LONG-TERM GROUND WATER MONITORING PROGRAM GUIDANCE

Prepared for:
THE CALIFORNIA BASE CLOSURE ENVIRONMENTAL COMMITTEE

Submitted by:
SITE CHARACTERIZATION PROCESS ACTION TEAM

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PREFACE

The Base Realignment and Closure Act (BRAC) encourages the timely restoration and earliest possible reuse of military properties. The state of California, faced with the closure of many military bases, recognized the need to establish a base closure environmental committee to foster an ongoing dialogue and exchange of ideas between federal and state governmental bodies responsible for ensuring that closure and transfer occur in an environmentally safe and expeditious manner. Accordingly, the California Base Closure Environmental Committee (CBCEC) was formed. The committee includes representatives of the California Environmental Protection Agency (Department of Toxic Substances Control, the State Water Resources Control Board, and the Regional Water Quality Control Boards); the Governor's Office of Planning and Research; U.S. Environmental Protection Agency's Region IX office; the Departments of the Army, Navy, and Air Force; and the Department of Defence. The CBCEC's ultimate goal is to address issues affecting timely cleanup and reuse of closing military bases and to identify methods and techniques that promote accelerated restoration and expedited transfer of BRAC properties.

To help expedite completion of the committee's mission, it created several ad hoc subcommittees, called process action team (PAT), to investigate specific issues and to report back to the CBCEC with conclusions and recommendations. In several instances, PATs concluded that CBCEC sponsored guidance documents would provide the most appropriate means to expedite the safe closure and transfer of military bases. This manual is one of those documents.

Because the issues investigated by the Site Characterization PAT, the Technology Matching PAT, and the Mixed Waste PAT are interrelated, the guidance manuals developed by these PATs are intended to be complementary and should be used together when appropriate. To date, the Site Characterization PAT has produced two manuals entitled ***Recommended Content and Presentation of reporting Hydrogeologic Data During Site Investigations*** and ***Long-Term Ground Water Monitoring Program Guidance***, which are directly related to each other, and the Technology Matching PAT has produced a manual entitled ***Treatment Technologies Applications Matrix for Base Closure Activities***, which should be used in conjunction with the other two guidance manuals. In addition, these guidance manuals will be supplemented with Tech Memos that will be developed as circumstances and technological considerations dictate.

The first document developed by the Site Characterization PAT, ***Recommended Content and Presentation for Reporting Hydrogeologic Data During Site Investigations***, specifies data content and presentation methods needed to support hydrogeologic investigations. The document calls for ongoing development and review of hydrogeologic technical memoranda (Tech Memos) as an investigation progresses. The Tech Memos provide for development and

ongoing amendment of site-specific and installation-wide working hydrogeologic models to guide site investigations.

The second document, ***Long-Term Ground Water Monitoring Program Guidance***, calls for developing a ground water sampling plan to economically provide ground water elevation and chemical data needed to support site investigations, feasibility studies, remedial designs, remedial actions and long-term operation and maintenance activities. The document emphasizes development of a dynamic sampling program that provides for amendment of sampling frequencies and constituents analyzed to reflect changing data needs as a project progresses. The document provides for Quarterly and Annual Reports as the mechanism for reporting ground water elevation and chemistry data.

The Tech Memo, and the Quarterly and Annual Reports should be incorporated into one submittal to prevent the duplication of data reporting and evaluation. The content of this submittal will vary according to the hydrogeologic work performed during the reporting period. The minimum reporting requirement is the Quarterly and Annual Reports.

ACKNOWLEDGEMENTS

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LONG-TERM GROUND WATER MONITORING PROGRAM

Table of Contents

I. INTRODUCTION

The Long-Term Ground Water Monitoring Program is a strategy for assessing ground water contamination. This document provides guidance for developing and implementing a Long-Term Ground Water Monitoring Plan as the formal mechanism and timetable for assessing extent and movement of ground water contamination.

