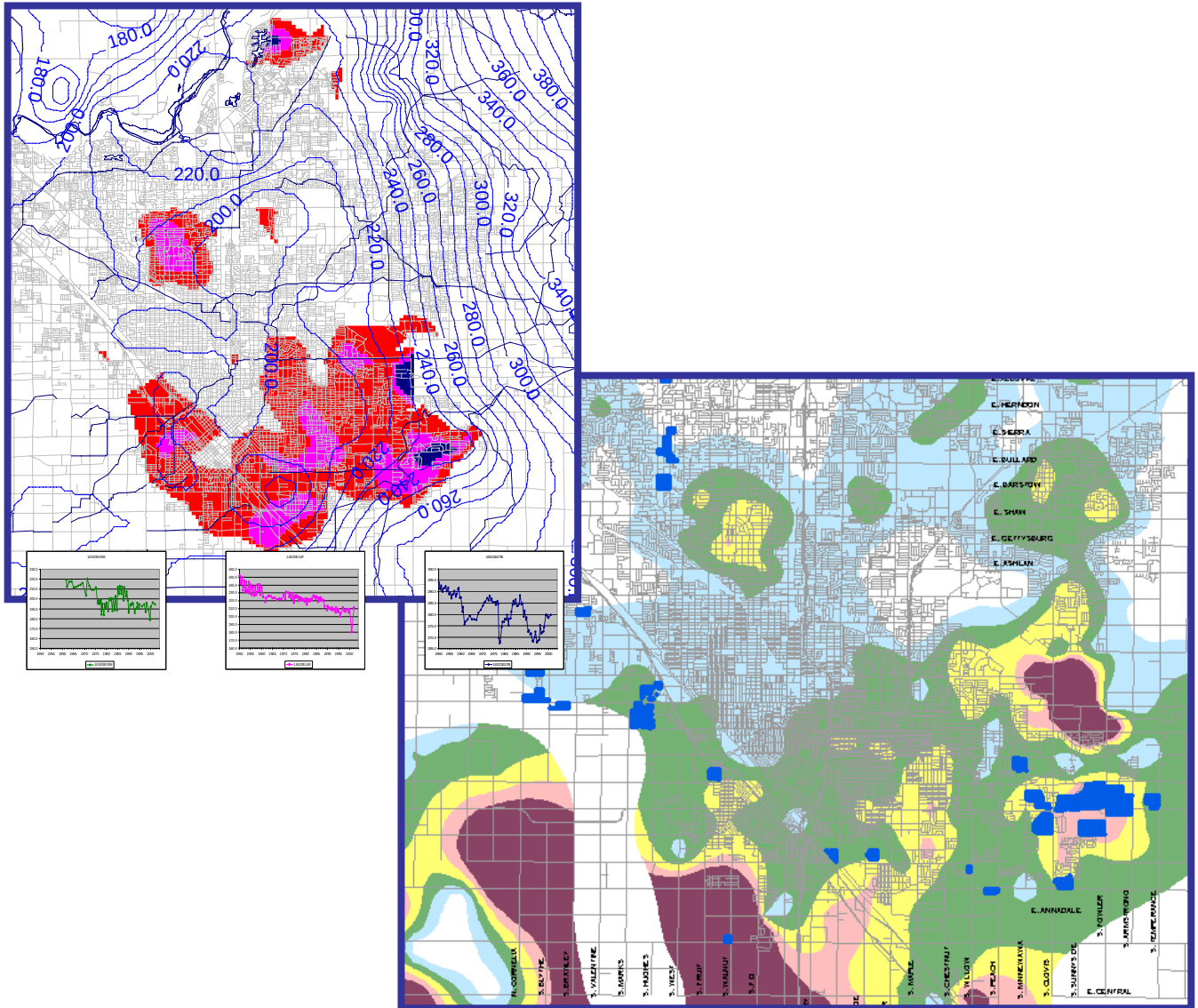




Water Division

Nitrate Management Plan



October 2006

BOYLE ENGINEERING CORPORATION

City of Fresno Nitrate Management Plan Report

City of Fresno

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October 2006

FR-F08-800-01
15945.00

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Section 1

Introduction

This section presents a brief background of the City of Fresno issues associated with nitrates in the groundwater, discusses the need for this Nitrate Management Plan, describes the objectives of the study, provides a brief description of the scope of work, and outlines the report organization.

1.1 Background

Over the past several decades there has been a significant increase in nitrate concentrations in the groundwater at various locations in the Fresno Metropolitan Area (FMA). This fact has been demonstrated in several studies and reports over the past several years. Nitrate discharges (or other forms of nitrogen that subsequently convert to nitrate in the soil) from a variety of sources have cumulatively resulted in substantial damage to the City of Fresno's (City) groundwater resource. Over time, nitrate (NO_3) concentrations in the aquifers under Fresno have varied, increasing in some locations while decreasing in other areas as influences such as increased or decreased nitrogen loading or increased groundwater recharge. Some wells within the FMA exceed the EPA maximum permissible contaminant level (MCL) of 45 milligrams per liter (mg/L). To deal with this, the City has removed from service a number wells (13 as of early 2004) with elevated nitrate concentrations, treated some by blending with other sources of groundwater, and treated two with ion-exchange wellhead treatment systems. All of these actions have been necessary to meet peak water demand within the City.

With the intent of adopting policies, programs, and projects to protect and preserve the groundwater for its highest and best use, the City retained Boyle Engineering Corporation (Boyle) to prepare a Nitrate Management Plan. In general, the scope of the Nitrate Management Plan was to investigate and tentatively identify past and present dischargers generating nitrate or total nitrogen loading high enough to pose significant adverse cumulative impact to the aquifers under the FMA. Boyle subcontracted a portion of the work to Kenneth D. Schmidt and Associates (Schmidt) and to Geomatrix Consultants, Inc (Geomatrix). The Boyle/Schmidt/Geomatrix Team (Team) worked together to conduct the various phases of the work required to develop the Nitrate Management Plan.

The City's primary objectives in the Nitrate Management Plan are:

1. Generally determine sources of nitrates in the FMA.
2. Identify significant ongoing releases of total nitrogen that could convert to nitrate concentrations exceeding 40 mg/L.
3. Determine, as apparent from available data, current and long-term septic tank nitrogen contribution trends and other selected constituents.
4. Project short- and long-term implications of continued nitrogen releases.
5. Identify and assess alternative nitrate management approaches.

6. Identify the preferred alternative(s) for nitrate management.
7. Implement recommended policies, programs, and projects, as appropriate.

The Boyle/Schmidt/Geomatrix work in developing the Nitrate Management Plan was divided in two major phases, each consisting of several tasks. Phase I primarily consisted of collection and review of groundwater data, identification of past and present major sources of nitrate in the groundwater, development of GIS mapping with an integrated data management system, and a hydrogeologic report summarizing the Phase I work.

The focus of the Phase II work was to identify and compare viable alternatives for management of nitrates in the groundwater and, with City staff concurrence, develop a preferred Nitrate Management Plan that provided a prioritized list of projects that could be implemented to either increase the amount of groundwater resources available or to decrease the amount of nitrate in the groundwater.

The general division of the Nitrate Management Plan work among the Team was as follows:

- Boyle provided overall project management, developed the nitrate management alternatives, and prepared the project technical memoranda and final report.
- Schmidt assisted with the collection of groundwater data, prepared the hydrogeologic report, and provided quality control review of the technical memoranda.
- Geomatrix developed the GIS mapping and integrated data management system. The various figures throughout the hydrogeologic report, technical memoranda, and this final report are a result of the Geomatrix work.

1.2 Authorization

The City of Fresno, recognizing the impacts that nitrates have had on the groundwater and the need to develop projects that can be implemented and policies for dealing with present and future nitrates, authorized Boyle, with the assistance of Kenneth D. Schmidt & Associates, and Geomatrix, to prepare this Nitrate Management Plan.

1.3 Study Scope

As indicated above, the work was divided into two major phases, each with individual tasks needed to complete the study. A brief summary of the scope by phases and tasks is listed below. Later sections of this report provide a more thorough discussion of the work accomplished along with the resulting findings and recommendations.

1.3.1 Phase I – Data Gathering and Evaluation of Existing Nitrates in the Groundwater

The Phase I work consisted primarily of gathering data and its analysis. The results of Phase I were then used to develop solutions to manage and/or mitigate the contaminated groundwater under Phase II. Phase I consisted of three major tasks described below.

1.3.1.1 Task 100 - Compile and Review Existing Data and Prepare GIS Mapping and Data Base

Boyle, with the assistance of Schmidt and Geomatrix, compiled and reviewed available previous studies conducted on the nitrate in groundwater in the Fresno urban area, compiling groundwater elevation and chemistry data, reviewing available information on past and existing high-nitrate dischargers.

A number of previous studies have been conducted on nitrate in groundwater of the Fresno urban area. These previous studies and their findings are detailed in Section 2.1 of this report.

Boyle also worked with the City and other agencies to compile groundwater elevations and groundwater chemistry data. The sources of this data and its use in this study are also detailed in Section 2.1.

This task also included sampling of 20 to 30 of the City's shallow groundwater monitor wells for nitrogen isotope differentiation testing. The isotope test data was evaluated to determine if the predominate source(s) of the prevalent nitrates are animal or non-animal.

Geographic Information System (GIS) mapping was developed for the project. GIS mapping is a system of computer mapping software that integrates the collection, management, and analysis of geographic data. The GIS mapping can be used to display the results of data queries as graphic maps and to analyze spatial distribution of whatever type of data is being considered. In the case of this Nitrate Management Plan, the GIS mapping was used to display historic and current chemical data, groundwater information (such as groundwater contours and flow directions), the sources of nitrate to groundwater, and potential components of engineering solutions to manage or mitigate the groundwater contamination. The GIS maps also showed the location of the City's monitoring wells, production wells, and water distribution system as a series of layers (known as shape files).

The groundwater elevation and chemistry data received from the City and others was then incorporated into a data management system compatible with the City's existing system(s). The data management system is a relational database, Microsoft Access. The data was then geo-referenced to the GIS mapping described above and included monitoring and supply well construction, groundwater water level, and groundwater quality data (for nitrate and other constituents) for the FMA. The data management system contained data querying tools and customized tools to create hydrographs and time-concentration plots for selected constituents.

This work task culminated with a workshop with City staff. The workshop included a presentation of the data gathering activities, the GIS mapping, and the data management system.

1.3.1.2 Task 200 – Data Evaluation

The GIS mapping and database prepared under Task 100 for the FMA was then used to evaluate the current nature and extent of nitrate (and other constituents as necessary) in groundwater, identify data gaps, and identify potential future area of impact from nitrates in groundwater. Using trend analysis and GIS spatial distribution maps, the lateral and vertical extent of nitrate

in groundwater was estimated. Sources and potential sources of nitrate in groundwater were also reviewed for correlation with known high-nitrate areas. In addition, estimates of groundwater gradient and aquifer properties and the present distribution of nitrate in groundwater were utilized to identify potential future areas of impact due to the migration of nitrate in groundwater.

Areas with insufficient water quality data (data gaps) were identified during the evaluation of the preliminary data. Identified data gaps were reviewed with the City and additional data was collected as needed and incorporated into the data management system and GIS mapping

The groundwater data were evaluated generally with respect to the issues described below.

- **Lateral Nitrate Distribution in Groundwater.** Multiple maps were prepared showing the distribution of nitrate and nitrate concentrations in the FMA, each representing groundwater conditions at a different depth. Past studies have shown a relation between permeable topsoils and high nitrate, and, thus, soil maps were also reviewed and compared to the nitrate distribution in the shallow groundwater.
- **Vertical Nitrate Distribution in Groundwater.** Subsurface geologic conditions highly control the vertical distribution of nitrate in groundwater in the FMA. A number of subsurface geologic cross sections were developed and the nitrate results from shallow and deep wells, nested monitoring wells, and test holes and test wells were plotted on these sections to show the vertical distribution of nitrate in groundwater.
- **Changes in Nitrate Concentrations with Time.** Time-concentration plots of nitrate in groundwater were prepared for pertinent wells in the FMA. These plots were used to assess the lateral and vertical transport (and attenuation) of nitrate in groundwater with time. Two important factors that influence time trends for nitrate are: 1) water-level changes, and 2) changes in well construction. Both of these factors were evaluated in the study area.
- **Sources of Nitrate in Groundwater.** Sources of high-nitrate concentrations in shallow groundwater of the Fresno area have been examined in a number of reports dating back to the mid 1960s. Information on former wastewater treatment facilities, unsewered areas relying on septic tanks, and industrial waste disposal sites are discussed in these reports. The most significant nitrate sources were identified and their estimated impact on the nitrate concentrations in groundwater beneath these areas was addressed.
- **Well Construction.** Factors, such as depth to the shallowest perforation, extent of the annular seal, and total depth of the well, have been shown by previous studies to be important in terms of nitrate concentrations, nitrate distribution vertically, and possible future mitigation of nitrate in groundwater. A preliminary evaluation was done to determine the potential for well deepening and for well replacement (by deeper wells) as a potential mitigation measure in specific areas and for specific wells.

1.3.1.3 Task 300 - Hydrogeologic Report

Kenneth D. Schmidt & Associates (Schmidt) then prepared a hydrogeologic report, summarizing the results of the Phase I evaluation performed in Tasks 100 and 200. The report summarized the data collected, the estimated vertical and lateral extent of nitrate in groundwater, identification of sources and potential sources of nitrate to groundwater, and estimation of potential future areas of impact. A copy of the Schmidt hydrogeologic report is included in Appendix A.

1.3.2 Phase II – Nitrate Management Plan Development

Phase II of the study primarily involved the development of projects and policies that, taken together, will comprise the City of Fresno Nitrate Management Plan. Phase II tasks are described below.

1.3.2.1 Task 400 - Develop and Evaluate Nitrate Management Alternatives

Using the information obtained in Phase I, a number of alternatives for management of nitrates were developed to a point where they could be equitably compared on a cost/benefit basis. Alternatives evaluated included those described below.

- Minimizing or eliminating sources of nitrate to reduce further degradation of the aquifer. This alternative included options such as changing operational practices, elimination of septic systems, cleanup of known discharges, etc.
- Extraction of nitrate-laden groundwater, treating or blending (with lower nitrate sources) the nitrate, and using the water for municipal supply. This method provides for the highest use of the water (drinking water) but could require the highest cost both for capital installations and for operations if only treatment is considered.
- Extraction of nitrate-laden groundwater and using it for irrigation. This alternative evaluated the possibility of delivering some high-nitrate water for irrigation (agricultural and/or large turf applications) with the potential for receiving low-nitrate surface water in exchange that would in turn be percolated or treated to drinking water standards.
- Aquifer Storage and Recovery Systems (ASR) was examined on a cursory basis as it may have utility in managing high nitrates.
- Managing existing nitrate plumes by deliberate upgradient recharge and/or extraction to limit migration of high-nitrate groundwater within the FMA.
- Constructing additional wells may be feasible to offset those wells that have already been lost to high-nitrate concentrations. This management alternative also includes well fields outside of the high-nitrate areas so that lower-nitrate water could be delivered to existing high-nitrate areas. Such supplies could be used for blending with high-nitrate supplies or to replace local supplies exceeding the nitrate MCL.

Boyle prepared a Task 400 Technical Memorandum (TM) that developed several alternatives and combinations of alternatives as projects. The projects were assessed to compare costs, benefits and ability to be implemented.

1.3.2.2 Task 500 – Comparison of Nitrate Management Alternative Projects

After evaluating the alternative projects developed in Task 400, a matrix was prepared as a comparison tool. The matrix included the comparison criteria listed below.

- Capital cost
- Positive groundwater impact
- Ease of implementation
- Cost effectiveness
- Implementation time
- Nitrate management effectiveness

The effect of the matrix and associated comparison criteria was to rate each alternative project for the amount of nitrate eliminated, the amount of water produced, the amount of groundwater recovered, the anticipated residual disposal impacts, and the expected overall cost. The purpose of the matrix is to constitute the basis for preparation and furthering of recommendations to the City concerning the apparent best methods of dealing with the nitrate contamination.

Boyle prepared a Task 500 Technical Memorandum describing the comparison criteria, the matrix, and the resulting project ranking.

Dr. Kenneth D. Schmidt reviewed both Task 400 and Task 500 Technical Memoranda and his comments were incorporated into this final report. Dr. Schmidt also offered suggested alternative nitrate plume management/remediation projects that were reviewed with City staff and are described in a conceptual manner in Section 5 of this report.

1.4 Organization of the Nitrate Management Plan Report

This Nitrate Management Plan report is organized in six sections, followed by appendices that provide more detailed information when needed and supporting documentation for the results and recommendations of this study. The six sections are briefly described below.

Section 1 – Introduction presents a brief background of the City’s problem with high-nitrate concentrations in the groundwater, discusses the need for this Nitrate Management Plan, and provides a summary of the study scope. A list of abbreviations is also provided to assist the reader in understanding the information presented in this report.

Section 2 – Compilation of Data and Hydrogeologic Study provides an overview of the data gathering activities, the GIS mapping and data management system, and a synopsis of the report entitled, “Distribution and Sources of Nitrate in Groundwater in and Near the City of Fresno” prepared by Kenneth D. Schmidt & Associates. As noted above, the Schmidt hydrogeologic report is included in Appendix A.

Section 3 – Nitrate Management Alternatives describes a number of alternative projects that could be implemented for management of nitrates. This section summarizes the Task 400 TM work.

Section 4 – Comparison of Nitrate Management Projects describes the methods and logic used to compare the nitrate management projects developed in Task 400. This section summarizes the Task 500 TM work.

Section 5 – Plume Management Alternative Projects provides general descriptions of projects that could be instituted to manage two of the most critical known nitrate plumes within the FMA: 1) the Sunnyside area and 2) the area generally along Clovis Avenue between Belmont and McKinley Avenues. These projects are presented as conceptual projects that could provide the City with the ability to manage these nitrate plumes if other projects prove to be not politically or financially feasible.

Section 6 – Nitrate Management Plan Recommendations and Policies outlines the recommendations that are a result of this study and provide potential policies that may be adopted by the City, if desired.

1.5 Acknowledgements

Boyle wishes to acknowledge and thank Martin McIntyre, Former Director of Public Utilities; Patrick Weimiller, Former Interim Director of Public Utilities; Rene Ramirez, Assistant Director of Public Utilities; Lon Martin, Water Division Manager; and Brock Buche, Water Division Professional Engineer for their assistance in this study. Boyle also wishes to acknowledge the cooperation of the City of Clovis, the Bakman Water Company, the Fresno County Environmental Health Department, Malaga Community Water District, the Regional Water Quality Control Board (RWQCB), and others. Their cooperation and courtesy in obtaining the variety of necessary data and providing input to the study were invaluable components in completing this Nitrate Management Plan.

1.6 Boyle Project Staff

The following Boyle staff members were involved in the preparation of this Nitrate Management Plan:

Project Manager: Mark A. Ysusi, PE

Project Engineers: Henry Liang, PE
Doug Lade, EIT

1.7 Abbreviations and Definitions

To conserve space and to improve readability, the following abbreviations are used in this report.

AFY	acre-feet per year
Bakman	Bakman Water Company
CEQA	California Environmental Quality Act
City	City of Fresno
Clovis	City of Clovis
County	County of Fresno
CVP	Central Valley Project
DHS	California Department of Health Services, Office of Drinking Water
DWR	California Department of Water Resources
EPA	U.S. Environmental Protection Agency
FID	Fresno Irrigation District
FMA	Fresno Metropolitan Area
FMFCD	Fresno Metropolitan Flood Control District
GIS	Geographical Information System
gpm	gallons per minute
MCL	maximum contaminant level
MG	million gallons
mgd	million gallons per day
mg/L	milligrams per liter
TM	Technical memorandum
WRMP	Fresno/Clovis Metropolitan Water Resources Management Plan
WTP	water treatment plant

Section 2

Compilation of Data and Hydrogeologic Study

This section provides a summary of the data gathering activities and the hydrogeologic report prepared by Kenneth D. Schmidt & Associates.

2.1 Compilation of Existing Data and Data Management System

Boyle, with the assistance of Schmidt and Geomatrix, compiled and reviewed available previous studies conducted on the nitrate in groundwater in the Fresno urban area, compiled groundwater elevation and chemistry data, and reviewed available information on past and existing high-nitrate dischargers.

A number of previous studies have been conducted on nitrate in groundwater of the Fresno urban area. These studies include but are not limited to the following:

- California Department of Water Resources, “Fresno-Clovis Metropolitan Area Water Quality Investigation” (1965).
- K. D. Schmidt Dissertation, “Distribution of Nitrate in Groundwater in Fresno-Clovis Metropolitan Area” (1971).
- 208 Non-point Source Water Quality Report for County of Fresno and Other Entities (1978).
- 205J Non-point Source Water Quality Report for County of Fresno and Other Entities (1986).
- City of Fresno/Clovis Water Resources Master Plan, Appendix B, Hydrogeology (1992).
- Numerous publications of the USDA Agricultural Research Service, particularly on the rural area east of Fresno (1960s, 1970s, and 1980s).

The above studies were reviewed to provide a baseline understanding of the sources and extent of nitrate in groundwater in the Fresno urban area. Boyle also worked with the City and other agencies to compile groundwater elevations and groundwater chemistry data. The sources of this data were:

- Fresno City supply wells, test holes and test wells, and nested monitor wells
- Bakman Water Co. supply wells, test holes, and test wells
- City of Clovis test wells and supply wells
- Selected private/public domestic wells (Fresno County Environmental Health)
- Malaga CWD supply wells, test holes, and test wells

- Selected private domestic wells (Fresno County Environmental Health);
- Monitoring wells for environmental and groundwater contamination sites (RWQCB).

RWQCB and Fresno County records were researched to identify past and existing potential dischargers of significant total nitrogen quantities. Potential dischargers, both past and present, of significant amounts of total nitrogen include:

- Septic tanks in the FMA
- Wineries, tanneries, and food processors
- Certain major farming and/or other agricultural operations including confined animal operations
- Agricultural chemical formulating plants

Estimates of septic tank flow and nitrogen application in large turf areas such as golf courses were made.

Twenty to thirty of the City's shallow groundwater monitor wells were sampled for nitrogen isotope differentiation testing. The isotope test data was evaluated to determine if the predominant source(s) of the prevalent nitrates are animal or non-animal; however, the isotope tests were inconclusive and not used as part of this study.

As explained in the previous section, GIS mapping was developed for the project. GIS mapping is a system of computer mapping software that integrates the collection, management and analysis of geographic data. The GIS mapping can be used to display the results of data queries as graphic maps and to analyze spatial distribution of whatever type of data is being considered. In the case of this Nitrate Management Plan, the GIS mapping was used to display historic and current chemical data, groundwater information (such as groundwater contours and flow directions), the sources of nitrate to groundwater, and potential components of engineering solutions to manage or mitigate the groundwater contamination. The GIS maps also showed the location of the City's monitoring wells, production wells, and water distribution system as a series of layers (known as shape files). The nitrate and groundwater data incorporated into the GIS mapping and data management system covered a time period of approximately the last four decades.

The groundwater elevation and chemistry data received from the City and others was then incorporated into a data management system compatible with the City's existing system(s). The data management system is a relational database, Microsoft Access. The data was then geo-referenced to the GIS mapping described above and included monitoring and supply well construction, groundwater water level, and groundwater quality data (for nitrate and other constituents) for the FMA. The data management system contained data querying tools and customized tools to create hydrographs and time-concentration plots for selected constituents.

The project study GIS mapping and data management system were delivered to the City for their use and maintenance. If kept current, the GIS mapping and data management system will be a very

helpful tool in determining both short and long-term effectiveness of various nitrate management alternatives.

2.2 Hydrogeologic Study

2.2.1 Overview

Using the data previously collected, Kenneth D. Schmidt and Associates (Schmidt) prepared a hydrogeologic report detailing the past and present status of nitrates in the groundwater under the Fresno Metropolitan Area. The graphics contained in the Schmidt report were developed using the project GIS mapping and data management system. The Schmidt report addresses available nitrate data over the last four decades and presents the hydrogeologic data as follows:

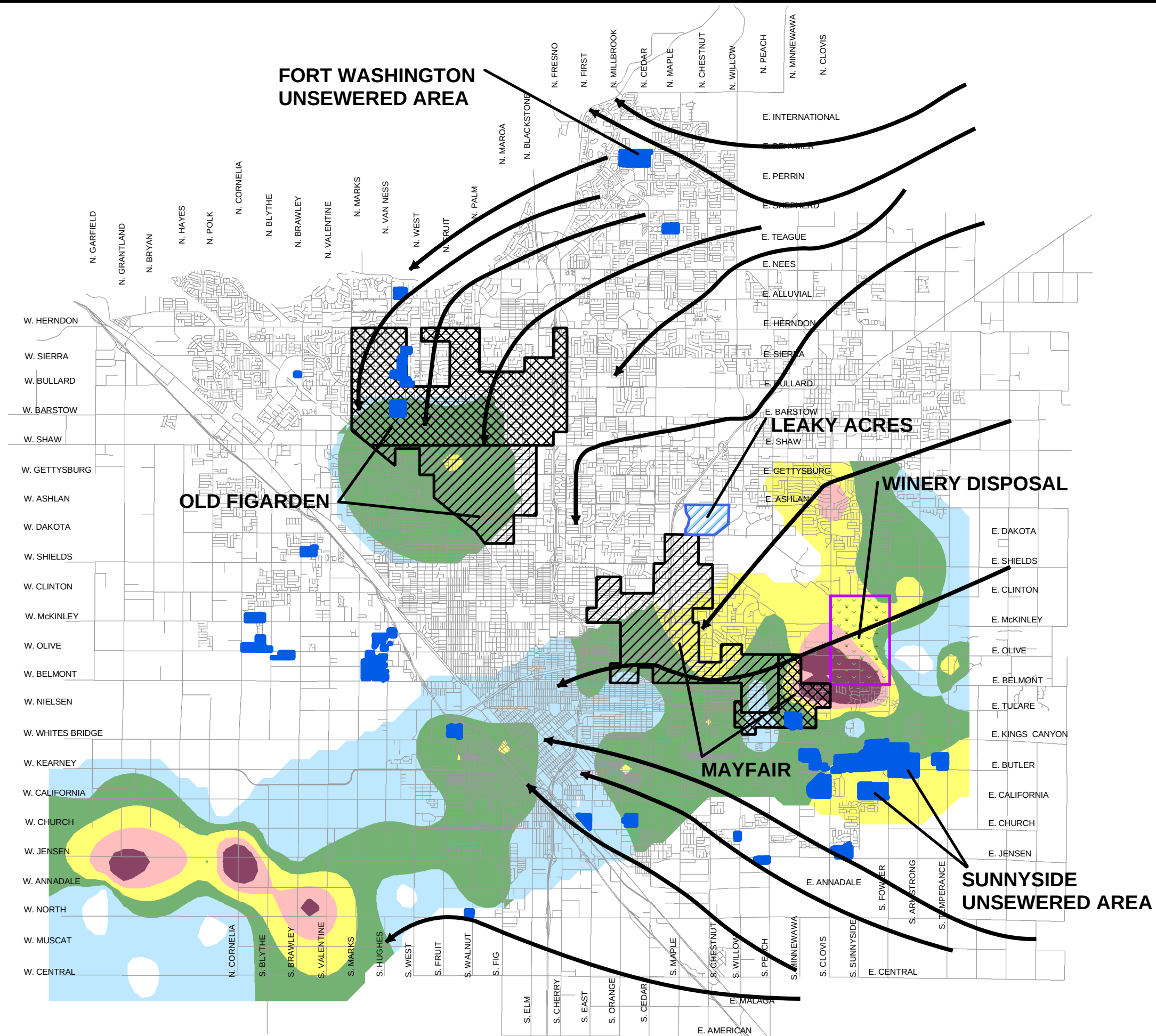
- To promote a clear understanding of groundwater movement and quality in the Fresno area, the hydrogeologic framework is first discussed including subsurface geologic conditions, water levels, aquifer characteristics, and sources of recharge and discharge.
- Potential sources of nitrate in groundwater beneath the City are presented. Information on nitrate sources over the past three decades is also detailed.
- The historic geographic and vertical distribution of nitrate in the groundwater is then documented.
- Known time trends for nitrate in well water in the FMA are presented and interpreted.
- The report then divides the FMA into six subareas with significant nitrate concentrations that are discussed in more detail. The six subareas are:
 - Old Figarden
 - Fresno North Growth Area
 - South and east of Fresno Air Terminal (including Mayfair)
 - Sunnyside
 - Calwa-Malaga
 - Southwest Area
- Finally, recommended enhanced well construction practices are described in detail.

2.2.2 Key Report Findings and Conclusions

The Schmidt hydrogeologic report notes a number of key findings that offer significant insight into the development of both short- and long-term elements of a nitrate management plan. The historical groundwater nitrate concentration mapping data, coupled with the identification of significant sources of nitrate provide examples of observed increases of nitrate concentrations over a period of years in an area and then, in some cases, reduction of the nitrate concentrations following remedial actions.

Figures 2-1, 2-2, and 2-3 on the following pages are modifications of Figures 10, 11, and 12 of the Schmidt report that illustrate the variation of groundwater nitrate concentration between the years of 1968 to 2004. Major sources of nitrate identified in the Schmidt report, such as unsewered areas,

V:\F0880001\CAD\DESIGN\GIS\Nitrates\Plumes-FIG-2-1.mxd



Legend

Year Sewered

- Old Figarden 70-75
- Old Figarden 75-80
- Mayfair 70-75
- Mayfair 75-80
- Winery Disposal
- Leaky Acres

1968-77 Nitrate Concentrations

- No data
- 10-20 mg/L
- 20-30 mg/L
- 30-40 mg/L
- 40-50 mg/L
- >50 mg/L
- Unsewered Residential Area
- General Direction of Groundwater Flow

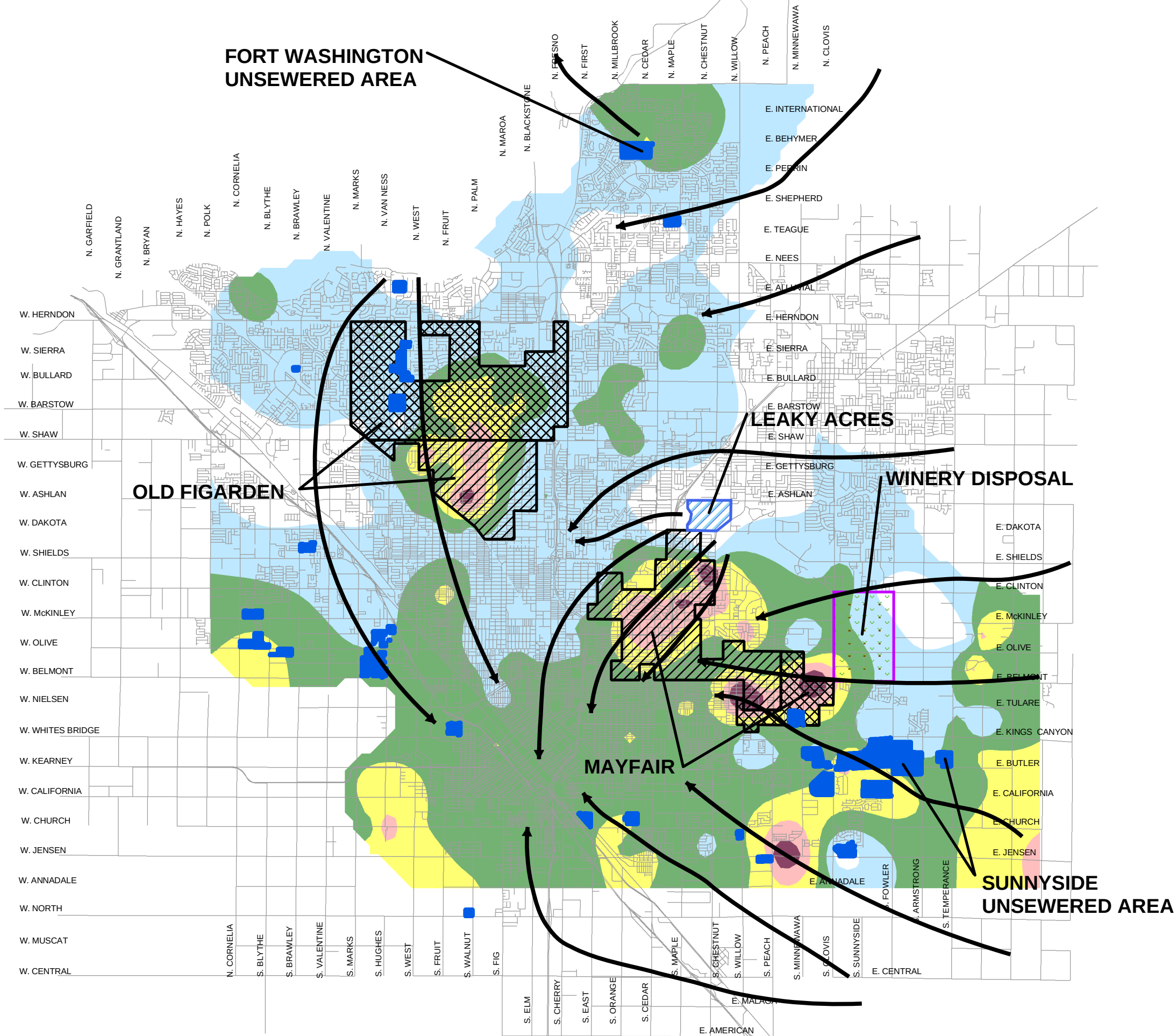
0 0.5 1 2 3 Miles

City of Fresno
1968-1977 Nitrate Concentrations

DATE 2/06	FIGURE 2-1	PROJECT NO. F0880001
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Boyle Engineering Corporation

V:\F08180001\CAD\DESIGN\GIS\Nitrate Plumes_1980-FIG-2-2.mxd



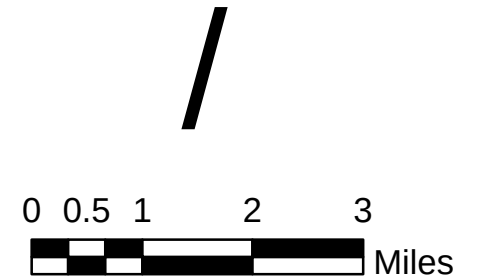
Legend

Year Sewered

- Old Figarden 70-75
- Old Figarden 75-80
- Mayfair 70-75
- Mayfair 75-80

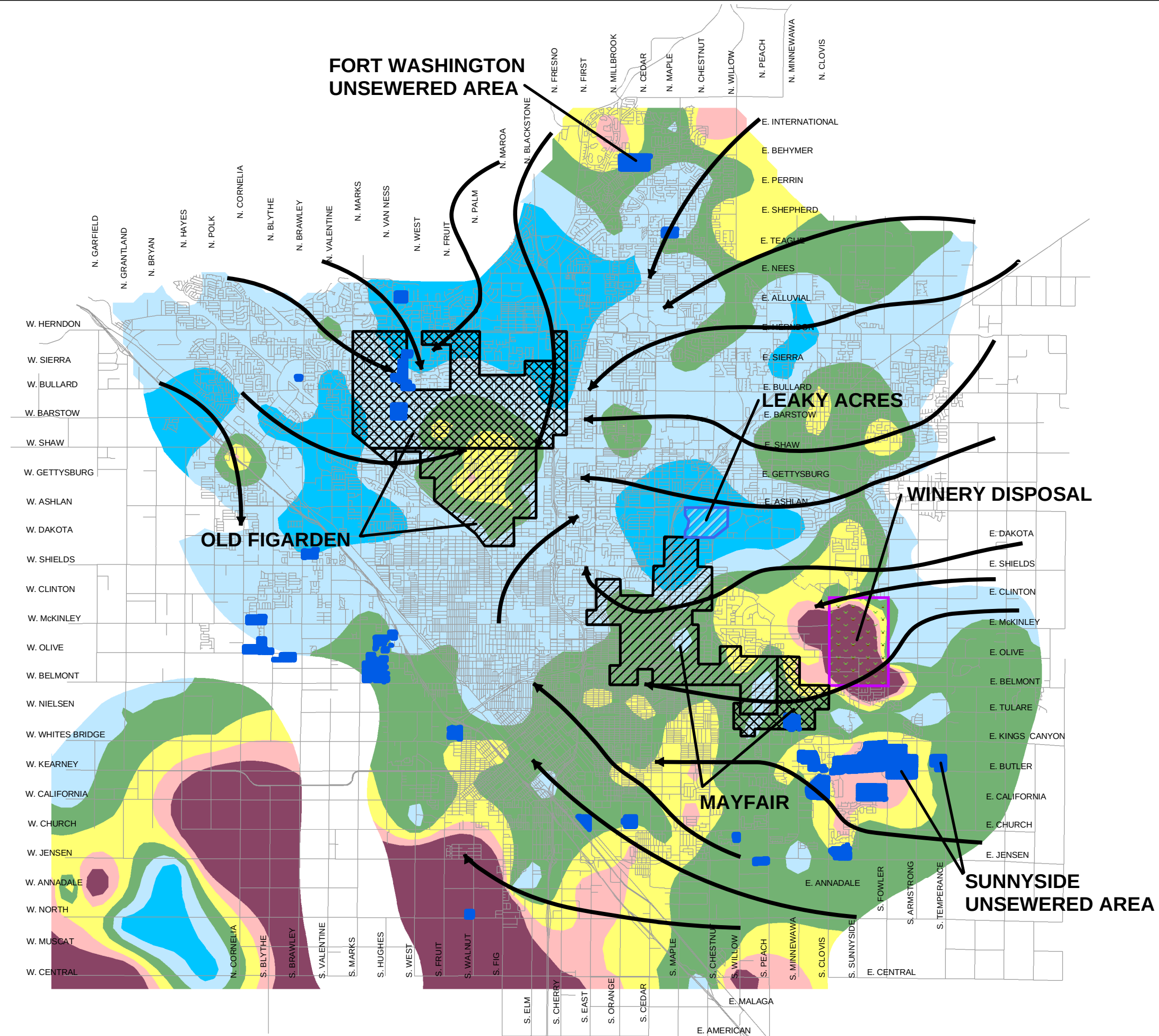
Mid 80s Nitrate Concentrations

- No data
- 10-20 mg/L
- 20-30 mg/L
- 30-40 mg/L
- 40-50 mg/L
- >50 mg/L
- Winery Disposal
- Leaky Acres
- Unsewered Residential Area
- General Direction of Groundwater Flow



City of Fresno Mid 80s Nitrate Concentrations		
DATE 2/06	FIGURE 2-2	PROJECT NO. F0880001
Boyle Engineering Corporation		

V:\F0800001\CAD\DESIGN\GIS\Nitrates Plumes_2000-FIG-2-3.mxd



have been added to these figures to show the effects that the contributing areas have on the downgradient groundwater. Of particular note are the Old Figarden (formerly unsewered), Mayfair (formerly unsewered), Sunnyside (much of which remains unsewered), and Fort Washington (remains unsewered) areas and the area along Clovis Avenue between Belmont and McKinley. The areas of highest groundwater nitrate concentration in the vicinity of the unsewered areas from 1968 to 1977 are clearly illustrated in Figure 2-1. Figure 2-2 shows the lingering results of the formerly unsewered areas even though both the Old Figarden and Mayfair areas had been sewered during the 1970s. Figure 2-2 also illustrates the sharply increasing nitrate concentrations beneath and downgradient of the Sunnyside area and the area along Clovis Avenue between Belmont and McKinley and increasing concentrations downgradient from the Fort Washington area. The effects of sewerage the Old Figarden and Mayfair areas, however, are shown clearly in Figure 2-3. Though still elevated, the nitrate concentrations downgradient of the Old Figarden area are reduced, and the nitrate concentrations downgradient of the Mayfair area are significantly reduced. As indicated in the Schmidt hydrogeologic report, the more marked reduction downgradient from Mayfair than Old Figarden is largely attributable to the commencement of direct recharge activities at Leaky Acres in 1970. The groundwater concentrations beneath portions of the Mayfair area reached their highest nitrate levels in the mid-1980s of between 40 and 50 mg/L and by the early 2000s were reduced to 20 to 30 mg/L.

Figures 2-1, 2-2, and 2-3 also clearly indicate the continued elevated nitrate concentrations beneath and downgradient of the Sunnyside and Fort Washington areas that remain unsewered. Figure 2-3 particularly illustrates that both these areas and the area along Clovis Avenue between Belmont and McKinley are continuing sources of nitrates into the FMA groundwater.

The Schmidt hydrogeologic report and review of Figures 2-1, 2-2, and 2-3 lead to conclusions that were used to guide the development of alternative nitrate management projects. Significant conclusions include the following:

- Removing the source of the nitrate has been shown to reduce the concentrations of nitrate in the groundwater beneath and downgradient of the source. While this may seem to be an obvious conclusion, it is presented as an alternative to continuing to allow the source of nitrate to contribute to the elevated nitrate concentrations in the groundwater and either treating the nitrate or removing it by some other method. It is also presented as an alternative since it has consistently been shown (as described above) to be a very effective method of reducing groundwater nitrate contamination. The most obvious remaining sources of nitrate groundwater beneath the FMA are the unsewered areas of Sunnyside and Fort Washington and the area along Clovis Avenue between Belmont and McKinley. Removing these three sources will require sewerage the Sunnyside and Fort Washington areas and affecting a cessation of the nitrate contributions in the area along Clovis Avenue between Belmont and McKinley.
- As demonstrated by the rapid improvement in the groundwater downgradient from the Mayfair area, recovery of the groundwater is accelerated when there is also an upgradient source of intentional recharge of surface water. According to Schmidt, the rapid improvement in the Mayfair area has most likely been assisted by the Leaky Acres recharge activities that began in 1970.

- It may be possible to drill new City wells in high-nitrate areas that produce acceptable nitrate concentrations if they are done carefully, following the procedures outlined in the Schmidt report. This means that the construction of new production wells should be part of the alternative considered.

Section 3

Nitrate Management Alternatives

This section describes a number of alternative projects that could be implemented for management of nitrate in the groundwater beneath the FMA, provides estimates of their respective costs, and provides sufficient detail as the basis for later detailed comparison of the alternatives. It is critical to note that the Schmidt hydrogeologic study findings and conclusions guided the development of alternatives for management of nitrates.

Some of the projects included in the list of alternative projects will require the cooperation of other agencies such as the Fresno Irrigation District (FID) and the Fresno Metropolitan Flood Control District (FMFCD).

3.1 Alternative Projects Requiring Other Agency Cooperation

3.1.1 Fresno Irrigation District

As a part of this study, City of Fresno Water Division staff and Boyle met with FID staff to discuss alternative projects that could have the potential of being a part of a plan to manage nitrate in the groundwater. Projects were discussed generically, but the principal type of project discussed was the diversion of FID surface water from one or more of their canals into percolation basins in exchange for an equal amount of groundwater containing nitrate concentrations above the drinking water standard pumped by the City into an FID canal. This could be accomplished using existing City wells with nitrate in the water above the nitrate standard if the pump is set up to accommodate the lower head and piping is installed to deliver the pumped groundwater to the FID canal.

FID indicated their willingness to cooperate with this type of project. The alternative projects presented in this section include the potential for pumping groundwater to FID canals.

3.1.2 Fresno Metropolitan Flood Control District

The City of Fresno and FMFCD have an ongoing cooperative practice of using FMFCD basins for recharge of surface water during the annual dry period if the basins have good percolation characteristics. Delivery of the surface water to these basins is normally from nearby FID canals. Strategic placement of surface water in FMFCD basins with high percolation characteristics upgradient of areas of high-nitrate concentrations in the groundwater have the potential of the overall reduction of the nitrate, particularly if done in concert with a downgradient project to pump high-nitrate groundwater into an FID canal. This is clearly demonstrated by the Mayfair/Leaky Acres combination of actions.

The alternative projects presented in this section include the use of existing FMFCD basins with high percolation characteristics. Planned basins are also included in some alternatives.

3.2 Budgeted City Projects

As part of the normal budgetary process, the City has budgeted for a number of projects to be constructed in the near future that are specifically aimed at being a part of both short- and long-term management of nitrates in the groundwater. Currently budgeted projects are described below.

3.2.1 New Wells in the Southeast Area of Fresno

The Schmidt report indicated that new wells, following a careful test well procedure, and tested and generally sealed to deeper depths, might be an effective short-term nitrate management tool. The City has budgeted for two new wells of this type. They are included in the list of alternatives to be considered. The estimates for alternative projects involving new City wells all included the test well procedures outlined in the Schmidt hydrogeologic report.

3.2.2 New Well at or Near Leaky Acres

This new well would supplement the well that was recently constructed near Leaky Acres and pumped into the 24-inch transmission main that carries groundwater from under Leaky Acres to the southeast portion of the City.

3.2.3 New Ground Storage Reservoirs

The City has identified two new ground storage reservoir projects that are planned for implementation, as funds are available. The two projects are listed below:

- A second reservoir (T-2) at the T-1 site identical to the existing reservoir is needed. The project would also include necessary booster pump improvements and additional piping.
- Additional storage is also needed in the vicinity of Temperance and Dakota Avenues. This second project would include a new 3-MG ground storage reservoir (T-3) and booster pumping station.

3.2.4 Transmission Main Improvements – Leaky Acres to Southeast Area

Critical improvements are needed to sections of the existing 24-inch transmission pipeline being fed from the Leaky Acres wells and transporting the water to the southeasterly portions of Fresno. This project would involve replacing (or installing parallel piping) specific sections of the pipeline where the flow is forced through fittings or sections of pipeline that are smaller than 24 inches, causing excessive velocities and high pressure loss.

3.2.5 40 Acres for Percolation and Future WTP Site

As already described, the long-term plan for management of nitrate in the groundwater beneath the City will most likely include percolation ponds located upgradient of high-nitrate areas, which would most strategically be located in the easterly portion of the FMA. This project would involve

the purchase of approximately 40 acres of land to be used for percolation and, at some time in the future, possibly for a second surface water treatment plant as a part of the City's overall plan for FMA water resources management.

3.3 Alternative Nitrate Management Projects

A summary of projects that have been identified as potential short- and long-term alternative nitrate management projects are detailed in Table 3-1. The alternative projects included those projects already identified and budgeted as well as those projects specifically developed as a result of this study.

Table 3-1
City of Fresno Nitrate Management Plan
Summary of Alternative Projects

Project No.	Description	Estimated Capital Cost
P-1	Construct sewers in the unsewered areas in the Sunnyside area and connect to the City collection system (estimated cost includes septic tank abandonment, sewer laterals, trunk mains, manholes, connection fees, assessment district engineering, design engineering, and construction management).	37,000,000
P-2	Construct sewers in the unsewered areas in the Fort Washington area and connect to the City collection system (estimated cost includes septic tank abandonment, sewer laterals, trunk mains, manholes, connection fees, assessment district engineering, design engineering, and construction management).	3,000,000
P-3	Construct a pipeline from FID Fancher Creek or Briggs Canal to planned basin BM for recharge. This project will lower the nitrate levels in PS 276, PS 223-1 and PS 223-2 as the percolated water reaches the groundwater. No return from City wells to FID canals is included in this project.	750,000
P-4	Construct pipeline from FID Fancher Creek to FMFCD basin BK. Refit PS 223-1 and 223-2 (currently off line due to high nitrates) to pump high-nitrate water to Fancher Creek <u>downstream</u> of the outlet to basin BK.	280,000
P-5	Construct pipeline from FID Fancher Creek to FMFCD basin BH. Refit PS 223-1 and 223-2 (currently off line due to high nitrates) to pump high-nitrate water to Fancher Creek <u>downstream</u> of the outlet to basin BH. This project is similar to P-4 but basin BH has better percolation characteristics than basin BK. The pipeline from the wells will be longer in this project than in project P-4.	1,100,000

Project No.	Description	Estimated Capital Cost
P-6	Construct pipeline from FID Fancher Creek to FMFCD basin BH. Refit PS 223-1 and 223-2 (currently off line due to high nitrates) to pump high-nitrate water to Fancher Creek <u>upstream</u> of the outlet to basin BH. This project is similar to P-5 but the high-nitrate water is returned upstream and diluted. The pipeline from the wells will be shorter in this project than in project P-5.	760,000
P-7	Construct pipeline from PS 295 to PS 294 (currently off line due to high nitrates) and blending facilities.	230,000
P-8	Construct ion exchange or membrane treatment facilities at PS 140 (currently off line due to high nitrates).	500,000
P-9	Construct a new, deeper well near PS 140 and blending facilities so that the production of the two wells can be combined. Projects P-8 and P-9 should be considered to be mutually exclusive.	400,000
P-10	Construct pipeline from PS 185 to Enterprise Canal <u>downstream</u> of WTP intake. This project may be coupled with other projects in other parts of the City for water exchange purposes with FID. The connection to the Enterprise Canal may be located upstream of the WTP intake if the City has constructed the pipeline from the Friant-Kern Canal to the WTP.	190,000
P-11	Refurbish PS 40A or construct new City well in the vicinity of PS 40A.	500,000
P-12	Construct a pipeline from FID Victoria West Branch Canal to FMFCD basin AL for recharge. No return from City wells to FID canals is included in this project.	130,000
P-13	Construct a pipeline from FID Central Canal to FMFCD basin AW2 for recharge. No return from City wells to FID canals is included in this project.	210,000
P-14	Construct a pipeline from FID Fanning Ditch to FMFCD basin FF for recharge. No return from City wells to FID canals is included in this project.	400,000
P-15	Construct a pipeline from FID Brawley Canal to FMFCD basin II1 for recharge. No return from City wells to FID canals is included in this project.	290,000
P-16	Construct a pipeline from FID Fresno Colony Canal to FMFCD basin LL for recharge. No return from City wells to FID canals is included in this project.	130,000
P-17	Construct a pipeline from FID Houghton Canal to FMFCD basin UU3 for recharge. No return from City wells to FID canals is included in this project.	350,000
P-18	Construct two new wells in the southeasterly portion of Fresno. These two new wells will be constructed as described above.	900,000
P-19	Construct new well near Leaky Acres.	300,000
P-20	Install necessary improvements along the 24-inch transmission pipeline from Leaky Acres to the southeasterly portion of Fresno. This project is necessary to make project P-18 more effective.	150,000

Project No.	Description	Estimated Capital Cost
P-21	Construct a second 2-MG reservoir at the T-1 site identical to the existing reservoir. The project would also include necessary booster pump improvements and additional piping.	3,000,000
P-22	Construct a new 2-MG steel reservoir, booster pumping station, and piping in the vicinity of Temperance and Dakota Avenues.	1,500,000
P-23	Install reservoir-mixing facilities at reservoir T-1.	60,000
P-24	Purchase 40 acres and construct a new percolation basin on a portion of the site. The site will ultimately be used for a new surface water treatment plant.	4,000,000
P-25	Construct membrane treatment facilities at PS 274.	600,000
P-26	Construct membrane treatment facilities at PS 276.	600,000
P-27	Construct one new well near PS 274 and PS 276 and blending facilities so that the production of all three wells can be combined. Project P-27 would replace P-25 and P-26. The advantage of P-27 being that the production of all three wells would be gained.	750,000
P-28	Construct a new, deeper well near PS 223 and blending facilities so that the production of PS 223-1, PS 223-2, and the new well can be combined. The advantage of this project being that the production of all three wells would be gained. This project should be considered mutually exclusive to projects P-4, P-5, and P-6 listed above.	400,000
P-29	Install a sleeve inside the well casing at PS 223-2 to reduce the nitrate concentration to a point where PS 223-2 could be blended with PS 223-1 so that the resulting production is below the nitrate MCL. Projects P-28 and P-29 should be considered mutually exclusive. Loss of some production at PS 223-2 can be expected but the resulting production of both PS 223-1 and PS 223-2 would be gained. This project should also be considered mutually exclusive to projects P-4, P-5, and P-6 listed above.	\$150,000
P-30	Abandon the well at PS 223-1 and drill a replacement well so that the production of the new well could be blended with PS 223-2 so that the resulting production is below the nitrate MCL. Projects P-28, P-29, and P-30 should be considered mutually exclusive. This project should also be considered mutually exclusive to projects P-4, P-5, and P-6 listed above.	400,000
P-31	Construct new, deeper well near PS-201 and blending facilities so that the production of both wells can be combined. This well was recently lost due to high nitrates and is a site with GAC vessels for DBCP and 1,1-DCE treatment. A successful new, deeper well will require that the geology contains an upper confining layer so that the contaminants in the upper aquifers are prevented from migrating downward. The advantage of this project being that the production of both wells would potentially be gained.	500,000

Project No.	Description	Estimated Capital Cost
P-32	Construct a new, deeper well near PS 152. The combined flows of both wells can then be pumped to T-1. This well was recently lost due to high nitrates and is a site with GAC vessels for DBCP treatment. A successful new, deeper well will require that the geology contains an upper confining layer so that contaminants in the upper aquifers are prevented from migrating downward.	500,000
P-33	Maintain aggressive use of Basins TT1, II1, KK, LL, II2, and GG for percolation to decrease nitrate concentrations in the southwest.	N/A
P-34	Increase use of Basin BZ for percolation to decrease nitrate concentrations near the unsewered Fort Washington area.	N/A
P-35	Purchase new 20-acre site for percolation in the southeast.	2,000,000

Section 4

Comparison of Nitrate Management Projects – Analysis Matrix

This section describes the methodology used to compare the alternative projects described in Section 3.

The alternative projects described in Table 3-1 differ with respect to their overall anticipated impacts and effectiveness in managing or remediating specific nitrate problem areas in the FMA. The primary purpose of this phase of the study was to develop a comparison matrix based on a balanced evaluation and comparison of the projects. The comparison matrix factors (described in greater detail below) used to evaluate the alternative projects were used to assess project characteristics against each other in order to establish a priority for implementation of the projects detailed in Table 3-1.

4.1 Comparison Characteristics

To promote consistency with previous water resources studies and work in the FMA, the criteria used for comparative evaluation of the alternative projects developed in Task 400 of the Nitrate Management Plan were based, as applicable, on the alternative evaluation criteria developed in the Fresno/Clovis Metropolitan Water Resources Management Plan (WRMP). Some criteria do not apply and were altered accordingly, but the WRMP evaluation criteria were used as a guideline. A discussion of the WRMP, its objectives, the alternative water supply plans considered and evaluated in the WRMP, and the applicability of the WRMP evaluation criteria to the Nitrate Management Plan follows.

4.2 Fresno/Clovis Metropolitan Water Resources Management Plan Background

In 1991, the City of Fresno, with the participation of the City of Clovis (Clovis), the Fresno Irrigation District (FID), the Fresno Metropolitan Flood Control District (FMFCD), and other interested stakeholders, initiated preparation of the Fresno/Clovis Metropolitan Water Resources Management Plan (WRMP). The purpose of the WRMP was to develop an effective and feasible plan for water supply in the FMA to the year 2050. The final WRMP Implementation document was adopted in 1994.

4.2.1 WRMP Objectives

The stated objectives of the WRMP were as listed below:

1. Develop a water supply that will adequately meet the projected water demands of the FMA and accommodate the future land-use decisions by the cities and county.

2. Provide for the protection of the groundwater aquifer from future degradation. (It should be noted that page 3-4 of the WRMP states, “The groundwater reservoir beneath the FCMA is an irreplaceable resource.”) This is not a completely correct characterization of the groundwater in that it is, in fact, replaceable by recharge, but the groundwater should be considered invaluable and protected accordingly.
3. Develop a WRMP that can be implemented.

Factors considered in the development of alternatives meeting the above objectives included water supply, aquifer protection (preventing the future loss of wells due to contamination), contaminant plume management, groundwater quality protection (controlling the quality of water entering the aquifer), and institutional requirements.

4.2.2 WRMP Alternatives

The three basic alternatives evaluated in the WRMP are described below:

1. Alternative 1 – All supply from wells; surface water used only for groundwater recharge.
2. Alternative 2 – Highest direct surface water use, with one large regional surface water treatment plant.
3. Alternative 3 – Use of groundwater and surface water, with two smaller treatment plants.

From a water supply perspective, the alternatives differed primarily in the way surface water would be used, amount of groundwater used, degree of wellhead treatment required, and amount of urban intentional recharge that would be involved. All three of the alternatives provided groundwater recharge in excess of the amount required to achieve a groundwater balance. The excess recharge was to be for groundwater level restoration and drought contingency storage. All three alternatives relied heavily on flood control basins for aquifer recharge.

Required improvements were conceptually laid out and sized in the WRMP for each alternative to accomplish the overall objectives of the WRMP. Only major facilities were identified and in “very general terms.” Further descriptions of the three alternatives are briefly detailed in the following paragraphs.

Alternative 1. The Alternative 1 facilities included pipelines to serve the northeastern and southwestern areas in the near term. This alternative utilized the concept of a “northwestern wellfield,” which was speculated to consist of dispersed wells throughout northwestern Fresno with capacities in excess of local demands. The dispersed wells would be connected to the pipe grid that would carry the excess water to large-diameter pipelines leading to the northeast and southwest. This alternative included a pipeline to the southwest that was to serve the then fast-growing area of poor groundwater quality. It also included a pipeline to serve the then fast-growing areas of Woodward Park and northeastern Clovis. With this alternative, the remaining areas of the FMA would be served by local wells with and without wellhead treatment.

Alternative 2. A major surface water treatment plant in the northeast formed the cornerstone of this alternative with large transmission mains to distribute water to groundwater-short northeastern Fresno and Clovis and the eastern edge of the FMA to offset the need for wellhead treatment in the

most contaminant-impacted areas of the FMA. The raw water source for the surface water treatment plant was assumed to be the Fresno Irrigation District Enterprise Canal with an optional direct connection to the Friant-Kern Canal. This alternative included transmission mains to carry treated water to the then-existing Pinedale plume and the southwestern DBCP plume area.

Alternative 3. Alternative 3 adopted the concept of localized supply. Two smaller surface water treatment plants were included in this plan. One surface water treatment plant was to be located in the northeast, along the Enterprise Canal (with potential service from the Friant-Kern Canal) at the same site as the Alternative 2 location to serve the northeastern area. The other surface water treatment plant would be located along the Gould Canal northeast of the Fresno Air Terminal. Transmission pipelines to the Pinedale and southwestern areas were to be identical to Alternative 2.

4.2.3 WRMP Alternatives Evaluation

The three WRMP alternative water supply plans were compared against each other, as a part of the WRMP development, using several criteria. A summary of the WRMP alternative water supply plans comparison criteria along with brief descriptions and pertinent information regarding each criterion are presented in the following paragraphs.

4.2.3.1 Capital Cost

The criterion “capital costs” in the WRMP included several components including estimated capital and O&M costs for the elements listed below.

- Conservation program
- Untreated surface water
- Surface water treatment plants
- Existing wells (plume management, with and without wellhead treatment)
- New wells (plume management, with and without wellhead treatment)
- Ground-level storage tanks
- Transmission pipelines
- Distribution pipelines
- Groundwater recharge (existing and new recharge only and flood control basins)

This “capital cost” criterion was intended to represent the total relative estimates of costs required to implement each alternative.

4.2.3.2 Approximate Rate Impacts

The intent of this criterion was to represent the estimated average impact of each alternative across the FMA (both Fresno and Clovis) expressed in terms of changes in the monthly water bill of a typical single-family residence.

4.2.3.3 Water Budget Impacts

This criterion was included in the WRMP, but each alternative was found to achieve a slight positive groundwater balance. Therefore, the three alternatives were determined to have no real distinction between them from a water budget standpoint.

4.2.3.4 Drought Resiliency

The WRMP acknowledged that an important characteristic of good water supply plan is its ability to provide a reliable supply of water under extended drought conditions. This criterion compared each alternative's relative ability to provide adequate water supply in extended drought conditions. Given that the entire Fresno area had relied solely on groundwater for water supply and that all three alternatives were supposed by the WRMP preparers to contain enough groundwater recharge to maintain a slightly positive groundwater balance in the long term, the WRMP concluded that all three alternatives provided an acceptable level of drought resiliency. Alternatives 1 and 3 were found to be somewhat superior to Alternative 2 in that they would require no change in the operation of the system other than reduction of the amount of surface water used for recharge.

4.2.3.5 Groundwater Response

The WRMP included an analysis of the potential responses of the groundwater system to the three alternatives using a reconnaissance-level groundwater model of the FMA. The evaluation of the three alternatives included comparison of the relative overall water budget components (urban water demand, agricultural recharge, pumpage, stream recharge, intentional recharge, etc.) affecting the FMA. The reconnaissance-level groundwater model produced anticipated groundwater level changes and changes in groundwater flow directions. Noted findings included the anticipation that all of the alternatives were expected to cause a significant rise in groundwater levels and under each of the alternatives, groundwater flow directions are affected by the relative changes in pumping and recharge distribution.

4.2.3.6 Response to Regulatory Changes

The WRMP noted that surface water supply regulations are generally well established, while those for groundwater-based systems are still developing and that groundwater is more susceptible to contamination and, once contaminated, very difficult to clean up. For these reasons, reliance on groundwater was seen in the WRMP to decrease the ability of a plan to respond to changing regulations or to newly discovered (or regulated) pollutants. Alternative 2 was considered to be the most desirable from this point of view, while Alternative 1 was considered least desirable.

4.2.3.7 Compatibility with Phased Construction

Each of the three WRMP alternatives required development of significant physical facilities and it was deemed important, to the extent possible, for the alternatives to provide an orderly plan

for the staged development of the required infrastructure. Alternative 3 was considered the best of the three alternatives in terms of staging ability because it included two “modular water treatment plants” that could be brought on line quickly and two segments of transmission pipelines in the early years. Alternative 1, which concentrated on the installation of numerous wellhead treatment systems to meet immediate capacity requirements and provided the least amount of transmission conveyance capability, was considered the least desirable of the three alternatives in this respect.

4.2.3.8 Ease of Implementation

The WRMP defined, for purposes of the study, that “ease of implementation” was a measure of the level of effort required to implement each alternative given the then-existing legal and institutional framework for water resources management and regulation. Alternative 1 was felt to be a continuation of the present method of operation and, as such, required the least legal and institutional changes, the large number of wellhead treatment sites to be acquired notwithstanding. It was speculated that Alternative 2, with its shift to heavy reliance on the direct use of surface water supplies, would entail considerably more implementation effort and that agreements would have to be in place to facilitate the delivery of potable water between purveyors. Alternative 1 was considered to be the most easily implemented of the three alternatives, while Alternative 2 was probably the most difficult to implement.

4.2.3.9 Environmental and Socioeconomic Impacts

The three alternatives were considered essentially equal in terms of environmental and socioeconomic consequences.

4.2.3.10 Sensitivity to CVP Renewal

The WRMP states that the City of Fresno’s Class I CVP contract for 60,000 acre-feet per year (AFY) would expire on January 12, 2006 (although the actual expiration date is March 1, 2006) and that the contract does not contain a right of renewal. For this reason, the three alternatives were weighed against each other with respect to their respective sensitivity to the loss of at least a part of the CVP Class 1 water supply. The loss of all or part of this supply would have the greatest impact on Alternative 2 because of its heavy reliance on the direct use of surface water. Alternative 1 was felt to be least impacted because it uses all surface water for groundwater recharge, providing a storage buffer and making it less directly impacted by demand.

4.2.3.11 Madera County Growth

This criterion addressed the relative impact that groundwater overdrafting due to the anticipated growth across the San Joaquin River north of the FMA could have on the groundwater conditions in the FMA. The WRMP noted that Alternative 1 would likely be the most susceptible to this type of impact due to its reliance on groundwater supplies and Alternative 2 would most likely be the least affected.

4.2.3.12 University of California Campus

At the time that the WRMP was being prepared, Fresno County and FID had a proposed water supply plan for the proposed newest University of California Campus planned to be located somewhere in the Central Valley. This criterion was added to identify any adverse impact on any of the plan alternatives that could result from supplying water to the new campus. No impacts were noted for any of the alternatives.

4.2.3.13 Ability to Accommodate Changing Land-Use Plans

The horizon of the WRMP extended to 2050. The WRMP noted that the urban land base would have to be increased to accommodate projected population increases and also noted that it was difficult to anticipate with confidence the changes in land use patterns that could occur over this planning horizon. All of the alternatives were designed to be flexible and were intended to be updated periodically to respond to changes that might occur. Alternative 3, with two expandable subregional surface water treatment plants, an element of wastewater reuse, and the relatively high use of groundwater, was considered best able to respond to potential changes in land use. Alternative 1, with limited facilities for expanding service to the northeast, was considered least desirable from this perspective.

4.2.4 Summary of 1991 WRMP Evaluation Criteria

The evaluation and comparison of the WRMP alternative water supply plans are summarized in Table 4-1. Table 4-1 is a reproduction of Table 4-7 of the 1991 WRMP report. The evaluation of alternatives was presented in Table 4-7 (and below) in a best-versus-worst comparison.

Table 4-1
City of Fresno Nitrate Management Plan
Summary of WRMP Comparison of Alternative Plans

Criteria	Alternative	
	Best	Worst
Capital costs	1	2
Approximate rate impacts	All about equal	
Water budget impacts	All about equal	
Drought resiliency	1 and 3	2
Groundwater response	All about equal	
Response to regulatory changes	2	1
Compatibility with phased construction	3	1
Ease of implementation	1	2
Environmental and socioeconomic impacts	All about equal	
Sensitivity to CVP contract renewal	1	2
Madera County growth	2	1
University of California campus	All about equal	
Ability to accommodate changing land-use plans	3	1

The WRMP report included the following bulleted comments regarding Table 4-7:

- Alternative 1 was rated best 4 times
- Alternative 2 was rated best 2 times
- Alternative 3 was rated best 3 times
- Alternative 1 was rated worst 4 times
- Alternative 2 was rated worst 4 times
- Alternative 3 was never rated worst

The WRMP also commented with regard to the evaluation that, “Alternative 3 never received the worst ranking, and it received nearly half of the best rankings. Alternative 1, which also received about half of the best rankings, was ranked the worst 4 times.”

4.2.5 WRMP Conclusion and Recommended Alternative

As a result of the evaluation process, Alternative 3 was selected as the preferred alternative. It should be noted that selection of Alternative 3 has been the basis of critical water resource decisions. For example, the City has now constructed the first of the two surface water treatment plants called for in Alternative 3. A 30-mgd surface water treatment plant located near the intersection of Chestnut and Behymer Avenues went on line in June 2004 providing treated surface water to the northeasterly areas of Fresno. Preliminary investigations for a second surface water treatment plant, which is currently planned to be generally located in the easterly to southeasterly portion of Fresno, are presently being conducted by City of Fresno Water Division.

4.3 Applicability/Application of the WRMP Evaluation Criteria

As noted above, consistency with previous water resources studies and work concerning the FMA is deemed to be an appropriate element in the comparison of the alternative projects developed in this Nitrate Management Plan and as listed in Table 3-1 (Section 3). Primarily for this reason, the criteria used for comparative evaluation of the nitrate management alternative projects are based, as applicable, on the alternative evaluation criteria developed in the WRMP as detailed above. Some criteria do not apply well and some were altered as deemed appropriate, but the WRMP evaluation criteria were used as a guideline. A discussion of the applicability of the WRMP evaluation criteria and their application to the Nitrate Management Plan follows.

Each of the comparison criteria used in the WRMP are listed below along with an explanation as to whether they are applicable to the Nitrate Management Plan and, if they are, how they were be applied in the comparison matrix.

4.3.1.1 Capital Cost

As with the WRMP, this “capital cost” criterion is intended to represent the total relative estimates of costs **to the City** required to implement each alternative. It should be noted that Projects P-1 and P-2 shown in Table 3-1 reflect the estimated total capital costs, but it is anticipated that financing for these improvements would, in large part, be borne by the property

owners in these areas and the actual capital costs to the City would be administrative and small. As indicated above, the purpose of the Nitrate Management Plan Alternative Projects Comparison Matrix is to develop a list of effective capital improvement projects, present a balanced evaluation and comparison of the projects, and establish a priority for implementation of those projects. Projects P-1 and P-2 are considered to be essential, are both inherently of the highest priority, but really cannot be compared to other City-financed capital improvement projects on the basis of cost. For these reasons, Projects P-1 and P-2 are not included in the Nitrate Management Plan Alternative Projects Comparison Matrix as described below. This issue is discussed in further detail in Section 4.6 below.

4.3.1.2 Approximate Rate Impacts

The projects detailed in Table 3-1 should not have measurable impacts in rates. This criterion is not used in the Nitrate Management Plan comparison matrix.

4.3.1.3 Water Budget Impacts

As previously stated, this criterion was included in the WRMP but each alternative was declared by the WRMP preparers to achieve a slight positive groundwater balance and the three alternatives were determined to have no real distinction between them from a water budget standpoint. This criterion is not used in the Nitrate Management Plan comparison matrix.

4.3.1.4 Drought Resiliency

It is not anticipated that any of the projects detailed in Table 3-1 will have measurable, comparable impacts with respect to drought resiliency. Since this criterion is adequately dealt with in the WRMP, it will not be included as a criterion to be used in the Nitrate Management Plan comparison matrix.

4.3.1.5 Groundwater Response

As noted above, the WRMP included an analysis of the potential responses of the groundwater system to the three alternatives using a reconnaissance-level groundwater model of the FMA. This criterion is used in the comparison of Nitrate Management Plan projects with some alteration of application. In the comparison of Nitrate Management Plan projects, this criterion will be termed “**Positive Groundwater Impact**” and will reflect the relative ability of the project to affect a positive change in groundwater quality. This may be accomplished by reducing nitrogen loading, by providing a source of intentional upgradient percolation of fresh water, removal of nitrate from existing wells, blending two sources to produce water meeting drinking water standards, or some combination of these types of projects.

4.3.1.6 Response to Regulatory Changes

The projects detailed in Table 3-1 should have no measurable differences with respect to regulatory changes. This criterion is not used in the Nitrate Management Plan comparison matrix.

4.3.1.7 Compatibility with Phased Construction

This criterion, while applicable to the WRMP in terms long-term policies and water supply alternatives, is not applicable in the comparison of Nitrate Management Plan alternative projects. This criterion is not used in the Nitrate Management Plan comparison matrix.

4.3.1.8 Ease of Implementation

As noted above, the WRMP definition of “ease of implementation” was a measure of the level of effort required to implement each alternative given the then existing legal and institutional framework for water resources management and regulation. This criterion is used in the Nitrate Management Plan matrix and generally reflects the respective level of interagency coordination required, right-of-way acquisition difficulty and need, construction difficulty, and interface with existing facilities.

4.3.1.9 Environmental and Socioeconomic Impacts

The projects detailed in Table 3-1 should have no measurable differences with respect to environmental and socioeconomic impacts. This criterion is not used in the Nitrate Management Plan comparison matrix.

4.3.1.10 Sensitivity to CVP Renewal

The projects detailed in Table 3-1 should have no measurable differences with respect to sensitivity to CVP renewal. This criterion is not used in the Nitrate Management Plan comparison matrix.

4.3.1.11 Madera County Growth

The projects detailed in Table 3-1 should have no measurable differences with respect to Madera County growth. This criterion is not used in the Nitrate Management Plan comparison matrix.

4.3.1.12 University of California Campus

The University of California campus contemplated in the WRMP is being located near the City of Merced and is not applicable to the Nitrate Management Plan. This criterion is not used in the Nitrate Management Plan comparison matrix.

4.3.1.13 Ability to Accommodate Changing Land-Use Plans

This criterion, while applicable to the WRMP in terms of long-term policies and water supply alternatives, is not applicable in the comparison of Nitrate Management Plan alternative projects. This criterion is not used in the Nitrate Management Plan comparison matrix.

4.4 Nitrate Management Plan Additional Comparison Criteria

The criteria developed for the WRMP were structured toward comparison of a water supply plan involving multiple large-scale projects for the FMA to the year 2050. In reviewing the WRMP comparison criteria and their applicability to the comparison of the Nitrate Management Plan projects, it was apparent that some additional comparison criteria would be appropriate to provide a more thorough comparison of the specific projects that have been identified as a part of the Nitrate Management Plan.

Recommended additional comparison criteria are listed below along with a description of how they will be incorporated into the Nitrate Management Plan comparison matrix.

