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FINAL GROUNDWATER REMEDIAL INVESTIGATION REPORT

DEL AMO STUDY AREA
LOS ANGELES, CALIFORNIA

Volume I
Text, Tables & Figures

FOR

SHELL OIL COMPANY

AND

THE DOW CHEMICAL COMPANY

PREPARED BY:

DAMES & MOORE

MAY 15, 1998

FINAL
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LOS ANGELES, CALIFORNIA

This Groundwater Remedial Investigation Report for the Del Amo study area was prepared by Dames & Moore in a manner consistent with the level of care and skill ordinarily exercised by professional geologists. To the best of my knowledge, the Remedial Investigation procedures described in the report were conducted in accordance with currently accepted methods and the associated data and findings are technically accurate and complete.

Thomas A. Vinckier

Thomas A.Vinckier, R.G., C.HG.

Registered Geologist
State of California No. 003707
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May 15, 1998

Jeffrey A. Dhont
U.S. Environmental Protection Agency, Region IX
Mail Stop SFD-7-1
75 Hawthorne Street
San Francisco, California 94105

RE: Administrative Order on Consent (AOC): U.S. EPA Docket No. 92-13
Final Groundwater Remedial Investigation Report
Del Amo Study Area
Los Angeles, California

Dear Mr. Dhont:

Enclosed please find one copy of the above-referenced final report. Enclosed with the report are written responses to all comments received from USEPA on earlier drafts of the report. Per your request, additional copies of the completed final report with all appendices will be sent to USEPA, and other agencies and interested parties, in accordance with the attached distribution list. Please contact me or John Dudley of Dames & Moore if you have questions or require additional information.

Sincerely,

C.B. Paine /sba

C.B. Paine
Project Coordinator For Respondents

Attachment

ENCLOSURE

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FIRST INSTALLMENT EPA COMMENTS ON DRAFT DEL AMO GROUNDWATER REMEDIAL INVESTIGATION REPORT

OVERALL COMMENTS

Overall, the Remedial Investigation (RI) report is a comprehensive, well written and documented report. There are a few data gaps that need to be filled in and additional evaluations that will need to be addressed in the final RI report. These additional tasks are listed below, and elaborated in the general and specific comments:

- *Quantification of vertical gradients based on measured potentiometric heads*
- *Display of inorganic constituents of concern and discussion of those inorganics, particularly with respect to reinjection of extracted groundwater*
- *Discussion of organic and inorganic concentrations relative to regulatory standards*
- *Expansion of discussion on geochemical indicators of biodegradation in the hydrostratigraphic units below the water table*
- *Provide information on local water supply wells other than the municipal wells*

Although the hydrostratigraphic interpretations presented are generally acceptable for use to develop the groundwater model and proceed with evaluations in the Feasibility Study (FS), there are several general and specific comments that need to be addressed regarding inconsistencies between tables and figures. In addition, at some locations, the thickness of some of the aquitards seems to be overestimated.

GENERAL COMMENTS

[A]. Conceptual Model, Sec. 3

Hydrostratigraphic Interpretations. *Overall, the hydrostratigraphic interpretations are reasonable. However, there are several inconsistencies that were noted among the cross sections, the hydrostratigraphic unit thickness and basal elevation tables, and the hydrostratigraphic unit contour maps. These inconsistencies are summarized in a comment table in the specific comments section. In some cases, aquitard thicknesses displayed on the cross sections are thinner than those listed in Table 3.2-2.*

Response: Each noted inconsistency has been addressed and a description of the type of response (i.e., any changes to figures, tables, or cross sections) is presented in the last column of Table 1 (attached).

[B]. Groundwater Cond., Sec. 4

Groundwater Flow. *The text does not include a quantitative evaluation of the vertical gradients between the more permeable hydrostratigraphic units.*

This section describes observation of a rise on groundwater elevations in all units of approximately 1 foot per year since 1965 (confirmed by hydrographs). The Section does not provide an explanation for the rise on groundwater elevations. Why are the water levels rising?

Is there some regional cause (i.e., modifications in basin operational scheme such as reduced production or increased injection)? This should be addressed.

Aquifer Properties. *This section is a bit confusing to review because it is difficult to identify which wells were analyzed in each test. For example, the ratio test wells are listed in tables and mentioned in text, but the recovery test wells are only listed in a table, and the slug test well is only identified in Appendix H in the title of a figure illustrating the data curve. It should be better organized by stating in text which wells are tested as representative of each unit, and then mentioning that schematic diagrams of each well's construction is included in the appendix.*

Response:

Groundwater Flow

The text has been modified to provide a more quantitative evaluation of vertical gradients. Vertical gradients between the more permeable hydrostratigraphic units have been calculated for each well cluster present in the study area and a range and average value reported.

The documented rise in groundwater levels may be associated with adjudication of the basin in 1961 and a corresponding decrease in pumping. This has been added to the text.

Aquifer Properties

The text has been modified as suggested, to include a list of each well tested by unit and referencing the location of the schematic diagrams.

[C]. Nature and Extent, Sec. 5
Total Dissolved Solids (TDS). *The text does not adequately address dissolved inorganics. In particular, concentration plots of total dissolved solids and nitrate, and other constituent of concern should be added.*

In Section 7, although statements are made regarding the unsuitability of the Upper Bellflower Aquitard and Gage Aquifer as drinking water supplies due to high TDS concentrations, no TDS concentration maps are presented to support the discussion. In addition, it is not stated (and should be) that the water is classified as potential drinking water by the State of California.

Also, if water is to be injected into selected areas , it will be important to establish background inorganics of concern, especially in the areas where reinjection is proposed.

Metals. *The text includes statements that elevated metals concentrations (above MCLs) are naturally occurring and not related to Del Amo site activities. Additional discussion needs to be added to support these statements (see specific comments).*

Qualification of Statements on Contaminant Trends. *Section 5.2 discusses the statistical basis used to evaluate whether increasing and decreasing concentration trends are statistically significant (Appendix G2). Subsequent statements about concentration trends in Section 5 are*

not qualified as being "statistically significant" trends. The discussion of any concentration trend in Section 5 should be so-qualified.

Discussion of MCLs. *The text is inadequate in regard to: (1) including primary or secondary MCL values, and (2) discussing concentrations of contaminants relative to each contaminant's MCL. Ideally, MCLs should be discussed in the text and presented in tables and on plots. In Section 5, the MCL is not included on any of the 41 contaminant display maps (Figures 5.2-1 to 5.2-41) nor the table (Table 5.2-1). In addition, very few MCLs are discussed in the text in Section 5. The text should include a discussion of VOC concentrations relative to MCLs.*

Response:

Total Dissolved Solids
A brief characterization of general groundwater chemistry for each HSU, including total dissolved solids, is presented in Section 4.3 of the document. This section has been modified to include brief text and figures describing the distribution of TDS concentrations for each HSU. The distribution of nitrate concentrations for Del Amo monitoring locations is included in discussions of biodegradation indicators (Section 6), and illustrated on Figures 6.2-7 (water table), 6.2-12 (MBFB), 6.2-17 (MBFC), and 6.2-22 (Gage aquifer). Discussion of the status of the Bellflower aquitard as a drinking water supply is presented in Section 7 of the report.

The Respondents' believe that with the modifications to the text and figures regarding TDS and metals described herein, the report will adequately describe inorganic conditions at the study area. Data regarding other inorganic parameters that may be of interest to the reader are available in Appendix G1.

Metals
Please refer to the response for specific comment No. 29.

Qualification of Statement on Contaminant Trends
Discussions of trends in the text are limited to those trends that are statistically significant. The text has been modified to make this clear.

Discussion of MCLs
The Respondents have modified the appropriate text, figures, and tables to take into consideration MCLs.

[D]. Sec. 6, Biodegradation
Electron Acceptor Consumption in Each Hydrostratigraphic Unit. *In Section 6.2.5, the data presented to demonstrate biodegradation using the AFCEE protocol isappears* [sic] *adequate at this time. The interpretation of which electron acceptors are facilitating biodegradation processes in the water table zone also appear acceptable.*

However, although concentration contour plots of electron acceptors in the Middle Bellflower B sand are included, biodegradation in this unit is not discussed.

The discussion of electron acceptors in the Middle Bellflower C Sand and Gage Aquifer suggests that there is insufficient data to draw conclusions about which electron acceptors are contributing to biodegradation of hydrocarbons.

Upgradient vs. In-Plume Comparison of Electron Acceptor Concentrations. *The AFCEE protocol recommends a comparison of upgradient and in-plume concentrations of electron acceptors. The difference between the concentrations will enable assessment of the amount of each electron acceptor consumed by biodegradation. See specific comments in Subsection 6.2.5.3.*

Response: See response to Specific Comment No. 37.

[E]. Sec. 7, Water Supply Wells
The discussion of water supply wells is incomplete, only five existing and one new municipal supply wells are discussed. In the Preliminary Review Draft of the Remedial Investigation Report for the Montrose Site (Hargis + Associates, 1996), 34 water supply wells were located within 2 miles of the Montrose site (directly adjacent to Del Amo). These 34 wells include six public water supply wells, eight industrial water supply wells, eight domestic water supply wells, and 12 irrigation supply wells. The Del Amo RI report should add a discussion of the domestic, industrial, and irrigation water supply wells within 2 miles of the Del Amo site.

Response: Section 7 of the Groundwater RI report has been expanded to include a discussion of all water supply wells located within a two-mile radius of the Del Amo plant site, including those designated for municipal, domestic, irrigation and industrial supply purposes. Information for all wells has been tabulated and includes the following, as available: well identification; owner(s); location with respect to distance from site and position relative to groundwater flow direction; year of installation; depth; screened interval(s); use; operational status; water production within the past two water years; and, hydrostratigraphic unit completion zones. Information sources used to compile these data include recent Watermaster Service reports and other publicly available groundwater resources-related publications, as well as prior studies conducted by Dames & Moore and Hargis + Associates in the area.

[F]. Appendix G
Additional documentation needs to be provided regarding the statistical analysis of contaminant trends. The text should include a definition of the confidence interval used around the slope of the regression line.

Response: The text has been modified to include a statement regarding the confidence level for the identified trends. The trends were identified using a default setting of 99% confidence. That is, 99 out of every 100 trends that are identified are in fact "real," and not due to random variation in the data. The confidence level takes into account both the number of concentration values used and the scatter of the points relative to the best fit (least squares regression) line. In this way, if relatively few concentration values are available, the scatter about a best fit line must be very low to achieve the 99% confidence level necessary for trend identification.

[G] Appendix H
In general, the aquifer test analysis using the ratio method is not described in sufficient detail in Appendix H to evaluate the validity of the results presented in Table 4.2-3. Additional information is needed, and some clarification is required regarding some of the (pumped) aquifer parameters used in estimating values of drawdown s, in the pumped aquifer and dimensionless time t_D.

Response: The text has been modified, as suggested, to include additional detail in Appendix H regarding the ratio method analyses. This comment is further addressed under Specific Comments 47, 52, 53 and 54.

SPECIFIC COMMENTS
1. Table of Contents
In the list of tables, the title for Table 3.2-2 is different than the title of the table in the report.

Response: Care has been taken to ensure that the Table of Contents accurately lists the titles of all figures and tables as they appear in the main body of the Groundwater RI report.

2. p. ES-3, par. 1, last sent.
To be more accurate and consistent with descriptions in the main body of the text, the structural dip direction should be revised to "east to northeast", not just "northeast".

Response: Comment acknowledged. The wording in the Executive Summary has been revised to indicate an east to northeast structural dip of stratigraphic units beneath the study area.

3. Sec. 1.1, bullet 1
The first bullet should be reworded for clarification. All of the hydrostratigraphic units of concern, including the aquifers and aquitards, are "water-bearing" units. Clarify if the focus is on higher-permeability units or on both aquifers and aquitards.

Response: Wording of the first bullet has been revised to indicate that stratigraphic investigations were conducted to evaluate the distribution and physical character of aquifer and aquitard units beneath the study area, and that this information was used to guide investigations of groundwater flow and contaminant transport within the identified hydrostratigraphic units.

4. Figure 1.0-1
The box near lower left of flow diagram has a typographical error. The word should be "contaminant" instead of "containment".

Response: Comment acknowledged. The typographical error noted in Figure 1.0-1 has been corrected.

5. Secs. 1.3.1 and 1.3.2
Several features described in these sections are not displayed on the Figures in the text. Features missing include the Santa Ana Mountains and San Joaquin Hills (p. 3-1), anticlinal domes from Gardena to Playa Del Rey and through Wilmington to Torrance (p. 3-2, neither

cities nor features displayed), and the Gardena syncline (p. 3-3). Please add these features and/or describe their locations in relation to information presented on the figures.

Response: It is believed that the comment reference to "*Sects. 1.3.1 and 1.3.2*" actually applies to Sections 3.1 and 3.2. The requested cultural and geographic features have been added to Figure 3.1-1. An additional figure has been prepared (Figure 3.1-2) to illustrate major geologic structures within the West Coast basin, including the Gardena syncline, the northwest-southeast trending zone of anticlinal domes and the Newport-Inglewood structural zone.

6. Sec. 2.2.2, par. 1, last sent.
The statement about characterizing all dissolved constituents in the last sentence needs to be qualified. The vertical and horizontal extent of all dissolved inorganics (e.g., TDS and nitrate) are not defined in Section 5. In addition, this report also does not fully characterize the extent of dissolved VOCs in the target water bearing zones that are related to activities at adjacent facilities. The broad statement implies that the extent of VOCs from adjacent sites is also characterized.

Response: Sufficient field and laboratory data for dissolved inorganic constituents are available for all aquifer units and these data are sufficient to define the lateral and vertical extent of these constituents within the Del Amo study area. Concentration contour diagrams illustrating nitrate within the hydrostratigraphic units under investigation are presented in Section 6 of the draft Groundwater RI report, and figures illustrating TDS data for all units have been added to Section 5 of the revised document.

Groundwater investigations conducted as part of the current study were not intended to characterize conditions related to past or current activities at adjacent facilities, but have focused upon evaluating the character and distribution of VOCs primarily within and down gradient of the former Del Amo plant site. Conditions related to adjacent facilities have been evaluated to the extent that: (1) dissolved contaminants attributable to past or current activities at these facilities have migrated beneath the study area, and coalesced with contaminant plume(s) associated with prior Del Amo plant site activities; and/or, (2) dissolved contaminants attributable to nearby, unrelated facilities may be influenced by possible groundwater remedial actions. Additionally, considerable effort has been made to compile and evaluate existing groundwater data from nearby facilities to assist in developing an understanding of regional conditions to support the groundwater flow and contaminant transport model. The distribution of principal contaminants of concern from these adjoining facilities is illustrated in Figures 5.3-2, 5.3-3 and 5.3-4 of the Groundwater RI report.

The wording in question has been modified to reflect an emphasis upon groundwater contamination apparently emanating from the Del Amo plant site. An additional statement has been added in the revised text to indicate the regional groundwater data compilation effort completed to support the groundwater flow and contaminant transport modeling conducted as part of the Groundwater FS.

7. Sec. 3.1.2, p. 3-3, last par.
The second sentence incorrectly states that the "Gage aquifer is not utilized as a source of groundwater in this part of the basin". According to Section 7.2, three municipal supply wells

within 2 miles of the Del Amo site, owned by the City of Torrance, are partially completed within the Gage Aquifer.

Response: Paragraph has been modified to read as follows "As further discussed in Section 7.0, the underlying Gage aquifer is not utilized as a source of drinking water by the major water purveyor in this area (Dominguez Water Company, personal communication, 1993, 1996a, 1996b). However, limited groundwater is apparently produced by the City of Torrance from several municipal supply wells completed partially in the lower portion of the Gage aquifer. These wells are located approximately two miles southwest of the former plant site in a cross gradient position."

8. Sec. 3.2.1, par. 2, last sent.
As more accurately stated in Section 3.1.2, the units dip to the "east to northeast", not just to the "northeast".

Response: This sentence has been changed to be consistent with the statement in Section 3.1.2 and read "east to northeast".

9. Sec. 3.2.2.2
Define the term and use of the word "mud" in this section. According to the American Geological Institute's Dictionary of Geological terms, a mud is a sticky, fine-grained marine sediment consisting of silt or clay sized material. The lithology of the Middle Bellflower Mud described in this section is that of silts and very fine sands, not silts and clays. In other subsections (e.g., 3.2.2.3 to 3.2.2.5), the term "muddy" is generically used to describe some of the sediments in the deeper units.

Response: The terms sand, mud, and muddy and their usages with respect to this report have been defined in a new second paragraph to Section 3.2.1. The intent is to retain the descriptive term "mud" to describe the generally fine-grained, low permeability nature of the MBFB, LBF, GLA, and portions of the UBF. However, the usage of the term has been clearly defined and used consistently throughout the Groundwater RI report.

10. Secs. 3.5.1 and 3.5.2
An alternate interpretation of the depositional environment of the Gage Aquifer is that the deposits are transitional between near shore marine and coastal estuary deposits. The lateral continuity of this unit in the West Coast Basin suggests this type of environment rather than purely a coastal estuary. This section should also include this alternate interpretation.

Response: We agree that the lateral continuity of the Gage aquifer, basin wide, could suggest a depositional environment transitional between near shore marine and coastal estuary. This interpretation is consistent with the CDWR Bulletin 104 description of the Gage aquifer as being composed "mainly of mixed continental and marine, or in some areas, solely marine sediments." However, the sedimentary structures and depositional sequences observed in core samples retrieved from the Gage aquifer at numerous locations across the study area clearly indicate deposition of this unit in a tidal channel of a coastal estuary environment. The cross stratification, basal shell lag, repeating fining up sequences, and pervasive bioturbation observed

in the core samples would not support a near shore or transitional interpretation. It is entirely consistent to have portions of "transitional" deposits reflect only one of the two environments.

To address this comment the Groundwater RI report sections 3.2.2.4 (Gage aquifer), and 3.5.2 (Depositional Setting) have been modified to further support the coastal estuary depositional interpretation and provide a discussion of the basin-wide interpretation presented in CDWR Bulletin 104.

11. Sec. 3.5.3
The major structural features, including major folds and faults in the West Coast Basin should be displayed and a discussion of the these features and their effect (or lack of effect) on the Del Amo site should be included. The text mentions the Gardena syncline but its location is not adequately described nor displayed.

Response: As discussed in the response to Specific Comment 5, a new Figure 3.1-2 has been added to Section 3 which illustrates the major geologic structures within the West Coast Basin. The discussion of the effect of the local structure on the hydrostratigraphic model has been expanded in Section 3.5.3

12. Figure 3.4-1
To be consistent with the text in Section 3.2.2.2 (UBF average thickness of 65 feet and MBFM thickness of 7 feet), the average thickness of the MBFM in Figure 3.4- should be changed from 10 to 7 feet.

Response: Based upon the comments provided in Table 1 (attached), modifications to hydrostratigraphic unit thicknesses have been made and new average thicknesses have been calculated. These new average thicknesses are included in the revised Figure 3.4-1 and accompanying text descriptions. Effort has been made to ensure consistency throughout the revised document regarding hydrostratigraphic unit thicknesses.

13. Sec. 3, Cross-Sec. Figs.
In general, the hydrostratigraphic interpretations on the cross-sections appear reasonable. In some cases, there are inconsistencies between the cross-sections and the tables that list elevations and thicknesses of the units. The attached table lists (Table 1) areas that these inconsistencies were noted and areas where alternate hydrostratigraphic interpretations are recommended.

In order to facilitate the consistency of interpretations among cross sections, the location of cross-section intersections should be added to the cross sections.

Response: Responses to comments regarding inconsistencies between cross sections and tables are presented in the last column of Table 1 (attached). Cross section intersections have been added to all cross sections to facilitate consistency.

14. Sec. 3, Thickness Figs.
The final RI report should include hydrostratigraphic unit thickness figures for each hydrostratigraphic unit.

Response: Thickness figures for each hydrostratigraphic unit have been added to the revised Groundwater RI report.

15. Sec. 4.1.2, p. 4-2, par. 3
The text should provide an explanation (or set of reasonable possibilities and the information which would support them) for mounding of water at the Del Amo Waste Pit Area.

Response: The possibility of leaking water supply pipelines and/or sewer pipelines are stated in the text as possible reasons for mounding of groundwater in the vicinity of the Waste Pit Area. The Respondents have no additional information by which to verify this possibility, nor any information that would suggest other likely mechanisms for the mounding.

16. Sec. 4.1.2, p. 4-3, par. 2
The text should reference the location (i.e., specific appendix) of the upper Bellflower effective porosity data discussed in this section. This same comment applies to the discussion of deeper hydrostratigraphic units in subsequent sections.

Response: The text has been modified to reference Appendix F1 as the location where physical testing data, including effective porosity, can be found.

17. Sec. 4.1, gradients
The gradient values used to calculate groundwater flow velocities are reasonable average values. However, the water table and Bellflower B Sand potentiometric contour maps have a wide range of gradients across the site. For example, in the areas that mounding occurs at the water table, the gradient may be as much as an order of magnitude higher than the average value used to estimate the groundwater flow velocity. The text should provide a range of hydraulic gradients and explain where the gradients differ.

Response: Calculation of gradient values is subjective in that it depends on the size of the area of interest. The Respondents have modified the text to indicate a range and site average for the gradient in the water table and MBFB, and indicate the areas where the gradient appears to be at a maximum and minimum.

18. Sec. 4.1.7
This section needs to address the following topics:

- *Explain the significance of the decreasing heads with depth in relation to dissolved contaminant transport.*
- *Explain the magnitude of the vertical gradients and explain where and when the gradients are reversed (upward).*
- *Describe the hydraulic links between the Gage and Lynwood Aquifers with the shallower units. Do the units seem to be hydraulically connected? Do they display the same water level fluctuations with time?*

Response: The Respondents believe that it would be inappropriate to link contaminant transport with decreasing hydraulic heads in Section 4.1.7, as hydraulic head is only one of many factors that determine contaminant transport. A more complete discussion of factors affecting

contaminant transport is presented in Section 6. The text has been modified to reflect the following discussion:

Decreasing hydraulic head with depth indicates only a *potential* for downward groundwater flow and contaminant transport. While interpretive, the potentiometric groundwater elevation contours (Plates 4-2 through 4-4) more effectively illustrate groundwater flow direction in the vertical plane than discussion of hydraulic head or vertical gradients. Plates 4-2 through 4-4 illustrate that groundwater flow is generally vertical in finer grained units, and generally horizontal in coarser grained units. An example of the evidence supporting this is the similar groundwater elevations in the upper and lower Gage aquifer (XG-02 and XLG-01, respectively). Furthermore, because of typically large differences between the vertical hydraulic conductivities in the finer grained aquitards and the horizontal hydraulic conductivities in the coarser grained aquifers (up to several orders of magnitude), horizontal flow velocity greatly exceeds vertical flow velocity.

The text has been modified as suggested to include a quantitative summary of vertical gradients and identify where the gradient is reversed. All reversed gradients have been identified based on Third Sampling Period 1995 groundwater level measurements.

The text has also been modified to include inferences regarding hydraulic interconnection. Based on the similarity in groundwater elevations and changes in groundwater elevations through time, the water table, MBFB, and MBFC are likely hydraulically interconnected. The Gage aquifer is reported to be merged with the overlying units approximately ½ mile west of the plant site. The hydraulic interconnection between the Gage aquifer and overlying units is likely significantly decreased in the plant site vicinity by the presence of the LBF aquitard, and it is therefore believed that the distal area of merging is largely responsible for the mirrored water level fluctuations in the Gage aquifer and overlying units at the plant site. It is important to keep in mind that while some degree of hydraulic interconnection across the LBF aquitard beneath the site likely exists, vertical flow of ground water across the aquitard is comparatively small compared to the horizontal flow in the adjacent MBFC and Gage aquifers.

The Lynwood aquifer is relatively isolated from the overlying units. This judgement is based on the observed presence of the Gage-Lynwood aquitard, the approximately 11 foot difference in groundwater levels between the Lynwood and Gage aquifers, and fluctuations in Lynwood aquifer groundwater elevations that are not mirrored in overlying units.

19. Section 4.3

The report should include TDS concentration contour maps for each hydrostratigraphic unit. Without these maps, the statements about the majority of wells completed at the water table and in the Middle Bellflower C Sand being above the TDS MCL are not well supported.

Response: The report has been modified to include maps presenting TDS data for each HSU.

20. Plate 4.1-1

The points denoted with diamonds on the historical hydrograph are labeled as XBF-06 in the legend and XBF-02 on the graph. This inconsistency should be corrected.

Response: Figure 4.1-1 has been corrected to be consistent between the explanation and the hydrograph.

21. Sec. 4, Plates
The date of potentiometric groundwater contour elevation measurements should be clearly indicated on the potentiometric groundwater elevation contour plates. Where no data is available and the potentiometric contours are inferred, the contour lines should be dashed. Where contour lines are extended well beyond the available data, the contours should be queried.

Response: The potentiometric groundwater contour elevation plates have been modified as suggested.

22. Plate 4-3
The note in the lower left hand corner that refers to Boring XEB-09 appears to be misplaced (this boring is not on Plate 4-3). We believe this note should have been placed on Plate 4-4 where this boring is located.

Response: Plate 4-3 has been modified as suggested.

23. Sec. 5.2, par. 1, last sent.
The references to the section numbers are switched.

Response: The references to the section numbers have been modified as suggested.

24. Sec. 5.2.1.1, p. 5-6, par. 2
The wording of the first sentence should be changed from "Trends of ..." to "Statistically significant trends of ..." This comment applies to all of the statements made in this subsection and the rest of the text regarding increasing or decreasing trends of contaminants. The text incorrectly implies that concentration increases have been limited to only one well rather than more accurately qualifying the statistical basis of the statement.

Response: The text has been modified to indicate that only statistically significant trends of increasing or decreasing concentration are discussed.

25. Sec. 5.1.2, par. 1
The text should note that the reason DNAPL is suspected along the western plant site boundary is that past TCE concentrations were above 1% of the TCE solubility limit (11,000 ug/L) in water table wells. That is, TCE concentrations for samples collected between February and August 1993 and also in June 1995 were in excess of 1% of the TCE solubility limit. Because current dissolved concentrations of TCE (since June 1995) are less than 1% of the solubility limit, we recommend that this information be added.

Response: The text has been modified as suggested.

26. Sec. 5.2.1.4, par. 1
The paragraph should include the MCL for each metal.

Response: The text has been modified to include the metal MCLs as suggested. The introductory text for Section 5.2 has also been modified to explain that while MCLs are provided and discussed to put concentrations in perspective, MCLs are not clean-up standards, but rather drinking water point-of-use and municipal well standards.

27. Figs. 5.2-8 and 5.2-19
The text should explain why detection limits for naphthalene at wells SWL0002 (30,000 µg/L) and SWL0004 (10,000 µg/L), and PZL0013 (5,000 µg/L) are so high relative to the other sampling locations.

Response: The text has been modified to explain that naphthalene detection limits are elevated at locations SWL0002, SWL0004, and PZL0013 due to high concentrations of other VOCs, chiefly benzene.

28. Sec. 5.2.2.4, par. 1
The paragraph should include the MCL for each metal.

Response: The text has been modified as suggested.

29. Sec. 5.3.2.4
The discussion of elevated metals concentrations is not adequate. For metals that have concentrations that exceed MCLs, the following questions need to be answered: Are elevated concentrations widespread and ubiquitous on and off-site, with no apparent pattern, suggesting that concentrations may be related to naturally occurring metals? Are concentrations elevated beneath any of the suspected source areas? Do metals concentrations vary significantly with time? Why are some arsenic concentrations elevated near the Del Amo Waste Pit Area? It is not appropriate to compare metals with a range of known concentrations for the entire state of California, as "background" must be ascertained locally, and it must be shown that there is no apparent pattern in the metals data.

Response: Please note that the report text has been corrected to reflect the corrected section number of 5.3.3.4 rather than 5.3.2.4.

Figures 5.2-11 and 5.2-22 have been modified so that the reader can more easily identify those locations with metals MCL exceedances and subjectively judge whether the distribution of metal MCL exceedances exhibits any patterns or clusters. Review of the existing metals figures indicates that the occurrence of metal MCL exceedances is not widespread. As explained in the text, many of the exceedances (notably aluminum and chromium) are limited to unfiltered samples, and are likely associated with sediment in the water rather than dissolved metals.

Comparison of the metals figures with other figures showing VOC and other contaminant plumes reveals no apparent correlations. Comparison with figures indicating areas of historical chemical storage or use (Plate 1-2) also reveals no consistent patterns. Review of the time-series data indicate that aside from the noted disparity between total and dissolved concentrations for some metals, most concentrations of metals with one or more MCL exceedances are relatively stable through time. An exception occurs for nickel at SWL0028, approximately 1500 feet south of the plant site, where the most recent result for nickel (October, 1994) is elevated relative to all

previous results which are less than the MCL for this compound (100 μg/l). The reason for the elevated concentration for the October 1994 sampling event is not known.

The metals figures do indicate that a cluster of exceedances for arsenic exists in the vicinity of the southwest corner of the site. The two locations near the south side of the Waste Pit Area with arsenic exceedances (SWL0008 and PZL0025) are considered part of this cluster. While not indicated on the figures as having an arsenic exceedance, location XMW-14 could also be considered as part of this cluster, since review of the time-series data indicates that the most recent arsenic concentration (the value used for consideration in the report) was only slightly below the MCL, and all previous values equaled or exceeded the MCL.

With the exception of those metal MCL exceedances related to unfiltered samples, the origins of the elevated metal concentrations are not known with any certainty. The elevated concentrations could be associated with either natural and/or anthropogenic sources from on or offsite areas. However, the metals detected at concentrations in excess of MCLs are not known to have been used or stored at the Del Amo plant site. Furthermore, the panhandle area near the southwest corner of the plant site, where the cluster of elevated arsenic concentrations exists, was kept fenced and separated from the rest of the plant site, and has no significant history of development or use.

30. Sec. 5.3.3.1, p. 5-18
The last sentence ends with "as oxygen content is likely to decrease with depth". The text should make a more definitive statement based on the actual dissolved oxygen data presented in Section 6.

Response: References to biodegradation and decreased dissolved oxygen content with depth have been deleted.

31. Table 5.2-1
Recommend that two additional columns be added to this table: (1) Number of locations analyzed and (2) MCL for each compound.

Response: The table has been modified as suggested.

32. Figure 5.2-2
Eight wells with concentrations above the benzene MCL of 1 ug/L are plotted on the map but are outside of the 1 ug/L contours. These include two wells near the northwest corner of the former copolymer plant (PZL0003 and CWL0046), three wells at the north end of the former butadiene plant (CWL0045, CWL0044, and CWL0022), one well on the former copolymer plant north of Knox Street (CWL0041 at 43.0 ug/L), and two wells near the east end of the Del Amo Waste Pit Area (PZL0022 and CWL0042). In addition, Well PZL0025, located near the west end of the Del Amo Waste Pit Area, has a benzene concentration of 12,000 ug/L and therefore should be located inside, not outside, the 10,000 ug/L (10^4) contour.

Response: The Respondents recognize that the contours do not in all cases reflect the posted concentration values at the locations indicated in the comment, and have modified some contours as indicated in the table below. It should be noted however, that concentrations posted at well

point locations represent one-time measurements from temporary installments with a screen length that is less than the permanent monitoring well locations. The one-time sampling of well points make the concentration data from these locations less reliable than the data for monitoring wells which have been sampled several or more times, allowing a history of concentration data to be developed. Furthermore, given the shorter screen length of the well points relative to monitoring wells, well point concentrations are not completely comparable to data for monitoring wells with longer screen lengths, and in some instances, may overestimate concentrations relative to what would be measured from a co-located monitoring well. Therefore, while well point data is taken into consideration in interpreting concentration contours, more weight is given to monitoring well data when available for a given area.

The following modifications have been made:

Location	Area	Modification
PZL0003	NW corner	None. October 1995 result anomalous. Six of eight results indicate benzene <0.5 μg/l.
CWL0046	NW corner	Extended queried 1 μg/l contour up to CWL0046.
CWL0022	butadiene plant	Added a queried circular contour around CWL0022.
CWL0045	butadiene plant	Added a queried semi-circular contour around the south side of CWL0045.
CWL0044	butadiene plant	None. Posted concentration is <1 μg/l.
CWL0041	copolymer plant	Added queried 1 and 10 μg/l circular contours around CWL0041.
PZL0022	Waste Pit Area	Corrected posted concentration to 1.3 μg/l, adjusted contour to go through PZL0022.
CWL0042	southern styrene plant	None. Data at PZL0018, PZL0022, and SWL0005 suggest that 1 μg/l contour lies to south of CWL0042. Given the greater reliability of the data at the permanent monitoring locations, these data are given preference.
PZL0025	Waste Pit Area	Moved 10,000 μg/l contour outside of (south of) PZL0025.

33. Figures 5.2-6 and 5.2-7

A 1 ug/L (10^0) contour line should be added to these water table figures. TCE and PCE occur above their MCL of 5 ug/L at several wells, but their locations are not readily apparent because the minimum concentration contour is 10 (10^1) ug/L. For example, at Well CWL0045, PCE and TCE were detected at 6 and 5 ug/L, but no contours are drawn around this well. A 1 ug/L contour line should also be added to the other TCE and PCE concentration contour maps in the deeper units (e.g., Middle Bellflower C Sand).

Response: The TCE and PCE figures have been modified as suggested.

34. Figs. 5.2-28 and 5.2-29

The text should explain why detection limits for the chlorinated hydrocarbons at wells XBF-04 (300 μg/L) and XBF-07 (500 μg/L) are so high relative to the other sampling locations. These detection limits are well above the MCLs for TCE and PCE. Also, the contour outside of Well SWL0054 on Figure 5.2-28 should be 10^2 instead of 10^0 ug/L.

Response: The text has been modified to explain that high chlorobenzene concentrations at locations XBF-04 and XBF-07 resulted in elevated detection limits for PCE at these locations. The labels for the contours around SWL0054 have been modified as suggested.

35. Figures 5.3-3 and 5.3-4

Please provide an explanation for the relatively square shaped contours east of the Del Amo site and north of Del Amo Boulevard. Alternately, adjust the contours. Some contours are located in areas where no data points are displayed.

Response: Compound concentration isopleths are based not only on concentration data points, but also upon knowledge of the boundaries of inactive landfills in the area that are likely to have influenced contaminant concentrations based on the nature of the land use and concentration data. The figures have been modified to include a note explaining the origin of the contours in question.

36. Sec. 6.2.3

The dispersivity values given in the last paragraph (e.g., longitudinal dispersivity is 1 foot) are not consistent with the preceding discussion in this section. According to the discussion in the text, longitudinal dispersivity should be about one-tenth of the scale of interest; given that the scale of the plume is closer to 1,000 feet than 10 feet, the longitudinal dispersivity should be closer to 100 feet (one-tenth of 1,000 feet) rather than 1 foot (one-tenth of 10 feet).

In addition, the text states that the lateral dispersivity should be one-tenth to one-third of the longitudinal dispersivity. The ratio of lateral dispersivity (0.5 feet) to longitudinal dispersivity (1.0 foot) is one-half which is too high according to the discussion. The text should provide additional references to support the dispersivity values used and/or explain why the values used in the model differ from the values recommended in the earlier discussion.

Response: The discussion of dispersivity values is intended to be used as a guide for development of site-specific values, and is based on a statistical evaluation of empirical data obtained from 59 sites. Starting with the reported empirical observations by Gelhar et al (1992), site-specific values were refined through the use of numerical modeling. Accordingly, the scale of interest is a function of the grid cell size used in the numerical model, 200 feet by 200 feet. Through sensitivity analyses and historical plume matching, the reported site-specific dispersivity values were developed. This information will be added to the revised text discussion.

37. Section 6.2.5.3
The text should include a discussion of the geochemical indicators of biodegradation in the Middle Bellflower B Sand; although plots of geochemical indicators are included (Figure 6.2-10 to 6.2-14), no mention is made of electron acceptor-specific biodegradation processes in this unit.

Response: The text has been modified to discuss the generally anaerobic conditions which exist in the MBFB. No comparison can be made between DO concentrations upgradient versus within the BTEX plume due to the presence of upgradient contaminant plumes from offsite sources. Similarly, nitrate and sulfate concentration distributions are equivocal. Methane distribution, however, strongly suggests the occurrence of methanogenesis in the MBFB.

38. Sec. 6.2.5.4
The text should cite references to support the statements that the literature biodegradation rates are consistent with the focused transport calibration values. The discussion should include references to biodegradation rates for conditions similar to Del Amo (i.e., similar mass of dissolved oxygen).

Response: Reported degradation rates for benzene vary. Rafai et al. (1995) compiled a table of field-derived benzene degradation rates ranging from nondetectable to approximately 70 days, with the average rate of about 350 days. Also Olsen and Davis (1990) report a half-life of 110 days. This information will be added to the revised text discussion.

39. Sec. 6.3.1, par. 2, sent. 2
The wording in this sentence should be changed. As written, the sentence implies that there was a discrete release event in the past and no subsequent releases.

Response: The text has been modified to indicate that the distribution of LNAPL in the well XMW-20 area is believed to be the result of low water table levels during the period over which LNAPL could have been released, in conjunction with the concurrent, and subsequent rise in the water table.

40. Sec. 6.4.1, sent. 1
The sentence should be modified to read "...that <u>continued benzene flux from source areas and</u> advective transport of benzene is <u>generally</u> balanced by biodegradation" (underlined portions are recommended new text).

Response: The referenced text has been modified to read: "...provide strong support for concluding that *continued benzene flux from remaining source areas, where present, and* advective transport of benzene is *generally* balanced by biodegradation."

41. Sec. 6.4.1, par. 1, last sent.
The sentence should be modified from "is controlled" to "is mainly controlled".

Response: The text has been modified as requested.

42. Sec. 6.4.1, par. 3, last sent.
A statement should be included about geochemical parameter evidence of biodegradation in the deeper aquifer units (see comment on Section 6.2.5.3).

Response: The report has been modified to indicate the following:
Time-series chemical data clearly demonstrate plume stability in deeper units, indicating transport and attenuation mechanisms are balanced. Although sufficient data are not available to discern which specific degradation processes is dominant, the presence of BTEX degrading organisms, methane, and stability of the benzene plumes in the higher permeability MBFC and Gage supports the conclusion that biodegradation is an active process in the lower HSUs. Further conclusions regarding the nature of the active biodegradation mechanisms are not supportable due to two principal conditions: (1) there are coincident and upgradient contaminant plumes which potentially impact measurable parameters used as biodegradation indicators; and, (2) dissolved contaminant distribution originating from the site becomes increasingly restricted in deeper HSUs. This later condition results in fewer data points required to define the nature and distribution, thus fewer data points to characterize the biodegradation processes which contribute to the observed plume stability.

43. Sec. 7.1, par. 1
According to Section 3 (see Figure 3.4-1), the Lynwood Aquifer is part of the Lakewood Formation, not the San Pedro Formation as indicated in this section. However, USGS Bulletin 104 (June 1961) includes the Lynwood Aquifer in the San Pedro formation. The inconsistency should be corrected.

Response: Comment acknowledged. The Lynwood aquifer lies within the San Pedro formation, and not within the Lakewood formation as indicated within Section 3. The text within Section 3 has been modified accordingly. Additionally, Figure 3.4-1 (Comparison of Stratigraphic Nomenclature) has been modified to accurately indicate the formational assignment of each identified HSU.

44. Sec. 7.2 and Table 7.2-1
The text should describe the position of the water supply wells in relation to groundwater flow from the Del Amo site. That is, are the wells up-, down-, or cross-gradient of Del Amo? Recommend that this information, and the distance between the Del Amo site and each well, be added to Table 7.2-1.

Response: As available, the requested information has been added to Table 7.2-1. See response to General Comment E.

45. Section 7.4.2, par. 2
In the last sentence, the wording should be changed from "...wells would..." to "...wells installed by the Dominguez Water Corporation would..."

Response: The statement in question has been deleted from the referenced paragraph and moved to the end of the preceding paragraph which discusses general water industry well construction practices in the area directed at preserving and protecting groundwater quality.

46. Appendix B
The elevations are missing from the lithologic log for SWL0021.

Response: Comment acknowledged. The missing elevations have been added to the lithologic log for boring SWL0021.

47. Appendix H
Derivation of drawdown s, in the pumped aquifer at the distance from the pumping well of the observation well in the aquitard is not shown. The text in each of Sections H1.2.1, H1.2.2, and H1.2.3 says that s was derived from the aquifer diffusivity and the Theis (1935) method, but no examples or equations are shown.

The values of storativity, S, that are cited in each of sections H1.2.1, H1.2.2, and H1.2.3 are not related in space to the values of transmissivity T, cited in each of these sections in derivation of t_D values. In other words, are the values of S from a portion of the pumped aquifer so far away so as to cause uncertainty in their applicability? It is clear that T was derived from analysis of recovery data from the pumping well. But what well was used to derive S? Also, there was no mention of the potential effects on the estimated values of T, if any, of partial penetration of the pumping wells (shown on Figures H1-1 and H1-2).

Derivation of t_D' from s'/s and the t_D curves should be presented in graphical displays.

Response:

Derivation of Drawdown, s

Derivation of drawdown s, in the pumped aquifer at the same radial distance from the pumping well as the observation well in the aquitard has been discussed in further detail, as suggested. The estimated drawdown (s) in the pumped aquifer at the same radial distance from the pumping well as the aquitard observation well was derived using the Theis (1935) nonequilibrium well equation, as follows.

$$s = \frac{Q}{4\pi T} w(u) \qquad (1)$$

where,

s = drawdown (ft)
Q = pumping rate (ft^3/min)
T = transmissivity (ft^2/min)
w(u) = well function

w(u) is the well function of *u* and represents an exponential integral:

$$u = r^2 \frac{S}{4Tt} \qquad (2)$$

where,

R	=	distance from center of pumped well to the point where drawdown is measured (ft)
S	=	coefficient of storage (dimensionless)
T	=	transmissivity (ft^2/minute)
t	=	elapsed time since pumping began (minutes)

In the case of our study, r is the distance from the pumped well to the location of the observation well in the aquitard. T was derived from analysis of the recovery data in the ratio method pumped well, and S values were obtained from previous pumping test studies (Hargis + Associates, 1990d).

The S values selected for each ratio method test analysis were from the closest available data point to the aquitard monitoring well location. S values for the MBFB/C sand were obtained from Theis drawdown analyses conducted by Hargis + Associates (Theis, 1935 for confined aquifers). The values for S derived by Hargis + Associates for the upper Bellflower aquitard do not vary by more than one order of magnitude. The value of S used in the ratio method analysis for well pair SWL0023/SWL0024 was 5 x 10^{-4} which was obtained from the Theis drawdown result derived by Hargis +Associates for well XBF-15, located approximately 3,000 feet west/southwest of SWL0023. The S value for the MBFB/C sand for the ratio method test at the SWL0014/SWL0043 well cluster was 1 x 10^{-4}, which was obtained from the Hargis + Associates Theis drawdown analyses for well XBF-7, located approximately 3,000 feet west of SWL0014/SWL0043.

The S value used for the Gage aquifer for the ratio method analysis at well pair XDA-1B/SWL0043 was 3 x 10^{-4}. This value was obtained from taking the average of the Theis drawdown analysis results for wells XG-5, XG-11 and XG-13 derived by Hargis + Associates. The values for S derived by Hargis + Associates ranged from 1.3 x 10^{-4} to 3.3 x 10^{-4}.

