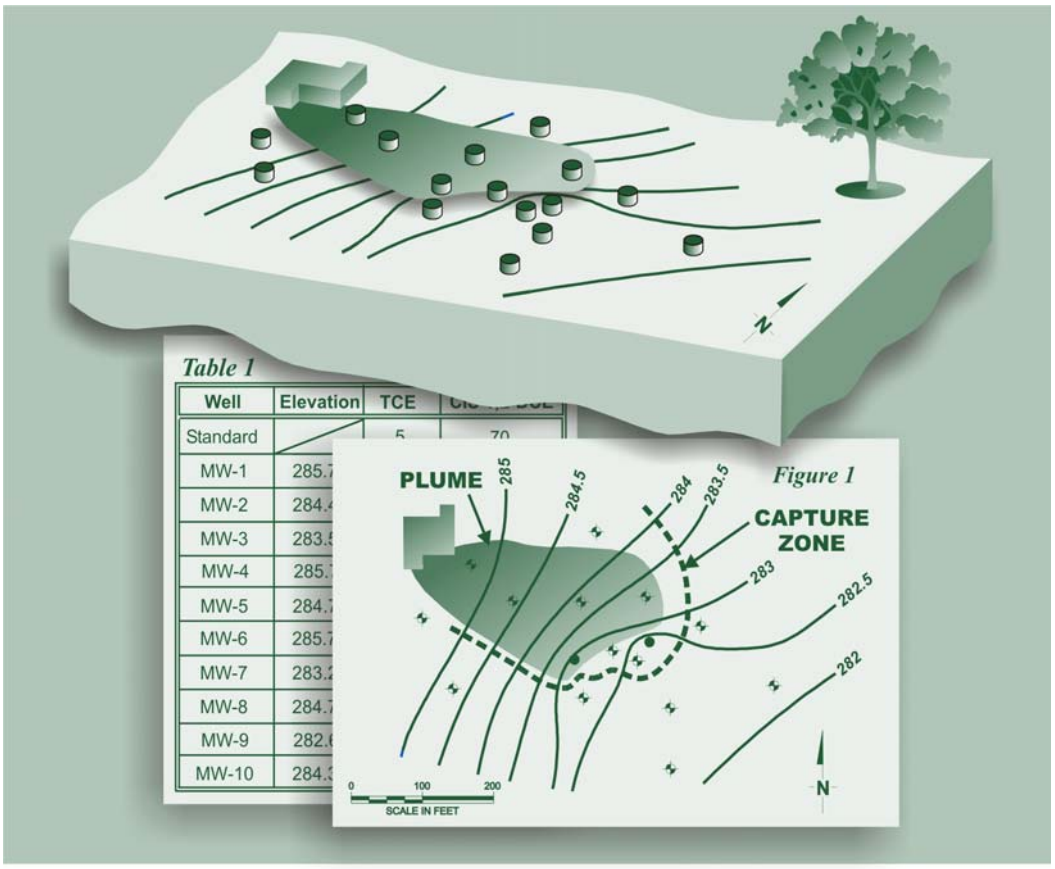
O&M Report Template for Ground Water Remedies

(with Emphasis on Pump and Treat Systems)



One of a Series on Optimization

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Office of Solid Waste
and Emergency Response
(5102G)

OSWER 9283.1-22FS
EPA 542-R-05-010
April 2005
www.cluin.org
www.epa.gov/superfund

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DISCLAIMER

This document provides references to models and processes in use by outside parties and other Federal Agencies. Mention of these models and processes does not imply endorsement for specific purposes.

This fact sheet is not intended to be a detailed instruction manual. In addition, this fact sheet is not a regulation; therefore, it does not impose legally binding requirements on EPA, States, or the regulated community, and may not apply to a particular situation based upon the circumstances. The document offers technical recommendations to EPA, States and others who manage or regulate long-term ground water remedies as part of the Superfund program or other cleanup programs. EPA and State personnel may use other approaches, activities and considerations, either on their own or at the suggestion of interested parties. Interested parties are free to raise questions and objections regarding this document and the appropriateness of using these recommendations in a particular situation, and EPA will consider whether or not the recommendations are appropriate in that situation. This fact sheet may be revised periodically without public notice. EPA welcomes public comments on this document at any time and will consider those comments in any future revision of this document.

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PREFACE

This fact sheet provides a recommended report template that can be used to present information on the operations and maintenance (O&M) of a ground water remedy, particularly for those remedies including pump and treat (P&T). It is part of a series of fact sheets that the EPA Office of Superfund Remediation and Technology Innovation (OSRTI) is preparing as guidance to the ground water remediation community on effectively and efficiently designing and operating long-term ground water remedies. This series is available at www.cluin.org/optimization and consists of the following fact sheets, plus others that will be available in the future.

- *Elements for Effective Management of Operating Pump and Treat Systems*
  OSWER 9355.4-27FS-A, EPA 542-R-02-009, December 2002

- *Cost-Effective Design of Pump and Treat Systems*
  OSWER 9283.1-20FS, EPA 542-R-05-008, April 2005

- *Effective Contracting Approaches for Operating Pump and Treat Systems*
  OSWER 9283.1-21FS, EPA 542-R-05-009, April 2005

- *O&M Report Template for Ground Water Remedies (with Emphasis on Pump and Treat Systems)*
  OSWER 9283.1-22FS, EPA 542-R-05-010, April 2005

In addition, access to a wider range of EPA documents is available at www.cluin.org.

The recommendations contained in this series of fact sheets are based on professional experience in designing and operating long-term ground water remedies and on lessons learned from conducting Remediation System Evaluations (RSEs) at Superfund-financed P&T systems. The results of the first 20 RSEs conducted at Superfund-financed P&T systems are summarized in *Pilot Project to Optimize Superfund-Financed Pump and Treat Systems: Summary Report and Lessons Learned* (EPA 542-R-02-008a), and the site-specific recommendations from the evaluations are available in the individual RSE reports (EPA 542-R-02-008b through 542-R-02-008u). The content of these fact sheets is relevant to almost any P&T system. Therefore, these documents may serve as resources for managers, contractors, or regulators of any P&T system, regardless of the regulatory program. Most elements of this report template are also pertinent to other ground water remedies.

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A. INTRODUCTION

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Operating ground water remedies such as pump and treat (P&T) systems generally require operation and maintenance (O&M) activities to occur over a long period of time, sometimes decades. Routine O&M reports accomplish the following:

- present operational data associated with the treatment plant, and identify operational problems and/or system modifications associated with the treatment plant
- summarize subsurface data that have been collected, and interpret progress towards short-term and long-term remedy goals
- suggest system modifications to improve performance, reduce costs, and/or increase likelihood of site closeout

Contractors typically prepare these reports annually once the system is operating routinely, but in some cases, reports are prepared quarterly or semi-annually.

Effective O&M reports are much more than a series of data tables and/or maps for the most recent reporting period. O&M reports should also include an interpretation of the data with respect to system performance (subsurface and above-ground) and historical trends. O&M reports should be prepared and submitted as soon after the end of the reporting period as is practicable, so that the data and associated interpretations can be used as a basis for system modifications in a timely manner.

Interpreting data, preparing reports, and submitting data and/or reports can be facilitated by electronic data management. Spreadsheet, database, and/or geographic information system (GIS) software allows data to be stored, retrieved, interpreted, updated, and plotted in a timely and cost-effective manner. It also facilitates generating report tables and figures, and it significantly reduces the possibility of entry errors. Therefore, site-related data (including ground water quality, water levels, and process monitoring results) should be managed electronically whenever possible. Data should also be submitted electronically whenever possible because it facilitates data management for all site stakeholders. This includes the exchange of data between laboratories, consultants, site representatives, and site regulators. In some cases, this may mean sharing or submitting spreadsheets, database files or even graphics or plotting files. Some regulatory agencies have developed specific formats for electronic data deliverables. The use of commonly-used software or non-proprietary open data standards (e.g., XML) should help facilitate data retrieval, particularly after long-term storage.

Organization of this Document

With regard to reports, it is often appropriate to submit an electronic (e.g., PDF) version of the O&M report in addition to or instead of a hard copy. The electronic version facilitates distributing the report to a wider audience, such as owners of adjacent impacted properties, the public, or remedy evaluation teams.

The purpose of this document is to provide site managers, contractors, and regulators with a recommended report template for preparing effective O&M reports. Although this fact sheet provides important information to be included in an O&M report, it does not replace the need for active management and oversight to ensure a protective and cost-effective remedy that is optimized over time based on O&M data. In addition, even though preparing an O&M report involves interpreting data and documenting potential modifications to improve the system, it does not replace the value of performing independent optimization evaluations. Independent evaluations are designed to provide objective evaluation of the remedy and provide recommendations for potential improvements. For additional information on how O&M reports relate to overall management and optimization of a P&T

system, the reader is referred to *Elements for Effective Management of Operating Pump and Treat Systems, December 2002* (EPA 542-R-02-009/OSWER 9355.4-27FS-A).

B. SUGGESTED STRUCTURE AND CONTENT OF AN O&M REPORT

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Each site is unique, and it is not possible to provide a template for the content of an O&M report that is suitable for every site. However, this document does provide a suggested structure for an O&M report, and also provides suggested items that should typically be included in the content of an O&M report. Sample tables (Appendix A) and sample figures (Appendix B) are included to highlight items discussed within this document and to serve as a guide for format and/or content of such tables and figures in an O&M report.

An O&M report generally contains the following sections:

- letter of transmittal and title page
- executive summary
- table of contents
- introduction
- operations summary
- subsurface performance summary
- suggested system modifications
- tables and figures

Tables and figures are included to present data and support interpretations discussed in the text. The location of tables and figures within the O&M report is a stylistic preference. In most cases, the tables and figures are placed at the end of the document (prior to any appendices) or at the end of chapters where they are referenced. In other cases, tables and figures are placed immediately after they are referenced in the text, but this approach complicates formatting of the document.

In some cases, the O&M report will also include appendices. The appendices might include raw data, copies of letters, copies of permits, chain of custody forms, or any other information that does not fit easily into the main body of the report.

C. O&M REPORT TEMPLATE

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The remainder of this document provides a recommended O&M report template, organized according to the typical sections of an O&M report listed earlier. The following conventions are utilized:

- Plain text is used to list sections or subsections that should be included in the O&M report, and to list items that should generally appear in the specific section or subsection being discussed.
- Text enclosed in brackets ("[ ]") indicates that site-specific information should be added, as appropriate.
- Plain text boxes (unshaded, outlined with plain lines) present samples of report content (such as a sample cover letter).
- Text boxes with shadow-style outlines are used at the end of sections or subsections to list sample tables (in Appendix A) or sample figures (in Appendix B) that pertain to that specific section or subsection, and to highlight important aspects of those samples.

It is not the intent of this document to provide a report template, or sample tables and figures, that can be directly applied for all sites. Some site-specific issues that might add additional complexity to an O&M report include the following:

- multiple aquifers are impacted by contaminants
- multiple contaminant types (e.g., metals, volatile organic compounds, pesticides, etc.) are present
- multiple media are being sampled (e.g., ground water, surface water, sediments)

For remedies other than P&T, there may be some sections in this report template that do not apply. For instance, a monitored natural attenuation (MNA) remedy may not have an "operations summary" section, since there is no active treatment system. In other cases, there may be multiple treatment systems, such as P&T coupled with soil vapor extraction (SVE) or free-product recovery in a source area. This may require additional sections of text, and/or additional tables and figures, compared to this report template.

LETTER OF TRANSMITTAL

Sample Letter of Transmittal

[Letter-Head of Organization Sending Report]

[date report signed or sent]

[name of person receiving report]
[address of person receiving the report, line 1]
[address of person receiving the report, line 2]
[address of person receiving the report, line 3]

Reference: [reference line 1]
[reference line 2]

Dear [fill in as appropriate]:

[Organization sending report] is pleased to submit [number of copies] copies of the attached [annual, quarterly, etc.] O&M report for [site name and/or system name] located in [location]. This report summarizes O&M activities for the period [begin date] to [end date]. This report is submitted in accordance with [any regulatory stipulations]. The supporting data are being submitted electronically [describe format and method of submittal].

[Summary of any non-routine items that merit mention in the letter of transmittal].

If there are any questions regarding this report, please contact [name] at [phone number and/or email address].

Sincerely,
[signature]

[printed name of sender]
[title]

Enclosures: O&M report [indicate number of volumes if more than 1]
[any other enclosures, such as electronic data]

cc: [list name and organization of others receiving the report, indicate if "cover letter only"]

The reference line(s) indicate the following:

- the nature of the report contents (e.g., "O&M Progress Report")
- the frequency associated with this reporting (e.g., "annual", "quarterly", etc.)
- the reporting period (e.g., "January 1, 2003 to December 31, 2003")
- the site name and location, and regulatory case number for the site (if applicable)

Non-routine items of importance that merit inclusion in the letter include a discharge of effluent that exceeded permit limits, a major change to the system or system status, a change of contractor, a change in the individual or organization submitting the report, major community relations activity, or a major new finding in the subsurface.

TITLE PAGE

Sample Title Page

[annual, quarterly, etc.] O&M Report
Reporting Period [begin date] to [end date]

[site name and/or system name]
[site location]
[regulatory identification number, if applicable]

Submitted To:

[name of person receiving report]
[address of person receiving the report, line 1]
[address of person receiving the report, line 2]
[address of person receiving the report, line 3]

Prepared By:

[name/organization sending report]
[address of sender, line 1]
[address of sender, line 2]
[phone number of sender]

[date report signed/prepared]

[signature lines, if appropriate]

EXECUTIVE SUMMARY

Purpose of Report

Provide a brief (i.e., one paragraph) introduction that identifies the following:

- type of remedy that the report covers (e.g., P&T or some other ground water remedy)
- the site name and location
- whether or not this report is associated with a specific reporting frequency (e.g., annual, quarterly)
- the reporting period ("begin date" to "end date")
- any regulatory stipulation mandating the submission of this report and/or the contents of the report

This section should generally be duplicated from Section 1.1 of the main report.