4.4.1.1 Cost Effectiveness

This added criterion reflects the comparative cost effectiveness of the Nitrate Management Plan projects. It considers the estimated amount of drinking water meeting drinking water standards that will be produced as a result of the project against the estimated project costs. It is expressed in AFY/\$1,000. Projects anticipated to result in higher production of drinking water for less capital expenditure were ranked higher in this category than projects anticipated to produce lower amounts of drinking water even though costing more. It should be noted that some projects are specifically intended to eliminate the source of nitrates and are not expected to produce additional drinking water. This type of project naturally scored lower with respect to this criterion.

4.4.1.2 Implementation Time

This added criterion reflects the comparative swiftness that individual Nitrate Management Plan projects could be brought on line. This criterion differs from “ease of implementation,” which is generally an expression of the respective level of interagency coordination required, right-of-way acquisition difficulty and need, construction difficulty, and interface with existing facilities. This “implementation time” reflects the actual time that is anticipated it will take to bring a project from approval and being budgeted to being functional. Some of the Nitrate Management Plan projects listed in Table 3-1 may be easy to implement because they will not require a great deal of interagency coordination or right-of-way acquisition but, due to their complexity, will require significant design, statutory (as in the cases of an assessment district or environmental impact report), and/or construction time.

4.4.1.3 Nitrate Management Effectiveness

This criterion was added to specifically reflect the anticipated ability of a project to effectively manage nitrates. It was intended to be a broad criterion that is an expression of how effectively a specific project is anticipated to positively impact nitrates in the groundwater.

4.5 Nitrate Management Plan Projects Comparison Criteria

The six criteria that will be used in the Nitrate Management Plan comparison matrix are shown in the bullets below.

- Capital cost
- Positive groundwater impact
- Ease of implementation
- Cost effectiveness
- Implementation time
- Nitrate management effectiveness

The application of the comparison criteria is discussed in Section 4.7 – Nitrate Management Plan Alternative Projects Comparison Matrix.

4.6 Sunnyside, Fort Washington, and Clovis Avenue Area Impacts

As stated in Section 2.2.2, it has been clearly shown that the most effective method of reducing long-term nitrate contamination of the groundwater in the FMA is to remove the source of nitrates and that the most obvious remaining sources of nitrates in the FMA are the unsewered areas (septic tanks) of Sunnyside and Fort Washington and the area along Clovis Avenue generally between Belmont and McKinley Avenues that has historically received nitrogen loading on crops in excess of agronomic rates. Removing these three sources would require constructing sewers in the Sunnyside and Fort Washington areas and reducing the nitrate application rate along the Clovis Avenue lands. These three sources of nitrates should not be considered “point sources” of nitrates since their respective areas of application are large. However, developing effective methods of eliminating or significantly reducing the nitrate loading reaching the groundwater from these areas should be considered essential to an effective Nitrate Management Plan in the FMA.

Financing and construction of sewers in the Sunnyside area (Project P-1) and the Fort Washington area (Project P-2) could be accomplished by assessment district proceedings as were the cases in both the Mayfair and Old Figarden sewer construction projects. If assessment district proceedings were used, the bulk of the costs for the sewers would be borne by the landowners and the only costs, if any, which would likely be borne by the City, would be small and administrative in nature. Since the actual costs to the City would be negligible, Projects P-1 and P-2 will not be included in the Nitrate Management Plan Alternative Projects Comparison Matrix.

As indicated above, effecting a cessation of or significantly reducing the nitrate reaching the groundwater in the Clovis Avenue area generally between Belmont and McKinley Avenues should be considered essential to a long-term nitrate management plan in the FMA, but the costs to the City

to affect a cessation or significant reduction of nitrate contributions and the relative degree of difficulty are unknown. Alternatives may include reduction of the nitrate loading rate (which would involve operational changes nitrate reduction treatment), installation of extraction wells to remove nitrates in the shallow groundwater and pumping the high-nitrate water to Mill Ditch, or disposing of high-nitrate material into available sewers. Since the exact solution is not presently known and a specific action or project cannot be identified as a capital improvement project, correction of this problem area is also not included in the Nitrate Management Plan Alternative Projects Comparison Matrix.

In summary, the purpose of the Nitrate Management Plan Alternative Projects Comparison Matrix is to develop a list of effective capital improvement projects, present a balanced evaluation and comparison of the projects, and establish a priority for implementation of those projects. Projects P-1 and P-2 and correcting the nitrate problem in shallow groundwater along Clovis Avenue are all considered to be essential and are all inherently of the highest priority, but they cannot be equitably compared to other more easily definable, City-financed capital improvement projects. For these reasons, Projects P-1 and P-2 and correcting the nitrate problem along Clovis Avenue are not included in the Nitrate Management Plan Alternative Projects Comparison Matrix. These projects and issues are addressed as nitrate management policies and recommendations Sections 5 and 6.

4.7 Nitrate Management Plan Alternative Projects

As indicated above, one key purpose of this study is to compare the alternative projects described in Table 3-1 against each other with respect to their overall anticipated effectiveness in the comparison matrix described in this section of the report. The comparison matrix factors described above were used to evaluate the alternative projects and assess project characteristics against each other to establish a priority for implementation of projects.

In general, all of the Nitrate Management Plan projects, with the exception of P-1 and P-2 for the reasons outlined above, were be ranked in the comparison criteria. In the following subsections, the scoring and ranking criteria of each of the Nitrate Management Plan alternative project comparison criteria are discussed.

4.7.1 Capital Cost

The projects listed in Table 3-1 (excluding Projects P-1 and P-2) will be scored according to their anticipated cost to the City. The scoring is from 1 to 5 with least costly projects receiving higher scores. The scoring will be as detailed below.

- \$0 to \$249,000 5 points
- \$250,000 to \$499,000 4 points
- \$500,000 to \$749,000 3 points
- \$750,000 to 999,000 2 points
- \$1,000,000 or more 1 point

4.7.2 Positive Groundwater Impact

As detailed above, this criterion will be used to score each project on the basis of its anticipated respective ability to affect a positive change in groundwater quality. As also explained above, a positive groundwater impact may be accomplished by reducing nitrogen loading, by providing a source of intentional upgradient percolation of fresh water, removal of nitrates from existing wells, blending two sources to produce water meeting drinking water standards, or some combination of these types of projects. The scoring for this comparative criterion is from 1 to 5 as detailed below.

- Very positive impact 5 points (upgradient percolation and extraction)
- Positive impact 4 points (upgradient percolation only)
- Moderate positive impact 3 points (extraction, wellhead treatment, or blending)
- Minimal positive impact 2 points (pipelines, alternative supplies, or storage facilities)
- No impact 1 point (no upgradient percolation or extraction)

4.7.3 Ease of Implementation

As detailed above, this criterion will be used to score each project on the basis of its anticipated respective level of interagency coordination required, right-of-way acquisition difficulty and need, construction difficulty, and interface with existing facilities. The scoring for this comparative criterion is from 1 to 5 as detailed below.

- Very easily implemented 5 points
- Easily implemented 4 points
- Moderately complicated 3 points
- Very complicated 2 points
- Nearly impossible 1 point

4.7.4 Cost Effectiveness

The purpose of this criterion is to provide an added consideration to the comparison of the projects that compares the relative additional drinking water per-unit cost each project is anticipated to produce. It considers the estimated amount of additional drinking water meeting drinking water standards that will be produced as a result of the project against the estimated project costs. It is not intended to be an expression of the total amount of additional drinking water but to compare the relative cost of the expected additional drinking water. For example, some projects are the construction of a new, deeper well near one or more existing wells and blending the water from both or all of the wells to produce water meeting drinking water standards while some of the projects are for construction of treatment facilities to remove the nitrates from an existing well water. For the comparative matrix, the cost and anticipated production of the resulting projects is considered based on the assumptions noted below. A project anticipated to produce 1,500 gpm of water in compliance with drinking water standards as a result of water blended from three 500-gpm wells for a lower cost than the treatment costs for one 500-gpm well will naturally be ranked higher with respect to this criterion. This criterion is expressed in AFY/\$1,000.

As stated above, projects anticipated to result in higher production of drinking water for less capital expenditure would be ranked higher than projects anticipated to produce lower amounts of drinking water costing more. As also stated above, some projects are solely intended to eliminate the source of nitrates and are not directly intended to produce additional drinking water but are intended to produce a positive effect on the groundwater by reducing nitrate levels. This type of project will naturally score lower with respect to this criterion.

The assumptions used to define this criterion are as follows:

1. All wells (with the exception of Project P-19), both new and existing, are assumed to produce approximately 500 gpm and are assumed to run 50 percent of the time on an annual basis, making the resulting production per well to be 400 AFY. It is likely that new wells in the southeast area will produce more than 500 gpm, but recently drilled wells in the southeast area have produced unpredictable results. The anticipated yield from some recent wells has been so poor that they were filled in without development. In general, wells in the southeast area can be expected to produce lower well yields than other areas of Fresno, and 500 gpm is used as an average well yield for comparison purposes.
2. Project P-19 is assumed to produce 2,000 gpm and run 50 percent of the time on an annual basis, making the resulting production to 1,600 AFY.
3. Relative pumping costs are considered to be approximately equal and not included in the comparison. The comparative ranking is based on estimated capital costs alone.

The scoring for this criterion is also from 1 to 5 with the most cost-effective projects receiving higher scores. City of Fresno wells typically run about 35 percent of the time annually. The wells in the southeast area are typically required to run more than other areas. This is reflected in Assumptions 1 and 2 above as the wells in the southeast area are assumed to run 50 percent of the time. Those projects that provide no apparent additional drinking water are not without contribution to additional drinking water (even though difficult to quantify) since they would be available for use during emergency conditions. For this reason, the 1 to 5 scoring is deemed appropriate. The scoring will be as detailed below.

- | | |
|----------------------------------|----------|
| • 1.5 to 2.0 or more AFY/\$1,000 | 5 points |
| • 1.0 to 1.5 AFY/\$1,000 | 4 points |
| • 0.5 to 1.0 AFY/\$1,000 | 3 points |
| • 0 to 0.5 AFY/\$1,000 | 2 points |
| • 0 AFY/\$1,000 | 1 point |

4.7.5 Implementation Time

This “Implementation Time” reflects the actual time that is anticipated it will take to bring a project from approval to being functional. The scoring for this comparative criterion is from 1 to 5 as detailed below.

- | | |
|----------------------|----------|
| • Less than 1 year | 5 points |
| • One to three years | 4 points |

- Three to four years 3 points
- Four to five years 2 points
- Over five years 1 point

4.7.6 Nitrate Management Effectiveness

As detailed above, this criterion specifically reflects the anticipated ability of a project to effectively manage nitrates. This broad, somewhat subjective criterion will be scored on the basis of how effectively a specific project is anticipated to positively impact nitrates in the groundwater in the FMA. The scoring for this comparative criterion is from 1 to 5 as detailed below.

- Very effective 5 points
- Effective 4 points
- Moderately effective 3 points
- Minimally effective 2 points
- Not effective 1 point

4.7.7 Comparison Criteria Adjustment Factors

It is important to acknowledge that the Nitrate Management Plan project comparison criteria presented above will not be equal in their ability to affect correction of the problem of nitrates in the groundwater within the FMA. For this reason, it is recommended that the comparison criteria be weighted with adjustment factors to reflect the relative differences in criteria. The weighting factors are subjective but are a reflection of the anticipated effectiveness and impact of the various criteria in managing nitrates. The recommended criteria adjustment factors are as detailed below.

- Capital cost 2
- Positive groundwater impact 2
- Ease of implementation 1
- Cost effectiveness 1
- Implementation time 1
- Nitrate management effectiveness 3

4.8 Project Comparison Matrix

Table 4-2 is a spreadsheet summary of the Nitrate Management Plan projects compared against one another in a matrix format. Table 4-2 lists the projects in the order they are presented in Table 3-1 except that Projects P-1 and P-2 have been deleted from the comparison as explained above. Each project is scored as detailed above with each score adjusted in accordance with the appropriate adjustment factors.

Table 4-2
City of Fresno Nitrate Management Plan
Alternative Projects Comparison Matrix

Project No.	Project Description	Est. Cost to City	Capital Cost			Positive Groundwater Impact			Ease of Implementation			Cost Effectiveness			Implementation Time			Nitrate Management Effectiveness			Total Score
			Raw Score	Adjustment	Adjusted Score	Raw Score	Adjustment	Adjusted Score	Raw Score	Adjustment	Adjusted Score	Raw Score	Adjustment	Adjusted Score	Raw Score	Adjustment	Adjusted Score	Raw Score	Adjustment	Adjusted Score	
P-3	Construct a pipeline from FID Fancher Creek or Briggs Canal to planned basin BM for recharge. This project will lower the nitrate levels in PS 276, PS 223-1 and PS 223-2 as the percolated water reaches the groundwater. No return from City wells to FID canals is included in this project.	\$750,000	2	2	4	4	2	8	3	1	3	1	1	1	4	1	4	5	3	15	35
P-4	Construct pipeline from FID Fancher Creek to FMFCD basin BK. Refit PS 223-1 and 223-2 (currently off line due to high nitrates) to pump high nitrate water to Fancher Creek <u>downstream</u> of the outlet to basin BK.	\$280,000	4	2	8	5	2	10	3	1	3	1	1	1	4	1	4	4	3	12	38
P-5	Construct pipeline from FID Fancher Creek to FMFCD basin BH. Refit PS 223-1 and 223-2 (currently off line due to high nitrates) to pump high nitrate water to Fancher Creek <u>downstream</u> of the outlet to basin BH. This project is similar to P-4 but basin BH has better percolation characteristics than basin BK. The pipeline from the wells will be longer in this project than in project P-4.	\$1,100,000	1	2	2	5	2	10	3	1	3	1	1	1	4	1	4	5	3	15	35
P-6	Construct pipeline from FID Fancher Creek to FMFCD basin BH. Refit PS 223-1 and 223-2 (currently off line due to high nitrates) to pump high nitrate water to Fancher Creek <u>upstream</u> of the outlet to basin BH. This project is similar to P-5 but the high nitrate water is returned upstream and diluted. The pipeline from the wells will be shorter in this project than in project P-5.	\$760,000	2	2	4	5	2	10	3	1	3	1	1	1	4	1	4	5	3	15	37
P-7	Construct pipeline from PS 295 to PS 294 (currently off line due to high nitrates) and blending facilities.	\$230,000	5	2	10	3	2	6	5	1	5	5	1	5	5	1	5	3	3	9	40
P-8	Construct ion exchange or membrane treatment facilities at PS 140 (currently off line due to high nitrates).	\$500,000	3	2	6	3	2	6	5	1	5	3	1	3	4	1	4	3	3	9	33
P-9	Construct a new, deeper well near PS 140 and blending facilities so that the production of the two wells can be combined. Projects P-8 and P-9 should be considered to be mutually exclusive.	\$400,000	4	2	8	3	2	6	4	1	4	5	1	5	5	1	5	3	3	9	37
P-10	Construct pipeline from PS 185 to Enterprise Canal <u>downstream</u> of WTP intake. This project may be coupled with other projects in other parts of the City for water exchange purposes with FID. The connection to the Enterprise Canal may be located upstream of the WTP intake if the City has constructed the pipeline from the Friant-Kern Canal to the WTP.	\$190,000	5	2	10	3	2	6	3	1	3	1	1	1	4	1	4	3	3	9	33
P-11	Refurbish PS 40A or construct new City well in the vicinity of PS 40A.	\$500,000	3	2	6	3	2	6	5	1	5	3	1	3	5	1	5	3	3	9	34
P-12	Construct a pipeline from FID Victoria West Branch Canal to FMFCD basin AL for recharge. No return from City wells to FID canals is included in this project.	\$130,000	5	2	10	4	2	8	3	1	3	1	1	1	4	1	4	4	3	12	38
P-13	Construct a pipeline from FID Central Canal to FMFCD basin AW2 for recharge. No return from City wells to FID canals is included in this project.	\$210,000	5	2	10	4	2	8	3	1	3	1	1	1	4	1	4	4	3	12	38
P-14	Construct a pipeline from FID Fanning Ditch to FMFCD basin FF for recharge. No return from City wells to FID canals is included in this project.	\$400,000	4	2	8	4	2	8	3	1	3	1	1	1	4	1	4	4	3	12	36
P-15	Construct a pipeline from FID Brawley Canal to FMFCD basin II1 for recharge. No return from City wells to FID canals is included in this project.	\$290,000	4	2	8	4	2	8	3	1	3	1	1	1	4	1	4	4	3	12	36
P-16	Construct a pipeline from FID Fresno Colony Canal to FMFCD basin LL for recharge. No return from City wells to FID canals is included in this project.	\$130,000	5	2	10	4	2	8	3	1	3	1	1	1	4	1	4	4	3	12	38
P-17	Construct a pipeline from FID Houghton Canal to FMFCD basin UU3 for recharge. No return from City wells to FID canals is included in this project.	\$350,000	4	2	8	4	2	8	3	1	3	1	1	1	4	1	4	4	3	12	36
P-18	Construct two new wells in the southeasterly portion of Fresno. These two new wells will be constructed following the procedures detailed in the Schmidt report.	\$900,000	2	2	4	1	2	2	4	1	4	3	1	3	4	1	4	3	3	9	26
P-19	Construct new well near Leaky Acres.	\$300,000	4	2	8	2	2	4	4	1	4	5	1	5	4	1	4	3	3	9	34
P-20	Install necessary improvements along the 24-inch transmission pipeline from Leaky Acres to the southeasterly portion of Fresno. This project is necessary to make project P-19 more effective.	\$150,000	5	2	10	2	2	4	5	1	5	4	1	4	5	1	5	3	3	9	37
P-21	Construct a second 2-MG reservoir at the T-1 site identical to the existing reservoir. The project would also include necessary booster pump improvements and additional piping.	\$3,000,000	1	2	2	2	2	4	4	1	4	1	1	1	4	1	4	3	3	9	24
P-22	Construct a new 2-MG steel reservoir, booster pumping station, and piping in the vicinity of Temperance and Dakota Avenues.	\$1,500,000	1	2	2	2	2	4	4	1	4	1	1	1	4	1	4	3	3	9	24
P-23	Install reservoir-mixing facilities at reservoir T-1.	\$60,000	5	2	10	1	2	2	5	1	5	1	1	1	5	1	5	1	3	3	26
P-24	Purchase 40 acres and construct a new percolation basin on a portion of the site. The site will ultimately be used for a new surface water treatment plant.	\$4,000,000	1	2	2	4	2	8	2	1	2	1	1	1	3	1	3	4	3	12	28
P-25	Construct membrane treatment facilities at PS 274.	\$600,000	3	2	6	3	2	6	4	1	4	3	1	3	4	1	4	3	3	9	32

Table 4-2
City of Fresno Nitrate Management Plan
Alternative Projects Comparison Matrix

Project No.	Project Description	Est. Cost to City	Capital Cost			Positive Groundwater Impact			Ease of Implementation			Cost Effectiveness			Implementation Time			Nitrate Management Effectiveness			Total Score
			Raw Score	Adjustment	Adjusted Score	Raw Score	Adjustment	Adjusted Score	Raw Score	Adjustment	Adjusted Score	Raw Score	Adjustment	Adjusted Score	Raw Score	Adjustment	Adjusted Score	Raw Score	Adjustment	Adjusted Score	
P-26	Construct membrane treatment facilities at PS 276.	\$600,000	3	2	6	3	2	6	4	1	4	3	1	3	4	1	4	3	3	9	32
P-27	Construct one new well near PS 274 and PS 276 and blending facilities so that the production of all three wells can be combined. Project P-27 would replace P-25 and P-26. The advantage of P-27 being that the production of all three wells would be gained.	\$750,000	2	2	4	3	2	6	4	1	4	5	1	5	4	1	4	3	3	9	32
P-28	Construct a new, deeper well near PS 223 and blending facilities so that the production of PS 223-1, PS 223-2, and the new well can be combined. The advantage of this project being that the production of all three wells would be gained. This project should be considered mutually exclusive to projects P-4, P-5, and P-6.	\$400,000	4	2	8	3	2	6	4	1	4	5	1	5	4	1	4	3	3	9	36
P-29	Install a sleeve inside the well casing at PS 223-2 to reduce the nitrate concentration to a point where PS 223-2 could be blended with PS 223-1 so that the resulting production is below the nitrate MCL. Projects P-28 and P-29 should be considered mutually exclusive. Loss of some production at PS 223-2 can be expected but the resulting production of both PS 223-1 and PS 223-2 would be gained. This project should also be considered mutually exclusive to projects P-4, P-5, and P-6.	\$150,000	5	2	10	3	2	6	5	1	5	5	1	5	5	1	5	3	3	9	40
P-30	Abandon the well at PS 223-1 and drill a replacement well so that the production of the new well could be blended with PS 223-2 so that the resulting production is below the nitrate MCL. Projects P-28, P-29, and P-30 should be considered mutually exclusive. This project should also be considered mutually exclusive to projects P-4, P-5, and P-6.	\$400,000	4	2	8	3	2	6	5	1	5	5	1	5	4	1	4	3	3	9	37
P-31	Construct new, deeper well near PS-201 and blending facilities so that the production of both wells can be combined. This well was recently lost due to high nitrates and is a site with GAC vessels for DBCP and 1,1-DCE treatment. A successful new, deeper well will require that the geology contain an upper confining layer so that contaminates in the upper aquifers are prevented from migrating downward. The advantage of this project being that the production of both wells would potentially be gained.	\$500,000	3	2	6	3	2	6	4	1	4	5	1	5	4	1	4	3	3	9	34
P-32	Construct a new, deeper well near PS 152. The combined flows of both wells can then be pumped to T-1. This well was recently lost due to high nitrates and is a site with GAC vessels for DBCP treatment. A successful new, deeper well will require that the geology contain an upper confining layer so that contaminates in the upper aquifers are prevented from migrating downward.	\$500,000	3	2	6	3	2	6	4	1	4	5	1	5	4	1	4	3	3	9	34
P-33	Maintain aggressive use of Basins TT1, II1, KK, LL, II2, and GG for percolation to decrease nitrate concentrations in the southwest.	\$0	5	2	10	4	2	8	4	1	4	1	1	1	5	1	5	5	3	15	43
P-34	Increase use of Basin BZ for percolation to decrease nitrate concentrations near the unsewered Fort Washington area.	\$0	5	2	10	4	2	8	4	1	4	1	1	1	5	1	5	4	3	12	40
P-35	Purchase new 20-acre site for percolation in the southeast.	\$2,000,000	1	2	2	4	2	8	2	1	2	1	1	1	3	1	3	4	3	12	28

Table 4-3
City of Fresno Nitrate Management Plan
Alternative Projects Comparison Matrix - Sorted by Score

Project No.	Project Description	Est. Cost to City	Capital Cost			Positive Groundwater Impact			Ease of Implementation			Cost Effectiveness			Implementation Time			Nitrate Management Effectiveness			Total Score
			Raw Score	Adjustment	Adjusted Score	Raw Score	Adjustment	Adjusted Score	Raw Score	Adjustment	Adjusted Score	Raw Score	Adjustment	Adjusted Score	Raw Score	Adjustment	Adjusted Score	Raw Score	Adjustment	Adjusted Score	
P-33	Maintain aggressive use of Basins TT1, II1, KK, LL, II2, and GG for percolation to decrease nitrate concentrations in the southwest.	\$0	5	2	10	4	2	8	4	1	4	1	1	1	5	1	5	5	3	15	43
P-7	Construct pipeline from PS 295 to PS 294 (currently off line due to high nitrates) and blending facilities.	\$230,000	5	2	10	3	2	6	5	1	5	5	1	5	5	1	5	3	3	9	40
P-29	Install a sleeve inside the well casing at PS 223-2 to reduce the nitrate concentration to a point where PS 223-2 could be blended with PS 223-1 so that the resulting production is below the nitrate MCL. Projects P-28 and P-29 should be considered mutually exclusive. Loss of some production at PS 223-2 can be expected but the resulting production of both PS 223-1 and PS 223-2 would be gained. This project should also be considered mutually exclusive to projects P-4, P-5, and P-6.	\$150,000	5	2	10	3	2	6	5	1	5	5	1	5	5	1	5	3	3	9	40
P-34	Increase use of Basin BZ for percolation to decrease nitrate concentrations near the unsewered Fort Washington area.	\$0	5	2	10	4	2	8	4	1	4	1	1	1	5	1	5	4	3	12	40
P-4	Construct pipeline from FID Fancher Creek to FMFCD basin BK. Refit PS 223-1 and 223-2 (currently off line due to high nitrates) to pump high nitrate water to Fancher Creek <u>downstream</u> of the outlet to basin BK.	\$280,000	4	2	8	5	2	10	3	1	3	1	1	1	4	1	4	4	3	12	38
P-12	Construct a pipeline from FID Victoria West Branch Canal to FMFCD basin AL for recharge. No return from City wells to FID canals is included in this project.	\$130,000	5	2	10	4	2	8	3	1	3	1	1	1	4	1	4	4	3	12	38
P-13	Construct a pipeline from FID Central Canal to FMFCD basin AW2 for recharge. No return from City wells to FID canals is included in this project.	\$210,000	5	2	10	4	2	8	3	1	3	1	1	1	4	1	4	4	3	12	38
P-16	Construct a pipeline from FID Fresno Colony Canal to FMFCD basin LL for recharge. No return from City wells to FID canals is included in this project.	\$130,000	5	2	10	4	2	8	3	1	3	1	1	1	4	1	4	4	3	12	38
P-6	Construct pipeline from FID Fancher Creek to FMFCD basin BH. Refit PS 223-1 and 223-2 (currently off line due to high nitrates) to pump high nitrate water to Fancher Creek <u>upstream</u> of the outlet to basin BH. This project is similar to P-5 but the high nitrate water is returned upstream and diluted. The pipeline from the wells will be shorter in this project than in project P-5.	\$760,000	2	2	4	5	2	10	3	1	3	1	1	1	4	1	4	5	3	15	37
P-9	Construct a new, deeper well near PS 140 and blending facilities so that the production of the two wells can be combined. Projects P-8 and P-9 should be considered to be mutually exclusive.	\$400,000	4	2	8	3	2	6	4	1	4	5	1	5	5	1	5	3	3	9	37
P-20	Install necessary improvements along the 24-inch transmission pipeline from Leaky Acres to the southeasterly portion of Fresno. This project is necessary to make project P-19 more effective.	\$150,000	5	2	10	2	2	4	5	1	5	4	1	4	5	1	5	3	3	9	37
P-30	Abandon the well at PS 223-1 and drill a replacement well so that the production of the new well could be blended with PS 223-2 so that the resulting production is below the nitrate MCL. Projects P-28, P-29, and P-30 should be considered mutually exclusive. This project should also be considered mutually exclusive to projects P-4, P-5, and P-6.	\$400,000	4	2	8	3	2	6	5	1	5	5	1	5	4	1	4	3	3	9	37
P-14	Construct a pipeline from FID Fanning Ditch to FMFCD basin FF for recharge. No return from City wells to FID canals is included in this project.	\$400,000	4	2	8	4	2	8	3	1	3	1	1	1	4	1	4	4	3	12	36
P-15	Construct a pipeline from FID Brawley Canal to FMFCD basin II1 for recharge. No return from City wells to FID canals is included in this project.	\$290,000	4	2	8	4	2	8	3	1	3	1	1	1	4	1	4	4	3	12	36
P-17	Construct a pipeline from FID Houghton Canal to FMFCD basin UU3 for recharge. No return from City wells to FID canals is included in this project.	\$350,000	4	2	8	4	2	8	3	1	3	1	1	1	4	1	4	4	3	12	36
P-28	Construct a new, deeper well near PS 223 and blending facilities so that the production of PS 223-1, PS 223-2, and the new well can be combined. The advantage of this project being that the production of all three wells would be gained. This project should be considered mutually exclusive to projects P-4, P-5, and P-6.	\$400,000	4	2	8	3	2	6	4	1	4	5	1	5	4	1	4	3	3	9	36
P-3	Construct a pipeline from FID Fancher Creek or Briggs Canal to planned basin BM for recharge. This project will lower the nitrate levels in PS 276, PS 223-1 and PS 223-2 as the percolated water reaches the groundwater. No return from City wells to FID canals is included in this project.	\$750,000	2	2	4	4	2	8	3	1	3	1	1	1	4	1	4	5	3	15	35
P-5	Construct pipeline from FID Fancher Creek to FMFCD basin BH. Refit PS 223-1 and 223-2 (currently off line due to high nitrates) to pump high nitrate water to Fancher Creek <u>downstream</u> of the outlet to basin BH. This project is similar to P-4 but basin BH has better percolation characteristics than basin BK. The pipeline from the wells will be longer in this project than in project P-4.	\$1,100,000	1	2	2	5	2	10	3	1	3	1	1	1	4	1	4	5	3	15	35
P-11	Refurbish PS 40A or construct new City well in the vicinity of PS 40A.	\$500,000	3	2	6	3	2	6	5	1	5	3	1	3	5	1	5	3	3	9	34
P-19	Construct new well near Leaky Acres.	\$300,000	4	2	8	2	2	4	4	1	4	5	1	5	4	1	4	3	3	9	34

Table 4-3
City of Fresno Nitrate Management Plan
Alternative Projects Comparison Matrix - Sorted by Score

Project No.	Project Description	Est. Cost to City	Capital Cost			Positive Groundwater Impact			Ease of Implementation			Cost Effectiveness			Implementation Time			Nitrate Management Effectiveness			Total Score
			Raw Score	Adjustment	Adjusted Score	Raw Score	Adjustment	Adjusted Score	Raw Score	Adjustment	Adjusted Score	Raw Score	Adjustment	Adjusted Score	Raw Score	Adjustment	Adjusted Score	Raw Score	Adjustment	Adjusted Score	
P-31	Construct new, deeper well near PS-201 and blending facilities so that the production of both wells can be combined. This well was recently lost due to high nitrates and is a site with GAC vessels for DBCP and 1,1-DCE treatment. A successful new, deeper well will require that the geology contain an upper confining layer so that contaminates in the upper aquifers are prevented from migrating downward. The advantage of this project being that the production of both wells would potentially be gained.	\$500,000	3	2	6	3	2	6	4	1	4	5	1	5	4	1	4	3	3	9	34
P-32	Construct a new, deeper well near PS 152. The combined flows of both wells can then be pumped to T-1. This well was recently lost due to high nitrates and is a site with GAC vessels for DBCP treatment. A successful new, deeper well will require that the geology contain an upper confining layer so that contaminates in the upper aquifers are prevented from migrating downward.	\$500,000	3	2	6	3	2	6	4	1	4	5	1	5	4	1	4	3	3	9	34
P-8	Construct ion exchange or membrane treatment facilities at PS 140 (currently off line due to high nitrates).	\$500,000	3	2	6	3	2	6	5	1	5	3	1	3	4	1	4	3	3	9	33
P-10	Construct pipeline from PS 185 to Enterprise Canal downstream of WTP intake. This project may be coupled with other projects in other parts of the City for water exchange purposes with FID. The connection to the Enterprise Canal may be located upstream of the WTP intake if the City has constructed the pipeline from the Friant-Kern Canal to the WTP.	\$190,000	5	2	10	3	2	6	3	1	3	1	1	1	4	1	4	3	3	9	33
P-25	Construct membrane treatment facilities at PS 274.	\$600,000	3	2	6	3	2	6	4	1	4	3	1	3	4	1	4	3	3	9	32
P-26	Construct membrane treatment facilities at PS 276.	\$600,000	3	2	6	3	2	6	4	1	4	3	1	3	4	1	4	3	3	9	32
P-27	Construct one new well near PS 274 and PS 276 and blending facilities so that the production of all three wells can be combined. Project P-27 would replace P-25 and P-26. The advantage of P-27 being that the production of all three wells would be gained.	\$750,000	2	2	4	3	2	6	4	1	4	5	1	5	4	1	4	3	3	9	32
P-24	Purchase 40 acres and construct a new percolation basin on a portion of the site. The site will ultimately be used for a new surface water treatment plant.	\$4,000,000	1	2	2	4	2	8	2	1	2	1	1	1	3	1	3	4	3	12	28
P-35	Purchase new 20-acre site for percolation in the southeast.	\$2,000,000	1	2	2	4	2	8	2	1	2	1	1	1	3	1	3	4	3	12	28
P-18	Construct two new wells in the southeasterly portion of Fresno. These two new wells will be constructed following the procedures detailed in the Schmidt report.	\$900,000	2	2	4	1	2	2	4	1	4	3	1	3	4	1	4	3	3	9	26
P-23	Install reservoir-mixing facilities at reservoir T-1.	\$60,000	5	2	10	1	2	2	5	1	5	1	1	1	5	1	5	1	3	3	26
P-21	Construct a second 2-MG reservoir at the T-1 site identical to the existing reservoir. The project would also include necessary booster pump improvements and additional piping.	\$3,000,000	1	2	2	2	2	4	4	1	4	1	1	1	4	1	4	3	3	9	24
P-22	Construct a new 2-MG steel reservoir, booster pumping station, and piping in the vicinity of Temperance and Dakota Avenues.	\$1,500,000	1	2	2	2	2	4	4	1	4	1	1	1	4	1	4	3	3	9	24

4.9 Project Ranking and Score

Table 4-3 is similar to Table 4-2 except that the projects have been sorted in accordance with their respective point rankings.

As noted in Tables 4-2 and 4-3, some of the projects are mutually exclusive but were included in the analysis so that the lower scoring projects could be eliminated from the list of projects that should be implemented primarily with respect to effective potable water supply projects. Some of these projects, however, may prove to be effective nitrate management percolation/extraction projects if they can be economically constructed and operated and may be considered in future nitrate management activities.

4.10 Project Comparison Matrix Summary

Table 4-4 lists the top 20 ranking projects that are recommended for implementation. Only the highest ranking of those projects described as mutually exclusive are included in the project implementation list. As noted above, some of the eliminated projects that are not included in Table 4-4 could prove to be effective nitrate management percolation/extraction projects if they can be economically constructed and operated and may be considered in future nitrate management activities. Sufficient funds will most likely not be available to implement all of the projects listed in Table 4-3 so a “cutoff point” was selected. As the recommended projects are implemented, the comparison matrix should be revisited to verify that conditions have not changed the relative nitrate management effectiveness.

Table 4-4
City of Fresno Nitrate Management Plan
Projects Recommended for Implementation

Project No.	Description	Total Score
P-33	Maintain aggressive use of Basins TT1, II1, KK, LL, II2, and GG for percolation to decrease nitrate concentrations in the southwest.	43
P-7	Construct pipeline from PS 295 to PS 294 (currently off line due to high nitrates) and blending facilities.	40
P-29	Install a sleeve inside the well casing at PS 223-2 to reduce the nitrate concentration to a point where PS 223-2 could be blended with PS 223-1 so that the resulting production is below the nitrate MCL. Loss of some production at PS 223-2 can be expected but the resulting production of both PS 223-1 and PS 223-2 would be gained.	40
P-34	Increase use of Basin BZ for percolation to decrease nitrate concentrations near the unsewered Fort Washington area.	40
P-12	Construct a pipeline from FID Victoria West Branch Canal to FMFCD basin AL for recharge. No return from City wells to FID canals is included in this project.	38

Project No.	Description	Total Score
P-13	Construct a pipeline from FID Central Canal to FMFCD basin AW2 for recharge. No return from City wells to FID canals is included in this project.	38
P-16	Construct a pipeline from FID Fresno Colony Canal to FMFCD basin LL for recharge. No return from City wells to FID canals is included in this project.	38
P-9	Construct a new, deeper well near PS 140 and blending facilities so that the production of the two wells can be combined.	37
P-20	Install necessary improvements along the 24-inch transmission pipeline from Leaky Acres to the southeasterly portion of Fresno. This project is necessary to make project P-18 more effective.	37
P-30	Abandon the well at PS 223-1 and drill a replacement well so that the production of the new well could be blended with PS 223-2 with the resulting production below the nitrate MCL.	37
P-14	Construct a pipeline from FID Fanning Ditch to FMFCD basin FF for recharge. No return from City wells to FID canals is included in this project.	36
P-15	Construct a pipeline from FID Brawley Canal to FMFCD basin II1 for recharge. No return from City wells to FID canals is included in this project.	36
P-17	Construct a pipeline from FID Houghton Canal to FMFCD basin UU3 for recharge. No return from City wells to FID canals is included in this project.	36
P-3	Construct a pipeline from FID Fancher Creek or Briggs Canal to planned basin BM for recharge. This project will lower the nitrate levels in PS 276, PS 223-1 and PS 223-2 as the percolated water reaches the groundwater. No return from City wells to FID canals is included in this project.	35
P-11	Refurbish PS 40A or construct new City well in the vicinity of PS 40A.	34
P-19	Construct new well near Leaky Acres.	34

Section 5

Alternative Nitrate Plume Management Projects

As stated in Section 2, the most obvious remaining sources of nitrate in the groundwater beneath the FMA are the unsewered areas of Sunnyside and Fort Washington and the area along Clovis Avenue between Belmont and McKinley. Removing these three sources would require sewerage the Sunnyside and Fort Washington areas and affecting a cessation of the nitrate contributions in the area along Clovis Avenue between Belmont and McKinley. This section describes conceptual alternative projects to manage the existing plumes of concentrated nitrate in the groundwater within the FMA. Two conceptual projects are described. The first project would extract shallow groundwater downgradient of the high concentration of nitrate found in the Sunnyside area. The second project would be a system of shallow extraction wells to manage the nitrate plume along Clovis Avenue generally between Belmont and McKinley Avenues. These conceptual projects are presented as potential alternatives to other projects described in previous sections. There is no alternative conceptual project that appeared to be viable and cost-effective in lieu of sewerage the Fort Washington area.

Removal of the source of nitrogen entering the soil column (such as large areas with numerous septic tanks) is a proven method for long-term reduction of nitrate reaching the FMA groundwater. This has been clearly shown in the cases of the sewerage of the Old Figarden and Mayfair areas. More rapid reduction of nitrate in the groundwater by upgradient groundwater recharge has also clearly been demonstrated in the Mayfair area by the addition of recharge of surface water in Leaky Acres.

If, for some reason, the projects described in previous sections are found to be infeasible, the alternative projects conceptually described in this section may provide viable tools for managing or mitigating high nitrate in the groundwater.

5.1 Alternative Sunnyside Nitrate Plume Management Project

5.1.1 1992 Southeast Fresno Groundwater Recharge Project

In a joint 1992 application entitled “Feasibility Study/Application for Groundwater Recharge Project Construction Loan” to the California Department of Water Resources (DWR) under the Water Conservation Bond Law of 1986, the City of Fresno and FID, with the cooperation of FMFCD, sought a construction loan from DWR for a project referred to as the Southeast Fresno Groundwater Recharge Project. The primary purpose of the project was to protect the City’s groundwater supply. The project, as described in the loan application, was a “multipurpose groundwater enhancement program.” Benefits of the project described in the loan application included:

- Providing a “barrier” to the further 1,2-dibromochloropropane (DBCP) movement and contamination of City water system wells and in so doing, preserving and enhancing Fresno’s groundwater as a long-term water source for the community
- Conserving and storing local surface water supplies for community use while decreasing overdraft
- Providing a measure of drought protection by storing excess local rainfall runoff
- Providing a low-cost alternative to treating DBCP-contaminated groundwater

The stated intent of the proposed project was to intercept and extract shallow groundwater contaminated with DBCP by means of strategically located existing and new wells (both agricultural and municipal wells), pump the extracted groundwater to Fancher Creek, Briggs Canal, and a portion of Central Canal, and construct FID canal system modifications to allow FMFCD basins to be used for intentional groundwater recharge. The project proposed an extraction of between 12,000 and 15,000 acre-feet of contaminated groundwater per year.

The estimated project cost in 1992 was approximately \$5 million. Preliminary hydrogeologic and engineering studies for this project indicated that it was technically sound and cost effective; however, this project failed to receive the necessary funding and was not constructed.

5.1.2 Southeast Fresno Groundwater Extraction for Nitrate Plume Management

Dr. Schmidt has indicated that the higher concentrations of nitrate in the groundwater in southeast Fresno are generally in the same shallow aquifers as the contaminant DBCP and that a project similar to the 1992 Southeast Fresno Groundwater Recharge Project may be an effective nitrate plume management tool.

Verification of the anticipated effectiveness of a similar groundwater extraction system is outside the scope of this report; however, a conceptual layout of a similar extraction and recharge system as proposed in 1992 is shown in Figure 5-1. Ideally, recharge basins located upgradient of the Sunnyside area would be more effective in effecting a reduction in nitrate concentration in the groundwater (as demonstrated in the Mayfair area with the Leaky Acres upgradient recharge). However, as indicated in the 1992 Southeast Fresno Groundwater Loan Recharge Project application, active recharge basins of good-quality surface water (similar to Leaky Acres recharge) downgradient of the nitrate plume would raise the downgradient groundwater level, flatten the groundwater level slope, and tend to slow the movement of the existing nitrate plume in the Sunnyside area. By slowing the movement of the nitrate plume, continued extraction of the high-nitrate groundwater is made more effective.

5.1.3 Regulatory Issues

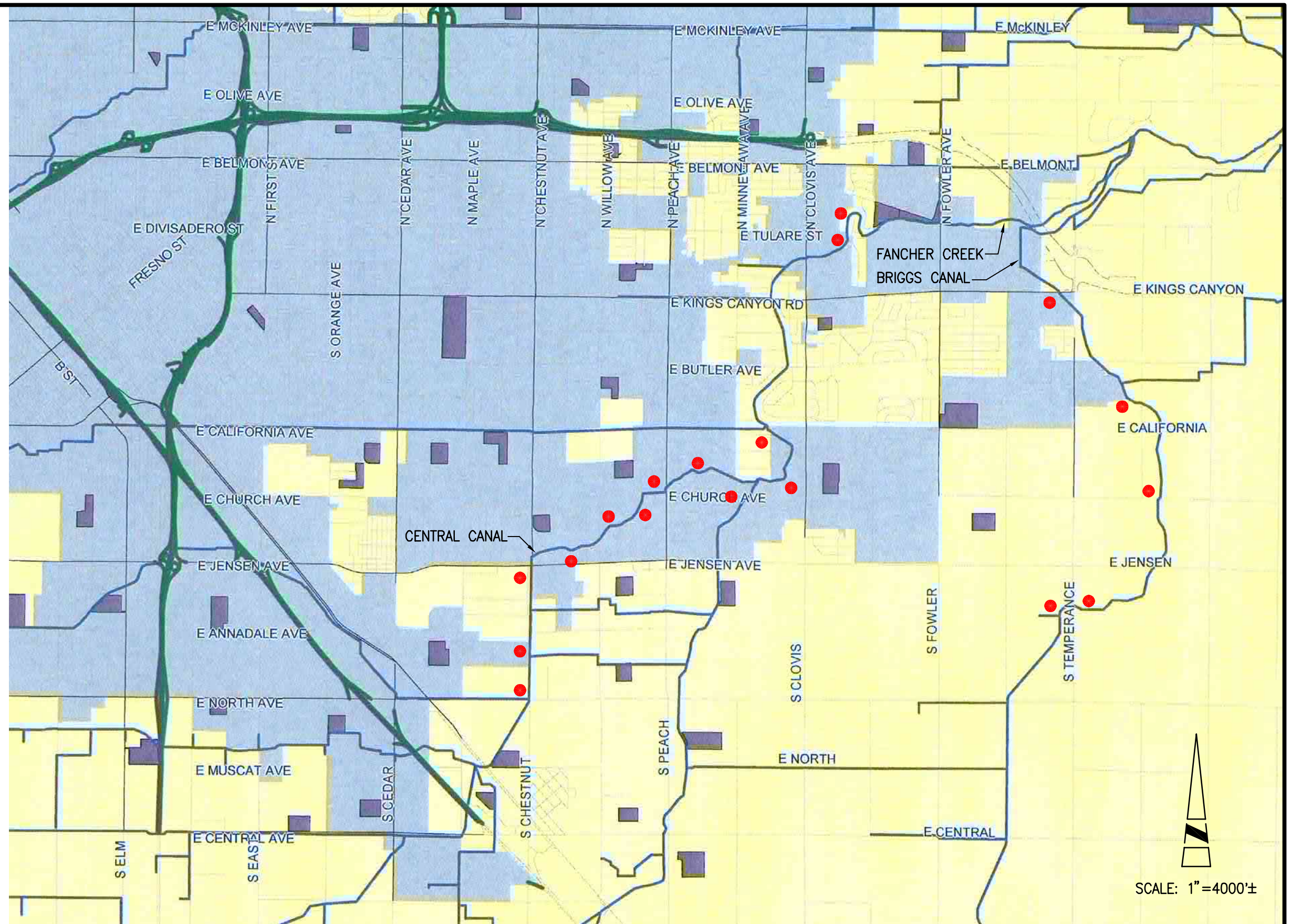
Extracting groundwater, containing nitrate in concentrations higher than drinking water standards, for transport to nearby canals and/or creeks will likely come under the review of the RWQCB and the California Department of Health Services, Office of Drinking Water (DHS).

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LEGEND

- FID CANALS
- FMFCD BASINS
- EXTRACTION WELLS

NOTE: THIS FIGURE SHOWS THE KEY ELEMENTS OF THE "1992 SOUTHEAST FRESNO GROUNDWATER RECHARGE PROJECT."



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CITY OF FRESNO
NITRATE CONTAMINATION STUDY

SOUTHEAST FRESNO
GROUNDWATER EXTRACTION AND
RECHARGE PROJECT

BEC
PROJECT NO.

FR-F08-800-01

FIGURE

5-1

The approval of these agencies for such a project would be necessary.

Other regulatory issues that will need to be addressed will be compliance with the California Environmental Quality Act (CEQA) by preparation of an appropriate environmental document, coordination with Fresno County and compliance with their requirements, and compliance with City of Fresno interdepartment requirements.

5.2 Alternative Clovis Avenue Plume Management Project

As discussed Section 2 and illustrated on Figures 2-1, 2-2, and 2-3, the presence of elevated concentrations of nitrate in the groundwater along Clovis Avenue generally between Belmont and McKinley Avenues is a documented and persistent problem. If the source of the nitrogen is removed, it is anticipated that it could take several decades (as was the case with the Old Figarden and Mayfair areas) before the nitrate concentrations in the groundwater are reduced by natural groundwater movement to acceptable levels. Regardless of what course the City chooses with regard to elimination of the nitrogen source, alternative nitrate plume management measures may be appropriate.

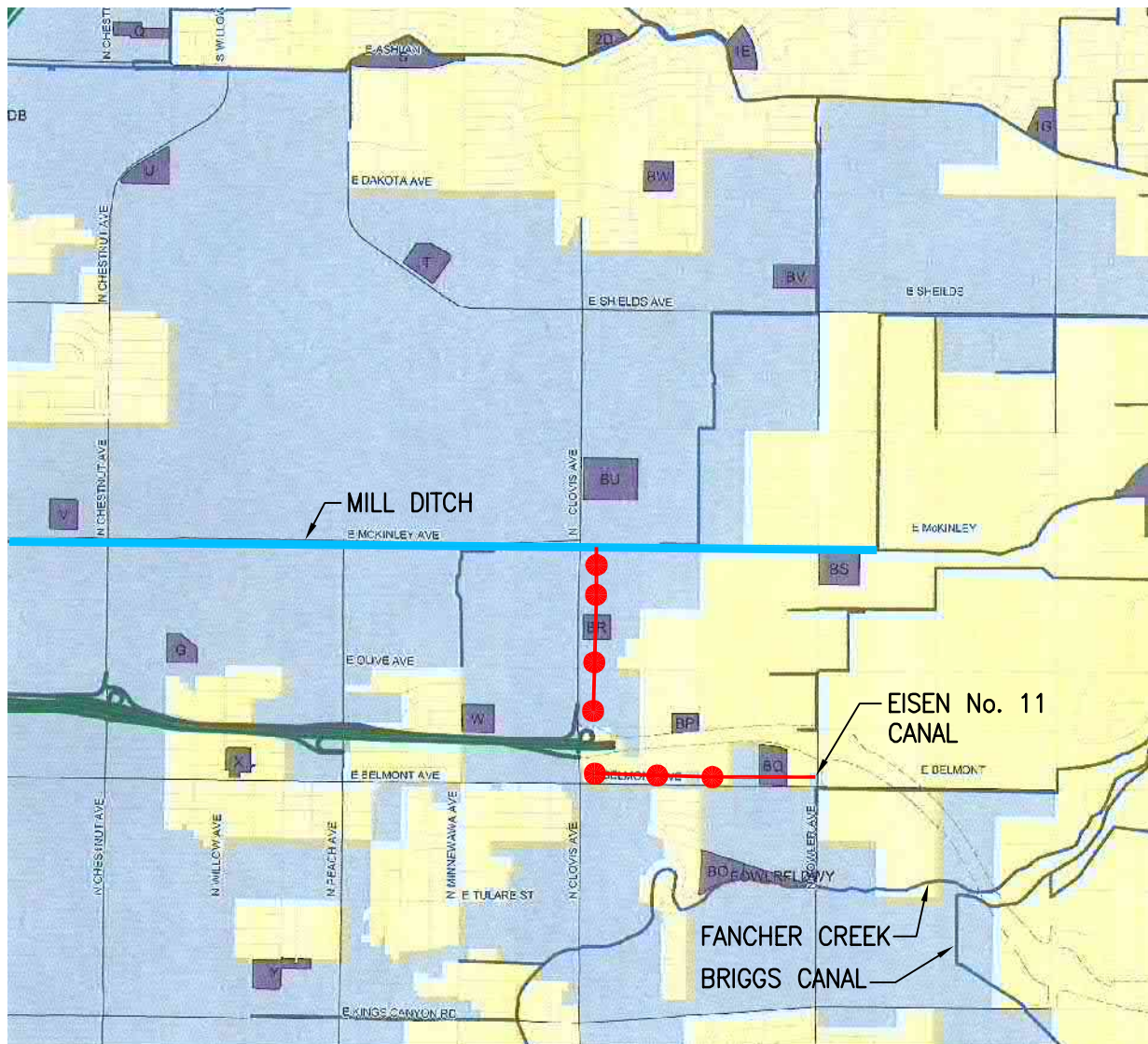
5.2.1 Clovis Avenue Groundwater Extraction for Nitrate Plume Management

This alternative project, as suggested by Dr. Schmidt, would provide a method of extracting the groundwater with high nitrate concentrations and then pumping it north along Clovis Avenue to Mill Ditch.

Design of this alternative extraction system is outside the scope of this report, but the system suggested by Dr. Schmidt would include the following key components:

- Five to six extraction wells located generally along the front of the nitrate plume along Clovis and Belmont Avenues
- Transmission pipelines to transport the extracted water to Mill Ditch and Eisen No. 11 Canal
- Outlet structures in compliance with FID requirements

The general idea of this system would be, after determining the vertical locations of the nitrate in the groundwater and designing wells to extract the high nitrate water, pump the extraction wells to remove the high nitrate water and deliver it to Mill Ditch and Eisen No. 11 Canal. Those wells showing higher levels of nitrate in the extracted water would be pumped even more. Pumping of those wells with lower nitrate levels would be curtailed. A simple system of this sort would result in removal of the high-nitrate groundwater faster than if there were no extraction. A conceptual layout of this extraction system is shown in Figure 5-2.



LEGEND

- FID CANALS
- FMFCD BASINS
- EXTRACTION WELLS
- TRANSMISSION PIPELINE



SCALE: 1"=4000'±

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CITY OF FRESNO NITRATE CONTAMINATION STUDY CLOVIS AVENUE NITRATE PLUME MANAGEMENT PROJECT

BEC
 PROJECT NO.

FR-F08-800-01

FIGURE

5-2

5.2.2 Regulatory Issues

Extracting groundwater, containing nitrate in concentrations higher than drinking water standards, for transport to Mill Ditch will likely come under the review of the RWQCB and DHS. The approval of these agencies for such a project would be necessary. It would be important to consider that Mill Ditch is the largest FID canal traversing the City and that the high-nitrate water would be highly diluted by the surface water in Mill Ditch upon entry into the canal and the resulting mix of water in Mill Ditch would contain nitrate concentrations that are lower than the drinking water standard of 45 mg/L.

Other regulatory issues that will need to be addressed will be compliance with CEQA by preparation of an appropriate environmental document, coordination with Fresno County and compliance with their requirements, and compliance with City of Fresno interdepartment requirements.

Section 6

Nitrate Management Plan

Recommendations and Policies

This section describes the recommendations and policies for long-term management of nitrates in the FMA.

6.1 FMA Nitrate Management Recommendations

The following actions and projects are recommended for nitrate reduction and management in the FMA:

1. The City of Fresno should work with Fresno County toward formation of an assessment district (or phased assessment districts) for the construction of a complete sewer collection system in the unsewered Sunnyside area. All existing septic tanks should be abandoned and taken out of service.
2. The City of Fresno should work with Fresno County toward formation of an assessment district for the construction of a complete sewer collection system in the unsewered Fort Washington area. All existing septic tanks should be abandoned and taken out of service.
3. The City of Fresno should actively work with the Regional Water Quality Control Board toward cessation of the source of nitrogen into the ground along Clovis Avenue generally between Belmont and McKinley Avenues. The source of nitrogen is apparently converting to nitrate in the groundwater and resulting in a plume of groundwater with nitrate that exceeds the drinking water standard. The Responsible Party or Parties for this nitrogen should be identified and be compelled to implement remediation measures.
4. The City should amend its sewer ordinance to prohibit the installation and construction of new septic tanks and seepage pits within the City. These facilities have clearly been shown to contribute to nitrate contamination in the groundwater in the FMA and their construction should not be further allowed.
5. The projects listed in Table 4-4 should be implemented as a part of the City's capital improvement program and as funds are available. The projects should be generally pursued in the priority listed in Table 4-4.

6.2 FMA Nitrate Management Policies

Both the City of Fresno Municipal Code and Fresno County Ordinance contain mandatory sewer connection regulations for developments that are connected to a septic tank or cesspool. Both

agencies require that any property within 100 feet of a public sewer system shall be connected to the public sewer system within three years after the public sewer system becomes available.

Appendix B contains the applicable portion of the Fresno Municipal Code and Appendix C contains the applicable portion of the Fresno County Ordinance.

In concert with the existing City and County regulations described above, the following policies are recommended as a part of reduction and management of nitrate in the groundwater under the FMA.

1. The City of Fresno should pursue the sewerage of all remaining small areas within the City that are still discharging wastewater to septic tanks, and all remaining septic tanks should be abandoned. Funding for these projects could be by assessment district or similar method. As recommended above, no further septic tanks or cesspools should be allowed within the City.
2. The City of Fresno should discourage new land uses and business within the Fresno Metropolitan Area that will result in generation and disposal of nitrogen (in any form) into the groundwater.
3. The City of Fresno should maintain its current recharge activities and expand recharge activities in those areas of the FMA having the highest nitrate concentration in the groundwater.
4. The City should pursue extraction of high nitrate groundwater and delivery to FID facilities in exchange for upgradient FID water delivered to percolation facilities similar to the project described as the 1992 Southeast Fresno Groundwater Loan Recharge Project.
5. The City should consistently use the enhanced well construction methods detailed by Dr. Schmidt.
6. The City should pursue blending of water sources when appropriate and economically feasible to reduce nitrate concentrations of the potable water.
7. The City should pump and treat nitrate-impaired wells when economically feasible.
8. The City of Fresno should initiate the regular testing of its existing cluster monitor wells, particularly for nitrate. A sampling frequency of once every three years is recommended.
9. All data obtained from the monitor well testing should be entered into the GIS mapping and data management system developed as part of this study. City Water Division staff should also regularly maintain and update the GIS mapping and data management system developed as a part of this study. The GIS mapping and data management system should be used by City staff as a tool to periodically evaluate nitrate levels throughout the FMA.

Appendix A
Kenneth D. Schmidt Report

**DISTRIBUTION AND SOURCES OF NITRATE IN
GROUNDWATER IN AND NEAR THE CITY OF FRESNO**

Final Report

**Prepared for
Boyle Engineering Corporation
Fresno, California**

**by
Kenneth D. Schmidt and Associates
Groundwater Quality Consultants
Fresno, California**

March 31, 2004

KENNETH D. SCHMIDT AND ASSOCIATES
GROUNDWATER QUALITY CONSULTANTS
600 WEST SHAW, SUITE 250
FRESNO, CALIFORNIA 93704
TELEPHONE (559) 224-4412

March 31, 2004

Mr. Mark Ysusi
Boyle Engineering Corporation
1360 E. Spruce Avenue
Suite 101
Fresno, CA 93720

Re: City of Fresno Nitrate
Management Plan

Dear Mark:

Submitted herewith is our final report on nitrate in groundwater in and near the City of Fresno. We appreciate the cooperation of the City of Fresno, Boyle Engineering Corporation, Geomatrix Consultants, Inc., County of Fresno Environmental Health, the City of Clovis, Bakman Water Company, and the Malaga County Water District in providing data for use in the evaluation.

Sincerely yours,



Kenneth D. Schmidt
Geologist 1578
Certified Hydrogeologist 176

KDS/pe

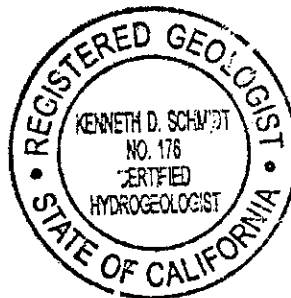
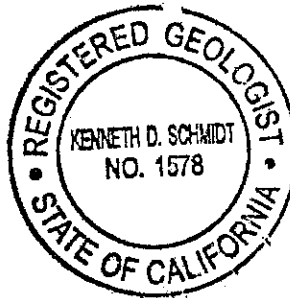


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DISTRIBUTION AND SOURCES OF NITRATE IN GROUNDWATER IN AND NEAR THE CITY OF FRESNO

INTRODUCTION

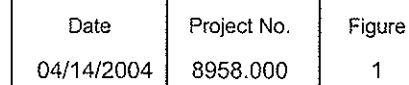
This hydrogeologic report was prepared as part of a management plan for nitrate in groundwater in the City of Fresno. As of early 2004, 13 City of Fresno wells had been taken out of service due to nitrate concentrations exceeding the maximum contaminant level (MCL) of 45 mg/l. In this report, the hydrogeologic framework is first discussed. This includes subsurface geologic conditions, water levels, aquifer characteristics, and sources of recharge and discharge. Understanding of these topics is important in understanding groundwater movement and groundwater quality. Next, potential sources of nitrate in groundwater beneath the City of Fresno are discussed. Information on a number of nitrate sources has been compiled and evaluated during the past three decades, and important evaluations are referenced. The geographic and vertical distribution of nitrate in groundwater is then discussed. This is followed by a discussion of time trends for nitrate in well water. Next, the study area is divided into six subareas, which are discussed in more detail. Lastly, well construction practices are reviewed, particularly in terms of the potential to mitigate high nitrate concentrations in well water through enhanced well construction practices.

A substantial amount of data on the hydrogeologic framework and groundwater quality was presented in Appendix D by Kenneth D. Schmidt and Associates of the Phase I report by CH₂M-Hill (1992) for the Fresno/Clovis Metropolitan Water Resources Management Plan. Some of this has been updated or expanded upon as necessary for this evaluation.

SUBSURFACE GEOLOGIC CONDITIONS

Page and LeBlanc (1969) provided the regional subsurface geologic framework for the Fresno area. Information from drillers logs, electric logs, and geologic logs have subsequently been used to provide much more detail on subsurface geologic conditions beneath the Fresno urban area. Figure 1 shows the locations of subsurface cross sections that have been developed in the urban area, to indicate conditions important in terms of water supply wells. Several of these were done as part of this evaluation. Presently available data now extend to a depth of about 500 to 600 feet throughout much of the area, particularly in northwest Fresno, the Fresno North Growth Area, in Clovis, in southeast Fresno, and along Highway 99. In addition, information is available in some parts of the urban area to depths ranging from 800 to 900 feet.

These cross sections demonstrate the predominance of coarse-grained deposits above a depth of several hundred feet in the urban area. These deposits were termed the Quaternary older alluvium by Page and LeBlanc (1969). Most of the public-supply wells in the urban area as of 1969 were relatively shallow and tapped only the Quaternary older alluvium. Finer-grained deposits below a depth of several hundred feet in the urban area are termed the Tertiary- Quaternary continental deposits, also following the terminology of Page and LeBlanc (1969). These deposits have been tapped by a number of deeper wells in the urban which have been drilled since about 1980.



Five subsurface geologic cross sections were developed in the North Fresno Growth Area by Kenneth D. Schmidt and Associates (KDSA) (1987). These sections illustrated the predominance of thick clay strata in the continental deposits beneath part of the North Fresno Growth Area, which limits the ability to drill deep wells in parts of that area.

As part of an evaluation of DBCP contamination in southeast Fresno for the City of Fresno, KDSA (1984) developed three sub-surface geologic cross sections in the Sunnyside Area. In 1991, some of these cross sections were revised and updated, and a new section was developed, based on additional information available by that time. These cross sections were developed as part of a hydro-geologic evaluation for a feasibility study that was conducted on behalf of the City of Fresno and the Fresno Irrigation District. One of the major findings from these cross sections was the predominance of fine-grained strata below a depth of several hundred feet in part of the Sunnyside area, particularly in the area east of Clovis Avenue. This limits the potential to drill deeper wells in part of this area.

As part of an evaluation of the Cities of Fresno and Clovis WWTF, KDSA (2003) developed two subsurface geologic cross sections in that area, in the southwest part of the study area. These sections indicated the presence of a major confining bed, about 350 feet deep. Coarse-grained highly productive strata are indicted to be present below this confining bed and above a depth of about 650 feet.

Because of the presence of high nitrate concentrations in the area south of the Fresno Air Terminal, in the Sunnyside area, in the Calwa-Malaga area, and in the southwest part of the Fresno urban area, four new subsurface cross sections were developed in these areas, as part of this evaluation. Appendix A contains all of the subsurface cross sections shown in Figure 1.

The alluvial deposits beneath the Fresno area have been subdivided into several types, based primarily on particle size and interpretation of the electric logs. One type comprises deposits that are primarily coarser than sand, usually cobbles, gravel, and sometimes boulders. Deposits of this type are generally the most permeable of the deposits, except when inter-mixed with clay. A second type comprises deposits that are primarily sand. Deposits of this type are also generally highly permeable. These two coarse-grained types comprise the major water-producing deposits of the urban area. A third type comprises deposits that are primarily clay. Deposits of this type are generally of the lowest permeability of all the deposits. If a sufficient thickness of these strata is present, then they may act as a confining bed, to partly separate groundwater in the overlying and underlying coarse-grained deposits. This type is extremely important in terms of the vertical distribution of nitrate and other chemical constituents in the groundwater. The fourth type comprises fine-grained deposits of an intermediate texture between sand and clay. Included in this type are silt, sandy clay, clayey sand, and silty clay deposits. Deposits of this type generally have a low to moderate permeability, contribute some water to wells, and do not act as significant confining beds in most cases. As in most alluvial basins in the southwest, these deposits are variable in thickness and extent, and sometimes individual units cannot be correlated for great distances laterally.

Subsurface geologic cross sections have also been developed in relatively small parts of the urban area as a result of site-specific investigations of groundwater contamination. Included are the Thompson-Hayward Facility (near McKinley and Temperance Avenues), the FMC, Floway, and Vendo facilities near Calwa, the Purity Oil facility near Malaga, the Pinedale TCE plume, and the Fresno Air Terminal Area VOC plumes.

At least three areas underlain by relatively thick clay strata in the continental deposits have been delineated in the Fresno urban area. One is a southwest-northwest oriented zone in the central part of the Fresno North Growth Area. Another is east of Clovis Avenue, extending from east of the Fresno Air Terminal to California Avenue. The third is smaller than the other two, and is between Calwa and Greenfield Village, primarily south of Kings Canyon Avenue. These are very important in terms of the potential to drill deep wells in part of the Fresno urban area, in order to obtain water with acceptable nitrate concentrations.

WATER LEVELS

Water-level measurements were obtained from the City of Fresno, City of Clovis, Fresno Irrigation District, and the California Department of Water Resources. This allowed fairly detailed depth to water and water-level elevation contour maps to be prepared for Spring 2003. Such detailed maps are also available for Spring 1991 from Appendix D of CH₂M (1992).

Depth to Water

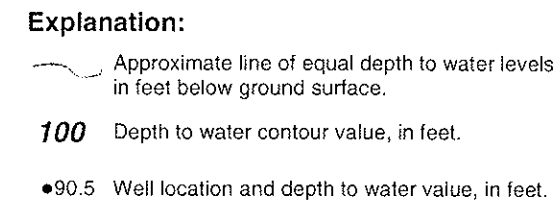
Figure 2 indicates that depth to water ranged from about 60 to 80 feet beneath adjacent rural areas to more than 160 feet in part of the urban area in Spring 2003. The depths shown are for water supply wells, and may not indicate depth to water in the shallowest saturated strata (such as shown by shallow monitor wells). Some of the shallowest water levels were in the southeast part of the urban area, and the deepest water levels were in parts of the Fresno North Growth Area. In most of the urban area, depth to water was between 80 and 150 feet. In general, depth to water is greater to the north, beneath topographically higher areas.

Water-Level Elevations

Figure 3 is a water-level elevation and direction of groundwater flow map for Spring 2003. In Spring 2003, the water table was relatively flat in the northwest part of the urban area, in downtown Fresno, and to the southwest. In Spring 2003, water-level elevations ranged from more than 300 feet above mean sea level in northeast Clovis and east of Sunnyside, to less than 190 feet in downtown Fresno.

Figure 3 also shows groundwater flowlines for Spring 2003, based on the water-level elevation contours. The direction of groundwater flow and hydraulic gradient are important in terms of determining rates and amounts of groundwater inflow into the urban area and into subareas within the urban area. They are also important in evaluating changes in groundwater quality that can be expected in the future. Historically the urban cone of depression has gradually expanded to the north and south. The historical boundaries of this cone of depression were provided in Appendix D of CH₂M-Hill (1992).

On Figure 3, there are a number of places where flowlines converge and effectively terminate. These are locations of groundwater discharge, which in the urban area are areas of concentrated pumping. Similarly, there are a number of places where flow lines diverge or begin, which are



Approximate scale:



0 0.5 1 2 3 Miles



N

Basemap modified from maps supplied by the cities of Fresno and Clovis.
Data provided by the cities of Fresno and Clovis.

DEPTH TO WATER IN SPRING 2003

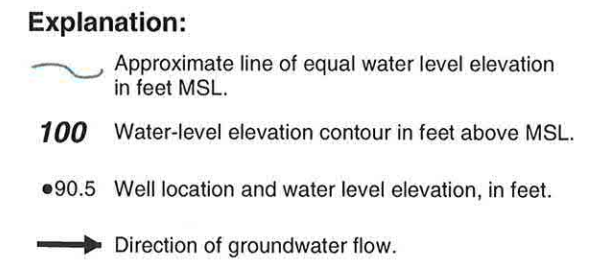
Ken D. Schmidt and Associates



Date
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Figure
2



Approximate scale:



0 0.5 1 2 3 Miles



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Basemap modified from maps supplied by the cities of Fresno and Clovis.
Data provided by the cities of Fresno and Clovis.

WATER LEVEL ELEVATIONS AND DIRECTION OF GROUNDWATER FLOW (SPRING 2003)

Ken D. Schmidt and Associates

 GEOMATRIX	Date 04/19/2004	Project No. 8958.000	Figure 3
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locations of groundwater recharge. A major source of recharge to the part of the urban area south of Ashlan Avenue and north of Kings Canyon Avenue is from intentional recharge at the City of Fresno Leaky Acres facility (operated since 1970) and the nearby former City of Clovis recharge facility. In southeast Fresno, inflow of groundwater from upgradient irrigated lands and canal seepage appear to be the major sources of recharge. There is some recharge in the north part of the Fresno urban area west of Highway 41 due to seepage of streamflow in the San Joaquin River. Canal seepage is an important source of recharge in and near the Fresno urban area.

Vertical Head Differences

Substantial information on vertical differences in hydraulic head has become available from the City of Fresno observation well installation and monitoring program and test holes or wells conducted for a number of water purveyors in the area. In general, each of these observation wells has several nested completions, each tapping different water-producing strata at the same site. Water-level measurements are now available for these wells at more than 140 sites in the urban area.

Fresno North Growth Area

Upon completion, some observation wells in this area had essentially no differences in hydraulic head with depth. These wells were usually 400 feet deep or less, and were not near relatively deep wells. Records at most sites indicated vertical differences in head of at least five feet. Records for several sites that were near deep public-supply wells indicated head differences ranging from 30 to almost 40 feet. These head differences are primarily between groundwater in the older alluvium and groundwater in the under-lying continental deposits. The observation wells showing large head differences were generally in areas where a significant confining bed is located in the upper part of the continental deposits, and where relatively deep supply wells were present.

Southeast Fresno Area

Observation wells in this area can be grouped into two geographic areas. Measurements at three sites near the Fresno Air Terminal showed difference in hydraulic head with depth ranging from 5 to 40 feet and averaging about 20 feet. In this same area, Bakman Water Company deep Well No. 13A was drilled, and a similar difference in water levels was observed between this new deep well and an adjacent old shallow well (No. 13). These differences are attributed to pumpage from some deep public-supply wells in the vicinity (such as City of Fresno PS 102 and Bakman Water Co. 13A) and also due to substantial clay layers in the upper part of the continental deposits. The head differences are again largely between shallow groundwater in the older alluvium and deeper groundwater in the continental deposits.

Measurements for several wells south of Kings Canyon Avenue prior to development of deep wells showed smaller differences in hydraulic head, usually about five feet or less. However, at that time, there was little pumpage from deep wells in the Sunnyside area.

Time Trends

Water-level hydrographs were prepared for numerous wells in and near the Fresno urban area as part of the Fresno/Clovis Metropolitan Water Resources Management Plan. In order to determine long-term water-level trends from the hydrographs, the period from Spring 1965 to Spring 1990 was previously evaluated. As part of this evaluation, representative water-level hydrographs were updated through Spring 2003 (Figure 4).

Southeast Fresno Area

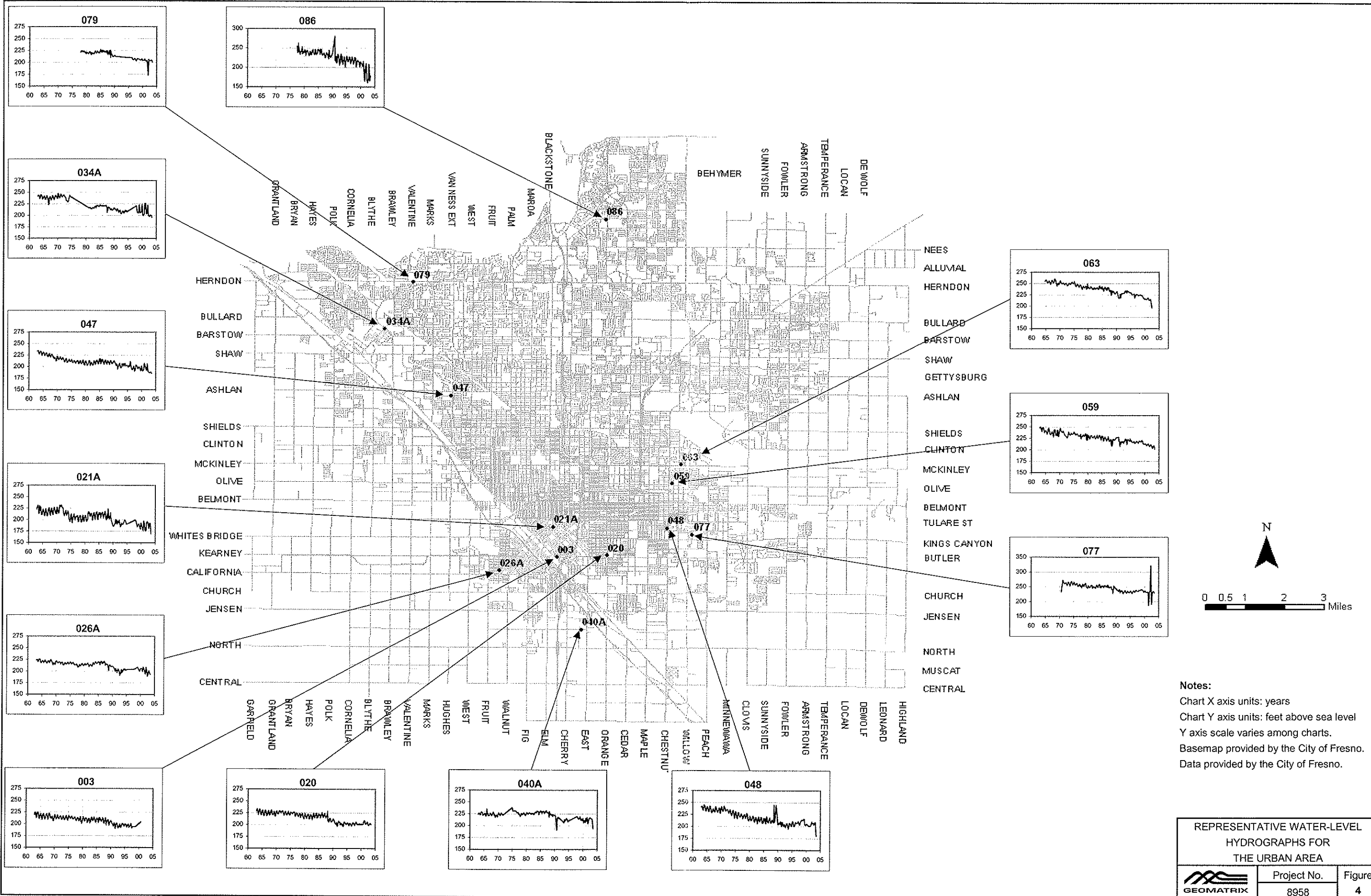
Water-level hydrographs were available for ten wells in the southeast part of the Fresno urban area. Most of these wells were downgradient of the high nitrate areas (to be described later in this report). For the period 1965-90, the average water-level decline was 0.9 foot per year. Trends through 2003 were generally the same as for 1965-90. Essentially, this area appears unaffected by recharge at Leaky Acres. In addition, irrigation of upgradient lands in this area has relied extensively on groundwater pumpage, as opposed to canal deliveries. Lastly, intentional recharge in this area has been limited due to subsurface geologic conditions beneath many of the basins that are used. An almost uniform water-level decline has occurred over the years, and there has been no obvious effect of intentional recharge.