The wells tested during this investigation were generally not fully penetrating. However, the potential effects of partial penetration are thought to be very small. In accordance to the procedures, T was derived using later time recovery data. During late time recovery, flow in the aquifer should be nearly radial, thus significantly reducing any potential impacts of partial penetration.

Derivation of t_D from s′/s and t_D

A figure presenting the Witherspoon et al. type curves used to derive t_D from s′/s and t_D has been included in the report.

48. Appendix H, p. H1-6
Line 3, which includes "...assuming radial flow...", should also include the additional assumptions of the Cooper, et al. (1967) method of confined conditions and a fully penetrating well.

Response: Comment noted. Cooper et. al. (1967) assumes confined conditions, radial flow, and a fully penetrating well. The method also considers the compressibility of both the aquifer and the formation (i.e., aquifer storage).

49. Appendix H, p. H1-3
The value of α used in the curve fit for the SWL0044 slug test plot should be added to the data below the graph.

Response: The slug test analysis for SWL0044 has been rerun. The value of α used in the curve fit is now included on the figure included in Appendix H-3. The program Aqtesolv which was used to perform the slug test data analysis does not include α in the output file. However, α can be obtained from the following relationship:

$$\alpha = \frac{r_w^2 S}{r_c^2} \qquad (1)$$

where r_w = effective radius of the well (ft)
r_c = internal radius of the well casing (ft)
S = storativity

For the SWL0044 slug test analysis,

r_w = 0.417 ft (assumes a 10-inch-diameter borehole)
r_c = 0.167 ft (for a 4-inch diameter well casing)
S = 9×10^{-4} (from reanalysis of slug test data).

Using these values and equation (1), α is equal to 5.6×10^{-3}.

50. Appendix H, p. H1-3
The aquifer test analysis for the slug test of well SWL0044 in general looks to be valid, considering that Aqtesolv, a somewhat automated aquifer test analysis data package, was used. However, there is no mention of the potential effects on the estimated aquifer parameters, if any, of the water level being below the top of the screen. This should be discussed and evaluated in the report.

Response: Slug tests provide an order of magnitude estimate of hydraulic conductivity, K. There are several factors that may influence slug test results including both procedural and well construction factors. One well construction factor that should be considered is the affect of the filter pack adjacent to the well screen. In the case of SWL0044, which is screened above the water table in the upper Bellflower aquitard, early time data will be effected by the transmissivity of the filter pack. The transmissivity of the filter pack in SWL0044 is likely one to two orders of magnitude greater than that of the surrounding formation material. Consequently, we may expect a relatively rapid drop or rise in water levels during the early portions of the slug test. Only the early time data should be affected by the filter pack transmissivity.

Review of the slug test data for SWL0044 indicates that the early time data were not significantly impacted by the filter pack transmissivity. Therefore, the fact that the static water level is below the screen does not seem to have significantly impacted the slug test results.

51. Appendix H, p. H1-3
The following text needs to be added to the end of the first sentence in the second paragraph of Section H1.2: from any pumped aquifer adjacent to the aquitard of interest.

Response: The text has been modified as suggested.

52. Appendix H, p. H1-4
The Neuman and Witherspoon (1972) ratio method uses a $z_{midpoint}$ parameter as is done in Section H1.2. What is the basis for deriving "lower-end" estimates of K_v' using the $z_{minimum}$ value as shown in the last paragraph of Section H1.2? The text should reference the appropriate publication or provide a discussion of the reason for this.

Response: Using the midpoint of the screened interval in the aquitard piezometer during the ratio method analysis results in an average K_v' for the portion of the aquitard between the midpoint of the screen and the aquifer/aquitard boundary. The midpoint is used as an average because of the uncertainty regarding the uniformity of the transient pressure front advancing through the aquitard. The method assumes that the pressure front is highly non-uniform and that selection of the screen midpoint will define the average distance the pressure front has travelled through the aquitard at the time that drawdown in the aquitard piezometer is observed. The ratio method calculations were also solved using an aquitard thickness measured from the top (or bottom) of the screen to the pumped aquifer ($z_{minimum}$). In this case, it is assumed that the observed drawdown occurs after the minimum possible travel distance. This modification of the method assumes the pressure front is advancing through the aquitard more or less uniformly. This allowed estimation of initial average K_v' for the model layers representing aquitards. It is important to note that the ratio method for estimating aquitard K_v' was intended to develop a reasonable range of values of K_v' for the aquitards for purposes of developing the regional groundwater flow model. The final K_v' values used in the model vary throughout the range of K_v' values (developed not only using the ratio method, but also from laboratory permeability test results) as dictated during flow calibration.

53. Appendix H, p. H1-4

The last paragraph in Section H1.2 should state that the average K_v' is only for the portion of the aquitard between the midpoint of the aquitard observation well screen interval and the aquifer/aquitard boundary. Since two different times were used to derive s'/s and subsequent K_v' values, as suggested by Neuman and Witherspoon (1972), it would be useful to present the average K_v' values for the two times in Table 4.2-3. The average "upper-end" K_v' values for the Lower Bellflower Aquitard are 0.79 and 0.035 from pumping in the Middle Bellflower C sand and Gage aquifers, respectively (Table 4.2-3). These values are for the upper and lower portions of the Lower Bellflower Aquitard, respectively. There is no discussion as to why the values differ by more than an order of magnitude for such a thin aquitard. There also should be a similar discussion as to why the "lower-end" K_v' values differ.

Response: Comment noted. The text has been modified to clarify that the average K_v' is only for the portion of the aquitard between the well screen in the aquitard and the aquifer/aquitard interface. The lower Bellflower aquitard consists of complex and heterogeneous layers of materials that result in varying K_v' values. Hence, it is reasonable that the K_v' for the upper and lower portion of the aquitard differ. In order to accommodate this variability, the lower Bellflower was divided into three distinct layers for the regional groundwater flow model.

54. Appendix H, Fig. H1-2

Note also that there is a discrepancy in the Lower Bellflower Aquitard thickness in Figure H1-2 between the sum of the z_{mid} values shown (33 feet) and the <u>depths</u> of the top and bottom of the aquitard (34 feet). Use of the correct value of z_{mid} for calculation of K_v' from equation 5a in Section H1.2 should be checked.

Response: The sum of the z_{mid} values as shown is 34 feet (15.7 feet + 18.3 feet = 34 feet). There was not a discrepancy on Figure H1-2 with respect to the sum of the z_{mid} values. The correct aquitard thickness is 34 feet. The correct values of z_{mid} were used in the calculations of K_v'.

Table 1						
Cross-section	*Contour Map Figure No.*	*Spreadsheet Figure No.*	*Boring No.*	*Inconsistency Among Figures and Tables*	*Incorrect Interpretation*	*Description*
B-B´	*Plate 3-2*		*SBL0014*	*X*		*According to the cross-section, the thickness of the MBFM is 3 feet. In Table 3.2-2, the thickness is three times thicker at 9 feet.* **Response:** Changed Table 3.2-1 base of MBFB from -38 to -44 feet. Corresponding changes to Table 3.2-2, thicknesses of MBFB and MBFM from 17 to 23 and 9 to 3 feet respectively. B-B´ left as is.
B-B´	*Plate 3-2*		*SBL0020*	*X*		*According to the cross section, the base of MBFM is at -40 feet and the thickness is 6 feet. In tables 3.2-1, the base of the MBFM is listed as -63 feet and in Table 3.2-2, the unit is listed at a thickness of over four times thicker at 28 feet.* **Response:** B-B´ changed to match K-K´.
C-C´	*Plate 3-3*		*SBL0019*	*X*		*At this boring, the MBFM does not exist on cross sections F-F´, J-J´, and Table 3.2-2. However, on cross section B-B´, the MBFM unit is shown as approximately 7 feet thick. The unit thickness inconsistency should be corrected.* **Response:** Eliminated the noted portion of MBFM on C-C´ to be consistent with F-F´ and J-J´.
E-E´	*Plate 3-5*		*SBL0033*	*X*		*The hydrostratigraphic data for SBL0033 (unit contacts and thicknesses) are not included on the spreadsheets and contour maps.* **Response:** Added SBL0033 data to Tables 3.2-1 and 3.2-2, Figures 3.2-3 through 3.2-8 which includes all depth to base of contour maps and the isopach map.

Table 1						
Cross-section	*Contour Map Figure No.*	*Spreadsheet Figure No.*	*Boring No.*	*Inconsistency Among Figures and Tables*	*Incorrect Interpretation*	*Description*
F-F´	*Plate 3-6*		*SBL0019*	*X*		*See comment on cross-section C-C´.* **Response:** See response to Cross section C-C´, Boring No. SBL0019.
G-G´	*Plate 3-7*		*SBL0077*		*X*	*The silty sand layer from elevation -175 to -186 feet shown on the cross-section is not on the boring log.* **Response:** Removed the noted silty sand intervals from the SBL0077 graphic columns of G-G´ and D-D´.
G-G´	*Plate 3-7*		*SBL0077*		*X*	*The lithologic data from boring SBL0077 suggest that the UBF aquitard thickness may be overestimated by 6 feet. The base of UBF is shown on the cross section at -48 feet, but the boring log suggests the contact should be at -42 feet. Use of the boring log interpretation will decrease the thickness of the MBF aquitard from 71 to 66 feet.* **Response:** Changed the UBF-MBFB/C contact on G-G´ from -48 to -42 feet consistent with D-D´. Changed elevation of base of UBF on Table 3.2-1 from -48 to -42 feet. Corresponding change to thickness of UBF from 71 to 65 feet, and MBFB from 12 to 17 feet.

Table 1						
Cross-section	*Contour Map Figure No.*	*Spreadsheet Figure No.*	*Boring No.*	*Inconsistency Among Figures and Tables*	*Incorrect Interpretation*	*Description*
G-G´	*Plate 3-7*		*SBL0108 and SBL0103*		*X*	*The lithologic and geophysical data presented at these two borings suggest the LBF may either be absent or much thinner than displayed on the cross section. At SBL0103, based on a 2 foot interval of silt and silty sand and another 1 foot interval of silty sand within a large interval of sand, an 18 foot thick aquitard layer is displayed on the cross section.* **Response:** We disagree that there is not substantial evidence on cross sections, boring logs, and geophysical logs presented in the RI to substantiate the LBF thickness shown on G-G´. Since SBL0103 and SBL0108 did not penetrate the entire thickness of the LBF and were not intended to do so, interpretation is based on the best available data. First note that the gamma logs at the base of both borings clearly suggest fine-grained material. Second, extrapolation from nearby borings on cross sections D-D´, G-G´ and K-K´ all support the interpreted LBF thickness shown on G-G´ unless an abrupt and uncharacteristic thinning of the LBF occurred. Finally, a U.S.C.S. classification of SP does not necessarily indicate a coarse-grained aquifer material. A soil composed of 95% very fine sand with 5% silt and clay is as much an aquitard material as it is an aquifer material. That material would not likely yield sufficient water to a well to justify classification of an aquifer.
J-J´	*Plate 3-9*		*SBL0019*	*X*		*At SBL0019, the LBF/Gage contact, although marked with a (?), is approximately 10 feet deeper on cross-section J-J´ than on cross section C-C´. This also results in a 10 feet difference in thickness of the LBF between the two cross-sections.* **Response:** Changed J-J´ to correspond to C-C´.

Table 1						
Cross-section	*Contour Map Figure No.*	*Spreadsheet Figure No.*	*Boring No.*	*Inconsistency Among Figures and Tables*	*Incorrect Interpretation*	*Description*
J-J´	*Plate 3-9*		*SBL0025*		*X*	*Based on the geophysical log at SBL0025, the top and bottom of the MBFB/C unit should be about 15 feet lower.* **Response:** The top of the MBFB/C unit has been lowered approximately 15 feet as suggested. The placement of the bottom of the unit relative to the geophysical log is judged to be consistent with the other borings on the cross section, and has not been changed.
K-K´	*Plate 3-10*		*SBL0020*	*X*		*Cross section K-K´ has two discontinuous layers of MBFM whereas cross-section B-B´, at the same borehole, includes only an upper layer of MBFM.* **Response:** B-B´ changed to match K-K´.
K-K´	*Plate 3-10*	*3.2-5*	*SBL0026*	*X*		*On cross section K-K´, boring SBL0026 does not reach the base of the LBF. Therefore, SBL0026 should be removed from Figure 3.2-5, the contour map for the base of the LBF.* **Response:** SBL0026 removed from Figure 3.2-5.

SECOND INSTALLMENT EPA COMMENTS ON DRAFT DEL AMO GROUNDWATER REMEDIAL INVESTIGATION REPORT

1. Page 1-7.
Reference to BHC. Note that BHC is not "associated with the production of DDT," as stated. BHC is an independent pesticide. BHC exists at Montrose because of the Stauffer Chemical pilot plant that was located on the property concurrently with the Montrose operation. The Stauffer pilot plant was involved with manipulating the isomers, as well as the production, of BHC.

Response: It is believed that the comment reference to "*Page 1-7*" actually applies to page ES-7. Comment acknowledged. The Respondents now understand that BHC was produced independently from DDT by Stauffer Chemical in a pilot plant located within the southeastern corner of the Montrose property. Wording in the executive summary has been modified to reflect this understanding.

2. Page ES-7.
Reference to BTEX, 1st sentence. "...a single source..." should be replaced by "...any single source..." There are many potential sources of BTEX.

Response: Comment acknowledged. The indicated text has been modified as suggested.

3. Page ES-8.
The list of aquifers that are designated as MUN is unclear and incomplete. UBF, Middle Bellflower, Gage, and Lynwood should all be listed as MUN. Also, where the report references "Bellflower Aquitard," does this correspond to the Report's use of the term "Upper Bellflower?"

Response: Comment acknowledged. The text discussions have been modified to clearly indicate all aquifers designated as municipal (MUN) water supplies. Additionally, the term "Bellflower aquitard" has been defined as including the following HSUs: the "upper Bellflower"; the "middle Bellflower B-sand"; the "middle Bellflower mud" (where present); the "middle Bellflower C-sand"; and, the "lower Bellflower". The term "upper Bellflower" applies to a discrete, predominantly fine-grained stratigraphic interval which overlies the predominantly sandy deposits of the middle Bellflower, both of which lie within the larger Bellflower aquitard. Please refer to Figure 3.4-1, which illustrates the associations among the various formations and HSUs identified at the study area.

4. Page ES-8.
"...limit their use..." should be replaced by "...likely limit their use..."

Response: The Respondents have modified this portion of the executive summary in response to this and subsequent EPA comments to take into account EPA concerns.

5. Page 1-9, Sanitary Sewer ¶.
describe here, and/or in other appropriate place(s), the nature of the sewer hookups, the location of the sewer hookups, which LA County trunk line the sewer hookup connected to, the nature of the wastewater flowing into the sewer (chemical constituents), and the volumes

(probably changed over time) of sewer water discharge (quantify to the extent possible). Cite all sources of information on sewer discharges. Did the hookup change over time (e.g. were other trunk lines used, etc.)? What areas/operations of the plant were drained to the sewer? We should discuss the degree of direct response vs. reference to other documents for this comment.

Response: The nature and availability of information regarding sewer connections and the chemical character and volume of wastewater streams at the former plant was discussed during a telephone conference held between Dames & Moore, EPA and CH2M Hill on April 8, 1997. It was identified during this conference that such research had not been conducted, and that it was uncertain exactly what type of information may be available to address the specific issues raised in the comment. It was mutually agreed during the conference that whatever information could be compiled in the short term from data currently available in-house would be reviewed and presented in Section 1.2.2.1 of the revised Groundwater RI report. Furthermore, it was agreed that the findings of additional research into the nature of sewer systems and wastewater streams at the plant would be presented in the "Soils RI report", to be prepared upon completion of pending Phase II site investigations.

6. Plant Operations.
Description of wastes and waste in various units is inadequate. The waste contents should be better-described. For instance, what was the source of the material in the waste pits (what portions of the plant did it come from)? What were its chemical constituents? What volume of waste was placed in the pits? Were the pits lined? As of what date? This section also describes "wastewater separators." But, what was in the wastewaters, and why did it need separation?

The Plant Operations section should describe whether plant operations ever significantly changed or were expanded over time, or were all the units on the property essentially present from the beginning? If there were changes, depict the changes with time in terms of production, chemical storage, and waste handling.

Response: The nature and availability of information regarding waste types, chemical constituents and volumes of wastes and the overall manufacturing process flow at the former plant was discussed during a telephone conference held between Dames & Moore, EPA and CH2M Hill on April 8, 1997. The overall physical and chemical character of wastes present in the Del Amo Waste Pit Area is discussed in Section 1.2.2.1 (Description of Plant Operations) and Appendix A, Section A.2.1 (Summary History of Study Area, Del Amo Waste Pit Area) of the Groundwater RI report. Additionally, the text refers the reader to reports presenting the findings of focused studies conducted at the Waste Pit Area for more detailed discussions of conditions in this area. It was agreed during the April 8 telephone conference that text discussions in the Groundwater RI report would be augmented to provide additional details of the Waste Pit Area, including waste constituents, volumes and sources and whether the waste pits were lined. It was also agreed during the conference that readily available information regarding plant wastewater streams and waste management practices would be provided in the revised document. However, further research necessary to adequately address comments regarding wastewater streams from the various operational areas and how possible changes to plant operations over time may have affected these waste streams would be deferred at this time

and presented in the "Soils RI report", to be prepared upon completion of pending Phase II site investigations.

7. Page 1-15, 3rd ¶, last sentence.
To be properly balanced, this sentence needs to acknowledge that the benzene emanating from the waste pits is also immediately adjacent to this area, and therefore, while there is evidence for the P1 NAPL, it may not be practical to separate the benzene from this source from the benzene emanating from the waste pits in the dissolved phase.

Response: The discussion in Section 1.3.4 does not address benzene specifically, nor does it attempt to distinguish between possible benzene sources within this area, rather it is oriented toward evaluating the origin of the refined petroleum hydrocarbon LNAPL detected in water table zone monitoring well P-1. While it is acknowledged that both the Waste Pits and the well P-1 LNAPL both contribute dissolved benzene to groundwater in the area, this issue is unrelated to evaluating the origin of the LNAPL in well P-1. No modifications have been made to the report text in response to this comment.

8. Figure 2.2-2.
Figure is missing the site background features. These should be added.

Response: Comment acknowledged. Historical site features have been added to the figure as requested.

9. Page 5-1, Last ¶.
It is not clear why 10% or solubility was chosen as a benchmark for NAPL in this case, especially when in the subsequent discussion you cite 1% as a literature benchmark on page 5-2 (for DNAPL). Why is 10% saturation applicable to benzene LNAPL whereas 1% is applicable for DNAPL? Would the conclusion differ significantly if 5% were the benchmark, or 1%? Either stronger support should be provided for this percentage or the 1% figure should be used.

Response: Based on the above comment and discussions with EPA during a teleconference the week of May 26, 1997, the Respondents have modified the RI to remove all references to a specific percentage of solubility as a criterion for identification of suspected NAPL areas. As now written, areas of suspected NAPL were subjectively identified after consideration of the following:

- Historical information indicating the former presence of facilities where large volumes of pure chemicals were stored, processed, or disposed of;

- Dissolved concentrations of a compound that are both elevated with respect to surrounding monitoring locations, and represent a significant fraction of the solubility of the compound; and,

- Deep soil gas (near the water table) concentration profiles similar to those measured in the vicinity of a known NAPL.

10. Page 5-7.
Reference to PCBSA and why plotting its distribution is useful. Plotting is also useful because there may be treatment implications, and therefore remedy selection implications, depending on the degree to which PCBSA must be treated, can be reinjected, discharged, etc. This should be mentioned as well.

Response: The text has been modified as suggested.

11. Figures 6.2.1+...
These Figures all say "Concentrations in units/L" in the legend. Were you intending to replace the term "units" with "micrograms"?

Response: The analytical method used to characterize the occurrence of BTEX biodegradation was developed by Salanitro, Diaz, Williams and Wisniewski, and described in Salanitro et al., 1993. According to the method described in the Paper *Simple Method to Estimate Aromatic Hydrocarbon Degrading Units (Microbes) in Soil and Ground Water*, by Salanitro et al. (1993). This method yields results in Units per liter (units/L). The report text has been modified to make it clear that units/L is the correct term.

12. Page 7-6, Section 7.4.2, first and second ¶.
The conclusions here assume that the Del Amo contamination does not migrate in the future to lower aquifers. The discussion also assumes that the current groundwater practices discussed remain in effect. Clarify and add discussion of these, for balance.

Adjudication - discussion here assumes that the adjudication remains forever. The report needs to make clear that this discussion applies to the current situation. Uncertainties in adjudication persistence should be addressed, if possible.

Finally, it is not clear that the Watermaster would be able to withhold water usage rights based on contamination alone. Thus, the issue of the effectiveness of an institutional control that uses Watermaster authority is open to question and should be evaluated. A better place for this evaluation is the FS report; however, the RI should make the ambiguity clear rather than implying that Watermaster controls would definitely be effective.

Response: The referenced section has been modified based on the above comment and subsequent comments from EPA to indicate that current well construction standards are not a guarantee that existing or future production wells will not be impacted by contamination. Discussion of adjudication is limited to the preceding section (7.4.1), and no statements are made in that section regarding the role of adjudication in addressing groundwater contamination associated with chemical releases. Limitations on groundwater withdrawals under the adjudicated management policies are based upon prescriptive water-use rights and the availability and quantity of groundwater. The Respondents have nowhere stated, nor intended to imply, that adjudication policies are intended to prevent produced groundwater from being impacted by existing or future chemical releases.

POTENTIOMETRIC CROSS-SECTION COMMENTS

Additional Detail on Previous Comments

1. Date of Data Used
As stated in previous comments, the date of the water level data used should be prominently labeled on the plates. An item in the legend states that the date of the phreatic surface is January 1996, suggesting that the data for the other wells was also collected during January 1996. However, according to the groundwater elevation data table (Table 4.1-1), groundwater elevations were not measured during January 1996. The closest time period that water levels were measured was February 1996. Based on a review of the potentiometric contours in the cross sections, the February 1996 data appears to have been used.

Response: The plates have been modified to prominently label the date of the water level data used, February, 1996.

2. Contour Lines
As stated in previous comments, were lines are extrapolated beyond data points, contour lines should be dashed or queried. As a specific example, on cross section J-J′, potentiometric head data for the Middle Bellflower B/C (MBFB/C) Sand, Lower Bellflower Aquitard, and Gage Aquifer are limited to one well in each of the MBFB/C Sand and Gage Aquifer at the south end of the cross section. Due to the speculation involved in drawing contour lines north of the existing data in these units (the left two-thirds of the cross-section), contour lines in these areas should be dashed or queried.

Response: The plates have been modified as suggested. The Respondents believe that the contour lines, while approximate, reflect more than just speculation. With respect to the example cited, review of the groundwater elevation data indicates that the -18 foot and -19 foot contours must pass through cross section J-J′ north of well SWL0023 in the MBFB/C (see Figure 3 of the First Sampling Period 1996 Groundwater Monitoring Report dated June 17, 1996.)

3. Cross-Section Intersection Lines
As per the previous comments on the hydrostratigraphic plates in Section 3, the location of cross-section intersections should be added to Section 4 cross section plates to facilitate the consistency of potentiometric contour interpretations among cross sections.

Response: The plates have been modified as suggested.

More Detailed Review Comments

1. Water Level Elevations
The water level elevation values should be placed adjacent to each well screen. Without these values, it is difficult to evaluate contouring.

Response: The plates have been modified as suggested. The reader should be aware however, that for wells that are projected onto the cross-sections, the posted groundwater elevations may be misleading with respect to where the contours should be placed. This is especially true for the groundwater table, where groundwater elevations increase or decrease significantly over short distances in some areas.

The Respondents acknowledge that evaluating the accuracy of the contouring is difficult; for the same reasons, developing the cross sections was very time consuming. However, the figures are of significant value in illustrating the direction of groundwater flow in the vertical plane. To aid in evaluation of the cross-sections, it is suggested that the cross section lines be plotted on groundwater elevation maps for each HSU for the February, 1996 sampling event. These maps are provided in the Groundwater Monitoring Report, First Sampling Period, 1996, dated June 17, 1996.

2. Potentiometric Contour Interpretations
Assuming February 1996 data are the basis for contouring, following are specific comments on the cross sections:

A. On Plate 4-2, the potentiometric elevation at SWL0032 (-18.29 feet mean sea level [msl]) is not consistent with contouring (placed between -17 and -18 msl contour lines).

Response: Well SWL0032 contains LNAPL, and the cited February 1996 groundwater elevation has not been adjusted to reflect this. Taking this into account, the contouring on the cross section is relatively accurate, as can be seen by water levels from adjacent well SWL004 (-17.07 feet), which does not contain LNAPL. Table 4.1-1 has also been modified to remove wells containing NAPL and erroneous groundwater elevations.

B. On Plate 4-4, based on the potentiometric elevation as SWL0023 (-19.05 feet msl), a -19 feet msl contour should be added to the cross section.

Response: Plate 4-4 has been modified as suggested.

THIRD INSTALLMENT EPA COMMENTS ON DRAFT DEL AMO GROUNDWATER REMEDIAL INVESTIGATION REPORT

GENERAL COMMENTS

1. The draft Groundwater RI has not been signed by a registered professional. Section 7835 of the California Business and Professions Code (Geologists and Geophysicists Act) requires that all geologic reports and documents be signed by a registered geologist or registered certified specialty geologist. Therefore, the RI must be signed by the registered professional who takes responsibility for the work and interpretations presented.

Response: Comment acknowledged. The revised Groundwater RI report will be transmitted under a cover letter bearing the signature of the California Registered Geologist with the overall responsibility for the work performed and the interpretations presented.

2. The context of this report, and definition of areas not covered by this particular document, and where they will be covered, should be more clearly discussed and defined in the document. For instance, the NAPL and soils data and interpretation are being presented in separate documents (MW-20 investigation and Soils RI (Phase II)) and the TCE and PCE plumes from Trico and McDonnell Douglas, while partially characterized by this report are not fully addressed by the report. You should mention that additional FS work is planned for the issues of NAPL recovery and possible cleanup of surface soils; the other RI efforts just mentioned will be used in conjunction with this GW RI to support those FS efforts.

Response: The overall context of the Groundwater RI report, and its relationship to other parallel tasks at the Del Amo study area, are described in Section 1.0 of the draft document. The reader is referred to the flow diagram illustrated in Figure 1.0-1, which depicts the interrelations among the various investigative elements of the Del Amo RI/FS process. The text in Sections 1.0 (Introduction and Background) and 1.3.2 (Monitoring Well XMW-20 LNAPL Area) will be modified to discuss where the findings from work currently in progress or proposed work currently in development may be found.

The concentration and distribution of dissolved PCE and TCE in groundwater has been evaluated to the extent that these compounds affect groundwater beneath the Del Amo study area. The distribution of these compounds is illustrated in concentration contour figures for the water table, MBFB and MBFC, and the limited occurrences of these compounds in the Gage aquifer are posted in another figure within Section 5.2 of the Groundwater RI report. Furthermore, existing PCE and TCE data for nearby sites has been compiled and illustrated in Section 5.3 in order to define regional groundwater conditions to the extent necessary to support the groundwater flow and contaminant transport modeling conducted as part of the Groundwater FS. As acknowledged in the comment, the available data strongly support the existence of off site sources for these compounds. Groundwater investigations conducted as part of the current study were not intended to characterize conditions related to past or current activities at adjacent facilities.

3. The discussion of plume stability for the water table zone should be expanded and made more balanced. This applies to several sections of the report including the Executive Summary and Section 6.1, "Plume Migration." The transect evaluated running south from the waste pits is not considered appropriate because of the presence of a groundwater mound to the south and slightly to the west of the waste pits. This provides a hydrologic influence which may slow groundwater migration in the southerly direction and push the flow to the southeast, where benzene is present further downgradient along a southeasterly transect. A more complete discussion/argument, using a different transect or set of transects, should be used. The conclusion of attenuation within 600 feet, and the argument based solely on the southward transect analysis, should be removed and replaced by arguments based on other factors and/or transects (e.g. if 600 ft. is still correct, support it by other more supportable means, else replace 600 ft. with the appropriate value based on such means). Specific factors which should be considered:

- *The uncertainties introduced by the presence of the groundwater mound and the P1 NAPL vis a vis being able to determine plume front stability;*
- *The uncertainties introduced by the presence of the landfills;*
- *Other relative degrees of uncertainty in overall plume stability as appropriate;*
- *Plausible explanations for why low concentrations of benzene appear to be spread over a wider area just offsite in the southeast corner of the UBF (not tightly confined around the sources as in other areas of the site);*
- *Acknowledgment that groundwater flow velocities in this unit are small due to its fine grained nature and the virtually flat gradient; therefore, the amount of time required to actually see movement of the plume may be substantial;*
- *Assessment of the amount of time the benzene has had to migrate and the actual distance it might have gone had degradation not been operating;*
- *Other more balanced and complete arguments for why plume fronts appear to be stable, including assessment of numbers of rounds of data for particular wells used in the argument.*

Response: Section 6 text has been amended to provide a more complete and balanced discussion of the lines of evidence used to assess plume stability and plume attenuation rates and to address each of the bulleted items above. Text modifications include a discussion of factors which contribute to uncertainties in estimating plume attenuation rates, and additional lines of evidence which support the conclusion of rapid benzene attenuation.

The Respondents continue to believe that the existing transect is the most appropriate for supporting evidence of plume attenuation and stability because it is not significantly impacted by offsite sources of contamination. However, the report text has been modified to include discussion of concentration attenuation along a second transect, extending south from well XMW-04HD to SWL0021, to further support the conclusions presented.

4. It appears that the parallel arguments for plume stability in the B Sand are somewhat lacking in the RI compared to those for the UBF (or water table). Similar arguments to those discussed above should be provided based on the concentrations on the B Sand plot.

Response: Beneath much of the western portion of the site the water table resides within or very near the MBFB sand. Therefore, in this area, discussions of attenuation in the water table presented in Section 6.1 apply to the MBFB sand. Towards the east, where the water table is well above the MBFB sand, the most significant dissolved contaminant distribution is present downgradient of the Waste Pit Area. Monitoring wells placed downgradient of the Waste Pit Area show the same rapid attenuation of benzene in the MBFB (see Figure 5.2-14, Monitoring Wells SWL0050, SWL0041, XP-03, SWL0052).

5. Page ES-3.
The description of the hydrostratigraphic conditions does not include the Silverado aquifer. The Silverado is below the hydrostratigraphic zones currently being investigated, however, it is the most significant drinking water aquifer in the West Coast Basin and should be mentioned in this section. As this is the Executive Summary, the text section addressing aquifers should also contain appropriate language about the Silverado. It is understood and accepted that the same level of detail is not available for the Silverado as for the other units, in which monitoring wells have been installed.

Response: The importance of the Silverado aquifer as a principal source of groundwater supplies within the West Coast is acknowledged and discussed in both the Executive Summary (page ES-8) and Section 7.0 (Groundwater Development and Use) of the draft report. Additional references to the Silverado aquifer will be added to the discussion of hydrostratigraphic conditions in the Executive Summary. As acknowledged in the comment, however, no site-specific data are available for the Silverado aquifer within the study area, consequently any discussions will be very generalized and based upon available geologic literature for the area.

6. Figure 5.2-3.
The basis for this figure should be clarified. It is confusing to see more queried and open contours in the 1995 plot than in the 1994 plot. This is due, according to discussions with you, to the fact that you kept the figure consistent with previous groundwater modeling reports. However, the contouring discrepancy is more apparent than the issue of report consistency.

Response: The Respondents agree. Review of the data suggests that open and queried contours south of the Waste Pit Area would be more appropriate on the 1994 plot. The figure has been modified to reflect this change.

7. Section 3.2.2.
The RI describes the B Sand and C Sand as merged wherever the Middle Bellflower mud is absent. However, the RI contours these units separately and shows different heads in the two units even though "merged." While the reason and basis for these are clear to EPA, the RI needs to more clearly explain why this was done, how the wells are designed to target the top and bottom of the Middle Bellflower (hence B Sand and C Sand) and why the heads are different in these two "merged" units (presumably because of differences in stratigraphic materials).

Response: Section 3.2.2 has been modified as suggested.

8. Section 4.1. Pages 4-21 through 4-4.
An approximate average horizontal flow velocity is presented for each hydrostratigraphic unit. The hydraulic conductivity and effective porosity values used in the calculations for the flow velocities are mean values. Since contaminants may move in preferential pathways, it would be valuable to report the range of flow velocities that can be calculated rather than just one value which is based upon mean values of the input parameters.

Response: After consideration of the above comment and discussion of the issue with EPA during a teleconference the week of May 26, 1997, the Respondents and EPA agreed to limit modification of the RI to reporting of the range of hydraulic conductivity values for each HSU. The RI has been modified to reflect this.

9. The vertical extent of the benzene plume in the southeastern corner of the site, near Hamilton Dutch/WRC, has not been completely defined in the B Sand. While there is more than 800,000 ppb in the UBF, there are no wells in the immediate vicinity of this concentration maximum below in the B Sand. The RI should clarify that, while the downgradient wells in the B Sand have all been non-detect since installation (correct?), and therefore you are confident that what is in the B Sand does not extend to those locations, it cannot be said with complete certainty that there is not benzene in the B Sand under the Hamilton Dutch/WRC UBF "bawls" areas.

It is noted that, while this deficiency may not limit the selection of a remedy, the remedy likely will have to acknowledge the data gap and may require that wells be installed in the B Sand as part of Remedial Design to answer this question. In addition, and perhaps more importantly, the ROD likely will require monitoring wells to ensure that contamination in the plume is not migrating, both laterally and vertically. It is reasonably certain that a well or wells will be required in the B Sand under the Hamilton Dutch/WRC UBF plume so as to be able to monitor whether contamination is migrating downward from the UBF to the B Sand at that location.

Response: The Respondents agree that the available data do not allow one to say with certainty whether or not benzene is present in the MBFB in the vicinity of the Hamilton Dutch/WRC areas. The report has been modified to clarify this. The Respondents are willing to discuss the necessity of any additional wells in this area, but have not modified the report to indicate that they will be installed.

10. Section 5.2.3.1 Middle Bellflower C Sand - VOCs, Page 5-12.
The document states that ethylbenzene is primarily limited to the area of the waste pits. There are areas on the west side of the site (not in proximity to the waste pits) where the actual ethylbenzene concentration has been masked by other contaminants due to interference. This should be noted in the discussion of the extent of the ethylbenzene.

Response: The report has been modified to acknowledge locations with elevated ethylbenzene detection limits.

11. Section 5.3.2 Plant Site Source Areas.
The draft GWRI states, "With the exception of source area 3 (the MW-20 LNAPL), the extent of the plant site source areas has not been fully evaluated, and should not be inferred from Figure 5.3.5."

This statement as presented appears to cast doubt on the comprehensiveness of the data presented in this report. We recommend that it be reworded to provide, once again, the context of this report in the larger project, so as to show by what other vehicle these areas will be investigated. Also, while the (Phase II) investigation will include soils and NAPL, and perhaps a very limited number of groundwater wells, the extent of groundwater contamination is well defined and the source areas to be investigated lie above the plume as defined by this document.

Response: The report has been modified to indicate that additional investigation of source areas is under consideration by the Respondents and EPA. Source areas are not limited to the vadose zone, and include LNAPL and DNAPLs below the groundwater table.

12. Page 5-18.
"A dry well or other unknown conduit may exist in the vicinity of SWL0041 by which concentrated contaminant solutions have been introduced directly to the MBFC and/or B/C Sand in the base without significantly impacting the overlying zones."

Has this theory been investigated? Is there evidence of an agricultural well in this area on any old maps, etc. Is this merely a conjecture, or is there some evidence for this hypothesis? The problem is that such old wells were typically screened along their entire length and so if contamination entered the C Sand by this means it would presumably have entered the B Sand by this means as well.

In general, the report should acknowledge that the contamination in the C Sand in the vicinity of SWL0041 is not well understood. In addition, it should state that the water table was never in the bottom of the C Sand where this well is screened and so it is not expect that "smeared LNAPL" could be in this location.

Response: The report has been modified to clarify that the inverted concentration profile (increasing with depth) in the vicinity of well SWL0041 is not well understood. The Respondents have no additional information that would give additional credence to any of the four explanations listed in the text. The Respondents agree that the water table is unlikely to have been at the bottom of the MBFC at SWL0040 during the time of plant operation, and that LNAPL is therefore also unlikely to be present at this location. The text has been modified to reflect this.

13. Page 5-18.
Dichlorinated compounds have been detected on and adjacent to the site area, however, there is not discussion of the distribution of these chemicals in the text (Figure 5.3-4 shows the distribution, but no text accompanies it.) A discussion should be provided.

Response: The Respondents have presented and discussed the distribution of an extensive list of compounds and do not believe that adding additional figures and text for any dichlorinated compounds would significantly improve the report. The distributions of dichlorinated compounds (1,1-DCE, 1,1-DCA, 1,2-DCA and trans- 1,2-DCE) at the plant site are closely related to, and typically within the distributions of TCE and PCE, which are illustrated on the figures and discussed in the text. Figures 5.3-3 and 5.3-4 showing regional tri- and dichlorinated compound distributions were presented to support conclusions of numerous offsite sources for chlorinated compounds, some of which have very high concentrations of these compounds.

14. Page 5-19.
The discussion of PCE and TCE does not include the plume immediately southeast of the Del Amo property. Please include a discussion of this plume in relation to the site source areas.

Response: The TCE and PCE plumes immediately southeast of the plant site are inferred to be associated with an inactive landfill in this area. The text has been modified to discuss this area.

15. Section 7.0.
The draft GWRI states that the well canvass study was recently updated for presentation in this draft document, however, the study in [sic] *not included. The study should be included in the report.*

Response: The findings of a well canvass study of the area lying within a 2-mile radius of the Del Amo plant site were originally presented in Appendix A of the Phase I RI report, dated October 29, 1993. As stated in the introductory paragraph of Section 7.0 of the draft Groundwater RI report, only that information regarding *municipal supply* wells was updated for presentation in the draft document. In response to EPA's "First Installment" comments requesting information for all water supply wells in the area, municipal and otherwise, the well canvass survey and accompanying text discussion that appears in the revised document has been considerably expanded from that which appeared in the draft Groundwater RI report.

16. Section 7.2. Municipal Water Supply Wells.
The one operating municipal supply well downgradient of the site is a Dominguez Water Corporation well 1.6 miles from the site. The draft GWRI states, "Construction details indicated this well is also screened exclusively within the Silverado aquifer at depths in excess of 500 feet below ground surface. (Table 7.2-1)."

The table also indicates that the well was drilled in 1916. A well of this "vintage" is most likely gravel packed most of its length even though it is screened only in the Silverado. Therefore, it is of greater concern than a more recently-constructed well. The actual well construction details of this well should be included and discussed in the Draft GWRI.

Response: As discussed above in response to Comment 15, the well canvass survey and accompanying text discussion in Section 7.2 has been considerably expanded from that which appeared in the draft Groundwater RI report. Based upon recent conversations with Dominguez Water Corporation, it was learned that Well 19A was actually completed during 1991 as a replacement for an older well (Well 19) originally installed during 1916. Based upon recent conversations with Mr. Robert Ellis of the Dominguez Water Corporation, the original Well 19

was destroyed in accordance with state of California well standards in 1991 when the replacement Well 19A was installed. The original Well 19 was not equipped with any sort of filter pack material, rather, the well screen was directly in contact with native sediments of the Silverado aquifer. The construction information for the recently installed replacement Well 19A is accurately presented in Table 7.2-1. The sand filter pack for this well lies entirely within the Silverado aquifer.

17. Section 8.0 Summary of findings and Conclusions, Page 8-1.
The draft GWRI states, "The groundwater table intersects and crosses stratigraphic boundaries, residing within the upper Bellflower aquitard west of a demarcation line near the western boundary of the Del Amo plant site, and within the underlying middle Bellflower B Sand to the east of the demarcation line."

This statement is reversed. The water table actually resides in the B Sand west of the demarcation line and in the Upper Bellflower aquitard to the east.

Response: Comment acknowledged. The indicated text has been revised to correctly describe the position of the water table with respect to the upper Bellflower and the underlying middle Bellflower B Sand.

18. Appendix C.
Appendix C contains a table with well construction information but the actual well construction logs for each well are not included. The actual well construction log for each well should be included as part of the report.

Response: Detailed well construction diagrams were not prepared for individual monitoring well completions. Schematic monitoring well construction diagrams are presented in Appendix C as Figures C-1 through C-5, and all pertinent information regarding individual monitoring well locations and specific construction details are presented in Tables C-1 through C-3.

The soil boring or cone penetrometer logs used to provide stratigraphic control for the installation and construction of individual monitoring wells completed during the current study are identified in Table C-1, along with the distance of these control points from the actual monitoring well locations. A complete picture of well-specific stratigraphic conditions and construction details can be developed using the construction information presented in Table C-2 with the appropriate reference soil boring log or cone penetrometer log presented in Appendix B (Lithologic Logs) or Appendix E (Cone Penetrometer Logs), respectively. The reader may gain a more broad understanding of the stratigraphic relationships among the numerous monitoring wells completed across the study area by referring to the appropriate hydrostratigraphic cross section(s) within which the well(s) of interest are depicted, as also identified in Table C-1.

19. Appendix H.
Figure H1-1 Well Cluster Details SWP0023, SWP0024, Ratio Test Method. This figure shows the B Sand with the Middle Bellflower Mud beneath it, however, at this location, the B Sand and C Sand are merged. This should be corrected. The figure also should show the B Sand/C Sand with the lower Bellflower beneath.

Response: This figure has been corrected to show that the B Sand and the C Sand are merged in this location and that the Middle Bellflower Mud is present beneath them.

FINAL INSTALLMENT EPA COMMENTS ON DRAFT DEL AMO GROUNDWATER REMEDIAL INVESTIGATION REPORT

1. *p.ES-2¶2. The first sentence is incorrect. The plants were constructed by some of these companies under contract with the United States. The United States did not directly build these facilities. Please revise the sentence to state this.*

The second sentence shall be revised as follows: "A number of private companies, including Shell and Dow, operated portions of the synthetic rubber plant under contract with the United States government between 1943 and 1955. In 1955, the United States sold the synthetic rubber plant to Shell Oil Company which then operated it until 1972. The synthetic rubber plant consisted of..."

Response: The report has been modified to delete any reference to the builder of the plant site and now indicates only that the plant was constructed between 1942 and 1943. The second sentence has been modified as requested.

2. *p.ES-2¶3. Revise the second sentence as follows: "The former plant site was sold by Shell Oil to Cabot, Cabot & Forbes who redeveloped the property into a business park in the mid-1970's."*

Response: The sentence has been modified to read as follows: "The former plant site was sold by Shell to affiliates of Cabot, Cabot & Forbes Interim Company, Inc. (CC&F). CC&F and Cadillac Fairview/California, Inc. redeveloped the property into a business park in the mid-1970s."

3. *p.ES-5¶2. Identify that the source of the NAPL near MW-20 may have been the large crude benzene tank and/or pipelines in the area.*

Response: The paragraph has been modified to include the following sentence: "The source of the LNAPL is not known with certainty, but may be associated with spills and/or leakage from storage tanks and pipelines in the area."

4. *p.ES-6¶2. Modify the first sentence as follows: "The occurrence of chlorobenzene is distinguishable from that of benzine in that chlorobenzene is interpreted to originate from past operations at the Montrose Chemical Corporation of California DDT manufacturing plant at 20201 Normandie Avenue to the west of the Del Amo plant site. The maximum distribution of chlorobenzene..."*

Response: The report has been modified as suggested.