Operations Summary

Include the following:

- a brief statement indicating the extent of system downtime (if any) during the reporting period, and whether or not any downtime was "non-routine"
- a statement indicating whether or not process monitoring indicated any exceedances of treatment system discharge limits during the reporting period
- a statement indicating whether or not there were any significant operational problems (sub-surface or above-ground) during the reporting period
- a statement indicating whether or not noteworthy system modifications were made or other non-routine maintenance was conducted (sub-surface or above-ground) during the reporting period
- for sites with significant public involvement, a statement indicating any contact with the public or public officials with respect to the remedy
- if staffing changes were made, a statement to this effect with new names and contact information

The purpose of including these statements in the executive summary is to clearly indicate to the reader whether or not non-routine items occurred during the reporting period, and if so, the general nature of those items. The details associated with these items should be provided in the body of the report.

Interpretation of Progress with Respect to System Goals

Include the following:

- a brief statement of the goals of the P&T system (e.g., containment and/or restoration, and the relative priority if multiple goals are present)
- a brief statement indicating if data collected during the reporting period (e.g., water levels, ground water concentrations, etc.) are consistent or inconsistent with expectations and/or previous data (if not, include

a brief description of the difference)

- a statement indicating if short-term remedy goals are being met, based on an interpretation of data collected and implementation of institutional controls

- a statement indicating if longer-term remedy goals are being met or when they will likely be met, based on an interpretation of data collected and implementation of institutional controls

- a statement indicating whether or not new inconsistencies or gaps in the current "site conceptual model" have been identified based on an interpretation of O&M data and whether or not the site conceptual model has been updated accordingly

Details regarding these interpretations should be provided in the body of the report.

Suggested Modifications to Ground Water Remedy and/or Long-Term Monitoring (LTM) Program

Include the following:

- a statement indicating whether or not there are any recommendations in this report to modify or enhance the ground water remedy and/or LTM program

- a brief description of any such recommendations

The details of recommended modifications, the rationale behind those recommendations, and estimated costs and/or savings associated with the recommendations will generally be provided in the body of the report.

TABLE OF CONTENTS

Sample Table of Contents

For longer O&M reports, it is appropriate to also include subsections in the Table of Contents. If tables and figures appear at the end of the report or the end of each section (the most common approaches), there is no need to provide page numbers for each table and figure.

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1.0 INTRODUCTION

1.1 PURPOSE OF THIS REPORT

Provide a brief (i.e., one paragraph) introduction that identifies the following:

- type of remedy that the report covers (e.g., P&T or some other ground water remedy)
- the site name and location (generally references a site location figure)
- whether or not this report is associated with a specific reporting frequency (e.g., annual, quarterly)
- the reporting period this report pertains to
- any regulatory stipulation mandating the submission of this report and/or the contents of the report

This section should be duplicated in the first section of the Executive Summary.

Sample Tables or Figures Relevant to Section 1.1

Figures (see Appendix B)
- *Site Vicinity and Well Locations (Sample Figure 1)*

Figures illustrating map features should include a north arrow, a graphic scale, and a legend. Ideally enough key features are included to provide adequate orientation to the reader, but not so much detail that the reader is distracted from the most important site features.

1.2 BRIEF SUMMARY OF SITE CONCEPTUAL MODEL

Identify the following in this section to briefly describe the site conceptual model:

- historic and continuing sources of ground water contamination, including soil contamination and non-aqueous phase liquid (NAPL)
- site hydrogeology, including depth to ground water, ground water flow direction (horizontal and vertical), approximate ground water flow magnitude, interaction of ground water with surface water
- potential human and ecological receptors
- historic and current extent of contaminant plume with respect to sources, potential receptors, and other landmarks such as property boundaries
- brief description of historic site remedies, such as source removal or control activities, that impact the site conceptual model

1.3 STATEMENT OF REMEDY GOALS AND CONDITIONS FOR TERMINATING THE GROUND WATER REMEDY

Identify the following in this section:

- brief description of the current ground water remedy (including extension of water lines, institutional controls, etc.) as outlined in a decision document, order, or permit
- the short-term and long-term remedy goals (cleanup, containment, or both)
- if both cleanup and containment are goals, the relative priority of each remedy goal as stated in decision documents or agreed upon by the site stakeholders
- the items to be measured to evaluate whether or not the goals are attained and if progress is being made with respect to those goals
- conditions that must be met to terminate all (or some) components of the ground water remedy as stated in decision documents or agreed upon by the site stakeholders

Also indicate if there is an impending change in responsibility for operation of the remedy, such as a Superfund "Fund-lead" site about to be turned over to a state, and the reason for the change.

1.4 REMEDY DESCRIPTION

1.4.1 Pump and Treat System Description

Provide a brief description of the extraction and treatment systems, including the following:

- the number of extraction wells and the approximate total flow rate
- a map indicating the locations of the extraction wells, the treatment plant, and discharge point
- the treatment components and general design parameters of each component
- where treated water is discharged

For other long-term ground water remediation technologies, such as in-situ bioremediation, the items described in this section could be replaced or augmented by other pertinent items, such as injection wells, injection volumes, etc.

1.4.2 Other Remedy Components

In this section, also identify other long-term ground water remedy components, such as institutional controls, that augment the P&T system. For institutional controls, include the following:

- what the institutional control is intended to accomplish
- who it is designed to inform and what area it applies to
- how the institutional control is implemented and maintained (e.g., zoning ordinance, deed restriction, recurring notices to property owners, etc.)

- when the institutional control was implemented or will be implemented
- the party that is responsible for compliance

1.5 INTERACTION WITH PUBLIC AND/OR AGENCIES

Indicate if there has been any significant interaction with the public or with regulators during the current reporting period, or if such interaction is planned for the next reporting period. This might include items such as visits to the site by concerned private citizens or community groups, or a site visit by regulatory agencies as part of a five-year review.

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2.0 OPERATIONS SUMMARY

2.1 SYSTEM DOWNTIME

2.1.1 Routine

Include the following in this section:

- if system does not run continuously by design, briefly explain why (this could alternatively be explained in a general system description presented in the introduction of the report)
- dates system was down for routine reasons, and briefly indicate the purpose for each downtime event

2.1.2 Non-Routine

Include the following in this section:

- dates system was down for non-routine reasons - indicate the cause, and indicate what actions were taken to resolve the situation
- actions that have been taken (or are expected to be taken) to avoid the same situation from occurring in the future or to otherwise minimize downtime in the future

Some evaluation should be made as whether or not such downtime may have resulted in unacceptable migration of contaminants, or if any investigation is merited to reach such a conclusion.

2.2 OPERATIONAL DATA AND PROCESS MONITORING DATA

2.2.1 Plant Influent and Effluent, and Efficiency of Above-Ground Treatment Components

Include the following in this section:

- treatment plant process monitoring schedule that clearly indicates the sampling locations within the treatment plant, and the frequency for monitoring different parameters
- flow rates and total volume treated (compare to historic values and design values)
- influent concentrations (compare to historic values and design values, and also compare to treatment plant discharge criteria to determine if treatment is actually required)
- any new or unexpected constituents detected in the influent
- effluent concentrations (compare to discharge criteria and historic values); any values that exceed discharge criteria should be highlighted and an explanation should be included
- compare plant influent concentrations to plant effluent concentrations to determine treatment efficiency of the entire treatment system (compare to design treatment efficiency)
- if there is process monitoring between treatment components, present and discuss the treatment efficiency of individual treatment components
- other data or information regarding efficiency, such as pressure differentials for filters, air-to-water ratios for air strippers, etc.

If actual values for flow rate, influent concentrations, or mass loading are very different from design values, an evaluation of alternative treatment technologies may be merited to determine if there is a more cost-effective option. Also, any additional sources of flow and/or mass loading to the system (e.g., purge water from well sampling, filter backwash, water from other operations at the site, etc.) should be indicated.

Sample Tables or Figures Relevant to Section 2.2.1

Tables (see Appendix A)
- *Treatment Plant Process Monitoring Schedule (Sample Table 1)*
- *Treatment Plant Flow Rate, VOC Influent Concentration, and VOC Mass Loading (Sample Table 2)*
- *Treatment Plant Influent/Effluent Concentrations and Air Stripper Efficiency (Sample Table 3)*

Parameter-specific discharge criteria should be included on tables that summarize effluent concentrations, and effluent values that exceed discharge limits should be highlighted using bolding and/or shading such that the reader can easily identify them. Explanations for exceedances should be included as a footnote to the table whenever possible and/or included in the text of the report. Also note that concentration values that are "not detected" should always be presented in a manner that clearly identifies the detection limit. If calculations are made that are based on non-detect values (such as the "air stripper efficiency" or an average concentration) a footnote should be used to indicate how non-detects were represented in the calculations. Often, one-half of the detection limit is used for such calculations.

Figures (see Appendix B)
- *Plant Influent Flow Rate over Time, Compared with Design Flow Rate (Sample Figure 2)*
- *Plant Influent VOC Concentration over Time, Compared with Design Concentration (Sample Figure 3)*
- *Plant Monthly Mass Loading and Cumulative Mass Loading (Sample Figure 4)*

These figures illustrate historical data in addition to data from the current reporting period. The sample figures clearly indicate the current reporting period, allowing the reader to compare recent data to historical data. Design values are also included on the sample figures so the reader can easily discern if actual data are consistent with design values. Axes for graphs should be clearly identified. Units used (such as "ug/l" for concentrations) should be clearly identified in axis labels, titles, or legends. Annotations should be added to figures when feasible to explain data that deviate from typical or expected values.

Note: Use footnotes on tables/figures to provide equations for calculations that are not obvious.

2.2.2 Extraction Well Data

Include the following in this section:

- flow rates at extraction wells (compare to design values and to the maximum, minimum, and average of the historic values); any significant changes should be highlighted, and an explanation should be included
- concentrations at extraction wells (compare to historic values)
- specific capacities at extraction wells (compare to design estimates and historic values)

Specific capacity is the pumping rate divided by the in-well drawdown relative to non-pumping (i.e., “static”) conditions. Decreases in specific capacity indicate the potential for well fouling, and measuring specific capacity may be important if there is a record of well fouling at the site. It is not always easy to compute specific capacity because the static water level is often not determined on a regular basis, and generally cannot be determined without shutting down pumping wells on a temporary basis. At many sites, it is not appropriate to shut down wells even temporarily, and such shutdowns should be justified by an evaluation that unacceptable migration of

contaminants will not occur. If static water level cannot be determined by intentionally shutting down pumping wells until they recover (or by another means), it may be necessary to estimate the static water level for calculating specific drawdown based on prior values (such as those determined during unintentional system shutdowns) or based on extrapolation of water levels measured outside the zone of influence.

Sample Tables or Figures Relevant to Section 2.2.2

Tables (see Appendix A)
- *Extraction Wells: Pumping Rates and VOC Concentrations (Sample Table 4)*
- *Specific Capacity at Extraction Wells (Sample Table 5)*

Figures (see Appendix B)
- *Average Flow Rates (Monthly) for Extraction Wells (Sample Figure 5)*

Declining extraction rates and/or declining specific capacities are indicative of potential fouling of the extraction well, and suggest the potential need for well rehabilitation. At some sites individual extraction wells may be pumping water that is below all pertinent ground water criteria, and discontinuing the pumping at those wells may be appropriate if that pumping is not required for plume capture.

2.3 UTILITIES, CONSUMABLES, AND WASTE HANDLING/DISPOSAL

2.3.1 Utilities Used

Include the following in this section:

- electricity and gas usage, and a list of components which use the majority of those resources
- water usage (indicate what it is used for)
- sewer usage (indicate discharge fee if one applies) for either a publicly owned treatment works (POTW) where treated or untreated ground water is discharged or for a sanitary sewer if those costs are significant
- phone/fax/internet costs (if they are significant)

2.3.2 Consumables Used

Identify the purpose of each item, quantities used, and replacement frequency (e.g., liquid GAC, vapor GAC, chemical additions, ion exchange resin, etc.).

2.3.3 Waste Handling/Disposal

Include the following in this section:

- types and quantities of waste generated (such as metals sludge, spent cartridge filters, etc.)
- where waste is disposed of (including manifest tracking number)
- any required waste sampling, and results of such sampling

If waste manifests are included as an appendix to the report, provide a reference to that appendix in this section.

2.4 PROBLEMS ENCOUNTERED WITH P&T COMPONENT OPERATION

2.4.1 Subsurface

Indicate problems identified (e.g., pump failures, well fouling, piping leaks, flooded vaults, etc.), and explain how the problems have been (or will be) addressed.

2.4.2 Above-Ground Treatment System

Indicate problems identified (e.g., equipment failures, safety problems, etc.), and explain how the problems have been (or will be) addressed.

2.5 SYSTEM MODIFICATIONS AND MAINTENANCE

2.5.1 Routine Maintenance

Summarize the routine maintenance activities performed during the reporting period, and identify planned routine maintenance for the next reporting period.

2.5.2 System Modifications and Non-Routine Maintenance

Summarize any system modifications or non-routine maintenance performed during the reporting period, including the reason the activity was performed and the results of the actions that were taken. If the remedy was modified, identify how the effectiveness of that modification may be tracked over time. Identify non-routine maintenance planned for the next reporting period (e.g., pump replacement, well rehabilitation, etc.). Identify schedule for major equipment replacement or reconstruction.