Northwest Fresno Area

The area considered in Northwest Fresno for the water-level hydrograph evaluation was generally bounded by Blackstone Avenue on the east, Belmont on the south, Highway 99 on the southwest, and the San Joaquin River on the north. Hydrographs were available for 30 wells in this area. For the period 1965-90, the average decline was 0.5 foot per year. The substantial reduction in the rate of water-level decline in this area after the late 1970's is similar to that experienced in the area affected by Leaky Acres. The primary reason for this is attributed to increased intentional recharge in storm basins in this area since 1978. Prior to 1978, such recharge had been small. Water-level trends through 2003 were generally the same as for 1978-90.

Fresno North Growth Area

The North Fresno Area considered for the hydrograph evaluation was bounded on the north by Copper Avenue, on the west by Ingram Avenue, on the south by Shaw Avenue, and on the east by Willow Avenue. Long-term hydrographs were available for 14 wells in this area. For the period 1965-90, the average rate of decline was 0.7 foot per year. Overall the rate of water-level decline in the part of this area north of Herndon Avenue during 1980-90 was similar to that observed in southeast Fresno. This is attributed to increased urban pumping after 1978, and to the relatively small amount of intentional recharge in this part of the urban area. After 1990, water-level declines in the Fresno North Growth Area increased considerably, due to development and pumping of a number of new City wells.



The rate of decline increased to the range of two to five feet per year. Limitations on intentional recharge in this area include the following:

1. Unfavorable subsurface geologic conditions beneath much of the area.
2. Stormwater from part of the area drains to the San Joaquin River, and flood basins aren't available in some parts of the area for recharge.
3. The lack of canal distribution facilities to allow intentional recharge in parts of the area.

AQUIFER CHARACTERISTICS

Aquifer tests are now available for about 80 large-capacity wells in and near the urban area. Aquifer tests are also available for recovery or extraction wells at a number of groundwater contamination sites. Information on aquifer characteristics was summarized in the report on the Fresno/Clovis Metropolitan Water Resources Management Plan Appendix D of CH₂M-Hill (1992).

Transmissivity

Transmissivity is an indication of the capability of the aquifer to transmit water through a specific width of the aquifer. Aquifer tests for wells in the North Fresno Growth Area indicate transmissivities ranging from 39,000 to 100,000 and averaging 60,000 gpd per foot. These values are among the lowest in the urban area, and are due to the predominance of fine-grained deposits in this interfan area (between large streams). Aquifer tests for wells in the southeast Fresno subarea indicate transmissivities ranging from about 65,000 to 155,000 and averaging 110,000 gpd per foot. Aquifer tests for wells in northwest Fresno indicate transmissivities ranging from 112,000 to 253,000 and averaging 190,000 gpd per foot. This area thus has the highest transmissivities of the urban area. This is primarily due to an abundance of stream channel and other coarse-grained deposits of the ancestral San Joaquin River beneath this part of the urban area.

Hydraulic Conductivity

Horizontal hydraulic conductivity values for coarse-grained (sand or coarser) strata in the older alluvium tapped by large-capacity wells have been determined by a number of the aquifer tests. Hydraulic conductivity values ranged from 1,600 to 2,600 gpd per square foot, and are for relatively clean sand, gravel, and cobbles. These values are typical of those found in similar deposits elsewhere in the southwestern U.S. Finer or dirtier (more silt and clay) sands generally have a lower conductivity, commonly ranging from about 200 to 700 gpd per square foot.

Vertical conductivities of confining beds in the urban area have not been determined by aquifer tests. However, comparing the nature of these beds to that observed elsewhere in alluvial deposits, it is estimated that vertical conductivities of these beds range from about 0.01 to 2 gpd per square foot.

Specific Yield

Page and LeBlanc (1969) presented estimates of specific yield for the Fresno area. JCE and HA (1969) utilized an average specific yield of 0.13 for the aquifer in the urban area, based on a review of drillers logs available at the time. Exact values of specific yield for the deeper alluvium (continental deposits) aren't available. However, average values for the older alluvium (generally above a depth of several hundred feet), in northwest Fresno and in the southeast Fresno subarea probably range from 0.15 to 0.20, based on the coarse-grained nature of these deposits. Average values for the underlying continental deposits probably range from about 0.07 to 0.12, based on the predominant fine-grained texture of these deposits.

SOURCES OF RECHARGE AND DISCHARGE

In agricultural areas with surface water supplies, major sources of recharge have been canal seepage and deep percolation of irrigation water applied in excess of the crop consumptive use. Additional recharge has been from seepage of Dry Creek, Dog Creek Redbank Creek, and the San Joaquin River.

Intentional recharge of canal water has been practiced at Leaky Acres by the City of Fresno since 1971, west of Tarpey Village by the City of Clovis since 1974, and by the FCWD, City of Fresno, and City of Clovis in Fresno Metropolitan Flood Control District storm runoff basins since 1978. In 1978, almost 24,000 acre-feet were recharged, about half of which was at Leaky Acres. Recharge had increased to over 40,000 acre-feet per year by 1984, and to almost 50,000 acre-feet per year by 1990. Some water has been diverted by F.I.D. for irrigation and lake filling at Woodward Park and at the Copper River Ranch, and this can be considered in-lieu recharge. Provost & Pritchard and Kenneth D. Schmidt and Associates (1999) discussed recharge by the City of Clovis. The City developed a recharge site near Leaky Acres in 1977 (the Clovis Basin) and another (Marion Basin) in the Herndon-Shepard Plan Area in 1996. In 1998, 10,200 acre-feet were recharged in the City of Clovis through FMFCD basins, the two City intentional recharge basins, and through creeks. In 2003, the total estimated intentional recharge in the urban area was 61,717 acre-feet.

POTENTIAL SOURCES OF NITRATE IN THE GROUNDWATER

In order to understand the occurrence of nitrate in groundwater of the Fresno urban area, it is essential to evaluate the possible sources in and upgradient of the area. Both natural and manmade sources are discussed in the following part of this report.

Feth (1966) and the American Water Works Association (1967) provided excellent reviews concerning nitrogen compounds in water. Nitrogen is generally found in wastewater in both organic and inorganic forms. During the movement of wastewater through the topsoil, the suspended organic solids are largely filtered out. Thus large quantities of organic nitrogen do not penetrate far into the topsoil. However, this organic matter may be gradually broken down (mineralized) through microbiological activity, thus contributing ammonia to the soil. The forms of dissolved nitrogen of primary interest in the study of groundwater in the Fresno area are ammonia, nitrate, and organic nitrogen.

Soil particles generally have a great capacity to adsorb ammonium. In the normal pH range of the topsoil in the area, nitrate is apparently not adsorbed or is bound only slightly by the topsoil. Nitrogen in soil can be incorporated into organisms as a result of biological activity.

The oxidation of ammonia to nitrate is termed nitrification. Nitrogen is often nitrified during drying periods for wastewater ponds. The nitrate is then readily leached during the subsequent wetting period. The term "denitrification" refers to the reduction of nitrate to nitrogen gases. Significant quantities of nitrogen may be lost from the topsoil by formation of the nitrogen gases.

Natural

High nitrate concentrations have been found in groundwater in some parts of the southwest U.S. where no man-made sources of contamination were present. Various sources of these "natural" high contents of nitrate have been evaluated. Weathering products of igneous and metamorphic rocks are low in nitrogen. Since most of the alluvium in the Fresno area is derived from such rocks, natural nitrogen concentrations are low in the alluvium. Surface waters, such as the San Joaquin and Kings Rivers, are extremely low in nitrate.

Soils of the Fresno urban area are typically low in organic matter. However, Haskell, et al. (1967) noted high nitrate concentrations in groundwater beneath some dry-farmed lands along the edge of the valley floor. Native grasses can accumulate nitrogen from the atmosphere during the growing season in the winter and spring, when abundant rains often occur. In the summer, these native grasses die and some of the nitrogen enters the topsoil. The next winter's rains can leach some of the nitrogen to the groundwater, before plants are present to consume the nitrogen that was stored in the soil. The area near the foothills is a likely place for this sequence to occur. Depth to groundwater is usually shallow, and rainfall approaches 20 inches per year in this area. Strahorn et al. (1912) noted that in the Fresno area, the "plains" supported a luxuriant growth of native grass during the winter and spring months. However, with the development of farming and urbanization, this effect became insignificant in the Fresno urban area many years ago.

Analyses of water from wells in the City and surrounding rural areas for the late 1940's and early 1950's indicate that nitrate concentrations were usually less than 5 mg/l. The only exceptions were several wells (i.e., such as the Van Sickle ice plant well) that had already been influenced by man-made sources of nitrogen. These analyses confirm that natural sources of nitrate are generally insignificant, in terms of the high nitrate concentrations (i.e., 35 mg/l or greater) found in water from some wells in the Fresno urban area.

Sewage Effluent

Nitrogen in secondary sewage effluent is usually about equally divided between ammonia and organic forms. About one-half of the organic nitrogen can be converted to ammonia, either during transport of wastes to the treatment plant or during treatment. Some removal of nitrogen takes place incidentally during treatment, and a removal of 20 to 50 per cent of the total nitrogen is common. Much of the organic nitrogen is contained as suspended solids, which is removed with the sludge. However, in treatment plants where the sludge is treated anaerobically, a large part of the nitrogen released by the process leaves the treatment plant in the effluent.

The total nitrogen concentration in sewage effluent ranges from about 20 to 30 mg/l when there is no specific treatment for nitrogen removal. This range has a nitrate equivalent of 90 to 130 mg/l (if all of the nitrogen in the effluent was to be converted to nitrate).

In the Fresno area, high nitrate concentrations were noted by the California Department of Water Resources (1965) in well water near the Fresno Sewage Treatment Plant. High nitrate concentrations were noted by Behnke and Haskell (1968) in well water near the Clovis Sewage Treatment Plant. A number of other sewage treatment plants (Figure 5) were also present, as indicated by the California Department of Water Resources (1965). The Clovis Sewage Treatment Plant and Malaga Sewage Treatment Plant had the highest nitrate concentrations in the effluent of all of these plants (Table 1). All of the wastewater treatment plants in the urban area were subsequently closed and hooked into the City of Fresno Regional WWTF, except for the Malaga CWD WWTF, which is still in operation. More recent information on the quality of effluent from the Cities of Fresno and Clovis WWTF was provided by KDSA (2003).

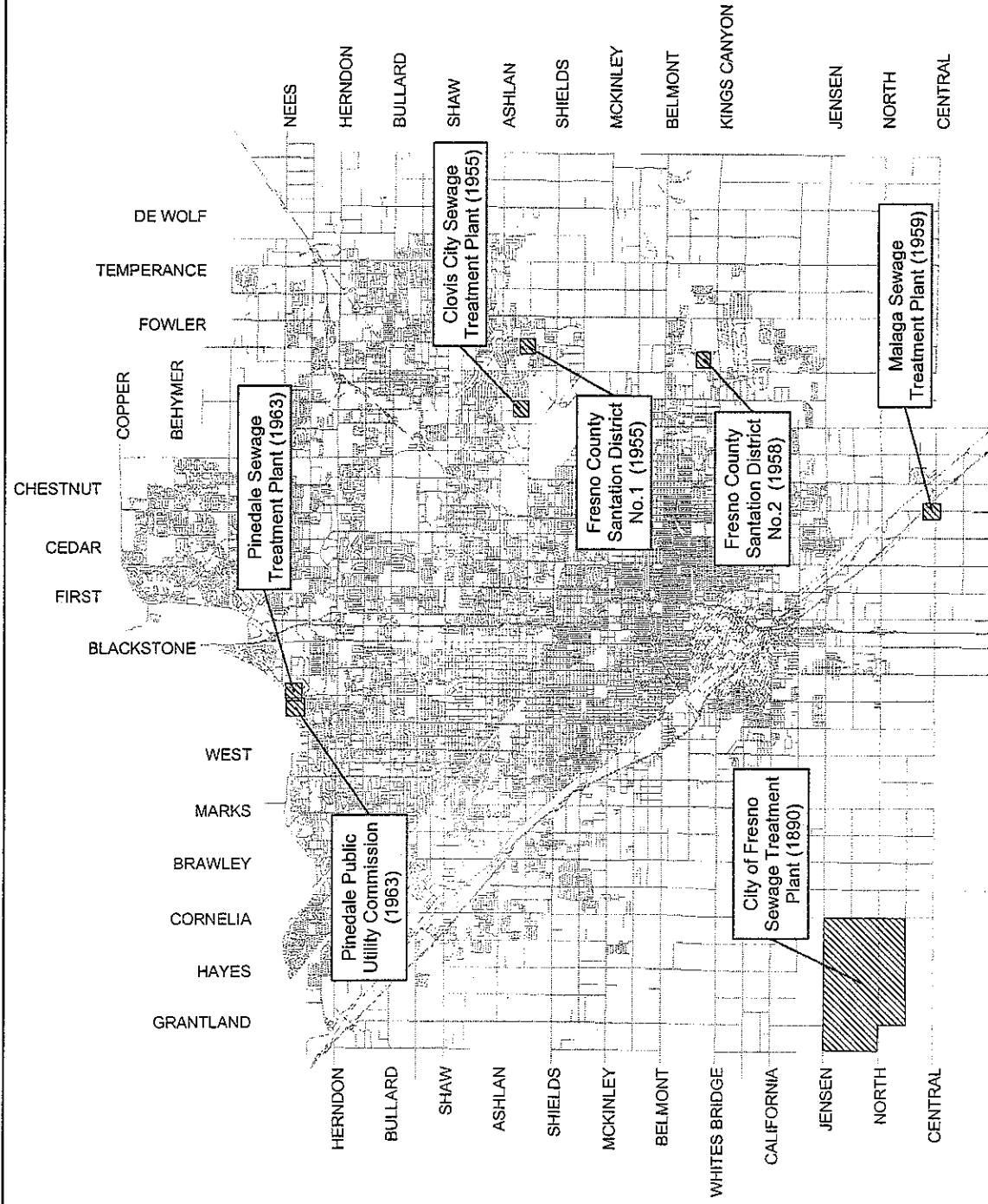
Septic Tanks

A septic tank allows solids to settle out, and a clarified effluent to be discharged. The two common effluent disposal systems are trenches and seepage pits. A seepage pit is a hole, normally 20 to 50 feet deep, with an open joint lining through which effluent from the septic tank seeps into the surrounding soil. Pits are normally used where shallow hardpan or clay necessitates bypassing the shallow soil. Trench systems utilize tiled porous drains embedded in gravel, which distribute the septic tank effluent over a large area of soil, (Clark and Viessman, 1969).

One of the most comprehensive studies of septic tanks and nitrate in groundwater was undertaken in Minnesota by Schroepfer and Polta (1969). This study indicated the likelihood of high nitrate concentrations from septic tank effluent. These authors found that most septic tank effluent had an ammonia-nitrogen concentration of 28 ppm, or a nitrate equivalent of about 123 ppm.

According to Engineering-Science (1972), about 110,000 people were served by individual septic tanks in 1969 in the Fresno urban area. There were also a number of community septic-tank systems, such as at schools. A number of previous investigators noted the high nitrate concentrations in groundwater beneath unsewered parts of the Fresno area, particularly the Mayfair area.

Figure 6 shows the location of unsewered areas (including rural residential) in and near the Fresno urban area as of 1970 and in 2003. The three largest dense septic tank areas in 1970 were the Figarden area, the Mayfair area, and the Sunnyside area. The Fresno City mandatory sewer ordinance required all new annexations to the City to be connected to municipal sewer systems. Sewering of the Mayfair area (the most dense septic tank area) began in June 1970. Formerly unsewered areas in most of the Fresno urban area were connected to the Fresno City regional sewer system by the early 1980's. However, much of the Sunnyside area, part of the Figarden Area north of Bullard Avenue, and Fort Washington Estates have remained unsewered. The County of Fresno rural residential areas (2.5-acre lots) also rely on septic tanks. Most of these areas are served by individual domestic wells.



Basemap modified from information supplied by the cities of Fresno and Clovis.
 Date of construction is given in parentheses next to facility name.



LOCATION OF WASTEWATER TREATMENT FACILITIES IN THE URBAN AREA AS OF 1970

Ken D. Schmidt and Associates



Date	Project No.	Figure
04/14/2004	8958.000	5

TABLE 1-WASTEWATER ANALYSES IN FRESNO-CLOVIS METROPOLITAN AREA, 1963

Waste Dis- charger	Date of Sample	pH	Ca	Mg	Na	K	SO ₄	Cl	NO ₃	B	HCO ₃	TDS	Organic Nitrogen	Total Nitrogen
1	4-63	7.4	14	9	34	10	16	20	1	0.4	177	263	18.3	18.5
2	4-63	7.0	11	28	80	16	40	42	73	0.5	107	534	25.6	42.1
3	11-63	7.3	16	15	44	9	7	18	1	0.1	207	362	--	--
4	11-63	7.3	26	12	33	10	7	15	1	0.0	199	360	--	--
5	4-63	7.0	12	16	71	12	33	26	2	0.8	236	433	29.0	29.4
6	4-63	6.9	11	20	83	15	33	35	1	0.8	244	456	39.7	40.0
7	6-63	7.4	74	12	121	19	49	92	52	1.7	313	633	--	--
8	4-63	7.3	28	10	42	70	5	19	1	0.5	287	439	10.3	10.5
9	10-63	4.8	52	52	102	920	177	41	2	0.2	366	1770	--	--
10	10-63	4.6	36	22	20	360	56	12	2	0.1	0	556	--	--
11	11-63	3.7	52	48	60	3300	115	68	2	0.0	0	3700	--	--
11	11-63	7.1	43	33	228	27	9	244	2	0.0	538	1196	--	--
1.	Fresno City Sewage Treatment Plant													
2.	Clovis City Sewage Treatment Plant													
3.	Pinedale Public Utility Commission													
4.	Pinedale Sewage Treatment Plant													
5.	Fresno County Sanitation District No. 1													
6.	Fresno County Sanitation District No. 2													
7.	Malaga Sewage Treatment Plant													
8.	Italian Swiss Colony Winery													
9.	Alta Vineyards													
10.	E & J Gallo Winery													
11.	Fresno Meat Packing Company													

Data from California Department of Water Resources (1965) in parts per million except for pH.

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EXPLANATION:

- Unsewered Urban Aas - 2003
- Rural Residential - 2000
- Unsewered Urban Areas - 1970
- Rural Residential - 1970

Approximate scale:
0 0.5 1 2 3 Miles



1970 unsewered areas derived from historical maps.
1970 rural residential areas derived from historical maps.
2003 unsewered areas information provided by the City of Fresno.
2000 rural residential areas derived from Fresno County 2000 General Plan.
Basemap modified from information supplied by the cities of Fresno and Clovis.

LOCATION OF FORMER AND
PRESENT UNSEWERED AREAS

Ken D. Schmidt and Associates



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04/15/2004	8958.000	6

Fertilizers

Anhydrous ammonia accounted for more than 90 percent of all nitrogen fertilizer used in the United States as of the 1960's (Smith, 1968). Solid forms include ammonium nitrate, ammonium phosphate, and ammonium sulfate. Urea has also become widely used for nitrogen fertilizer in the Fresno area since that time.

Iback and Adams (1967) summarized average nitrogen fertilizer rates for the San Joaquin Valley as of the 1960's (Table 2). In the San Joaquin Valley in 1973, a common application rate for corn was 175 pounds per acre, the rate for alfalfa was 20 pounds per acre, and the rate for vegetable crops ranged from 80 to 150 pounds per acre (Rauschkolb and Mikkelsen, 1978). Statewide, vineyards received an estimated 60 pounds per acre of nitrogen, whereas almond orchards received 190 pounds per acre for the 1991 crop year (National Agricultural Statistics Service and Economic Research Service, 1992).

Figure 7 shows the locations of irrigated lands in the study area as of 1976-77, as developed by the County of Fresno (1978) for the 208 Water Quality Management Program. The crop types shown have been indicated to be important in terms of groundwater quality, including nitrate concentrations, as discussed subsequently in this section of the report. Precise estimates of presently or recently applied nitrogen fertilizer on irrigated lands in the Fresno area are not available.

The Basin 5D (Tulare Lake Basin) study for the State Water Resources Control Board (1974) indicated that high nitrate concentrations were present in groundwater along the east side of the valley, and these often coincided with citrus orchards. Burow, Shelton, and Dubrovsky (1998) of the U.S. Geological Survey determined nitrate concentrations in shallow groundwater beneath irrigated lands in parts of the eastern San Joaquin Valley. They sampled a total of 60 private domestic wells and 30 monitor wells. Nitrate concentrations were determined in groundwater beneath vineyards, almond orchards, and corn, alfalfa, and vegetable crops. They found that nitrate concentrations in water samples from shallow wells were related to the rate of fertilizer application, and to the texture of the topsoil and shallow alluvium. Nitrate concentrations exceeded the drinking water standard in 30 percent of the private domestic wells that were sampled.

Nitrate concentrations were the highest in samples from the wells in the almond orchards, whereas concentrations were the lowest in samples from the vineyards. The corn, alfalfa, and vegetable lands had intermediate nitrate concentrations. Higher fertilizer application rates and coarser topsoil and alluvium were coincident with higher nitrate concentrations in the groundwater.

Industrial Sources

Many industries in the Fresno area are related to the processing of agricultural products. Some industries have been on the City of Fresno or Malaga CWD sewer systems, whereas others have had on-site disposal facilities.

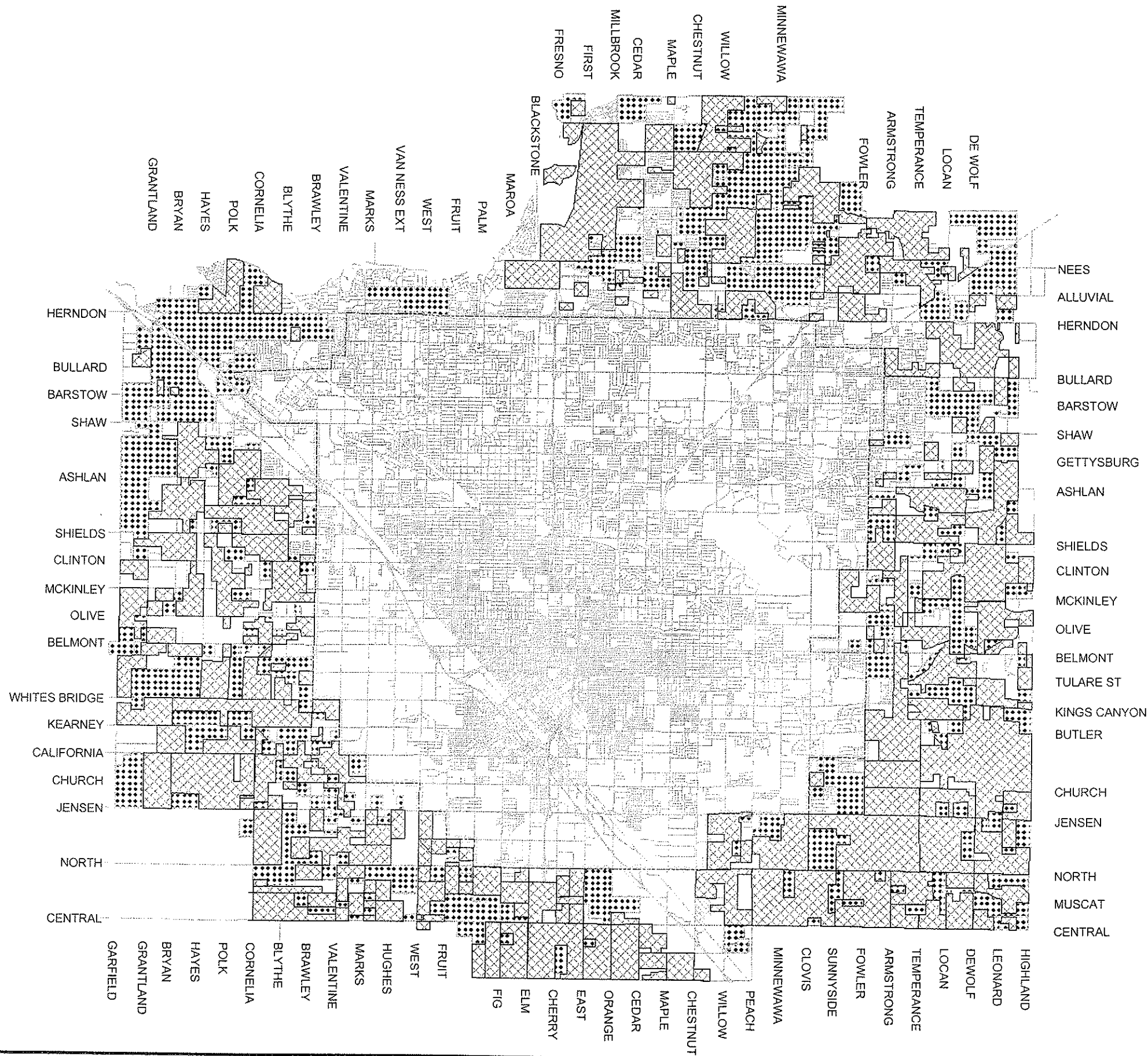
Engineering-Science, Inc. (1970) listed 19 industrial liquid waste dischargers in the Fresno urban area that were not on municipal systems in 1969 (Figure 8). Included in these dischargers were three wineries on Clovis Avenue (east of the Fresno Air Terminal), and two meat packing plants, both southwest of downtown Fresno (Table 3).

TABLE 2-AVERAGE RATES OF NITROGEN APPLICATION FOR
SELECTED CROPS IN THE SAN JOAQUIN VALLEY (1960's)

<u>Crop</u>	<u>Annual Nitrogen Application (Pounds/Acre)</u>
Corn	128
Sorghum	121
Cotton	114
Fruit and nuts	92
Beans	82
All Crops	91

From Iback and Adams (1967).

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EXPLANATION:

- Deciduous or Citrus Orchards
- All Other Crops
- Street System Area Boundary

Approximate scale:
0 0.5 1 2 3 Miles



Crop patterns dervied from:
Fresno Irrigation District 1977 Crop Survey,
Fresno County Public Works Department 1976 Land Use Survey,
California Department of Water Resources 1972 Crop Survey.
Basemap modified from information supplied by the cities of
Fresno and Clovis.

LOCATION OF IRRIGATED
AREAS AS OF 1976-77

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Date	Project No.	Figure
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LOCATIONS OF PAST AND PRESENT WINERIES, MEAT PACKING PLANTS, AND INDUSTRIES IN THE URBAN AREA

Ken D. Schmidt and Associates



Project No.
8958.000

Date
04/14/2004

Figure
8

- Explanation**
- ▲ Food Processing
 - ◆ Meat Packing
 - Miscellaneous
 - ▼ Raisin Processing
 - ◆ Wineries



Basemap modified from information supplied by
the cities of Fresno and Clovis.
Data from Engineering-Science, Inc. 1970

Approximate scale:

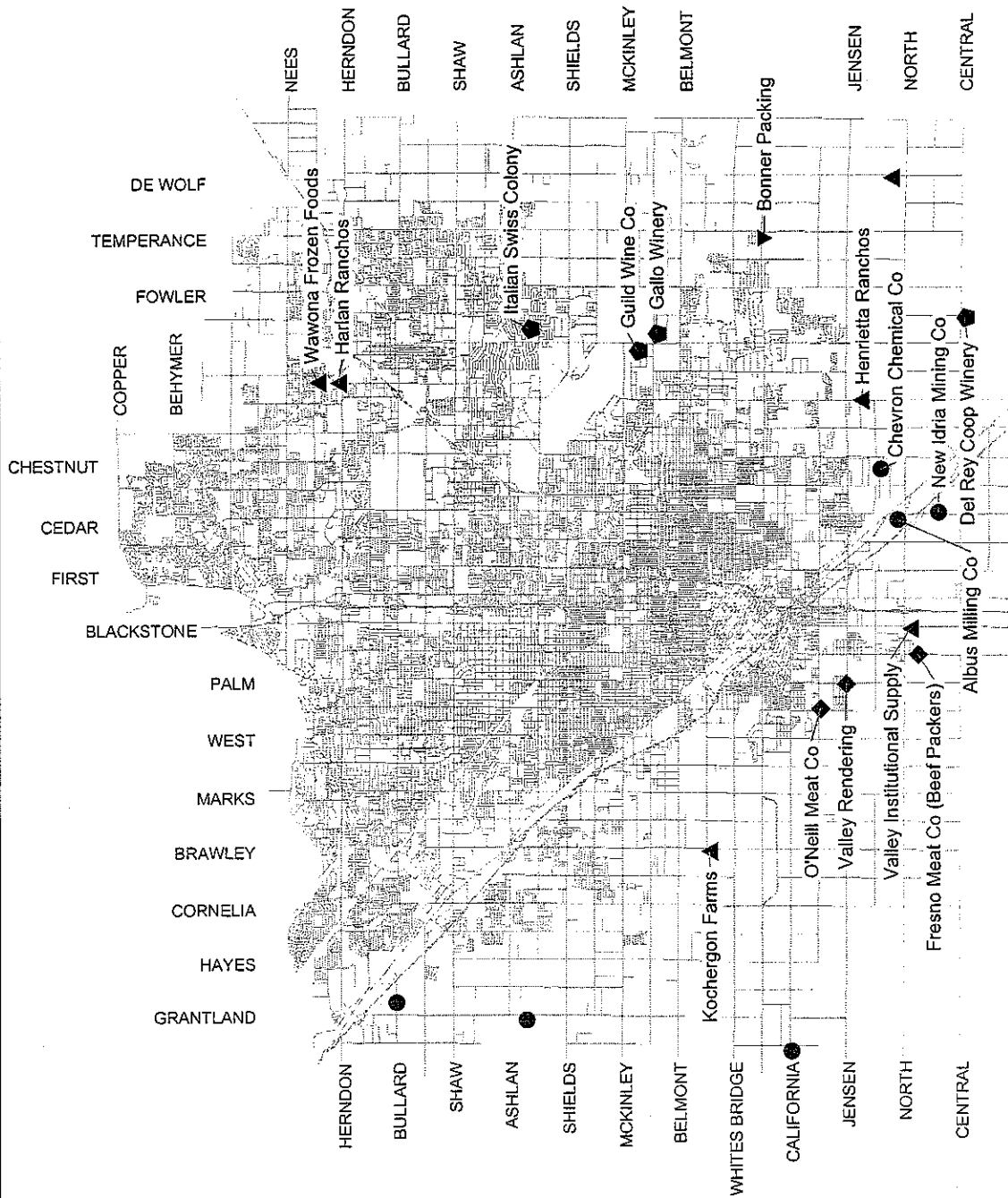


TABLE 3-LIQUID WASTE CHARACTERISTICS FOR SELECTED INDUSTRIES WITH INDEPENDENT WASTEWATER DISPOSAL SYSTEMS IN AND NEAR FRESNO URBAN AREA AS OF 1968

<u>Discharger</u>	<u>Annual Flow in 1968 (mg)</u>	<u>Period of Operation</u>	<u>Remarks</u>
Guild Wine Co. (Alta Vineyards)	16	9/1-12/1	Liquid waste from production of wine and brandy
Gallo Winery	50	9/1-12/1	Liquid waste from production of wine
Allied Winery (Italian Swiss Colony)	40	9/1-12/1	Liquid waste from production of wine
Fresno Meat Packing Company	15	Continuous	Liquid wastes from beef slaughter and meat packing
O'Neill Meat Company	35	Continuous	Liquid wastes from beef slaughter and meat packing

Data from Engineering-Science, Inc. (1970).

Several industries that are presently connected to the Fresno City sewer system relied on independent disposal facilities prior to municipal connection. Data tabulated by Engineering-Science, Inc. (1970) for major industries on municipal systems were utilized by Schmidt (1970) for an evaluation of historical connections. Information on the date of connection to the Fresno City sewer system was provided by the City of Fresno Sanitation Division (Lancor, 1970). Table 4 tabulates five industries that were apparently connected after 1920. These industries include two wineries in the Calwa area, the Roma Winery and Mont La Salle Vineyards, and one meat packing plant, Valley Rendering Corporation (near Church Avenue in southwest Fresno).

Of the industries in or near the Fresno urban area that were not sewered, several are known to generate wastes high in nitrogen concentrations. These include wineries, meat-packing plants, and raisin processing plants.

Meat Packing Plants

Concentration of organic plus ammonia nitrogen in meat-packing plant wastewater normally range from 100 to 300 mg/l. This is a nitrate equivalent of 440 to 1,320 ppm (American Water Works Association, 1967). The meat packing plants in the Fresno urban area have historically been in the southwest part of the area. The one that continues in operation is now operated by Beef Packers, Inc., and is located south of North Avenue and west of Fig Avenue. High nitrate concentrations were found in water from wells near that plant (formerly termed Fresno Meat Co.) in the 1970's.

Wineries

Engineering-Science, Inc. (1970), indicated that the winery industry contributed wastes with an average pH of 5.5, and high nitrogen concentrations (100's of mg/l) during a ninety-day period, usually starting September first. High nitrate concentrations have been found in groundwater beneath some wineries in the Fresno area. A number of wineries were located where sandy topsoils and shallow alluvium were present, which enhanced the periodic drying out of beds to which wastewater was applied.

Raisin Packing Plants

The former Bonner Raisin Packing plant (later Dole) was located south of Butler Avenue and east of Temperance Avenues. A number of ponds and irrigated land was used to dispose of raisin processing water. Such plants generate wastewater high in nitrogen and can be a source of high nitrate concentrations in the groundwater.

Dairies

Dairies are common in the Fresno area, especially in the area southwest of the City. Dairies have been present near the City of Fresno WWTF for at least one hundred years. High nitrate concentrations have been found in shallow groundwater near some dairies. The concentrations may be associated with lagoons or wastewater irrigation. More information on the influence of dairies on nitrate concentrations is expected to become available through monitoring programs that

TABLE 4-CHRONOLOGICAL SEQUENCE OF MAJOR INDUSTRIAL CONNECTION
TO FRESNO CITY SEWAGE SYSTEM BETWEEN 1920 AND 1955

<u>Industry</u>	<u>Date Connected</u>	<u>Remarks</u>
Schenley Distillers, Inc. (Roma Winery)	1936E	Expanded hookup (1961)
Mont La Salle Vineyards	1955E	Formerly Christian Brothers
Producers Cotton Oil Co.	8/53	
Ranchers Cotton Oil	10/53	
Valley Rendering Corp	11/55	Formerly Sierra Meat Co. and Sierra Rendering

Data from Lancor (1970). E is estimated.

have recently been requested by the Regional Board. The locations of dairies in specific parts of the study area are provided subsequently in this report.

PREVIOUS NITRATE STUDIES IN THE FRESNO AREA

Studies of nitrate in groundwater that have been undertaken in the Fresno urban area are reviewed in this section.

Bulletin 143-3 Study (1963)

The first comprehensive study of nitrate in groundwater of the Fresno urban area was conducted by the California Department of Water Resources (1965) and reported in Bulletin 143-3. Most of the water samples analyzed in this study were collected in 1963.

High nitrate concentrations were found in groundwater in the area southwest of the Fresno Air Terminal and in the vicinity of the Fresno Sewage Treatment Plant. As the detergent alkyl-benzene sulfonate (ABS) was also found in water from four wells near the Fresno Sewage Treatment Plant, the source of high nitrate in that area was identified as sewage effluent. Septic-tank effluent was given as the primary source of high nitrate in well water in the unsewered area (Mayfair) southwest of the Fresno Air Terminal. Most of the higher nitrate concentrations were from samples collected from shallow wells (Figure 9).

Analyses of surface waters of the area showed low concentrations of nitrate (generally less than 2 mg/l). Analyses of wastewater from wastewater treatment facilities and several industries were provided (Table 1). Total nitrogen concentrations for the wineries and meat packing plant weren't provided, but are indicated by subsequent sampling to be in the 100's of mg/l.

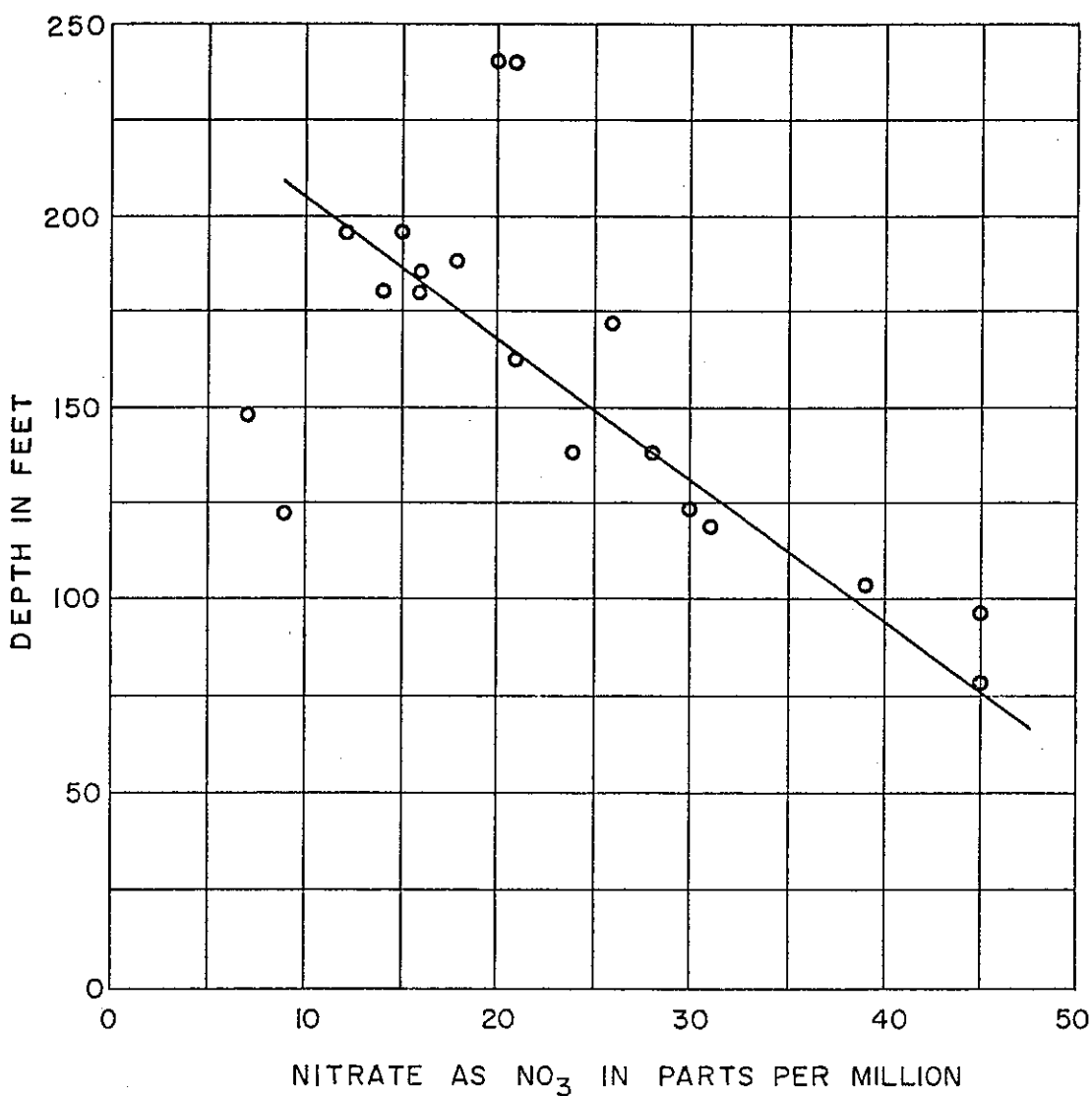
Eastern Fresno County Study (1967)

Haskell et al. (1967) reported on chemical analyses of groundwater between the Kings and San Joaquin Rivers in eastern Fresno County. Over eighty private domestic wells were sampled. The sampled wells ranged from 30 to 150 feet in depth, and depth to water ranged from 20 to 100 feet. Contours were presented for nitrate. These contours indicate the diluting effect that canal seepage had on groundwater quality. Low nitrate concentrations were generally found in water from wells near or downgradient of major canals.

Generally, groundwater samples had more than 19 ppm nitrate whereas surface waters had less than 3 ppm. When groundwater from a well contained less than 10 ppm nitrate, it was associated with a nearby ditch or canal. Low concentrations were also found in water from wells near the Kings River. Nitrate concentrations were generally higher beneath rural towns, as opposed to in the rural agricultural area.

Haskell et al. (1967) indicated an area of high nitrate in groundwater northeast of Fresno. Springs and wells along the valley margin had nitrate concentrations ranging from 3 to 40 ppm. Lower values were associated with nearby sources of surface water or thin soil profiles. High values were associated with a belt of dry farming along the eastern valley margin where soil profiles were well

(Depth is measured from ground surface to uppermost casing opening.
Figure modified from California Department of Water Resources, 1965.)



**FIGURE 9- RELATIONSHIP BETWEEN NITRATE AND WELL DEPTH
FOR AREA SOUTHWEST OF THE FRESNO AIR TERMINAL (1963)**

developed. The source of high nitrate concentrations in groundwater in that area was attributed to incorporation of nitrogen from the atmosphere by plants, and thence subsequent leaching from the soil by rainfall during the next year.

Fresno Air Terminal Study (1968)

Behnke and Haskell (1968) reported on nitrate in groundwater near the Fresno Air Terminal. About 50 wells were sampled in September 1966 for nitrate determinations. Two areas of high nitrate were delineated. One was beneath the Clovis Sewage Treatment Plant and the other was beneath a subdivision containing individual septic systems (Mayfair). A plume of high nitrate concentrations represented by the 25 ppm contour extended from the Clovis Sewage Treatment Plant in a southwesterly direction, following the direction of groundwater flow determined from a water-level elevation contour map.

In the septic tank area, nitrate concentrations decreased outward from a central high. The authors pointed out that nearby canals may have affected nitrate distribution, as these canals were often used for groundwater recharge when not conveying irrigation water.

Statistical Study of Nitrate and Salinity (1970)

Nightingale (1970) studied the salinity and nitrate concentrations in well water in the Fresno-Clovis urban area and the surrounding agricultural area (primarily to the northeast and east). Time trends of these constituents were statistically evaluated by dividing an 18-year period (1950-67) into three six-year periods. The urban area comprised the Fresno-Clovis area (95 square miles at that time) and its wastewater treatment facilities. A surrounding agricultural area of 106 square miles was selected for comparison.

The average electrical conductivity of the agricultural well water was 425 micromhos per centimeter for the 18-year period, as compared with 320 micromhos per centimeter for the urban area. Nightingale (1970) concluded that groundwater salinity of the agricultural area was higher because of concentration of salts through evapotranspiration, associated with crop irrigation.

Electrical conductivity of urban area well water increased linearly with time. This was apparently due to inflow of groundwater from the surrounding agricultural areas, and to the wide-spread use of septic tanks in the Fresno urban area at that time.

The mean nitrate concentration in urban area well water for the 18-year period was 14 mg/l, whereas the mean in the agricultural area was 10 mg/l. The mean nitrate content of urban area well water increased from 10.4 to 16.4 mg/l during the 18-year period. The greatest increase in nitrate concentrations of urban area well water occurred between 1950-55 and 1956-61.

The mean nitrate concentrations of the agricultural area well water increased by three times (from 5.5 to 15.8 mg/l) from the period 1950-56 to 1962-67. The reason for this increase was likely due to the use of chemical fertilizers, which largely commenced in the Fresno area in about 1950.

Engineering-Science, Inc. Study (1970)

Engineering-Science, Inc. (1970) discussed the nitrate concentrations in public supply wells in the Fresno urban area, as part of the County of Fresno HUD 701 program. This apparently was one of the first attempts to consider time trends for nitrate for individual wells in this area. Of four City of Fresno wells cited, three trends were noted. Well PS 32A showed an increasing nitrate trend from 1947 to 1962, followed by a constant trend from 1962 to 1969. The difference in trends was due to deepening of the well. Well PS 21A showed declining nitrate concentrations with time. Wells PS 28A and PS 50 showed essentially constant concentrations between the initial and final years evaluated, with relatively large fluctuations between.

For wells operated by the Fresno County Waterworks Districts and private water companies (most of which served unsewered urban areas), fifteen wells with ten-year sampling periods were studied. The earliest analyses averaged 9 ppm nitrate, whereas the latest averaged 19 ppm. Similar data for the City of Clovis showed an increase from 14 to 17 ppm and for Calwa County Water District an increase from 15 to 21 ppm. The Engineering-Science, Inc. study also provided substantial information on waste dischargers in the Fresno area, which was utilized in this evaluation.

K. D. Schmidt Dissertation

The Ph.D. dissertation by K. D. Schmidt (1971) focused on the distribution of nitrate in groundwater beneath the Fresno area. The geographic and vertical distribution of nitrate in groundwater was evaluated in detail through 1970. The locations of high nitrate areas in groundwater agreed well with the most likely sources in specific areas. Also, high nitrate concentrations continued to be limited to the shallow groundwater. The Fresno urban area was divided into several major subareas for evaluation, based on the predominant source or sources of nitrate.

1. The Figarden-Bullard Area (unsewered at the time).
2. The Fresno WWTF (the largest WWTF in the area).
3. The Mayfair-Fresno Air Terminal area (unsewered at the time, upgradient wineries, and the former City of Clovis WWTF).
4. The Downtown Fresno Area (sewered since the late 1800's).

Nitrate hydrographs were prepared, extending from as early as the late 1940's through 1970. Nitrate concentrations had increased substantially in unsewered parts of the urban area, and near other sources such as wastewater treatment facilities and wineries. Tri-linear diagrams were prepared for wastewater and well water to help differentiate various sources of nitrate. In the Mayfair-Fresno Air Terminal area, septic tanks, the former City of Clovis WWTF, and several wineries were indicated to be important sources. At the Fresno WWTF, moderate nitrate concentrations were present beneath and downgradient of effluent percolation ponds. The highest nitrate concentrations were found in groundwater beneath effluent irrigated areas. Schmidt (1971) also sampled numerous wells in the area between downtown Fresno and the Fresno WWTF, and delineated two southwest trending zones of high nitrate in groundwater beneath irrigated lands. These corresponded to areas of sandy topsoil, with minimal hardpan. Agricultural fertilizers were indicated to be the primary source of nitrate in this area.

Fresno County 208 Nonpoint Source Evaluation

The County of Fresno (1978) evaluated nitrate in groundwater of the Fresno urban area and the Northeast Fresno area (to the northeast), as part of an assessment of nonpoint sources of groundwater degradation. Substantial hydrogeologic information was provided and detailed water budgets were prepared. These water budgets were done for the Fresno urban area, the northeast rural residential area, and City future growth areas. Water-level hydro-graphs were updated for previous studies, and the influence of intentional recharge activities was discussed. Long-term overdraft was also determined. Up-to-date maps of concentrations of nitrate and several other constituents were presented. The previously prepared nitrate hydrographs were up-dated through 1977 as part of this evaluation. Nitrate data and sources of nitrate were interpreted and discussed in detail. The beneficial influence of sewerage previously unsewered areas and intentional recharge on groundwater quality was clearly evident by that time.

Fresno County 205J Program

The County of Fresno (1986) evaluated nitrate in groundwater of the Fresno urban area and the Northeast Fresno area, as part of an update of the 208 program evaluation. Up-to-date detailed maps of nitrate and DBCP concentrations were presented. The previously prepared nitrate hydrographs were updated through 1986. The reasons for trends in nitrate concentrations were provided. Continued mitigation of high nitrate concentrations in previously unsewered areas was occurring, and the beneficial influence of intentional recharge in the urban area was apparent.

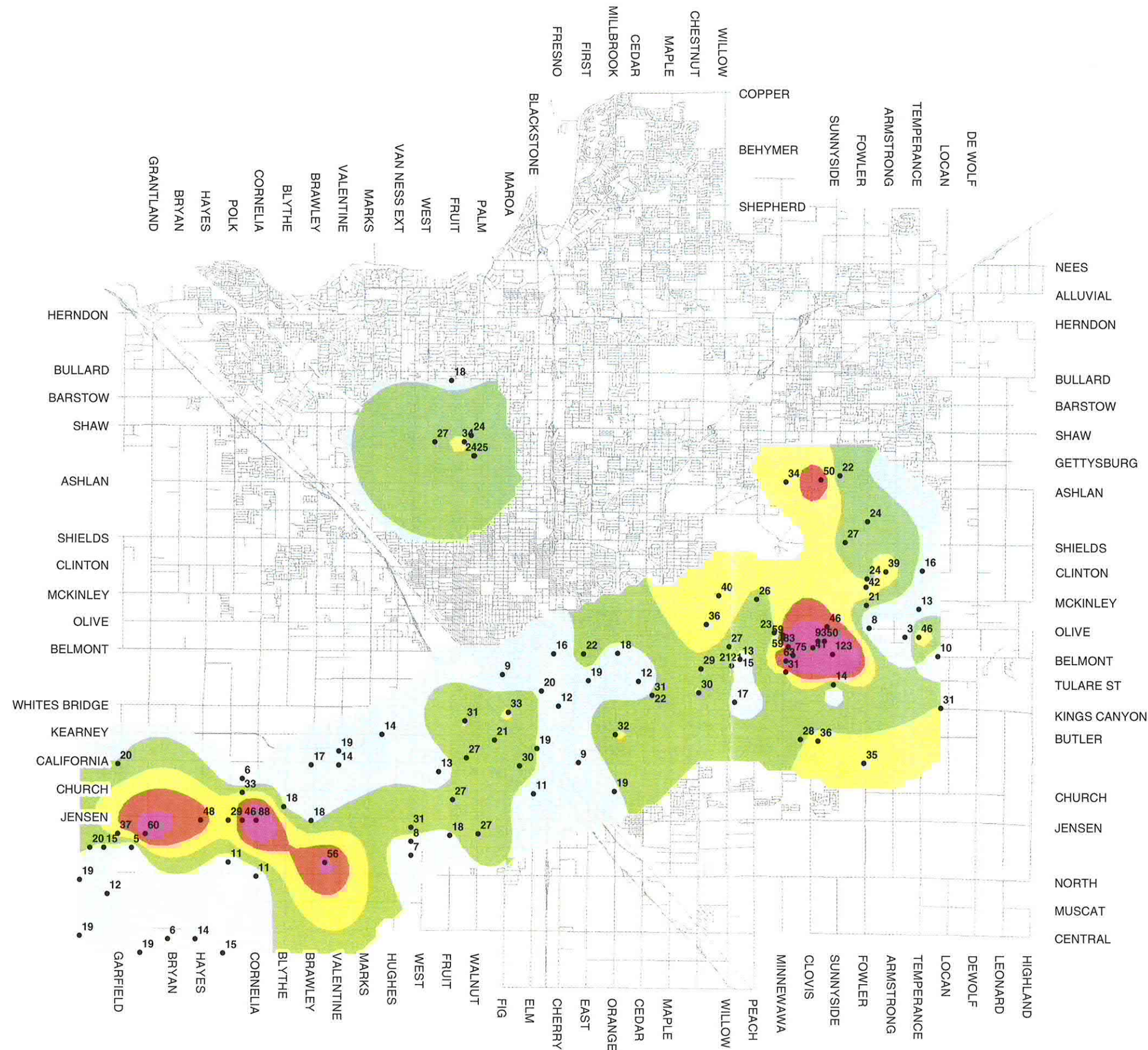
Fresno-Clovis Metropolitan Water Resources Management Plan

As part of this evaluation, up-to-date maps of nitrate, DBCP, and several other constituents were prepared (Appendix D of CH₂M-Hill, 1992). Substantial hydrogeologic information was also provided. The previously prepared nitrate hydrographs were updated through 1990. DBCP hydrographs for a number of wells were also prepared. Time trends for both constituents were discussed in detail. By this time, the influences of sewerage the formerly unsewered areas and of intentional recharge on groundwater quality were well established. Intentional recharge commenced in the urban area in 1970, and substantial improvements in well water quality were apparent over a fairly large area by 1990, particularly in the Mayfair area. In several areas, former increases in nitrate concentrations in well water had essentially stopped by this time.

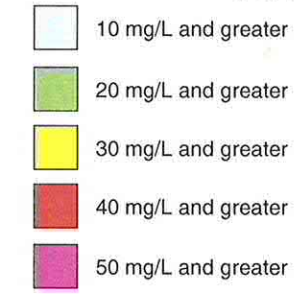
DISTRIBUTION OF NITRATE IN GROUNDWATER

Geographic Distribution

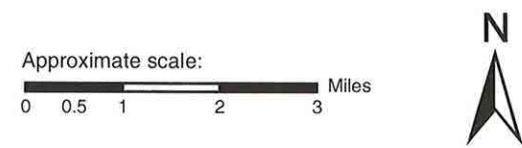
A series of maps is presented for three different time periods. The first is for 1968-70, which represents conditions prior to sewerage of previously unsewered areas and prior to intentional recharge in the urban area. Historically, most of the high nitrate concentrations in groundwater in the Fresno Urban Area have been found within a northeast-southwest trending area (Figure 10). The northwest boundary of this area extends from near the intersection of Highways 99 and 180 to



**NITRATE CONCENTRATIONS
IN GROUNDWATER (mg/L)**



●14.5 Well location and NO3 value, in mg/L.



Basemap modified from maps supplied by the cities of Fresno and Clovis.
Data provided by the cities of Fresno and Clovis.

**NITRATE CONCENTRATIONS
IN WELL WATER (1968 - 1977)**

Ken D. Schmidt and Associates

 GEOMATRIX	Date 04/22/2004	Project No. 8958.000	Figure 10
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the northeast, through the Fresno Air Terminal. The southwest edge extends from near Muscat Avenue and Cedar Avenue to the northeast, to near Butler and Temperance Avenues. This area generally has more permeable topsoil than in most other parts of the Fresno urban area. In contrast, nitrate concentrations have usually been much lower in groundwater beneath the northwest part of Fresno urban area. A large part of this area has soils of the San Joaquin series, which contain a low permeability iron-silica hardpan. The low permeability of this hardpan has generally protected the quality of groundwater from sources of nitrogen contamination at the land surface. However, one of the high nitrate areas is in the Old Figarden area, which was formerly unsewered. Seepage pits were used for septic tanks in this area, which effectively by-passed the protective hardpan layer. The other major high nitrate area in the north part of the urban area is generally located between Copper and Behymer Avenues. Permeable topsoils are also present in part of this area. Seepage pits have also been used in parts of the Sunnyside area, where hardpan is also present.

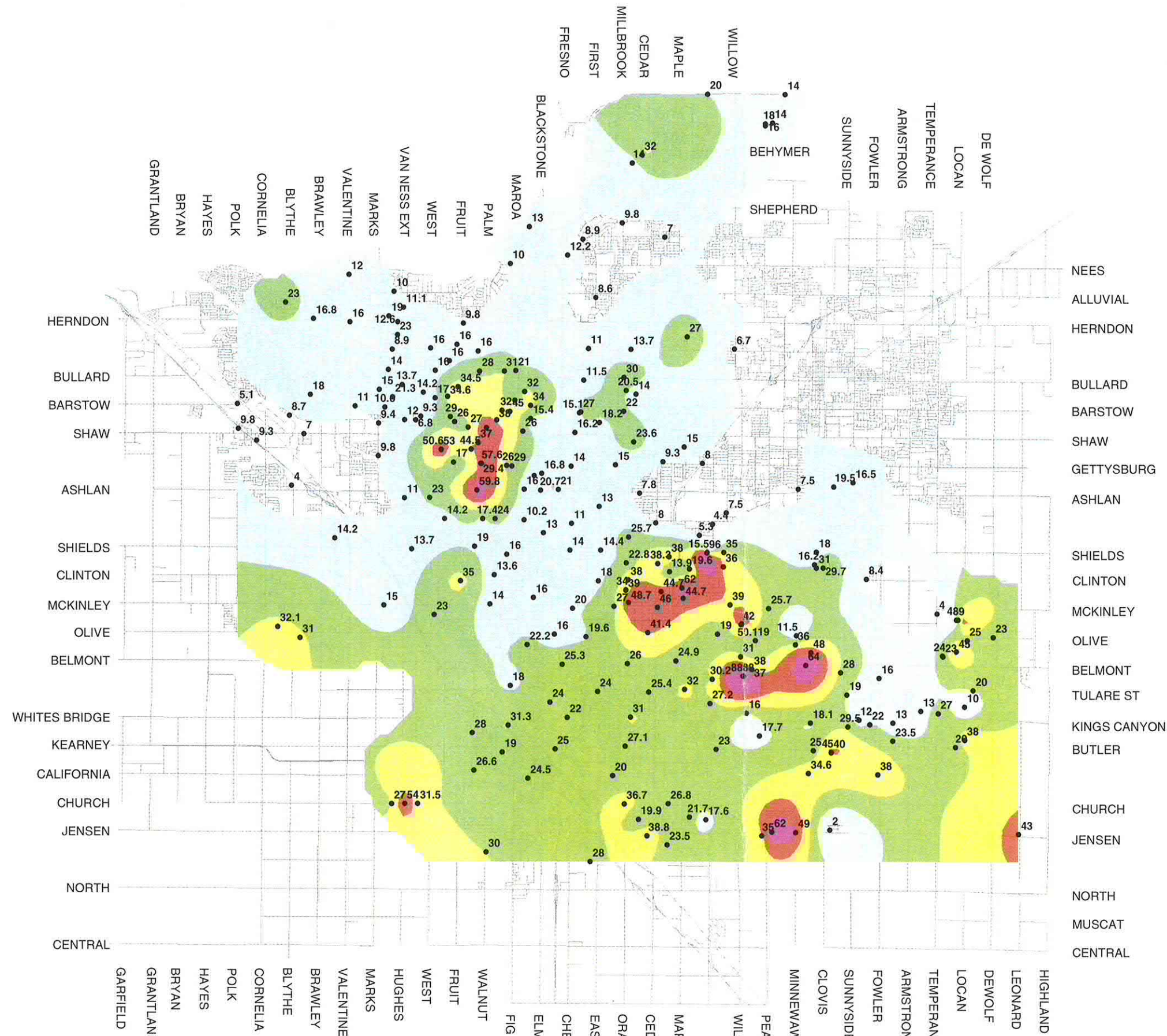
Figure 11 shows nitrate concentrations in well water as of the mid-1980's. Nitrate results were available for less wells in the area southwest of downtown Fresno, compared to in 1968-70. Nitrate concentrations were generally lower in the Mayfair-Fresno Air Terminal area than in the late 1960's. This was due to sewerage of the Mayfair area, intentional recharge in Leaky Acres, and the closure of the City of Clovis WWTF. Some reduction in nitrate concentrations was also apparent in the Figarden Area, where sewerage was largely complete by this time.

Figure 12 shows nitrate concentrations in well water in 2000-2004. Lower nitrate concentrations were present in the Figarden area, due to sewerage and some intentional recharge, which had been initiated in the area. Also, some wells were taken out of service due to high nitrate, and sample results were no longer available. Higher nitrate concentrations were indicated in part of the North Fresno Growth Area, due to the development of many new City wells, which were not available for sampling in the mid-1980's. Nitrate concentrations generally remained high near the Gallo Winery and an agricultural area to the east. Nitrate concentrations were higher in part of the Sunnyside area that remained on septic tanks. Nitrate concentrations remained high in well water near areas irrigated with sewage effluent.

By March 2004, 13 City of Fresno wells had been taken out of service due to high nitrate concentrations. Four of these were in the Sunnyside area, three were in the Fresno North Growth area, and two others were in the area west of the Gallo Winery. Two Bakman Water Co. wells had also been taken out of service in the area west of the Gallo Winery, and water from another had to be blended due to high nitrate concentrations.

Natural sources of nitrate are indicated to be insignificant in the Fresno urban area. This is primarily because of the low nitrogen concentrations in the hardrock from which the topsoil and alluvium were formed. This is documented by the low nitrate concentrations in wells in the Fresno area in the late 1940's and early 1950's. The predominant nitrate sources are indicated to be as follows:

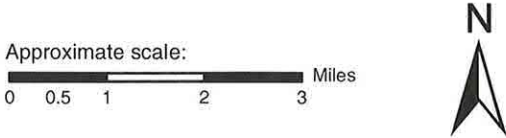
1. Old Figarden: Former septic tanks.
2. Fresno North Growth Area: Irrigation to the east and dense septic tanks to the west (Fort Washington Estates).



NITRATE CONCENTRATIONS
IN GROUNDWATER (mg/L)

- 10 mg/L and greater
- 20 mg/L and greater
- 30 mg/L and greater
- 40 mg/L and greater
- 50 mg/L and greater

●14.5 Well location and NO3 value, in mg/L.

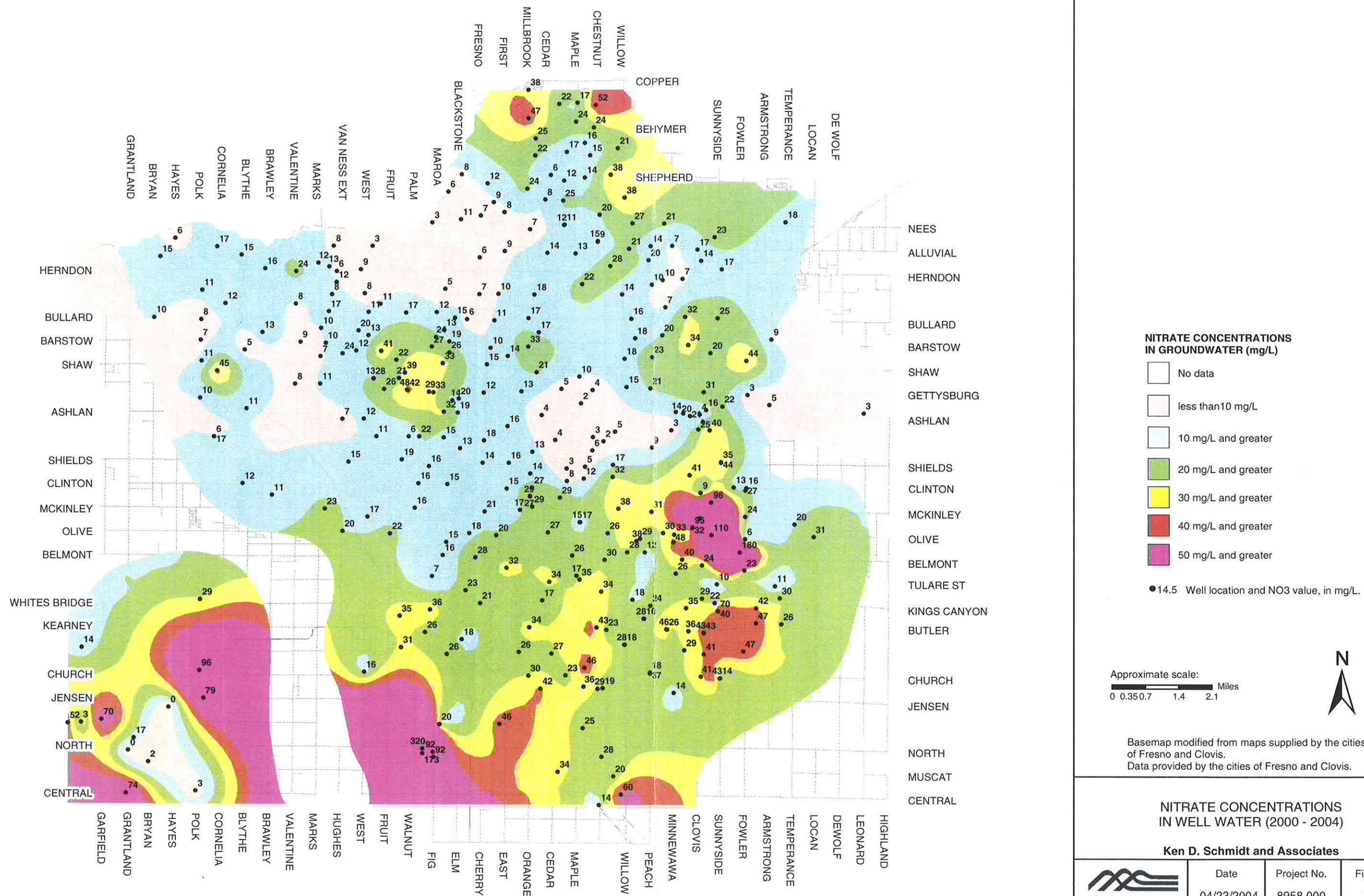


Basemap modified from maps supplied by the cities
of Fresno and Clovis.
Data provided by the cities of Fresno and Clovis.

NITRATE CONCENTRATIONS
IN WELL WATER (MID 1980s)

Ken D. Schmidt and Associates

	Date 04/22/2004	Project No. 8958.000	Figure 11
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3. South of Fresno Air Terminal: Wineries, agricultural irrigation, and formerly unsewered areas.
4. Sunnyside: Dense septic tanks and agricultural irrigation.
5. Calwa-Malaga: Former dense septic tanks in Calwa, agricultural irrigation, and possibly industrial sources.
6. Southwest Fresno: Former and present meat packing plants, irrigation, dairies, and effluent irrigation.

Most of these high nitrate areas have been discussed in previous reports.

Vertical Distribution

Information on the vertical distribution of nitrate has been obtained from a number of test wells, test holes, and City of Fresno nested monitor wells.

Fresno North Growth Subarea

There are ten City of Fresno nested monitor wells in or near areas with moderate to high nitrate concentrations in the shallow groundwater in this area. Nitrate concentrations usually ranged from about 30 to 70 mg/l in the shallow groundwater at most of these sites. Depths of the shallow monitor wells usually ranged from about 200 to 240 feet. Nitrate concentrations were substantially lower in monitor wells more than 300 feet deep. Nitrate concentrations in water from these wells were generally less than 20 mg/l and often less than 15 mg/l.

City of Clovis

Results of five casing hammer test wells are available in the City of Clovis, within one mile of the City of Fresno, between Shaw Avenue and Shephard Avenue. Table 5 summarizes information on nitrate concentrations and confining beds that separate water in strata with significantly different nitrate concentrations. The tops of the confining layers ranged from 175 to 250 feet in depth, and the bottoms ranged from about 185 to 295 feet in depth. Nitrate concentrations in groundwater below these confining layers were from about one-tenth to one-half of those in groundwater above these layers.

Subarea South of Fresno Air Terminal

Bakman Water Co. Well No. 17 was installed south of Olive Avenue, between Minnewawa and Clovis Avenues. This site is within a high nitrate plume west of the Gallo Winery. The highest nitrate concentration (52 mg/l) in water from the test well near Well No. 17 was from 136 to 140 feet in depth. The next highest nitrate concentration (38 mg/l) was from 256 to 260 feet in depth. Two confining clay layers were indicated. The upper layer was from 153 to 165 feet in depth, and separated overlying groundwater with a nitrate concentration of 52 mg/l from the underlying groundwater (nitrate concentration of 22 mg/l). The other clay layer was from 268 to 275 feet in depth, and separated overlying groundwater with a nitrate concentration of 38 mg/l from the underlying groundwater (nitrate concentration of 8-15 mg/l).

TABLE 5- NITRATE CONCENTRATIONS AND LOCAL
CONFINING LAYERS IN SUNNYSIDE AREA

<u>Test Well</u>	<u>Date</u>	<u>Nitrate Conc. (mg/l) in Overlying Groundwater</u>	<u>Confining Layer Depth Interval (feet)</u>	<u>Nitrate Conc (mg/l) in Underlying Groundwater</u>
Sunnyside TW-1	12/86	25	150-178	9-13
Sunnyside TW-2	1/87	30	200-250	2-8
Canterbury TW-1	6/85	43-50	214-229	18-21
Canterbury TW-2	7/85	44	125-135	12-17
Sunnyside H.S.	3/97	31-32	164-221	9-16

A test hole associated with City of Fresno PS 102 was done about 30 feet south of Belmont and 300 feet east of Sunnyside Avenue in July 1980. This hole was located near just south of the south edge of a high nitrate plume beneath a Gallo Winery stillage disposal area. Three clay layers were present at the site between 173 and 239 feet in depth. The nitrate concentration in groundwater above these layers was 18 mg/l, compared to 9 to 10 mg/l in the underlying groundwater.

There are seven City of Fresno nested monitor wells in the area south of the Fresno Air Terminal. Nitrate concentrations in water from at least three of these (MW-155, MW-253, and MW-289) have apparently been influenced by the Gallo Winery operations, as discussed in a later section of this report. Nitrate concentrations in water from the shallowest wells, usually ranging in depth from about 150 to 220 feet, ranged from about 35 to 50 mg/l. Nitrate concentrations in water from monitor wells deeper than 280 feet were usually below 13 mg/l. Nitrate concentrations were less than 8 mg/l in water from most deep monitor wells (greater than about 400 feet deep).

Sunnyside Subarea

Five casing hammer test wells have been completed in the Sunnyside area to determine subsurface geologic conditions and the vertical distribution of selected chemical constituents in groundwater in detail. Table 6 summarizes information on nitrate concentrations and confining beds that separate water in strata at different depths with significantly different nitrate concentrations.

The confining beds are clay layers, commonly from two to three, in the depth intervals shown for each site. The tops of these layers are usually from about 150 to 215 feet in depth, and the bottoms are normally from about 180 to 250 feet in depth. Nitrate concentrations in groundwater below the clay layers were usually about one-third to one-half of those in the overlying groundwater above the clay layers.

There are six City of Fresno nested monitor wells in the high nitrate part of the Sunnyside area. Nitrate concentrations in water from the shallow wells (ranging in depth from about 150 to 220 feet) usually ranged from about 25 to 50 mg/l. In contrast,

nitrate concentrations in water from the deeper wells (below about 270 feet in depth) were less than 20 mg/l.

Calwa-Malaga Area

There are three City of Fresno nested monitor wells in the moderate to high nitrate part of the Calwa-Malaga area. Nitrate concentrations ranged from 35 to 38 mg/l in two shallow wells (ranging from about 150 to 180 feet). Nitrate concentrations in water from monitor wells more than 350 feet deep were usually less than 20 mg/l.