5. *p.ES-6¶3. Revise the first sentence as follows: "The distribution of p-CBSA is geometrically similar to that of chlorobenzene and lies within the chlorobenzene plume. The p-CBSA is associated with releases of contaminants from the Montrose Chemical DDT manufacturing plant..."*

Response: Based on verbal communications from EPA subsequent to this comment, it is the Respondents' understanding that EPA did not intend to say that the p-CBSA plume lies within the chlorobenzene plume. The sentence has been revised as requested in EPA's January 12, 1998 letter to read as follows:

"The distribution of p-CBSA is generally geometrically similar to that of chlorobenzene, and the p-CBSA has a greater lateral extent than the chlorobenzene plume in each water-bearing unit where it occurs (i.e., the chlorobenzene plume lies within the p-CBSA plume). According to the U.S. EPA, the p-CBSA is associated with releases of contaminants from the Montrose Chemical DDT manufacturing plant."

6. *p.ES-7¶1. Eliminate the last sentence and replace it with "Detected DDT is believed to have originated from releases associated with the Montrose Chemical DDT manufacturing plant. Detected BHC is believed to have originated from releases associated with operations at 20201 Normandie Avenue conducted by Stauffer Chemical Company."*

Response: The last sentence of the paragraph has been deleted and replaced with the following two sentences: "EPA, Region IX believes that detected DDT originates from releases associated with the Montrose Chemical DDT manufacturing plant. EPA believes that detected BHC originates from releases associated with operations at 20201 Normandie Avenue conducted by Stauffer Chemical Company."

7. *p.ES-8¶1. Delete the last sentence of the paragraph. EPA does not agree that the benzene in the chlorobenzene plume is at steady state, or that, as the text says, the transport mechanisms are necessarily balanced.*

Response: The last sentence of the paragraph has been deleted as requested.

8. *p.ES-8¶3. The last sentence in the paragraph appears gratuitous and should be removed. Identify the production wells (whether in use or not) which are also screened in the Gage aquifer.*

Response: The Respondents believe that the existing usage and factors that restrict or limit usage of aquifers is relevant to the RI. However, the Respondents propose to modify the paragraph as follows to take into account EPA concerns:

"State of California Department of Water Resources documents indicate 80 to 90 percent of all groundwater produced in the West Coast Basin (potable or otherwise) is extracted from the Silverado aquifer, which underlies the Lynwood aquifer. The majority of the remaining groundwater is presently produced from the Lynwood aquifer. Groundwater production from the shallower Gage aquifer is presently limited, while production from the overlying Middle Bellflower and Upper Bellflower units is restricted by their naturally poor water quality (relatively high total dissolved solids and inorganic constituents). Groundwater production from the Upper Bellflower and the Middle Bellflower B Sand is also restricted by low production rates. Production rates from the Middle Bellflower C Sand are approximately equal to or slightly greater than for the Gage aquifer. The California Regional Water Quality Control Board has designated all groundwater in the water-bearing units at the Del Amo site, including the Gage

Aquifer, the Middle Bellflower and the Upper Bellflower, as a municipal water supply resource."

Production wells which are known to be at least partially screened in the Gage aquifer are indicated on Table 7.2-1, which is referenced in Section 7 of the report text.

9. *p.ES-8¶5. Delete paragraph—it is not pertinent to the RI. These issues are raised in the FS. The fact that there are well construction standards does not provide a guarantee against groundwater use that can be relied upon in a remedial context—nor does it allow EPA to ignore the State cleanup requirements.*

Response: The Respondents have modified the paragraph to take into account EPA's concerns, as indicated above and within the January 12 1998 comments. The modified paragraph now reads as follows:

"While not providing a guarantee that existing and/or future groundwater production wells will not be impacted by contamination, current California well construction standards and local water purveyor construction practices reduce the likelihood that this will occur. Existing protective measures include..." (continued unchanged to end of paragraph)

10. *p.1-1¶3. Change the end of the first sentence as follows: "...but groundwater in the immediate area has been primarily impacted from the Montrose Chemical NPL Site and the Del Amo NPL Site." Additionally, please update the paragraph to include the fact that EPA took over JGWFS on August 14, 1997 and is now completing the document.*

Response: The paragraph has been modified as requested.

11. *p.1-5¶1 (full). Second to last sentence. Revise as follows: "The Waste Pit Area was first investigated in approximately 1972..."*

Response: The sentence has been modified as requested.

12. *p.1-7¶2. It states here that the tank farms were bermed. However, in Appendix A it is stated that the tank farms were not always bermed (ca. 1960) and the prior to berming there were spills in the area. This detail should be added <u>and the basis for the berming contention should be cited.</u>*

Response: The paragraph references storage tanks within the 2500 area, as shown on Plate 1-1. Appendix A does not appear to contain any information that contradicts the statement that the tanks within the 2500 area were bermed. Further, review of available aerial photographs indicates that the berms around the tanks in this area were present in all photographs. EPA may be confusing these tanks with those in another area. Please check Appendix A and identify the section which was believed to indicate that the tank berms were not always present so that this issue can be resolved.

13. *p.1-12¶2. Fourth sentence. The conclusion here is inconsistent with the Waste Pit ROD in which it was concluded that the vadose zone contamination does pose a threat to groundwater as a continuing source. Change the word "could" to "does."*

Response: The sentence has been modified as follows:

"Soil contamination associated with the Waste Pit Area locally extends to groundwater, and residual soil contamination in the vadose zone poses a threat to groundwater as a continuing source."

14. *p.1-13¶1. Last sentence should be updated to reflect that the Waste Pit ROD has now been issued.*

Response: The sentence has been modified as requested.

15. *p.1-13¶3. Revise the fourth sentence as follows: "Historical information indicates that crude benzene was stored and used in this area as part of the operation of the synthetic rubber plant,..." Add to the end of the paragraph: "It is likely that the apparent lack of benzene in the vadose zone under the historical source area is due to a higher rate of biodegradation of benzene in the vadose zone compared to the water table zone, over the course of time since the plant was in operation."*

Response: The paragraph sentence has been revised as requested with the exception that the word "crude" has been omitted from the fourth sentence.

16. *p.1-13¶3. Top of paragraph. Focused investigations, while generating a wealth of information, have not fully identified the lateral and vertical extent as the sentence suggests, except in the gross sense, perhaps. Also, the distribution of residual saturations of NAPL has not been completely defined. While not stated, this might be inferred by the unwary reader. Please revise somewhat to give more balance.*

Response: The first two sentences of the paragraph have been combined and reworded to take into account EPA concerns:

"The spatial distribution, mode of occurrence, and physical characteristics of the benzene LNAPL at the MW-20 area were evaluated as part of focused investigations conducted under the current AOC."

17. *p.1-15¶4. Second sentence. Revise as follows: "The property on which the Montrose Chemical Company conducted its DDT manufacturing operations (the Montrose Plant Property)..."*

Then, throughout the document, general references (e.g. in next sentence and referenced figures including Figure 1.2-1) when referring specifically to the original land on which the Montrose facility operated should be changed to "Montrose Plant Property" instead of using "Montrose facility" or "Montrose site."

Response: The sentence and document have been modified as requested.

18. *p.1-16¶3. The latter part of the paragraph needs to be updated to reflect the current status of the GWFS. This comment should apply globally throughout the document to the extent it applies. Also, in this paragraph clarify whether Del Amo data shows the presence of these contaminants or whether (and to what degree) Hargis+Associates data is relied upon.*

Response: The paragraph has been modified as requested. A further modification has been made to change "trichloroethane (TCA)" to "trichloroethene (TCE)" and "tetrachloroethane (PCA)" to tetrachloroethene (PCE)". Both Del Amo and Hargis + Associates data reflects the presence of TCE and PCE in groundwater in the vicinity of the Montrose site. Figures 5.2-1 through 5.2-41 indicate which data is from Hargis + Associates.

19. *p.5-1¶1. Clarify the meaning of the term "future documents" to the extent possible.*

Response: Section 5.1 has been revised and the reference to future documents removed.

20. *p.5-3¶4. The existence of data after 1995 should be identified and discussed, even though the RI is based on 1995 third period data.*

Response: The first sentence of the preceding paragraph has already indicated the existence of groundwater data subsequent to the third sampling event 1995. The paragraph of concern has been modified to indicate that a detailed discussion of groundwater data from the first sampling period 1996 event is available within the "Groundwater Monitoring Report, First Sampling Period 1996" dated June 17, 1996.

21. *p.5-5 to 5-15. There is not much here to provide a reader with a context in interpreting the groundwater results. MCLs are discussed only with respect to metals results. If not already added in response to other comments, the MCLs, and other pertinent context-providing standards, should be referenced for the VOCs and SVOCs found at the site as well.*

Response: The text and figures have been revised to include MCLs.

22. *p.5-15¶5. (Last paragraph on page, onto top of next page). With the exception of the first sentence, this paragraph should be deleted. Again, while these may be issues the PRPs wish to raise, they are not appropriate to the RI report in this situation. The RI should not be dictating that the FS will deal with particular issues that may prove inconsequential within the regulatory context.*

Response: The paragraph has been modified as requested.

23. *p.5-15§5.3.3.1. Regarding benzene source attributions. The benzene near the Stauffer Research parcel at the Montrose property, and under the Montrose central processing area, is attributable to one or more of several possible causes which should be listed. These are (1) releases of chlorobenzene (benzene existed as a contaminant in chlorobenzene feedstock at the Montrose manufacturing plant), (2) possible releases of benzene from the Stauffer BHC manufacturing operations in which benzene feedstock was chlorinated to make BHC, (3) releases*

of benzene from the long-distance conveyance pipelines at the southern edge of the Montrose facility, and (4) dissolved transport of benzene from the Del Amo facility itself. With respect to (4), it can and should be noted that there appears to be a clean area between the Montrose and Del Amo sites, and that the benzene under the Central Processing Area is far cross-gradient, not downgradient, from the Del Amo sources. Thus, for Del Amo to have caused the contamination, significantly different local gradients would have had to exist in the past.

Response: The Respondents do not agree that explanation number four in the EPA comments is valid, and do not wish it to be listed with the other three. The Respondents propose the following modification to the bottom of the first paragraph of Section 5.3.3.1:

"A third plume area exists west of the plant site, in the vicinity of the Montrose Plant Property, and is partially merged with the western plant site plume. The benzene in this area may be attributable to one or more of the following potential sources:

- releases of chlorobenzene feedstock at the Montrose manufacturing plant that contained benzene as a contaminant;
- Possible releases of benzene from the Stauffer BHC manufacturing operations in which benzene feedstock was chlorinated to make BHC; and
- releases of benzene from long-distance conveyance pipelines at the southern edge of the Montrose facility.

The presence of an area between the Montrose and Del Amo plant areas where benzene is consistently at very low or non-detectable concentrations (well XMW-11) indicates that the Montrose area benzene plume cannot be attributable to the Del Amo plant site without significant deviations from groundwater gradients observed over the duration of the groundwater monitoring program. There is no indication from the dissolved VOC plume configurations in any other areas that such deviations have occurred."

24. *p.5-18¶6. Delete last sentence. EPA believes there is insufficient information to speculate about biodegradation of MCB.*

Response: The paragraph has been modified to delete the reference to biodegradation of chlorobenzene.

25. *§6.1. General. The discussion should be revised to distinguish between BTEX attenuation, fate, and transport versus other VOCs (PCE, TCE). Make clear that what is being discussed in most cases is benzene outside the MCB plume, ethyl benzene, naphthalene, etc. and not TCE and PCE, MCB, DDT, or other contaminants in the overall joint site plume.*

Response: The text has been revised to make a clear distinction between the fate and transport of BTEX and other VOCs.

26. *Appendix A. Appendix A presents a problem because EPA is unable to verify presently that the information the Respondents have provided is correct in light of existing documents, that key omissions are not misleading to the reader, and that the treatment is comprehensive. As we have agreed with the Respondents in the past, a more detailed and verified operational history is planned for the final RI, and yet this detail on operational history is important in understanding why the GWRI focused on the areas it did. To address this problem, we request that the Respondents attach the disclaimer shown below to the top of the appendix:*

EPA Disclaimer: This appendix has been prepared and provided by the Del Amo Respondents in order to provide a general background of the history of the Del Amo synthetic rubber facility. This appendix has not been independently verified for accuracy and completeness by EPA. As a result, while EPA has approved this report, EPA has not approved this appendix. EPA does not necessarily endorse or agree with any statement, including statements presented as facts, contained in this appendix. The reader is advised that the information in this appendix may be incomplete or inaccurate.

In addition, please address the following comments within Appendix A:

- *The ownership history seems focused only on the 1942-1955 time period, leaving out the period in which Shell operated the plant exclusively. More information about the post-1955 time period should be provided, if possible.*

- *The ownership and operations discussion should include the fact that Dow Chemical designed and built the Styrene plant, including most of the pits and ponds in the Waste Pit area.*

- *All laboratories at the facility need to be identified and marked on the map.*

Response: The Respondents will attach the EPA Disclaimer to Appendix A as requested.

Post 1955 ownership is discussed in the draft report beginning at the middle of Page A-3 and continuing to the end of the section on page A-4. This reflects all of the available information regarding ownership.

The Respondents do not agree that "Dow Chemical designed and built the Styrene Plant including most of the pits and ponds in the Waste Pit area." The following text is proposed to

replace Section A.1.1 (Styrene Plant) and more accurately describe the direction under which the Styrene plant was constructed and operated:

"From 1942-1955, the styrene plant operated under agreements between The Dow Chemical Company (Dow) and Rubber Reserve Company, a subsidiary of Reconstruction Finance Corporation (RFC), and its immediate successors, the Office of Rubber Reserve of RFC and later the Federal Facilities Corporation (collectively, Rubber Reserve). Dow, acting as agent for the Defense Plant Corporation (DPC), entered into a subcontract with Stone & Webster to produce the engineering drawings and direct construction work. Dow provided to the Stone & Webster engineers detailed information about the styrene process previously developed by Dow. DPC oversaw construction and retained the right to modify the work. Following construction, Dow's role included operation and management of the facility for the production of styrene as agent for Rubber Reserve. Rubber Reserve remained the ultimate authority over plant operation.

Construction in the field began on August 24, 1942 and partial production of styrene began on June 14, 1943, with full operation beginning on August 17, 1943. The production capacity was 25,000 short tons (2,000 lbs/ton) of styrene per year."

Section A.1.2 regarding the Butadiene plant has also been modified using language similar to that presented above, but substituting "Shell" in place of "Dow".

Response to third bulleted comment:
Laboratories are identified on Plate 1-2 of the report.

Other Modifications

The report has been recently modified to make corrections that were only recently noticed. These modifications are independent of EPA comments and are listed below:

1. p. ES-6, last paragraph, second line: The reference to the southeast corner of the plant has been corrected to southwest.

2. Plates 1-1 and 1-2: The 1300 and 2300 areas have been relabeled to indicate they were styrene production and propane cracking areas rather than for ethylbenzene production. Section 1.2.2.1 of the report text (see Styrene Plant description) has also been modified to reflect this correction.

3. p. A-1, paragraph 4 has been modified to delete "Agreements to Lease" and refer instead to "Agreements of Lease and Operation".

4. p. A-3, paragraph 1. The reference to "Uniroyal Goodrich Tire Company" has been changed to "Michelin North America, Inc." to correctly indicate the current name of the company that formerly operated the second and third copolymer units, the United States Rubber Company.
5. p. A-5, paragraph 2, fifth sentence. The sentence has been modified to read as follows: "In addition to these waste treatment facilities, historical aerial photographs indicate the presence of waste disposal impoundments in the southern portion of the styrene plant. This area is now designated as the Del Amo Waste Pit area."

6. p. A-7, Section A.2.1.4. This section has been modified to more accurately state the chronological history of propane cracking. The paragraph now reads as follows:

   "From the end of 1946 until August, 1947, ethylene was produced by purification of a gas stream from Southern California Gas. In August 1947, ethylene was produced by thermal cracking of propane at five cracking furnaces outside of the 1300 and 2300 areas. After Shell began operating the styrene plant in 1955, heavier feedstocks were used for cracking, including butane (C4) and cyclohexane (C6).

   According to the Styrene Process Manual (Carlstrom et al., 1955), the cracking process proceeded by ....etc. unchanged to end of section.

7. p. A-11, paragraph 3, last sentence. The sentence has been modified to become three sentences, and now reads as follows: "Photographs taken between 1952 and 1976 show the 2-series pits to be unused and covered. However, some small, irregular areas of tonal contrast are present at the 2-series pits in photographs dating from the 1950s and 1960s. These areas of tonal contrast could be stained soil, although it is also possible that they are only areas of vegetation."

8. p. A-12, paragraph 1, third sentence. The sentence has been modified to become two sentences and read as follows: "A large, irregular-shaped, dark area is present east of pit 1B in a 1947 aerial photograph. This area is inferred to be soil staining, although the quality of the photograph is poor, and it is conceivable that the dark area is due to vegetation.

9. p. A-20. Section A.2.3.4, first paragraph, fourth sentence. The reference to styrene "vapor" is incorrect; the styrene produced during the stripping process was a liquid. Therefore, the word "vapor" has been omitted.

EPA COMMENTS DATED MARCH 9, 1998
ON FEBRUARY 3, 1998 "CHECK DRAFT"
DEL AMO GROUNDWATER REMEDIAL INVESTIGATION

First Installment Comments

General Comments

[A] Table 1 includes responses to comments on Hydrostratigraphic cross sections and supporting text and tables. The following comments refer to the information listed in Table 1.

Plate 3-2 (B-B'). Well SBL0020 - The thickness of the MBFM (sum of both outcrops) in the same cross-section is shown as 23 feet, whereas the thickness in Table 3.2.2 is reported as 28 feet. The plate and table should be adjusted accordingly.

Response: Table 3.2.2 is modified, MBFM was changed from 28 to 23 feet with a corresponding change in thickness of the MBFC from 9 to 14 feet. Also, a corresponding change was made to Table 3.2.1 changing the depth to the base of the MBFM from -63 feet to -58 feet. Corresponding changes to Figures 3.2-10 and 3.2-11 were also made.

Plate 3-5 (E-E'). Well SBL0033 - The cross-section shows the top of the MBFC at -104 feet with a thickness of 4 feet. Table 3.2.1 lists the top at -115 feet and Table 3.2.2 lists the thickness as 15 feet. The tables should be adjusted to remain consistent with the cross-section. In addition, SBL0033 should be added to Figure 3.2-10 with an associated MBFC thickness of 4 feet.

Response: The top of the MBFC (base of the MBFM) was changed from -115 feet to -104 feet in Table 3.2.1. Corresponding changes to the thickness of the MBFM (from 15 feet to 4 feet) and MBFC (from 18 feet to 29 feet) were made to Table 3.2.2, and Figures 3.2-10 and 3.2-11.

Plate 3-7 (G-G'). Well SBL0077 - The cross-section shows a continuous MBFB/C layer from -42 feet to -108 feet (66 feet thick). Table 3.2.1 and Table 3.2.2 both divide this layer at -60 feet into MBFB (18 feet thick) and MBFC (48 feet thick) layers. Either the tables or cross-section should be modified to remain consistent, or an explanation of the reason for the unit split in the table should be made.

Response: This **new** comment would not only apply to SBL0077, but in fact all hydrostratigraphic control locations where the merged MBFB/C is present. Splitting the merged MBFB/C into discrete MBFB and MBFC intervals was required for construction of the joint

groundwater model. Generally, there was basis for the specific thickness assigned to each unit (subtle to distinct fining of the sand correlative to the MBFM). Where data indicated no discernible break within the MBFB/C, thicknesses for the MBFB and MBFC were assigned based on the site-wide proportioned average thickness of the MBFB and MBFC. An explanation was added as a footnote to table 3.2-2.

Plate 3-10 (K-K'). See comment for Plate 3-2 (B-B').

Response: Table 3.2.2 and Figure 3.2-10 are modified, MBFM is now 23 feet with a corresponding change in thickness to the MBFC from 9 to 14 feet. Also, a corresponding change was made to Table 3.2.1 changing the depth to the base of the MBFM from -63 feet to -58 feet.

[B] Vertical Gradients. There is insufficient information provided in the new vertical gradient text and supporting table to demonstrate that the vertical gradients were properly calculated. The date of water levels used to calculate the vertical gradient should be included in the text and in Table 4.1-2. The text on page 4-6, paragraph 3 indicates that the mid-point elevation of the well screens were used to calculate the vertical gradients. The text should either include a reference to where this information is in the report and/or the elevations should be included in Table 4.1-2.

Response: The report text and Table 4.1-2 have been modified to indicate the date of the water levels used in calculating the vertical gradients (third sampling period 1995). Well screen mid-points have been added to Table 4.1-2 as *requested.*

[E] Water Supply Wells. The text in Section 7 was modified to describe new information provided in Table 7.2-1 on water supply wells. EPA has reviewed the new text and table and has the following comments:

Assuming groundwater in the Gage Aquifer and deeper units flows to the southeast, there are 6 wells that are mis-categorized in Table 7.2-1 as being cross gradient, rather than downgradient, of the Del Amo site. These include LACDPW Well Numbers 814A, 825, 835E, and 846E, K, G. Please change these designations.

Response: We agree that 825, 835E, 846E, 846K and 846G are possibly downgradient and a conservative approach was taken by reclassification of these wells on Table 7.2-1. Well 814A, a water table well, is clearly up-gradient of any Del Amo site related groundwater contamination source areas and this designation should not change.

Table 7.2-1 includes the "Gardena" as a completion zone hydrostratigraphic unit. Because the Gardena Aquifer is not included in previous discussions of hydrostratigraphic units (i.e. the Gardena Aquifer is not included in Figure 3.4-1), please provide a brief description of its stratigraphic position relative to the hydrostratigraphic units described in the report.

Response: A brief description of the Gardena Aquifer's contemporaneous relation to the Gage Aquifer (CDWR, 1961) has been added to footnote number 6 of Table 7.2-1.

On page 7-3, paragraph 2, the last sentence is inaccurate. The sentence states "...wells designated with an "unknown" activity status are situated in excess of one mile up gradient of the Del Amo plant site." According to Table 7.2-1, LACDPW well 813Y is inactive but is only 0.7 miles up-gradient (less than 1 mile) of the Del Amo site. Also there are several wells with unknown status that are cross gradient of the Del Amo site. The text should be modified to accurately reflect the information provided in the table.

Response: The sentence has been modified to more accurately relfect the information in the table.

On page 7-5, paragraph 2, several statements are made regarding the small percentage of production from the Gage Aquifer relative to the Lynwood and Silverado Aquifers. First, Table 7.2-1 should include production data from the most recent available production year so that statements regarding relative production can be substantiated. Also, the second sentence in this paragraph states that there are only two active wells that pump water from the Gage Aquifer. According to Table 7.2-1, there are four active wells partially screened in the Gage Aquifer (LACDPW Well Numbers 802T, 776, 766A, and 766B). Third, please note that extremely old wells tended to be constructed with open gravel packs and must be noted as possibly being open to deeper units, where they exist.

Response: At the time of submittal of the response to first installment comments, submitted January, 1997, the most recent available production year data was presented (1996 production year) in Table 7.2-1. However, the reference citation in text Section 7.2 was not updated from 1995 to 1996 to reflect that the most recent available information had been used. The text citation will be updated.

The subject of the paragraph is "municipal supply wells" as stated in the first sentence. Two of the four wells cited in EPA's comment, LACDPW Well Numbers 802T and 776 are listed as irrigation supply wells, not municipal supply wells. Additionally, these two irrigation wells are listed in Table 7.2-1 as having no production for the 1994 through 1996 production years. Therefore, based on the most recent available data, the statement that only two wells (LACDPW

Well Numbers 766A and 766B) extract groundwater from the merged Gage- Lynwood Aquifer is correct. For clarity, the sentence will be modified to read "With comparatively minor production for municipal purposes from the two wells completed partially in the merged Gage-Lynwood Aquifer, totaling only about 6 percent of the total municipal production from within this two-mile radius, the great majority of groundwater produced for municipal supply within 2 miles of the plant site is extracted from the Silverado Aquifer."

A statement will be added to the end of Section 7.2 indicating that older wells tend to be constructed to a lower standard, possibly without annular sealing materials placed between aquifers or at the surface. Where these wells exist the potentially open annular space may allow hydraulic continuity between shallow and deeper aquifers.

Specific Comments

26. The last sentence of the response states that "....MCLs are not clean-up standards, but rather drinking water point-of-use and municipal well standards". Delete this sentence. EPA has not yet made a final determination of groundwater cleanup standards for groundwater at the Del Amo site. While MCLs were promulgated under the Drinking Water program as point-of-use and municipal well standards, the NCP was then promulgated which specifies that MCLs are, in general, to be considered relevant and appropriate standards for in-situ cleanup for groundwater where beneficial uses include use as drinking water. The sentence is therefore misleading. Moreover, it appears to relegate the role of defining cleanup standards to the GWRI, where it does not belong. Please delete the sentence; do not replace it with something else as the discussion of the determination of the use of MCLs in the cleanup decision is not appropriate to the RI.

Response: The Respondents' original response to this comment is reproduced below, with the last sentence deleted, as requested.

Response: The text has been modified to include the metal MCLs as suggested.

32. The second to last sentence of the response shall be changed from "may over-estimate concentrations" to "may over- or under-estimate concentrations".

Response: The response to the original comment is duplicated below, with the sentence modified as requested.

Response: The Respondents recognize that the contours do not in all cases reflect the posted concentration values at the locations indicated in the comment, and have modified some contours

as indicated in the table below. It should be noted however, that concentrations posted at well point locations represent one-time measurements from temporary installments with a screen length that is less than the permanent monitoring well locations. The one-time sampling of well points make the concentration data from these locations less reliable than the data for monitoring wells which have been sampled several or more times, allowing a history of concentration data to be developed. Furthermore, given the shorter screen length of the well points relative to monitoring wells, well point concentrations are not completely comparable to data for monitoring wells with longer screen lengths, and in some instances, may over- or underestimate concentrations relative to what would be measured from a co-located monitoring well. Therefore, while well point data is taken into consideration in interpreting concentration contours, more weight is given to monitoring well data when available for a given area.

The following modifications have been made:

Location	Area	Modification
PZL0003	NW corner	None. October 1995 result anomalous. Six of eight results indicate benzene <0.5 μg/l.
CWL0046	NW corner	Extended queried 1 μg/l contour up to CWL0046.
CWL0022	butadiene plant	Added a queried circular contour around CWL0022.
CWL0045	butadiene plant	Added a queried semi-circular contour around the south side of CWL0045.
CWL0044	butadiene plant	None. Posted concentration is <1 μg/l.
CWL0041	copolymer plant	Added queried 1 and 10 μg/l circular contours around CWL0041.
PZL0022	Waste Pit Area	Corrected posted concentration to 1.3 μg/l, adjusted contour to go through PZL0022.
CWL0042	southern styrene plant	None. Data at PZL0018, PZL0022, and SWL0005 suggest that 1 μg/l contour lies to south of CWL0042. Given the greater reliability of the data at the permanent monitoring locations, these data are given preference.
PZL0025	Waste Pit Area	Moved 10,000 μg/l contour outside of (south of) PZL0025.

33. Figure 5.2-2. The 1 ug/L concentration contour line (10^0) is not drawn through Well PZL0022 as indicated in the comment, but is rather drawn to the south of the well. Because the concentration at Well PZL0022 is above 1 ug/L, the contour line should be drawn north of the well. Because the 1 ug/L contour line should be drawn north of Well PZL0022, it is also logical to extend the 1 ug/L contour line to the north around temporary well point CWL0042.

Response: There are alternate plausible interpretations for the benzene concentration contours drawn around temporary well point CWL0041. The figure includes relatively tight contours around this point. An alternative interpretation of the 1 ug/L contour around well point CWL0041 is that it is continuous with the 1 ug/L contour just to the south of this well point. These alternate interpretations should be mentioned in the text.

Responses 33-35: The Respondents believe comments 33-35 pertain to the original comment No. 32. The text and figures referred to in these comments have been modified in accordance with discussions during our March 17, 1998 conference call regarding the EPA comments. Figure 5.2-2 has been modified so that the 1 μg/l contour is at PZL0022, and is queried between PZL0022 and PZL0012. The report text has been modified to indicate that the 1 μg/l contour at CWL0041 could alternatively be interpreted to be continuous with the 1 μg/l contour to the south of the well point. The isopleths in the vicinity of the offsite landfills on Figures 5.3-3 and 5.3-4 have been modified to reflect the uncertainty inherent with the limited data from this area. The contours are left open to the east, and are appropriately queried in other areas.

34. Figures 5.3-3 and 5.3-4. The explanation provided for the relatively square-shaped concentration contours east of the Del Amo site and north of Del Amo Boulevard is unacceptable. The chlorinated compound concentration contours should be modified based on available water quality data only. It is not appropriate to infer concentrations based on landfill boundaries. Landfill boundaries could be separately added to this map if the respondents want to relate the concentrations of the chlorinated compounds to these features.

Response: See response to Comments 33-35, above.

38. The response may be worded incorrectly. The response states "...benzene degradation rates ranging from nondetectable to approximately 70 days, with the average rate of about 350 days". Should the response be stated "...nondetectable to approximately 350 days, with an average rate of approximately 70 days"?

Response: The response to the original comment is duplicated below, modified to address EPA's concerns.

Response: Reported degradation rates for benzene vary. Rifai et al. (1995) compiled a table of field-derived benzene degradation rates ranging from no significant degradation to a half-life as short as 70 days. The average half-life is approximately 350 days. Also Olsen and Davis (1990) report a half-life of 110 days. This information will be added to the revised text discussion.

Third Installment Comments

Discussion on Comment #3 relating to Plume Stability and Biodegradation

Although the discussion of plume migration in Section 6.1 has been expanded from the previous version, the argument for stability of the benzene plume in the water-table units continues to be not well-supported as written. Specifically, EPA has found the argument to contain some inaccurate statements as written, to be lacking certain elements, and to be structured in an unsystematic way. While It appears that there is significant basis in the data in the report to make many of the arguments espoused in the section, the section fails to bring them to bear in a fashion which is compelling.

Because the ideas presented in this section are critical to the conclusions of the report, EPA has provided an extended discussion of this comment. The following discussion focuses on specific aspects of the initial comment that were not adequately addressed, and identify unsupported or inaccurate statements. In addition, because the argument for the relative stability of the benzene plume is not well presented overall, an alternative structure to the organization of Section 6 is presented at the conclusion of the specific comments. This alternative structure has been provided as guide to making the arguments in this section in a manner that presents the supporting evidence in a systematic and comprehensive manner.

This chapter argues both for the presence of the biodegradation and for indications of plume stability. We mention up-front that the Respondents should acknowledge within this discussion that there are limitations in the ability to interpret several of the supporting lines of evidence, ***when taken alone****, for "plume stability." It is only when multiple lines of evidence have been considered together that the arguments can become compelling. Therefore, large-scale conclusions (i.e. "this proves biodegradation and plume stability...") should not be drawn with each line of evidence, but only when all lines of evidence have been discussed in a systematic fashion. Also,* ***conditions*** *should be separated from* ***processes*** *in developing the argument. Spatial geometry of contaminant distribution, for instance, is related yet distinct from the factors of time, historical release, and plume movement. Likewise, the current location of contaminants is one matter, the* ***process*** *of biodegradation is another. The current argument mixes these together, presuming some before they have been discussed, and the result is confusing.*

The original comment #3 in the Third Installment identified seven bulleted factors that were to be addressed to support and provide balance to the conclusions regarding stability of the benzene plume. The discussion which follows is structured loosely on these seven bulleted factors, to which Dames & Moore tried to respond in EPA's original comment.

<u>Factor 1:</u> The uncertainties introduced by the groundwater mound and the P1 NAPL on the determination of plume stability in the vicinity of these features.

The text added in response to this factor sets off a series of problems, described below. As a result, these need to be corrected; at the same time, the original factor was not fully addressed. As these problems are also related to factors 4, 5, and 7, our discussion of those factors refers back to the following discussion as well.

Instead of exploring the implications of this factor, the response in Section 6.1 essentially ignores it by prematurely concluding that, "...the preponderance of data from many lines of evidence support the conclusion of plume stability." The five lines of evidence listed on page 6-2 are not systematically developed in the subsequent text to make a compelling case for plume stability. Our discussion here, therefore, focuses on the presentation of these "lines of evidence" and the steps that should be taken to present these lines of evidence better.

Specifically, the first line of evidence, "location and distribution of sources", is not well explained (i.e., no clear connection or discussion is made between the location and distribution of the sources and plume stability). Accordingly, the interrelationship among the following factors should be clearly and systematically discussed in turn: (I) location of sources; (ii) history of release; (iii) travel time of contaminants; and (iv) actual contaminant distribution/plume geometry. It is acknowledged that these items are mentioned on page 6-5, but that discussion does not specifically support the argument that "location and distribution of the sources"are related to plume stability. In addition, the fact that this discussion is located more than three pages from where "location and distribution of the sources" is listed as a line of evidence obfuscates the arguments being made. The structure of the argument for plume stability should be revised to present the evidence for the argument better. As mentioned, a guiding outline for revising the presentation of evidence is presented at the end of this discussion.

The second and third lines of evidence presented on page 6-2 relate to the consistency in time-series data, both inside the plume and as a function of distance along a groundwater flow path. There are several deficiencies related to the presentation of these lines of evidence:

- *There are no time-series data presented in Section 6 to support the statements. Reference is made to Section 5.2 for the data, but Section 5.2 simply refers the reader to Appendices*

G1 through G3. Time-series data cuts to the heart of evidence that could support plume stability. Plots of these data should be presented in Section 6 to support the claim that dissolved concentrations are not significantly changing with time, unless a very specific, identified set of figures from earlier chapters can be used to show this link without further adaptations.

- *Page 6-2 refers the reader to a discussion of the statistical validity of the time-series data is reportedly presented in Section 5.2; however, "the presence or absence of statistically valid trend in contaminant concentrations through time at all wells" is not discussed in Section 5.2 as stated on page 6-2 (first sentence following bullet points). The discussion of statistical validity in Section 5.2 is vague; the definition used for "statistical validity" is not stated.*
- *The discussion of trends is summarized by the general and unsupported statement on page 5-6: "Monitoring locations and key compounds for which statistically significant concentration trends are identified in the text below, and graphs illustrating the trends are included in Appendix G2." Yet, the only wells specifically identified and discussed in Section 5.2 are those in which the trend reflects a change in concentration (either increasing or decreasing) with time. The inference is that all remaining wells exhibit "stable" time series. However, wells which exhibit "no significant change with time" actually do exhibit a trend (i.e. unchanging with little variability), as opposed to wells which have data that are so variable over time as to be inconclusive with respect to establishing a particular trend as a function of time. Thus, while the discussion states that most wells do not show an increasing or decreasing trend, the evidence does not speak to whether these wells exhibit a trend of no statistically significant change in concentration with time (i.e., stability).*
- *The statement is made that concentrations are "typically relatively stable over time" (page 5-7). This statement requires that there be some discussion of how the term "relatively stable" is defined. The text in Section 6.1 (page 6-2, first paragraph under bullet points), similar to the text in Section 5.2, only identifies the wells that have "trends" as those in which the concentrations either increase or decrease over time. In fact, it is specifically stated that, "...the remaining 61 wells do not demonstrate any trend in benzene concentrations over time" (page 6-2, first paragraph under bullet points). As just discussed, if there is no trend in concentration as a function in time at a particular well, that does not mean that there is no change in concentration as a function of time. For stability to be supported, there must be a trend in the data, and that trend must indicate no change in concentration. This discussion and evidence is vital to case of plume stability, and must be incorporated into Section 6.*
- *Section 5.2 (page 5-7), and Section 6.1 (page 6-2), identifies wells in the water-table units that indicate concentrations are changing with time. No possible explanation for these less-than-stable conditions is presented in either section. In some cases, the changes in concentration are quite large (i.e., over several orders of magnitude) and deserve some*

discussion. The lack of discussion on these points weakens the argument for stability unnecessarily.

- *Section 6.1 (page 6-3) and Section 5.2 (page 5-7) use Figure 5.2-3 to illustrate the stability of the benzene plume. The scale of this figure makes it nearly useless for that purpose. The figure represents data in the water-table units, where groundwater velocities are on the order of less than 20 feet/year. It is therefore not unexpected that changes are not observed because the figure represents a change in conditions of only 3 years and the scale of the map is so small that changes of less than several hundred feet in the positioning of the contours cannot be reasonably detected. This figure should be omitted because its inclusion is misleading. In addition, the overall argument must admit the limitations in detection of plume movement implied by a short monitoring timeframe with low groundwater velocities. This is especially applicable to the UBF and B Sands.*

The line of evidence for plume stability pertaining to the consistency of time-series data also uses Figure 6.1-1 to support the argument. This figure does not readily support the argument for time-series consistency. Three points are made:

- *The text implies that the furthest upgradient well is PZL0025, but the figure identifies the well as PZL0020. This discrepancy should be corrected.*
- *The statement is made on page 6-3 that, "...the concentrations in these wells [used in Figure 6.1-1] are consistent with plume stability." This statement is not supported by the figure because the concentration data are plotted on a log scale, which tends to bunch together data from the upgradient well (which spans a range of several hundred thousand ppb) and spread out the lower concentration data at the furthest downgradient well. At a minimum both arithmetic and log plots should be developed and assessed before this conclusion can be supported graphically in this way.*
- *All of the wells used in this figure are in the water-table units, therefore the statement (page 6-3, paragraph 2) that the data in the figure support the conclusion for plume stability in <u>all</u> HSUs is incorrect. This statement should be omitted.*

The fourth line of evidence cited to support plume stability ("abrupt attenuation" of the plume occurring in a similar fashion in both water-table units and deeper HUs) is misleading for two reasons:

- *The term "attenuation" implies a <u>reduction</u> in concentration has occurred. Because it is not obvious that a reduction in concentration is occurring at this point in the discussion (i.e., the process of intrinsic biodegradation has not yet been introduced), this is a poor choice of words to characterize the shape of the contaminant distribution. While we agree that it appears bioattenuation is occurring, raising it as a given at this point weakens, rather than*

strengthens, the argument. This portion of the argument is describing a static condition (how far the contamination has moved). Attenuation refers to an action or process, and, although the potential movement of the plume is undoubtedly affected by intrinsic biodegradation based on various known factors, it is inappropriate to describe the shape of the front of the plume as being attenuated. For example, on page 6-1 (fourth sentence under 6.1), the steepness of the slope of the plot of concentration versus distance is related to the abruptness of the attenuation. This is misleading. The concentration gradient is what is abrupt or sharp; attenuation, while undoubtedly occurring, is not what is "abrupt."

- *The data, as depicted in maps of equal-concentration contours, show sharp edges to the plume (i.e., relatively high concentration gradients with respect to distance). In the water-table units, this is particularly the case in directions that are generally perpendicular (transverse) to the presumed principal directions of groundwater flow. The sharp edges of the plume, considered by themselves, do not necessarily imply that concentrations have been lowered, but represent one of several factors leading to this conclusion. The use of the term, "rapid benzene attenuation" (page 6-3, first sentence of second full paragraph), for example, is therefore a misleading use of wording as it combines notions of speed with contaminant reduction when the issue is simply a description of the geometry of the plume and its leading edge. On their own, sharp edges of a contaminant plume (high concentration gradients), do not necessarily imply stability with respect to movement of the plume over time. When viewed alone, the high concentration gradients at the edges of the benzene plume are also consistent with conventional advective-dispersive solute transport within relatively short distances from a source area. To derive conclusions of stability, factors of historical release, timing, groundwater flow, etc. must be brought to bear in conjunction with the observation of sharp contours.*

Therefore, based on the aforementioned, all reference to the word "attenuation" when describing the geometry of the plume should be deleted and the discussion modified as indicated.

<u>Factor 4.</u> Plausible explanations for why low concentrations of benzene appear to be found in the southeast corner in the UBF.

It is acknowledged that Section 6 discusses the low concentrations of benzene that commingle with the chlorobenzene plume, which explains the conditions in areas west and southwest of the Del Amo site. The discussion of the Gardena Valley #4 landfill, however, does not fully explore the potential link between this landfill, and other potential sources (within the Del Amo site), and the relatively low levels of benzene concentrations in this area. Consistent with the initial comment, this factor needs to be addressed.

<u>Factor 5.</u> Acknowledgement that groundwater flow velocities in this unit are small and therefore the time to see movement of the plume may be substantial.

Although the groundwater velocities are discussed on page 6-5, there is no reference to the fact that the period of record is too small to observe changes in the plume. Consistent with the initial comment, this factor needs to be addressed.

Factor 7. ***Other more balanced and complete arguments for why plume fronts appear to be stable, including assessment of numbers of rounds of data for particular wells used in the argument.***

This factor has not been adequately addressed. See remarks above under Factor 1 concerning the second and third lines of evidence presented on page 6-2. In addition, there should be acknowledgement that the period of record represents only 4 years.

Outline Guide for Argument for Section 6

Support for the argument of relative stability of the benzene plume needs to be presented in a systematic and comprehensive manner. The following outlines the topic of dissolved benzene mobility and identifies the principal factors that should be presented, with existing data, to make the case for the relative immobility of the benzene plume.

I. General description of the process that influence subsurface contaminant transport

- *Advection/dispersion*
- *Adsorption/retardation*
- *Intrinsic biodegradation*

II. Description of history and distribution of plume

- *Identification of (LNAPL) source areas*
- *History/Timing of release from source areas*
- *Present current spatial distribution (geometry) of the plume in each hydrostratigraphic unit, starting with the water-table units*

III. Mobility of benzene (Assess separately for each hydrostratigraphic unit)

Groundwater velocities

- *Identify significance of principal determining factors (hydraulic conductivity, hydraulic gradient)*
- *Calculate/discuss anticipated general advective travel times*

Time-Series Data

- *Present and discuss time-series concentration data (plots of C vs. t).*
- *Identify wells with statistically significant trends of concentration vs. time.*
- *Include/emphasize wells where the trend is no-change with time.*
- *Discuss significance of only 4 years in the period of record.*

Intrinsic biodegradation

*(Evidence for significant intrinsic biodegradation only, **not** plume stability, yet)*

- *Geochemical evidence (dissolved oxygen, methane, nitrate, etc.)*
- *Plume geometry evidence*
- *Expected vs. actual travel time distance*
- *Modeling performed in JGWFS Effort (e.g. the fact that current distributions cannot be reproduced without chemical degradation)*
- *Significant and heavily-documented knowledge of benzene biodegradation mechanisms based on laboratory and field study, citation of literature*

*Knowlege of benzene degradation at similar sites (doesn't **prove** it at Del Amo - again, another supporting line)*

IV. The Case for the Relative Stability of the Benzene Plume

The combination of pertinent factors, taken together:

- *Plume geometry*
- *Time-series data (including arithmetic plots)*
- *Evidence of intrinsic biodegradation*
- *Similarity in evidence in all hydrostratigraphic units*
- *Model simulations using calibrated half-lives do not show significant movement over time.*

----------*End of Discussion of Comment 3*----------

Response: Section 6 has been restructured and modified to address EPA's comments.