2.6 OTHER OPERATIONS INFORMATION

There may be important operations information that is not covered in the above sections. This section could be used to provide information such as the following:

- effectiveness of any institutional controls in accomplishing its intended goal, including the information collected and reviewed to evaluate this effectiveness
- any changes in contact information or the project team, including office-based contacts or treatment plant operators

3.0 SUBSURFACE PERFORMANCE SUMMARY

3.1 SAMPLING EVENTS PERFORMED DURING THIS REPORTING PERIOD

Include the following in this section:

- a site location map indicating sampling locations
- a list or table of sampling dates and sampling locations for water level measurements and water quality data (indicate which constituents were analyzed), and similar information for any other media sampled such as sediment, surface water, or air
- an indication of how the sampling in the current reporting period relates to an overall sampling schedule (e.g., "as per the O&M plan, sampling in this quarter was only performed at eight wells, while sampling next quarter will be performed at all 15 site wells")
- sampling and analysis methods
- for ground water wells, a "well construction" table that provides the following:
  - well name
  - date drilled
  - x-y coordinates (in a coordinate system that is identified)
  - ground surface elevation
  - measuring point, and how it is identified (such as "top of casing")
  - total depth
  - aquifer screened
  - screen interval (top/bottom screen in ft MSL and/or depth from ground surface)

Sample Tables or Figures Relevant to Section 3.1

Tables (see Appendix A)
- Well Construction Information (Sample Table 6)

Figures (see Appendix B)
- Site Vicinity and Well Locations (Sample Figure 1)

Wells screening different hydrogeologic units should be clearly differentiated on figures.

3.2 SAMPLING RESULTS AND INTERPRETATION

3.2.1 Water Levels

Include the following in this section:

- a table of water level measurements from the current reporting period that includes the following:
  - well name
  - aquifer or unit monitored
  - measuring point elevation
  - date

- depth to water
- water level elevation

- if appropriate, historical water level measurements (either in same table, a separate table, or an appendix)

- potentiometric surface contour maps (one map for each hydrostratigraphic unit of concern), for one or more dates during the reporting period

  - measured values should be indicated
  - target capture zone and interpreted capture zone should be indicated whenever possible
  - indicate if contouring was done by hand or with software
  - if software is used for the contouring, indicate the software used, the options selected for interpolating the data, and if any "pseudo data points" were added

- for sites where vertical flow is important, patterns of vertical flow evaluated in text, tables, and figures (The end result should be an understanding of flow in three dimensions. Such evaluation can include water levels at clustered locations with wells that screen in different aquifers or horizons and interpreted maps illustrating locations of upward and downward flow. The upward and downward flow could be indicated at cluster locations or can be based on contoured water levels in different aquifers or horizons.)

- if appropriate, hydrographs of individual wells to illustrate changes in water level versus time, and/or hydrographs for well pairs to illustrate head differences between the two locations over time (i.e., to establish upward or downward flow, inward flow across a boundary, etc.)

Sample Tables or Figures Relevant to Section 3.2.1

Tables (see Appendix A)
- *Water Level Measurements, October 2002 (Sample Table 7)*
- *Historical Water Level Elevations, ft MSL (Sample Table 8)*

Water level depths and elevations are generally reported to two decimal places. It is very important to clearly indicate whether specific data pertain to a "depth" or an "elevation". If data pertain to a depth, the measuring point should also be indicated so elevations can be established. For tables that span multiple pages, it is suggested that page numbers include the total number of pages in the table, so the reader can determine if pages are missing.

Figures (see Appendix B)
- *Shallow Water Levels, October 2002 (Sample Figure 6)*
- *Water Levels at PZ-2 versus Extraction Rate of EW-2 (Sample Figure 7)*
- *Hydrograph for MW-14 and MW-14D Well Cluster (Sample Figure 8)*

Note on the potentiometric surface map for shallow water levels that the actual measured values are indicated in addition to the contours, and that the contouring method is indicated. Also note that the target capture zone and interpreted capture zone are included on the figure. Potentiometric surface maps should include a north arrow, graphic scale, legend, and enough basemap features to adequately orient the reader. On hydrographs that illustrate water level versus time, axes should be clearly labeled. Note that one of these figures uses two different y-axes (water levels and pumping rates), with each axis clearly labeled including units of measurement. The scale of the y-axis should be selected so that variations in graphed values that are important can in fact be discerned by the reader. Sample Figure 8 illustrates a hydrograph used to interpret vertical flow potential (upward versus downward) at a specific location. Maps can also be used for such interpretations over space for a specific point in time.

3.2.2 Ground Water Concentrations

Include the following in this section:

- a table that provides the following data:
  - well name
  - aquifer or unit monitored
  - constituent and regulatory criteria for the constituent
  - date sampled
  - concentration (highlight values that exceed regulatory criteria)
  - units of measurement
  - any laboratory flags (e.g., "D", "J", etc.)
  - sampling method (if the sampling method has changed or multiple methods are used at the site)
- non-detect values reported in a manner that indicates the constituent was not detected above a specific value, such as "ND(10)" or "<10" (Non-detect values should not simply be reported as ND)
- if appropriate, historical concentration measurements (either in the same table, a separate table, or an appendix)
- maps indicating the extent of contamination ("Bubble maps", where the size of the bubble increases or color changes as concentration increases, may be effective for illustrating concentrations, either alone, or in conjunction with a contour map. Bubble sizes or colors should be explained in a legend and consideration should be given to choosing colors so that bubbles can be easily distinguished if the figure is printed in black and white. The concentration ranges that correspond to the various bubbles should be tied to meaningful values, such as the cleanup level or various orders of magnitude above the cleanup level.)
- the following information if concentration contours are generated:
  - measured values
  - method of contouring (e.g., by hand or with software)
  - if software is used for the contouring, the name of the software, the options selected for interpolating the data, and if any "pseudo data points" were added (The reader should be able to produce a similar plot based on the information provided.)
  - any changes in contour methods or the number of data points if contour methods or the number of data points have changed since previous reports
- if appropriate, plots of concentration versus time at individual wells or groups of wells to illustrate trends

3.2.3 Other Monitoring Results

O&M monitoring may also be performed for the following other media:

- surface water
- sediment
- air

Include tables, figures, and/or appendices to present current and historical sampling results for these media as appropriate.

Sample Tables or Figures Relevant to Section 3.2.2

Tables (see Appendix A)
- *Historical Concentration Data at Monitoring Wells (Sample Table 9)*

This is one of many formats that can be used. The format selected depends on the number of constituents, the number of wells, and the number of sampling events. For tables that span multiple pages (often the case), it is suggested that page numbers include the total number of pages in the table, so the reader can determine if pages are missing. Ground water criteria should be indicated on the table, and values that exceed the criteria should be highlighted using bolding and/or shading so they are easily identified. Values that are "not detected" should always be presented in a manner that clearly identifies the detection limit.

Figures (see Appendix B)
- *Shallow Benzene Concentrations, October 2002 (Sample Figure 9)*
- *Benzene Concentration versus Time at MW-8, MW-8D, and MW-9 (Sample Figure 10)*

The sample map for shallow benzene concentrations is a "bubble map", where the size of the bubble increases as concentrations increase. The legend is essential for such figures. It is recommended that bubble sizes allow concentrations below pertinent criteria to be easily identified. "Non-detect" values should be indicated with a unique symbol so they can be easily identified. Measured values should be displayed whenever possible. Concentration maps should include a north arrow, graphic scale, legend, and enough basemap features to adequately orient the reader. On the graphs of concentration versus time, axes should be clearly labeled. A logarithmic scale is often used for the y-axis because concentration ranges are so large. When using a logarithmic scale a value of "0" is not permitted, so values that are "not detected" should be plotted at one-half the detection limit, the detection limit, or an assigned value such as "0.1". The approach used for plotting "non-detects" should be indicated on the figure. Ground water criteria can also be indicated on the figure for clarity.

3.3 INTERPRETATION OF PROGRESS TOWARD SYSTEM GOALS

3.3.1 Progress with Respect to Short-Term Goals

Discuss if short-term goals (see Section 1.2) are being met, based on an interpretation of O&M data. Explain how the data support the conclusion. Statistical analysis of the data may be helpful in identifying/evaluating trends or comparing concentrations to baseline or cleanup levels because it helps eliminate bias during data interpretation.

3.3.2 Progress with Respect to Long-Term Goals

Discuss if long-term goals are being met (see Section 1.2) based on an interpretation of O&M data. Explain how the newly collected data and data trends support that conclusion. Compare the data to preset milestones, provide an estimate as to when long-term goals are expected to be achieved, and explain the basis for that estimate. Indicate if consideration of modified remedial strategy (more aggressive or less aggressive) and/or consideration of Technical Impracticability is appropriate. Statistical analysis of the data may be helpful in identifying/evaluating trends or comparing concentrations to baseline or cleanup levels because it helps eliminate bias during data interpretation. For additional information on statistical tools, the reader is referred to the following documents:

Gibbons, R. and D. Coleman, *Statistical Methods for Detection and Quantification of Environmental Contamination*, John Wiley & Sons, 2001

Methods for Evaluating the Attainment of Cleanup Standards, Volume 2: Ground Water, U.S. EPA, 1992 (EPA 230-R-92-014)

3.3.3 Gaps or Inconsistencies in Site Conceptual Model

Indicate whether or not there are gaps in the conceptual understanding of contaminant sources and/or contaminant transport at the site that prevent an adequate assessment of system effectiveness and progress towards remedy goals. If such gaps in the site conceptual model exist, suggest data collection activities that would mitigate the gaps, including a cost-benefit assessment as to whether or not such data collection should be pursued. When appropriate, provide a time table for when those suggested activities could be implemented. If new data have been collected that alters the site conceptual model, discuss how the site conceptual model has been modified.

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4.0 SUGGESTED SYSTEM MODIFICATIONS

4.1 SUGGESTIONS FOR SYSTEM MODIFICATION

Include suggestions for system modifications to improve performance, reduce costs, and/or increase likelihood of achieving cleanup goals. Components of O&M to be considered for modifications include the following:

- ground water extraction
- above-ground treatment
- disposal of treated water
- long-term monitoring program

Evaluate potential modifications based on system inefficiencies, technological developments, modified regulations, and recent revisions to the site conceptual model. Include an estimate of costs to implement the recommendations, and estimate the increase or decrease in annual costs likely to result from the recommendation. Summarize the findings and recommendations from recent evaluations and the progress toward implementing those recommendations.

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APPENDIX A:

SAMPLE TABLES

The sample tables presented herein are intended to highlight items discussed within this document and to serve as a guide for format and/or content of such tables in an O&M report. Obviously, it is not possible to provide sample tables that directly apply to all sites. Some site-specific issues that might add additional complexity include the following:

- multiple aquifers impacted by contaminants
- multiple contaminant types (e.g., metals, VOCs, pesticides, etc.)
- multiple remedies (e.g., P&T coupled with soil vapor extraction (SVE) or free product recovery)
- multiple media where sampling is performed (e.g., ground water, surface water, sediments)

There may also be site-specific requirements that mandate different formats and/or additional content to be displayed in tables.

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Sample Table 1. Treatment Plant Process Monitoring Schedule

	A (EQ tank eff)	B (filter eff)	C (air stripper eff)	D (GAC-1 eff)	E (GAC-2 eff)
metals	quarterly	quarterly			monthly
VOC's	quarterly		quarterly	quarterly	monthly

Sampling Points

A: Effluent from equalization tank (blended influent to treatment plant, prior to filters)
B: Effluent from filters (prior to air stripper)
C: Effluent from air stripper
D: After first of two GAC vessels operated in series
E: After second of two GAC vessels operated in series (plant effluent)

Sample Table 2. Treatment Plant Flow Rate, VOC Influent Concentration, and VOC Mass Loading

Month	Flow Rate (gpm)	Design Flow Rate (gpm)	Influent VOC Conc. (ug/L)	Design Influent VOC Conc. (ug/L)	Mass Loading This Month (lbs)	Design Mass Loading Per Month (lbs)	Cumulative Mass Loading (lbs)
Jan-99	62.2	100	1194.4	2000	26.7	71.9	26.7
Feb-99	65.1	100	843.7	2000	19.8	71.9	46.5
Mar-99	64.2	100	870.5	2000	20.1	71.9	66.6
Apr-99	65.3	100	806.4	2000	18.9	71.9	85.5
May-99	64.0	100	1008.4	2000	23.2	71.9	108.7
Jun-99	64.3	100	666.8	2000	15.4	71.9	124.2
Jul-99	63.3	100	623.2	2000	14.2	71.9	138.4
Aug-99	67.6	100	561.8	2000	13.7	71.9	152.0
Sep-99	62.9	100	686.5	2000	15.5	71.9	167.6
Oct-99	48.6	100	692.2	2000	12.1	71.9	179.7
Nov-99	62.6	100	629.1	2000	14.2	71.9	193.8
Dec-99	64.7	100	622.8	2000	14.5	71.9	208.3
Jan-00	65.7	100		2000	14.5	71.9	222.8
Feb-00	63.3	100		2000	14.5	71.9	237.3
Mar-00	65.0	100	400.3	2000	9.4	71.9	246.7
Apr-00	63.5	100		2000	9.4	71.9	256.0
May-00	65.3	100		2000	9.4	71.9	265.4
Jun-00	58.2	100	517.0	2000	10.8	71.9	276.2
Jul-00	57.4	100		2000	10.8	71.9	287.0
Aug-00	58.1	100		2000	10.8	71.9	297.9
Sep-00	54.9	100	563.8	2000	11.1	71.9	309.0
Oct-00	54.9	100		2000	11.1	71.9	320.1
Nov-00	55.0	100		2000	11.1	71.9	331.3
Dec-00	68.4	100	484.7	2000	11.9	71.9	343.2
Jan-01	66.0	100		2000	11.9	71.9	355.1
Feb-01	67.2	100		2000	11.9	71.9	367.0
Mar-01	62.5	100	571.5	2000	12.8	71.9	379.9
Apr-01	68.0	100		2000	12.8	71.9	392.7
May-01	63.2	100		2000	12.8	71.9	405.6
Jun-01	64.5	100	557.2	2000	12.9	71.9	418.5
Jul-01	62.1	100		2000	12.9	71.9	431.4
Aug-01	64.5	100		2000	12.9	71.9	444.4
Sep-01	59.9	100	582.7	2000	12.6	71.9	456.9
Oct-01	55.2	100		2000	12.6	71.9	469.5
Nov-01	54.2	100		2000	12.6	71.9	482.0
Dec-01	51.8	100	548.2	2000	10.2	71.9	492.3
Jan-02	50.8	100		2000	10.2	71.9	502.5
Feb-02	48.4	100		2000	10.2	71.9	512.7
Mar-02	65.9	100	397.8	2000	9.4	71.9	522.1
Apr-02	62.9	100		2000	9.4	71.9	531.5
May-02	66.2	100		2000	9.4	71.9	541.0
Jun-02	62.1	100	444.4	2000	9.9	71.9	550.9
Jul-02	63.8	100		2000	9.9	71.9	560.8
Aug-02	68.3	100		2000	9.9	71.9	570.8
Sep-02	67.5	100	364.4	2000	8.8	71.9	579.6
Oct-02	63.3	100		2000	8.8	71.9	588.5
Nov-02	65.6	100		2000	8.8	71.9	597.3
Dec-02	59.6	100	373.7	2000	8.0	71.9	605.3
Jan-03	68.1	100		2000	8.0	71.9	613.3
Feb-03	61.7	100		2000	8.0	71.9	621.3
Mar-03	64.7	100	337.2	2000	7.8	71.9	629.2
Apr-03	63.9	100		2000	7.8	71.9	637.0
May-03	62.5	100		2000	7.8	71.9	644.9
Jun-03	61.9	100	358.8	2000	8.0	71.9	652.9
Jul-03	62.1	100		2000	8.0	71.9	660.9
Aug-03	64.2	100		2000	8.0	71.9	668.9
Sep-03	64.3	100	349.4	2000	8.1	71.9	676.9
Oct-03	66.2	100		2000	8.1	71.9	685.0
Nov-03	67.0	100		2000	8.1	71.9	693.1
Dec-03	65.0	100	326.3	2000	7.6	71.9	700.7