TABLE 6-NITRATE CONCENTRATIONS AND LOCAL
CONFINING LAYERS IN CITY OF CLOVIS

<u>Test Well</u>	<u>Nitrate Conc. (mg/l) in Overlying Groundwater</u>	<u>Confining Layer Depth Interval (feet)</u>	<u>Nitrate Conc (mg/l) in Underlying Groundwater</u>
TW-91-C	27-35	179-265	11-12
TW-95-B	24-26	233-275	8-9
TW-02-C	22-28	206-265	4
TW-03-E	45	250-294	3-4
TW-95-A	20-29	175-185	13-16

Time Changes

Nitrate hydrographs have been prepared for a number of City Fresno wells, as part of previous evaluations. The first were prepared by Schmidt (1971), and the most recent update of these was for the 1992 Fresno-Clovis Metropolitan Resources Water Plan. Some of these hydrographs extend back to the late 1940's or early 1950's. The earliest available nitrate analyses for supply wells, which were relatively shallow (often less than 200 feet deep) at that time, generally indicated nitrate concentrations in the range of about 2 to 5 mg/l. This range is thus considered near background for the Fresno urban area. As of the late 1940's and early 1950's, nitrate concentrations were low in shallow groundwater beneath both the Fresno urban area and upgradient rural areas. This period was essentially prior to the development and use of chemical fertilizers in irrigated areas. It was also not too much later than the development of some of the first relatively dense unsewered areas in the Fresno area. Few of the public supply wells at that time were close to the wastewater treatment facilities that were formerly present in the urban area, or industrial wastewater sites that were sources of nitrate in the groundwater.

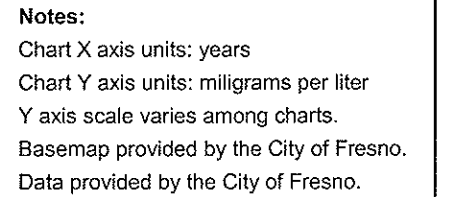
Major changes in nitrate concentrations that were indicated by 1970 included increased nitrate concentrations in groundwater beneath several unsewered areas, including the Figarden, Mayfair, and Sunnyside areas. In the Figarden area, these increases in nitrate concentrations generally continued into the 1980's, when sewerage of the area was completed. In the Sunnyside area, these increases have generally continued to the present in the part of this area that is still not sewerage. Another predominant trend was decreased nitrate concentrations in groundwater beneath the City of Fresno Leaky Acres recharge facility and downgradient areas to the southwest, extending to near downtown Fresno. In the early 1970's, nitrate concentrations were high (exceeding 100 mg/l) in groundwater beneath the former City of Clovis WWTF, which was located northeast of the Leaky Acres recharge facility. Once that WWTF was closed and recharge of canal water was commenced in this vicinity by the City of Clovis, nitrate concentrations in groundwater substantially decreased within a few years.

Beneath much of the Mayfair area, nitrate concentrations in groundwater decreased after the early 1970's, due to recharge at the Leaky Acres facility (upgradient of much of this area) and the cessation of the use of septic tanks in the Mayfair area.

As part of this evaluation, GeoMatrix Consultants, Inc. prepared nitrate hydrographs for 143 City of Fresno wells and 41 City of Clovis wells, extending as far back as to 1980 (Appendix B). 1980 is as far back as nitrate analysis records are available in an electronic format for City of Fresno wells. Figure 13 shows representative long-term nitrate hydrographs for the urban area.

Wells with nitrate hydrographs were grouped into three categories, based on long-term trends. Hydrographs for about 60 wells (or about one-third of the total) indicated no significant long-term change in nitrate concentrations. These wells were predominantly between the Leaky Acres recharge facility and downtown Fresno, in part of the Figarden area, and in the west part of the City of Clovis. Parts of these areas have been influenced by canal water recharge and the cessation of the use of dense septic tanks. In Clovis, replacement of former irrigated areas by urban lands and intentional recharge were likely factors in stabilizing nitrate concentrations in groundwater.

Nitrate hydrographs for about two dozen wells indicate decreased nitrate concentrations over the long-term. These wells were primarily between the Leaky Acres facility and downtown Fresno, and



LONG-TERM NITRATE HYDROGRAPHS



Project No.
8958

Figure 13

in and east of the Figarden area. The same factors likely caused the decreases as caused the stabilization of nitrate levels, particularly canal water recharge and sewerage of previously unsewered areas. Recharge was commenced in storm runoff basins in part of the Figarden area and to the east by the late 1970's.

The most predominant long-term nitrate trend was an increase, as demonstrated for hydrographs for about 110 wells (about 60 percent of the total). These wells are located primarily in the following areas.

1. Northwest trending area in Old Figarden
2. Fresno North Growth Area
3. Southwest part of the Herndon-Shepherd Plan Area in Clovis
4. City of Clovis between Bullard and Gettysburg Avenues and Chestnut and Peach Avenues
5. Tarpey Village and vicinity
6. South of Fresno Air Terminal
7. Sunnyside area
8. Calwa-Malaga area, and to the east

Several of these areas coincide with areas of large water-level declines (exceeding 50 feet) during the past decade. These include the Fresno North Growth Area and the southwest part of the Herndon-Shepherd Plan Area in Clovis. Lowered water levels alone may cause increased nitrate concentrations in well water, particularly for shallower wells. This is because the wells produce from strata increasingly close to the water level, which generally have higher nitrate concentrations.

In many of these areas, some sources of nitrate appear to be continuing. Included are septic tanks in Fort Washington Estates and some fertilizer applications in irrigated areas to the north and east, fertilizer applications in the present and former irrigated areas east of Tarpey Village and northeast of the Fresno Air Terminal, the land disposal of wastewater at the Gallo Winery, numerous septic tanks in the Sunnyside subarea, fertilizer applications in the irrigated area south of Church avenue (including Malaga and Calwa and extending to the east) and in the irrigated area southwest of downtown Fresno, and effluent irrigation near the Cities of Fresno and Clovis WWTF.

OLD FIGARDEN SUBAREA

Figure 14 shows the location of the Old Figarden Subarea. Prior to urban development, much of the area was in fig orchards. The area was unsewered prior to 1972. Water was served by several Fresno County Water Works Districts, often from fairly shallow wells. Seepage pits were used for septic tank effluent disposal in this area, due to a nearly impermeable hardpan that was present in much of the area. Because of this hardpan and the types of crops grown, nitrogen contributions to groundwater from irrigation have been small. Canals which traverse the area are also shown on Figure 14. Three deep City test holes have been drilled in or near the Old Figarden subarea. TH-193 was drilled to a depth of 816 feet near Clinton Avenue and the Santa Fe Railroad tracks. MW-213A was drilled north of Gettysburg and east of Fruit Avenue to a depth of 741 feet. TH-47A was drilled south of Ashlan and east of Hughes Avenue to a depth of 823 feet. All three of these test holes indicated substantial water producing strata below a depth of 300 feet. This is thus a favorable subarea for tapping deep low nitrate groundwater. The direction of groundwater flow has

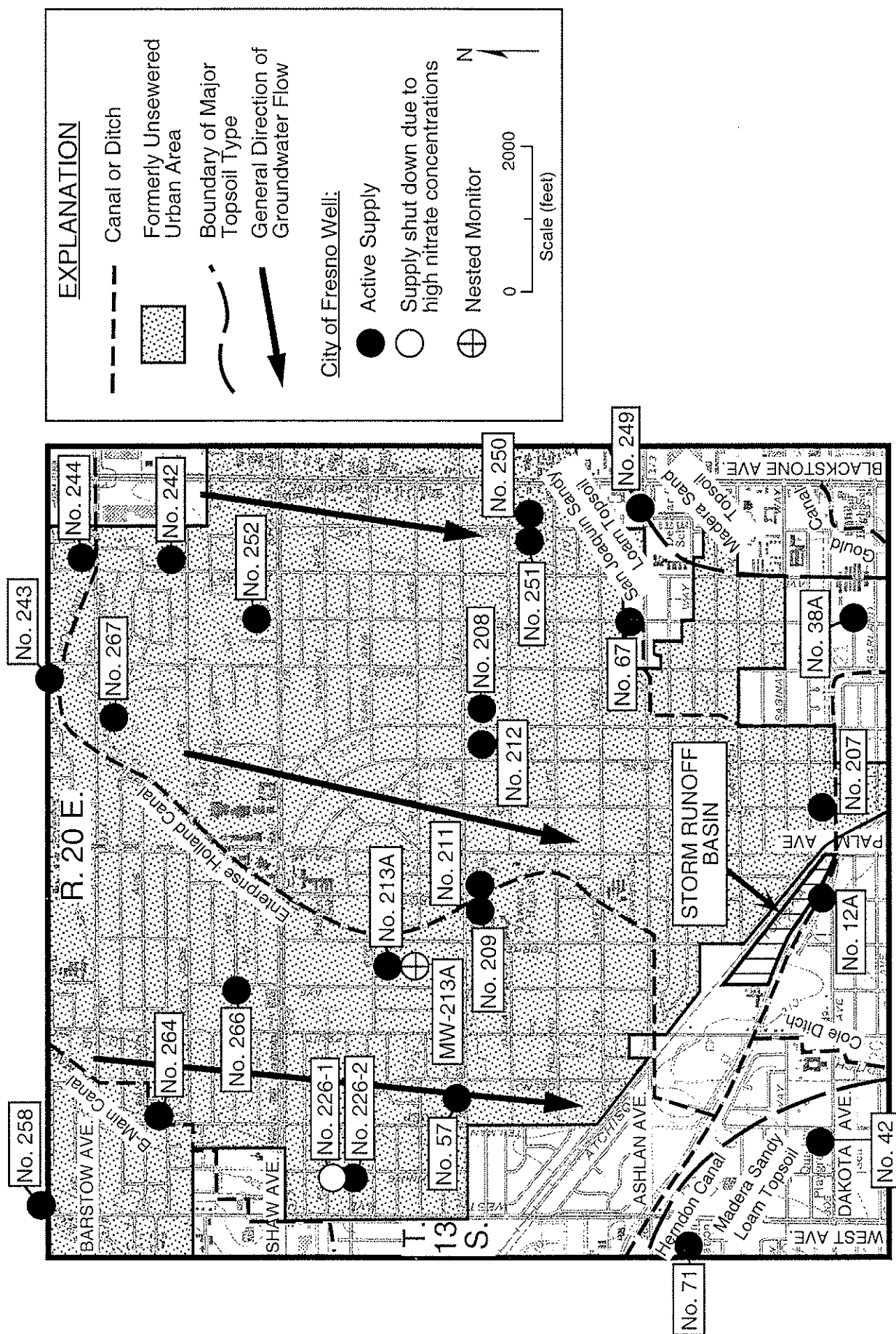


FIGURE 14 - LOCATION OF OLD FIGARDEN SUBAREA
AND POTENTIAL SOURCES OF NITRATE

generally been to the southwest or south in this subarea, and water levels have been relatively deep.

Historical analyses for both chloride and nitrate in well water indicate increasing concentrations after the 1950's. By 1990, nitrate concentrations were greater than 25 mg/l in groundwater beneath most of this area (between Bullard and Dakota Avenues and West and Blackstone Avenues). Nitrate concentrations in one City well (PS 226-1) in this subarea exceeded the MCL of 45 mg/l, and it was taken out of service. As discussed previously, nitrate concentrations have continued to increase beneath a northwest trending zone in this subarea. The zone extends from near West and Bullard Avenues to the northwest to near Ashlan and Maroa Avenue to the southeast. These increases in nitrate concentrations may be partly related to long-term water level declines. However, in much of the rest of this area, nitrate concentrations in water from wells have been constant or have decreased since 1980. Because most of the subarea was sewered by the 1980's, the primary source of nitrate in groundwater (septic tanks) was eliminated. Also, intentional recharge has been practiced at several storm runoff basins in the area, which would help decrease nitrate concentrations.

FRESNO NORTH GROWTH SUBAREA

Figure 15 shows the location of the subarea in north Fresno. The most important potential sources of nitrate in this subarea are as follows:

1. Septic tanks that are still used in the Fort Washington Estates.
2. Nitrogen fertilizer applications to irrigated lands, particularly deciduous tree crops and vegetable crops, that generally coincide with high nitrate in the groundwater. Golf course irrigation may also be a source of high nitrate concentrations in some parts of the subarea.

Prior to intense urban development, the direction of groundwater flow in this subarea was generally to the west (KDSA, 1987a). After a number of City wells were developed and put in service in the Fresno North Growth Area during the 1990's and early 2000's, the direction of flow changed to be more southerly. The Enterprise Canal passes through this area, and canal water has generally not been available in the area northwest of the canal, except for two areas along the Phillips Ditch. Canal water has been used at the Copper River Ranch and on the Aluisi Farms south of Copper Avenue. Extensive recharge with canal water has also been practiced during the past decade at the Copper River Ranch.

Only two test holes (PS 133 and TH-319) have been drilled to a depth of more than 650 feet in the subarea. Geologic and electric logs for four test holes at least 620 feet deep indicate highly productive strata below a depth of 300 feet and above the bottom of the hole (PS 133, TH-310, TH-318, and TH-319). Several holes were stopped in apparently productive deposits at depth. Bedrock (hardrock) has apparently not been encountered by any of the holes south of Copper Avenue and west of Willow Avenue. The nearest holes that have hit bedrock are in the eastern part of the Copper River Ranch, north of Copper Avenue, and east of Willow Avenue and north of Behymer Avenue.

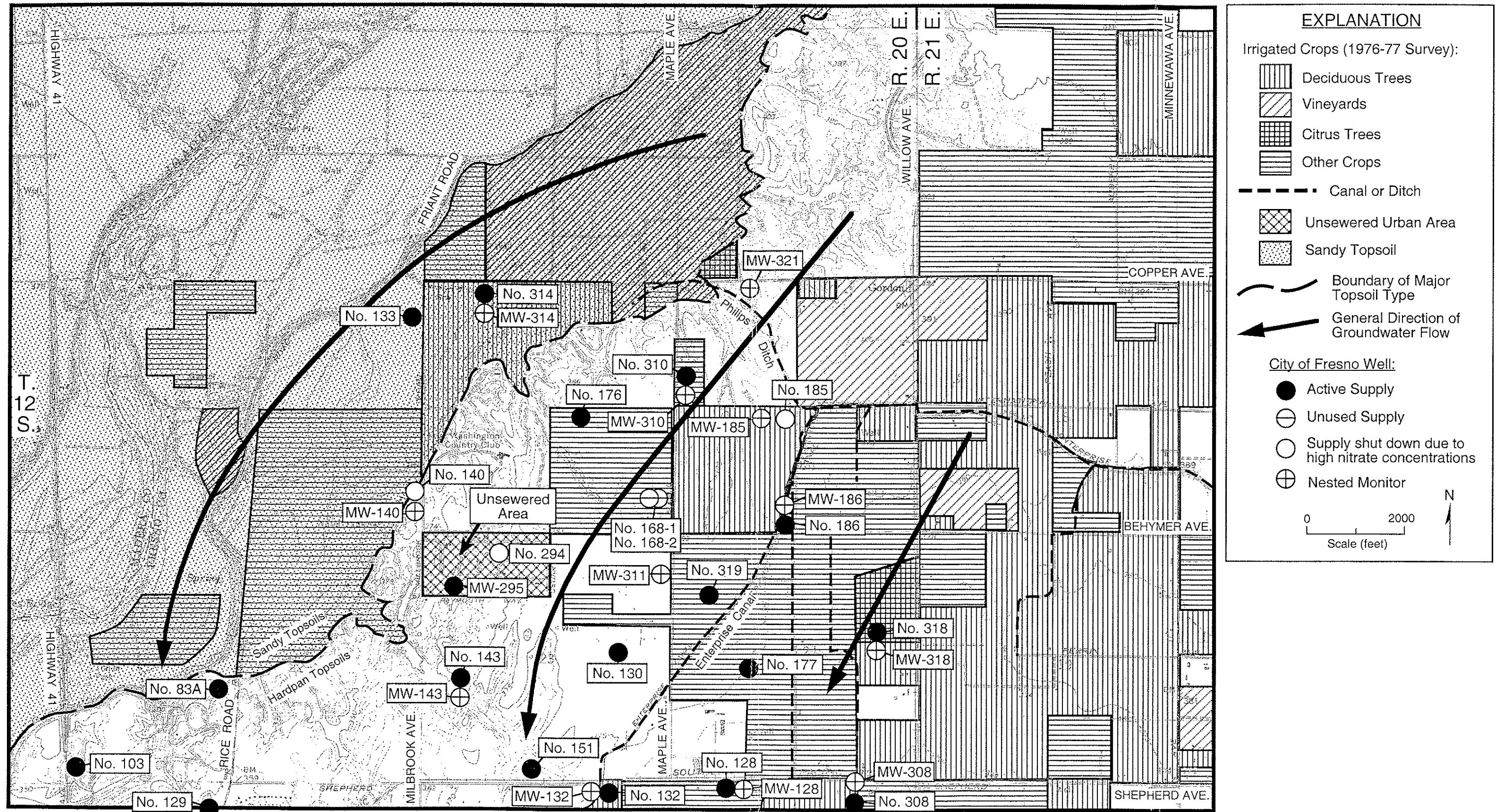


FIGURE 15 - LOCATION OF FRESNO NORTH GROWTH AREA SUBAREA AND POTENTIAL SOURCES OF NITRATE

There are two major topsoil types in this subarea. Lands that are on the lower terrace above the San Joaquin River floodplain generally have sandy, highly permeable soils, such as at Woodward Lake and the western part of the Copper River Ranch. Most of the topsoils on the higher terrace to the southeast have hardpan and are much less permeable.

The high nitrate area generally has an east to west trend, and is primarily between Behymer and Copper Avenues. The vertical distribution of nitrate in this subarea was discussed in a previous section of this report. City of Fresno Well PS 294 in Fort Washington Estates was taken out of service due to high nitrate concentrations. Septic tanks in this unsewered area are a continuous source of nitrate in groundwater. City Well PS 140, located west of the Fort Washington Country Club, was also shut down because of high nitrate concentrations. Water from PS 140 was treated to remove nitrate and the well was temporarily put in service during Summer 2002. Water from PS 185 also had high nitrate concentrations and was taken out of service. Water from this well was also treated for removal of nitrate and the well was used temporarily during Summers 2002 and 2003. The crop survey map for 1976-77 indicates that deciduous orchards were widely grown in the area south of Copper Avenue, particularly in the area east of Willow Avenue. Nitrogen fertilizer applications on irrigated lands are the most likely reason for the high nitrate concentrations in groundwater in most of this subarea. Nitrate concentrations have increased in most wells in this area, and this may be partly due to large water-level declines during the past decade.

SUBAREA SOUTH AND EAST OF FRESNO AIR TERMINAL

High nitrate concentrations have been noted in water from some wells in this subarea (Figure 16) since the 1960's. There are a number of potential sources:

1. Septic tanks in formerly unsewered urban areas
2. Wineries
3. Nitrogen fertilizers applied to irrigated lands
4. Dairies
5. Septic tanks in southeast rural residential area.

Nitrate concentrations in water from many water supply wells in this area have generally increased since 1980. Much of the area is underlain by sandy soils and alluvium. The Mayfair area (to the west) generally had the densest septic tanks (smallest unsewered lots) of the entire Fresno urban area. Either the City of Fresno or the Bakman Water Co. has served most of the water supply to the urbanized part of this subarea. Because of the sandy soils, the area is partially vulnerable to contamination. Winery wastewater generally has the highest nitrogen concentrations of any wastewater that is discharged to land in the Fresno urban area. DBCP is also present in shallow groundwater beneath the northeast and southeast parts of this subarea. The direction of groundwater flow has been to the west-southwest in most of this subarea in recent decades.

Mill Ditch, a major FID canal, passes through the subarea. The vertical distribution of nitrate in groundwater in this subarea was discussed in a previous section of this report. At least four Bakman Water Co. wells (No. 5, 6, 8, and No. 15) in this subarea have been affected by high nitrate concentrations. Well No. 5 was taken out of service due to high nitrate concentrations. Well No. 6 was temporarily taken out of service in 2003. Water from Well No. 8 is blended with that from a deep well (No. 8-A) with low nitrate concentrations prior to use. Well No. 15 was taken out of service and replaced by a new well (No. 15-A) in 2003. City of Fresno Wells PS 113 and PS

FIGURE 16 - LOCATION OF SUBAREA SOUTH AND SOUTHEAST OF FRESNO AIR TERMINAL
AND POTENTIAL SOURCES OF NITRATE

253-2A were taken out of service because of high nitrate concentrations. City of Fresno Well PS 155-2 was taken out of service due to high nitrate concentrations. However, water from this well was treated for nitrate removal and the well used temporarily during Summers 2002 and 2003.

Two subsurface geologic cross sections are particularly useful in the evaluation of this subarea, because they are located in or near fairly large areas of high nitrate concentrations in the shallow groundwater. Cross Section D-D' (Figure 17) extends from near the east edge of the Fresno Air Terminal on the north, through Sunnyside, to PS 107 at Greenfield Village on the south (Clovis and Jensen Avenues). This section shows the overwhelming predominance of clay at depth along parts of the section, for example at TH-145B near Clinton and Clovis Avenues and TH-145 near Butler and Clovis Avenues. Cross Section E-E' (Figure 18) extends from west to east through part of the subarea. The west end of the section is at PS 30-A near Belmont and Jackson Avenues and the east end at PS 147, near Armstrong and Huntington Avenues. This cross section illustrates the presence of a widespread restricting clay layer above the water table in much of the area west of Minnewawa Avenue, which is an important limitation for intentional recharge of canal water by basins in this area.

Deep public supply wells have been successfully drilled in parts of this subarea. Included are City of Fresno PS 102, PS 145, PS 155, and Bakman Water Co. Wells 4-A, 9-A, 13-A, and 15-A. More productive strata at depth are generally present west of Clovis Avenue and south of Olive Avenue in this subarea.

Gallo Winery

The Gallo Winery is located at the southeast corner of Clovis and Olive Avenues. There are 500 acres of land adjacent to the winery where winery wastewater is applied, and 74 acres on which solid wastes are composted. These lands extend north to Clinton Avenue, south to Belmont Avenue, and east to Fowler Avenue. The earliest wastewater disposal area for the winery was south of the winery tanks, east of Clovis Avenue, and north of East Olive Avenue (Block 18).

The Regional Board adopted Waste Discharge Requirements (WDR) Order No. 94-103 for Gallo's disposal of crush water and stillage to land. The following information was taken from the WDR. Monitoring data from 2000 and 2001 indicate an average crush water discharge of about 0.21 mgd and a maximum stillage discharge of 1.52 mgd. Gallo disposes of crush water and stillage by discharging it to long, narrow checks within separate blocks. The checks are allowed to dry for at least six days between wastewater applications. Rye grass is planted in portions of the disposal area in the winter and sudan grass in the late spring/early summer to uptake residual nitrogen from applied wastewater. Following are the locations for waste generated at the winery.

<u>Waste</u>	<u>Disposal Location</u>
Weighing Area Washdown	Block 11
Crush/Press Area Washdown	Blocks 16, 17, and 19
Stillage	Blocks 1-8 and 11-14
Compost	Blocks 9 and 10

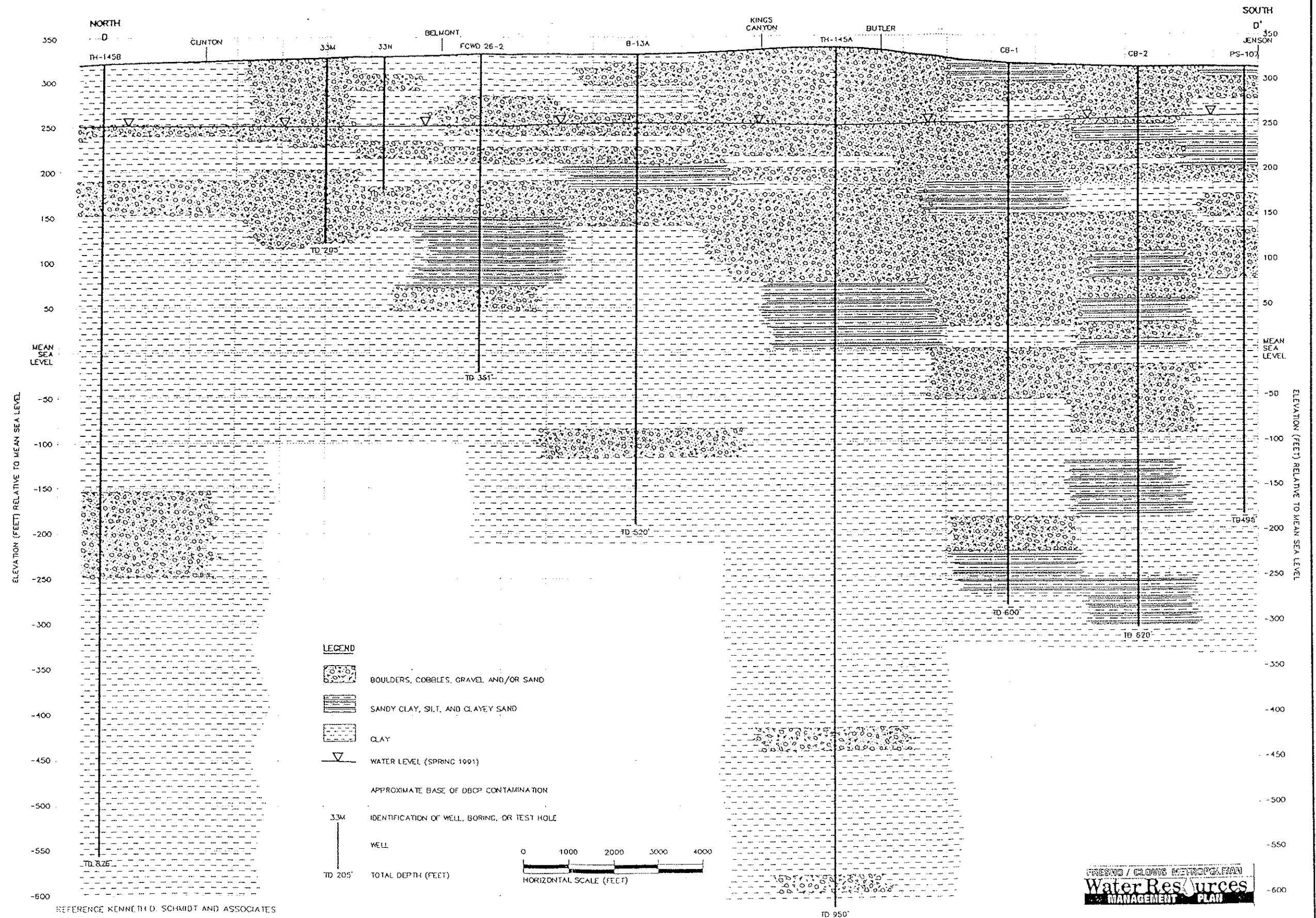


FIGURE 17- SUBSURFACE GEOLOGIC CROSS SECTION D-D'

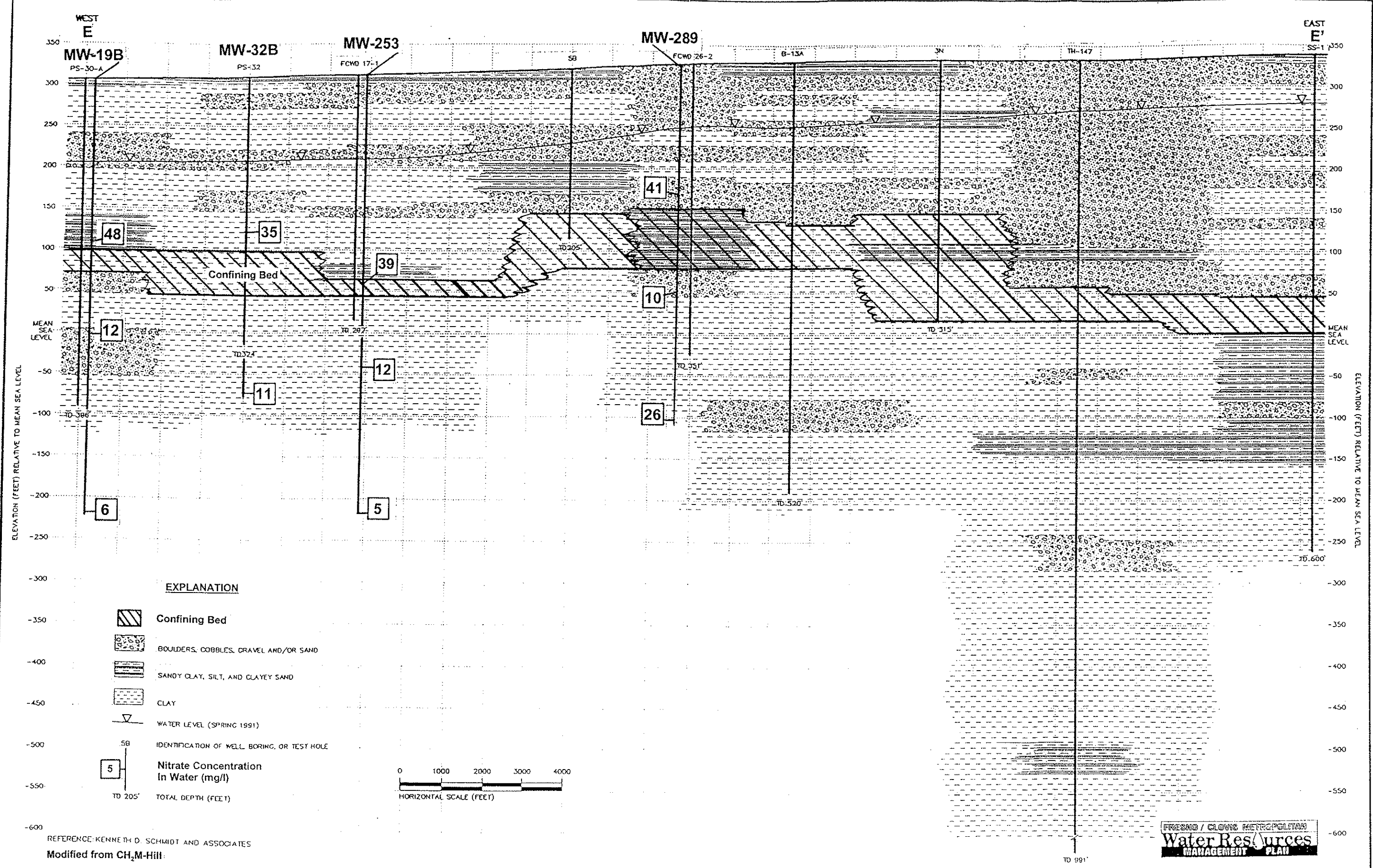


FIGURE 18- SUBSURFACE GEOLOGIC CROSS SECTION E-E'

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CH₂M-Hill

Figure 19 shows the locations of these blocks and other information. Gallo reportedly discharges about 10,000 gallons per day of washdown from the paved weighing area to Block 11. The composition of this wastewater has apparently not been characterized.

Crush Press/Area Wastewater

Gallo discharges washdown from its crush and screw press processes (crush/press area wastewater) to three blocks in the southern part of the lands. Typically, crush/press area wastewater disposal occurs from August through December. Table 7 summarizes the chemical quality for crush/press area wastewater for 2000-01. Total nitrogen concentrations averaged about 120 mg/l. The waste-water had a wide range in pH, and significant iron concentrations. The Regional Board staff estimated that about 80 percent of the crush water that was applied to land percolated to the groundwater.

Stillage

Gallo discharges stillage to alternate checks (about 8 feet wide) until it reaches a depth of several inches. Once applied, the stillage is allowed to dry from six days to several weeks. Table 8 summarizes monitoring data for the chemical quality of stillage in 2001. Total nitrogen concentrations averaged about 280 mg/l. The wastewater was acidic, with an average potassium concentration of 674 mg/l and sulfate concentration of 254 mg/l. Both iron and manganese concentrations were high (average of 5.1 and 4.7 mg/l, respectively). Regional Board staff performed a water balance to determine the amount of stillage that was discharged in 2001 that probably percolated to the groundwater. The estimated percolation was about 220 acre-feet from 361 acres of application area, or an average of about 7 inches per year.

Pomace

Solid material from the winemaking process (pomace) has been discharged to lands north of Blocks 12, 13, 14, and 15, northeast of the winery. Following winter rains, there is runoff of water contacting the pomace, and this has had the potential to adversely impact groundwater quality.

Ion Exchange Regenerate

Gallo processes some juice/wine through ion exchange units prior to bottling. The ion exchange units are regenerated with sulfuric acid. This ion exchange wastewater had a high potassium, ammonia-nitrogen, and sulfate concentration. For decades Gallo discharged spent regenerant to land, primarily to Block 18 immediately south of the winery's tank farm. After monitor wells were installed in 1994, the severity of the influence on groundwater quality from this discharge became apparent. From 1994 on, Gallo discharged spent regenerant to the City's WWTF.

Groundwater Monitoring

In 1994, seven shallow monitor wells were installed at the Gallo facility (Figure 19). MW-1, MW-2, and MW-3 were installed along the east edge of the property. MW-4, MW-5, MW-6, and MW-7

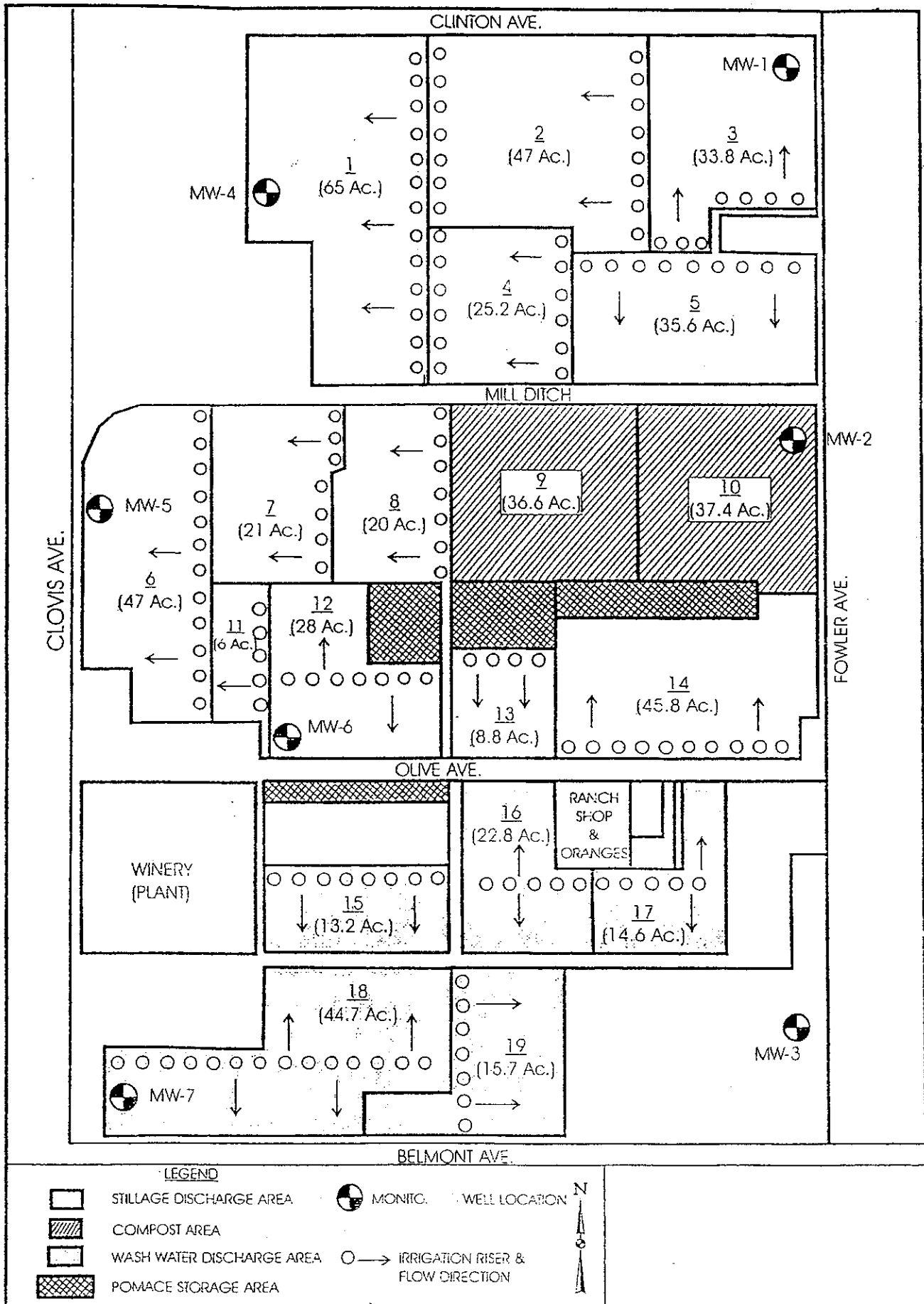


FIGURE 19 LOCATION OF GALLO WINERY
WASTE DISPOSAL AREAS AND MONITOR WELLS

TABLE 7-CHEMICAL QUALITY OF GALLO WINERY CRUSH/PRESS AREA WASTEWATER

<u>Constituent (mg/l)</u>	<u>Average</u>	<u>Minimum</u>	<u>Maximum</u>
Calcium	32	13	100
Magnesium	15	8	36
Sodium	46	30	65
Potassium	77	5	280
Sulfate	75	7	198
Chloride	28	9	51
Nitrate-Nitrogen	11	1	36
Total Kjeldahl Nitrogen	122	5	548
Total Nitrogen	131	8	584
Electrical Conductivity (micromhos/cm)	810	310	1,670
Total Dissolved Solids	1,760	60	12,000
pH	6.22	3.95	9.6
Iron	6.1	<0.01	19
Manganese	0.11	<0.01	0.31

From Regional Board WDR.

TABLE 8-CHEMICAL QUALITY OF GALLO WINERY STILLAGE

<u>Constituent (mg/l)</u>	<u>Average</u>	<u>Minimum</u>	<u>Maximum</u>
Calcium	33	9	58
Magnesium	23	5	43
Sodium	39	27	51
Potassium	674	22	1,300
Sulfate	254	61	606
Chloride	50	15	171
Nitrate-Nitrogen	6.3	1.1	16
Total Kjeldahl Nitrogen	272	103	788
Total Nitrogen	280	107	792
Electrical Conductivity (micromhos/cm)	2,540	1,100	4,140
Total Dissolved Solids	6,000	700	10,830
pH	4.14	3.33	6.58
Iron	5.1	1.4	14
Manganese	4.7	0.05	35

From Region Board WDR.

were installed along the west edge of the wastewater disposal area. The wells range in depth for about 100 to 110 feet, and are perforated over the lower forty feet. Depth to water has averaged about 70 feet beneath the east edge of the Gallo property to 90 feet beneath the west edge. Water-level elevation maps indicate that the direction of groundwater flow has generally been to the west-southwest. MW-1 and MW-2 are in the stillage disposal area and could be periodically influenced by winery wastewater disposal activities.

Table 9 provides a summary of mean concentrations for quarterly monitoring of these wells for 1994-2001. Water from MW-3 has had relatively high potassium concentrations (6.4 to 7.7 mg/l) and appears to have been influenced by winery wastewater disposal. The potassium in pomace stillage (674 mg/l average in 2001) are hundreds of times higher than background values in Fresno area groundwater. Background potassium concentrations in groundwater of the Fresno area are normally 3 mg/l or less. Although potassium is strongly adsorbed by the soil, it can still serve as tracer of winery wastewater in the groundwater. MW-2 has generally produced water with potassium concentrations averaging 2 mg/l (likely near the background value). During 2003, potassium concentrations in water from MW-5 and MW-6 were from 10 to 11 mg/l, clearly indicative of a winery wastewater influence at that time.

A careful review of the records for downgradient monitor wells MW-5 and MW-6 indicates significant increases in nitrate, potassium, calcium, magnesium, alkalinity, and chloride concentrations since 1998-99. Nitrate concentrations in water from MW-5 increased from 35 mg/l in June 1994 to 180 mg/l by October 2003. This well is downgradient of the northerly (more recent) stillage disposal area, and virtually upgradient of two City of Fresno wells (PS 155-1 and 2). Nitrate concentrations in water from both of these wells have also increased substantially in recent years. Similarly, the nitrate concentrations in water from MW-6 increased from 26 mg/l in June 1994 to 110 mg/l in October 2003. Both of these wells indicate the influence of stillage disposal in the area north of Olive Avenue. Apparently much of the winery wastewater seepage in this area did not reach the shallow groundwater until the late 1990's. Results for MW-7 indicate an influence of ion exchange regenerate, and further studies of this are in progress. This influence includes elevated sulfate and TDS concentrations.

Guild Winery

The Guild Winery (formerly Alta Vineyards) was located south of McKinley Avenue and west of Clovis Avenue. Wastewater flow was 16 million gallons in 1968. Wine was produced primarily during the winery season from September 1 to December 1 and brandy produced at other times of the year. About 4 million gallons per year of wastewater were disposed of through land application, and the remaining 12 million gallons were disposed of in Mill Ditch and through dry wells. A chemical analysis of this wastewater was presented in Table 1. The sample had 360 ppm potassium, 56 ppm sulfate, 12 ppm chloride, and a total dissolved solids of 556 ppm. This winery was connected to the City of Fresno sewer system in 1970, and was closed in the late 1970's. Apparent impacts to groundwater quality were apparently small, probably due to the relatively small amount of wastewater percolated, and that the winery was connected to the sewer system in 1970, then closed.

TABLE 9-GROUNDWATER MONITORING RESULTS FOR GALLO WINERY MONITOR WELLS
(1994-2001)

<u>Constituent (mg/l)</u>	<u>MW-1</u>	<u>MW-2</u>	<u>MW-3</u>	<u>MW-4</u>	<u>MW-5</u>	<u>MW-6</u>	<u>MW-7</u>
Calcium	70	29	112	96	29	82	343
Magnesium	43	16	60	57	17	46	167
Sodium	43	11	29	53	24	29	162
Potassium	5	2	6	8	4	7	24
Alkalinity	290	100	350	500	170	400	570
Chloride	16	4	25	25	10	34	116
Sulfate	59	18	84	57	16	33	1,170
Nitrate	59	49	168	61	36	33	73
Electrical Conductivity (micromhos/cm @ 25°C)	800	330	1,190	1,050	400	830	3,030
Total Dissolved Solids	500	220	730	650	260	520	2,550

Agricultural Irrigation

The 1976-77 crop survey map from the 208 program indicates that there was an abundance of deciduous tree crops east of Clovis Avenue in this subarea. The U.S. Agricultural Research Service (Day et al, 1978) sampled numerous private wells in the area between Clovis and Armstrong Avenues, and Olive and Belmont Avenues during 1971-77. A high nitrate area was indicated east of Fowler Avenue and south of Harvey Avenue. The high nitrate concentrations in shallow groundwater east of the Gallo Winery lands are most likely due to historical nitrogen fertilizer applications on sandy topsoil in the vicinity.

Rural Residential Area

The County of Fresno Southeast Rural Residential Area is located east of Temperance Avenue, between McKinley and Kings Canyon Road. At least part of this area is underlain by high nitrate concentrations in the shallow groundwater. Considering the status of rural residential development as of 1976-77, it is likely that previous nitrogen fertilizer practices on irrigated lands caused most of the high nitrate concentrations. Previous studies (County of Fresno, 1979) indicate these high nitrate concentrations correlated well with permeable topsoils in this area. Also, calculations indicated that for 2.5-acre rural residential lots, the septic tank effluent probably is not of a large enough volume to cause nitrate concentrations to exceed 45 mg/l in water from private domestic wells in this area.

THE SUNNYSIDE SUBAREA

Figure 20 shows the Sunnyside Subarea. The major potential sources of nitrate in this subarea are:

1. Septic tanks in urban areas
2. Historical nitrogen fertilizer applications in irrigated areas
3. Former wineries and raisin processing plants.

As discussed previously, the Sunnyside area remains unsewered, and is thus the largest remaining unsewered area in the Fresno urban area. Nitrate concentrations exceeded 30 mg/l in groundwater beneath most of this subarea as of the early 2000's. Nitrate concentrations exceeded 40 mg/l beneath part of the subarea between Kings Canyon Road and California Avenue. Nitrate concentrations in water from four shallow City wells (PS 232-1, 223-2, 274, and 276) exceeded the MCL, and these wells were taken out of service. However, water from PS 274 was temporarily treated to remove nitrate and the well was used during Summer 2002.

The south part of Section D-D' (Figure 17), and the east part of Section E-E' (Figure 18) pass through part of the Sunnyside subarea. Five relatively deep casing hammer test wells have been drilled in this subarea. Relatively deep wells that have been successfully drilled in this area include the John Wash School well, the Sunnyside High School well, Bakman Water Co. Well No. 4-A (at the TW-16 site), and City of Fresno PS 163, 164, and 165. More productive deposits at depth are generally present west of Fowler Avenue and to the west in this subarea. A number of City test holes have been drilled to about 800 feet in depth in the area between Jensen and California

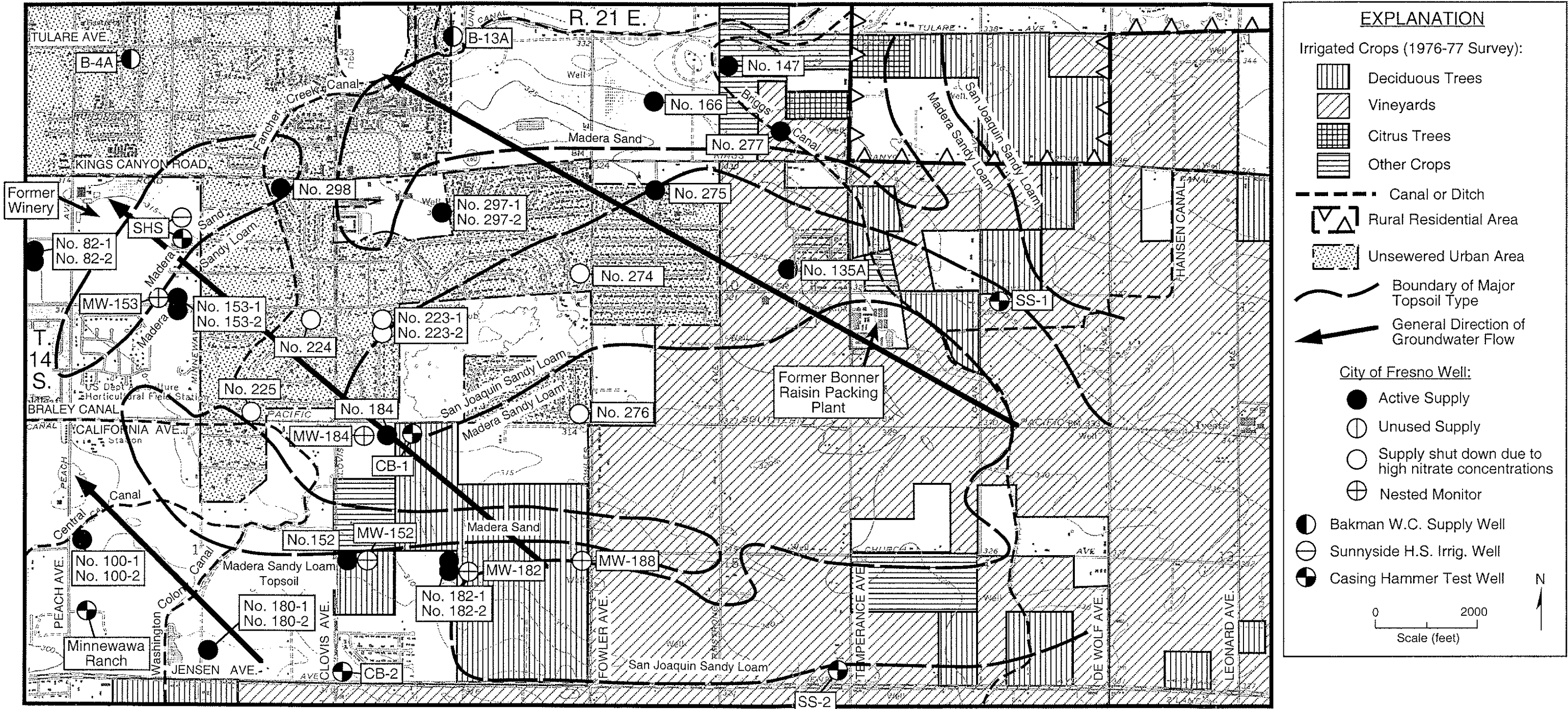


FIGURE 20 - LOCATION OF SUNNYSIDE SUBAREA AND POTENTIAL SOURCES OF NITRATE

Avenues. Productive strata below a depth of 300 feet are generally thicker and deeper to the west in this part of the subarea.

The general direction of groundwater flow in this area has been to the northwest. Water levels have been of moderate depth. A number of smaller FID canals traverse the area. Soils are variable and of several types, with varying amounts of hardpan. Vine-yards have been the predominant crop type in this area. Some intentional recharge basins are in the area, but overall, intentional recharge has been small. Nitrate concentrations have increased in a number of wells in this area during the past two decades. The Sunnyside area generally had the most widespread DBCP contamination in shallow groundwater in the Fresno urban area.

The crop survey map for 1976-77 indicates that deciduous orchards were common south of California Avenue and east of Clovis Avenue, which is upgradient of the high nitrate part of this subarea as of the early 2000's.

There were at least two old wineries in the Sunnyside subarea. One was northeast of Kings Canyon Road and Clovis Avenue, and the other south of Kings Canyon Road and east of Peach Avenue. Little information is available on these, as operations ceased many decades ago. The former Bonner Packing Raisin Processing Plant was located south of Butler Avenue and east of Temperance Avenue. Schmidt (1977) described groundwater quality and waste disposal at the Bonner Packing Co. facility. The wastewater was primarily for washing raisins and from the dehydrator. The average flow of wastewater from raisin washing was 70,000 to 100,000 gallons per day during a five-day work week in the mid 1970's. The dehydrator wastes averaged 37,000 gpd during a seven-day week when fresh grapes were being picked (summer and fall). Total nitrogen concentrations in the wastewater averaged about 100 mg/l, and the pH often ranged from 4 to 5. Chloride concentrations averaged 70 mg/l. Schmidt (1977) estimated that there were about 125 acre-feet per year of wastewater percolated from a 40-acre disposal area. Sampling of water from nearby shallow supply wells indicated high concentrations of iron and manganese, indicative of reducing conditions in the shallow groundwater. Monitor wells were not available to determine impacts on the quality of shallow groundwater.

CALWA-MALAGA SUBAREA

Figure 21 shows the locations of the Calwa-Malaga Subarea. Major potential sources of nitrate in groundwater include:

1. Formerly unsewered urban area of Calwa
2. Nitrogen fertilizers in irrigated areas
3. Malaga CWD WWTF ponds
4. Other industries, a stockyard, and a dairy.

The formerly unsewered urban area of Calwa was primarily south of Church Avenue, north of the SRF, and between Orange and Maple Avenue. Most of this subarea was underlain by nitrate concentrations exceeding 30 mg/l in the shallow groundwater by the early 2000's. Nitrate concentrations have generally been increasing in groundwater of this subarea during the past two decades. The direction of groundwater flow in this subarea is generally to the northwest. Vineyards were the predominant crop in the upgradient irrigated area as of 1976-77. There were

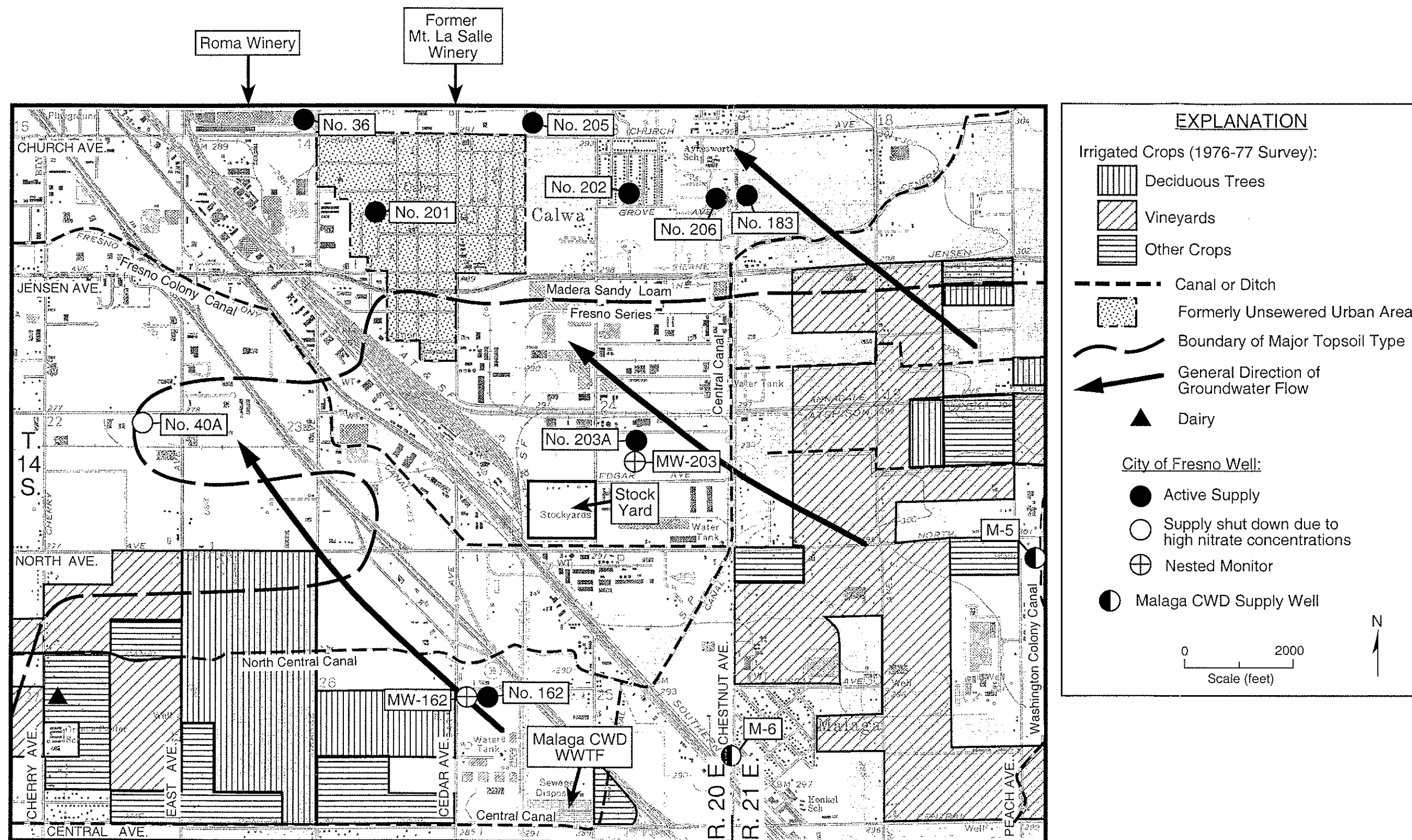


FIGURE 21 - LOCATION OF CALWA-MALAGA SUBAREA AND POTENTIAL SOURCES OF NITRATE

some deciduous tree crops south of Jensen Avenue and east of Willow Avenue, which was upgradient of the high nitrate area. Several smaller FID canals traverse the area.

Drilling of deep test holes and wells (700 to 900 feet deep) in this subarea indicates that permeable water producing strata are present west of Chestnut Avenue below a depth of 300 feet. However, in part of the area east of Chestnut Avenue (between Kings Canyon Avenue and Jensen Avenue), substantial clay strata are predominant below a depth of 300 feet. In the part of the subarea south of Jensen Avenue, highly productive black sand or gravel is present below a depth of about 550 feet. These same type of highly productive sands have been encountered at depth in the vicinity of the City of Kingsburg, and southeast of Sunnyside in the Lodestar area. Deep wells have been successfully drilled in the Malaga CWD, to the south at the Fresno County Juvenile Justice Campus, and at City of Fresno PS 170. City of Fresno PS 40-A was shut down due to high nitrate concentrations.

There were two wineries in the subarea that were connected to the regional sewer system as of 1970. Both of these (Roma Winery and Mt. LaSalle Vineyards) were north of Church Avenue, between East and Cedar Avenues. These were subsequently connected to a separate sewer line leading to the City of Fresno WWTF in the early 1970's. Both of these wineries are now closed. There are several other industries in Malaga that were unconnected at one time to the regional sewer system. Included were the Ranchers Cotton Oil Plant, Chevron Chemical, Producers Cotton Oil, and Henrietta Ranches. The Mana Pro Corporation feed mill is located north of North Avenue, between Cedar and Chestnut Avenues. The feed mill discharges boiler blowdown to a pond and has two septic tank systems for domestic wastewater. A dairy is also located near Cherry and Muscant Avenues. No information is available on the quality of shallow groundwater beneath these facilities. DBCP is also common in shallow groundwater in the Calwa-Malaga subarea. The source apparently was DBCP applications to upgradient vineyards to the southeast.

SOUTHWEST FRESNO SUBAREA

The southwest Fresno subarea (Figure 22) extends from the northeast at downtown Fresno to the southwest to the Cities of Fresno and Clovis WWTF. Most City public supply wells in this subarea are in the northeast part, which has been urbanized for many decades. Detailed irrigation well sampling by K. D. Schmidt in Summer 1971 in this subarea delineated several northeast trending zones of high nitrate concentrations. These were generally underlain by sandy topsoils (Madera sand) and coarse-grained alluvium. Because the area was predominantly irrigated, nitrogen fertilizers were the apparent source of nitrate in the groundwater. The direction of groundwater flow varies in the sub-area, from west-northwest in the southeast part to southwest in the central part. Near the regional WWTF, a significant recharge mound is present from which groundwater moves away in all directions.

Deep test holes and wells (about 750 to 950 feet deep) in this subarea indicate highly permeable deposits are usually present below a depth of about 900 feet. Two deep wells used for potable water have been drilled at the regional WWTF and at a winery to the south. In addition, deep test holes (such as City of Fresno MW-26B) in the northeast part of this subarea have indicated favorable conditions for development of such wells.

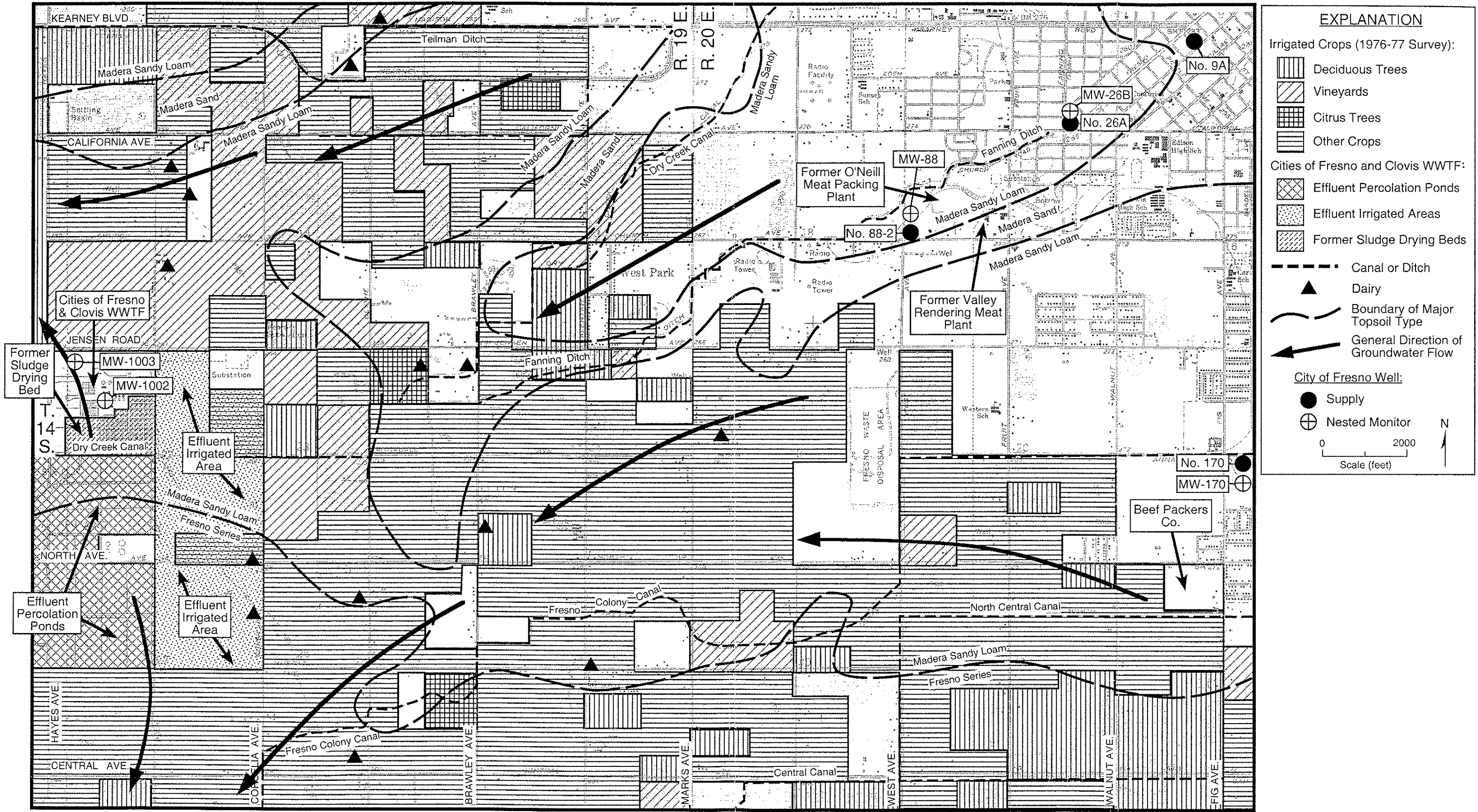


FIGURE 22 - LOCATION OF SOUTHWEST FRESNO SUBAREA AND POTENTIAL SOURCES OF NITRATE

The predominant potential sources of nitrate to groundwater in this subarea are:

1. Nitrogen fertilizer applications in irrigated areas
2. Present and former meat packing plants
3. Effluent irrigation near the regional WWTF
4. Dairies
5. Rural residential areas on septic tanks.

As part of previous evaluations for the regional WWTF, the locations of various dairies in the western part of this area were mapped. Some of these dairies have been present for many decades. Locations of dairies in the rest of this subarea were obtained from the Regional Board and the locations of these are also shown.

The Valley Rendering Co. meat packing plant had its own waste disposal facilities prior to connection to the City of Fresno regional sewer system in late 1955. The plant was located south-east of Snake Road (between California and Church Avenues) and west of Fruit Avenue. The former O'Neill Meat Company, which relied on on-site wastewater disposal, was located nearby. Both of these plants were in or near an area where nitrate concentrations in shallow groundwater exceeded 40 mg/l in about 1970.

The existing meat packing plant (Beef Packers) is located south of North Avenue and west of Fig Avenue. This plant was formerly operated by the Fresno Meat Company. Hides were formerly processed at the plant, which resulted in a high chloride waste-water. High nitrate and chloride concentrations had been found in water from some private wells west and northwest of that plant as of the 1970's. Wastewater was disposed of by ponds and irrigation until several years ago, when the wastewater from the plant was connected to the regional sewer system. The Regional Board required that monitor wells be installed at the Beef Packers plant. There are now five shallow monitor wells at the facility. All of these wells are perforated from 55 to 80 feet in depth. Nitrate concentrations in water from four of the wells ranged from 92 to 320 mg/l, exceeding the MCL of 45 mg/l. The highest concentration was in a monitor well downgradient of the former wastewater irrigated area (Kenneth D. Schmidt & Associates, 2004). There are no City of Fresno supply wells in this part of the subarea.

A number of monitor wells have been installed at the Cities of Fresno and Clovis WWTF. Both shallow and deep monitor wells are monitored. Kenneth D. Schmidt and Associates (2003) described groundwater quality in the vicinity of the WWTF. Nitrate concentrations in groundwater beneath effluent percolation ponds have generally been low, often non-detectable, in recent years. In contrast, nitrate concentrations in groundwater beneath effluent irrigated areas have often exceeded the MCL. Time trends in monitor wells at the Cities of Fresno and Clovis WWTF have been described in detail by Kenneth D. Schmidt and Associates (2003).

A variety of crops are grown in the irrigated part of this subarea, including vineyards, deciduous tree crops, and vegetable crops. Because of the permeable Madera sand topsoil in part of this subarea, and relatively shallow groundwater (usually less than 50 feet deep), it appears particularly vulnerable to nitrate degradation from nitrogen fertilizer applications.

Time trends in nitrate concentration aren't well known in most of this subarea, due to the paucity of City supply wells.

ENHANCED WELL CONSTRUCTION PRACTICES

Drilling of new City wells to produce acceptable nitrate concentrations involves several components that must be carefully done.

1. The lateral distribution of high nitrate areas and potential source areas should be considered in selecting well locations.
2. Specially designed test well or pilot hole sampling programs should be undertaken, prior to constructing the new well.
3. Perforations should only be placed opposite intervals with good quality groundwater. Continuous deep annular seals should be installed, to seal off all shallow high nitrate intervals and the confining bed(s) underlying them.
4. A step drawdown test should be done after the well is developed, and nitrate concentrations determined for different pumping rates. The test results should be evaluated to help determine acceptable pumping rates and drawdowns for the permanent pump to be placed in the well.

Previous casing hammer test wells in and near the Fresno urban area have precisely delineated the vertical distribution of nitrate and the most important confining bed or beds. This procedure provides optimal results for the following reasons.

1. Water samples can be readily collected from different depth intervals only about 30 feet apart.
2. Relatively high pumping rates (80 to 100 gpm) can be obtained from each water producing strata that is encountered.
3. Driving of the casing during drilling precludes mixing of drill cuttings, and no drilling mud or water is added during drilling. This allows superior collection of samples of drill cuttings and a precise delineation of the vertical extent of confining beds. Also, representative samples of water are readily collected.
4. Differences in water-level elevations at various depths are determined during drilling.
5. A good idea of the production capability of each water producing zone is obtained.

Once the test well results are available, the new well is designed, based on sieve analyses of the drill cuttings and the results of chemical analyses. Normally, one or more confining beds below the high nitrate area would be selected, and the annular seal placed from that depth to the land surface. After development, the well would be pump tested and an optimal pumping rate selected for the permanent pump. The goal would be to minimize the downward movement of high nitrate groundwater due to large downward head gradients.

It may be desirable to conduct Leaky Aquifer tests at specific new wells. Such tests normally take from three days to two weeks. An observation well is needed, perforated opposite the same interval as the pumped well. From such tests, the vertical conductivity of the confining beds can be determined. Using the vertical differences in hydraulic head, the amount of downward flow within

the cone of depression can be determined. Knowing the nitrate concentrations in groundwater above and below the confining bed, one can determine the optimal pumping rate for the new well more precisely, in order to obtain a desired nitrate concentration.