13. Figure 5.3-4 displays the distribution of dichlorinated compounds in the vicinity of the Del Amo site. EPA's comment requested that a discussion of the map be added to the text. The response to the comment is "The respondents have presented and discussed the distribution of an extensive list of compounds and do not believe that adding additional figures and text for any dichlorinated compounds would improve the report". First, U.S. EPA did not request that any additional figures displaying dichlorinated compounds be produced. Second, the refusal to discuss dichlorinated compounds in the text is non-responsive. The text should include the

explanation provided in the response that dichlorinated compounds at the plant site are closely related to the distributions of TCE and PCE.

as requested to indicate that the distribution of dichlorinated compounds at the plant site is closely related to the distributions of TCE and PCE.

Final Installment Comments

8. *The proposed revised text is acceptable except that the word "restricted" in the third and fourth sentences should be replaced by the word "limited". It is true that production from shallower hydrostratigraphic units is limited by higher TDS levels, but these TDS levels do not restrict the use of the water.*

Response: The word "restricted" has been replaced with "limited" in the text of the Executive Summary, as requested.

9. *EPA requested that paragraph 5 on page ES-8 be deleted (Also see first paragraph of Section 7.4.2). Instead of removing the paragraph, the respondents modified the paragraph. The first sentence of the proposed revised paragraph refers to California well construction standards as reducing the likelihood that wells will be impacted by contamination. The following text should be added after the first sentence "California well construction standards have been in place since December 1981 (Bulletin 74-81, December 1981, amended by Bulletin 74-90, June 1991). Wells installed before this December 1981 may not have surface seals. For wells without adequate seals, shallow contamination can be drawn down through annular materials to deeper units."*

Response: The report text (Executive Summary and Section 7.4.2) has been modified as requested.

NEW Comment: Figure 5.1-1. This comment arises due to issues of consistency with the JGWFS report. In lieu of data that shows otherwise, the delineation of "suspected NAPL areas" should encompass areas that represent the entire potential source. For instance, the suspected NAPL area at the pits (Area 10) should encompass all the pits. Additionally, the suspected NAPL area at the tank farm (Area 6) should encompass all the former tanks. Please update Figure 5.1-1 and any other figures that show NAPL locations accordingly.

Response: The figure has been modified to address EPA's concerns.

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ACRONYMS AND ABBREVIATIONS

μg/L μg/l	Micrograms per liter
ρ	Bulk density
AF	Acre-Feet
AFCEE	Air Force Center for Environmental Excellence
AOC	Administrative Order of Consent
ASTM	American Society of Testing and Materials
bgs	Below ground surface
BHC	Benzene hexachloride
BTE	Benzene, Toluene and Ethylbenzene
BTEX	Benzene, Toluene, Ethylbenzene and Xylenes
CAA	Cupric ammonium acetate
CB	Chlorobenzene
CC&F	Cabot, Cabot & Forbes
CDWR	California Department of Water Resources
cm^2/sec	Centimeters squared per second
cm^2/kg	Centimeters squared per kilogram
COC	Chain-of-custody
CRWQCB	California Regional Water Quality Control Board
CPT	Cone penetrometer testing
DDT	Dichlorodiphenyltrichloroethane
DHS	California Department of Health Services
DNAPL	Dense non-aqueous phase liquid
DO	Dissolved oxygen
DPC	Defense Plant Corporation
DQO/DQOs	data quality objectives
DTSC	California Department of Toxic Substance Control
EDB	Ethylene dibromide
EPA	U.S. Environmental Protection Agency
FFC	Federal Facilities Corporation
FFS	Focused Feasibility Study
FS	Feasibility Study
FTC	Focused Transport Calibration
FTS	Focused Transport Study
ft/day	feet/day
ft^2/minute	feet squared/minute

gpm	gallons per minute
GLA	Gage-Lynwood aquitard
H+A	Hargis + Associates
HSU/HSUs	Hydrostratigraphic unit(s)
ID	Identification
kg/cm^2	kilograms per square centimeter
kg/cm^3	kilograms per cubic centimeter
LADPW	Los Angeles Department of Public Works
LADWP	Los Angeles County Department of Water and Power
lb/ton	pounds per ton
LBF	Lower Bellflower aquitard
LCS	Laboratory control spike sample
LNAPL	Light non-aqueous phase liquid
MBF	Middle Bellflower aquitard
MBFB	Middle Bellflower B sand
MBFC	Middle Bellflower C sand
MBFM	Middle Bellflower mud
MCL/MCLs	Maximum contaminant level(s)
MOA	Memorandum of agreement
MOJ	Memorandum of justification
MSL	Mean sea level
NAPL	Non-aqueous phase liquid
PAH/PAHs	Polycyclic aromatic hydrocarbon(s)
PARCC	Precision, Accuracy, Representativeness, Comparability and Completeness
PCA	tetrachloroethane
PCB/PCBs	Polychlorinated biphenyl(s)
p-CBSA	para-chlorobenzene sulfonic acid
PCE	Tetrachloroethene or tetrachloroethylene
pcf	pounds per cubic foot
PES	Primary effluent separator
Plant Site	The approximately 300-acre former synthetic rubber manufacturing plant
ppmv	Parts per million by volume
psi	pounds per square inch
QA/QC	Quality assurance/quality control
QAPjP	Quality Assurance Project Plan
R	Retardation

ACRONYMS AND ABBREVIATIONS (Cont'd)

Respondents	Del Amo Respondents, consisting of Shell Oil Company and the Dow Chemical Company
RFC	Reconstruction Finance Corporation
RFE	Request for expenditures
RI/FS	Remedial Investigation/Feasibility Study
RI	Remedial Investigation
ROD	Record of Decision
ROW	Right of way
RPD	Relative percent difference
SDD	sodium dimethyldithiocarbamate
Study Area	Del Amo study area, includes the "plant site"
SVOC/SVOCs	Semi-volatile organic compound(s)
TCA	1,1,1-Trichloroethane
TCE	Trichloroethene or trichloroethylene
TDS	Total dissolved solids
TEA	Terminal electron acceptor
TOC	Total organic carbon
UBF	Upper Bellflower aquitard
USCS	Unified Soil Classification System
UST/USTs	Underground Storage Tank(s)
VOC/VOCs	Volatile organic compound(s)
WEFS	Waste Excavation Feasibility Study

SAMPLE DESIGNATIONS AND SAMPLE LOCATION DESIGNATIONS

To facilitate accurate tracking of records for samples and data obtained from field and laboratory investigations, all samples and sample locations have been assigned unique identification (ID) codes.

For sampling locations, these ID codes include a three character alphabetic designator and a four digit sequential number. The first two characters of the designator identify the general type of sampling methodology employed at the location (e.g., cone penetrometer, soil boring, well point, etc.), and the last character ("L") indicates that the designator identifies a location. The following table lists the sample location designators used during the Groundwater Remedial Investigation and presented in this report.

SAMPLE LOCATION DESIGNATOR	SAMPLE LOCATION TYPE
CPL	Cone Penetrometer Testing
CWL	Cone Penetrometer with Well Point
PZL	Piezometer
SBL	Soil Boring
SWL	Soil Boring/Monitoring Well
VWL	Vapor Well
WPL	Well Point

The four digit sequential numbers are assigned for each type of sample location, beginning with 0001.

For individual samples collected, each sample is identified by a unique eight digit sample ID. This ID includes a three character alphabetic designator and a five digit sequential number. The first two characters of the sample designator identify the sampled media (e.g., soil, groundwater, waste, etc.), and the last character ("S") indicates that the designator identifies a sample. The following table lists the sample designators used during the Groundwater Remedial Investigation and presented in this report.

SAMPLE DESIGNATOR	SAMPLE TYPE
GWS	Groundwater

The five digit sequential numbers are assigned for each type of sample, beginning at 00001.

The reader is referred to Appendix D of the RI/FS Work Plan (Dames & Moore, 1993a) for a complete listing of all designators used in the Del Amo RI/FS database.

EXISTING GROUNDWATER MONITORING POINTS

Existing groundwater monitoring well designations have been given the prefix "X" to distinguish them from groundwater monitoring points installed as part of the Del Amo Groundwater Remedial Investigation. For example, existing groundwater monitoring well MW-13, previously installed by Hargis + Associates, is discussed in the Groundwater RI report text and indicated in Groundwater RI report tables, figures and plates as "XMW-13". If similar location identifications were used by one or more previous investigations, the location identifications may be modified further. For example, previous investigations by Hargis + Associates and Woodward-Clyde Consultants each included monitoring wells G-1 and G-2. To eliminate this redundancy, the Hargis + Associates monitoring wells have been designated XHG-1 and XHG-2, and the Woodward-Clyde Consultants wells XWG-1 and XWG-2.

Some existing monitoring wells have been discussed and illustrated in earlier Del Amo project documents without the "X" designation, most notably monitoring well "MW-20" (XMW-20) and monitoring well "P-1" (XP-01). To minimize confusion and remain largely consistent with usage in earlier project documents, in these instances, the well itself is specified using the "X" prefix (e.g., monitoring well XMW-20 or XP-01), whereas when referring to the investigative area in proximity to these wells the prefix is not used (e.g., the MW-20 area or the P-1 area). An effort has been made to be consistent with these designator modifications; however, the reader is alerted to not become confused should they come across a case where such modifications may have been inadvertently overlooked.

EXECUTIVE SUMMARY
GROUNDWATER REMEDIAL INVESTIGATION REPORT
DEL AMO STUDY AREA
LOS ANGELES, CALIFORNIA

INTRODUCTION

Presented in this report are the findings of the Groundwater Remedial Investigation (Groundwater RI) conducted at the Del Amo study area, in Los Angeles, California. This report represents part of a larger, ongoing Remedial Investigation/Feasibility Study (RI/FS) being conducted under an Administrative Order of Consent (AOC) (Docket No. 092-13) between the U.S. Environmental Protection Agency (EPA), the California Environmental Protection Agency—Department of Toxic Substances Control (DTSC) and the Del Amo Respondents (Respondents), consisting of Shell Oil Company and the Dow Chemical Company (EPA, 1992b).

This Groundwater RI report describes the findings of investigations conducted throughout the study area to define hydrogeologic conditions, characterize the nature and extent of groundwater contamination, and evaluate the fate and mobility of chemical constituents in groundwater. Data developed as part of this groundwater RI will be used to support the Groundwater FS in the identification and evaluation of potential groundwater remedial alternatives.

This Groundwater RI Report was preceded by an interim Phase I Remedial Investigation Report which presented a description of historical plant site operations and the findings of hydrostratigraphic explorations, and chemical analyses of soil, soil gas and groundwater samples completed to that point. This Groundwater RI report expands upon groundwater findings presented in the Phase I RI report, and summarizes all groundwater-related investigations completed to date. Vadose zone conditions and the potential for non-aqueous phase liquid (NAPL) at groundwater contamination source areas identified in this document will be addressed in a subsequent document. Additional related investigations also outlined in the AOC include a Waste Excavation Feasibility Study and a Focused Feasibility Study for the Del Amo Waste Pit Area, and focused investigations in the well MW-20 area.

Work conducted by others at a former DDT manufacturing facility at the nearby Montrose Plant Site has provided additional information regarding groundwater conditions within the study area. These previous data have been incorporated into the current investigation as appropriate.

STUDY AREA DESCRIPTION

The Del Amo study area (study area) is situated in southern Los Angeles county, California, in proximity to the city of Torrance. The "study area" is defined as the area throughout which groundwater investigations were conducted and includes the approximately 300-acre former synthetic rubber manufacturing plant (plant site).

The plant site was constructed between 1942 and 1943. A number of private companies, including Shell and Dow, operated portions of the synthetic rubber plant under contract with the United States government between 1943 and 1955. In 1955, the United States sold the synthetic rubber plant to Shell Oil Company which then operated it until 1972. The synthetic rubber plant consisted of three individual facilities, including a butadiene plant, a styrene plant and a copolymer plant. Butadiene and styrene were produced independently then combined in the copolymer plant to form the final synthetic rubber product. Manufacturing and storage facilities were widely distributed throughout the 300-acre plant site. The approximately 4-acre Waste Pit Area occupies the south-central portion of the plant site and was used for disposal of process residues. Waste materials in this area are contained within a series of unlined pits excavated into native soils and are characterized by high concentrations of aromatic volatile organic compounds, principally benzene, toluene and ethylbenzene, and polynuclear aromatic hydrocarbons, principally naphthalene.

Rubber production ceased in 1972 and the plant site was decommissioned shortly thereafter. The former plant site was sold by Shell to affiliates of Cabot, Cabot & Forbes Interim Company, Inc. (CC&F). CC&F and Cadillac Fairview/California, Inc. redeveloped the property into a business park in the mid-1970s. Approximately 80-percent of the land surface within the business park is currently covered by buildings, parking areas and/or roadways. With the exception of three large unimproved areas, totaling approximately 57 acres, the majority of remaining land is landscaped. Surrounding land use is characterized by mixed residential-industrial development and has not changed appreciably since the synthetic rubber plant was in operation.

GEOGRAPHY AND HYDROSTRATIGRAPHIC CONDITIONS

The study area lies within an extensively developed, urbanized portion of the Torrance Plain subdivision of the West Coast groundwater basin. The study area is characterized by relatively subdued topography, with surface elevations ranging from approximately 25 to 50 feet above mean sea level. The land surface generally slopes gently toward the north and east, and is drained by a series of engineered storm drainage channels that eventually empty into the Pacific Ocean south of the study area near the city of Long Beach.

Water-bearing sediments underlying the study area include the lower Pleistocene San Pedro formation and the overlying upper Pleistocene Lakewood formation. Geologic units within the Lakewood formation comprise an alternating series of sandy aquifers and fine-grained aquitards identified, from top to bottom, as the Bellflower aquitard, the Gage aquifer, the Gage-Lynwood aquitard (GLA) and the Lynwood aquifer. Data developed during this investigation allow the Bellflower aquitard to be further subdivided into five discrete hydrostratigraphic units, including, from top to bottom, the upper Bellflower aquitard (UBF), the middle Bellflower B sand (MBFB), the middle Bellflower mud (MBFM—locally not present), the middle Bellflower C sand (MBFC), and the lower Bellflower aquitard (LBF). Where the middle Bellflower mud is absent, the B sand and the C sand are merged, and are jointly referred to as the Middle Bellflower B/C sand. Geologic units within the San Pedro formation include the Silverado aquifer and an unnamed aquitard which separates the Silverado aquifer from the overlying Lynwood aquifer of the Lakewood formation. A consistent, low angle structural dip toward the east to northeast is observed in all hydrostratigraphic units.

GROUNDWATER LEVELS AND FLOW CONDITIONS

The groundwater table crosses the stratigraphic boundary between the UBF and MBFB along a demarcation line near the western boundary of the plant site. The water table resides within the UBF to the east of the demarcation line, and within the MBFB to the west of the line. Groundwater conditions are therefore described with respect to the water table zone (UBF/MBFB), and the underlying confined water-bearing units, including the MBFB, the MBFC, the Gage aquifer, and the Lynwood aquifer.

Groundwater elevations have risen at an average rate of approximately one foot per year in the water table, MBFB, MBFC, and Gage aquifer, and approximately two feet per year in the Lynwood aquifer over the duration of the groundwater monitoring program, a period of approximately two years. Historical water level data and other indirect evidence indicate that the trend of rising groundwater elevations originated approximately 30 years ago, and may be associated with adjudication of the West Coast basin in 1961.

The water table is present at an average depth of approximately 58 feet below ground surface (bgs) at the plant site (-17 ft. MSL) with a generally south-southwest gradient of approximately 0.0025. The depth, flow direction, and gradient are variable in the study area due to local groundwater mounding. Flow velocities within the water table are estimated to be on the order of 0.05 feet/day.

Groundwater flow in the MBFB and MBFC is toward the south-southeast, and south, respectively, with an average gradient of 0.0008 for both hydrostratigraphic units. Flow velocities are estimated to be 0.11 ft./day for the MBFB and 0.87 ft/day for the MBFC. Groundwater flow for the Gage aquifer is consistently toward the southeast at a gradient of 0.0007, and flow velocity is estimated to be 0.17 ft/day. The groundwater data available for the Lynwood aquifer are insufficient to allow interpretation of flow directions, gradient and flow velocities.

Groundwater elevations generally decrease with each successively deeper unit although there is typically only a few feet of difference in groundwater elevations between the water table, MBFB, and MBFC, and a few more feet between the MBFC and the Gage aquifer for a given location. Changes in groundwater elevations through time are mirrored in each successively deeper hydrostratigraphic unit from the water table through the Gage aquifer. Based on these observations, the water table, MBFB and MBFC are likely hydraulically interconnected at the plant site. The Gage aquifer is also judged to be hydraulically interconnected, but to a lesser extent. The LBF aquitard separates the Gage and overlying MBFC at the plant site, however these units are reported to be merged approximately ½-mile west of the plant site. This distal area of merging is believed to be largely responsible for the mirrored water level fluctuations between the Gage aquifer and overlying units at the plant site. The Lynwood aquifer is judged to be relatively isolated from the overlying units based on an approximately 11 foot difference in water levels with the overlying Gage aquifer, and independent fluctuations in groundwater elevations.

Cross sections illustrating potentiometric groundwater elevation contours indicate that groundwater flow is generally horizontal in the coarser grained aquifers, and generally vertical in the finer grained aquitards. Due to large differences between the horizontal hydraulic conductivities of the coarser grained units and the vertical hydraulic conductivities of the finer grained aquitards, horizontal flow velocities typically greatly exceed vertical flow velocity.

AQUIFER PROPERTIES

Aquifer test results for the UBF indicate a wide range of values for transmissivity and hydraulic conductivity. Transmissivity ranges from 0.001 to 0.13 ft^2/minute and hydraulic conductivity ranges from 0.1 to 10 ft/day. The range of values is attributable to the heterogeneous and complexly interbedded character of sediments constituting the UBF. Hydraulic properties of the underlying MBFB, MBFC, and Gage aquifers were found to vary within a more narrow range. Aquifer test results for the MBFB indicate transmissivity and hydraulic conductivity values

ranging between 0.11 and 0.96 ft^2/minute and between 9 and 50 ft/day, respectively. Results of tests within the MBFC for both the Del Amo RI and the Montrose RI indicate transmissivity ranges from 1.1 to 5.5 ft^2/minute and hydraulic conductivity ranges from 27 to 400 ft/day. Results for tests conducted in the Gage aquifer, during both the Del Amo RI and the Montrose RI, indicate transmissivity ranges from 0.92 to 1.5 ft^2/minute and hydraulic conductivity ranges from 23 to 36 ft/day.

GENERAL GROUNDWATER CHEMISTRY

General mineral and physical properties are similar for groundwater from the water table, MBFB, MBFC and Gage aquifer. Groundwater from each tends to be non-dominated to calcium dominated with respect to cations, and bicarbonate dominated to chloride dominated with respect to anions. Total dissolved solids (TDS) content is very similar for the water table and MBFB, ranging from several hundred to a few thousand milligrams per liter (mg/l). The MBFC and Gage aquifer typically have lower TDS concentrations than the overlying units. TDS and surfactant concentrations are elevated at MBFB and MBFC monitoring locations near the eastern end of the Waste Pit Area (SWL0041 and SWL0040), and may be related to elevated VOC concentrations at the same locations, although the nature of this relationship is uncertain.

GROUNDWATER CONTAMINATION SOURCE AREAS

Numerous regional and plant site groundwater contamination source areas have been identified within the study area. Twelve groundwater contamination source areas associated with the Del Amo plant site have been identified. Past releases from former plant site facilities or operations are inferred to have occurred and impacted groundwater at these twelve source areas. Further evaluation of the plant site source areas is currently under consideration by EPA and the Respondents.

NAPL AREAS

Light Non-Aqueous Phase Liquid (LNAPL) is present in the vicinity of well XMW-20, near the central portion of the western plant site boundary. This LNAPL is composed almost entirely of benzene, and extends laterally over an area of approximately 17,500 square feet (0.4 acre). Rising groundwater has trapped the LNAPL in the saturated zone, and the residual LNAPL is discontinuously present in isolated blobs or "ganglia", over an approximately 30-foot vertical interval extending downward from the water table. The source of the LNAPL is not known with certainty, but may be associated with spills and/or leakage from storage tanks and pipelines in the area.

LNAPL is suspected, but has not been directly observed, at five additional areas within the former plant site: at a former VOC storage tank area southeast of the MW-20 LNAPL, at a former ethylbenzene production area in the styrene plant, at a portion of the Waste Pit Area, in the Hamilton-Dutch area where a section of benzene pipeline is suspected of leaking, and at an area along the eastern plant site boundary in the vicinity of a former laboratory. Four of the suspected LNAPLs are likely to be composed primarily of benzene and/or ethylbenzene, while the remaining LNAPL is likely to be composed chiefly of benzene and toluene.

The possibility of additional unidentified areas of LNAPL cannot be ruled out. However, if present, additional LNAPL areas are likely to be coincident with one of the 12 groundwater contamination source areas, as is the case for the existing areas of confirmed or suspected LNAPL. Additional investigations to evaluate the potential presence of LNAPL in areas where it has not already been confirmed are currently under consideration by the Respondents and EPA.

Dense NAPL (DNAPL) is suspected, but not confirmed, at a single area along the western plant site boundary, northwest of the MW-20 LNAPL. Dissolved TCE and PCE concentrations are elevated in this area. It is not certain from the available data whether the high concentrations are associated exclusively with known source areas outside of the Del Amo plant site, or whether there is an additional contribution from former facilities/features associated with the plant site.

Known areas of NAPL outside of, but in proximity to the former plant site, include the monitoring well P-1 LNAPL and an LNAPL encountered in boring SBL0102, both situated south of the plant site, an LNAPL at monitoring well XMW-7, west of the southwest corner of the plant site and near the Jones Chemical property, and a chlorobenzene DNAPL at the Montrose Plant Property. None of the NAPL areas outside of the Del Amo plant site are believed to be associated with facilities or operations at the plant site, and they are therefore not being considered for further investigation as part of the Del Amo RI.

DISSOLVED CONTAMINATION

VOCs, specifically chlorobenzene and benzene, are considered to be the primary dissolved contaminants within the study area based on their relatively broad distribution, high concentrations, and known toxicity. Benzene is interpreted to have originated primarily from the Del Amo plant site, at which there are multiple benzene source areas. The individual benzene plumes from these source areas have largely coalesced, resulting in the observed distribution of an eastern and western plume area. Most other non-benzene plumes associated with the plant site lie entirely within the coalesced benzene plume area.

The occurrence of chlorobenzene is distinguishable from that of benzene in that chlorobenzene is interpreted to originate from past operations at the Montrose Chemical Corporation of California DDT manufacturing plant at 20201 Normandie Avenue, to the west of the Del Amo plant site. The maximum distribution of chlorobenzene occurs in the MBFC rather than the overlying water table zone.

Ethylbenzene is also present at high concentrations within the study area. The inferred source areas for this compound largely overlap with those for benzene, and the ethylbenzene distribution is consequentially very similar.

The distribution of p-CBSA is generally geometrically similar to that of chlorobenzene, and the p-CBSA has a greater lateral extent than the chlorobenzene plume in each water-bearing unit where it occurs (i.e., the chlorobenzene plume lies within the p-CBSA plume). According to the U.S. EPA, the p-CBSA is associated with releases of contaminants from the Montrose Chemical DDT manufacturing plant.

Tetrachloroethane (PCE) and TCE concentrations within the study area are also quite high relative to MCLs and other detected compounds. The distributions of these compounds are distinct from benzene and chlorobenzene, and likely originate from different sources. The primary source areas for PCE and TCE are interpreted to exist west of the southwest corner of the plant site, and also further north, along the western plant site boundary. The groundwater data and historical information indicate sources unrelated to the plant site for both areas, although an additional PCE/TCE contribution from former plant site facilities may have occurred for the more northerly of the two suspected source areas.

Semi-volatile organic compounds (SVOCs) have been detected almost exclusively in the water table and MBFB, primarily within the southern plant site area and the area west of the southwest corner of the plant site. This distribution is entirely within the area of high VOC concentrations. SVOCs are judged to be associated in part with releases from the Del Amo plant site and in part with LNAPL releases from petroleum pipelines unrelated to the plant site.

Metals concentrations in excess of MCLs have been sporadically detected for several compounds, primarily arsenic and aluminum, within the water table, MBFB, and MBFC. The aluminum exceedances are attributed to suspended sediment in the samples, as MCL exceedances were not detected for filtered samples from the same monitoring locations. Relatively few instances of MCL exceedances for metals exist compared to VOCs, especially if one subtracts the aluminum exceedances attributable to unfiltered samples. Metals concentrations in excess

of MCLs are not interpreted to be associated with the plant site given the poor correlation between their distribution pattern and both historical areas of chemical use and storage and VOC plumes at the plant site. Furthermore, no concentrated solutions or substances containing the metals for which there are MCL exceedances are known to have been used at the plant site.

Detection of pesticides at the Del Amo plant site is limited to the extreme southwest corner of the area, and is part of a larger dissolved contaminant plume that underlies and extends downgradient of the Montrose Plant Property. Detected pesticides are limited to isomers of p,p´-dichlorodiphenyl-trichloroethane (DDT) and benzene hexachloride (BHC). EPA Region IX believes that detected DDT originates from releases associated with the Montrose Chemical DDT manufacturing plant. EPA believes that detected BHC originates from releases associated with operations at 20201 Normandie Avenue conducted by Stauffer Chemical Company.

BTEX CONTAMINANT MOBILITY

Dissolved benzene concentrations are shown to attenuate abruptly from any single source, where dissolved chlorinated compounds are not present. In the water table, dissolved benzene concentrations attenuate from 100,000 μg/L to non-detectable concentrations (less than 0.5 μg/L) in less than 600 feet in a downgradient direction. Although multiple sources and a non-uniform water table surface may obfuscate interpretation of contaminant migration pathways, the abrupt attenuation of benzene concentrations in the water table zone is consistent with attenuation observed in lower units which have few source areas and uniform potentiometric surfaces. In the MBFB and MBFC, benzene concentrations decrease from 100,000 μg/L to non-detectable concentrations in less than 550 feet downgradient. These concentration trends are consistent over the period of monitoring, indicating that dissolved benzene plumes are stable, neither migrating farther downgradient away from sources, nor receding upgradient toward sources. Site-specific data indicate that this dissolved benzene distribution is primarily a function of advective-dominated transport and biodegradation-dominated attenuation.

Based on published guidance criteria, there is strong evidence that both aerobic and anaerobic (denitrification and methanogenesis) biodegradation of BTEX occurs in the study area. This conclusion is based on: (1) the presence of BTEX degrading microorganisms in water samples; (2) the inverse spatial relationship between BTEX concentrations and each of dissolved oxygen and nitrate concentrations; (3) the direct spatial relationship between dissolved BTEX concentrations and methane concentrations; and (4) evidence of benzene mass reduction.

Downgradient from the Montrose central process area (source area), dissolved benzene concentrations do not attenuate abruptly as observed downgradient of the former plant site

sources. Low concentrations of benzene (less than 100 μg/L) are broadly distributed (over 1,500 feet along flow direction in the MBFC and Gage aquifer) where dissolved chlorobenzene and p-CBSA are also present.

The results of detailed field and laboratory studies conducted in the MW-20 area demonstrate that LNAPL is trapped below the water table as isolated singlets, doublets, and ganglia. Laboratory testing of relative fluid saturations, intrinsic flow properties, and relative permeability indicates that the majority of samples tested exhibit LNAPL saturations at or below residual levels; and therefore, it is inferred that most LNAPL is immobile under the current flow regime.

GROUNDWATER DEVELOPMENT AND USE

The Silverado and Lynwood aquifers constitute the principal municipal groundwater supply resources for the West Coast basin. State of California Department of Water Resources documents indicate 80 to 90 percent of all groundwater produced in the West Coast Basin (potable or otherwise) is extracted from the Silverado aquifer, which underlies the Lynwood aquifer. The majority of the remaining groundwater is presently produced from the Lynwood aquifer. Groundwater production from the shallower Gage aquifer is presently limited, while production from the overlying Middle Bellflower and Upper Bellflower units is limited by their naturally poor water quality (relatively high total dissolved solids and inorganic constituents). Groundwater production from the Upper Bellflower and the Middle Bellflower B Sand is also limited by low production rates. Production rates from the Middle Bellflower C Sand are approximately equal to or slightly greater than for the Gage aquifer. The California Regional Water Quality Control Board has designated all groundwater in the water-bearing units at the Del Amo site, including the Gage Aquifer, the Middle Bellflower and the Upper Bellflower, as a municipal water supply resource.

Groundwater production from the West Coast basin has been managed since the basin was adjudicated in 1961. The basin Watermaster reports that groundwater extractions account for only 15 percent of total water usage in the West Coast basin, with the remaining 85 percent being imported from outside the Los Angeles area. Records indicate that six municipal supply wells exist within a two-mile radius of the plant site, four of which have recorded groundwater production during one or both of the last two water years annual reporting periods.

While not providing a guarantee that existing and/or future groundwater production wells will not be impacted by contamination, current California well construction standards and local water purveyor construction practices are intended to reduce the likelihood that this will occur.

California well construction standards have been in place since December 1981 (Bulletin 74-81, December 1981, amended by Bulletin 74-90, June 1991). Wells installed before December 1981 may not have surface seals. For wells without adequate seals, shallow contamination can be drawn down through annular materials to deeper units. Existing protective measures include locating wells in areas removed from known or suspected surface or subsurface contamination, use of protective conductor casings during drilling and well construction, and use of deep protective seals to isolate the upper portions of wells from potential soil and groundwater contamination.

CONTINUING GROUNDWATER-RELATED WORK

Water level measurement and collection and chemical analysis of groundwater samples from selected wells completed in the water table zone, MBFB, MBFC and Gage aquifer will continue on a periodic basis as part of the ongoing groundwater monitoring program. The findings of these periodic sampling events will be reported to EPA as they become available.

A joint Groundwater Feasibility Study (FS) Report for the Montrose/Del Amo study area is currently being completed by EPA. The FS will include results of predictive groundwater flow and contaminant transport modeling performed to assist in the evaluation of the effectiveness and influences of potential groundwater remedial alternatives that may be implemented.

1.0 INTRODUCTION AND BACKGROUND

Presented in this report are the findings of the Groundwater Remedial Investigation (Groundwater RI) conducted at the Del Amo study area, in Los Angeles, California. The Del Amo study area (study area) includes the approximately 300-acre former synthetic rubber manufacturing plant complex (plant site), which was the focus of the groundwater investigation. This report represents part of a larger, ongoing Remedial Investigation/Feasibility Study (RI/FS) being conducted under an Administrative Order of Consent (AOC) (Docket No. 092-13) between the U.S. Environmental Protection Agency (EPA), the California Environmental Protection Agency—Department of Toxic Substances Control (DTSC) and the Del Amo Respondents (Respondents), consisting of Shell Oil Company and The Dow Chemical Company (EPA, 1992b).

This Groundwater RI report describes the findings of investigations conducted throughout the study area to define hydrogeologic conditions, characterize the nature and extent of groundwater contamination, and evaluate the fate and mobility of chemical constituents in groundwater. Data developed as part of this Groundwater RI will be used to support the Groundwater FS in the identification and evaluation of potential groundwater remedial alternatives.

As discussed later in this report, groundwater conditions within the study area reflect contaminant contributions from numerous sources, but groundwater in the immediate area has been primarily impacted from the Montrose Chemical NPL site and the Del Amo NPL Site. Discrete dissolved contaminant plumes emanating from various sources in this predominantly industrial area have overlapped, and in some cases have commingled. Any remedial measure under consideration for these sites must, therefore, account for the possible influences such action(s) may have with respect to the distribution of dissolved and separate phase chemical constituents from other sources in the vicinity. Groundwater remedial measures are considered within the joint Groundwater FS for the Del Amo and Montrose study area currently being completed by EPA. The joint Groundwater FS report includes the results of predictive groundwater flow and contaminant transport modeling performed to assist in the evaluation of the effectiveness and influences of potential groundwater remedial alternatives that may be implemented.

In addition to the RI and FS reports, the AOC also specifies additional focused investigations to be performed within the study area. These focused investigations include a Waste Excavation Feasibility Study (WEFS), a Treatability Study, and a Focused Feasibility Study (FFS) for the Del Amo Waste Pit Area, and focused investigations and associated non-aqueous phase liquid (NAPL) pilot extraction program in the well XMW-20 area. Focused investigations conducted at the Waste Pit Area have been completed and EPA is preparing to issue a Record of Decision (ROD) for Waste Pit Area during late 1997. Focused investigations being conducted in the well XMW-20 area are still in progress and will be reported separately upon completion. The background and findings of these related investigations are briefly described below in Section 1.3 of this report. It is currently anticipated that additional studies will be completed during a subsequent phase of work to further evaluate subsurface conditions in selected portions of the study area. The specific location and nature of these pending investigations is currently under discussion with EPA, but will most likely be focused upon evaluating vadose zone soil conditions as well as the potential for NAPL in selected groundwater contamination source areas. The findings of these pending investigations will be used in conjunction with previously completed work, including this Groundwater RI report, to support a subsequent FS report specific to vadose zone soils and NAPL occurrence. The flow chart presented in Figure 1.0-1 shows the overall RI/FS process and illustrates the relationships among the various investigative elements associated with the Del Amo study area as well as the relationship between the various work products completed for the Montrose and Del Amo study areas.

The scope of initial soil and groundwater investigations conducted under the current AOC for the Del Amo study area are described in the Remedial Investigation/Feasibility Study Work Plan (Dames & Moore, 1993a). The results of these initial investigations are reported in the Phase I Remedial Investigation report and include the findings of soil, soil gas and groundwater investigations completed to that date (Dames & Moore, 1993d). Comments on this draft report were provided to the Respondents by EPA and DTSC for guidance in planning future studies (EPA, 1993b and 1994c; DTSC, 1994). The Del Amo Respondents provided written responses to all EPA comments on the Phase I RI report (Shell, 1995a). In accordance with the AOC, the Phase I RI report is an interim report, and was not revised to address these comments. The Phase I RI report has not received agency approval, and will be used only as reference until subsequent RI documents, including this Groundwater RI report, are formally approved by EPA.

Following completion of the Phase I RI report, a groundwater monitoring program was implemented to evaluate the behavior of dissolved groundwater contaminants throughout the study area over time. The nature and scope of this monitoring program is described in the Groundwater Monitoring Program document (Dames & Moore, 1994a). After approximately

two years of groundwater monitoring had been completed, the Respondents proposed modifications to the scope of the monitoring program (Shell, 1996b). Following receipt of EPA comments on these proposed modifications (EPA, 1996b), agreement was reached on the scope of subsequent groundwater monitoring events (Shell, 1996c; EPA, 1996c). Periodic groundwater monitoring continues to date, as modified.

Subsequent to the Phase I RI report, a draft Phase II Remedial Investigation Work Plan was submitted to EPA for their review and approval (Dames & Moore, 1994b). While the general nature and scope of these proposed Phase II investigations have been discussed informally with EPA, no agency comments have been received for this draft document and the investigations proposed therein have neither been formally approved nor implemented.

Shortly after preparation of the draft Phase II work plan, at the prompting of EPA, the emphasis of the RI shifted to focus almost exclusively upon groundwater conditions within the study area. In recognition of this transition, the Respondents and EPA entered dialogue to identify data gaps in the groundwater characterization completed to that point and develop the scope for additional groundwater investigations necessary to complete a Groundwater RI, and to satisfy the needs of a Groundwater FS. Following a series of teleconferences and meetings, the scope of Phase II groundwater investigations was identified and memorialized in the Interim Plan, Phase II Groundwater Investigations document (Shell, 1995b). This Interim Plan document describes the nature, scope, rationale and methods of Phase II groundwater investigations and effectively served as the work plan document for all subsequent groundwater characterization investigations conducted throughout the study area since that date.

1.1 PURPOSE AND OBJECTIVES

The overall purpose of the Groundwater RI was to assess groundwater flow conditions, characterize the nature, distribution and behavior of dissolved and NAPL contaminants, and to provide the chemical and physical data necessary to evaluate potential groundwater remedial alternatives. The principal objectives of groundwater investigations completed within the Del Amo study area were to:

- Develop a study area-wide conceptual hydrostratigraphic model to identify and characterize aquifer and aquitard units and guide investigations of groundwater flow and contaminant transport within these units;

- Assess spatial and temporal variations in groundwater flow conditions throughout the study area, including horizontal and vertical components of flow;

- Assess the lateral and vertical extent of dissolved contaminants within the various identified hydrostratigraphic units (HSUs);

- Assess the potential occurrence of NAPL (Note: the findings of NAPL accumulation rates will be presented in subsequent documents associated with focused investigations in the well MW-20 area);

- Assess the spatial and temporal variation of groundwater chemistry and dissolved contaminant chemistry within the various HSUs;

- Assess contaminant transport mechanisms, including processes influencing the natural attenuation of dissolved contaminants in groundwater;

- Identify potential groundwater contaminant source areas;

- Assess the physical/hydraulic properties of the various HSUs; and,

- Provide sufficient physical and chemical data to meet the needs of the predictive groundwater flow and contaminant transport model and the Groundwater FS.

1.2 STUDY AREA CONDITIONS

Presented below is a summary of study area conditions, including the location and general description of the former synthetic rubber manufacturing plant and surrounding study area, a brief review of the ownership, layout and operational history of the former synthetic rubber manufacturing plant, and a summary of previous pertinent groundwater investigations conducted within the vicinity.

1.2.1 Study Area Location and Description

The study area is situated in the city of Los Angeles, California within the southwestern portion of Los Angeles county, in proximity to the cities of Torrance and Carson. The term "study area" is defined here to include the geographic area throughout which groundwater investigations were conducted under the current AOC. Within the study area lies the approximately 300-acre plant site, which is the focus of the current investigation. The plant site generally occupied the area between 190th Street and Knox Street on the north, Vermont Avenue and Hamilton Avenue on the east, and Del Amo Boulevard on the south. The western boundary of the plant site is approximately 500 feet east of Normandie Avenue (Figure 1.2-1). The limits of the predictive groundwater flow and transport model domain, encompassing an area of approximately 4,200 acres, or 6.6-square miles, are also illustrated in Figure 1.2-1. Again, the results of groundwater flow and mass transport modeling will be presented in the joint Montrose/Del Amo Groundwater FS Report being completed by EPA.

The former synthetic rubber manufacturing plant was decommissioned and largely redeveloped during the early- to mid-1970s, and is currently occupied by a business park. Land use within the business park is characterized by light industrial/manufacturing activities, import/export and warehousing businesses and commercial office space. Approximately 80% of the land surface within the business park is currently covered by buildings, parking areas and/or roadways. With the exception of three large unimproved areas, totaling approximately 57 acres, the majority of remaining land is landscaped. An approximately 4-acre undeveloped area in the southern portion of the plant site, known as the Del Amo Waste Pit Area, had at one time been used for disposal of synthetic rubber plant process residues (Figure 1.2-2). The Waste Pit Area was first investigated in approximately 1972 during reconnaissance geotechnical investigations in preparation for plant site redevelopment. As discussed below, numerous previous investigations have been conducted at the Waste Pit Area outside the focused studies required under the current AOC.

Surrounding land use within the study area and vicinity is characterized by mixed residential-industrial development. A residential neighborhood lies adjacent to the southern boundary of the former styrene plant, south of Del Amo Boulevard. Land use to the east, north and west of the plant site is mixed residential and industrial/commercial. Surrounding land use has not changed appreciably since the synthetic rubber plant was in operation.

1.2.2 Summary History of Former Synthetic Rubber Plant

Presented in this section is a brief description of the layout and operations of the former synthetic rubber manufacturing plant. A detailed discussion of the ownership and operational history of the plant site is presented in Appendix A of this report. The information presented here and in Appendix A has been summarized from Section 3.0 and Appendix A of the Phase I Remedial Investigation Report (Dames & Moore, 1993d). For more detailed plant site history information, including the findings of regulatory agency file reviews and reviews of historical maps and aerial photographs, the reader is referred to the Phase I RI report.

Plates 1-1 and 1-2 illustrate the detailed layout of the former plant site, and should be used as reference when reviewing the information presented in the following sections and in Appendix A.

1.2.2.1 Description of Former Plant Operations

A photogrammetric historical base map of the study area was developed using stereo pairs of enlarged aerial photographs of the plant site and vicinity taken in 1972. This historical map forms the base for Plates 1-1 and 1-2 provides locations within ±5 feet of most historical facilities at the plant site. The former styrene, butadiene and copolymer plants (plancors) are each subdivided into operational areas based on the process or function performed in that area. Plate 1-1 shows the designated operational areas in each Plancor and Plate 1-2 identifies the individual facilities and features within each of the operational areas. Those facilities/features targeted for investigation during the RI are highlighted in color on Plate 1-2.

The former synthetic rubber plant consisted of three interrelated process plants: a butadiene plant, a styrene plant, and a copolymer plant where butadiene and styrene were combined to produce synthetic rubber (Figure 1.2-2). The processes used to produce the butadiene, styrene, and synthetic rubber are summarized in the following sections.

During plant operation raw materials were received via surface transport (truck and rail) and aboveground and underground pipelines. Raw materials and finished products were stored primarily in aboveground tanks. General information regarding former synthetic rubber plant waste streams and waste management practices was obtained from a variety of documents, ranging from descriptive pamphlets prepared by the U.S. Government (Rubber Producing Facilities Disposal Commission 1953a, 1953b, 1953c, and Defense Plant Corporation, a,b,c - undated) to technical papers from industry trade journals (Hebbard et al, 1947; Rostenbach,

1952; Martin and Rostenbach, 1953). The butadiene, styrene, and copolymer plants were each equipped with a primary wastewater treatment system. Effluent from these individual primary treatment systems was collected and routed to a common wastewater treatment unit, located at the northeast corner of the butadiene plant, for final neutralization and treatment prior to discharge to the sanitary sewer or the Dominguez channel (via the Knox Street drain). During early plant operations, stormwater, cooling water and sanitary wastes were apparently commingled with the plant process waste stream; however, improvements made during the early 1950s apparently provided for the separate handling of the non-process waste streams thereby allowing discharge directly into the municipal sewer system. The available literature indicates that process waste streams included primarily aqueous oil/water emulsions, with lesser acidic and caustic aqueous solutions and minor tarry process residuals. General plant practices included recovery, treatment and reuse of materials in the waste stream whenever possible. Hydrocarbons essential to the manufacturing processes were generally only slightly soluble in water. Separable hydrocarbons and suspended solids were removed by skimming in settling basins and API-type gravity separators. Separated hydrocarbons were typically returned to process areas for use as boiler feed or other purposes. Partial distillation of separated wastes and remaining effluent containing dissolved hydrocarbon constituents was used to further clean aqueous waste stream prior to discharge to the Knox Street drain. Detailed discussions of process waste streams from the individual plancors and discrete operational areas within each plancor are provided in Appendix A, Section A.2.

In addition to these waste treatment facilities, according to historical aerial photographs, waste disposal impoundments were present in the southern portion of the styrene plant in the area currently designated as the Del Amo Waste Pit Area. The Waste Pit Area included four unlined evaporation ponds (including three 1 series pits and the eastern evaporation pond) and six unlined waste pits (including the 2 series pits) (Figure 1.2-3). The 1 series pits reportedly received an aqueous waste, and the 2 series pits received generally semi-viscous to viscous process wastes.

