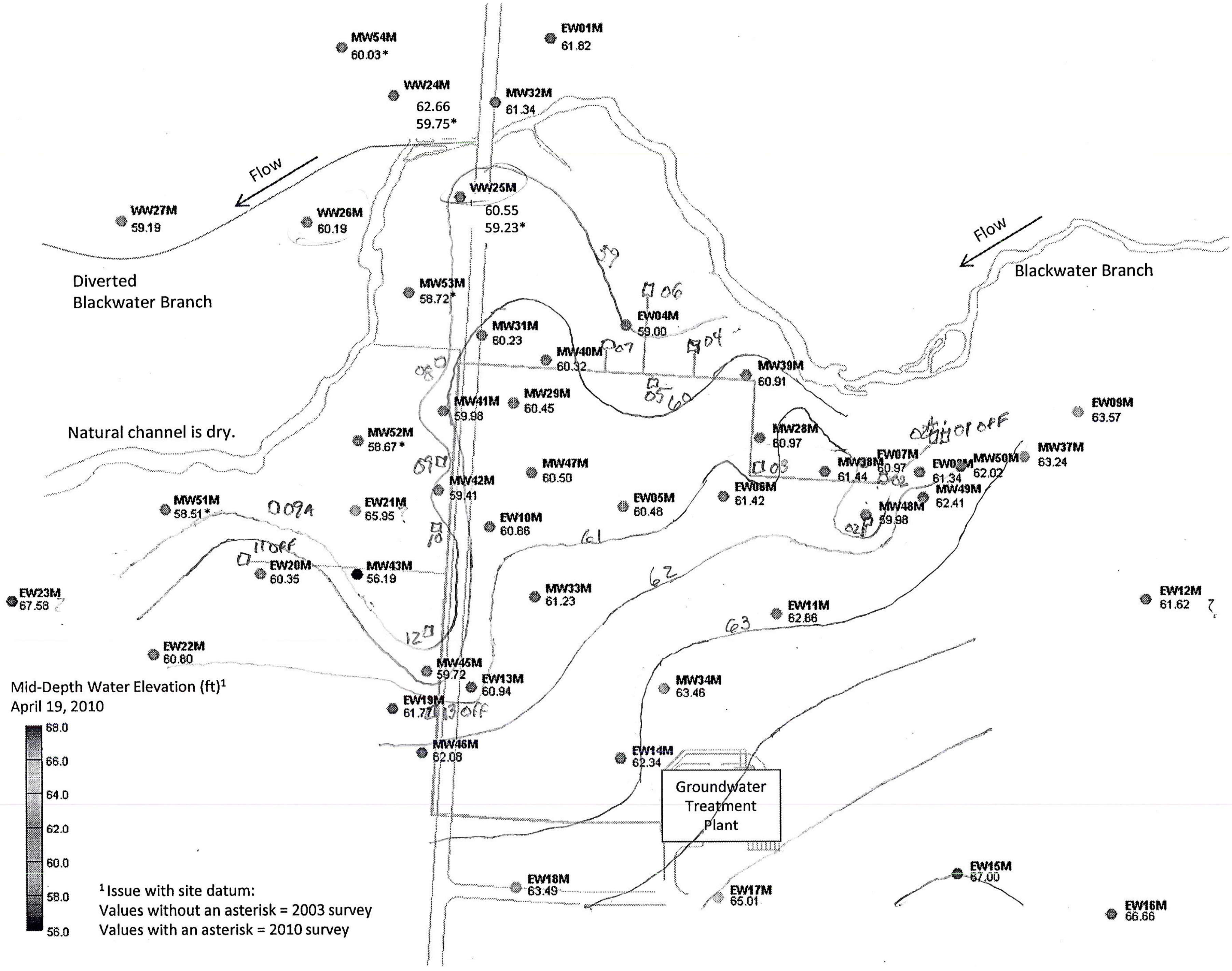
Figure 2-2. Treatment plant as currently operated





Shallow Water Elevations (ft)[1]
April 19, 2010

[1] Issue with site datum:
Values without an asterisk = 2003 survey
Values with an asterisk = 2010 survey



Mid-Depth Water Elevation (ft)[1]
April 19, 2010

[1] Issue with site datum:
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Values with an asterisk = 2010 survey

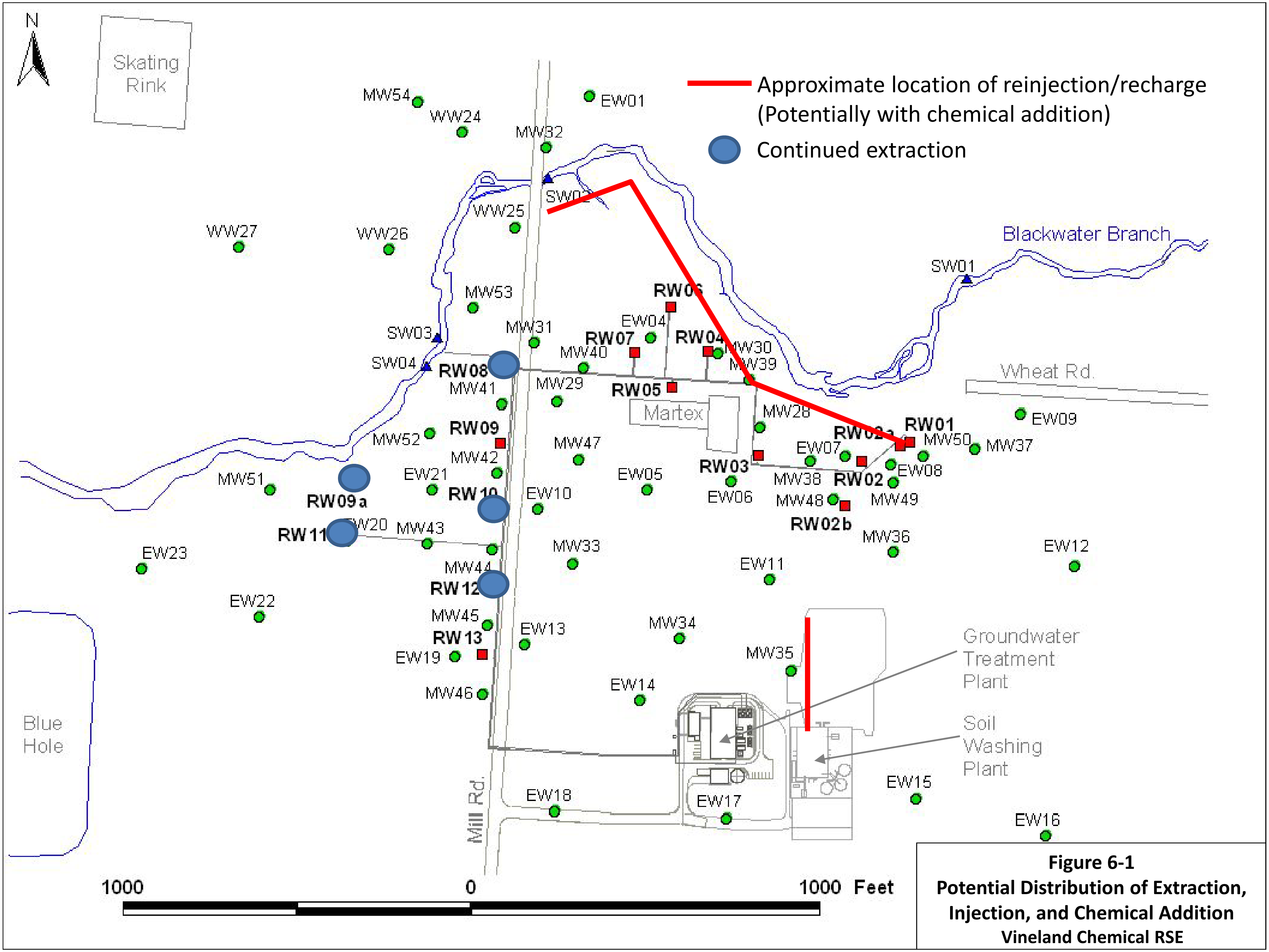


Figure 6-1
Potential Distribution of Extraction, Injection, and Chemical Addition
Vineland Chemical RSE

ATTACHMENT A

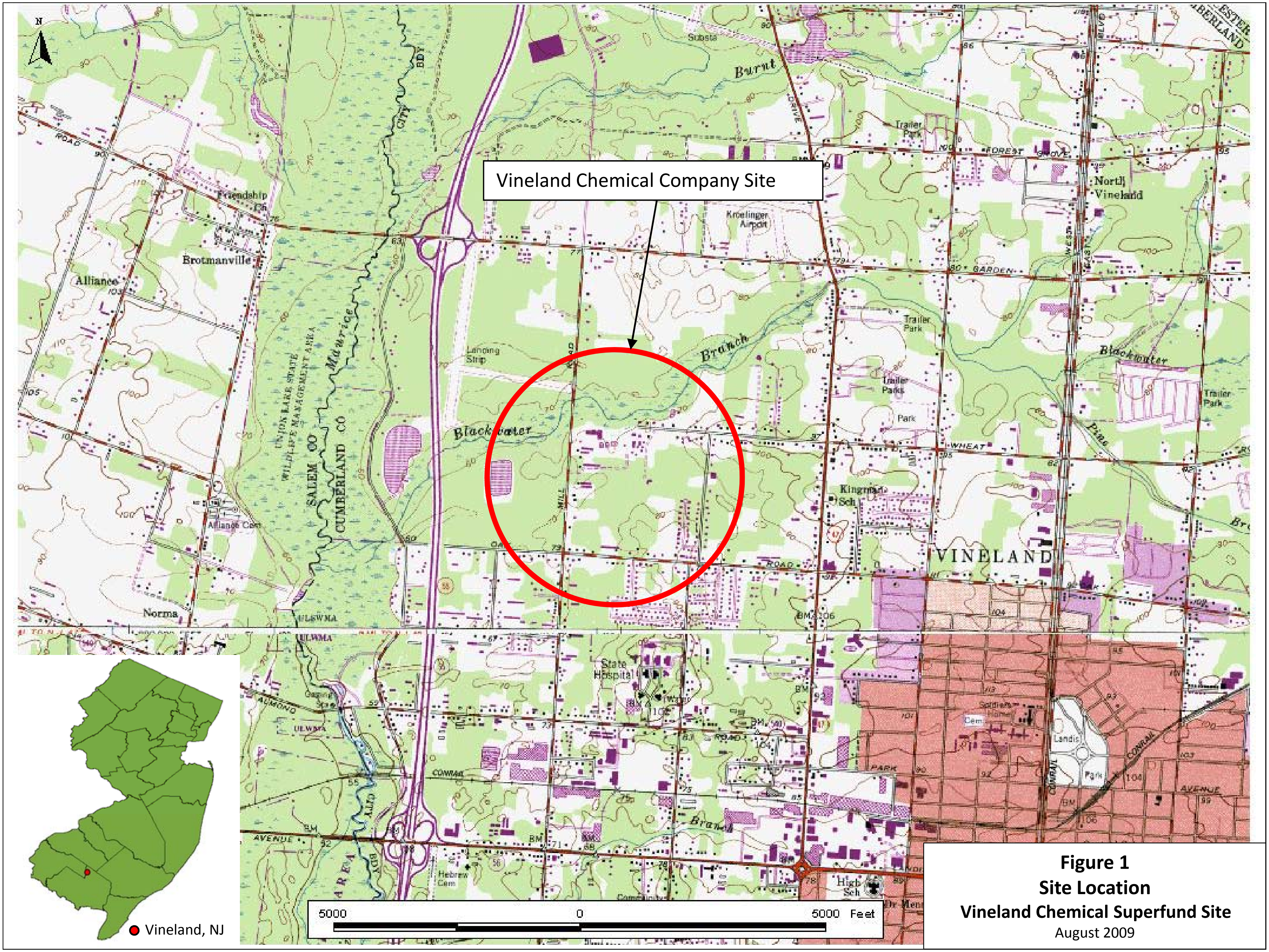


Figure 1
Site Location
Vineland Chemical Superfund Site
August 2009

Vineland Chemical Ground Water Elevations - August 1999 Pre-Pumping

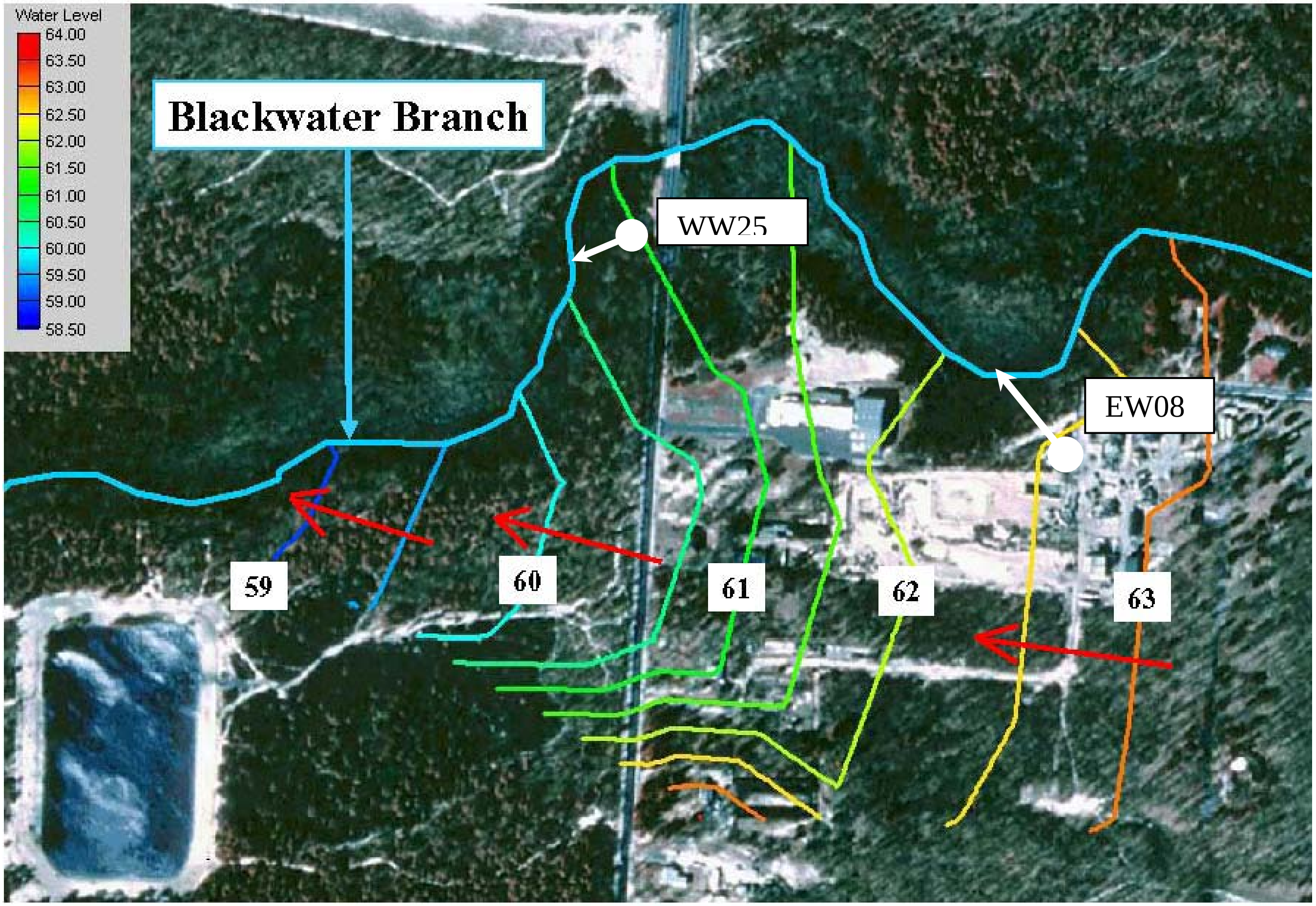


Figure 6

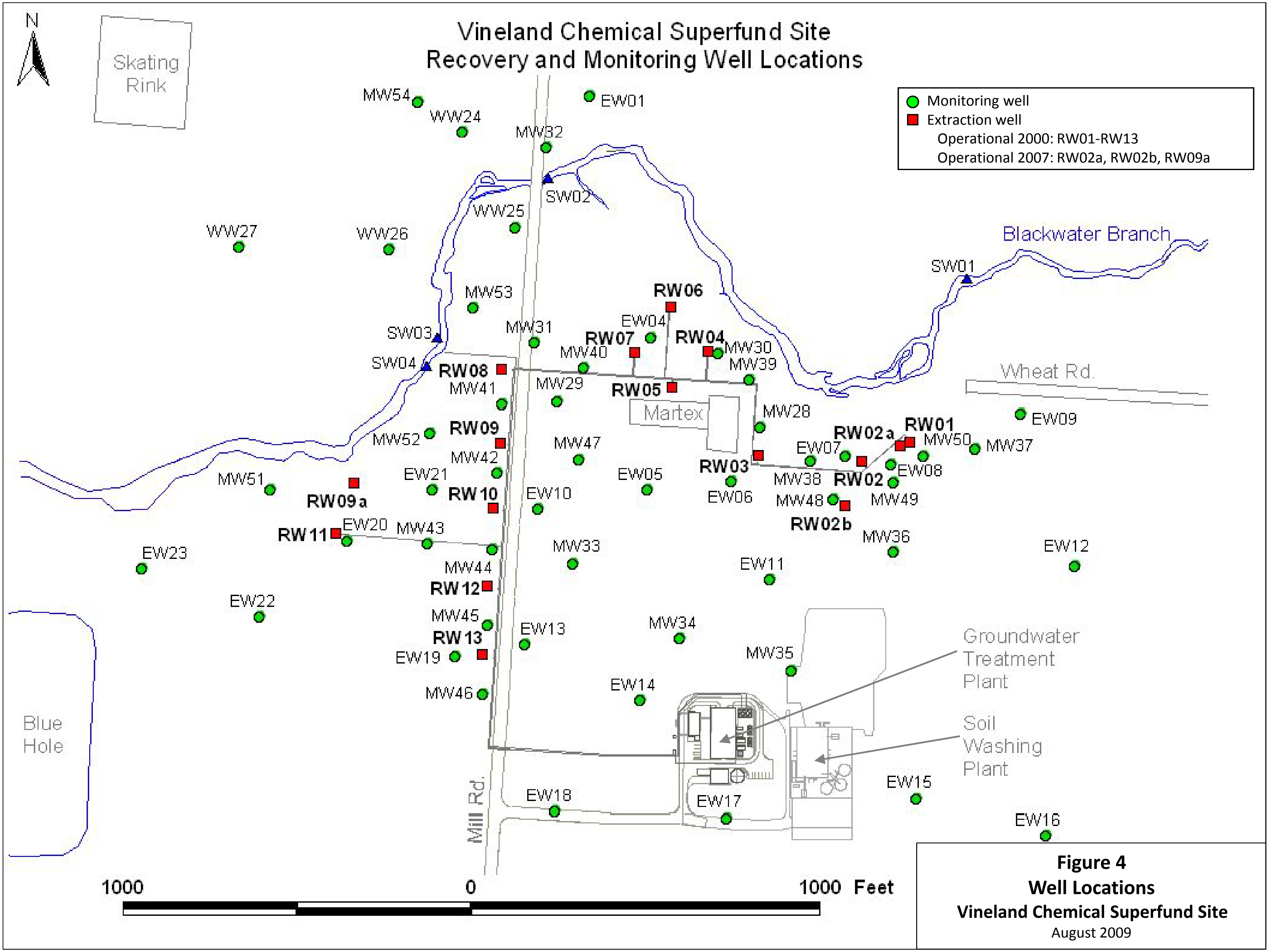
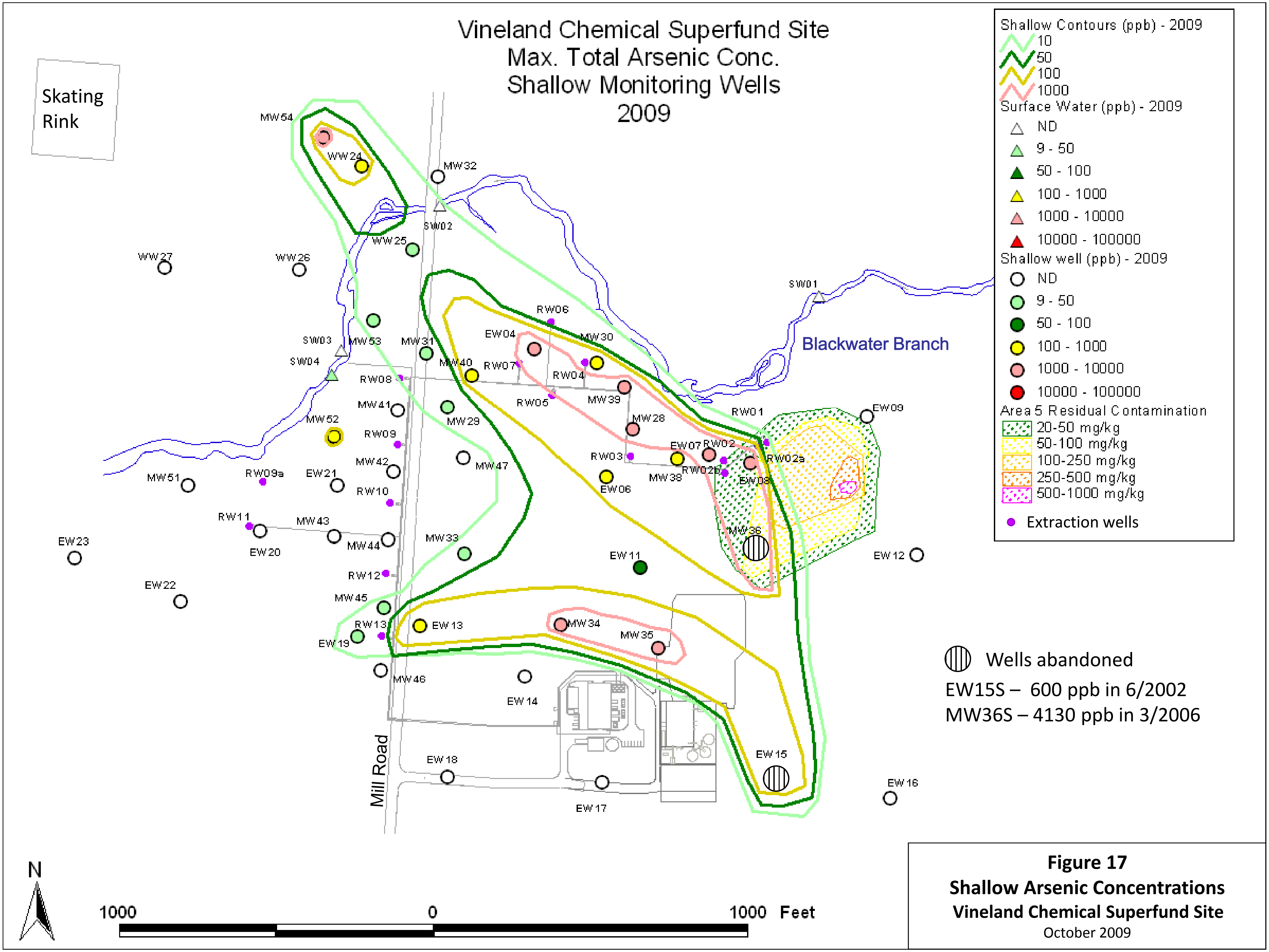


Figure 4
Well Locations
Vineland Chemical Superfund Site
August 2009



Wells abandoned

EW15S – 600 ppb in 6/2002

MW36S – 4130 ppb in 3/2006

Figure 17

Shallow Arsenic Concentrations

Vineland Chemical Superfund Site

October 2009

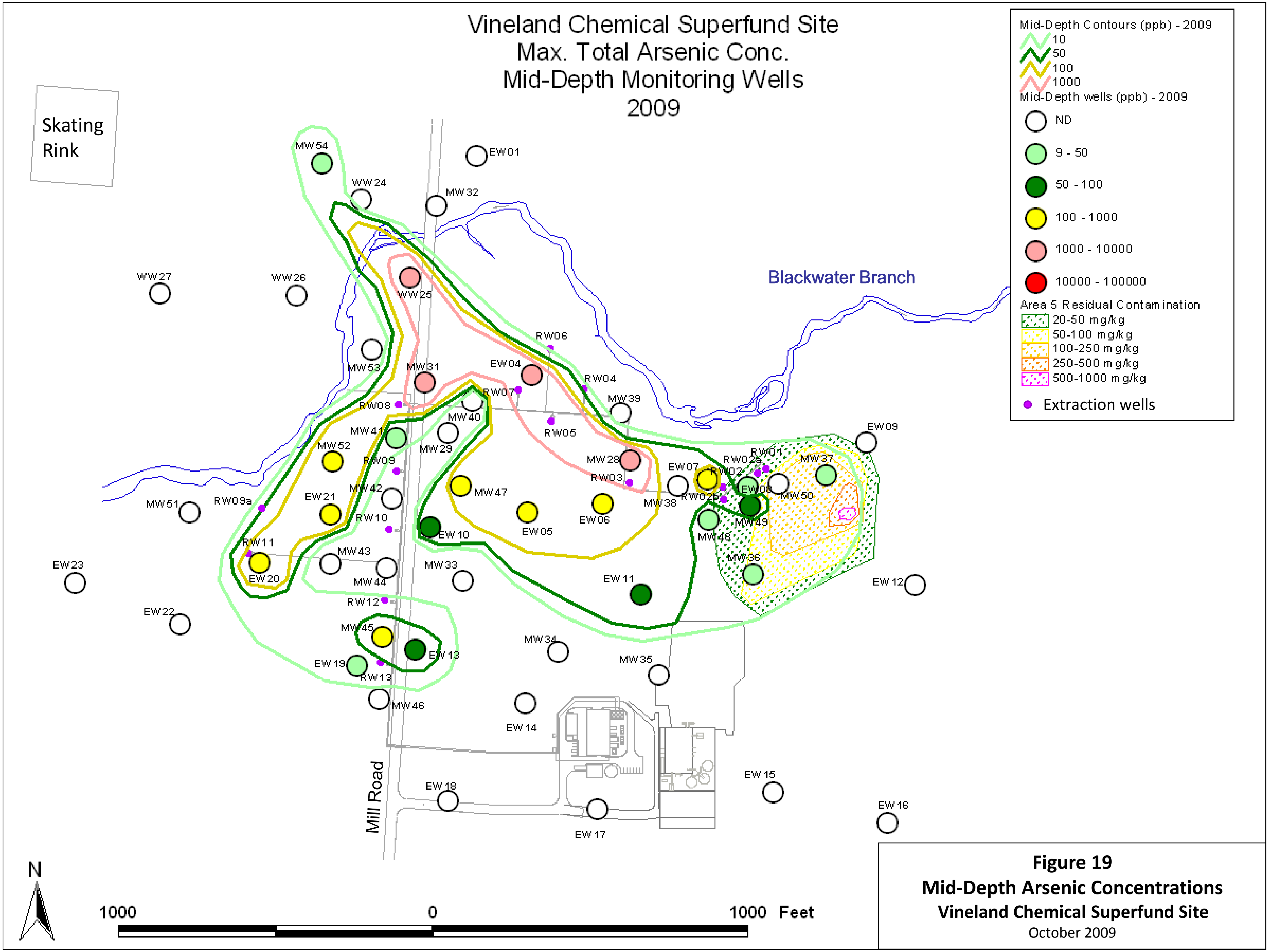
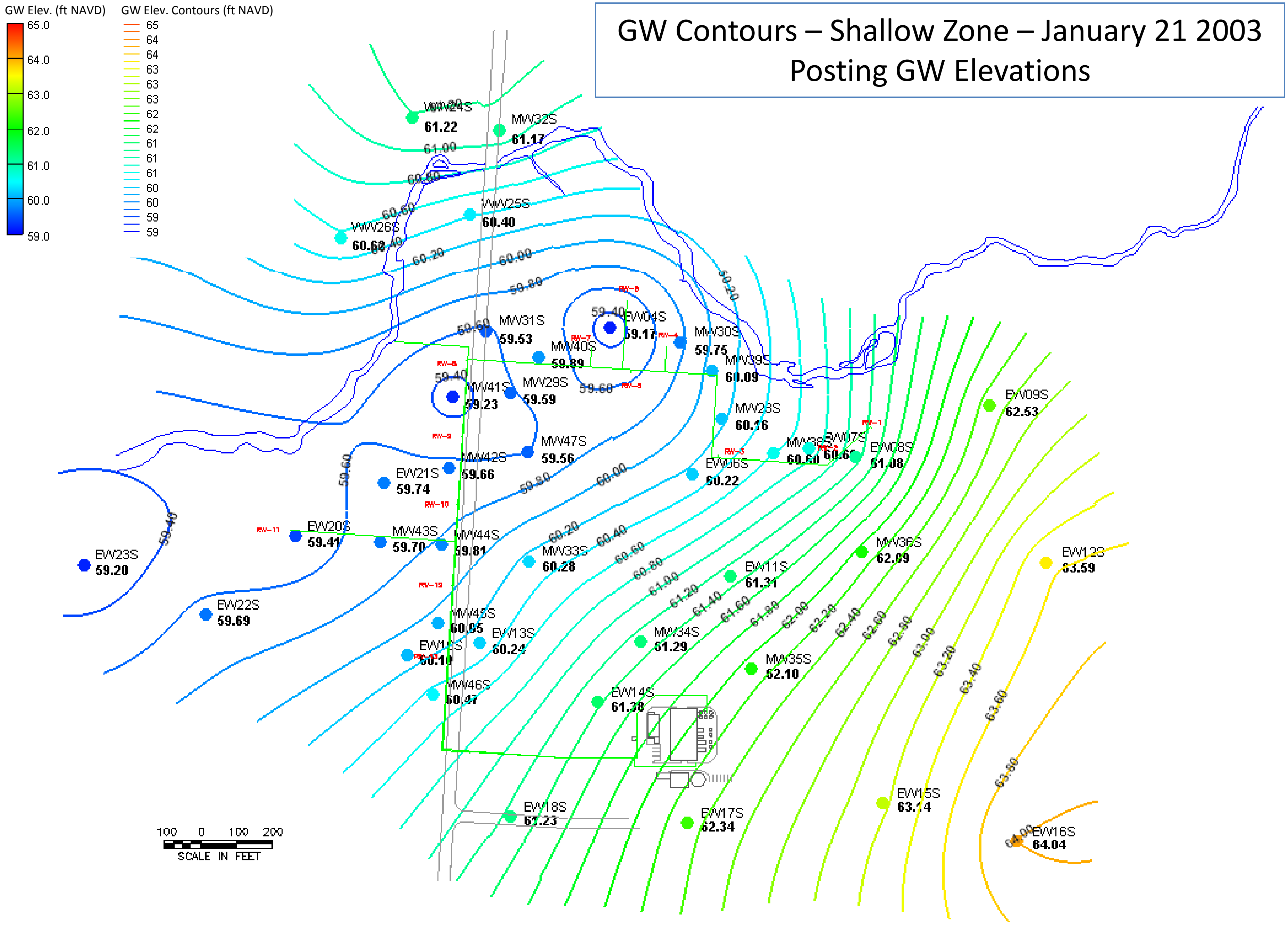
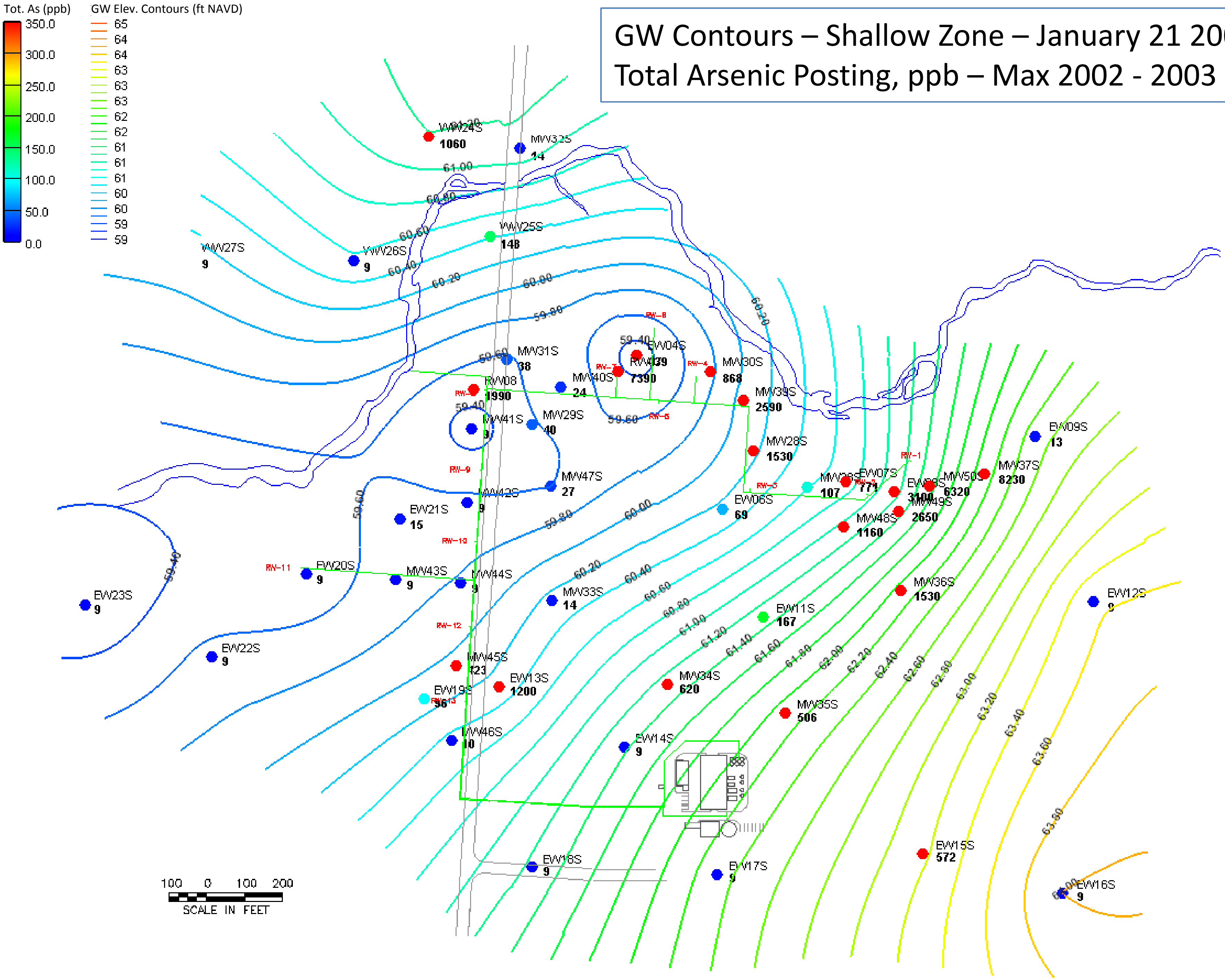


Figure 19
Mid-Depth Arsenic Concentrations
Vineland Chemical Superfund Site
October 2009

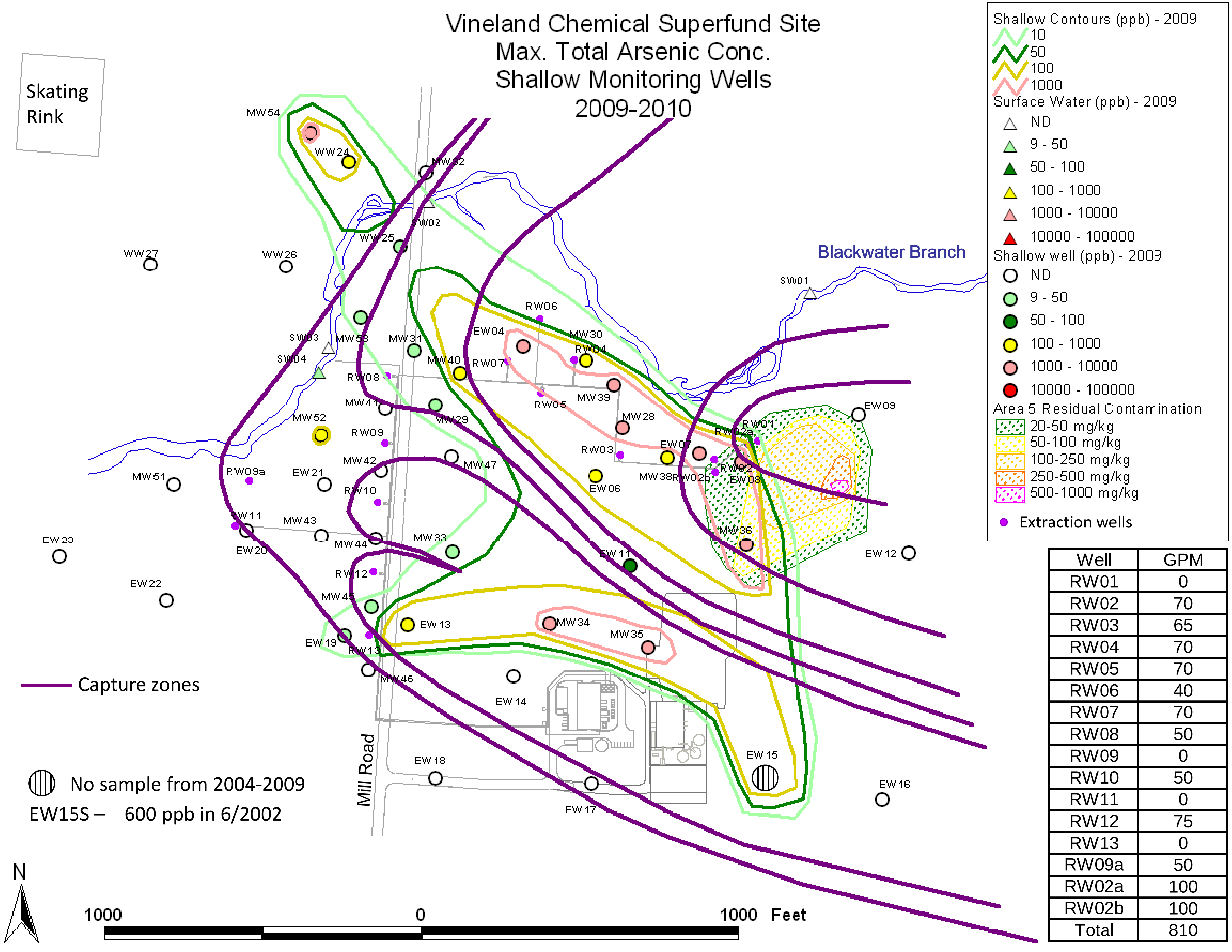
GW Contours – Shallow Zone – January 21 2003
Posting GW Elevations



GW Contours – Shallow Zone – January 21 2003
Total Arsenic Posting, ppb – Max 2002 - 2003

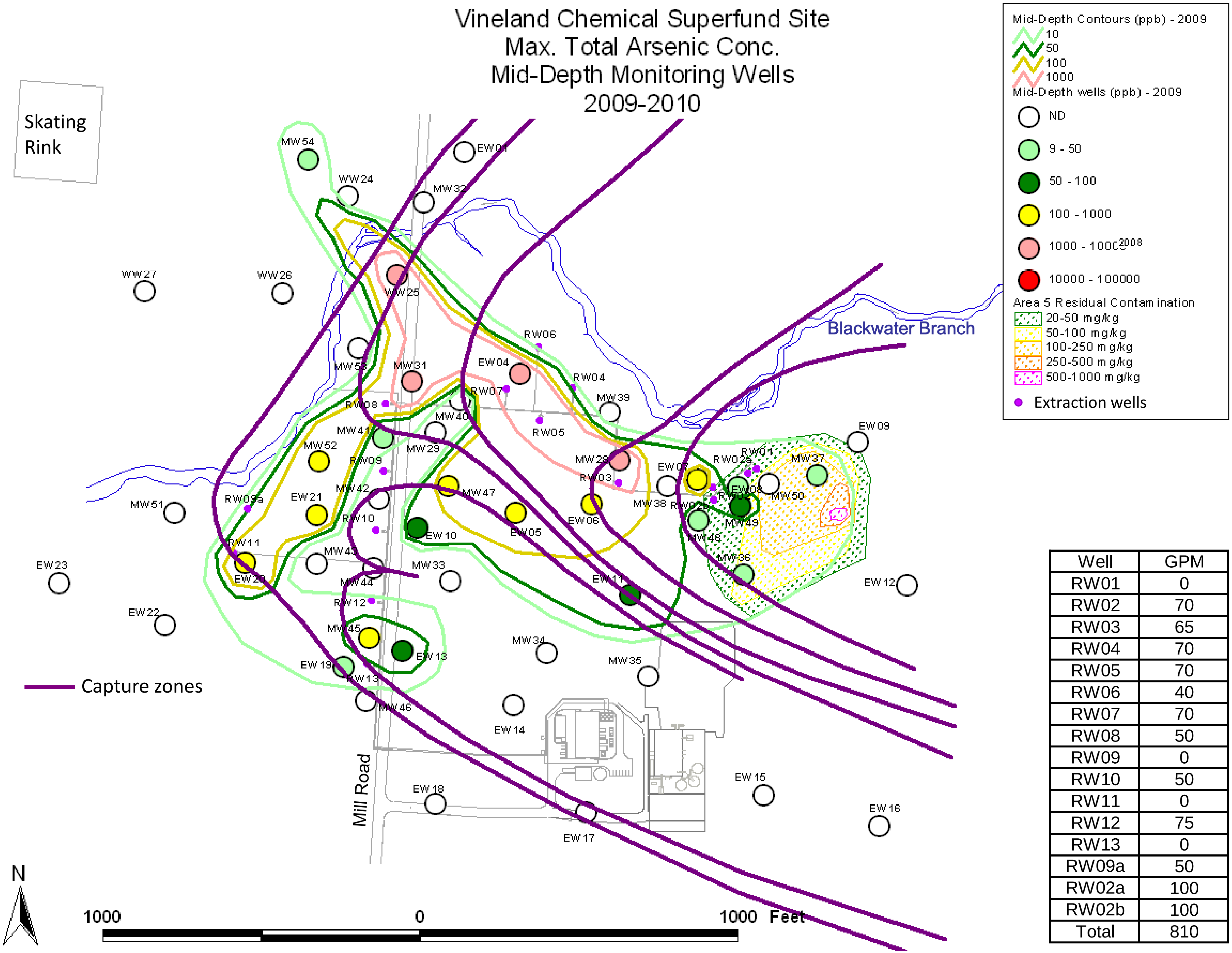


Vineland Chemical Superfund Site
Max. Total Arsenic Conc.
Shallow Monitoring Wells
2009-2010



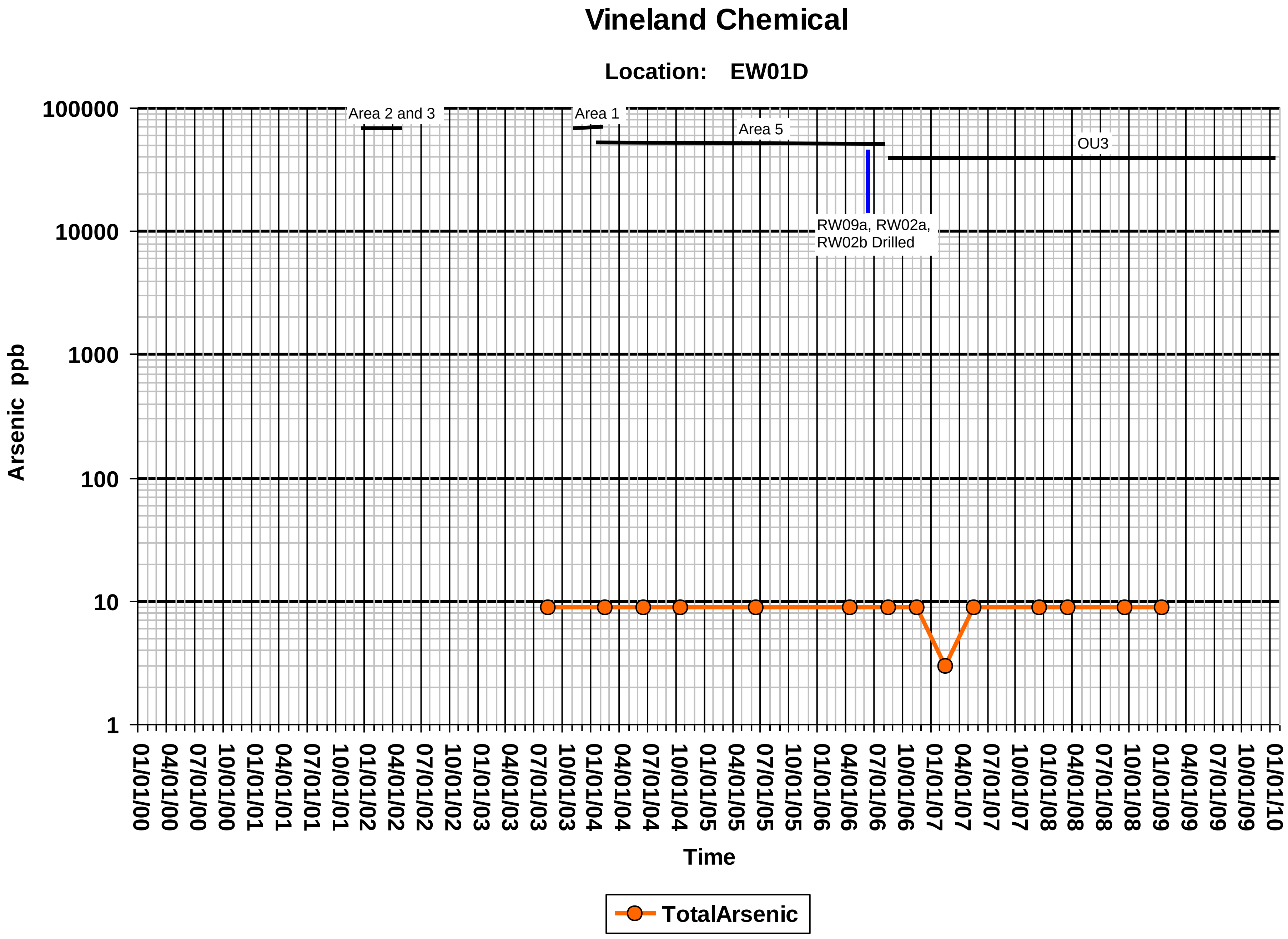
Well	GPM
RW01	0
RW02	70
RW03	65
RW04	70
RW05	70
RW06	40
RW07	70
RW08	50
RW09	0
RW10	50
RW11	0
RW12	75
RW13	0
RW09a	50
RW02a	100
RW02b	100
Total	810

Vineland Chemical Superfund Site
Max. Total Arsenic Conc.
Mid-Depth Monitoring Wells
2009-2010



Well	GPM
RW01	0
RW02	70
RW03	65
RW04	70
RW05	70
RW06	40
RW07	70
RW08	50
RW09	0
RW10	50
RW11	0
RW12	75
RW13	0
RW09a	50
RW02a	100
RW02b	100
Total	810

ATTACHMENT B


Vineland Chemical
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Arsenic ppb
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10000
1000
100
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Area 2 and 3
Area 1
Area 5
OU3
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01/01/00
04/01/00
07/01/00
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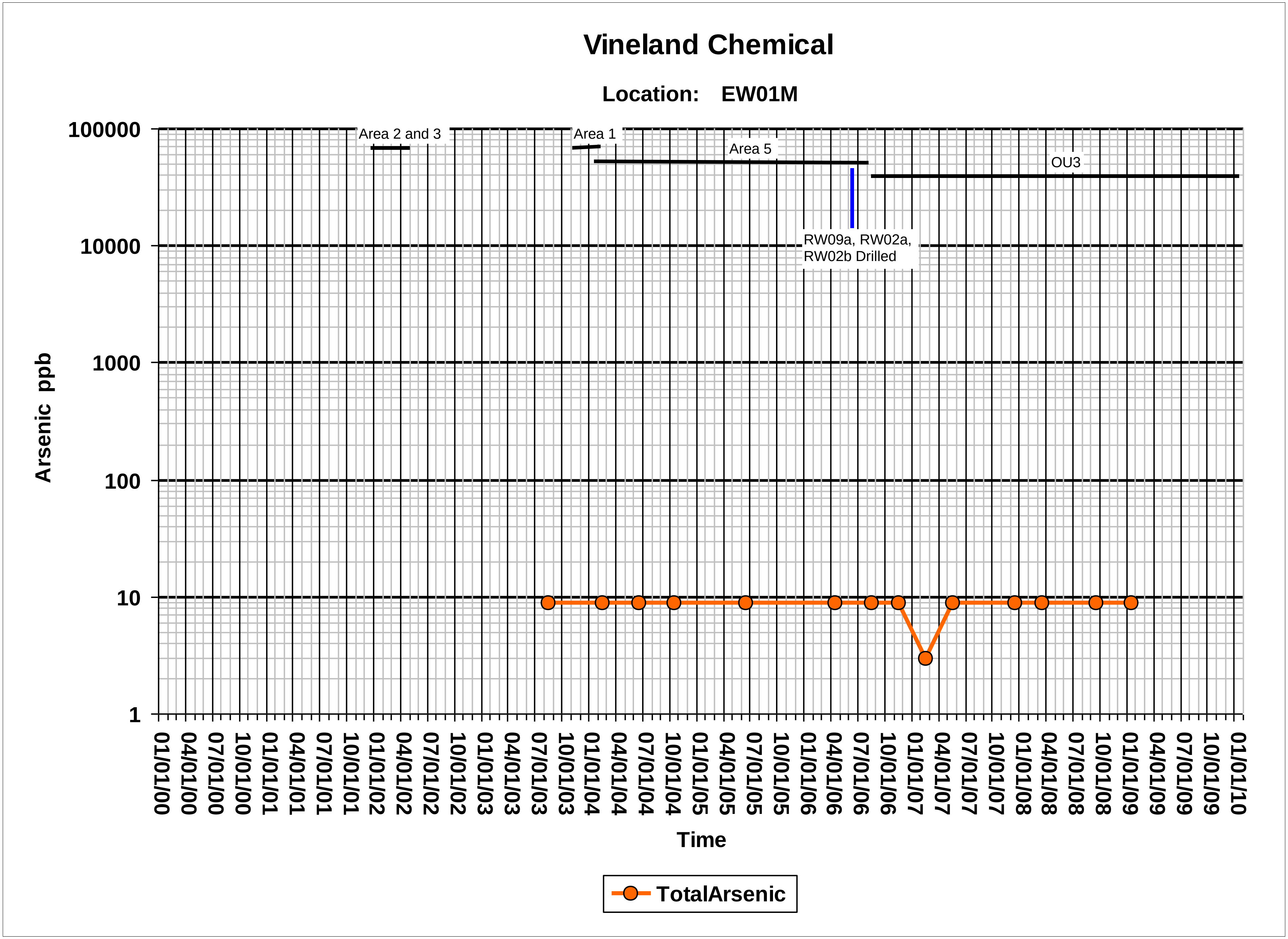
Time
TotalArsenic


Vineland Chemical
Location: EW01M
Arsenic ppb
100000
10000
1000
100
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1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
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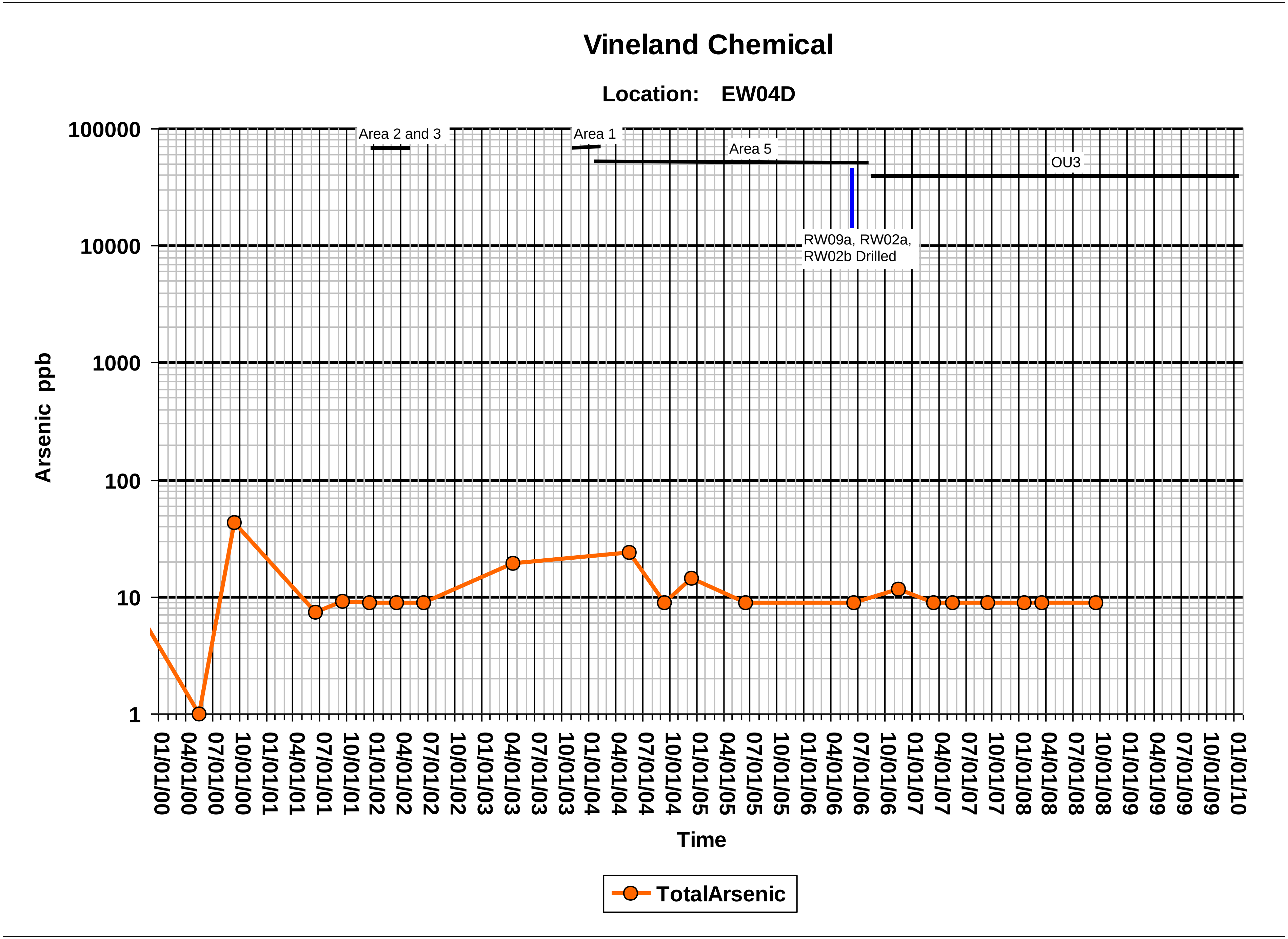
Time
TotalArsenic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Arsenic ppb
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Area 2 and 3
Area 1
Area 5
OU3
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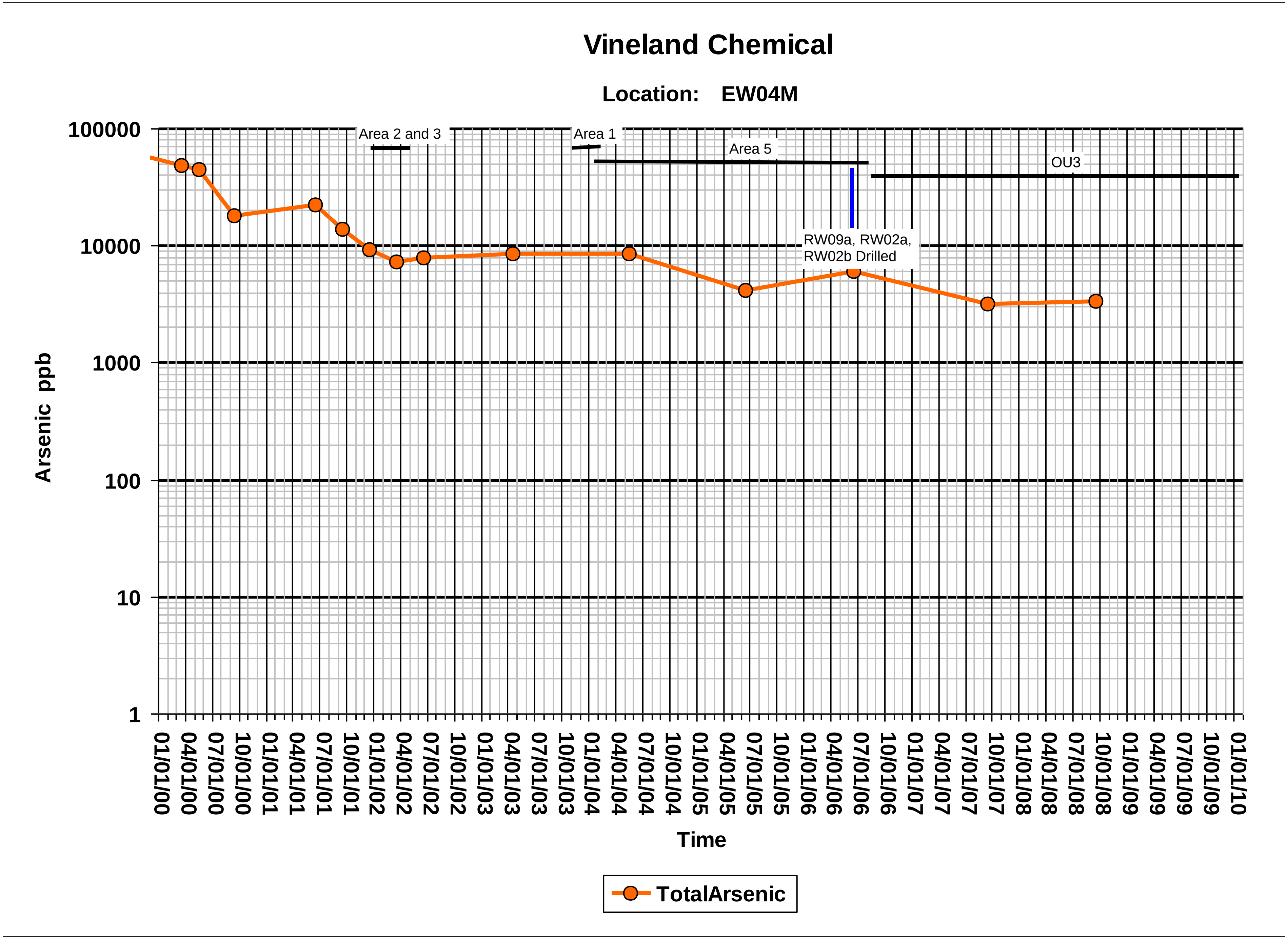
TotalArsenic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Arsenic ppb
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Area 2 and 3
Area 1
Area 5
OU3
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10/01/00
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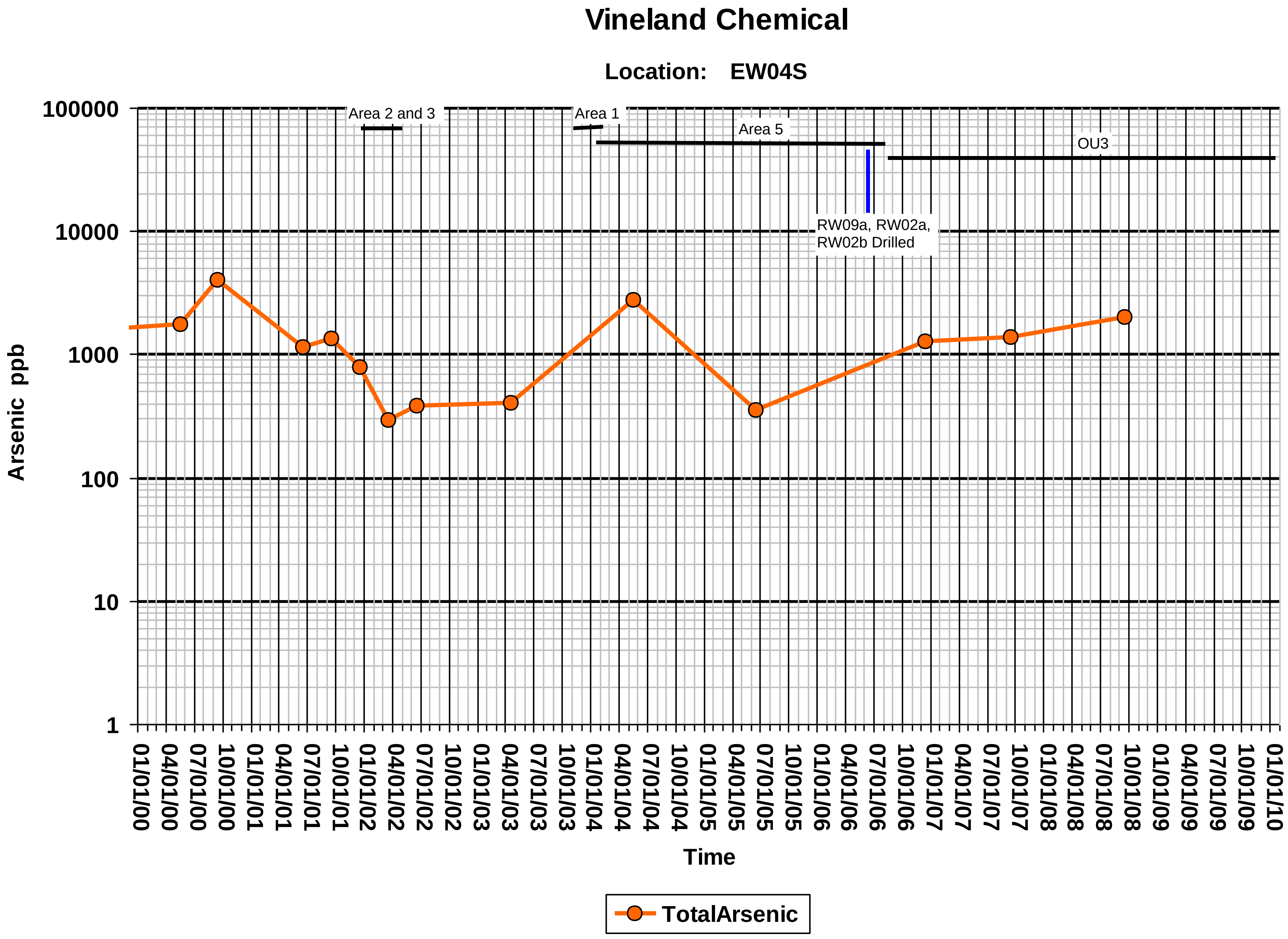

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Area 5
OU3
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04/01/00
07/01/00
10/01/00
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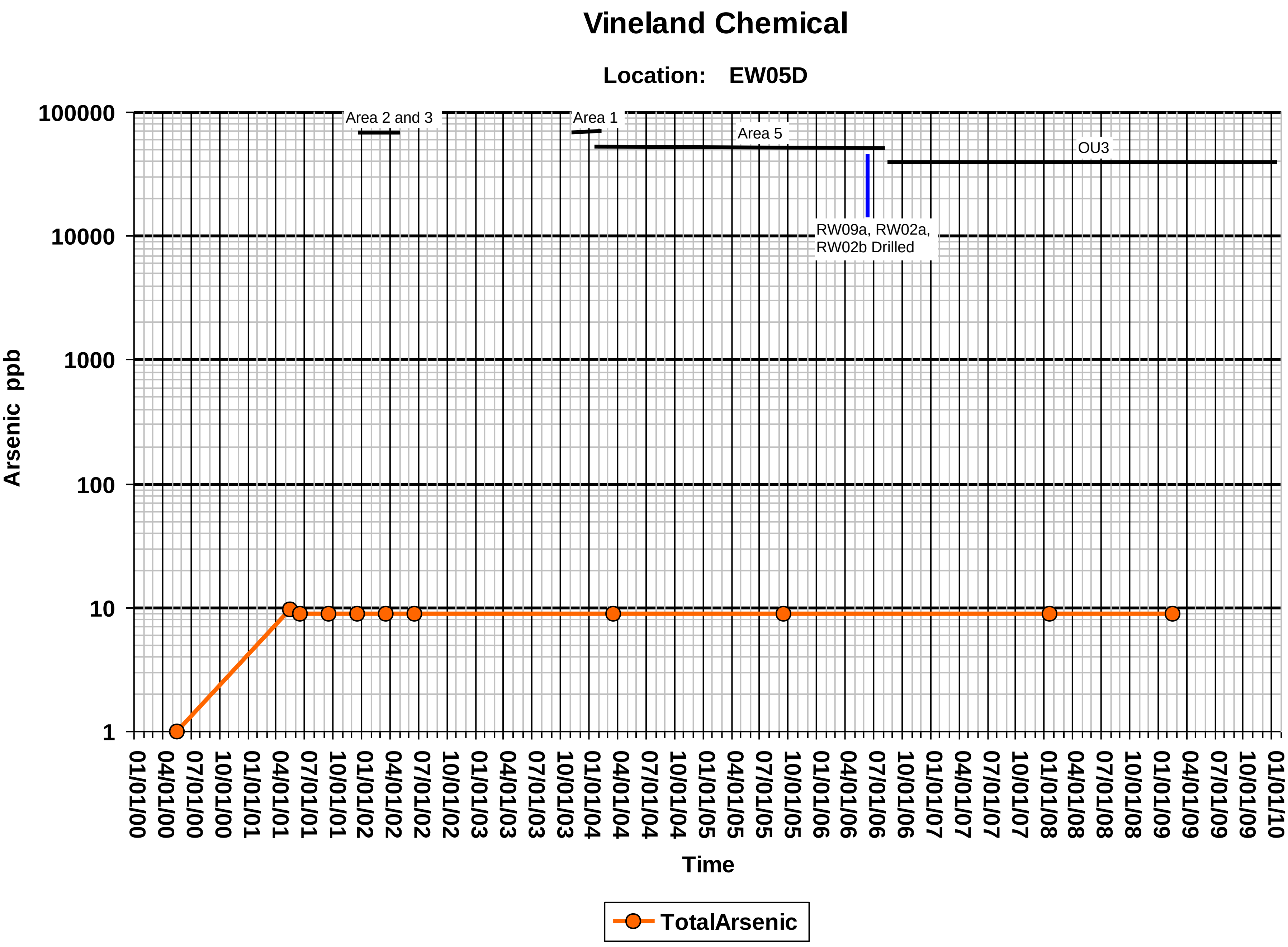
Time
TotalArsenic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Area 5
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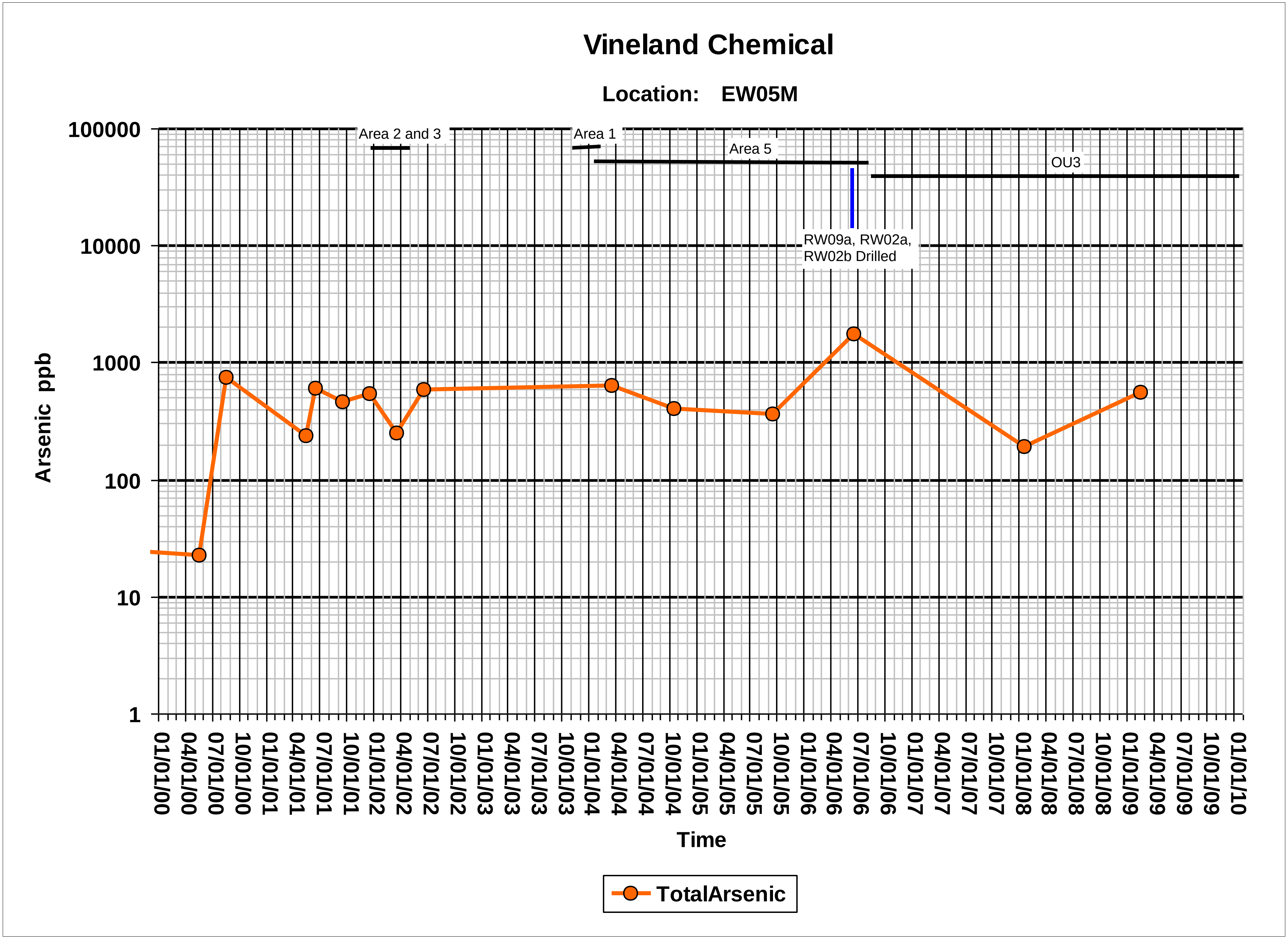
TotalArsenic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Arsenic ppb
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Area 2 and 3
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Area 5
OU3
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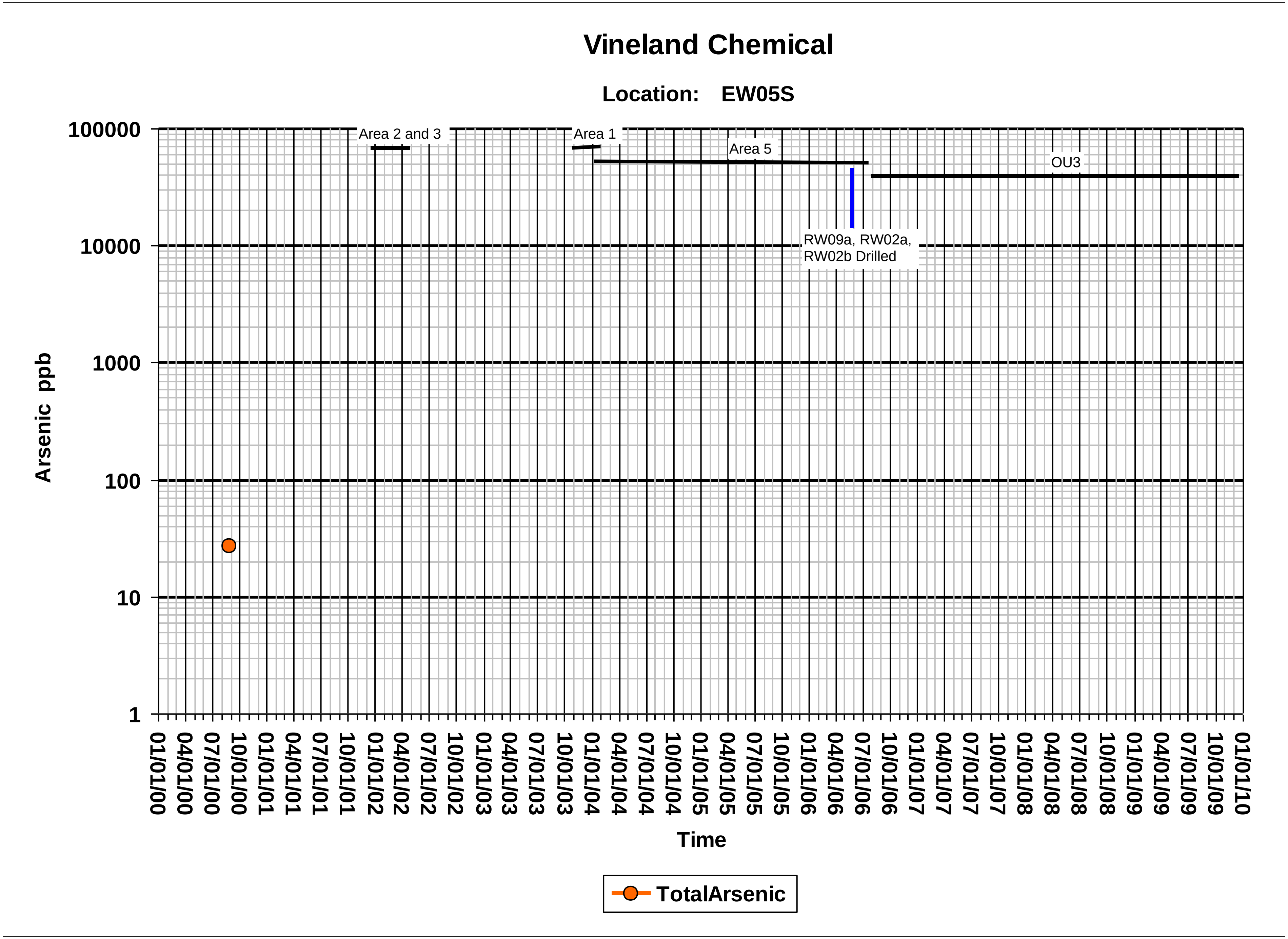
Time
TotalArsenic


Vineland Chemical
Location: EW05S
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
10/01/02
01/01/03
04/01/03
07/01/03
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01/01/04
04/01/04
07/01/04
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01/01/08
04/01/08
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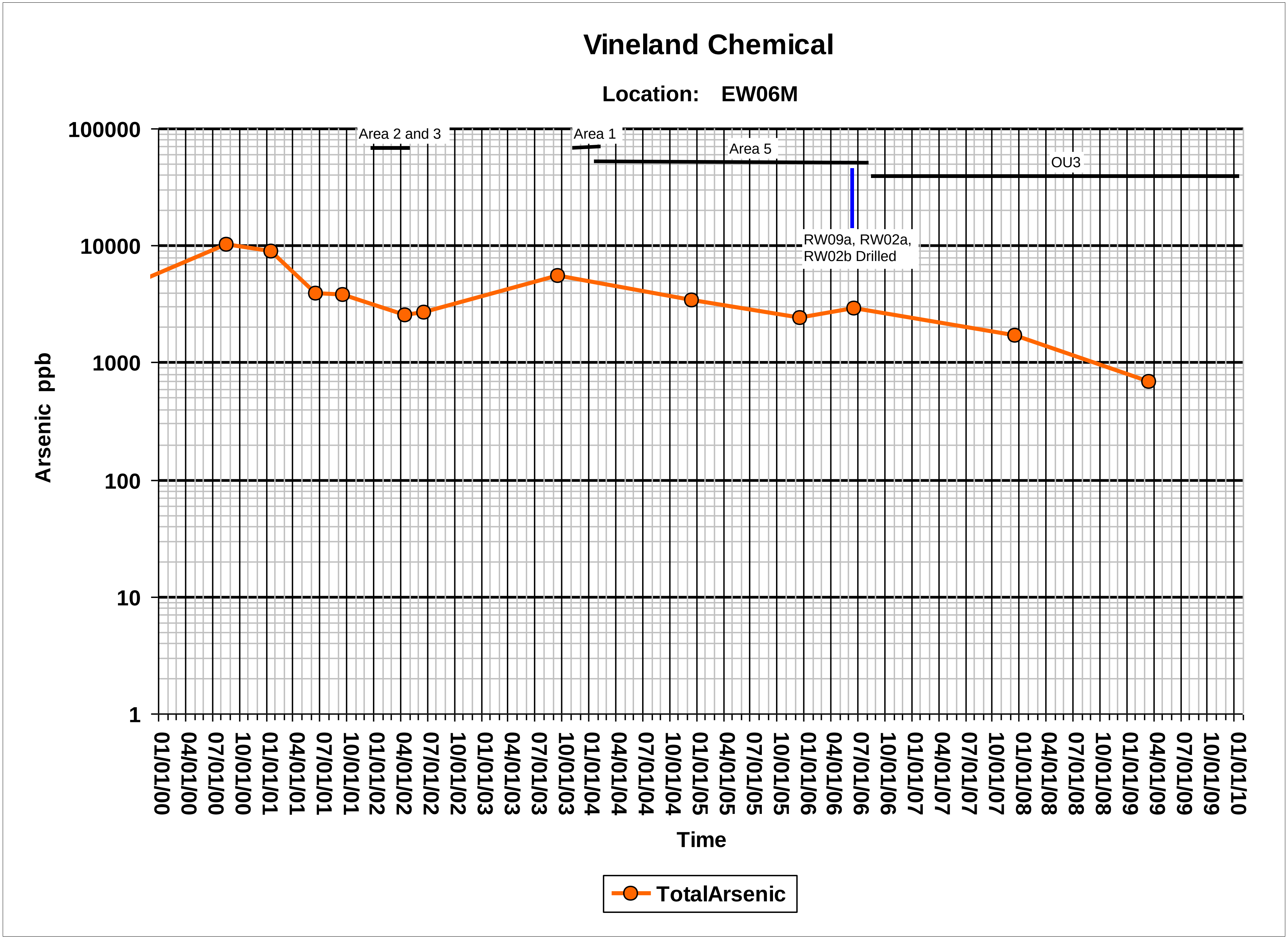
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: EW06M
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
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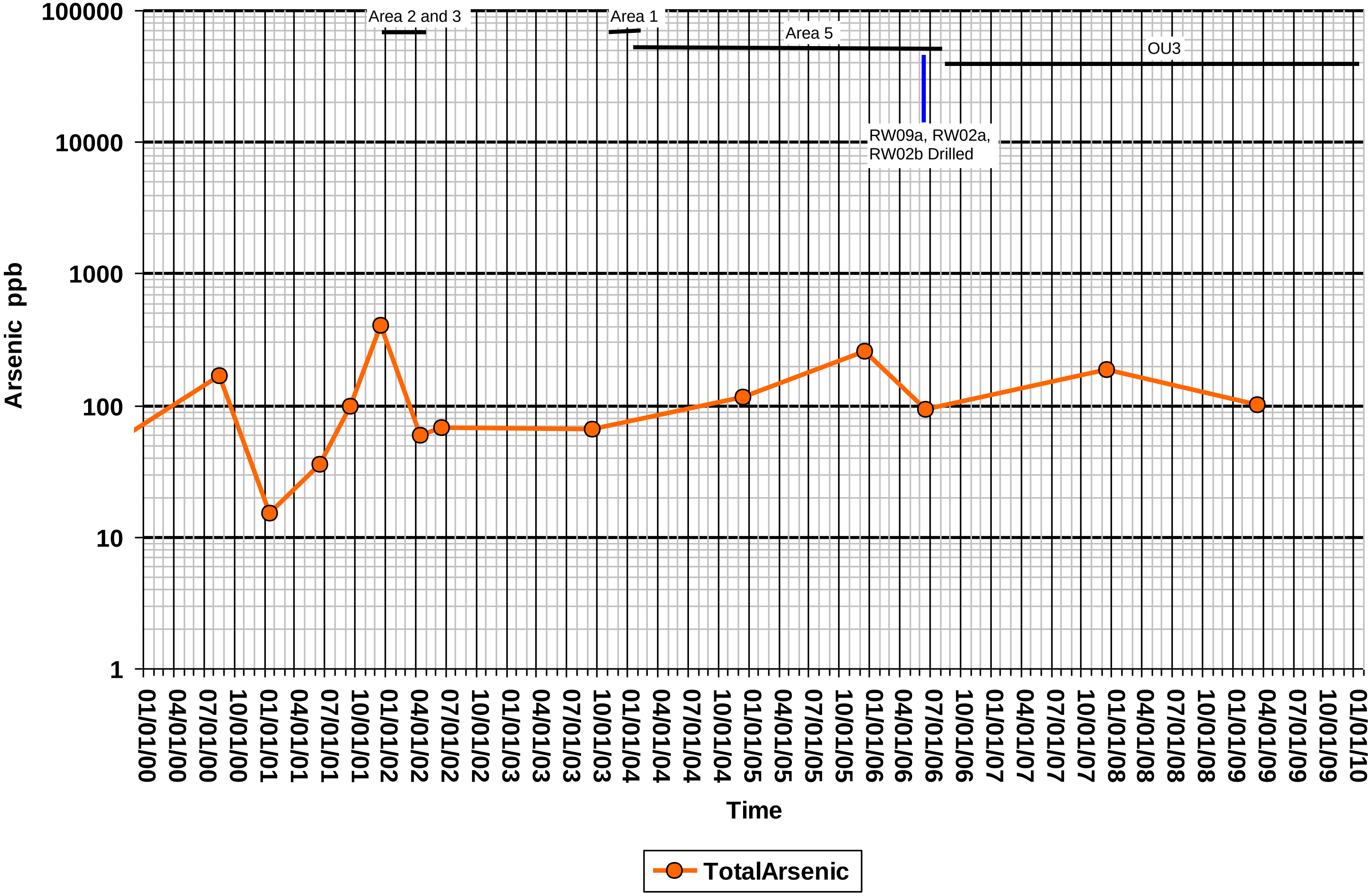
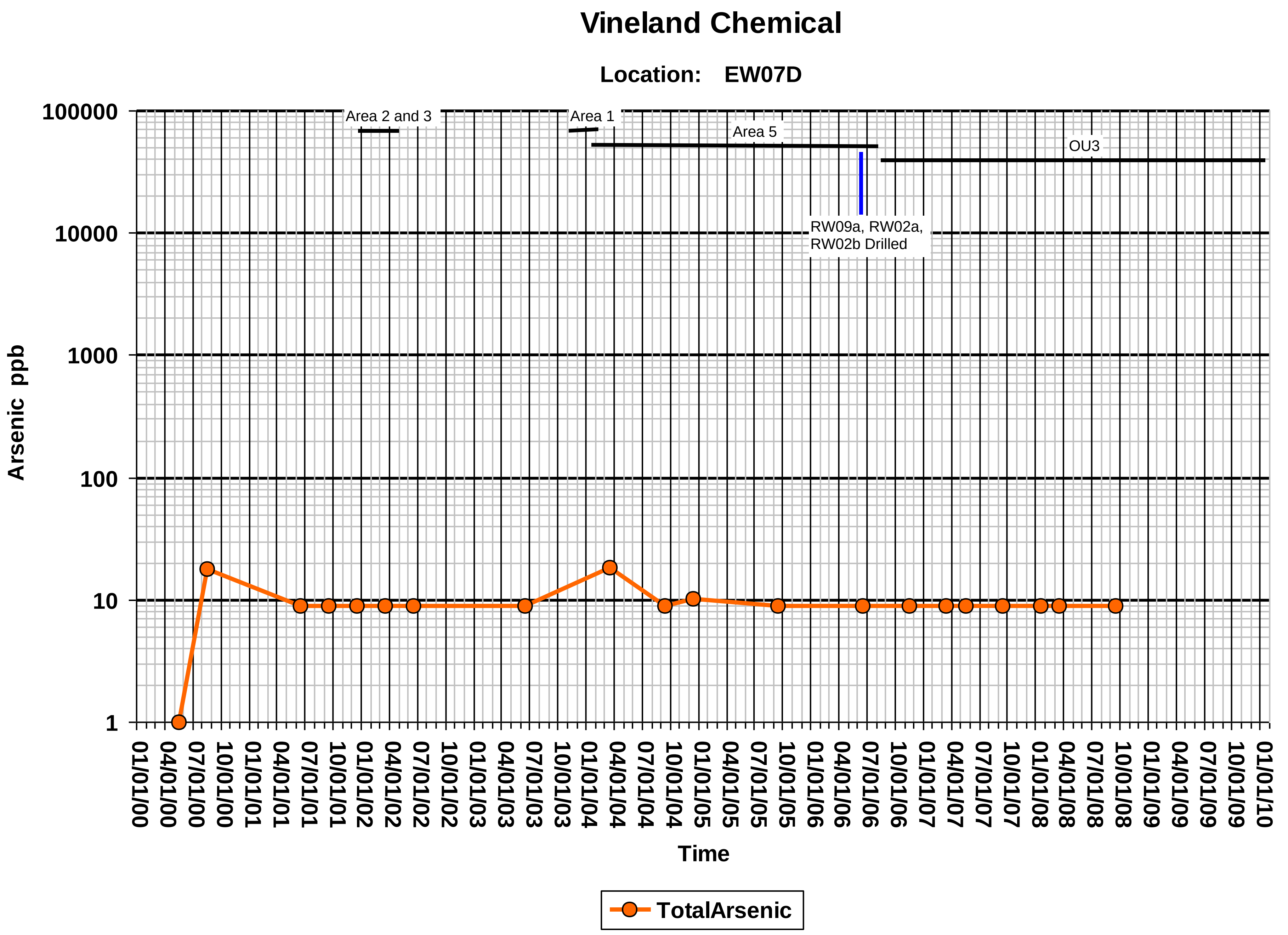
01/01/08
04/01/08
07/01/08
10/01/08
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic

Vineland Chemical

Location: EW06S





Vineland Chemical
Location: EW07D
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
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07/01/06
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01/01/07
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01/01/08
04/01/08
07/01/08
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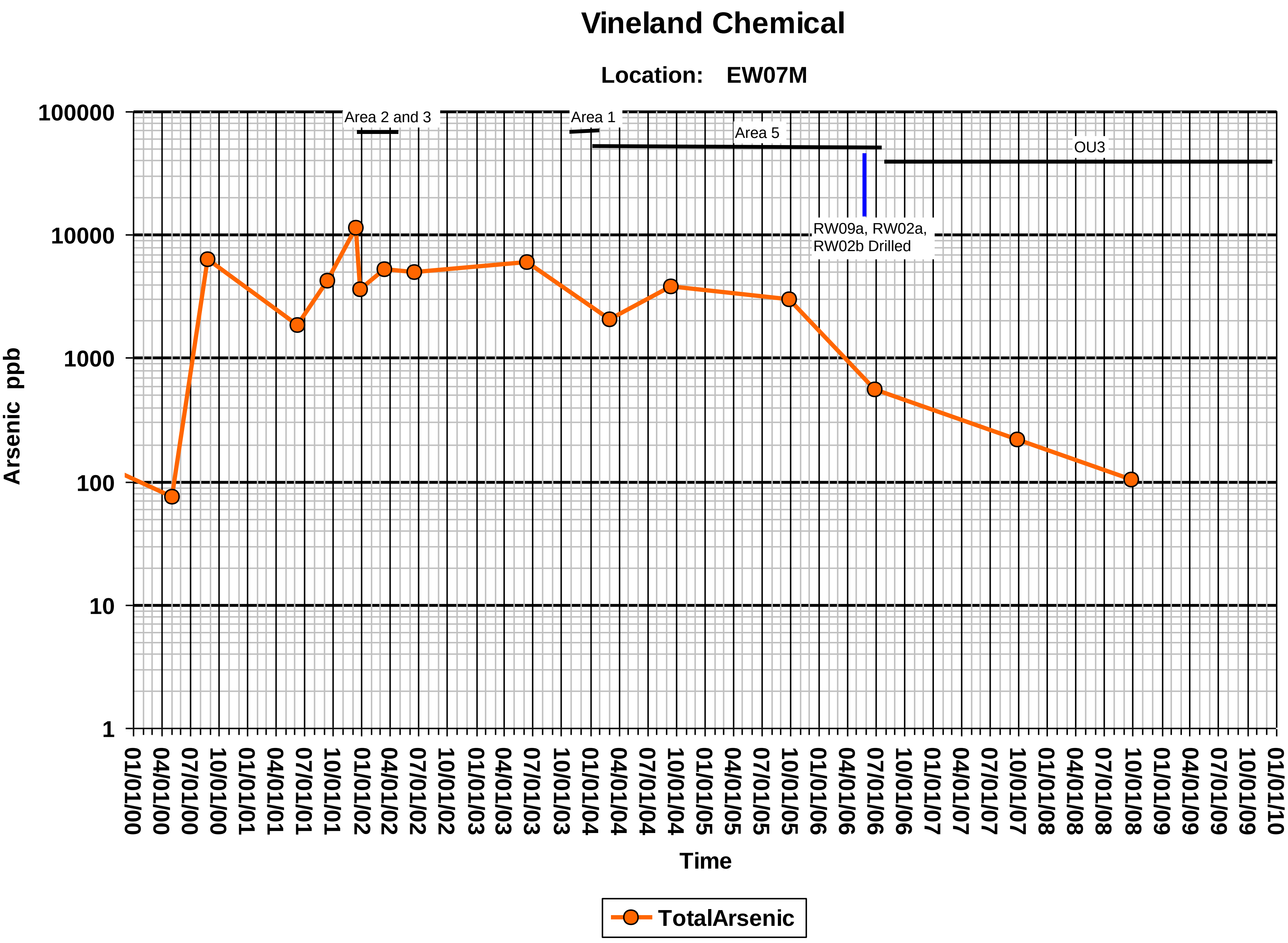
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: EW07M
100000
10000
1000
100
10
1
Arsenic ppb
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
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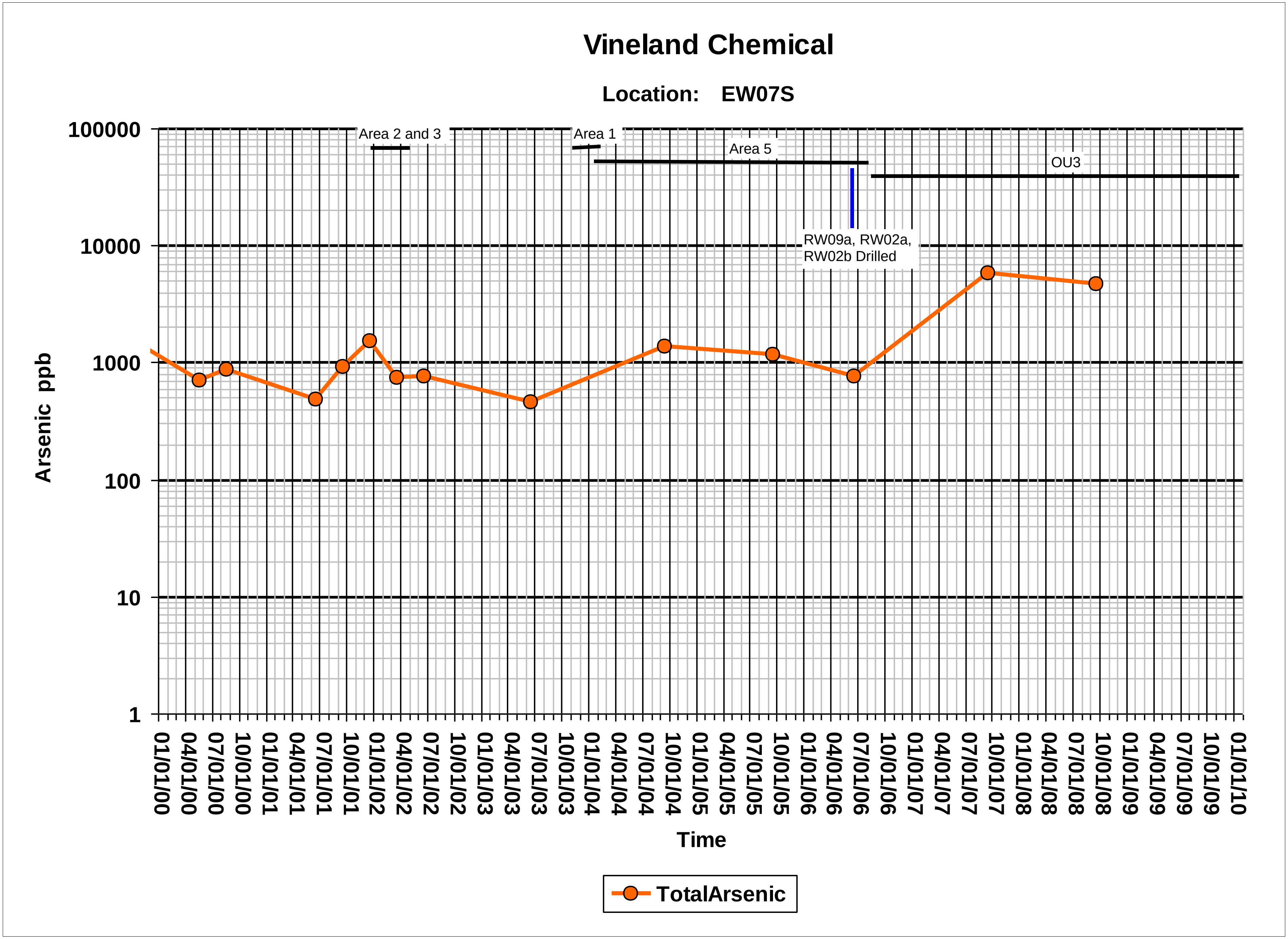
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: EW07S
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
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04/01/09
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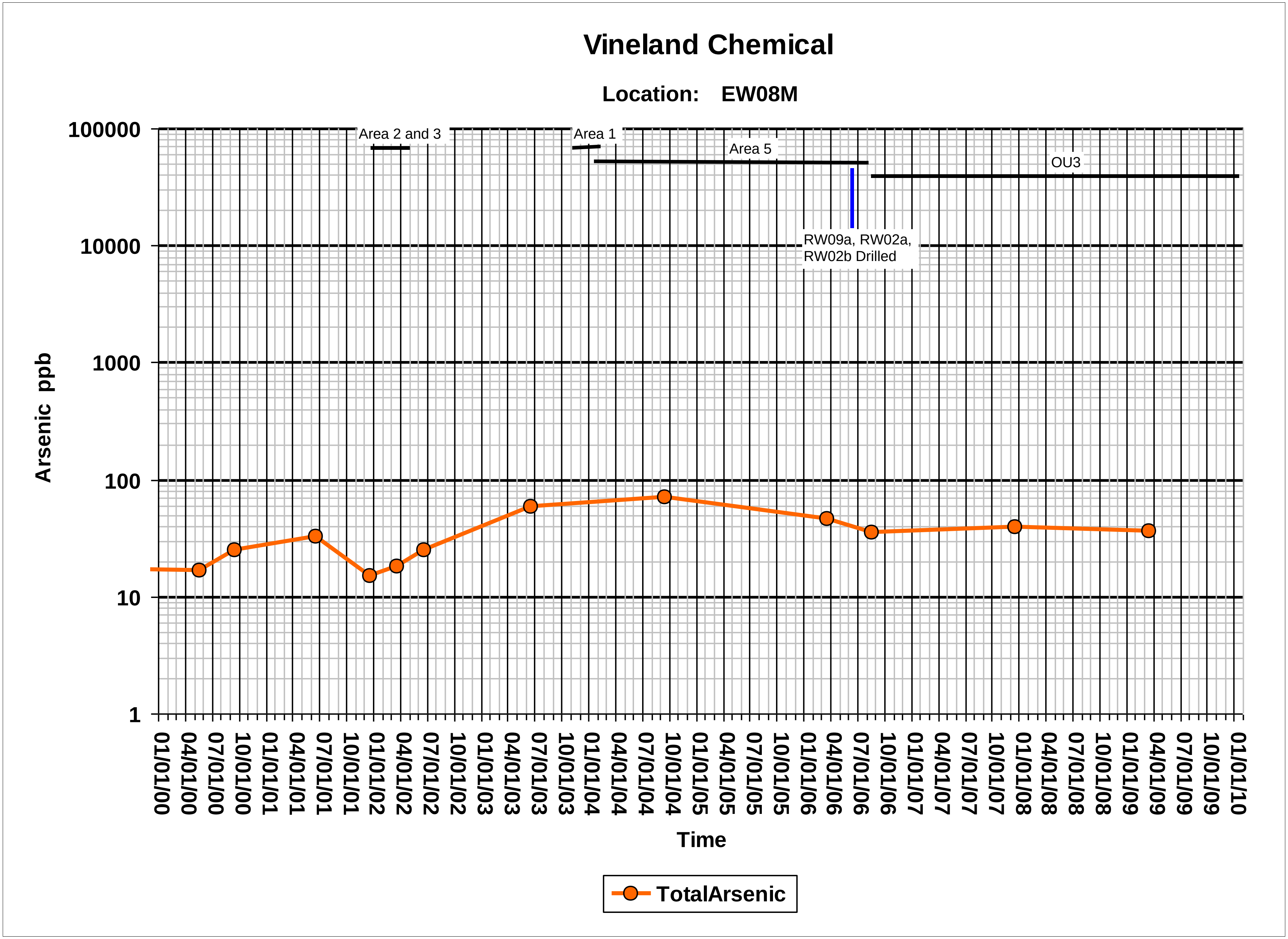
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: EW08M
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
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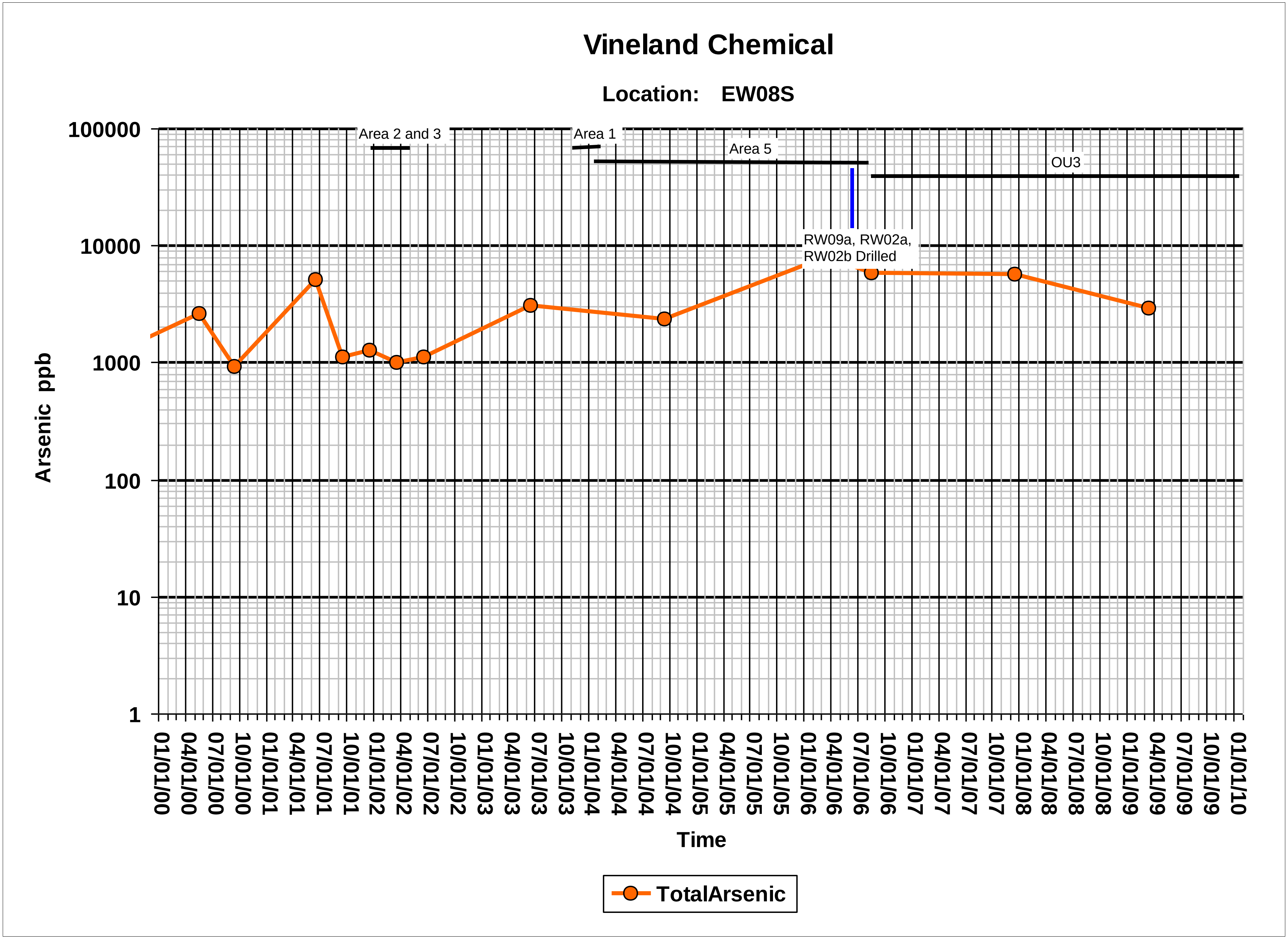
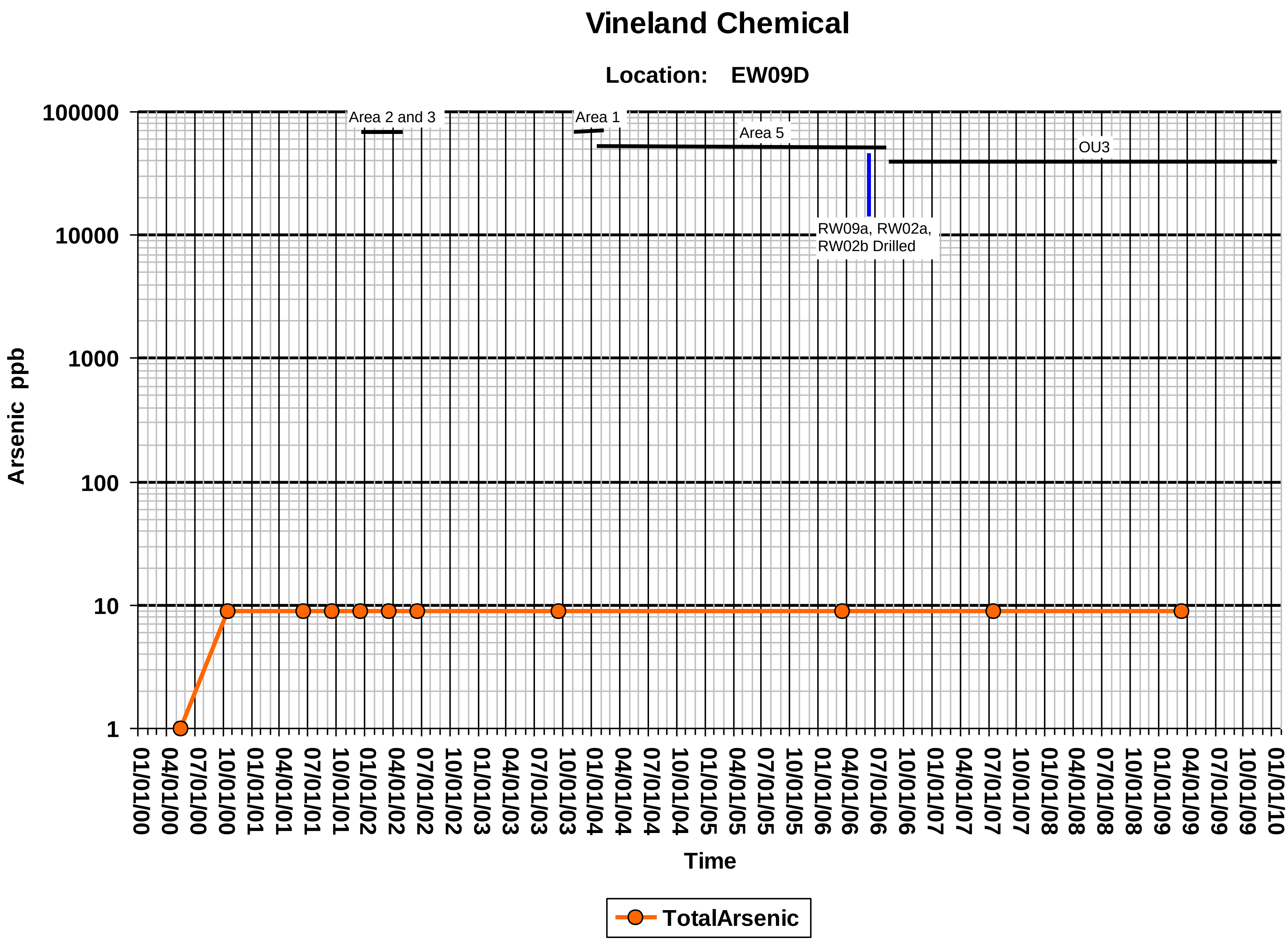
10/01/09
01/01/10
Time
TotalArsenic