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APPENDIX A
SUBSURFACE GEOLOGIC CROSS SECTIONS

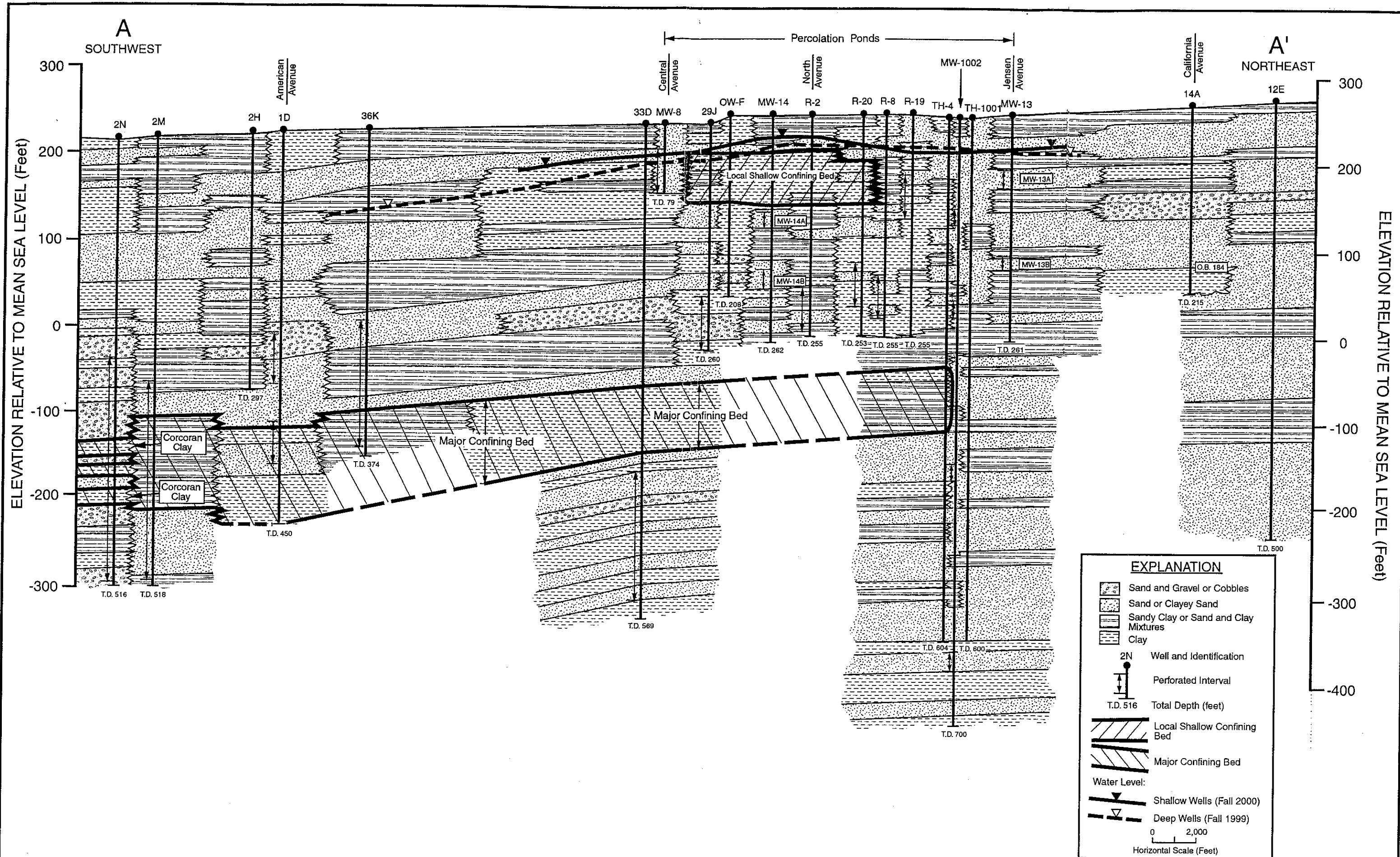


FIGURE 3 - SUBSURFACE GEOLOGIC CROSS SECTION A - A'

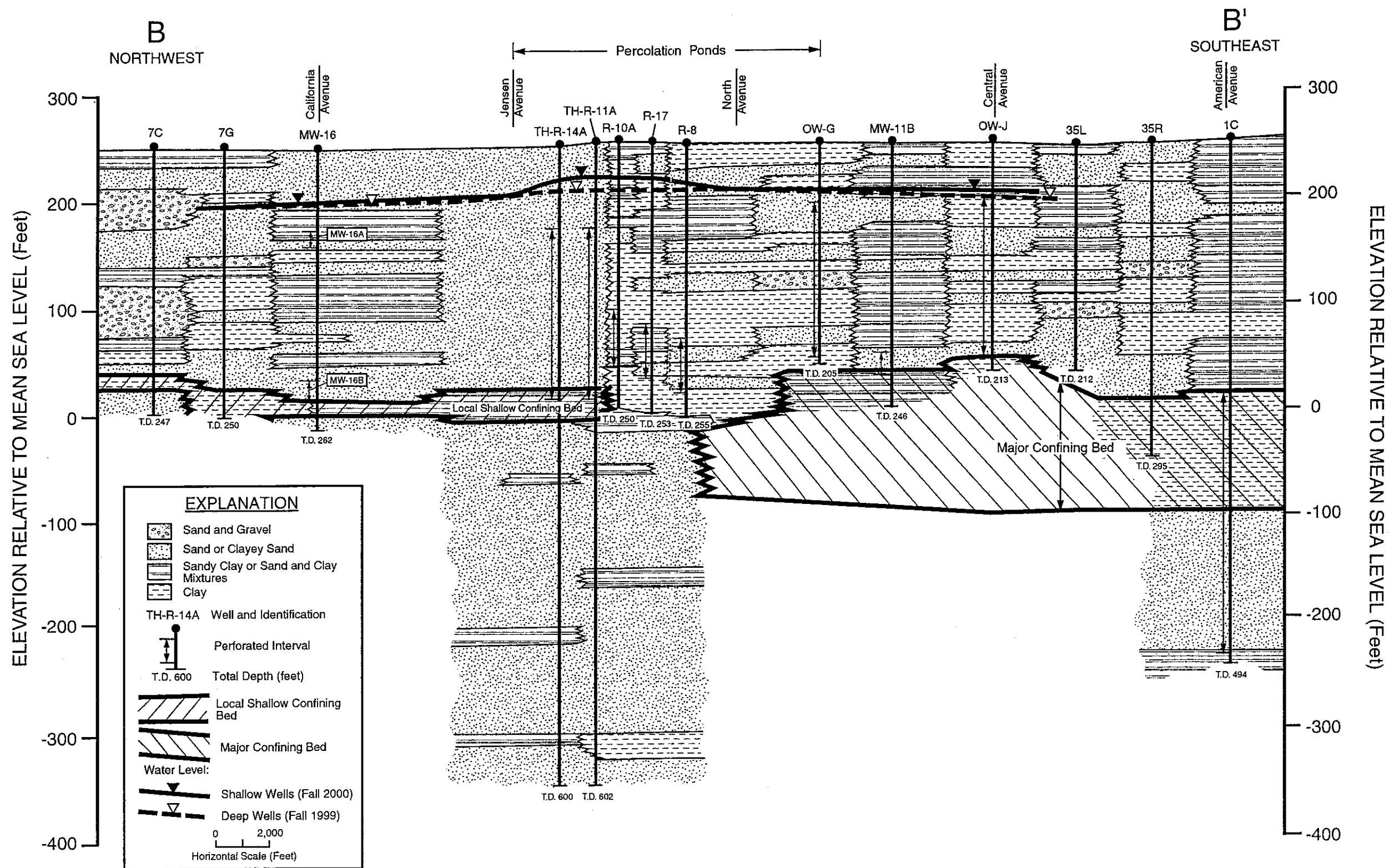


FIGURE 4 - SUBSURFACE GEOLOGIC CROSS SECTION B - B'

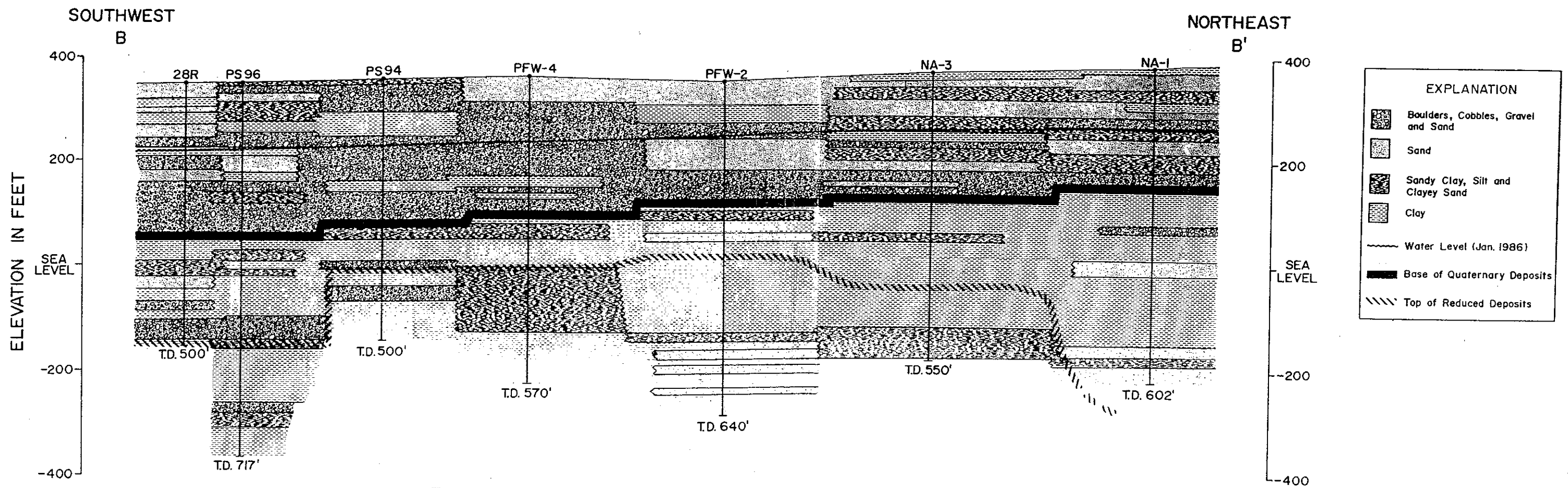


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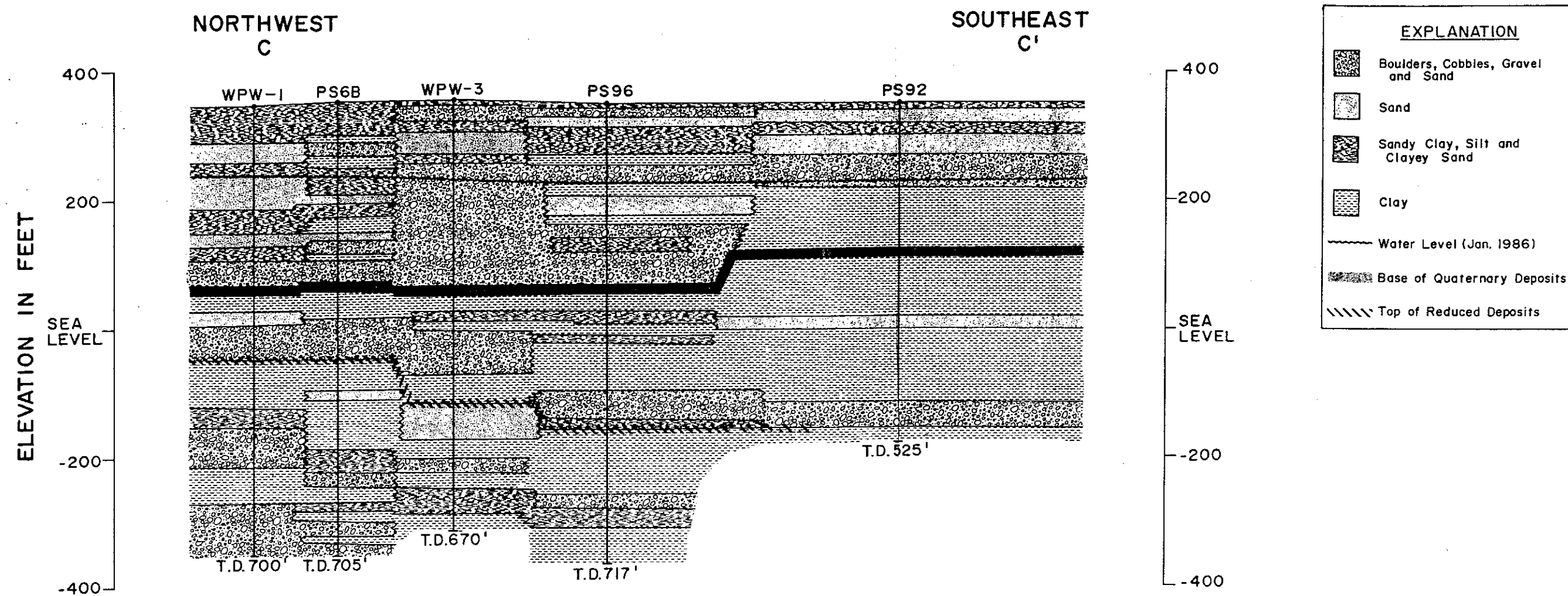


FIGURE 6 - SUBSURFACE GEOLOGIC CROSS-SECTION C-C'

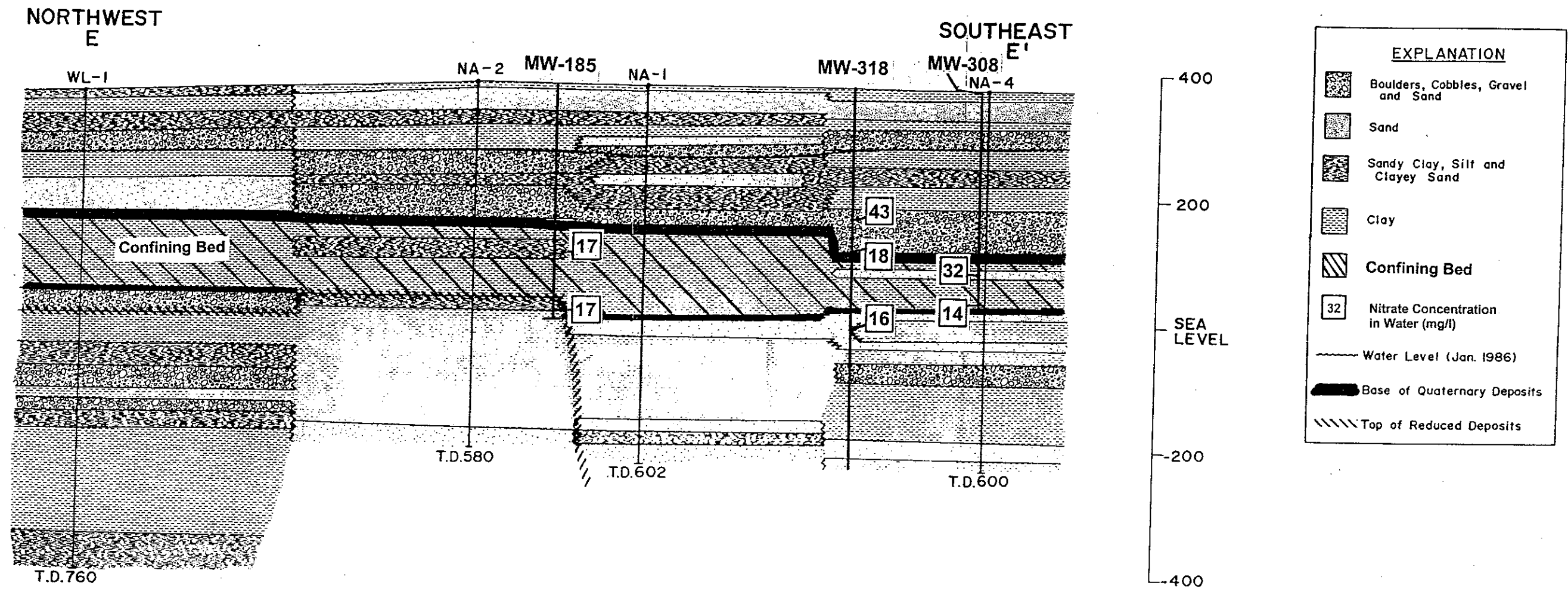
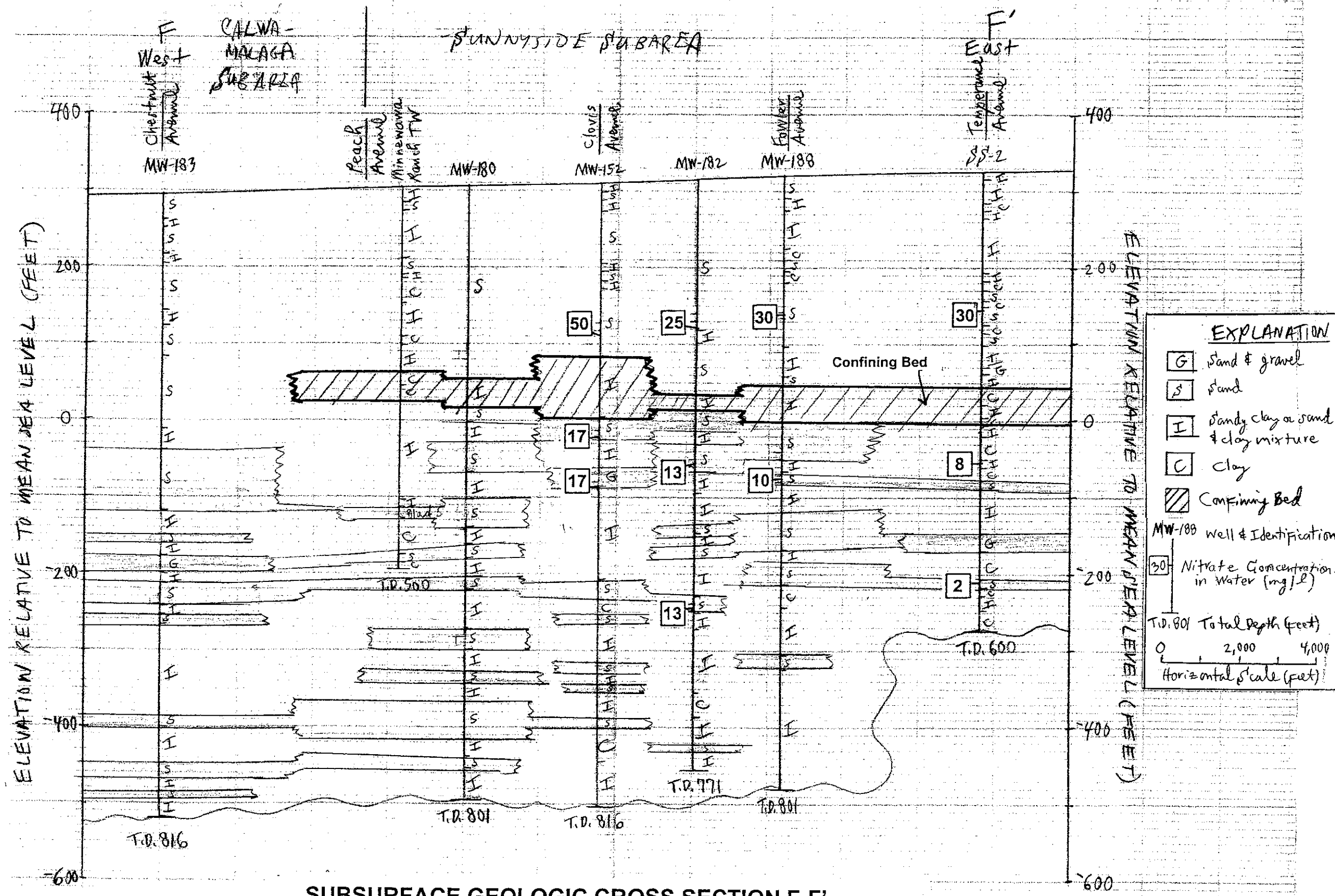
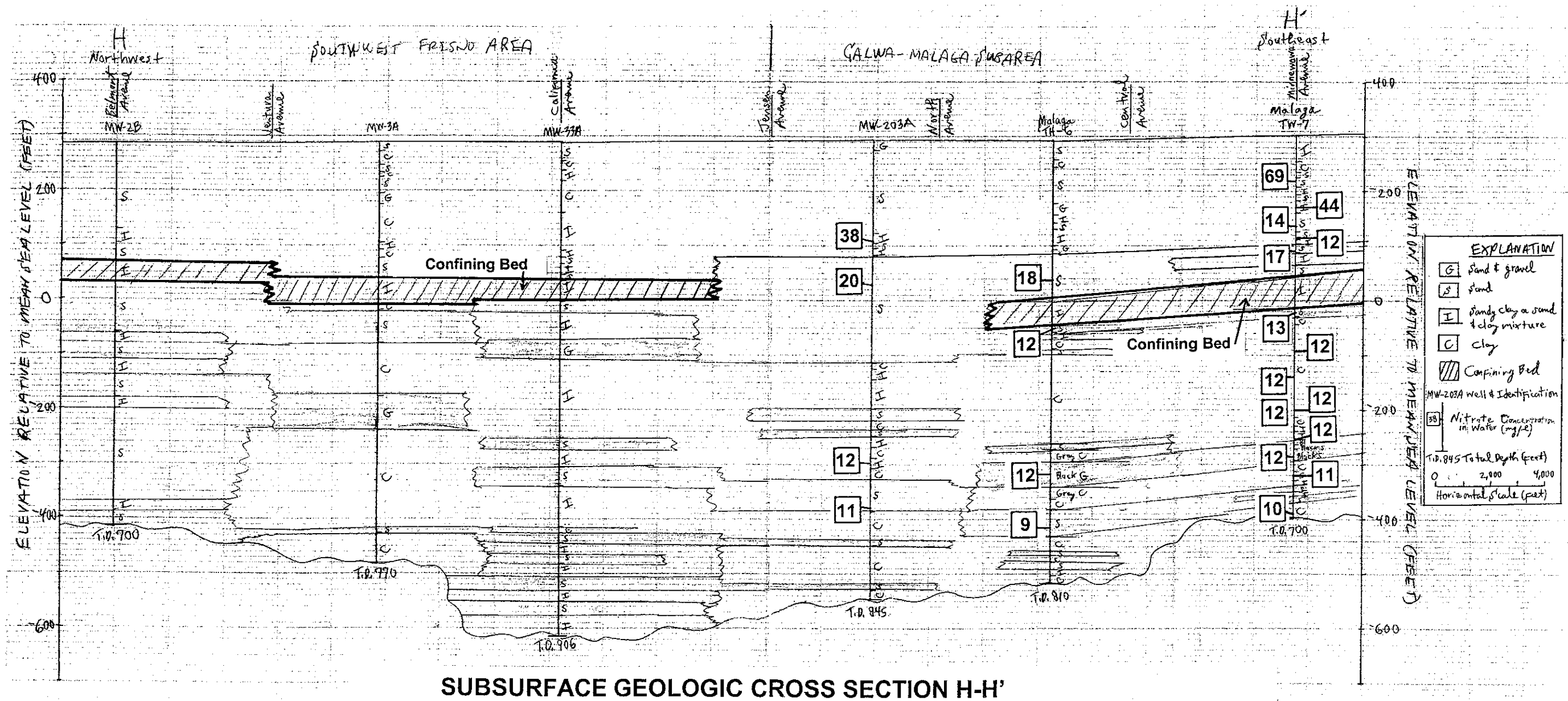
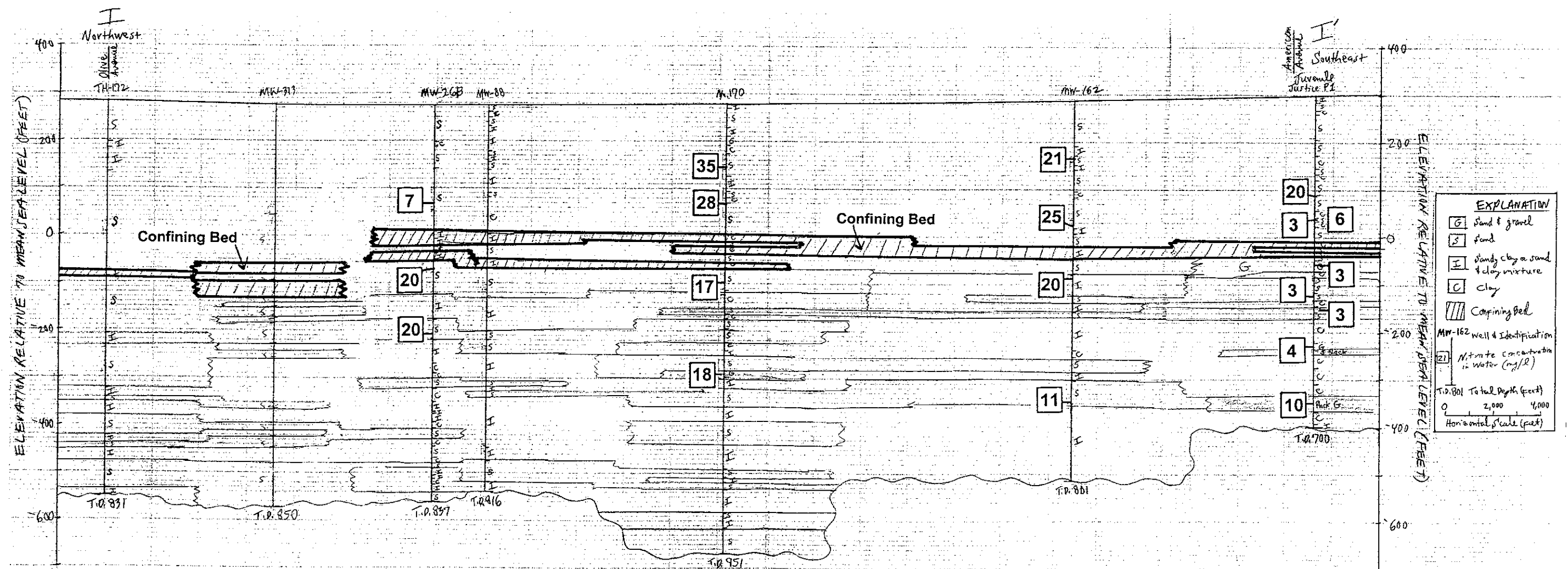


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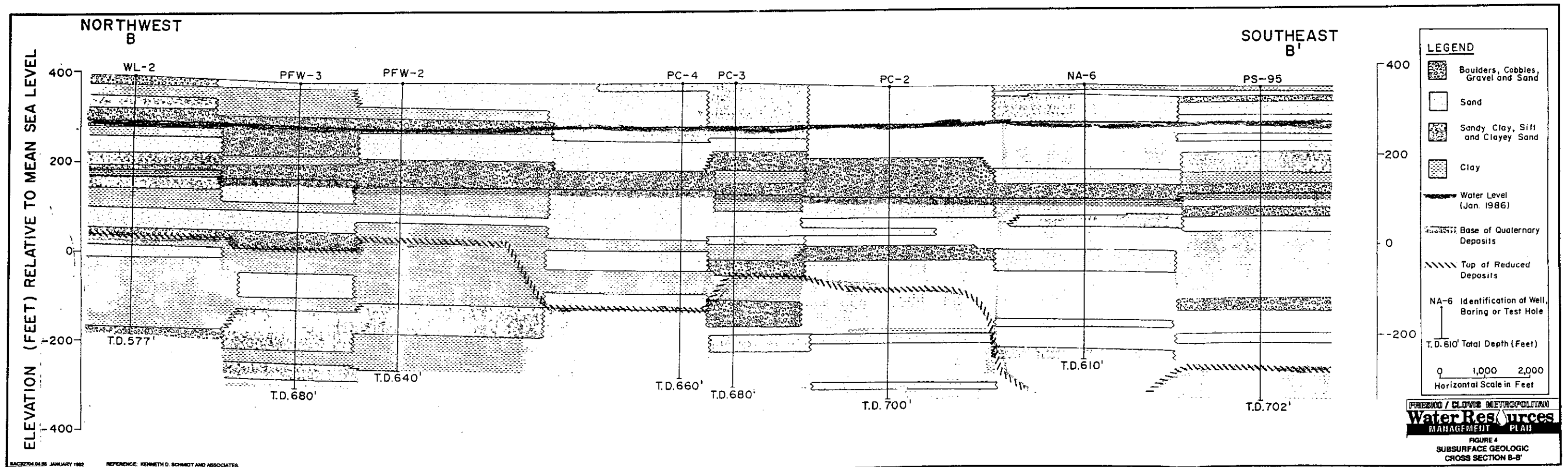
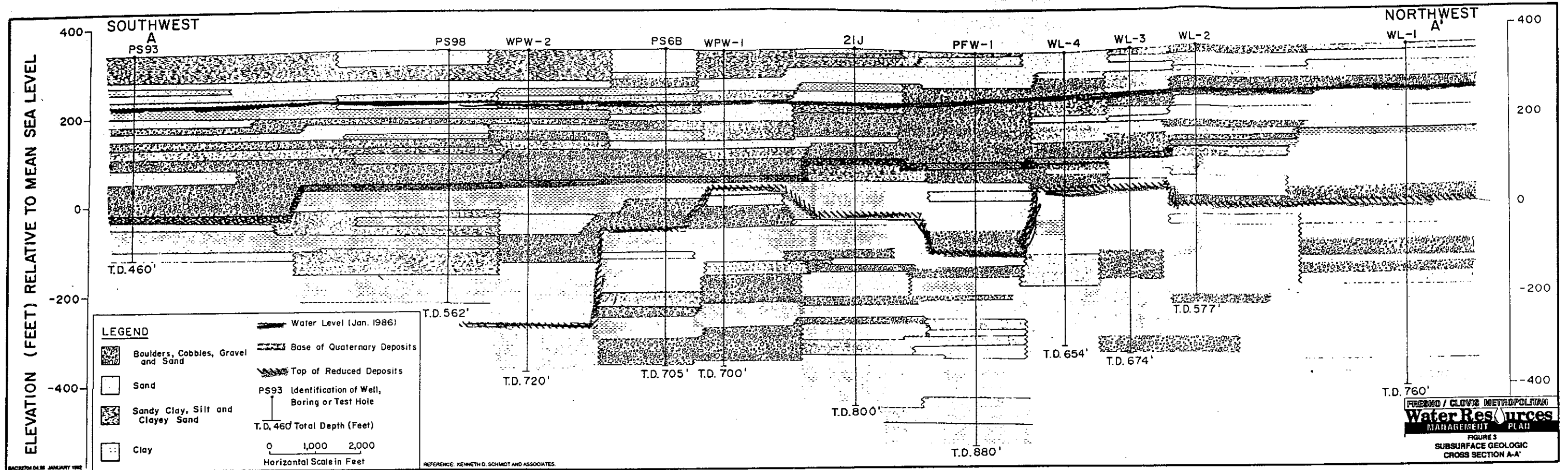


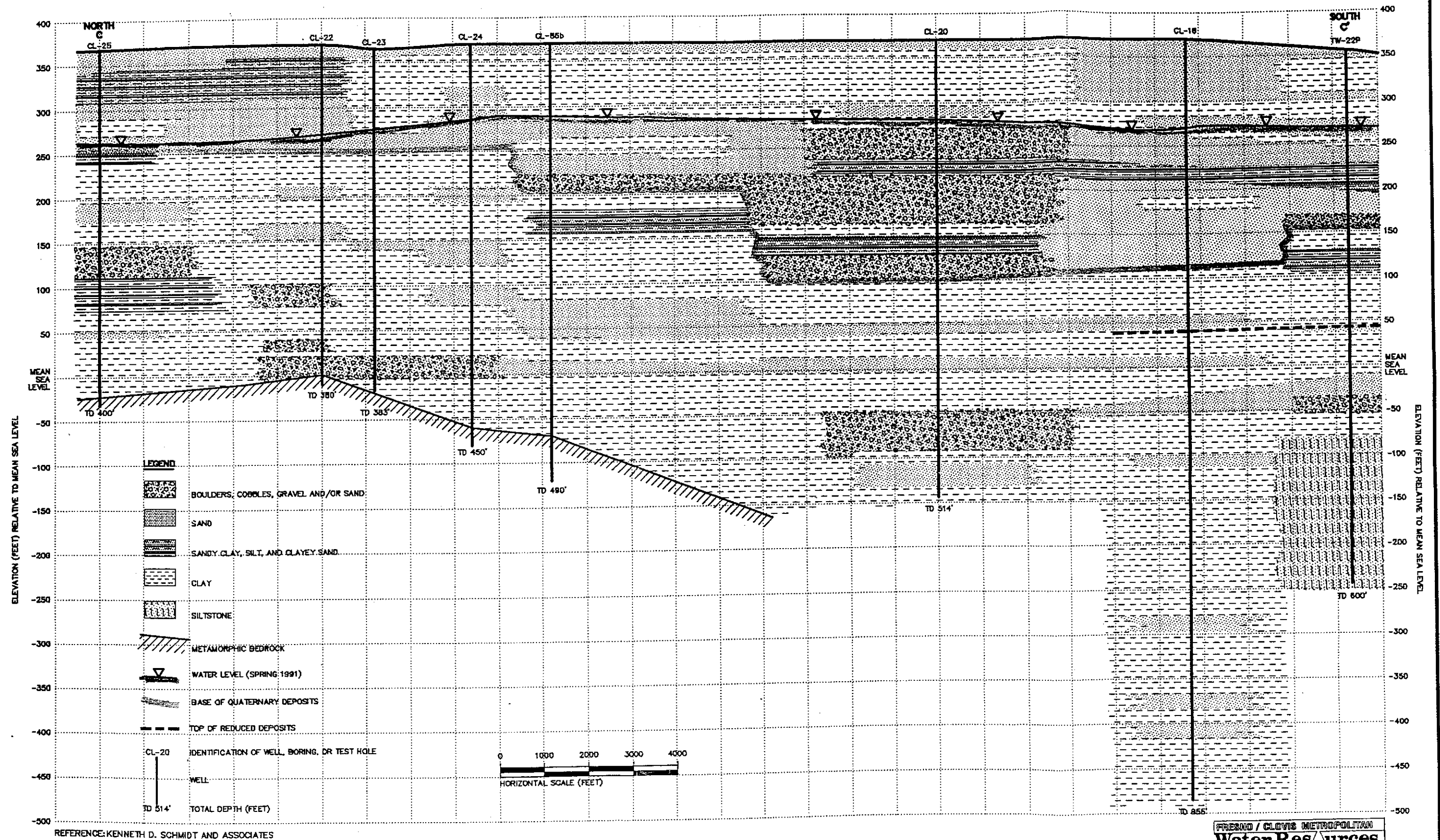
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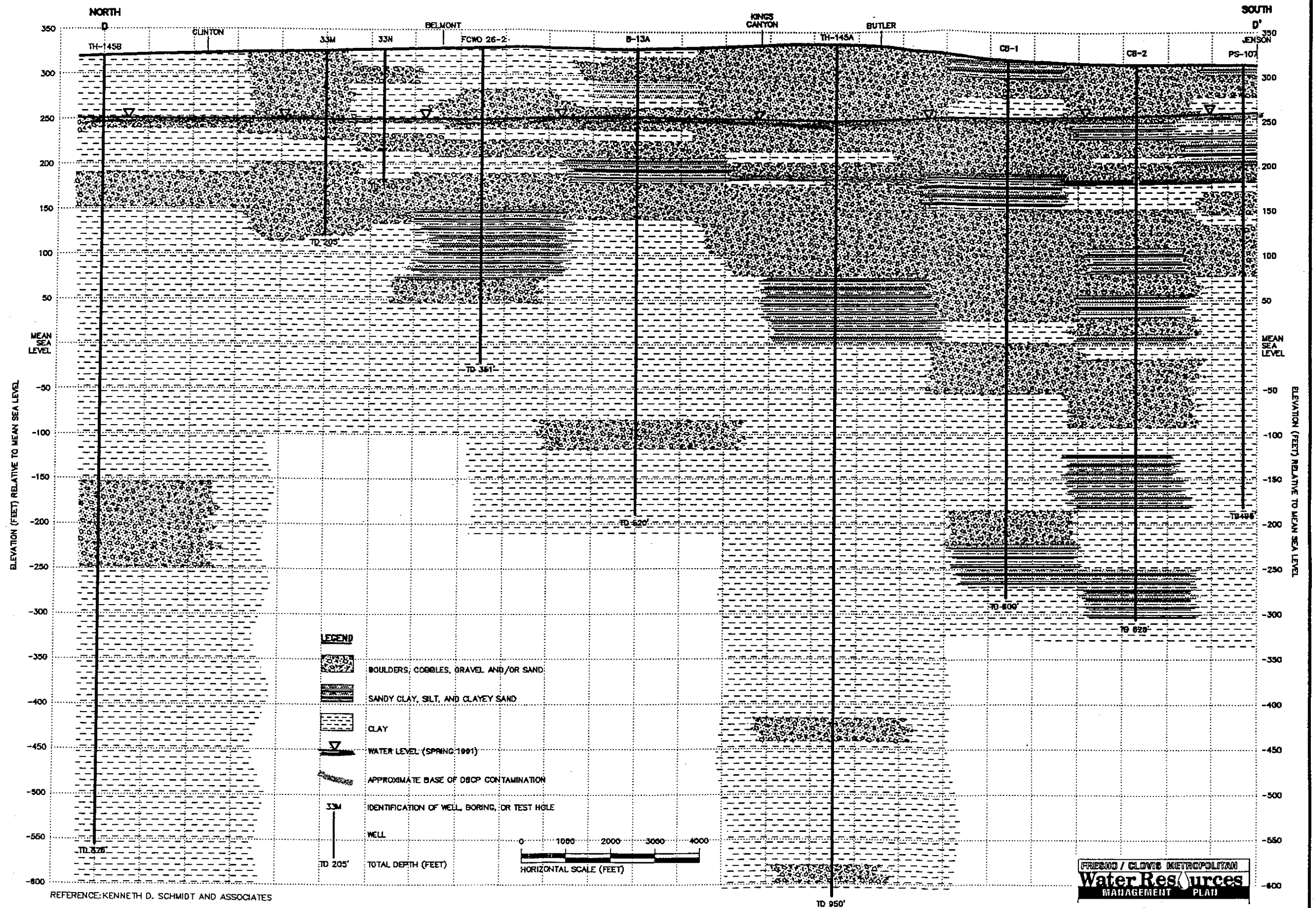




SUBSURFACE GEOLOGIC CROSS SECTION I-I'







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Water Resources
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FIGURE 6
 SUBSURFACE GEOLOGIC
 CROSS SECTION D-D'

CHM HILL

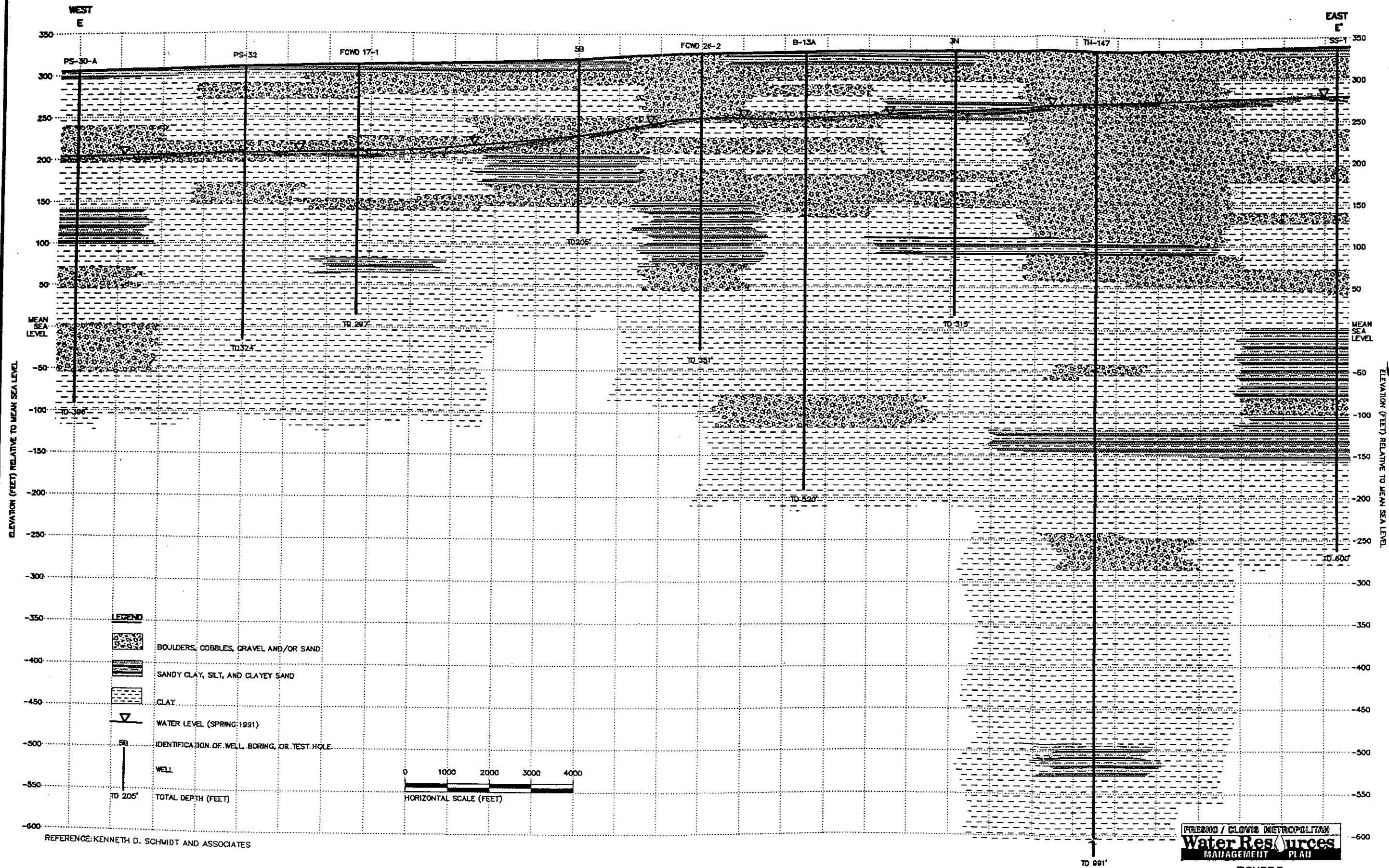
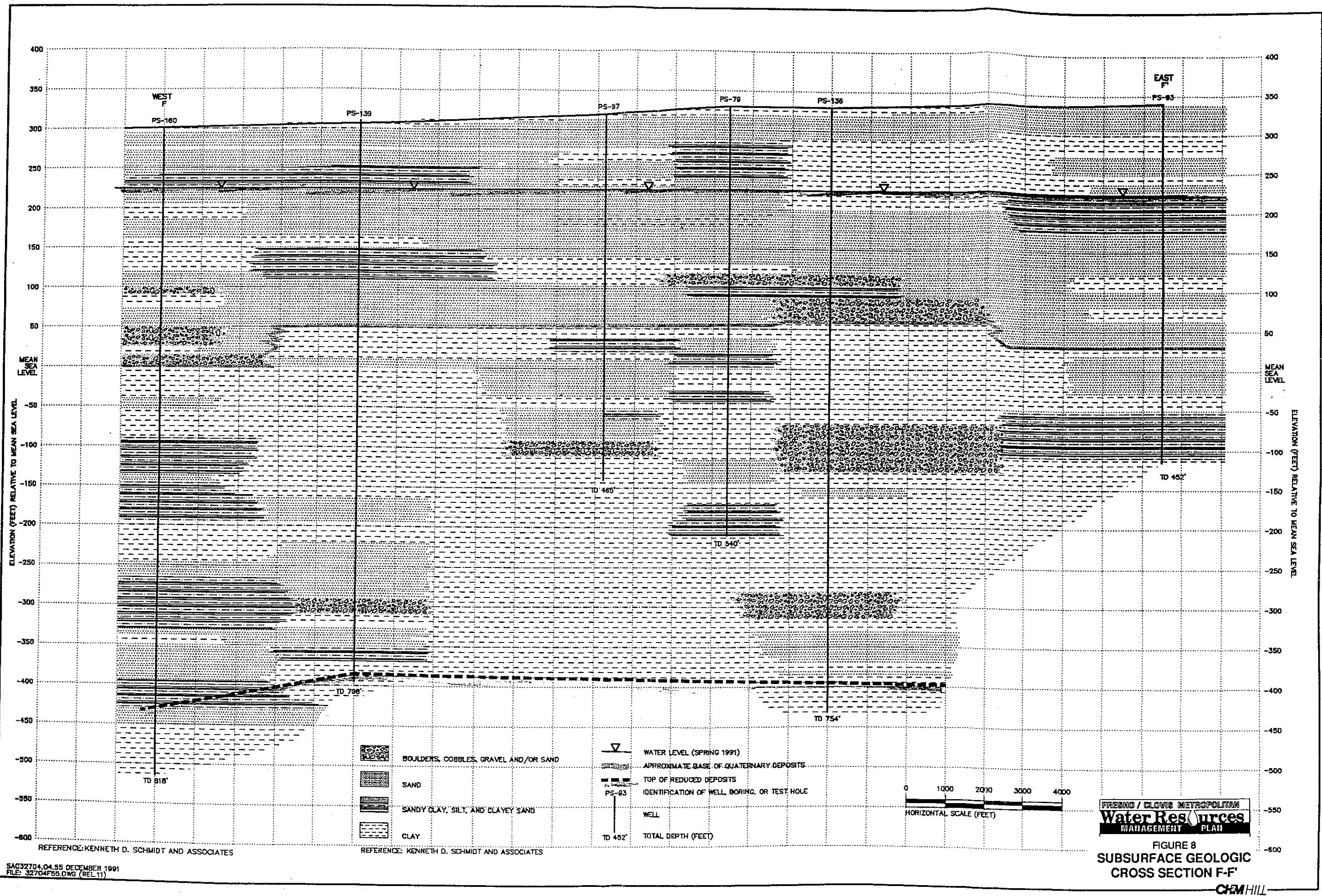
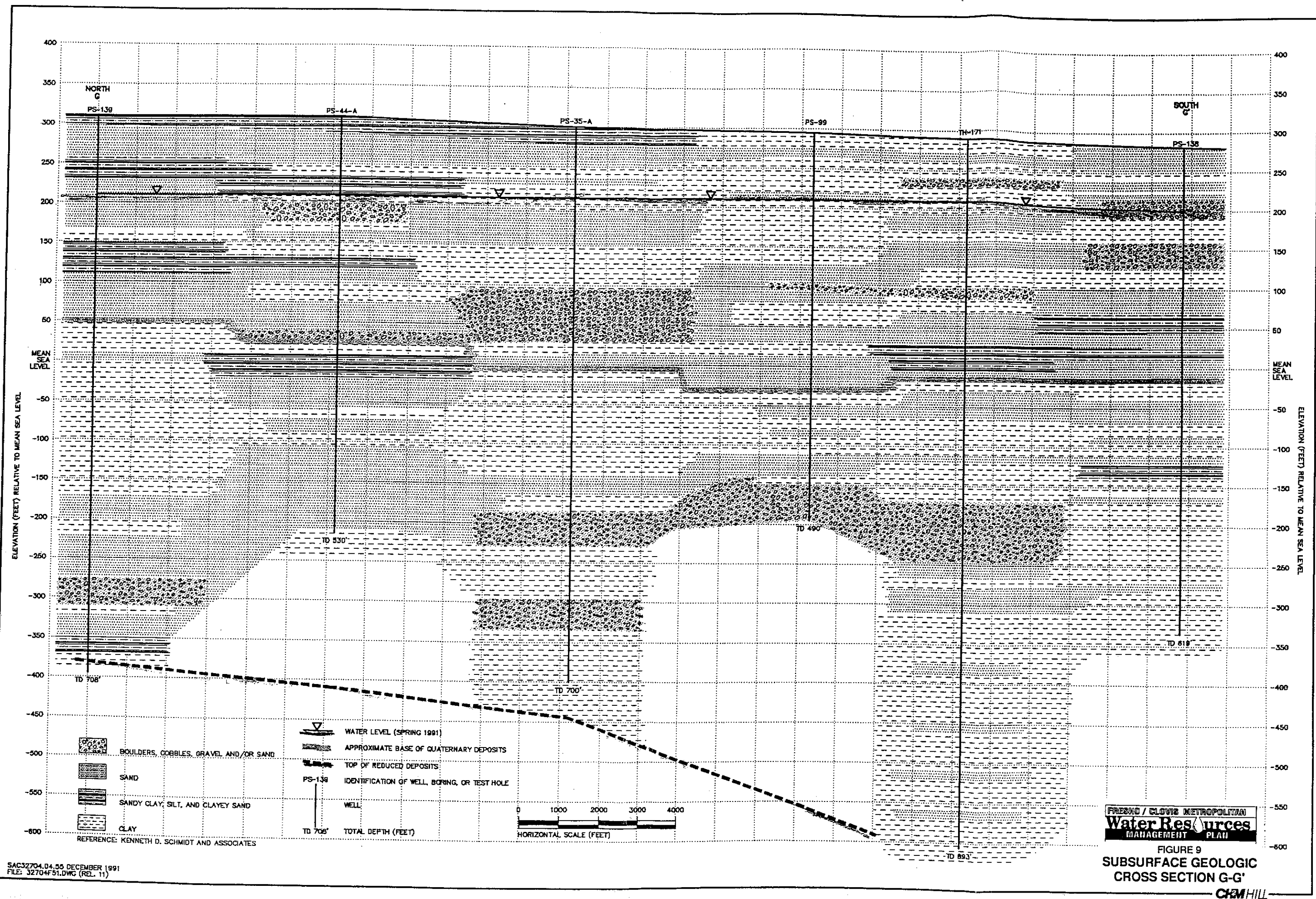


FIGURE 7
SUBSURFACE GEOLOGIC
CROSS SECTION E-E'





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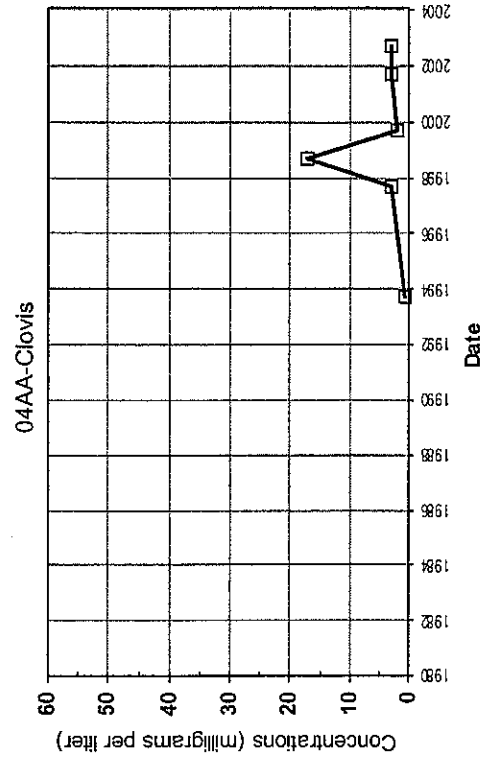
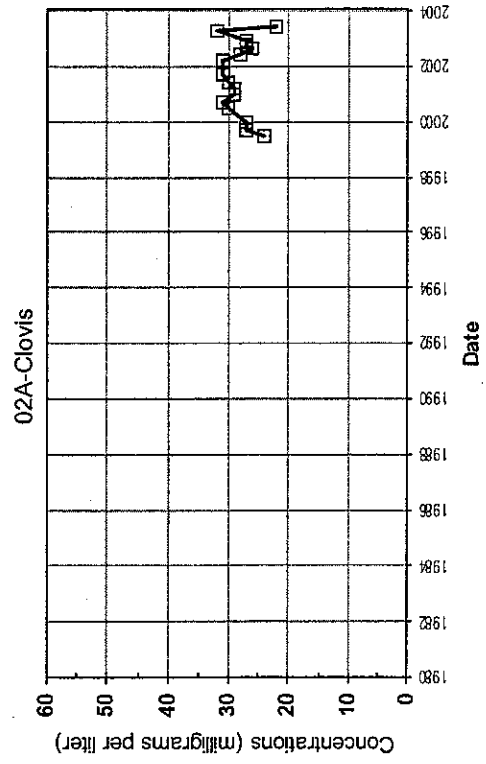
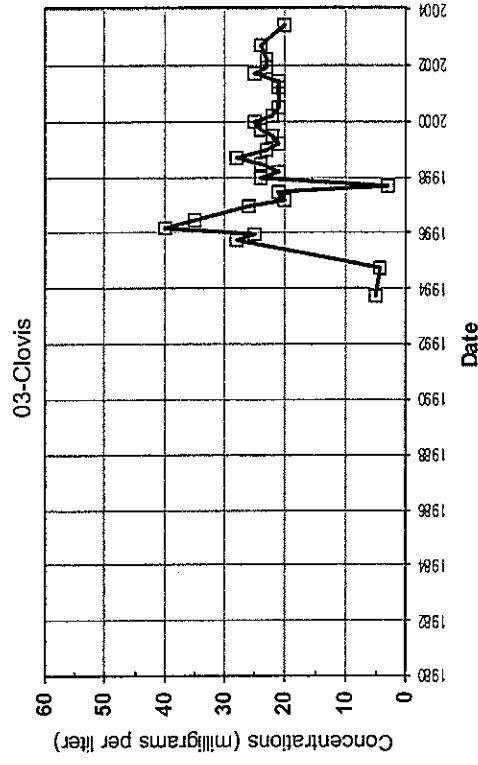
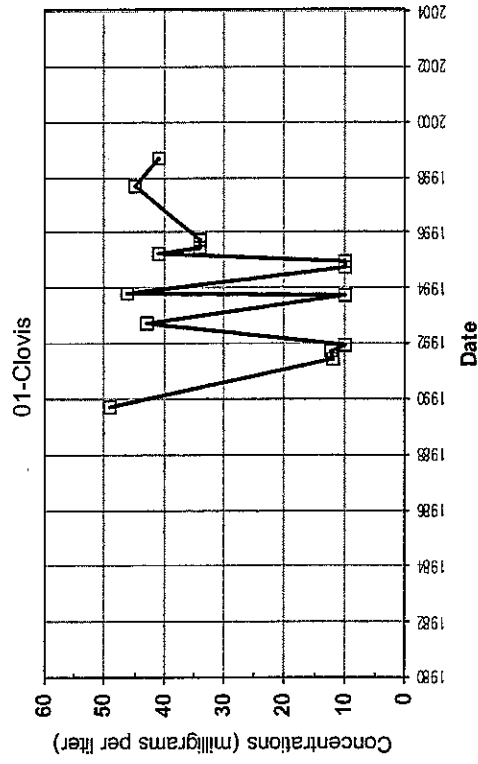
FRESNO / CLOVIS METROPOLITAN
Water Resources
MANAGEMENT PLAN

FIGURE 9
SUBSURFACE GEOLOGIC
CROSS SECTION G-G'

CHM HILL

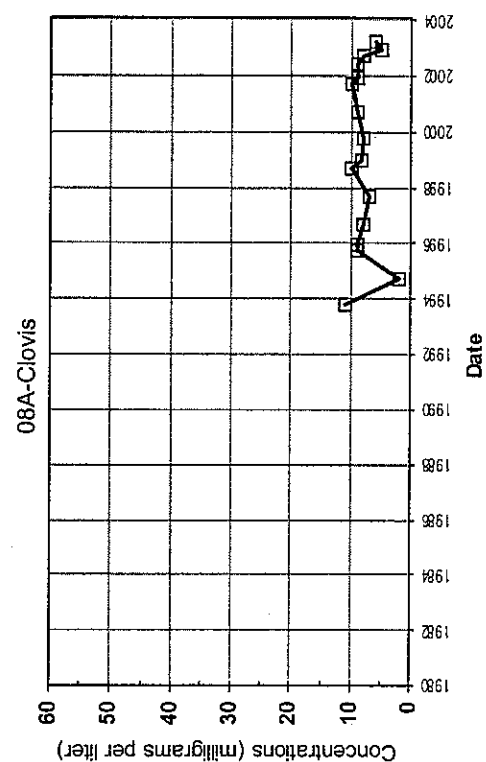
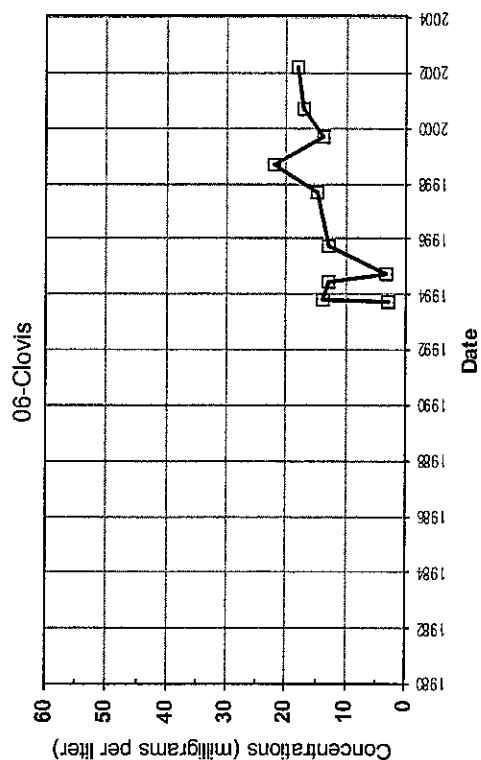
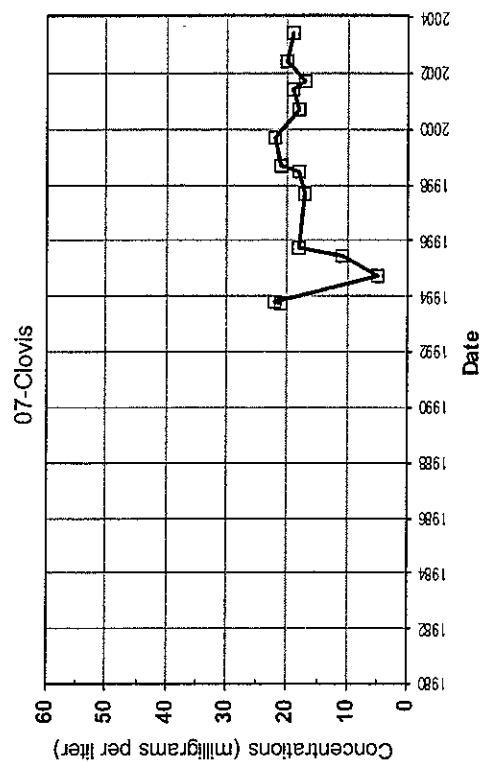
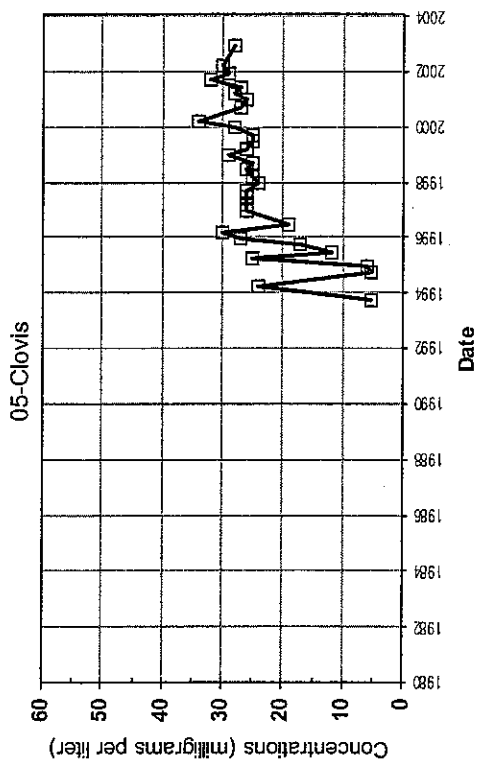
APPENDIX B
NITRATE HYDROGRAPHS

NO3 Concentrations



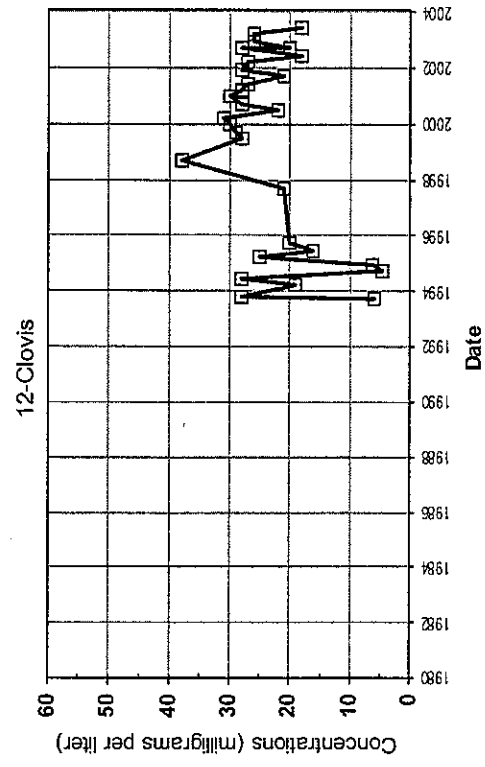
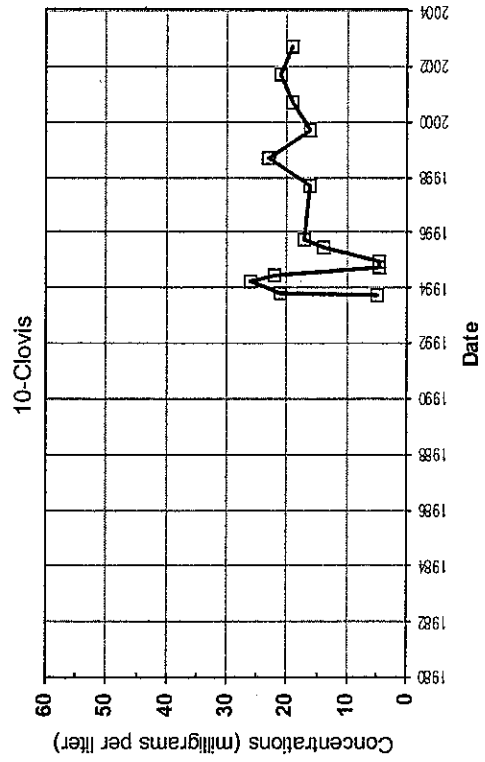
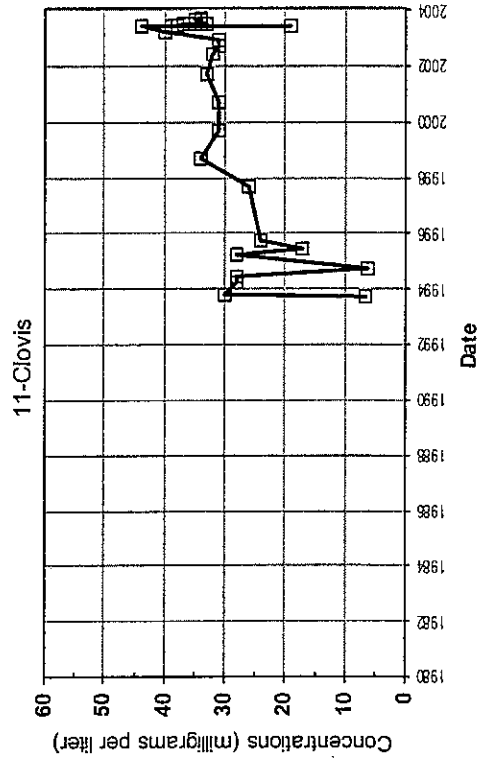
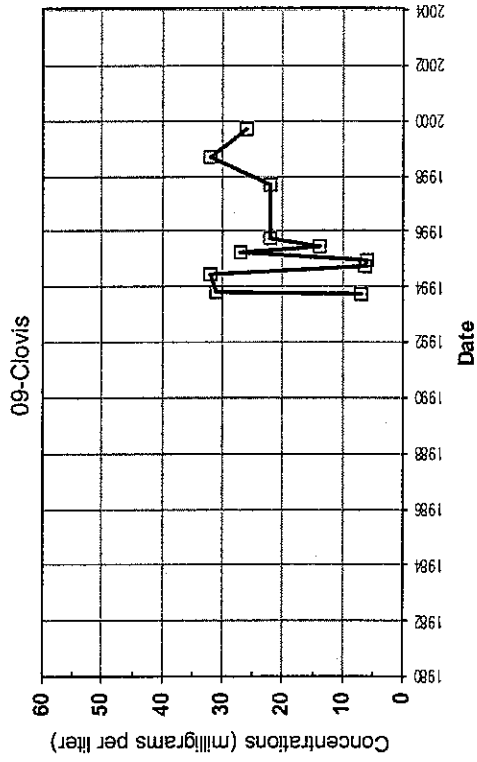


NO3 Concentrations



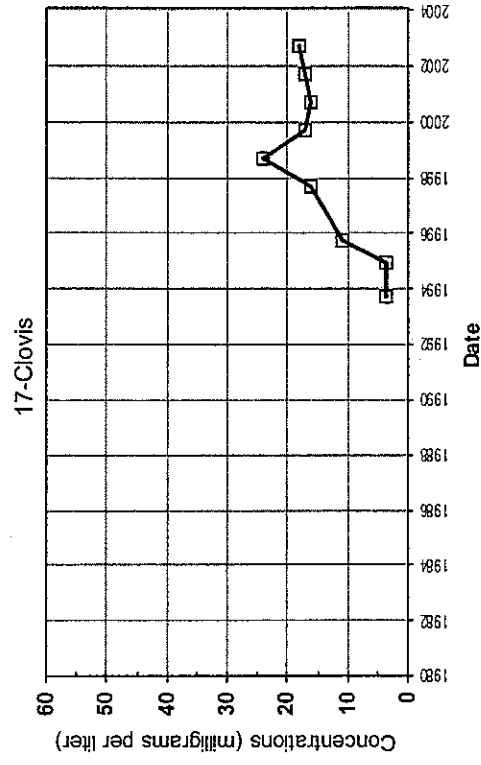
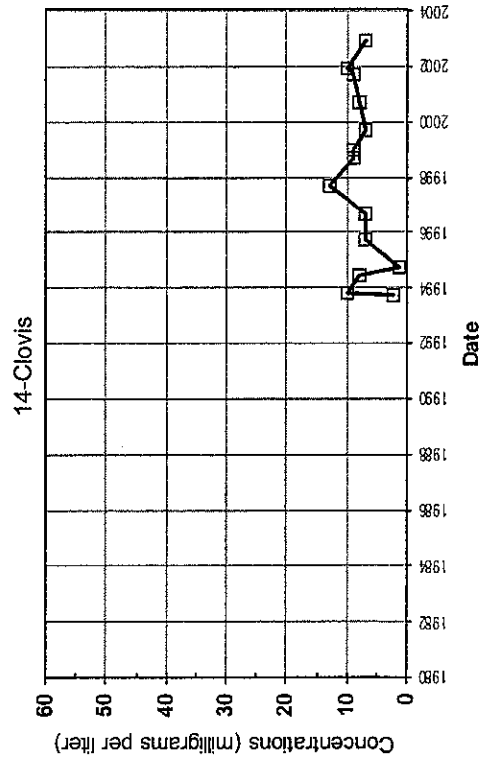
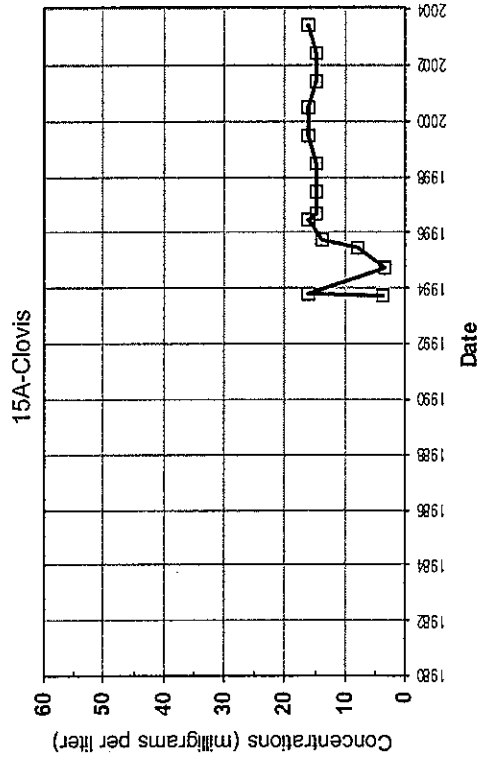
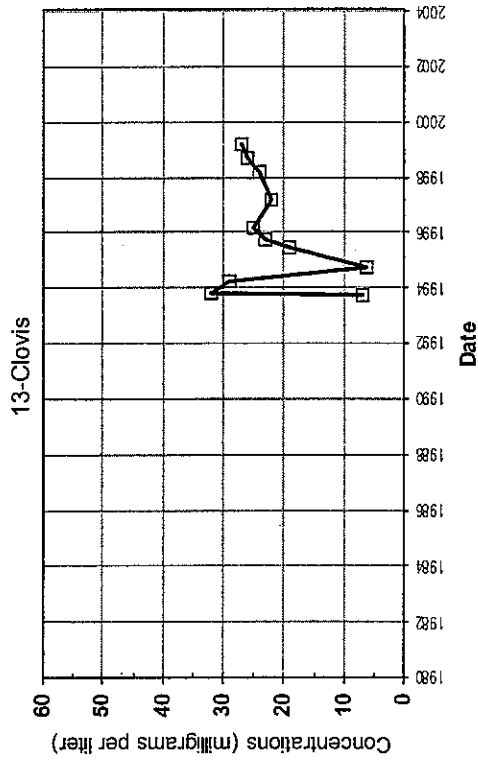


NO3 Concentrations

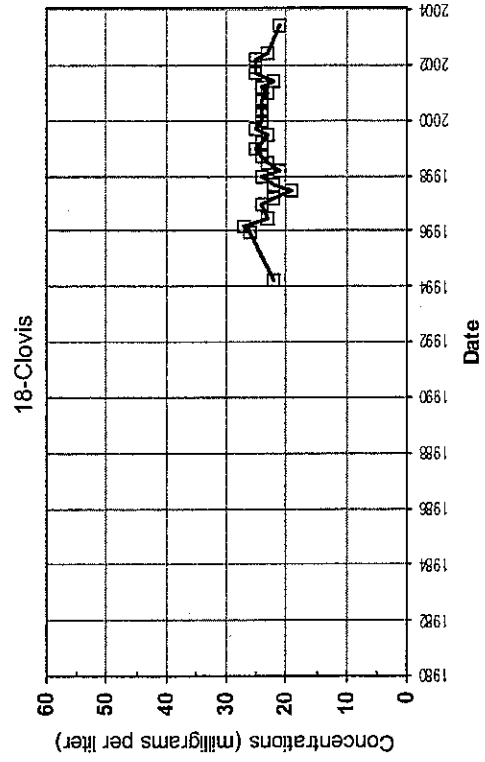
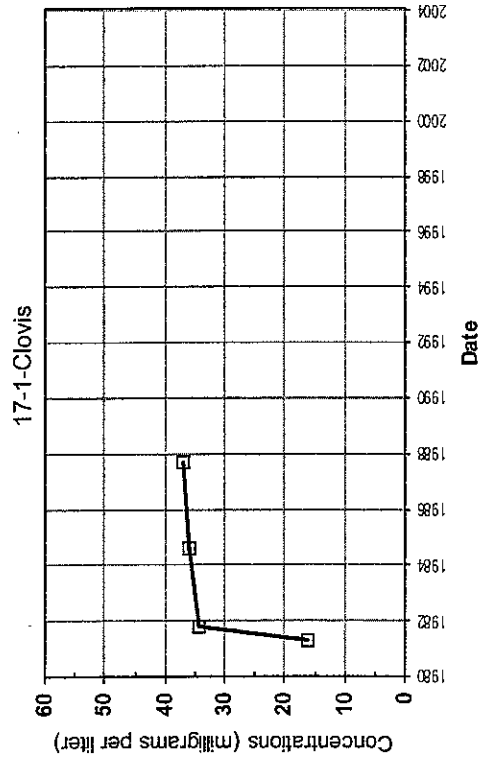
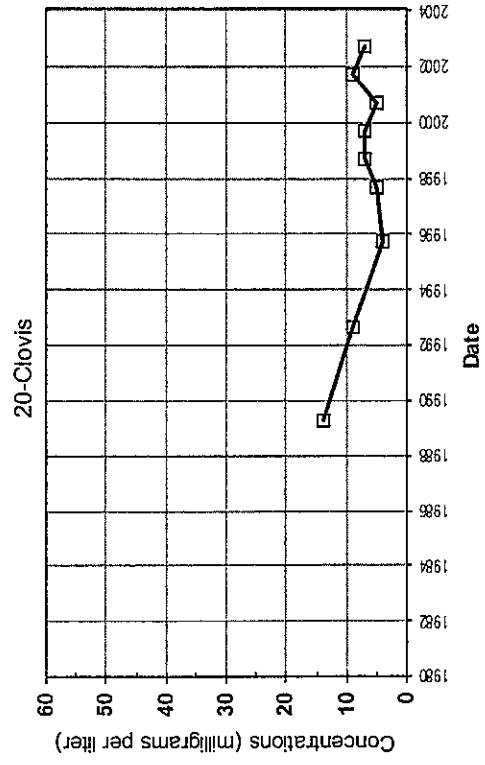
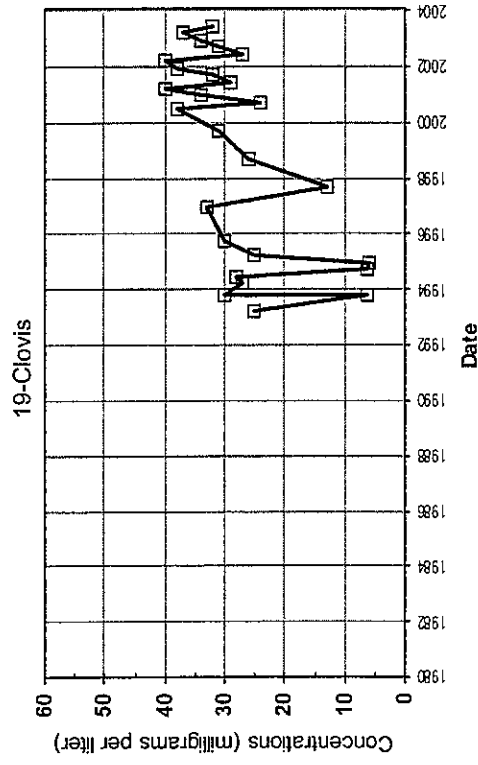




NO3 Concentrations

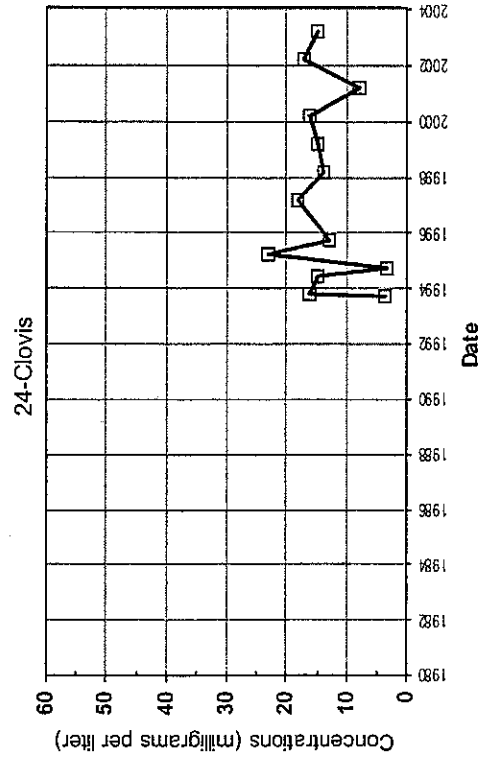
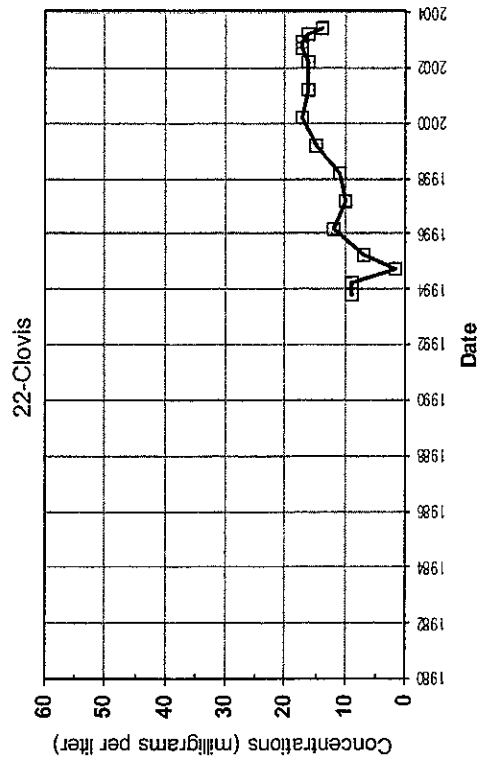
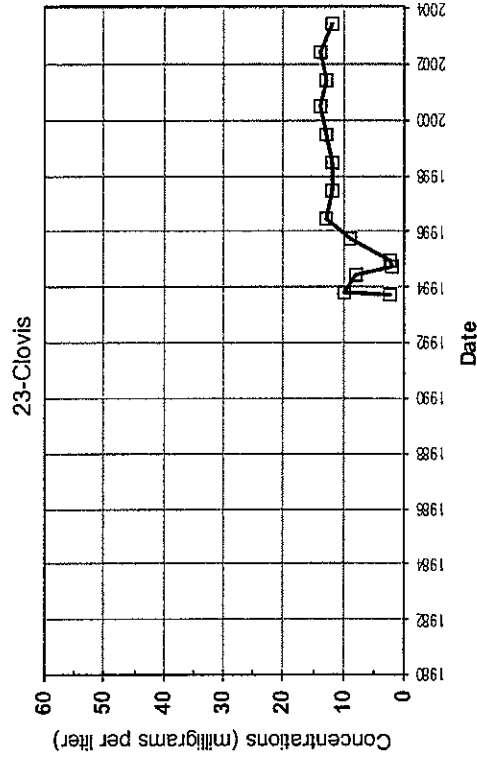
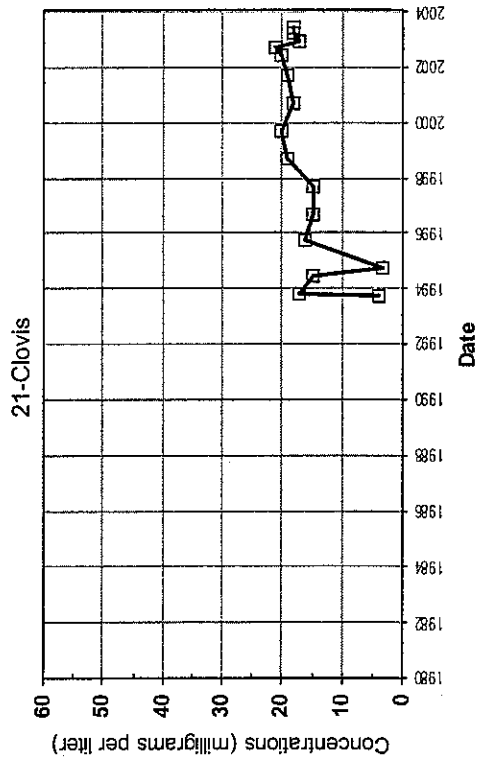