Notes: Mass per Month (lbs) = Q (gpm) * C (ug/L) * 3.785L/gallon * 1440min/day * 2.2lbs/1E9ug * 30day/month

Sample Table 3. Treatment Plant Influent/Effluent Concentrations and Air Stripper Efficiency

Month	Influent Benzene (ug/L)	Influent Nickel (ug/L)	Influent Lead (ug/L)	Effluent Benzene* (ug/L)	Effluent Nickel (ug/L)	Effluent Lead (ug/L)	Benzene Between Air Stripper and GAC (ug/L)	Air Sripper Efficiency*** (%)
Discharge Limit	**5**	**200**	**50**	**5**	**200**	**50**		
Jan-99	1194.4	29.6	25.2	ND(1)	20.8	13.1	19.2	98.39%
Feb-99	843.7	16.8	23.8	ND(1)	15.6	9.2	7.1	99.16%
Mar-99	870.5	41.4	28.7	ND(1)	25.0	16.2	13.9	98.40%
Apr-99	806.4	42.0	27.3	ND(1)	27.3	18.0	11.1	98.62%
May-99	1008.4	41.9	25.2	**9.4****	29.2	19.4	15.4	98.47%
Jun-99	666.8	29.1	11.3	ND(1)	14.0	8.0	10.3	98.46%
Jul-99	623.2	21.7	18.8	ND(1)	18.5	11.4	9.1	98.54%
Aug-99	561.8	34.2	21.2	ND(1)	16.4	9.8	5.6	99.00%
Sep-99	686.5	38.4	32.2	ND(1)	26.8	17.6	11.8	98.28%
Oct-99	692.2	10.8	10.9	ND(1)	10.3	5.2	5.7	99.18%
Nov-99	629.1	29.1	28.4	ND(1)	16.1	9.6	10.7	98.30%
Dec-99	622.8	16.7	19.9	ND(1)	14.6	8.4	3.7	99.41%
Jan-00				ND(1)	20.7	13.0		
Feb-00				ND(1)	11.2	5.9		
Mar-00	400.3	32.5	23.5	ND(1)	22.8	14.6	4	99.00%
Apr-00				ND(1)	20.5	12.9		
May-00				ND(1)	13.5	7.6		
Jun-00	517.0	12.8	7.6	ND(1)	10.2	5.2	3.9	99.25%
Jul-00				ND(1)	18.7	11.5		
Aug-00				ND(1)	12.0	6.5		
Sep-00	563.8	38.5	30.1	ND(1)	19.3	12.0	2.9	99.49%
Oct-00				ND(1)	26.7	17.5		
Nov-00				ND(1)	16.7	10.0		
Dec-00	484.7	29.8	14.7	ND(1)	22.3	14.2	1.1	99.77%
Jan-01				ND(1)	17.8	10.8		
Feb-01				ND(1)	21.3	13.5		
Mar-01	571.5	29.1	20.8	ND(1)	26.9	17.7	5.2	99.09%
Apr-01				ND(1)	17.8	10.9		
May-01				ND(1)	17.1	10.4		
Jun-01	557.2	34.3	22.8	ND(1)	17.1	10.3	5.1	99.08%
Jul-01				ND(1)	29.1	19.3		
Aug-01				ND(1)	15.5	9.1		
Sep-01	582.7	30.6	23.2	ND(1)	22.4	14.3	5	99.14%
Oct-01				ND(1)	11.0	5.7		
Nov-01				ND(1)	15.2	8.9		
Dec-01	548.2	26.0	32.9	ND(1)	24.8	16.1	4.9	99.11%
Jan-02				ND(1)	12.5	15.8		
Feb-02				ND(1)	20.2	13.0		
Mar-02	397.8	21.7	11.5	ND(1)	11.5	7.1	5.5	98.62%
Apr-02				ND(1)	25.6	15.2		
May-02				ND(1)	24.4	8.9		
Jun-02	444.4	28.5	12.2	ND(1)	12.9	7.5	ND(1)	99.89%
Jul-02				ND(1)	20.3	9.0		
Aug-02				ND(1)	15.6	12.7		
Sep-02	364.4	30.6	27.8	ND(1)	13.2	13.9	4.3	98.82%
Oct-02				ND(1)	15.8	20.0		
Nov-02				ND(1)	26.7	18.6		
Dec-02	373.7	14.4	35.8	ND(1)	10.5	16.4	3.9	98.96%
Jan-03				ND(1)	12.6	9.4		
Feb-03				ND(1)	18.9	8.1		
Mar-03	337.2	15.8	33	ND(1)	14.8	16.2	2.3	99.32%
Apr-03				ND(1)	26.2	17.1		
May-03				ND(1)	14.2	18.7		
Jun-03	358.8	35.2	26.5	ND(1)	20.3	8.6	1.8	99.50%
Jul-03				ND(1)	25.1	19.0		
Aug-03				ND(1)	24.9	11.6		
Sep-03	349.4	19.7	20.1	ND(1)	13.5	18.2	ND(1)	99.86%
Oct-03				ND(1)	27.6	6.9		
Nov-03				ND(1)	22.6	14.5		
Dec-03	326.3	37.7	23.4	ND(1)	29.1	17.6	ND(1)	99.85%

* ND(1) indicates sample was "not detected" above a detection limit of 1.0 ug/l

** Exceedance of discharge criteria due to fouled carbon, more frequent carbon changeouts instituted thereafter

*** If sample between stripper and GAC was "not detect", the air stripper efficiency is calculated using half the detection limit

Sample Table 4. Extraction Wells: Pumping Rates and VOC Concentrations

	Pumping Rate (gpm)				VOC Concentration (ug/l)		
Month	EW-1	EW-2	EW-3	Total	EW-1	EW-2	EW-3
Jan-99	3.4	16.4	42.4	62.2	3983.2	2836.8	335.5
Feb-99	5.0	19.6	40.5	65.1			
Mar-99	3.8	19.3	41.1	64.2			
Apr-99	3.8	18.1	43.4	65.3	3613.2	1625.9	218.9
May-99	4.6	19.0	40.4	64.0			
Jun-99	3.7	17.4	43.2	64.3			
Jul-99	3.8	18.6	40.9	63.3	2067.8	1234.6	210.9
Aug-99	5.0	19.3	43.3	67.6			
Sep-99	3.3	15.4	44.2	62.9			
Oct-99	4.0	19.8	24.8	48.6	2959.1	907.6	154.5
Nov-99	3.3	17.0	42.3	62.6			
Dec-99	4.6	18.7	41.4	64.7			
Jan-00	4.9	16.7	44.1	65.7			
Feb-00	3.2	17.3	42.8	63.3			
Mar-00	3.1	19.3	42.6	65.0			
Apr-00	4.2	19.0	40.3	63.5	2544.2	584.0	243.3
May-00	3.9	16.5	44.9	65.3			
Jun-00	3.8	14.0	40.4	58.2			
Jul-00	3.7	11.0	42.7	57.4			
Aug-00	3.8	10.2	44.1	58.1			
Sep-00	4.5	9.6	40.8	54.9			
Oct-00	3.7	9.8	41.4	54.9	2989.7	696.7	142.9
Nov-00	3.9	8.4	42.7	55.0			
Dec-00	4.9	18.8	44.7	68.4			
Jan-01	3.7	19.2	43.1	66.0			
Feb-01	3.3	19.4	44.5	67.2			
Mar-01	4.6	16.0	41.9	62.5			
Apr-01	3.5	19.9	44.6	68.0	3086.9	751.3	116.4
May-01	4.9	15.6	42.7	63.2			
Jun-01	3.7	18.7	42.1	64.5			
Jul-01	3.0	18.2	40.9	62.1			
Aug-01	3.0	19.7	41.8	64.5			
Sep-01	4.7	18.2	37.0	59.9			
Oct-01	3.2	16.5	35.5	55.2	2720.8	874.2	64.5
Nov-01	3.5	18.6	32.1	54.2			
Dec-01	3.1	19.0	29.7	51.8			
Jan-02	3.8	16.7	30.3	50.8			
Feb-02	3.1	19.0	26.3	48.4			
Mar-02	4.7	17.9	43.3	65.9			
Apr-02	4.3	17.8	40.8	62.9			
May-02	4.7	18.6	42.9	66.2			
Jun-02	4.7	16.0	41.4	62.1			
Jul-02	4.1	18.7	41.0	63.8			
Aug-02	3.5	20.0	44.8	68.3			
Sep-02	4.2	18.5	44.8	67.5			
Oct-02	3.6	15.3	44.4	63.3	2665.7	471.0	121.4
Nov-02	3.7	19.6	42.3	65.6			
Dec-02	3.6	15.3	40.7	59.6			
Jan-03	4.1	19.2	44.8	68.1			
Feb-03	4.3	16.3	41.1	61.7			
Mar-03	3.8	18.1	42.8	64.7			
Apr-03	3.5	18.0	42.4	63.9			
May-03	3.4	15.4	43.7	62.5			
Jun-03	3.1	16.0	42.8	61.9			
Jul-03	3.6	16.9	41.6	62.1			
Aug-03	3.2	16.1	44.9	64.2			
Sep-03	3.4	18.8	42.1	64.3			
Oct-03	4.0	17.8	44.4	66.2	3487.5	179.2	124.3
Nov-03	4.1	18.2	44.7	67.0			
Dec-03	3.3	16.8	44.9	65.0			

Sample Table 5. Specific Capacity at Extraction Wells

Sample Date	Pumping Rate (gpm)			In-Well Drawdown (ft)			Specific Capacity (gpm/ft)		
	EW-1	EW-2	EW-3	EW-1	EW-2	EW-3	EW-1	EW-2	EW-3
1/13/1999	3.6	17.0	44.4	12.54	25.32	24.22	0.29	0.67	1.83
4/6/1999	3.8	18.2	41.0	13.11	26.29	23.95	0.29	0.69	1.71
7/15/1999	3.7	18.6	40.3	13.44	25.77	24.33	0.28	0.72	1.66
10/5/1999	4.2	19.4	40.4	12.93	26.78	24.00	0.32	0.72	1.68
4/7/2000	4.1	19.4	40.8	13.22	37.44	25.00	0.31	**0.52**	1.63
10/1/2000	3.9	7.6	42.2	12.24	45.33	27.34	0.32	**0.17**	1.54
4/12/2001	3.5	19.9	43.0	11.43	25.00	35.33	0.31	0.80	**1.22**
10/14/2001	3.3	17.5	32.5	11.88	22.32	40.98	0.28	0.78	**0.79**
4/9/2002	4.1	17.0	40.8	13.32	20.87	24.04	0.31	0.81	1.70
10/3/2002	3.8	16.3	44.4	13.01	18.33	25.22	0.29	0.89	1.76
4/14/2003	3.7	18.0	45.0	12.34	21.10	25.39	0.30	0.85	1.77
10/16/2003	4.2	18.8	43.9	14.11	20.88	24.87	0.30	0.90	1.77

Notes: (1) specific capacity is pumping rate divided by in-well drawdown, shaded values indicate significant decreases in specific capacity that suggest well fouling
(2) well EW-2 rehabilitated November 2000, well EW-3 rehabilitated January 2002