The Long-Term Ground Water Monitoring Plan provides rationale and scope for continuing ground water monitoring throughout Remedial Investigation/Feasibility Study (RI/FS), Remedial Design (RD), and Remedial Action (RA) phases. The plan produced according to this guidance should be reviewed and updated at least annually, and more often if necessary to remain consistent with progress on the RI/FS, RD and RA. Updates should evaluate the objectives and goals of the monitoring effort as site investigation moves to remediation. Implementation of the plan should meet the following objectives:

- Identify the lateral and vertical extent of groundwater contamination;
- Track rate and direction of horizontal and vertical plume movement, to determine the impact on beneficial uses and the threat to nearby receptors;
- Provide a long-term ground water monitoring strategy that includes the constituents of concern, monitoring locations, frequency, and analytical methods;
- Develop a program which has documentable quality assurance/quality control (QA/QC) and defined procedures for sample collection, analysis, and well maintenance;
- Specify a method and frequency for collecting ground water level measurements to perform hydraulic analyses that include the determination of flow directions, gradients, and potential seasonal variations in the hydraulic system;
- Improve understanding of the site hydrogeologic conceptual model;
- Validate and optimize the effectiveness of ground water remedial measures;
- Determine when remedial objectives have been met;
- Ensure ground water sampling is performed in a cost effective manner;
- Provide a system for effective data management.

II. GROUND WATER MONITORING PLAN CONTENT

A Ground Water Monitoring Plan should address the ground water monitoring needs of the entire installation, and account for sampling objectives that result from different site-specific conditions and stages of investigation and remediation. The following information should be addressed in the plan.

A. Background Information

Background information should include past chemical uses and previous ground water investigations at the installation. In addition, individual site and facility-wide hydrogeological conceptual models should be presented. The following are subjects to be covered in narrative form, supported by summary tables or graphics where appropriate.

1. Overview of regulatory framework, history of site operation (including chemical use and waste disposal), previous investigations and remedial measures.

2. A presentation of the working hydrogeological model. This is necessary to support ground water sampling and analysis, and should include the following:

   a. Site stratigraphy and aquifer designation (supported by hydrogeological cross sections).
   b. Monitoring, water supply, and other wells, including site map with well locations. For sites with multiple aquifers a well map should be constructed for each aquifer.
   c. A table with rationale for monitoring well locations, along with the site map featuring well placement.
   d. Ground water flow direction in each aquifer (supported by potentiometric surface maps)
   e. Site hydrogeological conceptual model. (This section should discuss the interpretation of the existing data with respect to the interaction between aquifers and relative rates of ground water and contaminant movement.)

3. History of ground water monitoring (include data summary for each well as an appendix).

4. Nature and extent of ground water contamination, specifically:

   a. Description of the ground water contaminants present
   b. Description of individual ground water contamination plumes (with isoconcentration maps)
   c. Other sites at the facility with related contamination

5. An evaluation and discussion of data gaps.

Discussions of the above subjects should be supported by graphical data presentation such as isoconcentration maps, ground water elevation contour maps, water elevation hydrographs, and cross-sections. Graphical presentation detail is presented in *Recommended Content and Presentation for Reporting Hydrogeologic Data During Hazardous Waste Site Investigations*, The California Base Closure Environmental Committee, August 5, 1993.

B. Sampling Plan

The Sampling Plan should describe the rationale for selecting particular monitoring wells for sampling, constituents to be analyzed, and the sampling frequency. The Sampling Plan should also provide criteria for a systematic decision process that would be used every year to update the Ground Water Monitoring Plan. The following are the minimum components of the Sampling Plan:

1. Establishing Background Water Quality

   Background conditions are used as a baseline to evaluate water quality potentially impacted by installation operations. Background conditions should be established by:

a. Using monitoring wells upgradient of any possible contaminant discharge by the installation;
b. Obtaining ground water samples representative of each water bearing zone that is impacted or threatened;
c. Sampling upgradient wells for a broad spectrum of constituents, such as minerals, metals, chemical of concerns, etc.;
d. Obtaining sufficient number of samples for statistical analysis.

2. Frequency of Water Level Measurements

Water level measurements should be taken to establish installation wide and site specific ground water gradients. These measurements would be used to determine the relationship between the monitoring well and a plume (side, cross-gradient, or other); the position of new wells to fill data gaps; seasonal variations; and the capture zone of a ground water treatment system. Guidelines for the frequency of taking water level measurements are as follows:

a. Initially, water levels should be measured monthly in all monitoring wells at the site for a minimum of one year. This should establish an indication of seasonal variations and a baseline to evaluate future ground water gradients.

b. Water levels should be measured prior to purging any well.

c. All water levels should be obtained within as short a time period of each other as practicable.

d. The frequency of water level measurements should be considered for reduction if variation of flow direction and rate has been quantified. Reducing the frequency of measurements to quarterly after one year is recommended.

Note that the frequency of water level measurements should be dependent on local climatic, cultural, and hydrologic conditions and other site specific objectives to the program. Examples of conditions to consider include but are not limited to:

- More frequent measurements during wet season to understand the effects of precipation;
- Irrigation patterns;
- Proximity to a stream or river;
- Tidal influences.