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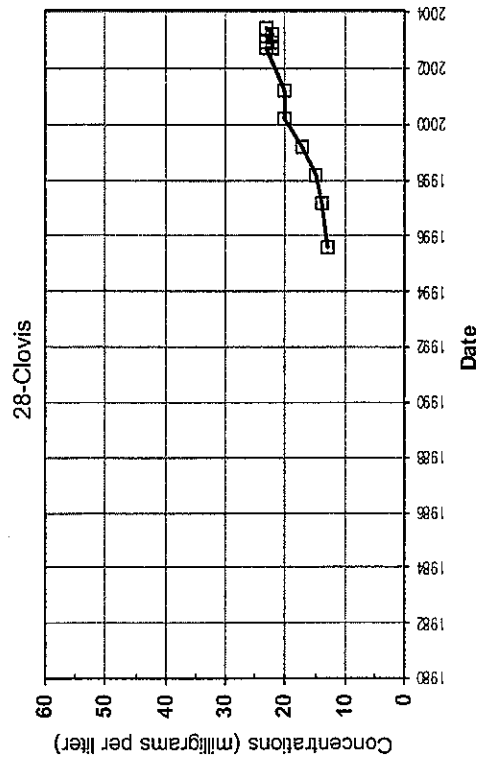
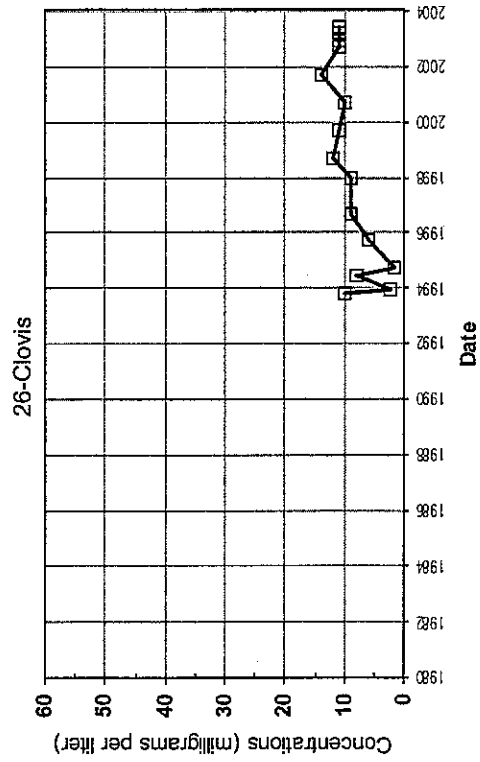
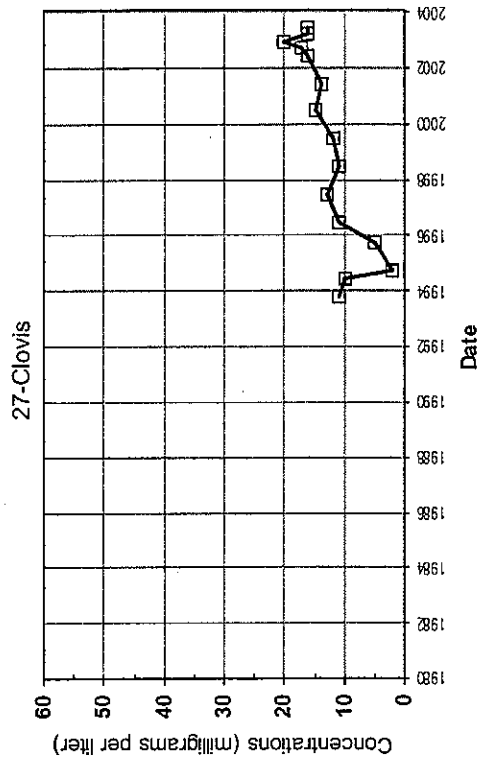
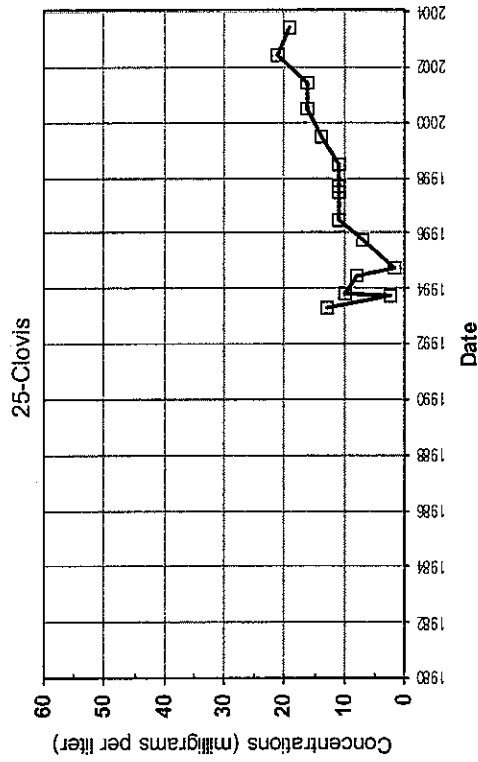


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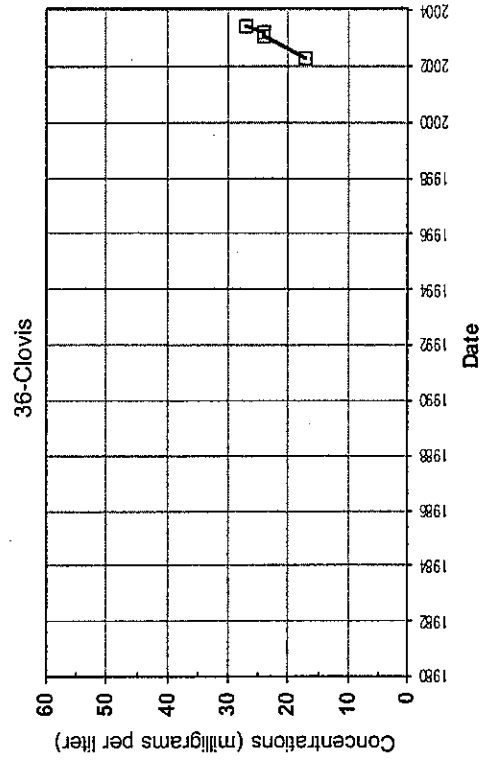
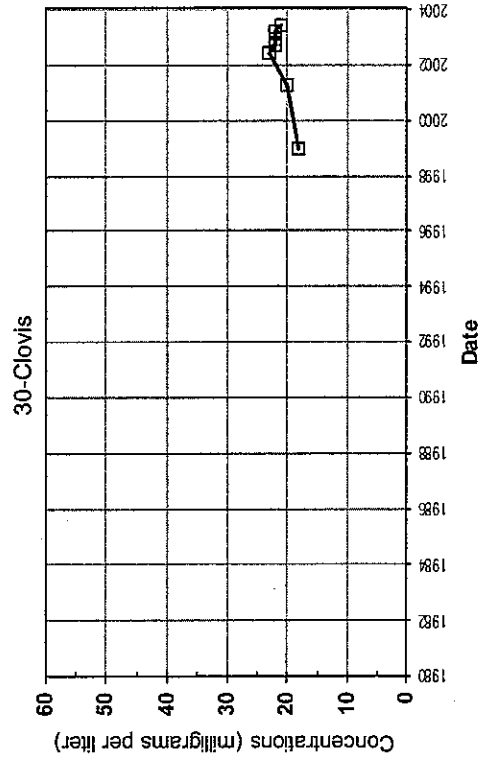
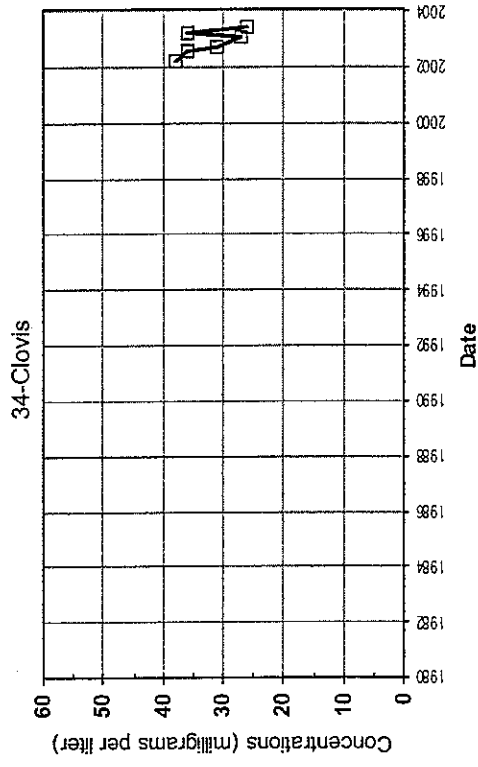
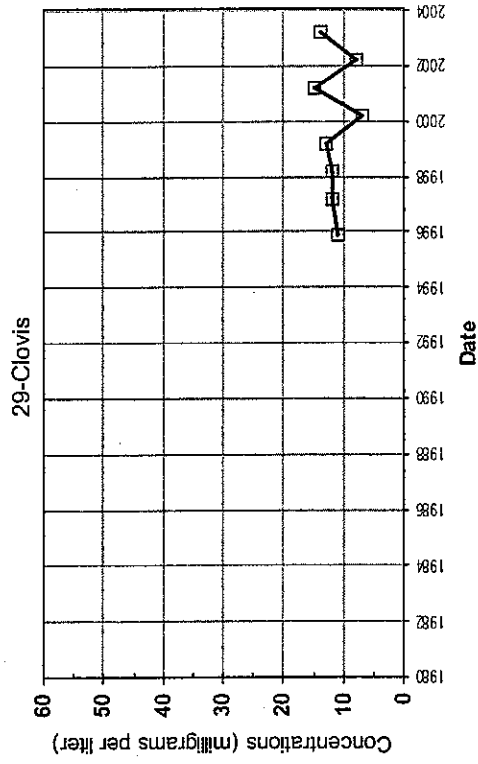


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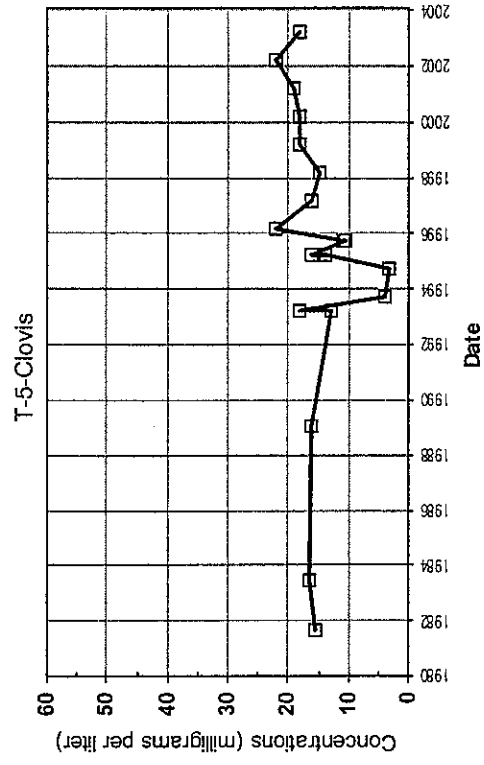
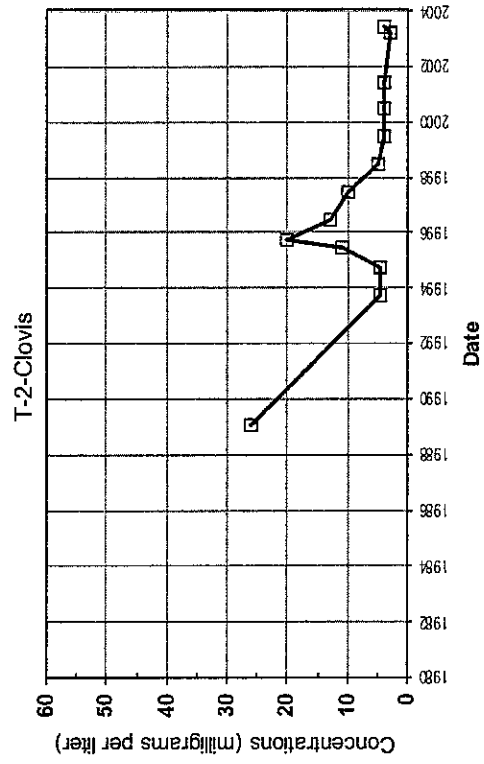
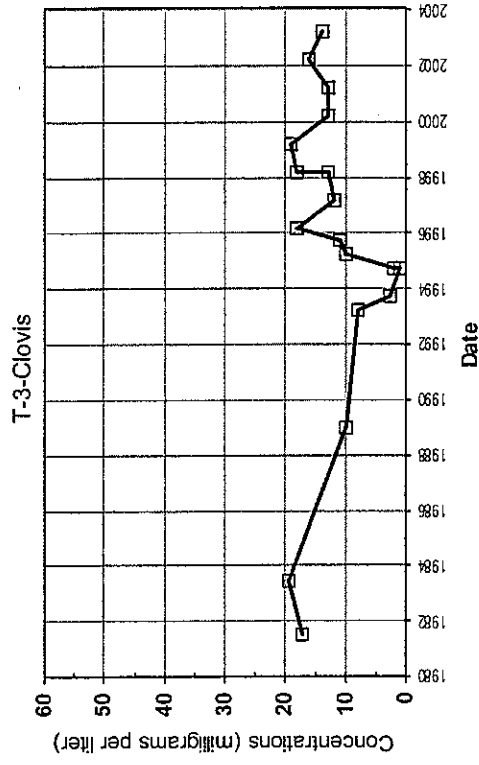
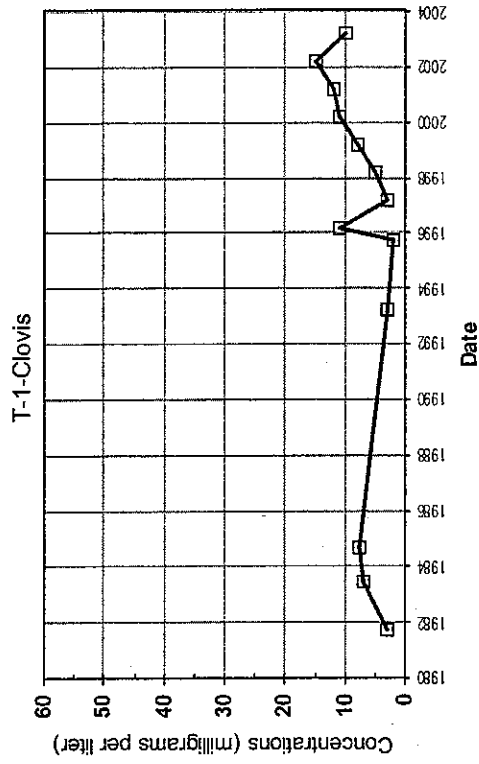


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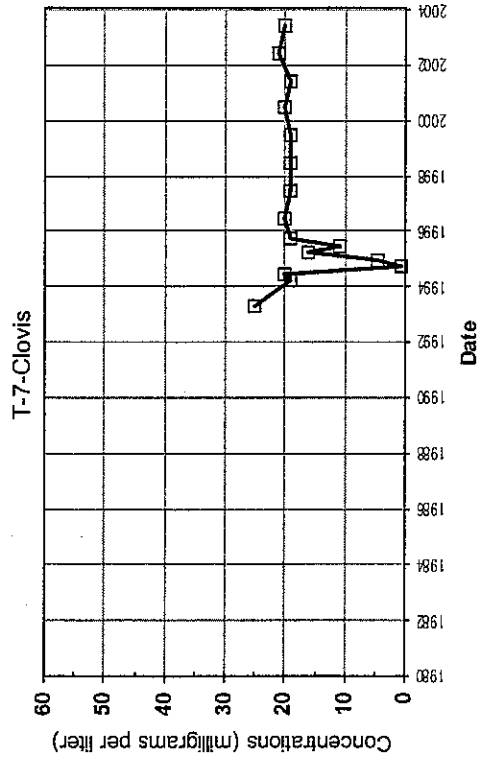
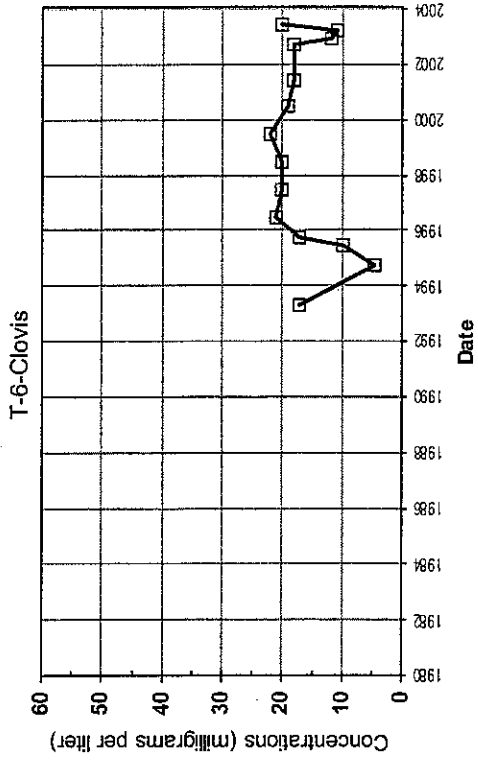
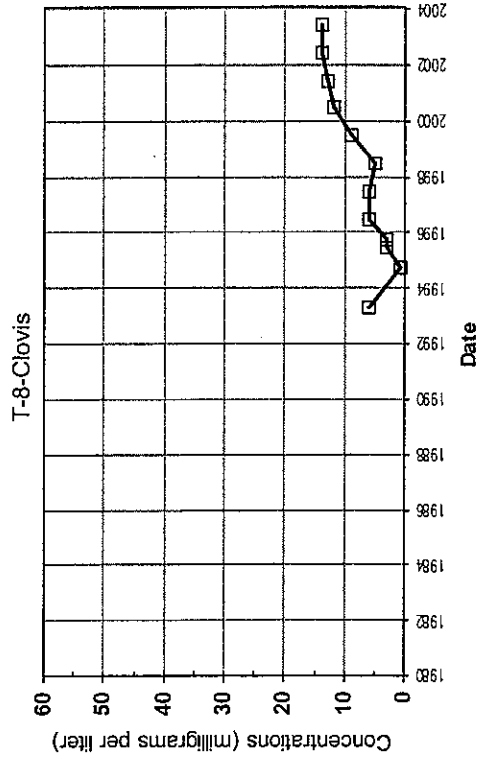




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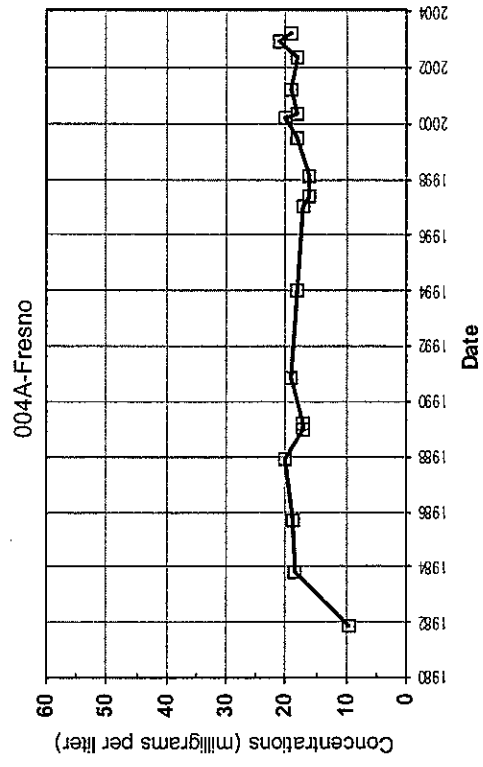
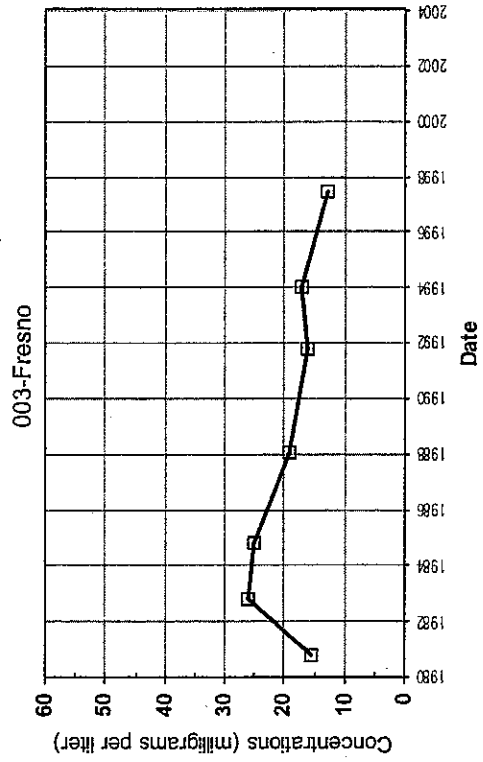
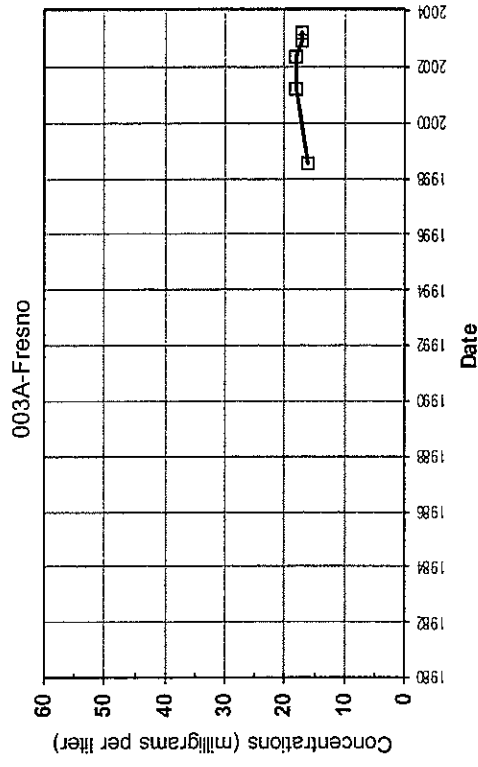
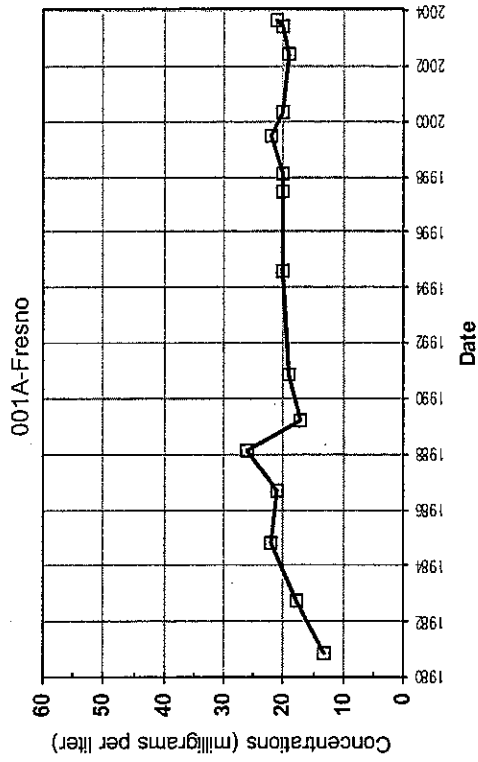


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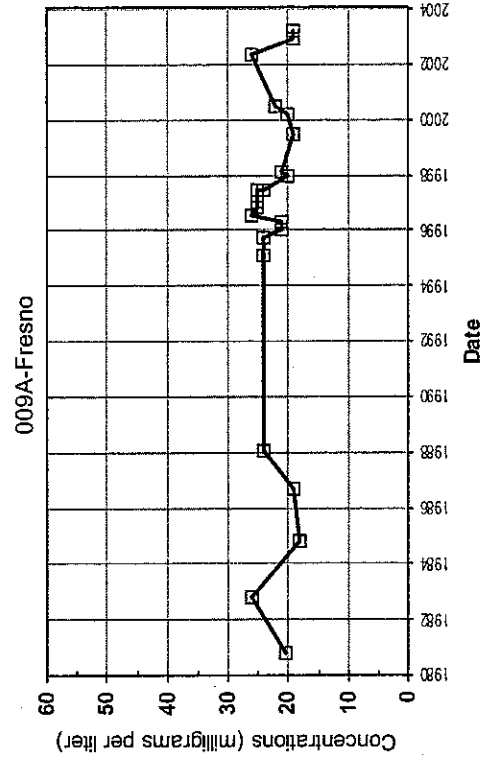
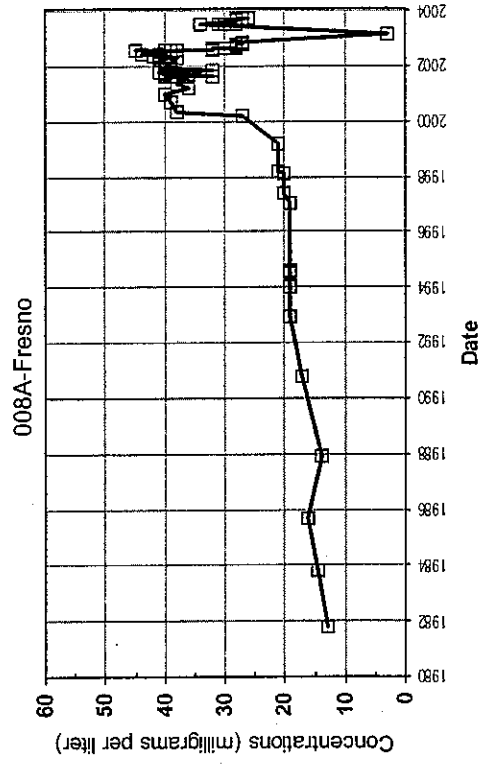
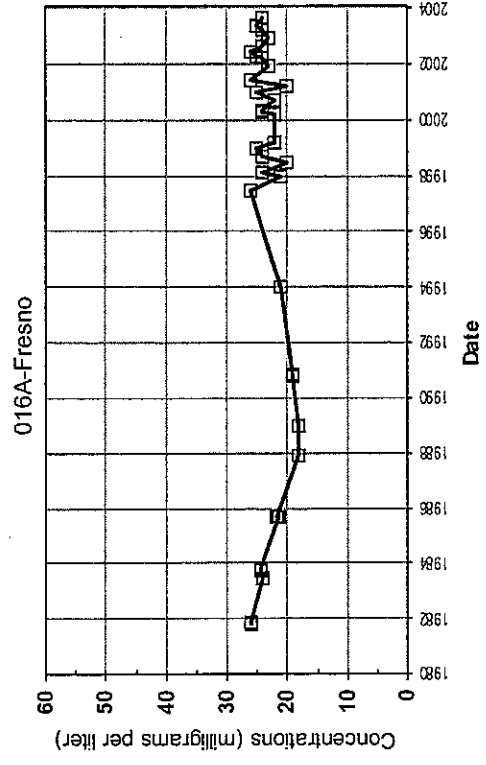
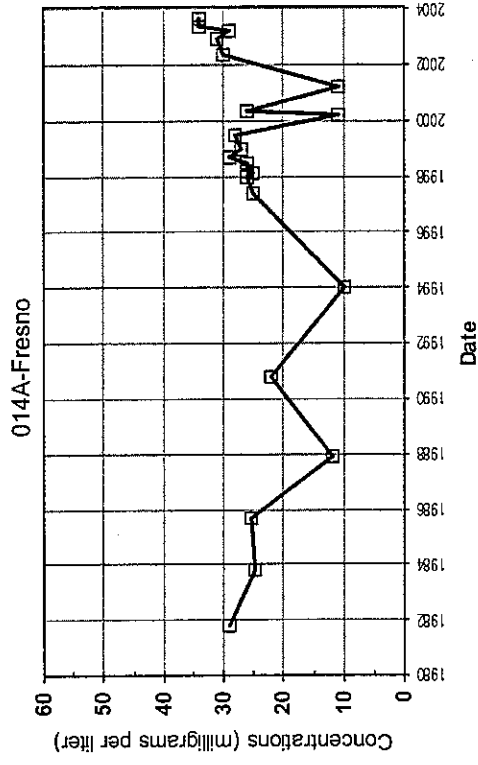




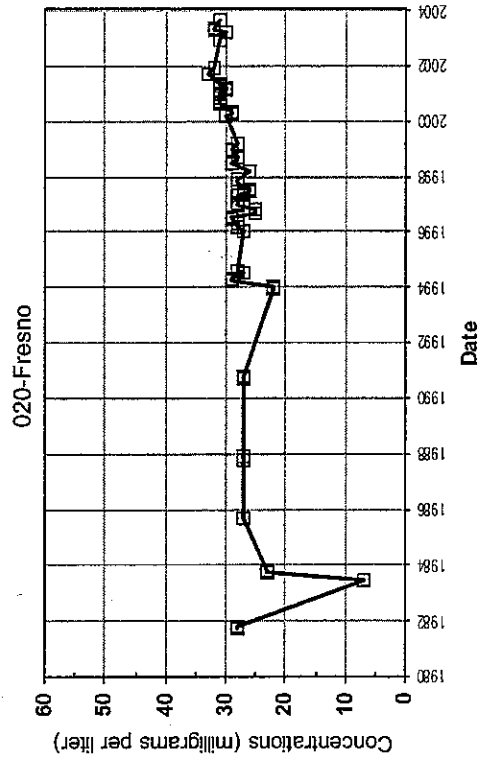
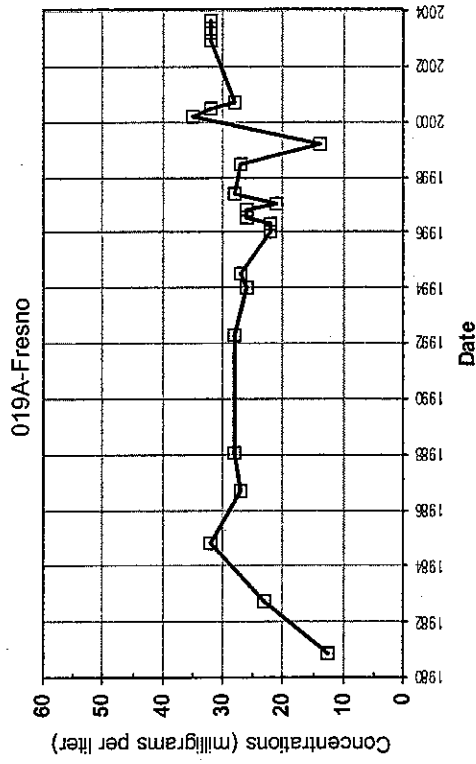
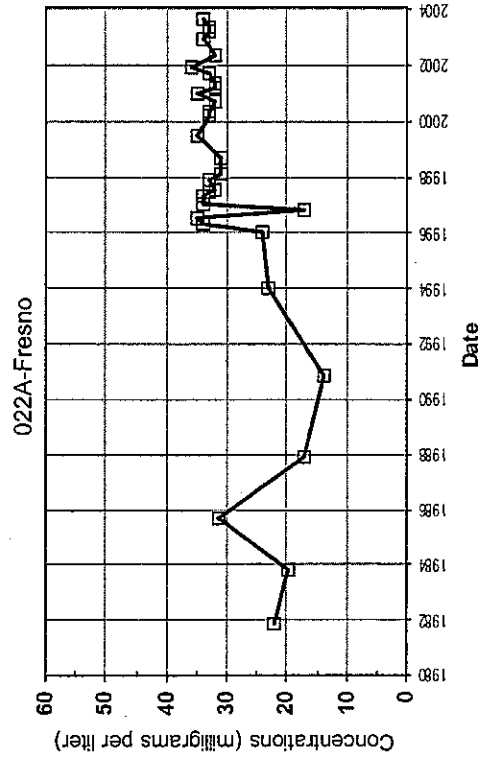
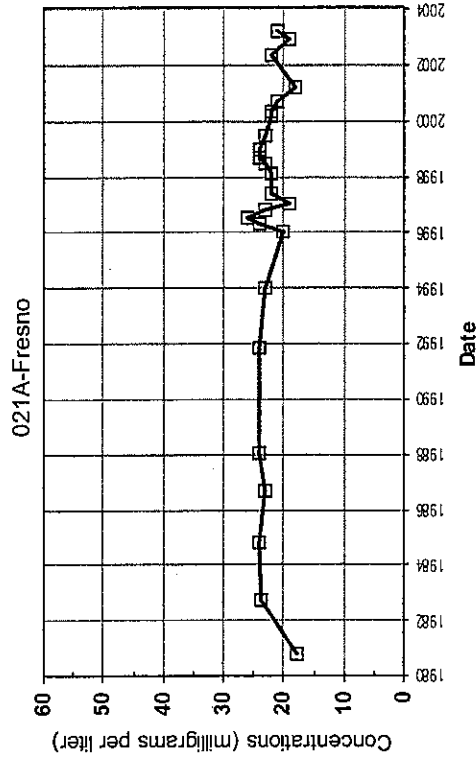
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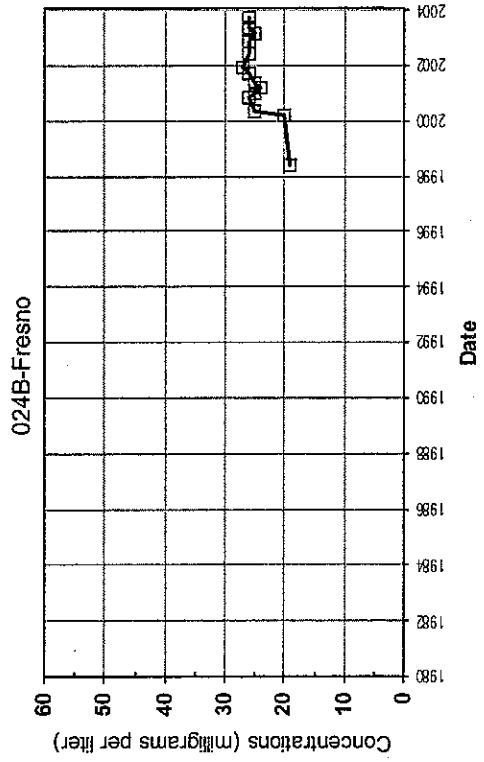
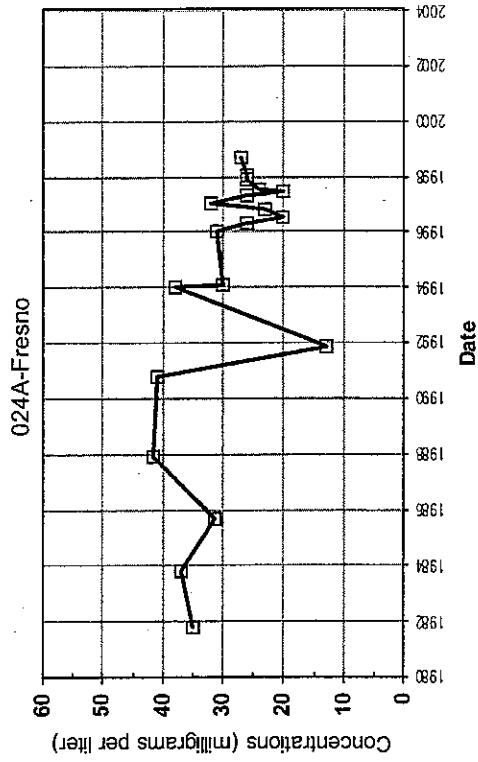
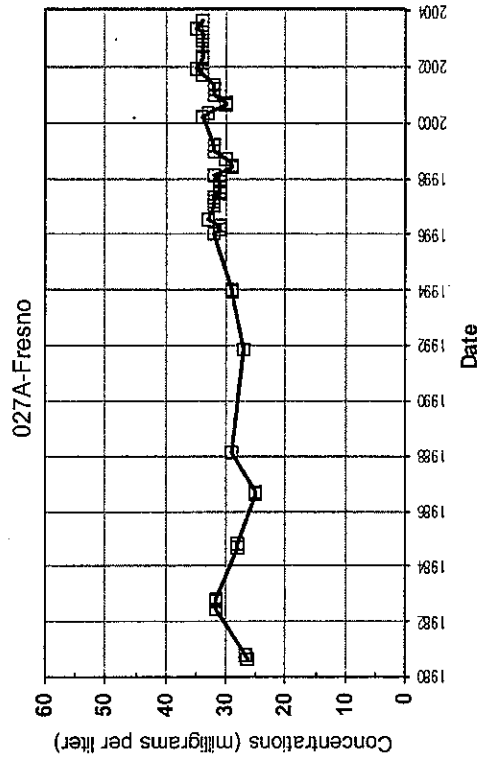
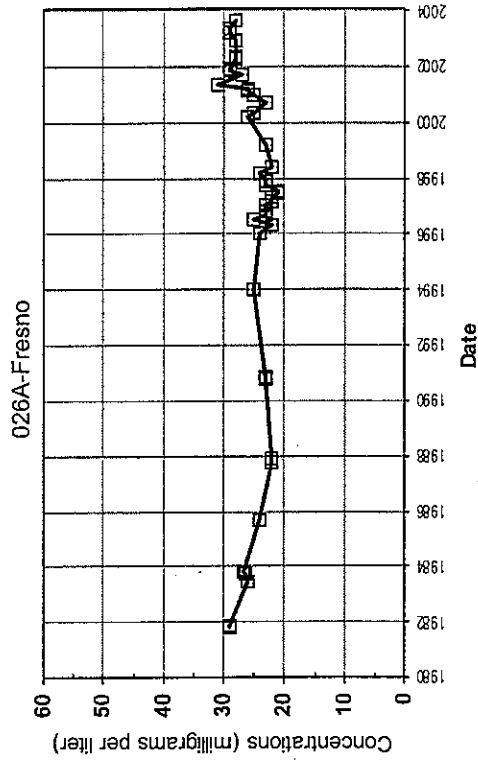
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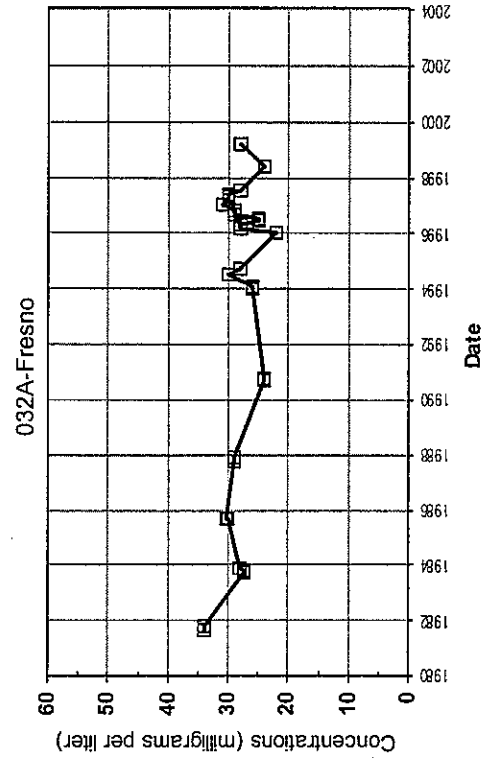
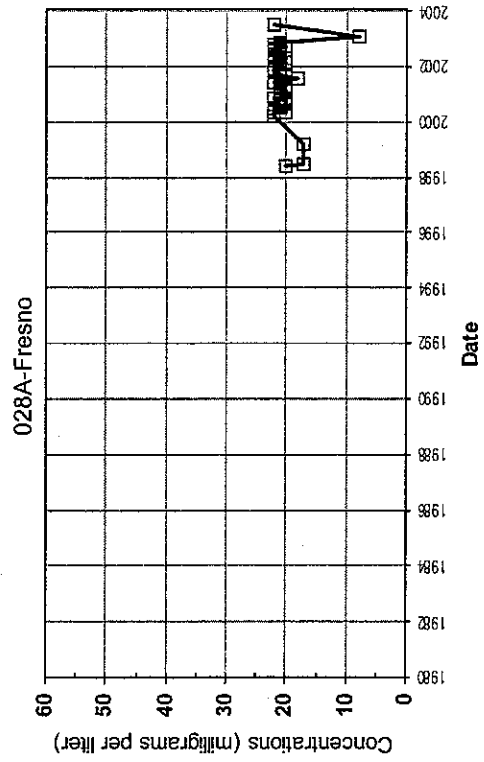
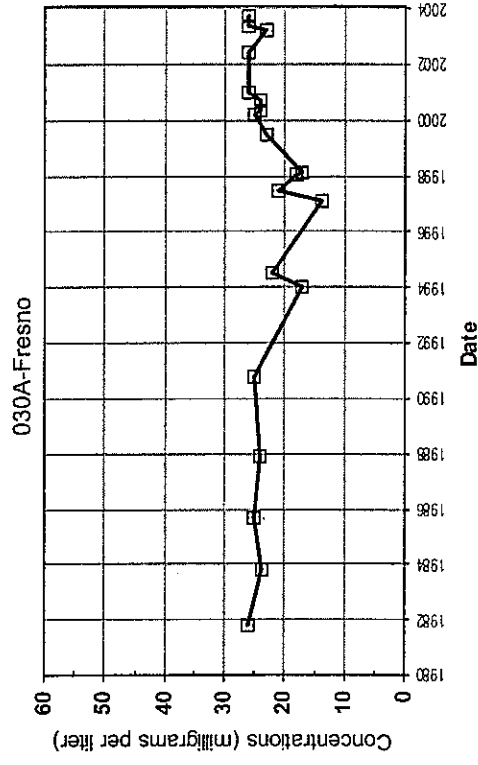
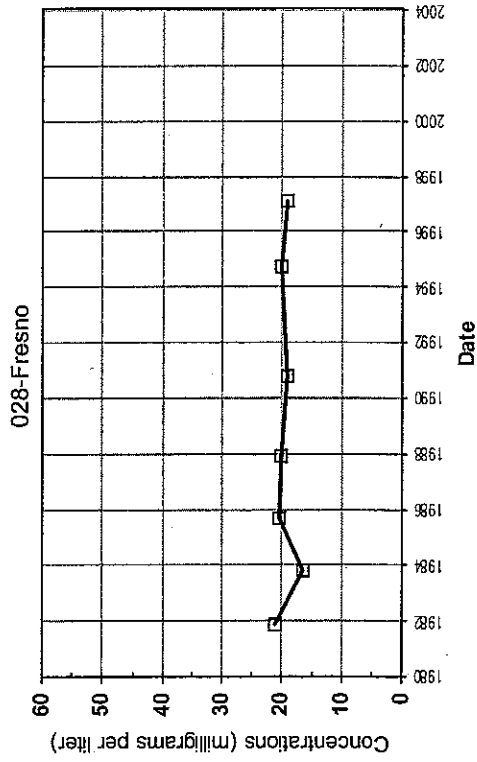
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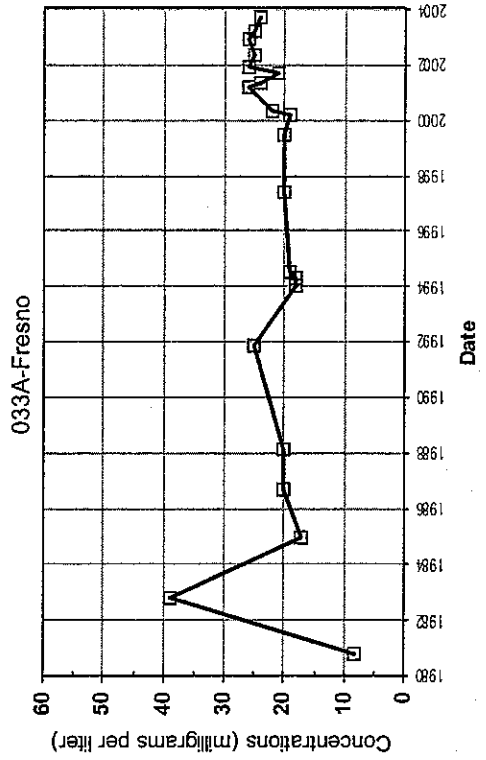
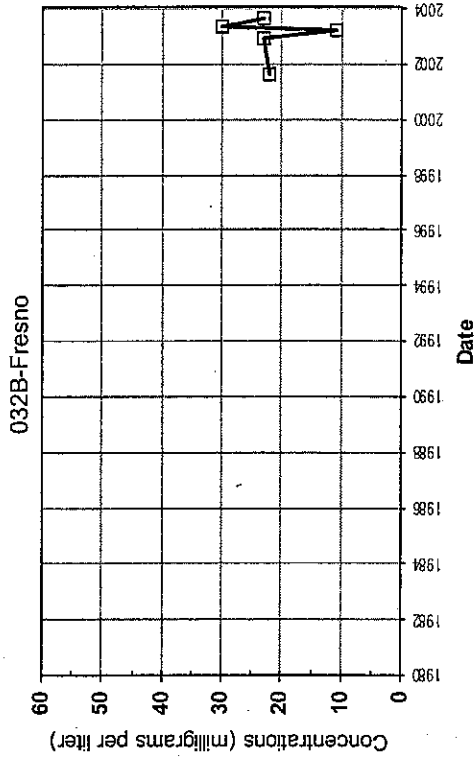
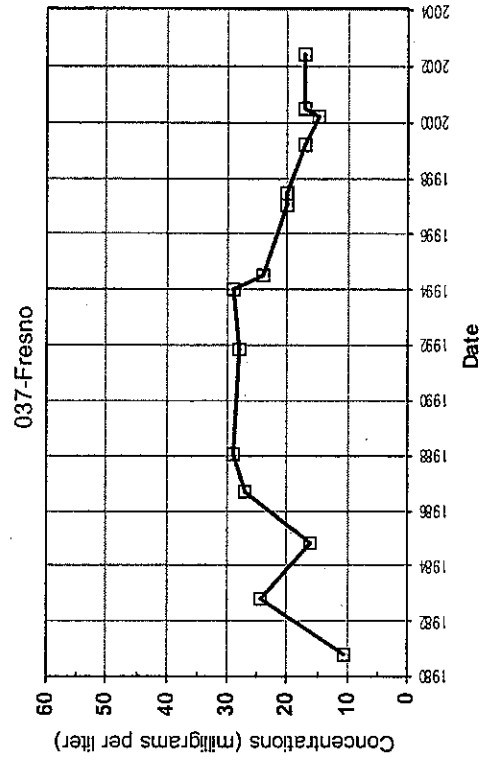
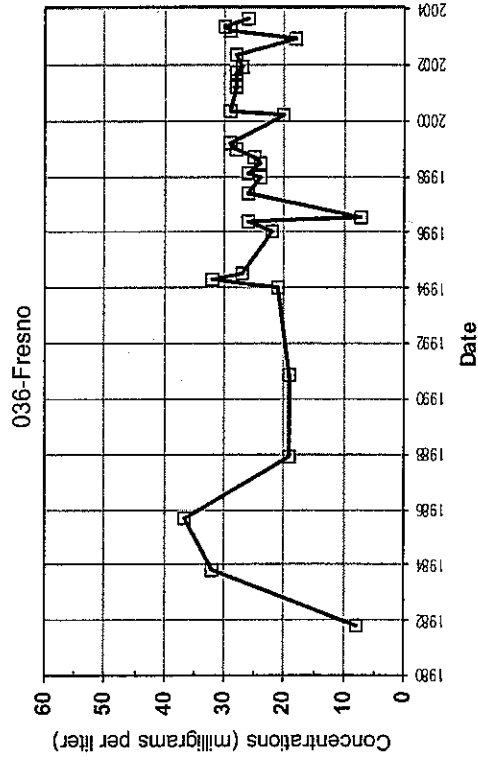
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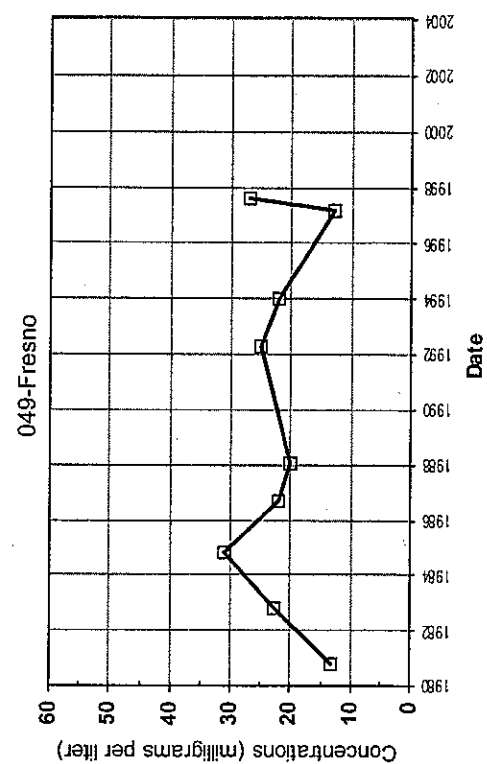
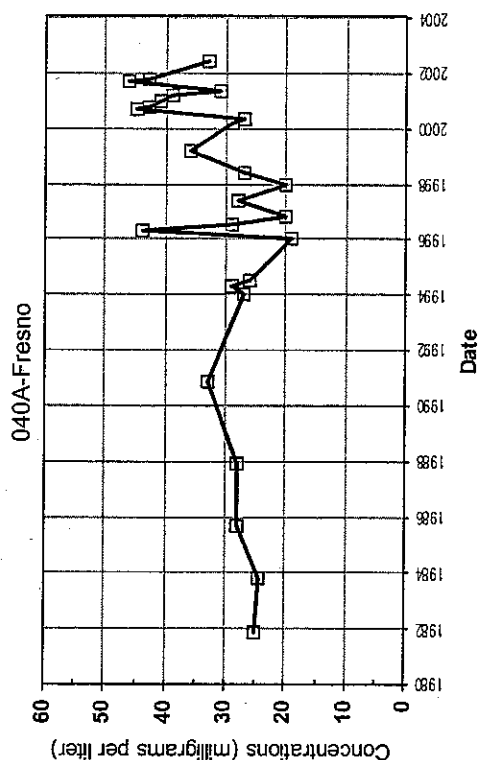
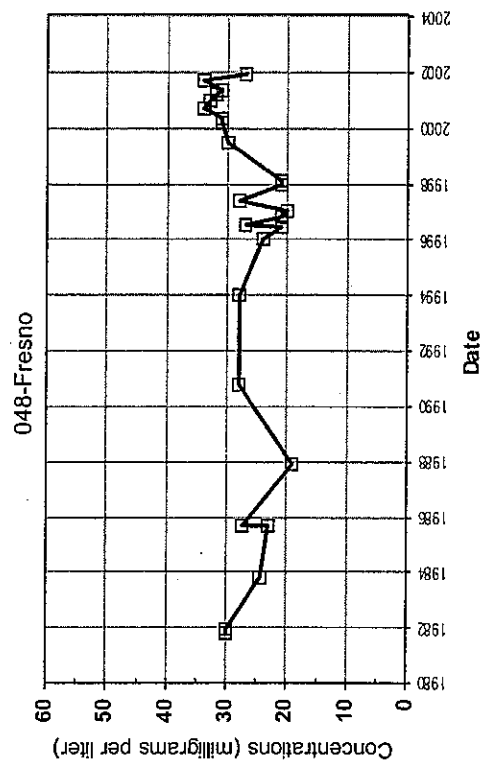
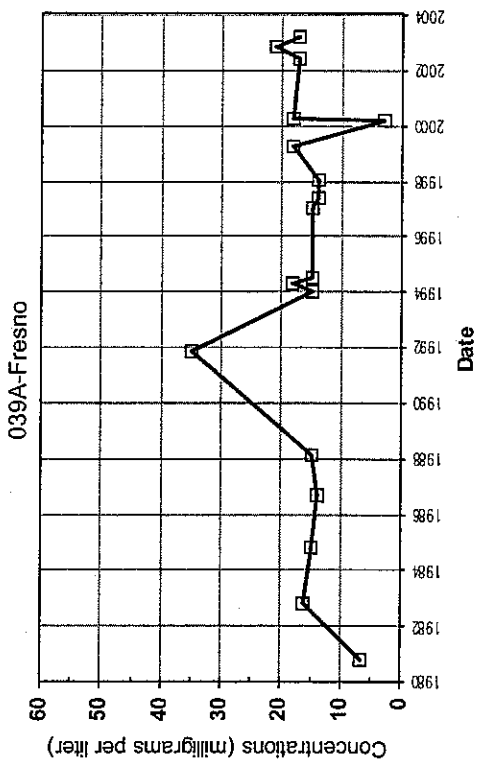
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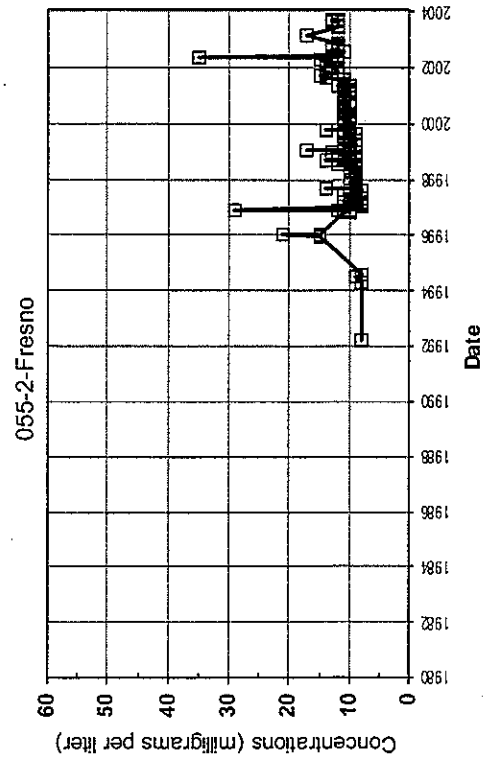
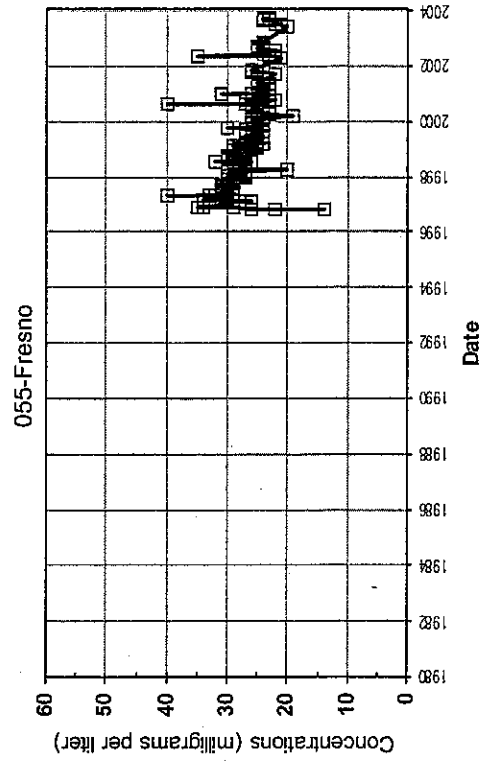
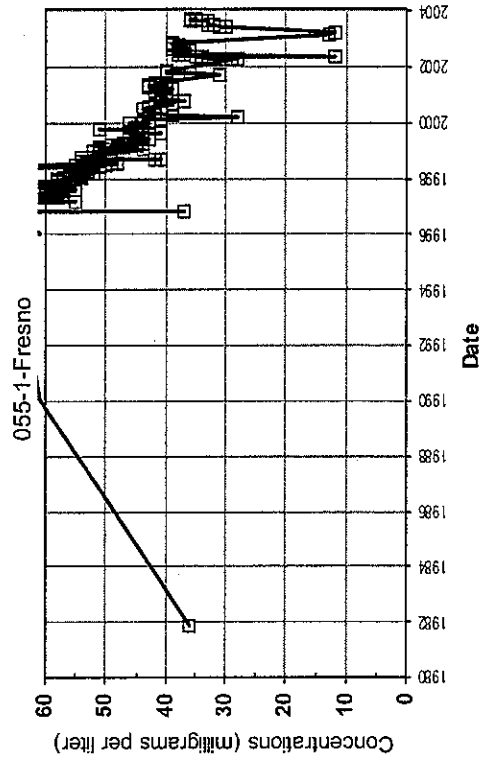
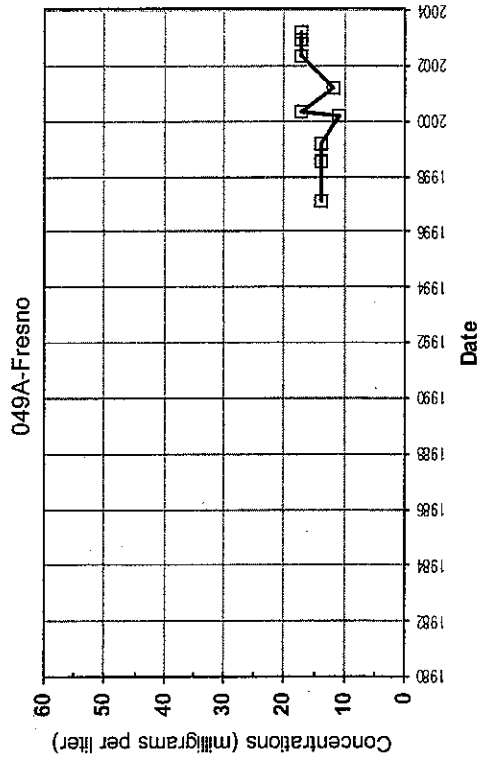
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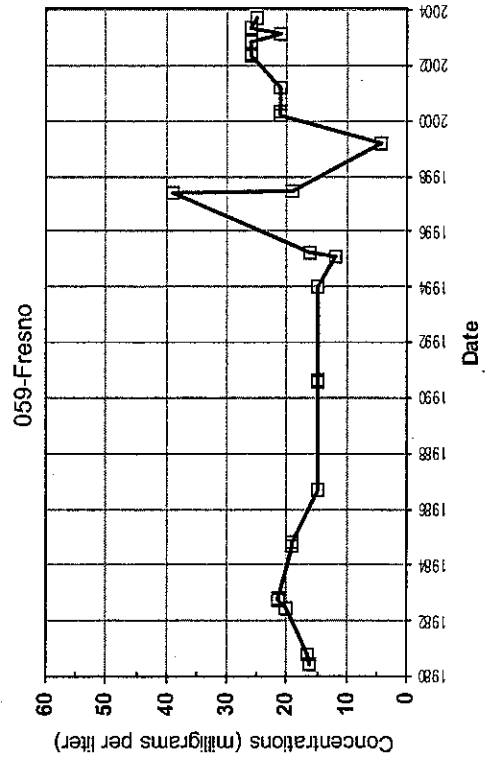
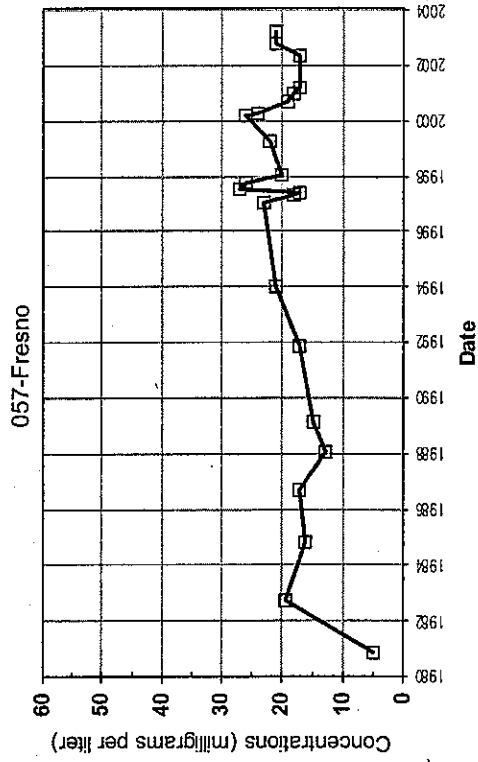
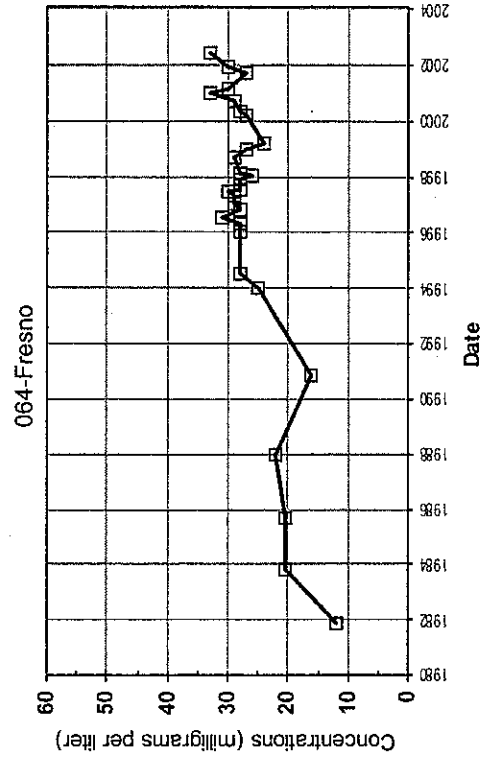
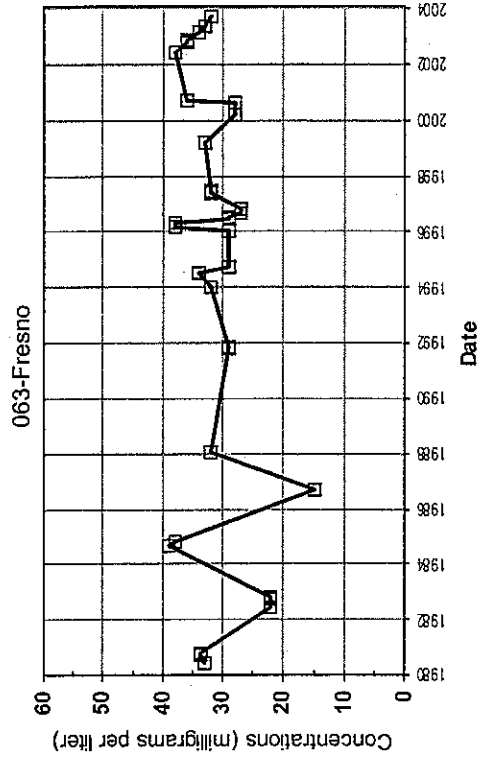


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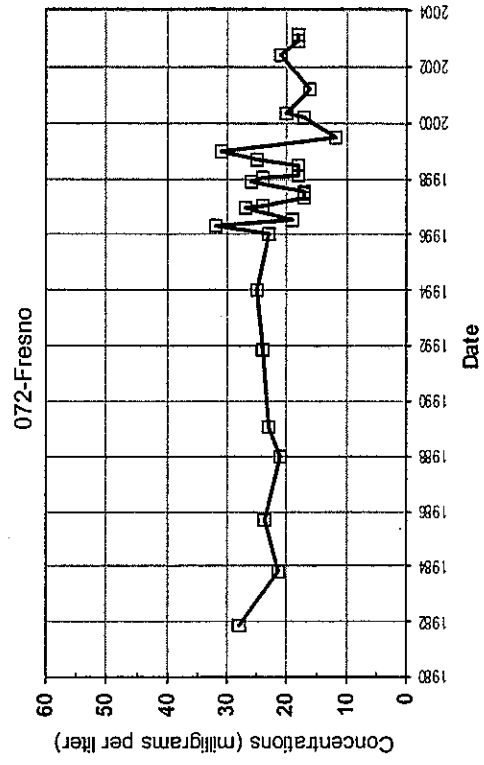
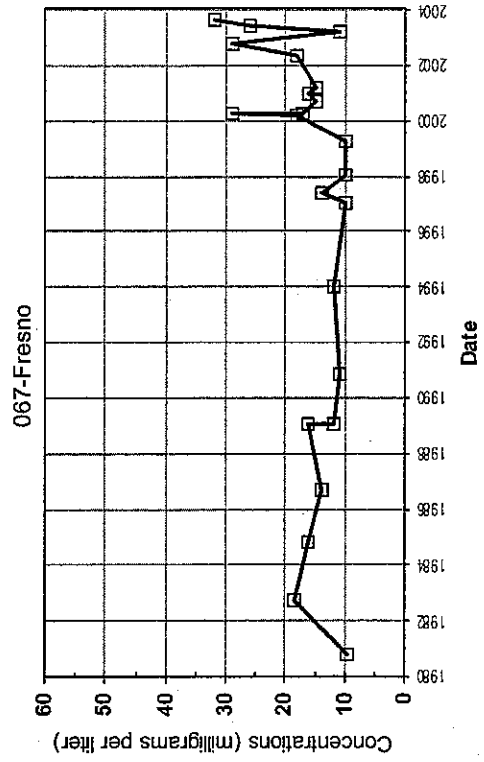
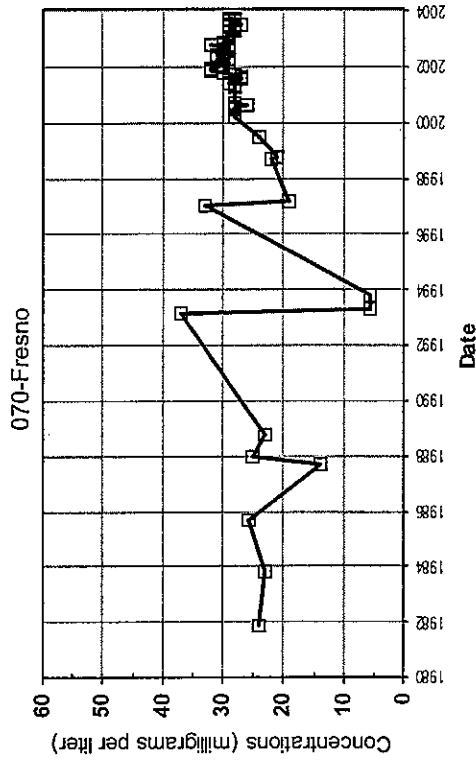
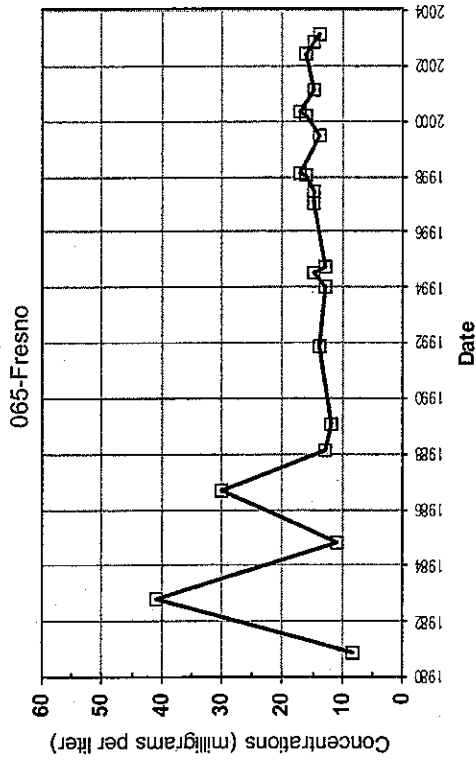