Styrene Plant

The styrene plant, designated plancor 929 by the Defense Plant Corporation (DPC), consisted of approximately 106 acres, of which 92 acres were fenced and formed the main plant. The primary feedstocks for styrene manufacture were propane and benzene. Other chemicals used or produced in the process include toluene, ethylbenzene, styrene, caustic, hydrochloric acid, sulfuric acid, and smaller amounts of ethylchloride, aluminum chloride, iron-oxide catalyst (Shell 105), and tertiary butyl catechol. By-products included heavy oils, tar, and coke. Propane was thermally cracked to produce ethylene, which was then purified by distillation. Ethylene and

benzene were combined in an alkylation process to form ethylbenzene, and the resulting mixture was purified through settling and fractionation steps. Styrene was produced by the dehydrogenation of ethylbenzene, then purified through fractionation steps.

The styrene production area was divided into two production lines oriented in the north-south direction as shown on Plate 1-1. The styrene production area consisted of the following units: ethylene purification unit in the 1100 area, two ethylbenzene production units in the 1200 and 2200 areas, two styrene production and propane "cracking" (dehydrogenation) units in the 1300 and 2300 areas, one styrene finishing unit in the 2400 area, and one combined styrene finishing and benzene purification unit in the 1400 area. Water treatment and steam production plants were located in the northwestern corner of the plant site in the 1000 area and provided low pressure steam to both the styrene plant and the copolymer plant to the north. An alcohol ethylene production plant was present during early plant operations in the 1100 area. Associated administrative and support areas, including offices, a laboratory, cafeteria, garage, fire station, carpenter shop, paint shop, instrument shop, and machine shop were located in the 2600 area along the eastern boundary of the styrene plant. Bermed tank farms containing large and small cylindrical aboveground storage tanks were located in the 2500 area close to the western styrene plant site boundary. Tanks were reported to have contained feedstock and finished materials including styrene, benzene, ethylbenzene, toluene, polyethylbenzenes, resin fraction, and fuel oil. Cooling towers and an electrical substation were present in two separate locations designated as the 2600 area, located within the western and south-central portions of the styrene plant. What is now designated as the Del Amo Waste Pit Area was located along the southern boundary of the styrene plant.

Del Amo Waste Pit Area

Portions of the southern styrene plant were used for waste management purposes and included six small rectangular pits and four large rectangular impoundments or evaporation ponds (Figure 1.2-3). Historical information indicates that these waste impoundments were excavated into fine-grained native soils and were apparently unlined. The six small rectangular pits have been designated as the 2 series pits, and include pits 2-A through 2-F. The 1 series pits were former large evaporation ponds located directly east of the 2 series pits and include, from east to west, pits 1-A, 1-B and 1-C. A fourth large pond, designated in the Phase I RI report as the eastern evaporation pond, was located directly east of Pit 1-A. The 1 series pits received aqueous wastes from process areas within the synthetic rubber plant, and are estimated to jointly contain a total of roughly 8,856 cubic yards of insitu clayey sludge-like waste materials. The 2 series pits were used for disposal of generally semi-viscous to viscous wastes which apparently originated within a portion of the styrene plant, and are estimated to jointly contain a total of

roughly 6,604 cubic yards of insitu waste materials. The area currently designated as the Del Amo Waste Pit Area includes all the 2 series and 1 series pits as well as the eastern evaporation pond.

Waste materials in these pits and ponds are characterized by high concentrations of aromatic volatile organic compounds (VOCs), principally benzene, toluene and ethylbenzene, and polynuclear aromatic hydrocarbons (PAHs), principally naphthalene. The chemical characteristics of the waste materials in the 1 series and 2 series pits, as well as adjacent contaminated soil, are fully described in the Phase I RI report and Waste Pit Area data summary report (Dames & Moore, 1993d and 1996b).

Review of historical aerial photographs indicates that the 2 series pits were first present sometime after late 1941 and before 1947. By December 1951 the 2 series pits appeared to be covered with fill material. The 2 series pits appeared to be covered and unused in aerial photographs dated between about 1952 and 1976; however, small irregular areas of tonal contrast, inferred to be soil staining, were observed over some of the 2 series pits in several aerial photographs dating from the 1950s and 1960s.

The four larger evaporation ponds (including the 1 series pits and the eastern evaporation pond), were apparently active for a longer period of time than were the adjacent 2 series pits. It appears that these larger ponds were developed sequentially. Pits 1-B and 1-C are the oldest and are visible on aerial photographs from November 1946 through September 1965. Pits 1-B and 1-C were covered in an October 1967 photograph. Pit 1-A is visible in aerial photographs from May 1951 through September 1965, and was covered in an October 1967 photograph. The eastern evaporation pond was observed in photographs from May 1951 to January 1958, and was covered in a May 1960 photograph.

Butadiene Plant

The butadiene plant, designated plancor 963 by the DPC, consists of approximately 90 acres in the southeast portion of the former synthetic rubber plant. Dehydrogenation and purification of butylene and butane feedstocks and purification of butadiene occurred within the butadiene plant. Purified butadiene was piped to the copolymer plant, where it was combined with styrene to manufacture synthetic rubber.

Butadiene is a gas at standard temperature and pressure. It is derived from butylene (also known as butene), a product derived from the cracking process of oil at refineries or made from butane, a component of natural gas. Butadiene feedstock, including a mixture of butane, butylene, and

butadiene, was reportedly received primarily by pipeline from the Southern California Gas Company, the Shell Oil refinery, and a butane dehydrogenation plant in El Segundo, by tank truck, and as recycled product from the styrene and copolymer plants. Other materials used at the butadiene plant included absorption oil, acetic acid, acetone, ammonia, caustic soda, liquid chlorine, sulfuric acid, hydrated lime, soda ash, copper metal, and dehydrogenation catalyst.

Wastes generated during the extraction and purification of butadiene include waste gases which were discharged to the gas holder or burned in a flare, and liquid wastes which were discharged to basins at the wastewater treatment area. The major quantities of materials classified as wastes were in aqueous form and were diverted to the wastewater treatment area in the northeast portion of the butadiene plant. Several basins were located in this area, including two waste oil recovery basins, an absorption oil recovery basin and a chemical basin. Slop oil recovered from the waste oil recovery basins was pumped to a fuel oil storage tank. The chemical basin received water that contained primarily caustic, acid, and copper solution which was neutralized before being discharged to the sanitary sewer or the Dominguez Channel (via the Knox Street drain).

As shown on Plates 1-1 and 1-2, the production area included six major process units: a purification and distillation unit in the 100 area; a catalytic dehydrogenation unit in the 200 area; a gas recovery unit in the 300 area; a solvent extraction unit for purification of butadiene and isoprene in the 400 area; water treatment, waste disposal, boiler, and administration units in the 500 area. Other production facilities included cooling towers in the 540 area; control houses and a compressor building in the 300 area; boilers and steam production facilities in the 500 area; and a water treatment building in the 520 area. The 500 area along the eastern plant site boundary included administrative buildings, a laboratory building, a garage and fire station, cafeteria, change houses, store houses, shops, and research facilities. The 650 Area, located along the western plant site boundary, included a railroad spur and associated loading racks.

The 600 area contained spherical gas storage pressure-vessels which were used for containment of product butadiene. Other gas storage vessels and vertical storage tanks were located on the butadiene plant. Several vertical storage tanks in the 700 area, located south of the Los Angeles Department of Water and Power (LADWP) right-of-way, reportedly contained fuel oil, lean oil, and isobutylene dimer or tolusol. Tanks for the storage of wastewater, skimmed oil, and water treatment chemicals were present in the wastewater treatment unit in the 560 and 580 areas located along the northern boundary of the butadiene plant.

The wastewater treatment system at the northern plant boundary included skimmer basins or clarifiers and neutralization basins. Process wastewater was conveyed to this treatment area from all three former plants. An oil skimmer unit and aqueous cupric ammonium acetate solvent collection basin appear to have been present west of the wastewater treatment system, at the southeast corner of Knox St. and the former Avenue B.

Copolymer Plant

The copolymer plant was designated plancor 611 by the DPC, and occupied approximately 82 acres north of the styrene plant. Synthetic rubber was produced in a series of reactions by combining styrene and butadiene with lesser amounts of other chemicals, including soap solutions and acid solutions. Other chemicals used in the rubber manufacturing process included cyclohexane, benzene, methanol, ajone DD (staining antioxidant), acosix (emulsifier), processing oils (naphthenic, aromatic and highly aromatic oils), and caustic solutions.

The rubber manufacturing process was divided into three parallel production lines oriented in an east-west direction. The locations of these features and numbered areas are shown on Plates 1-1 and 1-2. The production lines were numbered from south to north as the 3000 train, the 4000 train, and the 5000 train. Each production line consisted of the following units: feed formula preparation in areas 3400, 4400, and 5400; polymerization units in areas 3300, 4300, and 5300; recovery of unreacted monomers in areas 3200, 4200, and 5200; and finishing and storage of final rubber products in areas 3000, 4000, and 5000. Additional storage for final rubber products was provided in area 3700. Tank farms for monomer feed stock storage were located west of the production units in areas 3500, 4500, and 5500. Other support service buildings, such as a machine shop, laboratory, and pump houses were located within the production area. A cooling tower and waste transfer station were located in the 6010 Area, adjacent to the western plant site boundary. An approximately seven-acre area along the eastern portion of the plant site contained administration buildings, a guard house, a hospital, and garages (6000 area). The southern portion of the site, including the 6020 and 6030 Areas, consisted of largely open areas with a few features, including the fire training area, the final effluent pit, and the flare stack.

A number of primary and secondary wastewater separators and sumps were associated with the three production lines, as shown on Plate 1-2. Process wastewater from the copolymer plant production areas went to the common wastewater treatment and disposal system located in the northeast corner of the butadiene plant.

1.3 PREVIOUS GROUNDWATER INVESTIGATIONS

Numerous investigations have been completed within and surrounding the Del Amo study area prior to those conducted under the current AOC. Table 1.3-1 presents a listing of the more significant documents relating to previous groundwater investigations conducted to date within the study area. The findings and conclusions of these previous investigations assisted in developing an initial conceptual model for the study area, including the hydrogeologic characteristics and the nature and extent of groundwater contamination present. This conceptual model helped guide initial site characterization work as described in the Phase I RI report.

Following plant decommissioning, the discovery of contaminated soil during early geotechnical investigations at the former plant site in the 1970's prompted DHS to conduct limited soil sampling and chemical testing in the area corresponding to the Del Amo Waste Pit Area. Subsequent investigations were conducted between 1981 and the present by private parties within selected portions of the former synthetic rubber plant. The majority of data relating to groundwater conditions within the study area have been developed since 1983. Many of these data are from focused investigations conducted within portions of the plant site, including the Waste Pit Area, the area surrounding onsite monitoring well MW-20, the Hamilton Dutch area, situated in the southern portion of the former butadiene plant, and the monitoring well P-1 area (Figure 1.2-2). Considerable additional stratigraphic and groundwater data are available for other locations and facilities lying within the study area that are unrelated to the former synthetic rubber plant, and include nearby industrial/manufacturing facilities, landfills/disposal sites, and refineries. Groundwater conditions associated with these unrelated locations have assisted in placing plant site-related conditions in a regional context, and are considered in the predictive groundwater flow and contaminant transport model that will be presented in the Groundwater FS report. It should be noted that the predictive groundwater flow and contaminant transport model considers approximately 17 individual facilities that represent groundwater contamination sources unrelated to the former plant site. These contaminant sources were identified during agency file reviews conducted to support construction of initial model conditions. While these sources are important to consider for modeling purposes, the descriptions presented in the following sections are restricted primarily to those areas nearby or within the former plant site, as these have the most pronounced effect upon local groundwater conditions within the study area. Considerable data are available from the various focused investigations conducted in these locations.

The following sections present a brief summary of key findings to date for several specific locations/facilities within the study area, including the Del Amo Waste Pit Area (Section 1.3.1), the well MW-20 area (Section 1.3.2), the Hamilton Dutch area (Section 1.3.3) and the Montrose Plant Property (Section 1.3.4).

1.3.1 Del Amo Waste Pit Area

The Del Amo Waste Pit Area has been the subject of numerous investigations since approximately 1972 when reconnaissance geotechnical investigations were conducted in advance of plant site redevelopment. While early work was related primarily to geotechnical considerations, subsequent investigations were focused upon evaluating the nature and extent of buried waste materials present in the area and characterizing the nature and extent of soil, soil gas and groundwater contamination associated with these wastes.

The majority of information regarding environmental conditions at the Waste Pit Area was presented in reports prepared by Dames & Moore/Radian (1984), Woodward-Clyde Consultants (1985 and 1987), Ecology and Environment (1989a and 1989b) and Dames & Moore (1990, 1991a, 1993c, 1993d, 1996b). These documents present a considerable amount of analytical data, including analytical results for waste, soil, soil gas, surface and downhole vapor emissions, groundwater and ambient air. Findings presented in these documents indicate that waste constituents have migrated from the pits into the surrounding native soils and underlying groundwater. Soil contamination associated with the Waste Pit Area locally extends to groundwater, and residual soil contamination in the vadose zone poses a threat to groundwater as a continuing source. Soil matrix and vapor-phase contaminants associated with the Waste Pit Area are apparently restricted to a maximum lateral distance of approximately 70 feet from the limits of the pits, and do not extend into the nearby residential area to the south. Moreover, no significant vapor emissions have been detected emanating from the surface of the soil cover overlying the Waste Pit Area. Groundwater contamination in the area by VOCs and PAHs has resulted from contaminant contributions from multiple sources, including the Waste Pit Area and other former plant site facilities, as well as from nearby, unrelated facilities and petroleum transmission pipelines. Available data indicate that water table zone groundwater contamination extends beneath a portion of the residential area to the south of the Waste Pit Area, however, soil gas sampling and analyses conducted throughout the residential area indicate that no detectable concentrations of vapor-phase contaminants are present in shallow (upper 15 feet) soils in the residential area.

The findings of detailed characterization efforts at the Waste Pit Area, conducted in accordance with the current AOC, have been reported in numerous recent documents, including the treatability study, the Phase I RI report, the Waste Pit Area data summary report and the FFS (Dames & Moore, 1993c, 1993d, 1996b and 1996d). EPA issued a Record of Decision (ROD) for the Waste Pit Area on September 5, 1997.

1.3.2 Monitoring Well MW-20 LNAPL Area

Benzene light NAPL (LNAPL) was encountered by Hargis + Associates in April 1990 during installation and development of monitoring well MW-20, located in the western portion of the former styrene plant, as part of an ongoing remedial investigation of the neighboring Montrose Plant Property (Figure 1.2-2). The monitoring well MW-20 area has since become the subject of focused investigations conducted under the current AOC to characterize the nature and distribution of the benzene LNAPL that has accumulated in this well and to assess the feasibility of LNAPL recovery. Since this initial discovery, additional monitoring wells have been installed in the area to assist in delineating the lateral extent of this LNAPL. Two of these additional wells have also accumulated benzene LNAPL (Dames & Moore, 1993b). Benzene concentrations in groundwater in the well MW-20 area are at or near the aqueous solubility for this compound, but these levels decline abruptly within several hundred feet distance downgradient from the LNAPL-impacted area.

The spatial distribution, mode of occurrence, and physical characteristics of the benzene LNAPL at the MW-20 area were evaluated as part of focused investigations conducted under the current AOC. The benzene LNAPL is submerged beneath the groundwater table within an approximately 30-foot thick smear zone within the Bellflower aquitard as small, isolated ganglia trapped in sediment pore spaces at residual saturation (Dames & Moore, 1995d). Historical information indicates that benzene was stored and used in this area as part of the operation of the synthetic rubber plant, although vadose zone soil and soil gas investigations conducted throughout the monitoring well MW-20 area have not detected significant residual concentrations of benzene in soil (Dames & Moore, 1993d). It is likely that the apparent lack of benzene in the vadose zone under the historical source area is due to a higher rate of biodegradation of benzene in the vadose zone compared to the water table zone over the course of time since the plant was in operation.

A pilot LNAPL recovery and groundwater treatment system was installed and continuously operated over a period of approximately seven and one-half months, extending from early

September 1996 through late April 1997. Following an evaluation of the data obtained from this pilot program, a decision will be made regarding the potential need for further work in the area. The conclusions resulting from this pilot program may possibly be applicable to other locations within the study area if similar LNAPL conditions are encountered elsewhere during subsequent subsurface investigations. The feasibility of LNAPL recovery will be addressed in a subsequent FS effort.

1.3.3 Hamilton Dutch Area

Soil gas and related subsurface soil and groundwater sampling and testing was previously conducted by others in the southern portion of the former butadiene plant to support a commercial property transfer (Reidel Environmental, 1989; Emcon Associates, 1989; Hydro-Search, 1991; McLaren/Hart, 1991). Findings of these investigations revealed the presence of elevated VOC concentrations, principally benzene, in soil gas and groundwater samples collected within the Hamilton Dutch area (Figure 1.2-2). Analytical results for a groundwater grab sample collected in proximity to underground benzene pipelines formerly servicing the plant site reported benzene concentrations at the aqueous solubility limit for this contaminant, suggesting the presence of a residual benzene LNAPL in the vicinity. Based upon these findings, several groundwater monitoring wells were subsequently completed in this general area to further evaluate groundwater conditions. Analytical results for these monitoring wells reported benzene concentrations at approximately one-half the aqueous solubility limit for this compound, which may suggest the nearby presence of a residual benzene LNAPL. Although similar benzene concentrations persist in repeated sampling events conducted between 1994 and 1996 as part of the ongoing groundwater monitoring program for the Del Amo study area, NAPL has not been observed in any of the wells completed in this vicinity (Dames & Moore, 1996a). Although there is historical information to indicate that benzene was previously transmitted through this area via underground pipeline, and locally elevated soil gas benzene concentrations have been reported, vadose zone investigations conducted throughout this area have not detected significant residual concentrations of benzene in soil (Dames & Moore, 1993d). While no NAPL has been observed, the presence of residual benzene LNAPL in this area can be reasonably assumed based upon dissolved benzene concentrations in groundwater (historical high of 1300 mg/L benzene in well XMW-04HD). As discussed later in this report, the Hamilton Dutch area has been identified as a location where NAPL is likely present, and conditions within this area will be addressed at a later time.

1.3.4 Monitoring Well P-1 LNAPL Area

An LNAPL was encountered during installation and development of monitoring well P-1 in the residential area south of the Waste Pit Area as part of groundwater investigations conducted by Woodward-Clyde Consultants (Woodward-Clyde Consultants, 1987) (Figure 1.2-2). Laboratory analyses of the LNAPL indicate it to be a refined petroleum hydrocarbon product, similar to diesel but with a higher proportion of volatile constituents than is typical for diesel (Dames & Moore, 1992a). On behalf of the Del Amo Respondents, Dames & Moore has conducted focused investigations in the well P-1 area to evaluate the nature, distribution and origin of this LNAPL. These focused investigations were conducted with EPA oversight, but outside the AOC, and are not considered part of the RI for the Del Amo study area.

Findings of cone penetrometer (CPT)-assisted groundwater and NAPL sampling and chemical analysis indicate that the petroleum LNAPL is submerged beneath the groundwater table and trapped in sediment pore spaces within the predominantly fine-grained sediments of the Bellflower aquitard (Dames & Moore, 1992b). This general mode of occurrence is similar to that of the well MW-20 LNAPL, where more detailed studies have provided a more complete understanding of LNAPL distribution and physical conditions.

The results of deep CPT-assisted soil gas sampling and analyses conducted in the interval just above the groundwater table throughout the vicinity of well P-1 were used to map the distribution of the characteristic headspace vapor chromatographic signature associated with the well P-1 LNAPL. The highest VOC concentrations in deep soil gas samples matching those associated with the well P-1 LNAPL were detected in the area directly beneath an active petroleum transmission pipeline easement along Del Amo Boulevard, south of the Waste Pit Area (Dames & Moore, 1992b) (Figure 1.2-3). These pipelines are unrelated to former operations within the plant site. Subsequent excavation and soil sampling conducted by representatives of the oil companies owning/operating the pipelines in this easement indicated the presence of VOC soil contamination spatially associated with an apparently repaired pipeline segment (Shell, 1993). The preponderance of available data support the well P-1 LNAPL to have originated from a subsurface petroleum transmission pipeline release. Deposition statements describing a historical petroleum pipeline rupture and spill along this portion of Del Amo Boulevard (Tymstra, 1990) further support the conclusion that this pipeline easement represents the most likely source area for the well P-1 LNAPL.

1.3.5 Montrose Plant Property

The Montrose site has been the subject of an ongoing RI/FS conducted by Hargis + Associates under an AOC between EPA and the former Montrose Chemical Company. The property on which the Montrose Chemical Company conducted its DDT manufacturing operations (the Montrose Plant Property) is situated just west of the Del Amo study area, across Normandie Boulevard (Figures 1.2-1 and 1.2-2). During operation, the Montrose facility produced the pesticide dichlorodiphenyltrichloroethane (DDT). The former manufacturing facilities have been demolished and the majority of the Montrose Plant Property is currently paved.

Investigations conducted as part of the Montrose RI extend back to approximately 1985, and have provided the current study with valuable information regarding groundwater conditions within the Del Amo study area. The primary constituents of concern at the Montrose Plant Property include DDT, chlorobenzene and para-chlorobenzene sulfonic acid (p-CBSA), a highly mobile byproduct of DDT manufacturing. Investigations conducted by Hargis + Associates have identified an area of chlorobenzene dense NAPL (DNAPL) beneath the former central processing area of the Montrose Plant Property (Hargis + Assoc., 1992). Within the most transmissive water-bearing zone, the dissolved plume emanating from this chlorobenzene DNAPL area extends greater than 2 miles downgradient from its source area within Montrose Plant Property. The dissolved p-CBSA plume, being more highly mobile than chlorobenzene, extends further (> 2.6 miles) downgradient. The downgradient extent of the p-CBSA plume has not been identified.

Analytical results from the ongoing Del Amo study area groundwater monitoring program and sampling completed for the Montrose Plant Property by Hargis + Associates indicate that other VOCs are also present in groundwater beneath the Montrose Plant Property, including trichloroethene (TCE), tetrachloroethene (PCE), and benzene. These data also indicate that dissolved contaminants emanating from the Montrose Plant Property locally overlap, and to some extent may commingle, with dissolved constituents from the Del Amo study area (Dames & Moore, 1996a). Due to the proximity of these two sites and the locally overlapping nature of the dissolved contaminant plumes, a single Groundwater FS covering both sites is being prepared by EPA. The joint Groundwater FS will presents the findings of the predictive groundwater flow and contaminant transport modeling and evaluate the variety of remedial alternatives to address groundwater contamination associated with both sites.

1.4 REPORT ORGANIZATION

Section 1.0 describes the context within which groundwater investigations have been undertaken at the study area under the AOC, defines specific goals and objectives and presents a summary of relevant study area background information to place the current groundwater investigation in an accurate perspective with respect to historical operations and regional groundwater conditions. Section 2.0 describes the investigative approach used to guide data acquisition and summarizes investigative tasks completed during the Groundwater RI, including descriptions of goals and objectives, the nature and scope of investigations, the location and number of sampling locations and the overall availability of physical and chemical data collected during this study. The conceptual study area hydrostratigraphic model is presented in Section 3.0 and includes discussions of the regional physiographic and hydrogeologic setting, identification and description of the HSUs investigated and their correlation with regional nomenclature, descriptions of soil properties, and discussions of the sedimentology, depositional setting and structure of the various HSUs. Section 4.0 describes groundwater conditions within the study area, including groundwater levels and flow characteristics, hydraulic properties and general groundwater geochemistry. The nature and extent of groundwater contamination is presented in Section 5.0, including a description of LNAPL/DNAPL distribution, the concentration and distribution of dissolved groundwater contaminants, and identification of potential groundwater contamination source areas. An analysis of contaminant mobility and fate is presented in Section 6.0, including dissolved- and separate-phase mobility characteristics and natural attenuation mechanisms. Section 7.0 describes groundwater resources and use within the study area, focusing upon current municipal groundwater production, beneficial uses and administrative controls. Section 8.0 presents a summary review discussion of salient findings for each investigative task completed and the primary conclusions of the Groundwater RI. References cited in this report are presented in Section 9.0.

Supporting documentation for the Groundwater RI report is presented in the attached appendices, including the following: Appendix A—summary history of study area; Appendix B—lithologic logs; Appendix C—monitoring well construction details; Appendix D—downhole geophysical logs; Appendix E—cone penetrometer logs; Appendix F—summary of soil properties; Appendix G—groundwater analytical results; Appendix H—aquifer testing results; Appendix I—data quality assessment; and, Appendix J—groundwater sampling procedures.

TABLE 1.3-1
SIGNIFICANT DOCUMENTS PERTAINING TO PRIOR GROUNDWATER INVESTIGATIONS COMPLETED WITHIN DEL AMO STUDY AREA[1]

YEAR	AUTHOR	REPORT TITLE	REPORT DATE	LOCATION	PURPOSE/TOPIC OF REPORT
1983	Ecology & Environment, Inc.	Hydrogeological Assessment, Del Amo Site, Torrance, CA	11/11/83	Del Amo study area and vicinity	Consolidation and assessment of existing information regarding the hydrogeology and groundwater quality of the study area.
1984	Dames & Moore	Interim Summary of Findings, Del Amo Site Investigation, Los Angeles, CA, for Irell & Manella	6/15/84	Del Amo Waste Pit Area	Presents findings of an investigation of waste, soil, and groundwater conditions in the Waste Pit area performed in February and March, 1984 by Dames & Moore and Radian
1985	Woodward-Clyde Consultants	Del Amo Hazardous Waste Site Remedial Investigation/Feasibility Study—Description of Existing Site Conditions for the DOH	8/20/85	Del Amo Waste Pit Area	Provides a general site history and chronology, characterizes the site in terms of the nature of wastes, extent of soil and groundwater contamination, contribution to atmospheric levels of contaminants, hydrogeology and environmental setting, characterization of hazardous wastes known to be present in terms of chemical and physical properties, toxicology and safety hazards, and assesses impacts of the site on the environmental and on the public health and welfare.
1986	Metcalf & Eddy	Draft Preliminary Report RI/Part 1, Montrose Facility	3/86	Montrose Plant Property	Assess conditions, summarizing soil and groundwater sampling investigations that were performed.

TABLE 1.3-1

YEAR	AUTHOR	REPORT TITLE	REPORT DATE	LOCATION	PURPOSE/TOPIC OF REPORT
1987	Metcalf & Eddy	Technical Oversight & Feasibility Study, Montrose Chemicals—May 1987, Revised August 1987 (Preliminary Evaluation of Part 2—Onsite Soils & Groundwater)	8/87	Montrose Plant Property	Evaluation of field and analytical data from the Remedial Investigation, Part 2—Phase 1 onsite groundwater and soils investigation.
1987	Woodward-Clyde Consultants	Task 2 Final Report, Additional Data Acquisition and Interpretation, Del Amo Hazardous Waste Site—Los Angeles, CA—Volume 1 and 2	10/2/87	Del Amo Waste Pit Area	Evaluates the spatial distribution of soil contamination adjacent to the pits and presents findings of shallow groundwater investigations.
1987	Applied Geosciences	Toxic Hazard Assessment of the Cadillac Fairview Company's Pacific Gateway Center, prepared for Hazard Management Consulting, Inc.	10/15/87	Cadillac Fairview Property, Pacific Gateway Center	Results of a toxic hazard assessment and preliminary field investigation for the Cadillac Fairview Property, Pacific Gateway Center.
1988	Dames & Moore	Project Summary Report #1, for G.P. Holdings	6/9/88	Del Amo Waste Pit Area	Addressed actions taken to date during the reporting period, actions expected to be taken during the following two months; and summary reports of sample analyses, tests and other data generated or received.
1989	Reidel Environmental	Environmental investigation for 20221 Hamilton Avenue, for Andrex Development Company	3/22/89	Hamilton Dutch Investors 20221 Hamilton Avenue, Torrance, Ca.	Presents results of environmental investigation conducted on subject site

TABLE 1.3-1

YEAR	AUTHOR	REPORT TITLE	REPORT DATE	LOCATION	PURPOSE/TOPIC OF REPORT
1989	Emcon Associates	Assessment of Potential Soil Contamination, 20221 Hamilton Avenue, Los Angeles, Ca. for Wheeler, Augustini and Dorman	3/10/89	20221 Hamilton Avenue, Torrance, Ca.	Presents results of soil investigations conducted at the subject site and discusses implications of these data have regarding potential for groundwater contamination at the site
1989	Ecology & Environment, Inc.	CERCLA Expanded Site Inspection—Del Amo, Del Amo Blvd./Torrance Blvd., Torrance, CA—Los Angeles County for U.S. EPA	5/30/89	Del Amo Waste Pit Area	Site inspection to evaluate the groundwater exposure pathway from the Del Amo Waste Pit Area.
1989	Ecology & Environment, Inc.	CERCLA Expanded Site Inspection, for Del Amo Field Investigation Team Zone II	6/30/89	Del Amo study area	Expanded site inspection of the Del Amo study area (formerly known as Cadillac-Fairview), conducted to evaluate the contaminant exposure pathways from the Del Amo site, determine if an observed release to the drinking water aquifer occurred, to determine the impact of upgradient sites on local groundwater chemistry, and to determine if continuity exists between the uppermost contaminated aquifer near the Del Amo site (Gage aquifer) and the local drinking water aquifer (Lynwood aquifer) within 2 miles of the site.

YEAR	AUTHOR	REPORT TITLE	REPORT DATE	LOCATION	PURPOSE/TOPIC OF REPORT
1990	CKY Environmental	Laboratory Report for Samples received on 1/15/90, for Riedel Environmental	1/17/90	Hamilton Dutch Investors 20221 Hamilton Ave. Torrance, CA 90502	Laboratory data for groundwater and soil samples received on 1/15/90.
1990	Dames & Moore	Remedial Investigation Report, Del Amo Site, Los Angeles. CA, for GP Holdings, Dow Chemical Co., and Shell Oil	4/4/90	Del Amo Waste Pit Area	Consolidates existing data and presents conclusions regarding physical and chemical character of soil, waste, and groundwater in proximity to Del Amo Waste Pit Area.
1990	Hargis + Assoc.	Field Data Submittal—Part 2—Remedial Investigative Work—Phase 2B—Montrose Site, Torrance. August 1989 - April 1990	5/4/90	Montrose Plant Property	Summarizes field activities and presents geologic logs associated with exploratory drilling and monitoring well installation program.
1990	Hargis + Assoc.	Field Data Submittal—Part 2—Remedial Investigative Work—Phase 2B—Montrose Site, Torrance. April 1990 Groundwater Sampling	5/21/90	Montrose Plant Property	Summarizes field tasks completed during April 1990 groundwater sampling event for the Montrose RI.
1990	Hargis + Assoc.	Regional Hydrogeologic Assessment Report, Task 15—Volumes I (Text, Tables, Illustrations) and II (Appendices A - F)	5/29/90	Montrose Plant Property	Volume I: Presents data regarding the hydrogeologic environment in the vicinity of the Montrose property and identification of known and potential sources of groundwater contamination.

TABLE 1.3-1

YEAR	AUTHOR	REPORT TITLE	REPORT DATE	LOCATION	PURPOSE/TOPIC OF REPORT
1990	Engineering Enterprises	Report of Additional Subsurface Assessment and Groundwater Sampling Amoco Chemical Facility, Torrance	5/29/90	Amoco Chemical Company 1225 West 196th Street Torrance, CA	Evaluation of the vertical extent of styrene in soil and volatile organic compounds in groundwater samples collected from existing onsite monitoring wells.
1990	IT Corporation	Phase II Environmental Assessment Report, IT Corporation, for Pacific Bell	10/5/90	Pacific Bell 19310 Pacific Gateway Drive Los Angeles, CA	Presents findings of visual inspection of the site and surrounding area, results of laboratory analyses on soil and groundwater samples collected from the site and information obtained from aerial photographs and file review.
1990	Hargis + Assoc.	Results of Regional Well Sampling—Montrose Site, Torrance, CA Task 15	11/1/90	Montrose Plant Property	Results of regional well sampling within a 1-mile radius of the Montrose property, Torrance, CA.
1990	Levine-Fricke	Preliminary Subsurface Investigation—Harbor Technology	12/21/90	Harbor Technology Center 20280, 20300 Vermont Ave. Torrance, CA	Evaluation of soil and groundwater conditions in the northeast corner of the property, in the vicinity of previously reported occurrences of hydrocarbons in soils.
1991	Simon Environmental Engineering	Report of Groundwater Sampling and Analysis, Amoco Chemical Company, Torrance	1/21/91	Amoco Chemical Facility 1225 West 196th Street Torrance, CA	Presents findings of volatile and semi-volatile organic compounds detected in groundwater samples collected from onsite monitoring wells.

YEAR	AUTHOR	REPORT TITLE	REPORT DATE	LOCATION	PURPOSE/TOPIC OF REPORT
1991	Hydro-Search Inc.	Site Characterization Report, Torrance, CA. Volumes I (Text through Appendix F) and II (Appendices G & H)	2/20/91	Hamilton Dutch Investors Harbor Gateway Center 20221 Hamilton Ave. Torrance, CA 1991	Volume I: Assessed the distribution of regulated hydrocarbon compounds in soil near the northwest corner of Lot 62, presents an evaluation of local geology & hydrology, assesses the distribution of hydrocarbon compounds in shallow groundwater and identifies potential sources of benzene and other hydrocarbon compounds.
1991	McLaren/Hart	Site Investigation Part A at HDI Lot 62 Harbor City, CA. for Augustini and Wheeler	3/7/91	Hamilton Dutch Investors 20221 Hamilton Ave. Harbor City, CA	Presents results of site investigation to assess the extent of benzene contamination in the soil and groundwater at Lot 62.
1991	Dames & Moore	Feasibility Study Report, Del Amo Site	5/5/91	Del Amo Waste Pit Area	Identifies remedial action alternatives for the Del Amo Waste Pit Area.
1991	Simon Environmental Engineering	Report of Groundwater Sampling and Analysis, Amoco Chemical Company.	6/91	Amoco Chemical Facility 1225 West 196th Street Torrance, CA	Evaluated the concentration of volatile and semi-volatile organic compounds in groundwater samples collected from six onsite monitoring wells.
1991	Kennedy Jenks Chilton	Report of Technical Documents Review and Groundwater Sampling, McDonnell Douglas Co.	6/12/91	Douglas Aircraft Co. C6 Facility Torrance, CA (directly north of the Montrose Property)	Evaluated industrial operations and environmental conditions at or near the subject property that could have resulted in the presence of chloroform in shallow groundwater.

TABLE 1.3-1

YEAR	AUTHOR	REPORT TITLE	REPORT DATE	LOCATION	PURPOSE/TOPIC OF REPORT
1992	Simon Hydrosearch	Groundwater Sampling and Analysis Report Amoco Chemical Co., Torrance	1/92	Amoco Chemical Company 1225 West 196th Street, Torrance, CA	Evaluated the concentration of volatile and semi-volatile organic compounds in groundwater samples collected from six on-site monitoring wells.
1992	Dames & Moore	Analytical Results for NAPL from Monitoring Well P-1, Adjacent to the Del Amo Site, Los Angeles, CA for U.S. Environmental Protection Agency	1/23/92	Monitoring Well P-1, located approximately 350 feet south of the Del Amo Waste Pit Area.	Presents results of chemical analyses conducted on samples of petroleum hydrocarbon NAPL collected from Monitoring Well P-1.
1992	Dames & Moore	Focused Investigation of Non-Aqueous Phase Liquid (NAPL) Monitoring Well P-1, Torrance, California, for the Del Amo Participants	10/23/92	Monitoring Well P-1, located approximately 350 feet south of the Del Amo Waste Pit Area.	Summary of results of focused investigation to evaluate the source and chemical nature of the petroleum hydrocarbon NAPL present in Monitoring Well P-1 and surrounding soil
1992	Hargis + Assoc.	Final Draft Remedial Investigation Montrose Site, Volumes I - IV	10/29/92	Montrose Plant Property	Presents results of the Remedial Investigation conducted at the Montrose Property and vicinity.
1993	Dames & Moore	Focused Investigation, Nature and Extent of Non-Aqueous Phase Liquid (NAPL) Monitoring Well MW-20	3/5/93	Monitoring Well MW-20, former styrene plant, Del Amo study area.	Presents findings of investigations to characterize the MW-20 NAPL accumulation and provide data to assist in possible NAPL recovery.
1993	Hargis + Assoc.	Field and Raw Analytical Data Submittal, Groundwater Sampling, January 1993—Montrose Site	3/11/93	Montrose Plant Property	Presents findings and analytical results of recent groundwater sampling event

YEAR	AUTHOR	REPORT TITLE	REPORT DATE	LOCATION	PURPOSE/TOPIC OF REPORT
1993	Dames & Moore	P-1 NAPL Source Area Analysis / Del Amo study area	5/15/93	Monitoring Well P-1, located approximately 350 feet south of the Del Amo Waste Pit Area.	Presents chemical evidence that NAPL in monitoring well P-1 originated from an oil pipeline leak unrelated to the former synthetic rubber manufacturing plant.
1993	Dames & Moore	Phase I Remedial Investigation Report, Del Amo Study Area, Volumes I - V	10/29/93	Del Amo study area	Reports findings of Phase I site characterization investigations throughout Del Amo study area, including analytical results for soil, soil gas and groundwater
1994	Dames & Moore	Groundwater Monitoring Plan, Del Amo Study Area	2/11/94	Del Amo study area	Outlines scope of periodic groundwater monitoring program to be implemented at Del Amo study area
1994	Dames & Moore	Draft Phase II Remedial Investigation Work Plan, Del Amo Study Area	2/18/94	Del Amo study area	Outlines proposed scope for Phase II site characterization investigations in selected portions of the Del Amo study area. Presents recent analytical results for new soil gas locations and new groundwater monitoring wells.
1994	Dames & Moore	Quarterly Report—Groundwater Monitoring Program, First Quarterly Sampling Event, Del Amo Study Area	7/22/94	Del Amo study area	Presents findings and analytical results of periodic groundwater sampling event
1994	Dames & Moore	Quarterly Report Groundwater Monitoring Program Second Quarter Sampling Event 1994, Del Amo Study Area	12/15/94	Del Amo study area	Presents findings and analytical results of periodic groundwater sampling event

TABLE 1.3-1

YEAR	AUTHOR	REPORT TITLE	REPORT DATE	LOCATION	PURPOSE/TOPIC OF REPORT
1995	Dames & Moore	Quarterly Report, Groundwater Monitoring Program, Third Quarter Sampling Event 1994, Del Amo Study Area	2/9/95	Del Amo study area	Presents findings and analytical results of periodic groundwater sampling event
1995	Dames & Moore	Technical Memorandum, Interpretation of Montrose and Del Amo Pump and Slug Test Data	5/5/95	Del Amo study area	Presents results of recent pump tests and slug tests conducted by Dames & Moore, and offers a re-analysis of earlier pump test data previously presented by Hargis + Assoc. for the Montrose Plant Property
1995	Dames & Moore	Technical Memorandum, Assessment of Arsenic in Groundwater, Del Amo Study Area	5/19/95	Del Amo study area	Evaluates available data for arsenic in groundwater within the study area and offers hypotheses regarding the origin of elevated arsenic concentrations in the vicinity.
1995	Dames & Moore	Interim Plan, Phase II Groundwater Investigations, Del Amo Study Area	8/1/95	Del Amo study area	Outlines scope of Phase II monitoring well installation and groundwater characterization efforts.
1995	Dames & Moore	Groundwater Monitoring Report, Fourth Quarter 1994, Del Amo Study Area	5/23/95	Del Amo study area	Presents findings and analytical results of periodic groundwater sampling event

YEAR	AUTHOR	REPORT TITLE	REPORT DATE	LOCATION	PURPOSE/TOPIC OF REPORT
1995	Dames & Moore	Draft Report and Work Plan, Laboratory Data and Analysis and Hydraulic Extraction Work Plan, MW-20 Pilot Program, Del Amo Study Area	9/29/95	Del Amo study area—monitoring well MW-20 area	Presents laboratory results of fluid saturations and physical testing conducted on NAPL-containing soil samples and outlines proposed scope of work in support of pilot hydraulic extraction system to be constructed and operated at the monitoring well MW-20 area
1995	Dames & Moore	Groundwater Monitoring Report, First Quarter 1995, Del Amo Study Area	11/6/95	Del Amo study area	Presents findings and analytical results of periodic groundwater sampling event
1995	Dames & Moore	Groundwater Monitoring Report, Fourth Quarter 1994, Del Amo Study Area (revision of May 23, 1995 report)	11/17/95	Del Amo study area	Presents findings and analytical results of periodic groundwater sampling event; text revised at the request of EPA to eliminate conclusions
1995	Dames & Moore	Phase II Remedial Investigation Groundwater Contamination Source Areas, Data Summary and Proposed Target Areas, Del Amo Study Area	11/17/95	Del Amo study area	Presents summary of available data used to identify nature and location of potential groundwater contamination source areas within the Del Amo study area. Also indicates proposed locations for Phase II investigations
1995	Dames & Moore	Information Package Addressing Evaluation of NAPL Dissolution, MW-20 NAPL Area	12/1/95	Del Amo study area—monitoring well MW-20 area	Summarizes available data regarding NAPL dissolution mechanisms for the monitoring well MW-20 area

TABLE 1.3-1

YEAR	AUTHOR	REPORT TITLE	REPORT DATE	LOCATION	PURPOSE/TOPIC OF REPORT
1995	Dames & Moore	Groundwater Monitoring Report, Second Quarter 1995, Del Amo Study Area	12/22/95	Del Amo study area	Presents findings and analytical results of periodic groundwater sampling event
1996	Dames & Moore	Response to Comments: Draft Report And Work Plan, Laboratory Data and Analysis and Hydraulic Extraction Work Plan, MW-20 Pilot Program, Del Amo Study Area	1/12/96	Del Amo study area—monitoring well MW-20 area	Presents response to agency comments on 9/29/95 MW-20 NAPL area work plan
1996	Hargis + Assoc.	Groundwater Sampling Data Submittal, October through December 1995, Montrose Site	1/17/96	Montrose Plant Property	Presents findings and analytical results of recent groundwater sampling event
1996	Dames & Moore	Groundwater Monitoring Report, Third Sampling Period 1995, Del Amo Study Area	2/23/96	Del Amo study area	Presents findings and analytical results of periodic groundwater sampling event
1996	Dames & Moore	Technical Memorandum, Analysis of Groundwater Flow and Mass Transport, Del Amo Study Area	2/28/96	Del Amo study area—monitoring well MW-20 area	Summarizes results of focused groundwater flow and contaminant transport model for the monitoring well MW-20 area
1996	Dames & Moore	Groundwater Monitoring Report, First Sampling Period 1996, Del Amo Study Area	6/17/96	Del Amo study area	Presents findings and analytical results of periodic groundwater sampling event

[1] Partial listing only—limited primarily to documents presenting groundwater data/findings