3. Constituents Analyzed

This section of the Sampling Plan should identify the constituents to be analyzed at each site and the analytical method and detection limits to achieve data quality objectives. A systematic decision process should be established by means of a logic diagram (decision tree). The following are recommendations for decision criteria:

a. Proposed constituents should be based on chemicals used or disposed at the site and associated breakdown products, beneficial uses of ground water, and results of past sampling and analyses.

b. Analytical methods should provide detection limits to satisfy regulatory requirements.

4. Sampling Frequency

A systematic decision process should be developed with a logic diagram. Figure 1 shows an example decision tree, but the decision should be site-specific and rationale should be presented. The decision process will provide an objective approach to removing or adding constituents or wells and changing sampling frequency. Sampling frequency should be consistent with all other non-CERCLA sampling requirements. The following guidelines are provided as a starting point in the development of the decision process:

a. New Wells - All new wells should be incorporated into the monitoring system and sampled quarterly for at least four consecutive quarters. Additional quarterly sampling should be conducted if wide fluxations are observed.

b. Downgradient Wells - Quarterly sampling should be conducted to monitor the downgradient margins (leading edges) of a contaminant plume. Downgradient wells should be selected for each water-bearing zone impacted or threatened, and for each specific contaminant plume.

c. Guard Wells - Quarterly sampling should be conducted of wells used as an early warning to detect contaminants for the protection of private and municipal wells.

d. Wells in Plume - Semi-annual sampling should be conducted to monitor highly contaminated interior portions of a plume that have shown little variation in contaminant concentrations during the previous year.

e. Crossgradient Wells - Semi-annual sampling should be conducted if supported by consistent ground water flow direction; semi-annual sampling of crossgradient wells should be designed to monitor the lateral margins of a plume.

f. Background Wells - Annual sampling should be conducted to monitor background water quality.

g. Where adjacent wells are screened in the same water-bearing zone, one may be sampled at a reduced frequency after demonstrating that the two wells are providing redundant data. The demonstration should be based on an assessment of water chemistry, potentiometric data, and stratigraphy in the vicinity of the wells.

h. Every 24 to 36 months, samples from each well should be analyzed for all constituents historically detected in ground water or soil at a specific site.

i. Upon activation or deactivation of an extraction system, samples should be obtained and analyzed from each well comprising the extraction and monitoring system, and thereafter quarterly for at least four consecutive quarters. More frequent sampling may be required during startup.

j. If a well is determined unnecessary and it is anticipated that the well will not be used during any time during the monitoring program, that well should be proposed for abandoment according to relevant regulations.

5. Inspection and Well Maintenance

a. The condition of wells should be inspected at each sampling event, but not less than annually.

b. Specific well conditions to check:

- Surface seal
- Well locks
- Casing integrity
- Total depth of well
- Any other relevant conditions

c. Any necessary repairs should be made prior to the next quarterly sampling event.

d. If a well can not be properly repaired, it should be replaced or abandon.

6. Sampling Schedule

a. A proposed first year sampling program should be incorporated into the Sampling Plan. The sampling program would be based on the above systematic decision process.

b. A sampling schedule should be prepared showing dates on which sampling will occur.

C. Field Procedures

The Long-Term Ground Water Monitoring Plan should include standard operating procedures for the field activities necessary to meet the objectives of the ground water monitoring program. A Field Sampling Plan (FSP) should have been developed for the facility (See *EPA Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, October 1988). Relevant sections of the FSP should be provided as an appendix to the Long-Term Ground Water Monitoring Plan. If not developed, a FSP should be developed as part of this Long-Term Ground

Water Monitoring Plan. The FSP should include detailed procedures for water level measurement, purging, sampling, sample preservation, and well abandonment to be followed by field personnel.

D. Quality Assurance/ Quality Control (QA/QC) Plan

A Quality Assurance Project Plan (QAPP) should have been developed for the facility. Relevant sections of the QAPP should be provided as an appendix to the Long-Term Ground Water Monitoring Plan (See *EPA Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, October 1988). If not developed, a QA/QC Plan should be developed as part of this Long-Term Ground Water Monitoring Plan

E. Data Management Plan

A Ground Water Data Management Plan should be developed describing the methods that will be used to manage all ground water data. The Data Management Plan should assure the data are organized based on site-specific information, are easily retrievable, and are entered into the system on a regular basis. The Data Management Plan must also consider future needs for manipulation of data and ongoing reporting needs (refer to Section B). An electronic copy of the data and software used to create tables and graphics should be available at the facility on software agreed to by the project team. This data should be provided to regulatory agencies upon request.