Sample Table 6. Well Construction Information

Well_ID	Date Completed	X_Coord (ft)	Y_Coord (ft)	Ground Surface Elevation (ft MSL)	Measuring Point TOC* Elevation (ft MSL)	Total Depth (ft)	Aquifer Screened **	Depth To Top Screen (ft)	Depth To Bottom Screen (ft)	Elevation Top Screen (ft MSL)	Elevation Bottom Screen (ft MSL)
MW-1	Apr-95	2197.08	1992.72	653.97	655.47	62.77	S	50.00	60.00	603.97	593.97
MW-2	Apr-95	1777.64	2020.44	651.49	652.99	71.37	S	55.00	65.00	596.49	586.49
MW-3	Apr-95	1907.00	1978.72	656.06	657.56	62.17	S	50.00	60.00	606.06	596.06
MW-4	Nov-95	1966.36	1929.72	645.74	647.24	53.65	S	38.00	48.00	607.74	597.74
MW-5	Nov-95	1816.00	1901.72	647.98	649.48	47.42	S	35.00	45.00	612.98	602.98
MW-6	Nov-95	1616.64	1793.36	646.77	648.27	52.31	S	40.00	50.00	606.77	596.77
MW-7	Nov-95	2225.08	1796.72	655.58	657.08	50.64	S	37.00	47.00	618.58	608.58
MW-8	Nov-95	1942.00	1730.36	647.07	648.57	63.45	S	35.00	45.00	612.07	602.07
MW-9	Nov-95	1760.00	1601.00	656.89	658.39	50.58	S	40.00	50.00	616.89	606.89
MW-10	May-96	2050.36	1594.00	657.02	658.52	46.87	S	35.00	45.00	622.02	612.02
MW-11	May-96	1802.00	1464.64	656.70	658.20	57.33	S	38.00	48.00	618.70	608.70
MW-12	May-96	1924.36	1307.28	652.99	654.49	54.70	S	37.00	47.00	615.99	605.99
MW-13	May-96	1844.00	1205.92	658.51	660.01	57.66	S	38.00	48.00	620.51	610.51
MW-14	May-96	1936.17	1244.00	653.47	654.97	55.91	S	40.00	50.00	613.47	603.47
MW-15	May-96	1952.36	814.20	682.11	683.61	50.33	S	34.00	44.00	648.11	638.11
MW-16	May-96	2106.08	835.20	681.12	682.62	55.00	S	37.00	47.00	644.12	634.12
MW-17	May-96	1987.36	964.56	684.22	685.72	41.72	S	31.00	41.00	653.22	643.22
PZ-1	Nov-97	1959.36	1174.28	665.07	666.57	44.22	S	25.00	35.00	640.07	630.07
PZ-2	Nov-97	1817.87	1763.40	659.14	660.64	59.44	S	55.00	65.00	604.14	594.14
PZ-3	Nov-97	1982.37	1761.77	642.92	644.42	39.46	S	39.00	49.00	603.92	593.92
MW-8D	Nov-95	1945.00	1734.36	646.95	648.45	80.66	D	108.00	118.00	538.95	528.95
MW-11D	May-96	1805.00	1468.64	658.35	659.85	93.43	D	118.00	128.00	540.35	530.35
MW-14D	May-96	1940.17	1247.00	655.18	656.68	89.96	D	113.00	123.00	542.18	532.18
EW-1	Nov-97	1938.64	1167.56	666.00		60.00	S	25.00	55.00	641.00	611.00
EW-2	Nov-97	1805.64	1786.08	661.12		105.00	S	60.00	100.00	601.12	561.12
EW-3	Nov-97	1993.8	1786.08	642.99		85.00	S	40.00	80.00	602.99	562.99

* TOC indicates "Top of Casing"

** S indicates the shallow aquifer, and D indicates the deep aquifer

Sample Table 7. Water Level Measurements, October 2003

Well ID	Aquifer Screened *	TOC Elevation (ft MSL)	Depth to Water (ft)	Water Level Elevation (ft MSL)
MW-1	S	655.47	49.73	605.74
MW-2	S	652.99	47.64	605.35
MW-3	S	657.56	51.74	605.82
MW-4	S	647.24	37.79	609.45
MW-5	S	649.48	38.97	610.51
MW-6	S	648.27	28.53	619.74
MW-7	S	657.08	36.84	620.24
MW-8	S	648.57	36.91	611.66
MW-9	S	658.39	30.52	627.87
MW-10	S	658.52	31.26	627.26
MW-11	S	658.20	21.75	636.45
MW-12	S	654.49	11.93	642.56
MW-13	S	660.01	15.36	644.65
MW-14	S	654.97	12.33	642.64
MW-15	S	683.61	9.47	674.14
MW-16	S	682.62	8.29	674.33
MW-17	S	685.72	18.49	667.23
PZ-1	S	666.57	21.72	644.85
PZ-2	S	660.64	34.28	626.36
PZ-3	S	644.42	19.12	625.30
MW-8D	D	648.45	7.45	641.00
MW-11D	D	659.85	35.61	624.24
MW-14D	D	656.68	9.82	646.86

* S indicates the shallow aquifer, and D indicates the deep aquifer

Sample Table 8. Historical Water Level Elevations (ft MSL)

Well_ID	MW-1	MW-2	MW-3	MW-4	MW-5	MW-6	MW-7	MW-8	MW-9	MW-10	MW-11
Aquifer Monitored	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow
01/01/99	606.11	605.12	606.11	609.09	610.08	619.26	620.20	611.57	627.94	627.44	636.37
04/01/99	604.73	605.56	606.47	609.38	610.05	619.59	620.24	611.88	628.20	627.04	636.84
07/01/99	603.44	602.16	602.85	605.90	606.48	615.72	616.96	608.32	625.27	624.24	633.04
10/01/99	603.92	604.70	606.61	609.24	610.48	619.34	620.22	611.40	628.28	627.47	635.98
01/01/00	606.88	604.96	606.52	609.46	610.08	619.06	620.11	611.44	628.14	627.49	636.05
04/01/00	604.32	604.90	606.44	609.75	609.65	619.49	619.85	611.41	627.99	627.76	635.58
07/01/00	602.05	600.71	601.64	604.95	605.20	614.34	616.02	607.47	623.02	622.69	632.40
10/01/00	602.46	605.77	606.05	608.77	610.36	619.65	620.05	611.52	628.35	627.09	635.82
01/01/01	605.86	605.45	605.65	609.21	609.90	619.32	620.46	611.79	627.94	627.51	636.15
04/01/01	605.37	605.27	605.72	608.74	609.54	619.21	620.84	611.62	627.63	627.95	635.92
07/01/01	603.98	604.73	606.40	609.09	610.03	619.59	619.92	611.78	627.88	627.63	636.10
10/01/01	605.06	605.54	606.78	608.53	609.86	620.02	620.85	611.86	627.92	627.35	636.80
01/01/02	606.71	605.07	606.48	608.81	609.76	619.71	620.58	612.31	627.92	627.17	636.59
04/01/02	602.86	604.74	606.28	608.82	609.66	619.82	620.74	610.95	628.26	627.32	637.05
07/01/02	601.88	605.56	606.26	609.37	609.87	618.96	620.01	611.87	627.59	627.65	635.92
10/01/02	602.37	605.74	605.33	609.80	610.80	619.69	620.13	612.13	628.11	627.60	636.18
01/01/03	605.69	605.42	605.82	609.32	610.39	619.54	620.28	611.67	627.68	627.12	636.64
04/01/03	604.96	605.35	605.34	609.10	610.27	620.02	620.40	612.10	627.78	627.07	636.86
07/01/03	604.29	605.44	606.27	609.07	609.59	618.77	620.39	611.66	628.36	627.49	636.40
10/01/03	605.74	605.35	605.82	609.45	610.51	619.74	620.24	611.66	627.87	627.26	636.45

Sample Table 8. Historical Water Level Elevations (ft MSL)

Well_ID	MW-12	MW-13	MW-14	MW-15	MW-16	MW-17	PZ-1	PZ-2	PZ-3	MW-8D	MW-11D	MW-14D
Aquifer Monitored	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Deep	Deep	Deep
01/01/99	642.32	644.80	642.82	674.66	674.56	667.62	644.80	606.61	605.12	641.51	623.86	646.34
04/01/99	642.44	644.66	642.83	674.82	674.86	667.14	645.24	607.01	605.45	641.41	623.44	646.73
07/01/99	638.72	641.26	639.22	671.09	671.62	664.50	641.84	603.51	601.73	638.19	620.98	643.04
10/01/99	642.32	644.81	642.15	674.77	674.85	667.45	644.59	606.95	605.50	641.99	623.52	645.99
01/01/00	641.91	645.26	642.53	674.55	674.68	667.27	644.49	606.79	605.12	641.82	623.87	646.32
04/01/00	641.83	644.84	642.28	674.81	674.47	667.41	644.63	607.24	605.16	642.29	624.08	646.69
07/01/00	638.34	640.38	638.74	669.95	670.52	662.95	640.11	607.25	600.40	637.24	619.18	641.53
10/01/00	642.32	645.56	642.71	674.40	674.57	667.69	644.82	611.07	605.61	642.36	624.63	646.30
01/01/01	641.97	645.17	642.38	674.86	674.13	667.43	644.59	606.49	605.39	641.87	624.27	646.06
04/01/01	642.23	645.52	642.17	674.52	673.70	667.24	644.85	606.50	605.75	642.35	623.81	646.43
07/01/01	642.54	644.57	643.22	675.10	674.60	667.60	644.33	606.53	605.11	641.43	623.46	645.96
10/01/01	641.92	644.65	643.12	674.34	674.62	667.63	644.57	607.19	610.58	641.28	624.23	646.22
01/01/02	642.05	644.45	642.79	674.29	674.19	667.23	644.39	607.00	610.20	641.42	623.90	646.62
04/01/02	641.98	644.07	643.14	674.73	674.64	667.21	644.00	607.19	604.90	641.53	623.64	646.26
07/01/02	642.75	644.60	643.19	674.87	674.67	667.21	644.54	606.58	605.30	641.58	624.24	646.12
10/01/02	642.84	645.16	642.29	674.41	674.29	667.33	645.43	606.20	605.51	640.69	623.70	646.59
01/01/03	642.49	644.85	642.66	674.28	674.50	667.30	645.07	606.47	605.42	641.09	624.11	646.74
04/01/03	642.65	645.19	642.43	674.60	674.93	667.76	645.53	606.30	604.96	641.32	624.15	646.64
07/01/03	642.73	644.47	642.53	674.22	674.07	667.61	644.37	606.53	604.95	641.69	624.14	646.35
10/01/03	642.56	644.65	642.64	674.14	674.33	667.23	644.85	606.36	605.30	641.00	624.24	646.86

Sample Table 9. Historical Concentration Data at Monitoring Wells

Monitoring Well	Date	Benzene (µg/L)	Toluene (µg/L)	Ethyl Benzene (µg/L)	Total Xylenes (µg/L)	Total Nickel (µg/L)	Total Lead (µg/L)
MCL		**5**	**1000**	**700**	**10000**	**---**	**15**
MW-1 (shallow)	Jan-98	ND(1)	ND(1)	ND(1)	ND(1)	9.7	5.4
	Apr-98	ND(1)	ND(1)	ND(1)	ND(1)	5.6	5.0
	Jul-98	ND(1)	ND(1)	ND(1)	ND(1)	8.3	8.4
	Oct-98	ND(1)	ND(1)	ND(1)	ND(1)	7.2	9.5
	Oct-99	ND(1)	ND(1)	ND(1)	ND(1)	5.5	5.5
	Oct-00	ND(1)	ND(1)	ND(1)	ND(1)	5.0	7.6
	Oct-01	ND(1)	ND(1)	ND(1)	ND(1)	10.6	9.2
	Oct-02	ND(1)	ND(1)	ND(1)	ND(1)	5.6	6.1
MW-2 (shallow)	Jan-98	ND(1)	ND(1)	ND(1)	ND(1)	5.6	6.2
	Apr-98	ND(1)	ND(1)	ND(1)	ND(1)	11.6	6.0
	Jul-98	ND(1)	ND(1)	ND(1)	ND(1)	14.9	5.7
	Oct-98	ND(1)	ND(1)	ND(1)	ND(1)	8.0	5.9
	Oct-99	ND(1)	ND(1)	ND(1)	ND(1)	11.8	6.2
	Oct-00	ND(1)	ND(1)	ND(1)	ND(1)	10.4	6.1
	Oct-01	ND(1)	ND(1)	ND(1)	ND(1)	8.0	5.3
	Oct-02	ND(1)	ND(1)	ND(1)	ND(1)	13.5	5.3
{data omitted for many wells for this example}							
MW-8 (shallow)	Jan-98	**3153.5**	91.5	ND(1)	ND(1)	5.2	**26.5**
	Apr-98	**3684.2**	121.6	ND(1)	ND(1)	9.0	12.8
	Jul-98	**2209.1**	103.1	ND(1)	ND(1)	13.4	**20.7**
	Oct-98	**2324.8**	108.2	ND(1)	ND(1)	14.2	14.3
	Oct-99	**3191.7**	131.3	ND(1)	ND(1)	14.6	**29.7**
	Oct-00	**4197.4**	75.6	ND(1)	ND(1)	14.9	**18.3**
	Oct-01	**1614.8**	144.5	ND(1)	ND(1)	6.0	**23.1**
	Oct-02	**2728.8**	141.9	ND(1)	ND(1)	13.3	11.4
MW-8D (deep)	Jan-98	ND(1)	ND(1)	ND(1)	ND(1)	2.6	**22.3**
	Apr-98	ND(1)	ND(1)	ND(1)	ND(1)	ND(2)	**21.0**
	Jul-98	0.7J	ND(1)	ND(1)	ND(1)	ND(2)	**17.1**
	Oct-98	1.3	ND(1)	ND(1)	ND(1)	4.5	**22.7**
	Oct-99	ND(1)	ND(1)	ND(1)	ND(1)	3.0	**24.5**
	Oct-00	ND(1)	ND(1)	ND(1)	ND(1)	ND(2)	12.8
	Oct-01	1.1	ND(1)	ND(1)	ND(1)	3.9	13.2
	Oct-02	ND(1)	ND(1)	ND(1)	ND(1)	4.4	**28.8**
MW-9 (shallow)	Jan-98	**120.0**	ND(1)	ND(1)	ND(1)	30.5	**16.3**
	Apr-98	**53.0**	ND(1)	ND(1)	ND(1)	27.3	**17.2**
	Jul-98	**18.2**	ND(1)	ND(1)	ND(1)	30.7	7.8
	Oct-98	2.4	ND(1)	ND(1)	ND(1)	31.4	13.8
	Oct-99	ND(1)	ND(1)	ND(1)	ND(1)	20.2	6.6
	Oct-00	ND(1)	ND(1)	ND(1)	ND(1)	33.2	11.5
	Oct-01	1.3	ND(1)	ND(1)	ND(1)	37.8	10.4
	Oct-02	ND(1)	ND(1)	ND(1)	ND(1)	25.8	12.1
{data omitted for remaining wells for this example}							

Notes:
ND(1) indicates sample was "not detected" above a detection limit of 1.0 ug/l
J indicates "estimated value"
Values above the MCL are shaded and bolded

APPENDIX B:

SAMPLE FIGURES

The sample figures presented herein are intended to highlight items discussed within this document and to serve as a guide for format and/or content of such figures in an O&M report. Obviously, it is not possible to provide sample figures that directly apply to all sites. Some site-specific issues that might add additional complexity include the following:

- multiple aquifers impacted by contaminants
- multiple contaminant types (e.g., metals, VOCs, pesticides, etc.)
- multiple remedies (e.g., P&T coupled with soil vapor extraction (SVE) or free product recovery)
- multiple media where sampling is performed (e.g., ground water, surface water, sediments)

There may also be site-specific requirements that mandate different formats and/or additional content to be displayed on figures.