896/070

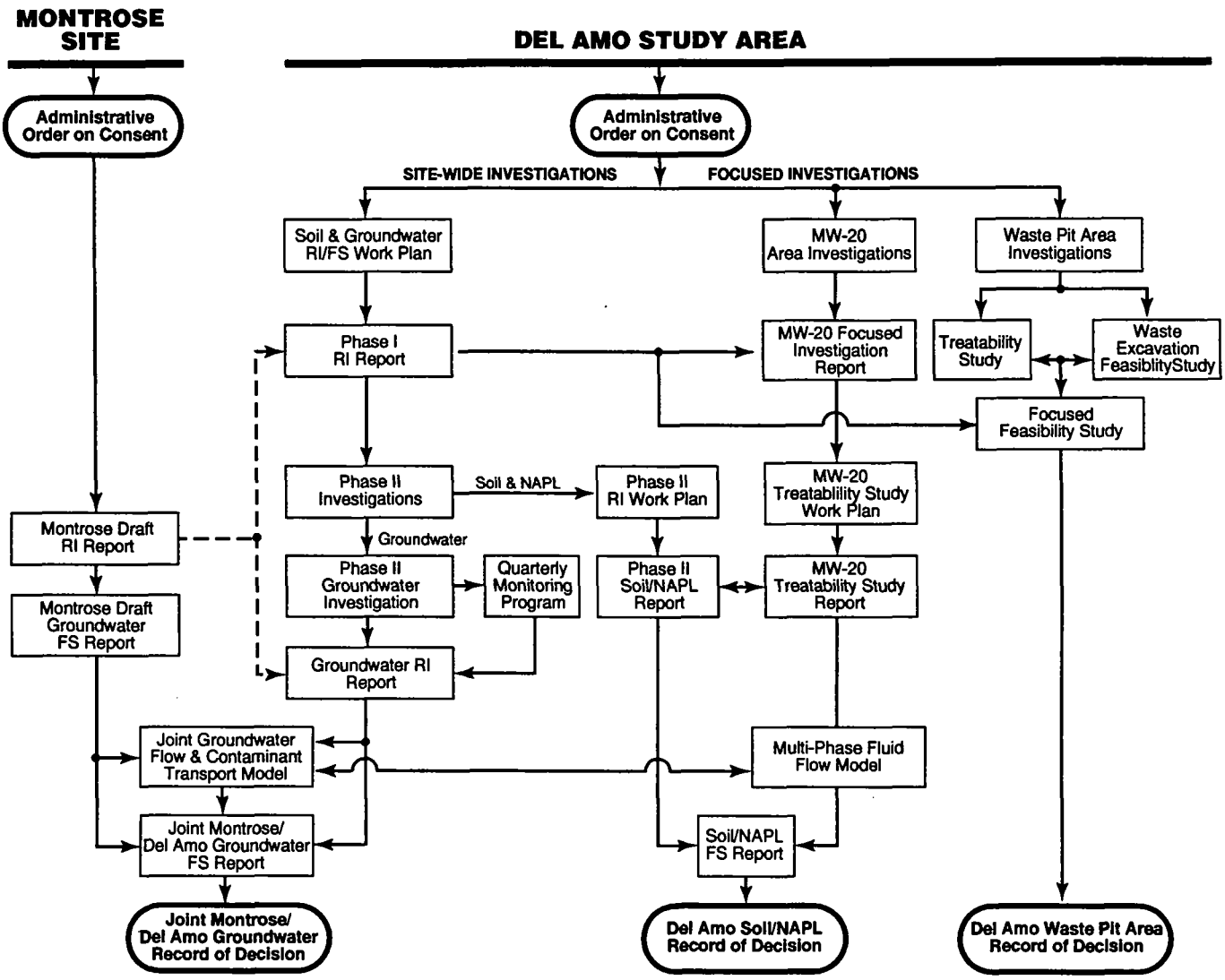
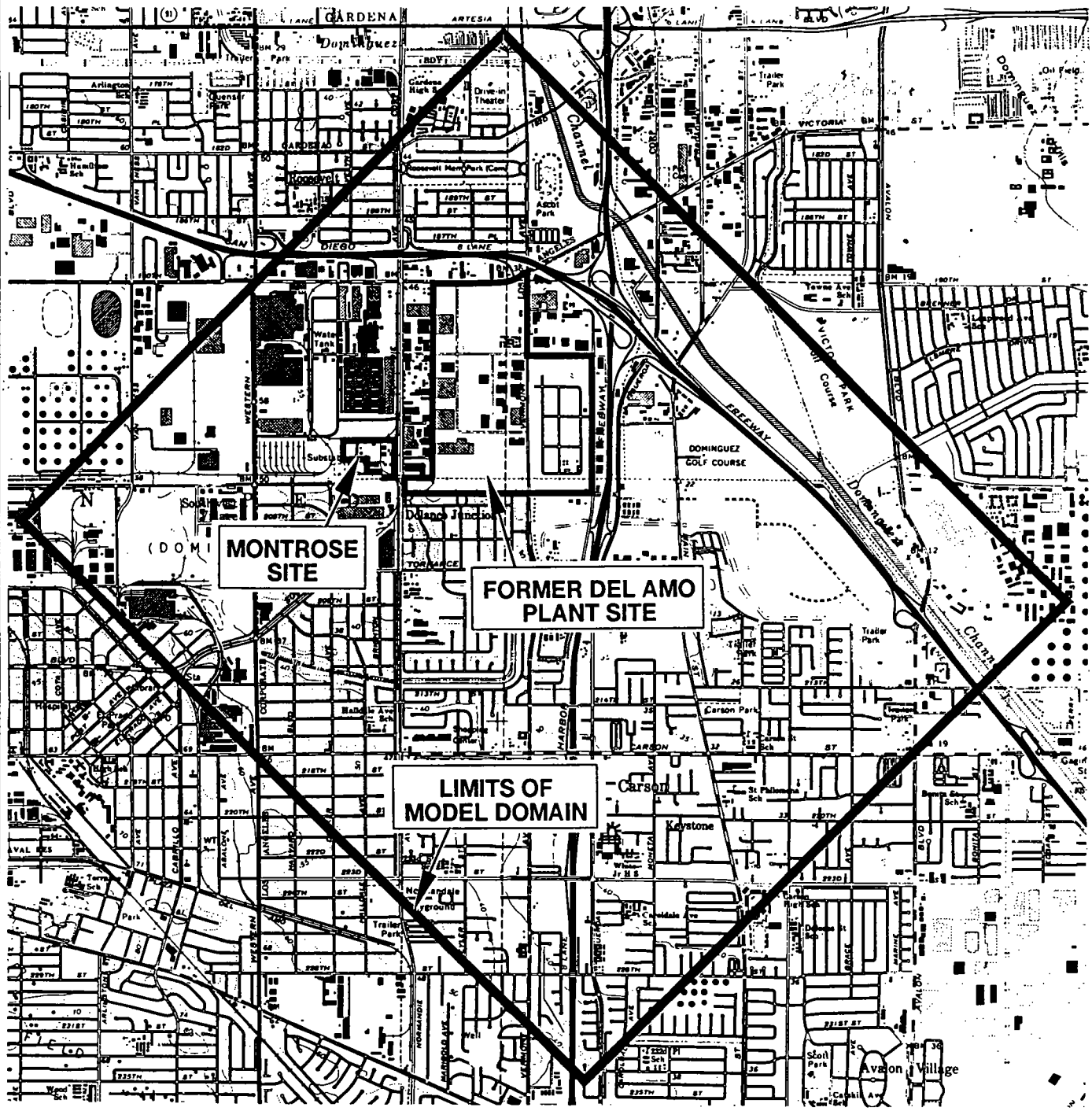


FIGURE 1.0-1

Del Amo RI/FS Process & Relationship of Investigative Tasks

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE



0 1/2 1

Scale in Miles

Base Map: USGS Topographic Quadrangle: Torrance, CA 1964; photorevised 1981

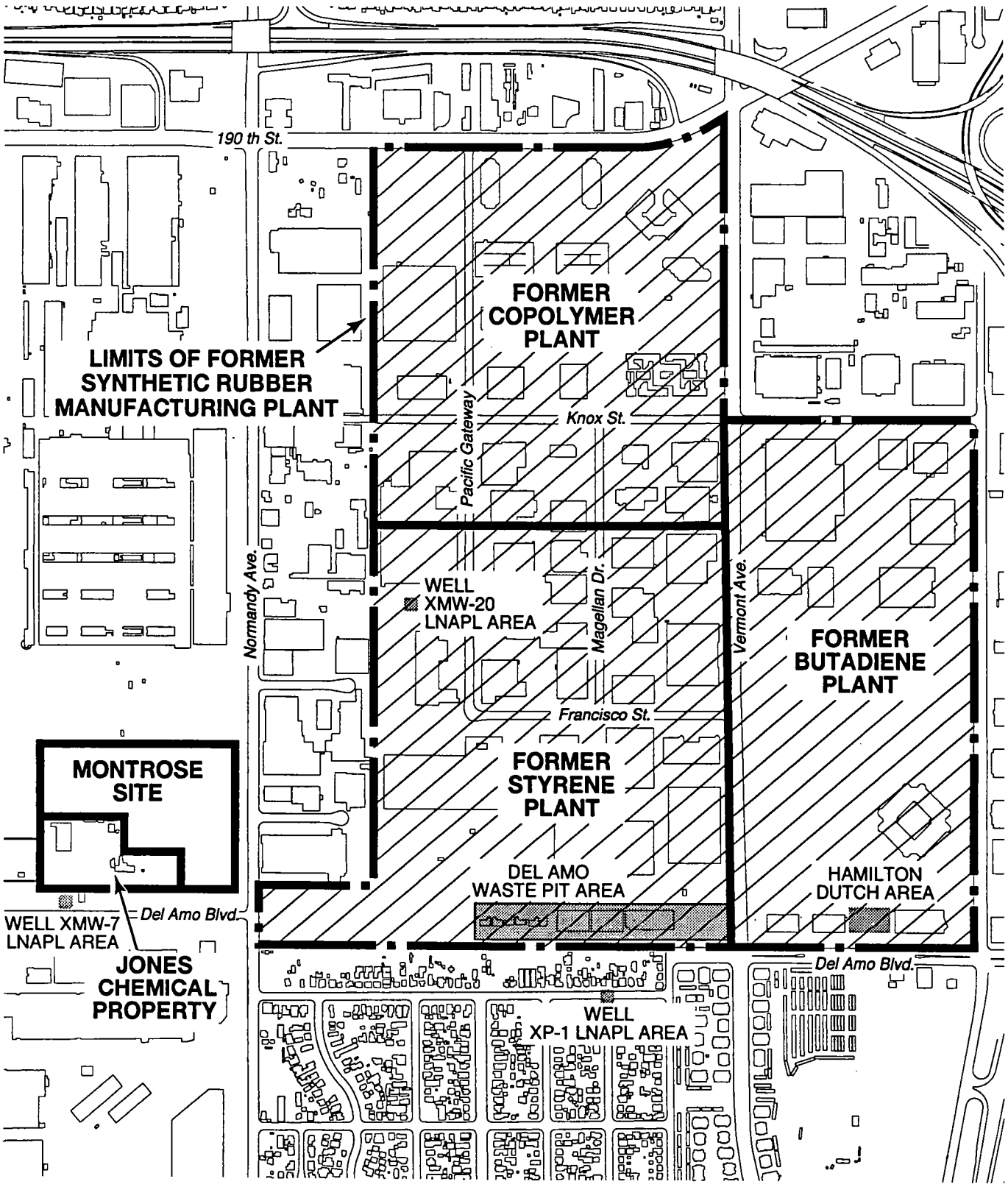
FIGURE 1.2-1

Del Amo Study Area and Joint Groundwater Model Domain

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

896/074



0 600 1,200

Scale in Miles

Base Map: USGS Topographic Quadrangle: Torrance, CA 1964; photorevised 1981

FIGURE 1.2-2

Investigative Areas

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

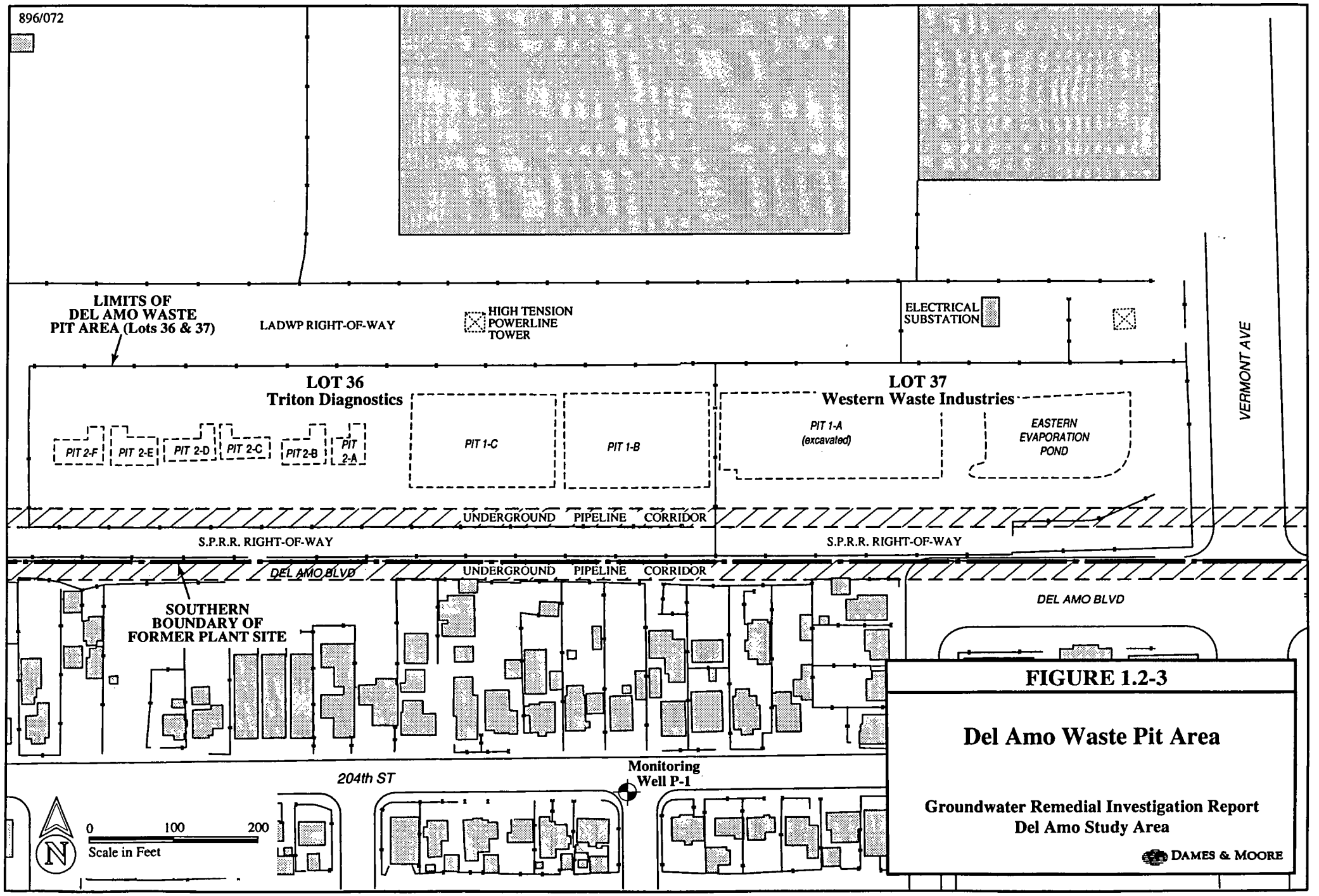


FIGURE 1.2-3

Del Amo Waste Pit Area

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

PARTIALLY SCANNED
OVERSIZE ITEM(S)

See document # 2259656
for partially scanned image(s).
PLATE 1-1 TO 1-2
(1 OF 20) (2 OF 20)
For complete hardcopy version of the oversize document
contact the Region IX Superfund Records Center

2.0 STUDY AREA GROUNDWATER INVESTIGATIONS

Presented in this section is a summary of the approach and investigative methods utilized and the nature, location and availability of physical and chemical data collected during this Groundwater RI. Following a discussion of the overall investigative approach to groundwater investigations conducted within the study area, the nature and scope of the various investigative elements completed are summarized. Descriptions of the individual tasks completed are presented under one of two sections: Hydrostratigraphic Investigations (Section 2.2.1) or Groundwater Investigations (Section 2.2.2). The discussion of hydrostratigraphic investigations includes descriptions of the stratigraphic explorations, geophysical testing and soil properties testing conducted to further refine the conceptual hydrogeologic model for the study area. The discussion of groundwater investigations is divided into individual sections describing the various subtasks completed to characterize groundwater conditions throughout the study area, including groundwater screening efforts, monitoring well installation and focused groundwater characterization work, aquifer testing and ongoing periodic groundwater monitoring.

This Groundwater RI report presents the findings of groundwater investigations and analytical testing completed up to and including the third monitoring period 1995 (Dames & Moore, 1996a). This time period was selected in order to keep a common reference data-set for presentation and analysis purposes in both the Groundwater RI and FS reports. An additional consideration was the desire to define initial conditions for use in the predictive groundwater flow and contaminant transport modeling based upon this same data-set.

2.1 INVESTIGATIVE APPROACH

Regional and local hydrogeological and groundwater data were coupled with information regarding plant site history to develop an initial conceptual model of the Del Amo study area. The nature and scope of groundwater investigations summarized in the Phase I Report were developed based upon this initial conceptual model. Subsequent groundwater investigations conducted accordance with the Interim Plan (Shell, 1995b)—hereafter referred to as "Phase II" groundwater investigations— provided additional data with which to further refine the initial conceptual model. This refined conceptual model reflects a greater level of detail and understanding, compared to that presented in the Phase I RI report, regarding groundwater flow conditions, lateral and vertical dissolved and separate phase contaminant distribution and time-series behavior, aquifer properties and natural attenuation mechanisms.

Information regarding groundwater levels and general contaminant distribution gathered from initial, screening-level groundwater investigations, in addition to historical information regarding former plant site facilities and operations, were used to identify those portions of the study area that merited further exploration and investigation, and helped establish the nature and location of additional data needs, including the installation of permanent groundwater monitoring locations. The subsequent installation of Phase II monitoring wells and collection of time-series groundwater data under the Groundwater Monitoring Plan provided further resolution of contaminant distribution within the dissolved plumes and allowed the identification of potential groundwater contamination source areas. The location and general character of these source areas have been previously described in the Phase I RI Report and the Draft Phase II RI Work Plan (Dames & Moore, 1993d and 1994b), and are further described in Section 5.0 of this report.

2.2 SCOPE AND METHODS

The following sections describe the various investigative tasks completed during groundwater investigations within the study area. The individual tasks are described below with respect to purpose and objectives, investigative methods, location and data availability. Detailed information regarding field procedures, sampling protocols and quality assurance/quality control (QA/QC) measures can be found in the RI/FS Work Plan (Dames & Moore, 1993a).

2.2.1 Hydrostratigraphic Investigations

The purpose of the hydrostratigraphic investigations was to evaluate site-specific stratigraphic and structural conditions that may influence groundwater flow and contaminant transport. Specific objectives of the hydrostratigraphic investigations were to: (1) evaluate the depositional environment and its relationship to regional and local hydrostratigraphy; (2) evaluate hydrostratigraphic conditions, including the occurrence and distribution of relatively permeable and impermeable zones and their influence on groundwater flow and contaminant migration; (3) evaluate the physical properties within each identified zone that would aid in determination of monitoring well location and design during subsequent field investigations; and, (4) provide data for the Groundwater FS.

A preliminary hydrostratigraphic model for the study area was presented in the RI/FS Work Plan (Dames & Moore, 1993a) and was developed based upon existing information regarding the hydrogeology of the Los Angeles basin and, more specifically, the study area vicinity (California Division of Water Resources [CDWR], 1961; Hargis + Assoc., 1990b and 1992; Ecology & Environment, 1989a and 1989b). Information gathered from these sources indicated that the subsurface materials underlying the study area include portions of the regionally extensive Bellflower aquitard, Gage aquifer, and Gage-Lynwood aquitard, which form part of the upper Pleistocene Lakewood formation. Additional data specific to the study area were collected during Phase I investigations to refine this hydrostratigraphic model, as described in the Phase I RI Report (Dames & Moore, 1993d).

Discrete HSUs identified during these investigations include, from shallowest to deepest, the upper Bellflower aquitard (UBF), the middle Bellflower B sand (MBFB), the middle Bellflower mud (MBFM), the middle Bellflower C sand (MBFC), the lower Bellflower aquitard (LBF), the Gage aquifer (Gage) and Gage-Lynwood aquitard (GLA). The Lynwood aquifer is known to underlie the GLA, based upon an understanding of regional hydrogeological conditions as well as from data collected by others at the nearby Montrose Plant Property. A description of these HSUs and a discussion of the conceptual hydrostratigraphic model developed from the findings of these investigations are presented in Section 3.0.

As further described below, a variety of investigative tools were used to meet the objectives of the hydrostratigraphic investigation, including continuous coring and detailed stratigraphic logging, downhole geophysical logging and CPT profiling, and laboratory soil properties testing. The distribution of exploratory borings and sampling points associated with hydrostratigraphic investigations were selected to provided broad geographic coverage of the study area, thereby allowing development of a representative conceptual model of subsurface conditions. The nature and availability of hydrostratigraphic data collected during this study are summarized in Table 2.2-1.

2.2.1.1 Stratigraphic Explorations

Stratigraphic explorations were conducted to gather detailed information regarding the nature, distribution and variability of subsurface materials underlying the study area. Continuous coring and geologic logging, downhole geophysical logging and CPT profiling were performed to: (1) observe and record soil types in accordance with Unified Soil Classification System (USCS) terminology; (2) evaluate stratigraphic sequences and sedimentary structures to assist in interpretation of depositional environments; (3) assist in identification of completion zones for

groundwater monitoring points; and, (4) assess the potential for soil contamination in the locations explored.

Stratigraphic explorations were performed in a phased manner, with initial subsurface data from widely distributed, deeply-penetrating exploratory borings and CPT profiles providing the basis for later, more focused, drilling and coring conducted in association with monitoring well installation. Initial exploratory borings locally extended into the GLA, and provided study area-wide geologic and geophysical data used to refine the conceptual hydrogeologic model and further confirm the nature and distribution of HSUs. Subsequent drilling and coring performed in advance of monitoring well installation provided the additional site-specific data necessary to confirm completion zones and construction details for monitoring wells. The nature and location of all stratigraphic explorations completed during this study area are illustrated in Figures 2.2-1 and 2.2-2. The results and findings of these explorations are presented in Section 3.0.

Continuous Coring

Approximately 11,600 feet of continuous stratigraphic core was collected and geologically logged from 152 exploratory borings completed throughout the study area (Figures 2.2-1 and 2.2-2). Stratigraphic exploration extended to a maximum depth of 268 feet below ground surface (bgs), terminating within the GLA. The majority of exploratory borings were completed using mud rotary drilling techniques, however, some shallow borings were completed using hollow-stem auger drilling equipment. Ninety-four of these borings were completed into portions of UBF, one completed into portions of the MBFB, six completed into portions of the MBFM, 12 completed into portions of the MBFC, 24 completed into portions of the LBF, eight completed into portions of the Gage aquifer and seven penetrated through the Gage aquifer into the GLA. No explorations extended through the GLA into the underlying Lynwood aquifer.

Detailed descriptions of the subsurface materials encountered were maintained by a field geologist at all boring locations. Geologic logs indicated the variety of soil types encountered, stratigraphic variations and sedimentary features, and any field evidence of soil contamination. All soils were described in accordance with USCS terminology. Following collection and field logging, continuous core was packaged, frozen and transferred to the laboratory where the majority of split core was photographed in color to create a permanent record of the sediments encountered. All collected core has been archived and is available for future examination and reference. The majority of retained core is stored in a frozen state. Logs of all exploratory borings completed as part of this study are presented in Appendix B. Drilling, coring, sampling and geologic logging of exploratory borings were conducted in accordance with procedures detailed in Appendix B of the RI/FS Work Plan (Dames & Moore, 1993a).

Downhole Geophysical Logging and CPT Profiling

Downhole geophysical data were collected at 30 individual locations across the study area and included the majority of boring locations that extended into an appreciable interval of the saturated zone. CPT profiles provided additional geophysical data in 100 locations (Figures 2.2-1 and 2.2-2). Geophysical data were collected to augment stratigraphic information obtained from the visual inspection of continuous core. Specifically, geophysical data were collected to: (1) provide objective data regarding general soil properties, grain-size, and sedimentary packages (e.g., fining- and coarsening-up sequences); (2) provide additional data with which to define and substantiate the character and distribution of HSUs throughout the study area; (3) determine depth to first groundwater; and, (4) assist in defining target completion zones of monitoring wells. Downhole geophysical work included collection natural gamma, spontaneous potential, caliper, guard resistivity, point resistivity, 16-inch and 64-inch normal resistivity, acoustic logs, and CPT profiles (Table 2.2-2). Downhole geophysical logging was conducted in accordance with procedures detailed in Appendix B of the RI/FS Work Plan (Dames & Moore, 1993a). Geophysical logs and CPT profiles are presented in Appendices D and E of this report, respectively.

2.2.1.2 Soil Properties Testing Program

A total of 294 selected soil samples collected from a range of depths at 68 separate locations across the study area were submitted for laboratory testing of intrinsic soil properties. Samples were selected to be representative of the variety of sediments encountered during subsurface explorations. A representative suite of such samples were collected from each HSU for testing. Soil samples were tested for one or more of the following properties: grain-size distribution; bulk density; moisture content; vertical and horizontal hydraulic conductivity; vertical and horizontal air permeability; and, plasticity (Atterberg limits). In addition to the above-listed tests, a total of 16 samples collected from 11 locations were subjected to consolidation testing to evaluate storativity of aquitard materials (Table 2.2-3).

Soil properties testing was completed to: (1) confirm field USCS soil classifications used for exploratory borings; (2) evaluate certain intrinsic physical and mechanical soil properties; and, (3) provide data to support the predictive groundwater flow and contaminant transport model and the Groundwater FS in evaluating potential remedial measures. In addition to the physical testing performed, 50 samples representative of the variety of sediments encountered were collected from a total of 18 individual locations across the study area and tested for total organic carbon (TOC) to evaluate sorptive capacities. Table 2.2-3 summarizes the nature and availability of soil properties data developed to date, and Figure 2.2-3 illustrates the distribution of available

soil properties sampling points across the study area. All testing was conducted in accordance with the methods described in Appendix C of the RI/FS Work Plan (Dames & Moore, 1993a). A summary of laboratory physical testing results is presented in Appendix F of this report.

2.2.1.3 Data Evaluation Methods

Detailed observations of core and geophysical logs were used to evaluate the depositional setting and identify HSUs. Based on the relative positions of the HSUs, an interpretation of geologic relationships and overall structure beneath the study area was developed. In areas where closely spaced data are available, interpretation of small-scale heterogeneities is possible. Site-specific data developed from hydrostratigraphic investigations provided additional detail regarding local and regional geologic and hydrogeologic conditions, and allowed development of a detailed conceptual hydrostratigraphic model for the study area. This hydrostratigraphic model represents the framework for the predictive groundwater flow and contaminant transport modeling conducted as part of the Groundwater FS.

The results of hydrostratigraphic investigations are presented in Section 3.0 and include various structural contour and isopach (thickness) maps of selected HSUs and a series of 10 stratigraphic cross sections. The cross sections illustrate the vertical arrangement, lateral continuity and relative thicknesses of the various identified HSUs and also illustrate the position of control points, such as borings, monitoring wells and CPT locations. The results of selected physical and geophysical tests are also posted on the cross sections.

Geologic logs for each exploratory boring are presented in Appendix B, geophysical logs are presented in Appendix D, CPT profiles are presented in Appendix E, and results of physical testing are presented in Appendix F of this report.

2.2.2 Groundwater Investigations

Groundwater investigations were conducted to evaluate groundwater occurrence and flow conditions, as well as to evaluate the nature and distribution of dissolved and separate phase groundwater contaminants across the study area. The specific objectives of the groundwater investigations were to: (1) evaluate the spatial and temporal variations in groundwater flow conditions throughout the study area, including horizontal and vertical components of flow; (2) define the lateral and vertical extent of dissolved contaminants apparently emanating from the Del Amo plant site within the target water-bearing zones; (3) evaluate the potential occurrence

of NAPL and, if present, document changes in the amount of NAPL accumulated over time in monitoring points; (4) assess the spatial and temporal variation of groundwater chemistry and dissolved contaminant chemistry within the target water-bearing zones; (5) identify potential groundwater contaminant source areas; (6) assess the physical/hydraulic properties of the target water-bearing zones; (7) compile existing physical and chemical data for nearby sites in order to define regional groundwater conditions to the extent necessary to support the groundwater flow and contaminant transport modeling effort conducted as part of the Groundwater FS; and, (8) provide sufficient physical and chemical data to meet the needs of the Groundwater FS.

Groundwater investigations evolved from initial screening-level sampling and analysis to more focused time-series data collection and groundwater characterization. Groundwater data obtained from temporary screening points were used to evaluate the need for, nature and location of additional data to be collected. Detailed time-series groundwater data were collected from a network of monitoring wells completed in the targeted water-bearing zones, including the water table zone (UBF and/or MBFB), the MBFB, the MBFC, and the Gage aquifer. Groundwater samples collected and analyzed from these permanent monitoring points provided sufficient information to define the nature, lateral and vertical distribution and time-series behavior of dissolved contaminants across the study area within each water-bearing zone and to identify potential groundwater contamination source areas.

Aquifer testing was conducted in selected locations in the UBF, MBFB, MBFC and Gage to assess the intrinsic hydraulic properties of these units. Aquifer test locations were selected to provide good spatial distribution of control points in areas of contaminant plumes for the HSUs evaluated. Existing data regarding groundwater conditions, aquifer properties and contaminant distribution for surrounding sites unrelated to the Del Amo study area were integrated into this analysis as available and appropriate.

Groundwater sampling locations are shown in Figures 2.2-4 and 2.2-5 which illustrate the type, identity and completion zone of each sampling point. Information regarding all monitoring points utilized during this investigation is presented in Appendix C, including information regarding the location and construction details for monitoring points completed as part of this study and as part of previous investigations. The following sections describe the nature, location and availability of groundwater data collected. The findings of groundwater investigations conducted as part of this Groundwater RI are presented in Section 4.0 and Section 5.0 of this report.

2.2.2.1 Groundwater Screening

Site-specific groundwater conditions were initially evaluated using a variety of groundwater screening tools. Screening-level groundwater investigations were conducted using temporary monitoring points, installed using either drilling or direct-push techniques. These sampling techniques allowed one-time measurement of water levels and collection of representative groundwater samples for chemical analysis.

Available information regarding regional and local groundwater flow conditions was evaluated in conjunction with site history information to assist in identifying the most appropriate placement of groundwater screening locations. Temporary monitoring points were then completed in positions directly downgradient of former plant site facilities/features identified during the Phase I site history investigation as having stored of handled large quantities of volatile chemicals. Examples of such former facilities targeted for groundwater screening included above- and underground chemical storage tanks and tank batteries, chemical process areas, impoundments and basins, sumps and clarifiers and wastewater treatment and disposal areas. The former facilities/features of interest were identified during the site history review conducted as part of Phase I investigations and appear highlighted in color on Plate 1-2. Groundwater screening in these areas was conducted to evaluate the potential presence of chemicals in groundwater known or suspected to be associated with these former facilities/features. Screening investigations were limited to the water table zone (UBF and/or MBFB), where chemicals released to the surface or subsurface would first encounter groundwater. A total of 123 groundwater screening sample analyses were conducted from a total of 48 discrete locations across the study area (Figure 2.2-4). A summary of the number and type of analytical tests conducted for groundwater screening locations is presented in Table 2.2-4.

The distribution of groundwater screening points within the study area was sufficient to evaluate general water table zone flow direction and distinguish areas of groundwater contamination from those areas relatively free of groundwater contamination. The nature, scope and location of further groundwater investigations were developed largely upon the findings of these initial groundwater screening investigations. Those portions of the study area found to contain groundwater contamination were identified for additional, more focused groundwater characterization investigations, whereas those areas found to be relatively free of contamination were largely eliminated from further consideration. Detected chemical concentrations in screening points were compared to federal maximum contaminant levels (MCLs) to assist in evaluating the need for further groundwater work at any given location. Based upon the findings

of the groundwater screening effort, permanent monitoring wells were completed in those areas requiring further characterization, as discussed below.

2.2.2.2 Groundwater Characterization

The results of groundwater screening investigations were used to identify prevalent chemical constituents, evaluate groundwater levels and general flow direction and define the overall lateral distribution of dissolved contaminants within the water table zone. Using these findings as a guide, numerous permanent monitoring wells were then completed within those portions of the study area requiring additional study. Further groundwater characterization work was prioritized to concentrate first upon the water table zone in areas where screening work indicated the presence of dissolved contaminants. Water table zone monitoring wells were installed in selected locations to assist in locating contaminant maxima and to define the limits of the dissolved contaminant plumes based upon MCLs for the various chemical constituents detected. Groundwater investigations extended into progressively deeper HSUs as additional data were developed, with the presence of a chemical constituent in exceedance of an MCL triggering investigation of groundwater conditions in the underlying HSU. The lateral and vertical limits of all dissolved constituents within the target water-bearing zones have been defined using this iterative approach to groundwater characterization.

Monitoring Wells

A total of 84 monitoring wells were installed in the various HSUs as part of this investigation. The great majority of monitoring wells within the study area were installed using mud rotary drilling techniques, although some water table zone wells were completed using hollow-stem auger drilling equipment. Numerous existing wells previously installed by others were also used to assist in characterization of groundwater conditions throughout the study area. The number of monitoring wells utilized for either groundwater level measurements and/or groundwater sample collection and analysis is summarized below by HSU.

HYDROSTRATIGRAPHIC UNIT	NUMBER OF WELLS		
	CURRENT INVESTIGATION	PREVIOUS INVESTIGATIONS	TOTAL WELLS UTILIZED
Water Table Zone	51	42	93
Middle Bellflower B sand	13	3	16
Middle Bellflower C sand	13	33	46
Gage Aquifer	7	22	29
Lynwood Aquifer	0	7	7

Monitoring well installations include examples of single wells and well clusters. Monitoring well clusters may consist of up to four closely-spaced wells, each individually constructed in a separate borehole and completed in a discrete HSU. For discussion purposes, the term well cluster is applied to a group of wells located within a radius of approximately 100-feet of each other and completed in different HSUs. All individual wells included in a given well cluster are identified in the tables presented in Appendix C.

While single well completions are useful in defining the lateral distribution of chemical constituents and groundwater levels in any given HSU, well clusters provide important information regarding vertical contaminant distribution and vertical gradients between different HSUs. Generally, all permanent monitoring points were completed in a sequential manner, beginning with water table zone installations and proceeding to progressively deeper HSUs, as necessary to define the vertical extent of dissolved contaminants in that location.

Whenever possible, drilling through a known contaminated interval into an underlying unit was avoided. When this became necessary, steel conductor casings were used to isolate the contaminated zone(s) during drilling and well installation activities. In some locations where sufficient chemical data were not available, *in situ* grab groundwater samples were collected ahead of the drill bit using a Hydropunch® sampler, or equivalent, and submitted for rush chemical analysis prior to well construction. Analytical results for these samples were then used to evaluate the need for, and completion details of, conductor casing installations.

Schematic monitoring well completion diagrams and construction details, including conductor casing information, are presented in Appendix C. All monitoring wells installed or otherwise used during to characterize groundwater conditions within the study area are illustrated in Figure

2.2-5. All monitoring wells completed as part of this study were installed in accordance with the methods and procedures described in the RI/FS Work Plan and the Interim Plan (Dames & Moore, 1993a and Shell, 1995b, respectively).

Water Level Measurement

Groundwater levels were measured on an approximately quarterly basis in up to 164 monitoring wells distributed throughout the study area, including up to 87 in the water table zone (UBF and/or MBFB), 16 in the MBFB, 43 in the MBFC, 27 in the Gage aquifer, and 7 in the Lynwood aquifer. Measurements of groundwater water levels were recorded to the nearest 0.01-inch using an electronic well sounder on a total of seven individual events between early 1994 and the end of 1995. Logistical considerations and access conditions sometimes resulted in a different number of wells being included in any given monitoring event.

Groundwater level measurements were used to prepare contour maps of groundwater levels for the water table zone, the MBFB, the MBFC, the Gage aquifer and the Lynwood aquifer. These water level contour maps were used to evaluate groundwater flow directions, gradients and flow velocities for each unit. The collection of time-series groundwater level measurements allowed assessment of possible changes in groundwater flow conditions through time. Groundwater level measurements at well clusters were used to evaluate vertical gradients between adjacent water-bearing zones, including between the water table zone and the MBFB, between the MBFB and the MBFC, between the MBFC and the Gage aquifer, and between the Gage aquifer and the underlying Lynwood aquifer.

As discussed further in Section 4.0, groundwater level measurements collected over the past two years for all HSUs are consistent with historical hydrographs from the area indicating that groundwater levels have been rising at a relatively constant rate for the last several decades. Natural fluctuations in barometric pressure may cause measurable changes in groundwater levels for confined or semi-confined water-bearing units. To quantify the actual effects barometric pressure fluctuation may have upon the groundwater system, pressure transducers were used to collect continuous records of atmospheric pressure variations synchronously with continuous collocated groundwater level measurements. Atmospheric pressure fluctuations were determined to cause groundwater level variation on the order of +/- 0.01 to 0.20 foot. This diurnal fluctuation is considered insignificant when compared to the range of groundwater level variation recorded across the study area during any given monitoring event. While such variation may be insignificant with respect to the determination of gradients, flow directions and velocities across such a large area, an understanding of these small variations is important to consider

when interpreting aquifer test results. A complete discussion of groundwater conditions, including site-specific time-series water level behavior, influences of barometric pressure variations and historical groundwater level trends, is presented in Section 4.0.

Groundwater level measurements were conducted in accordance with the methods and procedures described Appendix B of the RI/FS Work Plan (Dames & Moore, 1993a).

Evaluation of LNAPL Accumulation

The presence of LNAPL on the former Del Amo plant site was first reported in 1990 by investigators evaluating the lateral extent of contamination emanating from the nearby Montrose Plant Property (Hargis + Assoc., 1990a and 1990c). During the installation and development of monitoring well MW-20, in the western portion of the former styrene plant, a nearly pure benzene LNAPL was detected in the well. Since this initial discovery, additional monitoring wells have been installed in the MW-20 area by the Del Amo Respondents to further evaluate the lateral and vertical extent of LNAPL in this area. Investigations in this area were undertaken in accordance with the current AOC, which required focused studies to be conduced in the MW-20 area to evaluate the nature and distribution of NAPL and to assess the feasibility of NAPL recovery. In addition to well MW-20, benzene LNAPL has also accumulated in two of these recently-installed wells, including wells SWL0001 and well SWL0032. LNAPL has been consistently detected in each these three wells since their installation.

Weekly measurements of LNAPL thickness have bene made in each of these wells using an oil-water interface probe. These data have been used to evaluate LNAPL accumulation rates in the MW-20 area under existing, natural groundwater conditions. Further investigations are currently underway in the MW-20 area to evaluate the efficacy of hydraulic extraction as a remedial measure for this LNAPL, as described in the MW-20 Hydraulic Extraction Work Plan (Dames & Moore, 1995d).

Based upon available information, several other locations outside the former plant site but within the study area are either known or suspected to have NAPL present. A refined petroleum hydrocarbon product has been observed in monitoring well P-1, located in the residential area south of the former plant site, and in well XMW-7, adjacent to the Jones Chemical Co. property located west of the former plant site (Dames & Moore, 1992b, and, Hargis + Assoc., 1992, respectively) (Figure 1.2-2). Additionally, the presence of NAPL is suspected in a least five other locations within the former plant site at certain identified groundwater contamination source areas based upon reported chemical concentrations of some dissolved constituents. A

complete discussion of NAPL occurrence and behavior at the plant site is presented in Section 5.0, and the site-specific conceptual model for NAPL release, migration and mobility is presented in Section 6.0.

Sampling and Analysis of Monitoring Points

Initial groundwater samples collected from selected screening locations and permanent monitoring points were subjected to broad spectrum chemical analyses. Broad spectrum testing was conducted to evaluate the identity and gross distribution of chemicals present beneath the study area and to identify those chemicals which are most prevalent. Broad spectrum chemical analyses included tests for VOCs, semi-volatile organic compounds (SVOCs), metals, cyanide, and pesticides and polychlorinated biphenyls (PCBs). Locations for broad spectrum testing were selected to provide good geographic coverage for each target water-bearing zone, including the water table zone, the MBFB, the MBFC, and the Gage aquifer. Based upon the findings from the Phase I groundwater investigations, it was determined that aromatic VOCs, principally benzene, and to a lesser extent chlorinated VOCs, constituted the most widespread, frequently detected and characteristic chemicals present within the study area. The results of Phase I groundwater sampling and analyses are presented in the Phase I RI Report (Dames & Moore, 1993d).

The additional monitoring wells and groundwater chemical analyses completed during Phase II groundwater investigations expanded upon the available Phase I information by providing more focused groundwater data within those portions of the study area requiring more study. The chemical testing program for Phase II wells was developed with an understanding of the identity and general distribution of principal chemical constituents gained from earlier Phase I work, and was focused primarily upon further delineating the nature and lateral and, particularly, the vertical extent of VOC contamination within the various target water-bearing zones. Table 2.2-5 summarizes the type and number of chemical tests performed for each reoccupiable groundwater monitoring location sampled as part of this Groundwater RI. Groundwater sampling procedures are presented in Appendix J. The type and number of analyses conducted at groundwater screening locations was presented earlier in Table 2.2-4.

2.2.2.3 Groundwater Monitoring Program

Following completion of Phase I investigations, a Groundwater Monitoring Program was developed and implemented at the study area (Dames & Moore, 1994a). The overall goal of the monitoring program is to establish time-series data on groundwater conditions within the

study area, and includes collection of groundwater chemical data, the measurement of groundwater elevations, an assessment of potential NAPL presence and, where present, measurement of NAPL thickness. These data are necessary to evaluate temporal and spatial variations in groundwater contaminant distribution over time, assist in verifying the results of predictive groundwater flow and transport modeling, and to provide data necessary for completion of the Groundwater FS.

The nature and scope of the monitoring program was developed based upon the findings of the Phase I RI and other investigations previously completed within the study area. In addition to the standard field-measured parameters, chemical analyses conducted as part of the monitoring program include VOCs, SVOCs, metals, p-CBSA, general mineral and physical parameters, and selected biodegradability indicators, including benzene/toluene/ethylbenzene/xylenes (BTEX) degraders, dissolved oxygen (DO), methane, TOC, ammonium nitrogen, nitrate nitrogen, orthophosphate, and total plate counts.

Upon completion of Phase II monitoring wells, as described in the Interim Plan (Shell, 1995b), the scope of the groundwater monitoring program was expanded to incorporate these new wells as they were completed. Table 2.2-6 summarizes the chemical testing program for all wells included in the groundwater monitoring program as of the third sampling event 1995, the last groundwater sampling event included in this Groundwater RI report (Dames & Moore, 1996a). The findings of groundwater sampling and analyses are presented in the periodic groundwater monitoring program reports (Dames & Moore, 1994c, 1994e, 1995a, 1995c, 1995e, 1995f, 1995g, and 1996a).

After approximately two years of groundwater monitoring had been completed, the Respondents proposed modifications to the scope of the monitoring program (Shell, 1996b). Following receipt of EPA comments on these proposed modifications (EPA, 1996b), agreement was reached on the scope of subsequent groundwater monitoring events (Shell, 1996c; EPA, 1996c). Periodic groundwater monitoring continues to date, as modified. These changes went into effect with the second sampling event for 1996, and are therefore not reflected in the data presented in this report.