F. Statisical Analysis

Statisical methods should be used to evaluate water quality data. They should be described in Long-Term Ground Water Monitoring Plan. The sampling plan should identify the type and amount of data required by the statistical methods to be used.

G. Reporting

The reporting requirements discussed below focus on water level and water quality data. However, during periods of site investigation and remediation when other hydrogeologic data are generated (boring logs, well construction, etc.), these additional data need to be reported and evaluated with respect to the site model as described in the August 5, 1993 *Recommended Content and Presentation for Reporting Hydrogeologic Data During Site Investigations.* Technical Memorandums (Tech Memos) described in the above document, and Quarterly and Annual Reports described below should be submitted together as a single document. The content of this submittal will vary according to the hydrogeologic work performed during the reporting period, the Quarterly and Annual Reports being the minimum requirements for reporting.

1. Quarterly Report

The Quarterly Report is a written data presentation including a brief discussion and interpretation of the last quarter's sampling results. The last quarter's data, in summary table form, should include the following:

a. Water level data

b. Water quality data

c. Map or maps showing ground water elevation contours and contaminant concentrations, with isoconcentration contours (individual maps should be provided for each separate water-bearing zone)

d. Brief discussion or summary of the following:

1) Data collection problems and deviations from plan
2) Data anomalies
3) Obvious changes in water levels and water quality
4) Recommendations (if any) for future actions and improvement to the monitoring program

e. A summary of the QA/QC results, and in the case of cleanup, a summary of remediation system(s) operation and effectiveness

f. Field sampling logs and records

2. Annual Report

An Annual Report should include a detailed evaluation and discussion of the analytical data and results of the past four quarters, a discussion of anomalous data, and an evaluation and discussion of site-wide hydrogeologic data and remediation system(s). The Annual Report should:

a. Present and discuss changes in aquifer(s) potentiometric levels and gradients, and:

1) Incorporate the last four quarters of data with all the past years' data, and present this compilation in tabular form (include in appendices [see section H]). The table should include the elevations of well screen and filter pack intervals.

2) Update hydrographs for each well and present the last four quarters of ground water elevation contour maps (potentiometric surface maps) (include in appendices [see section H]),

3) Discuss potentiometric results (trends should be identified and discussed, and supported by hydrographs and ground water elevation maps).

b. Present water quality data with a discussion of plume(s) configuration, and:

1) Incorporate the last four quarters of data with all the past years data and present the compilation in tabular form (include in appendices [see section H]).

2) Provide an updated assessment of the nature, extent, and rate of migration of ground water contamination.

3) Discuss analytical results and identify and discuss trends.

c. Discuss any changes in the hydrogeologic conceptual model and update cross-sections based on well logs from new wells or borings.

d. Evaluate and discuss ground water remediation systems, such as:

1) The effectiveness of plume capture by the existing system(s),

2) Modifications to pumping regimes if necessary, including the addition of new wells to maintain hydraulic control, and

3) Effectiveness of remediation systems supported by graphs and tabular summaries.

e. Identify data gaps and potential deficiencies in the monitoring system or reporting program based on the above data.

f. Update the ground water Sampling Plan for sampling frequency and analyses. The update should:

1) Propose the subsequent revised sampling program using the systematic decision process developed in the ground water sampling plan.

2) Provide support for the adequacy of the proposed sampling.

H. Appendices

The appendices to the plan should be updated annually. Tables and graphics should be updated and presented in the annual report. The appendices should contain all hydrogeological and water quality data. The following should be included in the Ground Water Monitoring Plan appendices at a minimum:

1. Water Elevation Data

   a. Water elevation data presented by well in tabular form with historical data

   b. Ground water elevation contour maps

   c. Hydrographs (including precipitation data)