Vineland Chemical

Location: EW08S


Vineland Chemical
Location: EW09D
100000
10000
1000
100
10
1
Arsenic ppb
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
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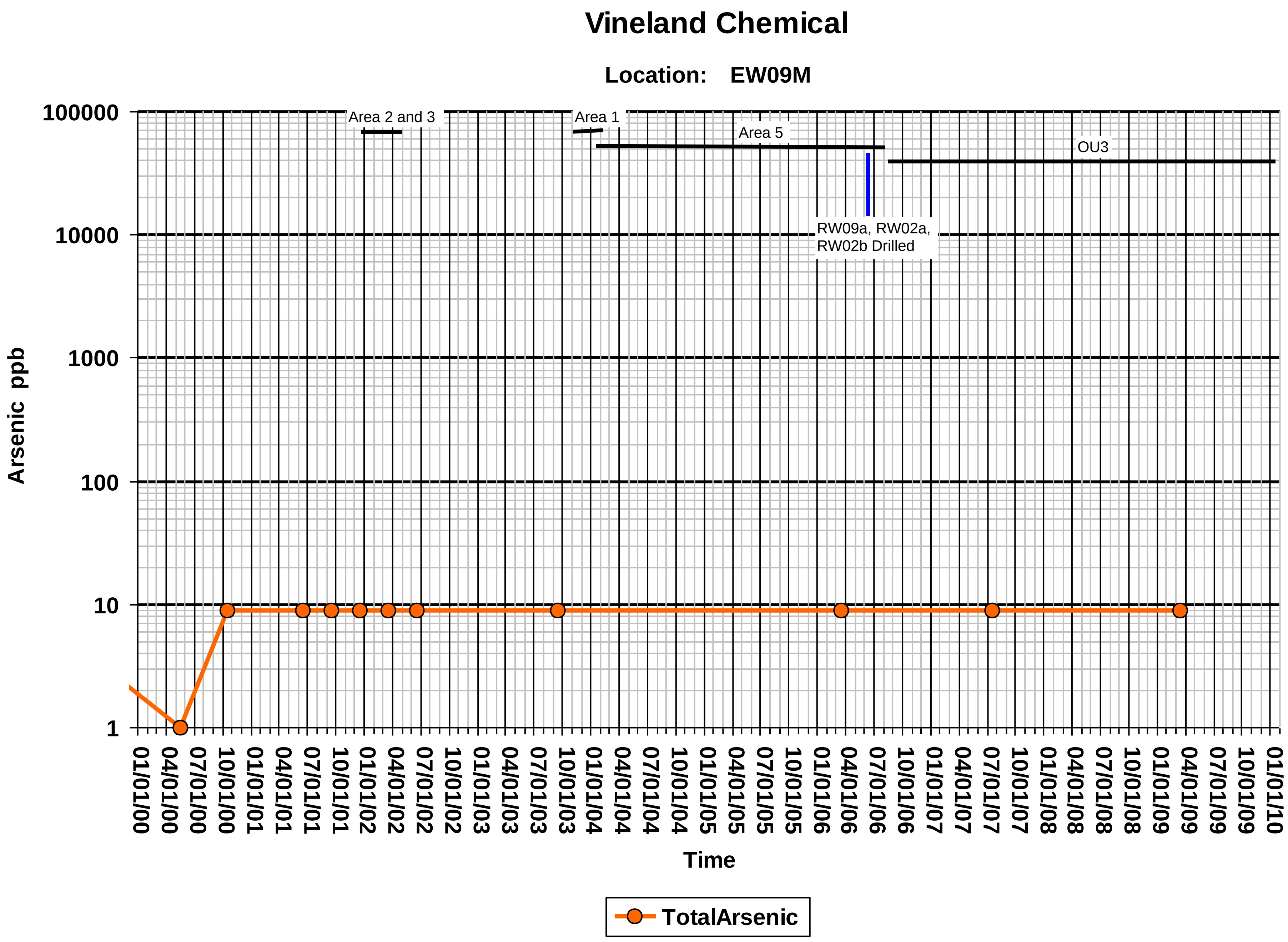
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: EW09M
Arsenic ppb
100000
10000
1000
100
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1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
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01/01/02
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04/01/09
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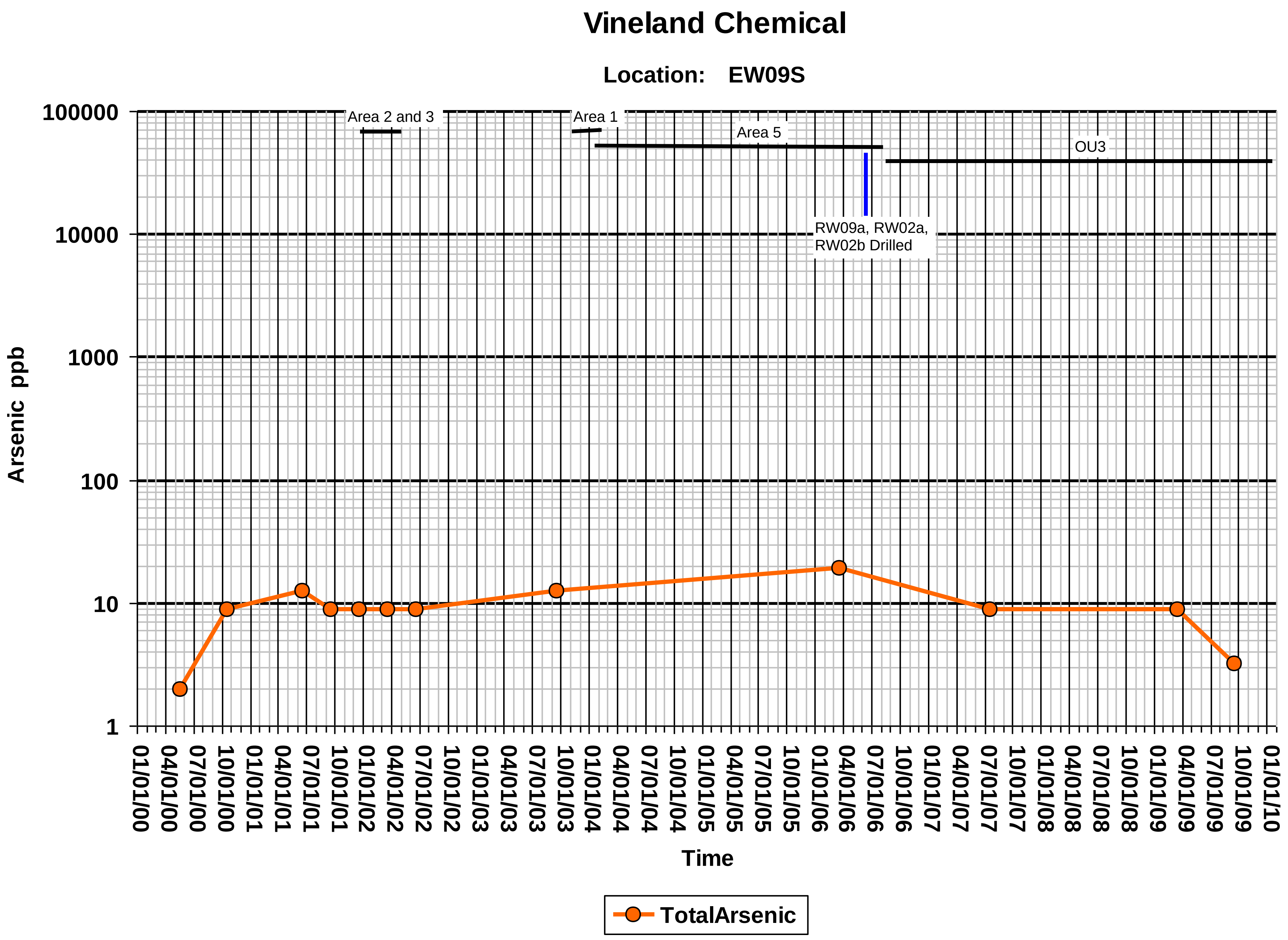
10/01/09
01/01/10
Time
TotalArsenic



Vineland Chemical
Location: EW09S
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
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04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
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01/01/02
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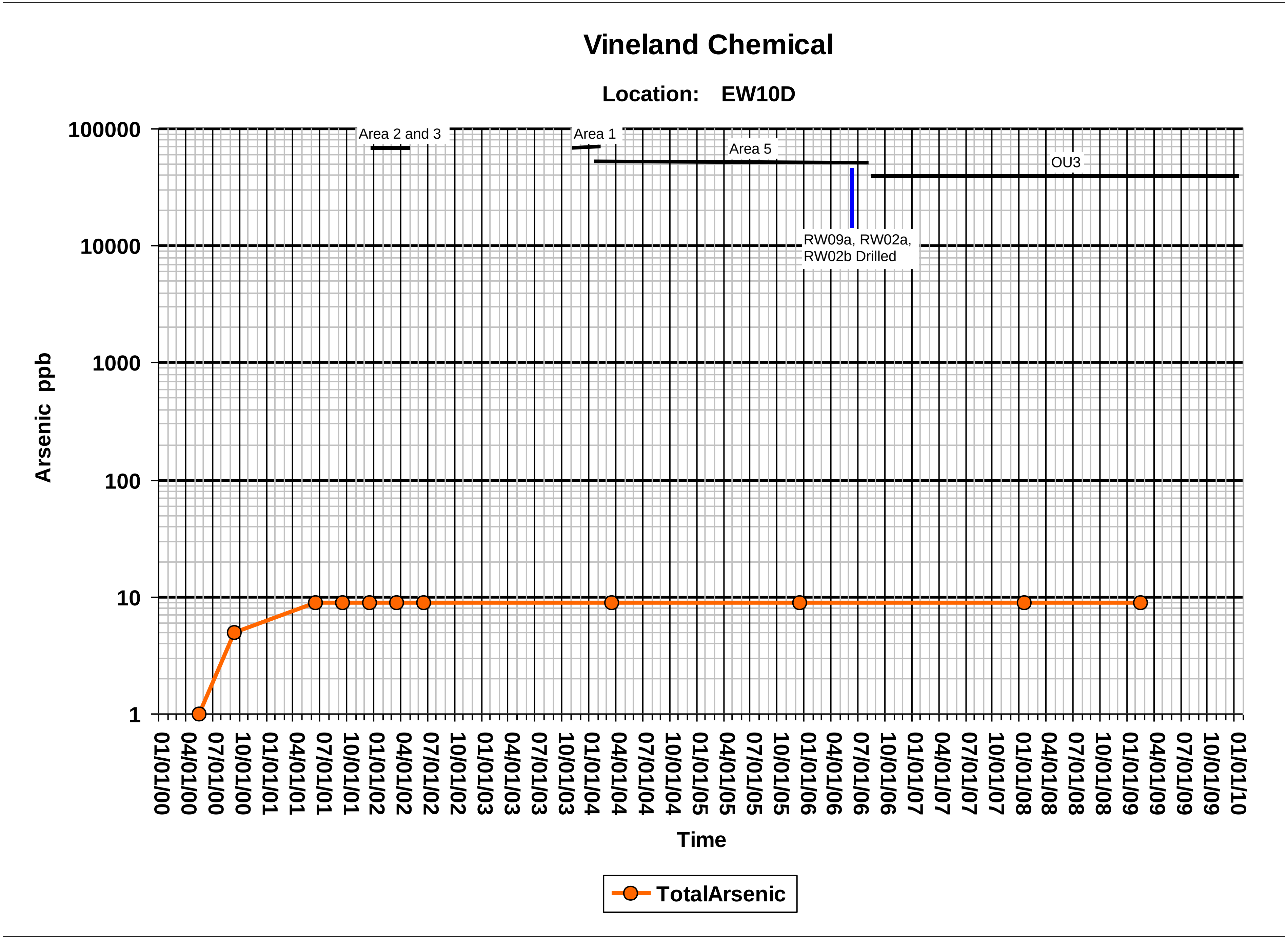
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: EW10D
Arsenic ppb
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10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
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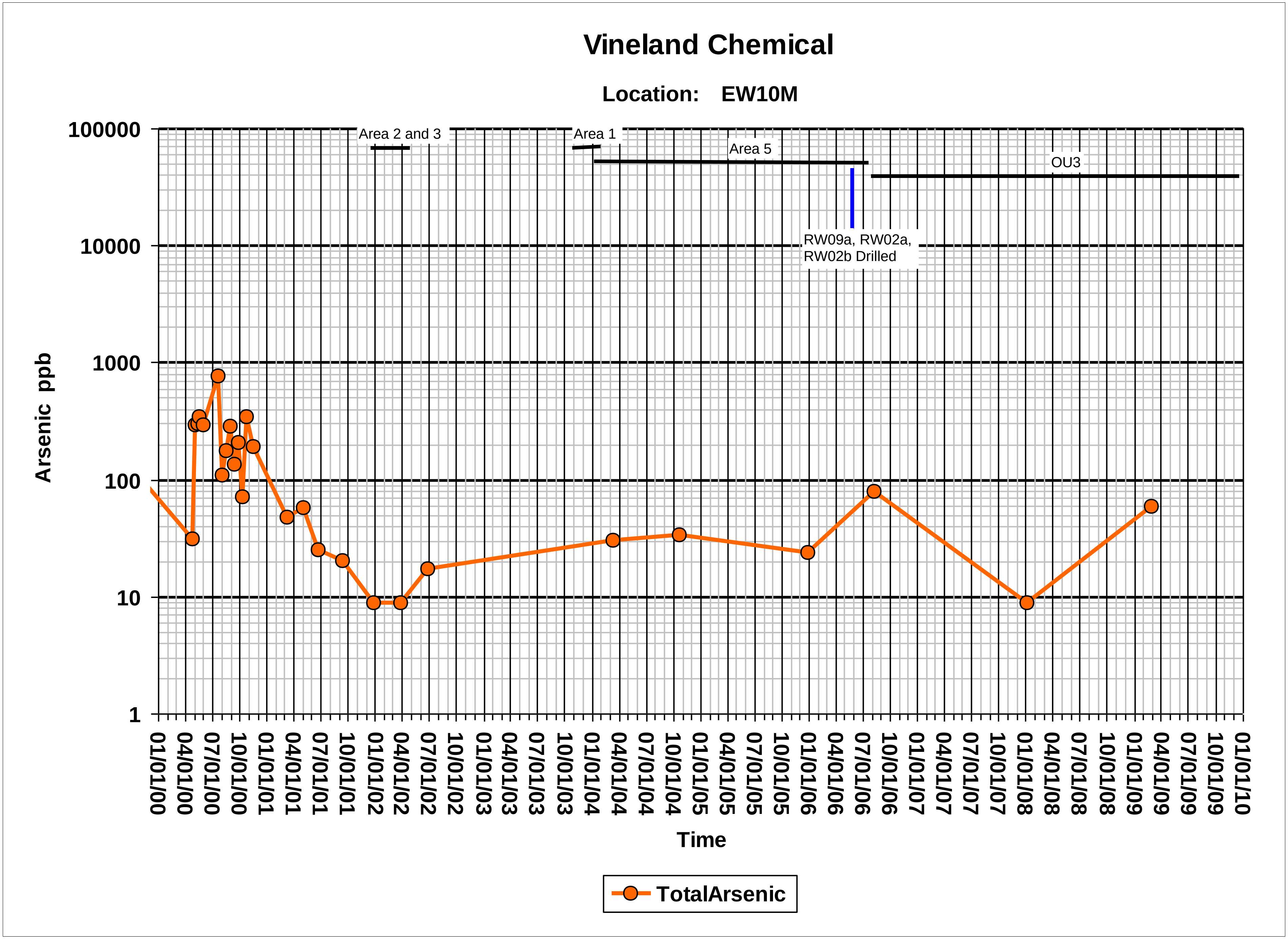
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: EW10M
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
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04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
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04/01/09
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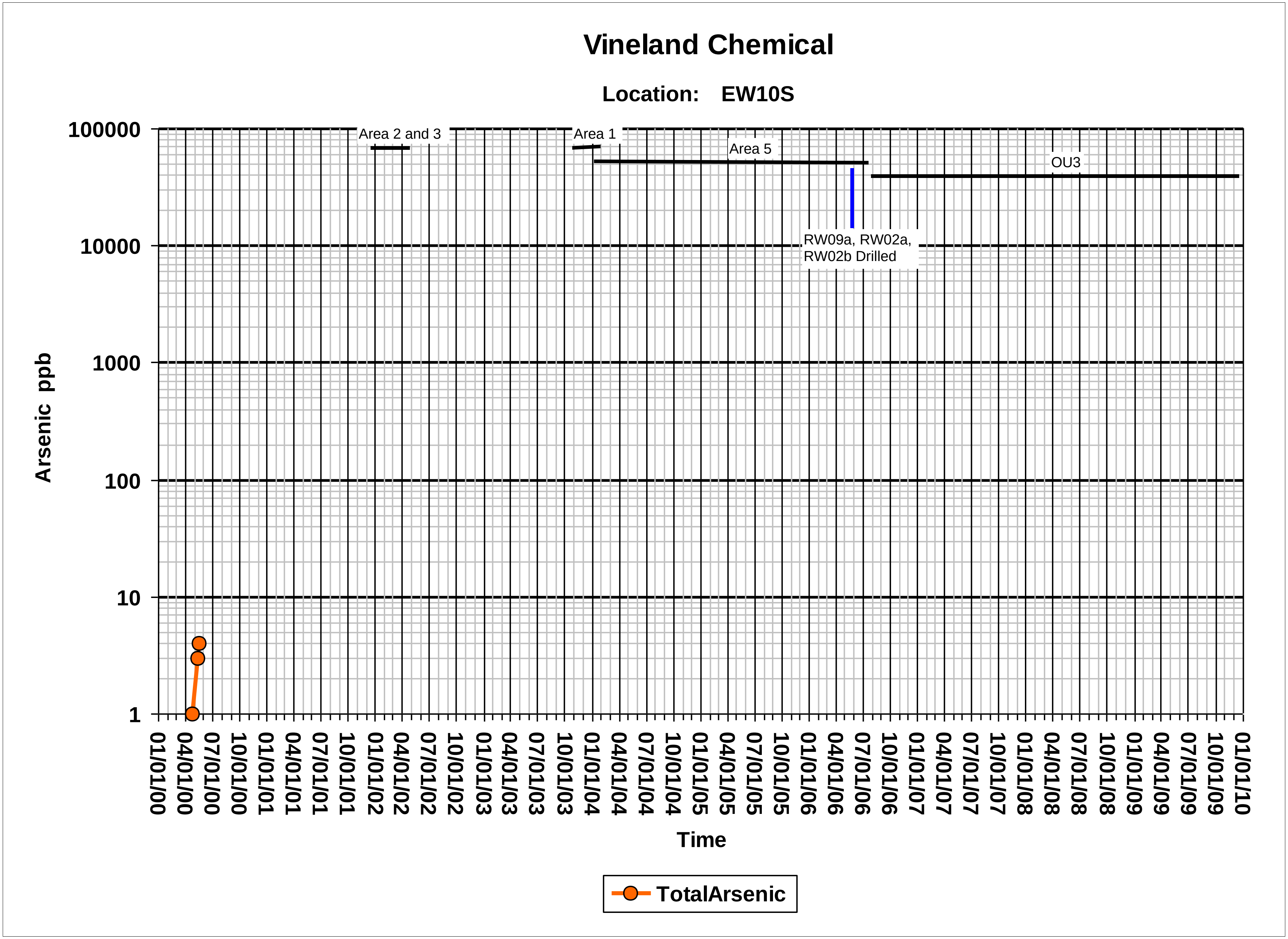
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: EW10S
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
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04/01/00
07/01/00
10/01/00
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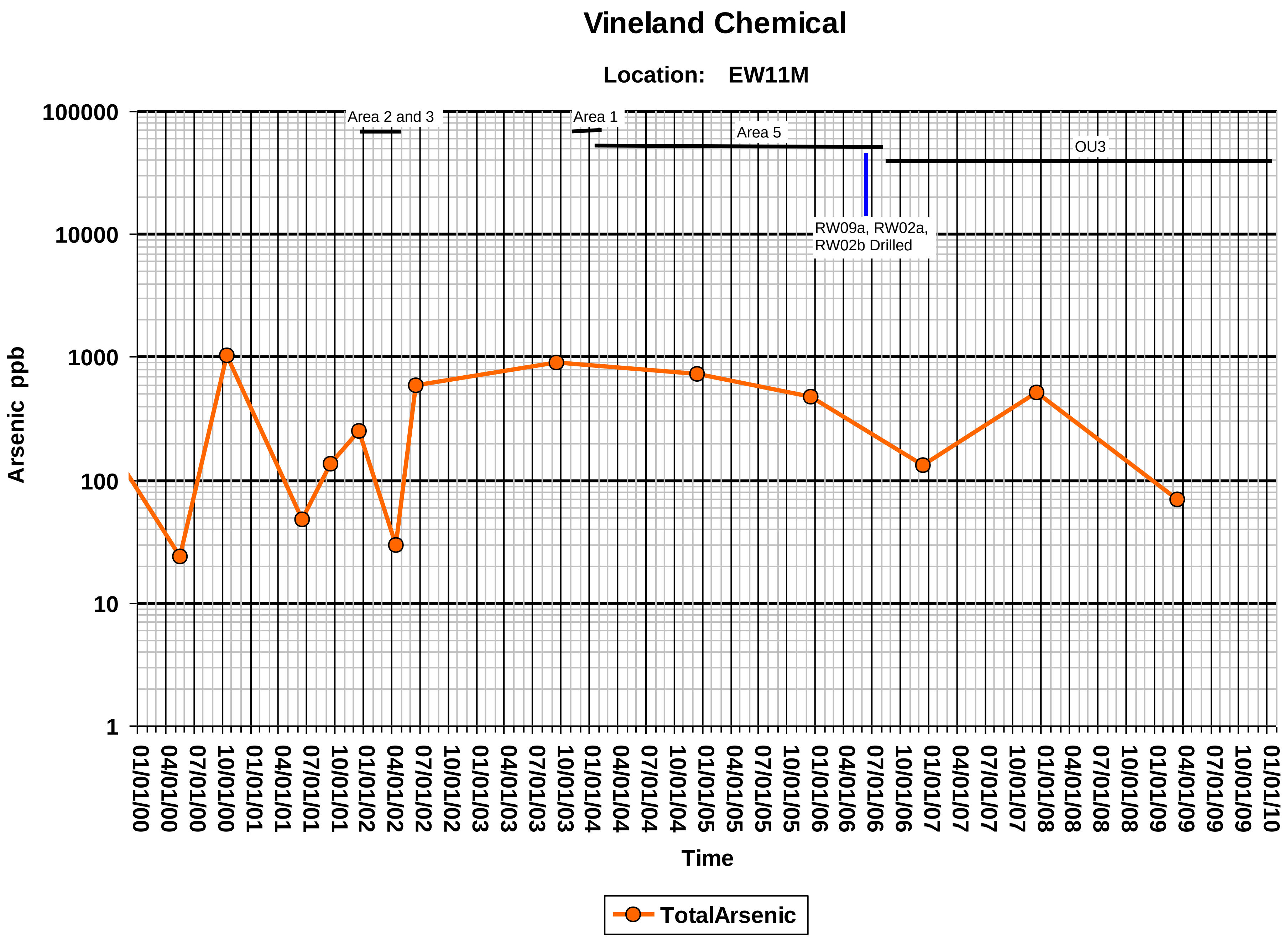
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: EW11M
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
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07/01/01
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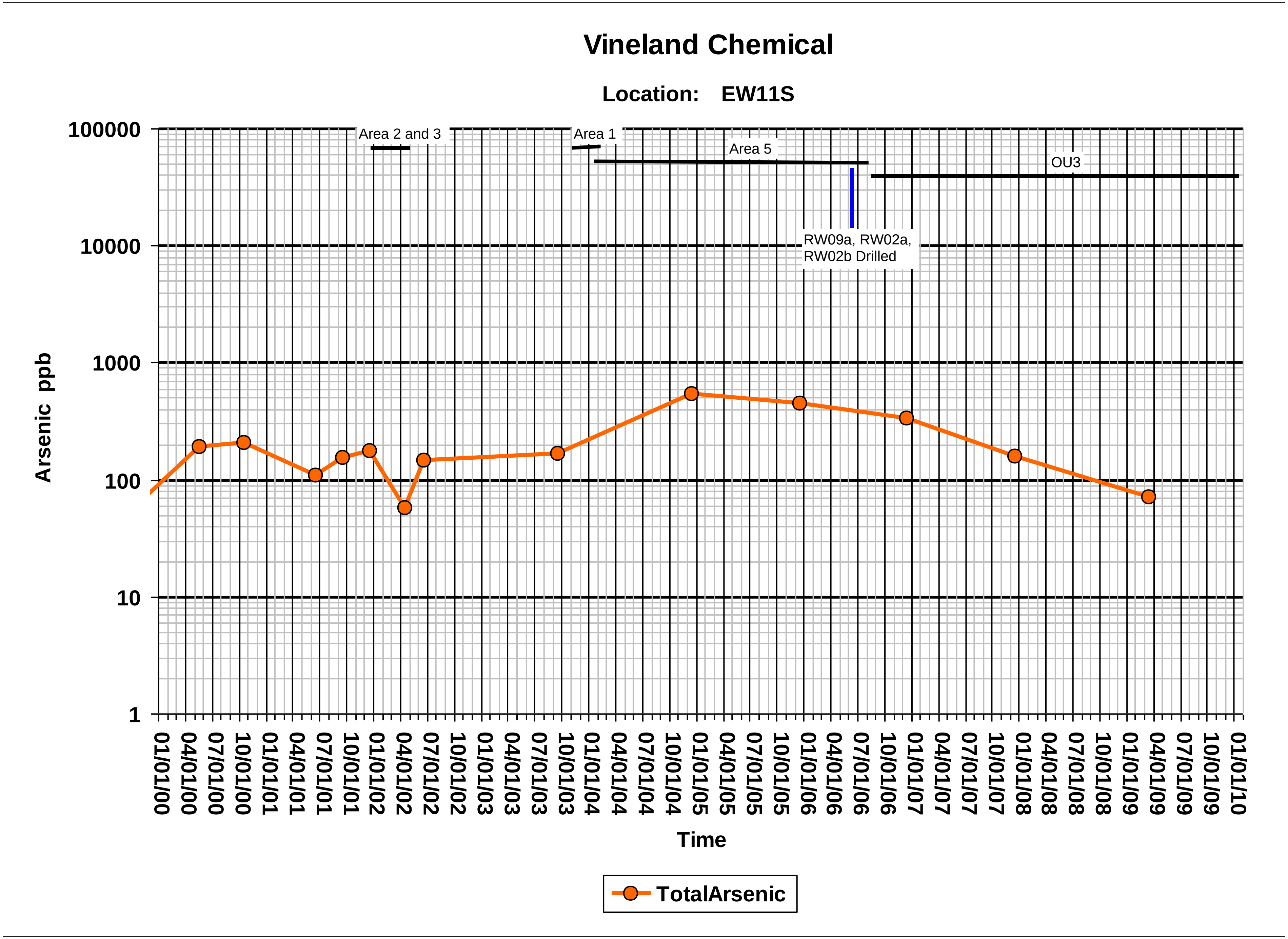
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: EW11S
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
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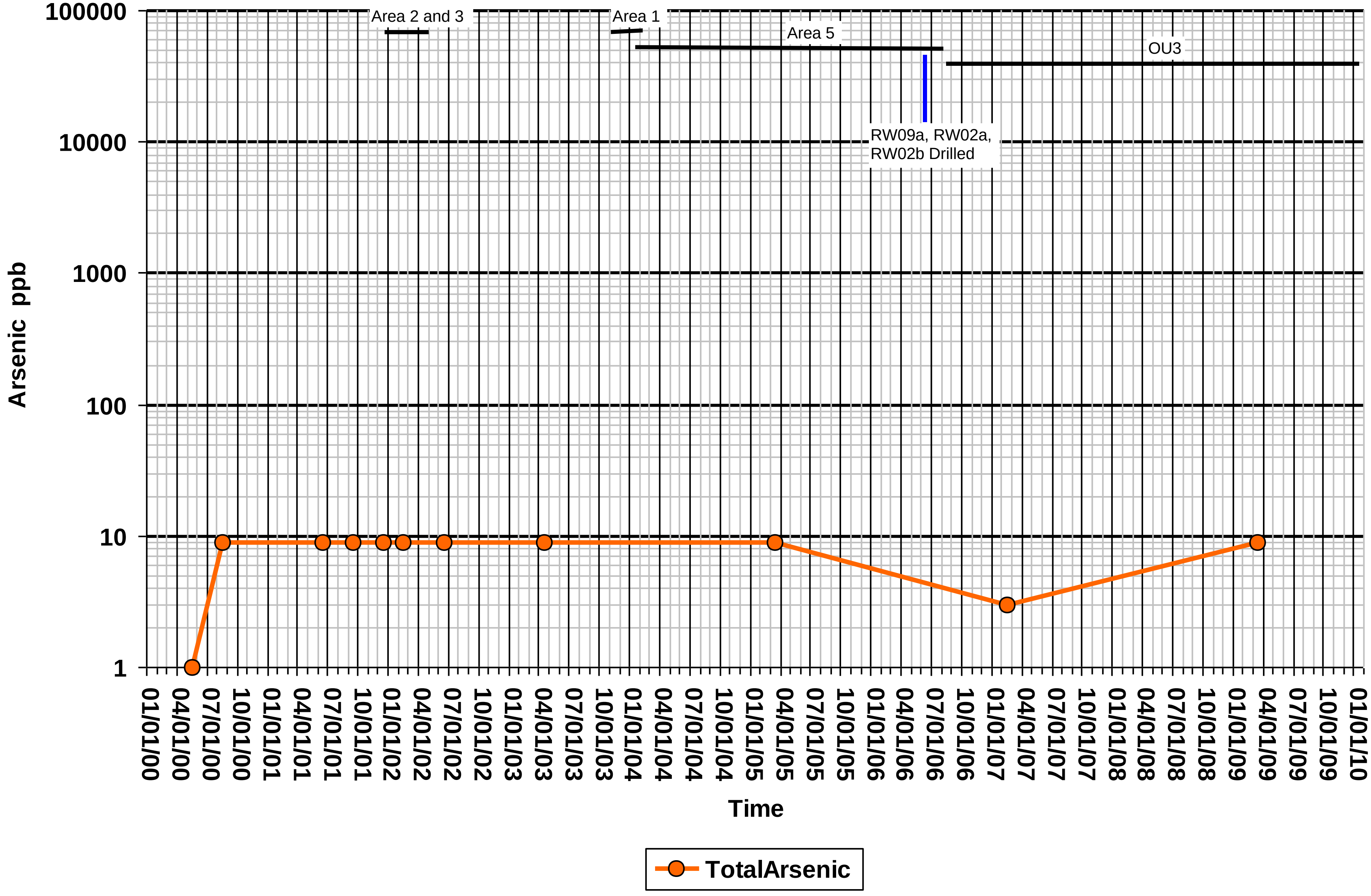
07/01/09
10/01/09
01/01/10
Time
TotalArsenic

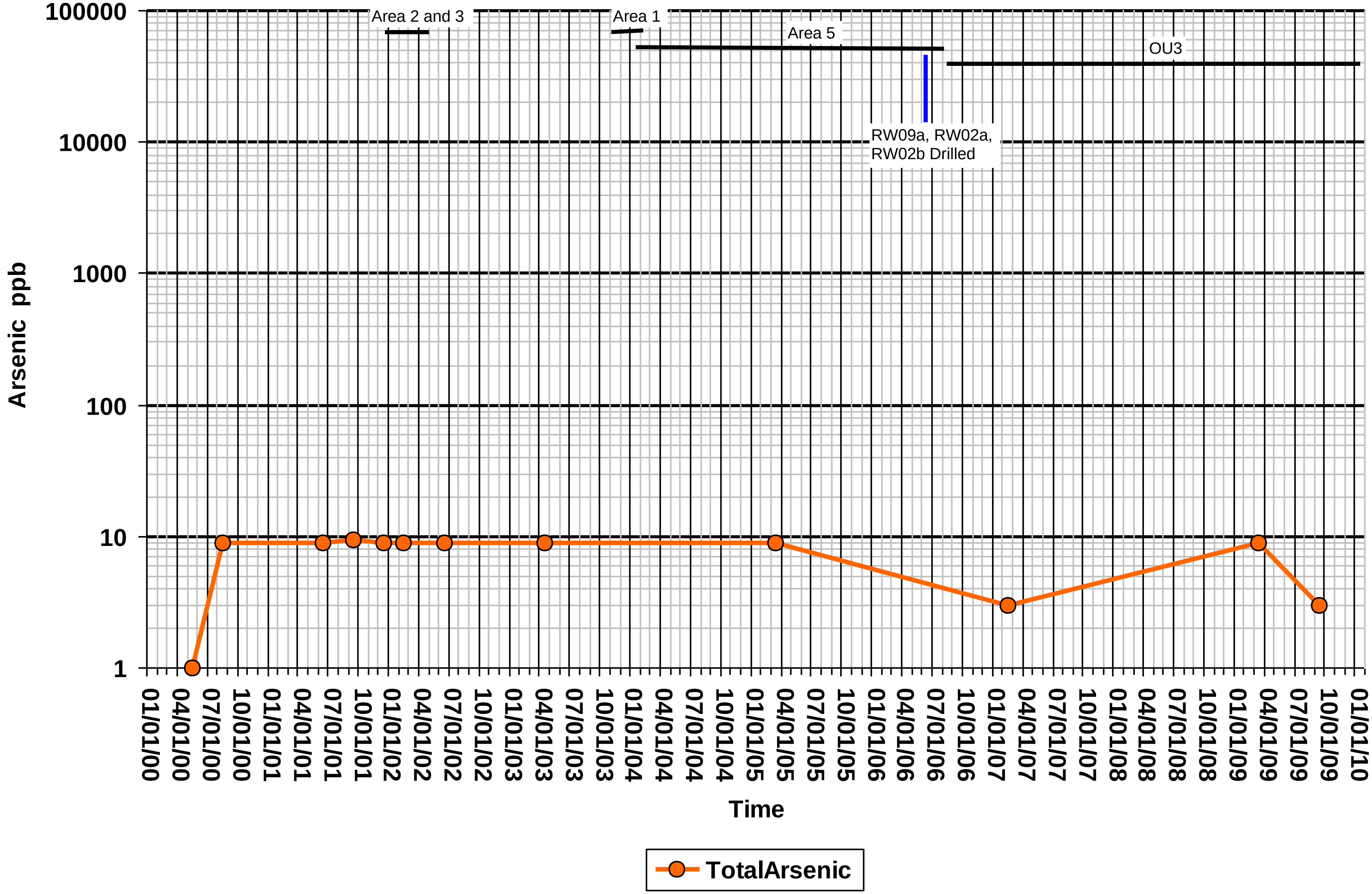
Vineland Chemical

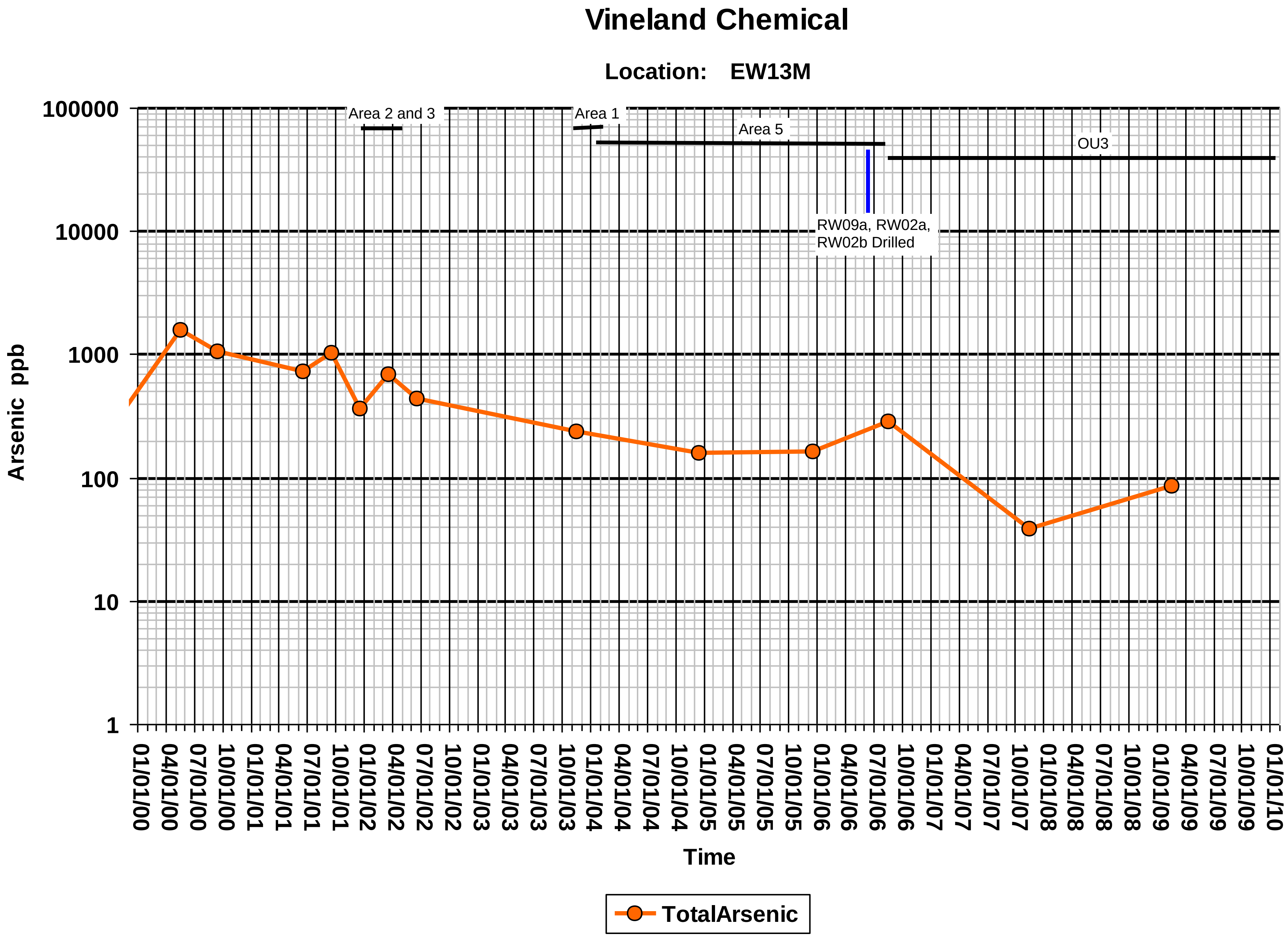
Location: EW12M



Vineland Chemical

Location: EW12S




Vineland Chemical
Location: EW13M
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
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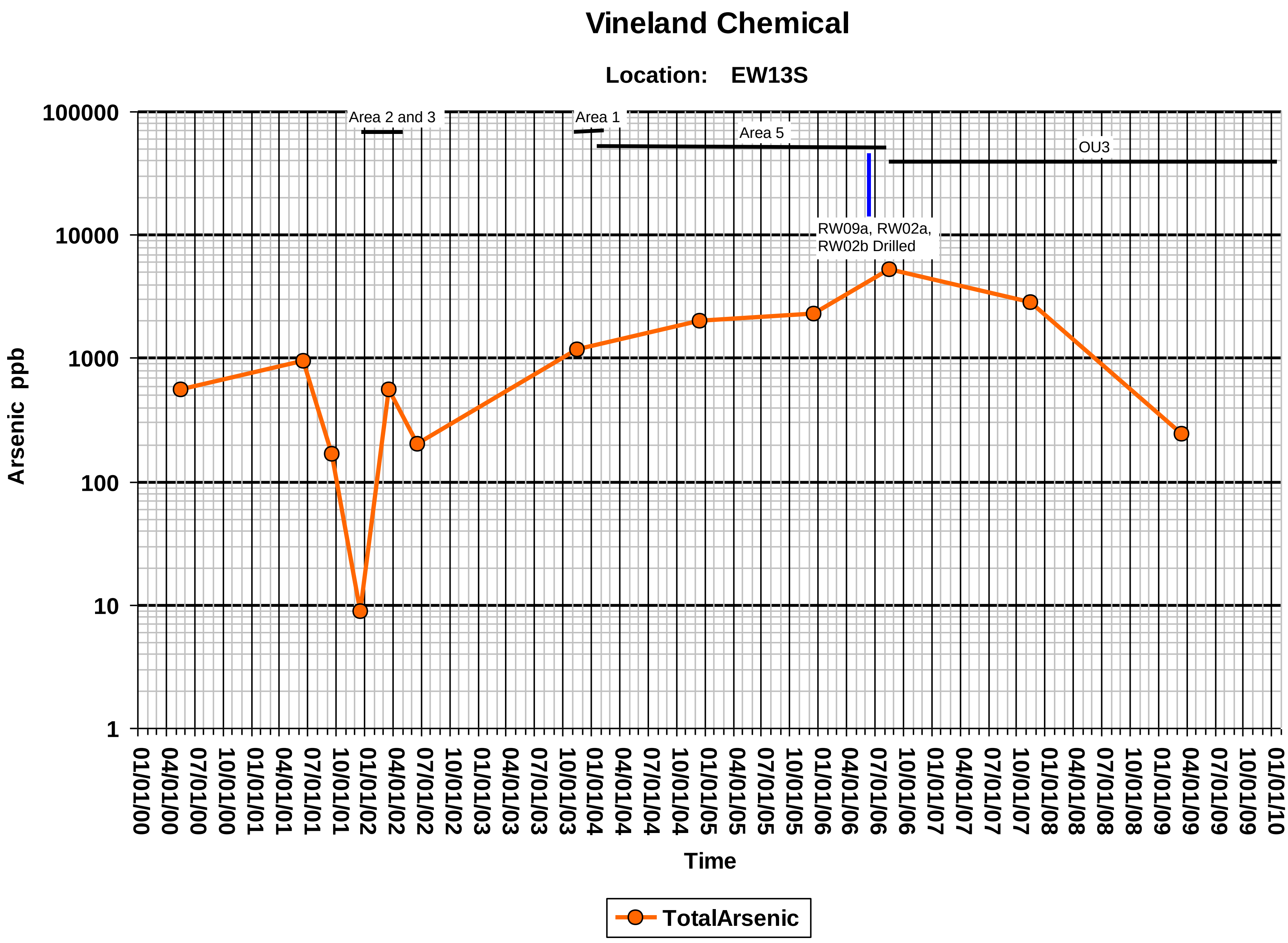
10/01/09
01/01/10
Time
TotalArsenic



Vineland Chemical
Location: EW13S
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
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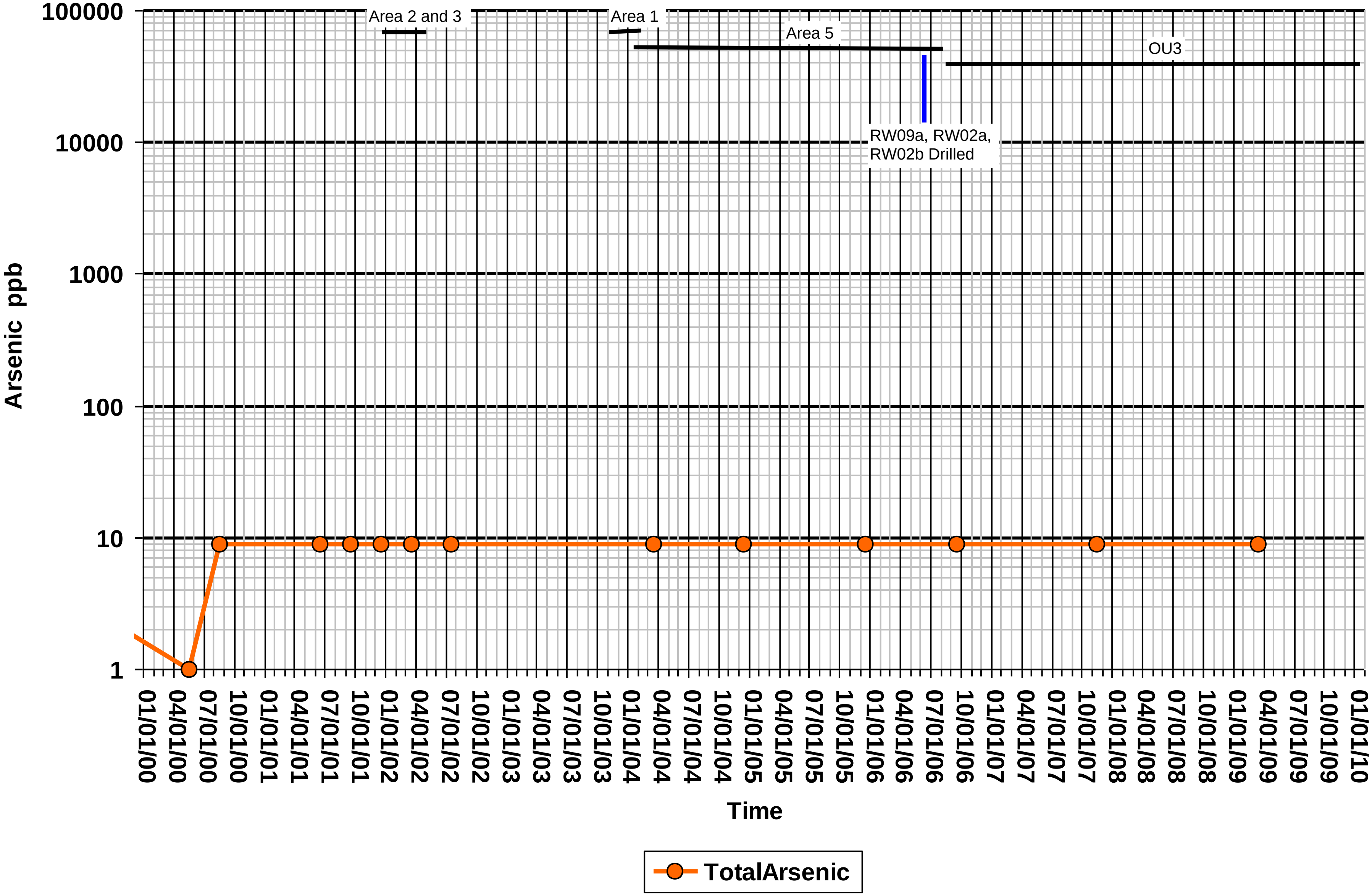
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic

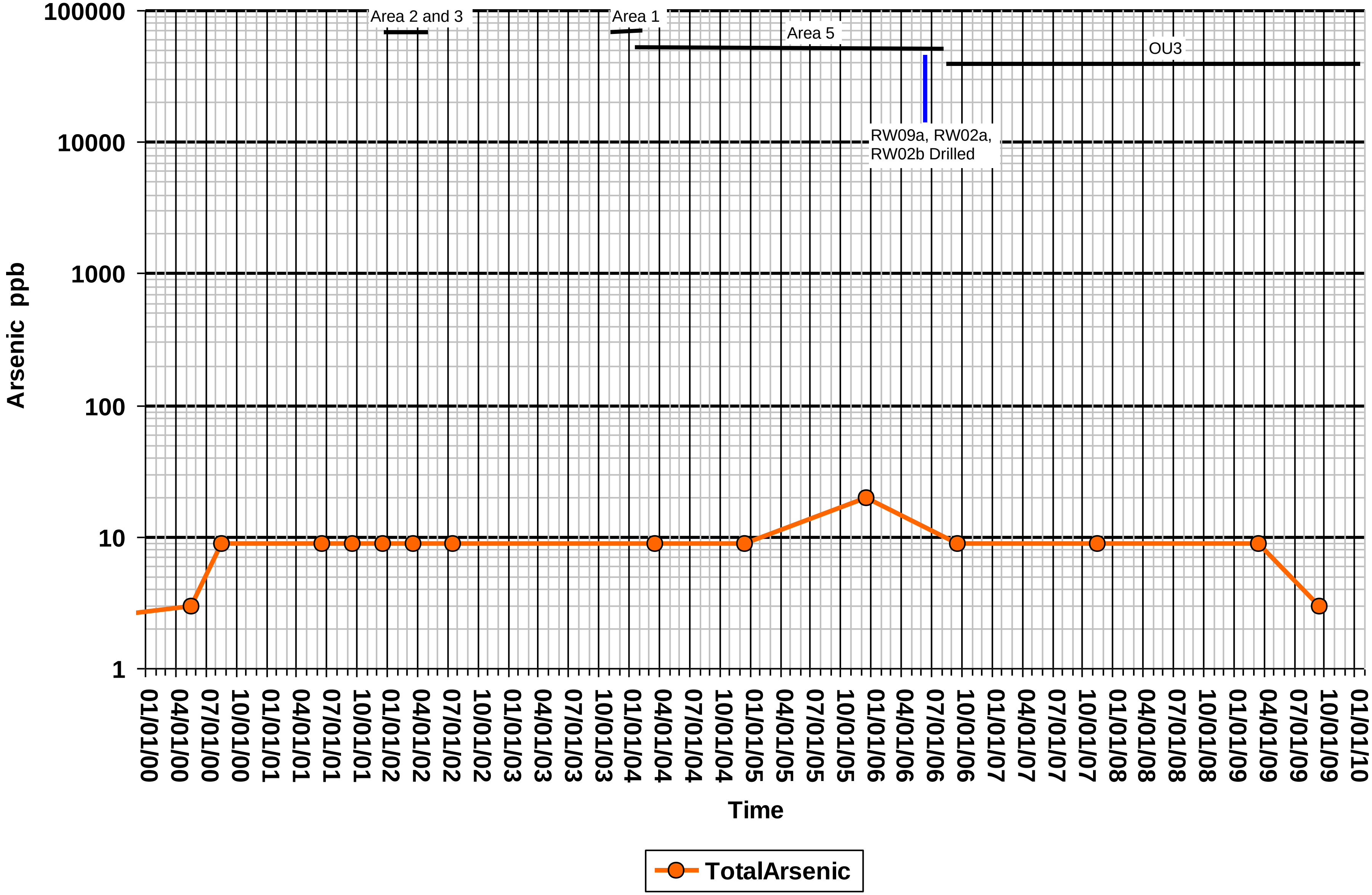
Vineland Chemical

Location: EW14M



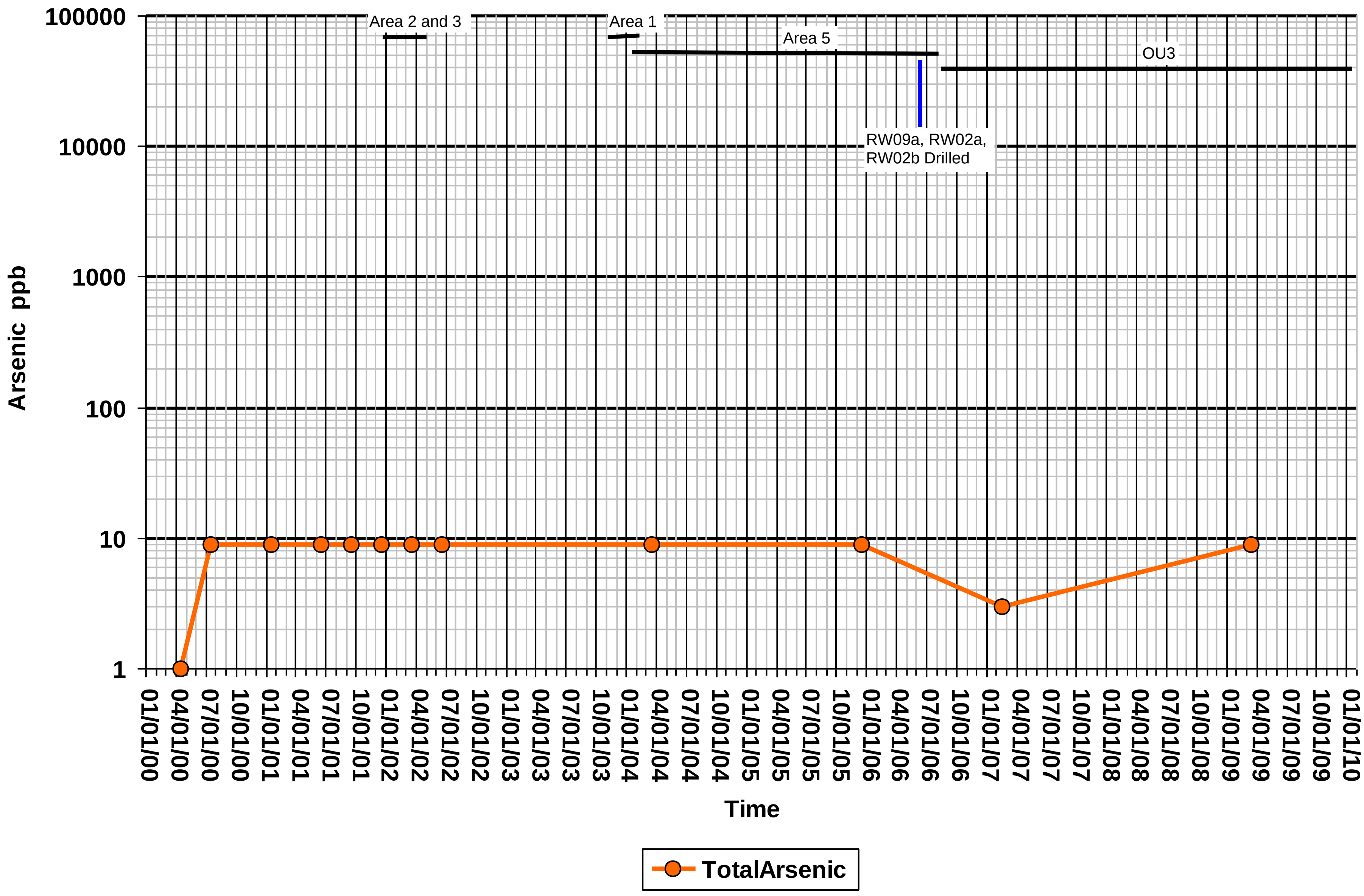
Vineland Chemical

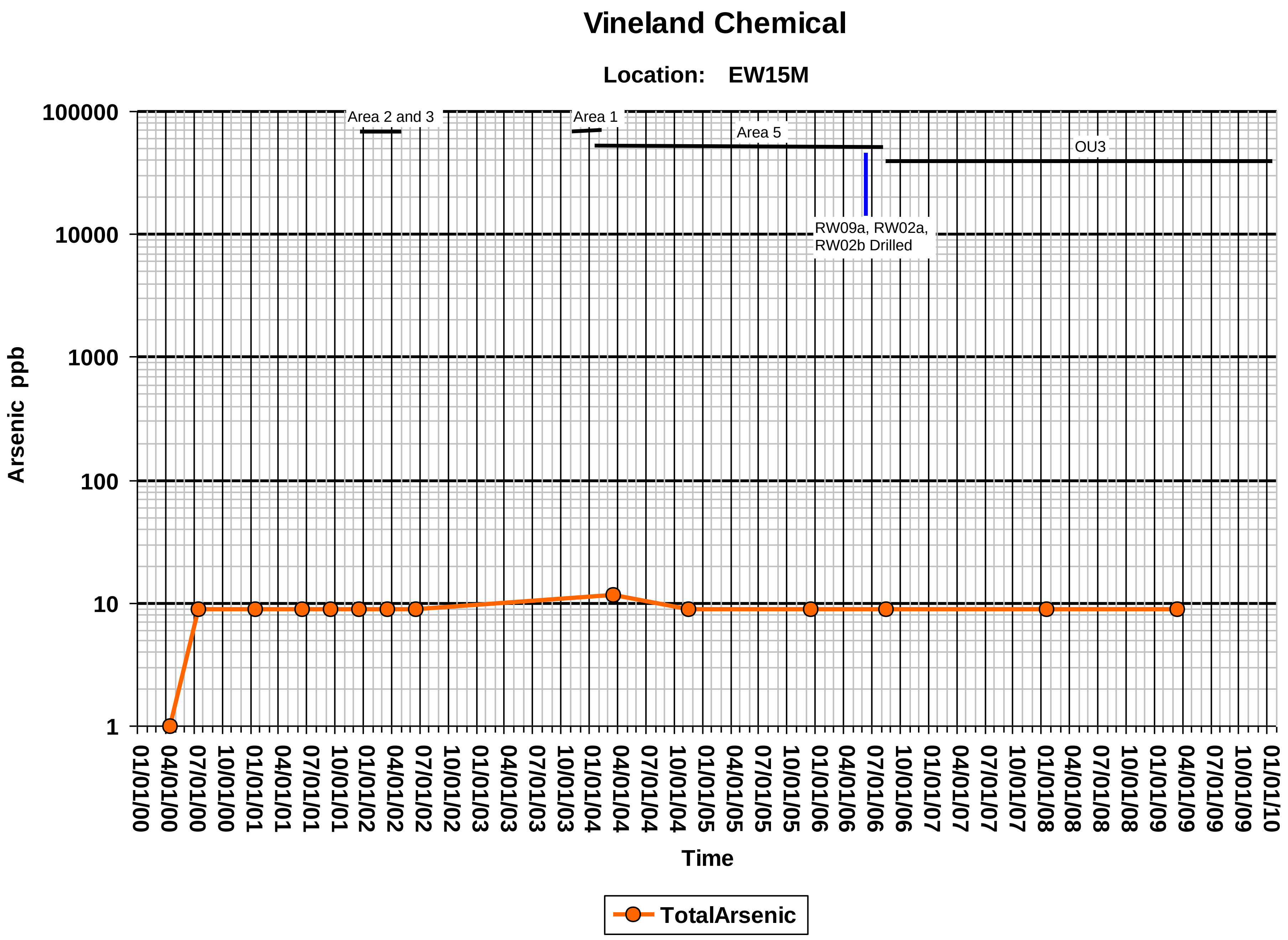
Location: EW14S



Vineland Chemical

Location: EW15D




Vineland Chemical
Location: EW15M
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
10/01/02
01/01/03
04/01/03
07/01/03
10/01/03
01/01/04
04/01/04
07/01/04
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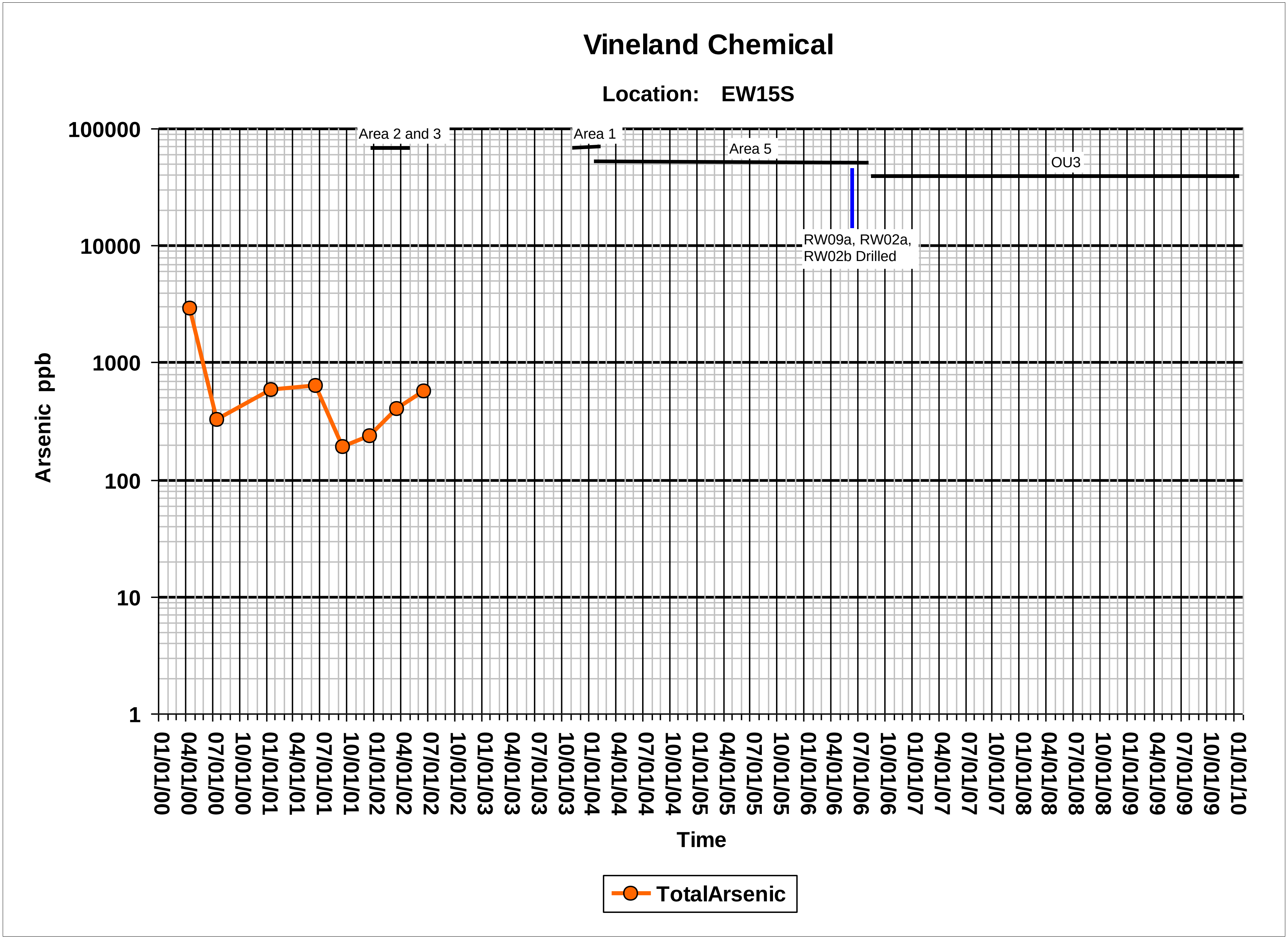
04/01/06
07/01/06
10/01/06
01/01/07
04/01/07
07/01/07
10/01/07
01/01/08
04/01/08
07/01/08
10/01/08
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: EW15S
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
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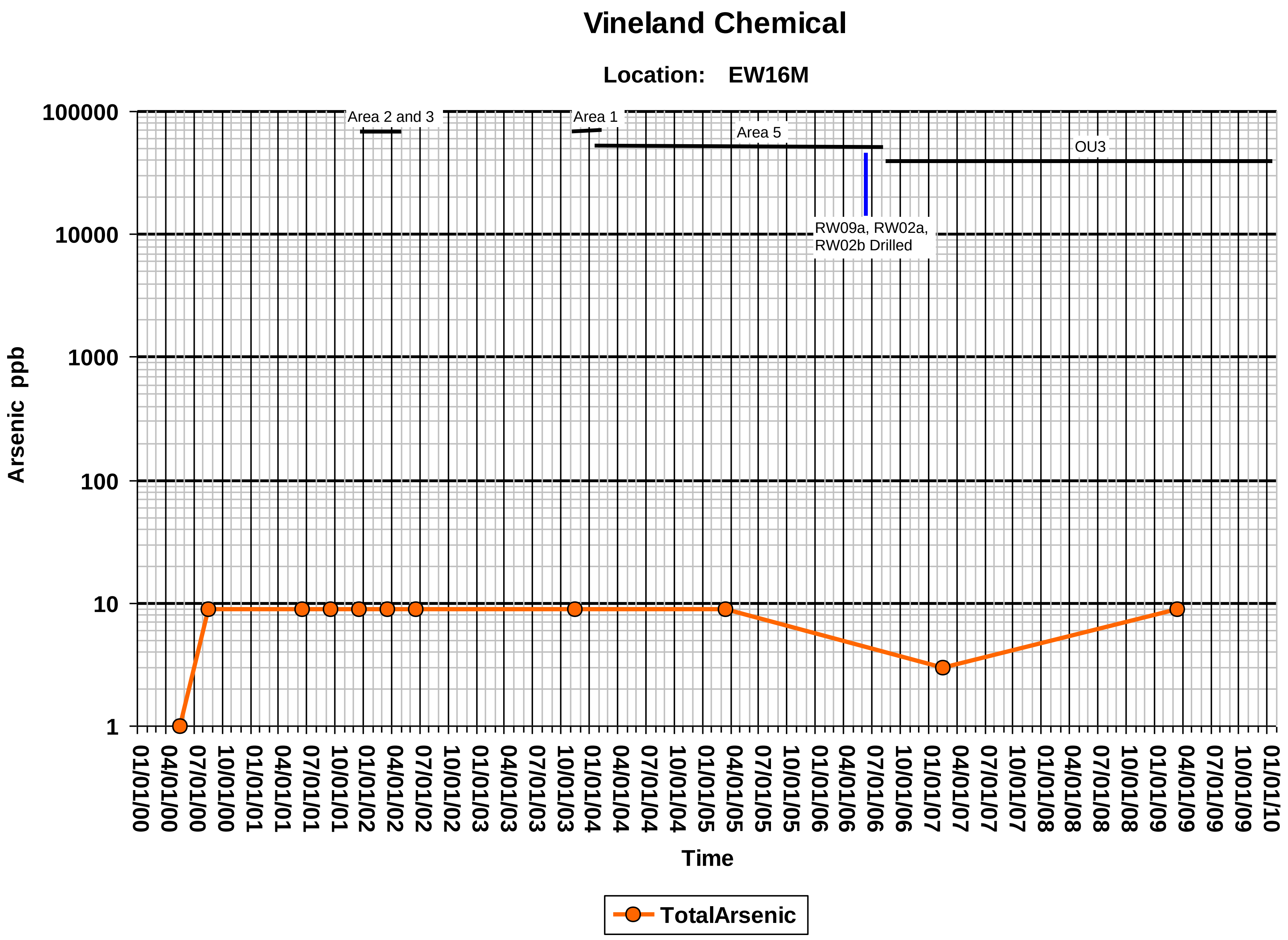
01/01/08
04/01/08
07/01/08
10/01/08
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: EW16M
100000
10000
1000
100
10
1
Arsenic ppb
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
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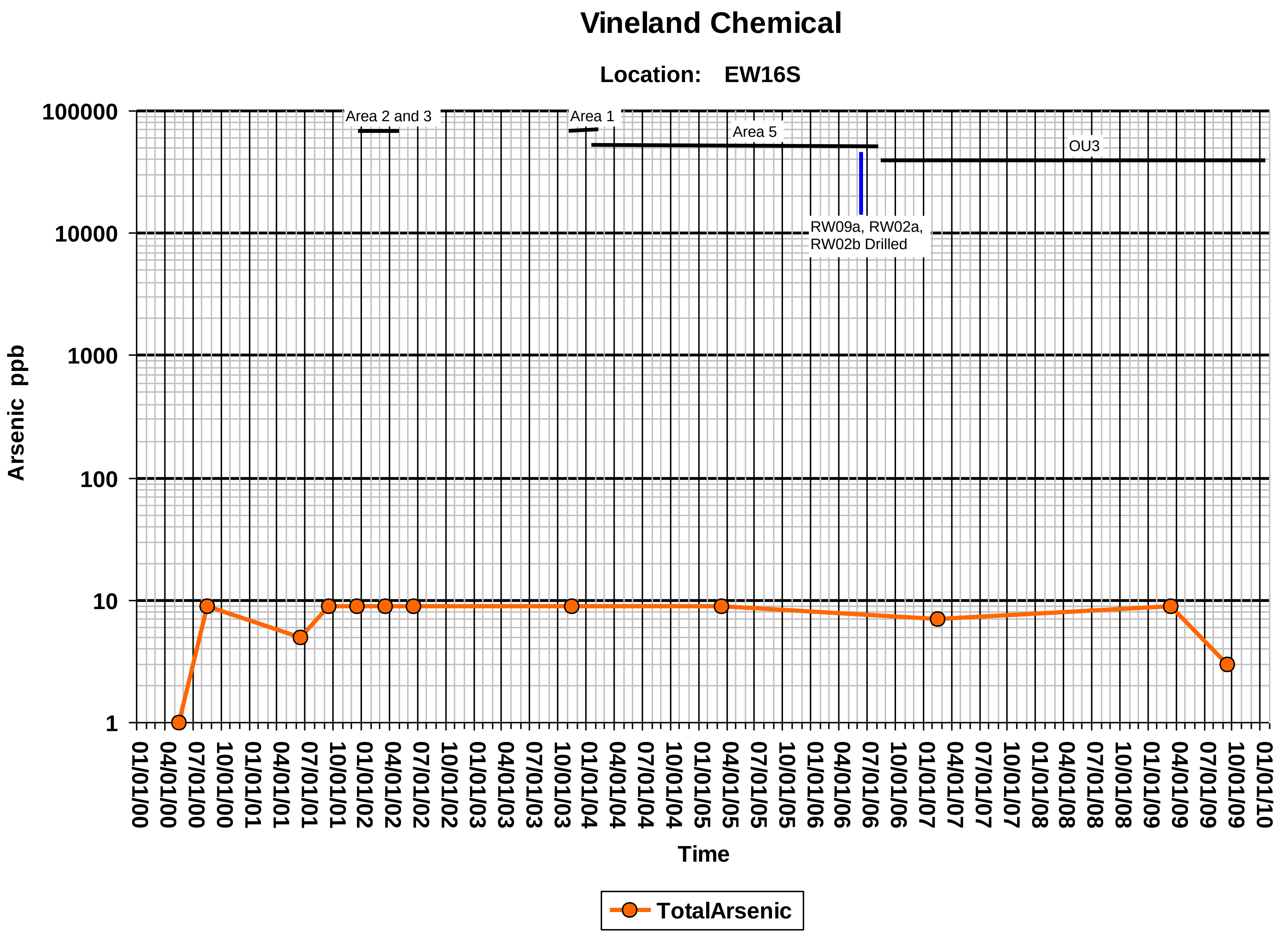
10/01/07
01/01/08
04/01/08
07/01/08
10/01/08
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic



Vineland Chemical
Location: EW16S
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
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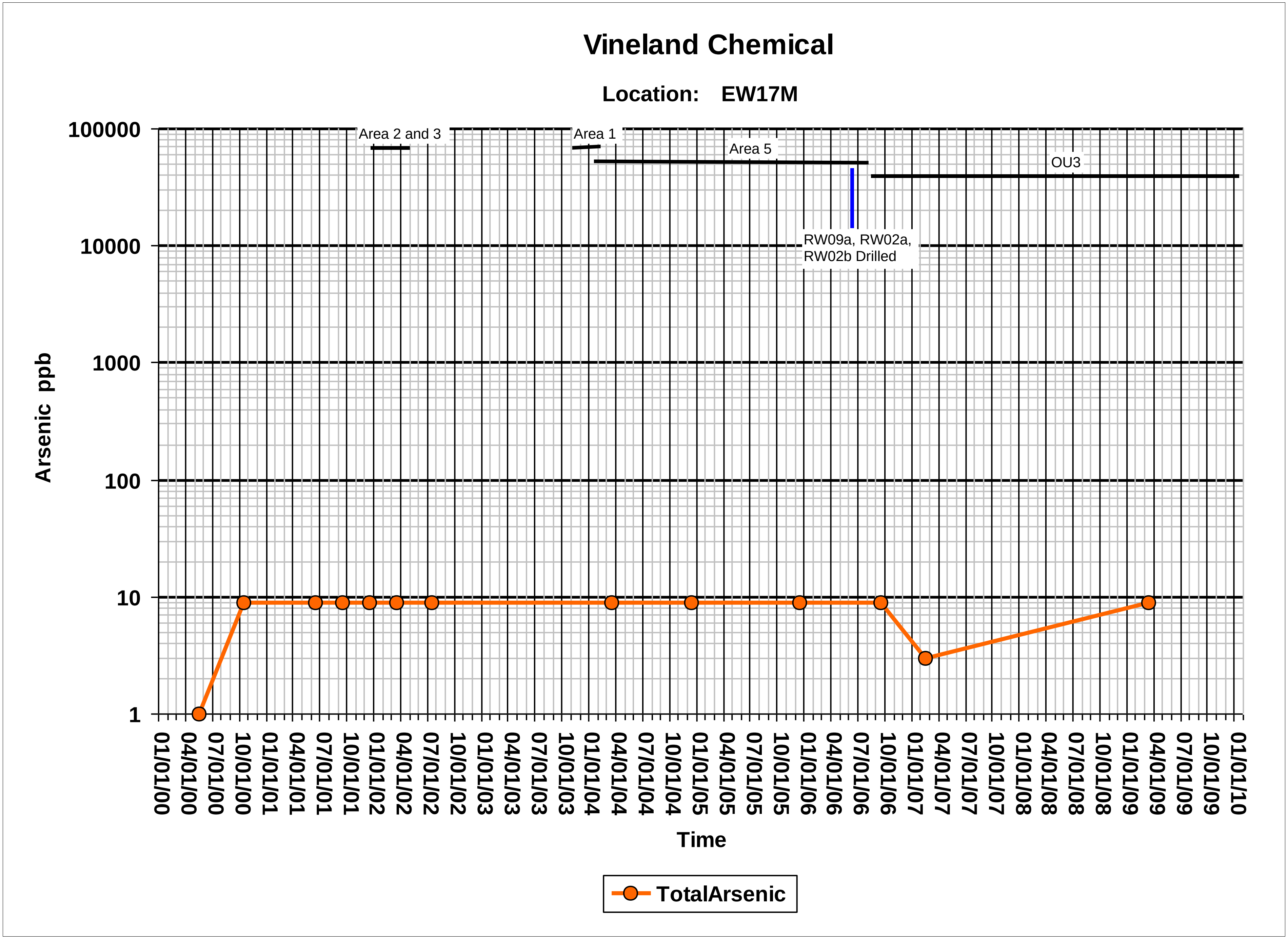
01/01/08
04/01/08
07/01/08
10/01/08
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: EW17M
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
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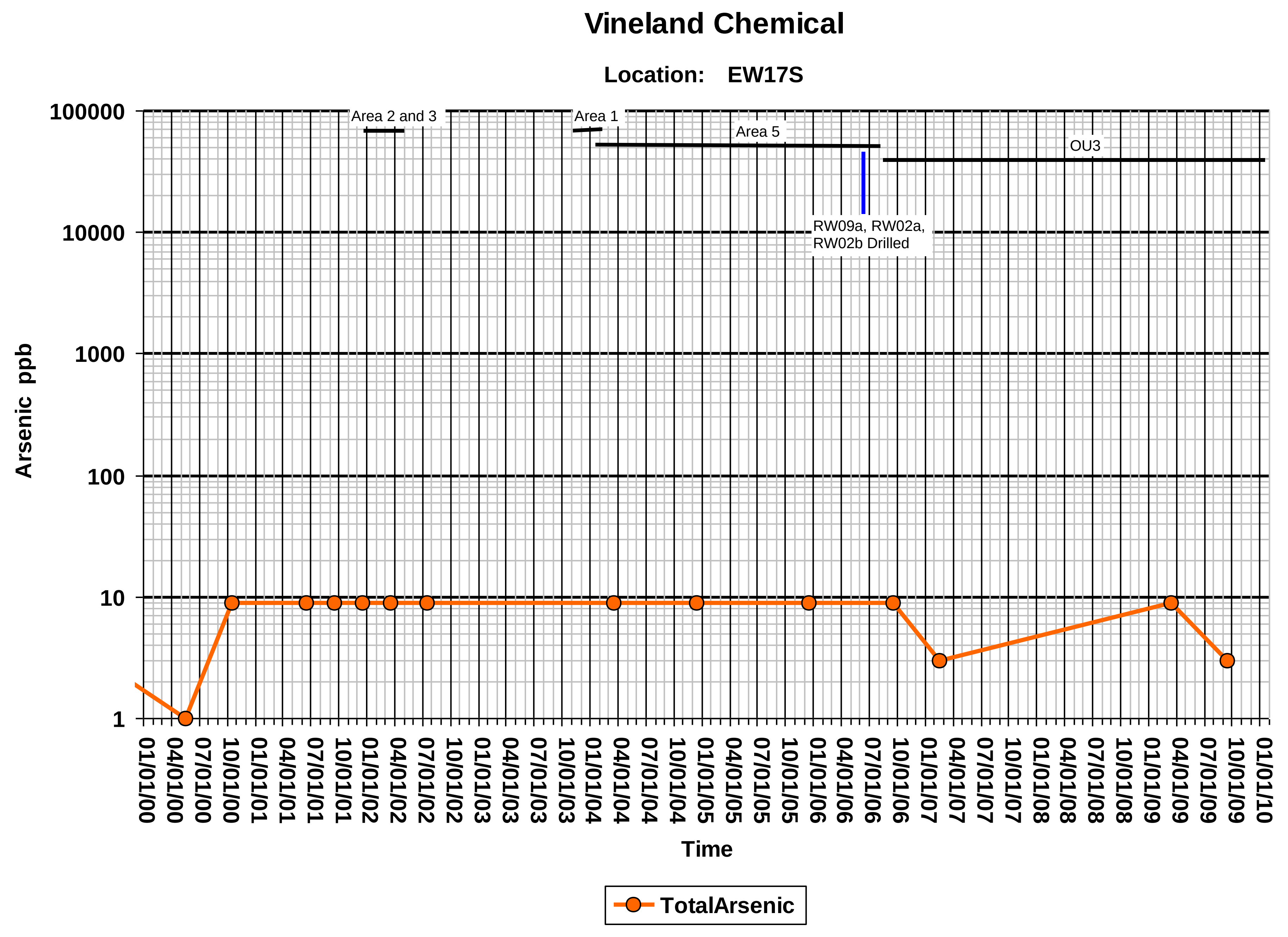
01/01/08
04/01/08
07/01/08
10/01/08
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: EW17S
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
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04/01/08
07/01/08
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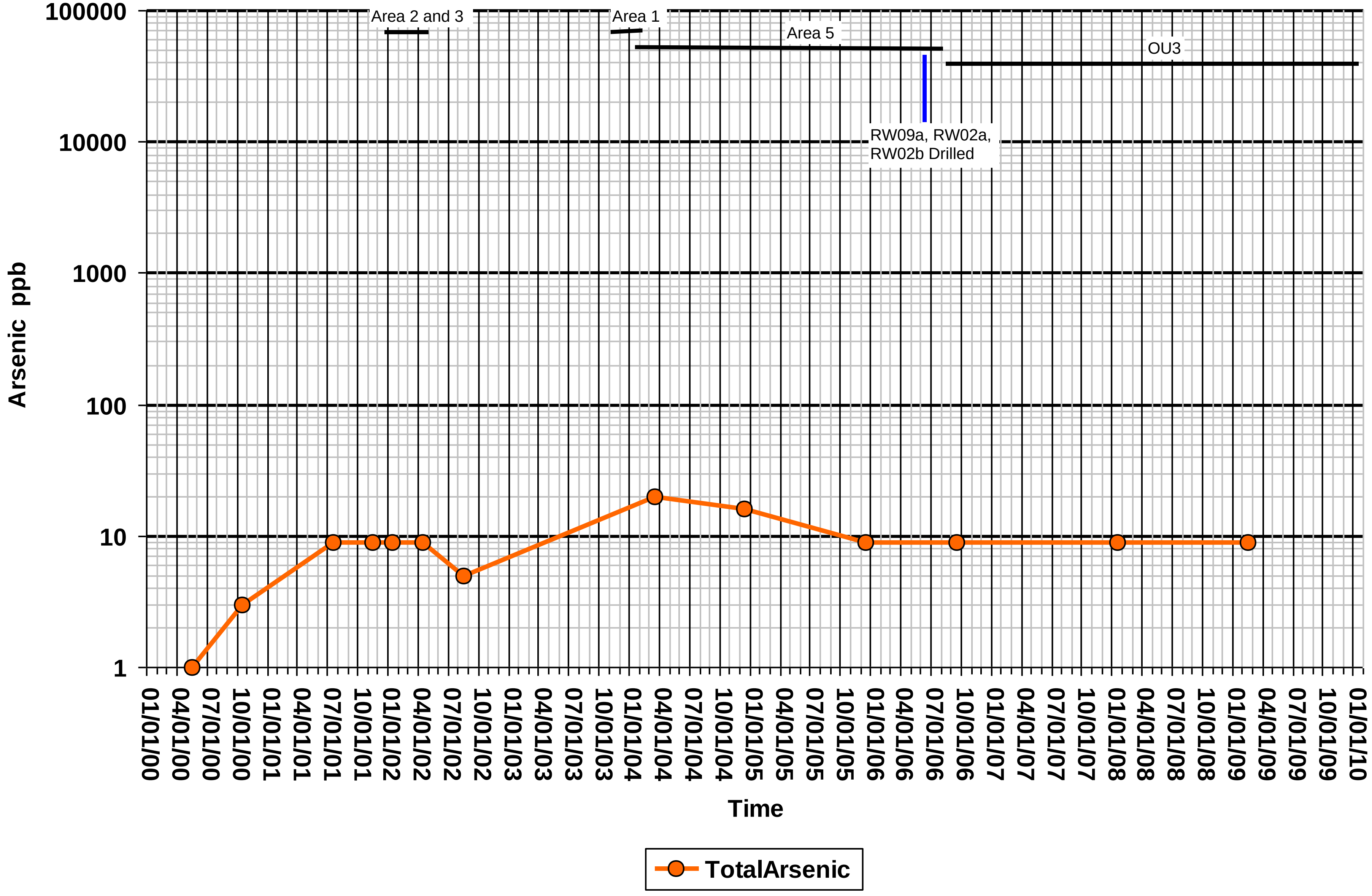
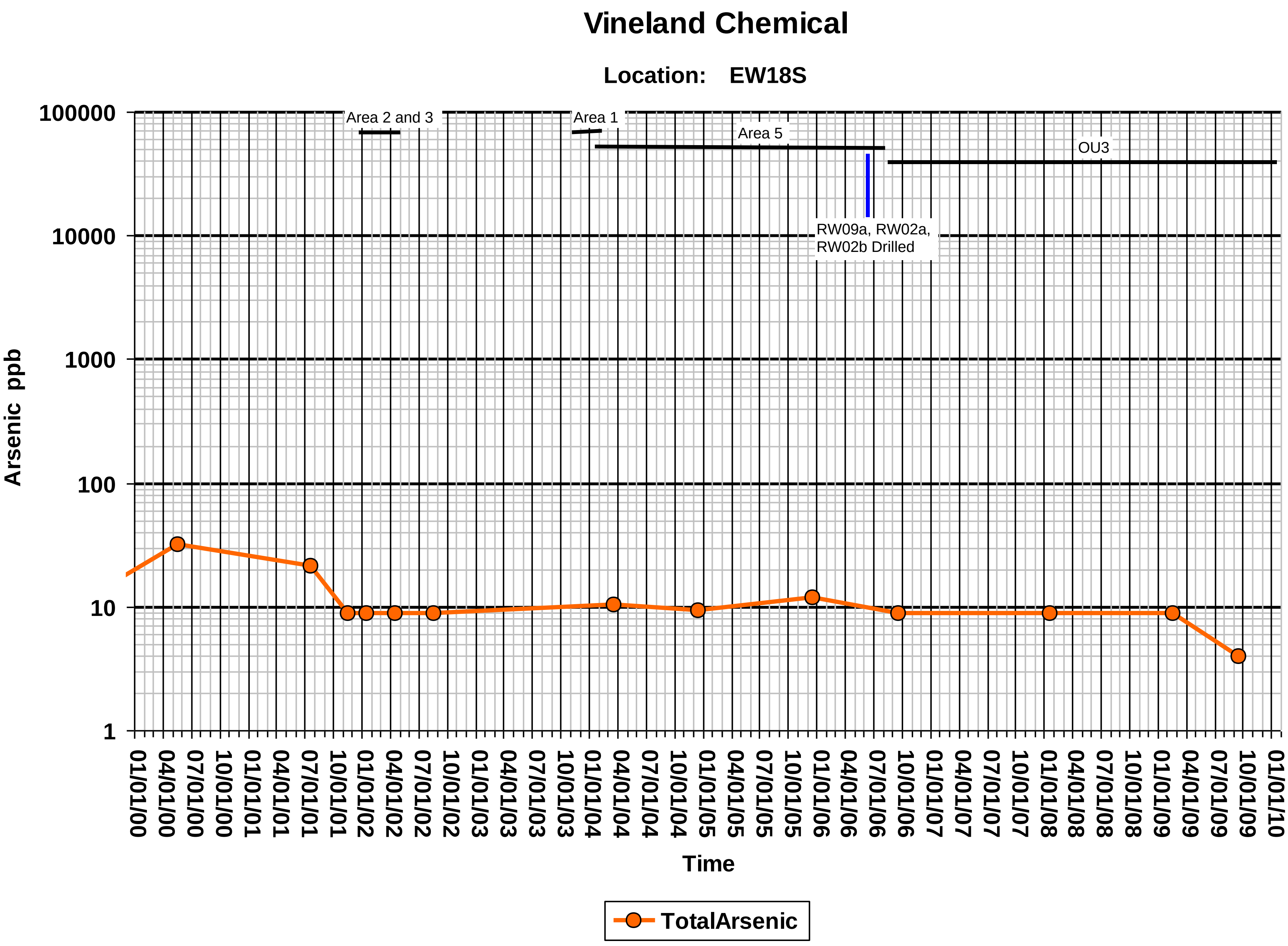
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic

Vineland Chemical

Location: EW18M




Vineland Chemical
Location: EW18S
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
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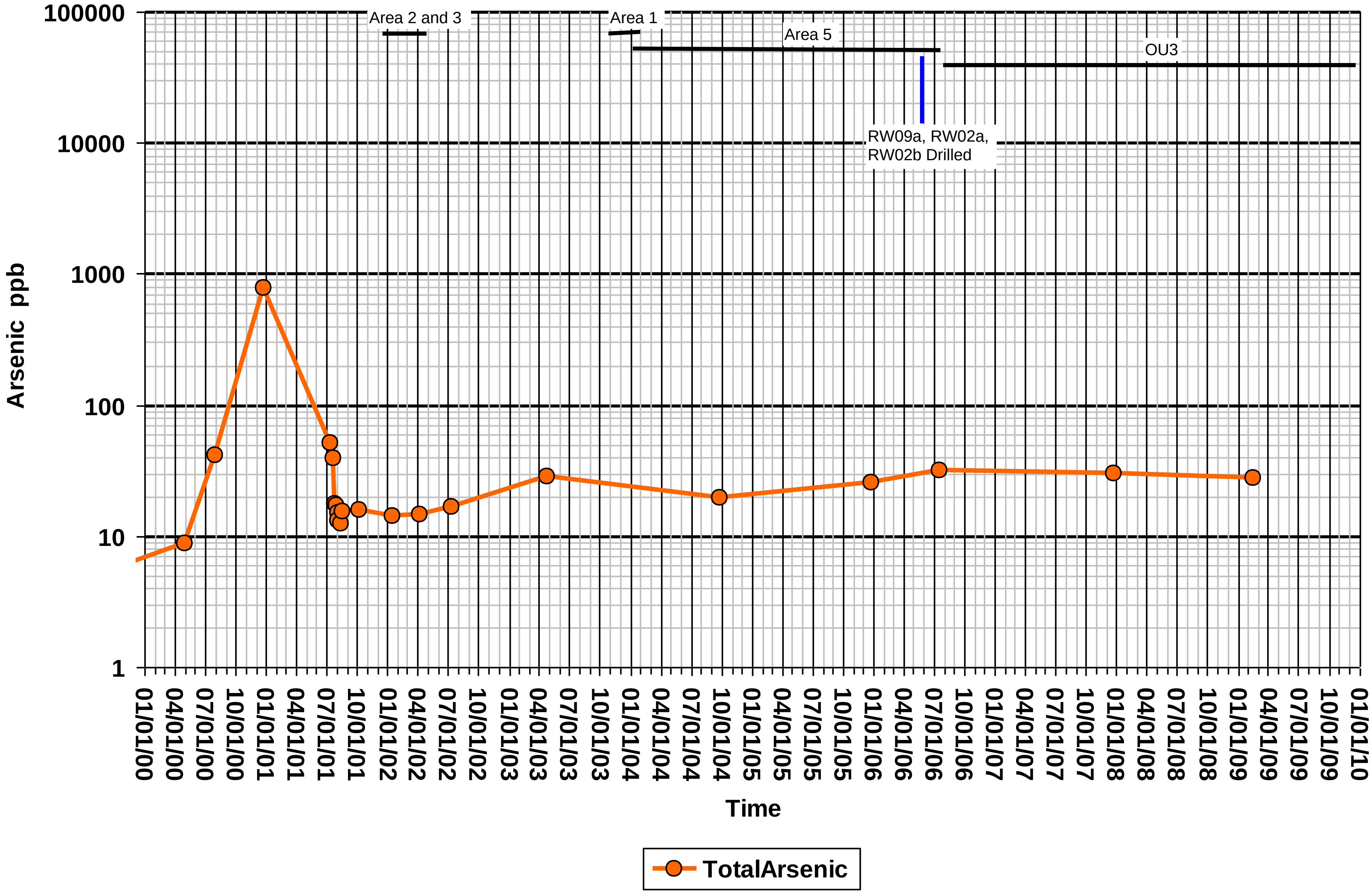
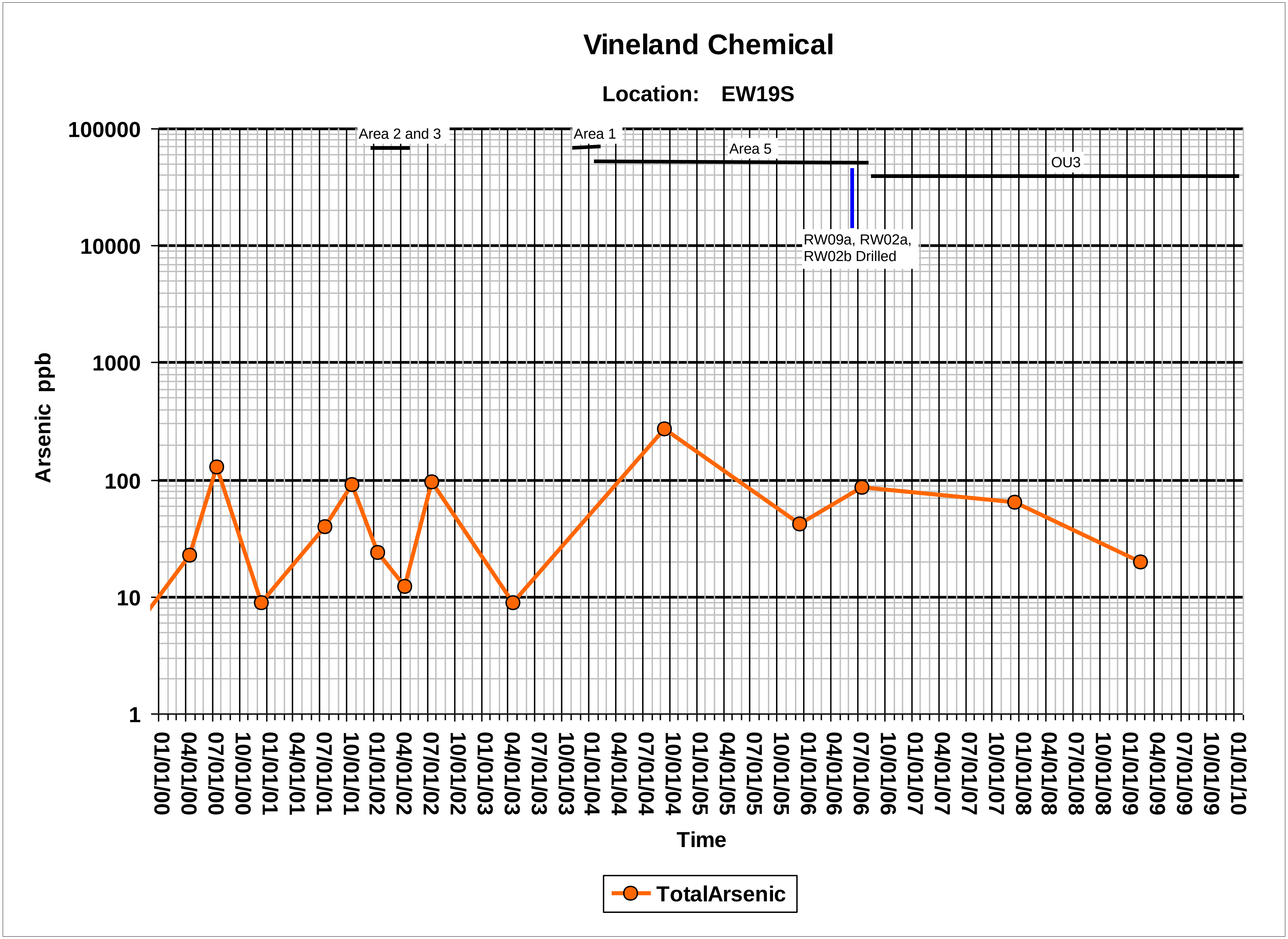
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic

Vineland Chemical

Location: EW19M




Vineland Chemical
Location: EW19S
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
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04/01/08
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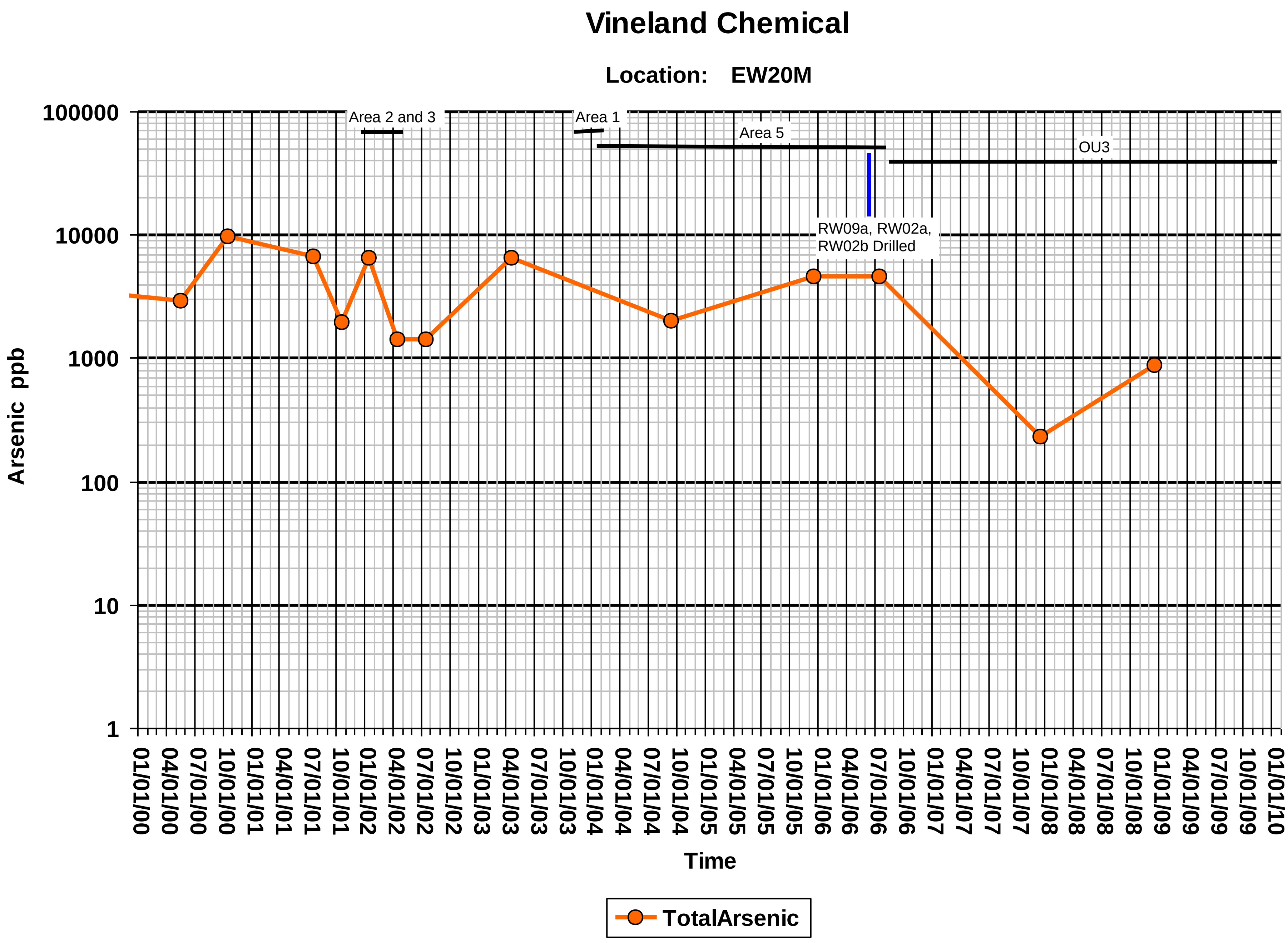
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: EW20M
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
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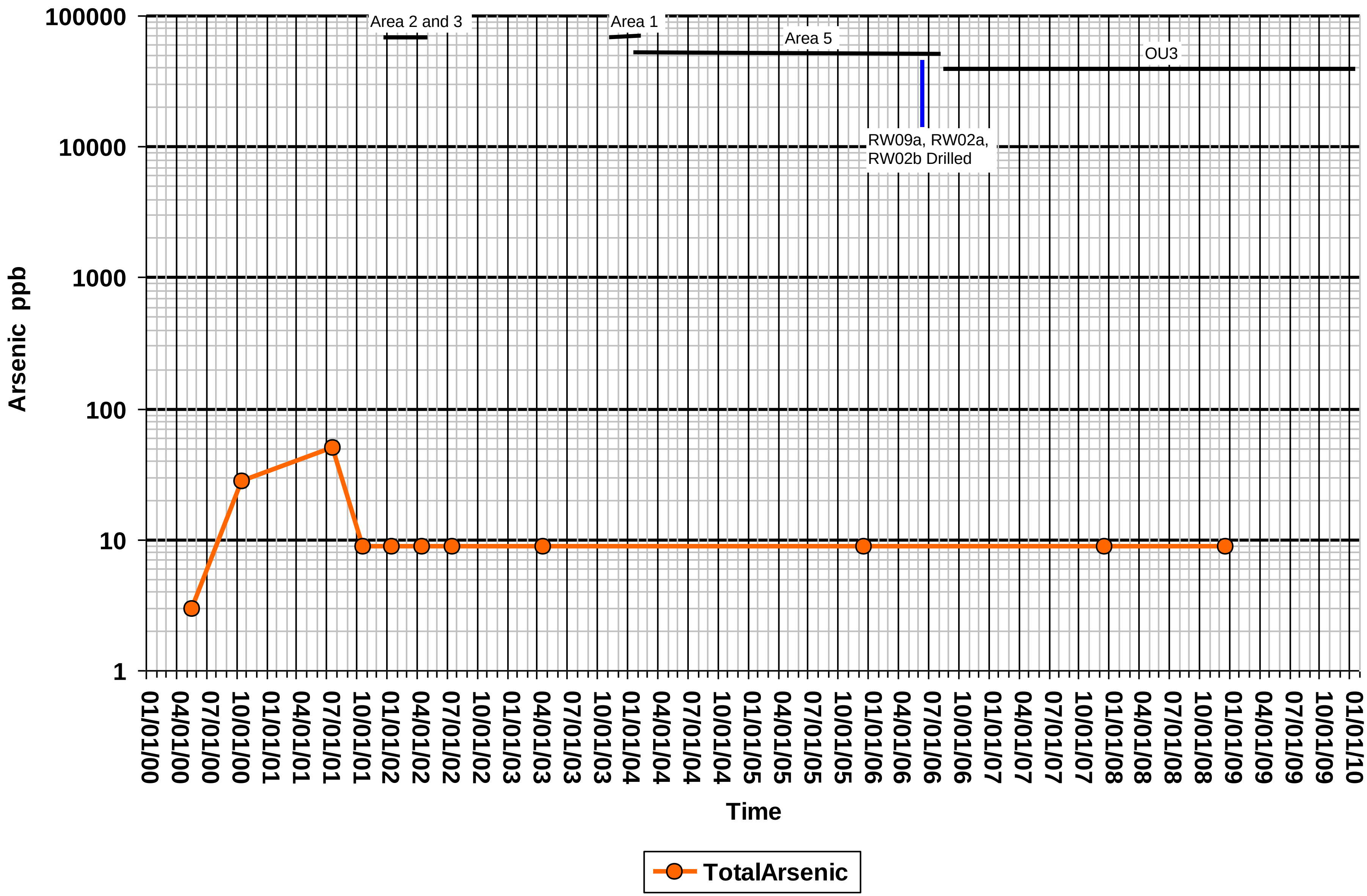
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic

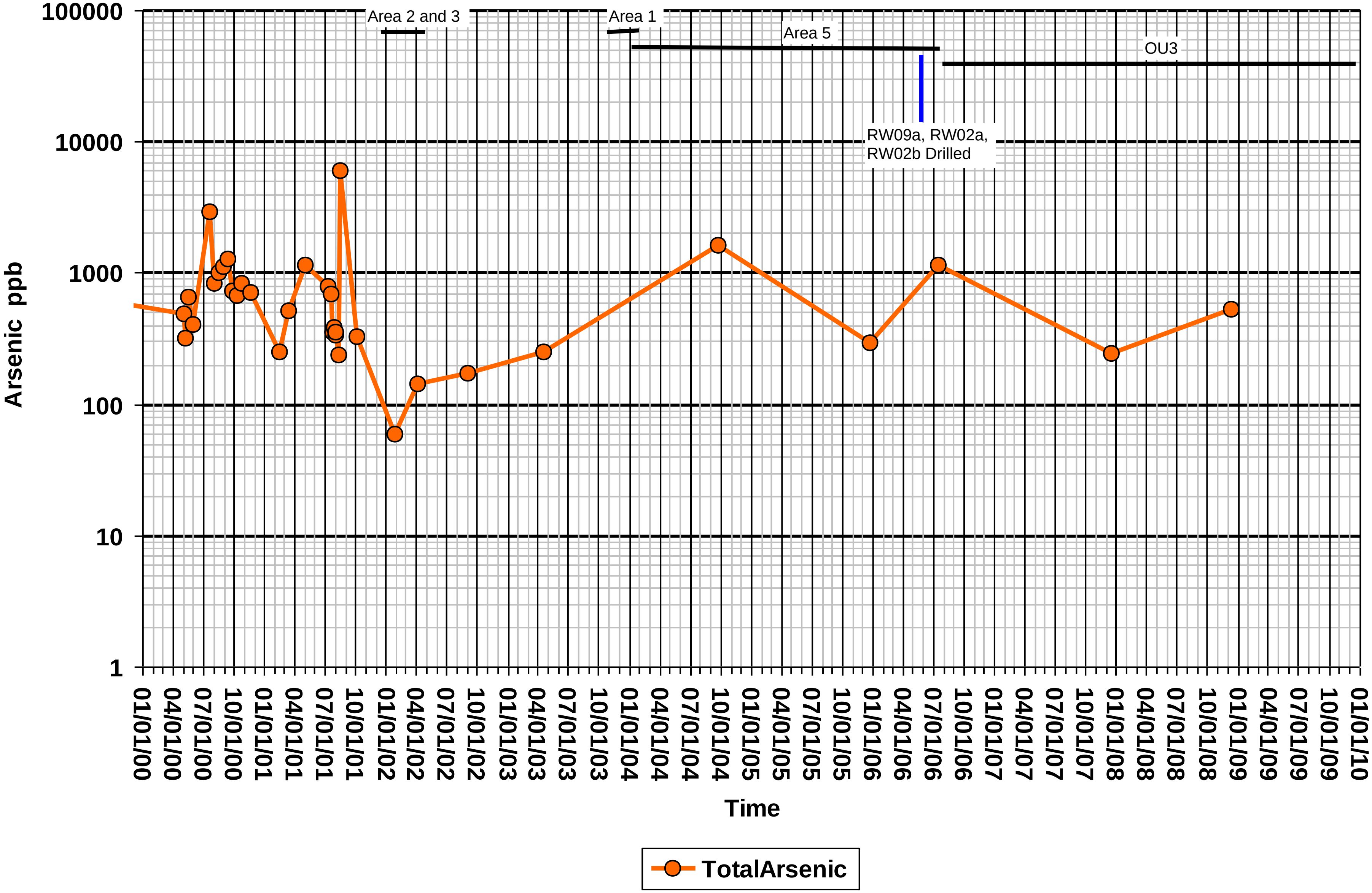


Vineland Chemical

Location: EW20S

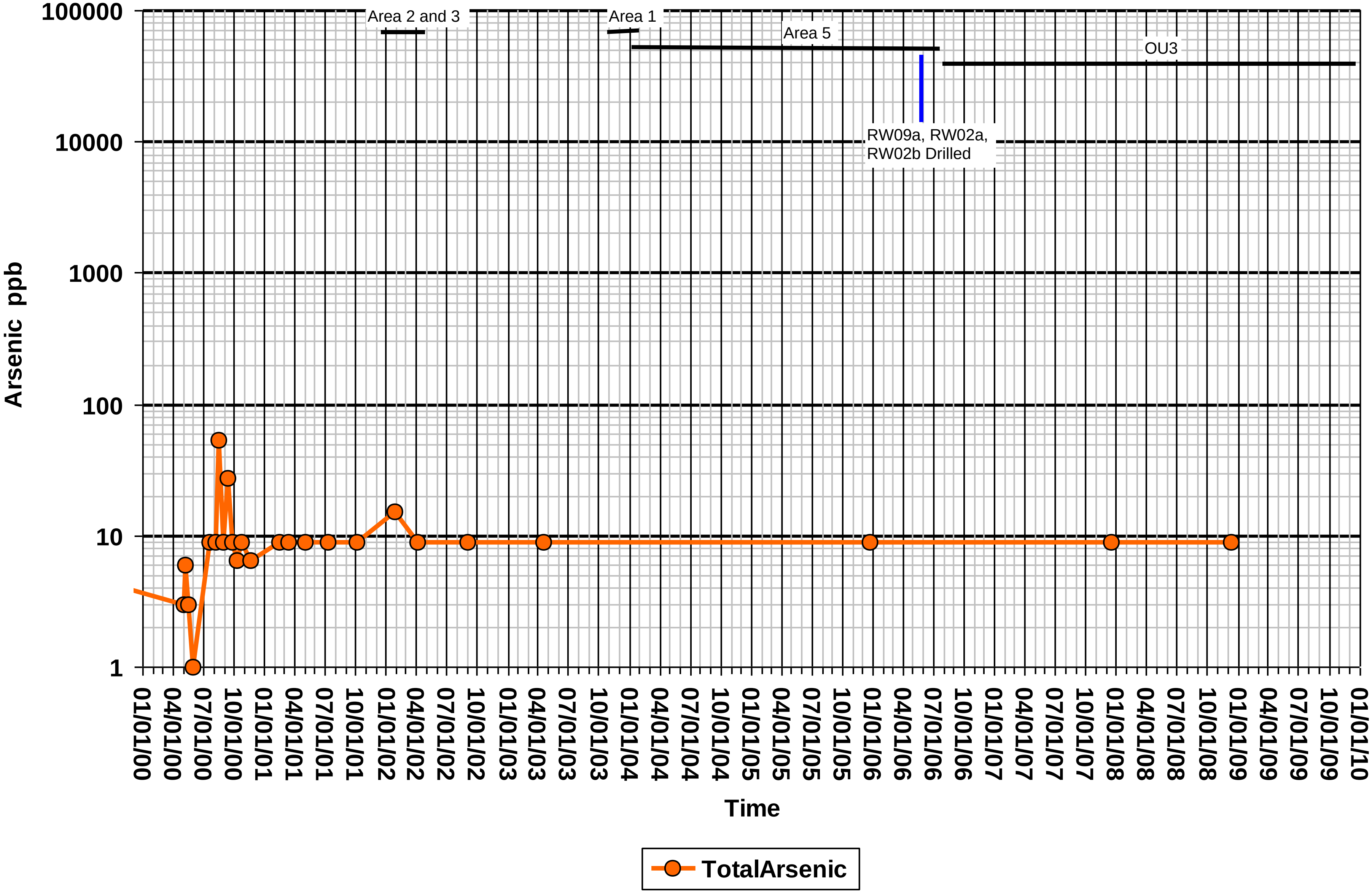
Vineland Chemical

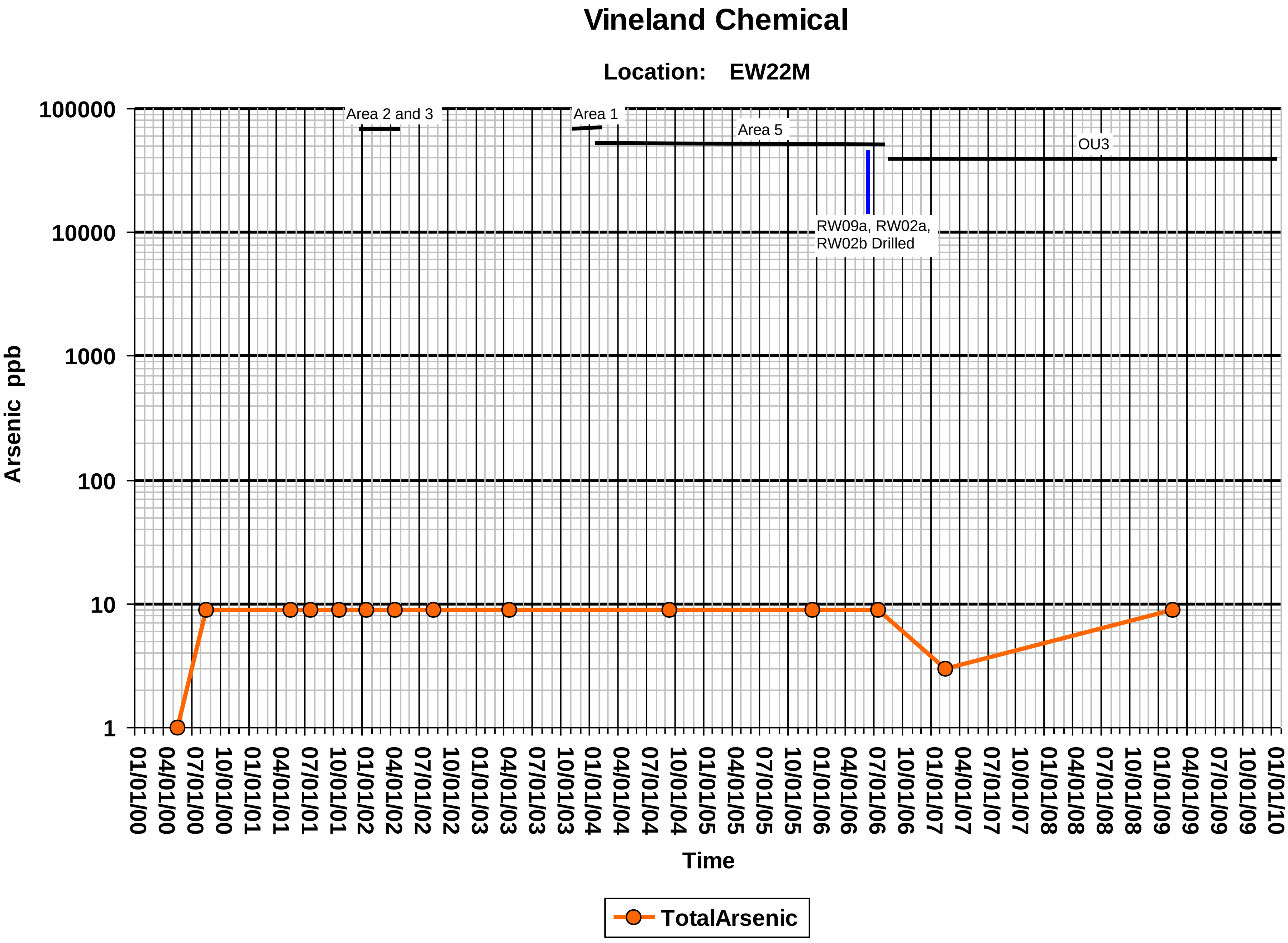
Location: EW21M



Vineland Chemical

Location: EW21S




Vineland Chemical
Location: EW22M
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
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01/01/08
04/01/08
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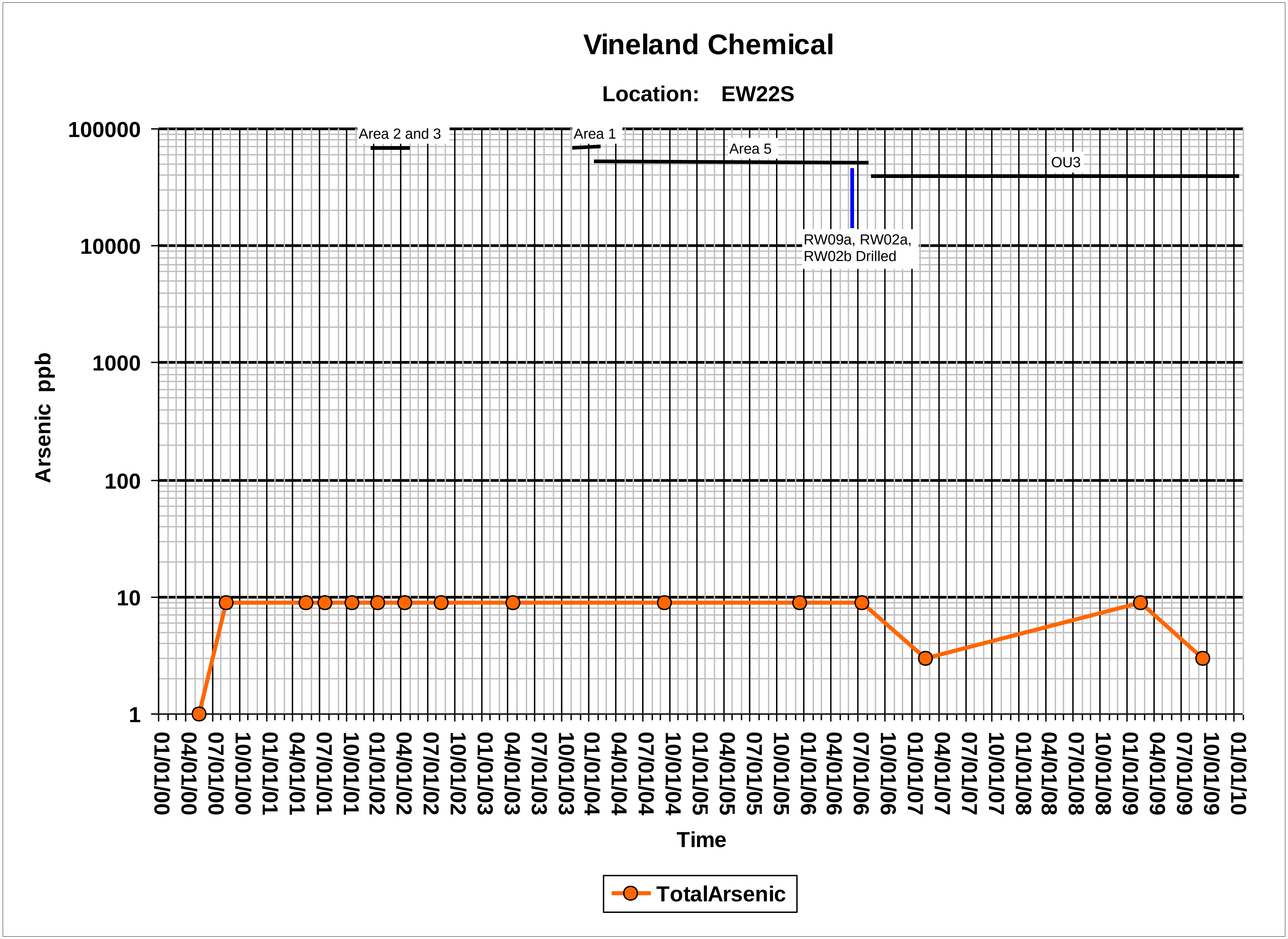
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: EW22S
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
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04/01/08
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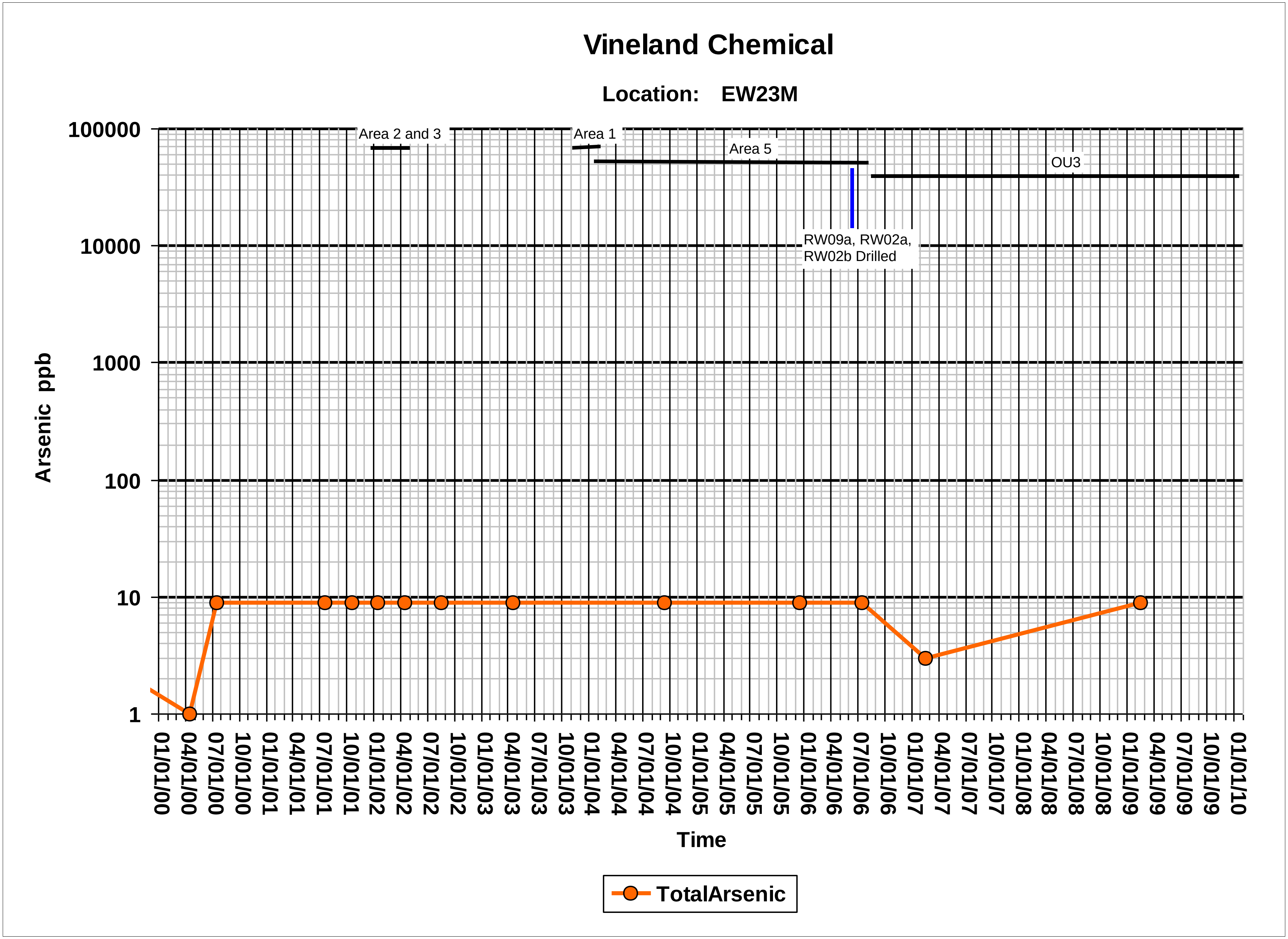
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: EW23M
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
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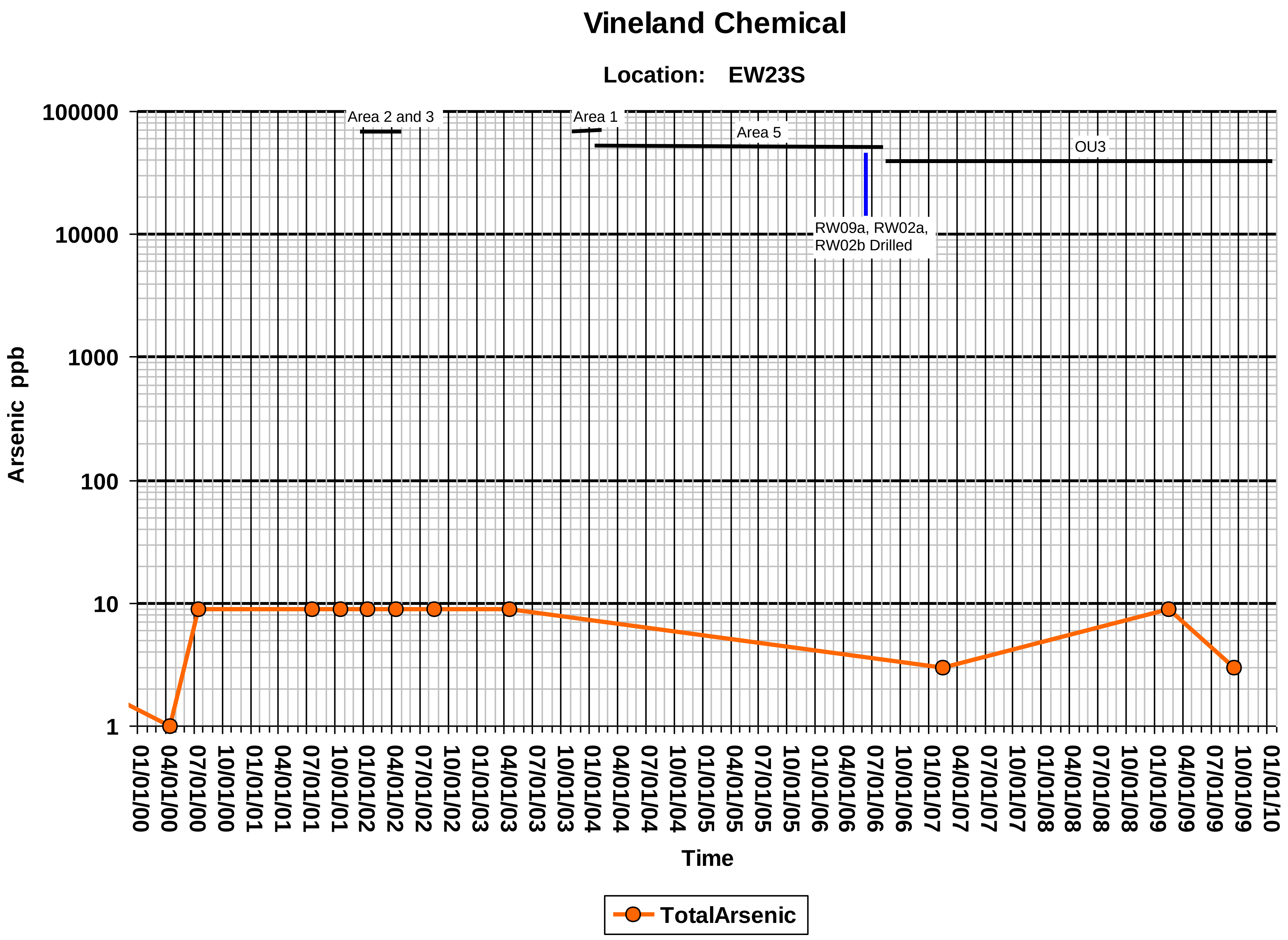
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic



Vineland Chemical
Location: EW23S
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
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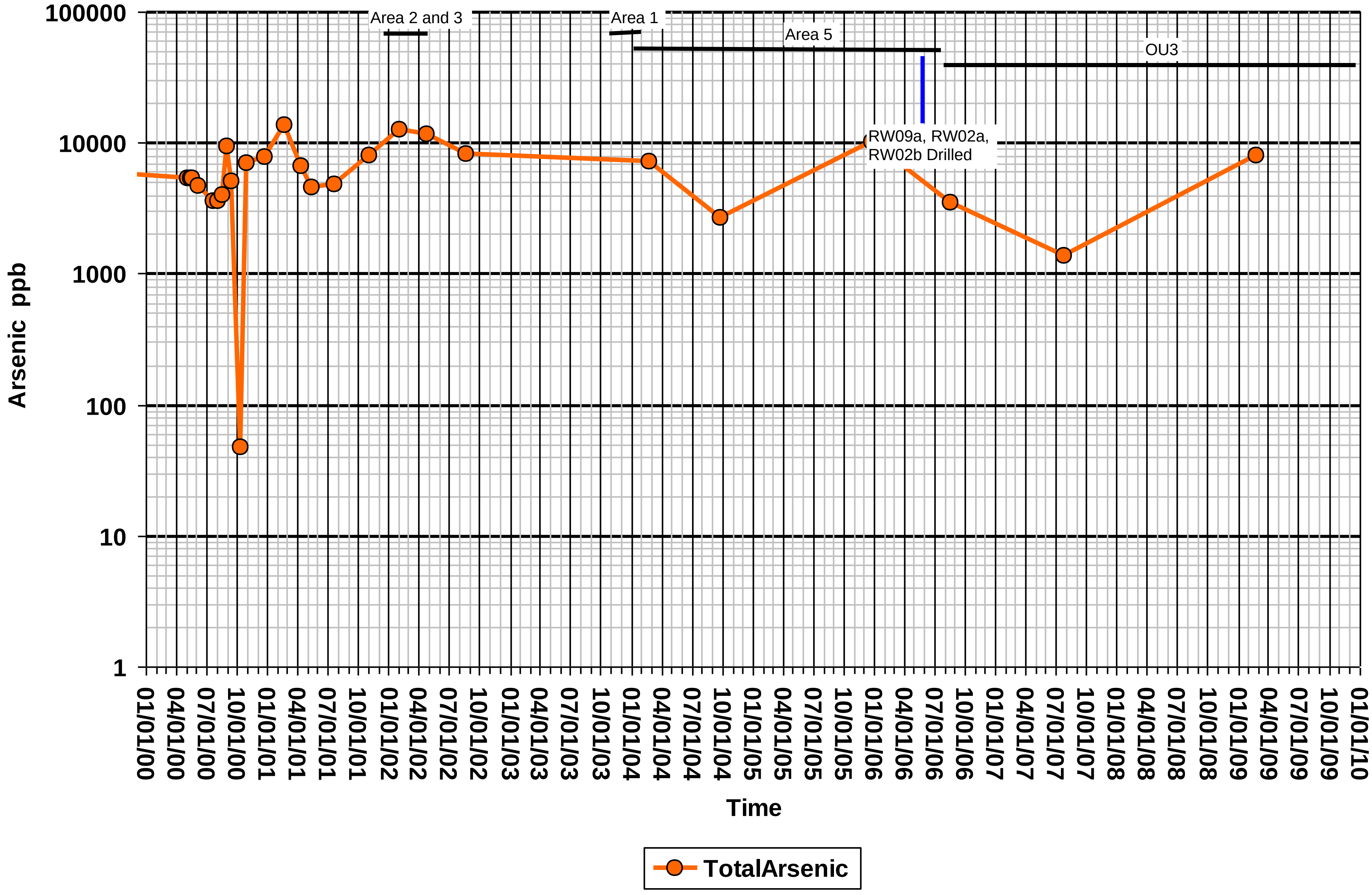
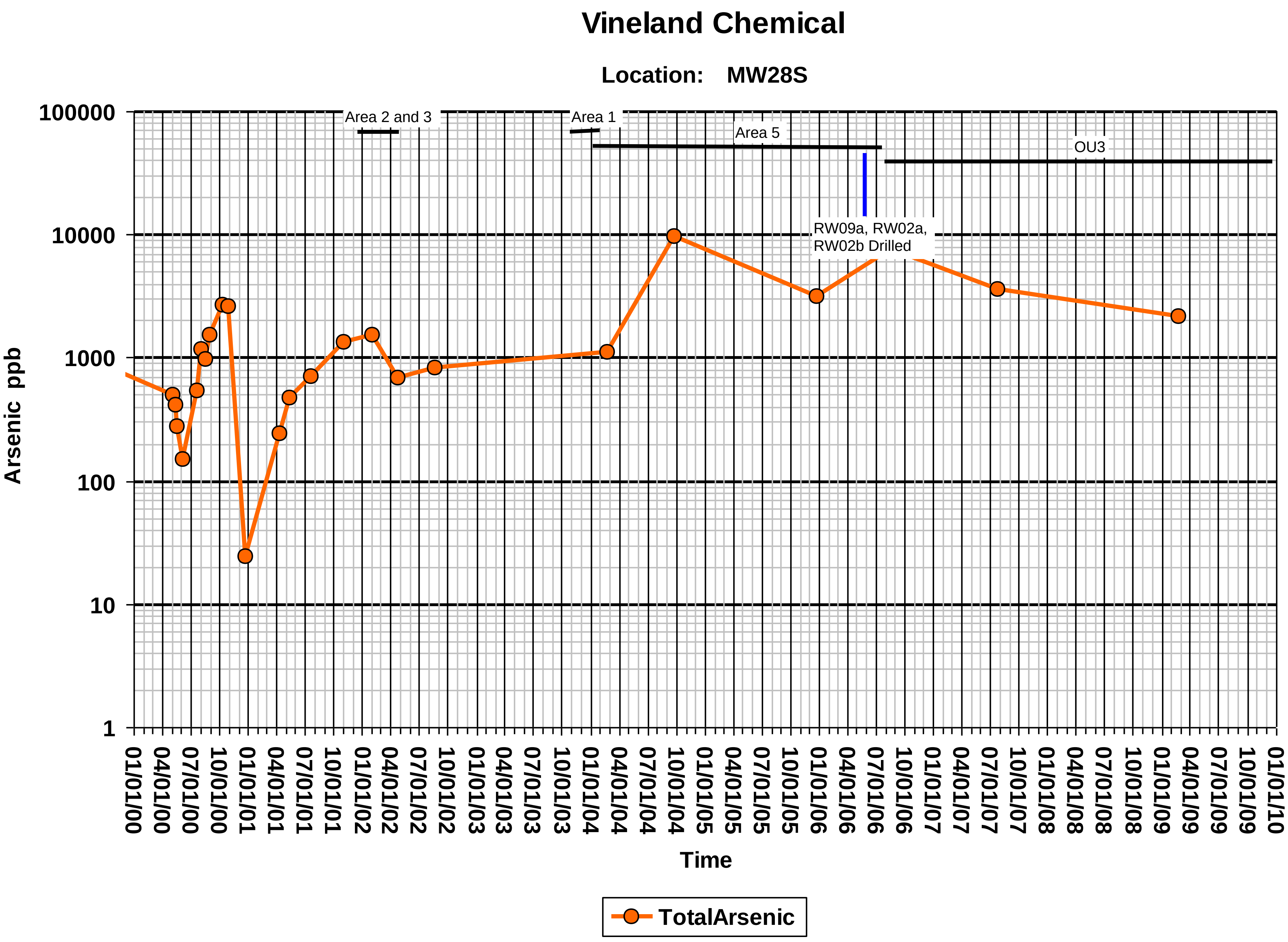
07/01/09
10/01/09
01/01/10
Time
TotalArsenic

Vineland Chemical

Location: MW28M




Vineland Chemical
Location: MW28S
100000
10000
1000
100
10
1
Arsenic ppb
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
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01/01/02
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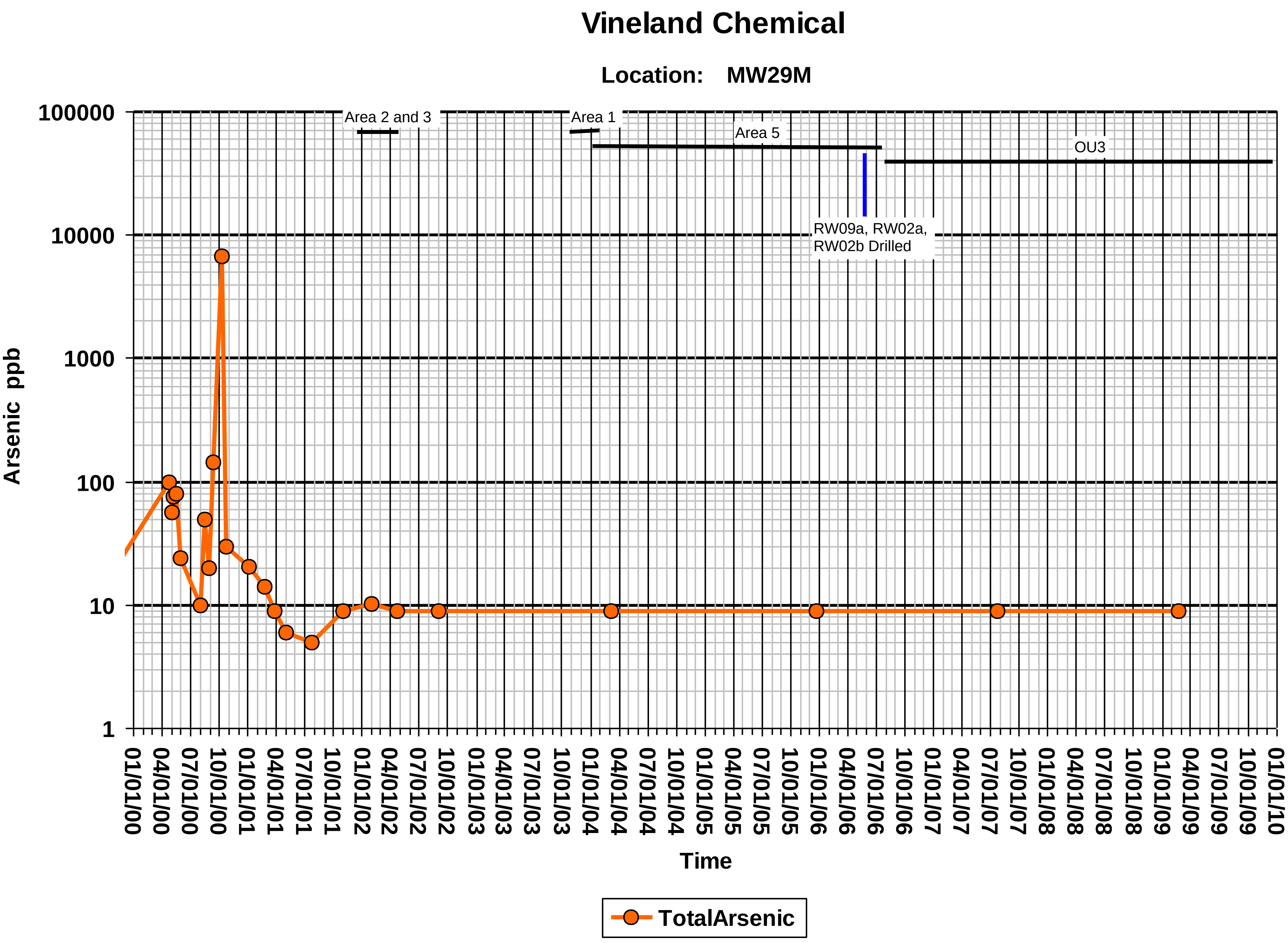
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: MW29M
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
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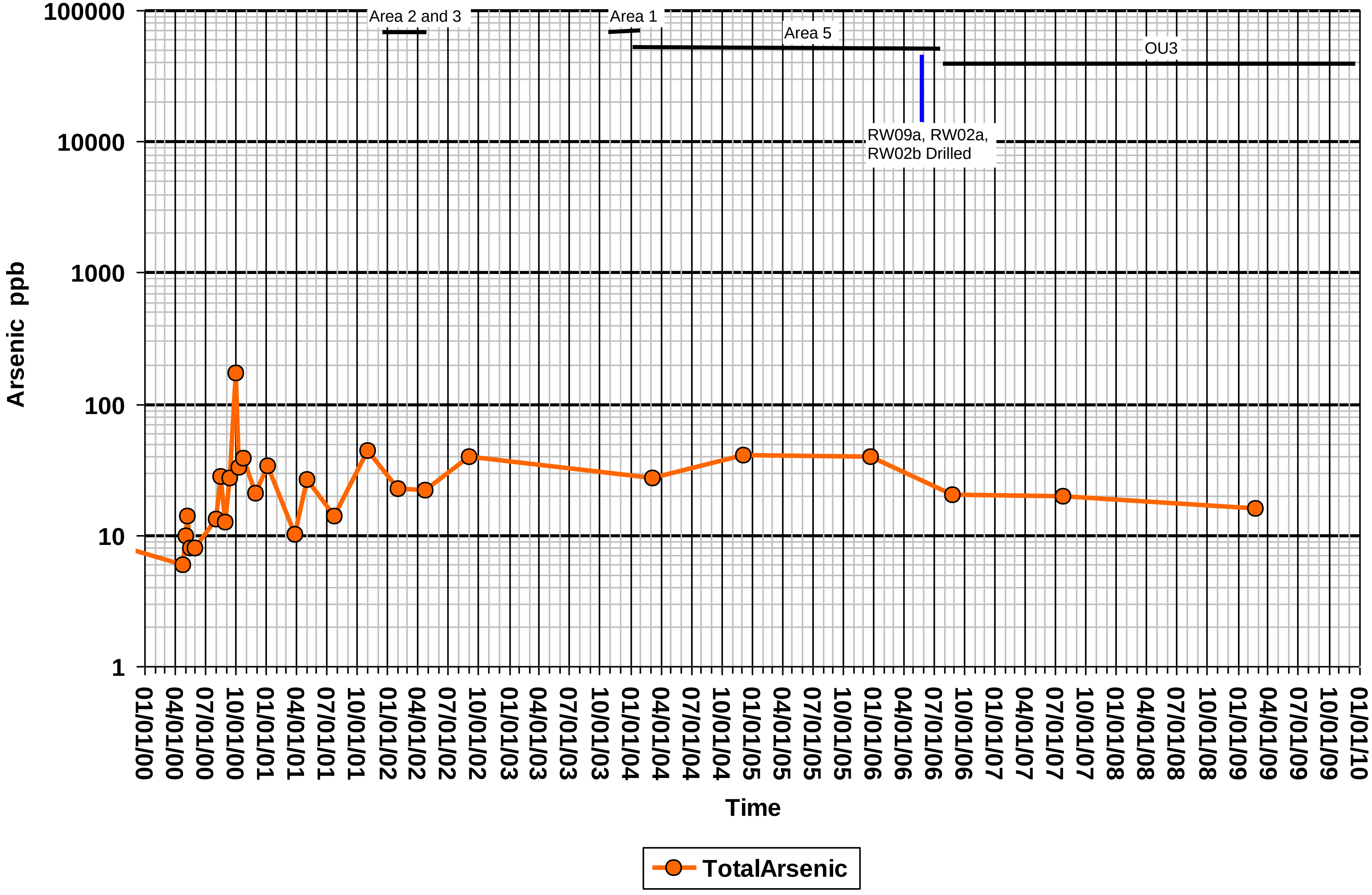
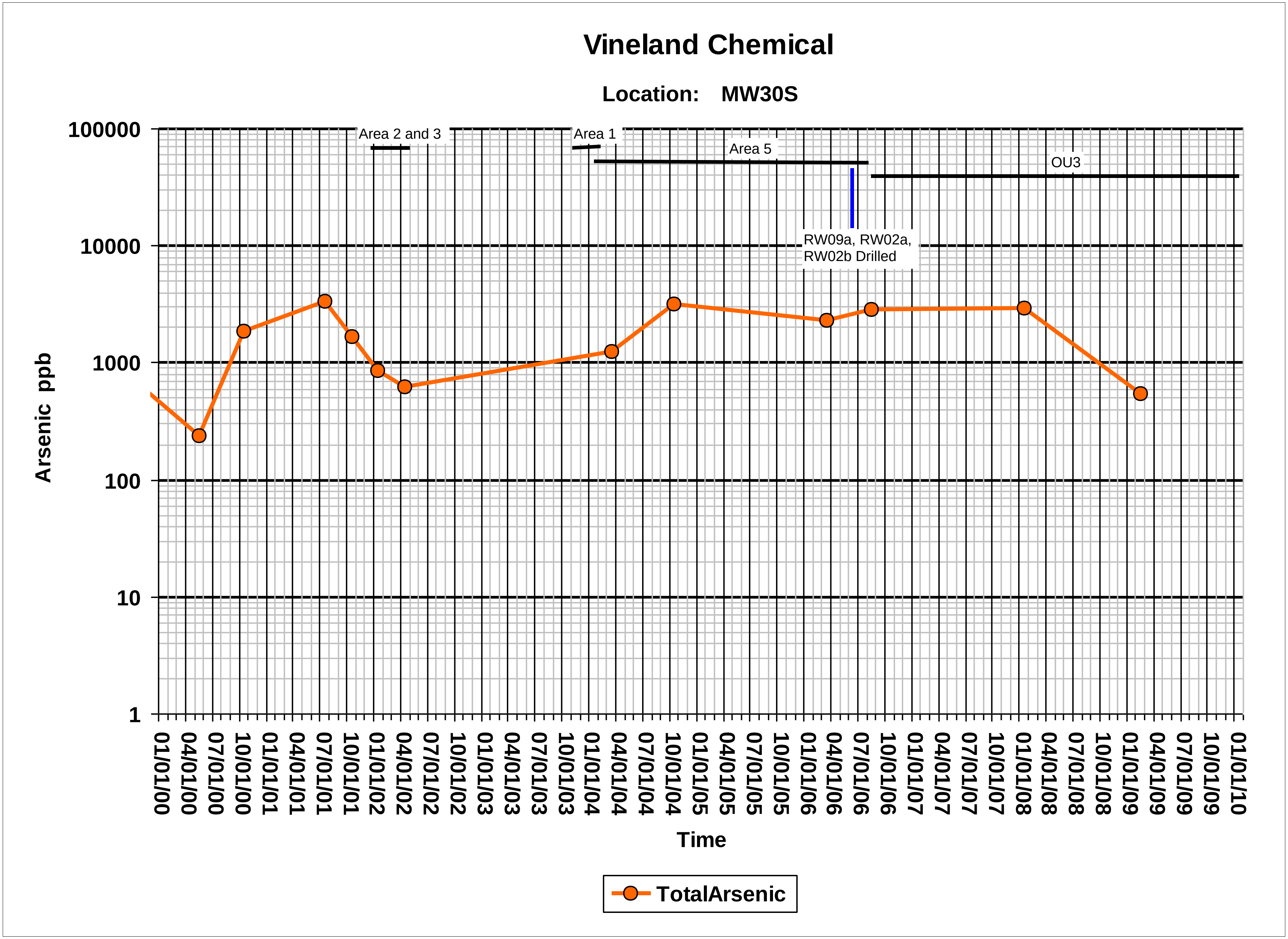
01/01/10
Time
TotalArsenic

Vineland Chemical

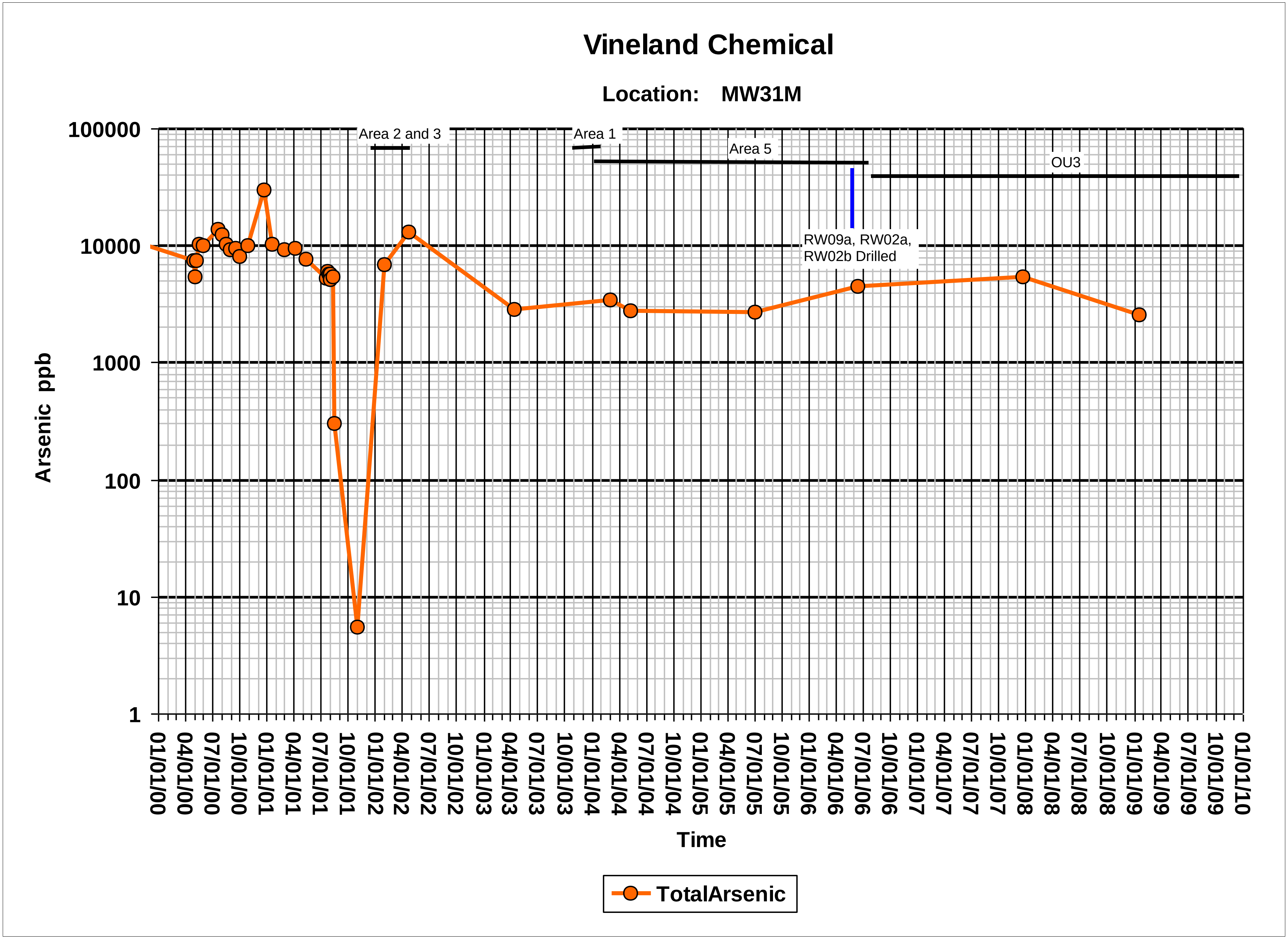
Location: MW29S





Vineland Chemical

Location: MW30S


Vineland Chemical
Location: MW31M
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
10/01/02
01/01/03
04/01/03
07/01/03
10/01/03
01/01/04
04/01/04
07/01/04
10/01/04
01/01/05
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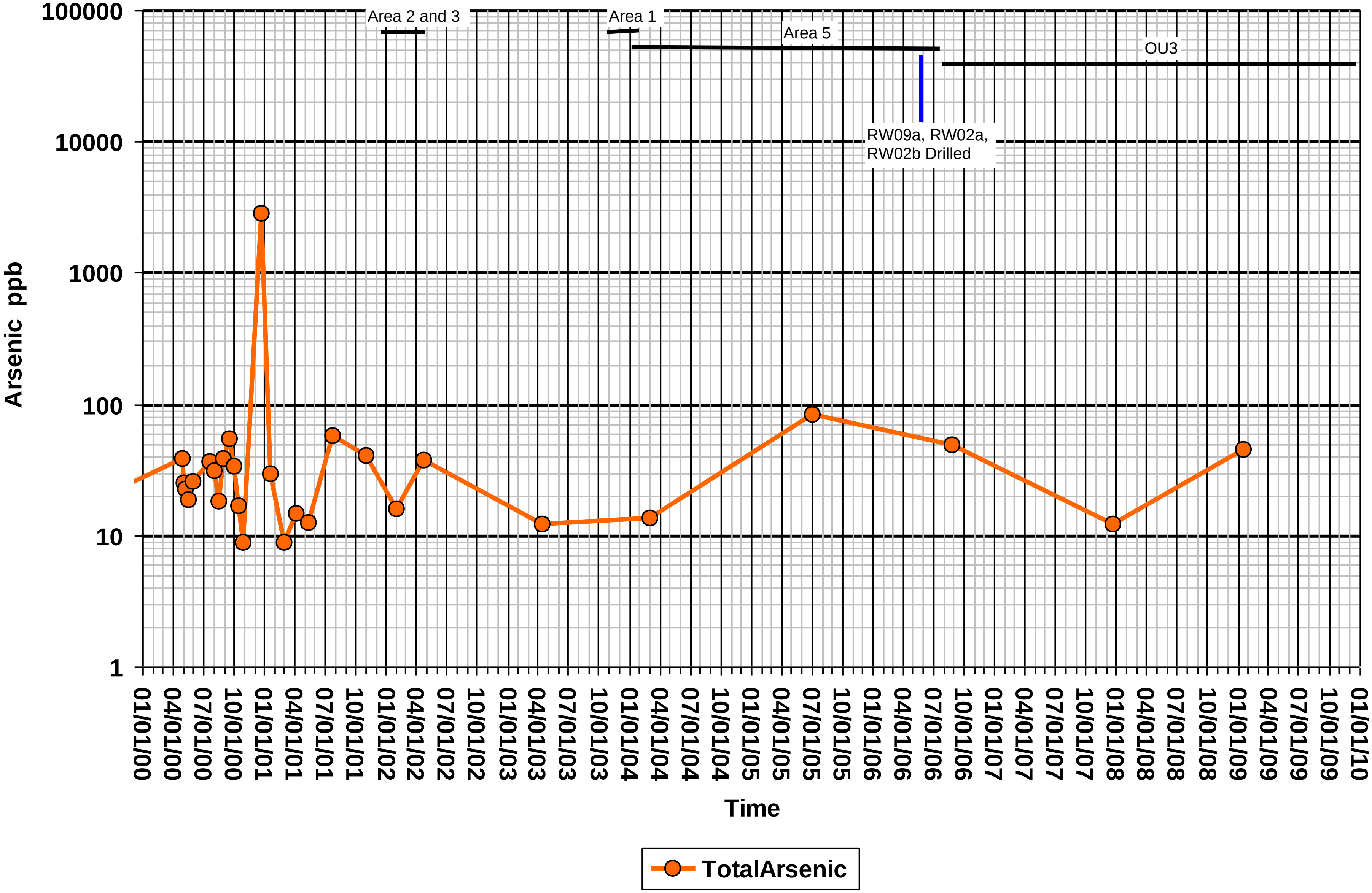
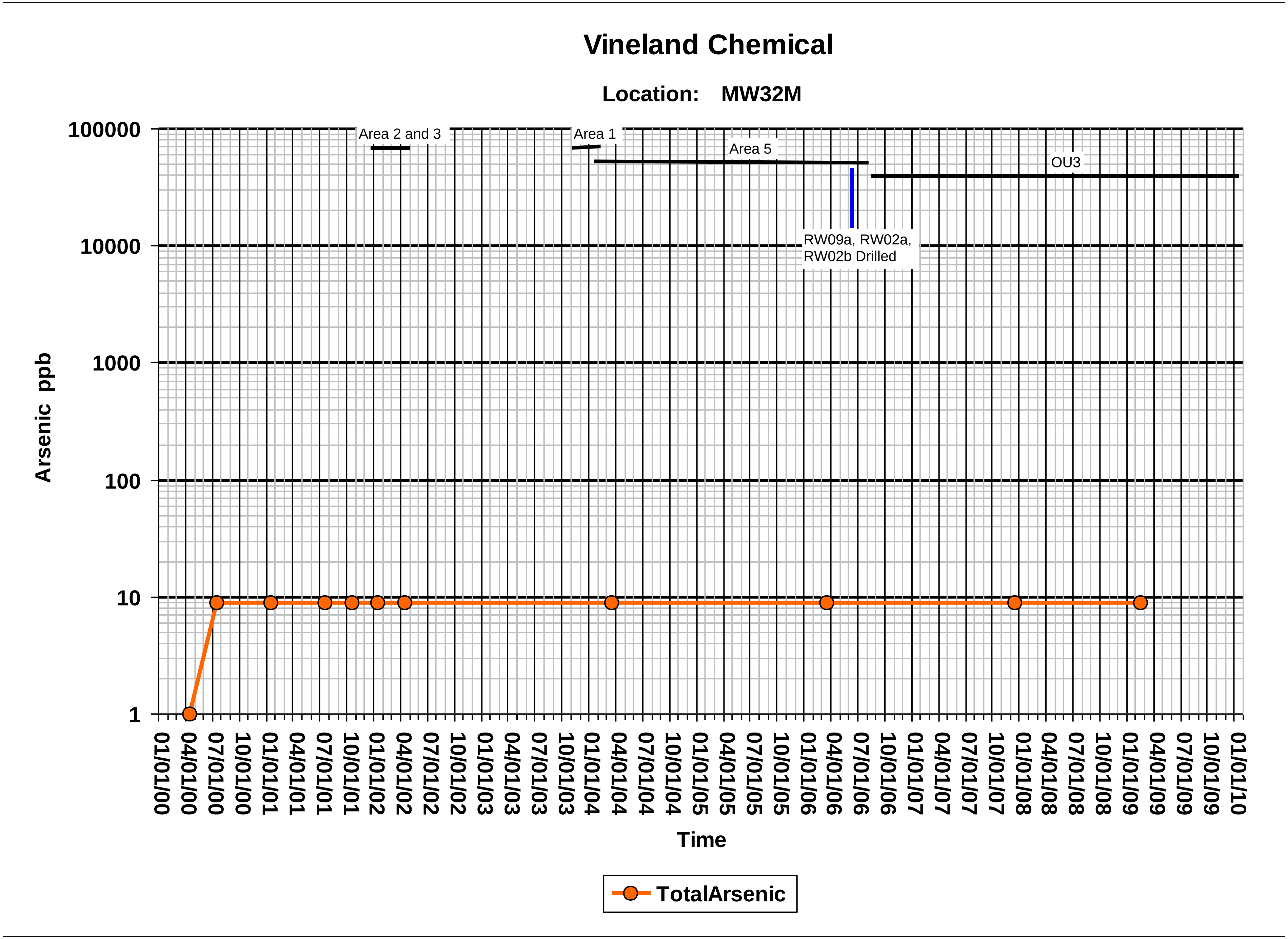
07/01/05
10/01/05
01/01/06
04/01/06
07/01/06
10/01/06
01/01/07
04/01/07
07/01/07
10/01/07
01/01/08
04/01/08
07/01/08
10/01/08
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic

Vineland Chemical

Location: MW31S




Vineland Chemical
Location: MW32M
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
10/01/02
01/01/03
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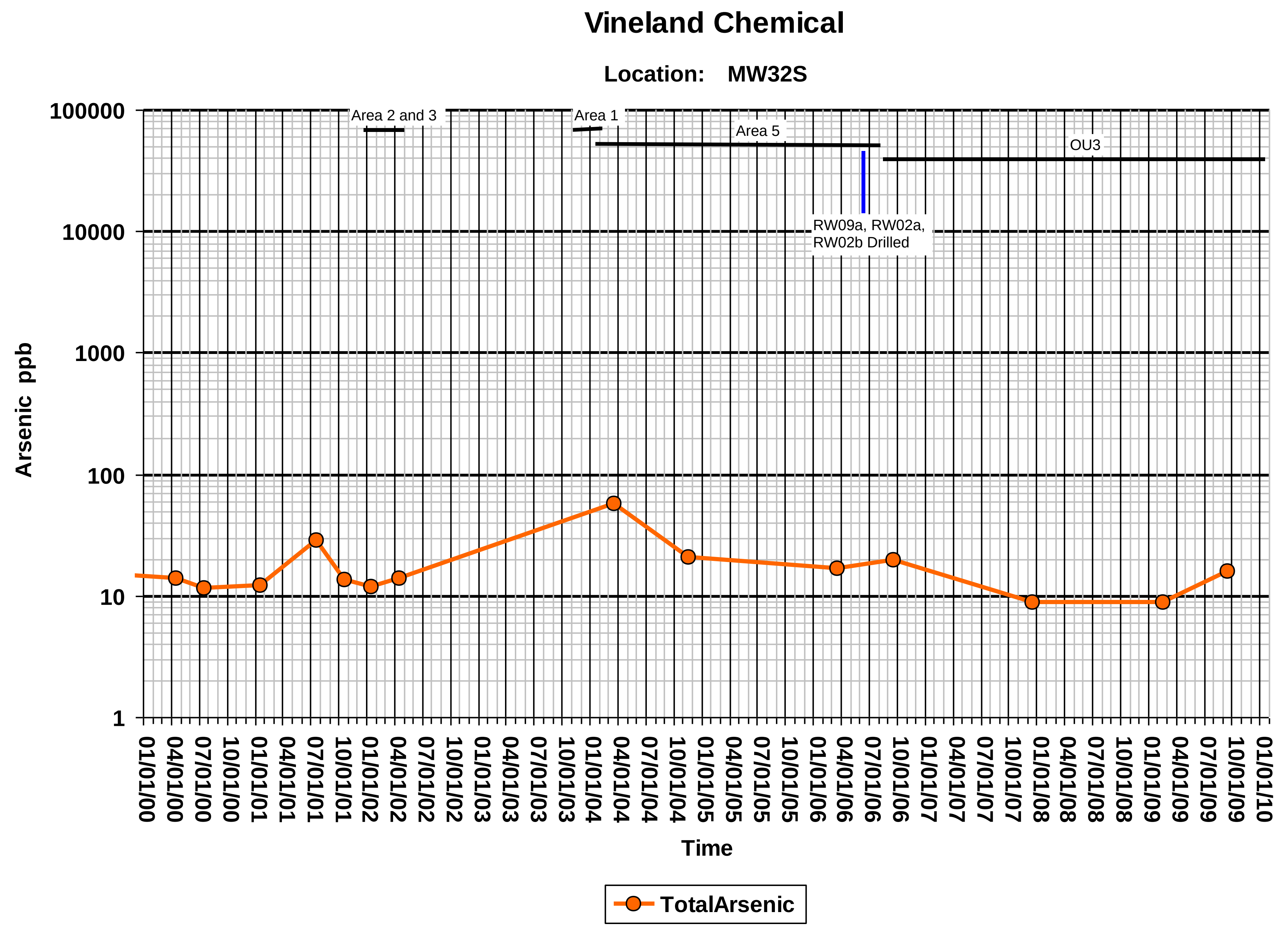
04/01/06
07/01/06
10/01/06
01/01/07
04/01/07
07/01/07
10/01/07
01/01/08
04/01/08
07/01/08
10/01/08
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: MW32S
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
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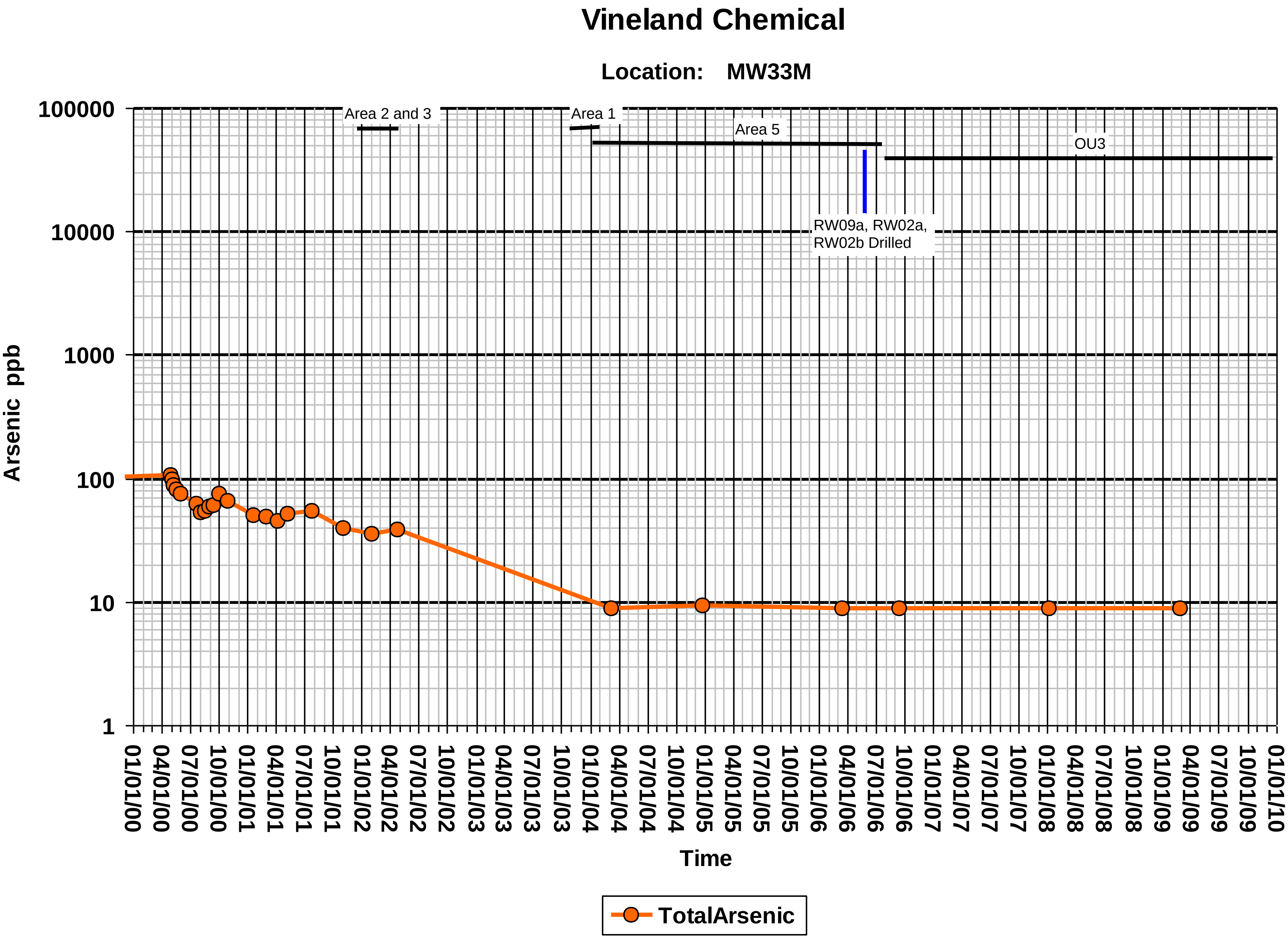
01/01/08
04/01/08
07/01/08
10/01/08
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: MW33M
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
10/01/02
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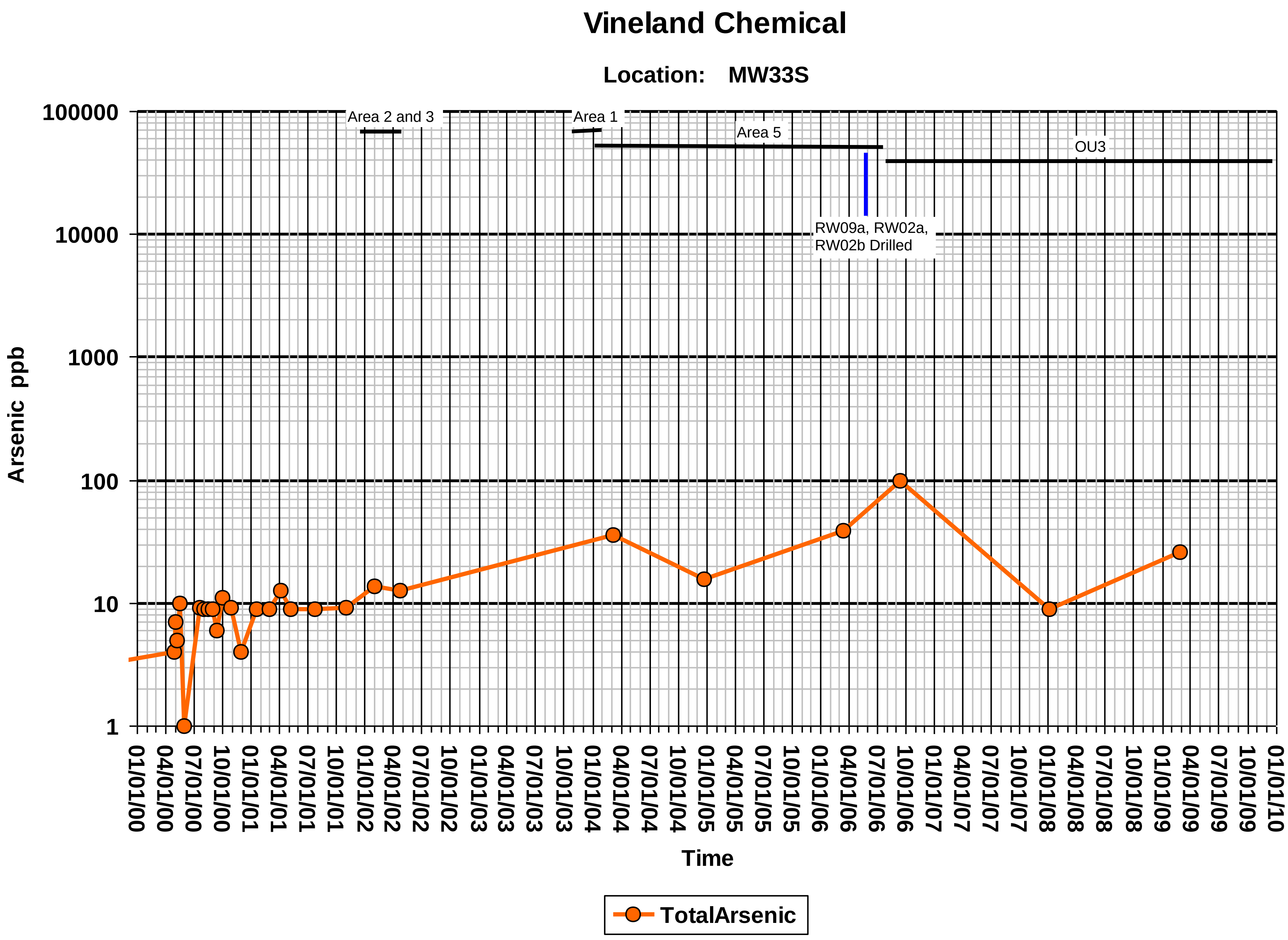
10/01/07
01/01/08
04/01/08
07/01/08
10/01/08
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: MW33S
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
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01/01/08
04/01/08
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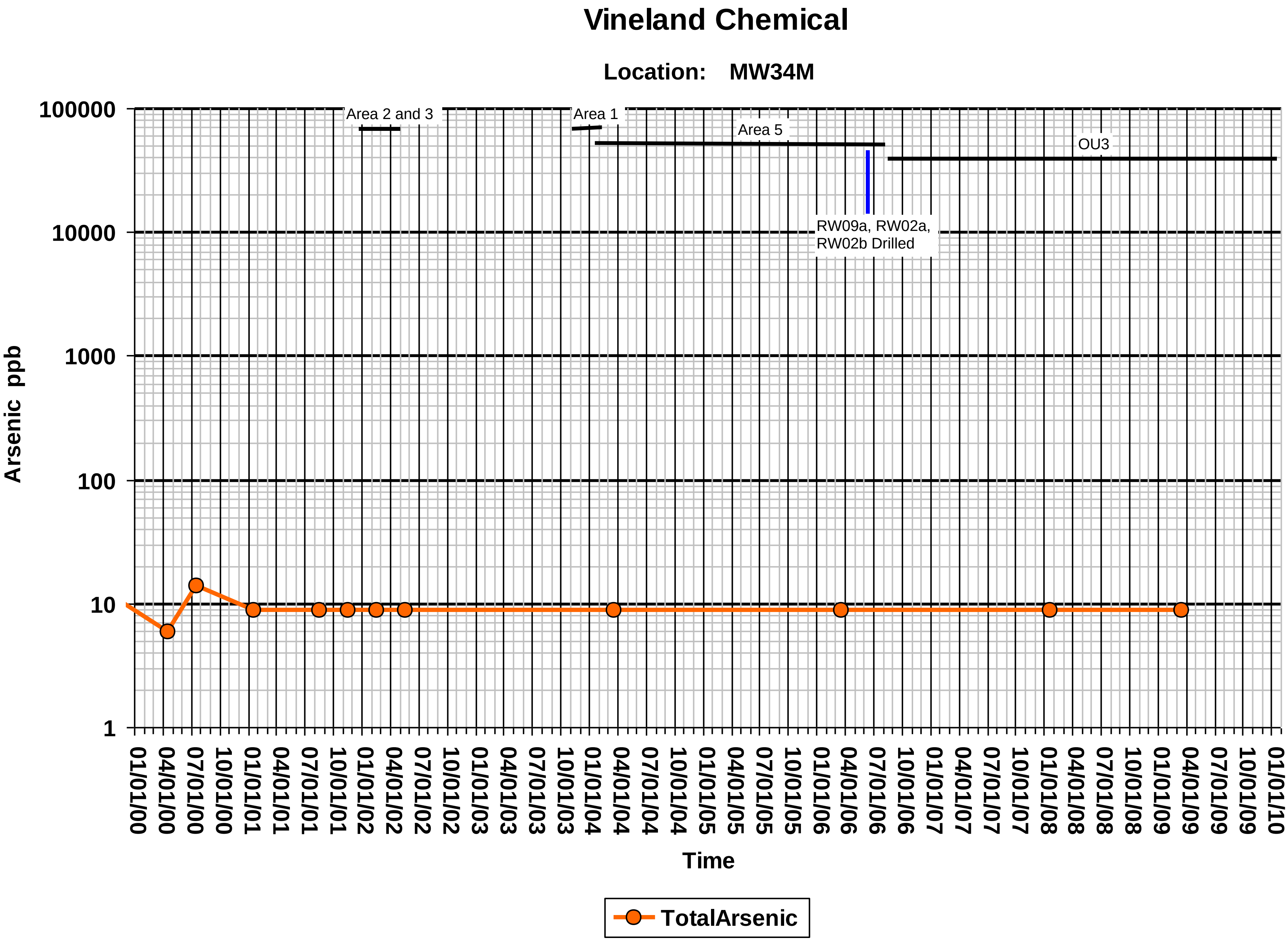
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: MW34M
100000
10000
1000
100
10
1
Arsenic ppb
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
10/01/02
01/01/03
04/01/03
07/01/03
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01/01/08
04/01/08
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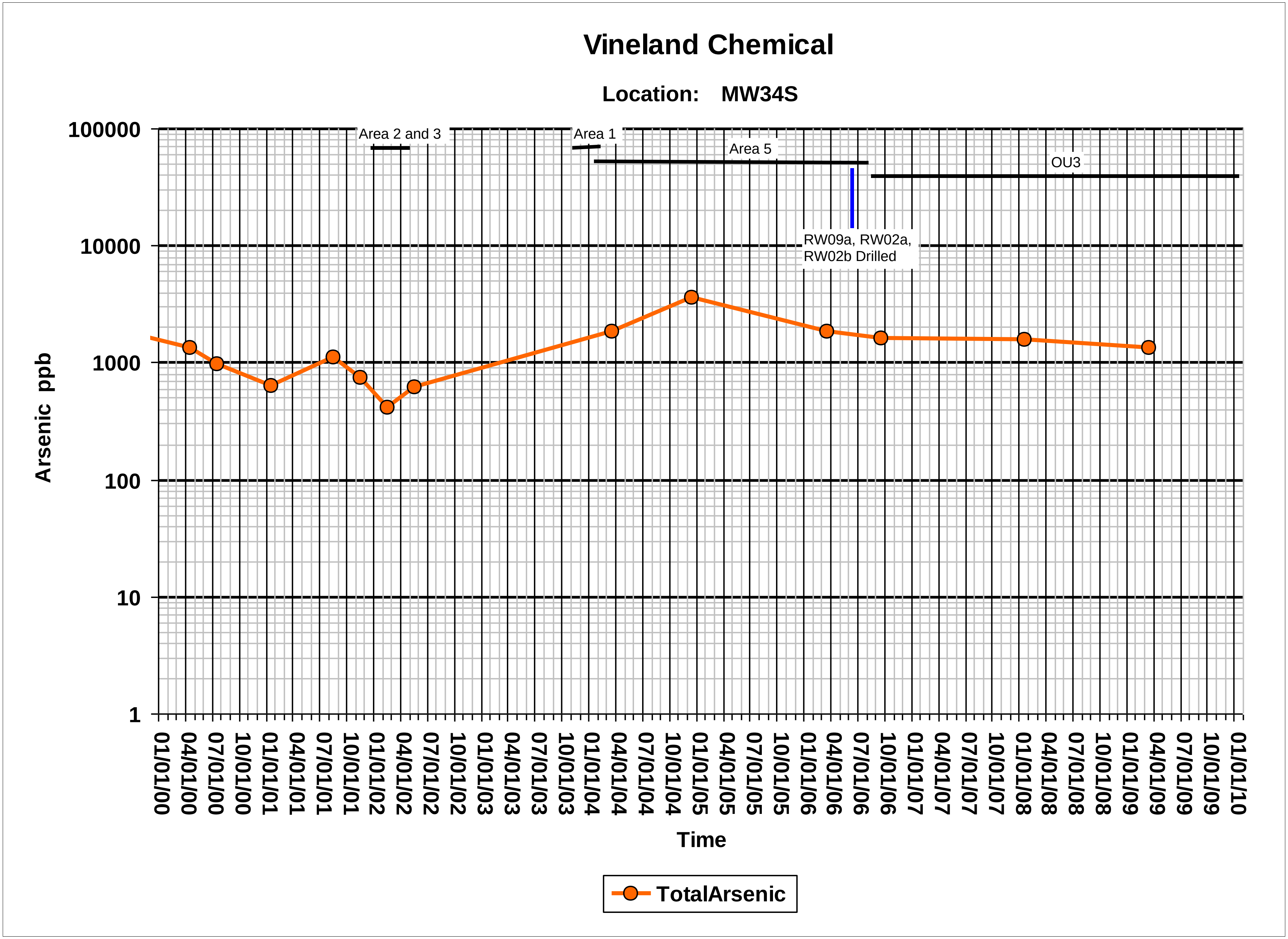
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: MW34S
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
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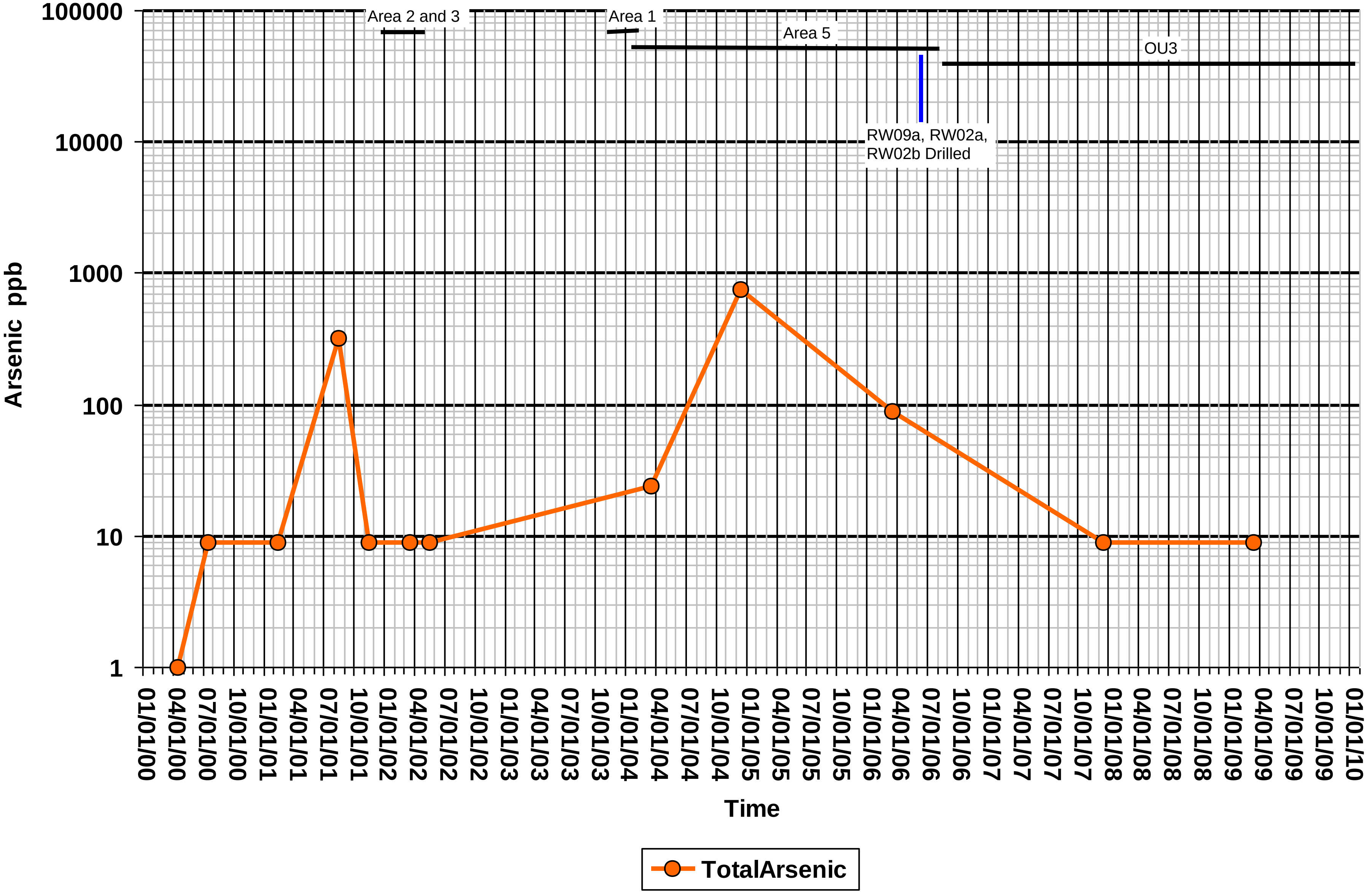
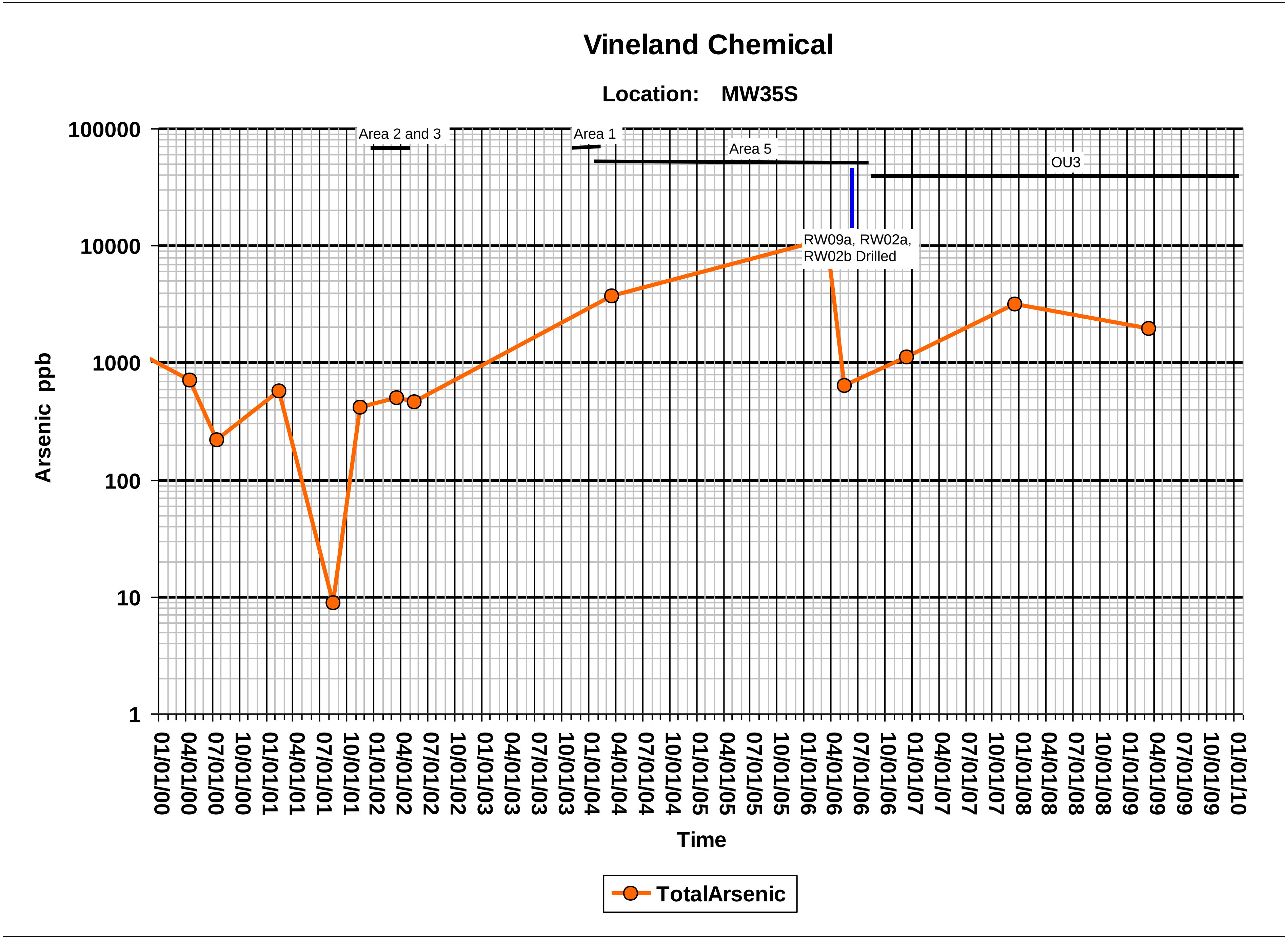
01/01/08
04/01/08
07/01/08
10/01/08
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic

Vineland Chemical

Location: MW35M




Vineland Chemical
Location: MW35S
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
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07/01/02
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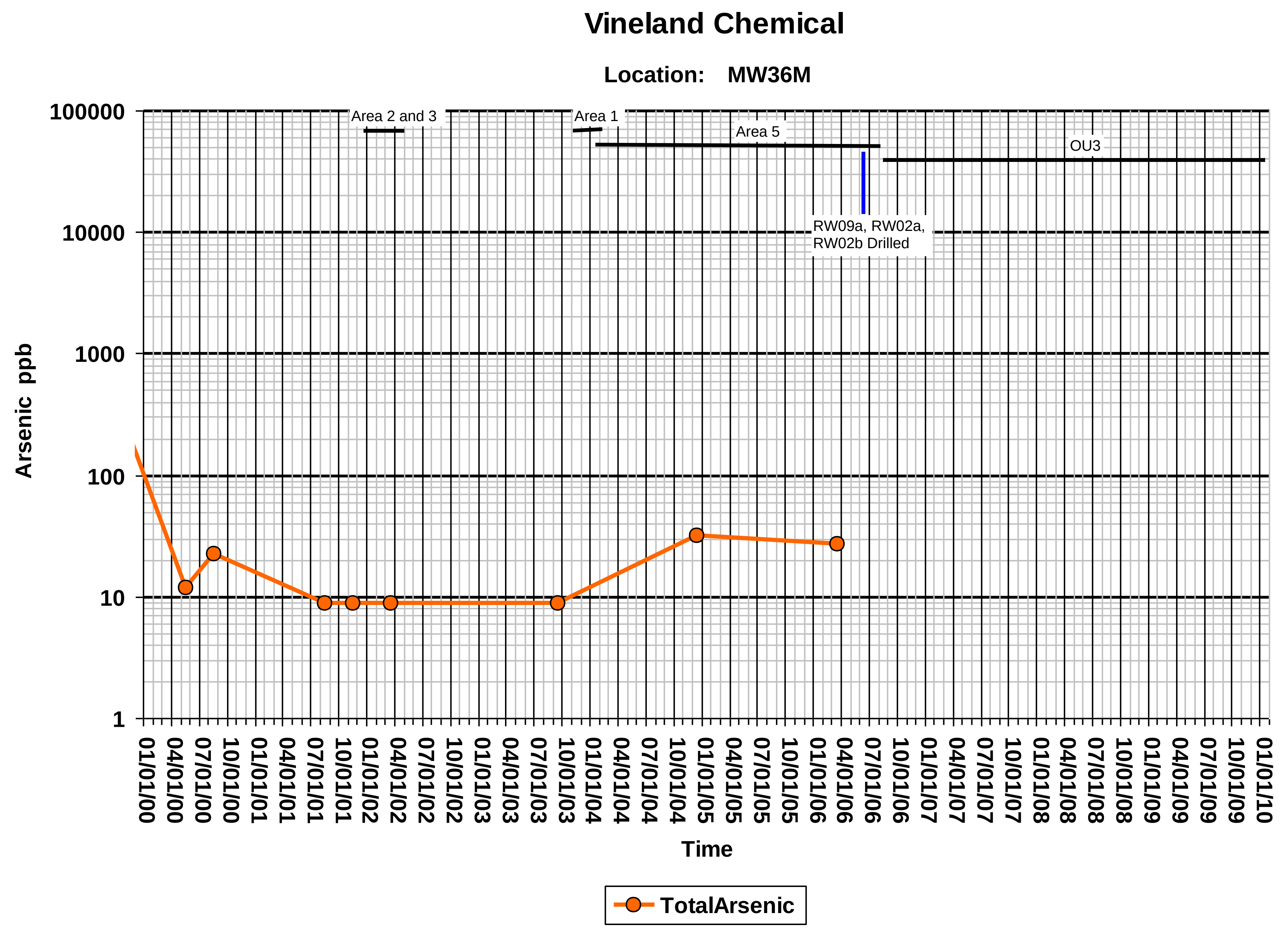
10/01/08
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: MW36M
100000
10000
1000
100
10
1
Arsenic ppb
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
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01/01/08
04/01/08
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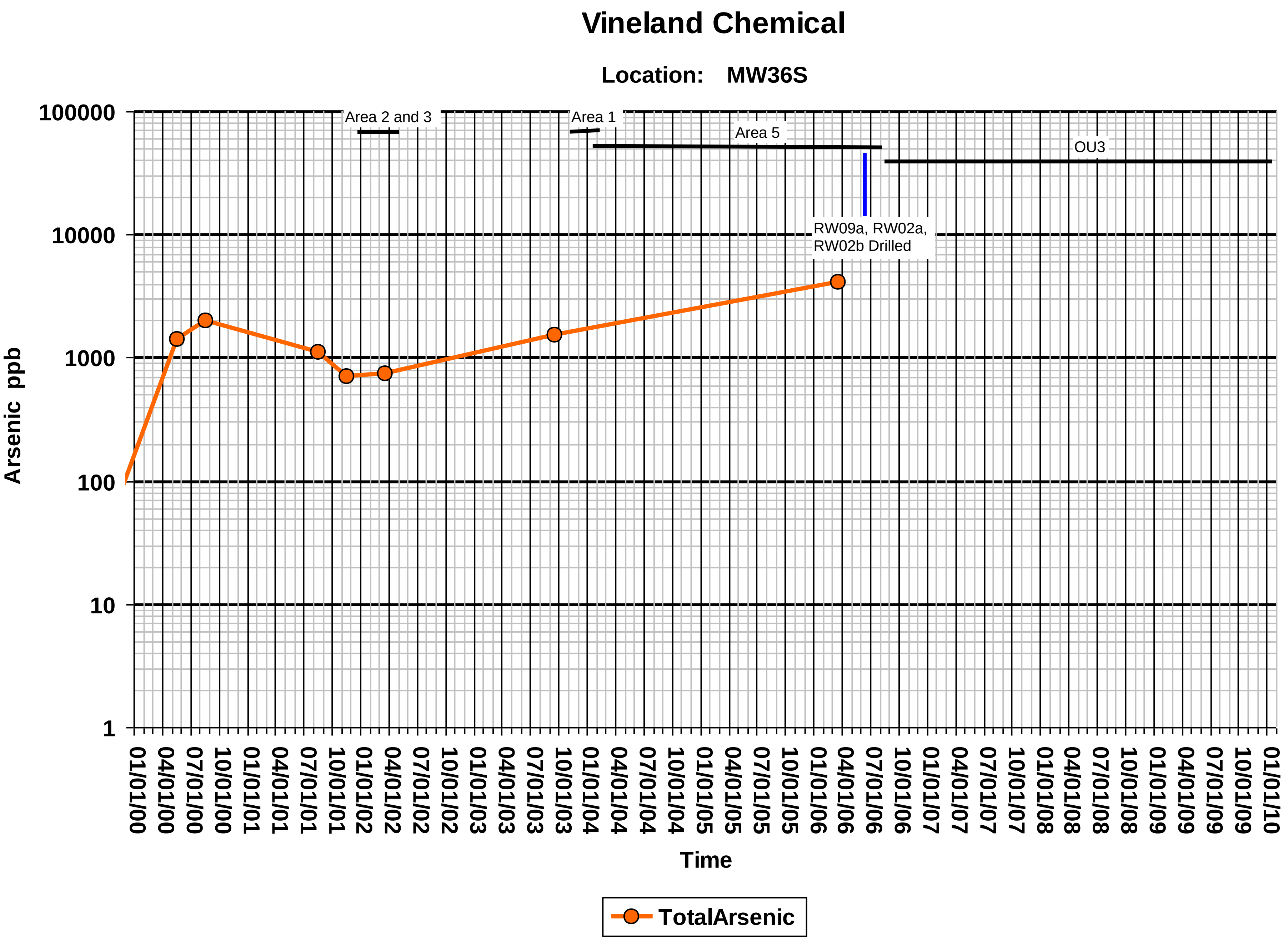
10/01/08
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: MW36S
100000
10000
1000
100
10
1
Arsenic ppb
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
10/01/02
01/01/03
04/01/03
07/01/03
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01/01/04
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07/01/05
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01/01/06
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01/01/07
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01/01/08
04/01/08
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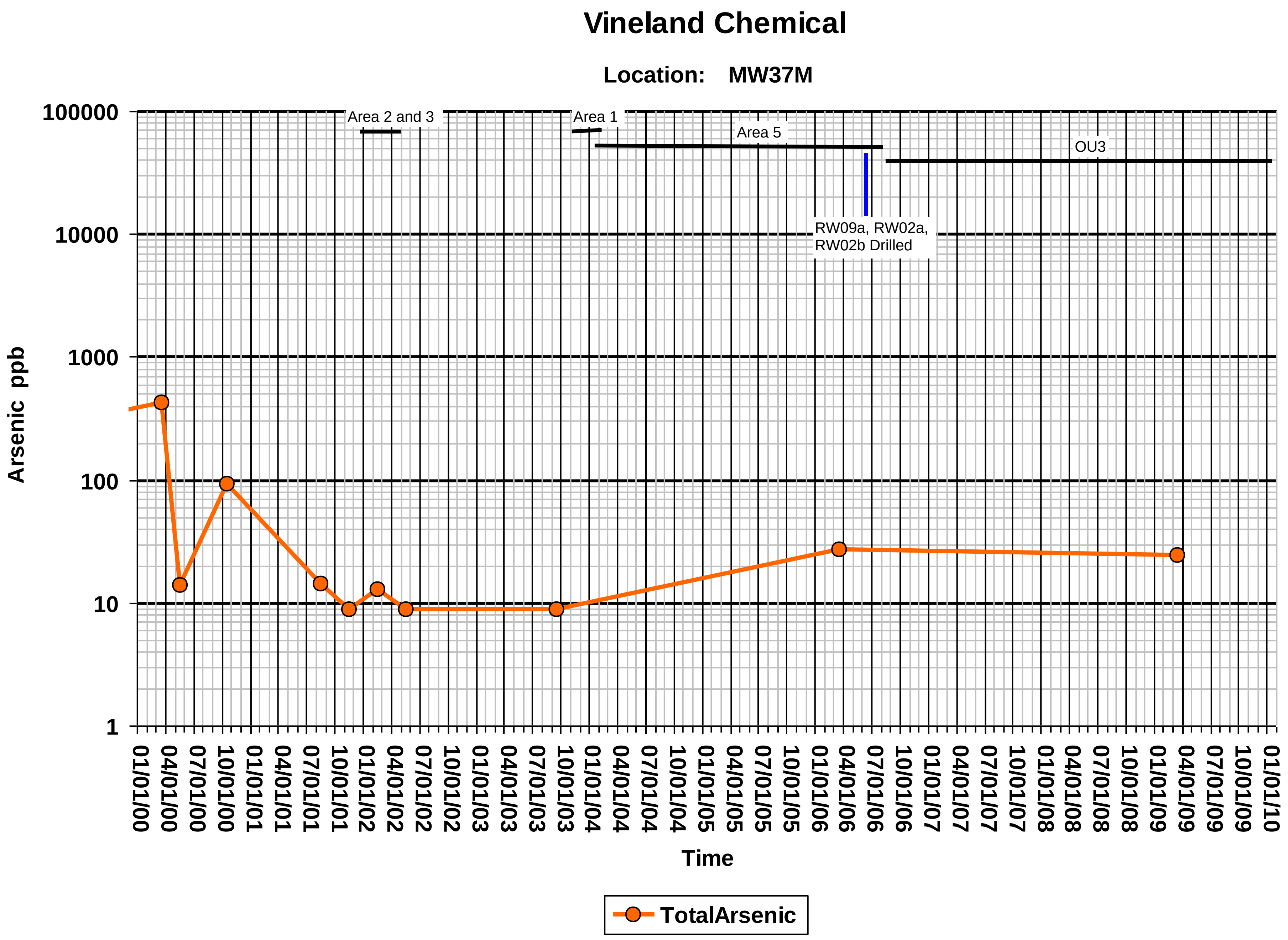
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: MW37M
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
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01/01/03
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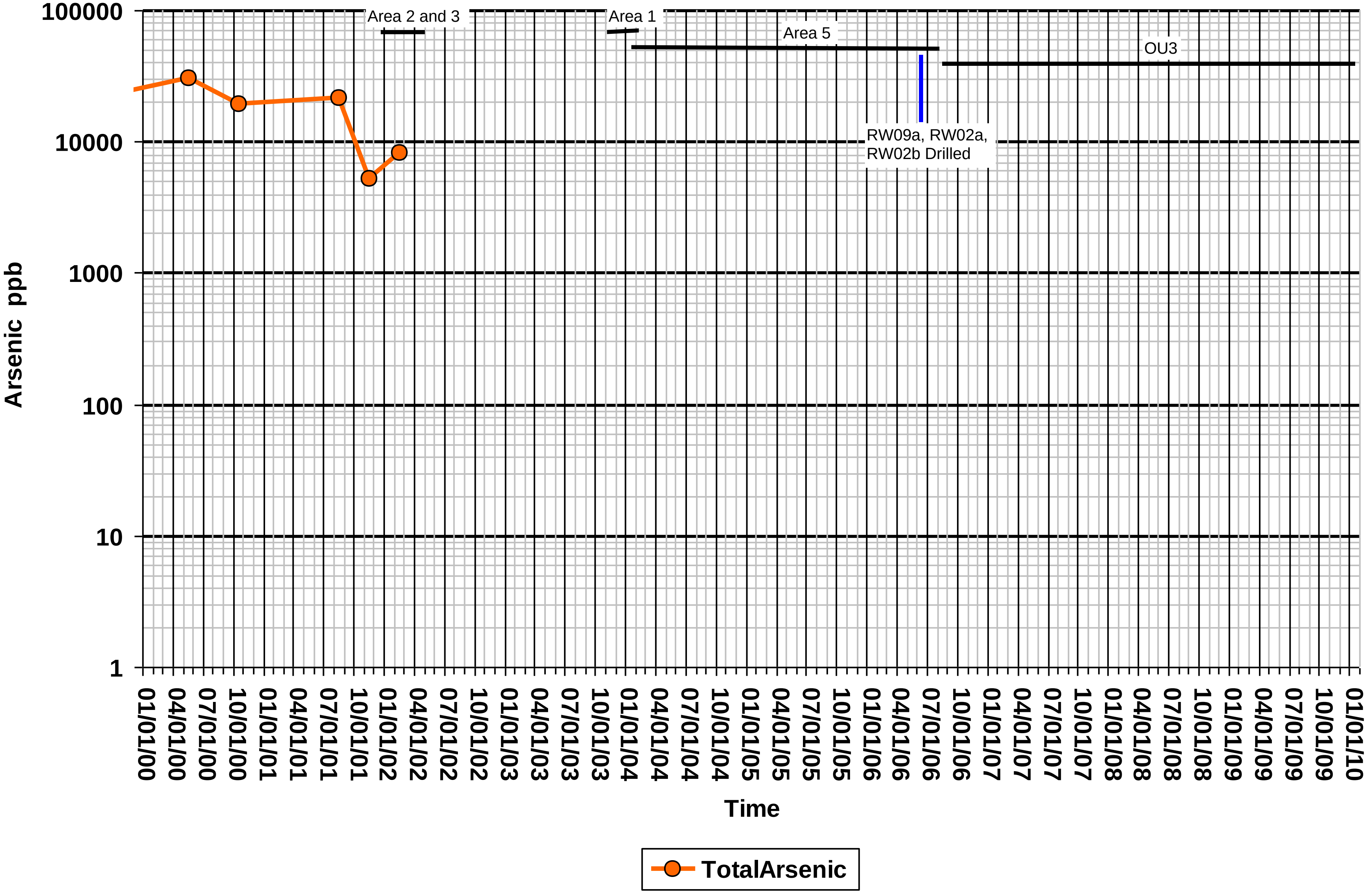
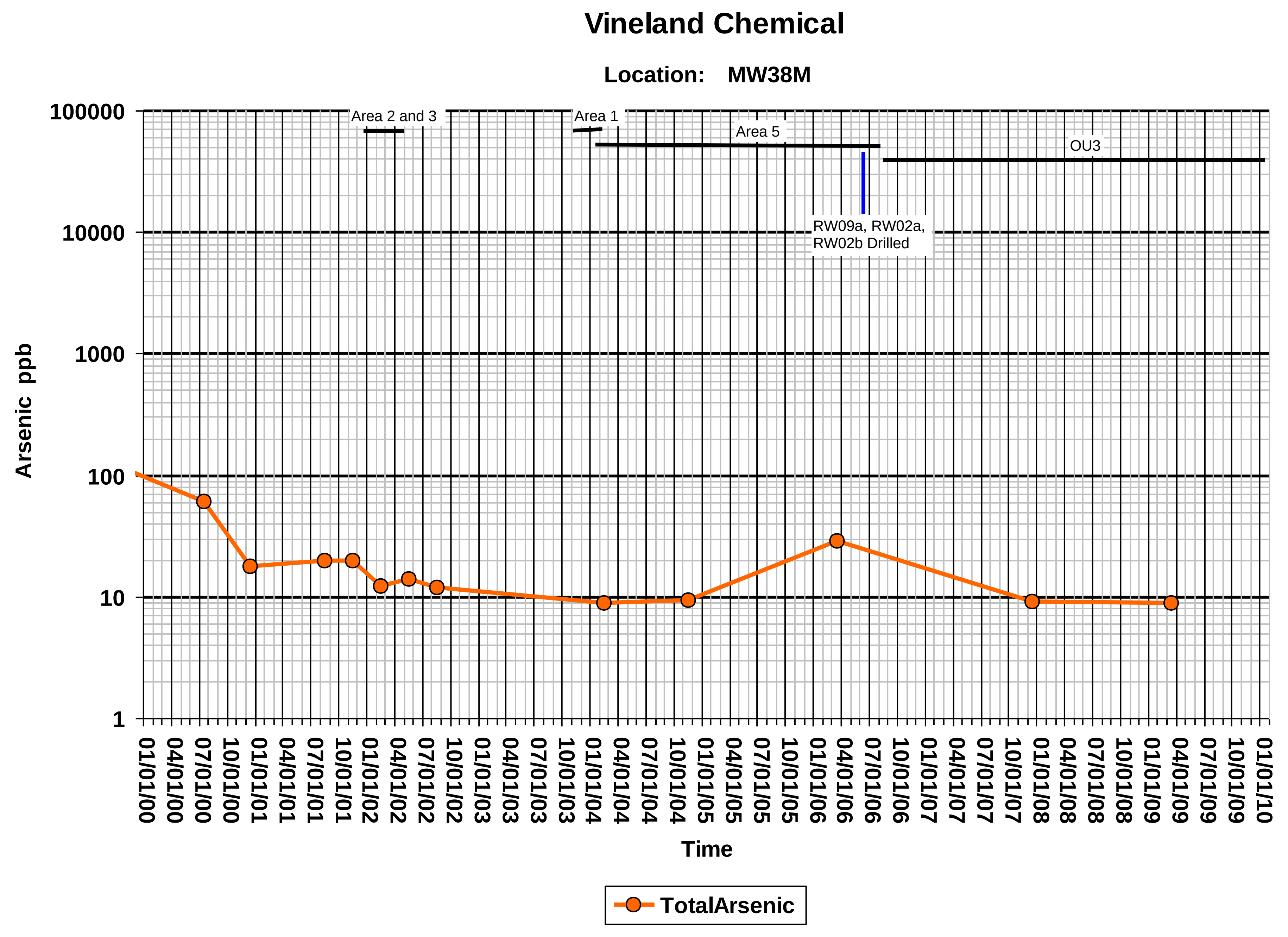
01/01/08
04/01/08
07/01/08
10/01/08
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic

Vineland Chemical

Location: MW37S




Vineland Chemical
Location: MW38M
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
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04/01/08
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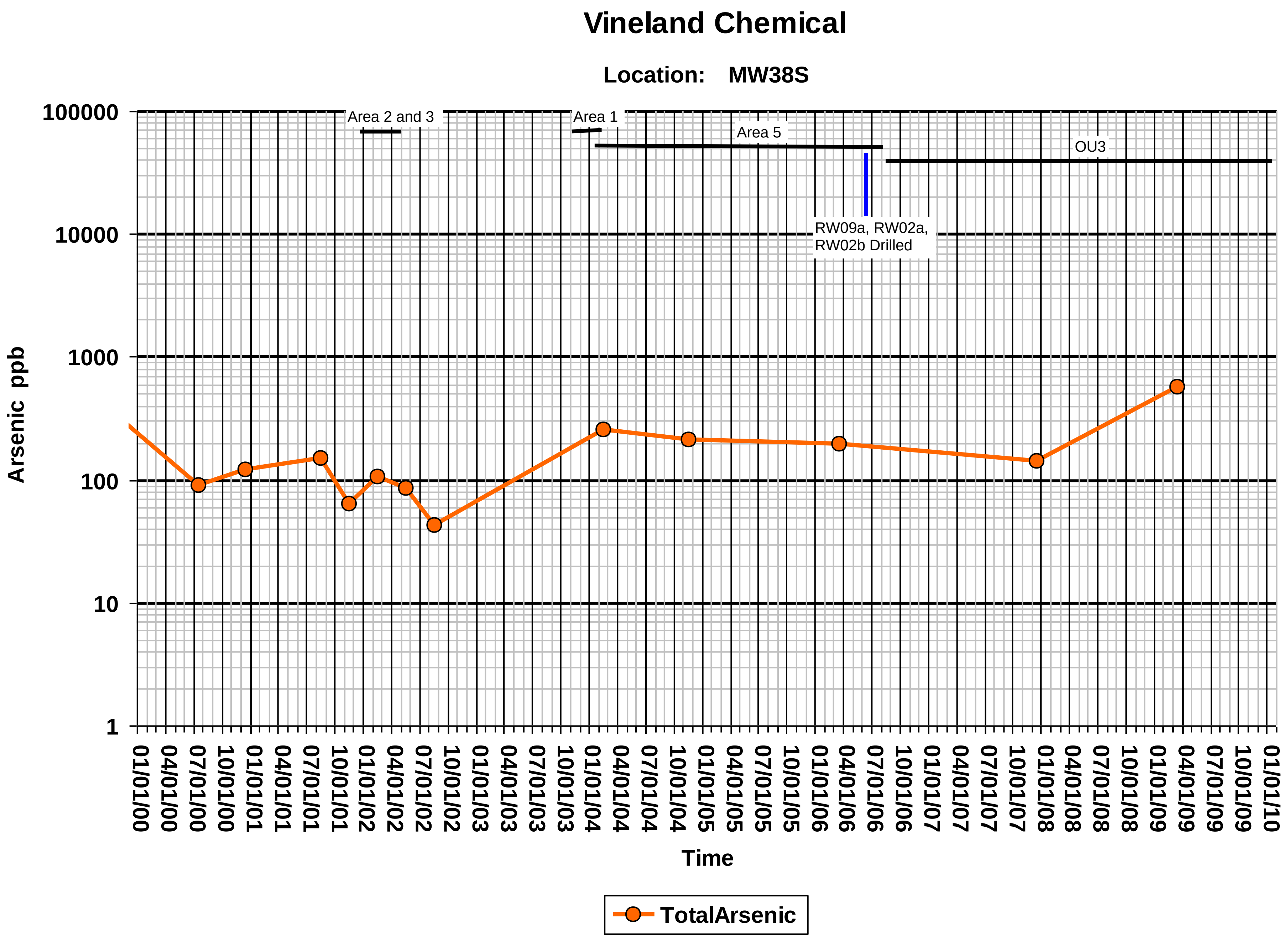
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: MW38S
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
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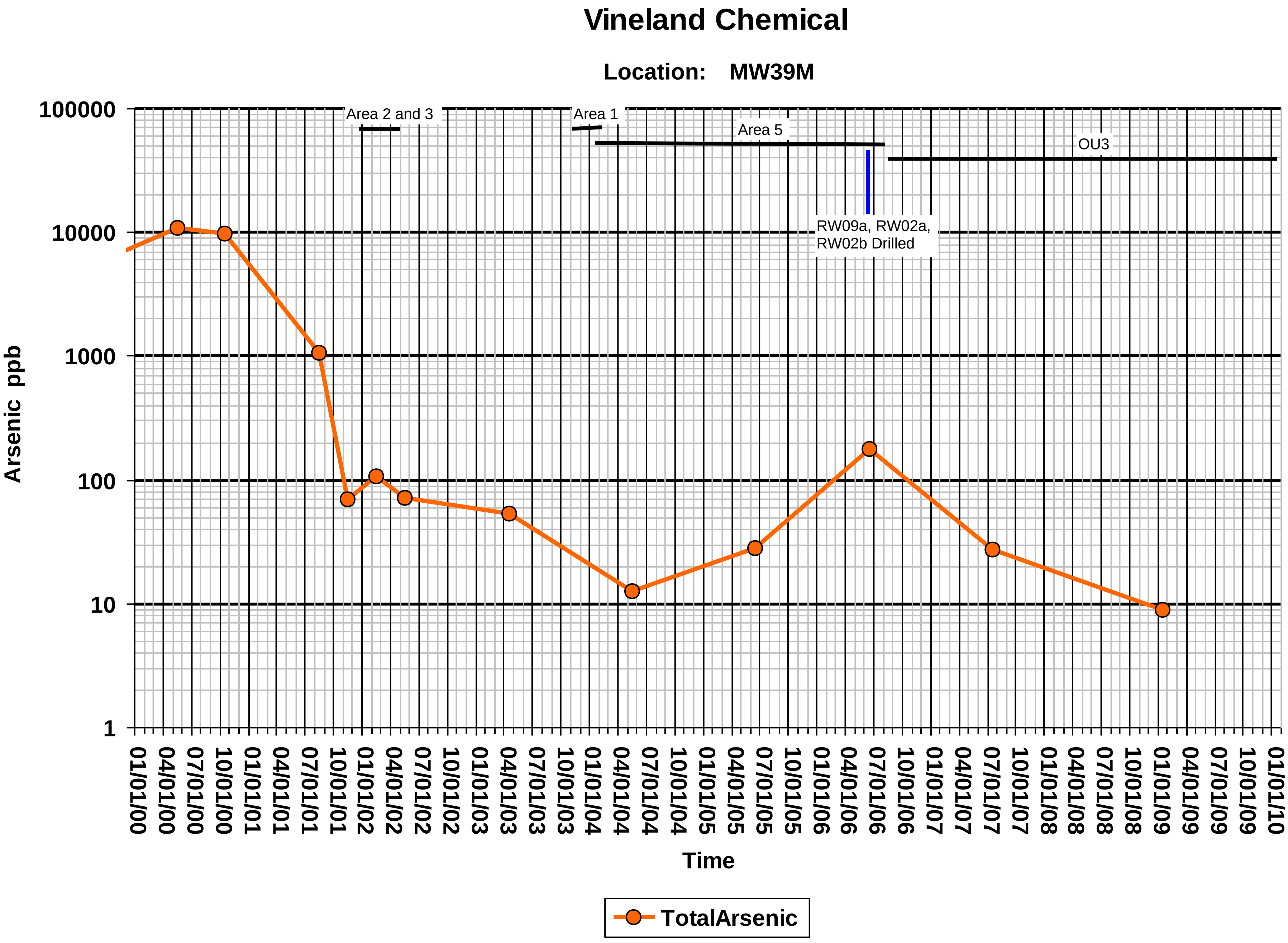
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: MW39M
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
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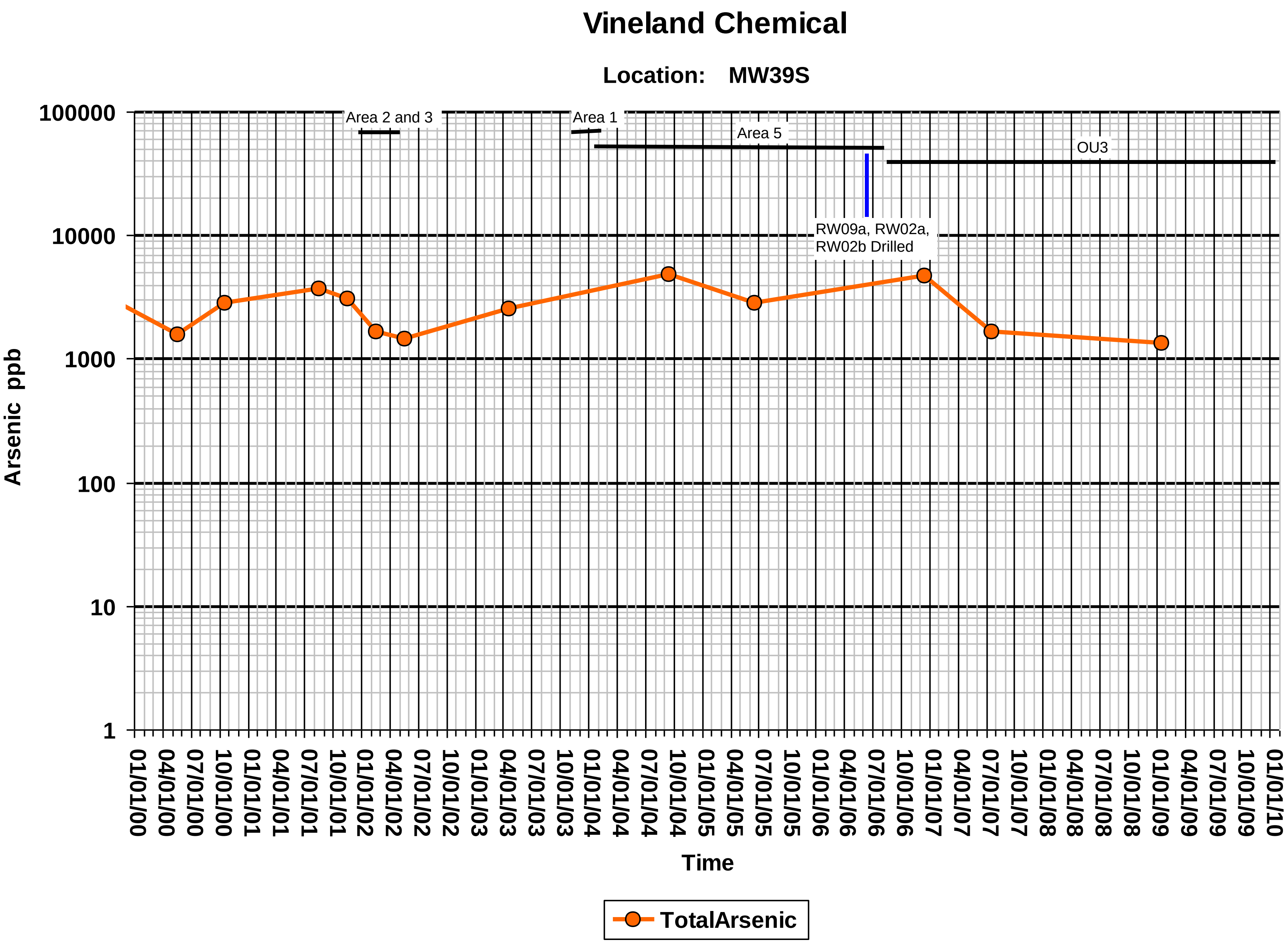
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: MW39S
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
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01/01/08
04/01/08
07/01/08
10/01/08
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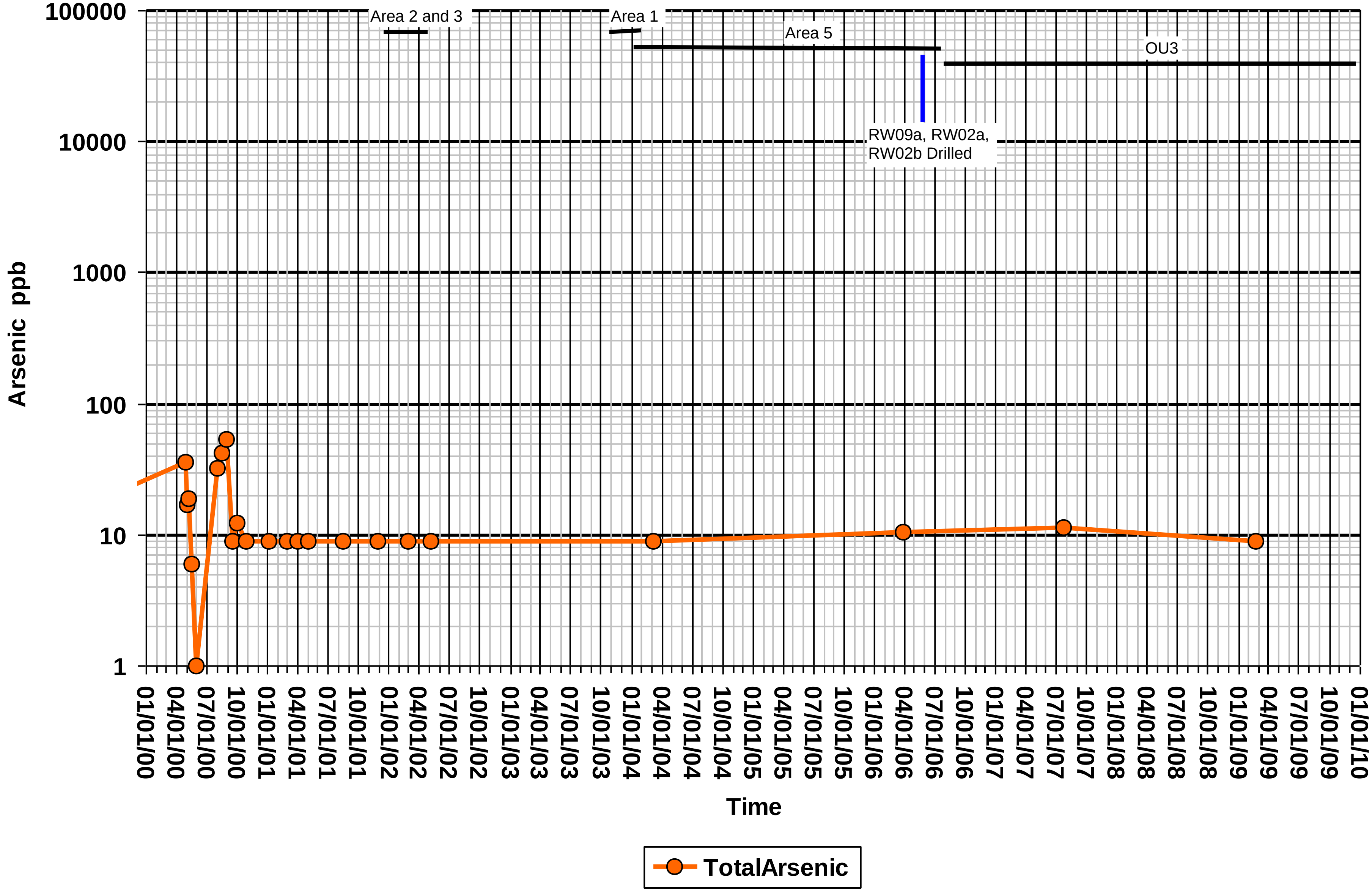
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic

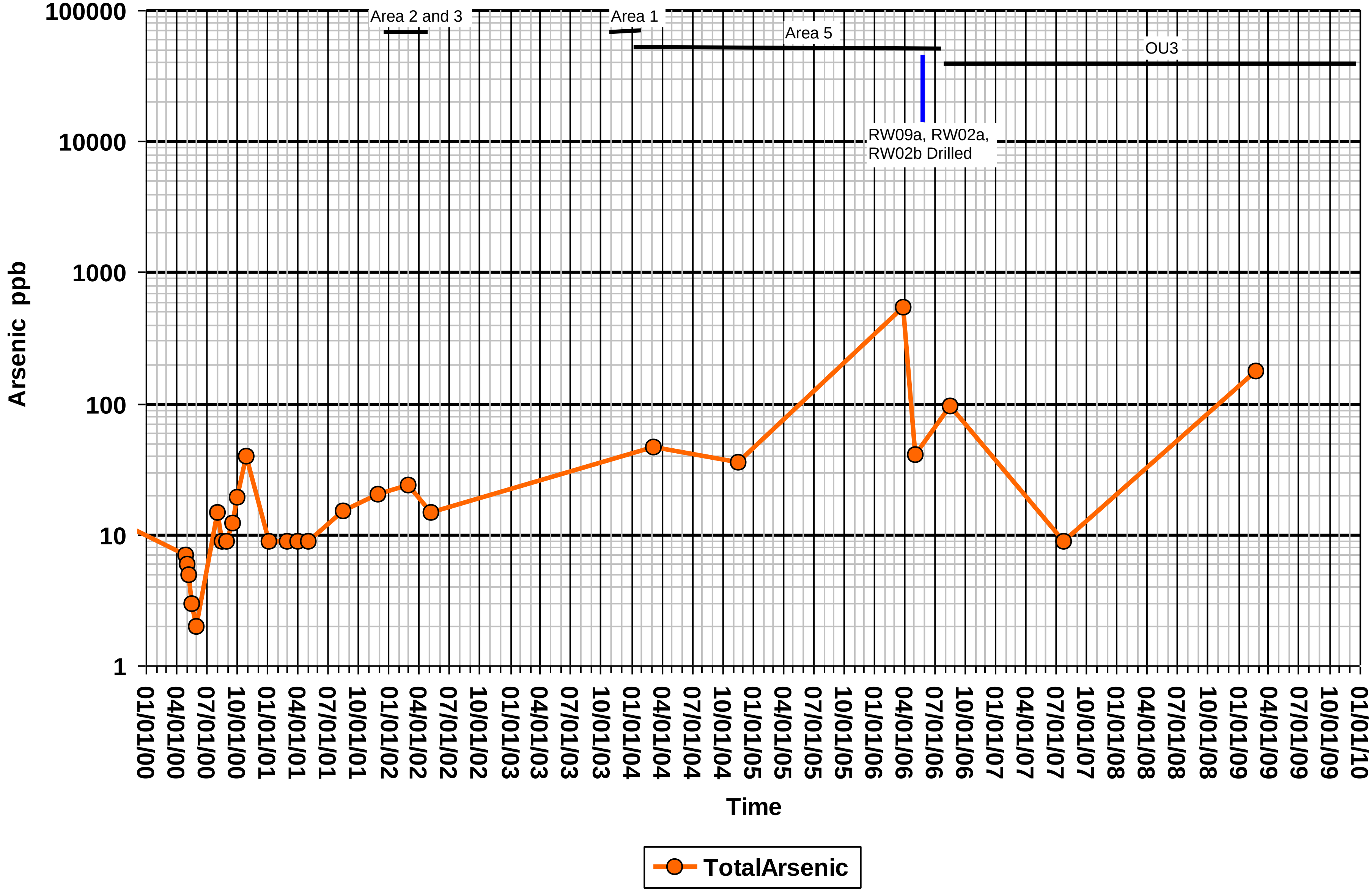
Vineland Chemical

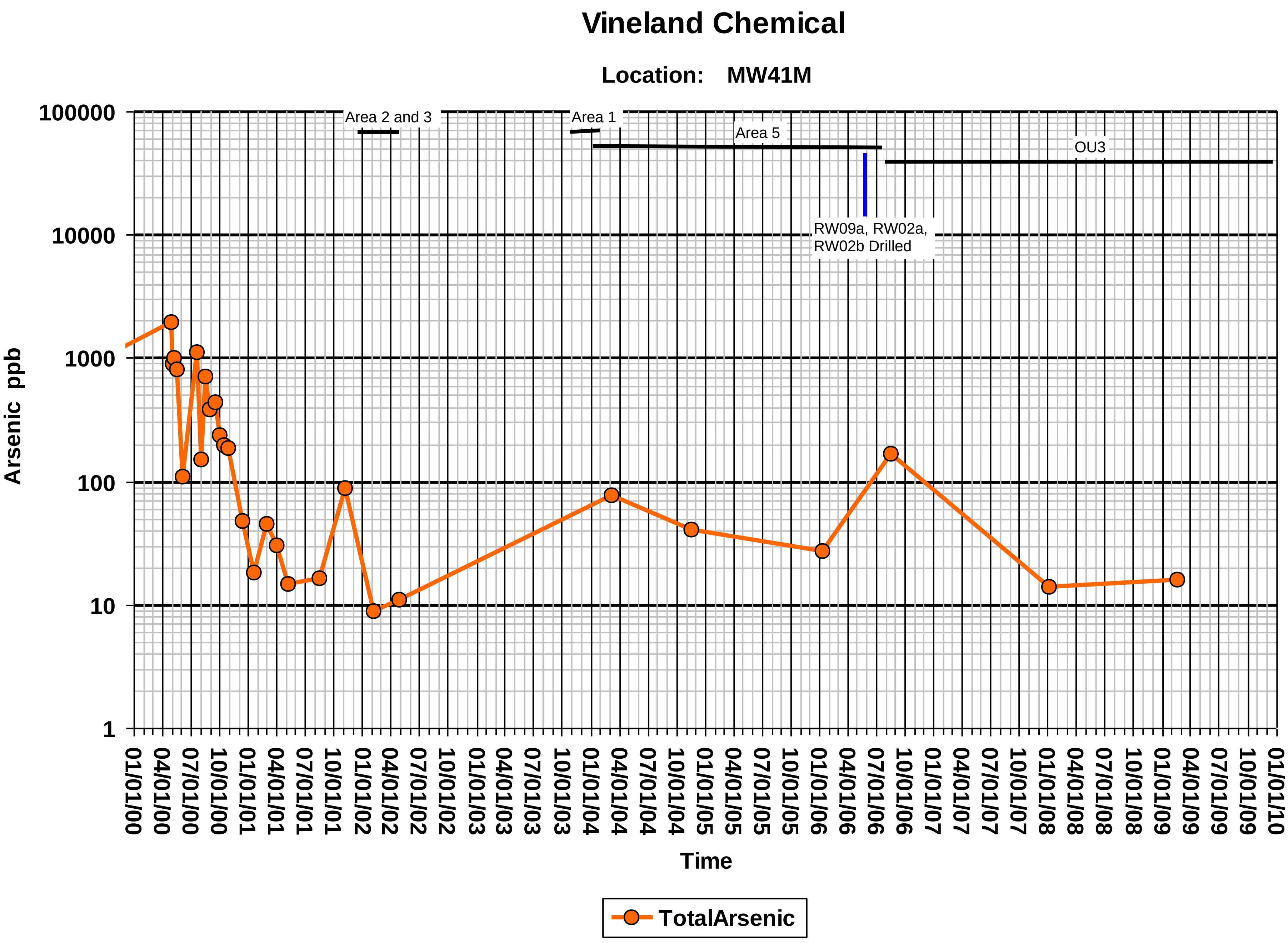
Location: MW40M



Vineland Chemical

Location: MW40S





Vineland Chemical
Location: MW41M
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
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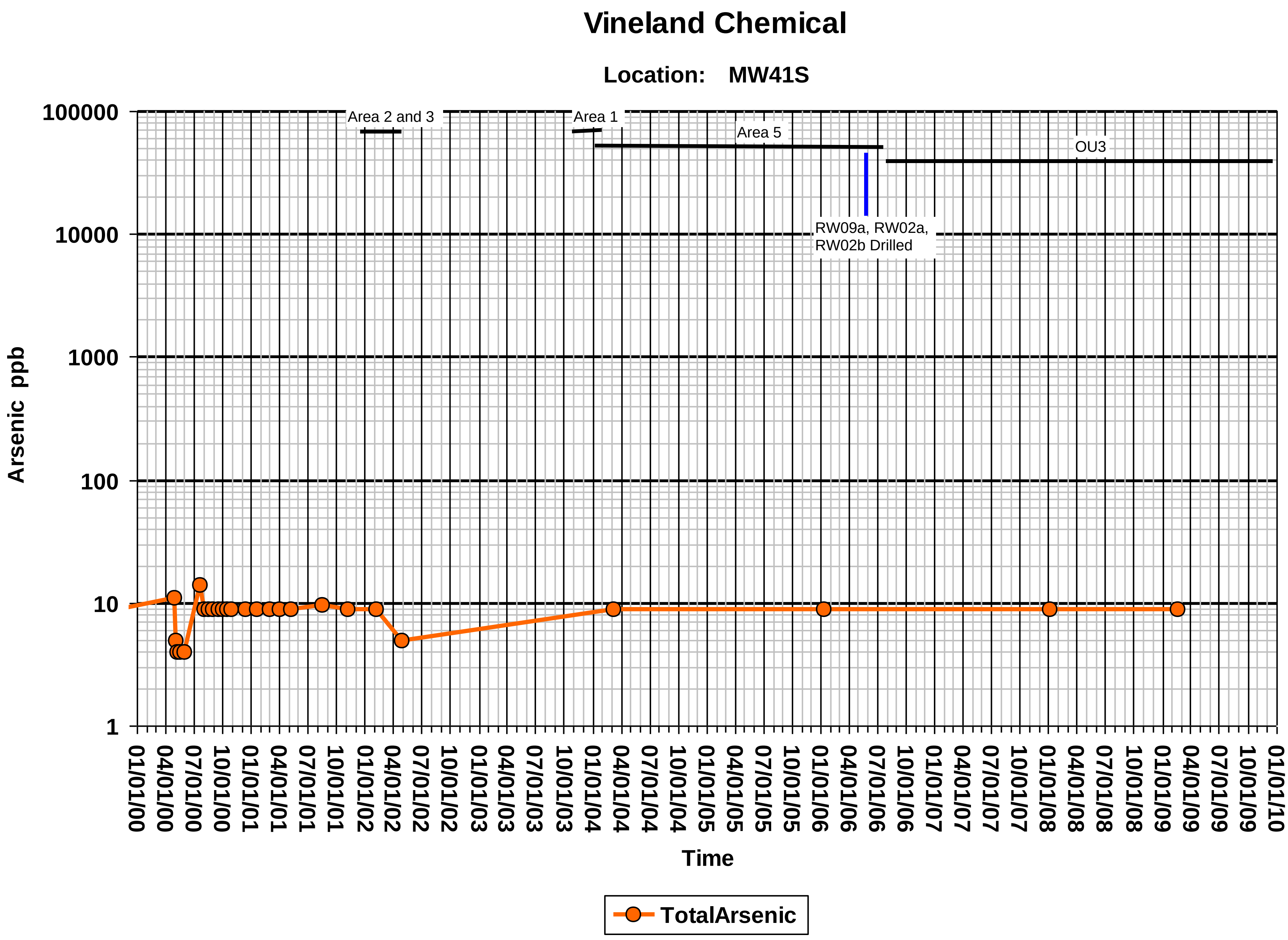
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: MW41S
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
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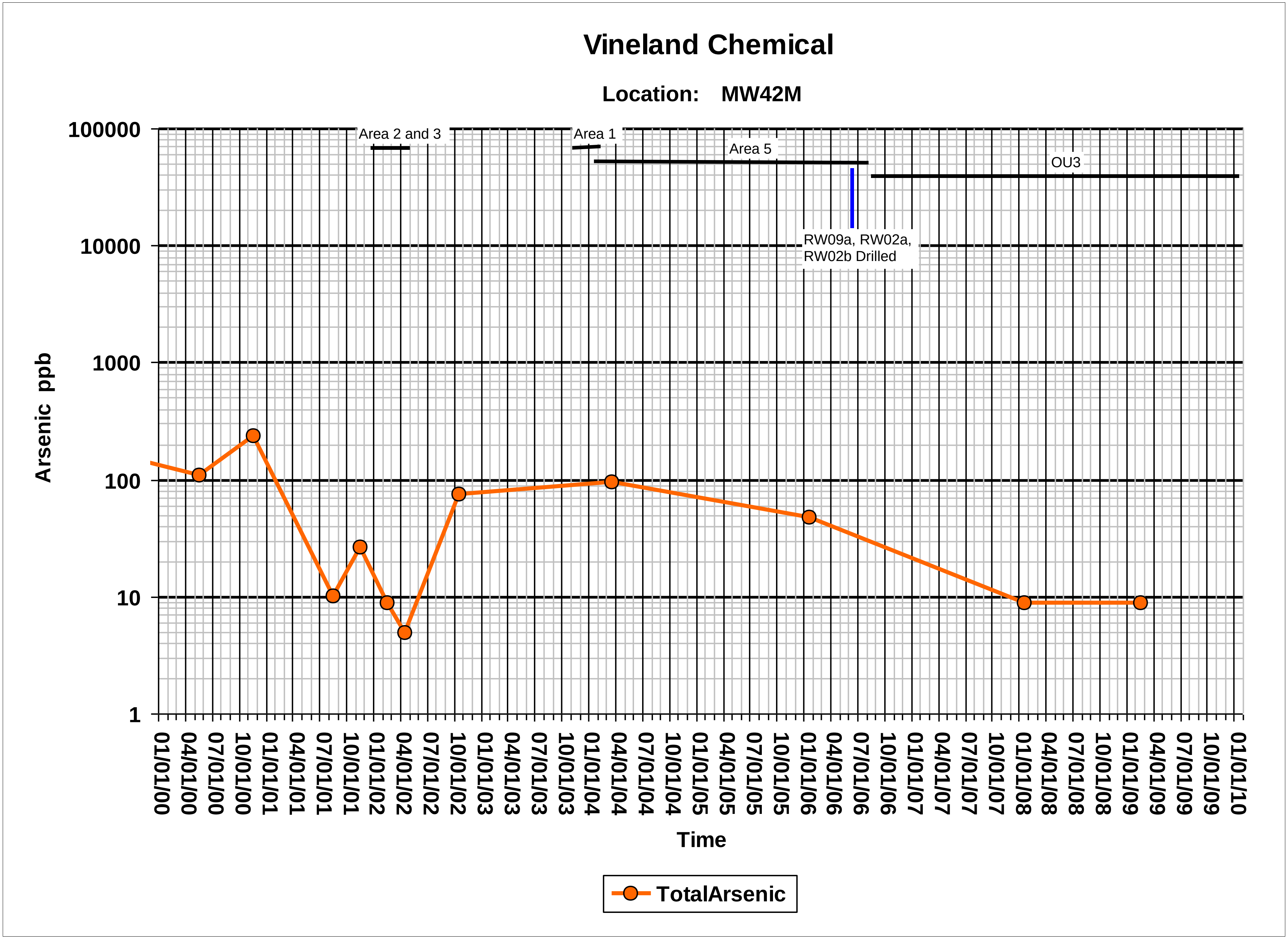
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: MW42M
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
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04/01/08
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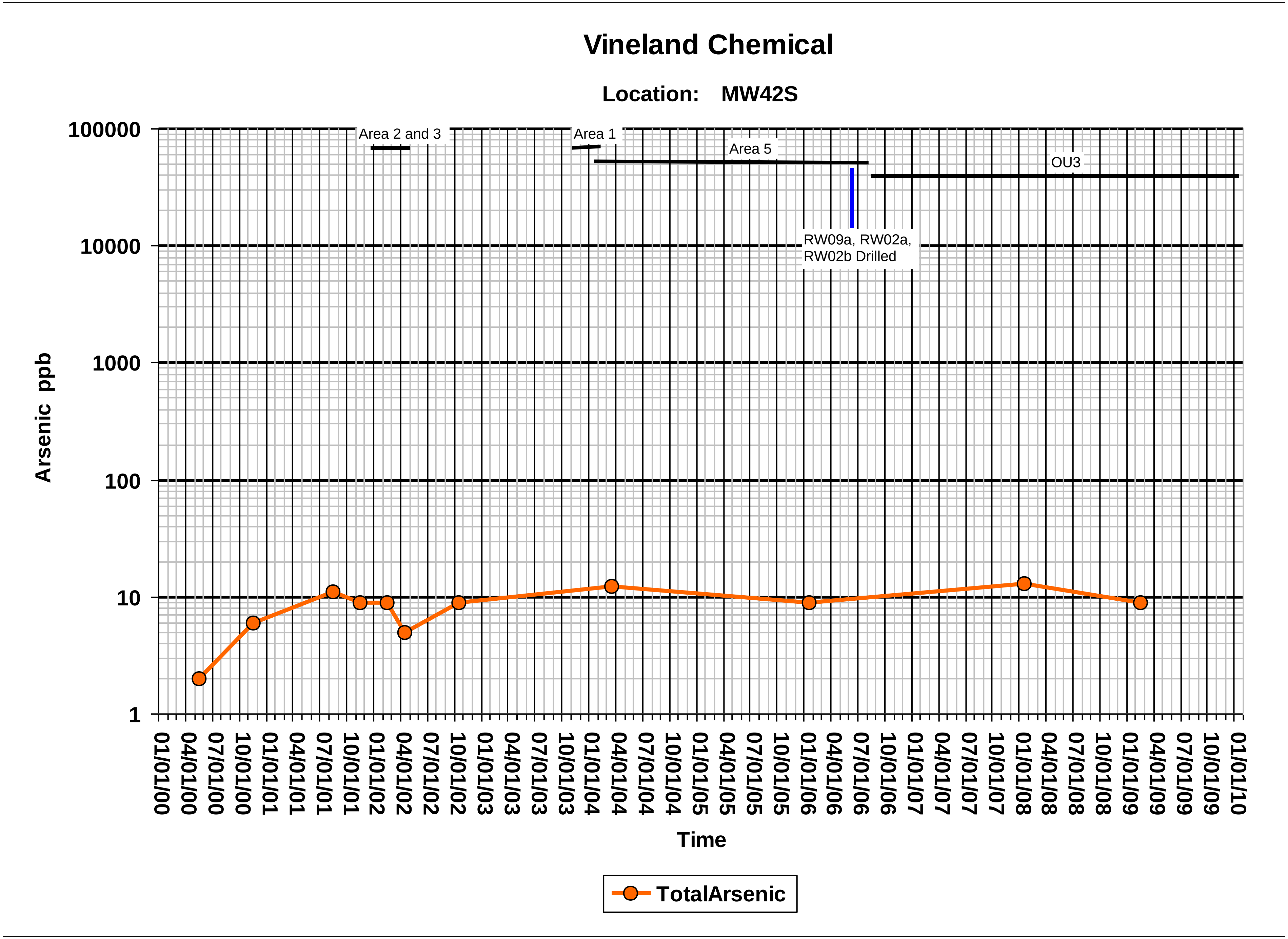
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: MW42S
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
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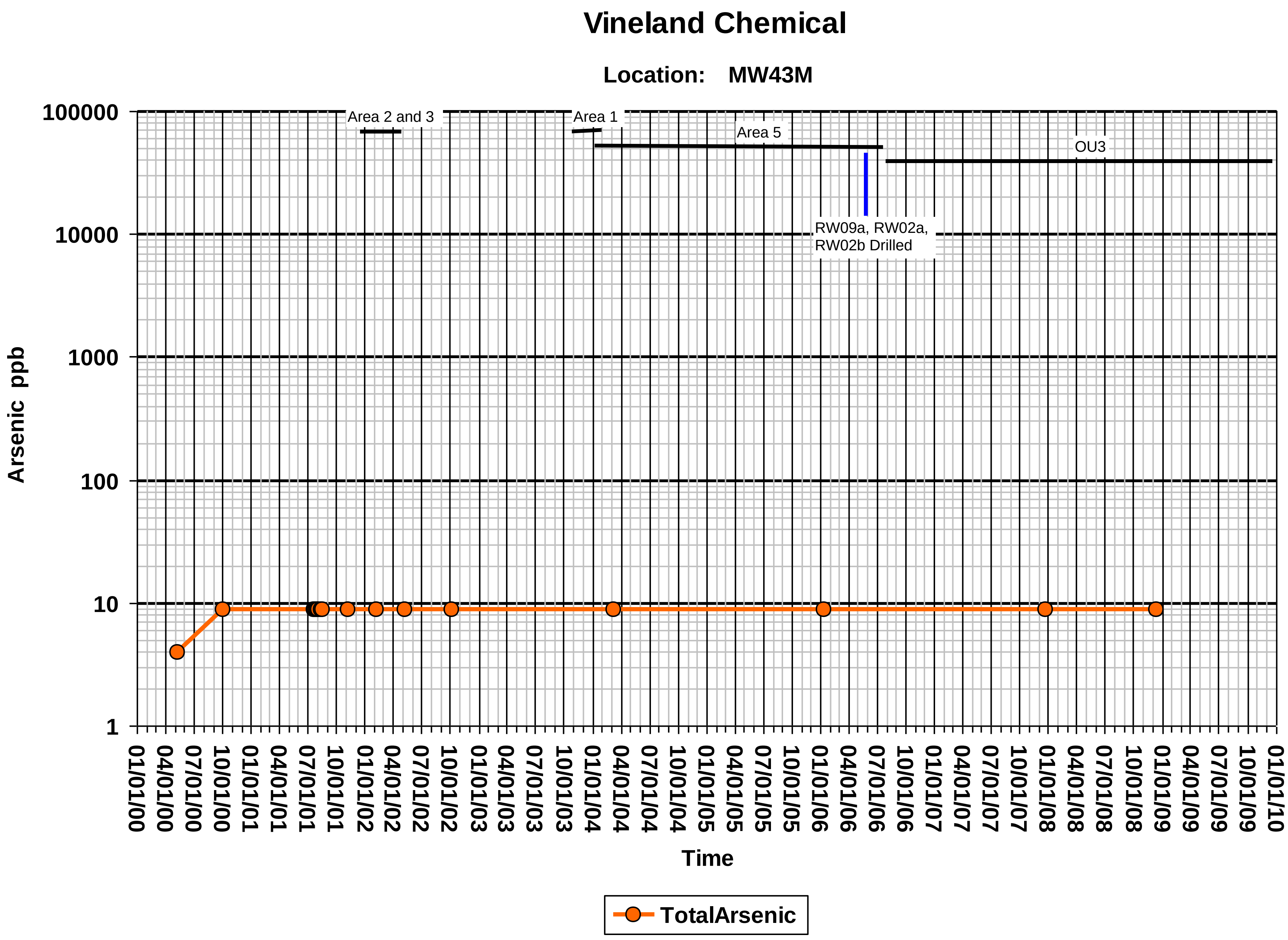
04/01/08
07/01/08
10/01/08
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: MW43M
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
10/01/02
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04/01/08
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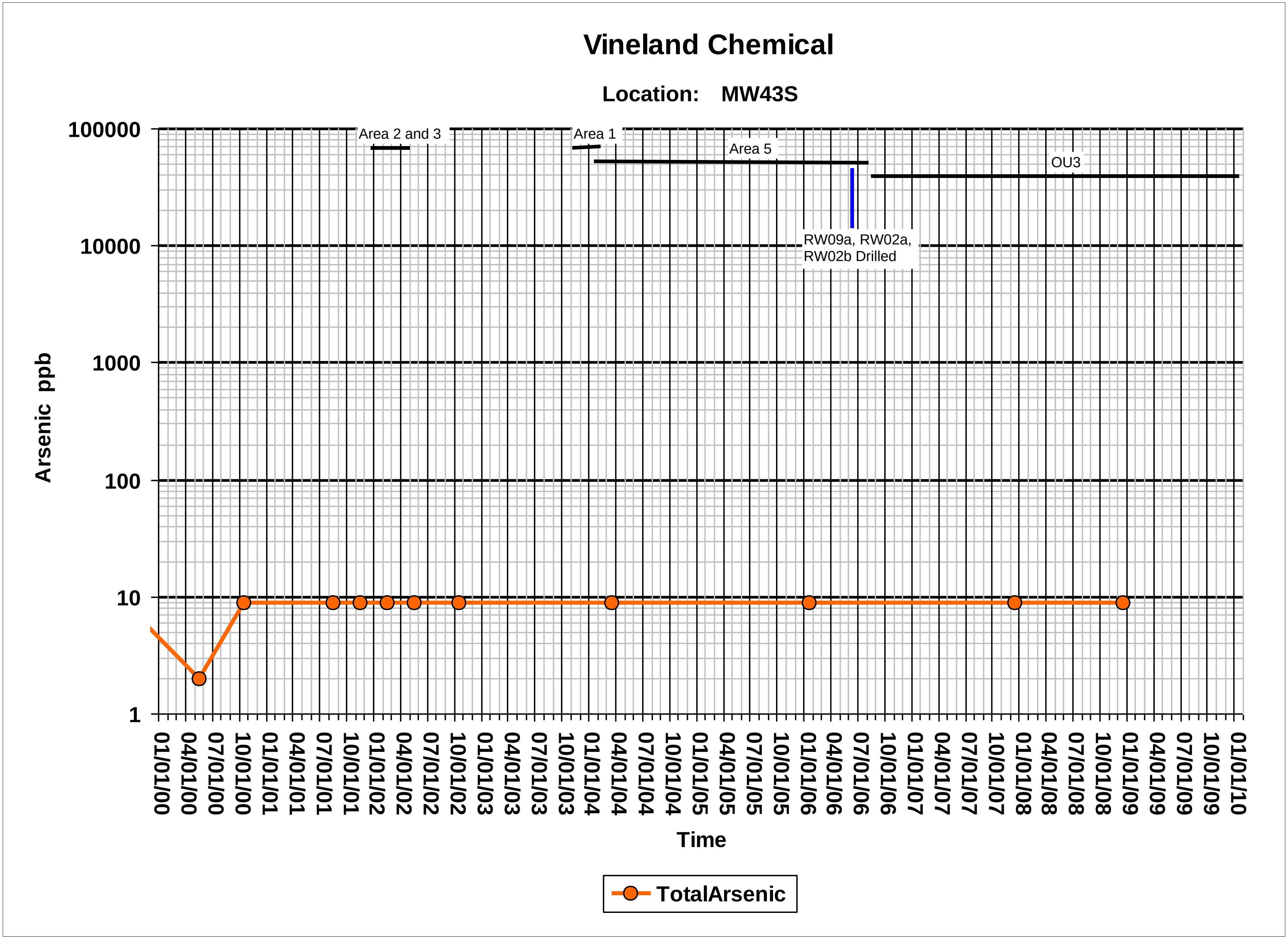
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: MW43S
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
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04/01/08
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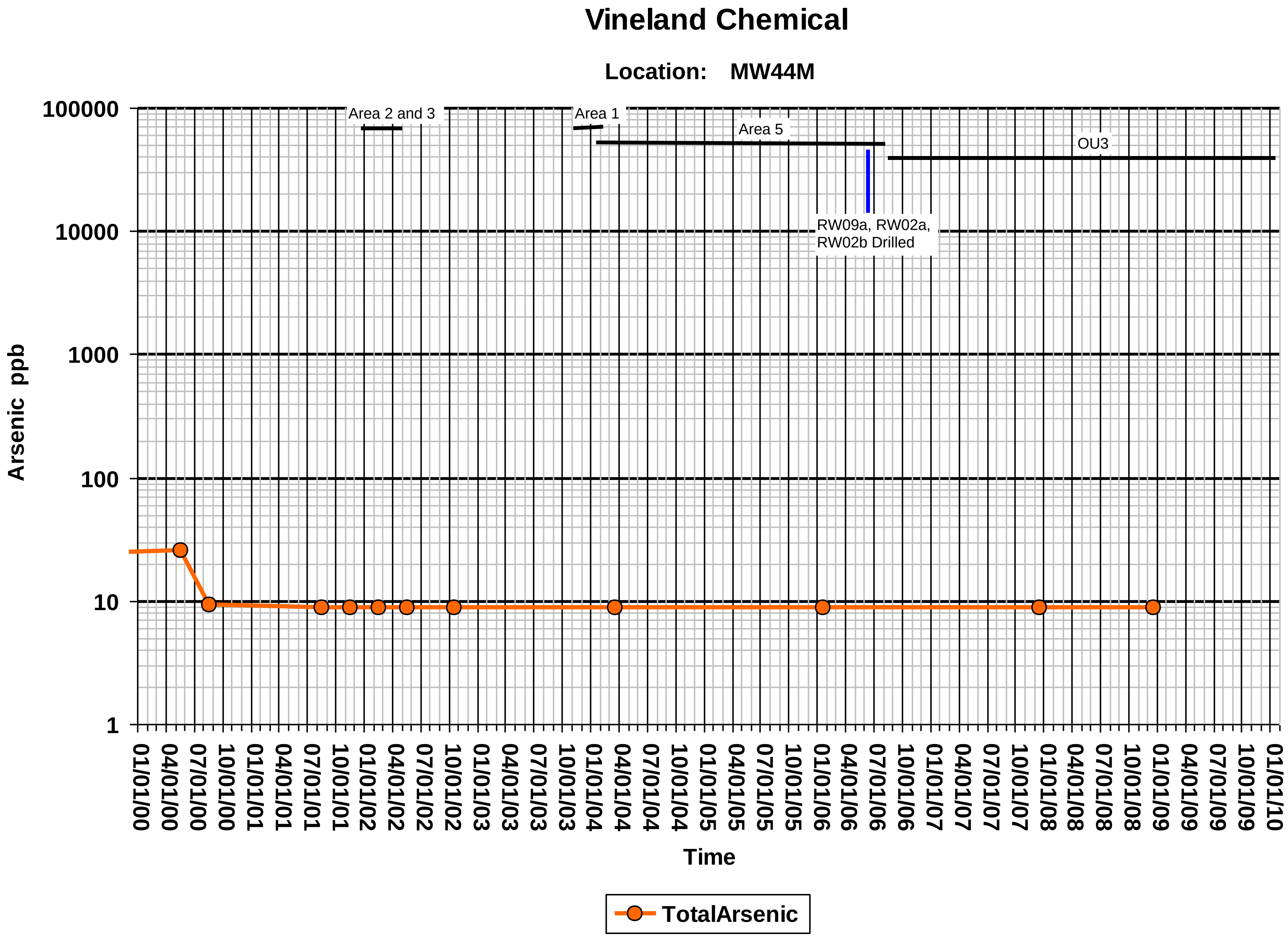
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: MW44M
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
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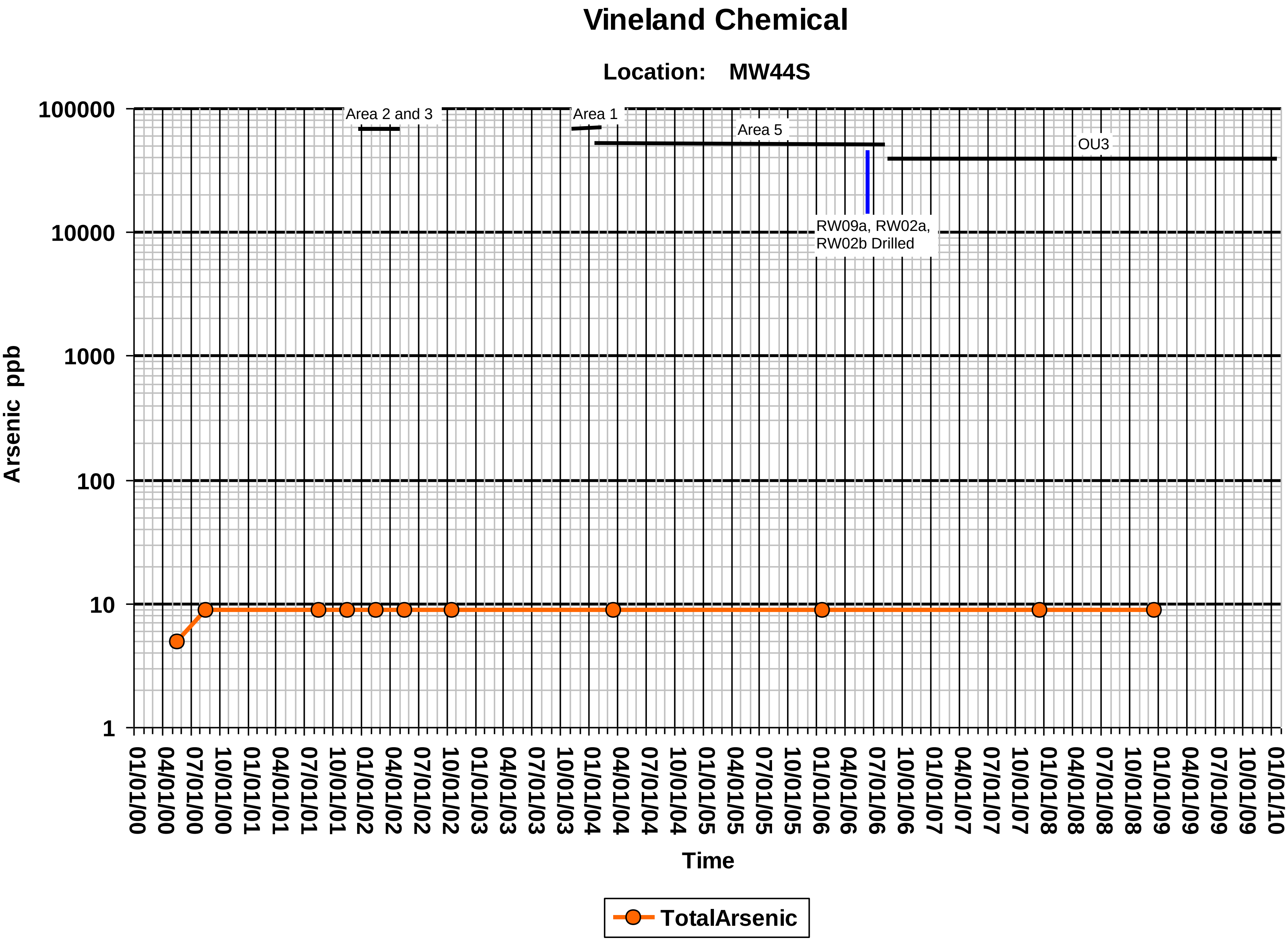
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: MW44S
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
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07/01/01
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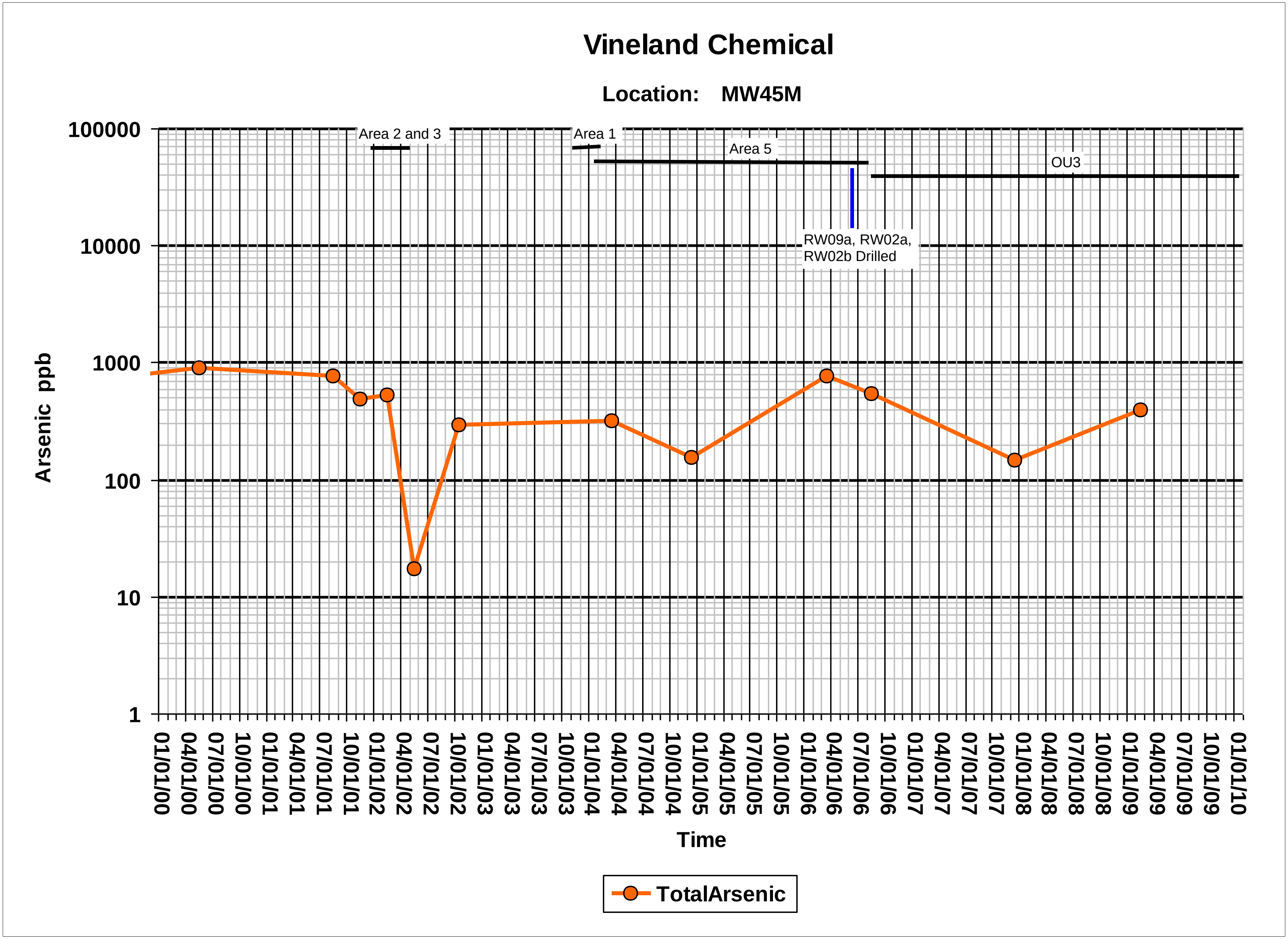
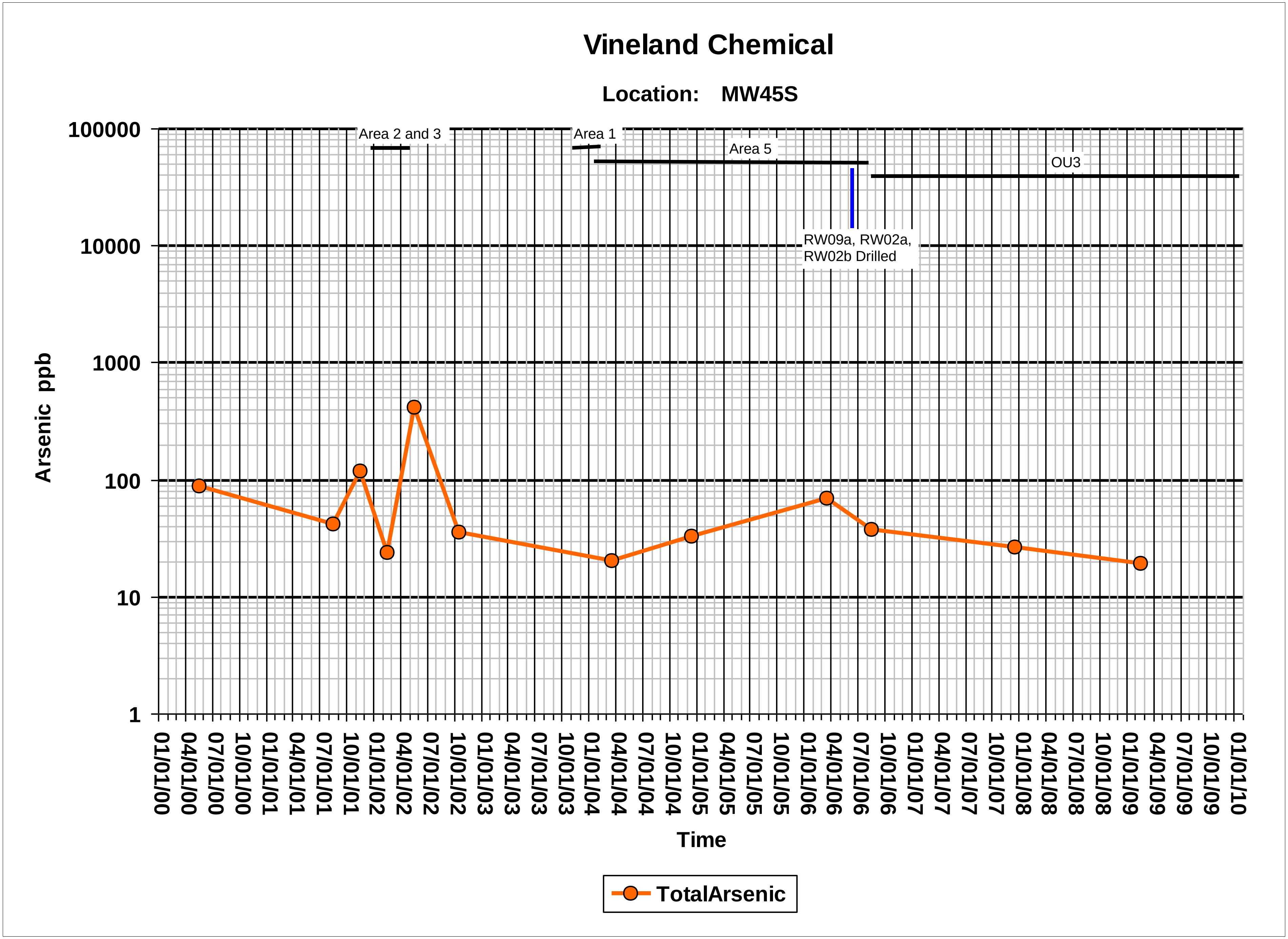
10/01/09
01/01/10
Time
TotalArsenic



Vineland Chemical

Location: MW45M


Vineland Chemical
Location: MW45S
Arsenic ppb
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10000
1000
100
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1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
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04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
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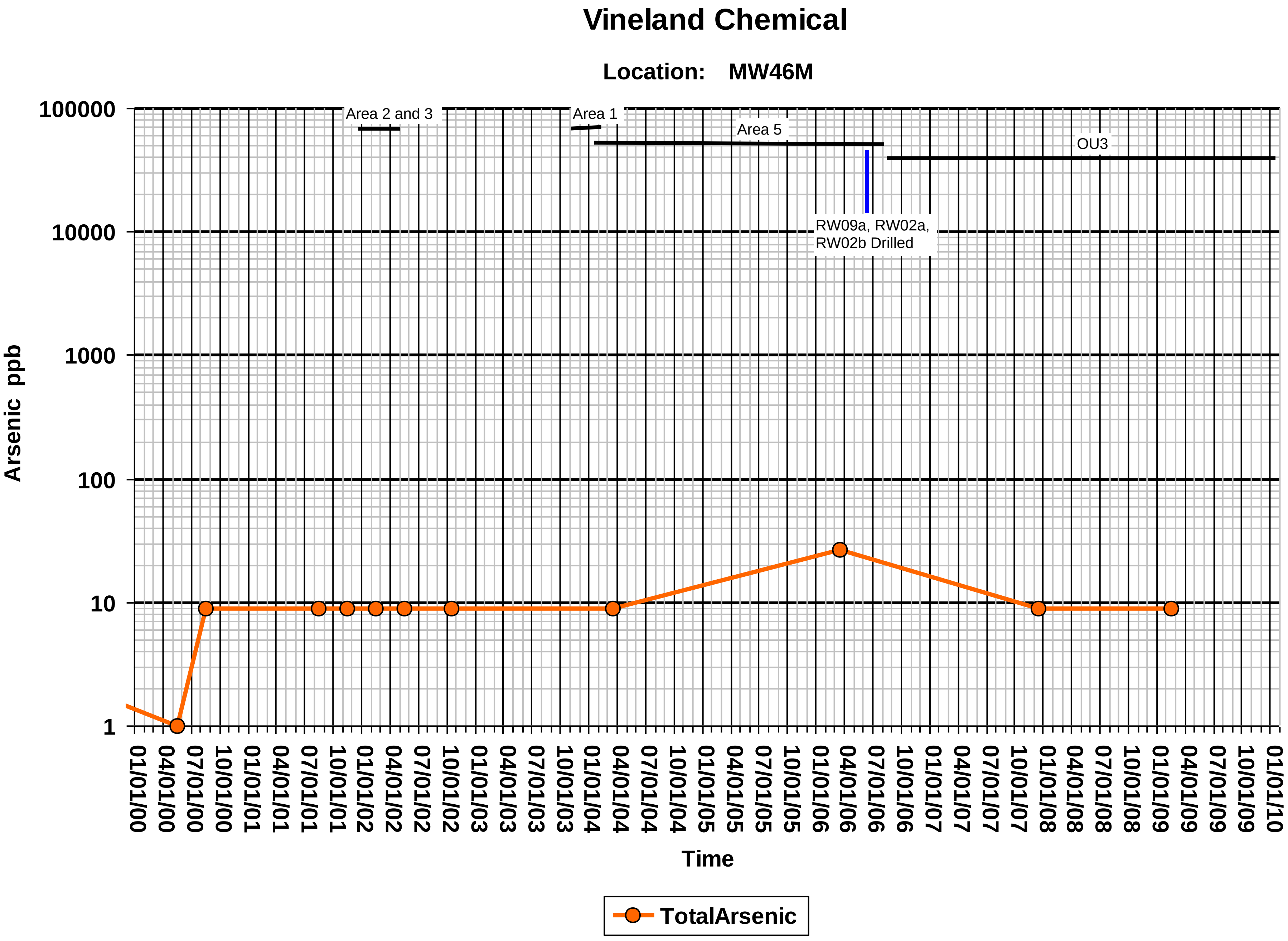
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: MW46M
100000
10000
1000
100
10
1
Arsenic ppb
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
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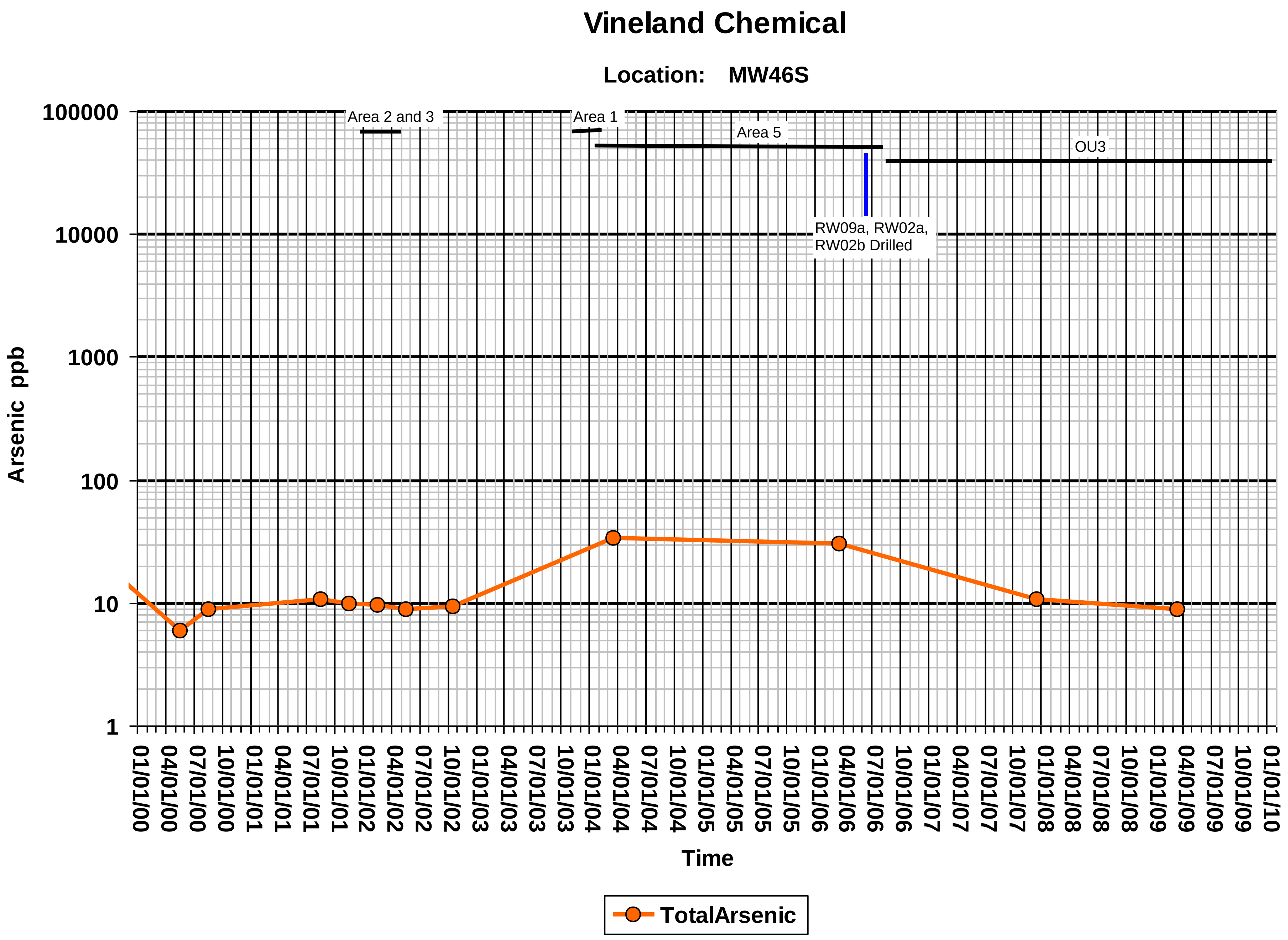
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: MW46S
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
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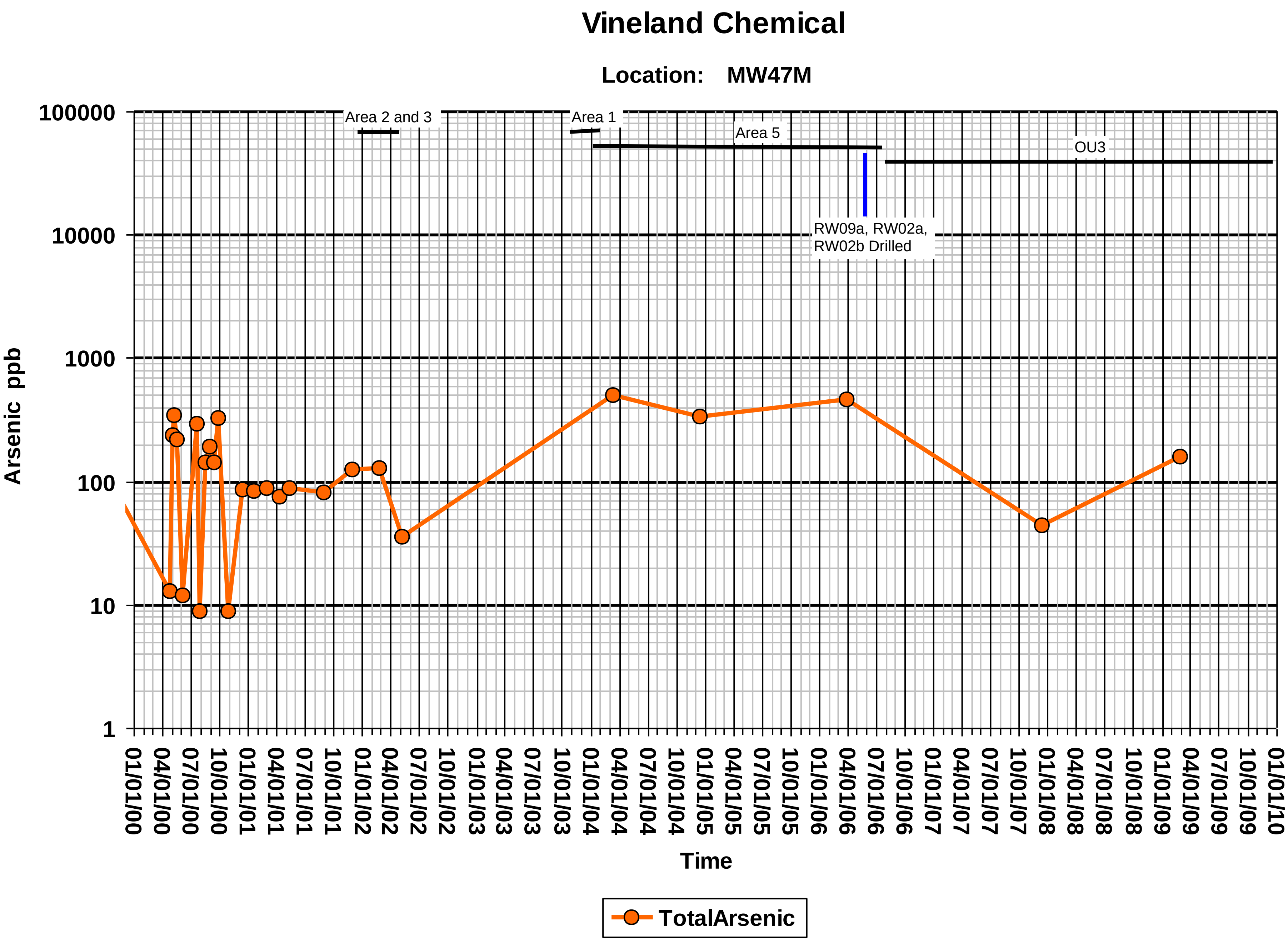
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic



Vineland Chemical
Location: MW47M
Arsenic ppb
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10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
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04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
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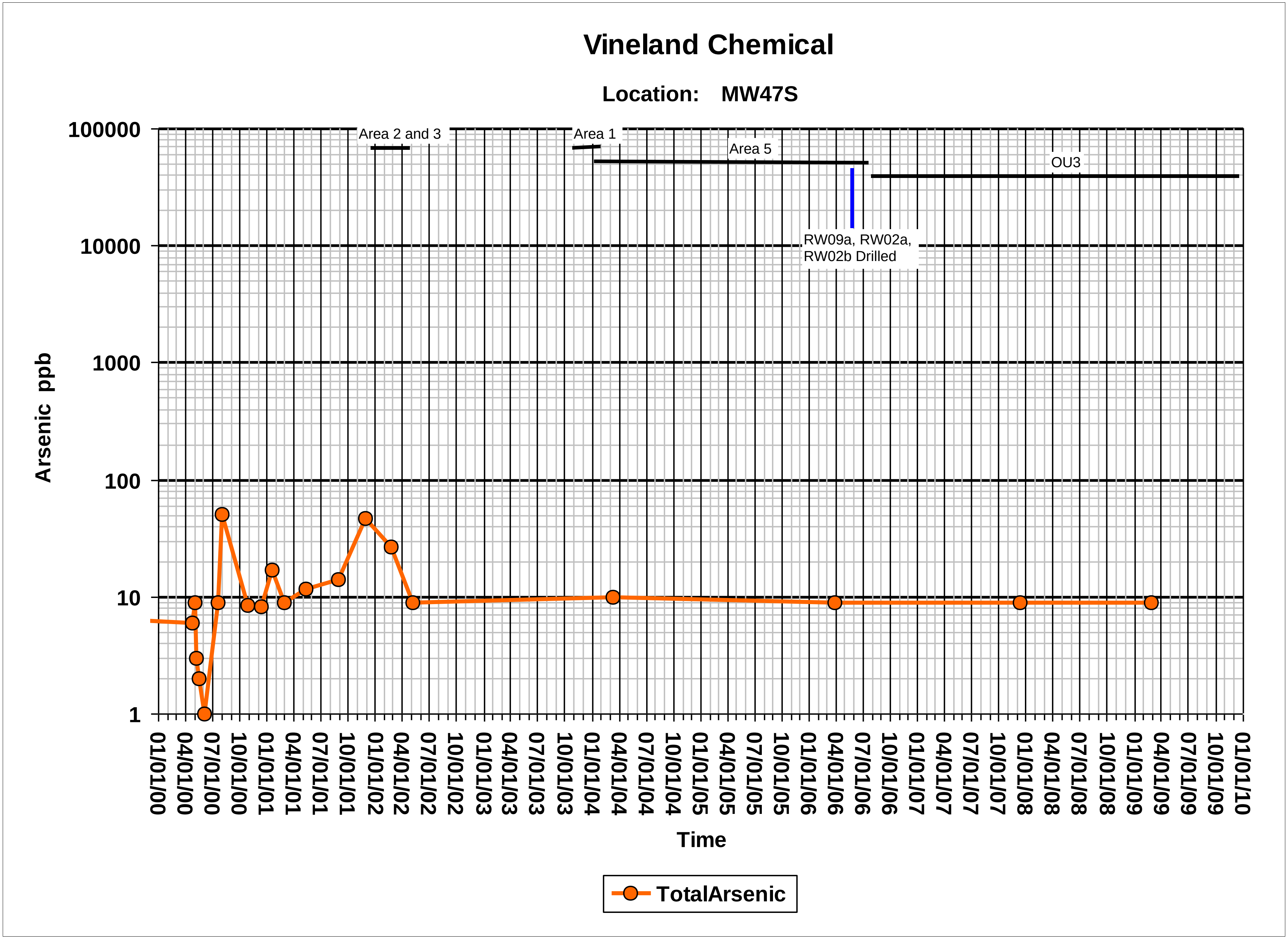
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: MW47S
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
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04/01/08
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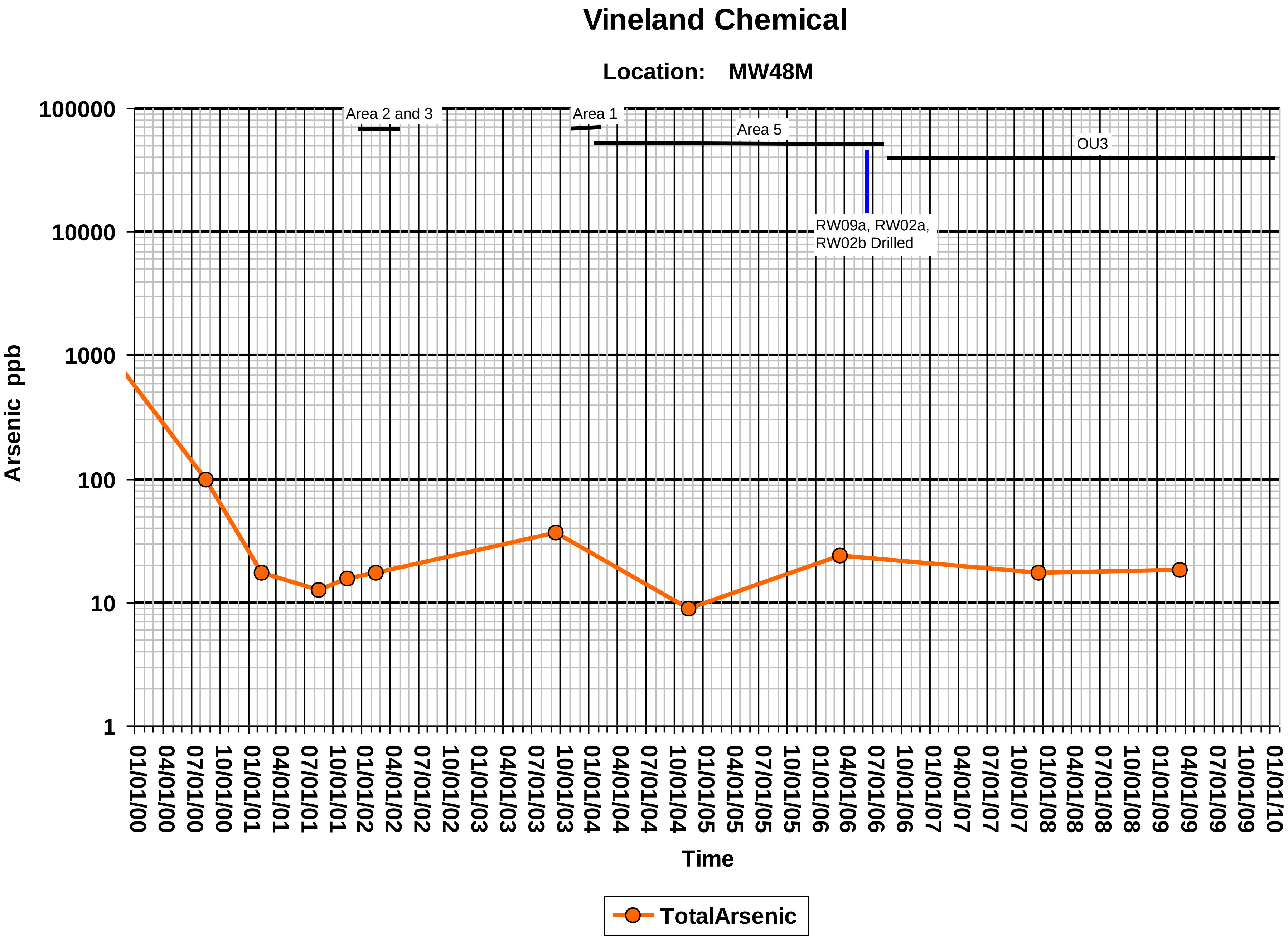
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: MW48M
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
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01/01/08
04/01/08
07/01/08
10/01/08
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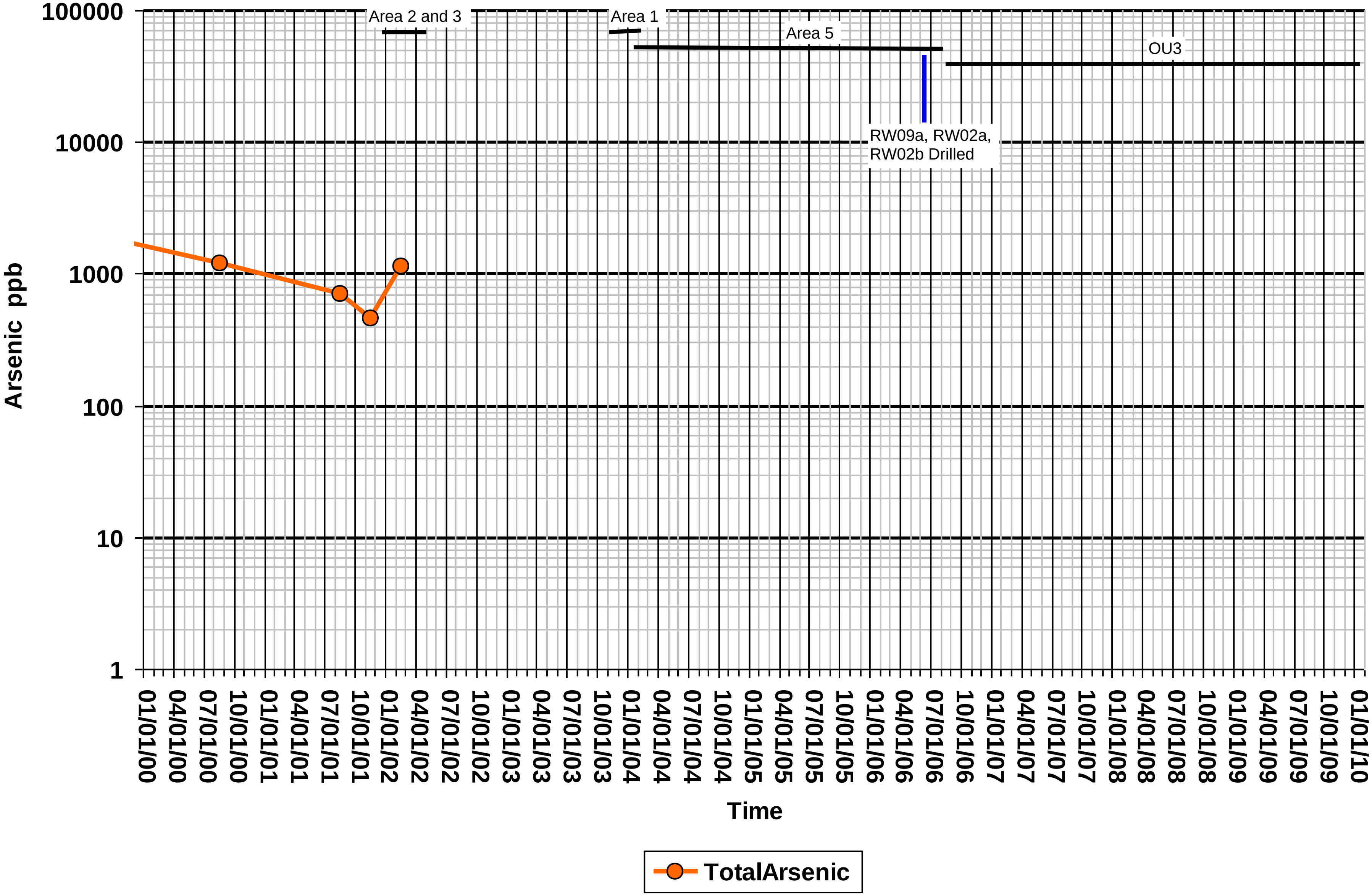
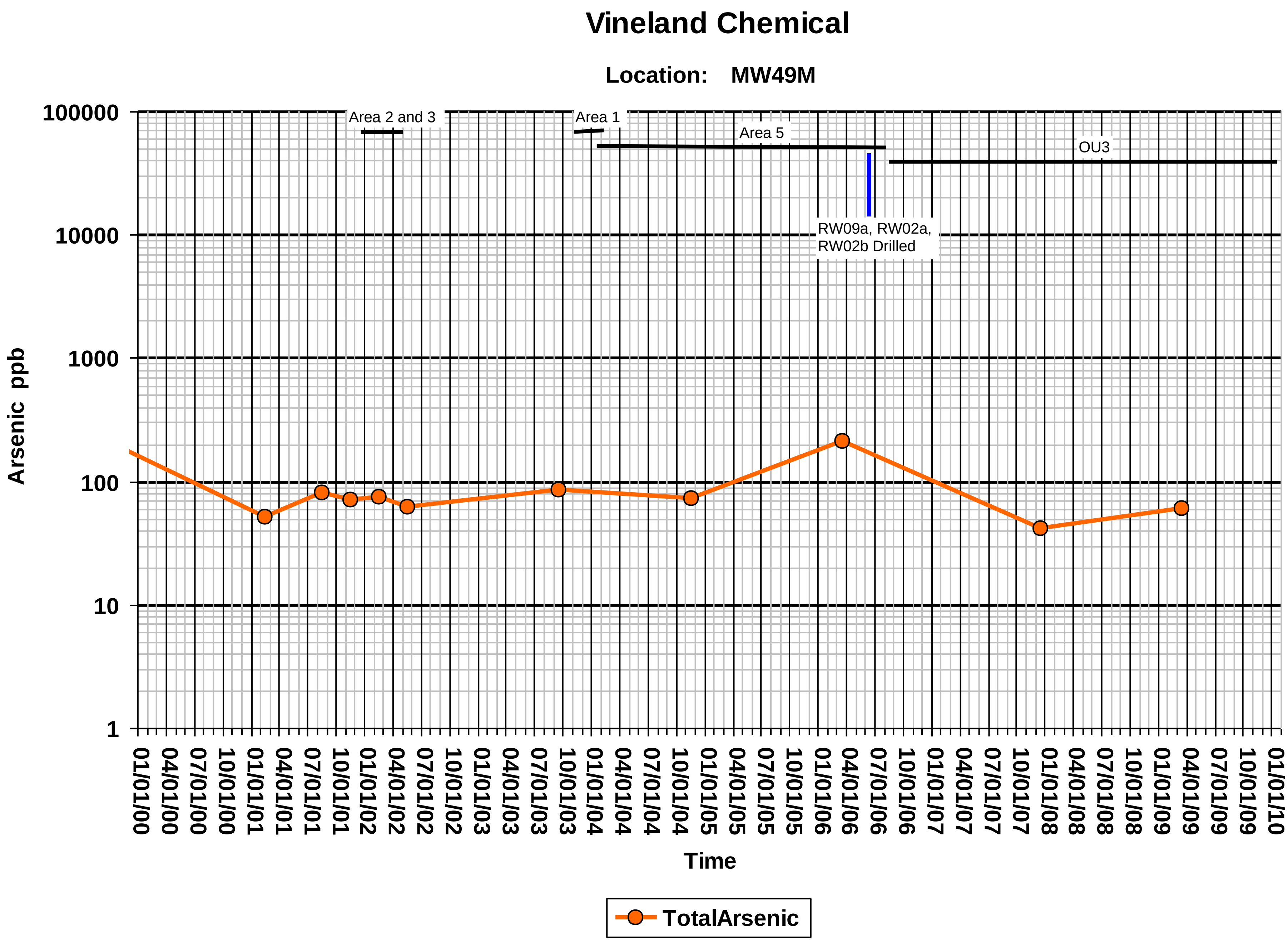
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic

Vineland Chemical

Location: MW48S




Vineland Chemical
Location: MW49M
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
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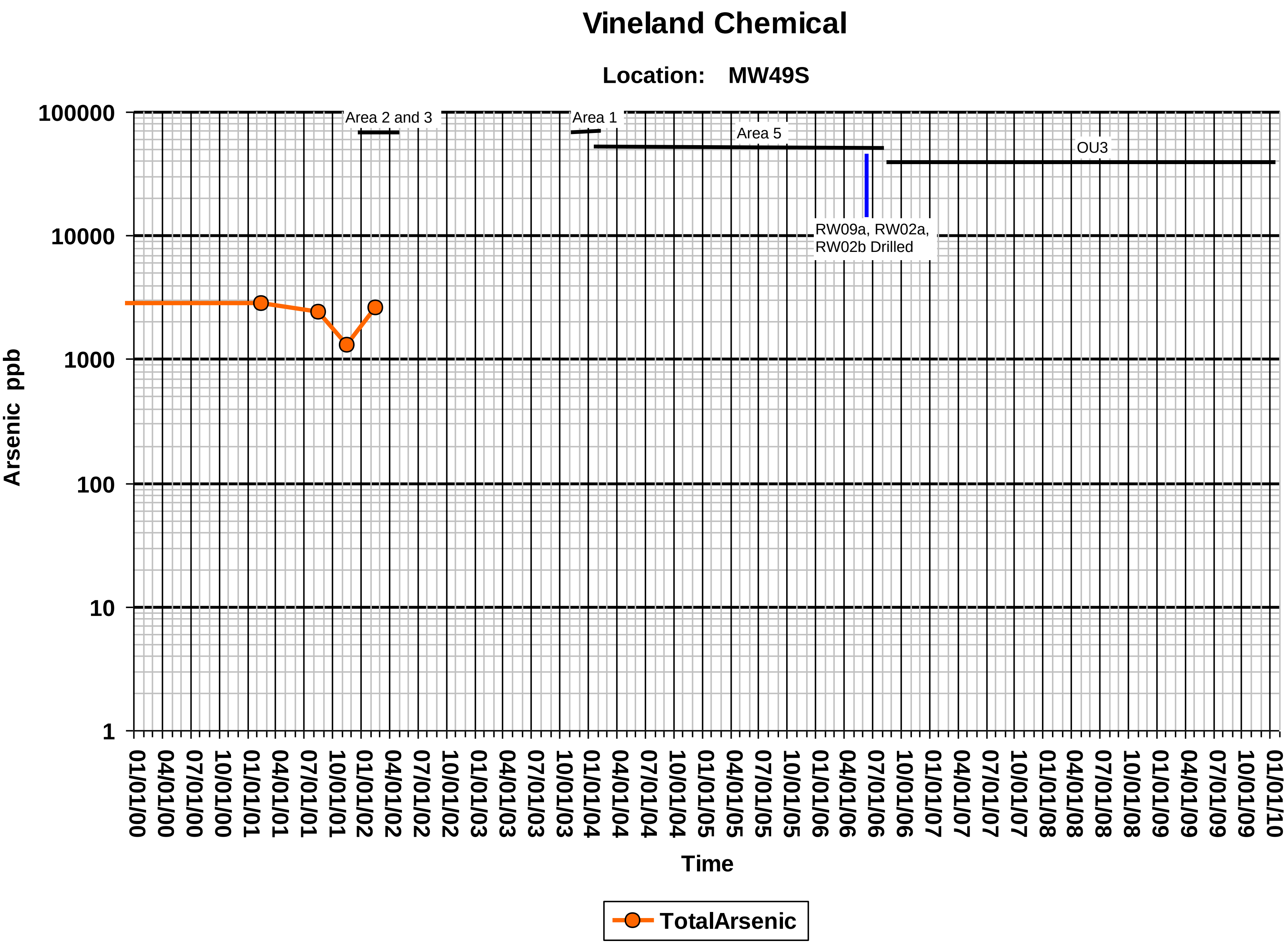
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic



Vineland Chemical
Location: MW49S
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
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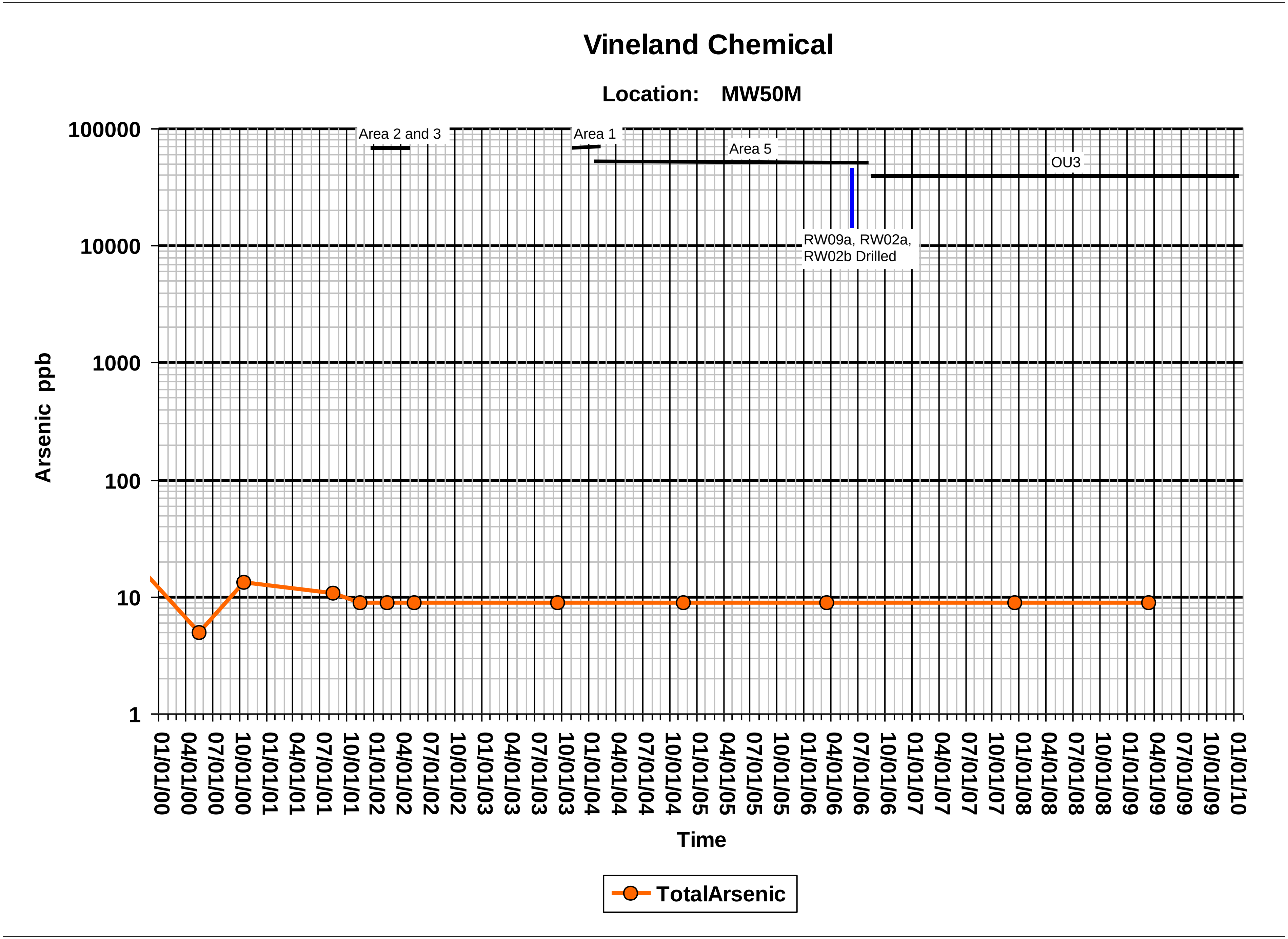
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: MW50M
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
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04/01/01
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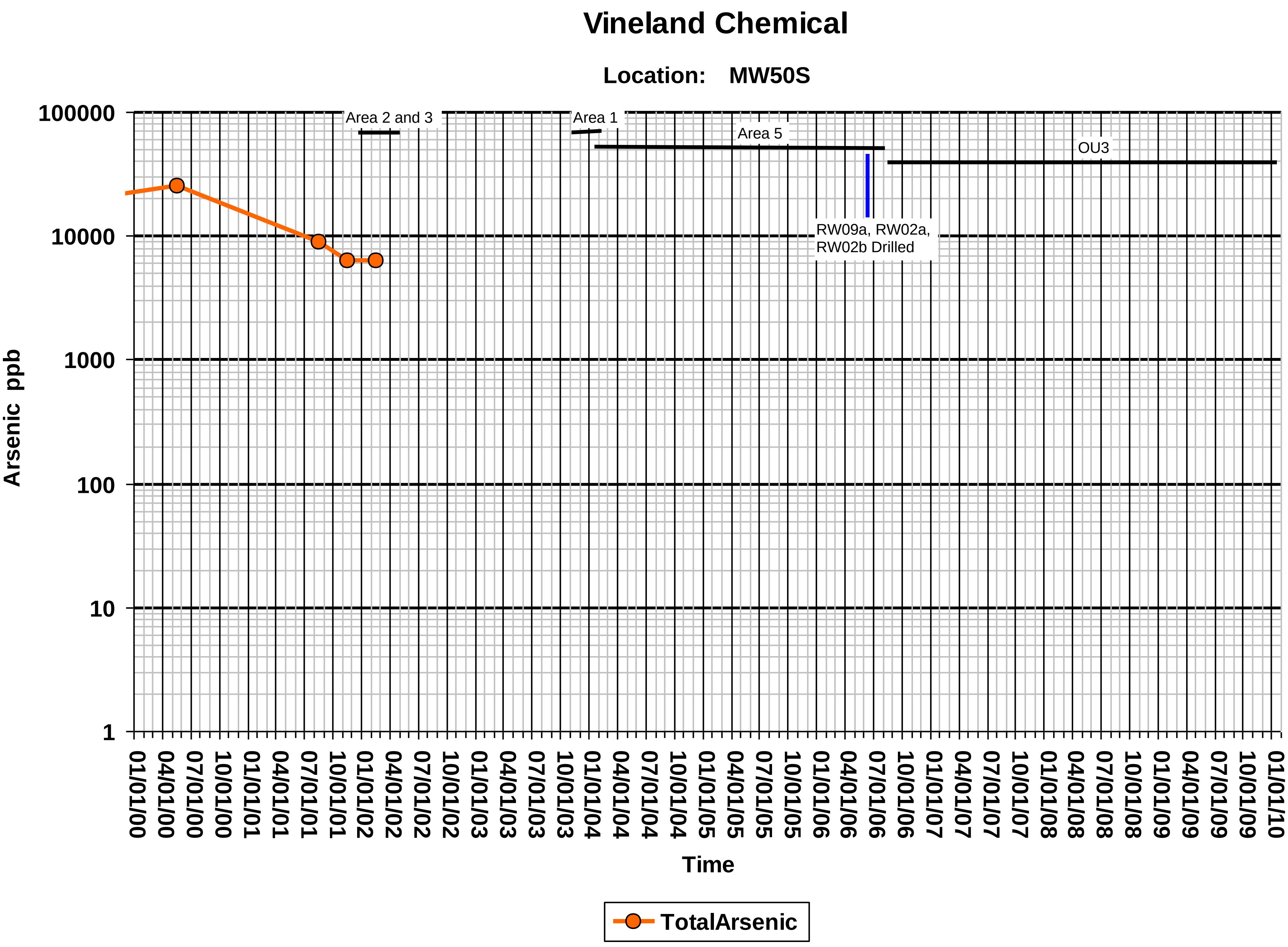
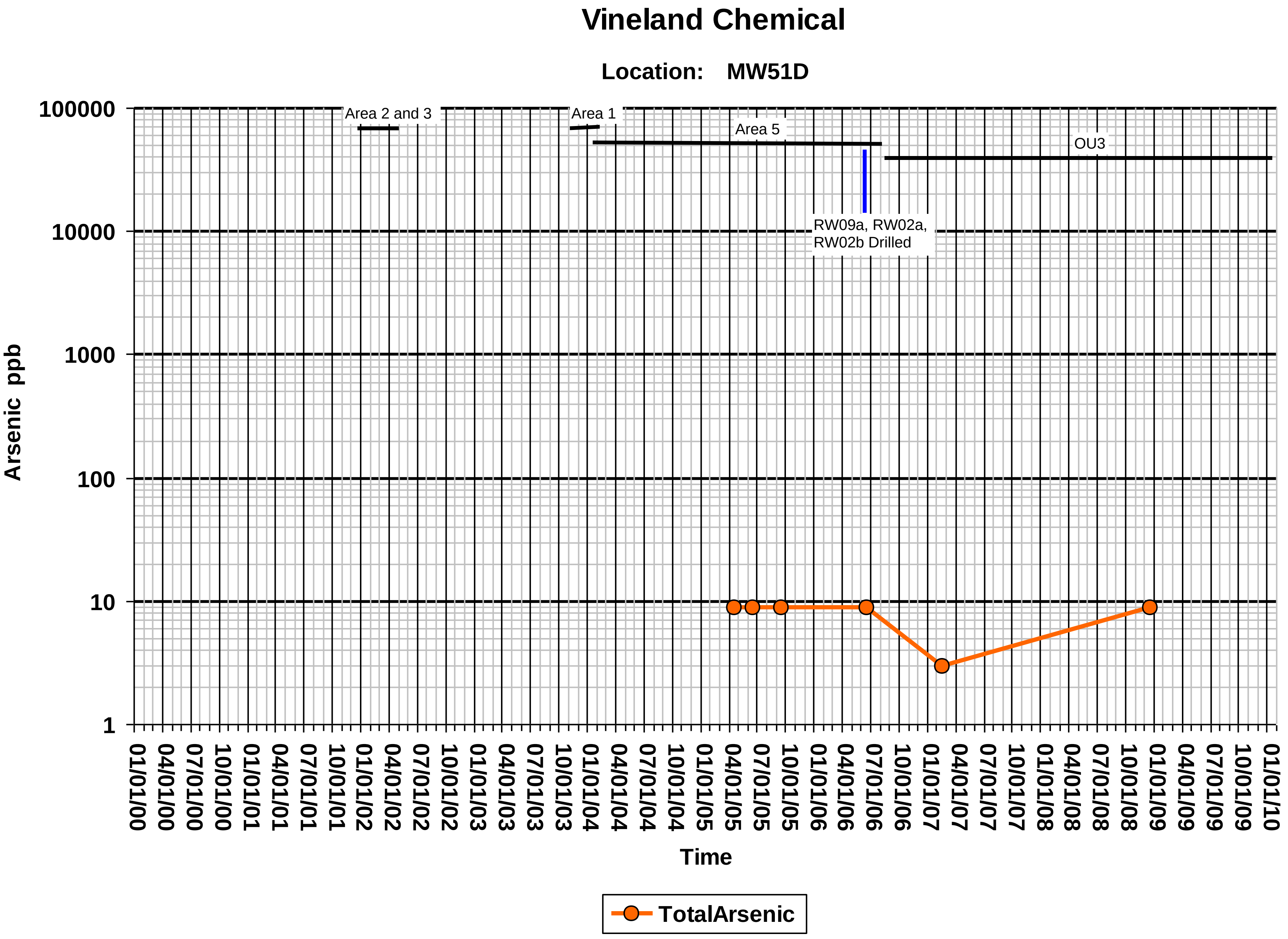
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: MW50S
100000
10000
1000
100
10
1
Arsenic ppb
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
10/01/02
01/01/03
04/01/03
07/01/03
10/01/03
01/01/04
04/01/04
07/01/04
10/01/04
01/01/05
04/01/05
07/01/05
10/01/05
01/01/06
04/01/06
07/01/06
10/01/06
01/01/07
04/01/07
07/01/07
10/01/07
01/01/08
04/01/08
07/01/08
10/01/08
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic

Vineland Chemical
Location: MW51D
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
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04/01/03
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04/01/06
07/01/06
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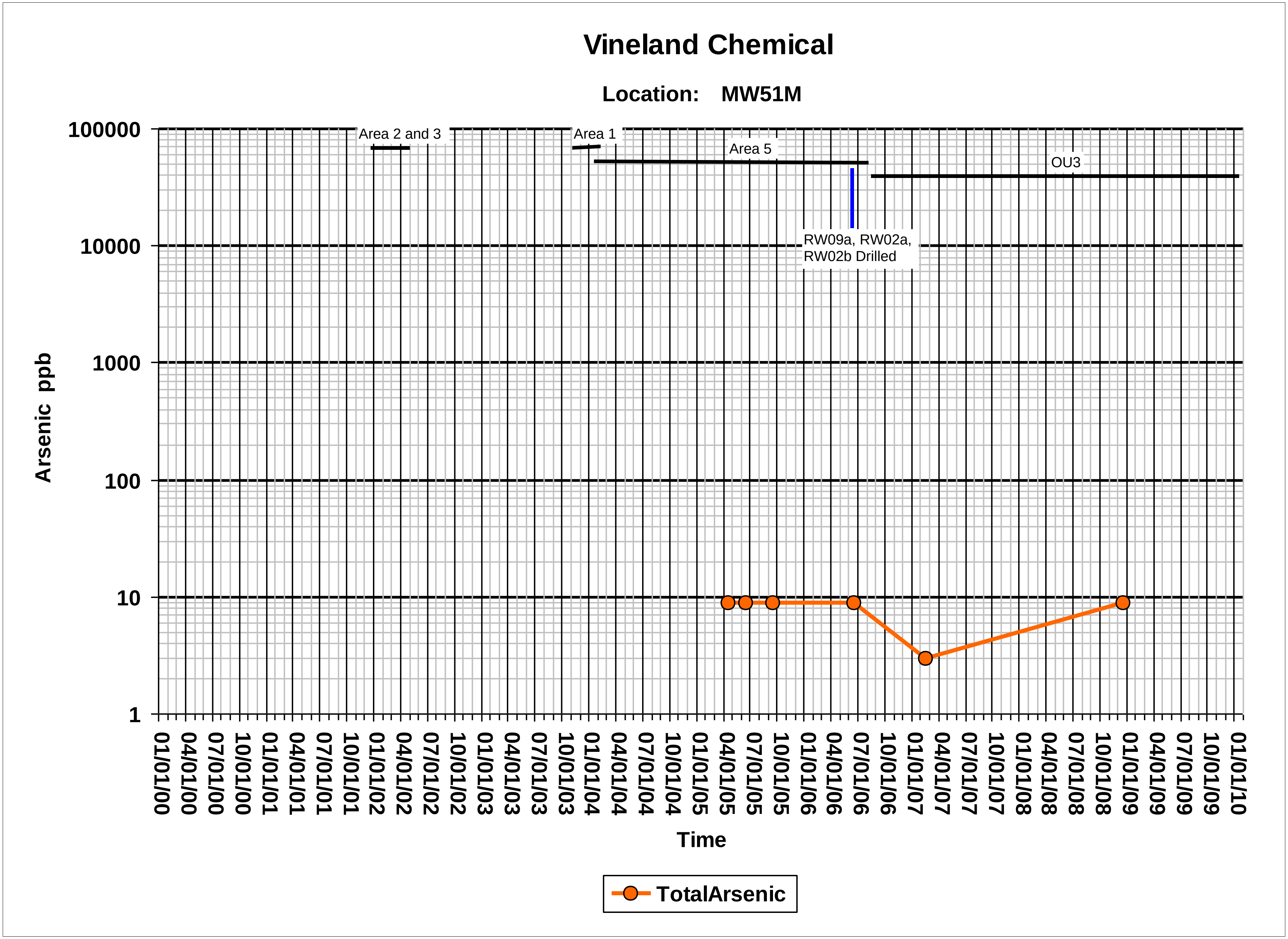
01/01/07
04/01/07
07/01/07
10/01/07
01/01/08
04/01/08
07/01/08
10/01/08
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: MW51M
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
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01/01/08
04/01/08
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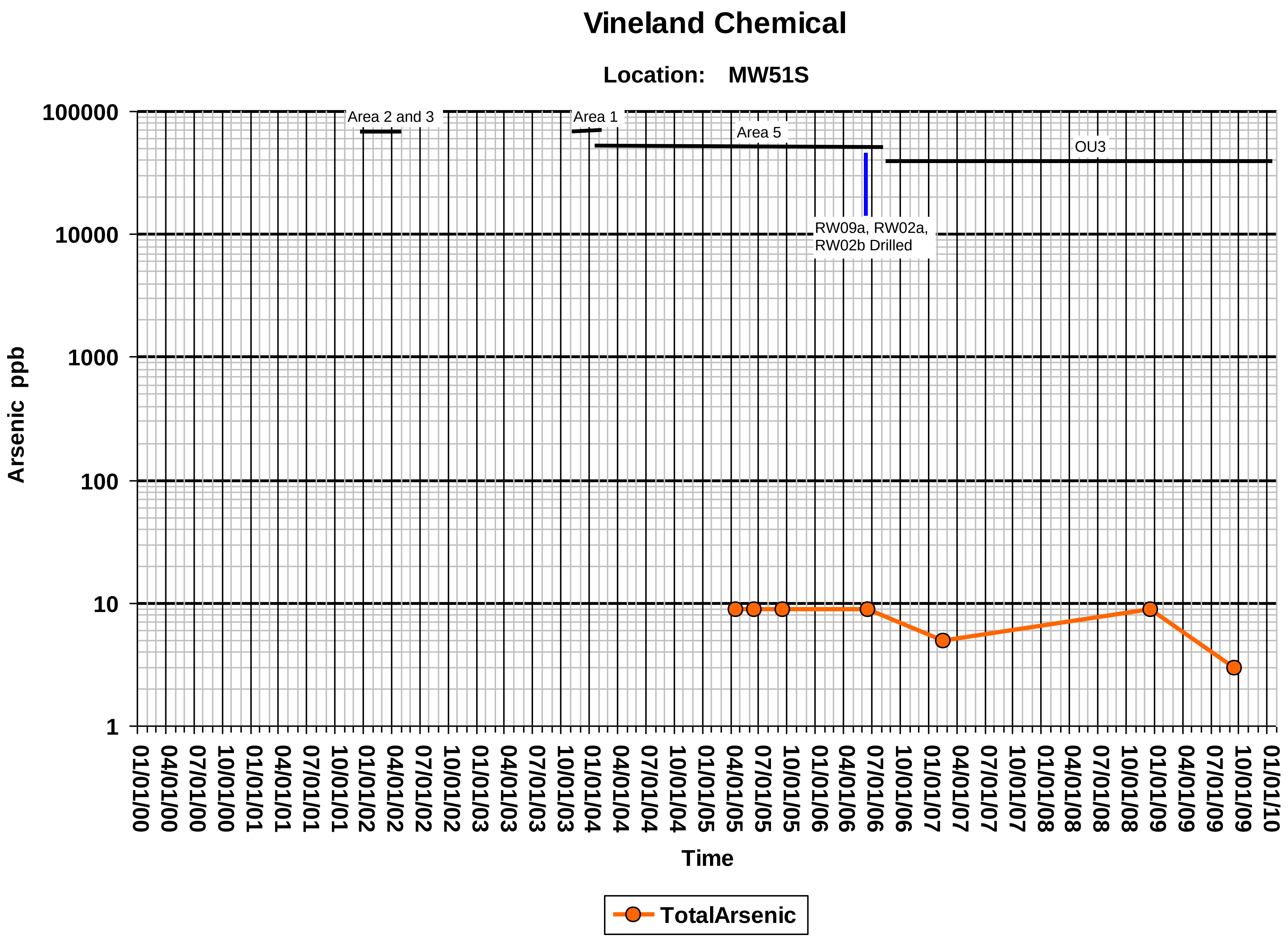
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: MW51S
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
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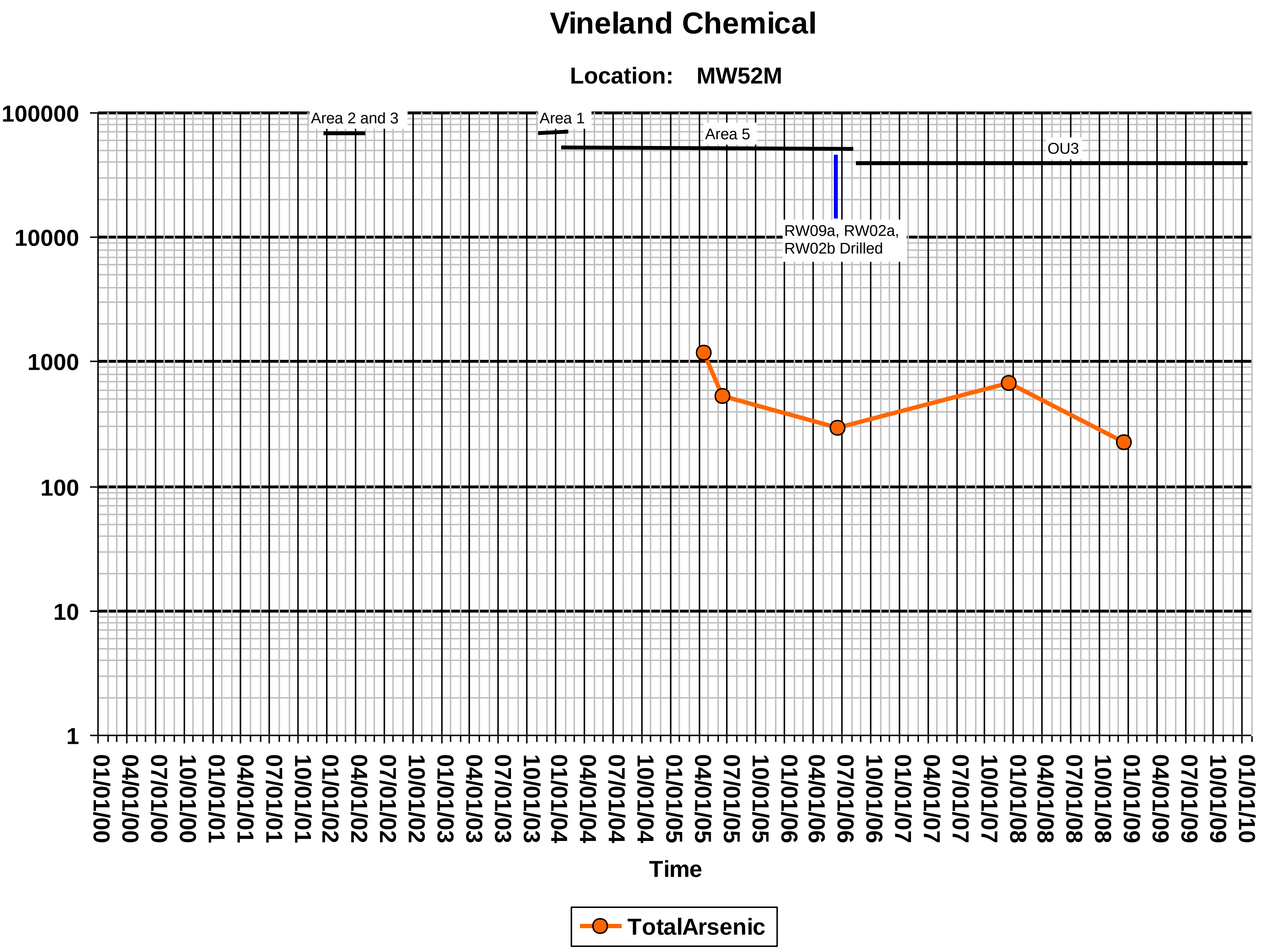
01/01/08
04/01/08
07/01/08
10/01/08
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: MW52M
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
10/01/02
01/01/03
04/01/03
07/01/03
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04/01/04
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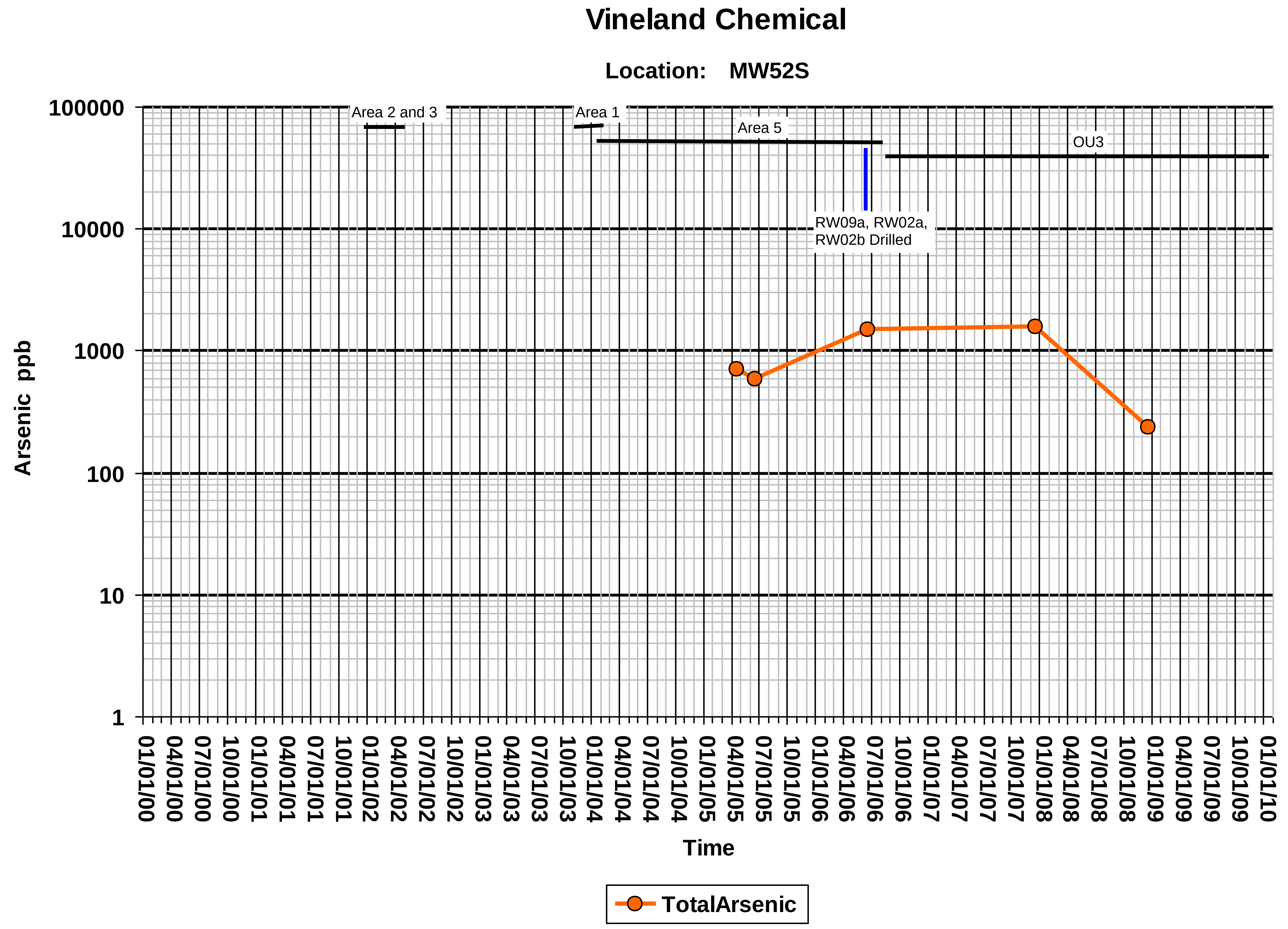
01/01/06
04/01/06
07/01/06
10/01/06
01/01/07
04/01/07
07/01/07
10/01/07
01/01/08
04/01/08
07/01/08
10/01/08
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: MW52S
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
10/01/02
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04/01/08
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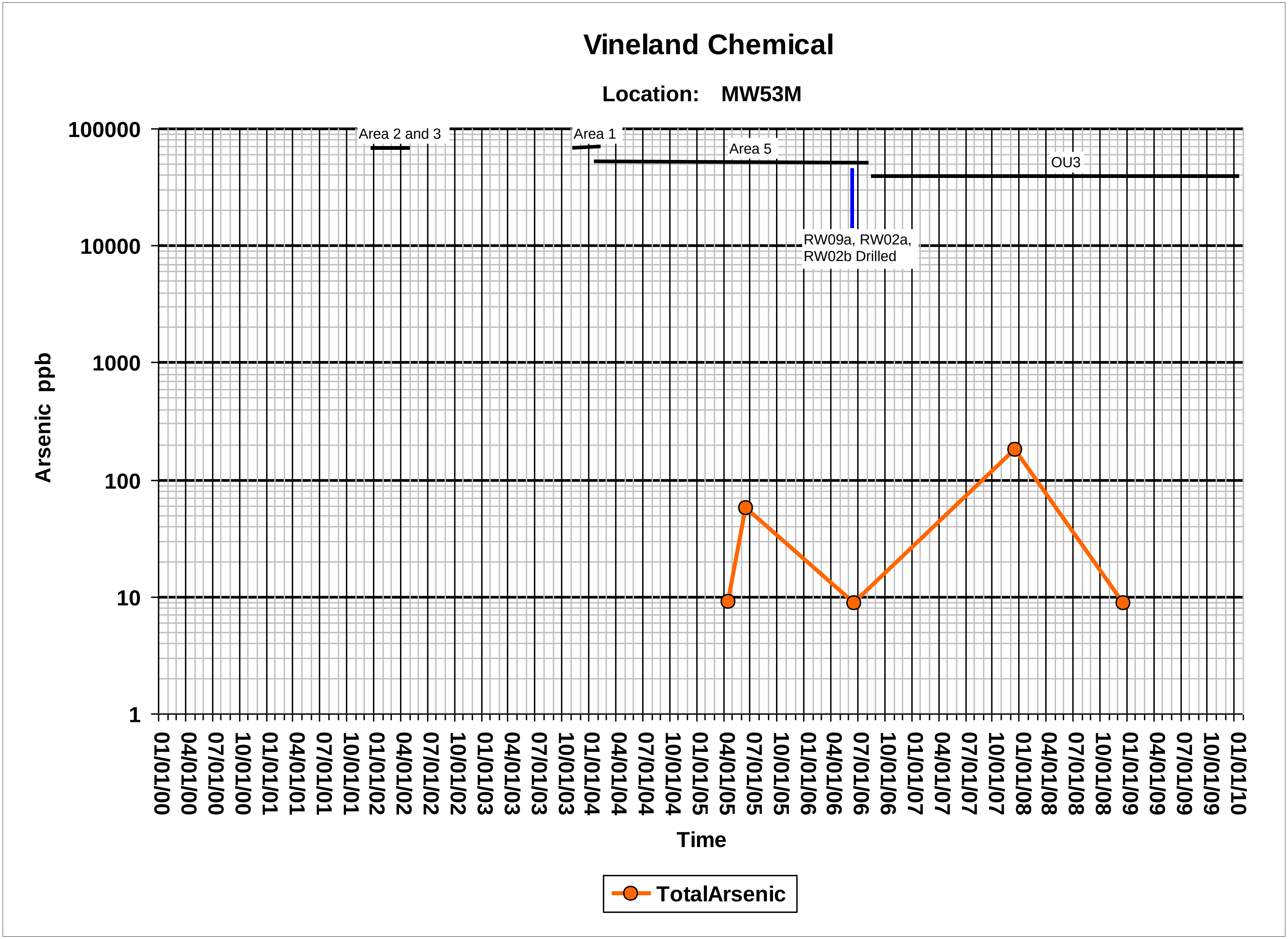
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: MW53M
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
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04/01/08
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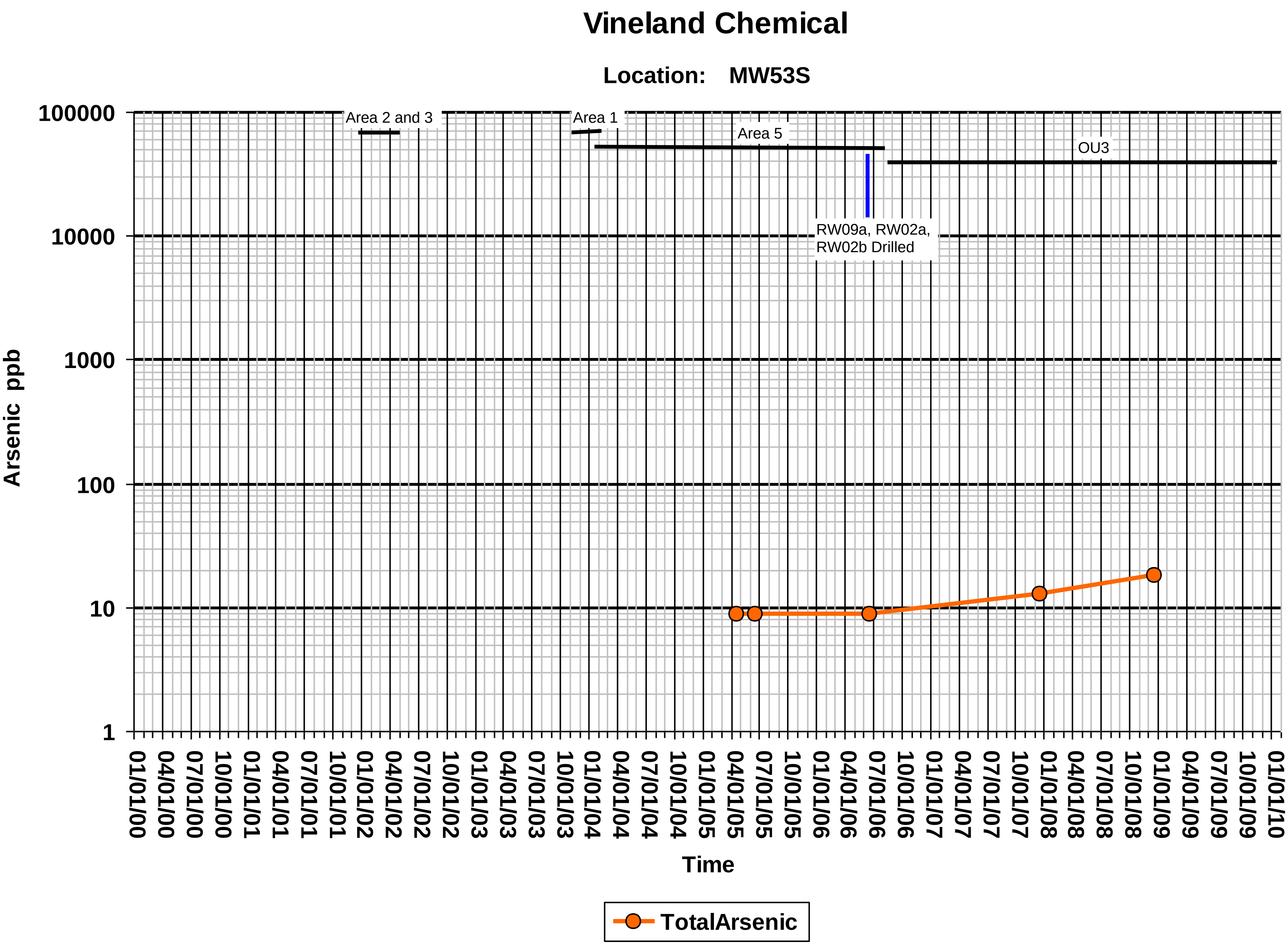
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic



Vineland Chemical
Location: MW53S
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
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04/01/08
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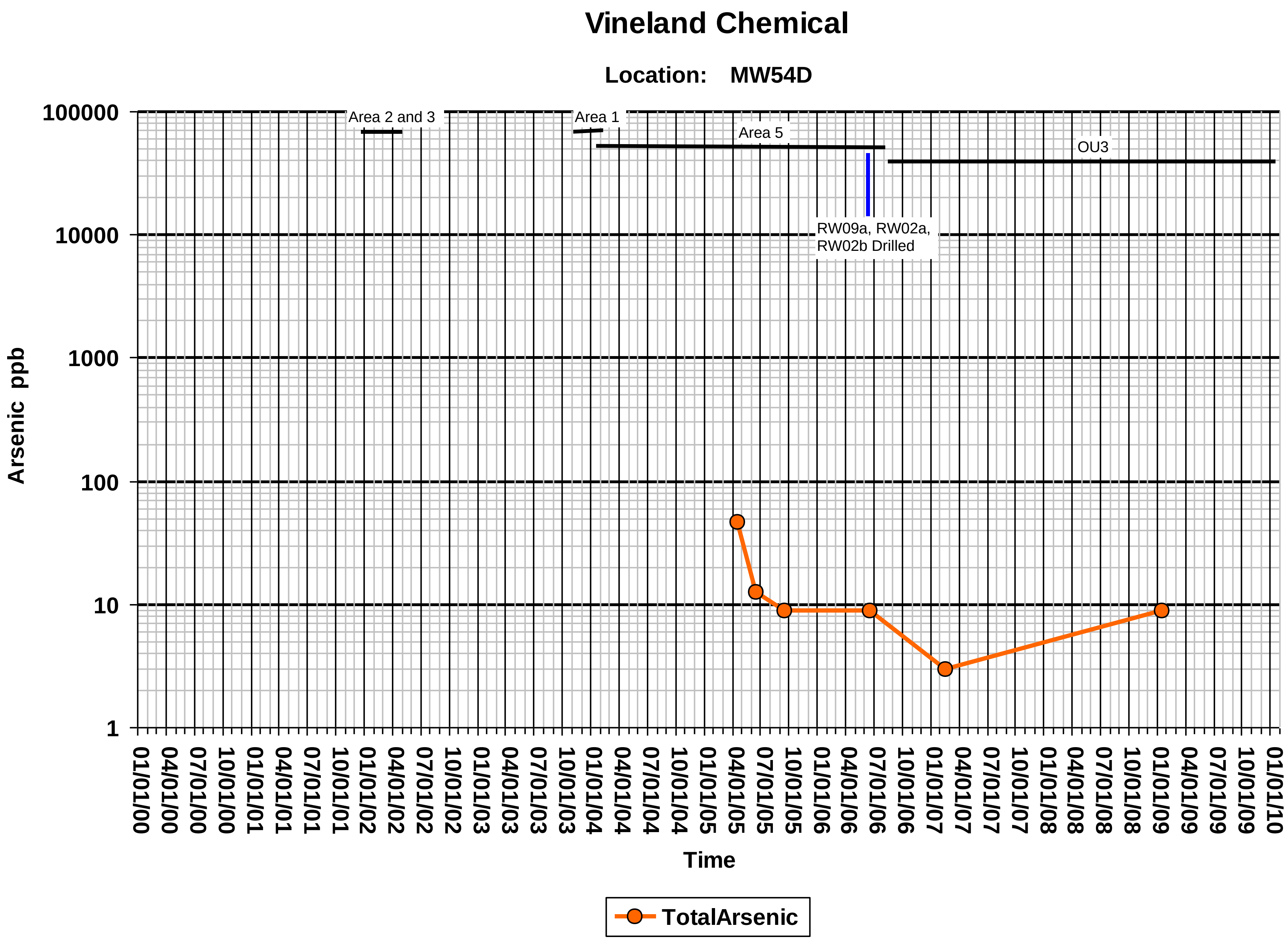
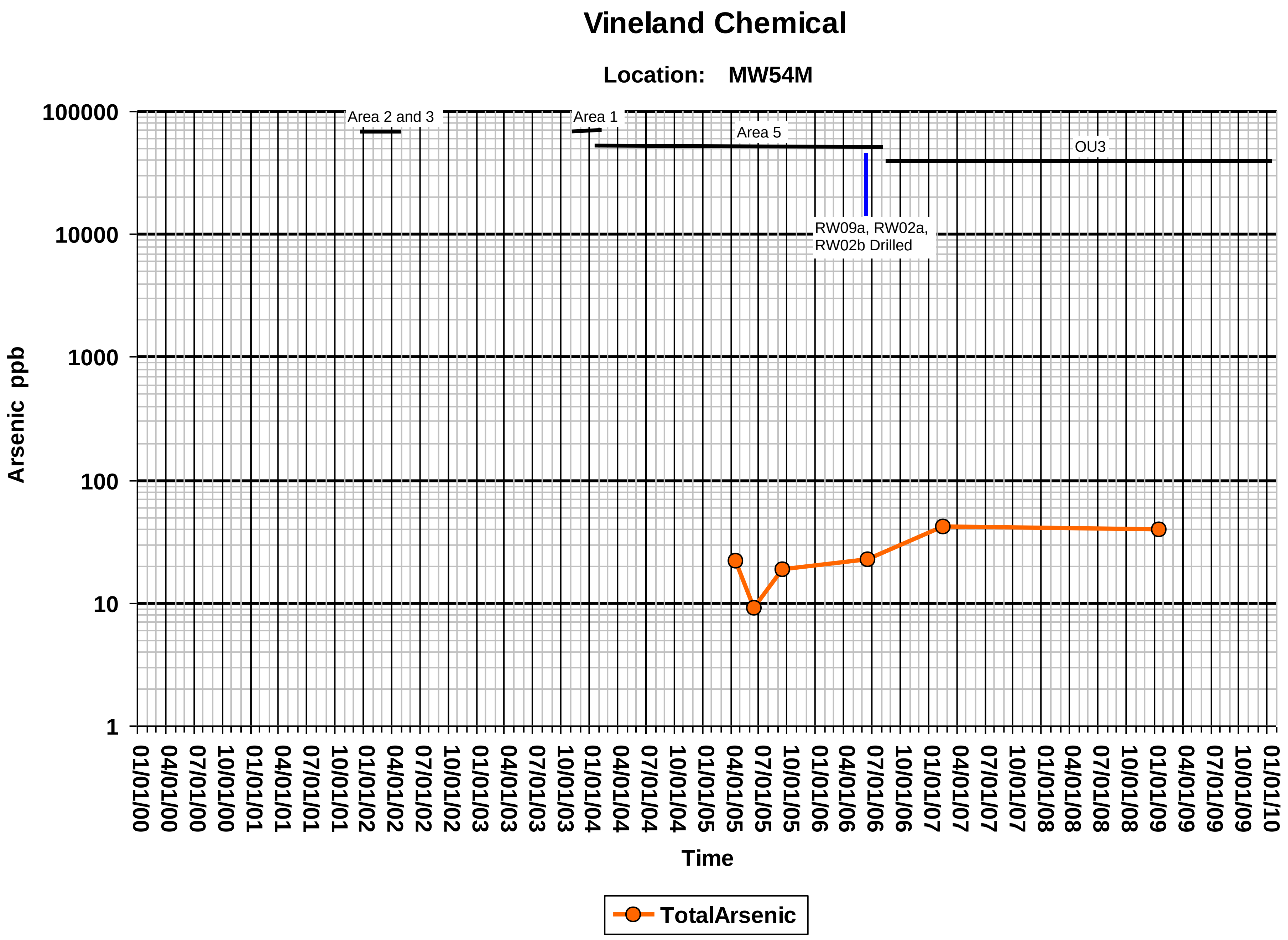
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic



Vineland Chemical

Location: MW54D


Vineland Chemical
Location: MW54M
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
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01/01/08
04/01/08
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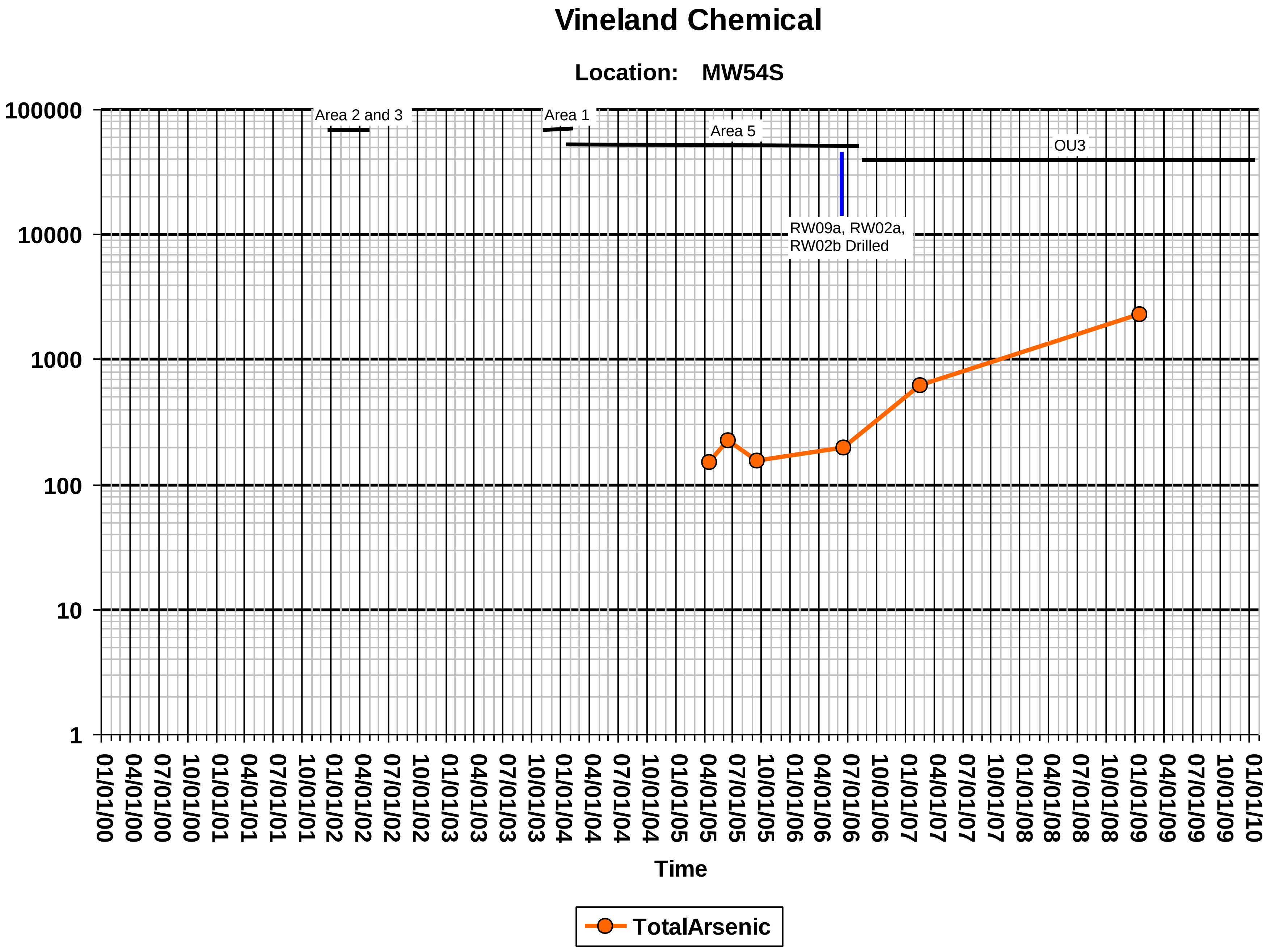
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: MW54S
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
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01/01/08
04/01/08
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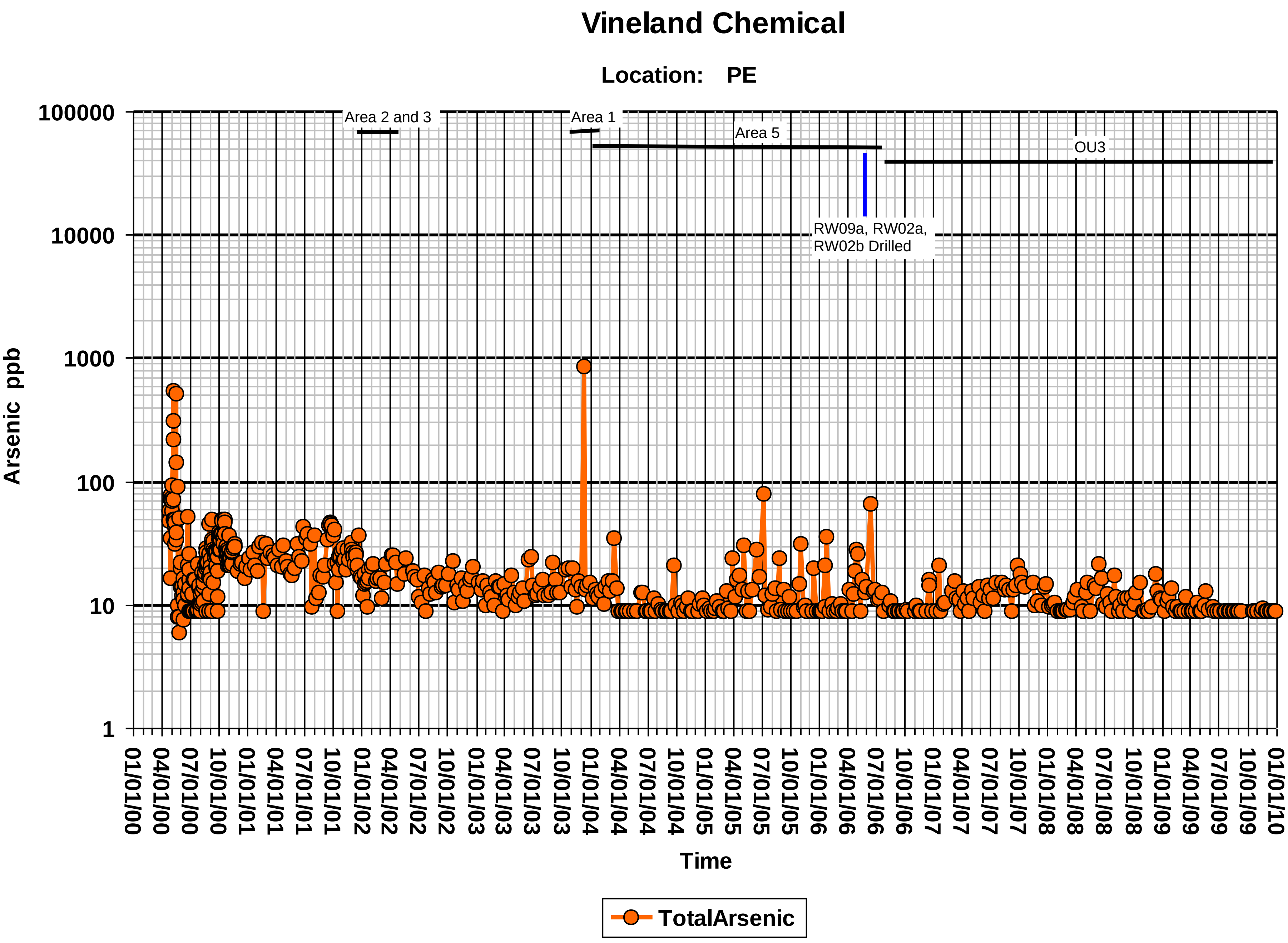
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: PE
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
10/01/02
01/01/03
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07/01/03
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01/01/08
04/01/08
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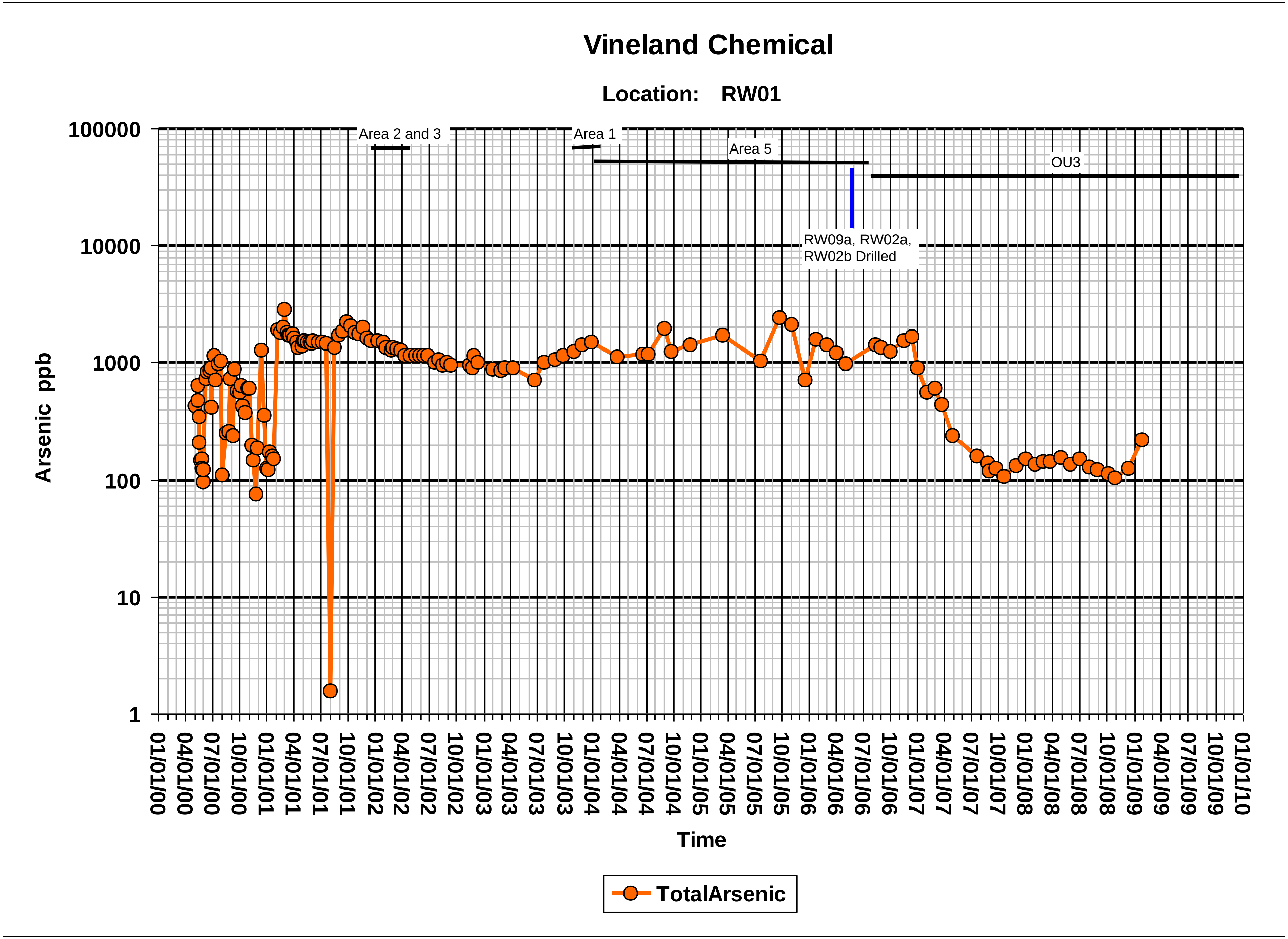
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: RW01
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
100000
10000
1000
100
10
1
Arsenic ppb
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
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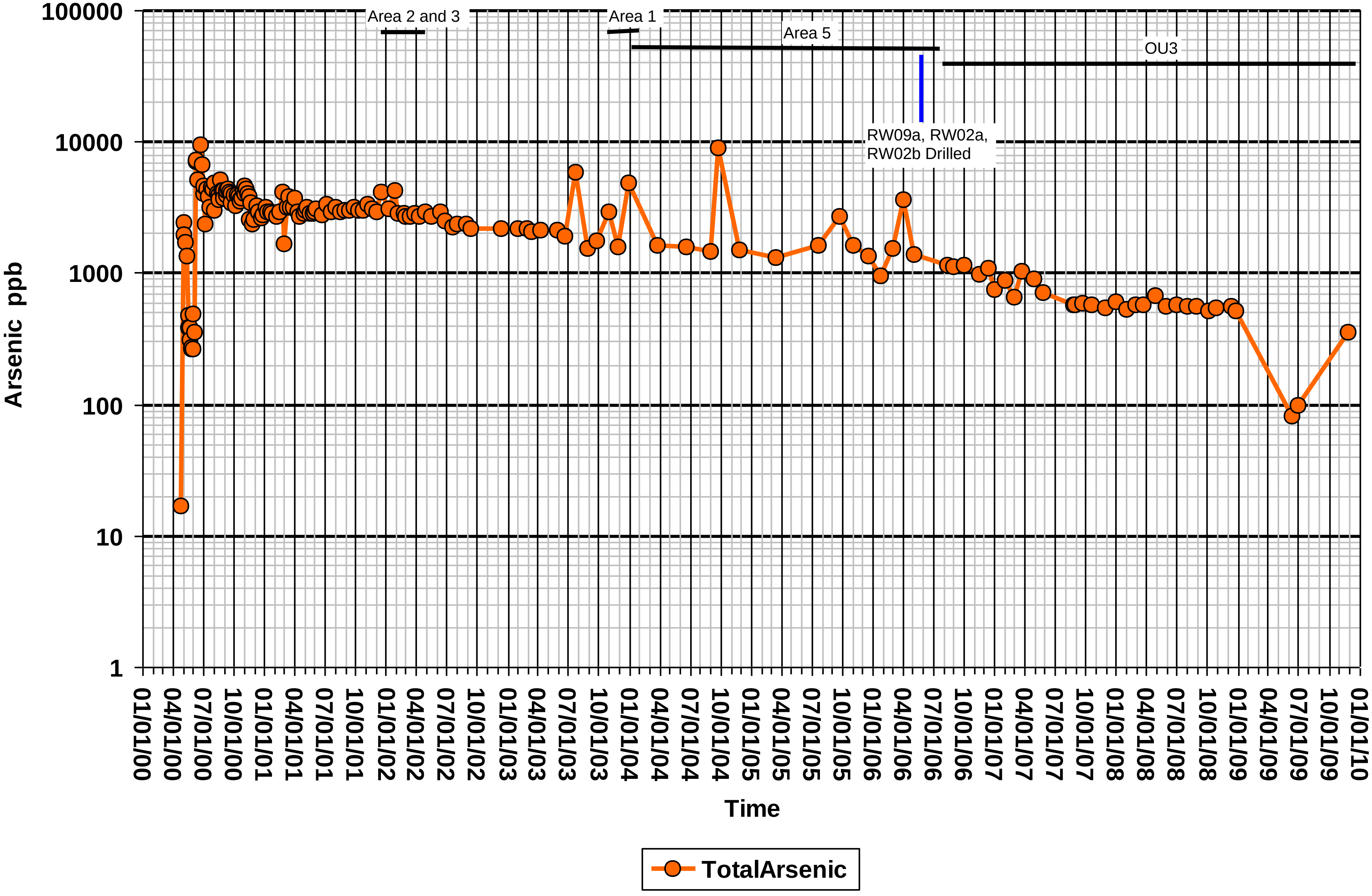
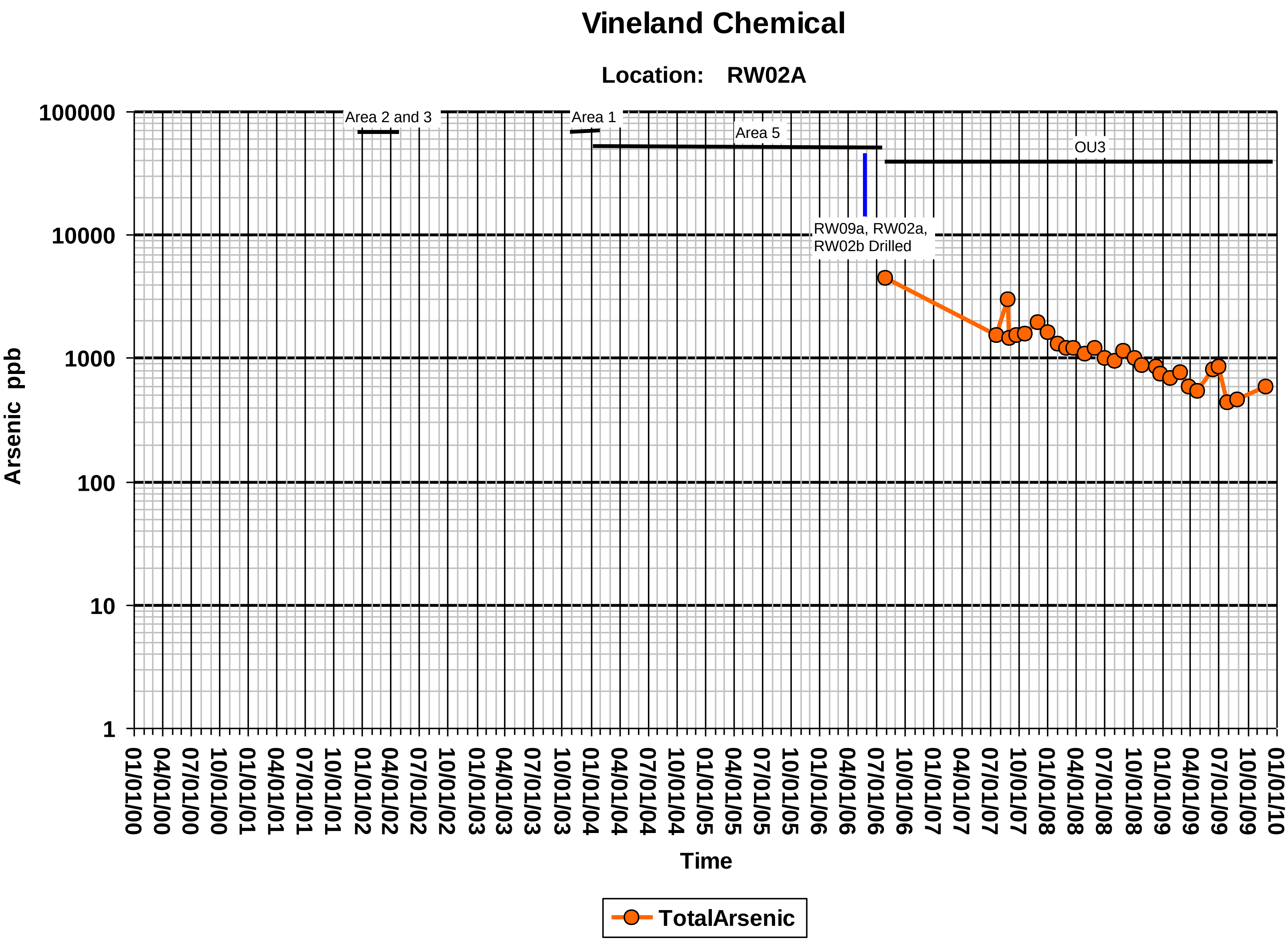
01/01/08
04/01/08
07/01/08
10/01/08
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic

Vineland Chemical

Location: RW02




Vineland Chemical
Location: RW02A
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
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04/01/08
07/01/08
10/01/08
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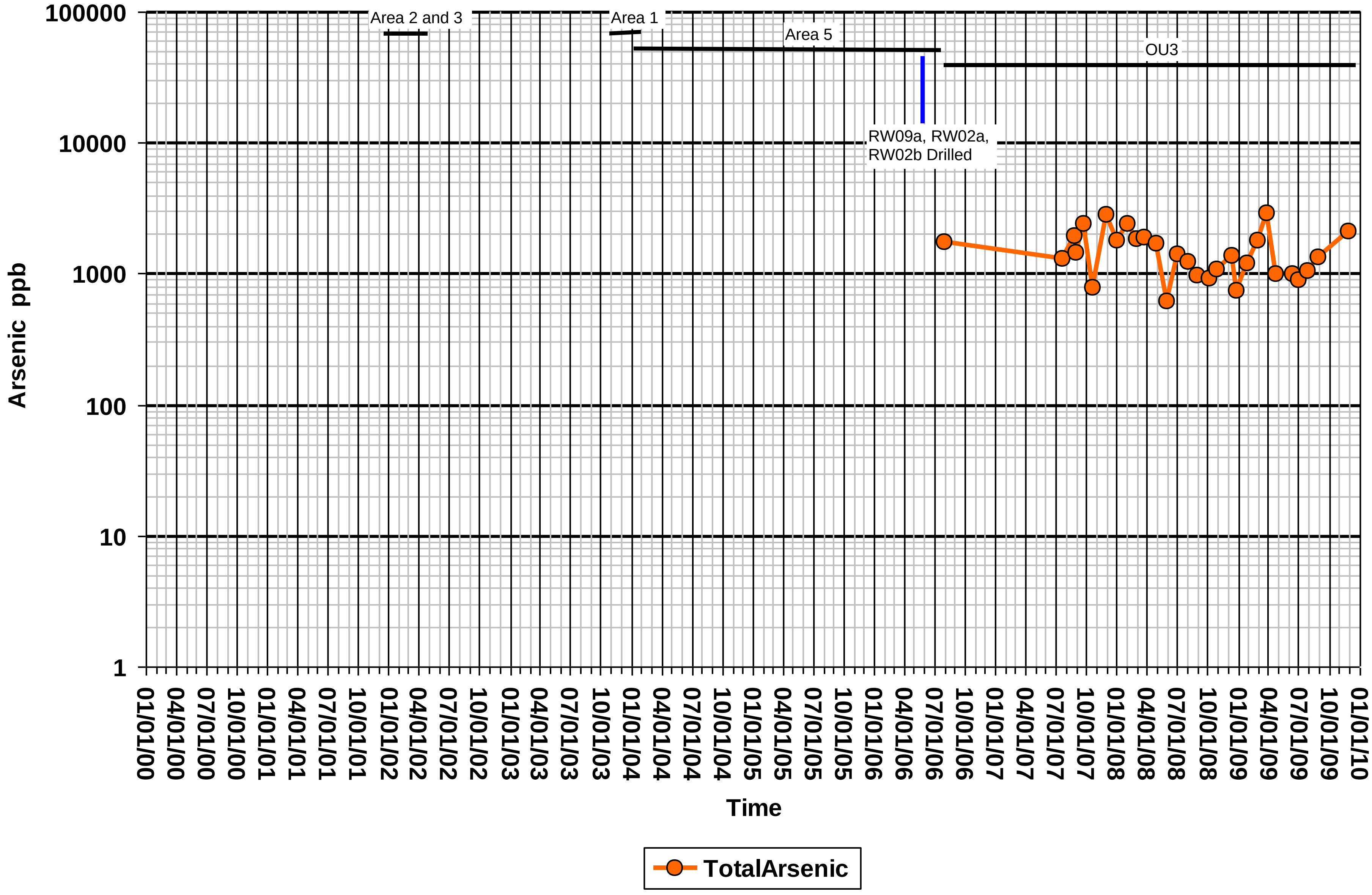
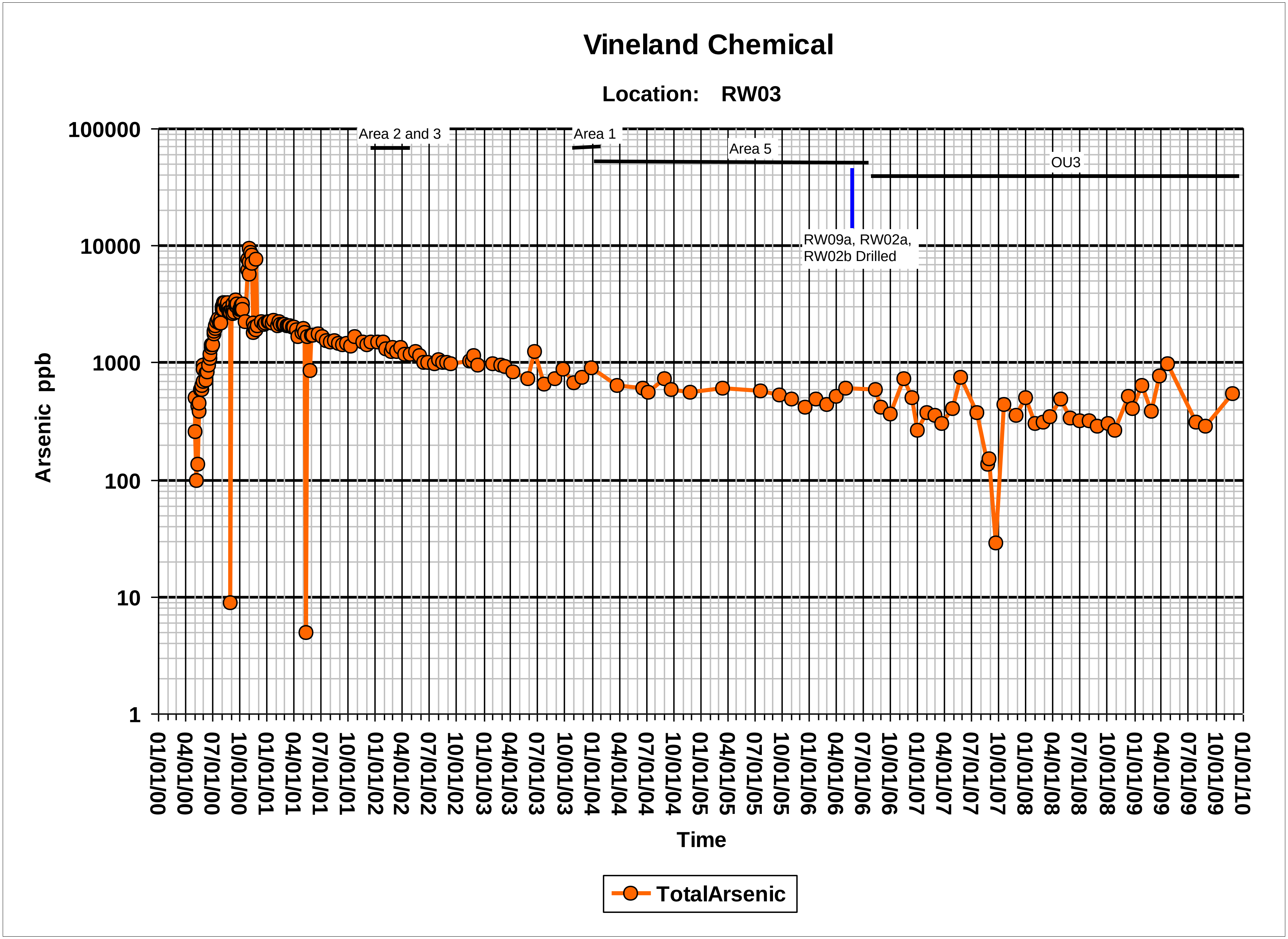
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic

Vineland Chemical

Location: RW02B




Vineland Chemical
Location: RW03
100000
10000
1000
100
10
1
Arsenic ppb
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
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01/01/08
04/01/08
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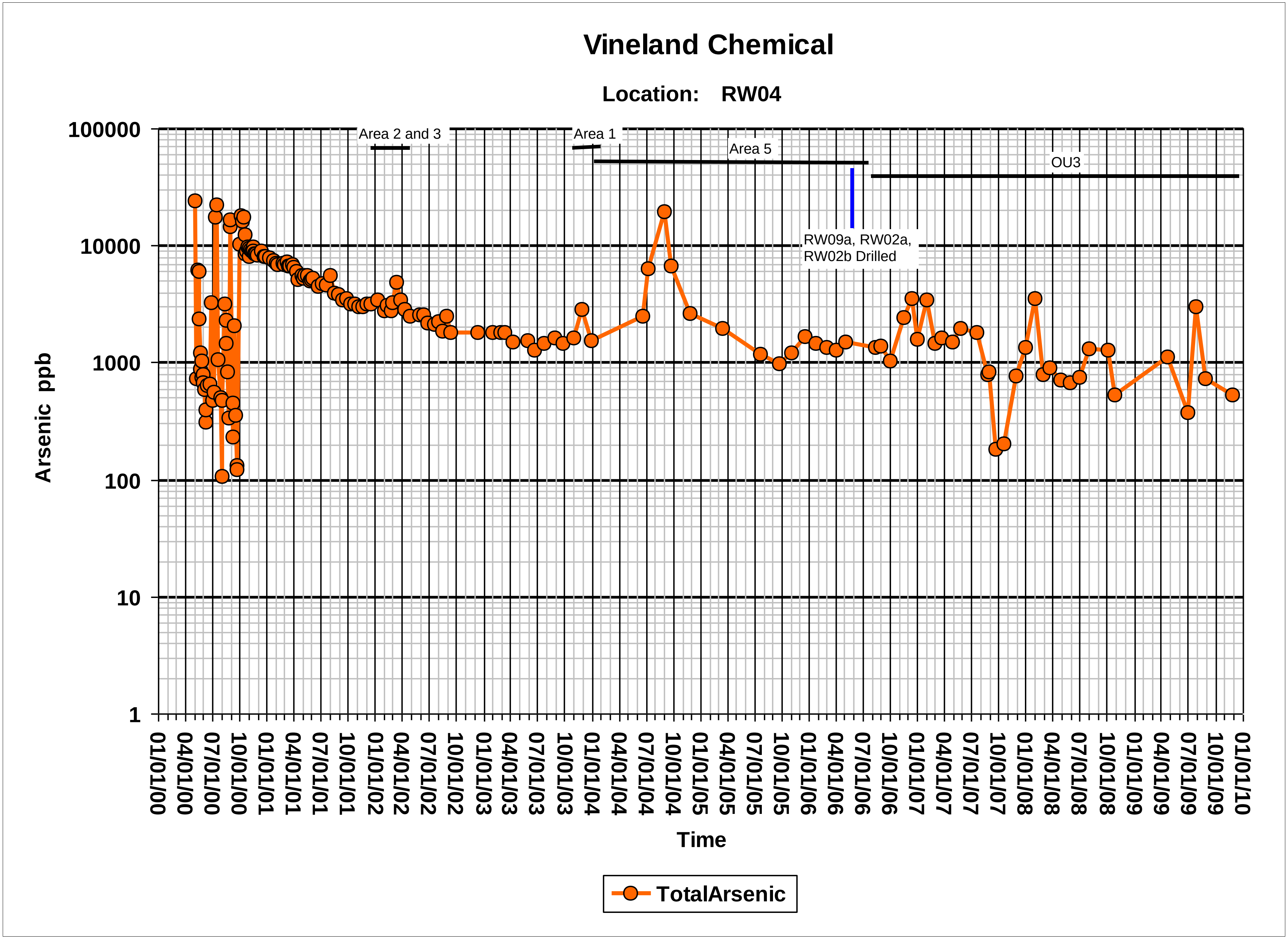
10/01/08
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: RW04
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a,
RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
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01/01/08
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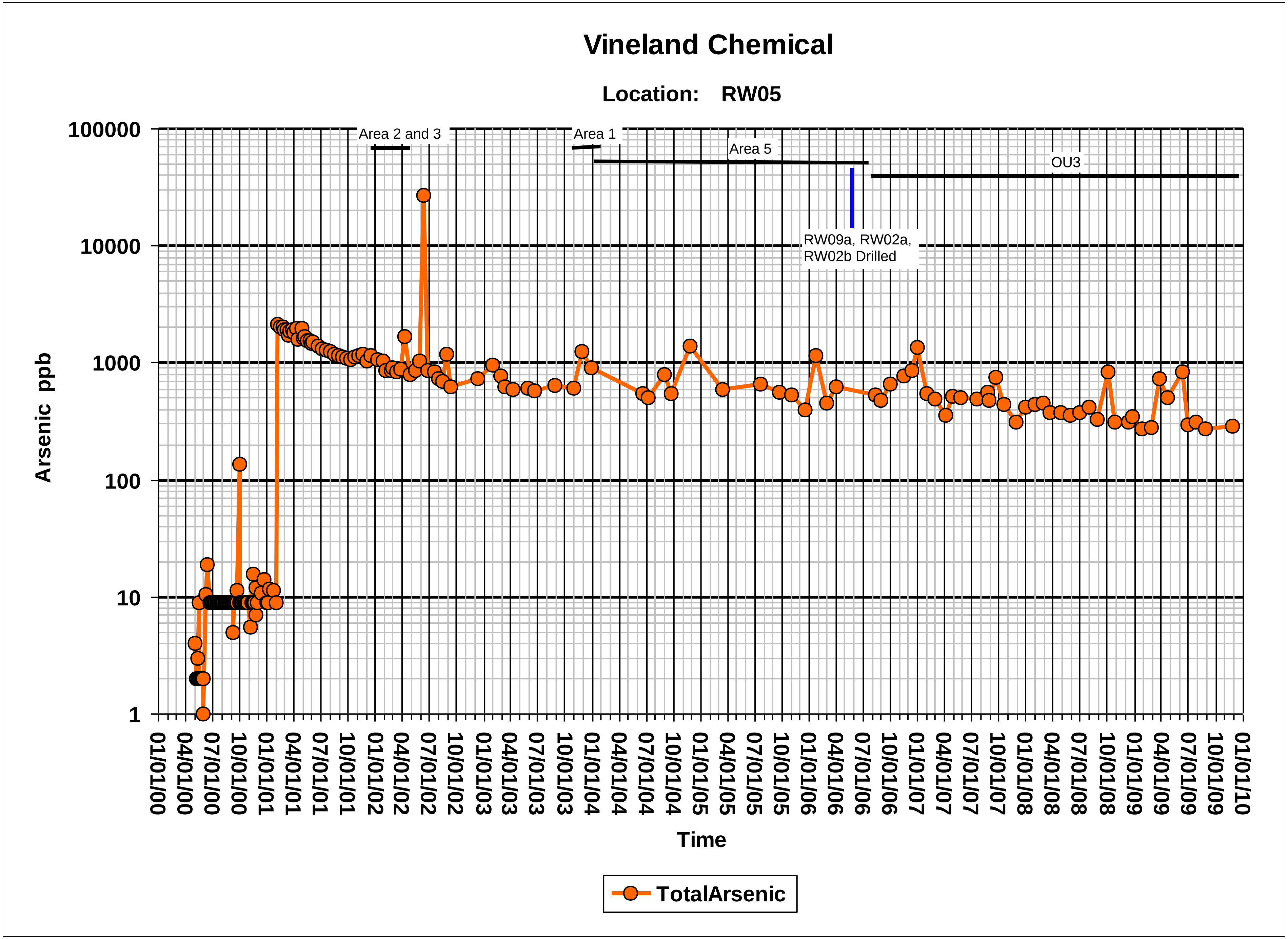
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: RW05
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
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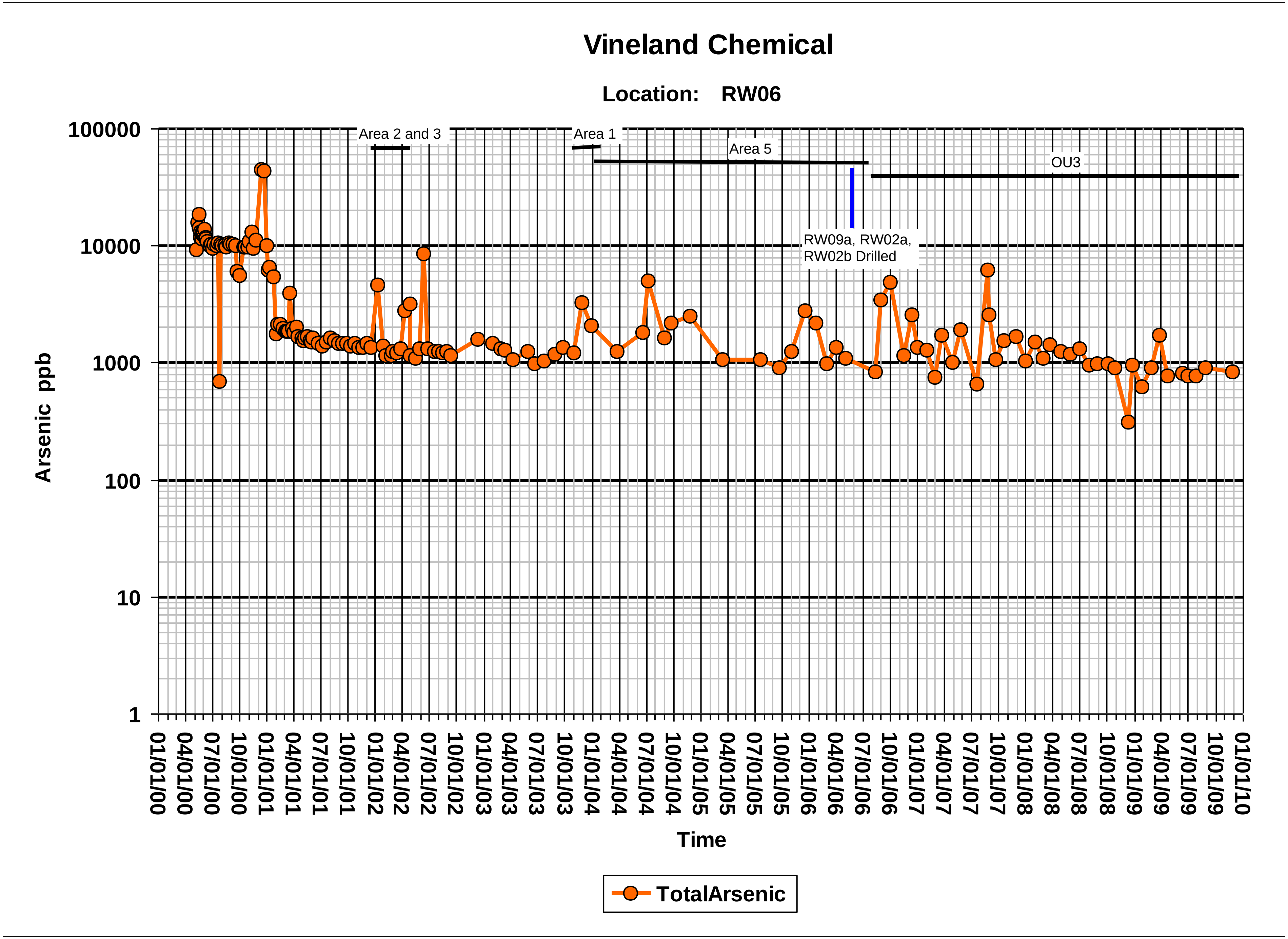
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: RW06
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
10/01/02
01/01/03
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07/01/03
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01/01/06
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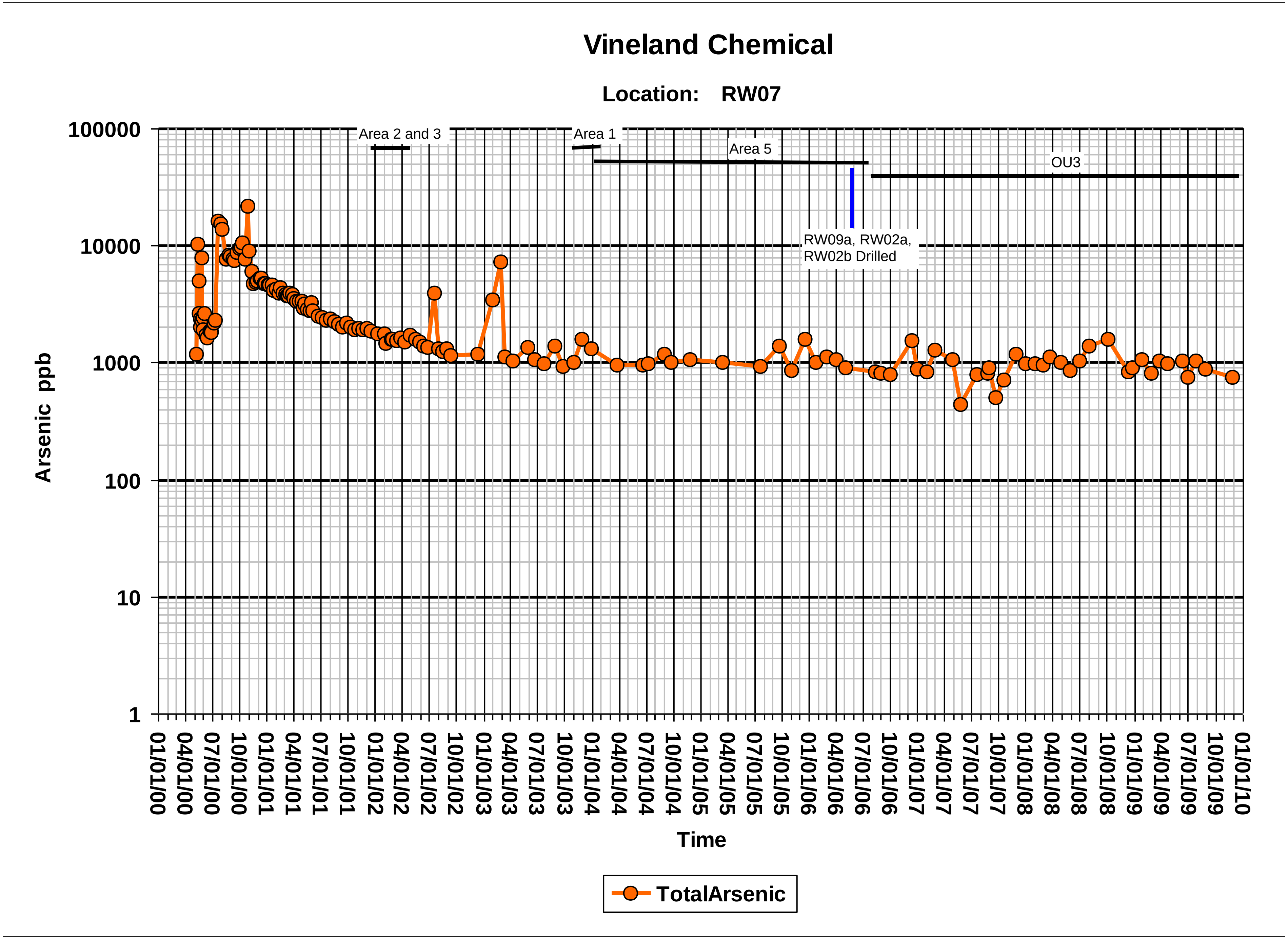
07/01/06
10/01/06
01/01/07
04/01/07
07/01/07
10/01/07
01/01/08
04/01/08
07/01/08
10/01/08
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: RW07
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
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07/01/04
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01/01/06
04/01/06
07/01/06
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01/01/07
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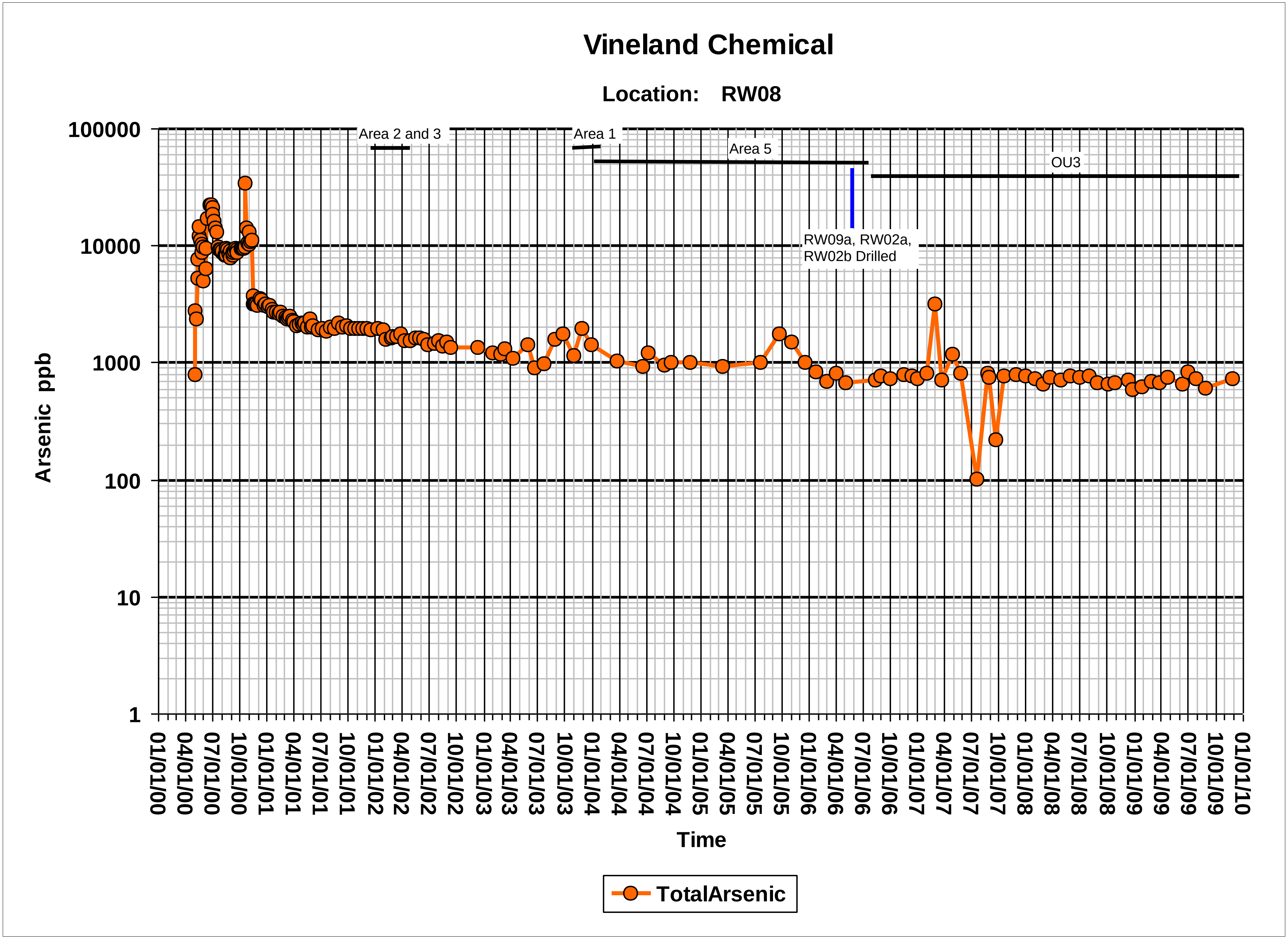
07/01/07
10/01/07
01/01/08
04/01/08
07/01/08
10/01/08
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: RW08
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
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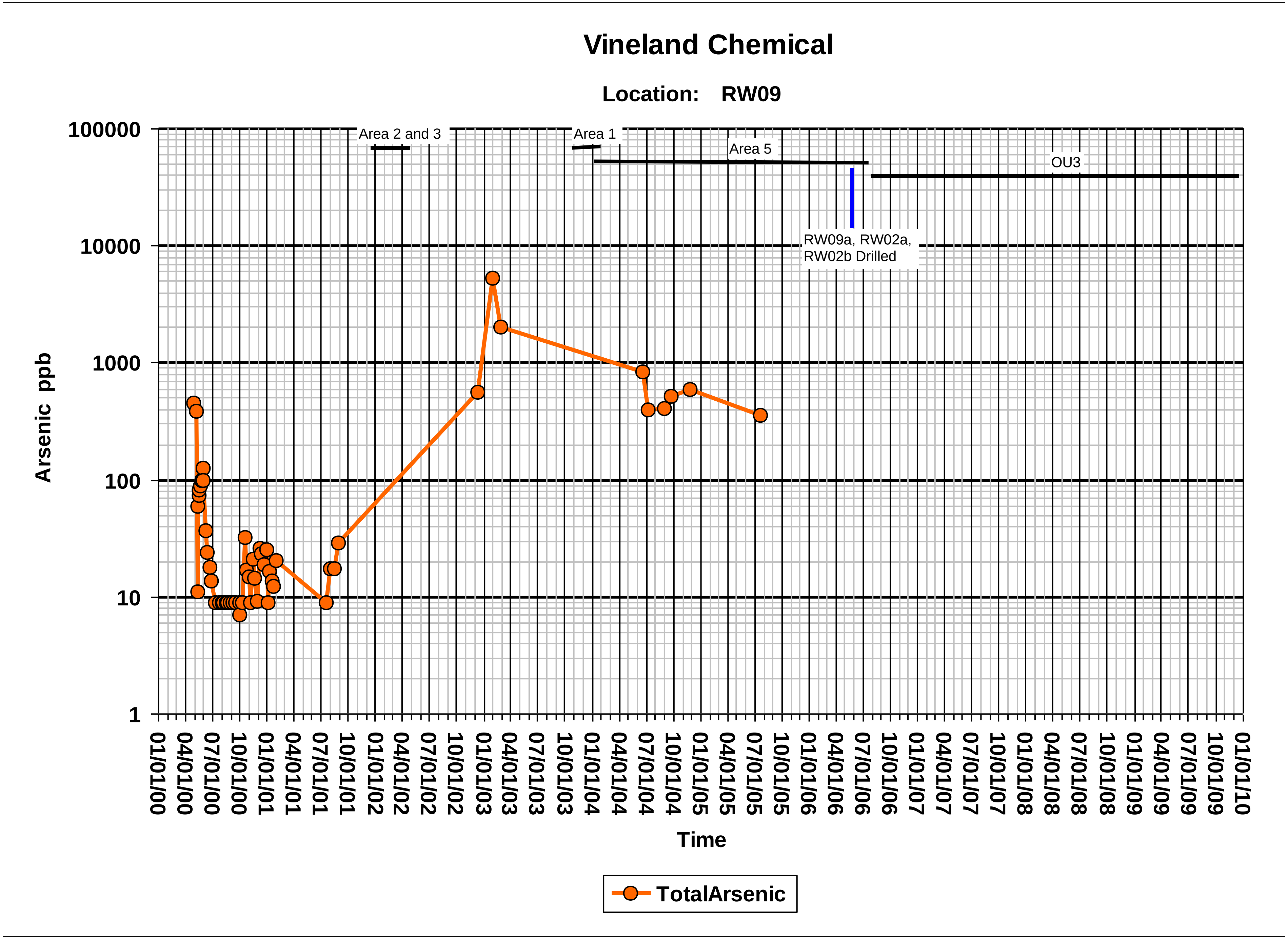
01/01/08
04/01/08
07/01/08
10/01/08
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: RW09
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
10/01/02
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01/01/08
04/01/08
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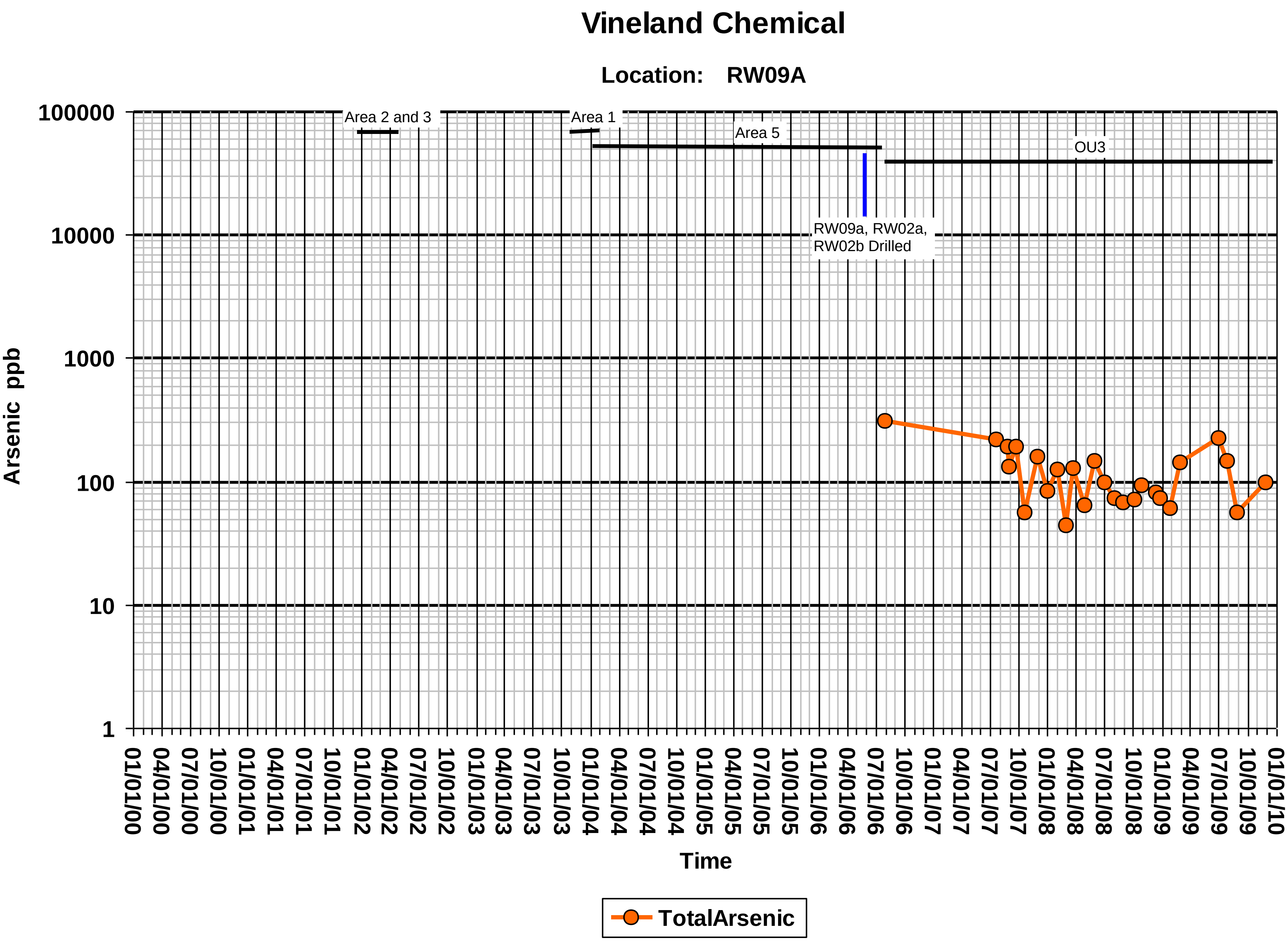
10/01/08
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic



Vineland Chemical
Location: RW09A
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
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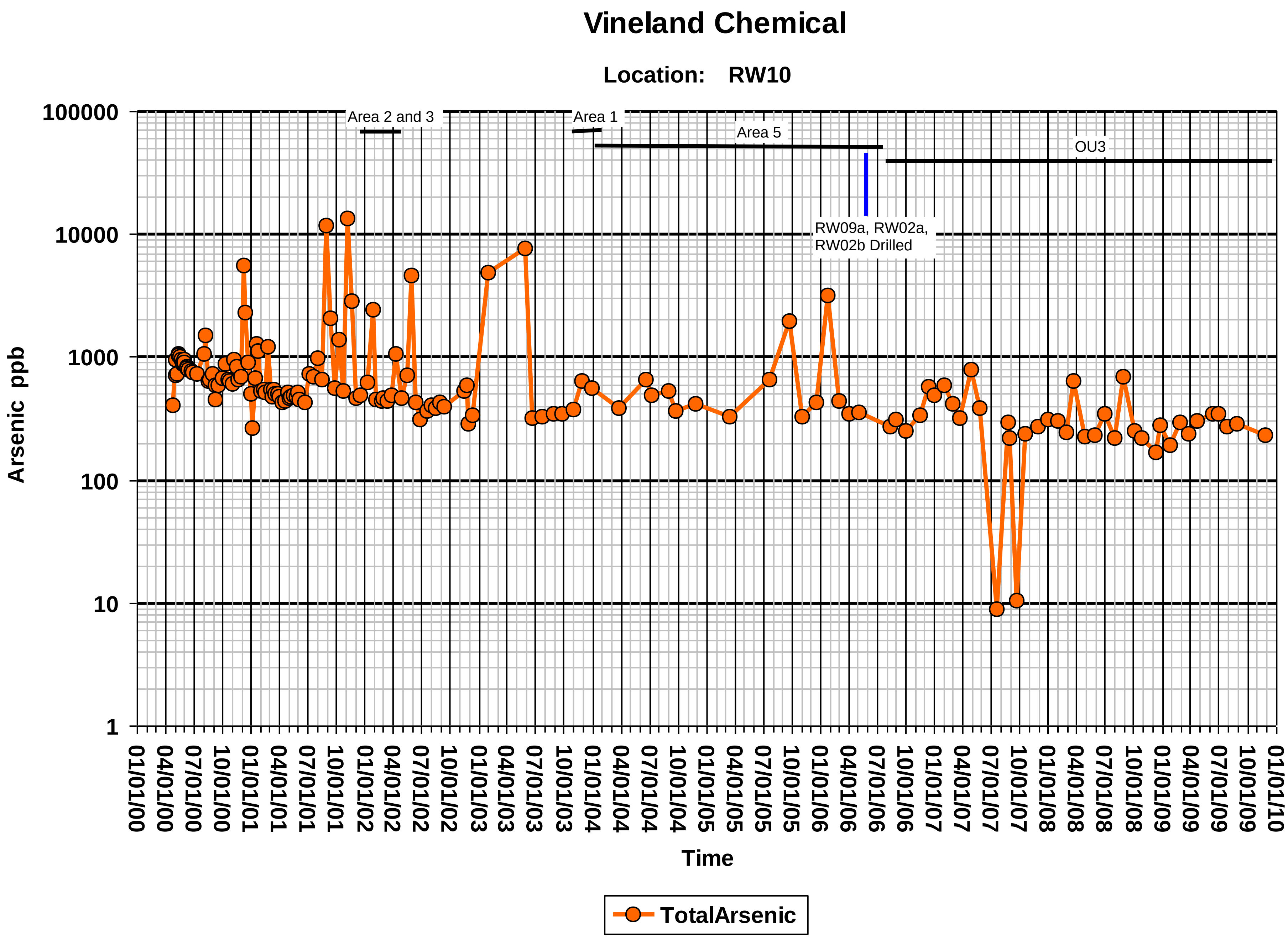
01/01/08
04/01/08
07/01/08
10/01/08
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic



Vineland Chemical
Location: RW10
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
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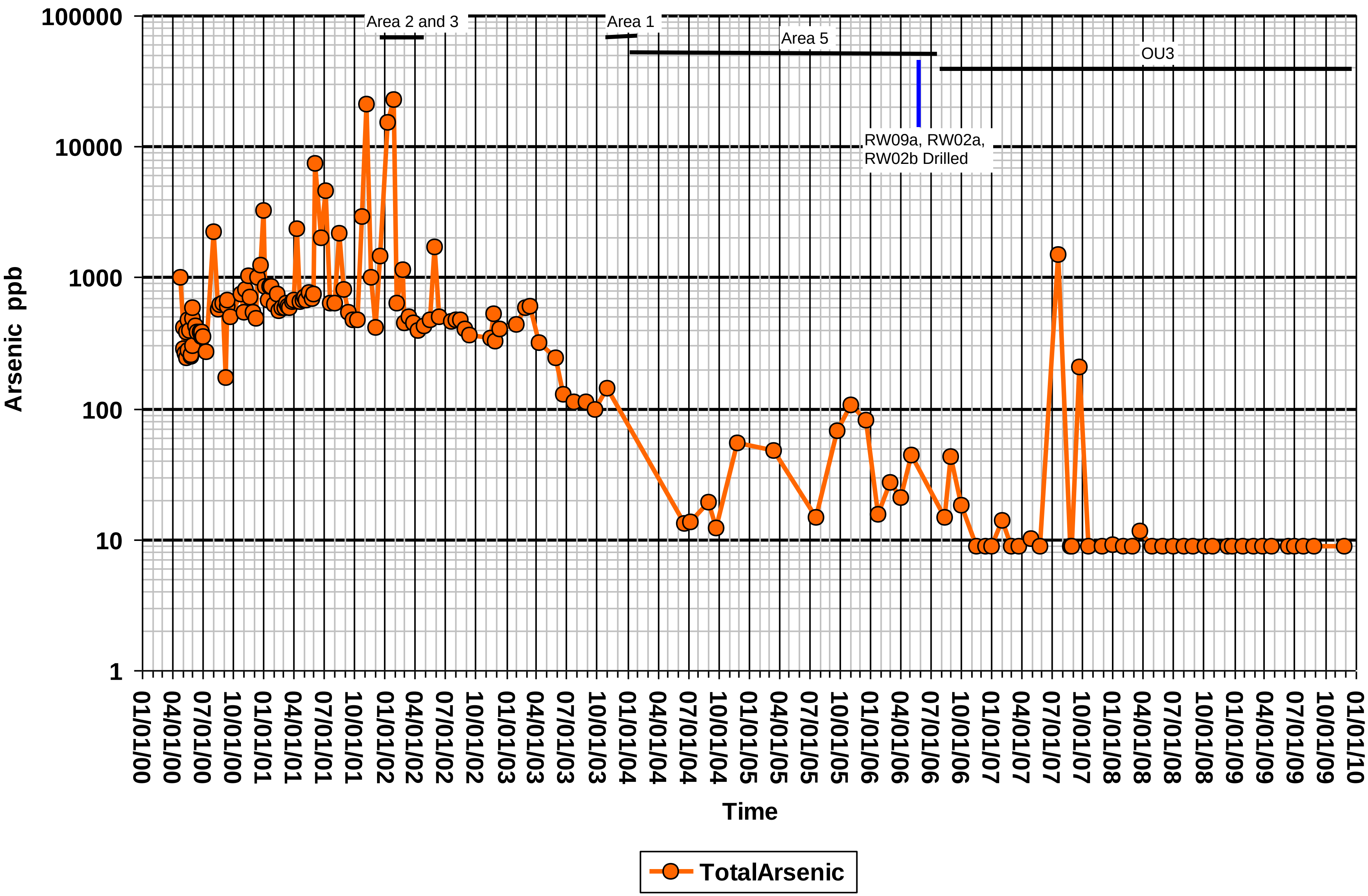
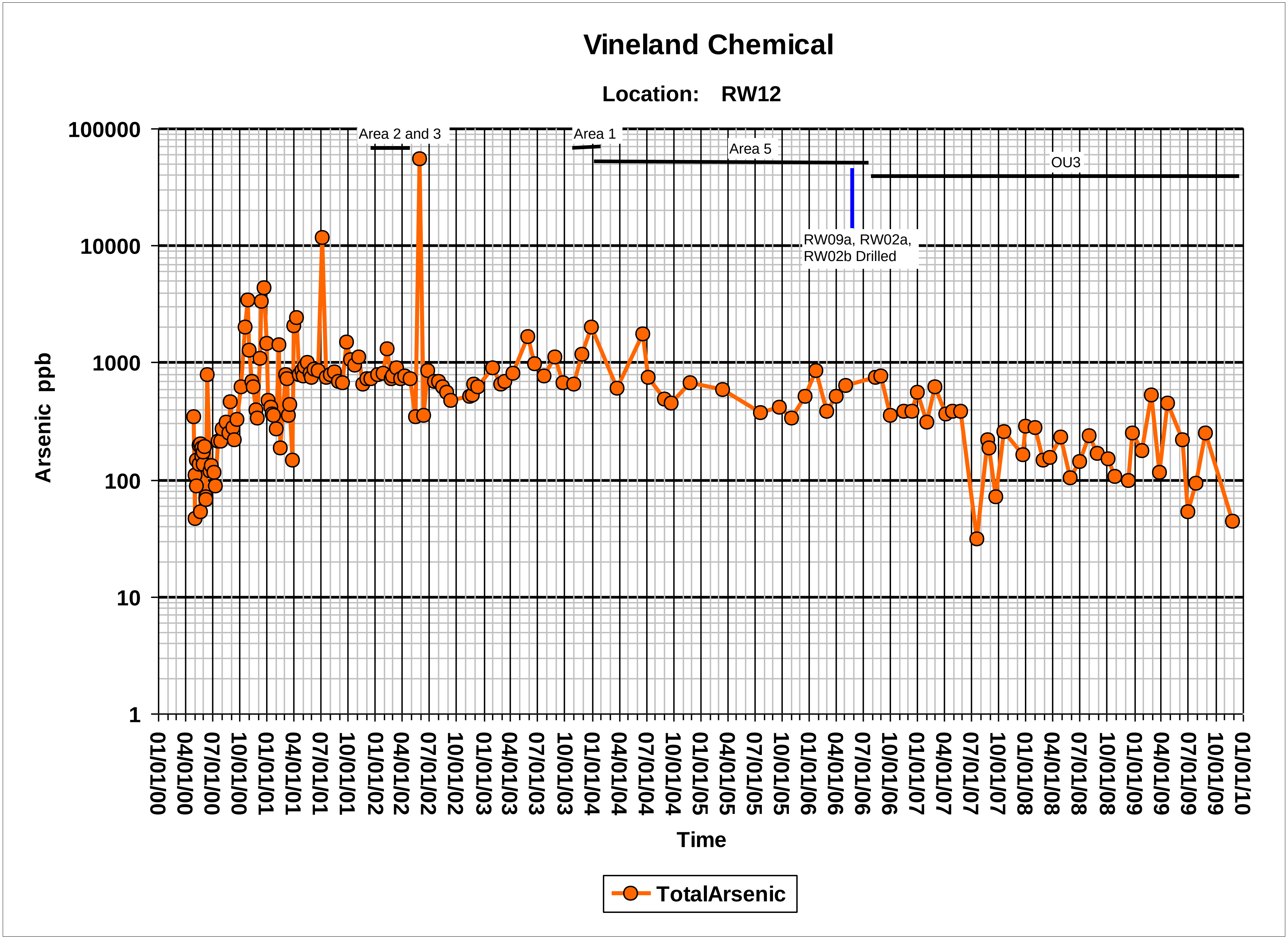
07/01/06
10/01/06
01/01/07
04/01/07
07/01/07
10/01/07
01/01/08
04/01/08
07/01/08
10/01/08
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic



Vineland Chemical

Location: RW11


Vineland Chemical
Location: RW12
100000
10000
1000
100
10
1
Arsenic ppb
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
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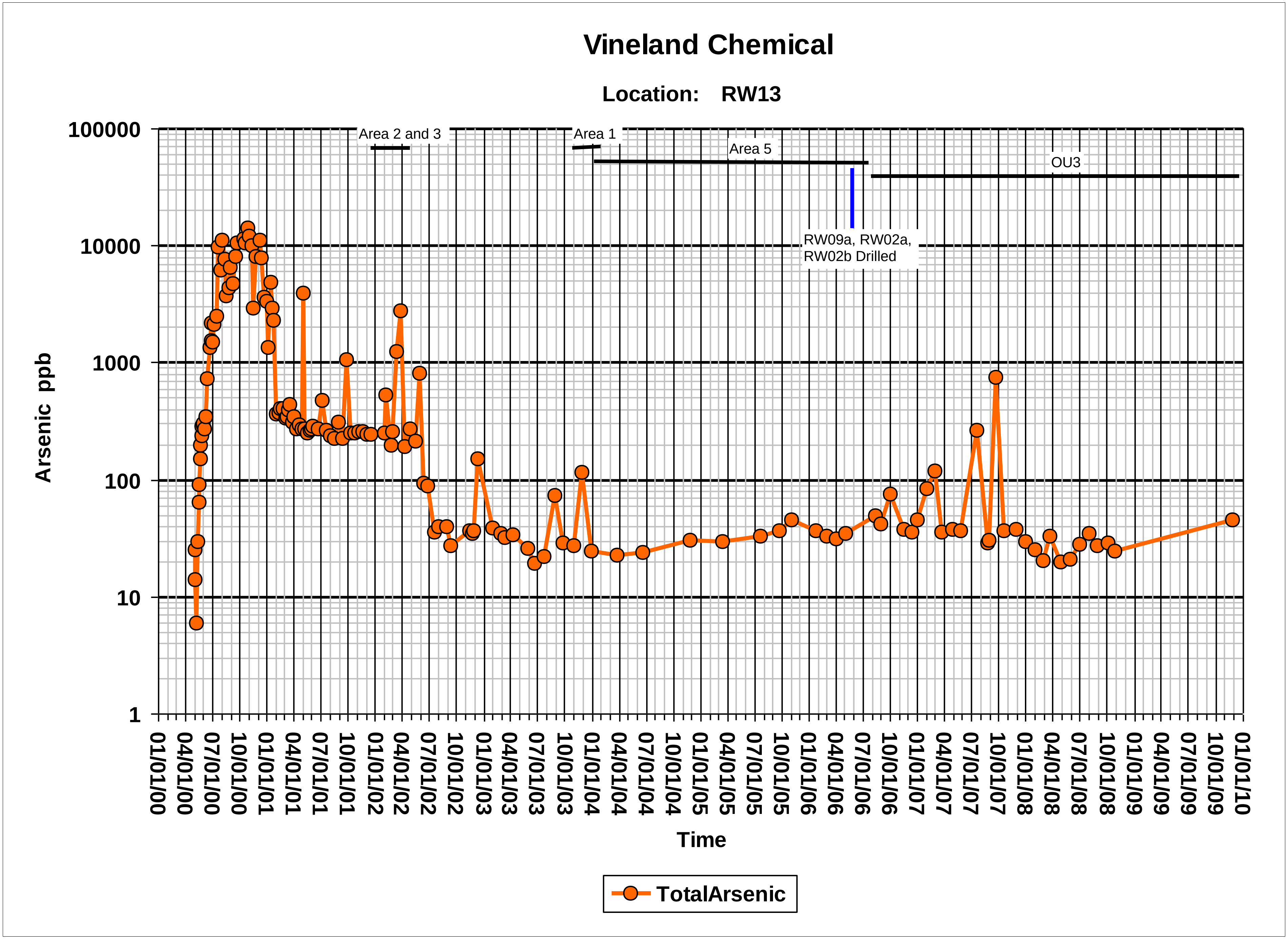
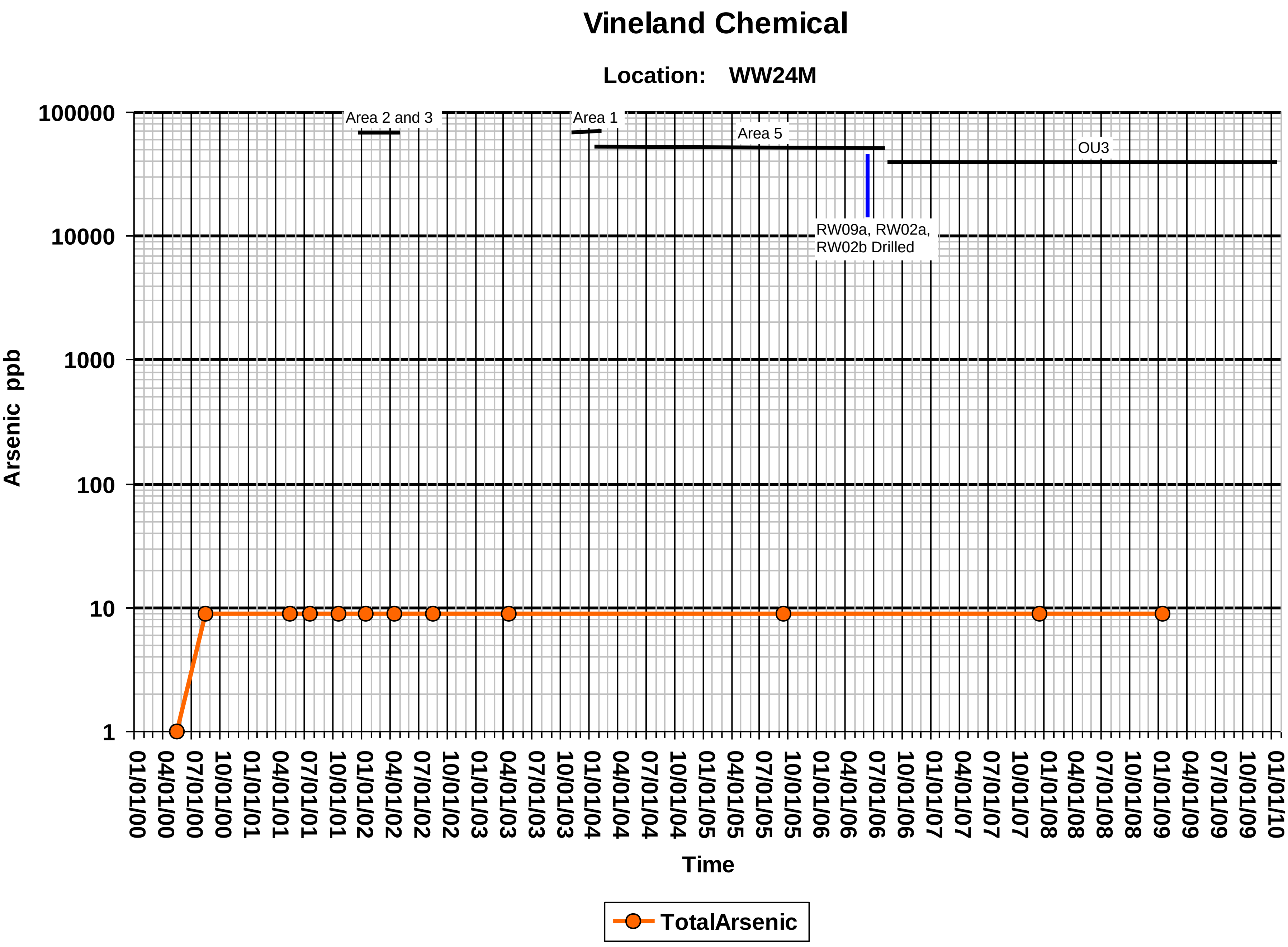
01/01/08
04/01/08
07/01/08
10/01/08
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic



Vineland Chemical

Location: RW13



Vineland Chemical
Location: WW24M
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
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04/01/03
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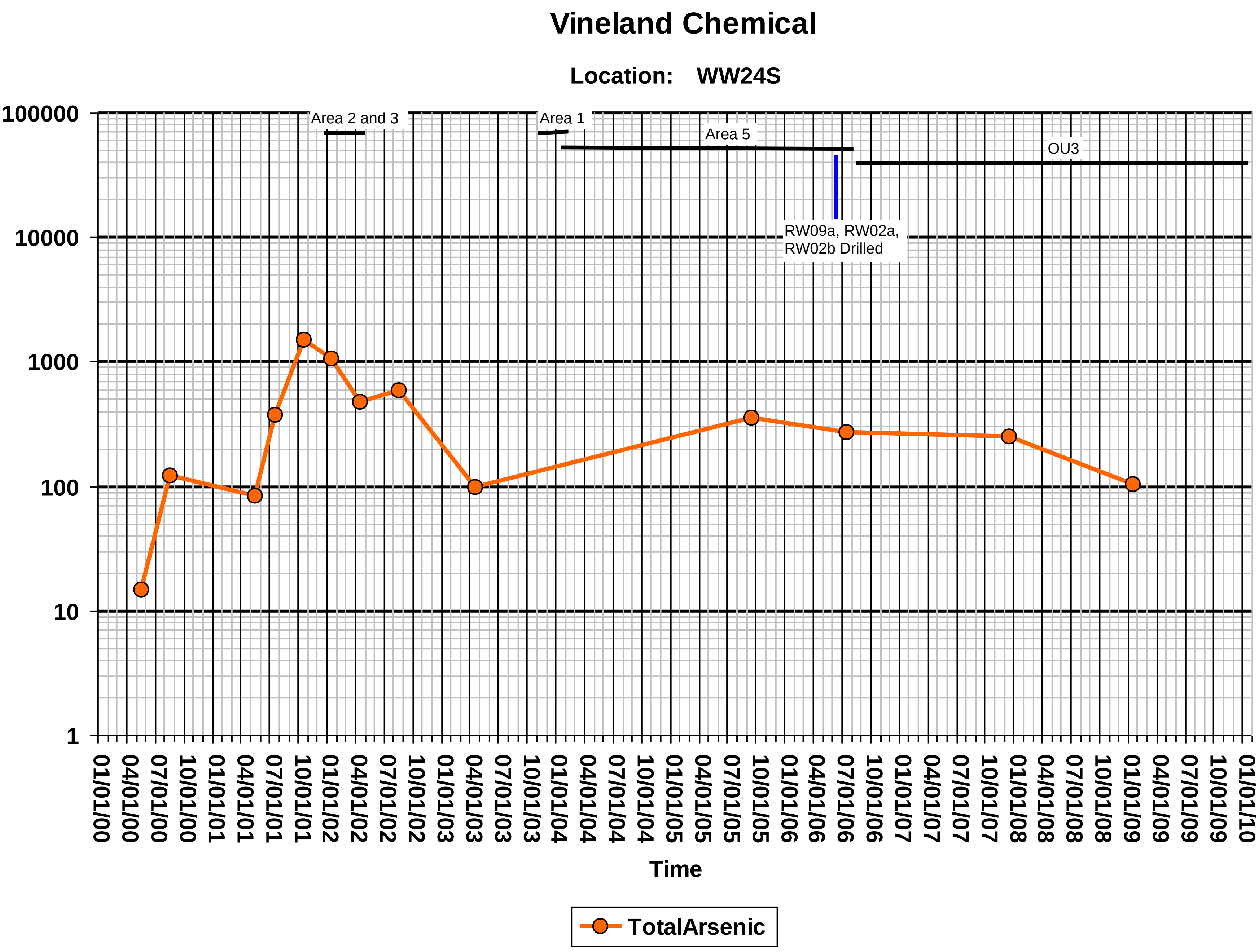
01/01/08
04/01/08
07/01/08
10/01/08
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: WW24S
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
07/01/02
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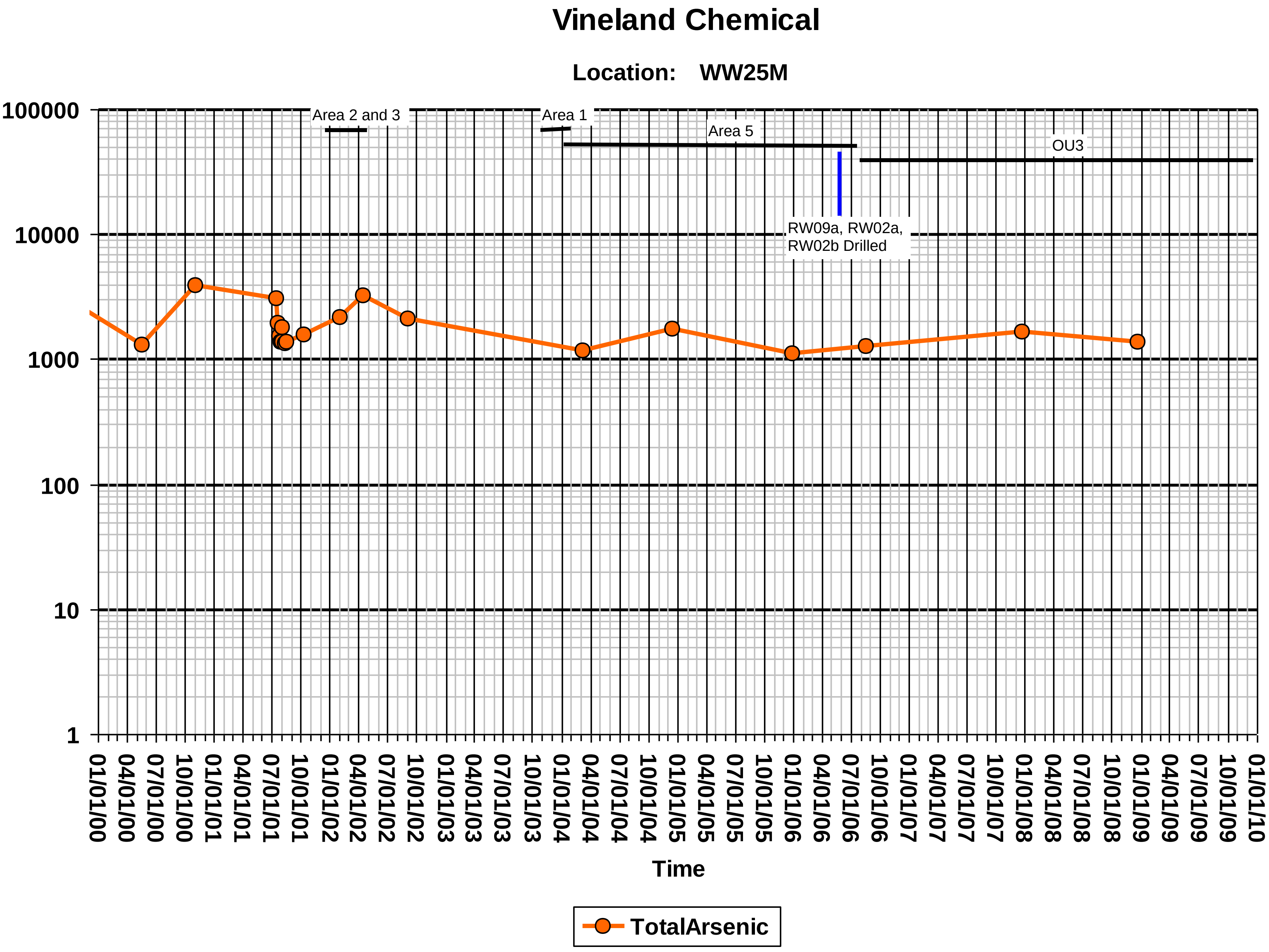
01/01/08
04/01/08
07/01/08
10/01/08
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: WW25M
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
04/01/02
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01/01/06
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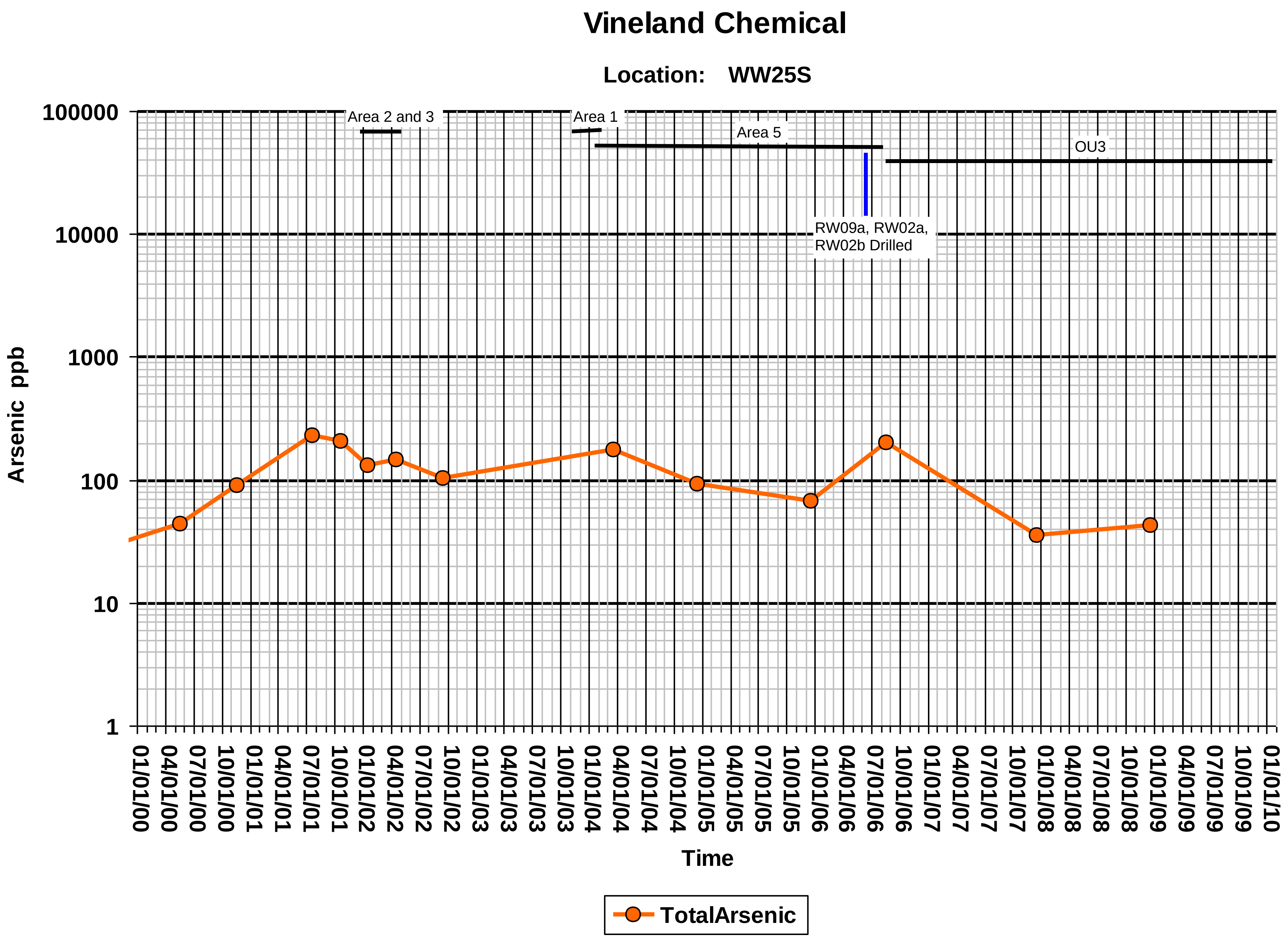
07/01/07
10/01/07
01/01/08
04/01/08
07/01/08
10/01/08
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: WW25S
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
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04/01/00
07/01/00
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07/01/01
10/01/01
01/01/02
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07/01/02
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01/01/06
04/01/06
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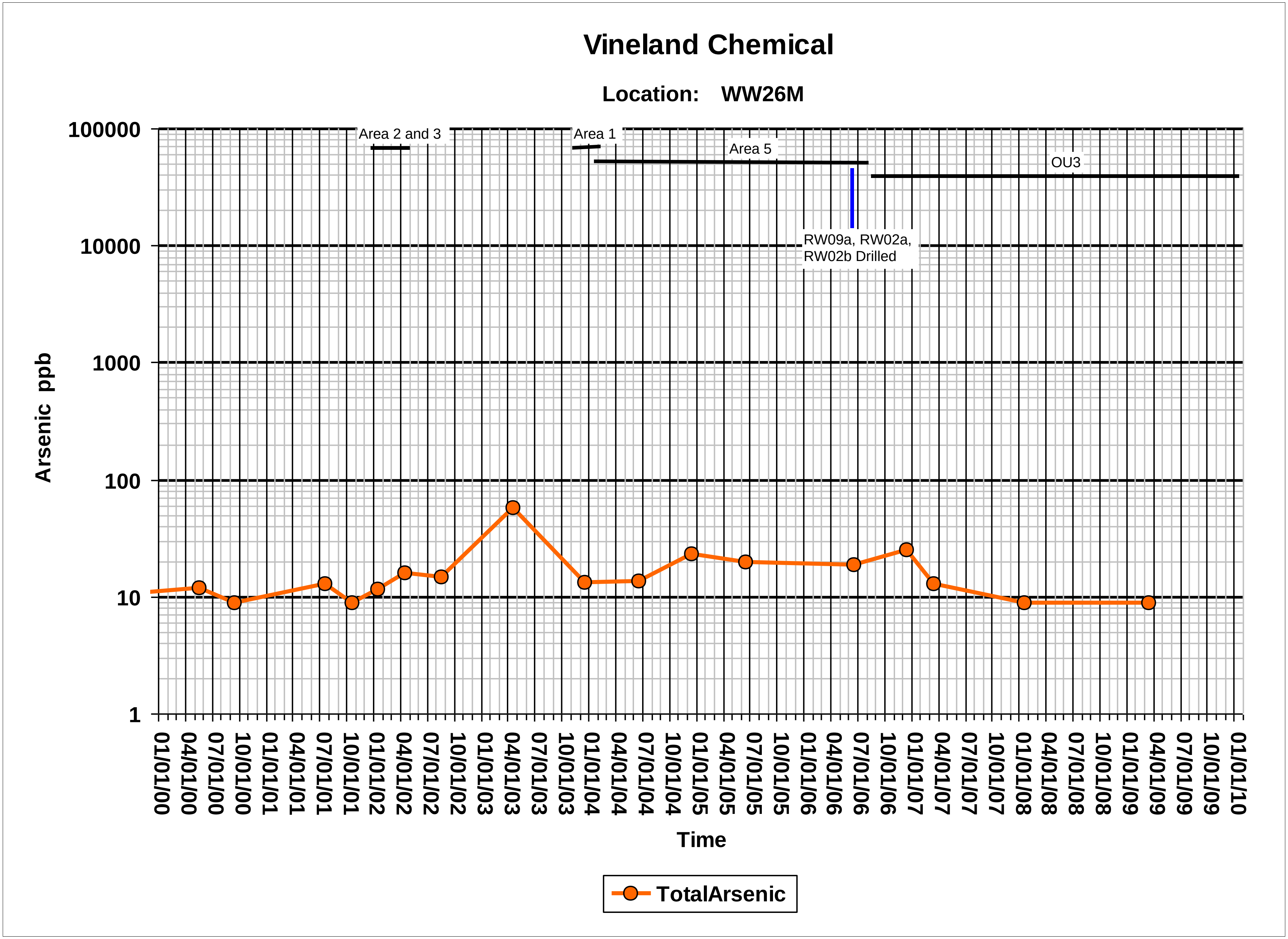
01/01/08
04/01/08
07/01/08
10/01/08
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: WW26M
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
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04/01/00
07/01/00
10/01/00
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04/01/01
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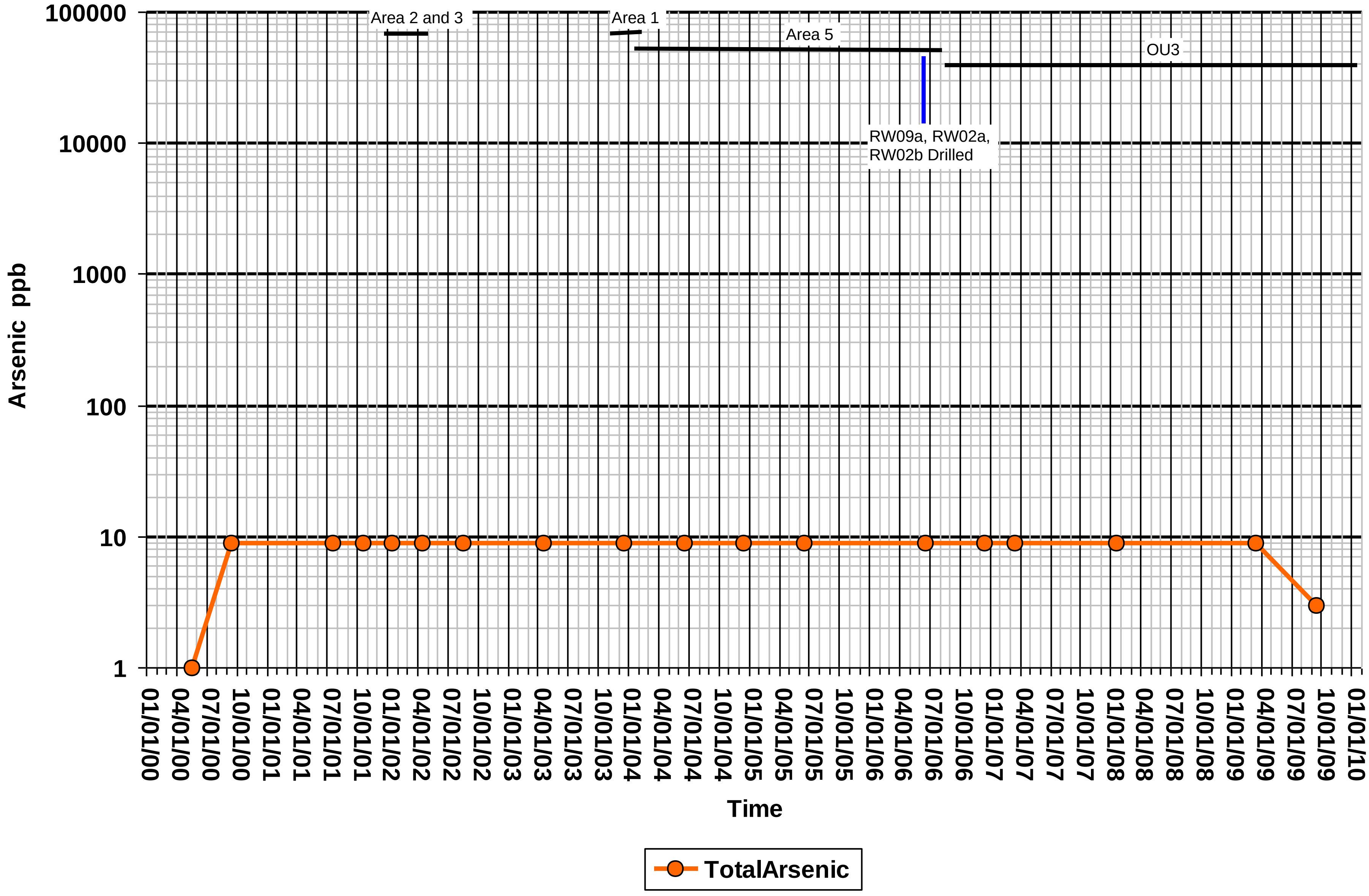
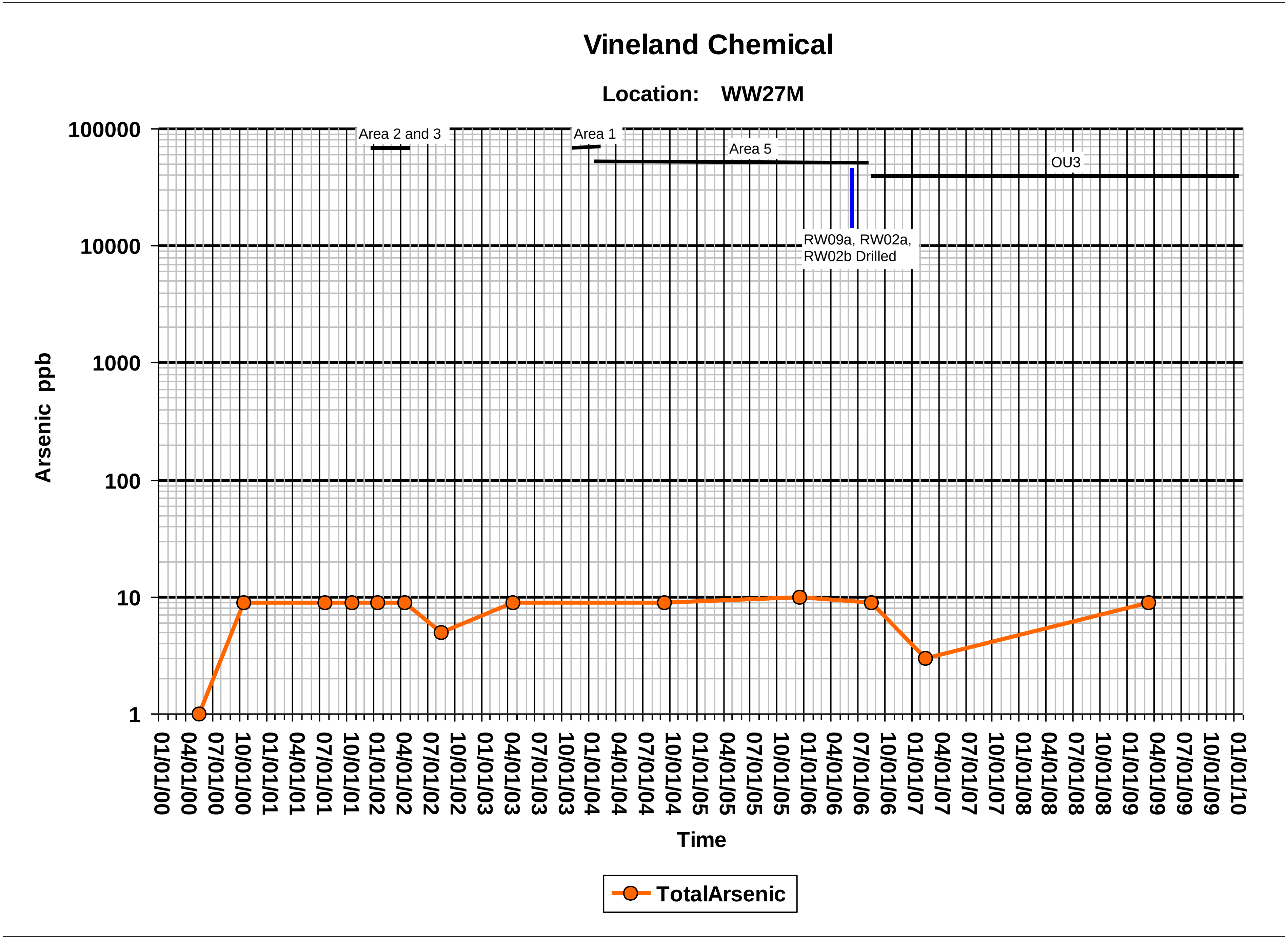
10/01/07
01/01/08
04/01/08
07/01/08
10/01/08
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic

Vineland Chemical

Location: WW26S




Vineland Chemical
Location: WW27M
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
04/01/01
07/01/01
10/01/01
01/01/02
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01/01/08
04/01/08
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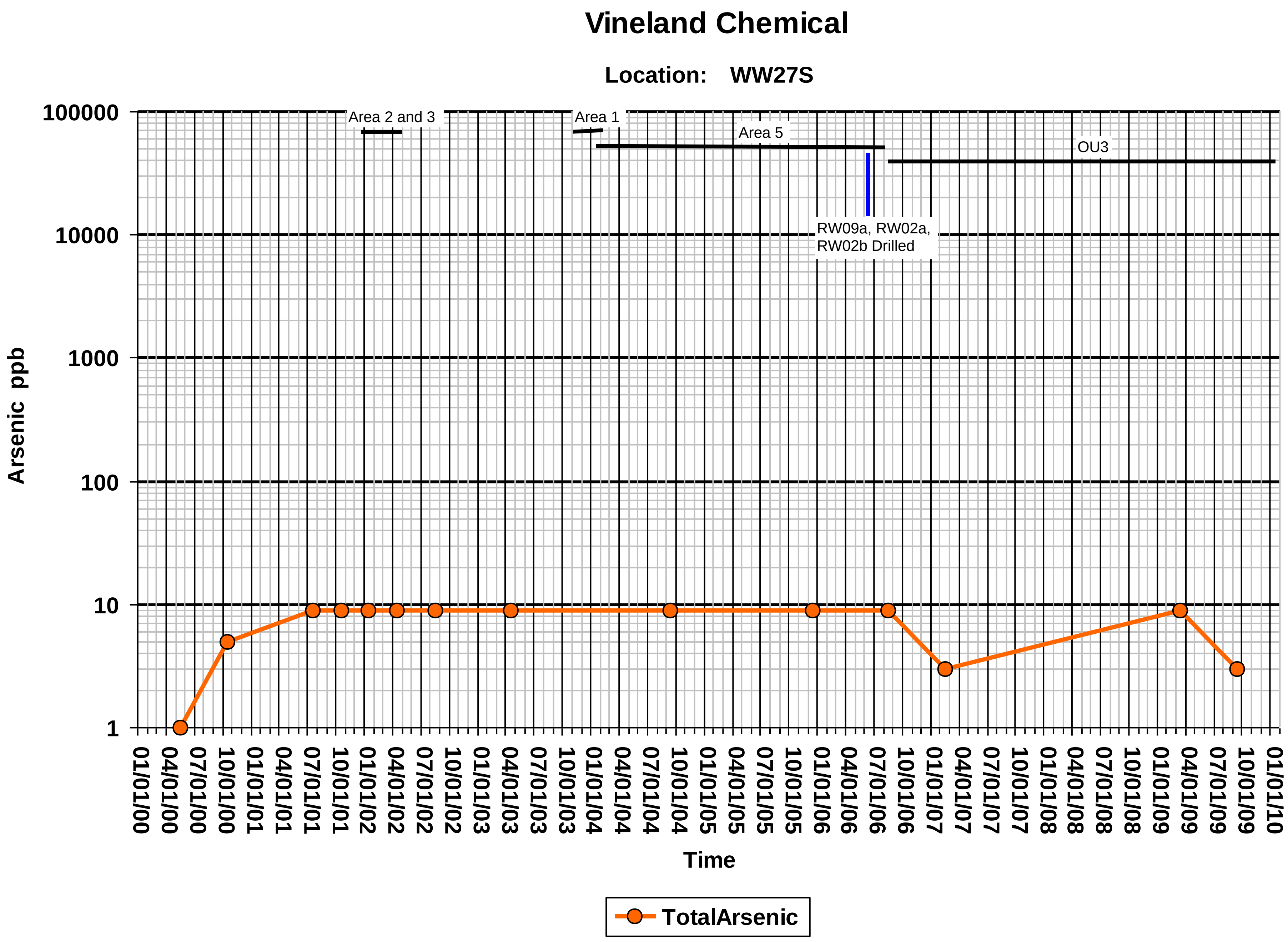
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic


Vineland Chemical
Location: WW27S
Arsenic ppb
100000
10000
1000
100
10
1
Area 2 and 3
Area 1
Area 5
OU3
RW09a, RW02a, RW02b Drilled
01/01/00
04/01/00
07/01/00
10/01/00
01/01/01
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04/01/08
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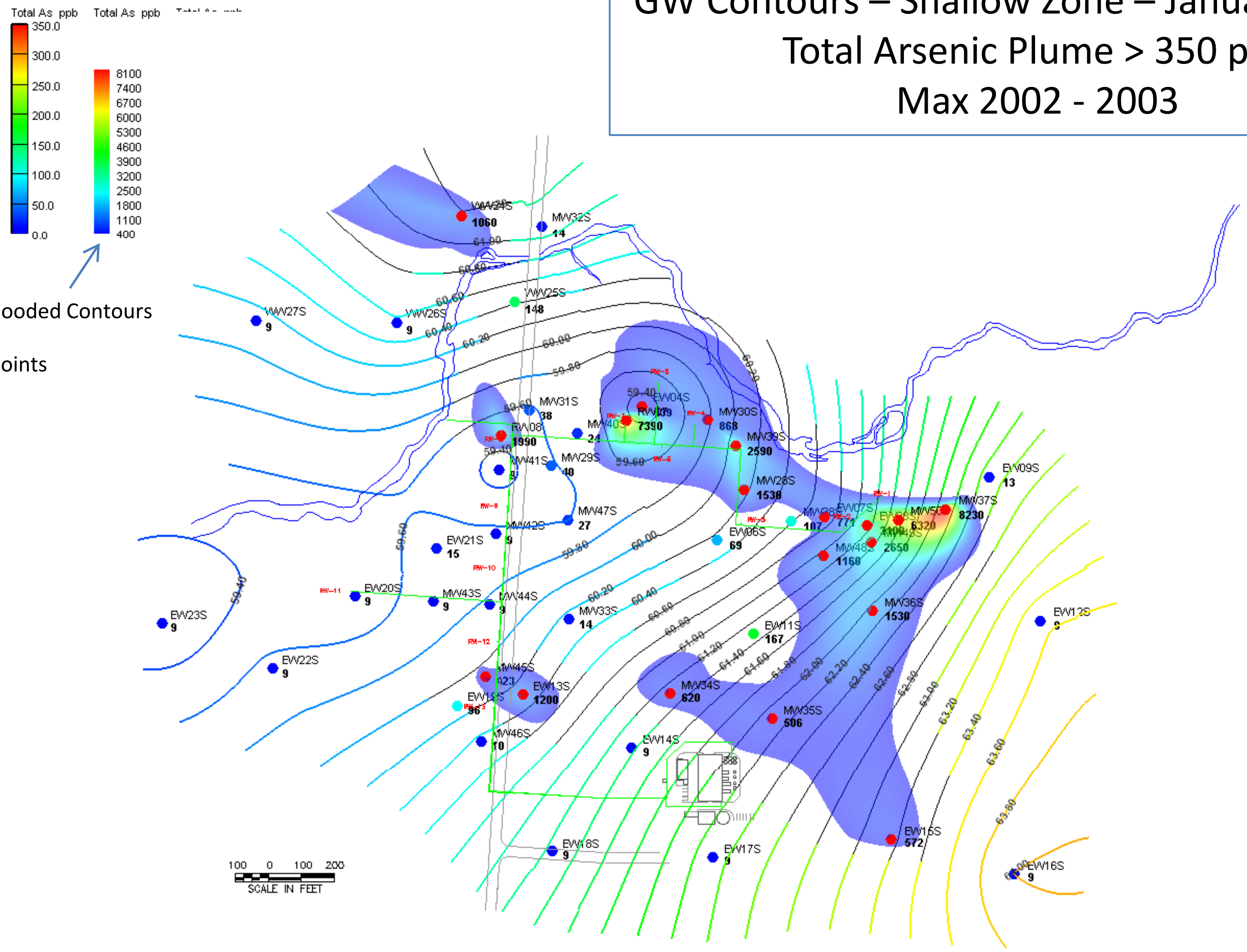
01/01/09
04/01/09
07/01/09
10/01/09
01/01/10
Time
TotalArsenic

ATTACHMENT C

Figure 1
GW Contours – Shallow Zone – January 21 2003
Total Arsenic Plume > 350 ppb
Max 2002 - 2003



Flooded Contours

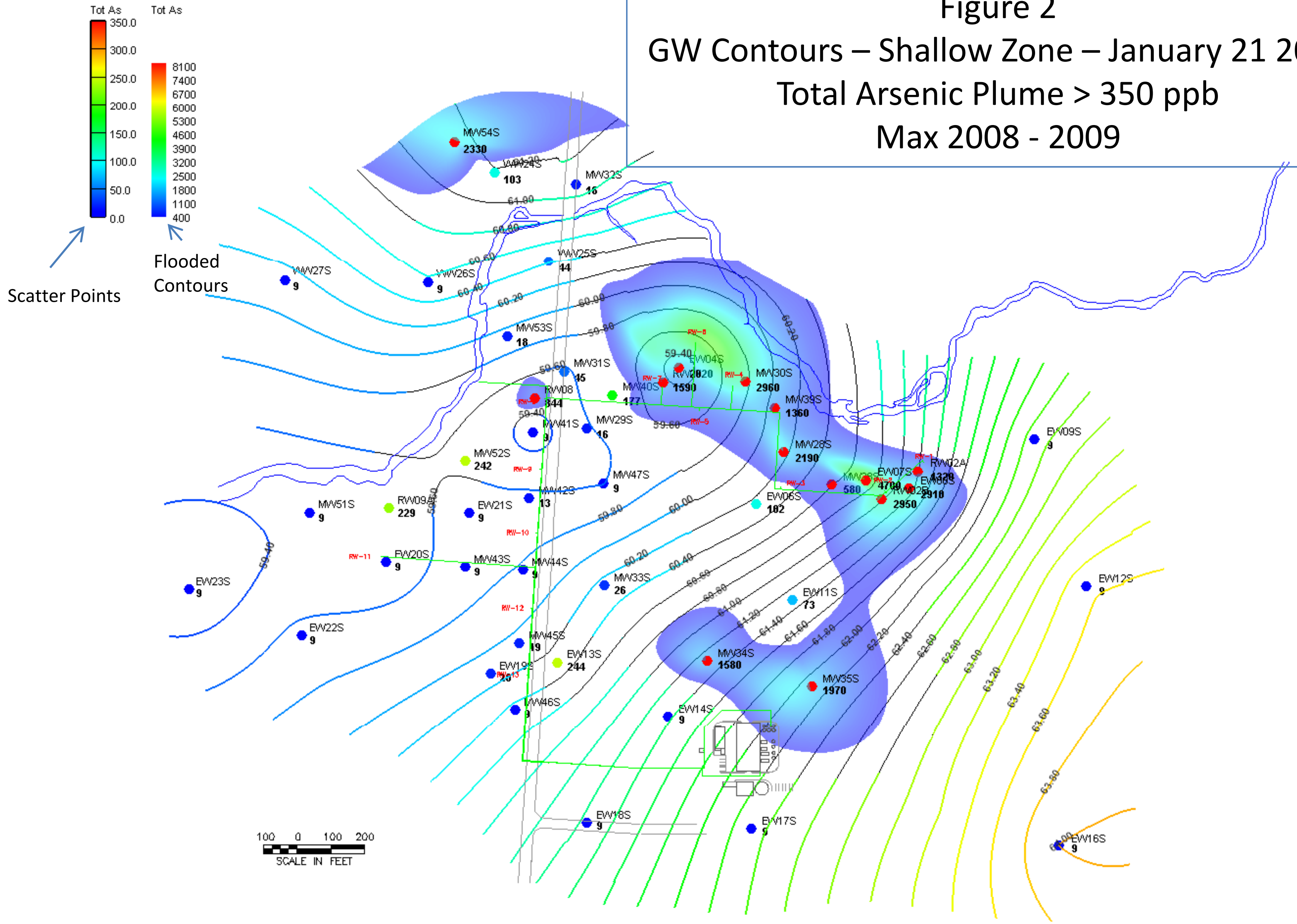
Scatter Points

Figure 2

GW Contours – Shallow Zone – January 21 2003

Total Arsenic Plume > 350 ppb

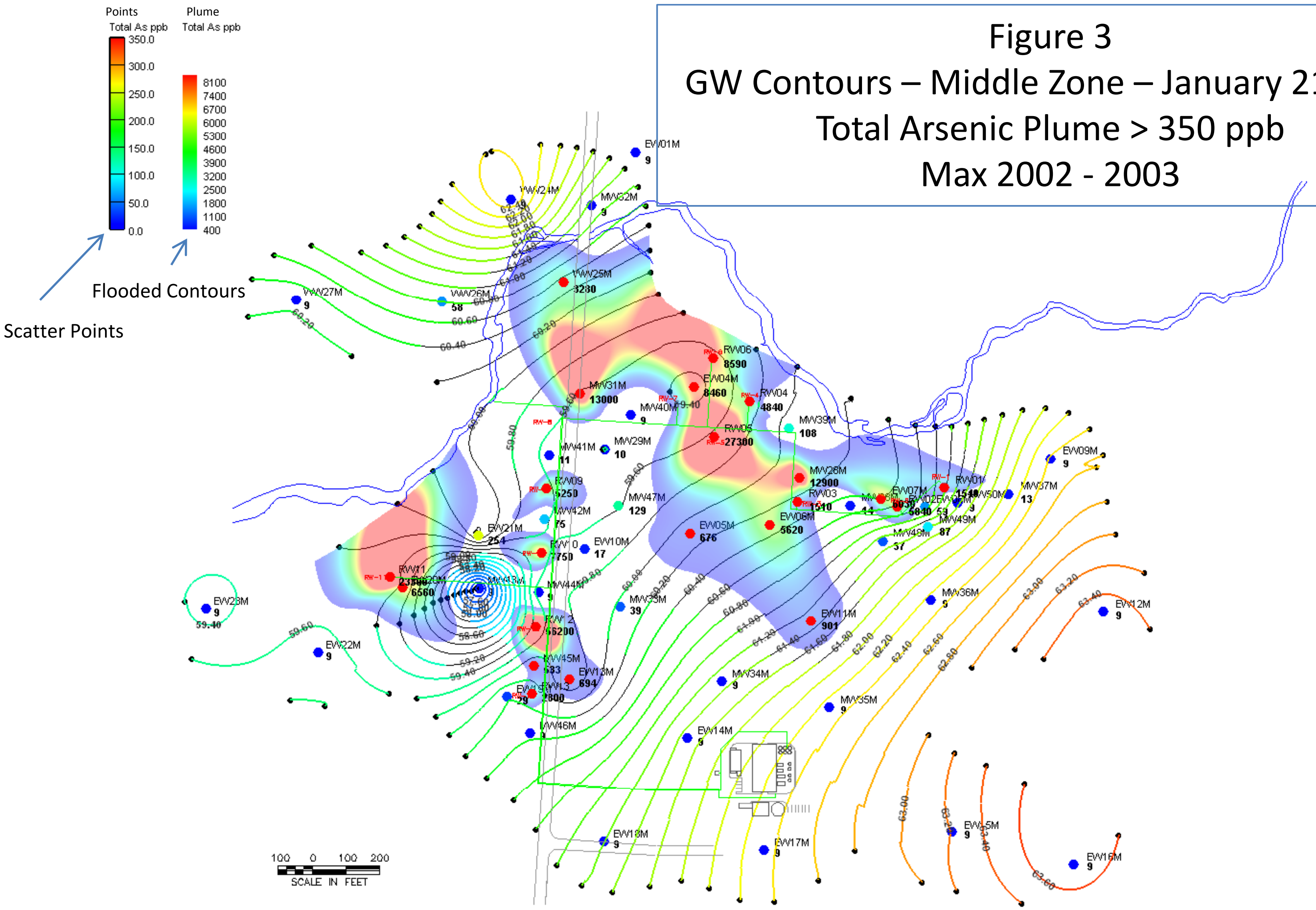
Max 2008 - 2009



Scatter Points

Flooded Contours

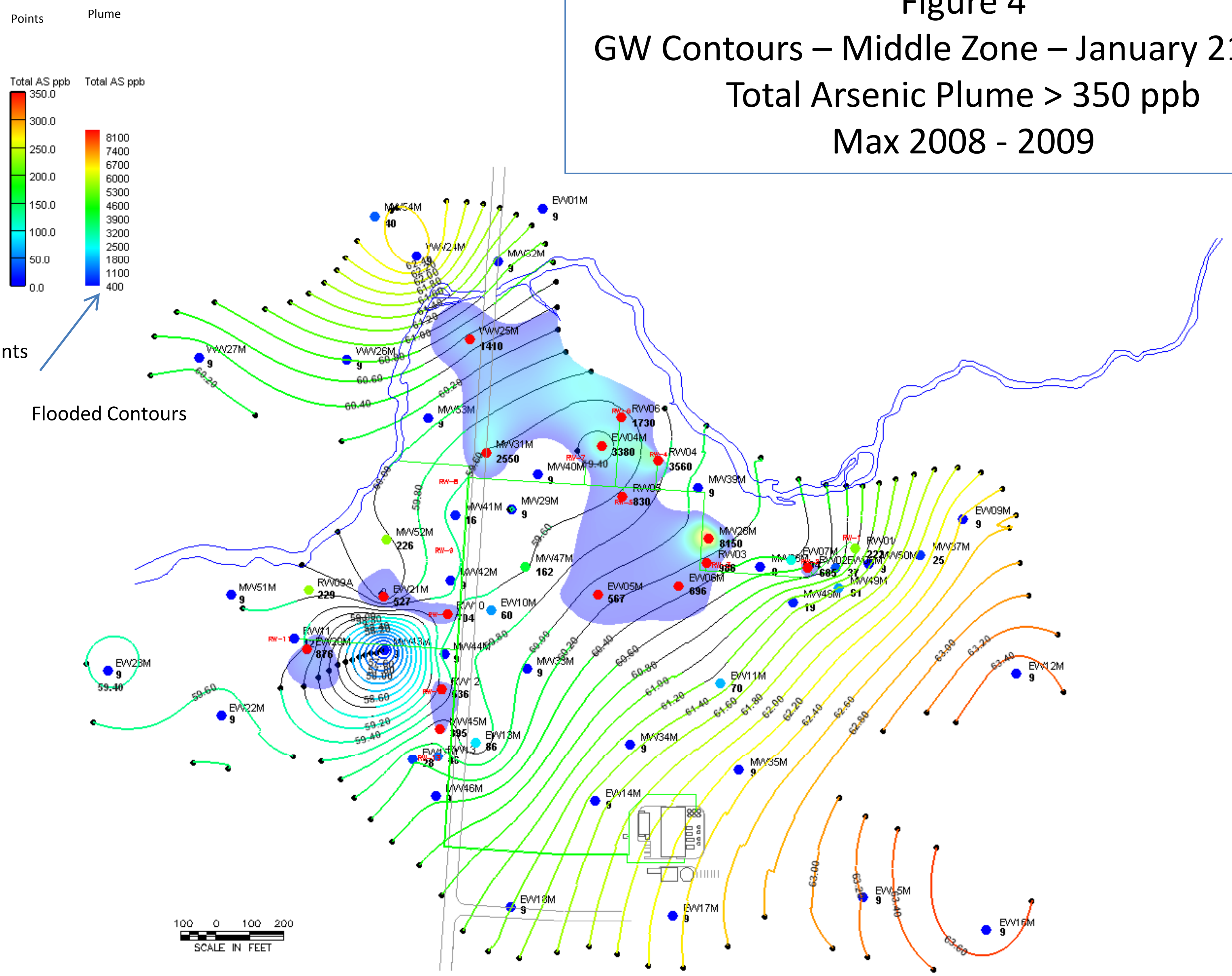
Figure 3
GW Contours – Middle Zone – January 21 2003
Total Arsenic Plume > 350 ppb
Max 2002 - 2003



Flooded Contours

Scatter Points

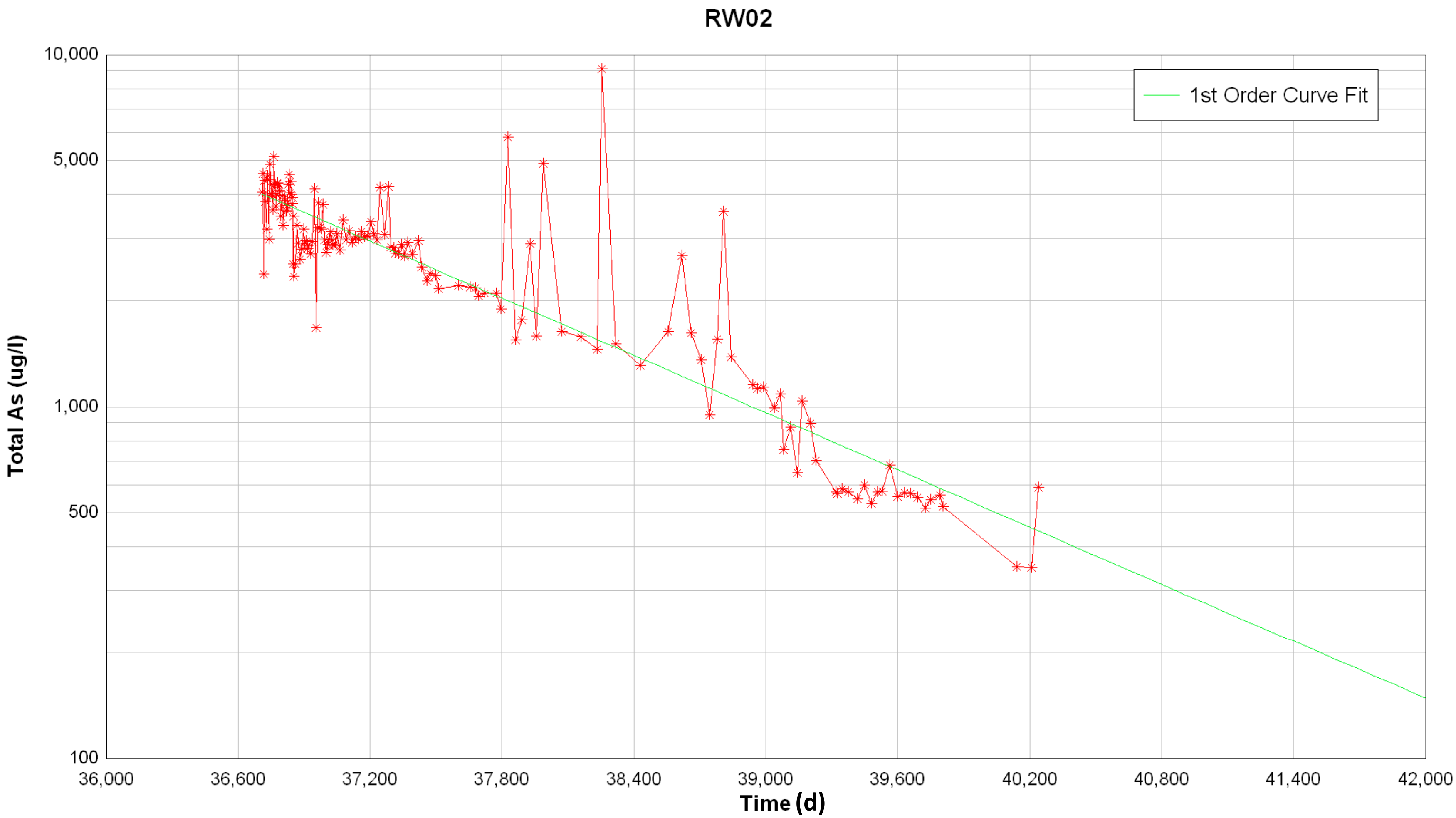
Figure 4
GW Contours – Middle Zone – January 21 2003
Total Arsenic Plume > 350 ppb
Max 2008 - 2009



Scatter Points

Flooded Contours

ATTACHMENT D



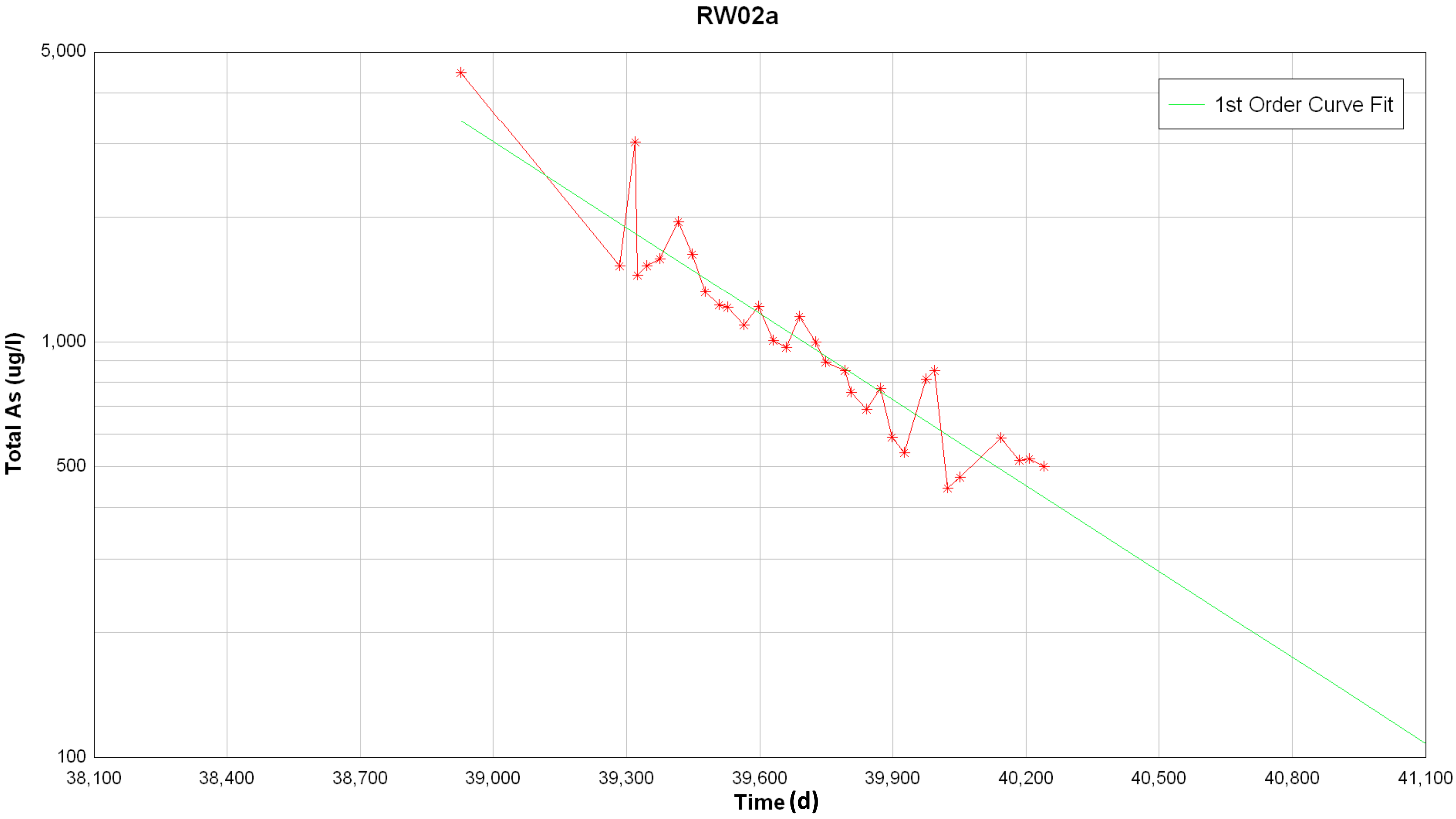
log(y) = C(0) + C(1)*x + C(2)*x**2 + ...
(log() = common logarithm)
Coefficients
C(00) 13.474690
C(01) -0.26891789E-03

Correlation coefficient is 0.91655122

ln(y) = D(0) + D(1)*x + D(2)*x**2 + ...
(ln() = natural logarithm)
Coefficients
D(00) 31.026621
D(01) -0.61920633E-03

Correlation coefficient is 0.91655122

Time to reach 0.35 mg/l = 1 year
Time to reach 0.05 mg/l = 9 years
Time to reach 0.01 mg/l = 16 years



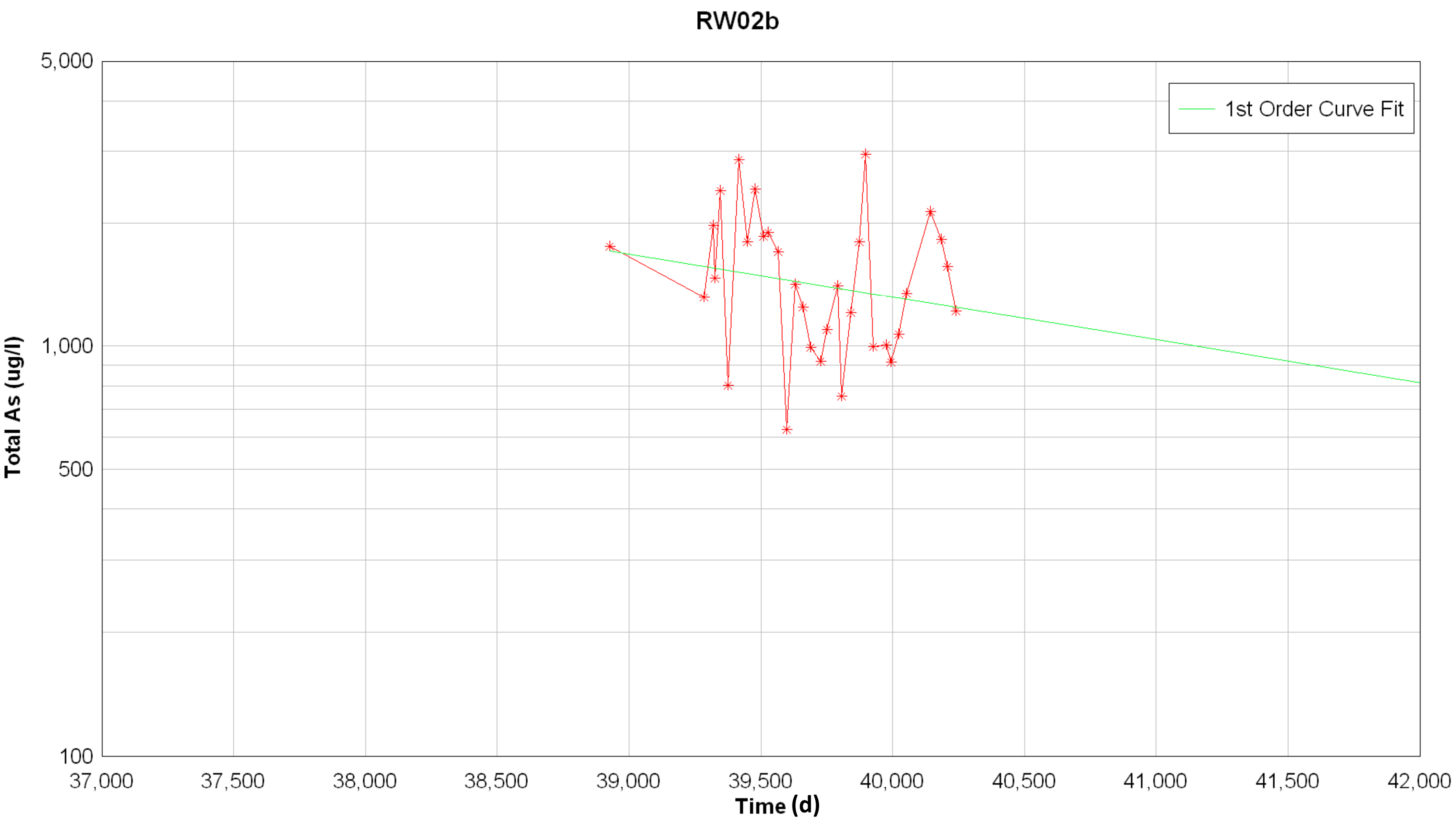
log(y) = C(0) + C(1)*x + C(2)*x**2 + ...
(log() = common logarithm)
Coefficients
C(00)   30.385174
C(01) -0.68982716E-03

Correlation coefficient is 0.93670640

ln(y) = D(0) + D(1)*x + D(2)*x**2 + ...
(ln() = natural logarithm)
Coefficients
D(00)   69.964449
D(01) -0.15883857E-02

Correlation coefficient is 0.93670640

Time to reach 0.35 mg/l = < 1 year
Time to reach 0.05 mg/l = 3 years
Time to reach 0.01 mg/l = 6 years



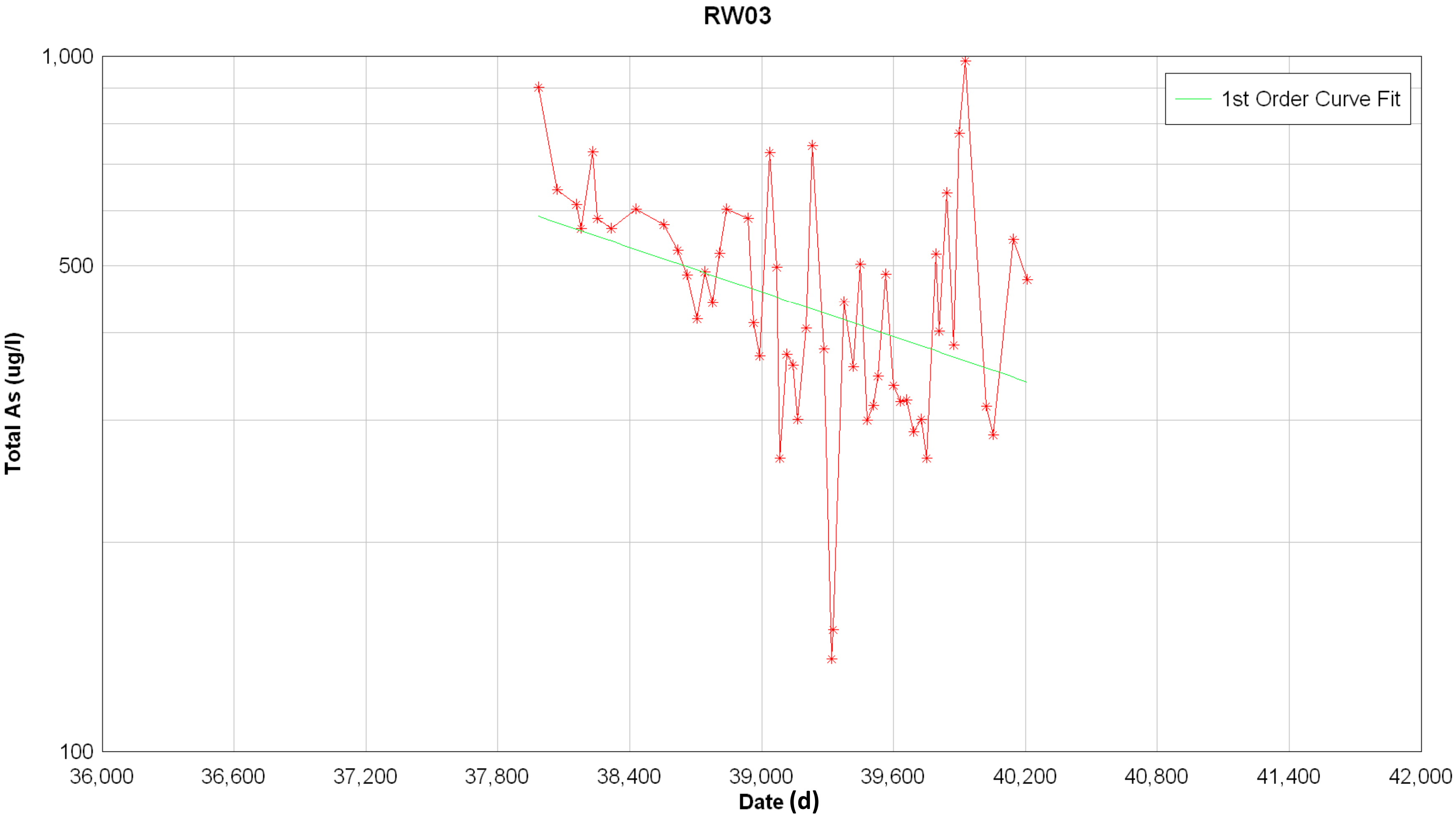
log(y) = C(0) + C(1)*x + C(2)*x**2 + ...
(log() = common logarithm)
Coefficients
C(00) 7.3380374
C(01) -0.10541420E-03

Correlation coefficient is 0.19858113

ln(y) = D(0) + D(1)*x + D(2)*x**2 + ...
(ln() = natural logarithm)
Coefficients
D(00) 16.896455
D(01) -0.24272516E-03

Correlation coefficient is 0.19858113

Time to reach 0.35 mg/l = 14 years
Time to reach 0.05 mg/l = 36 years
Time to reach 0.01 mg/l = 54 years



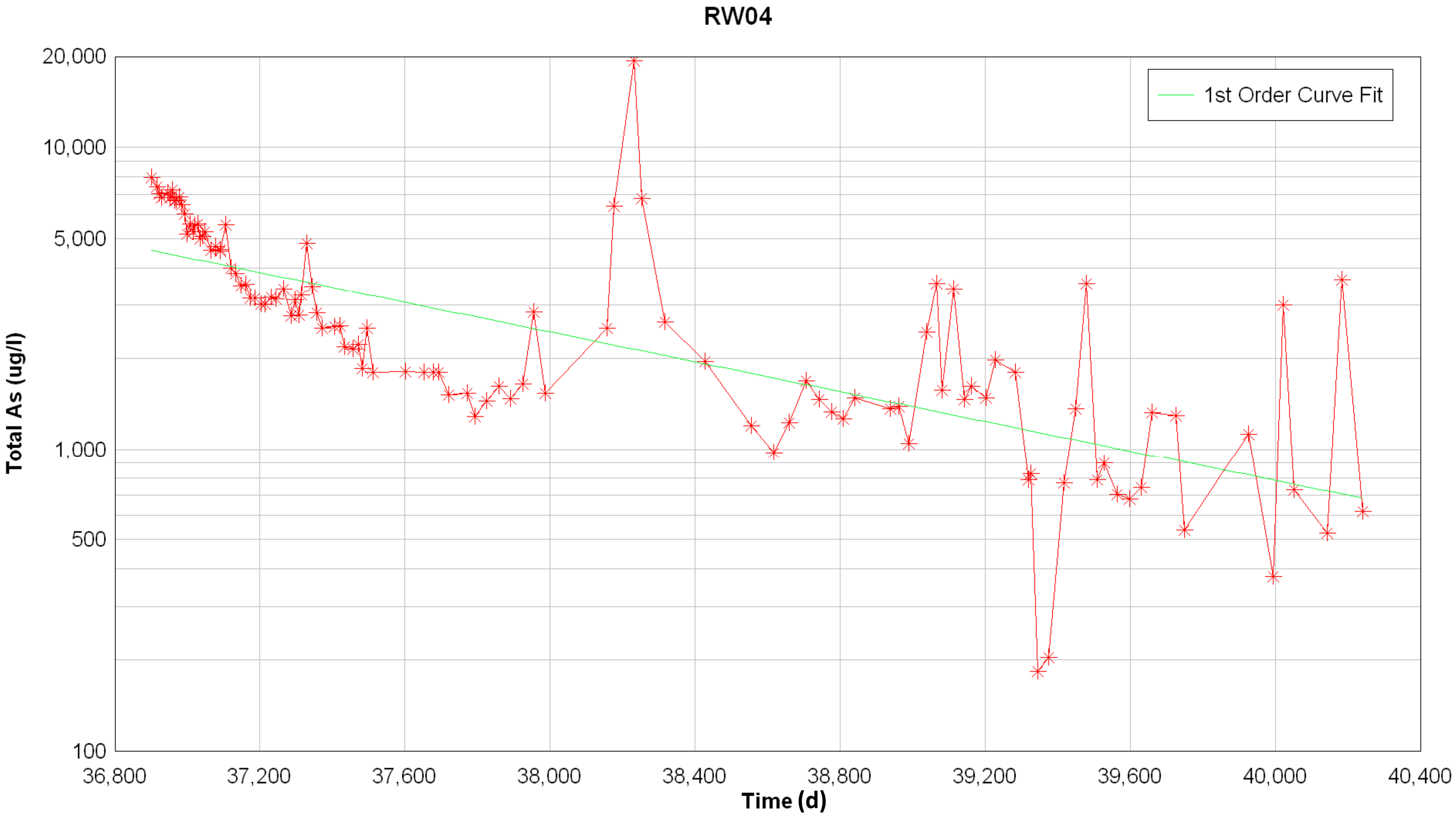
log(y) = C(0) + C(1)*x + C(2)*x**2 + ...
(log() = common logarithm)
Coefficients
C(00)   6.844025
C(01) -0.10725365E-03

Correlation coefficient is 0.37123800

ln(y) = D(0) + D(1)*x + D(2)*x**2 + ...
(ln() = natural logarithm)
Coefficients
D(00)   15.759819
D(01) -0.24696067E-03

Correlation coefficient is 0.37123800

Time to reach 0.35 mg/l = < 1 year
Time to reach 0.05 mg/l = 21 years
Time to reach 0.01 mg/l = 39 years



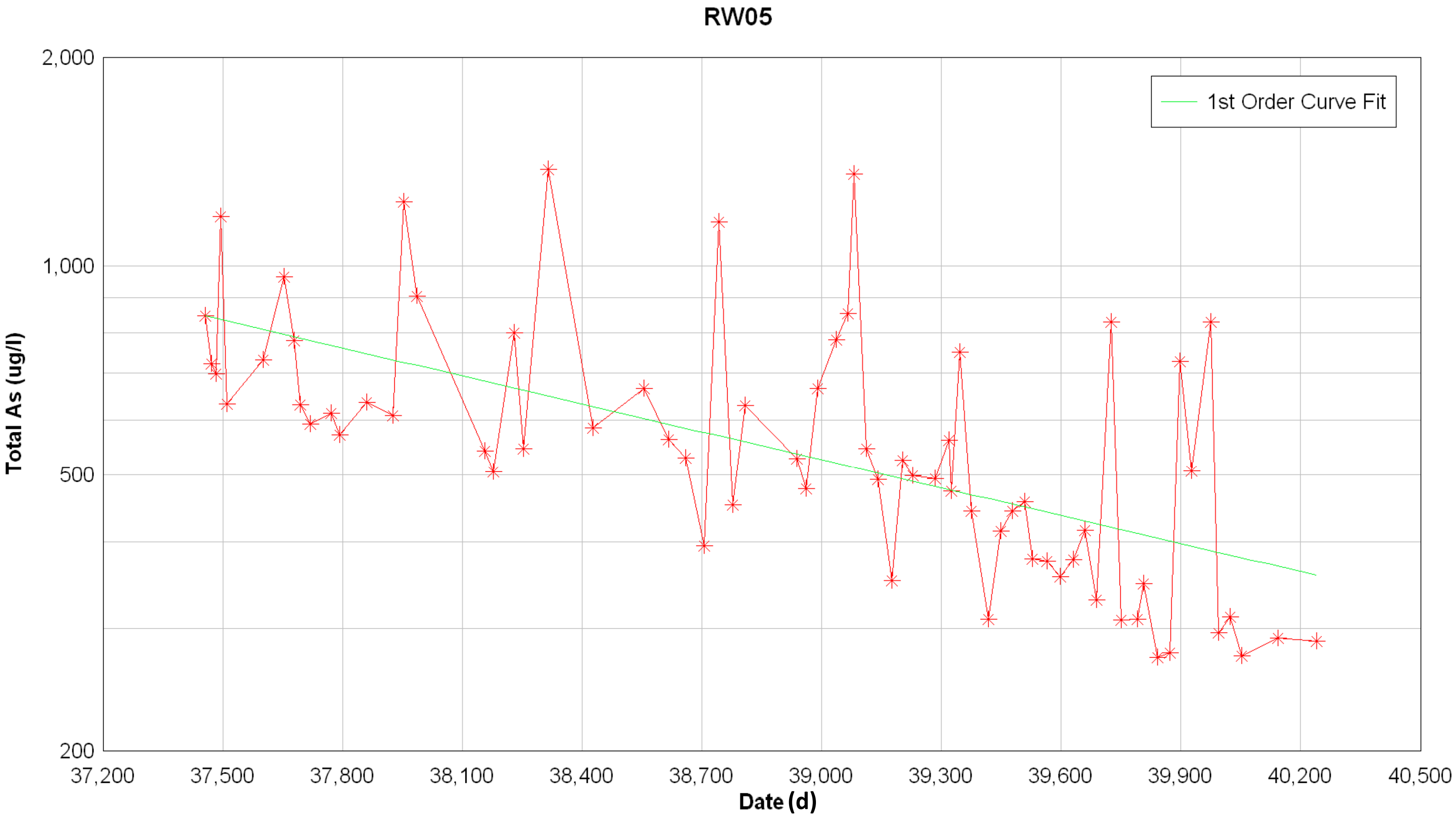
log(y) = C(0) + C(1)*x + C(2)*x**2 + ...
(log() = common logarithm)
Coefficients
C(00) 12.772188
C(01) -0.24690496E-03

Correlation coefficient is 0.73231222

ln(y) = D(0) + D(1)*x + D(2)*x**2 + ...
(ln() = natural logarithm)
Coefficients
D(00) 29.409050
D(01) -0.56851967E-03

Correlation coefficient is 0.73231222

Time to reach 0.35 mg/l = 3 years
Time to reach 0.05 mg/l = 12 years
Time to reach 0.01 mg/l = 20 years



log(y) = C(0) + C(1)*x + C(2)*x**2 + ...
(log() = common logarithm)
Coefficients
C(00) 7.9582482
C(01) -0.13429409E-03

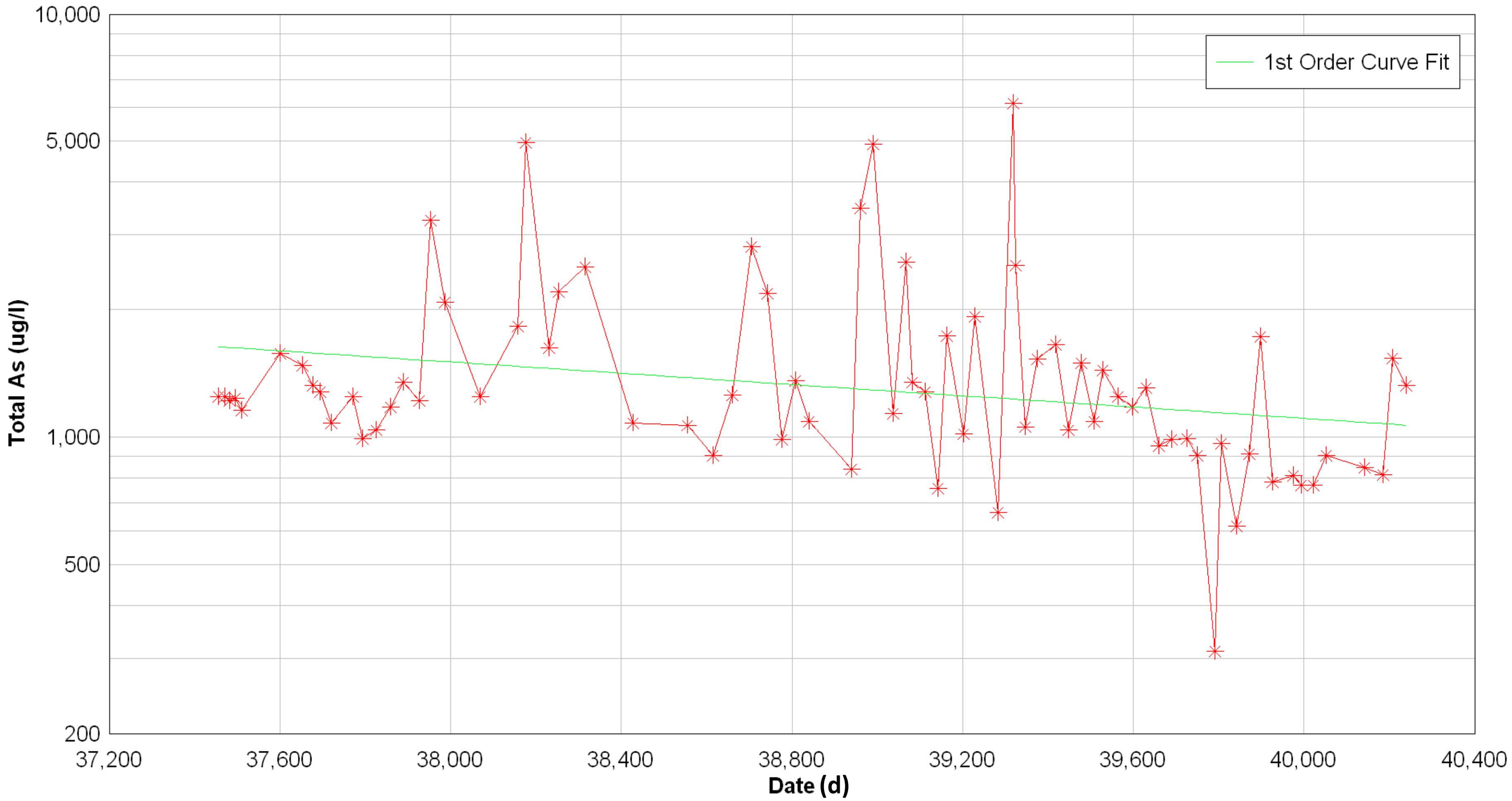
Correlation coefficient is 0.63003592

ln(y) = D(0) + D(1)*x + D(2)*x**2 + ...
(ln() = natural logarithm)
Coefficients
D(00) 18.324544
D(01) -0.30922357E-03

Correlation coefficient is 0.73231222

Time to reach 0.35 mg/l = N/A
Time to reach 0.05 mg/l = 17 years
Time to reach 0.01 mg/l = 31 years

RW06



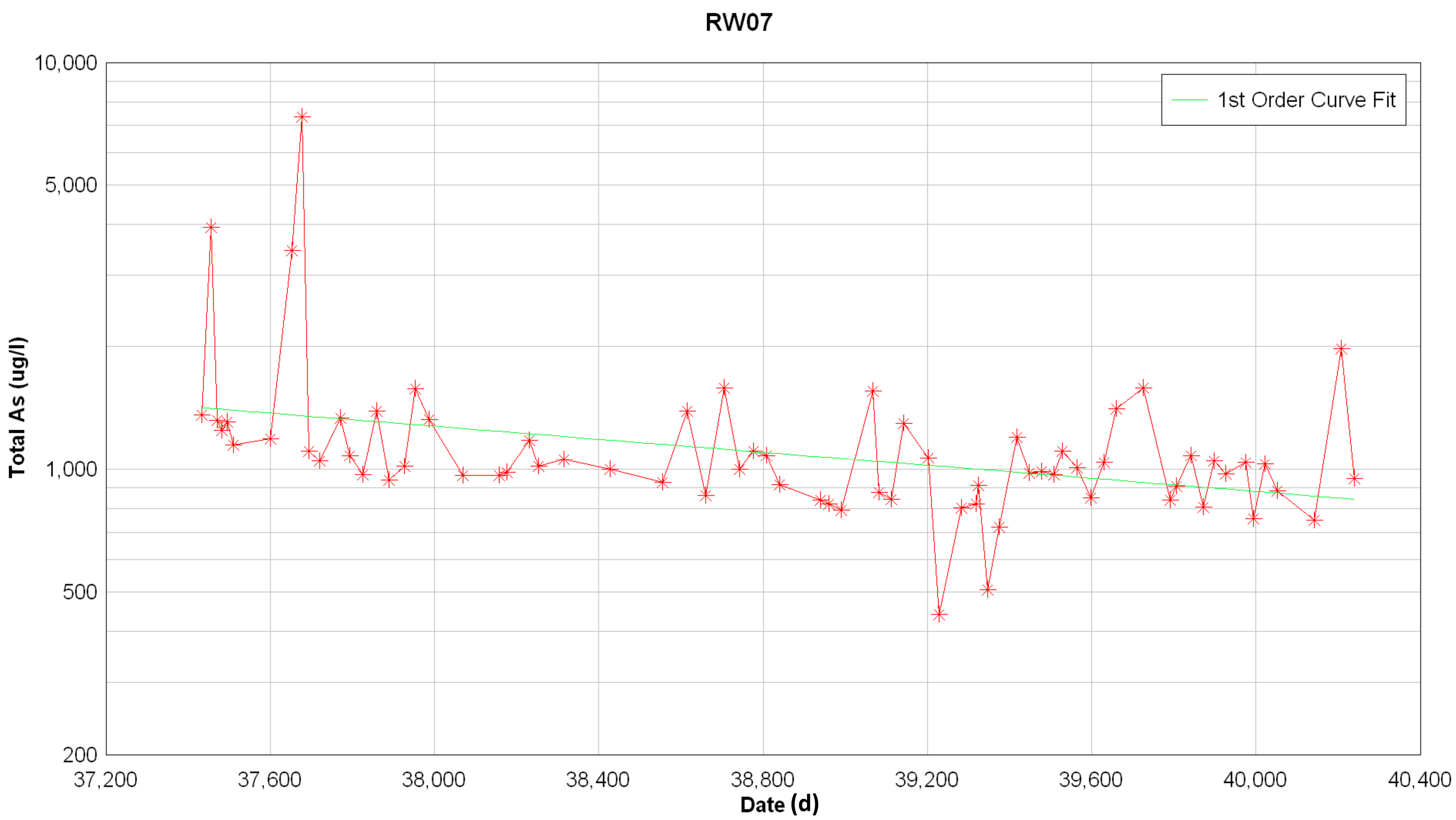
log(y) = C(0) + C(1)*x + C(2)*x**2 + ...
(log() = common logarithm)
Coefficients
C(00) 5.7046108
C(01) -0.66480640E-03

Correlation coefficient is 0.26776477

ln(y) = D(0) + D(1)*x + D(2)*x**2 + ...
(ln() = natural logarithm)
Coefficients
D(00) 13.135352
D(01) -0.15307733E-03

Correlation coefficient is 0.26776477

Time to reach 0.35 mg/l = 20 years
Time to reach 0.05 mg/l = 54 years
Time to reach 0.01 mg/l = 83 years



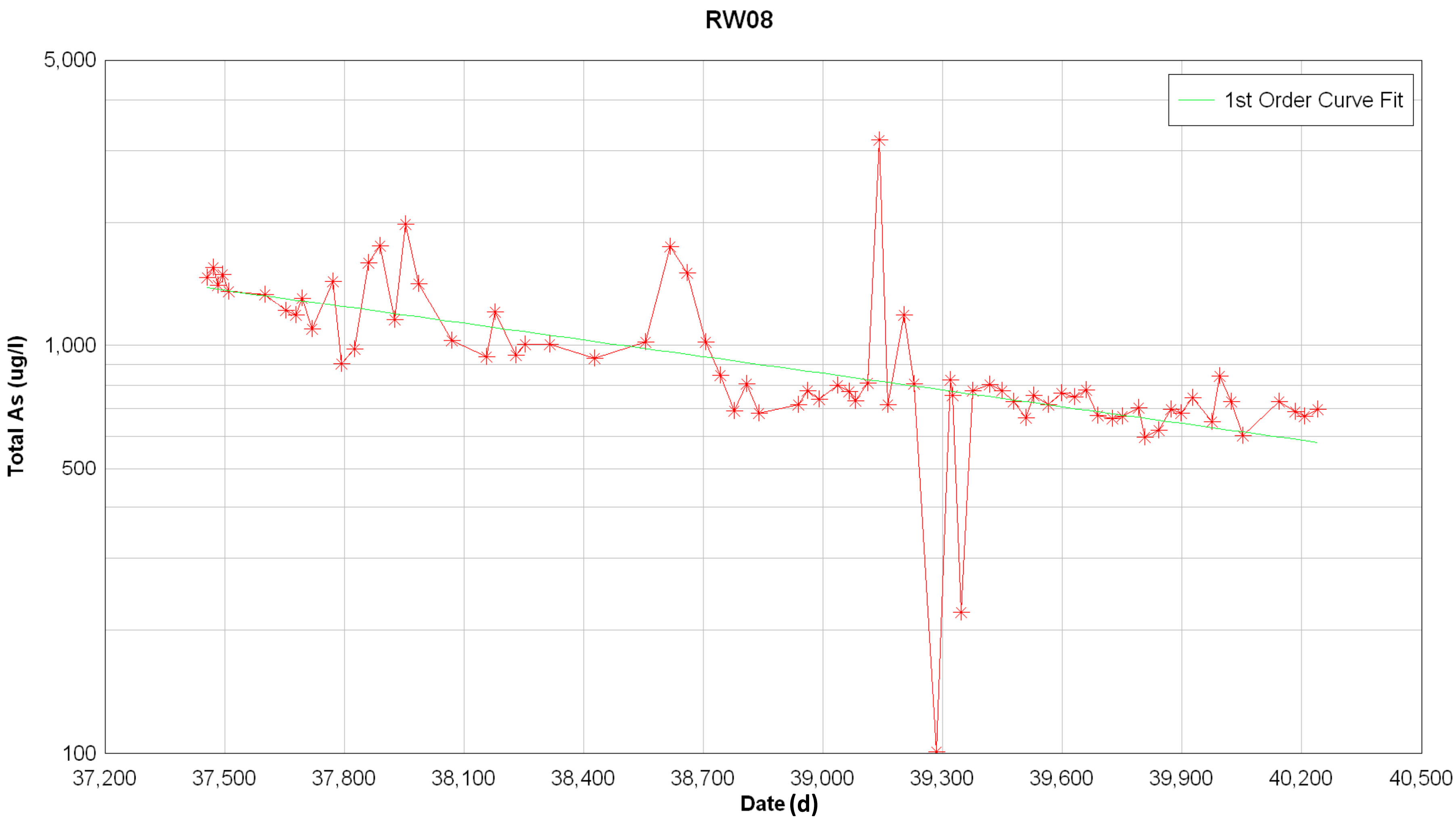
log(y) = C(0) + C(1)*x + C(2)*x**2 + ...
(log() = common logarithm)
Coefficients
C(00) 6.1601763
C(01) -0.80358367E-04

Correlation coefficient is 0.40470106

ln(y) = D(0) + D(1)*x + D(2)*x**2 + ...
(ln() = natural logarithm)
Coefficients
D(00) 14.184330
D(01) -0.18503198E-03

Correlation coefficient is 0.40470106

Time to reach 0.35 mg/l = 13 years
Time to reach 0.05 mg/l = 41 years
Time to reach 0.01 mg/l = 65 years