2.2.2.4 Aquifer Testing Program

Aquifer testing was performed to obtain estimates of transmissivity and hydraulic conductivity in the UBF, MBFB, MBFC, and Gage aquifer. These estimates were obtained by analyzing recovery data from constant discharge pumping tests conducted at 19 wells and a slug test in one

well. In addition, three tests were conducted to obtain estimates of vertical hydraulic conductivity of aquitards using the ratio method (Neuman and Witherspoon, 1972 and CDWR, 1971). One ratio method test was conducted to provide vertical hydraulic conductivity estimates for the UBF and two ratio method tests were conducted to provide vertical hydraulic conductivity estimates for the LBF.

Aquifer testing locations were selected to develop representative ranges of transmissivity and hydraulic conductivity values and provide spatial distribution of hydraulic properties in areas of contaminant plumes for the UBF, MBFB, and MBFC. Aquifer testing was conducted in areas near or overlain by contaminants to provide geographic distribution of control points for the groundwater flow and contaminant transport model. Tables 2.2-7 and 2.2-8 list the wells in which aquifer testing was performed, and the location of all aquifer tests considered in this report are illustrated in Figures 2.2-6 and 2.2-7.

Twelve-hour (nominal) constant discharge pumping tests were conducted in 11 UBF monitoring wells, six MBFB monitoring wells, one MBFC well and one Gage aquifer monitoring well. Ranges for transmissivity and hydraulic conductivity for the Gage aquifer, previously obtained by Hargis + Associates for the Montrose Plant Property, were supplemented with limited testing conducted during this investigation. The one slug test performed was to provide data from a very low-yield UBF well that would not have supported a 12-hour pumping test. A total of three ratio method tests were conducted in two separate locations where appropriately constructed co-located wells allowed the evaluation of aquitard properties by pumping in underlying and overlying aquifer units. Hydraulic conductivity values derived using transmissivity values obtained from analyses of aquifer testing data, including ratio method tests, were used primarily as input to the predictive groundwater flow and contaminant transport model. The results of this modeling effort will be presented in the Groundwater FS report.

The findings of the aquifer testing program are presented in Section 4.2 of this report. Aquifer testing data analysis methods are described in Appendix H1; schematics of each well tested, showing the aquifer thickness used to calculate hydraulic conductivity, are presented in Appendix H2; Theis recovery analysis plots are presented in Appendix H3; and raw field data collected during recovery tests are presented in Appendix H4. Aquifer testing was performed in accordance with the methods and procedures described in a technical memorandum submitted to EPA (Shell, 1996a), and took into consideration the recommendations and requests provided by EPA in their February 5, 1996 letter to Shell Oil Company (EPA, 1996a).

Table 2.2-1
Hydrostratigraphic Data Availability
Groundwater Remedial Investigation Report
Del Amo Study Area

Location ID	Type [a]	Total Depth [b]	HSU [c]	Hydrostratigraphic Data Availability				
				Database Boring Log (Depth)	Color Photo	Geophysical Log	Soil Physical Testing	Related Wells [d]
SBL0001	HSA	26	UBF	0 - 26			x	
SBL0002	HSA	32	UBF	0 - 32			x	
SBL0003	HSA	41	UBF	0 - 41			x	
SBL0004	HSA	17	UBF	0 - 17			x	
SBL0005	HSA	17	UBF	0 - 17			x	
SBL0006	HSA	14	UBF	0 - 14				
SBL0007	HSA	14	UBF	0 - 14				
SBL0008	HSA	8	UBF	0 - 8				
SBL0009	HSA	89	MBFM	19.5 - 89				
SBL0010	HSA	91	MBFM	55 - 91				
SBL0011	HSA	90	MBFC	61.7 - 90			x	
SBL0012	MRB	154	LBF	9 - 154	x	x	x	
SBL0013	MRB	181	LBF	0 - 181	x	x	x	SWL0017
SBL0014	MRB	150	LBF	0 - 150	x	x	x	
SBL0015	MRB	180	LBF	0 - 180	x	x	x	
SBL0016	MRB	150	LBF	0 - 150	x	x	x	
SBL0017	HSA	82	MBFM	0 - 82				
SBL0018 [e]								
SBL0019	MRB	174	LBF	0 - 174	x	x	x	PZL0007
SBL0020	MRB	150	LBF	0 - 150	x	x	x	
SBL0021	MRB	242	GLA	0 - 242	x	x	x	
SBL0022	MRB	234	GAGE	0 - 234	x	x	x	
SBL0023	MRB	155	LBF	0 - 155	x	x	x	
SBL0024	MRB	155	LBF	0 - 155	x	x	x	
SBL0025	MRB	165	LBF	0.4 - 165	x	x	x	PZL0005
SBL0026	MRB	164	LBF	0 - 164	x	x	x	
SBL0027	MRB	250	GLA	0 - 250	x	x	x	PZL0003
SBL0028	MRB	165	LBF	0 - 165	x	x	x	SWL23,24
SBL0029	MRB	160	LBF	0.2 - 160	x	x	x	
SBL0030	MRB	170	GAGE	0 - 170	x	x	x	SWL0007
SBL0031	MRB	165	LBF	0 - 165	x	x	x	
SBL0032	MRB	176	GAGE	0 - 176	x	x	x	
SBL0033	MRB	268	GLA	0 - 268	x	x	x	
SBL0034	MRB	187	LBF	0 - 187	x	x	x	
SBL0035	MRB	165	LBF	0 - 165	x	x	x	
SBL0036	HSA	40	UBF	0 - 40				
SBL0037	HSA	25	UBF	0.2 - 25				
SBL0038	HSA	25	UBF	0 - 25			x	
SBL0039 [f]								
SBL0040	HSA	20	UBF	0 - 20				
SBL0041	HSA	20	UBF	0 - 20				

Table 2.2-1
Hydrostratigraphic Data Availability
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Location ID	Type [a]	Total Depth [b]	HSU [c]	Hydrostratigraphic Data Availability				
				Database Boring Log (Depth)	Color Photo	Geophysical Log	Soil Physical Testing	Related Wells [d]
SBL0042	HSA	20	UBF	0 - 20				
SBL0043	HSA	20	UBF	0.1 - 20				
SBL0044	HSA	20	UBF	0.1 - 20				
SBL0045	HSA	20	UBF	0.1 - 20				
SBL0046	HSA	20	UBF	0 - 20				
SBL0047	HSA	20	UBF	0.1 - 20				
SBL0048	HSA	20	UBF	0.1 - 20				
SBL0049	HSA	93	MBFM	0.1 - 93				
SBL0050	HSA	78	MBFB	0 - 78				
SBL0051 [g]	MRB	190	GAGE	0 - 166		x		SWL9,10,25
SBL0052	MRB	195	GAGE	0 - 170		x	x	SWL11,13,22
SBL0053	MRB	200	GAGE	0 - 200	x	x	x	SWL14,43
SBL0054	MRB	207	GAGE	0.1 - 207	x	x	x	SWL15,19,20
SBL0055	HSA	56	UBF	0 - 56			x	SWL0008
SBL0056	HSA	53	UBF	0 - 53			x	
SBL0057	HSA	64	UBF	0 - 64			x	
SBL0058	HSA	59	UBF	0 - 59			x	
SBL0059	MRB	200	GAGE	0 - 200	x	x	x	SWL0018
SBL0060	HSA	58	UBF	0 - 58			x	
SBL0061	HSA	59	UBF	0 - 59			x	
SBL0062	HSA	60	UBF	0 - 60				
SBL0063	HSA	57	UBF	0 - 57			x	
SBL0064	HSA	60	UBF	0 - 60				
SBL0065	HSA	65	UBF	0 - 65			x	
SBL0066	HSA	25	UBF	0 - 25			x	
SBL0067	HSA	25	UBF	0 - 25			x	
SBL0068	HSA	62	UBF	0 - 62	x		x	
SBL0069	HSA	64	UBF	0.5 - 64	x		x	
SBL0070	HSA	82	MBFM	0 - 82	x		x	
SBL0071	HSA	84	MBFM	0 - 84	x		x	
SBL0072	HSA	43	UBF	0 - 43				
SBL0073	HSA	63	UBF	0 - 63	x		x	
SBL0074	HSA	26	UBF	0 - 26				
SBL0075	HSA	67	UBF	0 - 67				
SBL0076	HSA	55	UBF	0 - 55				
SBL0077	MRB	230	GLA	0 - 230	x	x	x	SWL26,27,28
SBL0078	MRB	235	GLA	0 - 235	x	x	x	SWL29,30,31
SBL0079	MRB	94	MBFC	0 - 94		x		SWL0032
SBL0080	MRB	225	GLA	0 - 225	x	x	x	SWL33,34
SBL0081	MRB	240	GLA	0 - 240	x	x	x	SWL16,35,36,37

Table 2.2-1
Hydrostratigraphic Data Availability
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Location ID	Type [a]	Total Depth [b]	HSU [c]	Hydrostratigraphic Data Availability				
				Database Boring Log (Depth)	Color Photo	Geophysical Log	Soil Physical Testing	Related Wells [d]
SBL0082	MRB	75	UBF	0 - 75				SWL0038
SBL0083	MRB	70	UBF	0.4 - 70				SWL0039
SBL0084	MRB	153	LBF	0 - 153				SWL40,41
SBL0085	MRB	90	MBFC	0 - 90			x	
SBL0086	MRB	90	MBFC	0 - 90			x	
SBL0087	MRB	90	MBFC	0 - 90			x	
SBL0088	MRB	90	MBFC	0 - 90			x	
SBL0089	MRB	90	MBFC	0 - 90			x	
SBL0090	MRB	90	MBFC	0 - 90			x	
SBL0091	MRB	90	MBFC	0 - 90			x	
SBL0092	MRB	90	MBFC	0 - 90			x	
SBL0093	MRB	90	MBFC	0 - 90			x	
SBL0094	MRB	90	MBFC	0 - 90			x	
SBL0095	MRB	61	UBF	0 - 61				SWL0042
SBL0096	HSA	46	UBF	0 - 46	x			
SBL0097	MRB	154	LBF	0 - 154	x	x		SWL0047
SBL0098	HSA	56	UBF	0 - 56	x			SWL0045
SBL0099	MRB	154	LBF	0 - 154	x	x		SWL0054
SBL0100	HSA	59	UBF	0 - 59	x			SWL0046
SBL0101	MRB	157	LBF	0 - 157	x	x	x	SWL0048
SBL0102	MRB	68	UBF	0.5 - 68	x			
SBL0103	MRB	154	LBF	0 - 154	x	x	x	SWL50,55
SBL0104	MRB	132	LBF	0 - 132	x	x	x	SWL0049
SBL0105	MRB	55	UBF	0 - 55	x		x	SWL0051
SBL0106	MRB	153	LBF	0 - 153	x	x	x	SWL52,53
SBL0107	MRB	74	UBF	0 - 74	x			SWL56,57
SBL0108	MRB	152	LBF	0.5 - 152	x	x	x	SWL0058
SBL0109 [h]	MRB	64	UBF					
PZL0003	HSA	73	UBF	50 - 60.5				
PZL0006	HSA	70	UBF	45 - 70				
PZL0009	HSA	69	UBF	42 - 69				
PZL0010	HSA	71	UBF	42 - 71				
PZL0011	HSA	56	UBF	30 - 56				
PZL0012	HSA	58	UBF	30 - 58				
PZL0013	HSA	62	UBF	34.5 - 62				
PZL0014	HSA	66	UBF	40 - 66				
PZL0015	HSA	72	UBF	0.1 - 72				
PZL0016	HSA	68	UBF	0.7 - 68				
PZL0017	HSA	70	UBF	35 - 70				
PZL0018	HSA	68	UBF	33 - 68				

Table 2.2-1
Hydrostratigraphic Data Availability
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Location ID	Type [a]	Total Depth [b]	HSU [c]	Hydrostratigraphic Data Availability				
				Database Boring Log (Depth)	Color Photo	Geophysical Log	Soil Physical Testing	Related Wells [d]
PZL0019	HSA	67	UBF	43 - 67				
PZL0020	HSA	68	UBF	38 - 68				
PZL0021	HSA	74	UBF	0.3 - 74				
PZL0022	HSA	62	UBF	0 - 62				
PZL0023	HSA	67	UBF	0 - 67				
PZL0024	HSA	65	UBF	0 - 65			x	
PZL0025	HSA	64	UBF	0 - 64			x	
PZL0026	HSA	54	UBF	0.5 - 54				
SWL0001	HSA	80	UBF	0 - 80			x	
SWL0002	HSA	79	UBF	0 - 79			x	
SWL0003	HSA	79	UBF	0 - 79				
SWL0004	HSA	80	UBF	0 - 80				
SWL0005	HSA	63	UBF	0 - 63			x	
SWL0006	HSA	61	UBF	0 - 61			x	
SWL0021	MRB	63	UBF	0.9 - 63				
VWL0001 [i]	HSA	55	UBF	0 - 55			x	
VWL0002 [i]	HSA	56	UBF	0 - 56			x	
VWL0003 [i]	HSA	42	UBF	0 - 42			x	
VWL0004 [i]	HSA	58	UBF	0 - 58			x	
VWL0005 [i]	HSA	42	UBF	0 - 42			x	
VWL0006 [i]	HSA	42	UBF	0 - 42			x	
VWL0007 [i]	HSA	42	UBF	0 - 42			x	
VWL0008 [i]	HSA	42	UBF	0 - 42			x	
VWL0009 [i]	HSA	41	UBF	0 - 41			x	
VWL0010 [i]	HSA	42	UBF	0 - 42			x	
WPL0001	HSA	65	UBF	0.5 - 65				
WPL0002 [j]	HSA	70	UBF					

NOTES:
[a] Type of exploration: MRB = Mud Rotary Boring; HSA = Hollow Stem Auger boring.
[b] Total depth of boring rounded to nearest foot.
[c] Deepest Hydrostratigraphic Unit reached: UBF = upper Bellflower aquitard; MBFB = middle Bellflower B-sand; MBFC = middle Bellflower C-sand; LBF = lower Bellflower aquitard; GAGE = Gage aquifer; LYN = Lynwood aquifer.
[d] Additional locations to which the lithologic conditions apply.
[e] SBL0018 was terminated due to shallow obstruction/refusal. The location ID was not used.
[f] All information for SBL0039 is stored as SWL0005, the co-located well. The location ID SBL0039 is not used.
[g] Boring SBL0051 was not logged from 36-58 feet and from 106-128 feet.
[h] Refer to SBL0108 for lithologic conditions.
[i] Boring logs presented in Dames & Moore 1993c.
[j] Refer to CWL0043 (CPT log) for lithologic conditions.

Table 2.2-2
Geophysical Data Availability
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Location ID	HSU [a]	Geophysical Data Availability							
		Gamma Log	SP[b] Log	16/64" Normal Resistivity	Point Resistivity	Guard Resistivity	Caliper Log	Acoustic Log	CPT Log[c]
SBL0012	LBF	x	x	x	x	x	x		
SBL0013	LBF	x	x	x	x	x	x		
SBL0014	LBF	x	x	x	x	x	x		
SBL0015	LBF	x	x	x	x	x	x		
SBL0016	LBF	x	x	x	x	x	x		
SBL0019	LBF	x	x	x	x	x	x		
SBL0020	LBF	x	x	x	x		x		
SBL0021	GLA	x	x	x	x	x	x		
SBL0022	GAGE	x	x	x	x	x	x		
SBL0023	LBF	x	x	x	x	x	x		
SBL0024	LBF	x	x	x	x	x	x		
SBL0025	LBF	x	x	x	x	x	x		
SBL0026	LBF	x	x	x	x				
SBL0027	GLA	x	x	x	x	x	x	x	
SBL0028	LBF	x	x	x	x	x	x		
SBL0029	LBF	x	x	x	x	x	x		
SBL0030	GAGE	x	x	x	x	x	x		
SBL0031	LBF	x	x	x	x	x	x	x	
SBL0032	GAGE	x	x	x	x	x	x		
SBL0033	GLA	x	x	x	x	x	x	x	
SBL0034	LBF	x	x	x	x	x	x		
SBL0035	LBF	x	x	x	x	x	x	x	
SBL0051	GAGE	x	x	x	x	x	x	x	
SBL0052	GAGE	x	x	x	x	x	x	x	
SBL0053	GAGE	x	x	x	x	x	x	x	
SBL0054	GAGE	x	x	x	x	x	x	x	
SBL0059	GAGE	x	x	x	x	x	x		
SBL0077	GLA	x	x	x	x	x	x		
SBL0078	GLA	x	x	x		x			
SBL0079	MBFC	x	x	x	x	x	x		
SBL0080	GLA	x	x	x	x	x	x		
SBL0081	GLA	x	x	x	x	x	x		
SBL0097	LBF	x	x	x	x				
SBL0099	LBF	x	x	x	x				
SBL0101	LBF	x	x	x	x				
SBL0103	LBF	x	x	x	x				
SBL0104	LBF	x	x	x	x				
SBL0106	LBF	x	x	x	x				

Table 2.2-2
Geophysical Data Availability
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Location ID	HSU [a]	Geophysical Data Availability							
		Gamma Log	SP[b] Log	16/64" Normal Resistivity	Point Resistivity	Guard Resistivity	Caliper Log	Acoustic Log	CPT Log[c]
SBL0108	LBF	x	x	x	x				
CPL0001	UBF								x
CPL0002	UBF								x
CPL0003	UBF								x
CPL0004	UBF								x
CPL0005	MBFB								x
CPL0006	MBFC								x
CPL0007	MBFB								x
CPL0008	LBF								x
CPL0009	MBFB								x
CPL0010	MBFB								x
CPL0011	MBFC								x
CPL0012 [d]	MBFC								x
CPL0021	MBFC								x
CPL0022	MBFC								x
CPL0023	MBFC								x
CPL0024	MBFC								x
CPL0025	MBFC								x
CPL0026	MBFC								x
CPL0027	MBFC								x
CPL0028	MBFC								x
CPL0029	MBFC								x
CPL0030	MBFC								x
CPL0031	MBFC								x
CPL0032	MBFC								x
CPL0033	MBFC								x
CPL0034	MBFC								x
CPL0035	MBFC								x
CPL0036	MBFC								x
CPL0037	MBFC								x
CPL0038	UBF								x
CPL0039	MBFC								x
CPL0040	MBFC								x
CPL0041	UBF								x
CPL0042	MBFC								x
CPL0043	MBFC								x
CPL0044	MBFC								x

Table 2.2-2
Geophysical Data Availability
Groundwater Remedial Investigation Report
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Location ID	HSU [a]	Geophysical Data Availability							
		Gamma Log	SP[b] Log	16/64" Normal Resistivity	Point Resistivity	Guard Resistivity	Caliper Log	Acoustic Log	CPT Log[c]
CPL0045	MBFC								x
CPL0046	MBFC								x
CPL0047	MBFC								x
CPL0048	MBFC								x
CPL0049	MBFM								x
CPL0050	MBFC								x
CPL0051	MBFM								x
CPT-1	MBFB								x
CPT-2	UBF								x
CPT-3	MBFB								x
CPT-4	MBFB								x
CPT-5	MBFB								x
CPT-6	MBFB								x
CPT-7	MBFB								x
CPT-8	MBFB								x
CPT-9	MBFB								x
CPT-10	MBFB								x
CPT-11	MBFB								x
CPT-12	UBF								x
CPT-13	MBFB								x
CPT-14	MBFB								x
CPT-15	UBF								x
CPT-16	MBFB								x
CPT-17	MBFB								x
CPT-18	MBFB								x
CWL0012 [e]	UBF								x
CWL0013	UBF								x
CWL0014	UBF								x
CWL0015	UBF								x
CWL0016	UBF								x
CWL0017	UBF								x
CWL0018	UBF								x
CWL0019	UBF								x
CWL0020	UBF								x
CWL0021	UBF								x
CWL0022	UBF								x
CWL0023	UBF								x

Table 2.2-2
Geophysical Data Availability
Groundwater Remedial Investigation Report
Del Amo Study Area

Location ID	HSU [a]	Geophysical Data Availability							
		Gamma Log	SP[b] Log	16/64" Normal Resistivity	Point Resistivity	Guard Resistivity	Caliper Log	Acoustic Log	CPT Log[c]
CWL0024	UBF								x
CWL0025	UBF								x
CWL0026	UBF								x
CWL0027	UBF								x
CWL0028	UBF								x
CWL0029	UBF								x
CWL0030	UBF								x
CWL0031	UBF								x
CWL0032	UBF								x
CWL0033	UBF								x
CWL0034	UBF								x
CWL0035	UBF								x
CWL0036	UBF								x
CWL0037	UBF								x
CWL0038	UBF								x
CWL0039	UBF								x
CWL0040	UBF								x
CWL0041	UBF								x
CWL0042	UBF								x
CWL0043	UBF								x
CWL0044	UBF								x
CWL0045	UBF								x
CWL0046	UBF								x
CWL0047	UBF								x
CWL0048	UBF								x

[a] Deepest Hydrostratigraphic Unit reached: UBF = upper Bellflower aquitard; MBFB = middle Bellflower B-sand; MBFC = middle Bellflower C-sand; LBF = lower Bellflower aquitard; GAGE = Gage aquifer; LYN = Lynwood aquifer.

[b] Spontaneous potential.

[c] CPT logs presented in Appendix E may have an alphabetic suffix after Location ID (e.g., CWL0019C), indicating multiple penetrations were performed at that location during attempts to reach the target depth. Copies of CPT logs presented in Appendix E include only the single highest quality and/or deepest penetrating profile of possible multiple attempts at a given location.

[d] Location IDs CPL0013 through CPL0020 were not used.

[e] Locations CWL0001 through CWL0011 were for NAPL screening purposes only. No CPT logs recorded.

Table 2.2-3
Soil Properties Data Availability
Groundwater Remedial Investigation Report
Del Amo Study Area

Location ID	Sample Depth	HSU	Soil Properties Data Availability								
			Horizontal and Vertical Air Permeability	Horizontal and Vertical Hydraulic Conductivity	Bulk Density	Moisture Content	Grain Size Distribution	Atterberg Limits	Total and Effective Porosity	Total Organic Carbon	Consolidation Test
PZL0024	33.5	UBF								x	
PZL0024	38	UBF								x	
PZL0025	44	UBF								x	
SBL0001	15.8	UBF	x	x					x		
SBL0001	20.3	UBF	x	x					x		
SBL0002	21	UBF	x	x					x		
SBL0002	26	UBF	x	x					x		
SBL0002	26.3	UBF	x	x					x		
SBL0003	26	UBF	x								
SBL0003	26.3	UBF	x								
SBL0003	30.8	UBF	x								
SBL0003	31	UBF	x								
SBL0004	10.5	UBF	x								
SBL0005	3.3	UBF	x								
SBL0005	3.5	UBF	x								
SBL0011	62.5	UBF					x				
SBL0011	69.5	UBF	x	x	x		x		x		
SBL0012	30	UBF	x	x	x	x	x	x	x		
SBL0012	133	LBF	x	x	x		x		x		
SBL0012	142.5	LBF	x	x	x	x	x	x	x		
SBL0013	31.5	UBF	x	x	x	x	x	x	x		
SBL0013	72	UBF	x	x	x	x	x	x	x		
SBL0013	115.5	MBFC	x	x	x	x	x	x	x		
SBL0013	171.5	LBF	x	x	x	x	x	x	x		
SBL0014	34	UBF	x	x	x	x	x	x	x		
SBL0014	119	MBFC	x	x	x	x	x	x	x		
SBL0014	135	LBF	x	x	x	x	x	x	x		
SBL0015	34	UBF	x	x	x	x	x	x	x		
SBL0015	77	MBFB	x	x	x	x	x	x	x		
SBL0015	94.5	MBFM				x		x			
SBL0015	110	MBFC	x	x	x	x	x	x	x		
SBL0015	145	MBFC	x	x	x	x	x	x	x		
SBL0016	45	UBF	x	x	x	x	x	x	x		
SBL0016	110	MBFC	x	x	x	x	x	x	x		
SBL0016	134	MBFC	x	x	x	x	x	x	x		
SBL0019	47	UBF	x	x	x		x		x		
SBL0019	123	MBFC	x	x	x		x		x		
SBL0019	128	LBF	x	x	x		x		x		
SBL0019	160	LBF	x	x	x		x		x		
SBL0019	168	LBF	x	x	x		x		x		
SBL0020	42	UBF	x	x	x		x		x		
SBL0020	48.5	UBF	x	x	x	x	x	x	x		
SBL0020	52	UBF	x	x	x		x		x		
SBL0020	81	MBFM	x	x	x	x	x	x	x		

Table 2.2-3
Soil Properties Data Availability
Groundwater Remedial Investigation Report
Del Amo Study Area

Location ID	Sample Depth	HSU	Soil Properties Data Availability								
			Horizontal and Vertical Air Permeability	Horizontal and Vertical Hydraulic Conductivity	Bulk Density	Moisture Content	Grain Size Distribution	Atterberg Limits	Total and Effective Porosity	Total Organic Carbon	Consolidation Test
SBL0020	82	MBFM	x	x	x		x		x		
SBL0020	111	MBFC	x	x	x		x		x		
SBL0020	141	LBF	x	x	x		x		x		
SBL0020	142	LBF	x	x	x	x	x	x	x		
SBL0021	97	MBFM	x	x	x	x	x	x	x		
SBL0021	104	MBFC	x	x	x	x	x	x	x		
SBL0021	137.5	LBF	x	x	x	x	x	x	x		
SBL0021	201	GAGE	x	x	x	x	x	x	x		
SBL0021	235	GLA	x	x	x		x	x	x		
SBL0022	35	UBF	x	x	x	x	x	x	x		
SBL0022	63	UBF	x	x	x	x	x	x	x		
SBL0022	89	MBFB	x	x	x	x	x	x	x		
SBL0022	152	LBF	x	x	x	x	x	x	x		
SBL0022	200	GAGE	x	x	x	x	x	x	x		
SBL0023	47	UBF	x	x	x		x	x	x		
SBL0023	81	MBFB	x	x	x	x	x	x	x		
SBL0023	125	MBFC	x	x	x	x	x	x	x		
SBL0024	41	UBF	x	x	x	x	x	x	x		
SBL0024	111	MBFC	x	x	x	x	x	x	x		
SBL0024	144	LBF	x	x	x		x	x	x		
SBL0025	29	UBF	x	x	x	x	x	x	x		
SBL0025	90	MBFC	x	x	x	x	x	x	x		
SBL0025	130	MBFC	x	x	x	x	x	x	x		
SBL0025	150	LBF	x	x	x	x	x	x	x		
SBL0026	35	UBF	x	x	x	x	x	x	x		
SBL0026	71	UBF	x	x	x	x	x	x	x		
SBL0026	140	MBFC	x	x	x	x	x	x	x		
SBL0026	160	LBF	x	x	x	x	x	x	x		
SBL0027	25	UBF	x	x	x	x	x	x	x		
SBL0027	50	UBF	x	x	x	x	x	x	x		
SBL0027	151	MBFC	x	x	x	x	x	x	x		
SBL0027	158	LBF	x	x	x	x	x	x	x		
SBL0027	186	GAGE	x	x	x	x	x	x	x		
SBL0028	38	UBF	x	x	x	x	x	x	x		
SBL0028	72	UBF	x	x	x	x	x	x	x		
SBL0028	121	MBFC	x	x	x	x	x	x	x		
SBL0028	155.5	MBFC	x	x	x	x	x	x	x		
SBL0029	46	UBF	x	x	x	x	x	x	x		
SBL0029	80	MBFC			x	x	x	x	x		
SBL0029	129	MBFC			x	x	x	x	x		
SBL0029	145.5	LBF			x	x	x	x	x		
SBL0030	40	UBF	x	x	x	x	x	x	x		
SBL0030	90	MBFB			x	x	x	x	x		
SBL0030	123	MBFC			x	x	x	x	x		

Table 2.2-3
Soil Properties Data Availability
Groundwater Remedial Investigation Report
Del Amo Study Area

Location ID	Sample Depth	HSU	Soil Properties Data Availability								
			Horizontal and Vertical Air Permeability	Horizontal and Vertical Hydraulic Conductivity	Bulk Density	Moisture Content	Grain Size Distribution	Atterberg Limits	Total and Effective Porosity	Total Organic Carbon	Consolidation Test
SBL0030	132	MBFC			x	x	x	x	x		
SBL0031	46	UBF	x	x	x	x	x	x	x		
SBL0031	71	UBF	x	x	x	x	x	x	x		
SBL0031	105	MBFC	x	x	x	x	x	x	x		
SBL0031	150	LBF	x	x	x	x	x	x	x		
SBL0032	37	UBF	x	x	x	x	x	x	x		
SBL0032	52	UBF	x	x	x	x	x	x	x		
SBL0032	73	UBF	x	x	x	x	x	x	x		
SBL0032	105	MBFB	x	x	x	x	x	x	x		
SBL0032	136	MBFC	x	x	x	x	x	x	x		
SBL0033	81	UBF	x	x	x	x	x	x	x		
SBL0033	120	MBFB	x	x	x	x	x	x	x		
SBL0033	154	MBFC	x	x	x	x	x	x	x		
SBL0033	192	GAGE	x	x	x	x	x	x	x		
SBL0033	261	GLA	x	x	x	x	x	x	x		
SBL0034	39	UBF	x	x	x	x	x	x	x		
SBL0034	52	UBF	x	x	x	x	x	x	x		
SBL0034	104	MBFB	x	x	x	x	x	x	x		
SBL0034	174	LBF	x	x	x	x	x	x	x		
SBL0035	37	UBF	x	x	x	x	x	x	x		
SBL0035	60	UBF	x	x	x	x	x	x	x		
SBL0035	97	MBFB	x	x	x	x	x	x	x		
SBL0035	140	LBF	x	x	x	x	x	x	x		
SBL0035	145	LBF	x	x	x	x	x	x	x		
SBL0038	8	UBF			x	x	x	x			
SBL0052	105	MBFB	x	x	x		x		x		
SBL0052	141.5	MBFC	x	x	x		x		x		
SBL0052	170	LBF	x	x	x		x		x		
SBL0053	59	UBF	x	x	x		x		x		
SBL0053	86	MBFB	x	x	x		x		x		
SBL0053	124	MBFC	x	x	x		x		x		
SBL0053	146.5	LBF	x	x	x		x		x		
SBL0053	155	LBF	x	x	x		x		x		
SBL0053	170	GAGE	x	x	x		x		x		
SBL0054	78	UBF	x	x	x		x		x		
SBL0054	132	MBFC	x	x	x		x		x		
SBL0054	154	LBF	x	x	x		x		x		
SBL0054	175	LBF	x	x	x		x		x		
SBL0054	187	GAGE	x	x	x		x		x		
SBL0055	30	UBF								x	
SBL0056	5	UBF				x					
SBL0056	10	UBF	x		x	x			x		
SBL0056	15	UBF				x					
SBL0056	20	UBF	x		x	x			x		

Table 2.2-3
Soil Properties Data Availability
Groundwater Remedial Investigation Report
Del Amo Study Area

Location ID	Sample Depth	HSU	Soil Properties Data Availability								
			Horizontal and Vertical Air Permeability	Horizontal and Vertical Hydraulic Conductivity	Bulk Density	Moisture Content	Grain Size Distribution	Atterberg Limits	Total and Effective Porosity	Total Organic Carbon	Consolidation Test
SBL0056	25	UBF				x					
SBL0056	30	UBF				x					
SBL0056	35	UBF				x					
SBL0056	40	UBF				x					
SBL0056	43	UBF				x					
SBL0056	48	UBF				x				x	
SBL0056	51	UBF	x		x	x			x		
SBL0057	10	UBF	x		x	x			x		
SBL0057	15	UBF				x				x	
SBL0057	18	UBF				x					
SBL0057	20.5	UBF	x		x	x			x		
SBL0057	25	UBF				x					
SBL0057	30	UBF				x					
SBL0057	35	UBF				x					
SBL0057	39.5	UBF				x					
SBL0057	40	UBF				x					
SBL0057	44.5	UBF				x					
SBL0057	50.5	UBF				x					
SBL0057	55	UBF				x					
SBL0057	56	UBF				x					
SBL0057	58	UBF	x		x				x		
SBL0057	64	UBF				x					
SBL0058	10	UBF	x		x				x		
SBL0058	12	UBF				x					
SBL0058	15	UBF				x					
SBL0058	20	UBF	x		x	x			x		
SBL0058	25	UBF				x					
SBL0058	30	UBF				x					
SBL0058	35	UBF				x					
SBL0058	40	UBF				x					
SBL0058	45	UBF				x					
SBL0058	50	UBF				x					
SBL0058	55	UBF	x		x	x			x		
SBL0059	64	UBF	x	x	x		x		x		
SBL0059	69	UBF	x	x	x		x		x		
SBL0059	139	MBFC	x	x	x		x		x		
SBL0059	168	LBF	x	x	x		x		x		
SBL0059	187	GAGE	x	x	x		x		x		
SBL0060	5	UBF				x					
SBL0060	10	UBF				x					
SBL0060	15	UBF				x					
SBL0060	20	UBF				x					
SBL0060	25	UBF				x					
SBL0060	30	UBF				x					

Table 2.2-3
Soil Properties Data Availability
Groundwater Remedial Investigation Report
Del Amo Study Area

Location ID	Sample Depth	HSU	Soil Properties Data Availability								
			Horizontal and Vertical Air Permeability	Horizontal and Vertical Hydraulic Conductivity	Bulk Density	Moisture Content	Grain Size Distribution	Atterberg Limits	Total and Effective Porosity	Total Organic Carbon	Consolidation Test
SBL0060	35	UBF				x					
SBL0060	40	UBF				x					
SBL0060	45	UBF				x					
SBL0060	50	UBF				x					
SBL0060	55	UBF				x					
SBL0061	5	UBF				x					
SBL0061	10	UBF				x					
SBL0061	15	UBF				x					
SBL0063	5	UBF				x					
SBL0063	10	UBF				x					
SBL0063	15	UBF				x					
SBL0065	5.5	UBF				x					
SBL0065	10	UBF				x					
SBL0065	15	UBF				x					
SBL0066	5	UBF				x					
SBL0066	10	UBF				x					
SBL0066	15	UBF				x					
SBL0067	5	UBF				x					
SBL0067	10	UBF				x					
SBL0067	15	UBF				x					
SBL0068	7	UBF	x	x	x				x		
SBL0068	20	UBF	x	x	x				x		
SBL0068	25	UBF	x	x	x				x		
SBL0068	55	UBF	x	x	x				x		
SBL0069	8	UBF	x	x	x				x		
SBL0069	30	UBF	x	x	x				x		
SBL0069	43.5	UBF	x	x	x				x		
SBL0069	47	UBF	x	x	x				x		
SBL0069	53	UBF	x	x	x				x		
SBL0070	10	UBF	x	x	x				x		
SBL0070	26.5	UBF	x	x	x				x		
SBL0070	40	UBF	x	x	x				x		
SBL0071	27	UBF	x	x	x				x		
SBL0071	34	UBF	x	x	x				x		
SBL0071	71	UBF			x				x		
SBL0073	13	UBF	x	x	x				x		
SBL0073	55.5	UBF	x	x	x				x		
SBL0077	130	MBFC		x			x		x		
SBL0077	150	LBF		x		x	x	x	x		
SBL0077	165	GAGE		x			x		x		
SBL0077	166.3	GAGE					x				
SBL0078	63	UBF		x	x		x	x	x		
SBL0078	84	MBFB		x	x		x	x	x		
SBL0078	97	MBFM		x	x		x	x	x		

Table 2.2-3
Soil Properties Data Availability
Groundwater Remedial Investigation Report
Del Amo Study Area

Location ID	Sample Depth	HSU	Soil Properties Data Availability								
			Horizontal and Vertical Air Permeability	Horizontal and Vertical Hydraulic Conductivity	Bulk Density	Moisture Content	Grain Size Distribution	Atterberg Limits	Total and Effective Porosity	Total Organic Carbon	Consolidation Test
SBL0078	112	MBFC		x	x		x	x	x		
SBL0078	157	LBF		x	x		x	x	x		
SBL0078	164	GAGE		x	x		x	x	x		
SBL0080	72	UBF				x	x	x			
SBL0080	135	MBFC				x	x	x			
SBL0080	145	LBF				x	x	x			
SBL0080	177	GAGE				x	x	x			
SBL0080	220	GLA				x	x	x			
SBL0081	72	UBF				x	x	x			
SBL0081	163	LBF				x	x	x			
SBL0081	180	GLA				x	x	x			
SBL0085	64.5	UBF					x			x	
SBL0085	69.7	MBFB					x			x	
SBL0085	81.9	MBFM					x			x	
SBL0086	62.4	UBF					x			x	
SBL0086	64.5	UBF					x			x	
SBL0086	72.7	MBFB					x			x	
SBL0087	63.2	UBF					x			x	
SBL0088	71.2	MBFB					x			x	
SBL0089	64.6	UBF					x			x	
SBL0089	65.5	UBF					x			x	
SBL0089	66.2	UBF					x			x	
SBL0089	68.5	MBFB					x			x	
SBL0089	73.9	MBFB					x			x	
SBL0089	75.4	MBFM					x			x	
SBL0089	78.5	MBFM					x			x	
SBL0090	63.3	UBF					x			x	
SBL0090	66.7	UBF					x			x	
SBL0090	70.3	MBFB					x			x	
SBL0090	73.8	MBFB					x			x	
SBL0090	74.3	MBFB					x			x	
SBL0090	74.6	MBFB					x			x	
SBL0090	76.9	MBFM					x			x	
SBL0090	77.3	MBFM					x			x	
SBL0091	64.6	UBF					x			x	
SBL0091	72.5	MBFB					x			x	
SBL0091	72.6	MBFB					x			x	
SBL0091	78.2	MBFM					x			x	
SBL0091	79.3	MBFM					x			x	
SBL0092	80.5	MBFM					x			x	
SBL0093	76.7	MBFB					x			x	
SBL0093	77.8	MBFB					x			x	
SBL0093	81.7	MBFM					x			x	
SBL0093	83.7	MBFM					x			x	

Table 2.2-3
Soil Properties Data Availability
Groundwater Remedial Investigation Report
Del Amo Study Area

Location ID	Sample Depth	HSU	Soil Properties Data Availability								
			Horizontal and Vertical Air Permeability	Horizontal and Vertical Hydraulic Conductivity	Bulk Density	Moisture Content	Grain Size Distribution	Atterberg Limits	Total and Effective Porosity	Total Organic Carbon	Consolidation Test
SBL0093	88.5	MBFM					x			x	
SBL0093	89.5	MBFC					x			x	
SBL0094	71.3	MBFB					x			x	
SBL0094	79.8	MBFM					x			x	
SBL0094	81.5	MBFM					x			x	
SBL0094	81.7	MBFM					x			x	
SBL0094	88.8	MBFM					x			x	
SBL0101	158	LBF									x
SBL0103	152.5	LBF									x
SBL0104	131.5	LBF									x
SBL0105	56	UBF									x
SBL0106	85	MBFC					x				
SBL0106	125	MBFC					x				
SBL0106	152	LBF									x
SBL0108	120	MBFC					x				
SBL0108	126	MBFC					x				
SWL0001	72	UBF	x	x	x	x	x	x	x		
SWL0002	61	UBF	x	x	x	x	x	x	x		
SWL0005	4	UBF				x	x	x			
SWL0005	14	UBF				x	x	x			
SWL0005	24	UBF				x	x	x			
SWL0005	33	UBF				x	x	x			
SWL0005	44	UBF				x	x	x			
SWL0005	55	UBF				x	x	x			
SWL0005	61	UBF				x	x	x			
SWL0006	4	UBF				x	x	x			
SWL0006	14	UBF				x	x	x			
SWL0006	24	UBF				x	x	x			
SWL0006	33	UBF				x	x	x			
SWL0006	44	UBF				x	x	x			
SWL0006	58	UBF				x	x	x			
SWL0006	68	UBF				x	x	x			
SWL0043	70.5	UBF									x
SWL0043	72	UBF									x
SWL0043	73.5	UBF									x
SWL0043	133.5	LBF									x
SWL0043	156	LBF									x
SWL0043	163.5	LBF									x
SWL0048	76	UBF									x
SWL0050	62	UBF									x
SWL0052	70	UBF									x
VWL0001	30.3	UBF	x	x	x		x		x		
VWL0001	48.3	UBF	x	x	x		x		x		
VWL0001	48.5	UBF					x				

Table 2.2-3
Soil Properties Data Availability
Groundwater Remedial Investigation Report
Del Amo Study Area

Location ID	Sample Depth	HSU	Soil Properties Data Availability								
			Horizontal and Vertical Air Permeability	Horizontal and Vertical Hydraulic Conductivity	Bulk Density	Moisture Content	Grain Size Distribution	Atterberg Limits	Total and Effective Porosity	Total Organic Carbon	Consolidation Test
VWL0002	53.3	UBF	x	x	x		x		x		
VWL0002	53.5	UBF					x				
VWL0003	30.5	UBF	x	x	x		x		x		
VWL0003	35	UBF	x	x	x		x		x	x	
VWL0003	40	UBF	x	x	x		x		x		
VWL0004	36.5	UBF	x	x	x		x		x		
VWL0004	55	UBF	x	x	x		x		x		
VWL0004	55.5	UBF	x	x	x		x		x		
VWL0005	31	UBF	x	x	x		x		x		
VWL0005	37.5	UBF	x	x	x		x		x		
VWL0006	31.5	UBF	x	x	x		x		x		
VWL0006	37.5	UBF	x	x	x		x		x		
VWL0007	31.3	UBF	x	x	x		x		x		
VWL0007	37.3	UBF	x	x	x		x		x		
VWL0008	30	UBF	x	x	x		x		x	x	
VWL0008	35	UBF	x	x	x		x		x	x	
VWL0008	40	UBF	x	x	x		x		x	x	
VWL0009	30.3	UBF	x	x	x		x		x		
VWL0009	37.5	UBF	x	x	x		x		x		
VWL0010	31.3	UBF	x	x	x		x		x		
VWL0010	37	UBF	x	x	x		x		x		
VWL0010	41.3	UBF	x	x	x		x		x		

[a] Deepest Hydrostratigraphic Unit reached: UBF = upper Bellflower aquitard; MBFB = middle Bellflower B-sand; MBFC = middle Bellflower C-sand; LBF = lower Bellflower aquitard; GAGE = Gage aquifer; LYN = Lynwood aquifer.

[b] Porosity is a calculated, rather than measured, value.