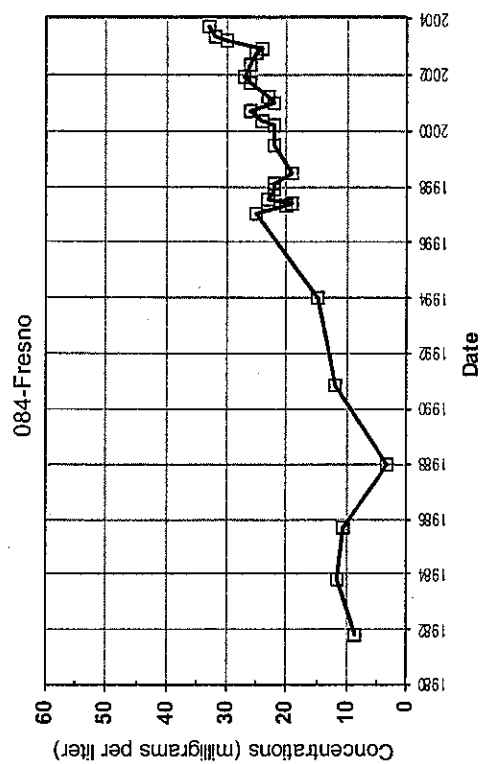
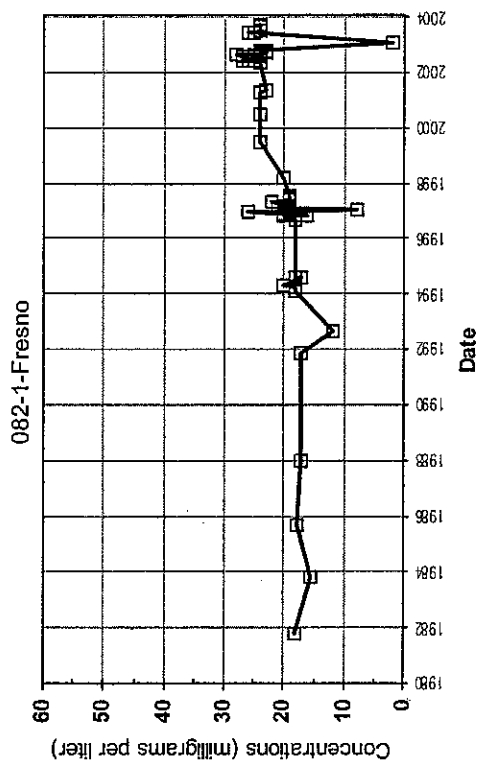
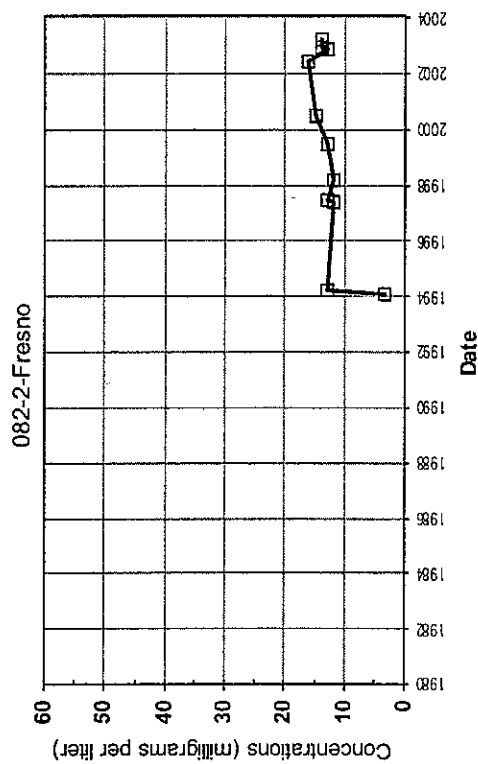
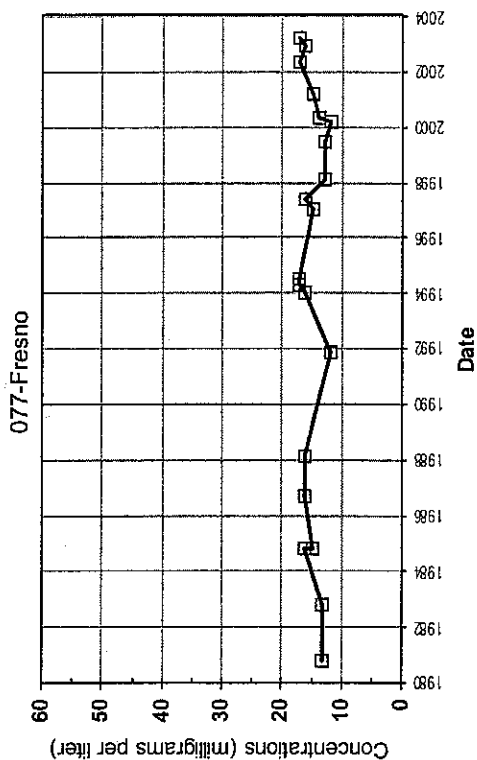
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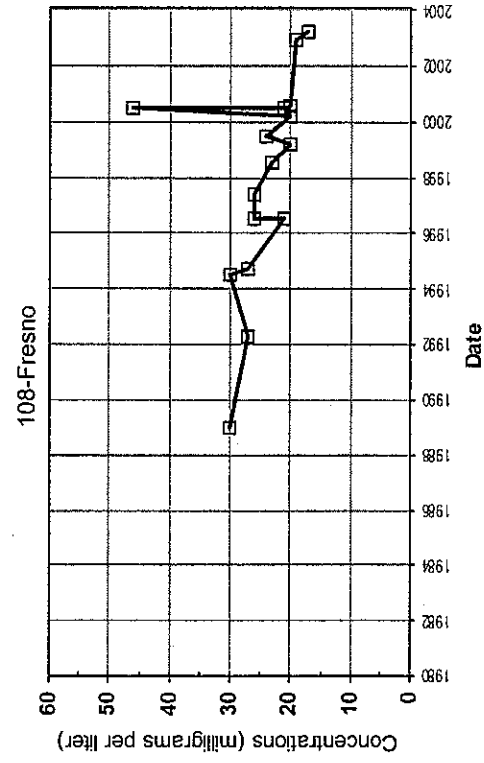
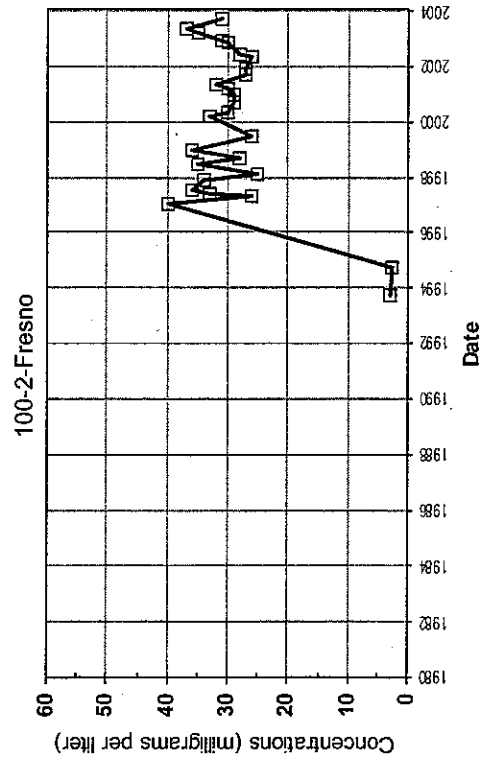
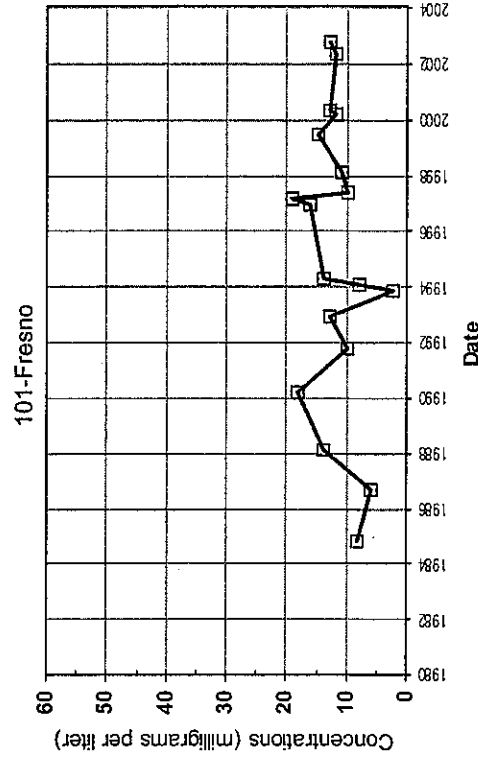
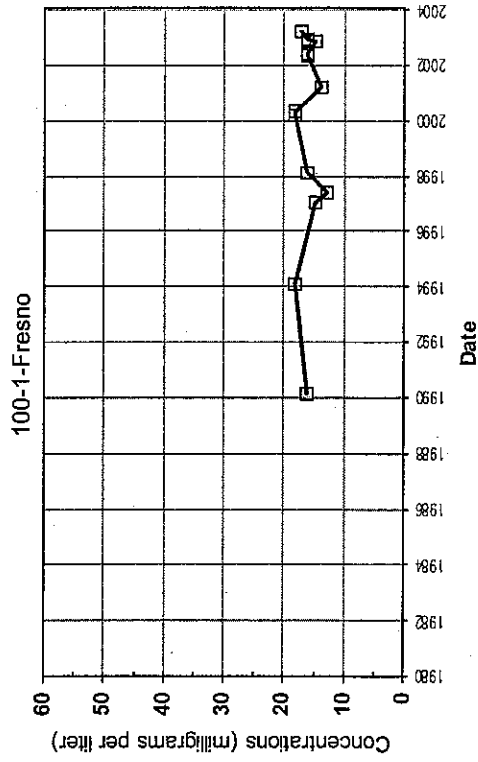


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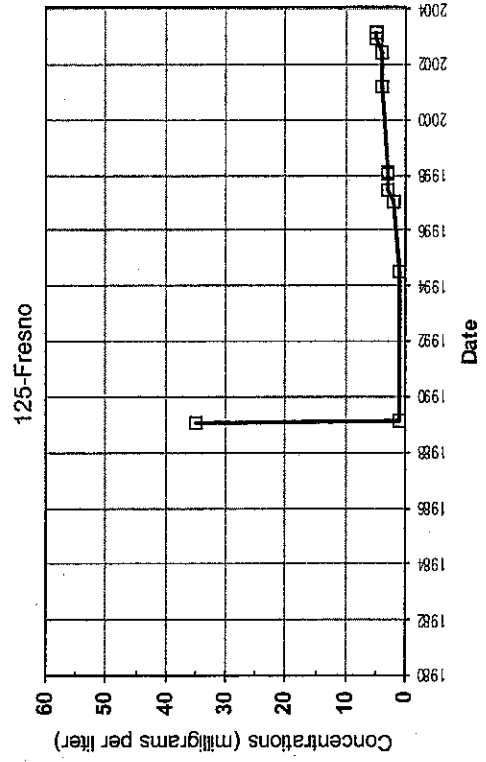
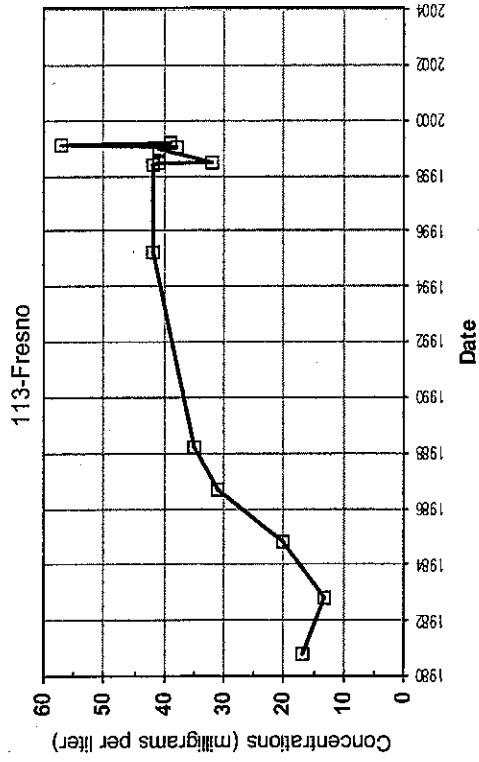
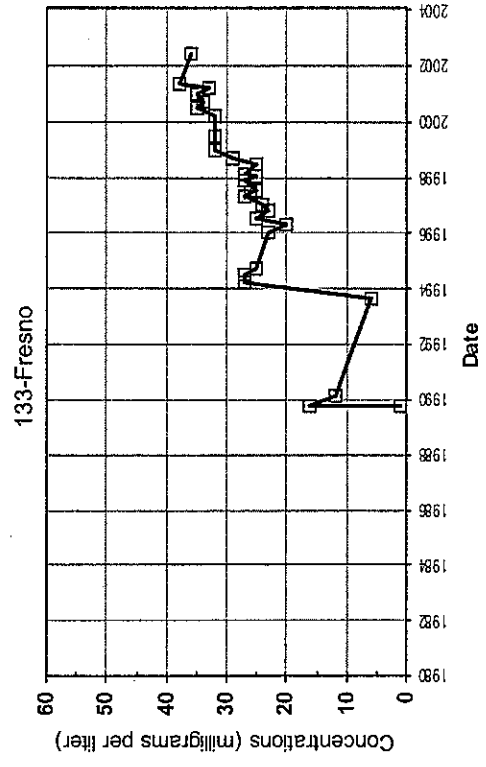
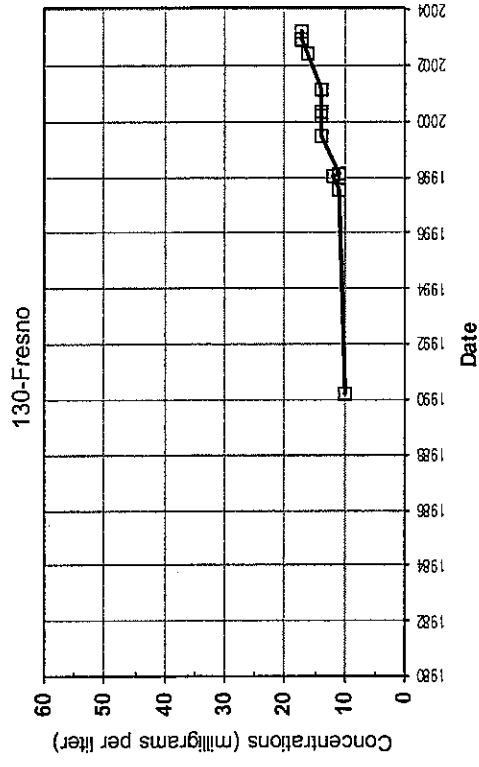


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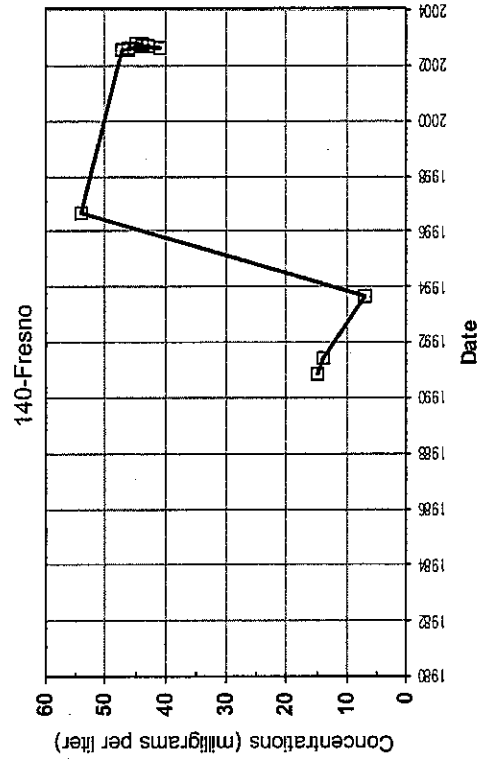
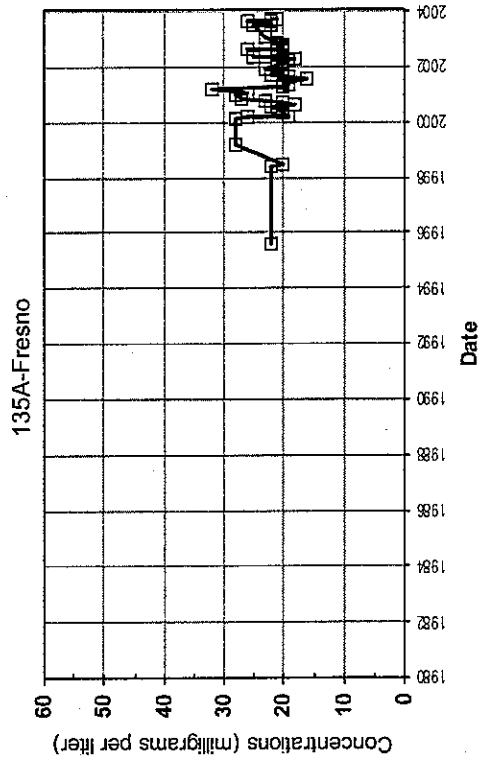
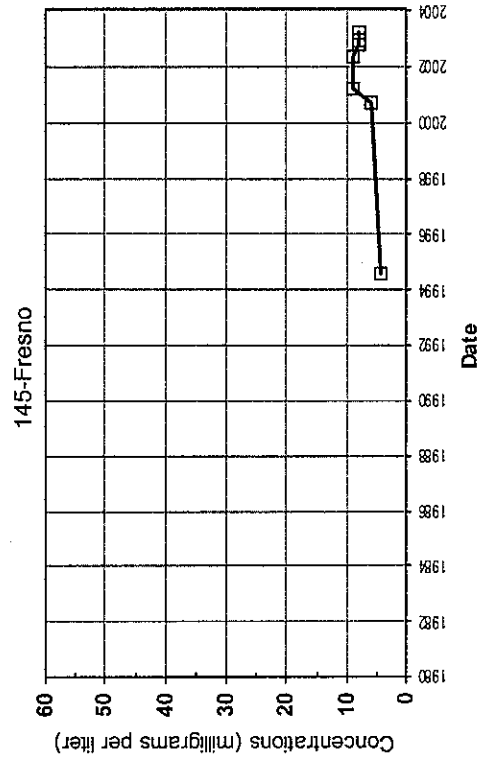
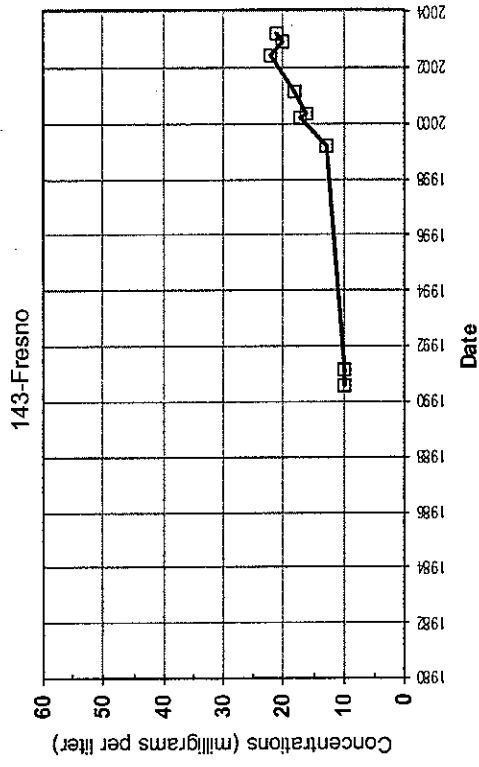




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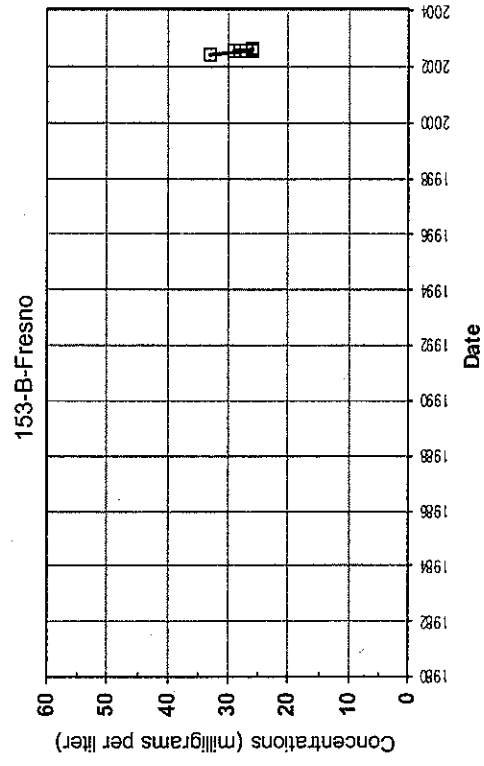
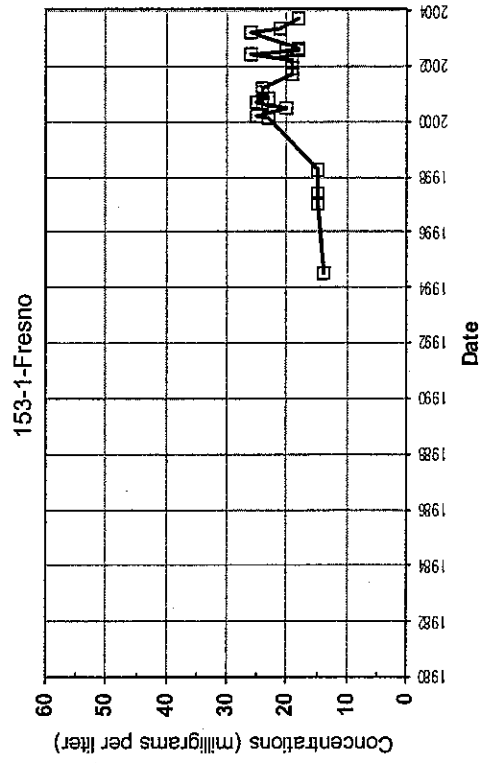
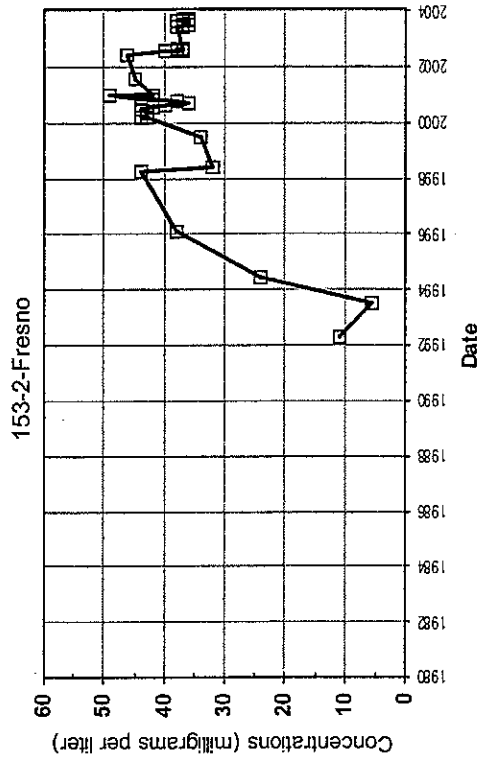
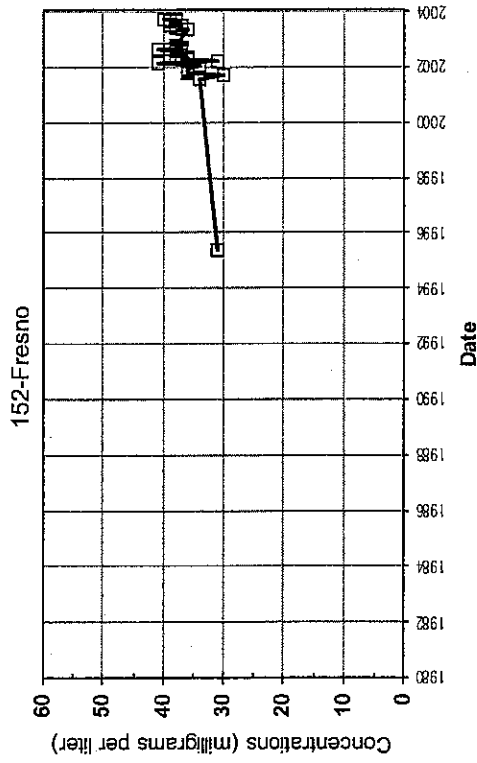


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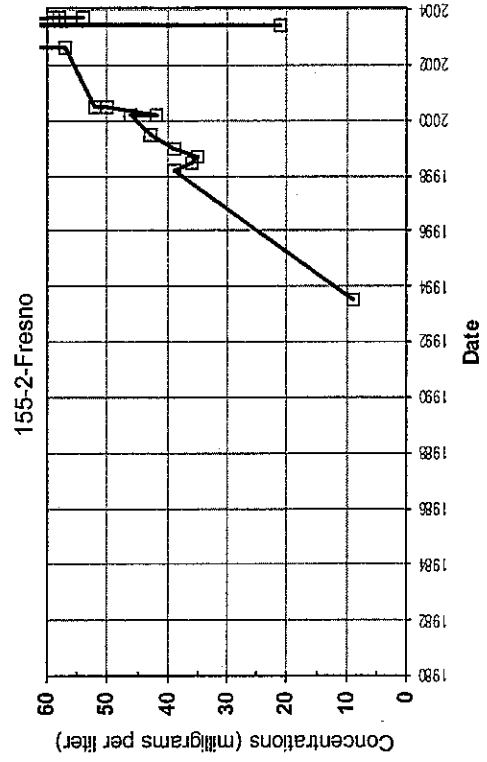
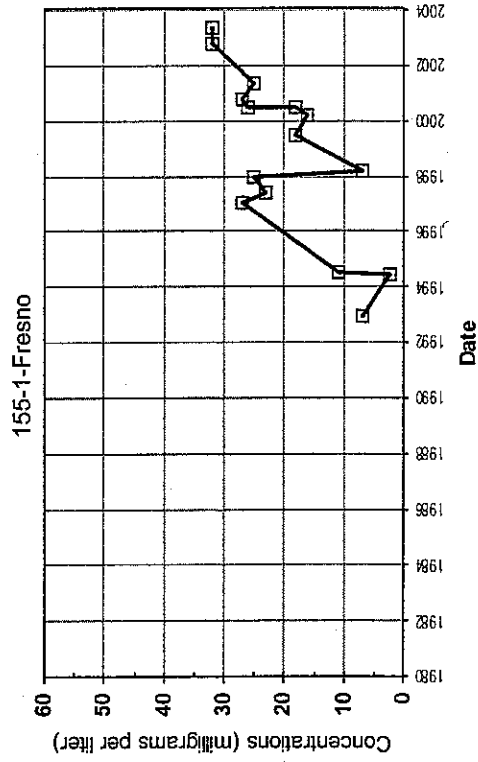
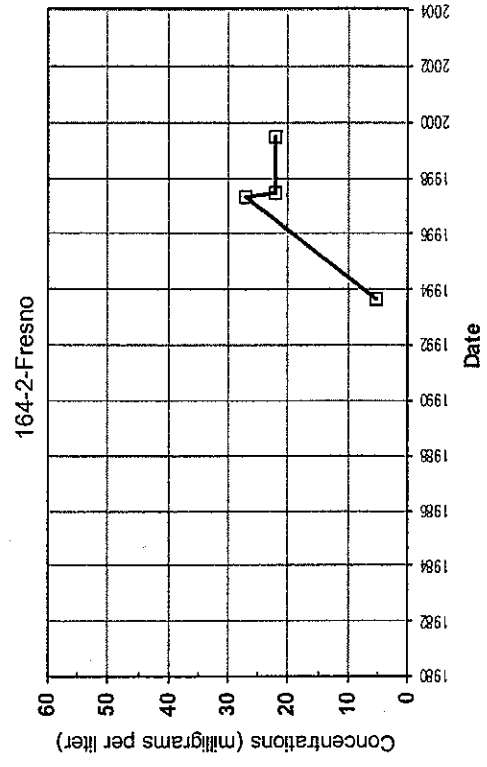
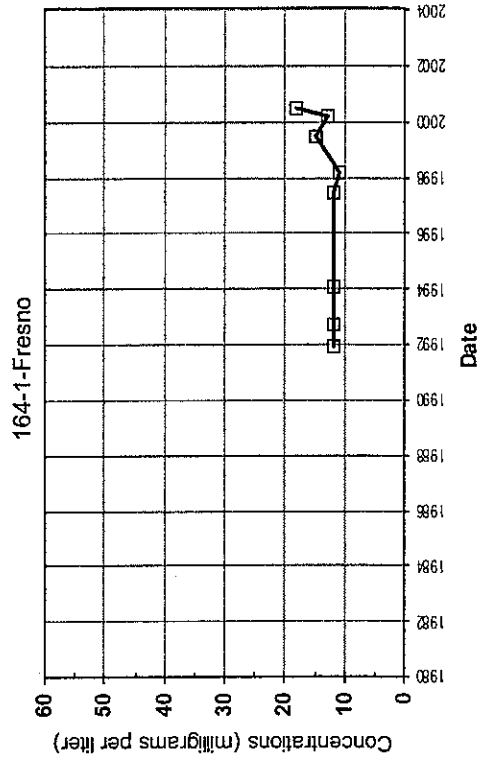




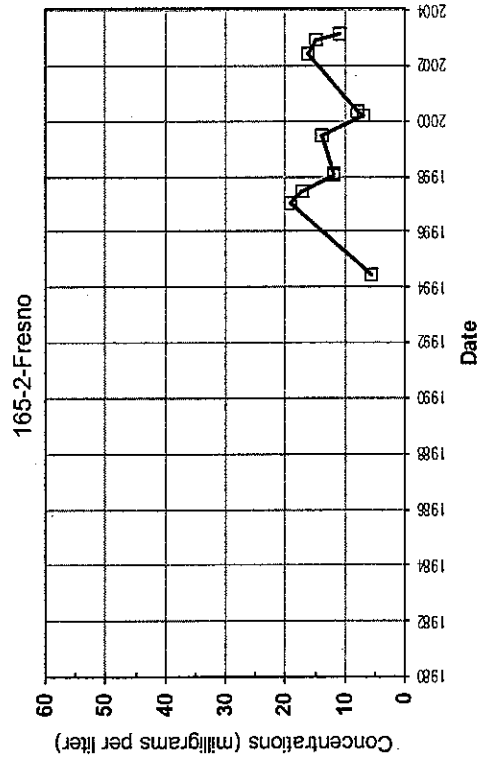
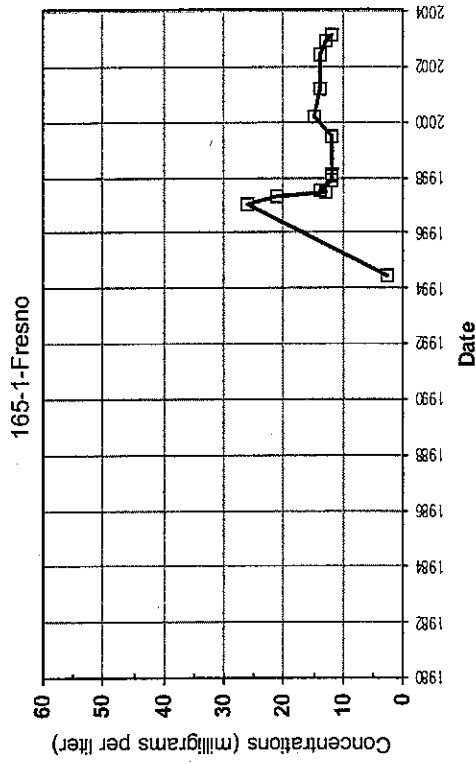
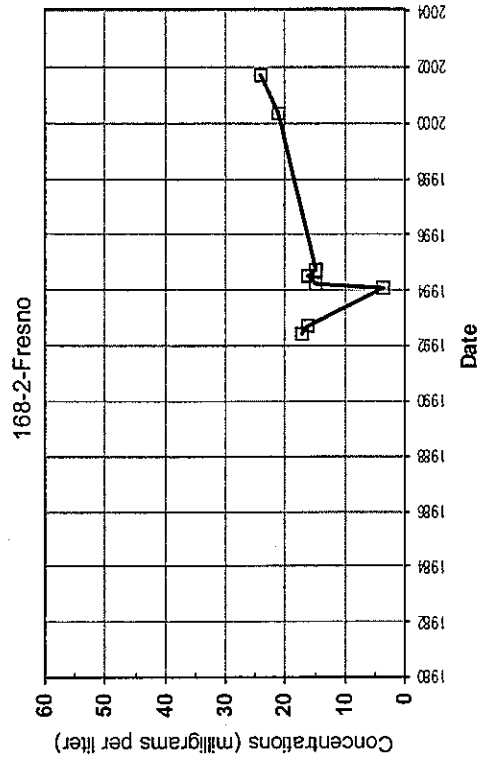
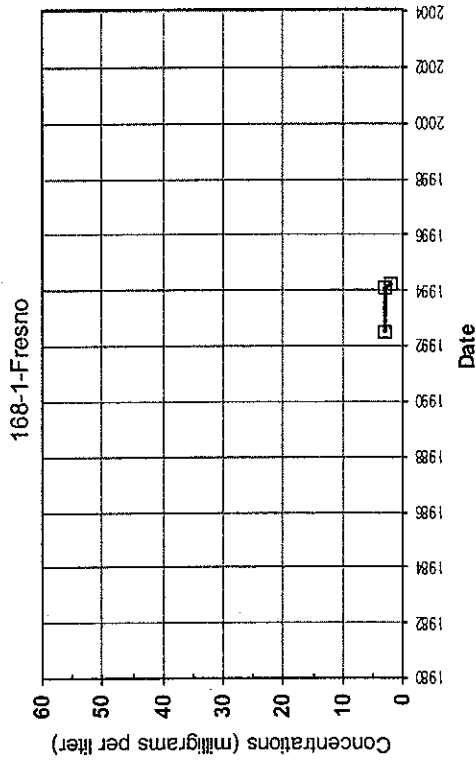
NO3 Concentrations



NO3 Concentrations

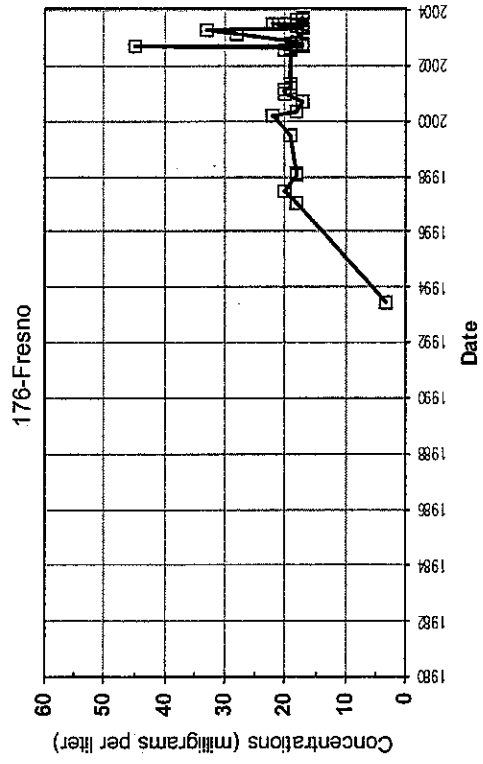
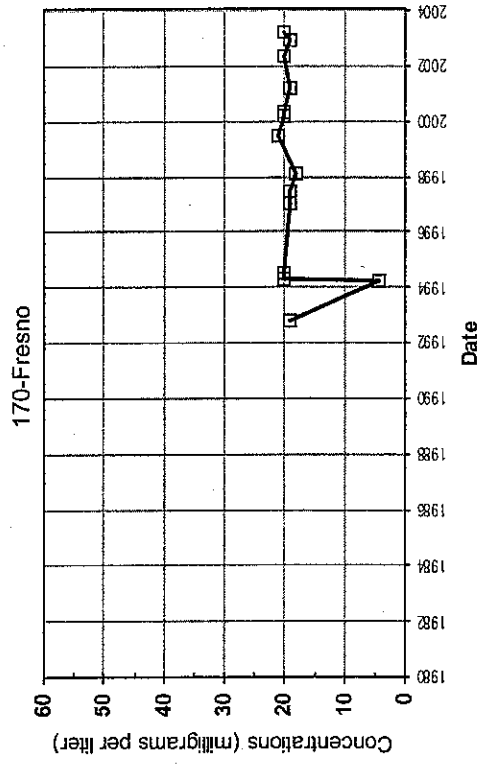
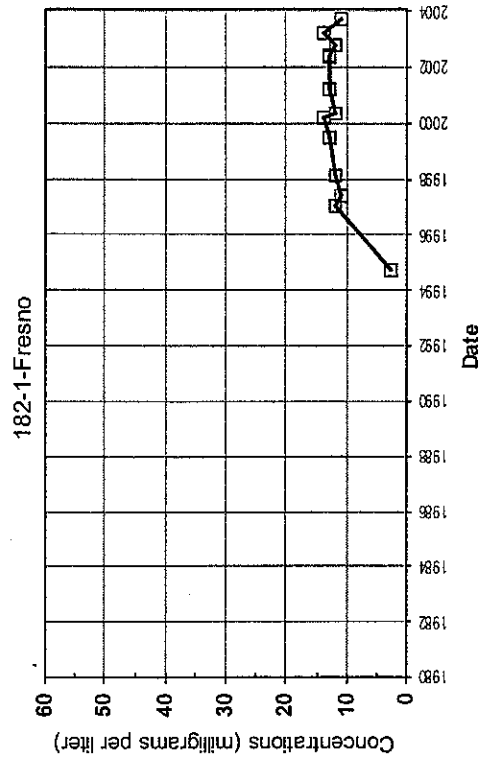
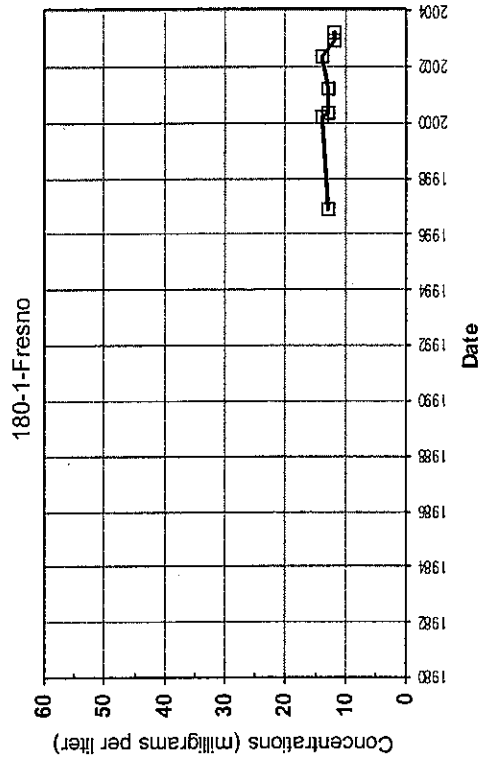


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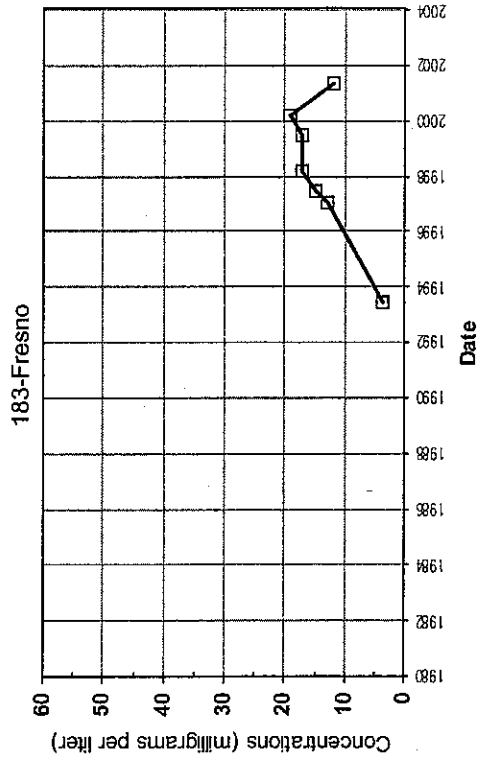
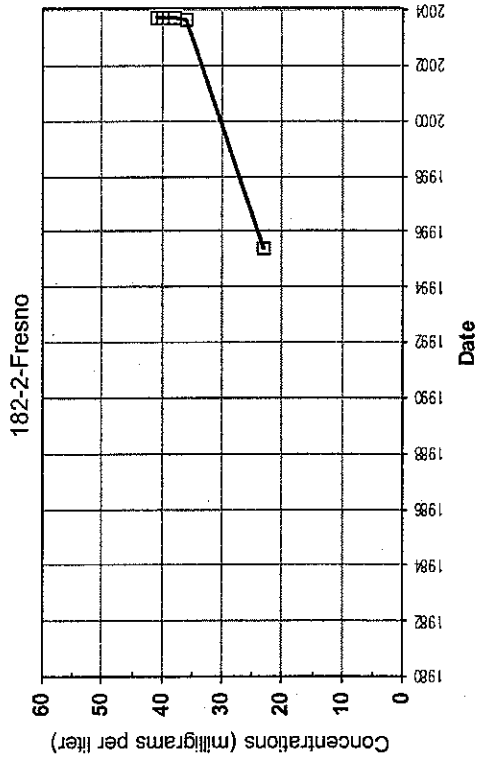
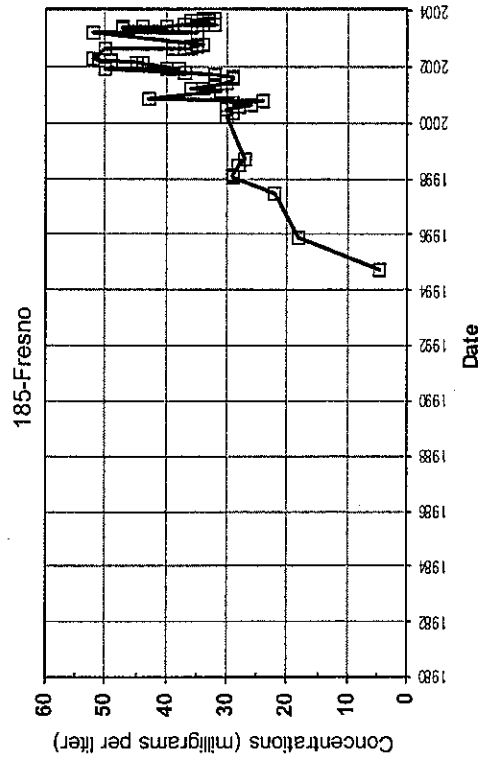
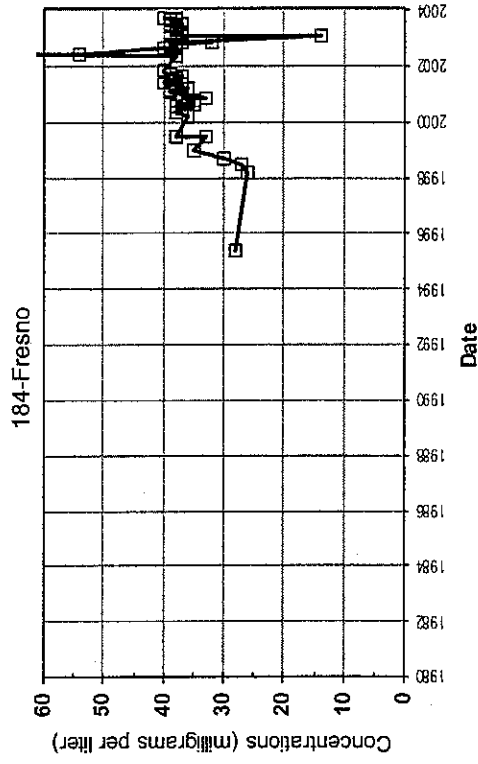




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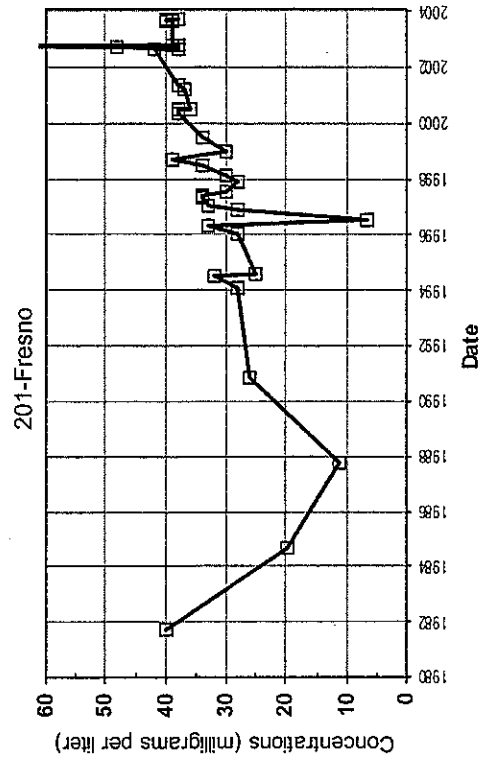
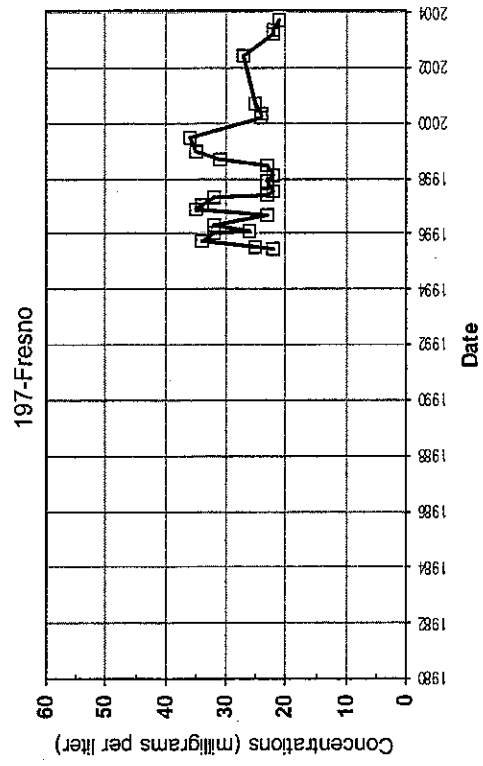
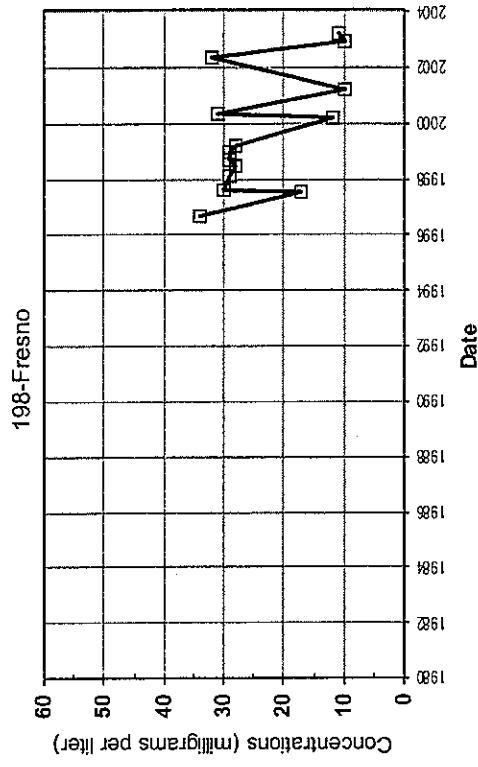
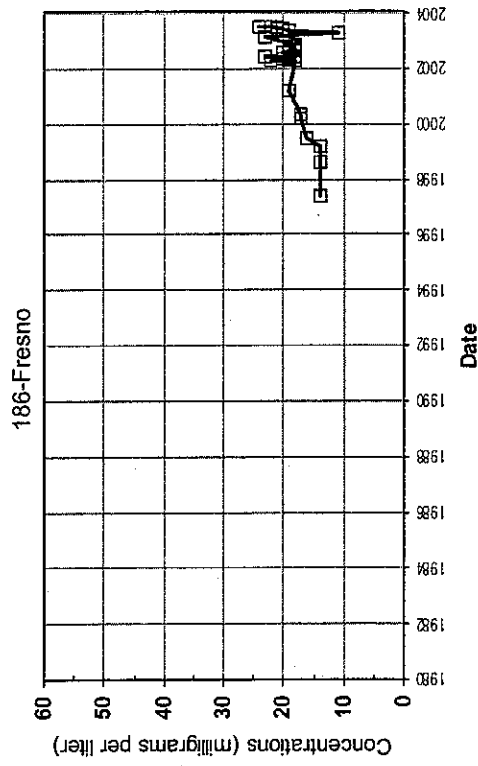


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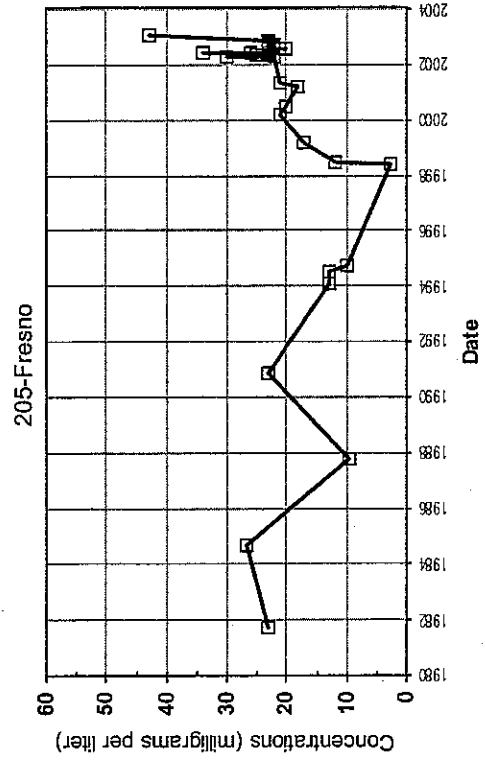
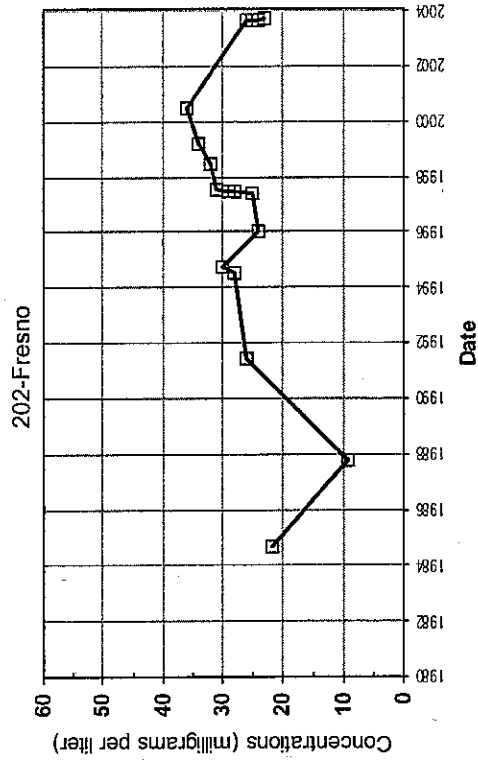
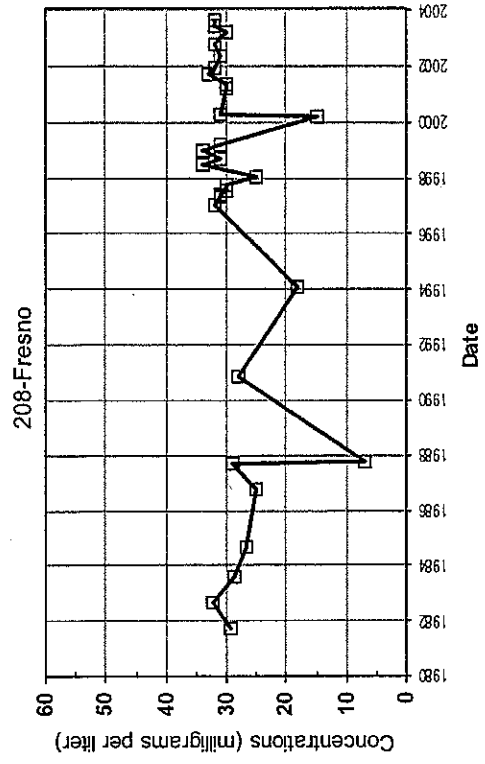
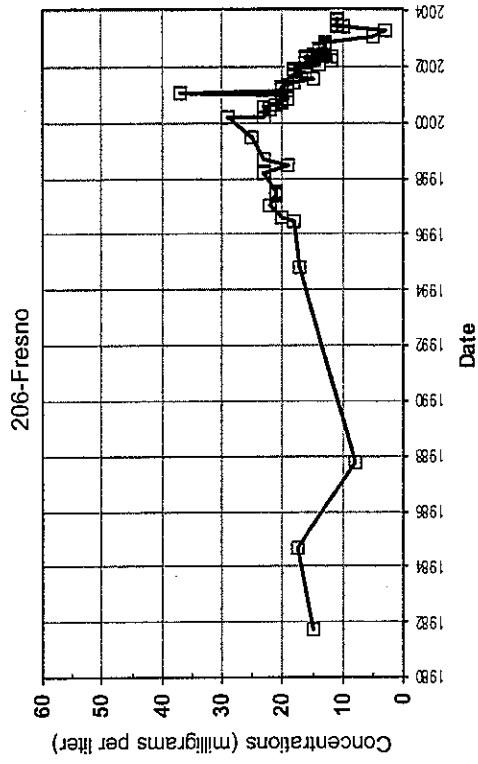


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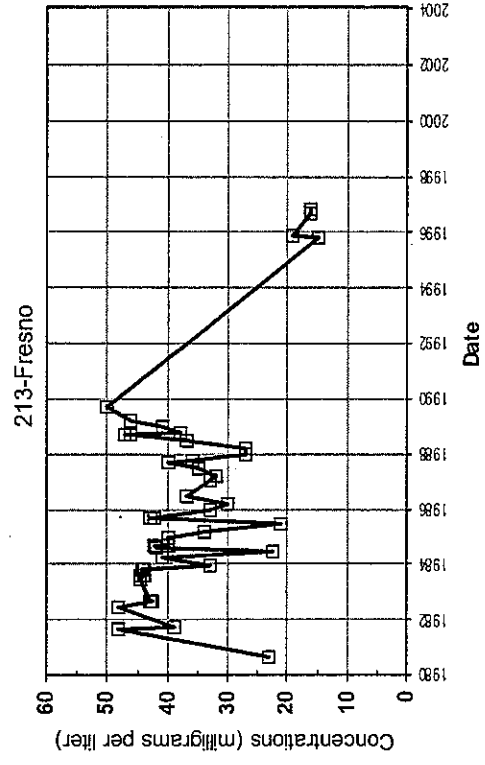
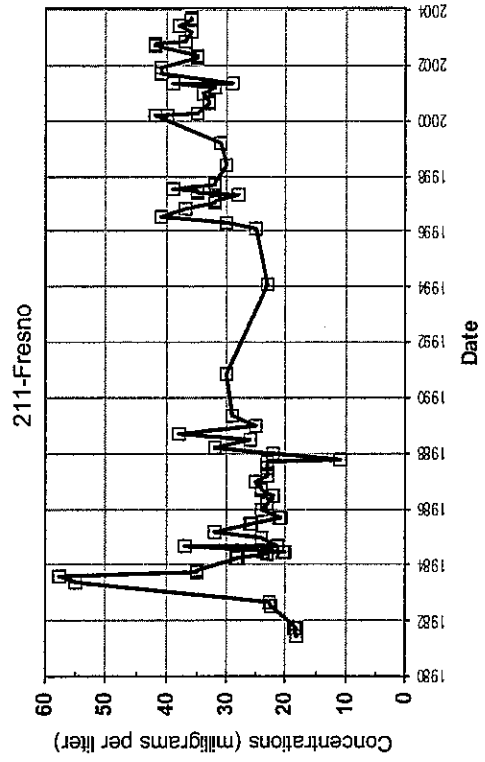
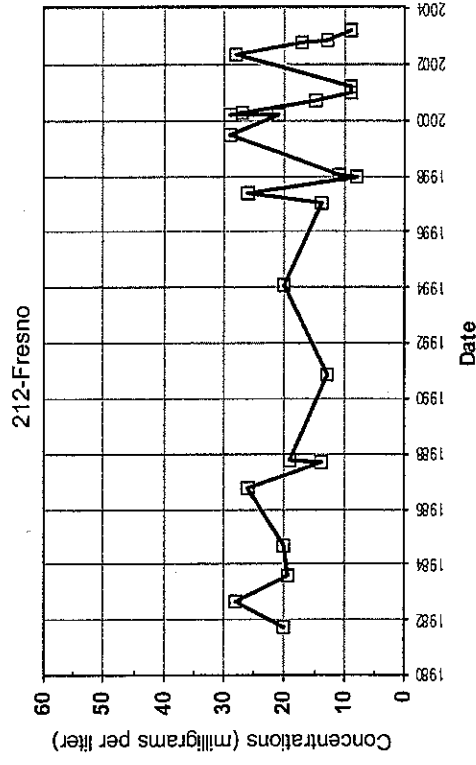
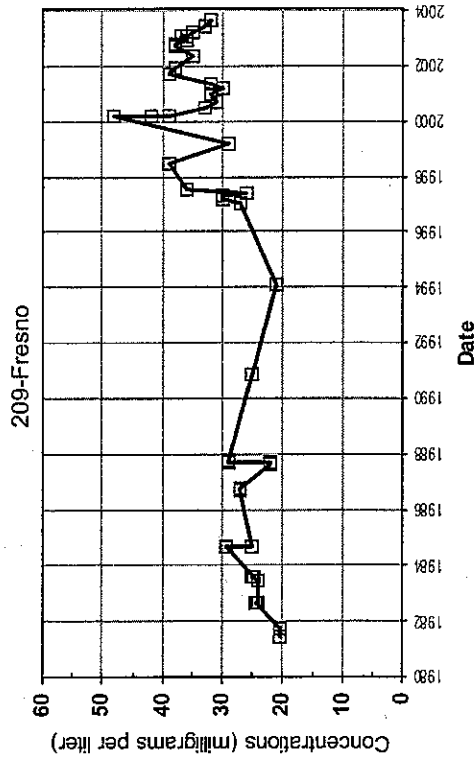




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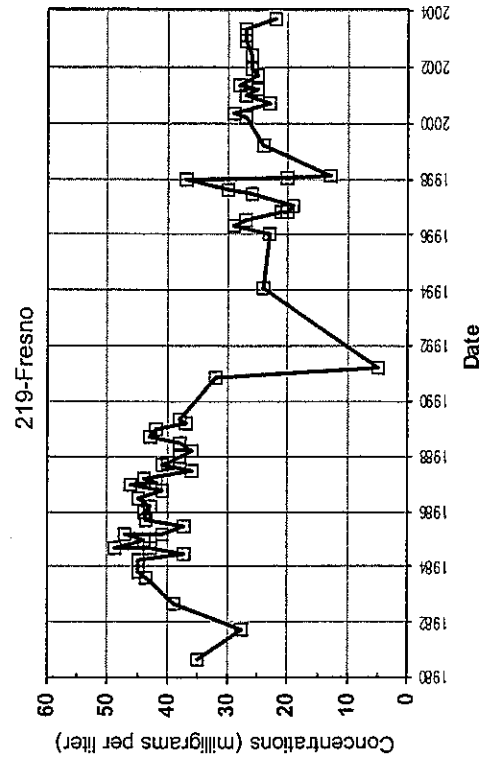
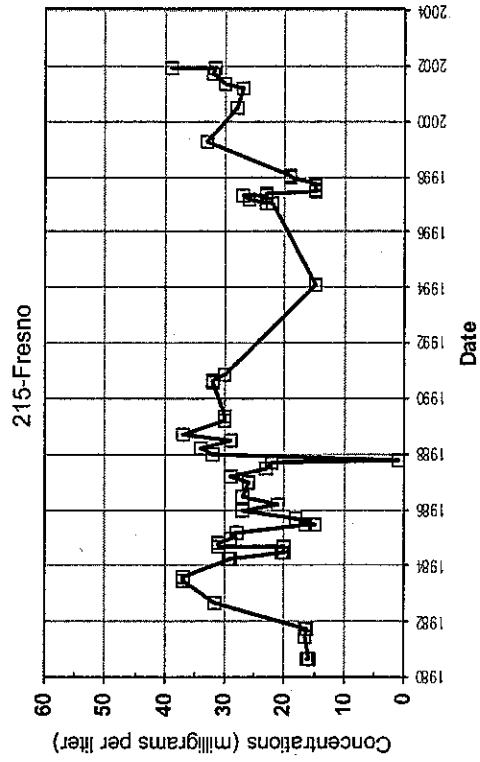
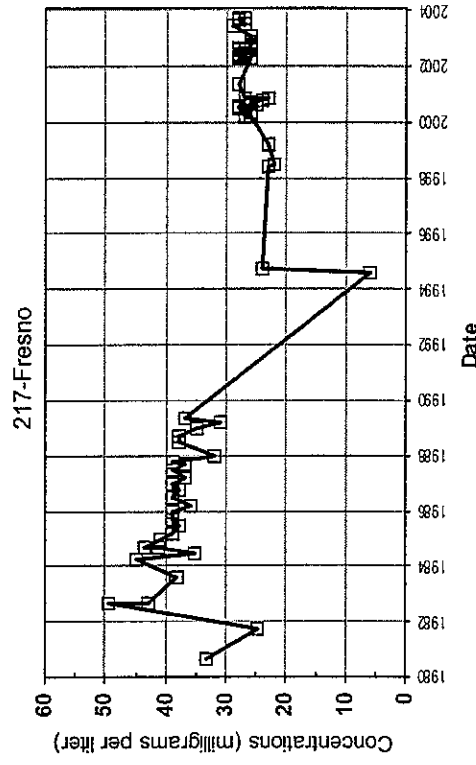
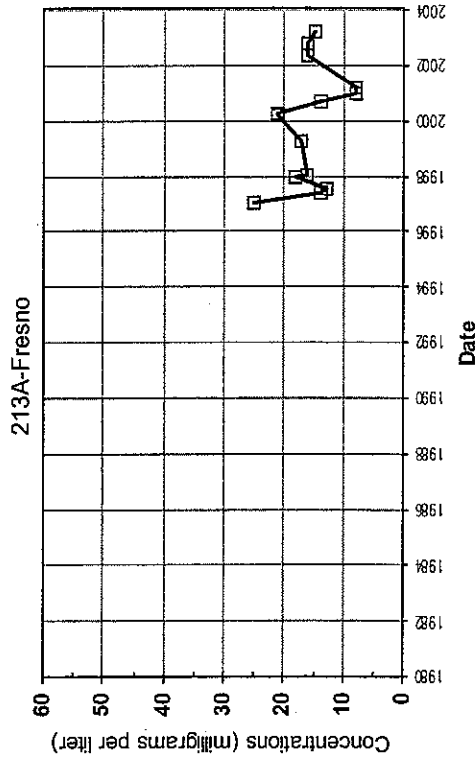


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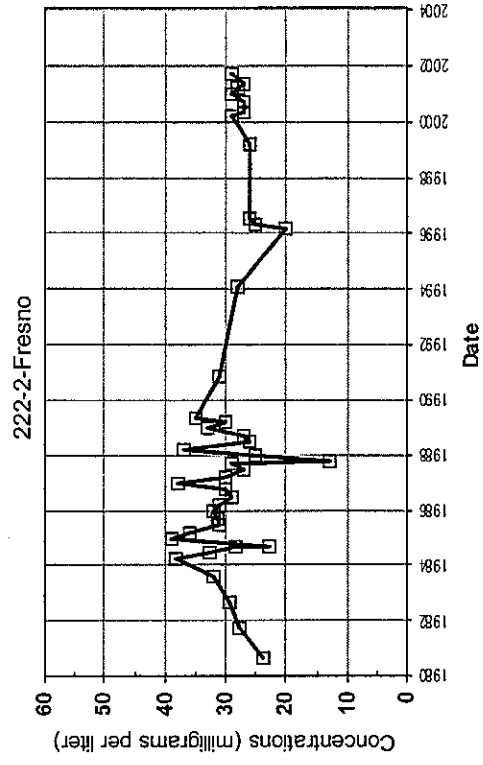
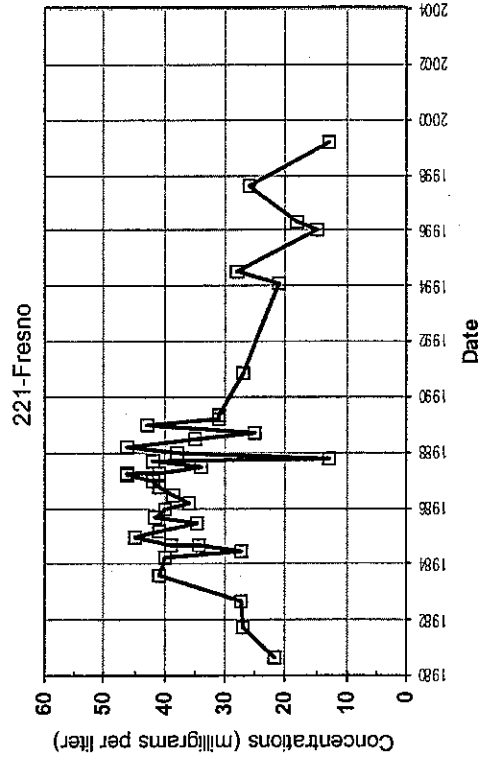
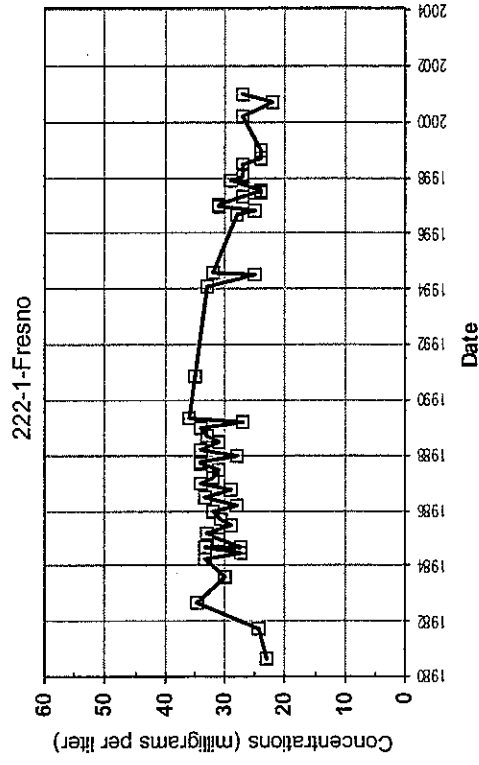
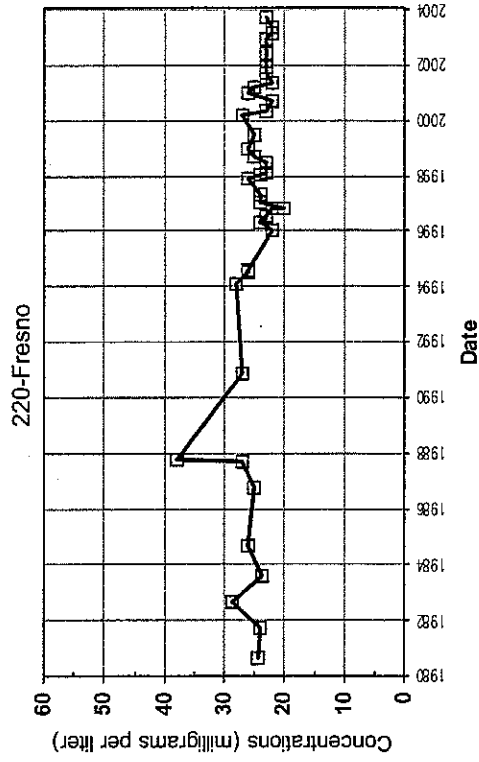


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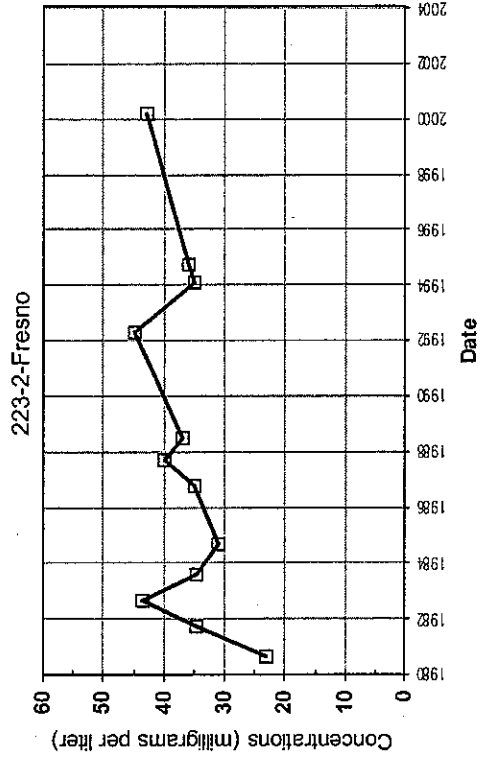
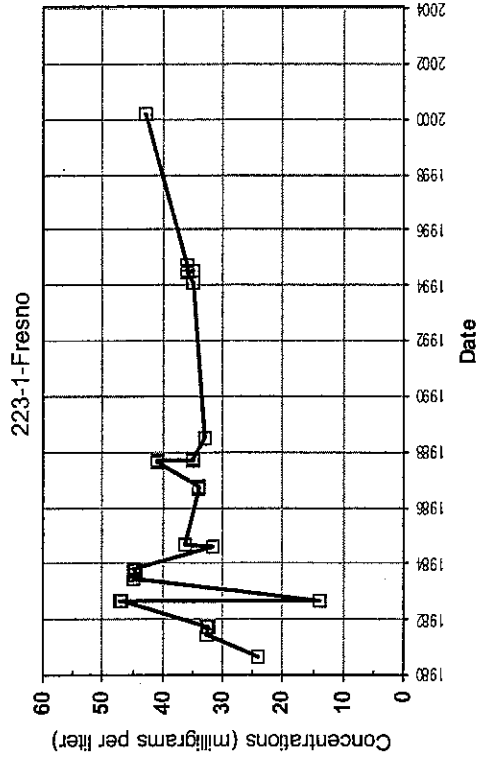
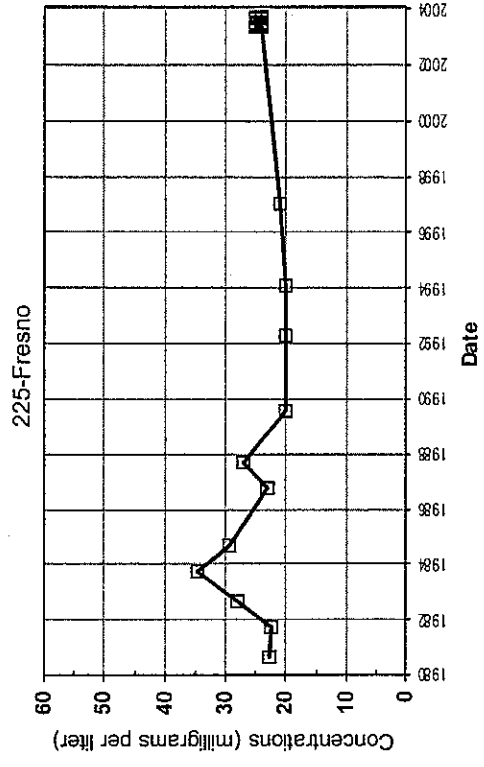
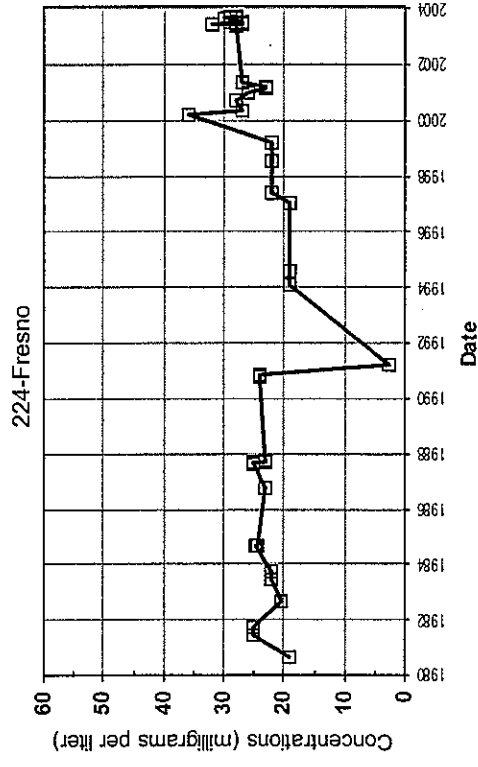


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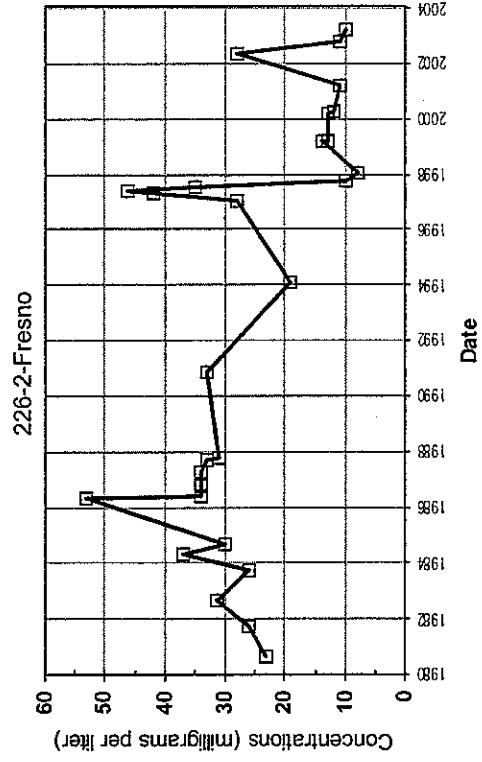
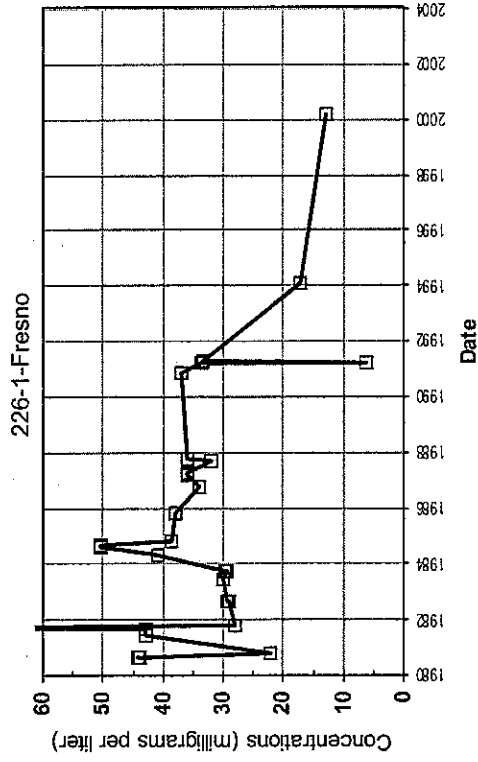
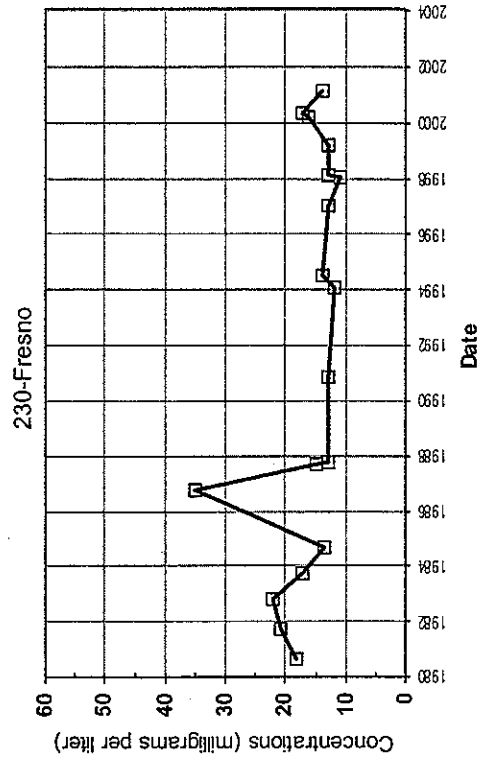
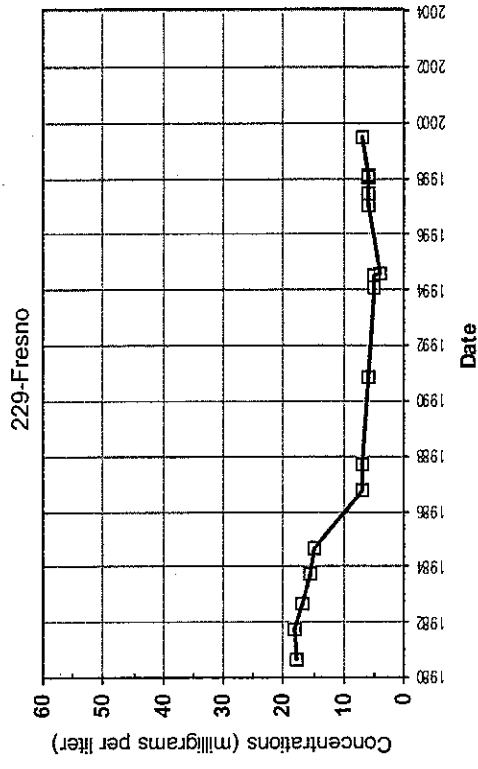