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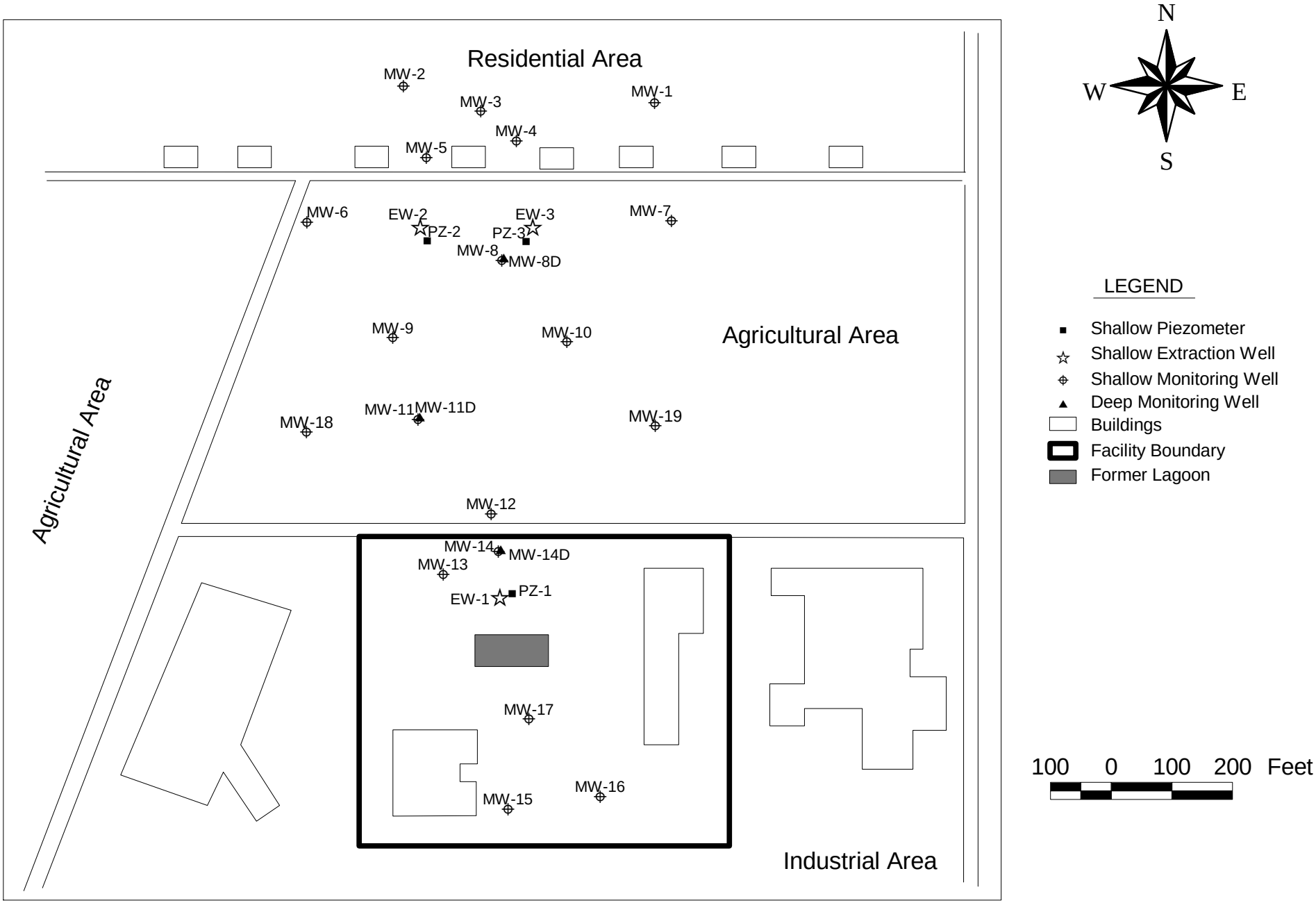
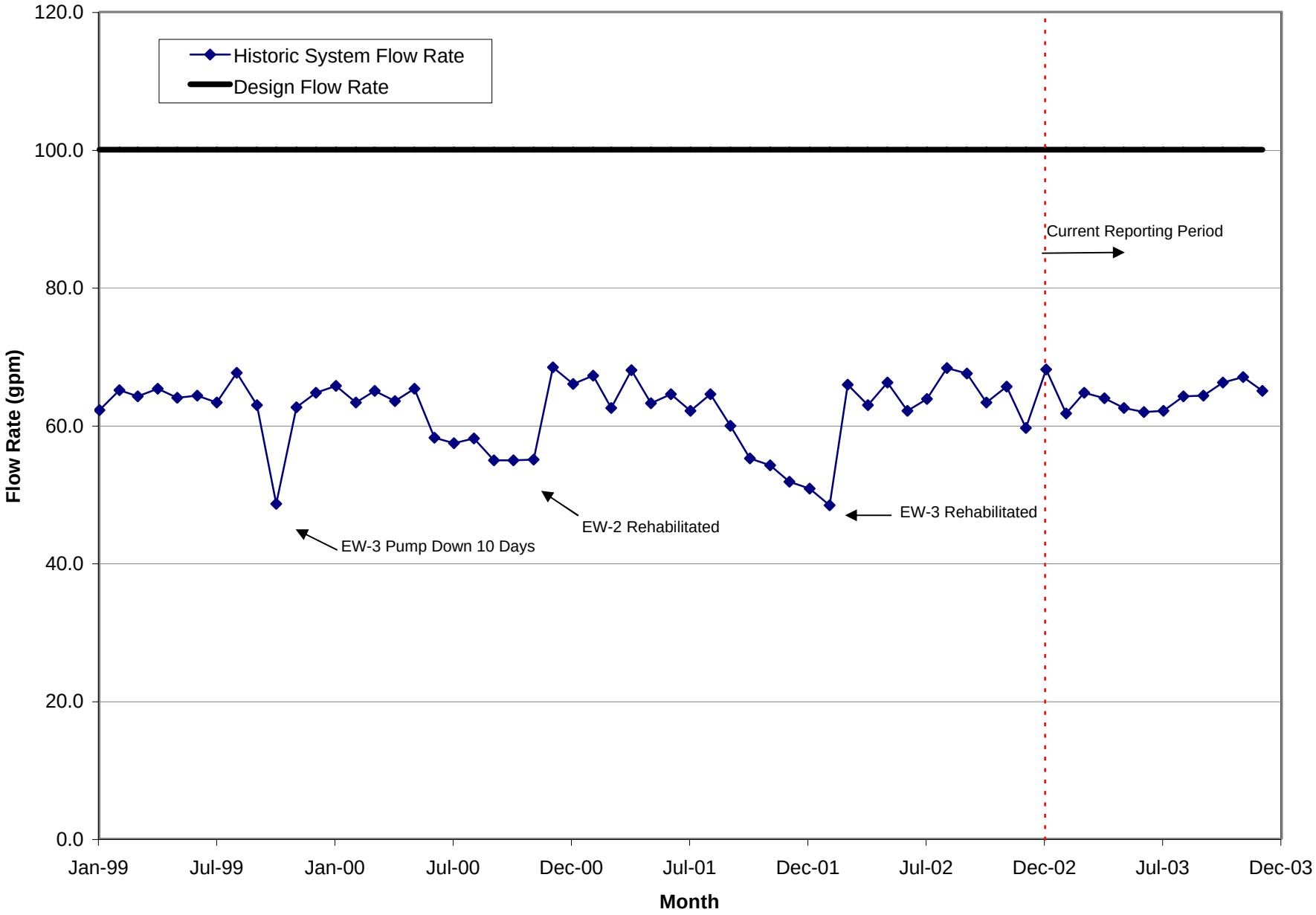
Sample Figure 1. Site Vicinity and Well Locations

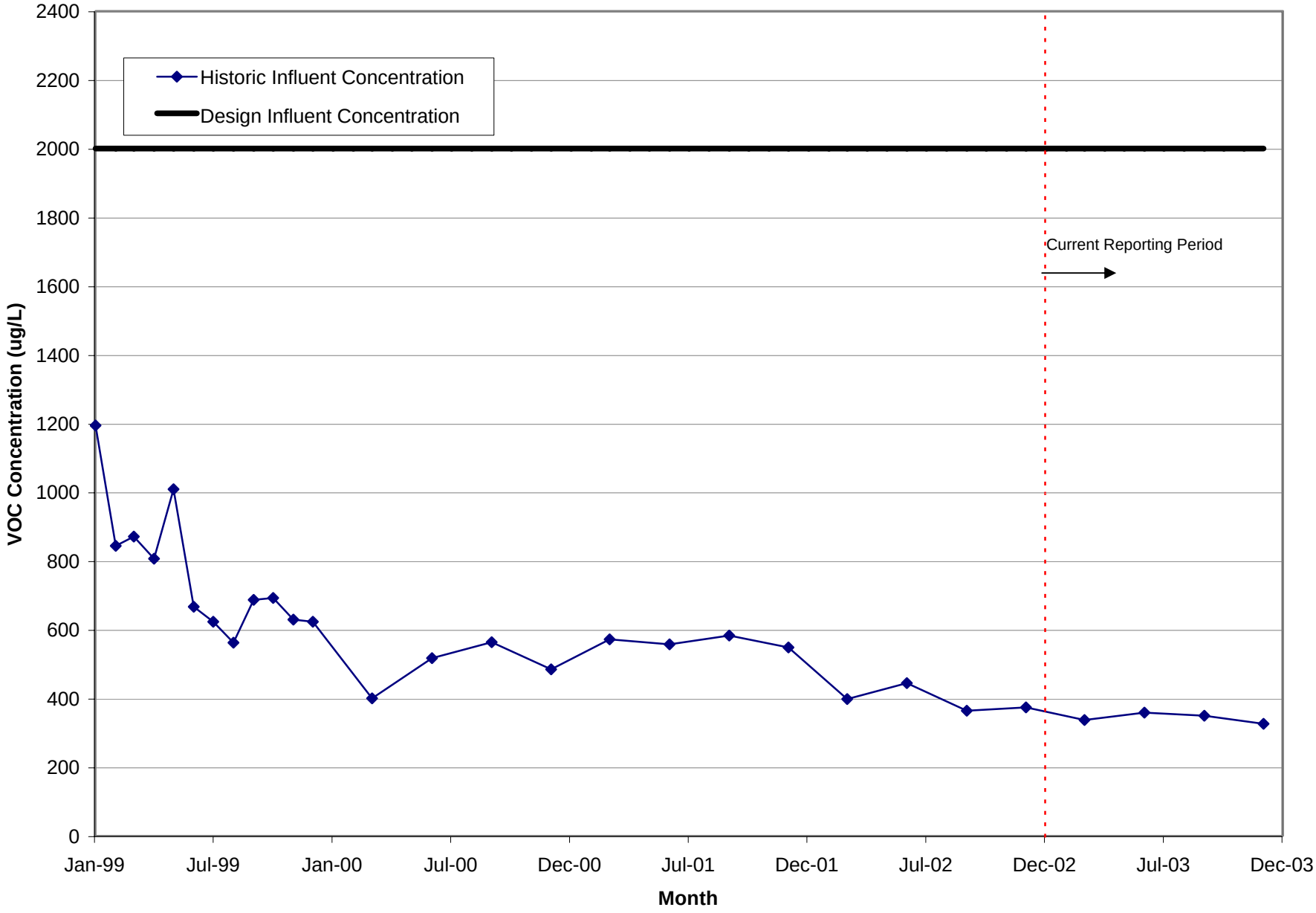


Sample Figure 2. Plant Influent Flow Rate Over Time, Compared With Design Flow Rate