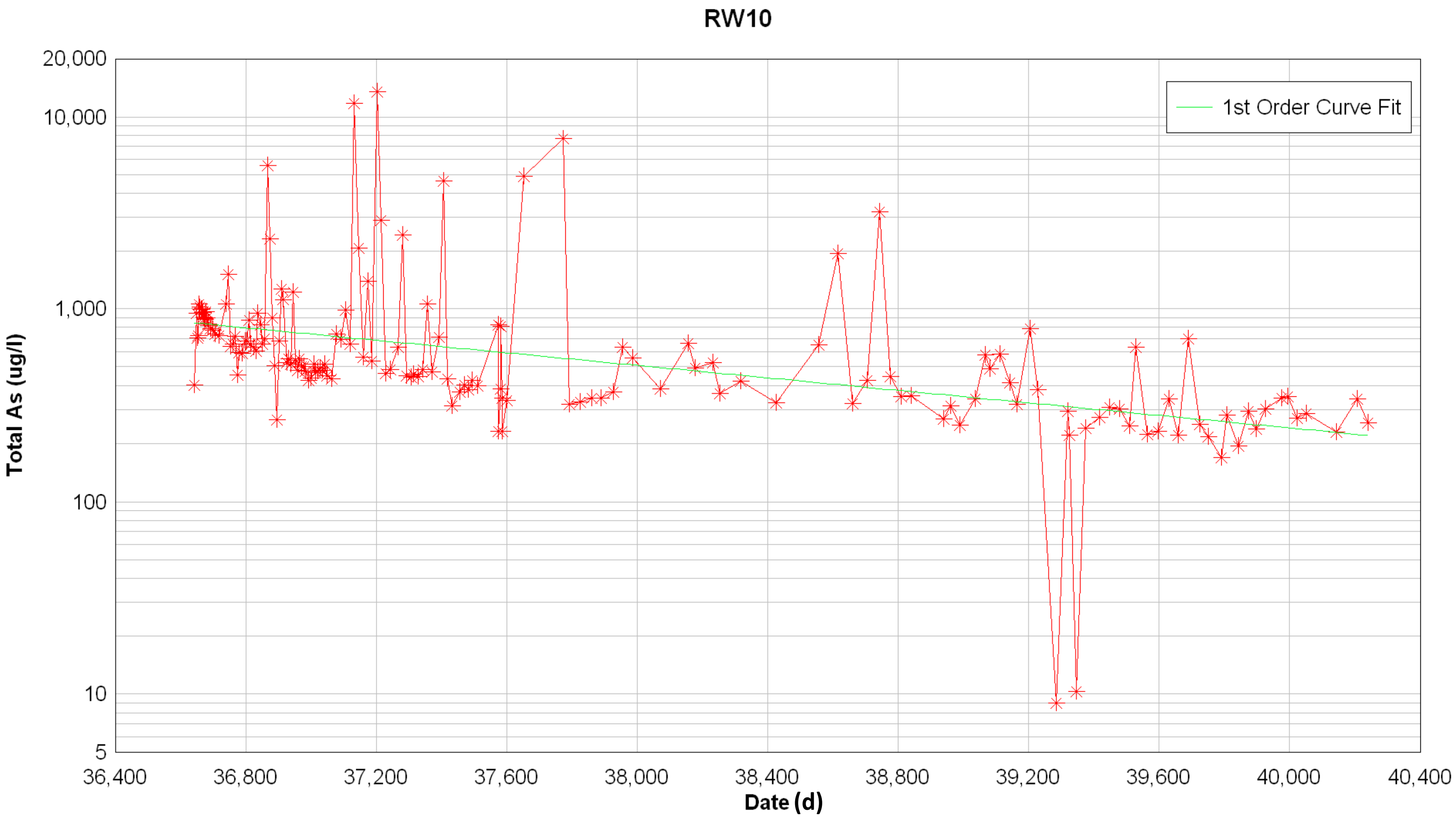
log(y) = C(0) + C(1)*x + C(2)*x**2 + ...
(log() = common logarithm)
Coefficients
C(00) 8.2402746
C(01) -0.13609750E-03

Correlation coefficient is 0.59266

ln(y) = D(0) + D(1)*x + D(2)*x**2 + ...
(ln() = natural logarithm)
Coefficients
D(00) 18.973933
D(01) -0.31337607E-03

Correlation coefficient is 0.59266

Time to reach 0.35 mg/l = 4 years
Time to reach 0.05 mg/l = 21 years
Time to reach 0.01 mg/l = 35 years



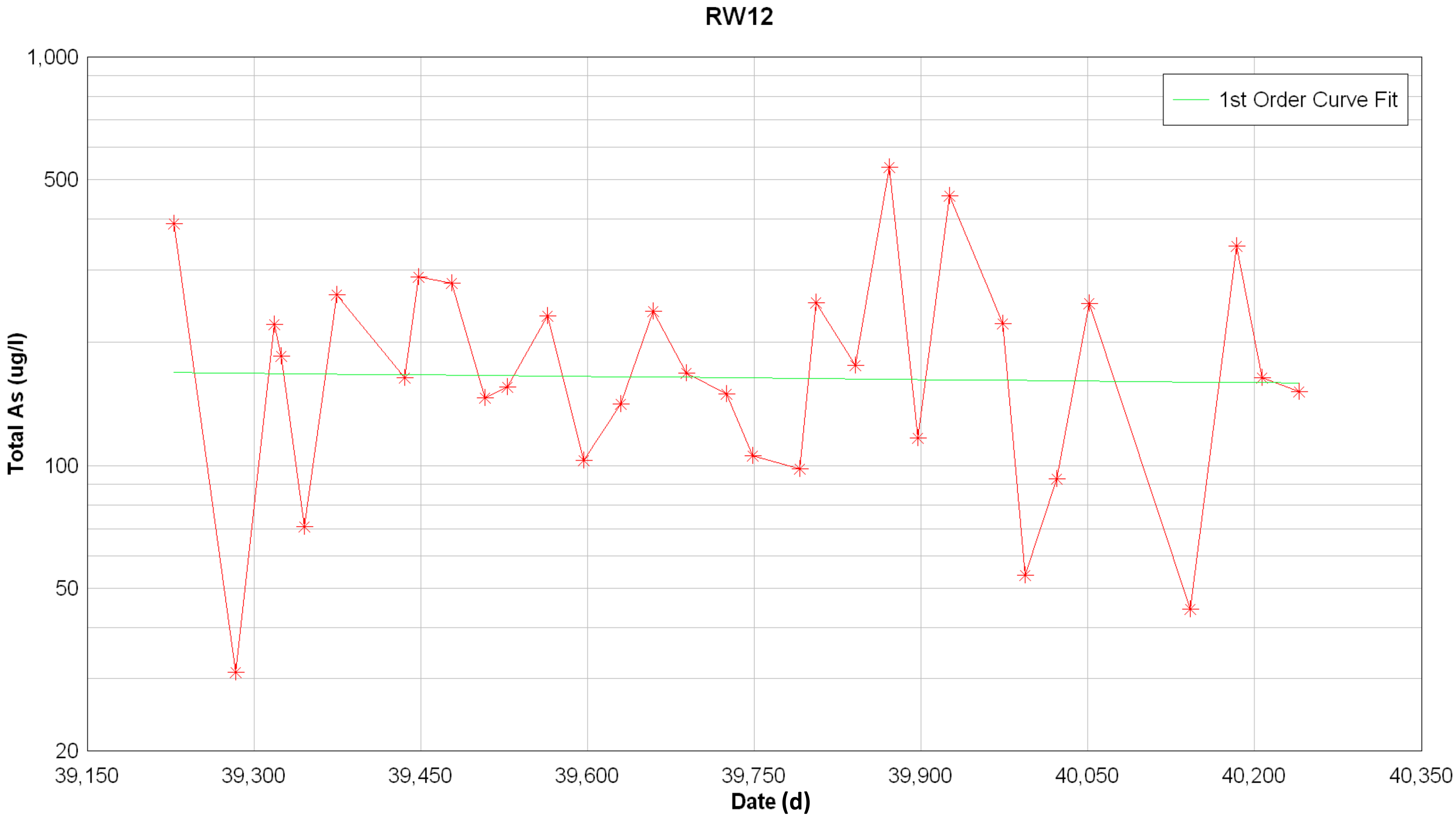
log(y) = C(0) + C(1)*x + C(2)*x**2 + ...
(log() = common logarithm)
Coefficients
C(00) 8.8804672
C(01) -0.16243981-03

Correlation coefficient is 0.48904069

ln(y) = D(0) + D(1)*x + D(2)*x**2 + ...
(ln() = natural logarithm)
Coefficients
D(00) 20.448031
D(01) -0.37403148E-03

Correlation coefficient is 0.48904069

Time to reach 0.35 mg/l = N/A
Time to reach 0.05 mg/l = 11 years
Time to reach 0.01 mg/l = 22 years



log(y) = C(0) + C(1)*x + C(2)*x**2 + ...
(log() = common logarithm)
Coefficients
C(00) 3.2244755
C(01) -0.25393429-04

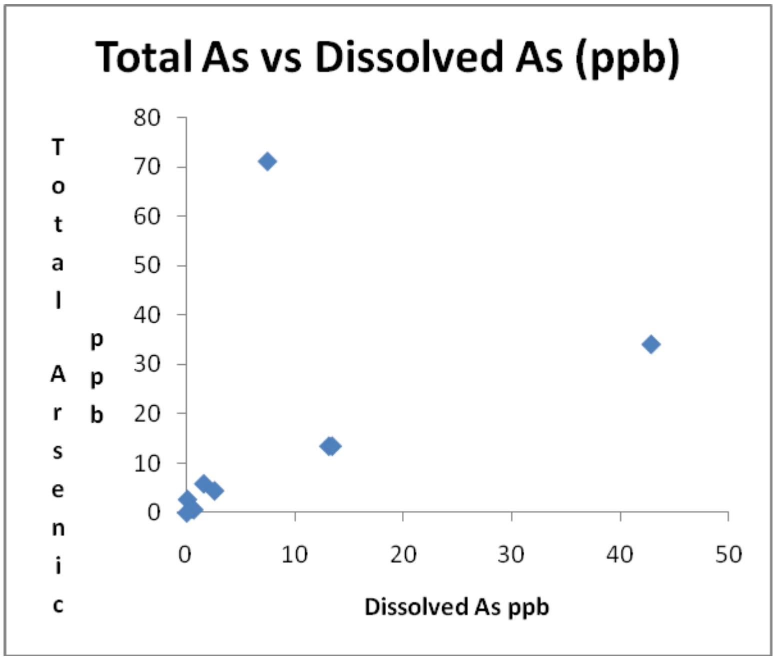
Correlation coefficient is 0.26809553E-01

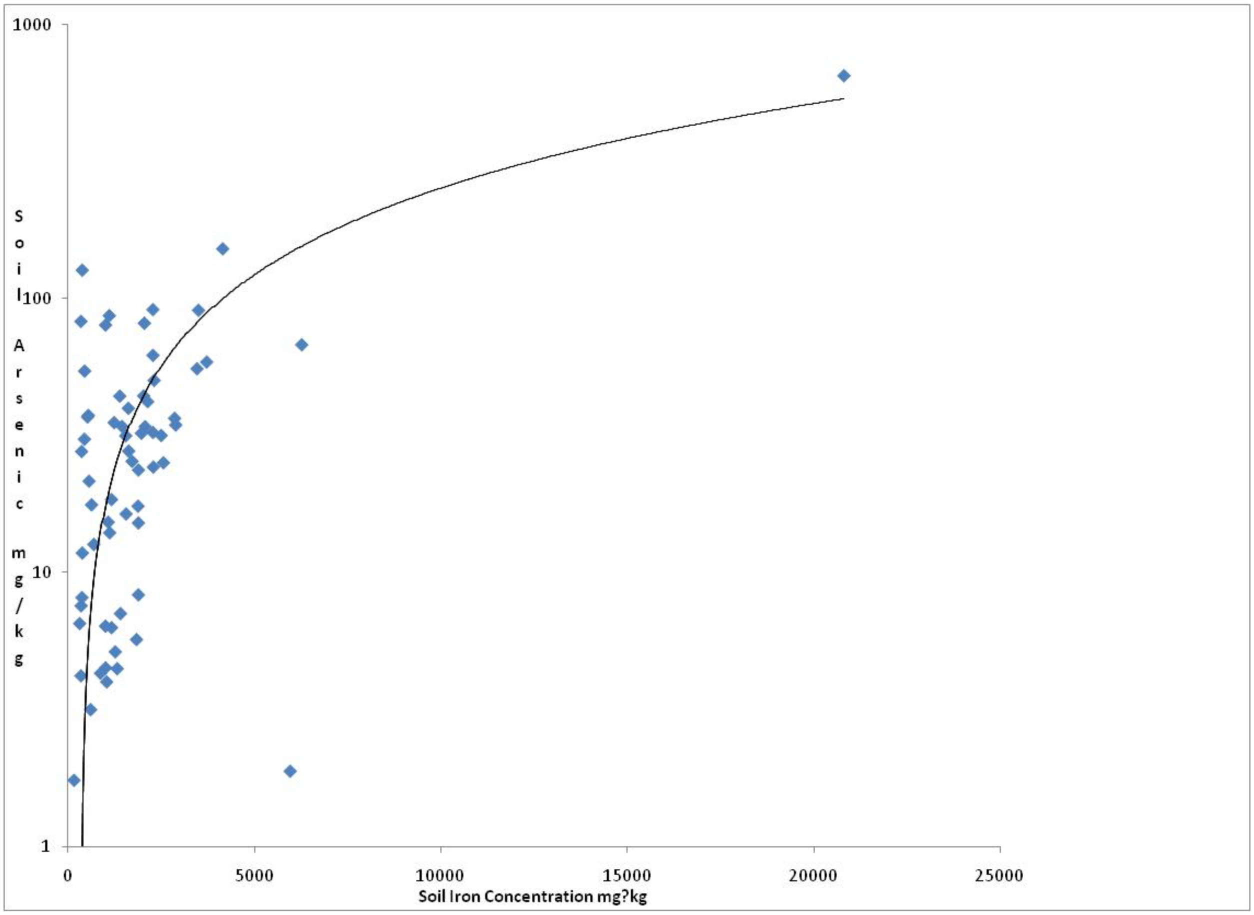
ln(y) = D(0) + D(1)*x + D(2)*x**2 + ...
(ln() = natural logarithm)
Coefficients
D(00) 7.4246291
D(01) -0.58470530E-04

Correlation coefficient is 0.26809553E-01

Time to reach 0.35 mg/l = N/A
Time to reach 0.05 mg/l = 54 years
Time to reach 0.01 mg/l = 129 years

ATTACHMENT E


Total As vs Dissolved As (ppb)
Total Arsenic ppb
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
Dissolved As ppb


Soil Arsenic mg/kg
1000
100
10
1
0
5000
10000
15000
20000
25000
Soil Iron Concentration mg?kg

ATTACHMENT F

Table 1

MAROS Statistical Trend Analysis Summary

Project: Vineland Superfund Shallow

Location: Vineland

User Name: Dave Becker

State: New Jersey

Time Period: 5/1/2000 **to** 9/15/2009

Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Maximum

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value

Well	Source/ Tail	Number of Samples	Number of Detects	Average Conc. (mg/L)	Median Conc. (mg/L)	All Samples "ND" ?	Mann-Kendall Trend	Linear Regression Trend
ARSENIC								
EW04S	T	13	13	1.4E+00	1.3E+00	No	S	NT
EW05S	T	1	1	2.8E-02	2.8E-02	No	N/A	N/A
EW06S	T	13	13	1.3E-01	9.9E-02	No	NT	NT
EW07S	S	13	13	1.6E+00	9.0E-01	No	I	I
EW08S	S	13	13	3.2E+00	2.6E+00	No	I	I
EW09S	T	11	5	7.0E-03	4.5E-03	No	NT	NT
EW10S	T	1	1	4.0E-03	4.0E-03	No	N/A	N/A
EW11S	T	13	13	2.1E-01	1.7E-01	No	S	NT
EW12S	T	11	2	4.2E-03	4.5E-03	No	S	NT
EW13S	T	11	11	1.5E+00	1.1E+00	No	I	NT
EW14S	T	13	3	5.4E-03	4.5E-03	No	NT	NT
EW15S	T	8	8	7.4E-01	4.9E-01	No	NT	PD
EW16S	T	11	2	4.2E-03	4.5E-03	No	NT	NT
EW17S	T	14	1	3.9E-03	4.5E-03	No	S	NT
EW18S	T	13	5	8.8E-03	4.5E-03	No	D	D
EW19S	T	14	12	6.5E-02	4.1E-02	No	NT	NT
EW20S	T	10	3	1.1E-02	4.5E-03	No	NT	NT
EW21S	T	13	5	9.5E-03	4.5E-03	No	PD	NT
EW22S	T	15	2	4.2E-03	4.5E-03	No	S	NT
EW23S	T	11	1	3.7E-03	4.5E-03	No	S	NT
MW28S	S	16	16	2.4E+00	1.4E+00	No	I	I
MW29S	T	16	16	4.5E-02	2.7E-02	No	NT	NT
MW30S	T	12	12	1.8E+00	1.8E+00	No	NT	NT
MW31S	T	15	14	2.2E-01	3.8E-02	No	NT	NT
MW32S	T	14	12	1.8E-02	1.4E-02	No	NT	S
MW33S	T	15	12	2.1E-02	1.3E-02	No	I	I
MW34S	S	13	13	1.4E+00	1.3E+00	No	NT	I
MW35S	S	13	12	1.9E+00	6.4E-01	No	I	I
MW36S	T	7	6	1.6E+00	1.4E+00	No	NT	NT
MW37S	S	5	5	1.7E+01	2.0E+01	No	S	D
MW38S	S	12	12	1.7E-01	1.3E-01	No	PI	I
MW39S	T	12	12	2.7E+00	2.7E+00	No	S	S
MW40S	T	16	13	6.8E-02	2.2E-02	No	I	I
MW41S	T	13	2	5.4E-03	4.5E-03	No	PD	S
MW42S	T	11	5	6.2E-03	4.5E-03	No	NT	NT

MAROS Statistical Trend Analysis Summary

Well	Source/ Tail	Number of Samples	Number of Detects	Average Conc. (mg/L)	Median Conc. (mg/L)	All Samples "ND" ?	Mann-Kendall Trend	Linear Regression Trend
ARSENIC								
MW43S	T	10	1	4.3E-03	4.5E-03	No	NT	NT
MW44S	T	10	1	4.6E-03	4.5E-03	No	S	S
MW45S	T	12	12	7.8E-02	3.7E-02	No	D	PD
MW46S	T	11	8	1.2E-02	9.6E-03	No	NT	NT
MW47S	T	13	9	1.6E-02	1.0E-02	No	D	D
MW48S	T	4	4	8.9E-01	9.4E-01	No	S	S
MW49S	T	4	4	2.3E+00	2.5E+00	No	S	S
MW50S	S	4	4	1.2E+01	7.7E+00	No	D	D
MW51S	T	5	2	4.3E-03	4.5E-03	No	S	D
MW52S	T	4	4	1.1E+00	1.2E+00	No	S	S
MW53S	T	4	2	1.0E-02	8.8E-03	No	NT	I
MW54S	T	5	5	7.3E-01	2.4E-01	No	NT	I
WW24S	T	12	12	4.3E-01	3.2E-01	No	NT	NT
WW25S	T	13	13	1.2E-01	1.1E-01	No	PD	PD
WW26S	T	17	1	4.2E-03	4.5E-03	No	NT	NT
WW27S	T	14	2	3.9E-03	4.5E-03	No	S	NT

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); No Detectable Concentration (NDC)

The Number of Samples and Number of Detects shown above are post-consolidation values.

Table 2

MAROS Spatial Moment Analysis Summary

Project: Vineland Superfund Shallow

Location: Vineland

User Name: Dave Becker

State: New Jersey

	0th Moment	1st Moment (Center of Mass)			2nd Moment (Spread)		
Effective Date	Estimated Mass (Kg)	Xc (ft)	Yc (ft)	Source Distance (ft)	Sigma XX (sq ft)	Sigma YY (sq ft)	Number of Wells
ARSENIC							
5/1/2000	1.2E+02	335,183	246,993	233	74,721	93,195	42
8/1/2000	4.7E+01	334,955	246,930	277	182,545	109,326	27
11/1/2000	6.0E+01	334,911	247,221	148	79,801	64,264	22
2/1/2001	4.1E+01	335,066	246,751	437	51,521	65,893	16
5/1/2001	2.9E+01	334,750	247,312	329	77,603	129,762	15
8/1/2001	9.8E+01	335,054	247,148	40	174,688	109,940	43
11/1/2001	1.1E+02	335,055	247,190	2	111,462	108,277	44
2/1/2002	7.1E+01	335,049	247,077	111	131,403	112,969	43
5/1/2002	2.4E+01	334,810	247,074	271	193,267	234,988	38
8/1/2002	3.6E+01	334,915	247,012	225	177,226	135,646	22
11/1/2002	0.0E+00						5
5/1/2003	2.6E+01	334,672	247,338	412	84,758	75,267	14
11/1/2003	1.6E+01	335,051	246,779	409	75,807	41,361	6
2/1/2004	4.3E+01	334,754	247,029	341	37,255	106,387	22
5/1/2004	0.0E+00						2
11/1/2004	6.1E+01	334,806	247,193	249	78,192	104,458	23
5/1/2005	4.6E+01	334,678	247,204	377	91,272	104,112	10
11/1/2005	4.0E+01	334,572	247,169	483	82,781	122,411	18
2/1/2006	1.0E+02	334,988	247,035	168	66,244	76,673	17
5/1/2006	3.8E+01	334,522	247,156	534	72,217	66,523	9
8/1/2006	1.6E+02	334,833	247,124	231	51,907	66,181	19
2/1/2007	5.2E+01	334,636	247,341	446	130,124	118,596	13
8/1/2007	0.0E+00						5
11/1/2007	4.8E+01	334,847	247,192	208	105,058	84,157	23
2/1/2008	8.0E+00	334,539	247,071	529	17,578	47,858	7
11/1/2008	0.0E+00						5
2/1/2009	4.7E+01	334,993	247,032	168	128,670	104,756	32
9/15/2009	2.1E+00	334,550	247,102	513	323,269	151,051	12

Project: Vineland Superfund Shallow

Location: Vineland

User Name: Dave Becker

State: New Jersey

Moment Type	Constituent	Coefficient of Variation	Mann-Kendall S Statistic	Confidence in Trend	Moment Trend
Zeroth Moment: Mass					
	ARSENIC	0.85	-80	94.0%	PD
1st Moment: Distance to Source					
	ARSENIC	0.51	68	95.2%	I
2nd Moment: Sigma XX					
	ARSENIC	0.60	-14	62.5%	S
2nd Moment: Sigma YY					
	ARSENIC	0.39	-14	62.5%	S

Note: The following assumptions were applied for the calculation of the Zeroth Moment:

Porosity: 0.25 **Saturated Thickness:** Uniform: 20 ft

Mann-Kendall Trend test performed on all sample events for each constituent. Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A)-Due to insufficient Data (< 4 sampling events).

Note: The Sigma XX and Sigma YY components are estimated using the given field coordinate system and then rotated to align with the estimated groundwater flow direction. Moments are not calculated for sample events with less than 6 wells.

Table 3

MAROS First Moment Analysis

Project: Vineland Superfund Shallow

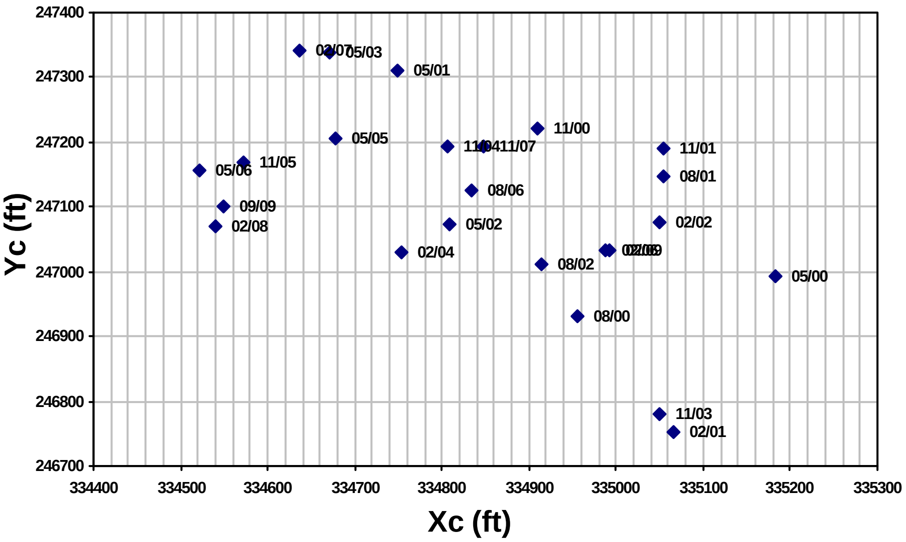
User Name: Dave Becker

Location: Vineland

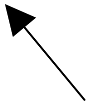
State: New Jersey

COC: ARSENIC

Change in Location of Center of Mass Over Time



Groundwater Flow Direction:



Source Coordinate:

X:	335,055
Y:	247,188

Effective Date	Constituent	Xc (ft)	Yc (ft)	Distance from Source (ft)	Number of Wells
5/1/2000	ARSENIC	335,183	246,993	233	42
8/1/2000	ARSENIC	334,955	246,930	277	27
11/1/2000	ARSENIC	334,911	247,221	148	22
2/1/2001	ARSENIC	335,066	246,751	437	16
5/1/2001	ARSENIC	334,750	247,312	329	15
8/1/2001	ARSENIC	335,054	247,148	40	43
11/1/2001	ARSENIC	335,055	247,190	2	44
2/1/2002	ARSENIC	335,049	247,077	111	43
5/1/2002	ARSENIC	334,810	247,074	271	38
8/1/2002	ARSENIC	334,915	247,012	225	22
11/1/2002	ARSENIC				5
5/1/2003	ARSENIC	334,672	247,338	412	14
11/1/2003	ARSENIC	335,051	246,779	409	6
2/1/2004	ARSENIC	334,754	247,029	341	22
5/1/2004	ARSENIC				2
11/1/2004	ARSENIC	334,806	247,193	249	23
5/1/2005	ARSENIC	334,678	247,204	377	10
11/1/2005	ARSENIC	334,572	247,169	483	18
2/1/2006	ARSENIC	334,988	247,035	168	17
5/1/2006	ARSENIC	334,522	247,156	534	9
8/1/2006	ARSENIC	334,833	247,124	231	19
2/1/2007	ARSENIC	334,636	247,341	446	13
8/1/2007	ARSENIC				5
11/1/2007	ARSENIC	334,847	247,192	208	23
2/1/2008	ARSENIC	334,539	247,071	529	7

MAROS First Moment Analysis

Effective Date	Constituent	Xc (ft)	Yc (ft)	Distance from Source (ft)	Number of Wells
11/1/2008	ARSENIC				5
2/1/2009	ARSENIC	334,993	247,032	168	32
9/15/2009	ARSENIC	334,550	247,102	513	12

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events). Moments are not calculated for sample events with less than 6 wells.

Table 4. Heuristic Analysis Results

MAROS Site Results

Project: Vineland Superfund Shallow

User Name: Dave Becker

Location: Vineland

State: New Jersey

User Defined Site and Data Assumptions:

Hydrogeology and Plume Information:

Groundwater Seepage Velocity:	100 ft/yr
Current Plume Length:	1500 ft
Current Plume Width	1200 ft
Number of Tail Wells:	43
Number of Source Wells:	8

Down-gradient Information:

Distance from Edge of Tail to Nearest:

Down-gradient receptor:	1 ft
Down-gradient property:	1 ft

Distance from Source to Nearest:

Down-gradient receptor:	1500 ft
Down-gradient property:	1500 ft

Source Information:

Source Treatment: Excavation

NAPL is not observed at this site.

Data Consolidation Assumptions:

Time Period: 5/1/2000 **to** 9/15/2009

Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Maximum

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value

Plume Information Weighting Assumptions:

Consolidation Step 1. Weight Plume Information by Chemical

Summary Weighting: Weighting Applied to All Chemicals Equally

Consolidation Step 2. Weight Well Information by Chemical

Well Weighting: No Weighting of Wells was Applied.

Chemical Weighting: No Weighting of Chemicals was Applied.

Note: These assumptions were made when consolidating the historical montoring data and lumping the Wells and COCs.

1. Compliance Monitoring/Remediation Optimization Results:

Preliminary Monitoring System Optimization Results: Based on site classification, source treatment and Monitoring System Category the following suggestions are made for site Sampling Frequency, Duration of Sampling before reassessment, and Well Density. These criteria take into consideration: Plume Stability, Type of Plume, and Groundwater Velocity.

COC	Tail Stability	Source Stability	Level of Effort	Sampling Duration	Sampling Frequency	Sampling Density
ARSENIC	S	PI	M	Remove treatment system if previously reducing concentration or PRG met.	No Recommendation	30

Note:

Plume Status: (I) Increasing; (PI)Probably Increasing; (S) Stable; (NT) No Trend; (PD) Probably Decreasing; (D) Decreasing

Design Categories: (E) Extensive; (M) Moderate; (L) Limited (N/A) Not Applicable, Insufficient Data Available

Level of Monitoring Effort Indicated by Analysi Moderate

2. Spatial Moment Analysis Results:

Moment Type	Constituent	Coefficient of Variation	Mann-Kendall S Statistic	Confidence in Trend	Moment Trend
Zeroth Moment: Mass					
	ARSENIC	0.85	-80	94.0%	PD
1st Moment: Distance to Source					
	ARSENIC	0.51	68	95.2%	I
2nd Moment: Sigma XX					
	ARSENIC	0.60	-14	62.5%	S
2nd Moment: Sigma YY					
	ARSENIC	0.39	-14	62.5%	S

Note: The following assumptions were applied for the calculation of the Zeroth Moment:

Porosity: 0.25 **Saturated Thickness:** Uniform: 20 ft

Mann-Kendall Trend test performed on all sample events for each constituent. Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A)-Due to insufficient Data (< 4 sampling events).

Table 5.

MAROS Sampling Frequency Optimization Results

Project: Vineland Superfund Shallow

User Name: Dave Becker

Location: Vineland

State: New Jersey

The Overall Number of Sampling Events: 28

"Recent Period" defined by events: **From** Winter 2007 **To** Fall 2009

2/1/2007 9/15/2009

"Rate of Change" parameters used:

Constituent	Cleanup Goal	Low Rate	Medium Rate	High Rate
ARSENIC	0.05	0.025	0.05	0.1

Units: Cleanup Goal is in mg/L; all rate parameters are in mg/L/year.

Well	Recommended Sampling Frequency	Frequency Based on Recent Data	Frequency Based on Overall Data
ARSENIC			
EW04S	Quarterly	Quarterly	Quarterly
EW06S	Quarterly	Quarterly	Quarterly
EW07S	Quarterly	Quarterly	Quarterly
EW08S	Quarterly	Quarterly	Quarterly
EW09S	Annual	Annual	Annual
EW11S	Quarterly	Quarterly	Quarterly
EW12S	Annual	Annual	Annual
EW13S	Quarterly	Quarterly	Quarterly
EW14S	Annual	Annual	Annual
EW16S	Annual	Annual	Annual
EW17S	Annual	Annual	Annual
EW18S	Annual	Annual	Annual
EW19S	Quarterly	Quarterly	Quarterly
EW20S	Annual	Annual	Annual
EW21S	Annual	Annual	Annual
EW22S	Annual	Annual	Annual
EW23S	Annual	Annual	Annual
MW28S	Quarterly	Quarterly	Quarterly
MW29S	Annual	Annual	Annual
MW30S	Quarterly	Quarterly	Quarterly
MW31S	Annual	Annual	Annual
MW32S	Annual	Annual	Annual
MW33S	SemiAnnual	SemiAnnual	SemiAnnual
MW34S	Quarterly	Quarterly	Quarterly

Project: Vineland Superfund Shallow

User Name: Dave Becker

Location: Vineland

State: New Jersey

Well	Recommended Sampling Frequency	Frequency Based on Recent Data	Frequency Based on Overall Data
MW35S	Quarterly	Quarterly	Quarterly
MW38S	Quarterly	Quarterly	Quarterly
MW39S	Quarterly	Quarterly	Quarterly
MW40S	Quarterly	Quarterly	Quarterly
MW41S	Annual	Annual	Annual
MW42S	Annual	Annual	Annual
MW43S	Annual	Annual	Annual
MW44S	Annual	Annual	Annual
MW45S	SemiAnnual	SemiAnnual	SemiAnnual
MW46S	Annual	Annual	Annual
MW47S	Annual	Annual	Annual
MW51S	Annual	Annual	Annual
MW52S	Quarterly	Quarterly	Quarterly
MW53S	Annual	Annual	Annual
MW54S	Quarterly	Quarterly	Quarterly
WW24S	Quarterly	Quarterly	Quarterly
WW25S	SemiAnnual	SemiAnnual	SemiAnnual
WW26S	Biennial	Annual	Annual
WW27S	Annual	Annual	Annual

Note: Sampling frequency is determined considering both recent and overall concentration trends. Sampling Frequency is the final recommendation; Frequency Based on Recent Data is the frequency determined using recent (short) period of monitoring data; Frequency Based on Overall Data is the frequency determined using overall (long) period of monitoring data. If the "recent period" is defined using a different series of sampling events, the results could be different.

Table 6

MAROS Sampling Location Optimization

Results by Considering All COCs

Project: Vineland Intermediate

User Name: Dave Becker

Location: Vineland

State: New Jersey

Sampling Events Analyzed: **From** Winter 2008 2/1/2008 **to** Fall 2009 9/15/2009

Well	X (feet)	Y (feet)	Number of COCs	COC-Averaged Slope Factor*	Abandoned?
EW04S	334600.56	247536.44	1		☐
EW06S	334829.06	247129.22	1	0.191	☐
EW07S	335156.09	247201.20	1		☐
EW08S	335285.13	247175.61	1	0.386	☐
EW09S	335657.66	247321.58	1	0.668	☐
EW11S	334937.78	246843.97	1	0.360	☐
EW12S	335812.53	246883.78	1	0.521	☐
EW13S	334238.03	246659.00	1	0.560	☐
EW14S	334568.59	246498.09	1	0.522	☐
EW16S	335731.63	246111.45	1	0.412	☐
EW17S	334815.03	246161.73	1	0.408	☐
EW18S	334324.94	246179.55	1	0.136	☐
EW19S	334038.03	246626.73	1	0.272	☐
EW22S	333476.41	246738.47	1	0.177	☐
EW23S	333139.78	246876.63	1	0.009	☐
MW28S	334911.81	247283.53	1	0.195	☐
MW29S	334323.75	247354.23	1	0.064	☐
MW30S	334797.63	247493.91	1	0.230	☐
MW31S	334257.56	247524.66	1	0.047	☐
MW32S	334293.53	248085.34	1	0.669	☐
MW33S	334376.66	246887.61	1	0.180	☐
MW34S	334685.03	246664.27	1	0.464	☐
MW35S	334995.03	246588.30	1	0.470	☐
MW38S	335054.69	247188.13	1	0.033	☐
MW39S	334884.16	247416.95	1	0.079	☐
MW40S	334401.88	247454.22	1	0.426	☐
MW41S	334165.06	247343.08	1	0.347	☐
MW42S	334153.66	247147.42	1	0.277	☐
MW45S	334123.13	246715.27	1	0.090	☐
MW46S	334110.84	246517.73	1	0.522	☐
MW47S	334373.19	247191.78	1	0.531	☐
MW51S	333500.00	247105.00	1	0.000	☑

Project: Vineland Intermediate

User Name: Dave Becker

Location: Vineland

State: New Jersey

Well	X (feet)	Y (feet)	Number of COCs	COC-Averaged Slope Factor*	Abandoned?
MW52S	333963.00	247258.00	1		☐
MW53S	334088.00	247628.00	1		☐
MW54S	333930.00	248210.00	1	0.806	☐
WW25S	334212.63	247852.27	1		☐
WW26S	333851.63	247788.92	1	0.437	☐
WW27S	333425.31	247796.73	1	0.000	☑

Note: the COC-Averaged Slope Factor is the value calculated by averaging those "Average Slope Factor" obtained earlier across COCs; to be conservative, a location is "abandoned" only when it is eliminated from all COCs; "abandoned" doesn't necessarily mean the abandon of well, it can mean that NO samples need to be collected for any COCs.

* When the report is generated after running the Excel module, SF values will NOT be shown above.

Table 7. Mid-Depth Well Trends

MAROS Statistical Trend Analysis Summary

Project: Vineland Intermediate

Location: Vineland

User Name: Dave Becker

State: New Jersey

Time Period: 5/1/2000 **to** 11/1/2009

Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Maximum

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value

Well	Source/ Tail	Number of Samples	Number of Detects	Average Conc. (mg/L)	Median Conc. (mg/L)	All Samples "ND" ?	Mann-Kendall Trend	Linear Regression Trend
ARSENIC								
EW01M	T	13	0	4.5E-03	4.5E-03	Yes	S	S
EW04M	T	13	13	1.2E+01	8.5E+00	No	D	D
EW05M	T	13	13	5.4E-01	5.1E-01	No	S	NT
EW06M	T	12	12	4.1E+00	3.2E+00	No	D	D
EW07M	S	14	14	3.6E+00	3.4E+00	No	D	D
EW08M	S	12	12	3.5E-02	3.4E-02	No	I	I
EW09M	T	10	0	4.1E-03	4.5E-03	Yes	NT	NT
EW10M	T	15	11	1.3E-01	3.4E-02	No	PD	PD
EW11M	T	13	13	3.7E-01	2.5E-01	No	NT	NT
EW12M	T	10	0	3.8E-03	4.5E-03	Yes	NT	NT
EW13M	T	12	12	5.4E-01	3.6E-01	No	D	D
EW14M	T	12	0	4.2E-03	4.5E-03	Yes	NT	NT
EW15M	T	14	1	4.7E-03	4.5E-03	No	NT	NT
EW16M	T	10	0	3.8E-03	4.5E-03	Yes	NT	NT
EW17M	T	13	0	4.0E-03	4.5E-03	Yes	NT	NT
EW18M	T	13	3	6.1E-03	4.5E-03	No	PI	NT
EW19M	T	14	14	8.1E-02	2.7E-02	No	NT	NT
EW20M	T	13	13	3.9E+00	2.9E+00	No	D	D
EW21M	T	16	16	1.1E+00	5.2E-01	No	NT	NT
EW22M	T	14	0	4.0E-03	4.5E-03	Yes	NT	NT
EW23M	T	13	0	4.0E-03	4.5E-03	Yes	NT	NT
MW28M	S	16	16	7.6E+00	7.7E+00	No	S	D
MW29M	T	14	7	5.0E-01	4.5E-03	No	D	D
MW31M	T	16	16	7.7E+00	5.7E+00	No	D	S
MW32M	T	11	1	4.2E-03	4.5E-03	No	NT	NT
MW33M	T	15	10	3.7E-02	3.9E-02	No	D	D
MW34M	S	11	2	5.5E-03	4.5E-03	No	S	S
MW35M	S	12	4	1.0E-01	4.5E-03	No	NT	NT
MW36M	T	8	5	1.5E-02	1.1E-02	No	NT	NT
MW37M	S	9	8	6.9E-02	1.4E-02	No	NT	NT
MW38M	S	12	10	1.8E-02	1.3E-02	No	D	D
MW39M	T	12	11	1.9E+00	7.1E-02	No	D	D
MW40M	T	13	5	1.2E-02	4.5E-03	No	NT	NT
MW41M	T	15	14	2.6E-01	4.1E-02	No	D	PD
MW42M	T	11	7	5.7E-02	2.7E-02	No	PD	NT

MAROS Statistical Trend Analysis Summary

Well	Source/ Tail	Number of Samples	Number of Detects	Average Conc. (mg/L)	Median Conc. (mg/L)	All Samples "ND" ?	Mann-Kendall Trend	Linear Regression Trend
ARSENIC								
MW43M	T	10	1	4.5E-03	4.5E-03	No	NT	NT
MW44M	T	10	2	7.2E-03	4.5E-03	No	PD	PD
MW45M	T	12	12	4.5E-01	4.5E-01	No	S	S
MW46M	T	11	1	6.2E-03	4.5E-03	No	NT	PI
MW47M	T	14	14	2.2E-01	1.5E-01	No	S	S
MW48M	T	10	9	2.6E-02	1.7E-02	No	NT	NT
MW49M	T	10	10	8.3E-02	7.3E-02	No	S	I
MW50M	S	11	4	6.3E-03	4.5E-03	No	D	D
MW51M	T	4	0	3.8E-03	4.5E-03	Yes	S	PD
MW52M	T	4	4	6.1E-01	5.0E-01	No	S	S
MW53M	T	4	2	7.5E-02	5.6E-02	No	NT	NT
MW54M	T	5	5	3.1E-02	2.5E-02	No	I	I
RW01	T	30	30	1.2E+00	1.2E+00	No	D	D
RW02	T	31	31	2.9E+00	2.5E+00	No	D	D
RW02A	T	10	10	1.5E+00	1.1E+00	No	D	D
RW02B	T	10	10	1.9E+00	1.7E+00	No	S	S
RW03	T	33	33	1.3E+00	7.8E-01	No	D	D
RW04	T	32	32	5.1E+00	2.3E+00	No	D	D
RW05	T	32	32	1.7E+00	7.4E-01	No	D	NT
RW06	T	33	33	5.7E+00	1.9E+00	No	D	D
RW07	T	33	33	3.3E+00	1.3E+00	No	D	D
RW08	T	33	33	3.8E+00	1.3E+00	No	D	D
RW09	T	10	10	8.2E-01	4.1E-01	No	PI	I
RW09A	T	10	10	1.6E-01	1.4E-01	No	S	PD
RW10	T	33	33	2.1E+00	6.4E-01	No	D	D
RW11	T	32	25	2.4E+00	8.1E-02	No	D	D
RW12	T	33	33	3.0E+00	7.1E-01	No	D	D
RW13	T	30	30	1.4E+00	6.1E-02	No	D	D
WW24M	T	12	0	4.2E-03	4.5E-03	Yes	NT	NT
WW25M	T	13	13	2.0E+00	1.7E+00	No	D	D
WW26M	T	16	12	1.6E-02	1.4E-02	No	NT	S
WW27M	T	13	1	4.4E-03	4.5E-03	No	NT	NT

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); No Detectable Concentration (NDC)

The Number of Samples and Number of Detects shown above are post-consolidation values.

Table 8

MAROS Spatial Moment Analysis Summary

Project: Vineland Intermediate

Location: Vineland

User Name: Dave Becker

State: New Jersey

	0th Moment	1st Moment (Center of Mass)			2nd Moment (Spread)		
Effective Date	**Estimated Mass (Kg)**	**Xc (ft)**	**Yc (ft)**	**Source Distance (ft)**	**Sigma XX (sq ft)**	**Sigma YY (sq ft)**	**Number of Wells**
ARSENIC							
5/1/2000	6.1E+02	334,453	247,532	693	76,931	36,948	55
8/1/2000	7.2E+02	334,554	247,366	532	164,417	50,187	41
11/1/2000	1.1E+03	334,538	247,403	560	114,569	79,508	38
2/1/2001	8.5E+02	334,602	247,360	485	120,789	66,410	31
5/1/2001	6.2E+02	334,427	247,234	630	186,868	87,492	29
8/1/2001	4.8E+02	334,421	247,421	675	142,040	71,718	56
11/1/2001	2.5E+02	334,508	247,321	563	186,397	71,078	56
2/1/2002	3.3E+02	334,427	247,472	689	134,613	65,492	54
5/1/2002	5.3E+02	334,511	247,459	608	81,348	56,228	54
8/1/2002	3.6E+02	334,583	247,355	501	142,095	67,864	36
11/1/2002	2.0E+02	334,615	247,260	445	98,901	33,465	18
2/1/2003	4.6E+02	334,427	247,232	630	89,501	29,717	13
5/1/2003	4.6E+02	334,405	247,218	651	95,725	50,680	26
11/1/2003	4.2E+02	334,601	247,199	454	100,254	69,312	23
2/1/2004	2.5E+02	334,663	247,429	460	95,512	64,650	37
5/1/2004	2.3E+02	334,462	247,357	616	48,141	66,773	18
11/1/2004	4.8E+02	334,644	247,345	440	138,980	65,014	44
5/1/2005	1.9E+02	334,503	247,283	560	140,294	92,851	23
11/1/2005	3.6E+02	334,622	247,301	448	171,036	80,729	35
2/1/2006	8.4E+01	334,724	247,297	349	104,721	47,264	32
5/1/2006	2.7E+02	334,512	247,305	555	61,545	50,034	23
8/1/2006	3.1E+02	334,513	247,344	564	192,667	91,786	34
2/1/2007	3.1E+02	334,607	247,322	468	104,337	66,396	23
5/1/2007	1.9E+02	334,555	247,312	516	75,130	49,966	13
11/1/2007	2.2E+02	334,451	247,494	677	78,151	62,587	47
2/1/2008	1.3E+02	334,723	247,343	366	112,932	69,106	25
5/1/2008	1.2E+02	334,561	247,250	497	99,458	29,523	15
8/1/2008	1.4E+02	334,542	247,261	518	94,347	27,235	15
11/1/2008	1.8E+02	334,472	247,341	602	80,733	71,376	23
2/1/2009	9.9E+01	334,542	247,344	537	128,303	86,005	52
5/1/2009	1.4E+02	334,543	247,245	515	77,020	23,913	13
8/1/2009	1.2E+02	334,588	247,282	476	93,433	23,907	12
11/1/2009	9.4E+01	334,569	247,240	489	89,625	31,152	14

Project: Vineland Intermediate

Location: Vineland

User Name: Dave Becker

State: New Jersey

Moment Type	Constituent	Coefficient of Variation	Mann-Kendall S Statistic	Confidence in Trend	Moment Trend
Zeroth Moment: Mass					
	ARSENIC	0.68	-354	100.0%	D
1st Moment: Distance to Source					
	ARSENIC	0.17	-124	97.2%	D
2nd Moment: Sigma XX					
	ARSENIC	0.33	-126	97.4%	D
2nd Moment: Sigma YY					
	ARSENIC	0.35	-102	94.1%	PD

Note: The following assumptions were applied for the calculation of the Zeroth Moment:

Porosity: 0.25 **Saturated Thickness:** Uniform: 50 ft

Mann-Kendall Trend test performed on all sample events for each constituent. Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A)-Due to insufficient Data (< 4 sampling events).

Note: The Sigma XX and Sigma YY components are estimated using the given field coordinate system and then rotated to align with the estimated groundwater flow direction. Moments are not calculated for sample events with less than 6 wells.

Table 9.

MAROS First Moment Analysis

Project: Vineland Intermediate

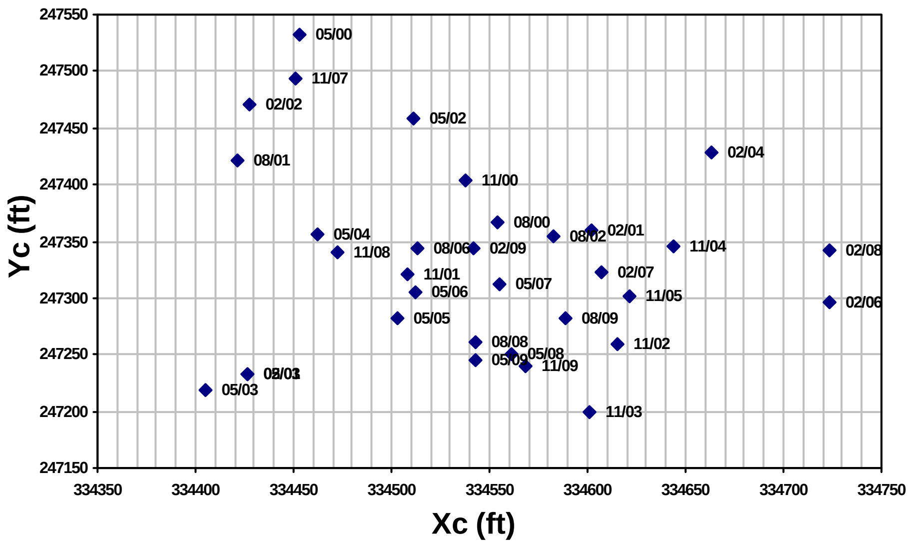
User Name: Dave Becker

Location: Vineland

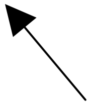
State: New Jersey

COC: ARSENIC

Change in Location of Center of Mass Over Time



Groundwater Flow Direction:



Source Coordinate:

X: 335,055

Y: 247,188

Effective Date	Constituent	Xc (ft)	Yc (ft)	Distance from Source (ft)	Number of Wells
5/1/2000	ARSENIC	334,453	247,532	693	55
8/1/2000	ARSENIC	334,554	247,366	532	41
11/1/2000	ARSENIC	334,538	247,403	560	38
2/1/2001	ARSENIC	334,602	247,360	485	31
5/1/2001	ARSENIC	334,427	247,234	630	29
8/1/2001	ARSENIC	334,421	247,421	675	56
11/1/2001	ARSENIC	334,508	247,321	563	56
2/1/2002	ARSENIC	334,427	247,472	689	54
5/1/2002	ARSENIC	334,511	247,459	608	54
8/1/2002	ARSENIC	334,583	247,355	501	36
11/1/2002	ARSENIC	334,615	247,260	445	18
2/1/2003	ARSENIC	334,427	247,232	630	13
5/1/2003	ARSENIC	334,405	247,218	651	26
11/1/2003	ARSENIC	334,601	247,199	454	23
2/1/2004	ARSENIC	334,663	247,429	460	37
5/1/2004	ARSENIC	334,462	247,357	616	18
11/1/2004	ARSENIC	334,644	247,345	440	44
5/1/2005	ARSENIC	334,503	247,283	560	23
11/1/2005	ARSENIC	334,622	247,301	448	35
2/1/2006	ARSENIC	334,724	247,297	349	32
5/1/2006	ARSENIC	334,512	247,305	555	23
8/1/2006	ARSENIC	334,513	247,344	564	34
2/1/2007	ARSENIC	334,607	247,322	468	23
5/1/2007	ARSENIC	334,555	247,312	516	13
11/1/2007	ARSENIC	334,451	247,494	677	47

MAROS First Moment Analysis

Effective Date	Constituent	Xc (ft)	Yc (ft)	Distance from Source (ft)	Number of Wells
2/1/2008	ARSENIC	334,723	247,343	366	25
5/1/2008	ARSENIC	334,561	247,250	497	15
8/1/2008	ARSENIC	334,542	247,261	518	15
11/1/2008	ARSENIC	334,472	247,341	602	23
2/1/2009	ARSENIC	334,542	247,344	537	52
5/1/2009	ARSENIC	334,543	247,245	515	13
8/1/2009	ARSENIC	334,588	247,282	476	12
11/1/2009	ARSENIC	334,569	247,240	489	14

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events). Moments are not calculated for sample events with less than 6 wells.

Table 10. Heuristic Analysis Results, Mid-Depth Wells

MAROS Site Results

Project: Vineland Intermediate

User Name: Dave Becker

Location: Vineland

State: New Jersey

User Defined Site and Data Assumptions:

Hydrogeology and Plume Information:

Groundwater Seepage Velocity: 100 ft/yr

Current Plume Length: 1500 ft

Current Plume Width 1200 ft

Number of Tail Wells: 59

Number of Source Wells: 8

Source Information:

Source Treatment: Excavation

NAPL is not observed at this site.

Down-gradient Information:

Distance from Edge of Tail to Nearest:

Down-gradient receptor: 1 ft

Down-gradient property: 1 ft

Distance from Source to Nearest:

Down-gradient receptor: 1500 ft

Down-gradient property: 1500 ft

Data Consolidation Assumptions:

Time Period: 5/1/2000 **to** 11/1/2009

Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Maximum

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value

Plume Information Weighting Assumptions:

Consolidation Step 1. Weight Plume Information by Chemical

Summary Weighting: Weighting Applied to All Chemicals Equally

Consolidation Step 2. Weight Well Information by Chemical

Well Weighting: No Weighting of Wells was Applied.

Chemical Weighting: No Weighting of Chemicals was Applied.

Note: These assumptions were made when consolidating the historical montoring data and lumping the Wells and COCs.

1. Compliance Monitoring/Remediation Optimization Results:

Preliminary Monitoring System Optimization Results: Based on site classification, source treatment and Monitoring System Category the following suggestions are made for site Sampling Frequency, Duration of Sampling before reassessment, and Well Density. These criteria take into consideration: Plume Stability, Type of Plume, and Groundwater Velocity.

COC	Tail Stability	Source Stability	Level of Effort	Sampling Duration	Sampling Frequency	Sampling Density
ARSENIC	S	S	M	Remove treatment system if previously reducing concentration or PRG met.	No Recommendation	30

Note:

Plume Status: (I) Increasing; (PI)Probably Increasing; (S) Stable; (NT) No Trend; (PD) Probably Decreasing; (D) Decreasing

Design Categories: (E) Extensive; (M) Moderate; (L) Limited (N/A) Not Applicable, Insufficient Data Available

Level of Monitoring Effort Indicated by Analysi Moderate

2. Spatial Moment Analysis Results:

Moment Type	Constituent	Coefficient of Variation	Mann-Kendall S Statistic	Confidence in Trend	Moment Trend
Zeroth Moment: Mass					
	ARSENIC	0.68	-354	100.0%	D
1st Moment: Distance to Source					
	ARSENIC	0.17	-124	97.2%	D
2nd Moment: Sigma XX					
	ARSENIC	0.33	-126	97.4%	D
2nd Moment: Sigma YY					
	ARSENIC	0.35	-102	94.1%	PD

Note: The following assumptions were applied for the calculation of the Zeroth Moment:

Porosity: 0.25 **Saturated Thickness:** Uniform: 50 ft

Mann-Kendall Trend test performed on all sample events for each constituent. Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A)-Due to insufficient Data (< 4 sampling events).

Table 11.

MAROS Sampling Frequency Optimization Results

Project: Vineland Intermediate

User Name: Dave Becker

Location: Vineland

State: New Jersey

The Overall Number of Sampling Events: 33

"Recent Period" defined by events: **From** Fall 2007 11/1/2007 **To** Fall 2009 11/1/2009

"Rate of Change" parameters used:

Constituent	Cleanup Goal	Low Rate	Medium Rate	High Rate
ARSENIC	0.05	0.025	0.05	0.1

Units: Cleanup Goal is in mg/L; all rate parameters are in mg/L/year.

Well	Recommended Sampling Frequency	Frequency Based on Recent Data	Frequency Based on Overall Data
ARSENIC			
EW01M	Biennial	Annual	Annual
EW04M	Quarterly	Quarterly	Quarterly
EW05M	Quarterly	Quarterly	Quarterly
EW06M	Quarterly	Quarterly	Quarterly
EW07M	Quarterly	Quarterly	Quarterly
EW08M	SemiAnnual	SemiAnnual	SemiAnnual
EW09M	Annual	Annual	Annual
EW10M	Quarterly	Quarterly	Quarterly
EW11M	Quarterly	Quarterly	Quarterly
EW12M	Annual	Annual	Annual
EW13M	Quarterly	Quarterly	Quarterly
EW14M	Annual	Annual	Annual
EW15M	Annual	Annual	Annual
EW16M	Annual	Annual	Annual
EW17M	Annual	Annual	Annual
EW18M	Annual	Annual	Annual
EW19M	SemiAnnual	SemiAnnual	SemiAnnual
EW20M	Quarterly	Quarterly	Quarterly
EW21M	Quarterly	Quarterly	Quarterly
EW22M	Annual	Annual	Annual
EW23M	Annual	Annual	Annual
MW28M	Quarterly	Quarterly	Quarterly
MW29M	Annual	Annual	Annual
MW31M	Quarterly	Quarterly	Quarterly

Well	Recommended Sampling Frequency	Frequency Based on Recent Data	Frequency Based on Overall Data
MW32M	Annual	Annual	Annual
MW33M	Annual	Annual	Annual
MW34M	Annual	Annual	Annual
MW35M	Annual	Annual	Annual
MW37M	Annual	Annual	Annual
MW38M	Annual	Annual	Annual
MW39M	SemiAnnual	SemiAnnual	SemiAnnual
MW40M	Annual	Annual	Annual
MW41M	Annual	Annual	Annual
MW42M	Annual	Annual	Annual
MW43M	Annual	Annual	Annual
MW44M	Annual	Annual	Annual
MW45M	Quarterly	Quarterly	Quarterly
MW46M	Annual	Annual	Annual
MW47M	Quarterly	Quarterly	Quarterly
MW48M	Annual	Annual	Annual
MW49M	Quarterly	Quarterly	Quarterly
MW50M	Annual	Annual	Annual
MW52M	Quarterly	Quarterly	Quarterly
MW53M	Quarterly	Quarterly	Quarterly
MW54M	SemiAnnual	SemiAnnual	SemiAnnual
RW01	Annual	Annual	Annual
RW02	Annual	Annual	Annual
RW02A	Annual	Annual	Annual
RW02B	Annual	Annual	Annual
RW03	Quarterly	Quarterly	Annual
RW04	Annual	Annual	Annual
RW05	Annual	Annual	Annual
RW06	Annual	Annual	Annual
RW07	Annual	Annual	Annual
RW08	Annual	Annual	Annual
RW09A	Annual	Annual	Annual
RW10	Annual	Annual	Annual
RW11	Annual	Annual	Annual
RW12	Annual	Annual	Annual
RW13	Annual	Annual	Annual
WW24M	Annual	Annual	Annual
WW25M	Quarterly	Quarterly	Quarterly

Project: Vineland Intermediate

User Name: Dave Becker

Location: Vineland

State: New Jersey

Well	Recommended Sampling Frequency	Frequency Based on Recent Data	Frequency Based on Overall Data
WW26M	Annual	Annual	Annual
WW27M	Annual	Annual	Annual

Note: Sampling frequency is determined considering both recent and overall concentration trends. Sampling Frequency is the final recommendation; Frequency Based on Recent Data is the frequency determined using recent (short) period of monitoring data; Frequency Based on Overall Data is the frequency determined using overall (long) period of monitoring data. If the "recent period" is defined using a different series of sampling events, the results could be different.

Table 12.

MAROS Sampling Location Optimization Results

Project: Vineland Intermediate **User Name:** Dave Becker

Location: Vineland **State:** New Jersey

Sampling Events Analyzed: **From** Winter 2009 2/1/2009 **to** Fall 2009 11/1/2009

Parameters used:

Constituent	Inside SF	Hull SF	Area Ratio	Conc. Ratio
ARSENIC	0.2	0.1	0.9	0.8

Well	X (feet)	Y (feet)	Removable?	Average Slope Factor*	Minimum Slope Factor*	Maximum Slope Factor*	Eliminated?
ARSENIC							
EW01M	334423.06	248236.41	☑	0.449	0.449	0.449	☐
EW05M	334584.69	247105.13	☑	0.282	0.282	0.282	☐
EW06M	334822.38	247129.81	☑	0.064	0.064	0.064	☐
EW08M	335282.69	247183.30	☑	0.317	0.317	0.317	☐
EW09M	335657.88	247326.73	☑	0.607	0.607	0.607	☐
EW10M	334273.47	247058.27	☑	0.033	0.033	0.033	☐
EW11M	334944.25	246843.64	☑	0.242	0.242	0.242	☐
EW12M	335812.53	246873.55	☑	0.395	0.395	0.395	☐
EW13M	334226.97	246670.30	☑	0.091	0.091	0.091	☐
EW14M	334576.69	246496.89	☑	0.206	0.206	0.206	☐
EW15M	335364.66	246214.66	☑	0.000	0.000	0.000	☐
EW16M	335726.00	246119.73	☑	0.000	0.000	0.000	☑
EW17M	334803.94	246161.19	☑	0.000	0.000	0.000	☑
EW18M	334329.84	246187.56	☑	0.000	0.000	0.000	☐
EW19M	334041.59	246619.63	☑	0.148	0.148	0.148	☐
EW22M	333479.31	246750.97	☑	0.171	0.171	0.171	☐
EW23M	333147.25	246882.34	☑	0.344	0.344	0.344	☐
MW28M	334910.03	247268.52	☑	0.458	0.458	0.458	☐
MW29M	334332.16	247354.81	☑	0.663	0.663	0.663	☐
MW31M	334257.28	247518.86	☑	0.480	0.480	0.480	☐
MW32M	334293.22	248080.13	☑	0.497	0.497	0.497	☐
MW33M	334376.59	246887.63	☑	0.660	0.660	0.660	☐
MW34M	334679.88	246664.66	☑	0.443	0.443	0.443	☐
MW35M	334999.31	246589.69	☑	0.394	0.394	0.394	☐
MW37M	335530.72	247221.02	☑	0.132	0.132	0.132	☐
MW38M	335061.56	247187.80	☑	0.747	0.747	0.747	☐
MW39M	334878.94	247418.59	☑	0.760	0.760	0.760	☐
MW40M	334407.75	247455.70	☑	0.718	0.718	0.718	☐

Project: Vineland Intermediate **User Name:** Dave Becker

Location: Vineland **State:** New Jersey

Well	X (feet)	Y (feet)	Removable?	Average Slope Factor*	Minimum Slope Factor*	Maximum Slope Factor*	Eliminated?
MW41M	334166.41	247338.44	☑	0.315	0.315	0.315	☐
MW42M	334153.66	247147.42	☑	0.676	0.676	0.676	☐
MW45M	334121.69	246709.91	☑	0.301	0.301	0.301	☐
MW46M	334111.19	246512.52	☑	0.589	0.589	0.589	☐
MW47M	334372.66	247187.59	☑	0.383	0.383	0.383	☐
MW48M	335156.84	247081.69	☑	0.408	0.408	0.408	☐
MW49M	335290.81	247123.06	☑	0.042	0.042	0.042	☐
MW50M	335379.91	247196.06	☑	0.694	0.694	0.694	☐
MW54M	333931.00	248215.00	☑	0.591	0.591	0.591	☐
RW01	335340.75	247239.47	☑	0.182	0.182	0.182	☐
RW02	335201.78	247183.59	☑	0.257	0.186	0.332	☐
RW02A	335312.00	247227.00	☑	0.260	0.055	0.364	☐
RW02B	335204.00	247145.00	☑	0.395	0.163	0.535	☐
RW03	334905.63	247198.69	☑	0.040	0.002	0.129	☐
RW04	334761.88	247496.75	☑	0.085	0.001	0.211	☐
RW05	334656.25	247391.86	☑	0.130	0.022	0.181	☐
RW06	334653.50	247624.25	☑	0.211	0.037	0.332	☐
RW07	334552.06	247493.39	☑	0.141	0.033	0.210	☐
RW08	334169.94	247445.88	☑	0.251	0.087	0.358	☐
RW09A	333736.00	247118.00	☑	0.475	0.447	0.511	☐
RW10	334142.91	247048.30	☑	0.268	0.029	0.410	☐
RW11	333695.16	246975.20	☑	0.665	0.631	0.749	☐
RW12	334127.94	246826.36	☑	0.208	0.011	0.319	☐
RW13	334115.22	246627.48	☑	0.174	0.174	0.174	☐
WW24M	334054.22	248099.25	☑	0.358	0.358	0.358	☐
WW26M	333849.22	247793.30	☑	0.601	0.601	0.601	☐
WW27M	333414.06	247798.97	☑	0.395	0.395	0.395	☐

Note: The Slope Factor indicates the relative importance of a well in the monitoring network at a given sampling event; the larger the SF value of a well, the more important the well is and vice versa; the Average Slope Factor measures the overall well importance in the selected time period; the state coordinates system (i.e., X and Y refer to Easting and Northing respectively) or local coordinates systems may be used; wells that are NOT selected for analysis are not shown above.
* When the report is generated after running the Excel module, SF values will NOT be shown above.

Table 13. Deep Well Trends.

MAROS Statistical Trend Analysis Summary

Project: Vineland Deep

Location: Vineland

User Name: Dave Becker

State: New Jersey

Time Period: 5/1/2000 **to** 2/1/2009

Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Maximum

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value

Well	Source/ Tail	Number of Samples	Number of Detects	Average Conc. (mg/L)	Median Conc. (mg/L)	All Samples "ND" ?	Mann-Kendall Trend	Linear Regression Trend
ARSENIC								
EW01D	T	12	0	4.3E-03	4.5E-03	Yes	S	S
EW04D	T	16	8	1.0E-02	4.5E-03	No	PD	NT
EW05D	T	8	1	4.7E-03	4.5E-03	No	NT	NT
EW07D	S	16	4	6.4E-03	4.5E-03	No	S	I
EW09D	S	9	0	4.1E-03	4.5E-03	Yes	NT	NT
EW10D	T	9	1	4.1E-03	4.5E-03	No	NT	NT
EW15D	T	10	1	3.9E-03	4.5E-03	No	NT	NT
MW51D	T	4	0	3.8E-03	4.5E-03	Yes	S	PD
MW54D	T	5	1	1.2E-02	4.5E-03	No	NT	NT

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); No Detectable Concentration (NDC)

The Number of Samples and Number of Detects shown above are post-consolidation values.

Table 14.

MAROS Spatial Moment Analysis Summary

Project: Vineland Deep

Location: Vineland

User Name: Dave Becker

State: New Jersey

	0th Moment	1st Moment (Center of Mass)			2nd Moment (Spread)		
Effective Date	Estimated Mass (Kg)	Xc (ft)	Yc (ft)	Source Distance (ft)	Sigma XX (sq ft)	Sigma YY (sq ft)	Number of Wells
ARSENIC							
5/1/2000	3.3E-01	335,045	246,995	193	71,819	43,517	6
8/1/2000	0.0E+00						2
11/1/2000	0.0E+00						3
2/1/2001	0.0E+00						1
5/1/2001	2.4E+00	334,995	246,995	202	73,135	45,004	6
11/1/2001	2.1E+00	335,014	247,014	179	76,536	47,242	6
5/1/2002	2.0E+00	335,027	246,991	199	75,374	43,632	6
5/1/2003	0.0E+00						2
9/1/2003	0.0E+00						2
3/1/2004	0.0E+00						5
6/1/2004	0.0E+00						2
11/1/2004	0.0E+00						3
5/1/2005	0.0E+00						4
11/1/2005	3.3E+00	334,433	247,193	622	147,502	110,622	6
5/1/2006	2.8E+00	334,439	247,600	741	153,616	46,894	6
10/1/2006	0.0E+00						3
3/1/2007	2.0E+00	334,451	247,298	614	74,241	157,862	6
6/1/2007	0.0E+00						3
9/1/2007	0.0E+00						3
2/1/2008	0.0E+00						5
9/21/2008	0.0E+00						3
2/1/2009	3.5E+00	334,819	247,318	269	123,581	149,097	6

Project: Vineland Deep

Location: Vineland

User Name: Dave Becker

State: New Jersey

Moment Type	Constituent	Coefficient of Variation	Mann-Kendall S Statistic	Confidence in Trend	Moment Trend
Zeroth Moment: Mass					
	ARSENIC	1.51	2	51.1%	NT
1st Moment: Distance to Source					
	ARSENIC	0.63	12	91.1%	PI
2nd Moment: Sigma XX					
	ARSENIC	0.36	14	94.6%	PI
2nd Moment: Sigma YY					
	ARSENIC	0.63	18	98.4%	I

Note: The following assumptions were applied for the calculation of the Zeroth Moment:

Porosity: 0.25 **Saturated Thickness:** Uniform: 60 ft

Mann-Kendall Trend test performed on all sample events for each constituent. Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A)-Due to insufficient Data (< 4 sampling events).

Note: The Sigma XX and Sigma YY components are estimated using the given field coordinate system and then rotated to align with the estimated groundwater flow direction. Moments are not calculated for sample events with less than 6 wells.

Table 15.

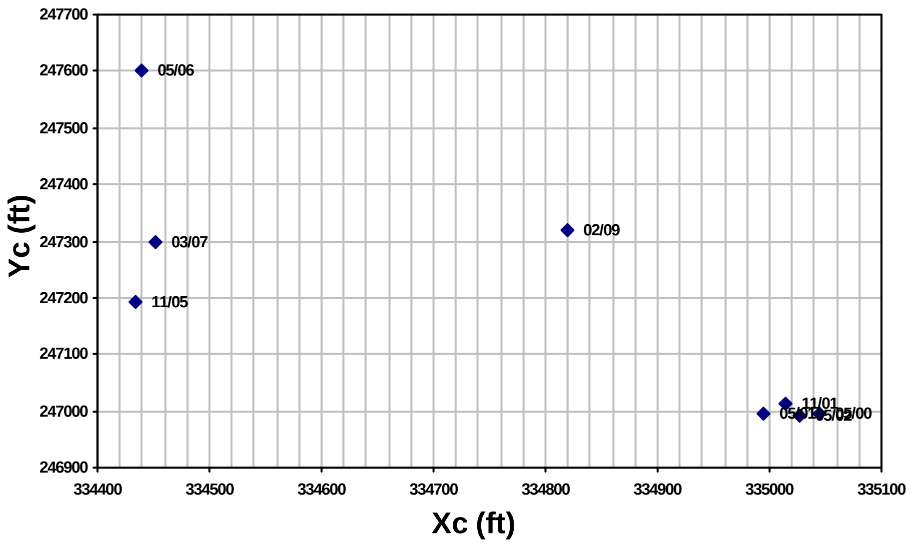
MAROS First Moment Analysis

Project: Vineland Deep **User Name:** Dave Becker

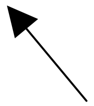
Location: Vineland **State:** New Jersey

COC: ARSENIC

Change in Location of Center of Mass Over Time



Groundwater Flow Direction:



Source Coordinate:

X: 335,055

Y: 247,188

Effective Date	Constituent	Xc (ft)	Yc (ft)	Distance from Source (ft)	Number of Wells
5/1/2000	ARSENIC	335,045	246,995	193	6
8/1/2000	ARSENIC				2
11/1/2000	ARSENIC				3
2/1/2001	ARSENIC				1
5/1/2001	ARSENIC	334,995	246,995	202	6
11/1/2001	ARSENIC	335,014	247,014	179	6
5/1/2002	ARSENIC	335,027	246,991	199	6
5/1/2003	ARSENIC				2
9/1/2003	ARSENIC				2
3/1/2004	ARSENIC				5
6/1/2004	ARSENIC				2
11/1/2004	ARSENIC				3
5/1/2005	ARSENIC				4
11/1/2005	ARSENIC	334,433	247,193	622	6
5/1/2006	ARSENIC	334,439	247,600	741	6
10/1/2006	ARSENIC				3
3/1/2007	ARSENIC	334,451	247,298	614	6
6/1/2007	ARSENIC				3
9/1/2007	ARSENIC				3
2/1/2008	ARSENIC				5
9/21/2008	ARSENIC				3
2/1/2009	ARSENIC	334,819	247,318	269	6

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events). Moments are not calculated for sample events with less than 6 wells.

Table 16. Heuristic Analysis Results, Deep Wells.

MAROS Site Results

Project: Vineland Deep

User Name: Dave Becker

Location: Vineland

State: New Jersey

User Defined Site and Data Assumptions:

Hydrogeology and Plume Information:

Groundwater Seepage Velocity: 100 ft/yr

Current Plume Length: 1500 ft

Current Plume Width 1200 ft

Number of Tail Wells: 7

Number of Source Wells: 2

Source Information:

Source Treatment: Excavation

NAPL is not observed at this site.

Down-gradient Information:

Distance from Edge of Tail to Nearest:

Down-gradient receptor: 1 ft

Down-gradient property: 1 ft

Distance from Source to Nearest:

Down-gradient receptor: 1500 ft

Down-gradient property: 1500 ft

Data Consolidation Assumptions:

Time Period: 5/1/2000 **to** 2/1/2009

Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Maximum

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value

Plume Information Weighting Assumptions:

Consolidation Step 1. Weight Plume Information by Chemical

Summary Weighting: Weighting Applied to All Chemicals Equally

Consolidation Step 2. Weight Well Information by Chemical

Well Weighting: No Weighting of Wells was Applied.

Chemical Weighting: No Weighting of Chemicals was Applied.

Note: These assumptions were made when consolidating the historical montoring data and lumping the Wells and COCs.

1. Compliance Monitoring/Remediation Optimization Results:

Preliminary Monitoring System Optimization Results: Based on site classification, source treatment and Monitoring System Category the following suggestions are made for site Sampling Frequency, Duration of Sampling before reassessment, and Well Density. These criteria take into consideration: Plume Stability, Type of Plume, and Groundwater Velocity.

COC	Tail Stability	Source Stability	Level of Effort	Sampling Duration	Sampling Frequency	Sampling Density
ARSENIC	NT	PI	E	Remove treatment system if previously reducing concentration or PRG met.	No Recommendation	30

Note:

Plume Status: (I) Increasing; (PI)Probably Increasing; (S) Stable; (NT) No Trend; (PD) Probably Decreasing; (D) Decreasing

Design Categories: (E) Extensive; (M) Moderate; (L) Limited (N/A) Not Applicable, Insufficient Data Available

Level of Monitoring Effort Indicated by Analysi Extensive

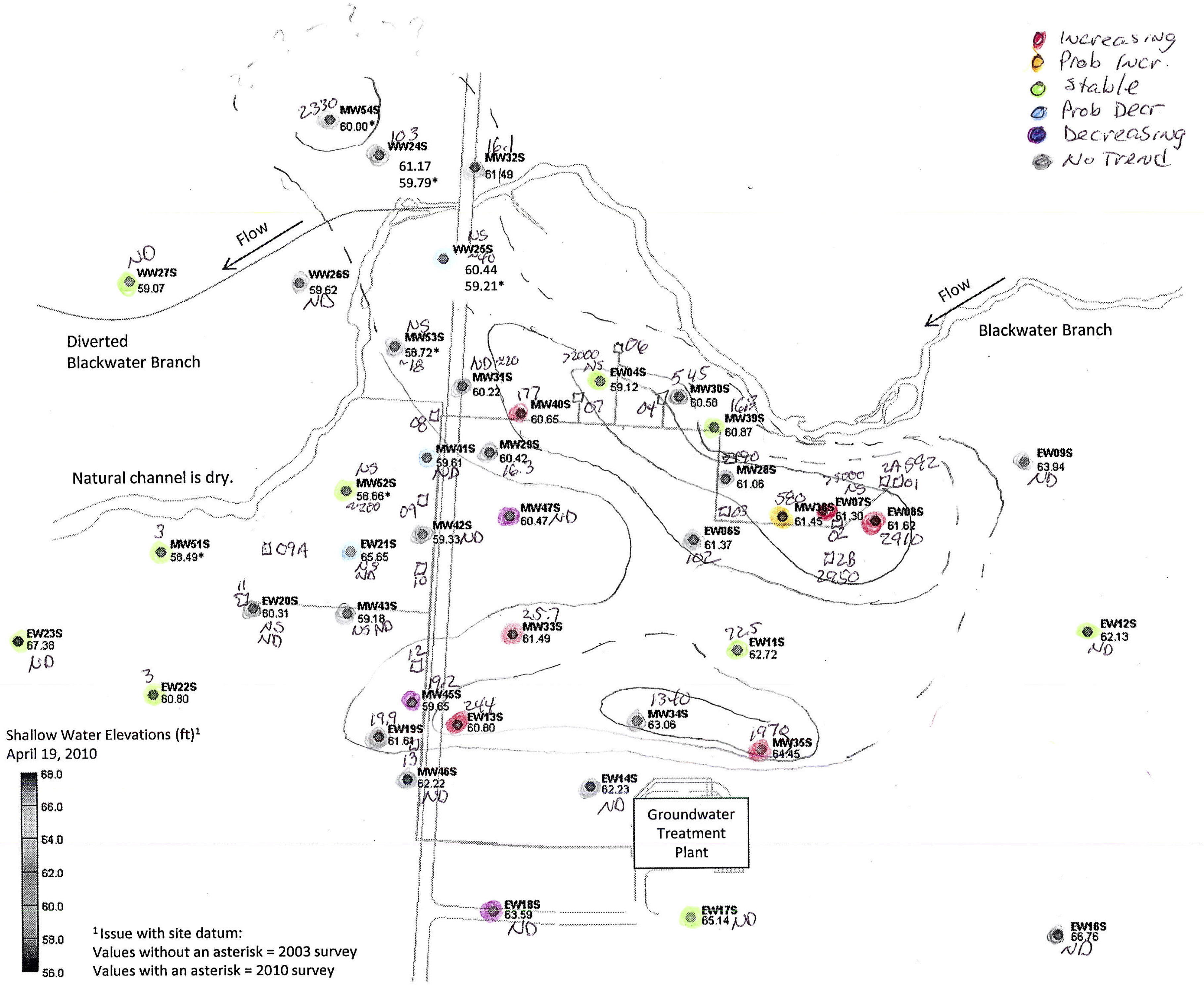
2. Spatial Moment Analysis Results:

Moment Type	Constituent	Coefficient of Variation	Mann-Kendall S Statistic	Confidence in Trend	Moment Trend
Zeroth Moment: Mass					
	ARSENIC	1.51	2	51.1%	NT
1st Moment: Distance to Source					
	ARSENIC	0.63	12	91.1%	PI
2nd Moment: Sigma XX					
	ARSENIC	0.36	14	94.6%	PI
2nd Moment: Sigma YY					
	ARSENIC	0.63	18	98.4%	I

Note: The following assumptions were applied for the calculation of the Zeroth Moment:

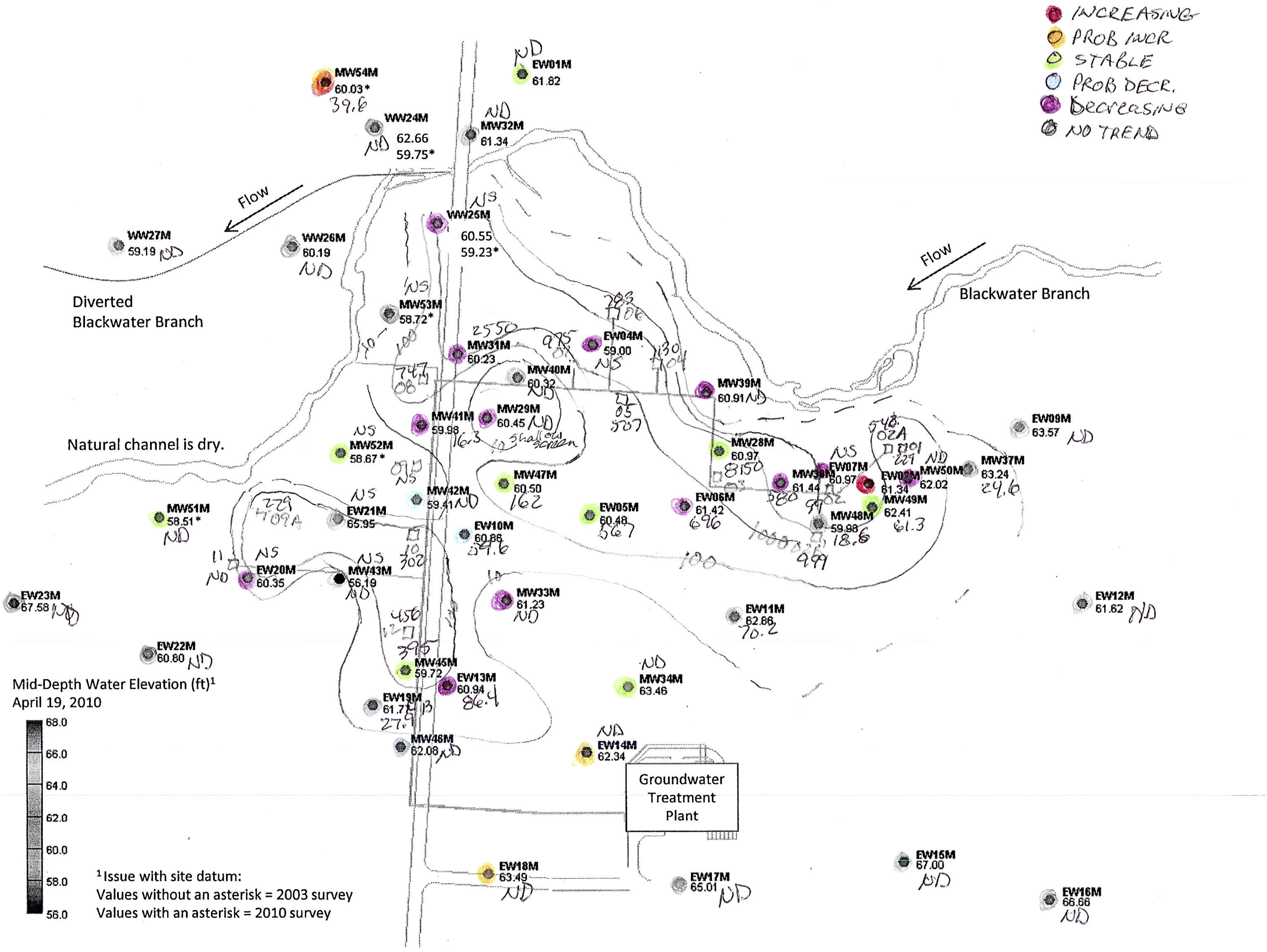
Porosity: 0.25 **Saturated Thickness:** Uniform: 60 ft

Mann-Kendall Trend test performed on all sample events for each constituent. Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A)-Due to insufficient Data (< 4 sampling events).



Shallow Water Elevations (ft)[1]
April 19, 2010

[1] Issue with site datum:
Values without an asterisk = 2003 survey
Values with an asterisk = 2010 survey



Mid-Depth Water Elevation (ft)[1]
April 19, 2010

[1] Issue with site datum:
Values without an asterisk = 2003 survey
Values with an asterisk = 2010 survey

ATTACHMENT G
Input Information and Results Only
(References for footprint conversion factors provided upon request)

Vineland Footprint Analysis
Green Remediation - Inventory of Energy, Material, Waste, and Other Remedy Aspects
Remedy Conceptual Design and Assumptions:
Existing Pump and Treat System

Overview

The remedy is a pump and treate system for OU2 of the Vineland Chemical Superfund Site. The system currently extracts approximately 750 gpm from 12 extraction wells. The water is pumped to an equalization tank and then to the following process components:
- *chemical oxidation where hydrogen peroxide is added*
- *coagulation where ferric chloride and sodium hydroxide are added*
- *flocculation where polymer is added and flox is formed*
- *dissolved air flotation to separate solids from the process water*
- *filtration with continuous backwashing sand filters*
- *discharge to surface water*

The removed solids are dewatered with a centrifuge and disposed of as hazardous waste. Groundwater sampling is conducted on an annual basis.

☐	White cells are for manual data input
🟨	Yellow cells are for manual data input from a drop-down list of selections and are protected
🟦	Blue cells are calculated cells that are protected

Instructions

1. Enter site or project name on row three of this tab.
2. Enter remedy name on row six of this tab.
3. Enter site and remedy description on row nine of this tab.
4. Copy the template tab and rename as a specific activity (e.g., O&M) on tab label and on row six of the tab.
5. Enter activity-specific information into the white and yellow cells on the copied/renamed tab.
6. Repeat steps 4 through 5 as needed for up to a total of 15 activities/tabs.
7. In cells E6 to S6 of the Summary tab, enter the names of the activity tabs from steps 4 through 6 (one name per cell).
8. In cells E4 to S4 of the Summary tab, enter the number (1 to 6) corresponding to the Level of the activity named in the corresponding cell in Row 6. For example, if the analysis defines Level 1 as construction, and the activities named in E6, F6, and G6 are all related to construction, then enter the number 1 in E4, F4, and G4.

Information from the activity tabs is compiled and summarized in the Summary tab. Some of the blue (calculated) cells of the activity tabs refer to the Lookup tab for conversion factors and default values. Each section of the activity tabs include white cells only if user override values are preferred instead of the default values from the Lookup tab.

All of the activities for a particular remedy to be included n the footprint analysis should be included in a single inventory spreadsheet. The spreadsheets are organized so that each remedy or remedy alternative has its own inventory spreadsheet.

This workbook is designed to assist EPA with conducting footprint analyses and to help EPA better understand the process of footprint quantification for environmental remedies. The workbook does not represent EPA guidance, requirements, or suggestions with respect to footprint quantification. The workbook is in draft status as of March 2011, and is intended for testing purposes. For more information about this draft template and footprint analyses at clean-up sites, contact:

Karen Scheuermann (EPA Region 9) at scheuermann.karen@epa.gov or Carlos Pachon (EPA OSRTI) at pachon.carlos@epa.gov.

Input for Groundwater Extraction

General Scope	***Typical Scope Items***	***Useful Information***
Groundwater extraction network - electricity for pumps - well maintenance		

Labor, Mobilizations, Mileage, and Fuel

Participant	**Crew Size**	**Number of Days**	**Hours Worked Per Day**	**Total Hours Worked**	**Trips to Site**	**Roundtrip Miles to Site**	**Mode of Transport.**	**Fuel Type**	**Total Miles Traveled**	**Miles Per Gallon**	**Total Fuel Used**	**Activity or Notes**
Well jetting contractor	2	2	8	32	2	80	Heavy-Duty Truck	Gasoline	160	10	16	
Well jetting oversight	1	2	8	16	2	80	Light-Duty Truck	Gasoline	160	15	10.7	

Equipment Use, Mobilization, and Fuel Usage

Equipment Type	**HP**	**Load Factor**	**Equip. Fuel Type**	**Gallons Fuel Used per Hour**	**Total Hours Operated**	**Gallons Fuel Used On-Site**	**Trips to Site**	**Roundtrip Miles to Site**	**Total Miles Transported**	**Transport Fuel Type**	**Miles per Gallon**	**Gallons Fuel Used for Transport.**	**Activity or Notes**
Other	50	0.5	diesel	1.275	8	10.2							pressure washer and pump towed behind truck
													assumes 8 wells per year
													1 hour per well at 1200 psi and 40 gpm

Electricity Usage

Equipment Type	**HP**	**% Full Load**	**Efficiency**	**Electrical Rating (kW)**	**Hours Used**	**Energy Used (kWh)**	**Notes**
Equip. with kW rating							
Equip. with kW rating							Extraction pumps
Direct kWh info.						441600	see equipment list
			Totals	0		441600	

Cells shaded in dark gray are not relevant to the equipment types noted

"Direct kWh info" refers to total electricity usage calculated or provided elsewhere (e.g., an electric meter).

Natural Gas Usage

Equipment Type	**Power Rating (btu/hr)**	**Efficiency**	**Total Hours Used**	**Btus Required**	**Total Therms Used**	**Notes**
		Totals		0	0	

If heat load is known instead of unit power rating, then enter power rating as 125% of heat load and choose 80% for efficiency.

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Input for Groundwater Extraction

Materials Usage

Material Type	Unit	Quantity	Site-Spec. One-Way Distance (miles)*	Number of Trips	Total One-Way Miles	Mode of Transport.	Fuel Type	Fuel Use Rate (mpg or gptm)	Total Fuel Use	Notes
Other 3 - acetic acid	lbs	1927.7076	40	1	40	Truck A (< 5 tons)	Diesel	8.5	4.7	acetic acid as surrogate for glycolic acid
Other 3 - acetic acid	lbs	3000	500	1	500	Truck A (< 5 tons)	Diesel	8.5	58.8	acetic acid as surrogate for Redux
			Empty Return Trips	2	540	**Truck A (< 5 tons)**	Diesel	8.5	63.5	

** Leave site-specific one-way miles blank if value is not known and a default will be used for*

Fuel Use Rate reported in miles per gallon (mpg) and gallons per ton-mile (gptm)

Laboratory Analysis

Parameter and Notes	Unit Cost	Number of Samples	Total Cost
VOCs			0
SVOCs			0
PCBs/Pesticides			0
Metals			0
Other			0
Other			0
Other			0
Other			0
Other			0
Other			0
	Totals	**0**	**0**

Waste Generation

Waste Type	Unit	Quantity	Site-Spec. One-Way Distance (miles)	Number of Trips	Total One-Way Miles	Mode of Transport.	Fuel Type	Fuel Use Rate	Total Fuel Use	Notes
	tons									
	tons									
	tons									
	tons									
	tons									
			Empty Return Trips			**Truck A (< 5 tons)**				

** Leave site-specific one-way miles blank if value is not known and a default will be used for calculating total-one way miles*

gptm = gallons per ton-mile

On-Site Water Usage (1000 x gallons) ***Fate of On-Site Water Usage (1000 x gallons)***

Resource Type	Quantity	Use of Resource	Discharge Location	Notes
Potable water	99	water for diluting glycolic acid	Reinjected to aquifer	
Water table drawdown (ft)				

If potable water is trucked to site, use "potable water" in materials section to calculate fuel use. Only the potable water use from the On-Site Water Use Section will be input into the Summary tab. It is assumed that the quantity of potable water in the Materials section is accounted for in in the On-Site Water Use Section.

Miscellaneous Emissions and Reductions

Item	Quantity	Activity or Notes
Other HAP emissions		
Other GHG emissions		
Other GHG reductions		
Other NOx reductions		
Other SOx reductions		
Other PM reductions		

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On-Site Renewable Energy Generation

Item	Quantity	Activity or Notes
Photovoltaic (kWh)		
Renewable Energy #1 (kWh)		
Renewable Energy #2 (kWh)		

Purchased Renewable Energy (including Renewable Energy Certificates "RECs")

Item	Quantity	Activity or Notes
Purchased from Utility (kWh)		
RECs (kWh)	441600	RECs, New Jersey area (eGRID non-base load)

Input for O&M

General Scope	***Typical Scope Items***	***Useful Information***
P&T System O&M		

Labor, Mobilizations, Mileage, and Fuel

Participant	Crew Size	Number of Days	Hours Worked Per Day	Total Hours Worked	Trips to Site	Roundtrip Miles to Site	Mode of Transport.	Fuel Type	Total Miles Traveled	Miles Per Gallon	Total Fuel Used	Activity or Notes
Full-time operators	3	260	8	6240	780	20	Light-Duty Truck	Gasoline	15600	15	1040	
part-time operator	1	130	8	1040	130	20	Light-Duty Truck	Gasoline	2600	15	173.3	

Equipment Use, Mobilization, and Fuel Usage

Equipment Type	HP	Load Factor	Equip. Fuel Type	Gallons Fuel Used per Hour	Total Hours Operated	Gallons Fuel Used On-Site	Trips to Site	Roundtrip Miles to Site	Total Miles Transported	Transport Fuel Type	Miles per Gallon	Gallons Fuel Used for Transport.	Activity or Notes

Electricity Usage

Equipment Type	HP	% Full Load	Efficiency	Electrical Rating (kW)	Hours Used	Energy Used (kWh)	Notes
Equip. with kW rating							
Equip. with kW rating							Usage for treatment plant
Direct kWh info.						875900	see equipment list
			Totals	0		875900	

Cells shaded in dark gray are not relevant to the equipment types noted

"Direct kWh info" refers to total electricity usage calculated or provided elsewhere (e.g., an electric meter).

Natural Gas Usage

Equipment Type	Power Rating (btu/hr)	Efficiency	Total Hours Used	Btus Required	Total Therms Used	Notes
					23657	from gas bills
		Totals		0	23657	

If heat load is known instead of unit power rating, then enter power rating as 125% of heat load and choose 80% for efficiency.

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Input for O&M

Materials Usage

Material Type	Unit	Quantity	Site-Spec. One-Way Distance (miles)*	Number of Trips	Total One-Way Miles	Mode of Transport.	Fuel Type	Fuel Use Rate (mpg or gptm)	Total Fuel Use	Notes
Hydrogen peroxide (50%, SG=1.19)	lbs	98000	40	2	80	Truck Heavy Load (gptm)	Diesel	0.011	21.6	
Other 1 - Ferric chloride	lbs	197000	40	12	480	Truck Heavy Load (gptm)	Diesel	0.011	43.3	
Potable water	gals	63840.819	40	12	480	Truck Heavy Load (gptm)	Diesel	0.011	117.1	water blended with FeCl3 by vendor
Sodium hydroxide (dry bulk)	lbs	256000	40.0	25	1000	Truck Heavy Load (gptm)	Diesel	0.011	56.3	
Potable water	gals	122781.77	40	25	1000	Truck Heavy Load (gptm)	Diesel	0.011	225.3	water blended with NaOH by vendor
Polymer	lbs	33485.1	40.000	8	320	Truck Light Load (gptm)	Diesel	0.024	16.1	assumes SG=1
			Empty Return Trips	84	3360	**Truck A (< 5 tons)**	Diesel	8.5	395.3	

** Leave site-specific one-way miles blank if value is not known and a default will be used for*

Fuel Use Rate reported in miles per gallon (mpg) and gallons per ton-mile (gptm)

Laboratory Analysis

Parameter and Notes	Unit Cost	Number of Samples	Total Cost
Arsenic	15	1300	19500
SVOCs			0
PCBs/Pesticides			0
Metals			0
Other			0
Other			0
Other			0
Other			0
Other			0
Other			0
	Totals	**1300**	**19500**

Waste Generation

Waste Type	Unit	Quantity	Site-Spec. One-Way Distance (miles)	Number of Trips	Total One-Way Miles	Mode of Transport.	Fuel Type	Fuel Use Rate	Total Fuel Use	Notes
Hazardous landfill	tons	260	700	20	14000	Truck Heavy Load (gptm)	Diesel	0.011	2002	
	tons									
	tons									
	tons									
	tons									
			Empty Return Trips	20	14000	**Truck A (< 5 tons)**	Diesel	8.5	1647.058824	

** Leave site-specific one-way miles blank if value is not known and a default will be used for calculating total-one way miles*

gptm = gallons per ton-mile

On-Site Water Usage (1000 x gallons)

Fate of On-Site Water Usage (1000 x gallons)

Resource Type	Quantity	Use of Resource	Discharge Location	Notes
Potable water	186.6226	associated with chemical blending	Discharge to surface water	
Potable water	12250	potable water use on-site from utility bills	Discharge to surface water	
Water table drawdown (ft)				

If potable water is trucked to site, use "potable water" in materials section to calculate fuel use. Only the potable water use from the On-Site Water Use Section will be input into the Summary tab. It is assumed that the quantity of potable water in the Materials section is accounted for in in the On-Site Water Use Section.

Miscellaneous Emissions and Reductions

Item	Quantity	Activity or Notes
Other HAP emissions		
Other GHG emissions		
Other GHG reductions		
Other NOx reductions		
Other SOx reductions		
Other PM reductions		

On-Site Renewable Energy Generation

Item	Quantity	Activity or Notes
Photovoltaic (kWh)		
Renewable Energy #1 (kWh)		
Renewable Energy #2 (kWh)		

Purchased Renewable Energy (including Renewable Energy Certificates "RECs")

Item	Quantity	Activity or Notes
Purchased from Utility (kWh)		
RECs (kWh)	875900	RECs, New Jersey area (eGRID non-base load)

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Input for Long-Term Groundwater Monitoring

General Scope	***Typical Scope Items***	***Useful Information***
Long-term groundwater monitoring		

Labor, Mobilizations, Mileage, and Fuel

Participant	Crew Size	Number of Days	Hours Worked Per Day	Total Hours Worked	Trips to Site	Roundtrip Miles to Site	Mode of Transport.	Fuel Type	Total Miles Traveled	Miles Per Gallon	Total Fuel Used	Activity or Notes
sampling technicians	2	50	8	800	50	40	Light-Duty Truck	Gasoline	2000	15	133.3	

Equipment Use, Mobilization, and Fuel Usage

Equipment Type	HP	Load Factor	Equip. Fuel Type	Gallons Fuel Used per Hour	Total Hours Operated	Gallons Fuel Used On-Site	Trips to Site	Roundtrip Miles to Site	Total Miles Transported	Transport Fuel Type	Miles per Gallon	Gallons Fuel Used for Transport.	Activity or Notes
Generator	4	0.51	Gasoline	0.11628	50	5.814							two 2HP gas power generators operated 8 hours per day

Electricity Usage

Equipment Type	HP	% Full Load	Efficiency	Electrical Rating (kW)	Hours Used	Energy Used (kWh)	Notes
Equip. with kW rating							
Equip. with kW rating							
Direct kWh info.							
			Totals	0		0	

Cells shaded in dark gray are not relevant to the equipment types noted

"Direct kWh info" refers to total electricity usage calculated or provided elsewhere (e.g., an electric meter).

Natural Gas Usage

Equipment Type	Power Rating (btu/hr)	Efficiency	Total Hours Used	Btus Required	Total Therms Used	Notes
		Totals		0	0	

If heat load is known instead of unit power rating, then enter power rating as 125% of heat load and choose 80% for efficiency.

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Input for Long-Term Groundwater Monitoring

Materials Usage

Material Type	Unit	Quantity	Site-Spec. One-Way Distance (miles)*	Number of Trips	Total One-Way Miles	Mode of Transport.	Fuel Type	Fuel Use Rate (mpg or gptm)	Total Fuel Use	Notes
			Empty Return Trips			**Truck A (< 5 tons)**				

** Leave site-specific one-way miles blank if value is not known and a default will be used for*

Fuel Use Rate reported in miles per gallon (mpg) and gallons per ton-mile (gptm)

Laboratory Analysis

Parameter and Notes	Unit Cost	Number of Samples	Total Cost
Arsenic	15	120	1800
SVOCs			0
PCBs/Pesticides			0
Metals			0
Other			0
Other			0
Other			0
Other			0
Other			0
Other			0
	Totals	**120**	**1800**

Waste Generation

Waste Type	Unit	Quantity	Site-Spec. One-Way Distance (miles)	Number of Trips	Total One-Way Miles	Mode of Transport.	Fuel Type	Fuel Use Rate	Total Fuel Use	Notes
	tons									
	tons									
	tons									
	tons									
	tons									
			Empty Return Trips			**Truck A (< 5 tons)**				

** Leave site-specific one-way miles blank if value is not known and a default will be used for calculating total-one way miles*

gptm = gallons per ton-mile

On-Site Water Usage (1000 x gallons) ***Fate of On-Site Water Usage (1000 x gallons)***

Resource Type	Quantity	Use of Resource	Discharge Location	Notes
Water table drawdown (ft)				

If potable water is trucked to site, use "potable water" in materials section to calculate fuel use. Only the potable water use from the On-Site Water Use Section will be input into the Summary tab. It is assumed that the quantity of potable water in the Materials section is accounted for in in the On-Site Water Use Section.