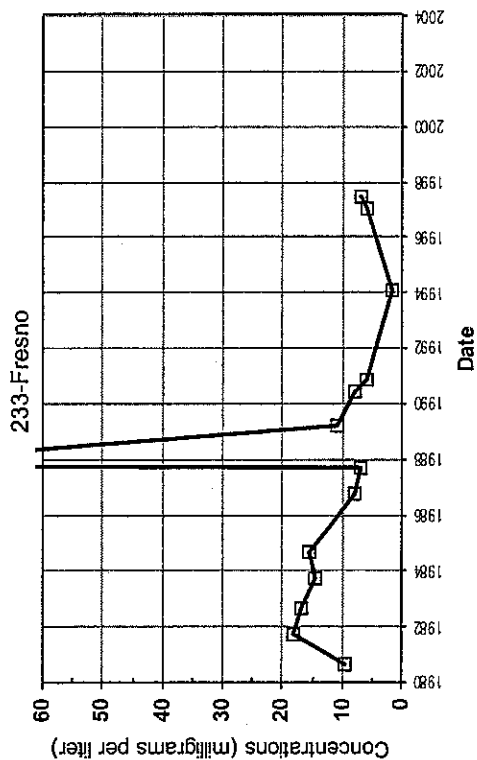
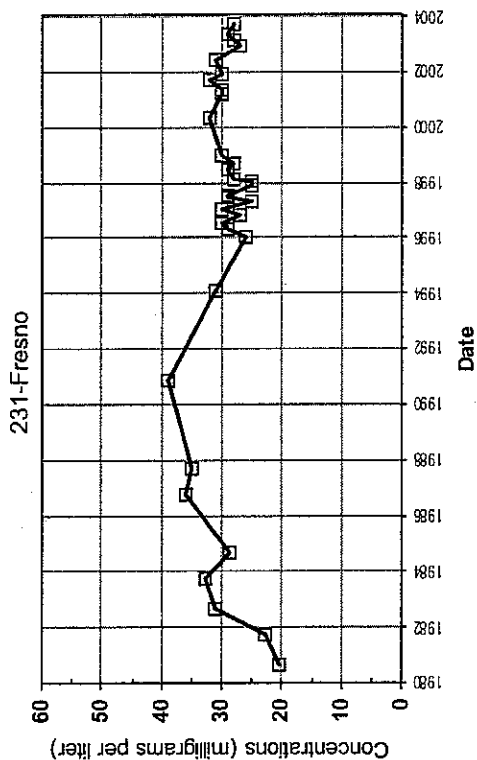
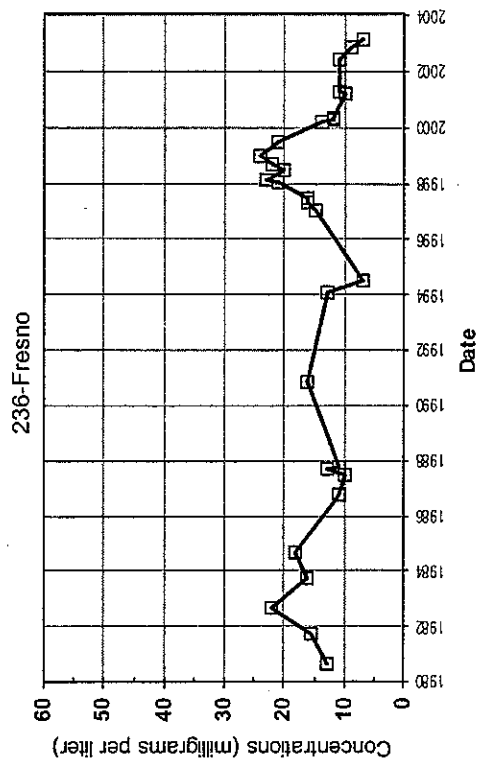
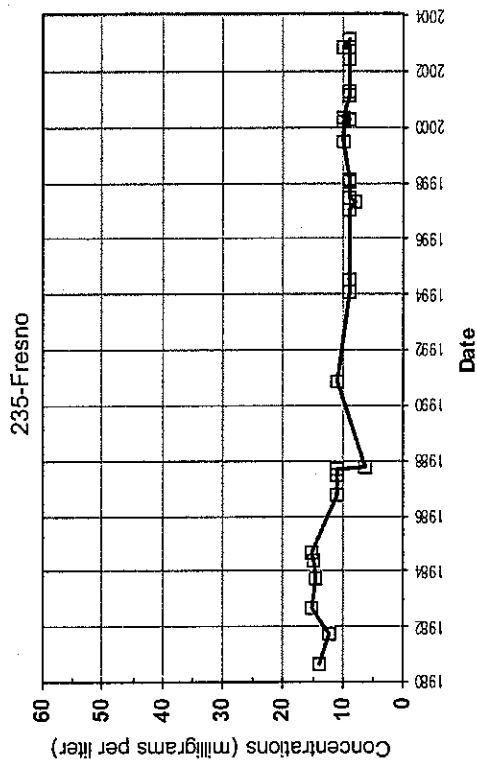
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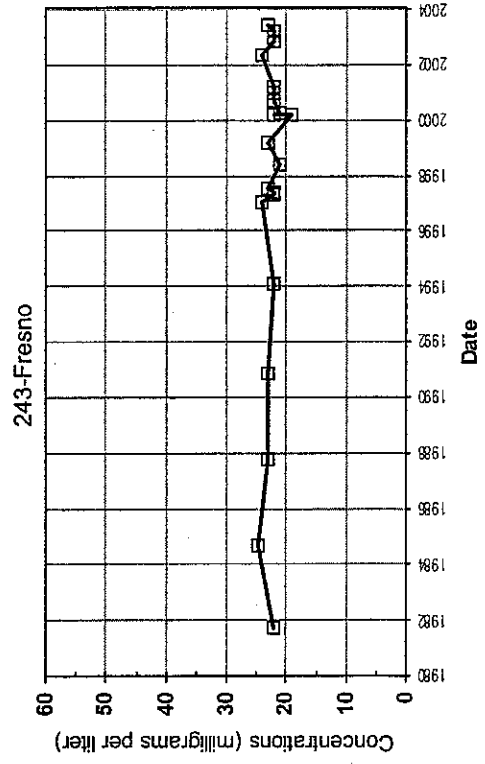
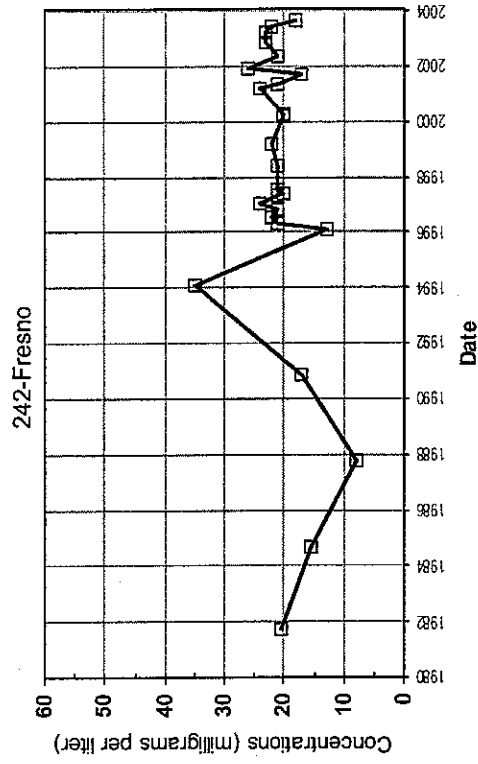
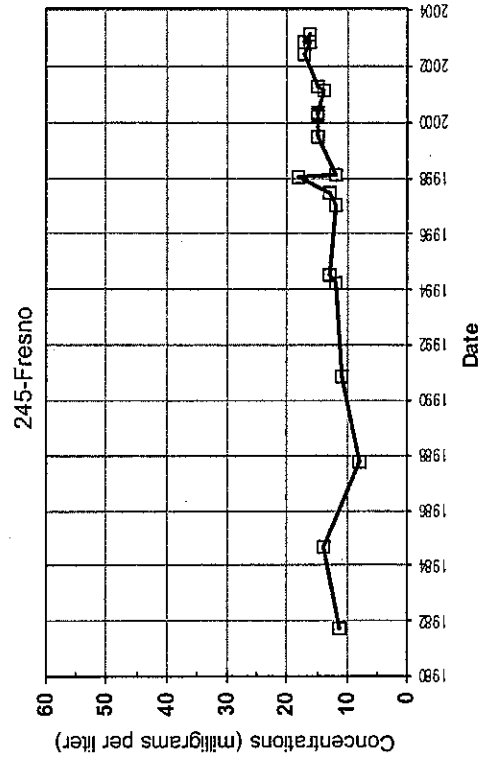
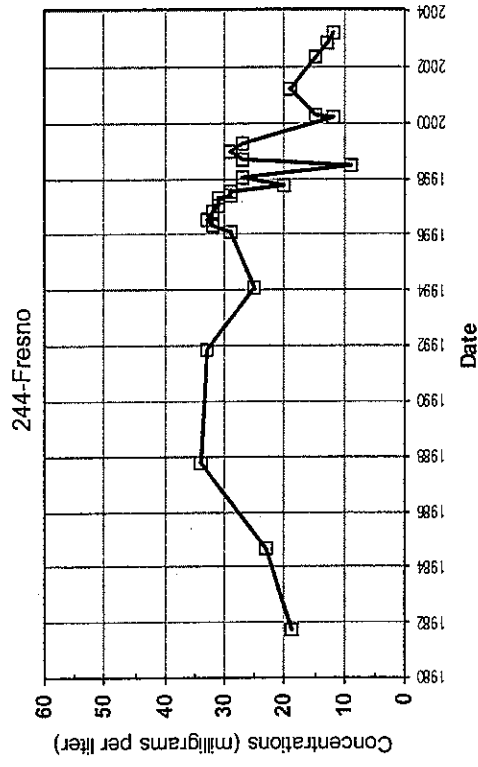
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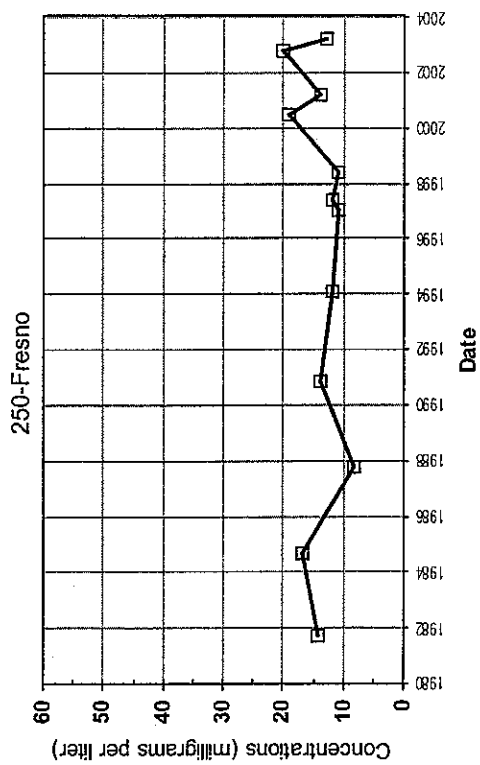
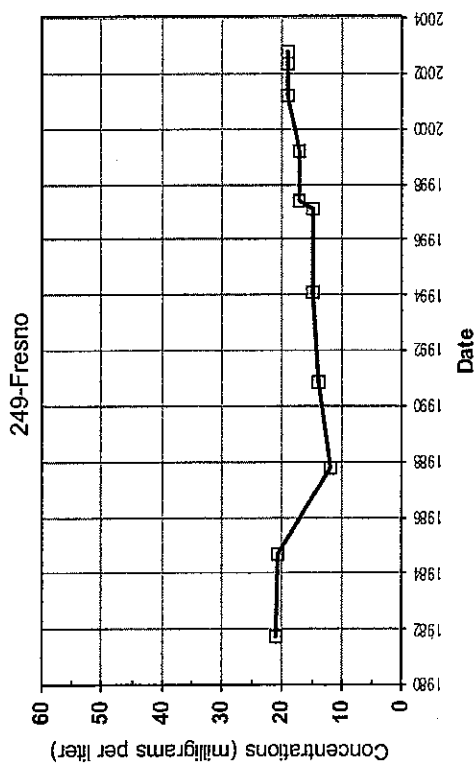
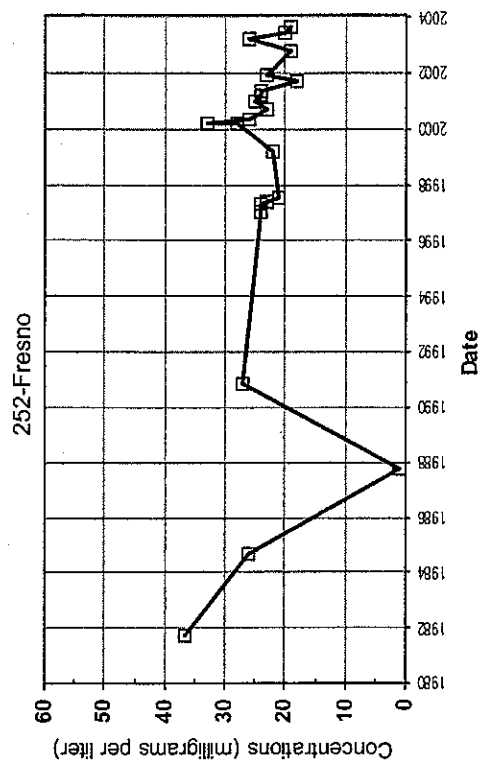
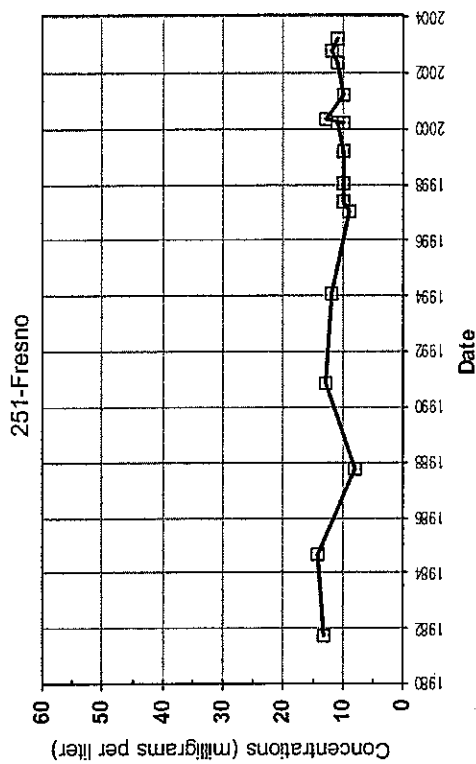


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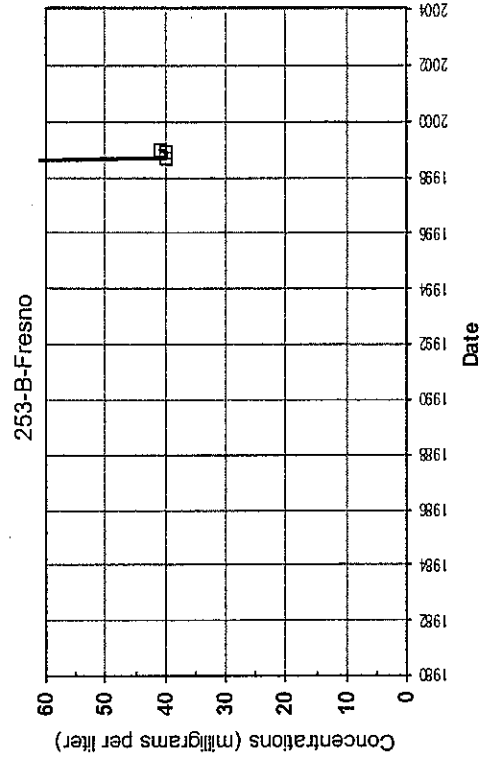
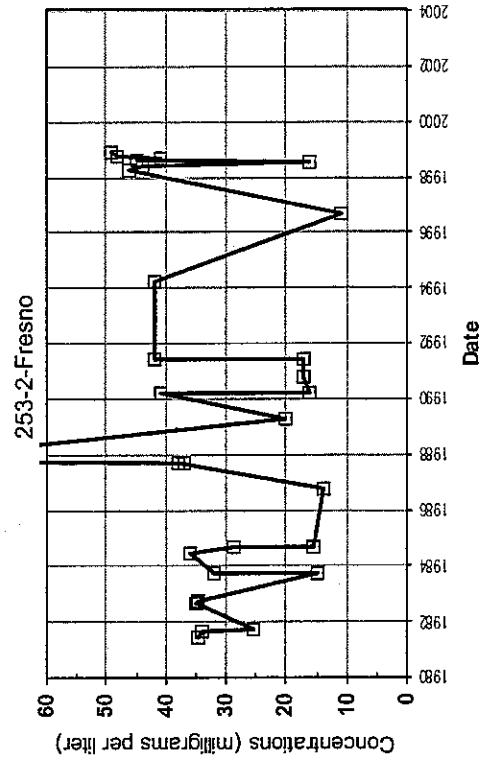
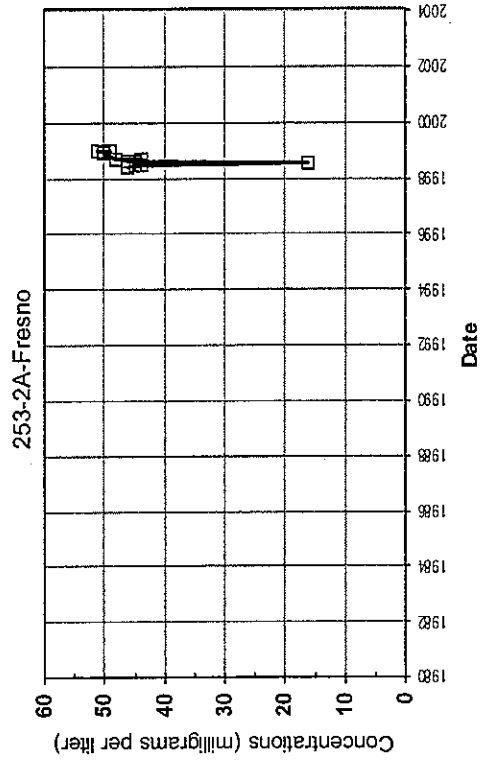
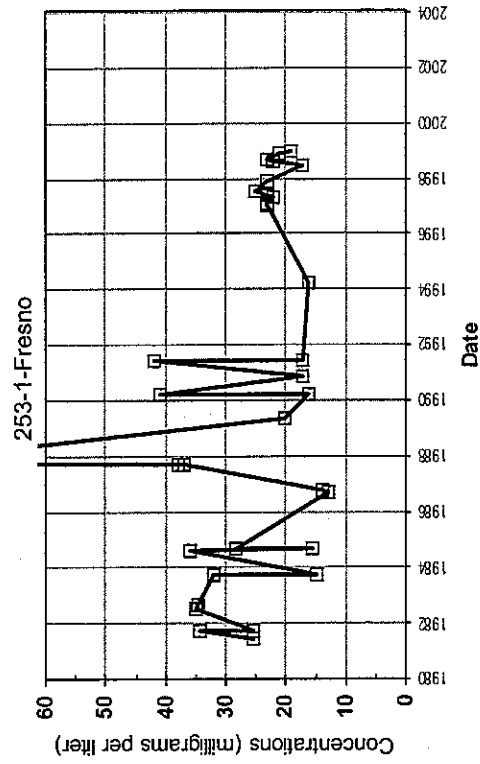


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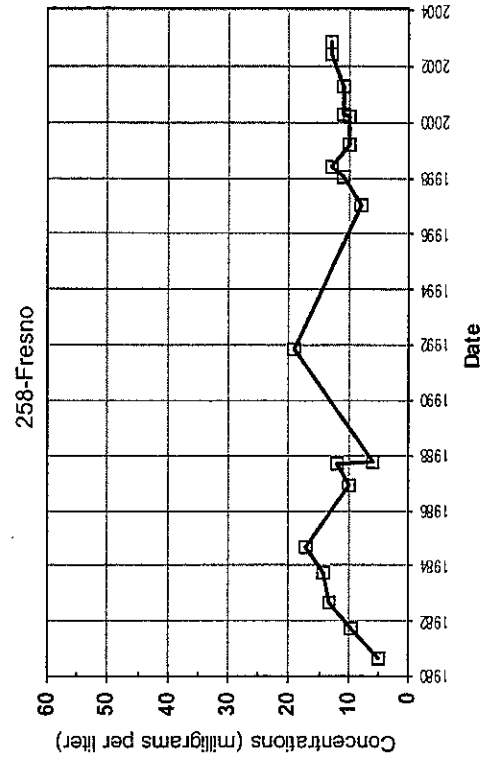
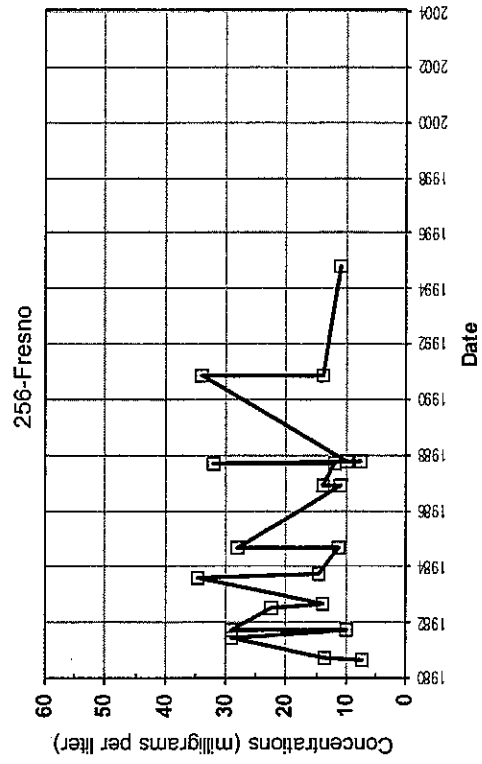
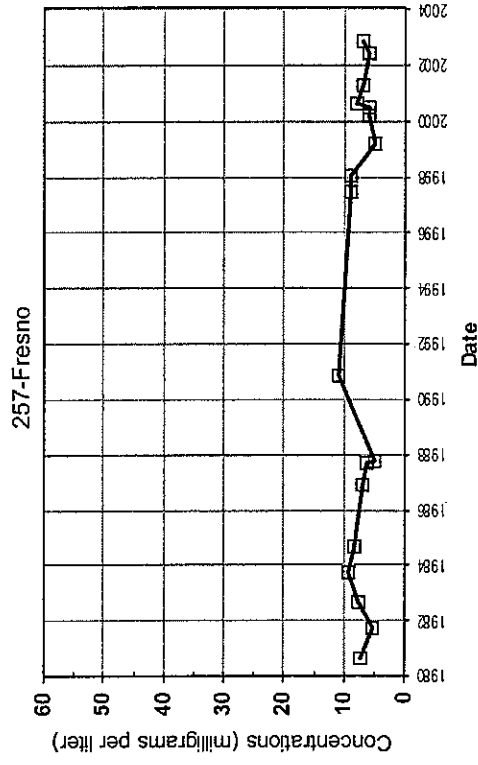
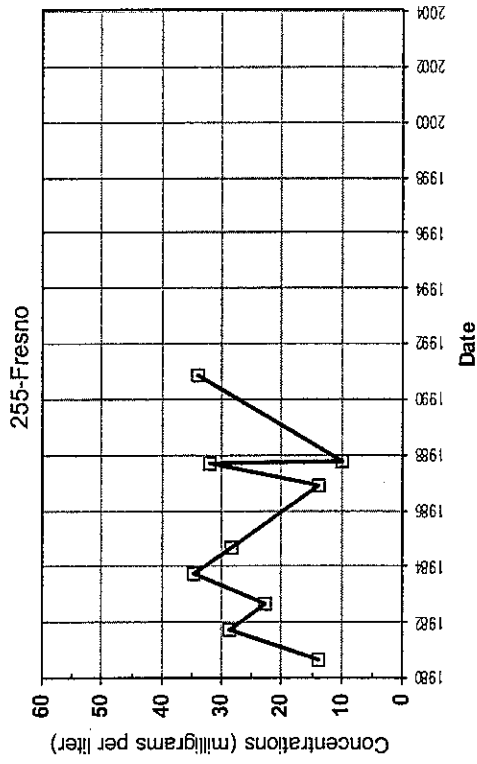




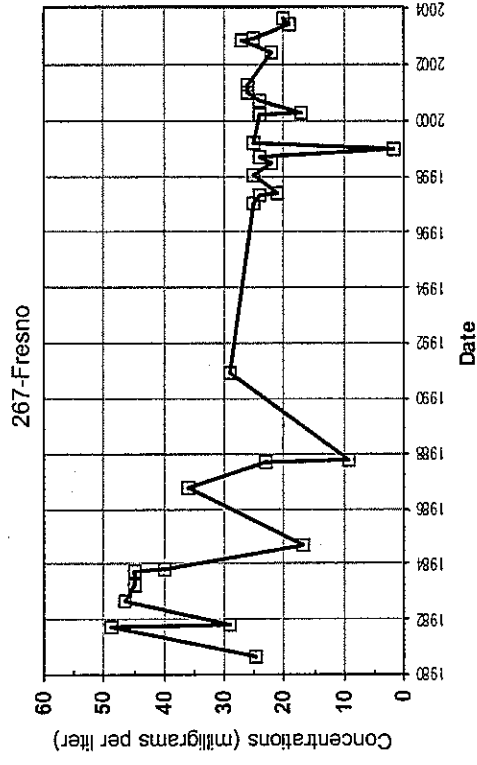
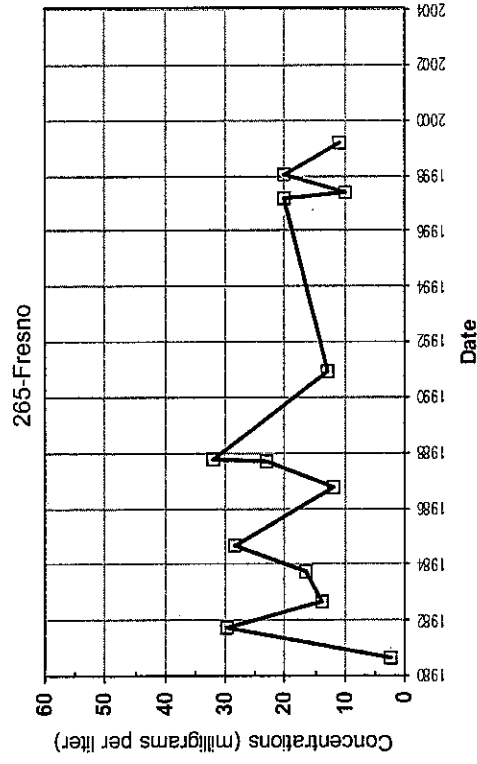
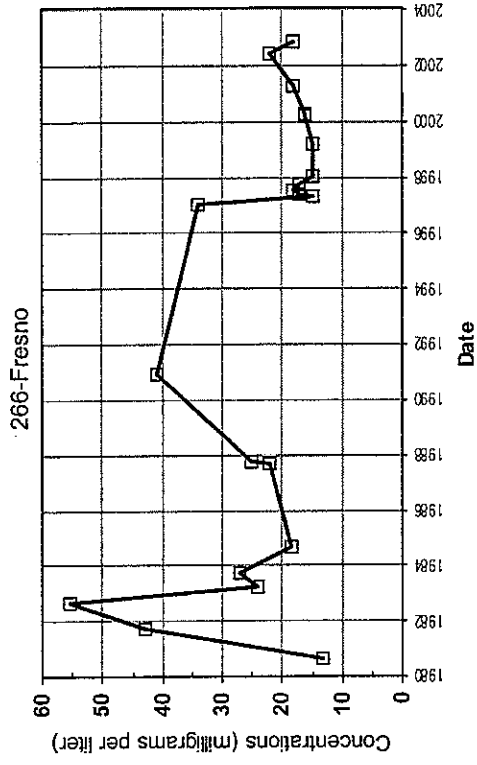
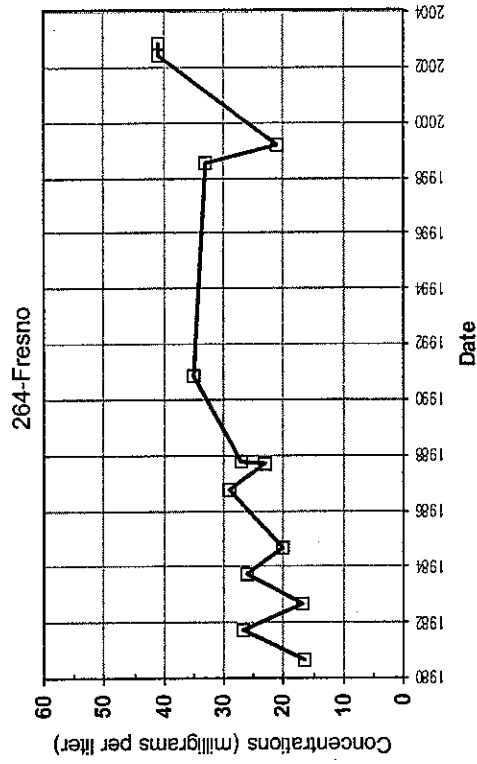
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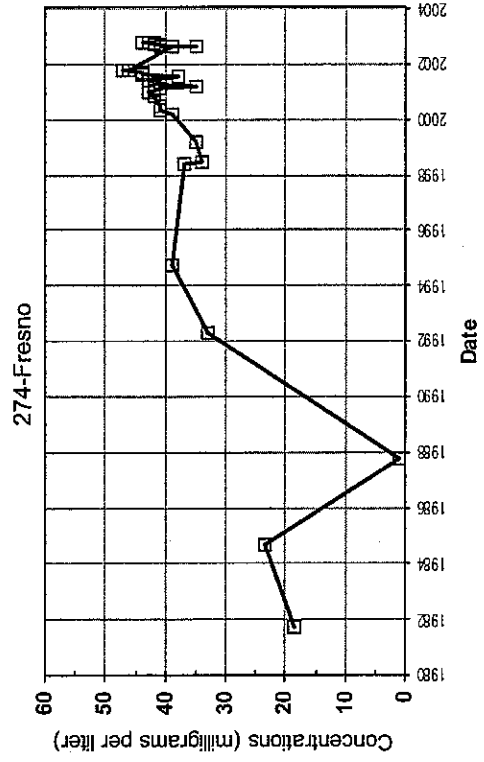
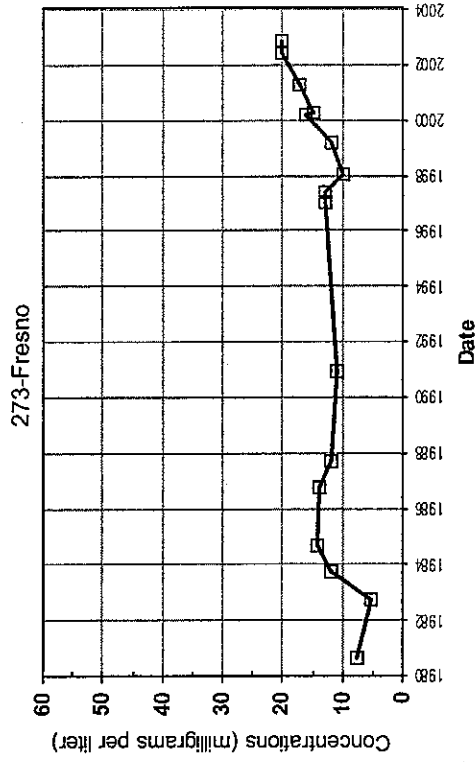
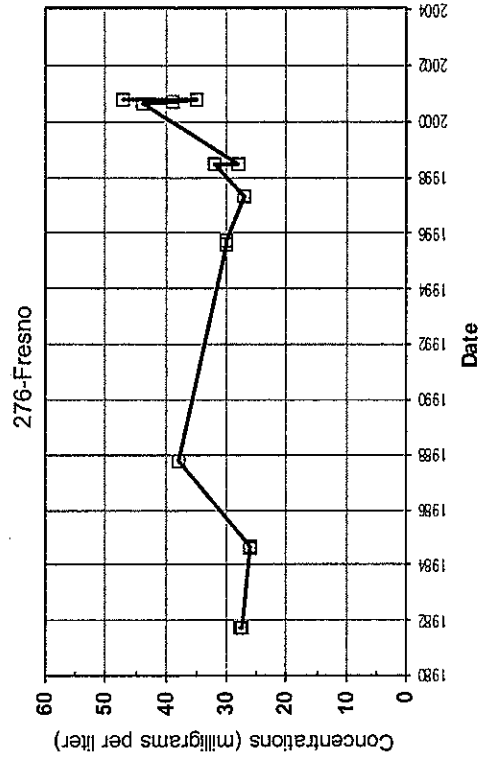
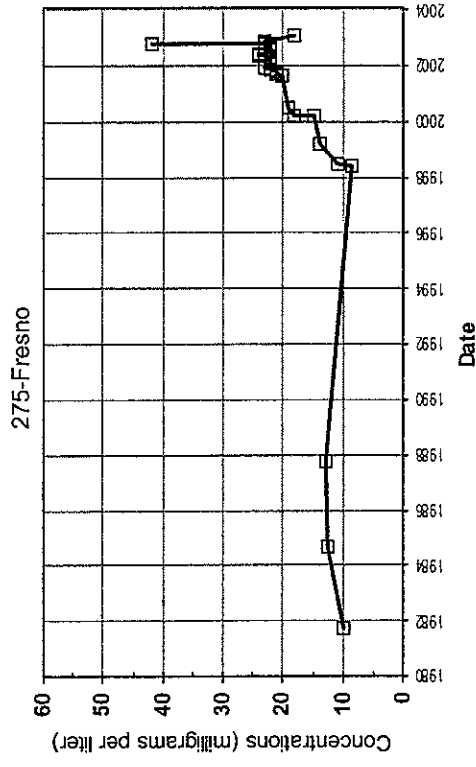
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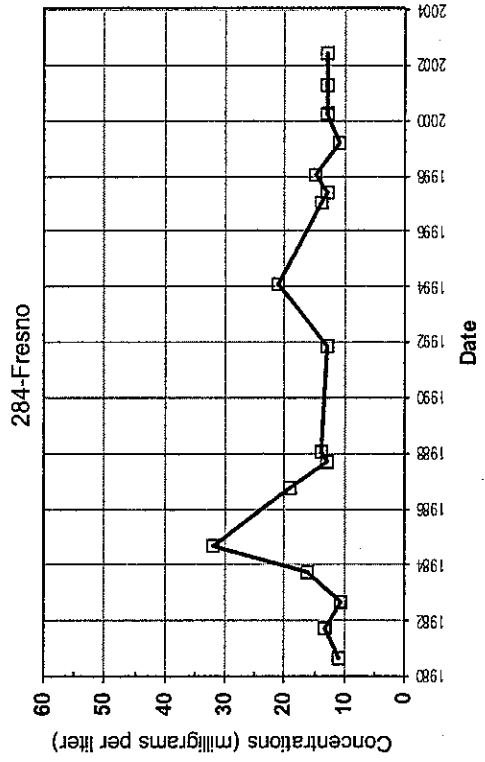
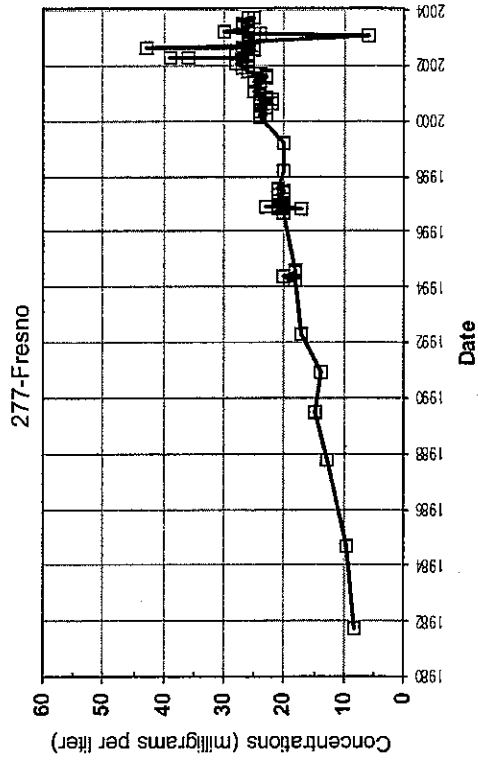
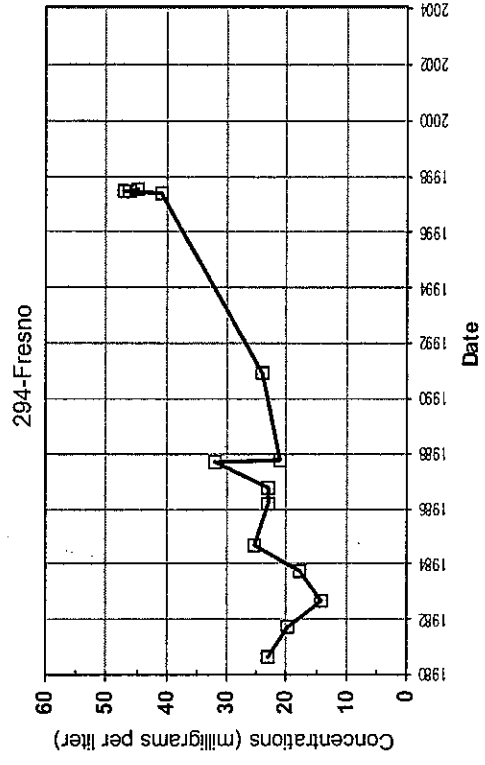
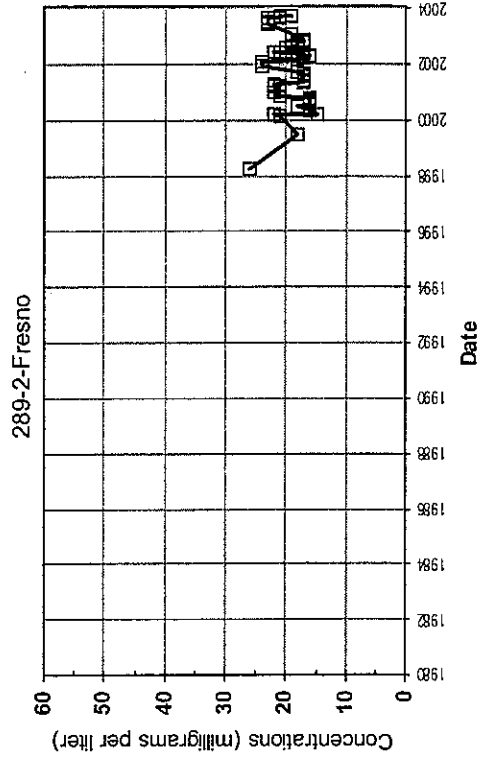
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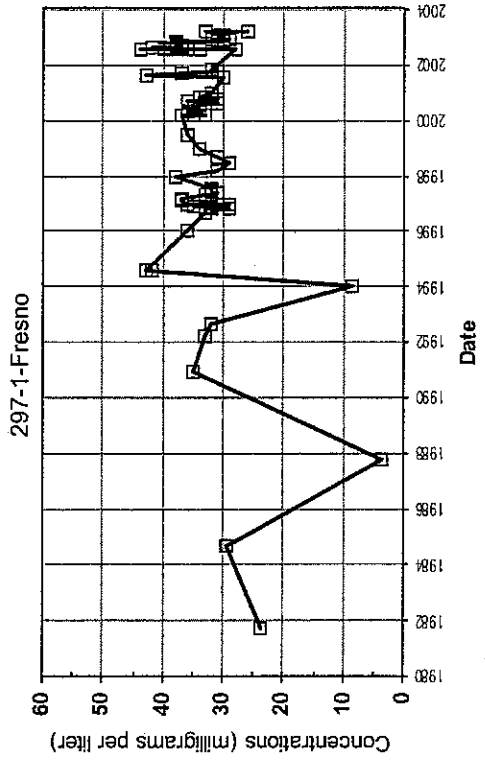
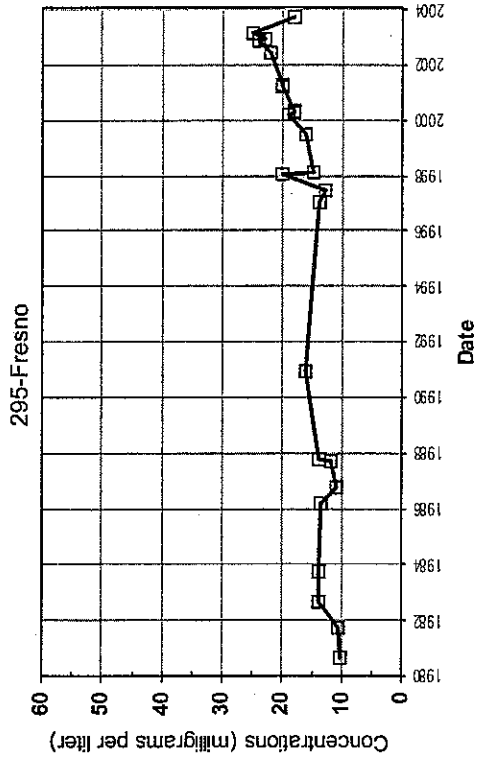
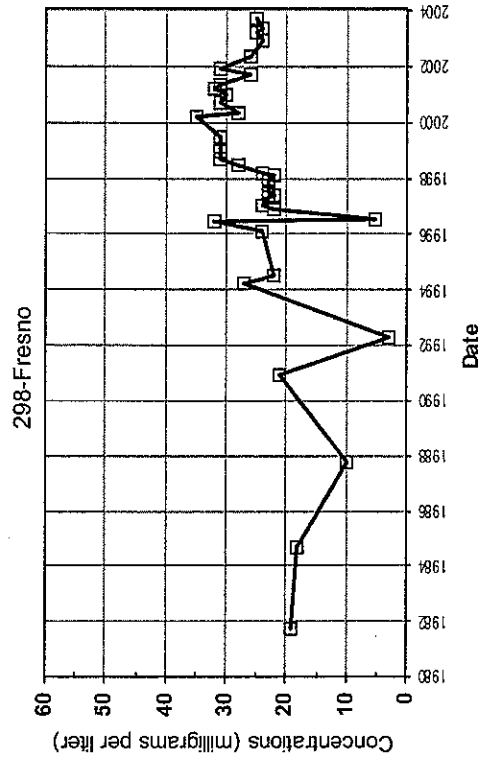
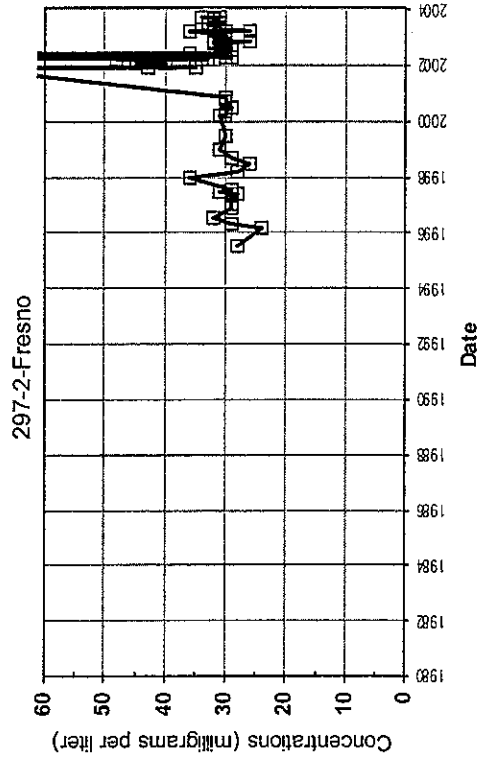
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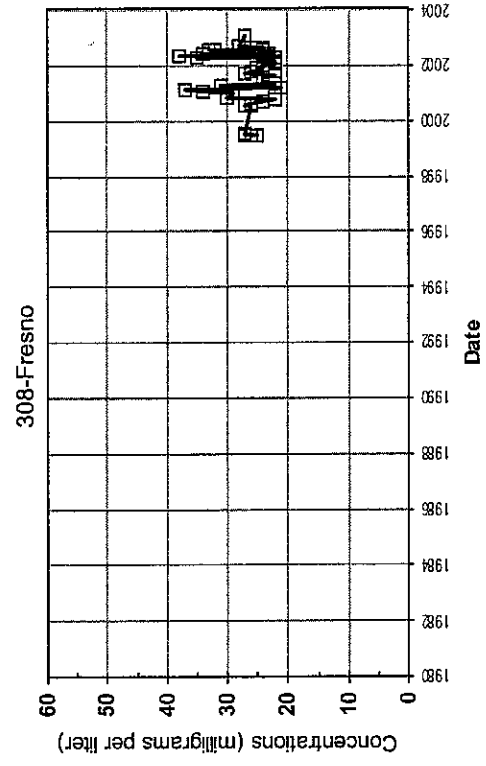
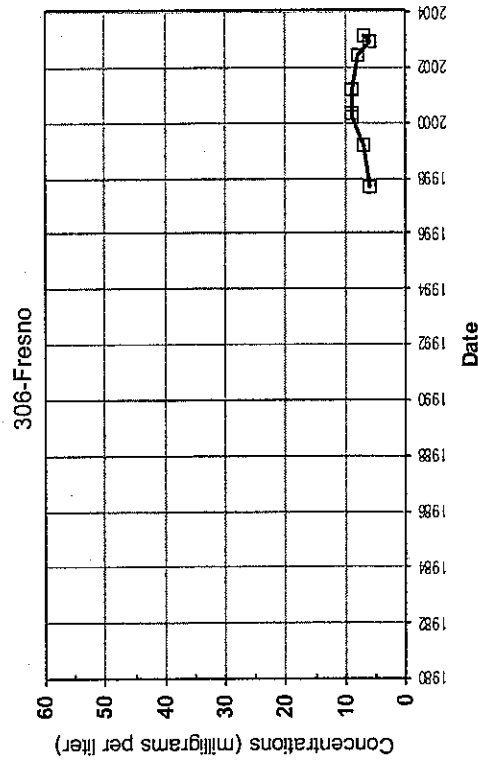
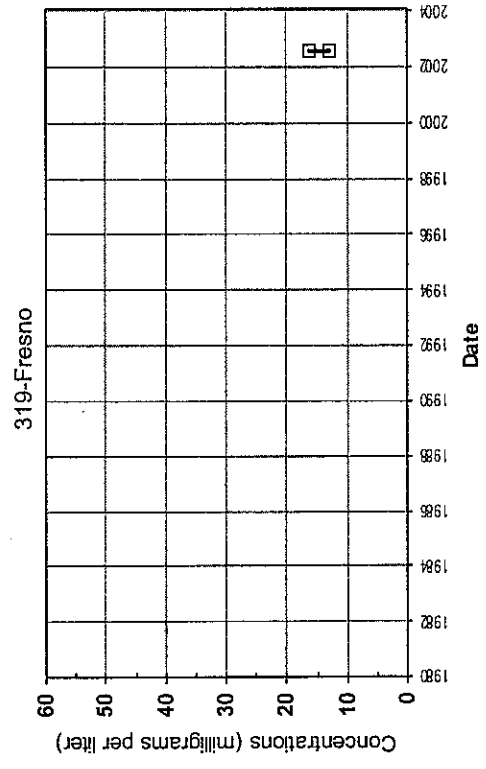
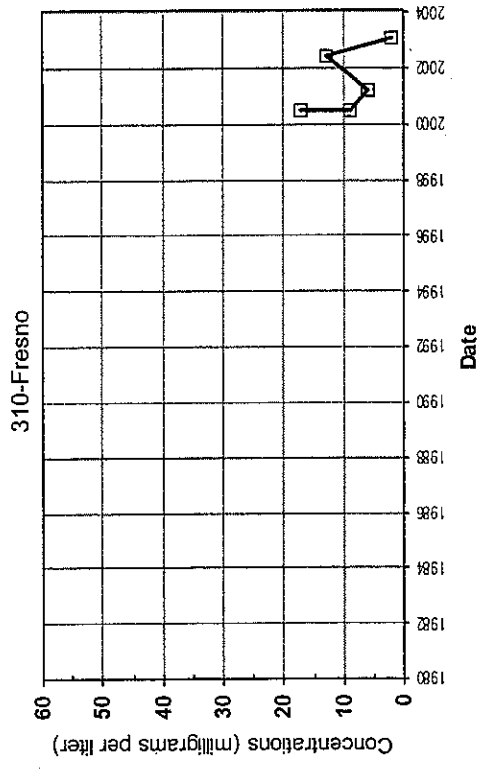


NO₃ Concentrations





NO3 Concentrations



Appendix B
Fresno Municipal Code
Sewer Connection Requirements

FRESNO MUNICIPAL CODE

SECTION 9-502. SEWER CONNECTION REQUIRED.

(a) Every building or structure in which plumbing fixtures are installed, and every premises having piping thereon, which conveys sewage or other liquid wastes to an approved point of disposal, shall be connected to the regional sewer system if it is available, except that:

(i) In the R-A, AE-5, and AE-20 zone districts, on a lot at least two net acres in size, and provided the lot, if not served by a community water system, contains one dwelling unit or septic system per 2.0 acres, such connection may be deferred until the use of the land changes either through district amendment or special permit.

(b) The regional sewer system is available, for the purposes of this section, if a sewer main has been constructed and is available for use in any public street, alley or right-of-way within 100 feet for the first unit plus 50 feet for each additional unit, to be measured along such public street, alley or right-of-way from the nearest property line to the sewer main. For the purpose of this section, the number of units computed shall include all units developed on contiguous property held under one ownership.

(c) Notwithstanding any provision to the contrary, buildings or structures, connected to a septic tank or cesspool at the time the regional sewer system becomes available, shall be connected to the regional sewer system within three years after the regional sewer system becomes available or, if the property has previously been subject to an earlier date by reason of requirements of a jurisdiction other than the city, then said connection shall be made on or before said earlier date, provided that if the Director determines the continued use of the septic tank or cesspool will create an immediate health menace, the property shall be connected within the time specified by the Director. Buildings or structures not connected as required by this section are public nuisances.

(d) No person shall cause, suffer or permit the disposal of sewage, or other liquid wastes into any drainage system on any lot which is not connected the regional sewer system when such connection is required by this section.

(e) Cemeteries will not be subject to the requirements of Section 9-502, except that any facilities used for other than cemetery purposes and separate major maintenance facilities fronting a public street shall be required to connect to the city sewer system subject to the availability of sewers as provided in Section 9-502. (Orig. Ord. 4726; Am. Ord. 5415, 1958; Am. Ord. 5777, 1960; Am. Ord. 6466, 1964; Am. Ord. 6882, 1966; Am. Ord. 6889, 1966; Am. Ord. 82-100, ' 1, eff.10-15-82; Am. Ord. 85-22, ' 1, eff. 3-22-85; Am. Ord. 98-87, ' ' 4, 5, 1-9-99)

SECTION 9-503. PERMIT REQUIRED AND PAYMENT OF SEWER CONNECTION CHARGES.

(a) No person shall connect any lot to the city sewer system without a permit from the Director of Development. No permit shall be issued by the Director of Development unless the following sewer connection charges, when applicable, have been paid:

(1) Lateral Sewer Charge. A Lateral Sewer Charge shall be required for each lot sought to be connected to the city sewer system based on the net area of such lot, in the amount per square foot as designated in the Master Fee Resolution.

Notwithstanding the above:

(i) Property, which has not previously had city sewer service, shall pay a Lateral Sewer Charge only to the extent that such Lateral Sewer Charge or the cost of the main serving the premises has not heretofore been paid by the applicant or his predecessor in interest.

(ii) Where the applicant is required to extend a sewer main across his property frontage as a condition precedent to receiving service, no such charge shall be collected for that portion of the frontage adjacent to the main which the applicant is required to extend.

(iii) When only a portion of a lot is developed and the remaining portion is to continue undeveloped or is to be used solely for the growing of agricultural crops, the Director may require the payment of the Lateral Sewer Charge applicable only to that portion of the lot developed or to be developed. When the balance of the lot is developed, the Lateral Sewer Charge on that portion shall be paid regardless of whether additional sewer service is required. The Director shall fix the portion of the lot that is to be considered as developed.

(iv) Properties, on behalf of which no contribution has been made to the cost of the sewer mains and which receive service from sewer main extensions made in other than dedicated and surfaced streets, shall pay to the city the same Lateral Sewer Charge as would be payable if the sewer main were located in a dedicated street adjacent to the property to be served.

(v) In the R-A, AE-5 and AE-20 zone districts on a developed lot at least two net acres in size, when a portion not fewer than twelve thousand five hundred square feet of such lot is to be improved with one additional single-family residence or the existing residence is to be connected to the city sewer system, the Director may require the payment of the Lateral Sewer Charge applicable only to the portion of such lot to be improved or occupied by the existing residence to be connected to the city sewer system. When the land use on the balance of the lot changes either through district amendment or special permit, the Lateral Sewer Charge shall be paid regardless of whether or not additional sewer service is required. The Director shall fix the portion of such lot which is to be considered as improved or occupied.

(vi) For separate maintenance facilities within cemeteries and on facilities used for other than cemetery purposes, the Director shall fix the area of the lot for Lateral Sewer Charges based on dimensions of the property actually used for such purposes.

(2) Oversize Sewer Charge. An Oversize Sewer Charge shall be required for each lot sought to be connected to the regional sewer system based on the net area of such lot, in the amount per square foot designated in the Master Fee Resolution. Parcels of land proposed for subdivision shall be assessed based on the parcels' net area prior to subdivision. Property which has wholly or proportionately paid the cost of sewer mains, when such fact has been or can be established to the satisfaction of the Director, need pay only the Oversize Sewer Charge applicable to the portion of the property for which the charge has not been paid.

Notwithstanding the above:

(i) When only a portion of a lot is developed, and the remaining portion is to continue undeveloped or is to be used solely for the growing of agricultural crops, or for public recreation uses not enclosed in a building, the Director may require the payment of the Oversize Sewer

Charge applicable only to that portion of the lot developed or to be developed, provided that the parcel for which such fees are charged shall have an area of not fewer than twelve thousand five hundred square feet. When the balance of the lot is developed, the Oversize Sewer Charge shall be paid regardless of whether or not additional sewer service is required. The Director shall fix the portion of the lot which is to be considered as developed.

(ii) In the R-A, AE-5 and AE-20 zone districts on a developed lot at least two net acres in size, when a portion not fewer than twelve thousand five hundred square feet of such lot is to be improved with one additional single-family residence or the existing residence is to be connected to the regional sewer system, the Director may require the payment of the Oversize Sewer Charge applicable only to the portion of such lot to be improved or occupied by the existing residence to be connected to the regional sewer system. When the land use on the balance of the lot changes either through district amendment or special permit, the Oversize Sewer Charge shall be paid regardless of whether or not additional sewer service is required. The Director shall fix the portion of such Lot which is to be considered as improved or occupied.

(iii) Oversize Sewer Charges shall be paid upon connection with the regional sewer system, except that in the UGM area, a subdivider may receive oversize sewer and extra depth sewer fee credits in the amount of reimbursements due at the reimbursement rate in effect at the time of construction, in accordance with subdivision (c) of Section 9-503.2, for property owned by such subdivider who has previously constructed oversize sewers in the Oversize Sewer Service Area which totally includes such property. This provision shall apply to all tract maps approved after July 1, 1983.

(iv) On separate maintenance facilities within cemeteries and on facilities used for other than cemetery purposes, the Director shall fix the area for Oversize Sewer Charges based on the dimensions of the property actually used for such purposes.

(3) House Branch Sewer Charge.

(i) For each lot, which requires a new or revised house branch for which the installation or revision of the house branch is arranged by the city, the applicant shall pay to the city a House Branch Sewer Charge for the cost of the installation or revision. The cost of installation or revision shall be equal to the contract price paid by the city, plus such amounts as are designated in the Master Fee Resolution for administration, engineering, and inspection.

(ii) Each lot or premises shall be served with a separate sewer house branch, unless approved by the Director and a recorded covenant, approved by the City Attorney's Office, is executed between the affected property owners.

(iii) Where a lot is sought to be connected to an existing house branch, for which the cost has not previously been paid on behalf of the lot, the House Branch Sewer Charge shall be the same as if the house branch were a new house branch. If such connection is sought more than one year after the installation of such branch, simple interest shall be added at the rate of seven per cent (7%) per annum to the cost of installation as defined above, except that no interest shall accrue beyond five years from the date of installation.

(4) Trunk Sewer Charge. A Trunk Sewer Charge shall be required for all residential lots, within an established Trunk Sewer Service Area, sought to be connected to the regional sewer system in the amount designated in the Master Fee Resolution. The purpose of this subdivision is

to ensure the provision of an adequate trunk sewer system to convey domestic and industrial wastes to the POTW treatment plant and to provide a means for levying and collecting charges to be used solely for the purpose of designing and constructing trunk sewer mains to serve designated Trunk Sewer Service Areas.

(i) The Council shall by resolution establish a Trunk Sewer Service Area, which is an area served by a trunk sewer main. The resolution may establish benefit to multiple Trunk Sewer Service Areas served from a common trunk sewer main, in which event, funds collected in the individual Trunk Sewer Service Areas may be used to finance the construction of the trunk sewer main. The service areas may be amended by the Council from time to time to reflect unusual sewer service capabilities or to reflect modifications in urban land use boundaries. The Director may make minor modifications to the Trunk Sewer Service Map, as sewer mains are extended at the fringes of the Trunk Sewer Service Areas, to reflect actual sewer service capabilities. Minor modifications are those changes to the Trunk Sewer Service Area boundary that when aggregated do not add or subtract more than forty acres to or from the Trunk Sewer Service Area. The Director shall maintain an official Trunk Sewer Service Map designating all established Trunk Sewer Service Areas.

(ii) The Council shall designate in the Master Fee Resolution a schedule of charges for each Trunk Sewer Service Area. The total amount of charges to be generated shall be based on the cost of the trunk sewer main to serve Trunk Service Area(s) or the cost to enhance the capacity of an existing trunk sewer main in a Trunk Sewer Service Area. The cost of a trunk sewer main shall include all of the direct and incidental costs of constructing the new trunk sewer main or the capacity enhancement for an existing trunk sewer main including, but not limited to, land acquisition, design and engineering, construction, financing costs, inspection and contract administration.

(iii) A Trunk Sewer Charge shall be required for every lot within a Trunk Sewer Service Area to be connected to the regional sewer system unless the Council, by resolution, waives the payment in that Trunk Sewer Service Area for existing developed lots without public sewer service. The total amount of charges to be generated in each Trunk Sewer Service Area shall be based on a reasonable allocation made by the Council considering the estimated or actual cost of design and construction of the trunk sewer main facilities and may include the cost to finance construction.

(iv) The Council may review and amend the Trunk Sewer Charges by amending the Master Fee Resolution from time to time to reflect inflation or any change in the factors affecting the cost of constructing such trunk sewer main facilities or the estimated number of units to be served by the facilities.

(v) All Trunk Sewer Charges collected from development within a Trunk Sewer Service Area shall be deposited in the Trunk Sewer Service Area account for that area. The Trunk Sewer Service Area account, including any accumulated interest, shall be used solely for the purposes of designing and construction, including costs of financing trunk sewer main facilities in that Trunk Sewer Service Area, and for administration, inspection, and engineering costs of the city directly related thereto, except that monies accumulated in that account may be

loaned to another Trunk Sewer Service Area as provided in this subdivision. In the event trunk sewer main facilities are designed or constructed by a developer, the Trunk Sewer Charges collected for such design and/or construction, less costs incurred by the city, shall be paid to the developer responsible for the design and/or construction, subject to Council approval.

(vi) The Council may authorize the use of funds accumulated in one Trunk Sewer Service Area account for construction of or making bonded debt payments for trunk sewer mains in another such area, provided the Council finds that the existing sewer service level in the Trunk Sewer Service Area with excess funds is adequate to provide service to all existing and approved development, and that the funds remaining on hand after the loan in that service area account are adequate to make the current bonded debt payments. The resolution authorizing a loan of funds to another Trunk Sewer Service Area shall establish the terms of the transaction and shall include provisions that the funds borrowed from a Trunk Sewer Service Area, including interest at a rate determined by the Controller to be the average annual rate received by the city on its investments, shall be repaid from Trunk Sewer Charges collected from subsequent development in the Trunk Sewer Service Area in which the trunk sewer was constructed. Loans from other Trunk Sewer Service Areas including interest shall be repaid in the order in which the Council approved such loans.

(5) Wastewater Facilities Charge. A Wastewater Facilities Charge shall be required for all residential sought to be connected to the regional sewer system in the amount designated in the Master Fee Resolution. The purpose of this subdivision is to ensure the provision of adequate POTW treatment plant and appurtenant facilities, and to provide a means for levying and collecting charges to be used solely for the purpose of designing and constructing a POTW treatment plant and appurtenant facilities.

(i) A Wastewater Facilities Charge in the amount designated in the Master Fee Resolution shall be required for every lot sought to be connected to the regional sewer system,

(ii) The Wastewater Facilities Charge shall be based on the cost of wastewater treatment facilities to be constructed to provide additional treatment capacity per unit for every lot sought to be connected to the regional sewer system for which sewerage treatment is provided by the subject facilities. The cost of the facilities providing expanded treatment capacity shall include all direct and incidental costs for constructing wastewater treatment plant facilities, including but not limited to, land acquisition, design, financing costs, inspection and contract administration.

(iii) All Wastewater Facilities Charges and interest thereon shall be deposited in the sewer service fund and shall be used solely for the purposes of design and construction, including costs of financing, and for administration, inspection and engineering costs of the city directly related to the enhancement of treatment capacity at the POTW treatment plant and appurtenant facilities.

(iv) The Council may review and amend the Wastewater Facilities Charge by amending the Master Fee Resolution from time to time to reflect inflation or any change in the factors affecting the cost of constructing such wastewater treatment facilities or the estimated number of units to be served by the facilities. The Council shall eliminate the charge at such time as revenues are no longer needed to enhance capacity at the POTW treatment plant or to pay the debt service related to capacity enhancement.

(b) When land is subdivided prior to the time the Final Map or Parcel Map is approved, the owner shall pay or cause to be paid all applicable sewer connection charges, except that the Wastewater Facilities Charge applicable to residential subdivisions shall be paid at the time of the issuance of a building permit for any structure to be constructed on such property.

(c) Payment of charges and issuance of permits pursuant to this section do not authorize the permittee to perform or cause to be performed work specified in this article to be performed by the city.

(d) Whenever the Council, the Board of Supervisors of the county, or the Board of a special district, whichever is applicable, has adopted a resolution of intention to construct regional sewer system improvements, no permit for additions to or connection to the regional sewer system to serve any lot included in the district subject to such resolution shall be issued until the hearing of protest has been finally determined in favor of the protestants or the proposed work has been consummated sufficiently to allow the lot to be served by such regional sewer system improvements.

(e) Payment of Lateral Sewer Charges pursuant to subdivision 9-503(a)(1), Oversize Sewer Charges pursuant to subdivision 9-503(a)(2), and House Branch Sewer Charges pursuant to subdivision 9-503(a)(4) may be deferred until issuance of a certificate of occupancy pursuant to an agreement which conforms to the requirements of Section 12-4.604.

(f) Payment of Trunk Sewer Charges pursuant to subdivision 9-503(a)(5), and Wastewater Facilities Charges pursuant to subdivision 9-503(a)(6) related to a business shall be deferred until issuance of a certificate of occupancy and collected pursuant to the requirements of Section 9-505.1.

(Orig. Ord. 4726; Am. Ord. 5777, 1960; Am. Ord. 5834, 1960; Am. Ord. 6261, 1963; Am. Ord. 6466, 1964; Am. Ord. 6821, 1966; Am. Ord. 6882, 1966; Am. Ord. 67-48, 1967; Am. Ord. 67-49, 1967; Am. Ord. 69-41, 1969; Am. Ord. 72-140, 1972; Added Ord. 72-170, 1072; Am. Ord. 73-84, ' 2, eff. 5-20-73; Am. Ord. 74-18, ' 1, eff. 3-10-74; Am. Ord. 75-11, ' 1, eff. 4-1-75; Am. Ord. 75-69, ' 4, eff. 7-27-75; Am. Ord. 75-96, ' 1, eff. 10-19-75; Am. Ord. 80-59, ' 5, eff. 5-9-80; Am. Ord. 80-115, ' 99, eff. 8-8-80; Am. Ord. 80-164, ' 4, eff. 12-5-80; Am. Ord. 82-82, ' 1, eff. 9-17-82; Am. Ord. 82-100, ' 2, eff. 10-15-82; Am. Ord. 83-122, ' 1, eff. 9-30-83; Am. Ord. 85-9, ' 1, eff. 2-15-85; Am. Ord. 85-22, ' 2, eff. 3-22-85; Am. Ord. 90-84, ' 6, eff. 8-31-90; Am. Ord. 90-123, ' 1, eff. 12-7-90; Am. Ord. 91-32, ' 1, eff. 5-10-91; Am. Ord. 92-69, ' ' 6, 7, eff. 9-25-92; Am. Ord. 95-38, ' 1, eff. 6-9-95; Am. Ord. 96-62, ' 1, eff. 10-25-96; Am. Ord. 98-87, ' ' 6, 7, eff. 1-9-99)

Appendix C
Fresno County Ordinance
Mandatory Sewer Connection Regulations

Chapter 14.12 MANDATORY SEWER CONNECTION REGULATIONS

14.12.010 Purposes.

14.12.020 Definitions.

14.12.030 Mandatory sewer connections.

14.12.040 Permits.

14.12.050 Administrative exception.

14.12.060 Violation--Penalty.

14.12.010 Purposes.

The board of supervisors of the county declares and finds that it is necessary to establish mandatory sewer connection regulations for the removal of sewage in those areas in the unincorporated area of Fresno County where public sewers are available in order to promote and protect the public welfare, safety, peace, comfort, convenience and general welfare and thereby obviate the danger to the public safety and welfare arising from placement of sewage upon individual parcels of property. (Ord. 470-A-39 § 2 (part), 1974)

14.12.020 Definitions.

A. "Unit" means any dwelling unit, apartment unit, guest room, residential trailer coach, each one thousand square feet of gross floor area or fraction thereof of a commercial building or building for similar use, and ten thousand square feet of net land area or fraction thereof devoted to an industrial, institutional or similar use.

B. "Premises" means all contiguous property under one ownership at the time of the last equalized assessment roll or thereafter becomes under one ownership at the time of application for a permit, as hereinafter provided in Section 14.12.040, any part of which is developed to be used as an occupancy, business, public gathering or meeting place.

C. "Availability of a public sewer" means a public sewer which has been constructed and is available for use in any public street, alley or right-of-way within one hundred feet of the first unit, plus fifty feet for each additional unit, to be measured along such public street, alley or right-of-way from the nearest point on the premises to the sewer. For the purposes of this chapter, the number of units computed shall include all units developed on contiguous property held under one ownership.

A public sewer shall also be deemed available where it is located within one hundred feet of a block or contiguous blocks and when

each block has on-site unit improvements upon premises comprised of more than fifty percent of the street frontage measured along either side of any one block.

A public sewer shall also be deemed available when more than four dwelling units are built upon a premises subsequent to May 8, 1969, and the distance in feet from the public sewer to the premises is equal to or less than the measurement determined as follows: $(50)(N-5)^{1.15} + 300$, where N equals the number of dwelling units or apartment units upon the premises.

D. "Block" means property facing on both sides of any street between the next intersecting streets or between the terminus of a street and an intersecting street.

(Ord. 470-A-39 § 2 (part), 1974.)

14.12.030 Mandatory sewer connections.

A. Every building or structure in which plumbing fixtures are to be initially installed and every premises having existing piping installed thereon which conveys sewage or other liquid waste to an approved point of disposal shall be connected to the public sewer, if it is available.

B. Notwithstanding any provision to the contrary, buildings or structures connected to a septic tank or cesspool, at the time a public sewer becomes available, shall be connected to the public sewer within three years after the sewer becomes available and written notice thereof given by the county provided that if the health officer determines the continued use of the septic tank or cesspool will create a health menace, the property shall be connected within the time specified by the health officer.

C. No person shall cause, suffer or permit the disposal of sewage, or other liquid wastes, into any drainage system on any lot which is not connected to a public sewer when such connection is required by this section.

D. Mandatory sewer connection shall not apply to wastewater from fruit processing operations to be reused for beneficial purposes through land application as a supplement to agricultural water supplies, providing the California Regional Water Quality Control Board has issued waste discharge permit on such land application.

(Ord. 96-015 § 1, 1996; Ord. 470-A-39 § 2 (part), 1974.)

14.12.040 Permits.

A. No permit shall be issued for the installation, alteration or repair of any private sewage disposal system, or part thereof, on any lot for which a connection with a public sewer is available.

B. No person shall connect any lot to any public sewer or house branch sewer without a permit from the building official.

C. No sewer connection permit shall be issued by the building official until all applicable fees have been paid.
(Ord. 470-A-39 § 2 (part), 1974.)

14.12.050 Administrative exception.

The building official shall grant an administrative exception to the requirement of a public sewer connection if he determines that any one of the following conditions exist:

A. A city requires annexation as a condition precedent to connection to a public sewer;

B. The public agency requires unreasonable conditions as condition precedent to connection to the public sewer; rates shall not be considered;

C. Physical conditions between the public sewer and the premises make it impractical to connect to the public sewer;

D. When the premises is served by community water supply and:

1. The unit density for dwelling units is less than one unit per thirty-six thousand square feet, or

2. The density of fixture units as defined in the Uniform Plumbing Code, 1964 Edition, Table 4-1, for the improvements on industrial, commercial, institutional or similarly used premises is less than one per two thousand square feet of premises;

E. Where the premises is served by a private water supply and:

1. The unit density for dwelling units is less than one hundred thousand square feet, or

2. The density of fixture units as defined by the Uniform Plumbing Code, 1964 Edition, Table 4-1, for improvements for industrial, commercial, institutional or similar used premises is less than one per six thousand square feet of premises;

F. The premises is within any block where a public sewer connection is required within three years, provided such exception shall expire at such time as the public sewer is extended to serve the units within the block.

If the building official determines that none of the above conditions exist, the property owner may appeal his decision within thirty days to the board of review, who shall conduct a hearing thereon. The decision of

the board of review shall be final. (Ord. 470-A-39 § 2 (part), 1974.)

**14.12.060 Violation--
Penalty.**

The penalty for violation of any of the provisions of this chapter shall be as prescribed in Section 1.12.010. (Ord. 470-A-39 § 2 (part), 1974.)