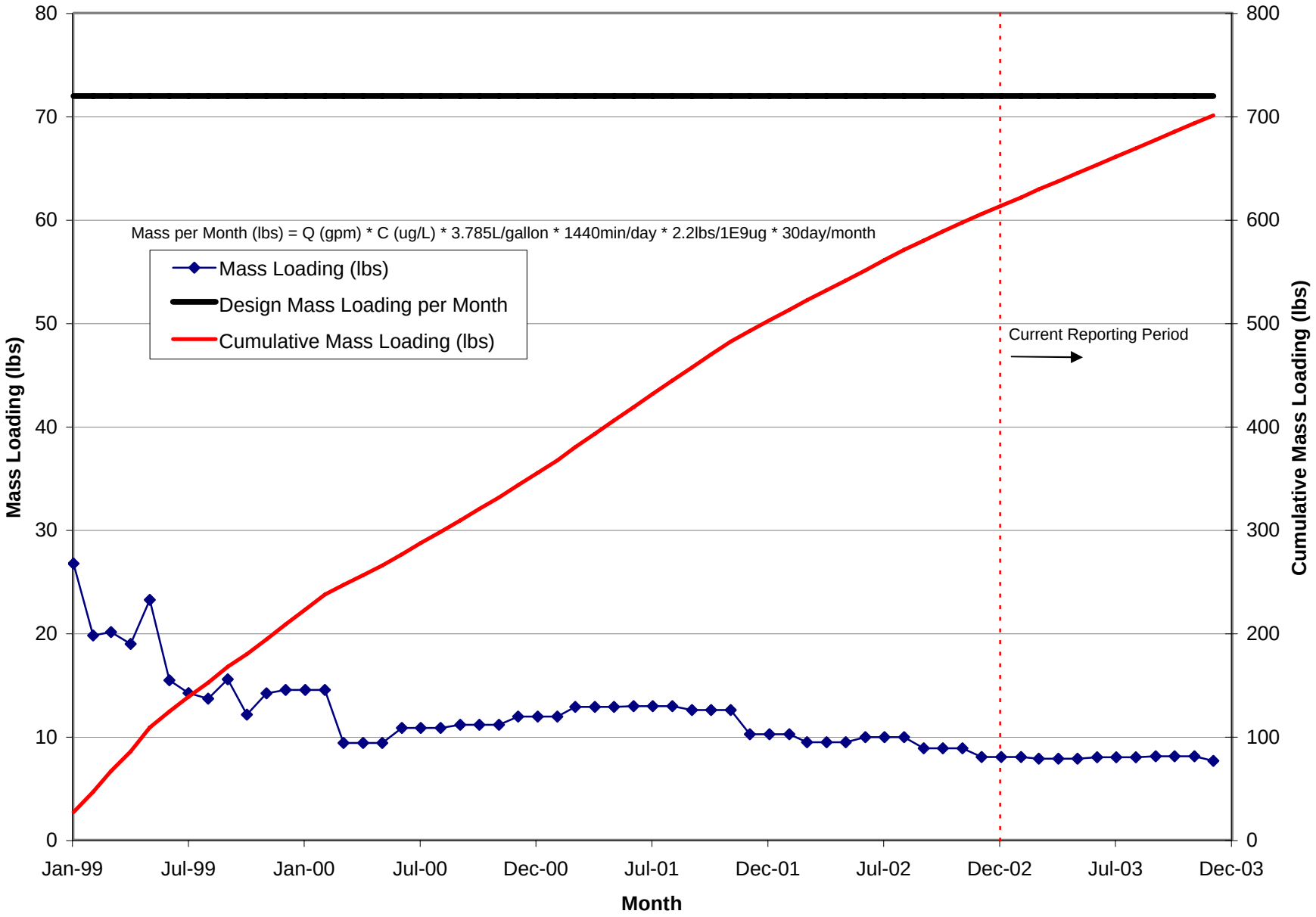
Note: Although flow rate is less than design flow rate, capture appears sufficient based on water level map interpretations

Sample Figure 3. Plant Influent VOC Concentration Over Time, Compared With Design Concentration



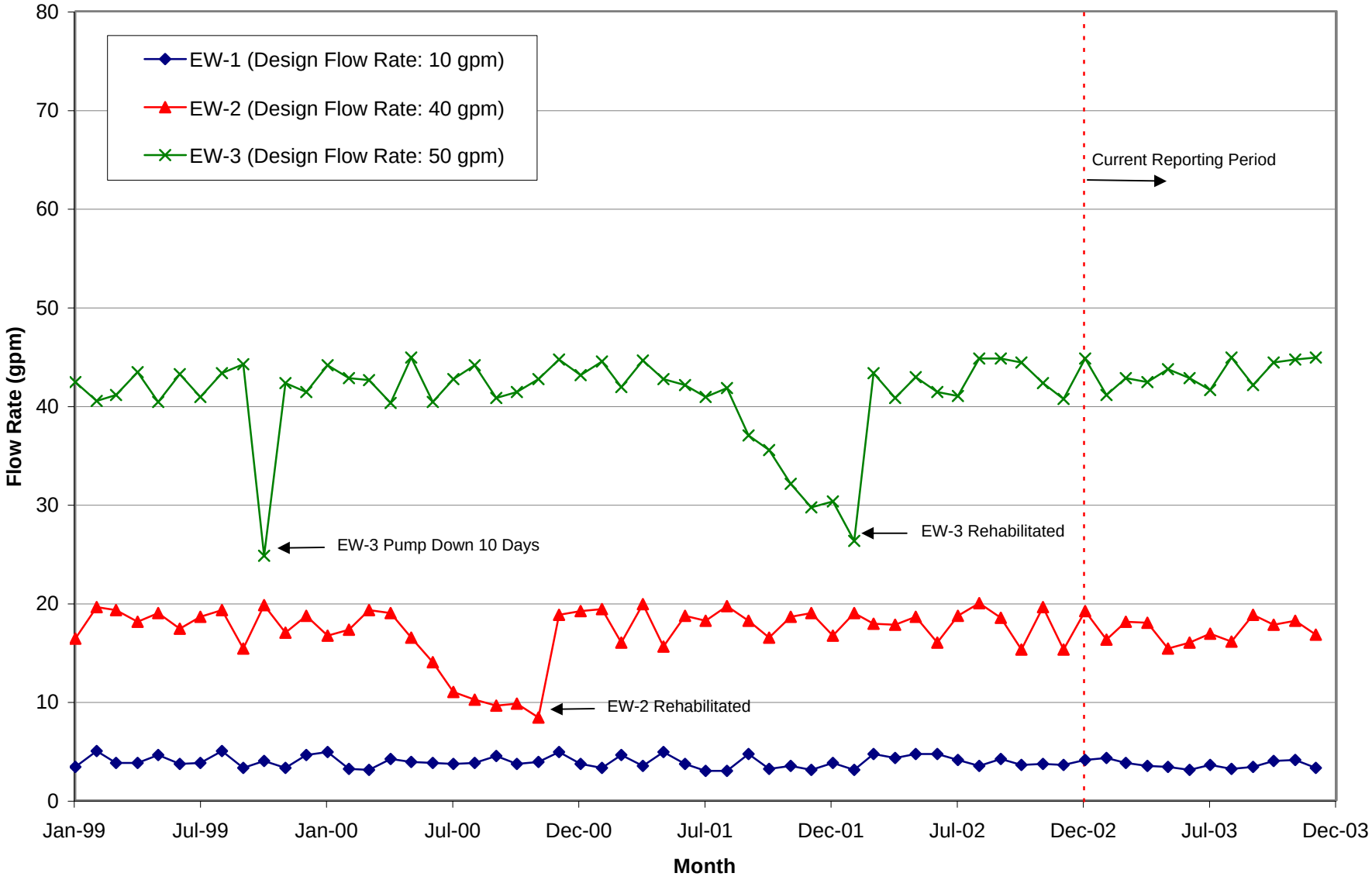
Note: Actual influent VOC's are far less than design values, cost-benefit analysis regarding alternative treatment technologies should be performed

Sample Figure 4. Plant Monthly Mass Loading and Cumulative Mass Loading

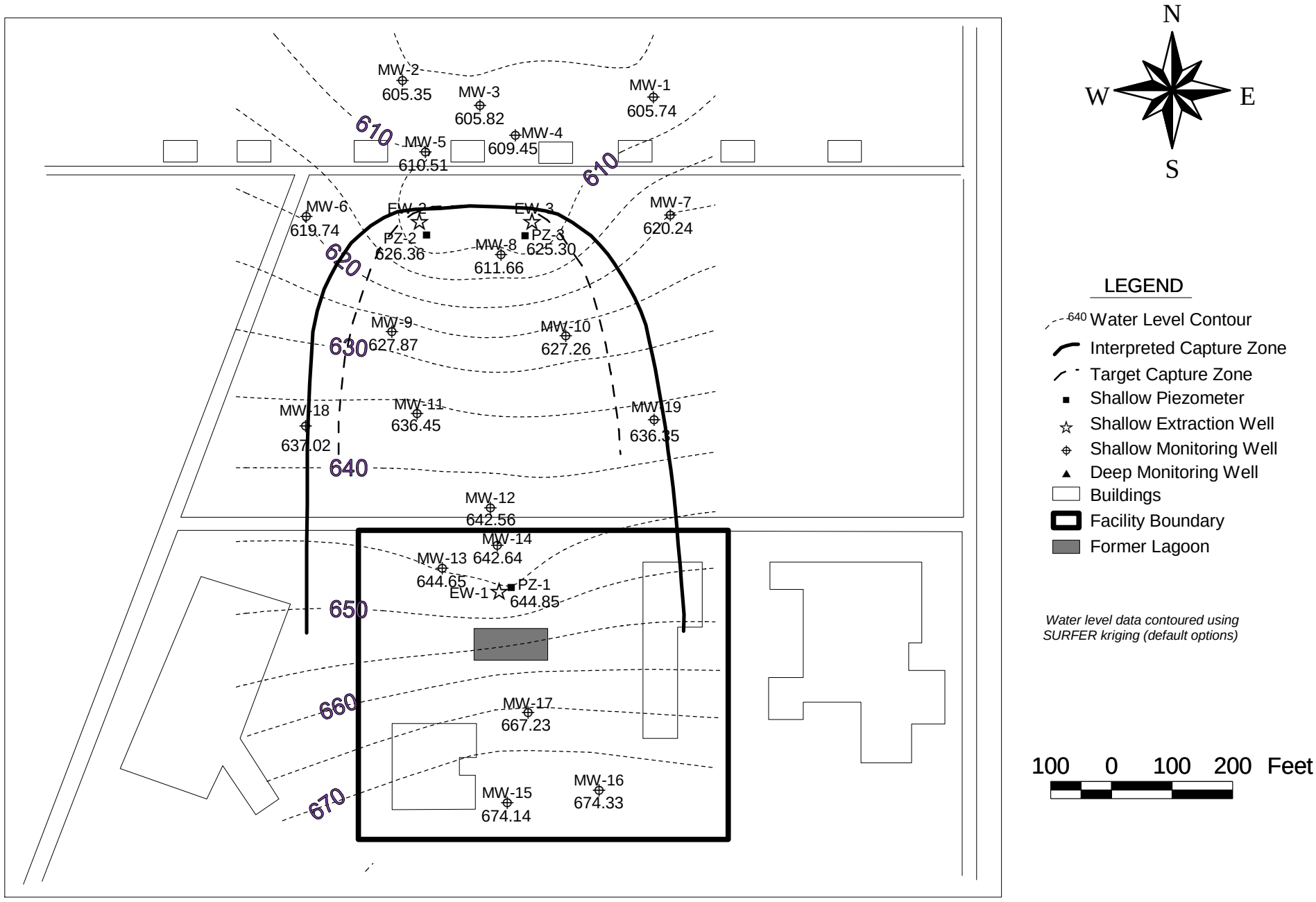


Note: Actual mass loading is far less than design values, cost-benefit analysis regarding alternative treatment technologies should be performed

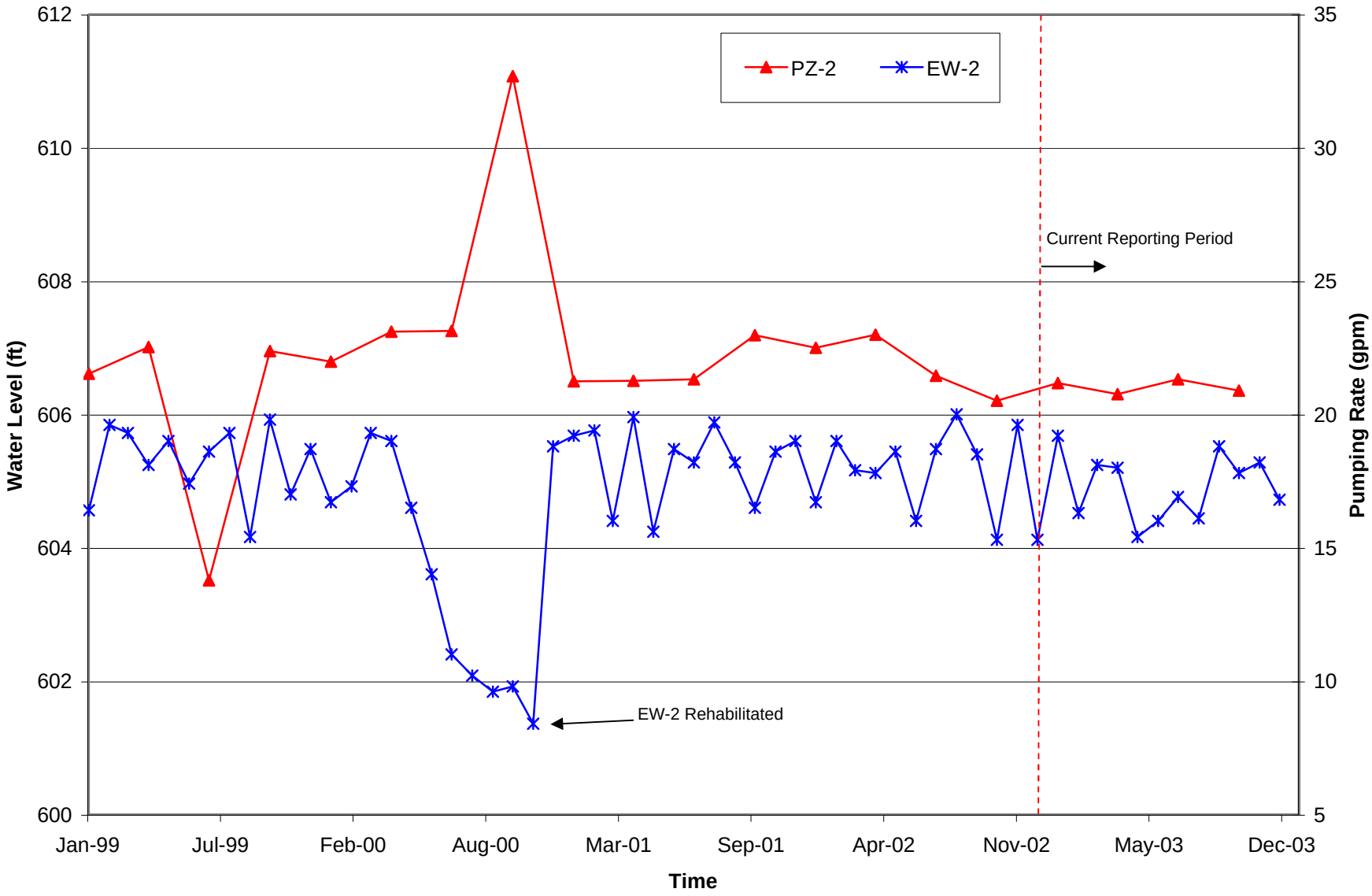
Sample Figure 5. Average Flow Rates (Monthly) for Extraction Wells