Miscellaneous Emissions and Reductions

Item	Quantity	Activity or Notes
Other HAP emissions		
Other GHG emissions		
Other GHG reductions		
Other NOx reductions		
Other SOx reductions		
Other PM reductions		

On-Site Renewable Energy Generation

Item	Quantity	Activity or Notes
Photovoltaic (kWh)		
Renewable Energy #1 (kWh)		
Renewable Energy #2 (kWh)		

Purchased Renewable Energy (including Renewable Energy Certificates "RECs")

Item	Quantity	Activity or Notes
Purchased from Utility (kWh)		
RECs (kWh)		

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Summary

Level		1	2	3	0	0	0	0	0	0	0	0	0	0	0	0	
Item		extraction	O&M	LTM													Total
Labor and Travel																	
Hours worked	(hrs)	48	7280	800													**8128**
Heavy equip. operating hours	(hrs)	8	0	50													**58**
Passenger trips to site	(trips)	4	910	50													**964**
Passenger vehicle miles	(miles)	320	18200	2000													**20520**
Heavy equip. trips to site	(trips)	0	0	0													**0**
Heavy equip. transport miles	(miles)	0	0	0													**0**
Materials transport trips	(trips)	4	168	0													**172**
Materials transport miles	(miles)	1080	6720	0													**7800**
Waste transport trips	(trips)	0	40	0													**40**
Waste transport miles	(miles)	0	28000	0													**28000**
Energy																	
On-site																	
Gasoline	(gallons)	0	0	5.814													**5.814**
E85	(gallons)	0	0	0													**0**
Diesel	(gallons)	10.2	0	0													**10.2**
B20	(gallons)	0	0	0													**0**
Photovoltaic	(MWh)	0	0	0													**0**
Other Renewable Energy #1		0	0	0													**0**
Other Renewable Energy #2		0	0	0													**0**
Off-site																	
Gasoline	(gallons)	26.7	1213.3	133.3													**1373.3**
E85	(gallons)	0	0	0													**0**
Diesel	(gallons)	127	4524.058824	0													**4651.058824**
B20	(gallons)	0	0	0													**0**
Total Fuel																	
Gasoline	(gallons)	26.7	1213.3	139.114													**1379.114**
E85	(gallons)	0	0	0													**0**
Diesel	(gallons)	137.2	4524.058824	0													**4661.258824**
B20	(gallons)	0	0	0													**0**
Electricity Demand	(kW)	0	0	0													**0**
Electricity Usage	(MWh)	441.6	875.9	0													**1317.5**
Purchased Renewable Electricity	(MWh)	441.6	875.9	0													**1317.5**
Natural gas usage	(therms)	0	23657	0													**23657**

Summary

Level		1	2	3	0	0	0	0	0	0	0	0	0	0	0	0	
Item		extraction	O&M	LTM													Total
Materials																	
Asphalt	(tons)	0	0	0													**0**
Bentonite	(tons)	0	0	0													**0**
Borrow	(tons)	0	0	0													**0**
Cement	(tons)	0	0	0													**0**
Cheese whey	(lbs)	0	0	0													**0**
Concrete	(tons)	0	0	0													**0**
Emulsified vegetable oil	(lbs)	0	0	0													**0**
GAC: regenerated	(lbs)	0	0	0													**0**
GAC: virgin coal-based	(lbs)	0	0	0													**0**
GAC: virgin coconut-based	(lbs)	0	0	0													**0**
Gravel/sand/clay	(tons)	0	0	0													**0**
HDPE	(lbs)	0	0	0													**0**
Hydrochloric acid (30%, SG = 1.18)	(lbs)	0	0	0													**0**
Hydrogen peroxide (50%, SG=1.19)	(lbs)	0	98000	0													**98000**
Hydroseed	(lbs)	0	0	0													**0**
Lime	(lbs)	0	0	0													**0**
Molasses	(lbs)	0	0	0													**0**
Nitrogen fertilizer	(lbs)	0	0	0													**0**
Other 1 - Ferric chloride	(lbs)	0	197000	0													**197000**
Other 2	()	0	0	0													**0**
Other 3 - acetic acid	(lbs)	4927.7076	0	0													**4927.7076**
Other 4	()	0	0	0													**0**
Other 5	()	0	0	0													**0**
Phosphorus fertilizer	(lbs)	0	0	0													**0**
Polymer	(lbs)	0	33485.1	0													**33485.1**
Potable water	(gals)	0	186622.5938	0													**186622.5938**
Potassium permanganate	(lbs)	0	0	0													**0**
PVC	(lbs)	0	0	0													**0**
Sequestering agent	(lbs)	0	0	0													**0**
Sodium hydroxide (dry bulk)	(lbs)	0	256000	0													**256000**
Stainless steel	(lbs)	0	0	0													**0**
Steel	(lbs)	0	0	0													**0**
Trees: root balls	(each)	0	0	0													**0**
Trees: whips	(each)	0	0	0													**0**
Waste																	
Non-hazardous landfill	(tons)	0	0	0													**0**
Hazardous landfill	(tons)	0	260	0													**260**
Recycling facility	(tons)	0	0	0													**0**
Hauled to POTW	(gals x 1000)	0	0	0													**0**
Incineration	(tons)	0	0	0													**0**
Location for reuse	(tons)	0															
Water Use																	
Potable water	(gals x 1000)	99	12436.62259	0													**12535.62259**
Extracted GW #1	(gals x 1000)	0	0	0													**0**
Extracted GW #2	(gals x 1000)	0	0	0													**0**
Surface water	(gals x 1000)	0	0	0													**0**
Reclaimed water	(gals x 1000)	0	0	0													**0**
Stormwater	(gals x 1000)	0	0	0													**0**

Summary

Level		**1**	**2**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
Item		**extraction**	**O&M**	**LTM**													**Total**
Water Discharge																	
Discharge to surface water	(gals x 1000)	0	12436.62259	0													**12436.62259**
Reinjected to aquifer	(gals x 1000)	99	0	0													**99**
Discharge to POTW	(gals x 1000)	0	0	0													**0**
Discharge to atmosphere	(gals x 1000)	0	0	0													**0**
Public Use	(gals x 1000)	0	0	0													**0**
Irrigation	(gals x 1000)	0	0	0													**0**
Industrial process water	(gals x 1000)	0	0	0													**0**
Other beneficial use	(gals x 1000)	0	0	0													**0**
Laboratory Analysis																	
Total samples	(samples)	0	1300	120													**1420**
Total cost	($)	0	19500	1800													**21300**
Other																	
Other HAP emissions	(lbs)	0	0	0													**0**
Other GHG emissions	(lbs)	0	0	0													**0**
Other GHG reductions	(lbs)	0	0	0													**0**
Other NOx reductions	(lbs)	0	0	0													**0**
Other SOx reductions	(lbs)	0	0	0													**0**
Other PM reductions	(lbs)	0	0	0													**0**

Lookup Table

Mode of Transport. For Personnel	Gasoline mpg	E85 mpg	Diesel mpg or pmpg	B20 mpg
Airplane	ERROR	ERROR	44.7	ERROR
Bus	ERROR	ERROR	95.6	ERROR
Car	20	14.6	22.3	20.6
Heavy-Duty Truck	10	7.3	11.2	10.3
Light-Duty Truck	15	10.95	16.7	15.4
Train	ERROR	ERROR	59.1	ERROR
Vehicle (other)	NO DATA	NO DATA	NO DATA	NO DATA

- Fuel usage for buses, airplanes, and trains are for passenger miles per gallon (pmpg)

- Airplane/jet fuel calculated as diesel for simplicity and due to similarities between kerosene and diesel

- Typical gasoline fuel efficiencies from from www.fueleconomy.gov

- E85 efficiences based on higher heating values (mmBtu per barrel) of 5.218 mmBtu (gasoline) and 3.539 for (ethanol), Climate Leaders Direct Emissions from Mobile Sources

- Diesel car and truck efficiences based on higher heating values (mmBtu per barrel) of 5.218 mmBtu (gasoline) and 5.825 for (diesel), Climate Leaders Direct Emissions from Mobile Sources

- B20 car and truck efficiences based on higher heating values of 5.825 mmBtu per barrel (diesel, Climate Leaders) and 127,960 btu per gallon (biodiesel, Alternative Fuels & Advanced Vehicles Data Center, www.afdc.energy.gov)

- Diesel airplane, bus, and train efficiences from converting average CO2 emissions Climate Leaders from Commuting, Business Travel and Product Transport to diesel usage assuming 22.5 lbs of CO2 per gallon of diesel.

Fuel Type for Equipment Transport	**mpg**
B20	7.09
Diesel	7.2

B20 efficiency based on higher heating value of 127,960 btu per gallon for biodiesel (Alternative Fuels & Advanced Vehicles Data Center, www.afdc.energy.gov.

Fuel Type for Equip. Use	**Gals. per HP-hr**
B20	0.052
Diesel	0.051
E85	0.078
Gasoline	0.057

Fuel consumption based on thermal efficiency of 36% for diesel and 38% for gasoline.

Mode of Transport. For Materials	rate (mpg or gptm)
Train (gptm)	0.0024
Truck A (< 5 tons)	8.5
Truck B (5-15 tons)	7.2
Truck C (15+ tons)	5.92
Truck Heavy Load (gptm)	0.011
Truck Light Load (gptm)	0.024

mpg = miles per gallon, gptm = gallons per ton-mile
Rail fuel usage from Climate Leaders, Direct Emissions from Mobile Sources
Truck usages from Climate Leaders, Direct Emissions from Mobil Sources and Effects of Payload on the Fuel Consumption of Trucks, Dept. for Transportation (Great Britain), December 2007. Truck heavy load based on Truck C carrying 15 tons. Truck light load based on Truck A carrying 5 tons.

Equipment Type	**Default Load**	**Typical HP**
Asphalt paver	0.62	
Backhoe	0.57	
Concrete paving machine	0.53	
Dozer (large)	0.55	
Dozer (small)	0.55	
Drilling - direct push	0.75	
Drilling - large rig (e.g., CME-75)	0.75	
Drilling - medium rig (e.g., CME-55)	0.75	
Dump truck	0.57	
Excavator (large)	0.57	
Excavator (medium)	0.57	
Excavator/hoe (small)	0.57	
Generator	0.51	
Grader	0.61	
Grout pump	0.51	
Hydroseeder	0.62	
Integrated tool carrier	0.43	
Loader	0.55	
Loader (small)	0.55	
Mobile laboratory	0.5	
Mowers	0.6	
Other	0.5	
Riding trencher	0.75	
Roller	0.56	
Rotary-screw air compressor (250 cfm)	0.48	
Skid-steer (small)	0.55	
Telescopic handler	0.43	
Tractor mower	0.6	
Water truck	0.57	

Default equipment loads obtained from Road Construction Emissions Model Version 6.3.2, Sacramento Air Quality Management District. Generators and grout pumps considerd "other general industrial equipment".

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For more information contact:
scheuermann.karen@epa.gov or pachon.carlos@epa.gov.

Lookup Table (continued)

Materials	Units	Conv. to tons	Default One-Way Distance from Source to Site (miles)
Asphalt	tons	1	30
Bentonite	tons	1	1000
Borrow	tons	1	30
Cement	tons	1	30
Cheese whey	lbs	0.0005	1000
Concrete	tons	1	30
Emulsified vegetable oil	lbs	0.0005	1000
GAC: regenerated	lbs	0.0005	1000
GAC: virgin coal-based	lbs	0.0005	1000
GAC: virgin coconut-based	lbs	0.0005	1000
Gravel/sand/clay	tons	1	30
HDPE	lbs	0.0005	1,000
Hydrochloric acid (30%, SG = 1.18)	lbs	0.0005	500
Hydrogen peroxide (50%, SG=1.19)	lbs	0.0005	500
Hydroseed	lbs	0.0005	500
Lime	lbs	0.0005	500
Molasses	lbs	0.0005	500
Nitrogen fertilizer	lbs	0.0005	500
Other 1 - Ferric chloride	lbs	0.0005	500
Other 2			0
Other 3 - acetic acid	lbs	0.0005	500
Other 4			0
Other 5			0
Phosphorus fertilizer	lbs	0.0005	500
Polymer	lbs	0.0005	1000
Potable water	gals	0.00417	25
Potassium permanganate	lbs	0.0005	1000
PVC	lbs	0.0005	1000
Sequestering agent	lbs	0.0005	1000
Sodium hydroxide (dry bulk)	lbs	0.0005	500
Stainless steel	lbs	0.0005	500
Steel	lbs	0.0005	500
Trees: root balls	each	NA	500
Trees: whips	each	NA	1000

Miles are one-way miles. In most cases a empty initial or return trip needs to be added.
Miles should be from manufacturer to supplier to site.

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Waste Disposal Facility	Default One-Way Distance (Miles)	Notes
Non-hazardous landfill	25	
Hazardous landfill	500	
Recycling facility	100	
Hauled to POTW	50	
Incineration facility	50	
Location for reuse	50	

TABLE G-1. SUMMARY OF ELECTRICITY USAGE

EQUIPMENT	# OF UNITS	POWER RATING (HP) PER UNIT	POWER RATING (KW) PER UNIT	VFD SETTING % LOAD	LOAD FACTOR	EFFICIENCY	HOURS OF OPERATION PER YEAR	KWH PER YEAR	% OF TOTAL ELEC. USE
Extraction System									
RW-1	1	7.5	5.6	28%	7%	75%	1752	956	0.1%
RW-2	1	7.5	5.6	83%	67%	75%	7884	39,564	3.0%
RW-2a	1	5	3.7	95%	92%	75%	7884	36,148	2.7%
RW-2b	1	5	3.7	100%	108%	75%	7884	42,161	3.2%
RW-3	1	5	3.7	100%	108%	75%	7008	37,476	2.8%
RW-4	1	2	1.5	85%	72%	70%	5256	8,094	0.6%
RW-5	1	2	1.5	100%	108%	70%	4380	10,038	0.8%
RW-6	1	5	3.7	100%	108%	75%	8322	44,503	3.4%
RW-7	1	2	1.5	95%	95%	70%	7008	14,230	1.1%
RW-8	1	5	3.7	98%	101%	75%	8322	41,886	3.2%
RW-9	1	0	0.0	0%	0%	75%	0	0	0.0%
RW-9a	1	7.5	5.6	100%	108%	75%	7884	63,242	4.8%
RW-10	1	7.5	5.6	90%	81%	75%	8322	50,287	3.8%
RW-11	1	7.5	5.6	46%	13%	75%	876	848	0.1%
RW-12	1	7.5	5.6	92%	84%	75%	8322	51,981	3.9%
RW-13	1	7.5	5.6	21%	3%	75%	876	202	0.0%
						EXTRACTION SYSTEM		**441,616**	**33.5%**
Treatment System									
Chem. Feed pumps*	1	6.67	5.0	N/A	80%	65%	8760	53,647	4.1%
EQ tank pump	1	40	29.8	20%	3%	80%	8760	8,713	0.7%
Oxidation tank mixer	1	3	2.2	N/A	80%	75%	8760	20,912	1.6%
Coag. Tank mixer	1	3	2.2	N/A	80%	75%	8760	20,912	1.6%
DAF #3 Floc. Mixer 1	1	5	3.7	50%	17%	75%	8760	7,261	0.6%
DAF #3 Floc. Mixer 2	1	0.5	0.4	50%	17%	75%	8760	726	0.1%
DAF #4 Floc. Mixer 1	1	5	3.7	50%	17%	75%	8760	7,261	0.6%
DAF #4 Floc. Mixer 2	1	0.5	0.4	50%	17%	75%	8760	726	0.1%
DAF recirc. Pump	1	7.5	5.6	N/A	80%	75%	8760	52,280	4.0%
Residuals sump mixer	1	1	0.7	N/A	80%	75%	8760	6,971	0.5%
Filter feed mixer	1	3	2.2	N/A	80%	75%	8760	20,912	1.6%
Filter feed pump	1	28	20.9	75%	50%	80%	8760	113,521	8.6%
Effluent pump	1	20	14.9	100%	108%	75%	8760	187,382	14.2%
Air compressor 1	1	10	7.5	N/A	80%	75%	6300	50,131	3.8%
Air compressor 2	1	10	7.5	N/A	80%	75%	6300	50,131	3.8%
Thickener skimmer	1	0.75	0.6	N/A	80%	65%	8760	6,032	0.5%
Thickener overflow	1	17.5	13.1	N/A	80%	75%	876	12,199	0.9%
Centrifuge**	1	12	9.0	N/A	80%	75%	2600	24,827	1.9%
Building lighting***								98,715	7.5%
Building HVAC****	1	30	22.4	N/A	80%	75%	4368	104,273	7.9%
Controls****	1	3	2.2	N/A	100%	100%	8760	19,605	1.5%
Plug loads****	1		10.0	N/A	100%	100%	876	8,760	0.7%
						Treatment System Subtotal		**875,896**	**66.5%**
							Total	**1,317,513**	**100.0%**

Totals For Parameters Used, Extracted, Emitted, or Generated - P&T

	Energy Used Mbtu	Grid Electricity Used MWh	All Water Used gal x 1000	Potable Water Used gal x 1000	Groundwater Extracted gal x 1000	CO2e Emitted lbs	NO x Emitted lbs	SO x Emitted lbs	PM Emitted lbs	Solid Waste Generated tons	Haz. Waste Generated tons	Air Toxics Emitted lbs	Mercury Released lbs	Lead Released lbs	Dioxins Released lbs
Level 1 - Extraction															
On-Site	1,508,599.	442.	99.	99.	0	230.	2.	0	0	0	0	0.0001	0	0	0
Electricity Generation	3,444,480.	26.	396,557.	0	0	185,994.	1,614.	1,509.	336.	0	0	132.48	0.0958272	-0.0565248	0.000000052992
Transportation	20,964.	0	0	0	0	3,381.	25.	1.	0	0	0	0.0017	0	0	0
Other Off-Site	211,423.	53.	108.	0	0	85,990.	212.	634.	52.	0	0	22.6737	0.001238332	0.009339962	0.000000012763
Extraction Total	***5,185,466.***	***521.***	***396,764.***	***99.***	***0***	***275,595.***	***1,853.***	***2,144.***	***388.***	***0***	***0***	***155.1555***	***0.097065532***	***-0.047184838***	***0.000000065755***
Level 2 - O&M															
On-Site	5,426,118.	876.	12,437.	12,436.6	0	288,615.	237.	0	18.	0	260.	0.1987	0.000615082	0.00118285	0
Electricity Generation	6,832,020.	53.	786,558.	0	0	368,913.	3,202.	2,993.	666.	0	0	262.77	0.1900703	-0.1121152	0.000000105108
Transportation	779,293.	0	0	0	0	125,572.	902.	29.	16.	0	0	0.0708	0	0	0
Other Off-Site	4,115,178.	420.	2,818.	0	0	987,539.	3,261.	3,986.	879.	6.3	0.167	110.3646	0.061643706	0.075675199	0.000000054352
O&M Total	***17,152,609.***	***1,349.***	***801,813.***	***12,436.6***	***0***	***1,770,639.***	***7,602.***	***7,008.***	***1,579.***	***6.3***	***260.167***	***373.4041***	***0.252329088***	***-0.035257151***	***0.00000015946***
Level 3 - LTM															
On-Site	721.	0	0	0	0	114.	1.	0	0	0	0	0.0002	0	0	0
Electricity Generation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation	16,529.	0	0	0	0	2,613.	15.	1.	0	0	0	0.0052	0	0	0
Other Off-Site	14,603.	1.	1.	0	0	2,412.	10.	9.	1.	0	0	0.2563	0.000026945	0.000459051	0.000000000146
LTM Total	***31,853.***	***1.***	***1.***	***0***	***0***	***5,139.***	***26.***	***10.***	***1.***	***0***	***0***	***0.2617***	***0.000026945***	***0.000459051***	***0.000000000146***
Level 4 - Not Used															
On-Site	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electricity Generation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Off-Site	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Not Used Total	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***
Level 5 - Not Used															
On-Site	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electricity Generation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Off-Site	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Not Used Total	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***
Level 6 - Not Used															
On-Site	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electricity Generation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Off-Site	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Not Used Total	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***
Total	***22,369,928.***	***1,871.***	***1,198,578.***	***12,535.6***	***0***	***2,051,373.***	***9,481.***	***9,162.***	***1,968.***	***6.3***	***260.167***	***528.8213***	***0.349421565***	***-0.081982938***	***0.000000225361***

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All Levels - Parameters Used, Extracted, Emitted, or Generated - P&T

			Energy		Grid Electricity		All Water		Potable Water		Groundwater		CO2e		NO x		SO x		PM		Solid Waste		Haz. Waste		Air Toxics		Mercury		Lead		Dioxins	
		Quantity Used	Conv. Factor	Used	Conv. Factor	Used	Conv. Factor	Used	Conv. Factor	Used	Conv. Factor	Extracted	Conv. Factor	Emitted	Conv. Factor	Emitted	Conv. Factor	Emitted	Conv. Factor	Emitted	Conv. Factor	Generated	Conv. Factor	Generated	Conv. Factor	Emitted	Conv. Factor	Released	Conv. Factor	Released	Conv. Factor	Released
				Mbtu		MWh		gal x 1000		gal x 1000		gal x 1000		lbs		lbs		lbs		lbs		tons		tons		lbs		lbs		lbs		lbs
Totals				***22,369,928.***		***1,871.***		***1,198,579.***		***12,535.6***		***0***		***2,051,374.***		***9,480.***		***9,162.***		***1,969.***		***6.***		***260.167***		***528.8214***		***0.349421563***		***-0.081982938***		***0.000000225362***
ON-SITE																																
Energy																																
Diesel (on-site use)	gal	10.2	139	1,418.	0	0	0	0	0	0	0	0	22.5	230.	0.17	2.	0.0054	0	0.0034	0	0	0	0	0	5E-06	0.0001	0	0	0	0	0	0
Gasoline (on-site use)	gal	5.814	124	721.	0	0	0	0	0	0	0	0	19.6	114.	0.11	1.	0.0045	0	0.0005	0	0	0	0	0	4E-05	0.0002	0	0	0	0	0	0
Natural gas (on-site use)	ccf	23657	103	2,436,671.	0	0	0	0	0	0	0	0	12.2	288,615.	0.01	237.	6E-06	0	0.0008	18.	0	0	0	0	8E-06	0.1987	3E-08	0.000615082	5E-08	0.00118285	0	0
Electricity (on-site use)	MWh	1317.5	3413	4,496,628.	1	1,318.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Photovoltaic (on-site system)	MWh	0	37922	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Energy 2	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Energy 3	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water																																
Groundwater Extracted On-site	gal x 1000	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potable Water Used On-site	gal x 1000	12535.623	0	0	0	0	1	12,536.	1	12,535.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other On-Site Water 1	gal x 1000	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other On-Site Water 2	gal x 1000	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other On-Site Water 3	gal x 1000	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Waste Generation																																
On-Site Solid Waste Generation	ton	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
On-Site Solid Waste Disposal		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
On-Site Hazardous Waste Generation	ton	260	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	260.	0	0	0	0	0	0	0	0
On-Site Hazardous Waste Disposal		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other																																
On-site process emissions (HAPs)	lbs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
On-site process emissions (GHGs)	lbs CO2e	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
On-site GHG storage	lbs CO2e	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
On-site NOx reduction	lbs	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
On-site SOx reduction	lbs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
On-site PM reduction	lbs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 1	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 2	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ON-SITE TOTAL			0	**6,935,438.**	0	**1,318.**	0	**12,536.**	0	**12,535.6**	0	**0**	0	**288,959.**	0	**240.**	0	**0**	0	**18.**	0	**0**	0	**260.**	0	**0.199**	0	**0.000615082**	0	**0.00118285**	0	**0**
ELECTRICITY GENERATION																																
Electricity production	MWh	1317.5	7800	10,276,500.	0.06	79.	900	1,185,750.	0	0	0	0	2400	3,162,000.	6.7	8,827.	15	19,763.	1.7	2,240.	0.0009	1.	0	0	0.7	922.25	0.0002	0.3162	4E-05	0.055335	4E-10	0.0000004743
Purchased Renewa ble Electricity	MWh	1317.5	0	0	0	0	-2	-2,635.	0	0	0	0	-1979	-2,607,093.	-3.045	-4,012.	-11.58	-15,261.	-0.94	-1,238.	-9E-04	-1.	0	0	-0.4	-527.	-2E-05	-0.0303025	-2E-04	-0.223975	-2E-10	-0.0000003162
TRANSPORTATION																																
Diesel (off-site use)	gal	4651.0588	139	646,497.	0	0	0	0	0	0	0	0	22.5	104,649.	0.17	791.	0.0054	25.	0.0034	16.	0	0	0	0	5E-06	0.0242	0	0	0	0	0	0
Gasoline (off-site use)	gal	1373.3	124	170,289.	0	0	0	0	0	0	0	0	19.6	26,917.	0.11	151.	0.0045	6.	0.0005	1.	0	0	0	0	4E-05	0.0536	0	0	0	0	0	0
Natural gas (off-site use)	ccf	0	103	0	0	0	0	0	0	0	0	0	12.2	0	0.01	0	6E-06	0	0.0008	0	0	0	0	0	8E-06	0	3E-08	0	5E-08	0	0	0
Other Transportation 1	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Transportation 2	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Transportation 3	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Transportation 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Transportation 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRANSPORTATION TOTAL			0	**816,786.**	0	**0**	0	**0**	0	**0**	0	**0**	0	**131,566.**	0	**942.**	0	**31.**	0	**17.**	0	**0**	0	**0**	0	**0.0778**	0	**0**	0	**0**	0	**0**

			All Levels - Parameters Used, Extracted, Emitted, or Generated - P&T																															
		Quantity Used	Energy		Grid Electricity		All Water		Potable Water		Groundwater		CO2e		NO x		SO x		PM		Solid Waste		Haz. Waste		Air Toxics		Mercury		Lead		Dioxins	
			Conv. Factor	Used	Conv. Factor	Used	Conv. Factor	Used	Conv. Factor	Used	Conv. Factor	Extracted	Conv. Factor	Emitted	Conv. Factor	Emitted	Conv. Factor	Emitted	Conv. Factor	Emitted	Conv. Factor	Generated	Conv. Factor	Generated	Conv. Factor	Emitted	Conv. Factor	Released	Conv. Factor	Released	Conv. Factor	Released
				Mbtu		MWh		gal x 1000		gal x 1000		gal x 1000		lbs		lbs		lbs		lbs		tons		tons		lbs		lbs		lbs		lbs
OFF-SITE OTHER																																		
Materials																																		
Asphalt	tons	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bentonite	tons	0	55	0	0.0027	0	0.13	0	0	0	0	0	6.7	0	0.033	0	0.03	0	0.004	0	0	0	0	0	4E-07	0	6E-11	0	1E-09	0	2E-16	0
Borrow (clean soil)	tons	0	15.75	0	6E-05	0	8E-05	0	0	0	0	0	2.52	0	0.0176	0	0.0018	0	0.0004	0	4E-08	0	0	0	1E-05	0	5E-09	0	2E-07	0	3E-15	0
Cement	dry-ton	0	4100	0	0.13	0	0.41	0	0	0	0	0	1800	0	3.6	0	2.1	0	0.0063	0	0	0	0	0	0.058	0	6E-05	0	0.0001	0	9E-11	0
Cheese Whey	lbs	0	1.87	0	0	0	0	0	0	0	0	0	1.1	0	0.0083	0	0.0099	0	0.0002	0	0	0	0	0	0	0	0	0	0	0	0	0
Concrete	tons	0	3019	0	0.096	0	0.34	0	0	0	0	0	1322	0	2.6	0	1.5	0	0.0054	0	1E-08	0	0	0	0.043	0	4E-05	0	1E-04	0	6E-11	0
Diesel Produced	gal	4661.2588	18.5	86,233.	0.0006	3.	0.0008	4.	0	0	0	0	2.7	12,585.	0.0064	30.	0.013	61.	0.0003	2.	4E-07	0	0	0	0.0001	0.5594	5E-08	0.00022374	2E-06	0.006991888	3E-14	0.00000000014
Emulsified vegetable oil	lbs	0	3.6	0	6E-05	0	2E-05	0	0	0	0	0	3.51	0	0.0265	0	0.031	0	0.0017	0	0	0	0	0	0	0	0	0	0	0	0	0
GAC: regenerated	lbs	0	9.6	0	0.0004	0	0.0064	0	0	0	0	0	2	0	0.025	0	0.015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GAC: virgin coal-based	lbs	0	10.8	0	5E-05	0	0	0	0	0	0	0	4.5	0	0.12	0	0.074	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GAC: virgin coconut-based	lbs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gasoline Produced	gal	1379.114	21	28,961.	0.0006	1.	0.0008	1.	0	0	0	0	4.4	6,068.	0.008	11.	0.019	26.	0.0005	1.	4E-07	0	0	0	0.0002	0.2207	9E-08	0.000117225	2E-06	0.003034051	3E-14	0.000000000043
Gravel/sand/clay	ton	0	55	0	0.0027	0	0.13	0	0	0	0	0	6.7	0	0.033	0	0.03	0	0.004	0	0	0	0	0	4E-07	0	6E-11	0	1E-09	0	2E-16	0
HDPE	lb	0	31	0	0.0003	0	0.0023	0	0	0	0	0	1.9	0	0.0032	0	0.0041	0	0.0006	0	4E-07	0	1E-06	0	3E-06	0	3E-09	0	2E-09	0	1E-09	0
Hydrochloric acid (30%, SG = 1.18)	lbs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen peroxide (50%, SG=1.19)	lbs	98000	4.95	485,100.	0.0006	59.	0.019	1,862.	0	0	0	0	1.35	132,300.	0.0087	853.	0.0066	647.	0.0025	245.	1E-05	1.	5E-07	0.047	0.0002	22.54	0	0	0	0	0	0
Hydroseed	lbs	0	0.049	0	1E-07	0	0.0001	0	0	0	0	0	0.0046	0	3E-06	0	5E-05	0	3E-07	0	0	0	0	0	8E-07	0	2E-11	0	1E-10	0	0	0
Lime	lbs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Molasses	lbs	0	1.31	0	5E-06	0	9E-05	0	0	0	0	0	0.4	0	0.003	0	0.0026	0	6E-05	0	0	0	0	0	0	0	0	0	0	0	0	0
Natural Gas Produced	ccf	23657	5.2	123,016.	0.0003	6.	8E-05	2.	0	0	0	0	2.2	52,045.	0.0037	88.	0.0046	109.	7E-05	2.	0	0	0	0	6E-06	0.1443	2E-08	0.000496797	9E-07	0.0212913	5E-14	0.000000001207
Nitrogen fertilizer	lbs	0	16.2	0	2E-05	0	0	0	0	0	0	0	1.5	0	0.0008	0	0.0174	0	7E-05	0	0	0	0	0	0.0003	0	6E-09	0	4E-08	0	0	0
Other Material #1 - Ferric Chloride (salt)	lbs	197000	2.31	455,070.	0.0003	67.	0.0003	53.	0	0	0	0	0.41	80,770.	0.0019	382.	0.0015	296.	0.0002	30.	1E-07	0	0	0	5E-05	10.638	3E-09	0.000591	4E-08	0.006895	3E-14	0.000000006304
Other Material #2 - Mulch	cy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Material #3 - acetic acid	lb	4927.7076	5.2	25,624.	2E-05	0	0	0	0	0	0	0	0.67	3,302.	0.0006	3.	0.02	99.	6E-05	0	0	0	0	0	0.0003	1.429	2E-09	0.000008377	1E-08	0.000049277	3E-15	0.000000000015
Other Material #4 - guar gum	lb	0	0.91	0	5E-05	0	0.0001	0	0	0	0	0	1	0	0.073	0	0.0068	0	0.0001	0	0	0	0	0	1E-05	0	1E-09	0	1E-07	0	6E-14	0
Other Material #5	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phosphorus fertilizer	lbs	0	3.39	0	7E-05	0	0	0	0	0	0	0	0.35	0	0.0017	0	0.017	0	0.0001	0	0	0	0	0	5E-05	0	2E-09	0	5E-08	0	0	0
Polymer	lbs	33485.1	15.39	515,336.	0.0023	75.	0.0018	60.	0	0	0	0	2.72	91,079.	0.013	435.	0.0098	328.	0.001	33.	8E-07	0	0	0	0.0004	12.0546	2E-08	0.000770157	2E-07	0.007735058	2E-13	0.000000007152
Potable Water	gal x 1000	12535.623	9.2	115,328.	0.0004	6.	0.021	263.	0	0	0	0	5	62,678.	0.0097	122.	0.0059	74.	0.016	201.	8E-07	0	0	0	2E-05	0.188	8E-09	0.000102792	7E-08	0.000839887	1E-13	0.000000001254
Potassium permanganate	lbs	0	29.22	0	0.0016	0	0.003	0	0	0	0	0	4.5	0	0.021	0	0.016	0	0.0017	0	1E-06	0	0	0	0.0006	0	4E-08	0	4E-07	0	4E-13	0
PVC	lbs	0	22	0	0.0006	0	0.0069	0	0	0	0	0	2.6	0	0.0048	0	0.0076	0	0.0012	0	2E-06	0	2E-06	0	0.0005	0	3E-07	0	1E-07	0	7E-09	0
Sequestering agent	lbs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sodium hydroxide (dry bulk)	lbs	256000	6.6	1,689,600.	0.0003	82.	0.0012	294.	0	0	0	0	1.37	350,720.	0.003	768.	0.0048	1,229.	0.0005	138.	2E-05	5.	5E-07	0.12	6E-05	15.872	2E-07	0.05632	3E-08	0.0064	2E-14	0.000000006144
Stainless Steel	lb	0	11.6	0	0.0006	0	0.0023	0	0	0	0	0	3.4	0	0.0075	0	0.012	0	0.0044	0	0.0006	0	0	0	0.0001	0	0	0	5E-07	0	2E-12	0
Steel	lb	0	4.4	0	0.0002	0	0.0006	0	0	0	0	0	1.1	0	0.0014	0	0.0017	0	0.0006	0	0.0003	0	0	0	7E-05	0	1E-07	0	3E-06	0	7E-12	0
Tree: root ball	trees	0	3.7	0	2E-06	0	0.004	0	0	0	0	0	0.6	0	0.003	0	0.0006	0	3E-05	0	1E-08	0	0	0	6E-06	0	2E-09	0	6E-08	0	0	0
Tree: whip	trees	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Off-Site Services																																		
Off-site waste water treatment	gal x 1000	0	15	0	0.0007	0	0.0029	0	0	0	0	0	4.4	0	0.016	0	0.015	0	0.0017	0	0.0024	0	0	0	0.0006	0	4E-08	0	4E-07	0	3E-13	0
Off-site Solid Waste Disposal	ton	0	160	0	0.0077	0	0.15	0	0	0	0	0	25	0	0.14	0	0.075	0	0.4	0	8E-06	0	0	0	0.0014	0	1E-06	0	8E-06	0	1E-11	0
Off-site Haz. Waste Disposal	ton	260	176	45,760.	0.0085	2.	0.165	43.	0	0	0	0	27.5	7,150.	0.154	40.	0.0825	21.	0.44	114.	9E-06	0	0	0	0.0015	0.4004	1E-06	0.00027742	8E-06	0.0021736	1E-11	0.000000003432
Off-site Laboratory Analysis	$	21300	6.49	138,237.	0.0004	7.	0.0007	14.	0	0	0	0	1	21,300.	0.0048	102.	0.0036	77.	0.0004	9.	0	0	0	0	0.0001	2.769	8E-09	0.00017892	9E-08	0.0018105	8E-14	0.000000001683
Other 1	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 2	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 3	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 4	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 5	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other																																		
Potable Water Transported	gal x 1000	12535.623	7.4	92,764.	0.0006	8.	0.0013	16.	0	0	0	0	0.9948	12,471.	0.0025	32.	0.0065	81.	0.0006	8.	6E-07	0	0	0	0.0003	3.2392	1E-08	0.000186253	1E-07	0.001376651	2E-13	0.000000001944
Electricity transmission	MWh	1317.5	410	540,175.	0.12	158.	0.24	316.	0	0	0	0	184.8	243,474.	0.468	617.	1.2	1,581.	0.1128	149.	0.0001	0	0	0	0.048	63.24	3E-06	0.0036363	2E-05	0.026877	3E-11	0.000000037944
Other 1	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 2	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 3	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OFF-SITE OTHER TOTAL			0	4,341,204.	0	474.	0	2,928.	0	0	0	0	0	1,075,942.	0	3,483.	0	4,629.	0	932.	0	6.	0	0.167	0	133.2946	0	0.062908981	0	0.085474212	0	0.000000067262

			Level 1 (Extraction) Parameters Used, Extracted, Emitted, or Generated - P&T																													
			Energy		**Grid Electricity**		**All Water**		**Potable Water**		**Groundwater**		**CO2e**		**NO x**		**SO x**		**PM**		**Solid Waste**		**Haz. Waste**		**Air Toxics**		**Mercury**		**Lead**		**Dioxins**	
		Quantity Used	**Conv. Factor**	**Used**	**Conv. Factor**	**Used**	**Conv. Factor**	**Used**	**Conv. Factor**	**Used**	**Conv. Factor**	**Extracted**	**Conv. Factor**	**Emitted**	**Conv. Factor**	**Emitted**	**Conv. Factor**	**Emitted**	**Conv. Factor**	**Emitted**	**Conv. Factor**	**Generated**	**Conv. Factor**	**Generated**	**Conv. Factor**	**Emitted**	**Conv. Factor**	**Released**	**Conv. Factor**	**Released**	**Conv. Factor**	**Released**
				Mbtu		**MWh**		**gal x 1000**		**gal x 1000**		**gal x 1000**		**lbs**		**lbs**		**lbs**		**lbs**		**tons**		**tons**		**lbs**		**lbs**		**lbs**		**lbs**
Totals				***5,185,466.***		***521.***		***396,764.***		***99.***		***0***		***275,595.***		***1,853.***		***2,144.***		***388.***		***0***		***0***		***155.1555***		***0.097065532***		***-0.047184838***		***0.000000065755***
ON-SITE																																
Energy																																
Diesel (on-site use)	gal	10.2	139	1,418.	0	0	0	0	0	0	0	0	22.5	230.	0.17	2.	0.0054	0	0.0034	0	0	0	0	0	5E-06	0.0001	0	0	0	0	0	0
Gasoline (on-site use)	gal	0	124	0	0	0	0	0	0	0	0	0	19.6	0	0.11	0	0.0045	0	0.0005	0	0	0	0	0	4E-05	0	0	0	0	0	0	0
Natural gas (on-site use)	ccf	0	103	0	0	0	0	0	0	0	0	0	12.2	0	0.01	0	6E-06	0	0.0008	0	0	0	0	0	8E-06	0	3E-08	0	5E-08	0	0	0
Electricity (on-site use)	MWh	441.6	3413	1,507,181.	1	442.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Photovoltaic (on-site system)	MWh	0	37922	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Energy 2	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Energy 3	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water																																
Groundwater Extracted On-site	gal x 1000	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potable Water Used On-site	gal x 1000	99	0	0	0	0	1	99.	1	99.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other On-Site Water 1	gal x 1000	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other On-Site Water 2	gal x 1000	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other On-Site Water 3	gal x 1000	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Waste Generation																																
On-Site Solid Waste Generation	ton	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
On-Site Solid Waste Disposal		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
On-Site Hazardous Waste Generation	ton	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
On-Site Hazardous Waste Disposal		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other																																
On-site process emissions (HAPs)	lbs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
On-site process emissions (GHGs)	lbs CO2e	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
On-site GHG storage	lbs CO2e	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
On-site NOx reduction	lbs	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
On-site SOx reduction	lbs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
On-site PM reduction	lbs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 1	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 2	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ON-SITE TOTAL			0	**1,508,599.**	0	**442.**	0	**99.**	0	**99.**	0	**0**	0	**230.**	0	**2.**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0.0001**	0	**0**	0	**0**	0	**0**
ELECTRICITY GENERATION																																
Electricity production	MWh	441.6	7800	3,444,480.	0.06	26.	900	397,440.	0	0	0	0	2400	1,059,840.	6.7	2,959.	15	6,624.	1.7	751.	0.0009	0.4	0	0	0.7	309.12	0.0002	0.105984	4E-05	0.0185472	4E-10	0.000000158976
Purchased Renewa ble Electricity	MWh	441.6	0	0	0	0	-2	-883.	0	0	0	0	-1979	-873,846.	-3.045	-1,345.	-11.58	-5,115.	-0.94	-415.	-9E-04	-0.4	0	0	-0.4	-176.64	-2E-05	-0.0101568	-2E-04	-0.075072	-2E-10	-0.000000105984
TRANSPORTATION																																
Diesel (off-site use)	gal	127	139	17,653.	0	0	0	0	0	0	0	0	22.5	2,858.	0.17	22.	0.0054	1.	0.0034	0	0	0	0	0	5E-06	0.0007	0	0	0	0	0	0
Gasoline (off-site use)	gal	26.7	124	3,311.	0	0	0	0	0	0	0	0	19.6	523.	0.11	3.	0.0045	0	0.0005	0	0	0	0	0	4E-05	0.001	0	0	0	0	0	0
Natural gas (off-site use)	ccf	0	103	0	0	0	0	0	0	0	0	0	12.2	0	0.01	0	6E-06	0	0.0008	0	0	0	0	0	8E-06	0	3E-08	0	5E-08	0	0	0
Other Transportation 1	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Transportation 2	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Transportation 3	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Transportation 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Transportation 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRANSPORTATION TOTAL			0	**20,964.**	0	**0**	0	**0**	0	**0**	0	**0**	0	**3,381.**	0	**25.**	0	**1.**	0	**0**	0	**0**	0	**0**	0	**0.0017**	0	**0**	0	**0**	0	**0**

			Level 1 (Extraction) Parameters Used, Extracted, Emitted, or Generated - P&T																													
			Energy		**Grid Electricity**		**All Water**		**Potable Water**		**Groundwater**		**CO2e**		**NO x**		**SO x**		**PM**		**Solid Waste**		**Haz. Waste**		**Air Toxics**		**Mercury**		**Lead**		**Dioxins**	
		Quantity Used	**Conv. Factor**	**Used**	**Conv. Factor**	**Used**	**Conv. Factor**	**Used**	**Conv. Factor**	**Used**	**Conv. Factor**	**Extracted**	**Conv. Factor**	**Emitted**	**Conv. Factor**	**Emitted**	**Conv. Factor**	**Emitted**	**Conv. Factor**	**Emitted**	**Conv. Factor**	**Generated**	**Conv. Factor**	**Generated**	**Conv. Factor**	**Emitted**	**Conv. Factor**	**Released**	**Conv. Factor**	**Released**	**Conv. Factor**	**Released**
				Mbtu		**MWh**		**gal x 1000**		**gal x 1000**		**gal x 1000**		**lbs**		**lbs**		**lbs**		**lbs**		**tons**		**tons**		**lbs**		**lbs**		**lbs**		**lbs**
OFF-SITE OTHER																																
Materials																																
Asphalt	tons	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bentonite	tons	0	55	0	0.0027	0	0.13	0	0	0	0	0	6.7	0	0.033	0	0.03	0	0.004	0	0	0	0	0	4E-07	0	6E-11	0	1E-09	0	2E-16	0
Borrow (clean soil)	tons	0	15.75	0	6E-05	0	8E-05	0	0	0	0	0	2.52	0	0.0176	0	0.0018	0	0.0004	0	4E-08	0	0	0	1E-05	0	5E-09	0	2E-07	0	3E-15	0
Cement	dry-ton	0	4100	0	0.13	0	0.41	0	0	0	0	0	1800	0	3.6	0	2.1	0	0.0063	0	0	0	0	0	0.058	0	6E-05	0	0.0001	0	9E-11	0
Cheese Whey	lbs	0	1.87	0	0	0	0	0	0	0	0	0	1.1	0	0.0083	0	0.0099	0	0.0002	0	0	0	0	0	0	0	0	0	0	0	0	0
Concrete	tons	0	3019	0	0.096	0	0.34	0	0	0	0	0	1322	0	2.6	0	1.5	0	0.0054	0	1E-08	0	0	0	0.043	0	4E-05	0	1E-04	0	6E-11	0
Diesel Produced	gal	137.2	18.5	2,538.	0.0006	0	0.0008	0	0	0	0	0	2.7	370.	0.0064	1.	0.013	2.	0.0003	0	4E-07	0	0	0	0.0001	0.0165	5E-08	0.000006586	2E-06	0.0002058	3E-14	0.000000000004
Emulsified vegetable oil	lbs	0	3.6	0	6E-05	0	2E-05	0	0	0	0	0	3.51	0	0.0265	0	0.031	0	0.0017	0	0	0	0	0	0	0	0	0	0	0	0	0
GAC: regenerated	lbs	0	9.6	0	0.0004	0	0.0064	0	0	0	0	0	2	0	0.025	0	0.015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GAC: virgin coal-based	lbs	0	10.8	0	5E-05	0	0	0	0	0	0	0	4.5	0	0.12	0	0.074	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GAC: virgin coconut-based	lbs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gasoline Produced	gal	26.7	21	561.	0.0006	0	0.0008	0	0	0	0	0	4.4	117.	0.008	0	0.019	1.	0.0005	0	4E-07	0	0	0	0.0002	0.0043	9E-08	0.00000227	2E-06	0.00005874	3E-14	0.000000000001
Gravel/sand/clay	ton	0	55	0	0.0027	0	0.13	0	0	0	0	0	6.7	0	0.033	0	0.03	0	0.004	0	0	0	0	0	4E-07	0	6E-11	0	1E-09	0	2E-16	0
HDPE	lb	0	31	0	0.0003	0	0.0023	0	0	0	0	0	1.9	0	0.0032	0	0.0041	0	0.0006	0	4E-07	0	1E-06	0	3E-06	0	3E-09	0	2E-09	0	1E-09	0
Hydrochloric acid (30%, SG = 1.18)	lbs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen peroxide (50%, SG=1.19)	lbs	0	4.95	0	0.0006	0	0.019	0	0	0	0	0	1.35	0	0.0087	0	0.0066	0	0.0025	0	1E-05	0	5E-07	0	0.0002	0	0	0	0	0	0	0
Hydroseed	lbs	0	0.049	0	1E-07	0	0.0001	0	0	0	0	0	0.0046	0	3E-06	0	5E-05	0	3E-07	0	0	0	0	0	8E-07	0	2E-11	0	1E-10	0	0	0
Lime	lbs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Molasses	lbs	0	1.31	0	5E-06	0	9E-05	0	0	0	0	0	0.4	0	0.003	0	0.0026	0	6E-05	0	0	0	0	0	0	0	0	0	0	0	0	0
Natural Gas Produced	ccf	0	5.2	0	0.0003	0	8E-05	0	0	0	0	0	2.2	0	0.0037	0	0.0046	0	7E-05	0	0	0	0	0	6E-06	0	2E-08	0	9E-07	0	5E-14	0
Nitrogen fertilizer	lbs	0	16.2	0	2E-05	0	0	0	0	0	0	0	1.5	0	0.0008	0	0.0174	0	7E-05	0	0	0	0	0	0.0003	0	6E-09	0	4E-08	0	0	0
Other Material #1 - Ferric Chloride (salt)	lbs	0	2.31	0	0.0003	0	0.0003	0	0	0	0	0	0.41	0	0.0019	0	0.0015	0	0.0002	0	1E-07	0	0	0	5E-05	0	3E-09	0	4E-08	0	3E-14	0
Other Material #2 - Mulch	cy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Material #3 - acetic acid	lb	4927.7076	5.2	25,624.	2E-05	0	0	0	0	0	0	0	0.67	3,302.	0.0006	3.	0.02	99.	6E-05	0	0	0	0	0	0.0003	1.429	2E-09	0.000008377	1E-08	0.000049277	3E-15	0.000000000015
Other Material #4 - guar gum	lb	0	0.91	0	5E-05	0	0.0001	0	0	0	0	0	1	0	0.073	0	0.0068	0	0.0001	0	0	0	0	0	1E-05	0	1E-09	0	1E-07	0	6E-14	0
Other Material #5	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phosphorus fertilizer	lbs	0	3.39	0	7E-05	0	0	0	0	0	0	0	0.35	0	0.0017	0	0.017	0	0.0001	0	0	0	0	0	5E-05	0	2E-09	0	5E-08	0	0	0
Polymer	lbs	0	15.39	0	0.0023	0	0.0018	0	0	0	0	0	2.72	0	0.013	0	0.0098	0	0.001	0	8E-07	0	0	0	0.0004	0	2E-08	0	2E-07	0	2E-13	0
Potable Water	gal x 1000	99	9.2	911.	0.0004	0	0.021	2.	0	0	0	0	5	495.	0.0097	1.	0.0059	1.	0.016	2.	8E-07	0	0	0	2E-05	0.0015	8E-09	0.000000812	7E-08	0.000006633	1E-13	0.00000000001
Potassium permanganate	lbs	0	29.22	0	0.0016	0	0.003	0	0	0	0	0	4.5	0	0.021	0	0.016	0	0.0017	0	1E-06	0	0	0	0.0006	0	4E-08	0	4E-07	0	4E-13	0
PVC	lbs	0	22	0	0.0006	0	0.0069	0	0	0	0	0	2.6	0	0.0048	0	0.0076	0	0.0012	0	2E-06	0	2E-06	0	0.0005	0	3E-07	0	1E-07	0	7E-09	0
Sequestering agent	lbs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sodium hydroxide (dry bulk)	lbs	0	6.6	0	0.0003	0	0.0012	0	0	0	0	0	1.37	0	0.003	0	0.0048	0	0.0005	0	2E-05	0	5E-07	0	6E-05	0	2E-07	0	3E-08	0	2E-14	0
Stainless Steel	lb	0	11.6	0	0.0006	0	0.0023	0	0	0	0	0	3.4	0	0.0075	0	0.012	0	0.0044	0	0.0006	0	0	0	0.0001	0	0	0	5E-07	0	2E-12	0
Steel	lb	0	4.4	0	0.0002	0	0.0006	0	0	0	0	0	1.1	0	0.0014	0	0.0017	0	0.0006	0	0.0003	0	0	0	7E-05	0	1E-07	0	3E-06	0	7E-12	0
Tree: root ball	trees	0	3.7	0	2E-06	0	0.004	0	0	0	0	0	0.6	0	0.003	0	0.0006	0	3E-05	0	1E-08	0	0	0	6E-06	0	2E-09	0	6E-08	0	0	0
Tree: whip	trees	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Off-Site Services																																
Off-site waste water treatment	gal x 1000	0	15	0	0.0007	0	0.0029	0	0	0	0	0	4.4	0	0.016	0	0.015	0	0.0017	0	0.0024	0	0	0	0.0006	0	4E-08	0	4E-07	0	3E-13	0
Off-site Solid Waste Disposal	ton	0	160	0	0.0077	0	0.15	0	0	0	0	0	25	0	0.14	0	0.075	0	0.4	0	8E-06	0	0	0	0.0014	0	1E-06	0	8E-06	0	1E-11	0
Off-site Haz. Waste Disposal	ton	0	176	0	0.0085	0	0.165	0	0	0	0	0	27.5	0	0.154	0	0.0825	0	0.44	0	9E-06	0	0	0	0.0015	0	1E-06	0	8E-06	0	1E-11	0
Off-site Laboratory Analysis	$	0	6.49	0	0.0004	0	0.0007	0	0	0	0	0	1	0	0.0048	0	0.0036	0	0.0004	0	0	0	0	0	0.0001	0	8E-09	0	9E-08	0	8E-14	0
Other 1	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 2	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 3	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 4	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 5	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other																																
Potable Water Transported	gal x 1000	99	7.4	733.	0.0006	0	0.0013	0	0	0	0	0	0.9948	98.	0.0025	0	0.0065	1.	0.0006	0	6E-07	0	0	0	0.0003	0.0256	1E-08	0.000001471	1E-07	0.000010872	2E-13	0.000000000015
Electricity transmission	MWh	441.6	410	181,056.	0.12	53.	0.24	106.	0	0	0	0	184.8	81,608.	0.468	207.	1.2	530.	0.1128	50.	0.0001	0	0	0	0.048	21.1968	3E-06	0.001218816	2E-05	0.00900864	3E-11	0.000000012718
Other 1	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 2	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 3	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OFF-SITE OTHER TOTAL			0	211,423.	0	53.	0	108.	0	0	0	0	0	85,990.	0	212.	0	634.	0	52.	0	0	0	0	0	22.6737	0	0.001238332	0	0.009339962	0	0.000000012763

			Level 2 (O&M) Parameters Used, Extracted, Emitted, or Generated - P&T																									
			Energy		**Grid Electricity**		**All Water**		**Potable Water**		**Groundwater**		**CO2e**		**NO x**		**SO x**		**PM**		**Solid Waste**		**Haz. Waste**		**Air Toxics**		**Mercury**		**Lead**		**Dioxins**	
		Quantity Used	**Conv. Factor**	**Used**	**Conv. Factor**	**Used**	**Conv. Factor**	**Used**	**Conv. Factor**	**Used**	**Conv. Factor**	**Extracted**	**Conv. Factor**	**Emitted**	**Conv. Factor**	**Emitted**	**Conv. Factor**	**Emitted**	**Conv. Factor**	**Emitted**	**Conv. Factor**	**Generated**	**Conv. Factor**	**Generated**	**Conv. Factor**	**Emitted**	**Conv. Factor**	**Released**	**Conv. Factor**	**Released**	**Conv. Factor**	**Released**
				Mbtu		**MWh**		**gal x 1000**		**gal x 1000**		**gal x 1000**		**lbs**		**lbs**		**lbs**		**lbs**		**tons**		**tons**		**lbs**		**lbs**		**lbs**		**lbs**
Totals				***17,152,609.***		***1,349.***		***801,813.***		***12,436.6***		***0***		***1,770,639.***		***7,602.***		***7,008.***		***1,579.***		***6.3***		***260.167***		***373.4041***		***0.252329088***		***-0.035257151***		***0.00000015946***
ON-SITE																																
Energy																																
Diesel (on-site use)	gal	0	139	0	0	0	0	0	0	0	0	0	22.5	0	0.17	0	0.0054	0	0.0034	0	0	0	0	0	5E-06	0	0	0	0	0	0	0
Gasoline (on-site use)	gal	0	124	0	0	0	0	0	0	0	0	0	19.6	0	0.11	0	0.0045	0	0.0005	0	0	0	0	0	4E-05	0	0	0	0	0	0	0
Natural gas (on-site use)	ccf	23657	103	2,436,671.	0	0	0	0	0	0	0	0	12.2	288,615.	0.01	237.	6E-06	0	0.0008	18.	0	0	0	0	8E-06	0.1987	3E-08	0.000615082	5E-08	0.00118285	0	0
Electricity (on-site use)	MWh	875.9	3413	2,989,447.	1	876.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Photovoltaic (on-site system)	MWh	0	37922	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Energy 2	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Energy 3	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water																																
Groundwater Extracted On-site	gal x 1000	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potable Water Used On-site	gal x 1000	12436.623	0	0	0	0	1	12,437.	1	12,436.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other On-Site Water 1	gal x 1000	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other On-Site Water 2	gal x 1000	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other On-Site Water 3	gal x 1000	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Waste Generation																																
On-Site Solid Waste Generation	ton	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
On-Site Solid Waste Disposal		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
On-Site Hazardous Waste Generation	ton	260	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	260.	0	0	0	0	0	0	0	0
On-Site Hazardous Waste Disposal		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other																																
On-site process emissions (HAPs)	lbs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
On-site process emissions (GHGs)	lbs CO2e	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
On-site GHG storage	lbs CO2e	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
On-site NOx reduction	lbs	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
On-site SOx reduction	lbs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
On-site PM reduction	lbs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 1	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 2	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ON-SITE TOTAL			0	**5,426,118.**	0	**876.**	0	**12,437.**	0	**12,436.6**	0	**0**	0	**288,615.**	0	**237.**	0	**0**	0	**18.**	0	**0**	0	**260.**	0	**0.1987**	0	**0.000615082**	0	**0.00118285**	0	**0**
ELECTRICITY GENERATION																																
Electricity production	MWh	875.9	7800	6,832,020.	0.06	53.	900	788,310.	0	0	0	0	2400	2,102,160.	6.7	5,869.	15	13,139.	1.7	1,489.	0.0009	0.8	0	0	0.7	613.13	0.0002	0.210216	4E-05	0.0367878	4E-10	0.000000315324
Purchased Renewa ble Electricity	MWh	875.9	0	0	0	0	-2	-1,752.	0	0	0	0	-1979	-1,733,247.	-3.045	-2,667.	-11.58	-10,146.	-0.94	-823.	-9E-04	-0.8	0	0	-0.4	-350.36	-2E-05	-0.0201457	-2E-04	-0.148903	-2E-10	-0.000000210216
TRANSPORTATION																																
Diesel (off-site use)	gal	4524.0588	139	628,844.	0	0	0	0	0	0	0	0	22.5	101,791.	0.17	769.	0.0054	24.	0.0034	15.	0	0	0	0	5E-06	0.0235	0	0	0	0	0	0
Gasoline (off-site use)	gal	1213.3	124	150,449.	0	0	0	0	0	0	0	0	19.6	23,781.	0.11	133.	0.0045	5.	0.0005	1.	0	0	0	0	4E-05	0.0473	0	0	0	0	0	0
Natural gas (off-site use)	ccf	0	103	0	0	0	0	0	0	0	0	0	12.2	0	0.01	0	6E-06	0	0.0008	0	0	0	0	0	8E-06	0	3E-08	0	5E-08	0	0	0
Other Transportation 1	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Transportation 2	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Transportation 3	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Transportation 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Transportation 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRANSPORTATION TOTAL			0	**779,293.**	0	**0**	0	**0**	0	**0**	0	**0**	0	**125,572.**	0	**902.**	0	**29.**	0	**16.**	0	**0**	0	**0**	0	**0.0708**	0	**0**	0	**0**	0	**0**

		Quantity Used	Level 2 (O&M) Parameters Used, Extracted, Emitted, or Generated - P&T																													
			Energy		Grid Electricity		All Water		Potable Water		Groundwater		CO2e		NO x		SO x		PM		Solid Waste		Haz. Waste		Air Toxics		Mercury		Lead		Dioxins	
			Conv. Factor	Used	Conv. Factor	Used	Conv. Factor	Used	Conv. Factor	Used	Conv. Factor	Extracted	Conv. Factor	Emitted	Conv. Factor	Emitted	Conv. Factor	Emitted	Conv. Factor	Emitted	Conv. Factor	Generated	Conv. Factor	Generated	Conv. Factor	Emitted	Conv. Factor	Released	Conv. Factor	Released	Conv. Factor	Released
				Mbtu		MWh		gal x 1000		gal x 1000		gal x 1000		lbs		lbs		lbs		lbs		tons		tons		lbs		lbs		lbs		lbs
OFF-SITE OTHER																																
Materials																																
Asphalt	tons	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bentonite	tons	0	55	0	0.0027	0	0.13	0	0	0	0	0	6.7	0	0.033	0	0.03	0	0.004	0	0	0	0	0	4E-07	0	6E-11	0	1E-09	0	2E-16	0
Borrow (clean soil)	tons	0	15.75	0	6E-05	0	8E-05	0	0	0	0	0	2.52	0	0.0176	0	0.0018	0	0.0004	0	4E-08	0	0	0	1E-05	0	5E-09	0	2E-07	0	3E-15	0
Cement	dry-ton	0	4100	0	0.13	0	0.41	0	0	0	0	0	1800	0	3.6	0	2.1	0	0.0063	0	0	0	0	0	0.058	0	6E-05	0	0.0001	0	9E-11	0
Cheese Whey	lbs	0	1.87	0	0	0	0	0	0	0	0	0	1.1	0	0.0083	0	0.0099	0	0.0002	0	0	0	0	0	0	0	0	0	0	0	0	0
Concrete	tons	0	3019	0	0.096	0	0.34	0	0	0	0	0	1322	0	2.6	0	1.5	0	0.0054	0	1E-08	0	0	0	0.043	0	4E-05	0	1E-04	0	6E-11	0
Diesel Produced	gal	4524.0588	18.5	83,695.	0.0006	3.	0.0008	3.	0	0	0	0	2.7	12,215.	0.0064	29.	0.013	59.	0.0003	2.	4E-07	0	0	0	0.0001	0.5429	5E-08	0.000217155	2E-06	0.006786088	3E-14	0.000000000136
Emulsified vegetable oil	lbs	0	3.6	0	6E-05	0	2E-05	0	0	0	0	0	3.51	0	0.0265	0	0.031	0	0.0017	0	0	0	0	0	0	0	0	0	0	0	0	0
GAC: regenerated	lbs	0	9.6	0	0.0004	0	0.0064	0	0	0	0	0	2	0	0.025	0	0.015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GAC: virgin coal-based	lbs	0	10.8	0	5E-05	0	0	0	0	0	0	0	4.5	0	0.12	0	0.074	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GAC: virgin coconut-based	lbs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gasoline Produced	gal	1213.3	21	25,479.	0.0006	1.	0.0008	1.	0	0	0	0	4.4	5,339.	0.008	10.	0.019	23.	0.0005	1.	4E-07	0	0	0	0.0002	0.1941	9E-08	0.000103131	2E-06	0.00266926	3E-14	0.000000000038
Gravel/sand/clay	ton	0	55	0	0.0027	0	0.13	0	0	0	0	0	6.7	0	0.033	0	0.03	0	0.004	0	0	0	0	0	4E-07	0	6E-11	0	1E-09	0	2E-16	0
HDPE	lb	0	31	0	0.0003	0	0.0023	0	0	0	0	0	1.9	0	0.0032	0	0.0041	0	0.0006	0	4E-07	0	1E-06	0	3E-06	0	3E-09	0	2E-09	0	1E-09	0
Hydrochloric acid (30%, SG = 1.18)	lbs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen peroxide (50%, SG=1.19)	lbs	98000	4.95	485,100.	0.0006	59.	0.019	1,862.	0	0	0	0	1.35	132,300.	0.0087	853.	0.0066	647.	0.0025	245.	1E-05	1.3	5E-07	0.047	0.0002	22.54	0	0	0	0	0	0
Hydroseed	lbs	0	0.049	0	1E-07	0	0.0001	0	0	0	0	0	0.0046	0	3E-06	0	5E-05	0	3E-07	0	0	0	0	0	8E-07	0	2E-11	0	1E-10	0	0	0
Lime	lbs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Molasses	lbs	0	1.31	0	5E-06	0	9E-05	0	0	0	0	0	0.4	0	0.003	0	0.0026	0	6E-05	0	0	0	0	0	0	0	0	0	0	0	0	0
Natural Gas Produced	ccf	23657	5.2	123,016.	0.0003	6.	8E-05	2.	0	0	0	0	2.2	52,045.	0.0037	88.	0.0046	109.	7E-05	2.	0	0	0	0	6E-06	0.1443	2E-08	0.000496797	9E-07	0.0212913	5E-14	0.000000001207
Nitrogen fertilizer	lbs	0	16.2	0	2E-05	0	0	0	0	0	0	0	1.5	0	0.0008	0	0.0174	0	7E-05	0	0	0	0	0	0.0003	0	6E-09	0	4E-08	0	0	0
Other Material #1 - Ferric Chloride (salt)	lbs	197000	2.31	455,070.	0.0003	67.	0.0003	53.	0	0	0	0	0.41	80,770.	0.0019	382.	0.0015	296.	0.0002	30.	1E-07	0	0	0	5E-05	10.638	3E-09	0.000591	4E-08	0.006895	3E-14	0.000000006304
Other Material #2 - Mulch	cy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Material #3 - acetic acid	lb	0	5.2	0	2E-05	0	0	0	0	0	0	0	0.67	0	0.0006	0	0.02	0	6E-05	0	0	0	0	0	0.0003	0	2E-09	0	1E-08	0	3E-15	0
Other Material #4 - guar gum	lb	0	0.91	0	5E-05	0	0.0001	0	0	0	0	0	1	0	0.073	0	0.0068	0	0.0001	0	0	0	0	0	1E-05	0	1E-09	0	1E-07	0	6E-14	0
Other Material #5	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phosphorus fertilizer	lbs	0	3.39	0	7E-05	0	0	0	0	0	0	0	0.35	0	0.0017	0	0.017	0	0.0001	0	0	0	0	0	5E-05	0	2E-09	0	5E-08	0	0	0
Polymer	lbs	33485.1	15.39	515,336.	0.0023	75.	0.0018	60.	0	0	0	0	2.72	91,079.	0.013	435.	0.0098	328.	0.001	33.	8E-07	0	0	0	0.0004	12.0546	2E-08	0.000770157	2E-07	0.007735058	2E-13	0.000000007152
Potable Water	gal x 1000	12436.623	9.2	114,417.	0.0004	5.	0.021	261.	0	0	0	0	5	62,183.	0.0097	121.	0.0059	73.	0.016	199.	8E-07	0	0	0	2E-05	0.1865	8E-09	0.00010198	7E-08	0.000833254	1E-13	0.000000001244
Potassium permanganate	lbs	0	29.22	0	0.0016	0	0.003	0	0	0	0	0	4.5	0	0.021	0	0.016	0	0.0017	0	1E-06	0	0	0	0.0006	0	4E-08	0	4E-07	0	4E-13	0
PVC	lbs	0	22	0	0.0006	0	0.0069	0	0	0	0	0	2.6	0	0.0048	0	0.0076	0	0.0012	0	2E-06	0	2E-06	0	0.0005	0	3E-07	0	1E-07	0	7E-09	0
Sequestering agent	lbs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sodium hydroxide (dry bulk)	lbs	256000	6.6	1,689,600.	0.0003	82.	0.0012	294.	0	0	0	0	1.37	350,720.	0.003	768.	0.0048	1,229.	0.0005	138.	2E-05	4.9	5E-07	0.12	6E-05	15.872	2E-07	0.05632	3E-08	0.0064	2E-14	0.000000006144
Stainless Steel	lb	0	11.6	0	0.0006	0	0.0023	0	0	0	0	0	3.4	0	0.0075	0	0.012	0	0.0044	0	0.0006	0	0	0	0.0001	0	0	0	5E-07	0	2E-12	0
Steel	lb	0	4.4	0	0.0002	0	0.0006	0	0	0	0	0	1.1	0	0.0014	0	0.0017	0	0.0006	0	0.0003	0	0	0	7E-05	0	1E-07	0	3E-06	0	7E-12	0
Tree: root ball	trees	0	3.7	0	2E-06	0	0.004	0	0	0	0	0	0.6	0	0.003	0	0.0006	0	3E-05	0	1E-08	0	0	0	6E-06	0	2E-09	0	6E-08	0	0	0
Tree: whip	trees	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Off-Site Services																																
Off-site waste water treatment	gal x 1000	0	15	0	0.0007	0	0.0029	0	0	0	0	0	4.4	0	0.016	0	0.015	0	0.0017	0	0.0024	0	0	0	0.0006	0	4E-08	0	4E-07	0	3E-13	0
Off-site Solid Waste Disposal	ton	0	160	0	0.0077	0	0.15	0	0	0	0	0	25	0	0.14	0	0.075	0	0.4	0	8E-06	0	0	0	0.0014	0	1E-06	0	8E-06	0	1E-11	0
Off-site Haz. Waste Disposal	ton	260	176	45,760.	0.0085	2.	0.165	43.	0	0	0	0	27.5	7,150.	0.154	40.	0.0825	21.	0.44	114.	9E-06	0	0	0	0.0015	0.4004	1E-06	0.00027742	8E-06	0.0021736	1E-11	0.000000003432
Off-site Laboratory Analysis	$	19500	6.49	126,555.	0.0004	7.	0.0007	13.	0	0	0	0	1	19,500.	0.0048	94.	0.0036	70.	0.0004	8.	0	0	0	0	0.0001	2.535	8E-09	0.0001638	9E-08	0.0016575	8E-14	0.000000001541
Other 1	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 2	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 3	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 4	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 5	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other																																
Potable Water Transported	gal x 1000	12436.623	7.4	92,031.	0.0006	8.	0.0013	16.	0	0	0	0	0.9948	12,372.	0.0025	31.	0.0065	80.	0.0006	8.	6E-07	0	0	0	0.0003	3.2136	1E-08	0.000184782	1E-07	0.001365779	2E-13	0.000000001928
Electricity transmission	MWh	875.9	410	359,119.	0.12	105.	0.24	210.	0	0	0	0	184.8	161,866.	0.468	410.	1.2	1,051.	0.1128	99.	0.0001	0.1	0	0	0.048	42.0432	3E-06	0.002417484	2E-05	0.01786836	3E-11	0.000000025226
Other 1	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 2	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 3	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OFF-SITE OTHER TOTAL			0	4,115,178.	0	420.	0	2,818.	0	0	0	0	0	987,539.	0	3,261.	0	3,986.	0	879.	0	6.3	0	0.167	0	110.3646	0	0.061643706	0	0.075675199	0	0.000000054352

		Quantity Used	Level 3 (LTM) Parameters Used, Extracted, Emitted, or Generated - P&T																													
			Energy		Grid Electricity		All Water		Potable Water		Groundwater		CO2e		NO x		SO x		PM		Solid Waste		Haz. Waste		Air Toxics		Mercury		Lead		Dioxins	
			Conv. Factor	Used	Conv. Factor	Used	Conv. Factor	Used	Conv. Factor	Used	Conv. Factor	Extracted	Conv. Factor	Emitted	Conv. Factor	Emitted	Conv. Factor	Emitted	Conv. Factor	Emitted	Conv. Factor	Generated	Conv. Factor	Generated	Conv. Factor	Emitted	Conv. Factor	Released	Conv. Factor	Released	Conv. Factor	Released
				Mbtu		MWh		gal x 1000		gal x 1000		gal x 1000		lbs		lbs		lbs		lbs		tons		tons		lbs		lbs		lbs		lbs
Totals				***31,853.***		***1.***		***1.***		***0***		***0***		***5,139.***		***26.***		***10.***		***1.***		***0***		***0***		***0.2617***		***0.000026945***		***0.000459051***		***0.000000000146***
ON-SITE																																
Energy																																
Diesel (on-site use)	gal	0	139	0	0	0	0	0	0	0	0	0	22.5	0	0.17	0	0.0054	0	0.0034	0	0	0	0	0	5E-06	0	0	0	0	0	0	0
Gasoline (on-site use)	gal	5.814	124	721.	0	0	0	0	0	0	0	0	19.6	114.	0.11	1.	0.0045	0	0.0005	0	0	0	0	0	4E-05	0.0002	0	0	0	0	0	0
Natural gas (on-site use)	ccf	0	103	0	0	0	0	0	0	0	0	0	12.2	0	0.01	0	6E-06	0	0.0008	0	0	0	0	0	8E-06	0	3E-08	0	5E-08	0	0	0
Electricity (on-site use)	MWh	0	3413	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Photovoltaic (on-site system)	MWh	0	37922	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Energy 2	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Energy 3	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water																																
Groundwater Extracted On-site	gal x 1000	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potable Water Used On-site	gal x 1000	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other On-Site Water 1	gal x 1000	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other On-Site Water 2	gal x 1000	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other On-Site Water 3	gal x 1000	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Waste Generation																																
On-Site Solid Waste Generation	ton	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
On-Site Solid Waste Disposal		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
On-Site Hazardous Waste Generation	ton	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
On-Site Hazardous Waste Disposal		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other																																
On-site process emissions (HAPs)	lbs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
On-site process emissions (GHGs)	lbs CO2e	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
On-site GHG storage	lbs CO2e	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
On-site NOx reduction	lbs	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
On-site SOx reduction	lbs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
On-site PM reduction	lbs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 1	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 2	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ON-SITE TOTAL			0	**721.**	0	**0**	0	**0**	0	**0**	0	**0**	0	**114.**	0	**1.**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0.0002**	0	**0**	0	**0**	0	**0**
ELECTRICITY GENERATION																																
Electricity production	MWh	0	7800	0	0.06	0	900	0	0	0	0	0	2400	0	6.7	0	15	0	1.7	0	0.0009	0	0	0	0.7	0	0.0002	0	4E-05	0	4E-10	0
Purchased Renewa ble Electricity	MWh	0	0	0	0	0	-2	0	0	0	0	0	-1979	0	-3.045	0	-11.58	0	-0.94	0	-9E-04	0	0	0	-0.4	0	-2E-05	0	-2E-04	0	-2E-10	0
TRANSPORTATION																																
Diesel (off-site use)	gal	0	139	0	0	0	0	0	0	0	0	0	22.5	0	0.17	0	0.0054	0	0.0034	0	0	0	0	0	5E-06	0	0	0	0	0	0	0
Gasoline (off-site use)	gal	133.3	124	16,529.	0	0	0	0	0	0	0	0	19.6	2,613.	0.11	15.	0.0045	1.	0.0005	0	0	0	0	0	4E-05	0.0052	0	0	0	0	0	0
Natural gas (off-site use)	ccf	0	103	0	0	0	0	0	0	0	0	0	12.2	0	0.01	0	6E-06	0	0.0008	0	0	0	0	0	8E-06	0	3E-08	0	5E-08	0	0	0
Other Transportation 1	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Transportation 2	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Transportation 3	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Transportation 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Transportation 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRANSPORTATION TOTAL			0	**16,529.**	0	**0**	0	**0**	0	**0**	0	**0**	0	**2,613.**	0	**15.**	0	**1.**	0	**0**	0	**0**	0	**0**	0	**0.0052**	0	**0**	0	**0**	0	**0**

			Level 3 (LTM) Parameters Used, Extracted, Emitted, or Generated - P&T																													
			Energy		Grid Electricity		All Water		Potable Water		Groundwater		CO2e		NO x		SO x		PM		Solid Waste		Haz. Waste		Air Toxics		Mercury		Lead		Dioxins	
		Quantity Used	Conv. Factor	Used	Conv. Factor	Used	Conv. Factor	Used	Conv. Factor	Used	Conv. Factor	Extracted	Conv. Factor	Emitted	Conv. Factor	Emitted	Conv. Factor	Emitted	Conv. Factor	Emitted	Conv. Factor	Generated	Conv. Factor	Generated	Conv. Factor	Emitted	Conv. Factor	Released	Conv. Factor	Released	Conv. Factor	Released
				Mbtu		MWh		gal x 1000		gal x 1000		gal x 1000		lbs		lbs		lbs		lbs		tons		tons		lbs		lbs		lbs		lbs
OFF-SITE OTHER																																
Materials																																
Asphalt	tons	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bentonite	tons	0	55	0	0.0027	0	0.13	0	0	0	0	0	6.7	0	0.033	0	0.03	0	0.004	0	0	0	0	0	4E-07	0	6E-11	0	1E-09	0	2E-16	0
Borrow (clean soil)	tons	0	15.75	0	6E-05	0	8E-05	0	0	0	0	0	2.52	0	0.0176	0	0.0018	0	0.0004	0	4E-08	0	0	0	1E-05	0	5E-09	0	2E-07	0	3E-15	0
Cement	dry-ton	0	4100	0	0.13	0	0.41	0	0	0	0	0	1800	0	3.6	0	2.1	0	0.0063	0	0	0	0	0	0.058	0	6E-05	0	0.0001	0	9E-11	0
Cheese Whey	lbs	0	1.87	0	0	0	0	0	0	0	0	0	1.1	0	0.0083	0	0.0099	0	0.0002	0	0	0	0	0	0	0	0	0	0	0	0	0
Concrete	tons	0	3019	0	0.096	0	0.34	0	0	0	0	0	1322	0	2.6	0	1.5	0	0.0054	0	1E-08	0	0	0	0.043	0	4E-05	0	1E-04	0	6E-11	0
Diesel Produced	gal	0	18.5	0	0.0006	0	0.0008	0	0	0	0	0	2.7	0	0.0064	0	0.013	0	0.0003	0	4E-07	0	0	0	0.0001	0	5E-08	0	2E-06	0	3E-14	0
Emulsified vegetable oil	lbs	0	3.6	0	6E-05	0	2E-05	0	0	0	0	0	3.51	0	0.0265	0	0.031	0	0.0017	0	0	0	0	0	0	0	0	0	0	0	0	0
GAC: regenerated	lbs	0	9.6	0	0.0004	0	0.0064	0	0	0	0	0	2	0	0.025	0	0.015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GAC: virgin coal-based	lbs	0	10.8	0	5E-05	0	0	0	0	0	0	0	4.5	0	0.12	0	0.074	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GAC: virgin coconut-based	lbs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gasoline Produced	gal	139.114	21	2,921.	0.0006	0	0.0008	0	0	0	0	0	4.4	612.	0.008	1.	0.019	3.	0.0005	0	4E-07	0	0	0	0.0002	0.0223	9E-08	0.000011825	2E-06	0.000306051	3E-14	0.000000000004
Gravel/sand/clay	ton	0	55	0	0.0027	0	0.13	0	0	0	0	0	6.7	0	0.033	0	0.03	0	0.004	0	0	0	0	0	4E-07	0	6E-11	0	1E-09	0	2E-16	0
HDPE	lb	0	31	0	0.0003	0	0.0023	0	0	0	0	0	1.9	0	0.0032	0	0.0041	0	0.0006	0	4E-07	0	1E-06	0	3E-06	0	3E-09	0	2E-09	0	1E-09	0
Hydrochloric acid (30%, SG = 1.18)	lbs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen peroxide (50%, SG=1.19)	lbs	0	4.95	0	0.0006	0	0.019	0	0	0	0	0	1.35	0	0.0087	0	0.0066	0	0.0025	0	1E-05	0	5E-07	0	0.0002	0	0	0	0	0	0	0
Hydroseed	lbs	0	0.049	0	1E-07	0	0.0001	0	0	0	0	0	0.0046	0	3E-06	0	5E-05	0	3E-07	0	0	0	0	0	8E-07	0	2E-11	0	1E-10	0	0	0
Lime	lbs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Molasses	lbs	0	1.31	0	5E-06	0	9E-05	0	0	0	0	0	0.4	0	0.003	0	0.0026	0	6E-05	0	0	0	0	0	0	0	0	0	0	0	0	0
Natural Gas Produced	ccf	0	5.2	0	0.0003	0	8E-05	0	0	0	0	0	2.2	0	0.0037	0	0.0046	0	7E-05	0	0	0	0	0	6E-06	0	2E-08	0	9E-07	0	5E-14	0
Nitrogen fertilizer	lbs	0	16.2	0	2E-05	0	0	0	0	0	0	0	1.5	0	0.0008	0	0.0174	0	7E-05	0	0	0	0	0	0.0003	0	6E-09	0	4E-08	0	0	0
Other Material #1 - Ferric Chloride (salt)	lbs	0	2.31	0	0.0003	0	0.0003	0	0	0	0	0	0.41	0	0.0019	0	0.0015	0	0.0002	0	1E-07	0	0	0	5E-05	0	3E-09	0	4E-08	0	3E-14	0
Other Material #2 - Mulch	cy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Material #3 - acetic acid	lb	0	5.2	0	2E-05	0	0	0	0	0	0	0	0.67	0	0.0006	0	0.02	0	6E-05	0	0	0	0	0	0.0003	0	2E-09	0	1E-08	0	3E-15	0
Other Material #4 - guar gum	lb	0	0.91	0	5E-05	0	0.0001	0	0	0	0	0	1	0	0.073	0	0.0068	0	0.0001	0	0	0	0	0	1E-05	0	1E-09	0	1E-07	0	6E-14	0
Other Material #5	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phosphorus fertilizer	lbs	0	3.39	0	7E-05	0	0	0	0	0	0	0	0.35	0	0.0017	0	0.017	0	0.0001	0	0	0	0	0	5E-05	0	2E-09	0	5E-08	0	0	0
Polymer	lbs	0	15.39	0	0.0023	0	0.0018	0	0	0	0	0	2.72	0	0.013	0	0.0098	0	0.001	0	8E-07	0	0	0	0.0004	0	2E-08	0	2E-07	0	2E-13	0
Potable Water	gal x 1000	0	9.2	0	0.0004	0	0.021	0	0	0	0	0	5	0	0.0097	0	0.0059	0	0.016	0	8E-07	0	0	0	2E-05	0	8E-09	0	7E-08	0	1E-13	0
Potassium permanganate	lbs	0	29.22	0	0.0016	0	0.003	0	0	0	0	0	4.5	0	0.021	0	0.016	0	0.0017	0	1E-06	0	0	0	0.0006	0	4E-08	0	4E-07	0	4E-13	0
PVC	lbs	0	22	0	0.0006	0	0.0069	0	0	0	0	0	2.6	0	0.0048	0	0.0076	0	0.0012	0	2E-06	0	2E-06	0	0.0005	0	3E-07	0	1E-07	0	7E-09	0
Sequestering agent	lbs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sodium hydroxide (dry bulk)	lbs	0	6.6	0	0.0003	0	0.0012	0	0	0	0	0	1.37	0	0.003	0	0.0048	0	0.0005	0	2E-05	0	5E-07	0	6E-05	0	2E-07	0	3E-08	0	2E-14	0
Stainless Steel	lb	0	11.6	0	0.0006	0	0.0023	0	0	0	0	0	3.4	0	0.0075	0	0.012	0	0.0044	0	0.0006	0	0	0	0.0001	0	0	0	5E-07	0	2E-12	0
Steel	lb	0	4.4	0	0.0002	0	0.0006	0	0	0	0	0	1.1	0	0.0014	0	0.0017	0	0.0006	0	0.0003	0	0	0	7E-05	0	1E-07	0	3E-06	0	7E-12	0
Tree: root ball	trees	0	3.7	0	2E-06	0	0.004	0	0	0	0	0	0.6	0	0.003	0	0.0006	0	3E-05	0	1E-08	0	0	0	6E-06	0	2E-09	0	6E-08	0	0	0
Tree: whip	trees	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Off-Site Services																																
Off-site waste water treatment	gal x 1000	0	15	0	0.0007	0	0.0029	0	0	0	0	0	4.4	0	0.016	0	0.015	0	0.0017	0	0.0024	0	0	0	0.0006	0	4E-08	0	4E-07	0	3E-13	0
Off-site Solid Waste Disposal	ton	0	160	0	0.0077	0	0.15	0	0	0	0	0	25	0	0.14	0	0.075	0	0.4	0	8E-06	0	0	0	0.0014	0	1E-06	0	8E-06	0	1E-11	0
Off-site Haz. Waste Disposal	ton	0	176	0	0.0085	0	0.165	0	0	0	0	0	27.5	0	0.154	0	0.0825	0	0.44	0	9E-06	0	0	0	0.0015	0	1E-06	0	8E-06	0	1E-11	0
Off-site Laboratory Analysis	$	1800	6.49	11,682.	0.0004	1.	0.0007	1.	0	0	0	0	1	1,800.	0.0048	9.	0.0036	6.	0.0004	1.	0	0	0	0	0.0001	0.234	8E-09	0.00001512	9E-08	0.000153	8E-14	0.000000000142
Other 1	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 2	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 3	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 4	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 5	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other																																
Potable Water Transported	gal x 1000	0	7.4	0	0.0006	0	0.0013	0	0	0	0	0	0.9948	0	0.0025	0	0.0065	0	0.0006	0	6E-07	0	0	0	0.0003	0	1E-08	0	1E-07	0	2E-13	0
Electricity transmission	MWh	0	410	0	0.12	0	0.24	0	0	0	0	0	184.8	0	0.468	0	1.2	0	0.1128	0	0.0001	0	0	0	0.048	0	3E-06	0	2E-05	0	3E-11	0
Other 1	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 2	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other 3	TBD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OFF-SITE OTHER TOTAL			0	14,603.	0	1.	0	1.	0	0	0	0	0	2,412.	0	10.	0	9.	0	1.	0	0	0	0	0	0.2563	0	0.000026945	0	0.000459051	0	0.000000000146

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Power Sources and Global Emissions Factors for Electricity Provided by *Vineland Municipal Electric Utility*

Type	% Used*	Water (gal/kWh)		CO2e (lbs/kWh)		NOx (lbs/kWh)		SOx (lbs/kWh)		PM (lbs/kWh)		HAPs (lbs/kWh)		Lead (lbs/kWh)		Mercury (lbs/kWh)		Dioxins (lbs/kWh)	
		Full Load	**Adjusted**	**Full Load**	**Adjusted**	**Full Load**	**Adjusted**	**Full Load**	**Adjusted**	**Full Load**	**Adjusted**	**Full Load**	**Adjusted**	**Full Load**	**Adjusted**	**Full Load**	**Adjusted**	**Full Load**	**Adjusted**
Biomass	0%	168	0	0	0	0.0015	0	0.00060	0	0.000084	0	0	0	0	0	0	0	0	0
Coal	100%	0.94	0.94	2.4	2.4	0.0067	0.0067	0.015	0.015	0.0017	0.0017	0.0007	0.0007	0.00000024	0.00000024	0.000000042	4.2E-08	3.8E-13	3.572E-13
Geothermal	0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydro	0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Natural Gas	0%	0.79	0	1.4	0	0.0012	0	0.012	0	0.000088	0	0.000193	0	1.31E-08	0	2.9E-09	0	0	0
Nuclear	0%	0.72	0	0.024	0	0.000056	0.0000000	0.000131	0	0.0000126	0	0.0000053	0	5.2E-09	0	4.6E-10	0	2.9E-15	0
Oil	0%	3.52	0	1.9	0	0.0036	0.0000000	0.0041	0	0.00029	0	0.0000902	0	0.00000129	0	1.01E-08	0	1.04E-12	0
Solar	0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wind	0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total based on kWh at plant	**100%**		**0.9**		**2.4**		**0.0067**		**0.015**		**0.0017**		**0.0007**		**0.00000024**		**4.2E-08**		**3.6E-13**
Total based on kWh at point of use (0.12 kWh/kWh lost in transmission)			**1**		**2.69**		**0.0075**		**0.0168**		**0.001904**		**0.000784**		**0.00000027**		**4.7E-08**		**4E-13**

** Based on the following:*

Obtain "generation mix" or "fuel blend" from the local utility provider and enter the percentages of each type of electrcity generation method into the "% Used" column of the above table. Percentages should add to 100%.*

The above table provides the conversion factors to convert each kWh of electricity from each generation type into each of the environmental parameters.

"Adjusted" refers to adjusting the footprint value by the percentage of electricity from that particular generation type (e.g., the adjusted value for CO2e emitted by nuclear is 10% of the full-load value if the % of electricity generated by nuclear is 10%).

Notes:

- *Water consumption for thermoelectric power plants in U.S. - 0.47 gallons per kWh**
- *Water consumption for hydroelectric power assumed to be 0 gallons per kWh (i.e., considers evaporation from reservoir as non-additive)*
- *Water consumption for coal resource extraction and fuel processing - 0.16 cubic meters per GJ of extracted energy, and 33% thermal energy conversion to electricity***
- *Water consumption for uranium resource extraction and fuel processing - 0.086 cubic meters per GJ of extracted energy and 33% thermal energy conversion to electricity***
- *Water consumption for natural gas resource extraction and fuel processing - 0.11 cubic meters per GJ of extracted energy and 33% thermal energy conversion to electricity***
- *Water consumption for oil resource extraction and fuel processing - 1.06 cubic meters per GJ of extracted energy and 33% thermal energy conversion to electricity***
- *Water consumption for biomass based on 55 cubic meters per GJ of extracted energy and 33% thermal energy conversion to electricity****
- *CO2e, Nox, SOx, and PM emissions from NREL LCI for each fuel type *****

** Consumptive Water Use for U.S. Power Production, December 2003 • NREL/TP-550-33905*

*** Gleick PH. Water and energy. Annu. Rev. Energy Environ. Vol 19, 1994. p 267-99.*

**** The Water Footprint of Energy Consumption : an Assessment of Water Requirements of Primary Energy Carriers, Winnie Gerbens-Leenes, Arjen Hoekstra, Theo an der Meer, ISESCO Science and Technology Vision, Volume 4 - Number 5, May 2008*

***** "NREL LCI" refers to the U.S. Dept. of Energy, National Renewable Energy Laboratory (NREL), Life-Cycle Inventory Database (www.nrel.gov/lci) maintained by the Alliance for Sustainable Energy, LLC.*

ATTACHMENT H

Analysis of Delisting the Vineland Arsenic-Contaminated
Groundwater Treatment Sludge

Background:

I have reviewed the Vineland ROD (9/28/1989) and ESD (9/10/2001) and EPA should be commended on these documents. EPA did an excellent job in thinking about the regulatory issues associated with the treatment of the Vineland Chemical site environmental media, specifically with media ‘containing hazardous waste' and what would be necessary in terms of treatment of the soils, groundwater and sediments to make a determination that the media ‘no longer contains' a listed hazardous waste (K031).

The ROD specifically states: "EPA Headquarter’s Site Policy and Guidance Branch personnel (SPGB) have determined that the arsenic-contaminated soils, sediment and groundwater at the Vineland Chemical Company site are considered the RCRA listed hazardous waste K 031."

The ROD explained how the environmental media could be treated so it ‘no longer contained’ a listed waste which would allow the groundwater, soil and sediment to be placed back onsite subject to meeting the necessary cleanup criteria.

-Soil and exposed sediment need to meet the cleanup criteria of 20 mg/kg and the extract would need to meet 0.32mg/l (EP Toxicity Test) to be eligible for delisting. The submerged sediment needs to achieve 120 mg/kg of arsenic. This allows material to be considered as no longer hazardous and subject to RCRA Subtitle C control.

-Groundwater treated in situ would not trigger LDRs, however, if groundwater is removed and then treated, it needs to meet the MCL for arsenic (50 ug/l at the time ROD was signed) in order for the groundwater to no longer "contain" hazardous waste per the "contained-in policy". Groundwater meeting the MCL for arsenic could be disposed onsite on land or surface water subject to meeting applicable surface water criteria.

In addition, the ROD provides an good explanation of EPA's "delisting" authorities and when NJDEP needs to be involved with a delisting petition (Offsite disposal in NJ) and when another RCRA authorized State may need to be involved (Offsite disposal in another state) in the "delisting" petition process. EPA discussed the delisting process for soil, groundwater and sediment but did not mention treatment derived sludge (Derived-From-Rule).

EPA does have provisions in RCRA to formally petition for delisting of a waste (40 CFR 260.22). As we discussed, this is an intensive effort to seek a determination from EPA and the RCRA authorized state that a waste may be ‘delisted.’ I also checked 40 CFR 261, Appendix IX, Table 2 to determine if any other pesticide facilities had successfully ‘delisted’ a treatment sludge and did not find any. There are some facilities from non-specific sources (Appendix IX-Table 1) that have obtained criteria and were successful in delisting a waste that contained arsenic but again, these were not pesticide facilities.

Concerns with attempting to Delist Water Treatment Sludge in order to allow disposal at a RCRA Subtitle D landfill:

1. The ROD states for OU #2 that: "The arsenic-contaminated sludge from the groundwater treatment process will be transported off-site for hazardous waste treatment and disposal." For OU #3 & #4: "The sludge from the extraction process will be transported off-site for hazardous waste treatment and disposal." Although the ROD clearly anticipated the possibility of 'delisting' the soil, sediment and groundwater, it does not include a discussion about delisting the sludge. My concern with this is if changing the waste classification of the sludge would be considered a 'significant' change or a 'fundamental' change. This would be the difference of whether EPA would need to issue an ESD or have to do a ROD amendment. My concern with doing a ROD amendment for this site is based on the fact that the MCL for arsenic in groundwater is now 10 ppb instead of 50ppb. Furthermore, NJDEQ has promulgated their soil remediation treatment standards (N.J.A.C. 7:26D) and these could all be potential issues if a ROD amendment is determined by EPA to be necessary. It was noted that the treatment standard for arsenic in soil appears to be consistent with the existing ROD cleanup criteria.

2. It is understood that the treatment sludge does not fail TCLP for arsenic and is not a characteristic hazardous waste (D004). Furthermore if you look at the LDRs (40 CFR 268.40), the treatment standard for K031, non-wastewater is meet 5.0 mg/l TCLP. Therefore the TSDF does not have to perform additional chemical treatment (e.g. stabilization) on the sludge prior to this material being placed in Subtitle C landfill. It might require treatment for free liquids if that is an issue.

3. There could be a potential cost savings if the arsenic containing treatment sludge is not a K031 listed hazardous waste because the tipping fees for a Subtitle D landfill versus Subtitle C landfill are typically less than half the cost. In addition, there is a potential transportation cost savings if there is a Subtitle D landfill closer to the Vineland site. In addition, if the treatment sludge is not a RCRA hazardous waste, there may be saving in preparing the shipments in accordance with EPA and DOT regulations. However, it must be fully understood, re-opening the ROD could present EPA with significant issues on the cleanup criteria since there has been a significant change in the MCL for arsenic.

4. The process necessary to formally petition for a delisting determination is an effort that could take over a year. The process described in 40 CFR 260.22 is specific on the information that must be submitted and it is not certain that EPA and NJDEQ would approve the delisting petition.

Recommendation from the Regulatory Perspective:

Recommend that it be investigated whether it would be cost effective to perform additional treatment on the arsenic-contaminated sludge to reduce the water content in the arsenic containing sludge to reduce the tonnage of waste requiring disposal at the RCRA Subtitle C landfill.

ATTACHMENT I

Attachment I
Summary of <u>Water, Sediment and Soil</u> Sampling and Analytical Program

Parameter	Matrix/Medium	Rationale for Analysis
Field SW/GW analyses (All field analyses performed on Total [un-filtered] samples)		**Parameters must be measured in the field because values can change during sample storage/transport**
Alkalinity (titration)	SW/GW	Mobilization/stabilization reactions vary with pH. Alkalinity data are helpful for predicting possible changes in pH (e.g., after exposure of GW or sediments to oxygen in the air).
Fe(II) (titration)	SW/GW	Fe(II) indicates how much reductive dissolution of ferric oxides might have occurred in the aquifer, and how much ferric oxide can be produced at the discharge ***Adsorption of As onto ferric oxide at the discharge is the most likely removal mechanism for As.***
Conductivity (probe)	SW/GW	Helps to identify flow paths and is necessary for prediction of the extent of removal of As or other reactions when using V-MINTEQ or other software for chemical equilibrium calculations.
Temperature (probe)	SW/GW	Helps to identify flow paths and is necessary for prediction of the extent of removal of As or other reactions when using V-MINTEQ or other software for chemical equilibrium calculations.
pH (probe)	SW/GW	The rate of oxidation of Fe(II) to form ferric oxides, the extent of adsorption of As onto ferric oxides, and other crucial reactions are strongly influenced by pH.
ORP (probe)	GW	Compare with prediction from redox couples (redox couples means sulfate/sulfide, ferric/ferrous, As(V)/As(III), as well as DO)
Turbidity (NTU)	SW/GW	Turbidity in the GW or spring discharge indicates possible migration of colloids or mixing of anoxic waters with oxic waters.
DO (probe)	SW/GW	Same comments as for ORP. It is difficult to analyze DO close to zero, but this will provide another check to see if sampling is OK and if ORP and redox-couple information are correct, and to predict oxidation reactions in surface waters
Odor and appearance	SW/GW	Note color, presence of suspended solids, sheens, odor, or other observations about the physical appearance of the samples.
GW/SW - <u>All</u> 0.45 micron Field Filtered, thus dissolved, (but not acidified)		**These GW and SW samples should be filtered with minimal exposure to air, particularly the GW and spring issuance point locations.**
Arsenic (D)	SW/GW	As is crucial and there are several possible interferences (oxidation of ferrous to ferric hydroxide and adsorption of As; precipitation of As sulfides - unexpected but possible for high sulfides). Accordingly measuring As (D) is recommended for both filtered and filtered/acidified samples.
As(III) & As(V) (D)	SW/GW	
Arsenic (D)	SW/GW	
Ferrous Iron [Fe(II)] & Ferric Iron [Fe(III)] (D)	SW/GW	Usually provides the best indication of redox conditions in the GW and subsequent precipitation of Fe(OH)3(s) - adsorption capacity for removing As.
Barium (Ba) (D)	SW/GW	Evaluate the potential presence of this arsenic containing mineral.
Calcium (Ca) (D)	SW/GW	Provides a check on cation/anion balance and helps identify GW flow paths and chemical equilibrium modeling.
Magnesium (Mg) (D)	SW/GW	Provides a check on cation/anion balance and helps identify GW flow paths and chemical equilibrium modeling.
Sodium (Na) (D)	SW/GW	Provides a check on cation/anion balance and helps identify GW flow paths and chemical equilibrium modeling.
Potassium (K) (D)	SW/GW	Provides a check on cation/anion balance and helps identify GW flow paths and chemical equilibrium modeling.
Chloride (Cl) (D)	SW/GW	Provides a check on cation/anion balance and helps identify GW flow paths and chemical equilibrium modeling.
Nitrate (NO3-) (D)	SW/GW	Provides a check on cation/anion balance and helps identify GW flow paths, chemical equilibrium modeling, & indication of up-gradient redox conditions.
Sulfate (SO4) (D)	SW/GW	Provides a check on cation/anion balance and helps identify GW flow paths, chemical equilibrium modeling, S-balance, & upstream redox conditions.
Dissolved Sulfide (D)	SW/GW	Upstream redox balance, mobility/precipitation of As
Alkalinity (D)	SW/GW	If this value changes from the field analysis of alkalinity, it indicates possible redox reactions have occurred in the sample, e.g., oxidation of Fe(II), S(-II), etc.
SiO2 (D)	GW	Assess Competing species for sorption of arsenic
pH (D)	SW/GW	Compare with field results to help identify changes in sample during storage, regulatory value for pH, QC
GW/SW - Totals, acidified in the field to pH<2 with HCl (environmental grade)		**NO Filtering, minimize air exposure into laboratory-supplied bottle containing sufficient HCl to achieve final pH ≤2**
Iron (T)	SW/GW	Adsorption onto Fe(OH)3(s) will be the dominant mechanism for removal of As in almost all the discharge points. This helps to predict total possible adsorption of As by existing or newly formed (after exposure to air) ferric oxides. If this is larger than dissolved iron, it indicates possible problems with the well or else mobility of particulate Fe (and As) in the GW.
Manganese (Mn) (T)	SW/GW	Same as for total Fe - not likely to be as important but easy to measure.
Arsenic (T)	SW/GW	For modeling As speciation in GW, and to predict removal/mobility of As in downstream surface samples.
Total Dissolved Solids (TDS)	SW/GW	
Total Suspended Solids (TSS)	SW/GW	
BTEX	SW/GW	
GW/SW - 0.45 micron Field Filtered w/o air contact (syringe/pressure filtration, no head space) & acidified to pH<2 w/HCl (env'l grade)		**0.45 micron Field Filter with minimal air exposure into laboratory-supplied bottle containing sufficient HCl to achieve final pH ≤2**
Iron (D)	SW/GW	Enables prediction of total new Fe(OH)3(s) that will be available for adsorption of As; with Fe(II) helps to predict GW ORP and partitioning of As in the sample (prior to oxidation of Fe(II)).
Ferrous Iron [Fe(II)] & Ferric Iron [Fe(III)] (D)	SW/GW	Usually provides the best indication of redox conditions in the GW and subsequent precipitation of Fe(OH)3(s) - adsorption capacity for removing As.
Arsenic (D)	SW/GW	Unless there's high sulfide (possible precipitation of As2S3), this should provide our best estimate of dissolved As in the sample.
As(III) & As(V) (D)	SW/GW	
Arsenic (D)	SW/GW	
Manganese (Mn) (D)	SW/GW	Same as for total Fe - not likely to be as important but worthy of measure.Helps to determine the extent of up-gradient redox reactions.
Sediments/ Soil		**Where possible, cores will be collected to observe possible anoxic zones underneath oxic zones in the sediment pools. Cores will be observed in the field for color changes (oxic and anoxic zones) and then take samples from both zones, if appropriate.**
Acid Volatile Sulfide (AVS)	sediments / soil	Indicates redox condition of sediments and possible reactions in anoxic zones for mobilization (or depending on pH, removal) of As.
Simultaneously Extracted Metals (SEM)	sediments / soil	Related to availability of sulfides to react with As. Cost included in AVS price.
Total Fe	sediments / soil	Digest/ICP. Max sorption capacity for As.
Reactive Fe	sediments / soil	Dithionite-citrate-bicarbonate (DCB) extraction or pH 3 ascorbic acid extraction. This determines only the most reactive forms of precipitated ferric oxides.
Total As	sediments / soil	Necessary for overall interpretation of results
XRD	sediments / soil	Minerals in crystalline form and high concentration, especially ferric oxides. Utilized to assess the potential capacity of sediments for adsorption and co precipitation of arsenic.
Soil pH	sediments / soil	

* Brooks Rand Labs does not have Oklahoma certification, but not necessarily required for these arsenic speciation evaluations. Method EPA 1632 HG-CT-AAS

(D)= Dissolved via field filtering with 0.45 micron filter paper

(T)= Total, NO filtering