2. Ground Water Quality Data

   a. Water quality data presented by well in tabular form with all historical data

   b. Plot contaminant concentration versus time for each well and constituent

   c. Isoconcentration maps

   d. Cross section with concentration profiles

3. Physical Data

   a. All geologic cross-sections

   b. Well Locations and boring/well logs

      1) Facility wide map with well locations

      2) Site maps with well locations

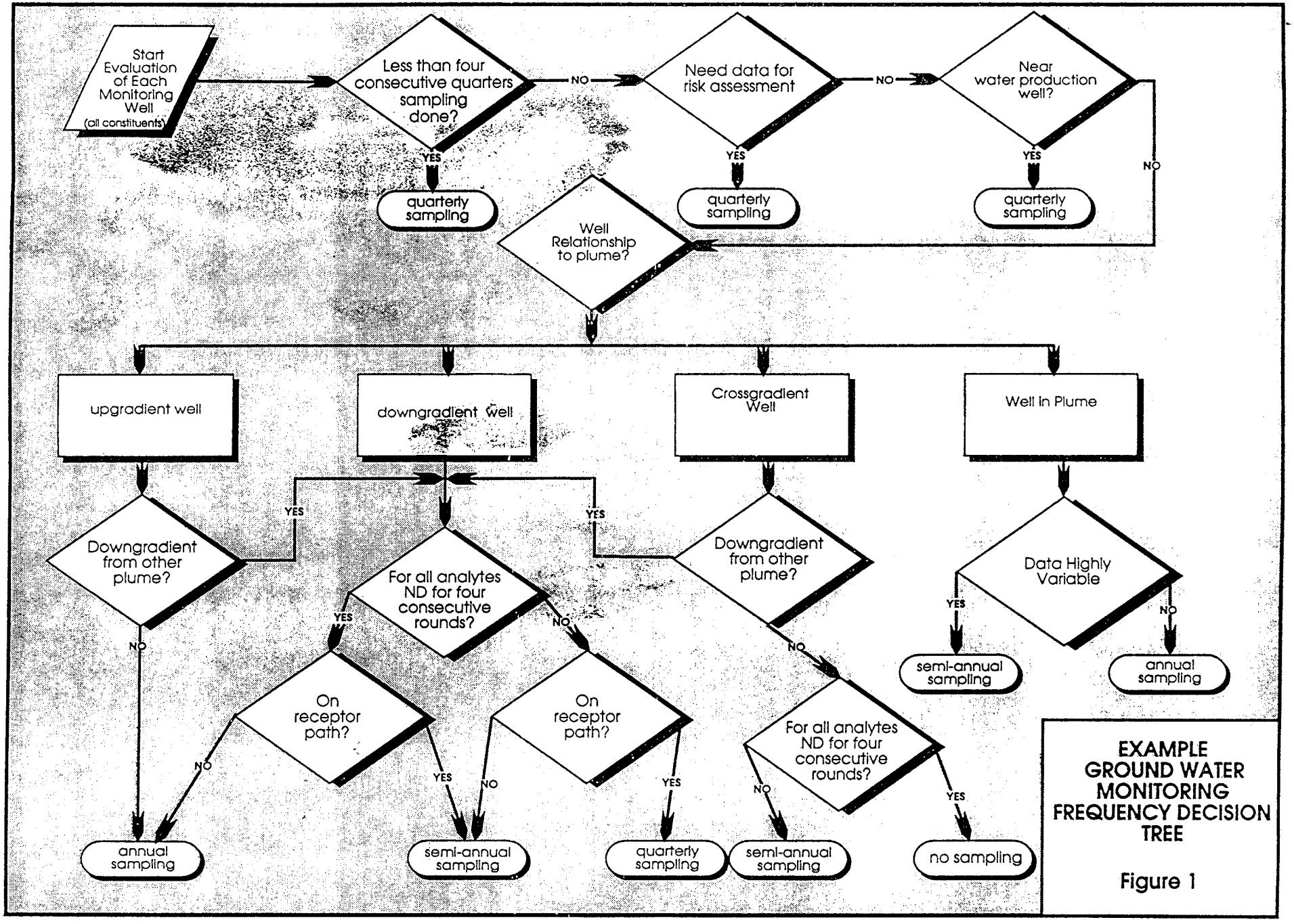
      3) Boring and well construction logs

      4) Well construction summary tables

   c. Structure contour maps

4. Field Procedures Sections

5. QA/QC Plan Sections


Start Evaluation of Each Monitoring Well (all constituents)
Less than four consecutive quarters sampling done?
NO
YES
quarterly sampling
Need data for risk assessment
NO
YES
quarterly sampling
Near water production well?
NO
YES
quarterly sampling
Well Relationship to plume?
upgradient well
downgradient well
Crossgradient Well
Well In Plume
Downgradient from other plume?
YES
NO
For all analytes ND for four consecutive rounds?
YES
NO
On receptor path?
NO
YES
annual sampling
semi-annual sampling
On receptor path?
YES
NO
quarterly sampling
semi-annual sampling
Downgradient from other plume?
YES
NO
For all analytes ND for four consecutive rounds?
NO
YES
semi-annual sampling
no sampling
Data Highly Variable
YES
NO
semi-annual sampling
annual sampling
EXAMPLE GROUND WATER MONITORING FREQUENCY DECISION TREE
Figure 1