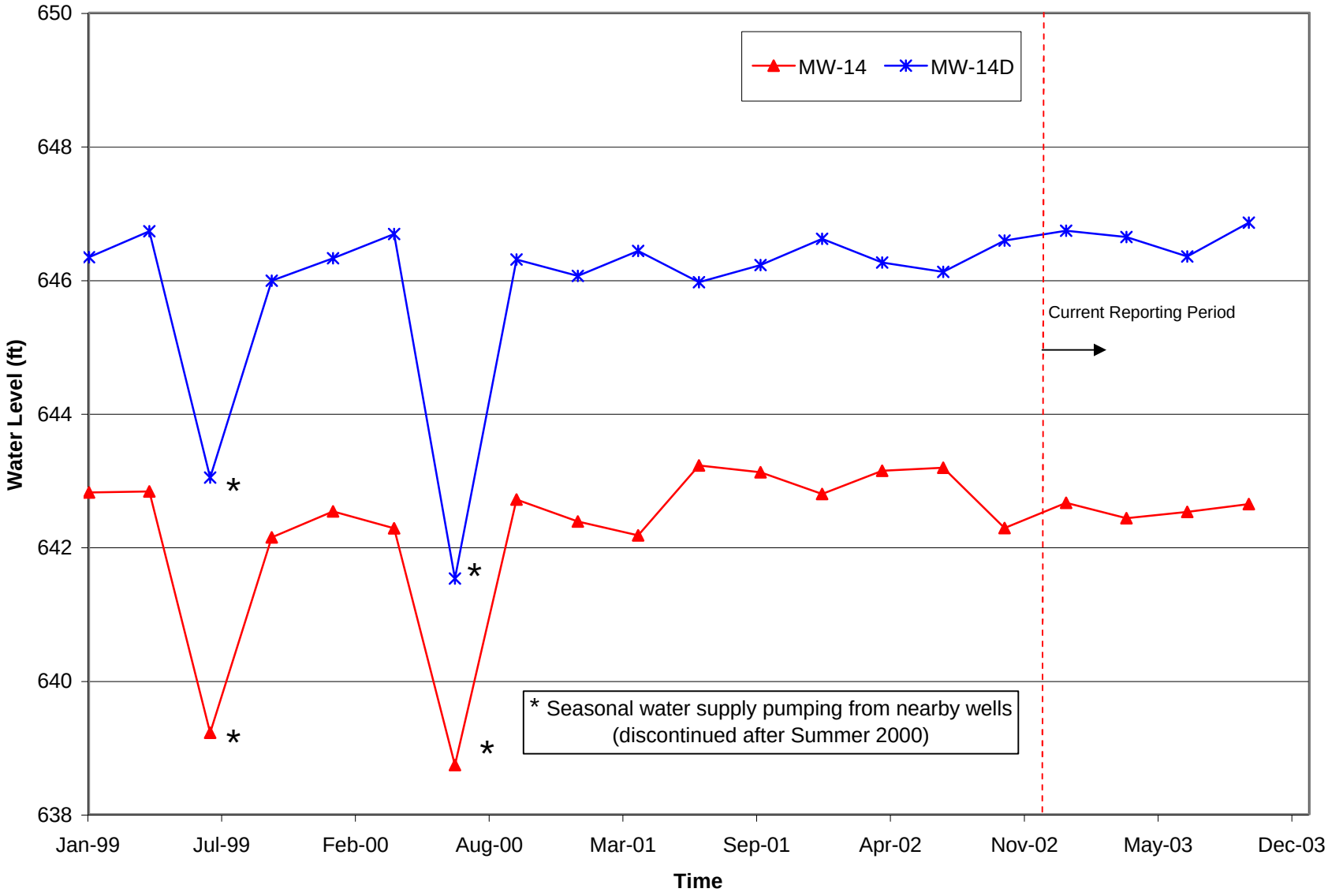
Sample Figure 6. Shallow Water Levels (October 2002)



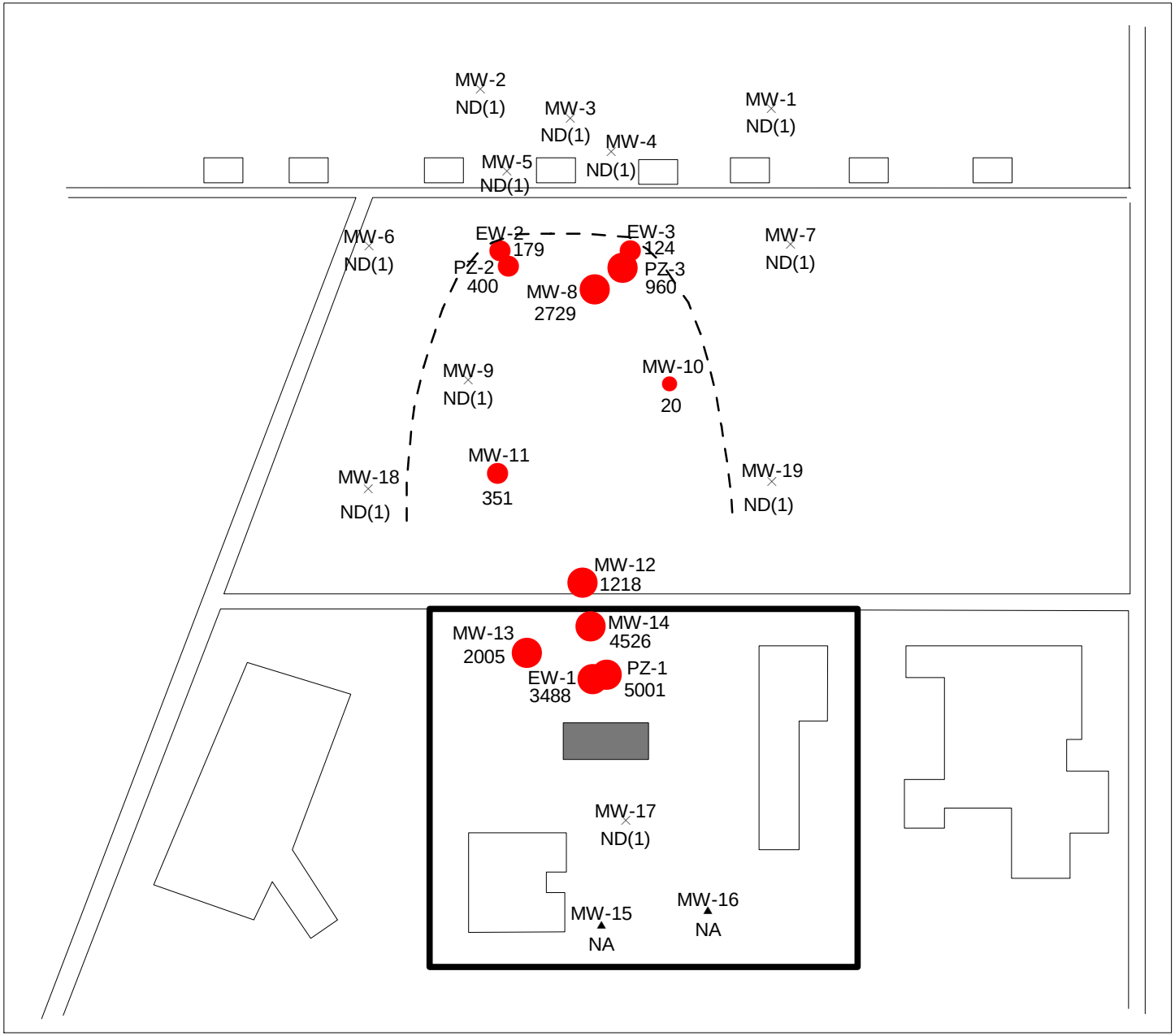
Sample Figure 7. Water Levels at PZ-2 versus Extraction Rate of EW-2

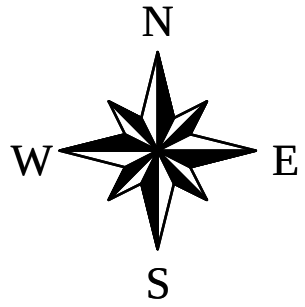


Sample Figure 8. Hydrograph for MW-14 and MW-14D Well Cluster



Sample Figure 9. Shallow Benzene Concentrations (October 2002)





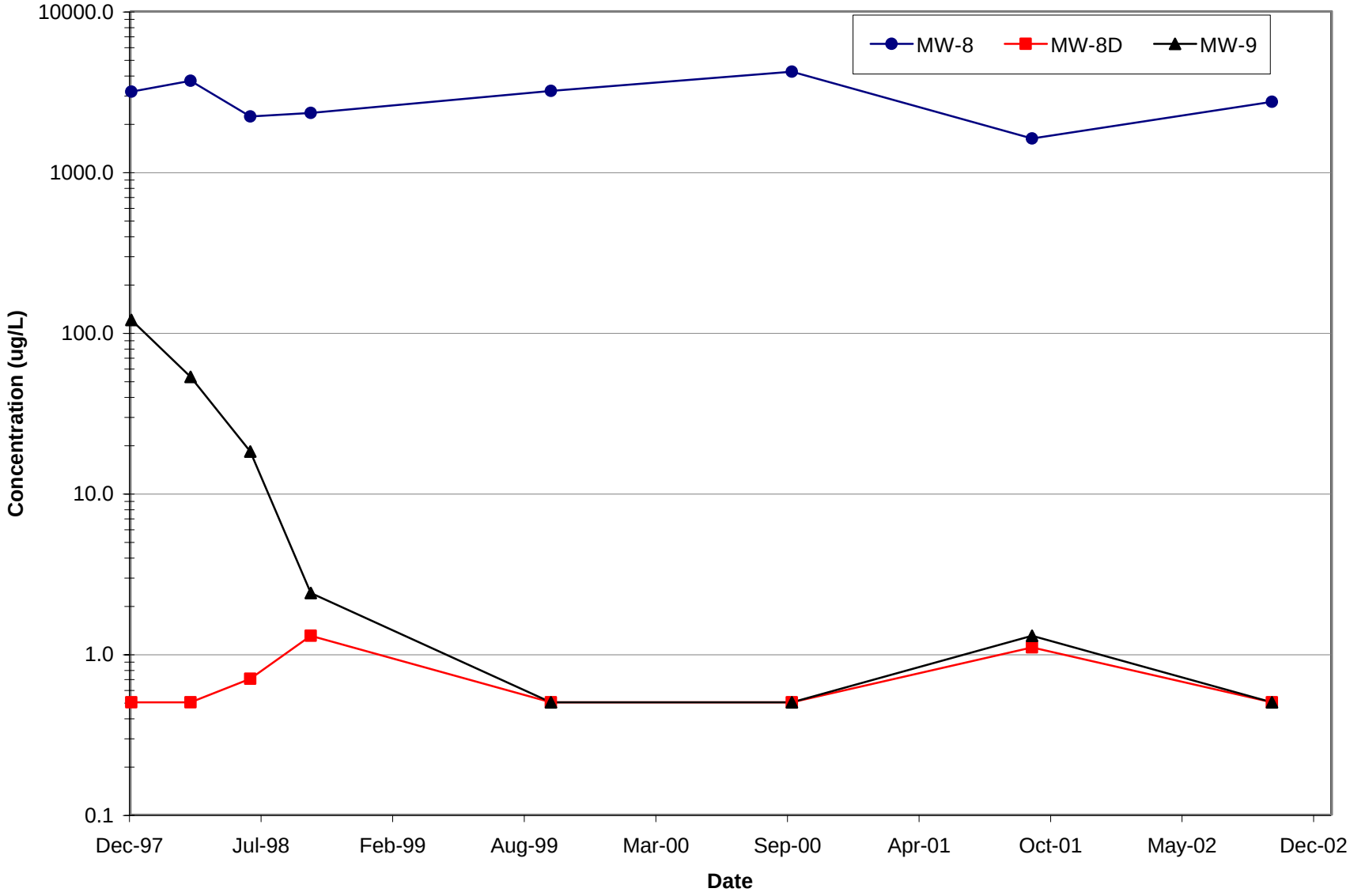
LEGEND

Benzene Concentration
(MCL = 5 ug/L)

- ND (Non Detect)
- <= 5 ug/L
- 5 - 50 ug/L
- 50 - 500 ug/L
- > 500 ug/L
- NA (Not Analyzed)
- Target Capture Zone
- Buildings
- Facility Boundary
- Former Lagoon

100 0 100 200 Feet

Sample Figure 10. Benzene Concentration versus Time at MW-8, MW-8D, and MW-9



Note: For samples that are "not detected", the value plotted is half the detection limit

NOTICE:

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