Table 2.2-4
Summary of Chemical Analyses Conducted - Groundwater Screening Points
Groundwater Remedial Investigation Report
Del Amo Study Area

HSU	Location	VOCs								p-CBSA	SVOCs			Pest./PCBs		Metals	General Minerals	Biodegradation Indicators		Other		
		EPA 8010	EPA 8015M	EPA 8020	EPA 8240	EPA 8260	Mobile 601	Mobile 602	Mobile 8020	Ionchrom.	EPA 8270	Mobile 604	Mobile 610	EPA 8080	Mobile 608	Various	Various	BTEX Degraders	Methane	Cyanide	EDB (EPA 504)	TPH (EPA 8015M)
Water Table	BWL0001				2																	
	CWL0012 a				1						1			2								
	CWL0013 b																					
	CWL0014				1						1			1		1	1			1		
	CWL0015				1						1			1								
	CWL0016				1						1			1								
	CWL0017				1						1						1					
	CWL0018				1						1											
	CWL0019				1						1											
	CWL0020				1						1											
	CWL0021 c																					
	CWL0022				1																	
	CWL0023						1	1														
	CWL0024						1	1			1			1								
	CWL0025						1	1														
	CWL0026						1	1														
	CWL0027						1		1													
	CWL0028				1		1		1		1											
	CWL0029						1		1													
	CWL0030				1		1	1	1													
	CWL0031						1	1														
	CWL0032						1	1														
	CWL0033						1	1														
	CWL0034						1	1														
	CWL0035						1	1														
	CWL0036				1		1	1														
	CWL0037				1		1	1														
	CWL0038				1		1	1			1											

Table 2.2-4
Summary of Chemical Analyses Conducted - Groundwater Screening Points
Groundwater Remedial Investigation Report
Del Amo Study Area

HSU	Location	VOCs								p-CBSA	SVOCs			Pest./PCBs		Metals	General Minerals	Biodegradation Indicators		Other		
		EPA 8010	EPA 8015M	EPA 8020	EPA 8240	EPA 8260	Mobile 601	Mobile 602	Mobile 8020	Ionchrom.	EPA 8270	Mobile 604	Mobile 610	EPA 8080	Mobile 608	Various	Various	BTEX Degraders	Methane	Cyanide	EDB (EPA 504)	TPH (EPA 8015M)
Water Table	CWL0039				1		1	1			1											
	CWL0040				1		1	1			1											
	CWL0041				1		1	1			1											
	CWL0042						1	1				1	1		1							
	CWL0043 d																					
	CWL0044						1	1														
	CWL0045						1	1														
	CWL0046						1	1														
	CWL0047						1	1														
	CWL0048						1	1														
	CWL12,WPL1 *															1				1		
	CWL15,16 *															1				1		
	CWL17,18 *													1		1				1		
	CWL19,20 *													1		1				1		
	CWL21,22 *															1				1		
	CWL36,37 *													1		1	1			1		
	CWL38,39 *													1		1				1		
	CWL40,41 *													1		1				1		
	WPL0001				1						1			1								
	WPL0002				1									1								

Values correspond to the number of times the analysis has been run for a given sample location.

[a] Locations CW0001 - CWL0011 were for NAPL screening purposes only. No chemical analyses conducted.

[b] Location CWL0013 encountered shallow refusal. Refer to location WPL0001 for groundwater analysis.

[c] Groundwater analysis not conducted at location CWL0021.

[d] Location CWL0043 encountered shallow refusal. Refer to location WPL0002 for groundwater analysis.

* Composite groundwater sample.

Table 2.2-5
Summary of Chemical Analyses Conducted - Groundwater Monitoring Points
August, 1992 through February, 1996
Groundwater Remedial Investigation Report
Del Amo Study Area

HSU	Location	VOCs								p-CBSA	SVOCs			Pest./PCBs		Metals	General Minerals	Biodegradation Indicators		Other		
		EPA 8010	EPA 8015M	EPA 8020	EPA 8240	EPA 8260	Mobile 601	Mobile 602	Mobile 8020	Ionchrom.	EPA 8270	Mobile 604	Mobile 610	EPA 8080	Mobile 608	Various	Various	BTEX Degraders	Methane	Cyanide	EDB (EPA 504)	TPH (EPA 8015M)
Water Table	PZL0001				8		1	1	1		8					4						
	PZL0002				8		1	1	1													
	PZL0003				8		1	1	1													
	PZL0004				8																	
	PZL0005				8		1	1	1													
	PZL0006	2			3		1	1	1		2			1			2	1				
	PZL0007				8		1	1	1													
	PZL0008				2						2						2	1				
	PZL0009	2			2		1		1		2						2	1				
	PZL0010				8		1	1	1													
	PZL0011	8			8		1		1		9					4						
	PZL0012	8			9			1	1		9					4						
	PZL0013	8			9		1		1		5					4						
	PZL0014				3			1	1		2						2	1				
	PZL0015						1	1	1													
	PZL0016	8			8		1		1		4					4						
	PZL0017				1																	
	PZL0018	7			9					4	5					4	1				1	
	PZL0019	8			9					4	9					4	2					
	PZL0020	8			9					4	9					4	2					
	PZL0021	8			9					4	4					4			3			
	PZL0022	8	1	6	9					4	8					4	3					
	PZL0023	4			5	1					5					4					1	
	PZL0024	8			9	1				4	9					4	4		3		1	
	PZL0025	8			9	1				4	9					4	8	6	3		1	
	PZL0026	5			6						6			1		2	6	3	3	1		
	SWL0001 a																					
	SWL0002	8			9		1		1								8	6	3			
	SWL0003	8			9		1		1													
	SWL0004	8			9		1		1								8	6	3			

Table 2.2-5
Summary of Chemical Analyses Conducted - Groundwater Monitoring Points
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Groundwater Remedial Investigation Report
Del Amo Study Area

HSU	Location	VOCs								p-CBSA	SVOCs			Pest./PCBs		Metals	General Minerals	Biodegradation Indicators		Other		
		EPA 8010	EPA 8015M	EPA 8020	EPA 8240	EPA 8260	Mobile 601	Mobile 602	Mobile 8020	Ionchrom.	EPA 8270	Mobile 604	Mobile 610	EPA 8080	Mobile 608	Various	Various	BTEX Degraders	Methane	Cyanide	EDB (EPA 504)	TPH (EPA 8015M)
Water Table	SWL0005				9		1	1		4	6			1		5	9	6	3	1		
	SWL0006				9		1	1		4	9			1		5	9	6	3	1		
	SWL0007		1	6	9						1			1		1	9	6	3	1		
	SWL0008	8			9				1	4	9			1		5	5			1		
	SWL0009				9						5			1		5	1			1		
	SWL0012				9						1			1		1	9	6	3	1		
	SWL0015				9						1			1		5	9	6	3	1		
	SWL0016				9						1			1		1	9	6	3	1		
	SWL0017				9						5			1		5	9	6	3	1		
	SWL0021				9						5			1		5	9	6	3	1		
	SWL0024				9						9			1		5	9	6	3	1		
	SWL0028				9						5			1		5	9	6	3	1		
	SWL0038				8						4					4						
	SWL0039				8						5					4						
	SWL0042	4			6						6					2	2	2				
	SWL0044	3			3					3	3								3			
	SWL0045				2						2						2	1				
	SWL0046				2						2						2	1				
	SWL0049	2			2					2	2						2	1	2			
	SWL0051				2						2						2	1				
	SWL0057				2					2	2						2	1	2			1
	XDM-02				1						1			1			1					
	XGW-07A				8						4					4						
	XMW-01				7					3	7					4	1					
	XMW-01HD				1																	
	XMW-01T				9									1								
	XMW-02HD				9						9					4						
	XMW-02T				9		1	1	1													
	XMW-03			2	2					2	2						2	1				
	XMW-03HD	8			9						1			1		5	9	5	3	1		

Table 2.2-5
Summary of Chemical Analyses Conducted - Groundwater Monitoring Points
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Groundwater Remedial Investigation Report
Del Amo Study Area

HSU	Location	VOCs								p-CBSA	SVOCs			Pest./PCBs		Metals	General Minerals	Biodegradation Indicators		Other		
		EPA 8010	EPA 8015M	EPA 8020	EPA 8240	EPA 8260	Mobile 601	Mobile 602	Mobile 8020	Ionchrom.	EPA 8270	Mobile 604	Mobile 610	EPA 8080	Mobile 608	Various	Various	BTEX Degraders	Methane	Cyanide	EDB (EPA 504)	TPH (EPA 8015M)
Water Table	XMW-04HD	8			9						8					4	8	5	3			
	XMW-10				8																	
	XMW-11				9					4				1								
	XMW-12	7			8					3				1			1					
	XMW-13	8			9					4	9			1		4	1					
	XMW-14	8			8					4	8					4	1					
	XMW-21	8			8														3			
	XMW-23				8					4							8	6	3			
	XMW-24				3												1					
	XMW-26				3												1					
	XMW-27				1									1								
	XMW-28	8			9						5			1		5	9	6	3	1		
	XMW-29	8			9					4	9			1		4	8	6	3			
	XMW-30				8					4							8	6	2			
	XP-02	8			9					4	9			1		4	1					
MBFB	PZL0021	8			9					4	4					4			3			
	SWL0001 a																					
	SWL0002	8			9		1		1								8	6	3			
	SWL0003	8			9		1		1													
	SWL0004	8			9		1		1								8	6	3			
	SWL0049	2			2					2	2						2	1	2			
	XDM-02				1						1			1			1					
	XMW-01				7					3	7					4	1					
	XMW-01T				9									1								
	XMW-02T				9		1	1	1													
	XMW-03			2	2					2	2						2	1				
	SWL0032 a																					
	XMW-10				8																	
	XMW-11				9					4				1								
	XMW-12	7			8					3				1			1					

Table 2.2-5
Summary of Chemical Analyses Conducted - Groundwater Monitoring Points
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Groundwater Remedial Investigation Report
Del Amo Study Area

HSU	Location	VOCs								p-CBSA	SVOCs			Pest./PCBs		Metals	General Minerals	Biodegradation Indicators		Other		
		EPA 8010	EPA 8015M	EPA 8020	EPA 8240	EPA 8260	Mobile 601	Mobile 602	Mobile 8020	Ionchrom.	EPA 8270	Mobile 604	Mobile 610	EPA 8080	Mobile 608	Various	Various	BTEX Degraders	Methane	Cyanide	EDB (EPA 504)	TPH (EPA 8015M)
MBFB	XMW-13	8			9					4	9			1		4	1					
	XMW-14	8			8					4	8					4	1					
	XMW-21	8			8														3			
	XMW-26				3												1					
	XMW-27				1									1								
	XMW-28	8			9						5			1		5	9	6	3	1		
	XMW-29	8			9					4	9			1		4	8	6	3			
	XMW-30				8					4							8	6	2			
	XP-02	8			9					4	9			1		4	1					
	SWL0010				9					4	5			1		5	1			1		
	SWL0011				9					4	1			1			2					
	SWL0019				9					4	1			1		1	1		3	1	1	
	SWL0023		1	6	9					4	5			1		5	9	4		1		
	SWL0029		1	6	8	1				5	5			1		5	4	3		1		
	SWL0037				8					4	4					4	8					
	SWL0041	8			8					8	8					4	8		3			
	SWL0047	2			2						2						2	1				
	SWL0048	2			2					2	2						2	1				
	SWL0050	2			2					2	2						2	1				
	SWL0052	2			2					2	2						2	1	2			
	SWL0056				2					2	2						2	1	2			1
	XG-01WC				4												4					
	XG-02WC				4												4					
	XGW-07C				8						4					4						
	XP-03				4												4					
MBFC	SWL0013				9					4	1			1			2					
	SWL0014				9					8	9			1		5	2			1	1	
	SWL0018				9					8	9			1		5	9	4		1	1	
	SWL0027				9					4	1			1		1	3			1		
	SWL0030				8	1				5	5			1		5	4	3		1		

Table 2.2-5
Summary of Chemical Analyses Conducted - Groundwater Monitoring Points
August, 1992 through February, 1996
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Del Amo Study Area

HSU	Location	VOCs								p-CBSA	SVOCs			Pest./PCBs		Metals	General Minerals	Biodegradation Indicators		Other		
		EPA 8010	EPA 8015M	EPA 8020	EPA 8240	EPA 8260	Mobile 601	Mobile 602	Mobile 8020	Ionchrom.	EPA 8270	Mobile 604	Mobile 610	EPA 8080	Mobile 608	Various	Various	BTEX Degraders	Methane	Cyanide	EDB (EPA 504)	TPH (EPA 8015M)
MBFC	SWL0033	8	1	6	8					8	4					4	8	4				
	SWL0035				8					4	4					4	8		3			
	SWL0040	8			8					8	8					4	8		3			
	SWL0043			4	6					6	6					2	3	2				
	SWL0053	2			2					2	2						2	1	2			
	SWL0054	2			2					2	2						2	1	2			
	SWL0055	2			2					2	2						2	1	2			
	SWL0058	2			2					2	2						2	1	2			
	XBF-04			1	2					2	2						2	1				
	XBF-05		1	5	8					7				1					2			
	XBF-06		1	6	9					8	5			1		5	2		3	1		
	XBF-07		1	6	8												1		3			
	XBF-10				8					8							1					
	XBF-13	8			9					8	9			1		4	8	4				
	XBF-14	8	1	6	8					8							1					
	XBF-15			2	2					2	2						2	1				
	XBF-19				2					2	2						2	1				
	XBF-21			1	2					2	1						2					
	XBF-23				8					8	8					4	8	4				
Gage	SWL0020				9					4	5			1		5	1			1		
	SWL0022				9					8	1			1		1	2		3	1		
	SWL0025				9					4	1			1		1	1			1		
	SWL0026				9					8	1			1		1	9	3		1		
	SWL0031				8	1				5	4			1		5	4	5	3	1		
	SWL0034	8	1	6	8					8	4					4	8	4				
	SWL0036				8					4	4					4	8		3			
	XDA-1B				8					8							1					
	XG-04		1	6	9					7				1			1					
	XG-05		1	6	9					8	1			1			1		3			
	XG-06			6	8					8							1					

Table 2.2-5
Summary of Chemical Analyses Conducted - Groundwater Monitoring Points
August, 1992 through February, 1996
Groundwater Remedial Investigation Report
Del Amo Study Area

HSU	Location	VOCs								p-CBSA	SVOCs			Pest./PCBs		Metals	General Minerals	Biodegradation Indicators		Other		
		EPA 8010	EPA 8015M	EPA 8020	EPA 8240	EPA 8260	Mobile 601	Mobile 602	Mobile 8020	Ionchrom	EPA 8270	Mobile 604	Mobile 610	EPA 8080	Mobile 608	Various	Various	BTEX Degraders	Methane	Cyanide	EDB (EPA 504)	TPH (EPA 8015M)
Gage	XG-08				8					8							1					
	XG-09				9					8	4					4	8	4	3			
	XG-11				9					8	5			1		4	1		3			
	XG-12		1	6	8					8	4					4	8	4				
	XG-13		1	6	8					8							1					
	XG-14				8					8												
	XG-17		1	6	9					8	1			1		1	2		3	1		

Values correspond to the number of times the analysis has been run for a given sample location.

[a] Locations SWL0001 and SWL0032 encountered LNAPL. No groundwater sample analyzed.

Table 2.2-6
Summary of Analytical Testing Program - Periodic Groundwater Monitoring Program
Third Sampling Period 1995
Groundwater Remedial Investigation Report
Del Amo Study Area

HSU	Sample Location	VOCs EPA Method 8240	Halocarbons EPA Method 8010	SVOCs EPA Method 8270	General Minerals	p-CBSA	Methane	Aerobic BTEX Degraders
Water Table	PZL0001	X		X				
	PZL0002	X						
	PZL0003	X						
	PZL0004	X						
	PZL0005	X						
	PZL0006	X	X	X	X			X
	PZL0007	X						
	PZL0008	X		X	X			X
	PZL0009	X	X	X	X			X
	PZL0010	X						
	PZL0011	X	X	X				
	PZL0012	X	X	X				
	PZL0013	X	X					
	PZL0014	X		X	X			X
	PZL0016	X	X					
	PZL0018	X	X		X			
	PZL0019	X	X	X	X	X		
	PZL0020	X	X	X	X			
	PZL0021	X	X			X	X	
	PZL0022	X*	X	X	X			
	PZL0024	X	X	X	X	X	X	
	PZL0025	X	X	X	X		X	
	PZL0026	X	X	X	X		X	
	SWL0002	X	X		X		X	
	SWL0003	X	X					
	SWL0004	X	X		X		X	
	SWL0005	X			X		X	
	SWL0006	X		X	X		X	
	SWL0007	X*			X		X	
	SWL0008	X	X	X	X			
	SWL0009	X						
	SWL0012	X			X		X	
	SWL0015	X			X		X	
	SWL0016	X			X		X	
	SWL0017	X			X		X	
	SWL0021	X			X		X	
	SWL0024	X		X	X		X	
	SWL0028	X			X		X	
	SWL0038	X						
	SWL0039	X						
	SWL0042	X	X	X				
	SWL0044	X	X	X		X	X	
	SWL0045	X		X	X			X
	SWL0046	X		X	X			X
	SWL0049	X	X	X	X		X	X
	SWL0051	X		X	X			X
	SWL0057	X						X
	XGW-07A	X						
	XMW-01	O+						
	XMW-01T	X						

Table 2.2-6
Summary of Analytical Testing Program - Periodic Groundwater Monitoring Program
Third Sampling Period 1995
Groundwater Remedial Investigation Report
Del Amo Study Area

HSU	Sample Location	VOCs EPA Method 8240	Halocarbons EPA Method 8010	SVOCs EPA Method 8270	General Minerals	p-CBSA	Methane	Aerobic BTEX Degraders
Water Table	XMW-02HD	X		X				
	XMW-02T	X						
	XMW-03	X*		X	X			X
	XMW-03HD	X	X		X		X	
	XMW-04HD	X	X	X	X		X	
	XMW-05	O						
	XMW-06	O				O		
	XMW-09	O						
	XMW-10	X						
	XMW-11	X				X		
	XMW-12	O+				O+		
	XMW-13	X	X	X		X		
	XMW-14	X	X	X		X		
	XMW-17	O				O		
	XMW-19	O				O		
	XMW-21	X	X				X	
	XMW-23	X			X		X	
	XMW-24	O+				O+		
	XMW-25	O				O		
	XMW-26	O+				O+		
	XMW-27	O+				O+		
	XMW-28	X	X		X		X	
	XMW-29	X	X	X	X		X	
	XMW-30	X			X		X	
	XP-02	X	X	X		X		
	XUBT-03	O						
MBFB	PZL0021	X	X			X	X	
	SWL0002	X	X		X		X	
	SWL0003	X	X					
	SWL0004	X	X		X		X	
	SWL0010	X						
	SWL0011	X						
	SWL0019	X					X	
	SWL0023	X*			X			
	SWL0029	X*						
	SWL0037	X			X			
	SWL0041	X	X	X	X		X	
	SWL0047	X	X	X	X			X
	SWL0048	X	X	X	X			X
	SWL0049	X	X	X	X		X	X
	SWL0050	X	X	X	X			X
	SWL0052	X	X	X	X	X	X	X
	SWL0056	X						X
	XG-01WC	X			X			
	XG-02WC	X			X			
	XGW-07C	X						
	XMW-01T	X						
	XMW-02T	X						
	XMW-03	X*		X	X			X
	XMW-05	O						

Table 2.2-6
Summary of Analytical Testing Program - Periodic Groundwater Monitoring Program
Third Sampling Period 1995
Groundwater Remedial Investigation Report
Del Amo Study Area

HSU	Sample Location	VOCs EPA Method 8240	Halocarbons EPA Method 8010	SVOCs EPA Method 8270	General Minerals	p-CBSA	Methane	Aerobic BTEX Degraders
MBFB	XMW-06	O				O		
	XMW-09	O						
	XMW-10	X						
	XMW-11	X				X		
	XMW-12	O+				O+		
	XMW-13	X	X	X		X		
	XMW-14	X	X	X		X		
	XMW-17	O				O		
	XMW-19	O				O		
	XMW-21	X	X				X	
	XMW-26	O+				O+		
	XMW-27	O+				O+		
	XMW-28	X	X		X		X	
	XMW-29	X	X	X	X		X	
	XMW-30	X			X		X	
	XP-02	X	X	X		X		
	XP-03	X			X			
MBFC	SWL0013	X						
	SWL0014	X		X		X		
	SWL0018	X		X	X			
	SWL0027	X			X			
	SWL0030	X						
	SWL0033	X*	X		X	X		
	SWL0035	X			X		X	
	SWL0040	X	X	X	X		X	
	SWL0043	X*		X		X		
	SWL0053	X	X	X	X		X	X
	SWL0054	X	X	X	X		X	X
	SWL0055	X	X		X			X
	SWL0058	X		X	X		X	
	XBF-04	X*		X	X			X
	XBF-05	X*				X	X	
	XBF-06	X*				X	X	
	XBF-07	X*					X	
	XBF-09	O				O		
	XBF-10	X			X			
	XBF-13	X	X	X	X			
	XBF-14	X*	X			X		
	XBF-15	X*		X	X			X
	XBF-18	O				O		
	XBF-19	X		X	X			X
	XBF-21	X*			X			
	XBF-23	X		X	X			
	XBF-24	O				O		
	XBF-26	O				O		
	XBF-30	O				O		
	XBF-31	O						
MBFC	XBF-32	O				O		
Gage	SWL0020	X						
	SWL0022	X				X	X	

Table 2.2-6
Summary of Analytical Testing Program - Periodic Groundwater Monitoring Program
Third Sampling Period 1995
Groundwater Remedial Investigation Report
Del Amo Study Area

HSU	Sample Location	VOCs EPA Method 8240	Halocarbons EPA Method 8010	SVOCs EPA Method 8270	General Minerals	p-CBSA	Methane	Aerobic BTEX Degraders
Gage	SWL0025	X						
	SWL0026	X			X			
	SWL0031	X					X	
	SWL0034	X*	X		X			
	SWL0036	X			X		X	
	XDA-1B	X				X		
	XG-04	X*				X		
	XG-05	X*				X	X	
	XG-06	X*				X		
	XG-08	X				X		
	XG-09	X			X		X	
	XG-10	O				O		
	XG-11	X				X	X	
	XG-12	X*			X			
	XG-13	X*				X		
	XG-14	X				X		
	XG-16	O				O		
	XG-17	X*				X	X	
	XG-18	O				O		
	XG-19	O				O		

X: Sampled By Dames & Moore.
O: Sampled by Hargis & Associates.
+: Sampled by Hargis & Associates - part of Dames & Moore sampling program.
*: Selected VOCs also analyzed by EPA Method 8020 due to elevated levels of chlorobenzene.

TABLE 2.2-7
AQUIFER TEST LOCATIONS
THEIS RECOVERY METHOD
GROUNDWATER REMEDIAL INVESTIGATION REPORT
DEL AMO STUDY AREA

UPPER BELLFLOWER AQUITARD		MIDDLE BELLFLOWER B SAND	MIDDLE BELLFLOWER C SAND	GAGE AQUIFER
SWL0005	SWL0021	SWL0011	SWL0014	XDA-1B
SWL0006	SWL0039	SWL0023		
SWL0009	SWL0042	SWL0037		
SWL0012	SWL0044[1]	SWL0047		
SWL0016	SWL0046	SWL0049[2]		
SWL0017	SWL0057	XMW-28[3]		

NOTES:

1 Slug test, rather than pumping test
2 Well SWL0049 is a water table well screened in the MBFB
3 Well XMW-28 is a water table well screened partially in the UBF and partially in the MBFB

TABLE 2.2-8
RATIO TEST METHOD LOCATIONS
GROUNDWATER REMEDIAL INVESTIGATION REPORT
DEL AMO STUDY AREA

AQUIFER WELL	AQUITARD WELL
MBFB SWL0023	UBF SWL0024
MBFC SWL0014	LBF SWL0043
Gage XDA-1B	LBF SWL0043

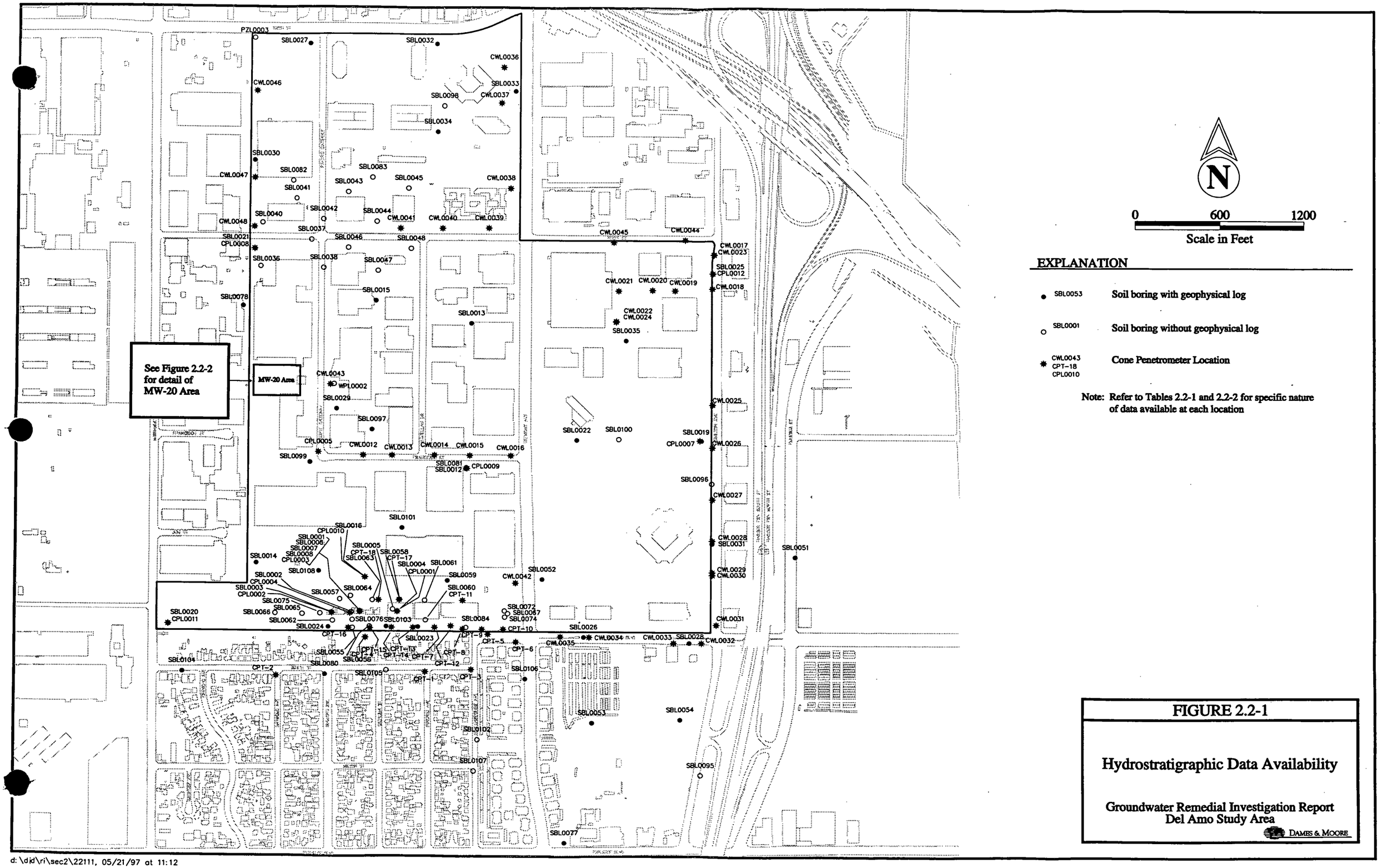


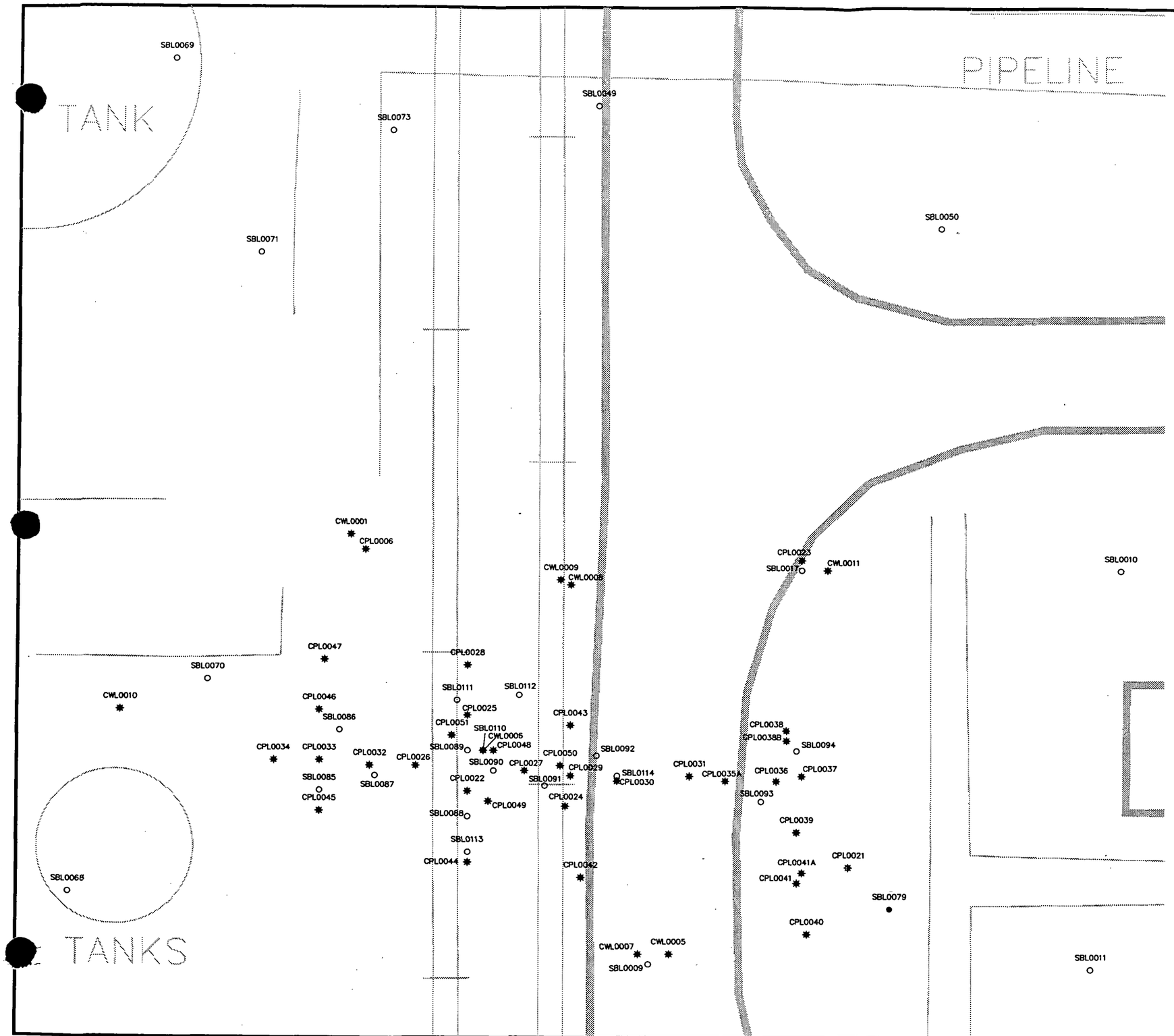
FIGURE 2.2-1

Hydrostratigraphic Data Availability

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

d:\did\ri\sec2\22111, 05/21/97 at 11:12



N

0 20 40

Scale in Feet

EXPLANATION

● SBL0053	Soil boring with geophysical log
○ SBL0001	Soil boring without geophysical log
✱ CPL0048 CWL0043	Cone Penetrometer Location
	Former Plant Facilities

Notes: Refer to Tables 2.2-1 and 2.2-2 for specific nature of data available at each location

Refer to Figure 2.2-1 for location of MW-20 area within the study area

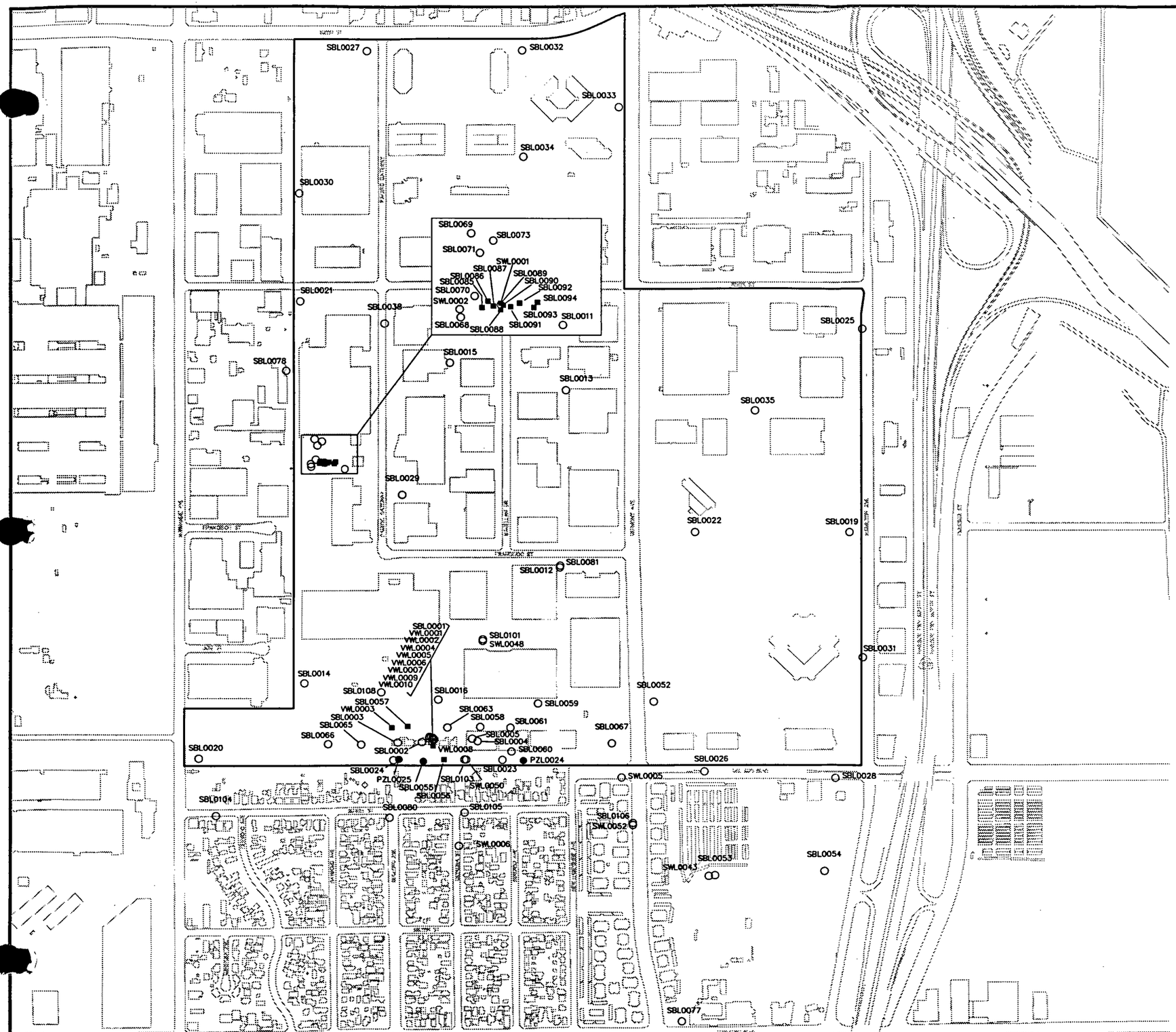
FIGURE 2.2-2

Hydrostratigraphic Data Availability Detail of MW-20 Area

Groundwater Remedial Investigation Report Del Amo Study Area

DAMES & MOORE

D:\DJD\RI\SEC2\22112, 04/22/97 at 14:26



EXPLANATION

- ● SBL0086 Location with soil TOC data
- ○ SBL0001 Location with soil physical test data
- ■ VWL0008 Location with both soil TOC data and physical test data

Note: Refer to Table 2.2-3 for specific nature of data available at each location

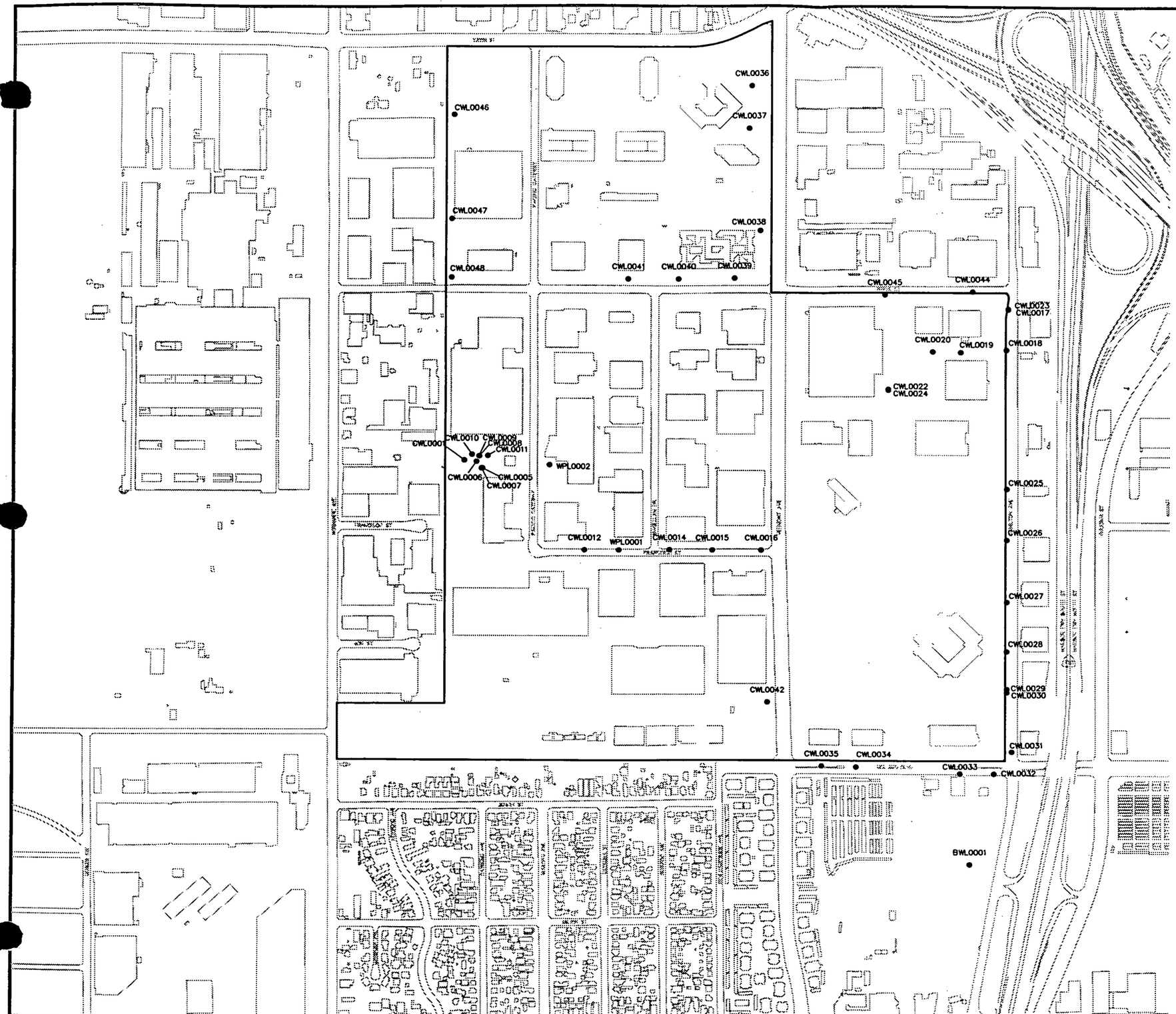
FIGURE 2.2-3

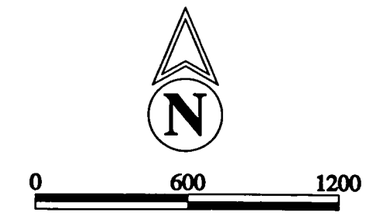
Soil Properties Data Availability

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

D:\DJD\RI\SEC2\22121, 10/15/96 at 15:46





EXPLANATION

● CWL0001, WPL0002, BWL0001 — Groundwater screening location

Note:
Refer to Table 2.2-4 for specific nature of data available for each location.

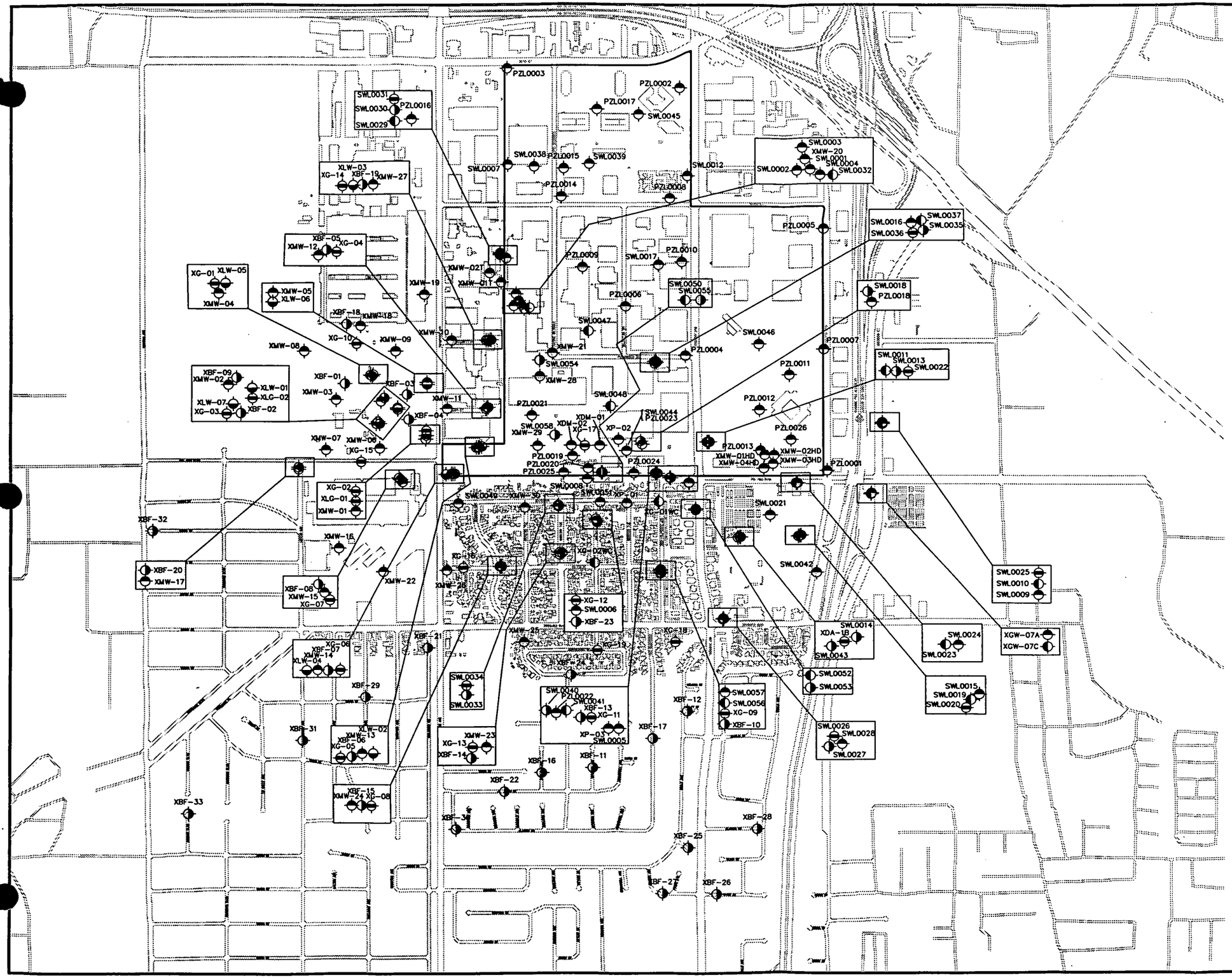
FIGURE 2.2-4

Groundwater Screening Locations

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

S:\DJD\NT_DWGS\22211, 10/03/96 at 16:14



EXPLANATION

- Water Table Zone monitoring well (UBF or MBFB)
- Middle Bellflower B Sand monitoring well.
- Middle Bellflower C Sand monitoring well.
- Gage Aquifer monitoring well.
- Lynwood Aquifer monitoring well.

Note: Refer to Table 2.2-5 for specific nature of data available at each location

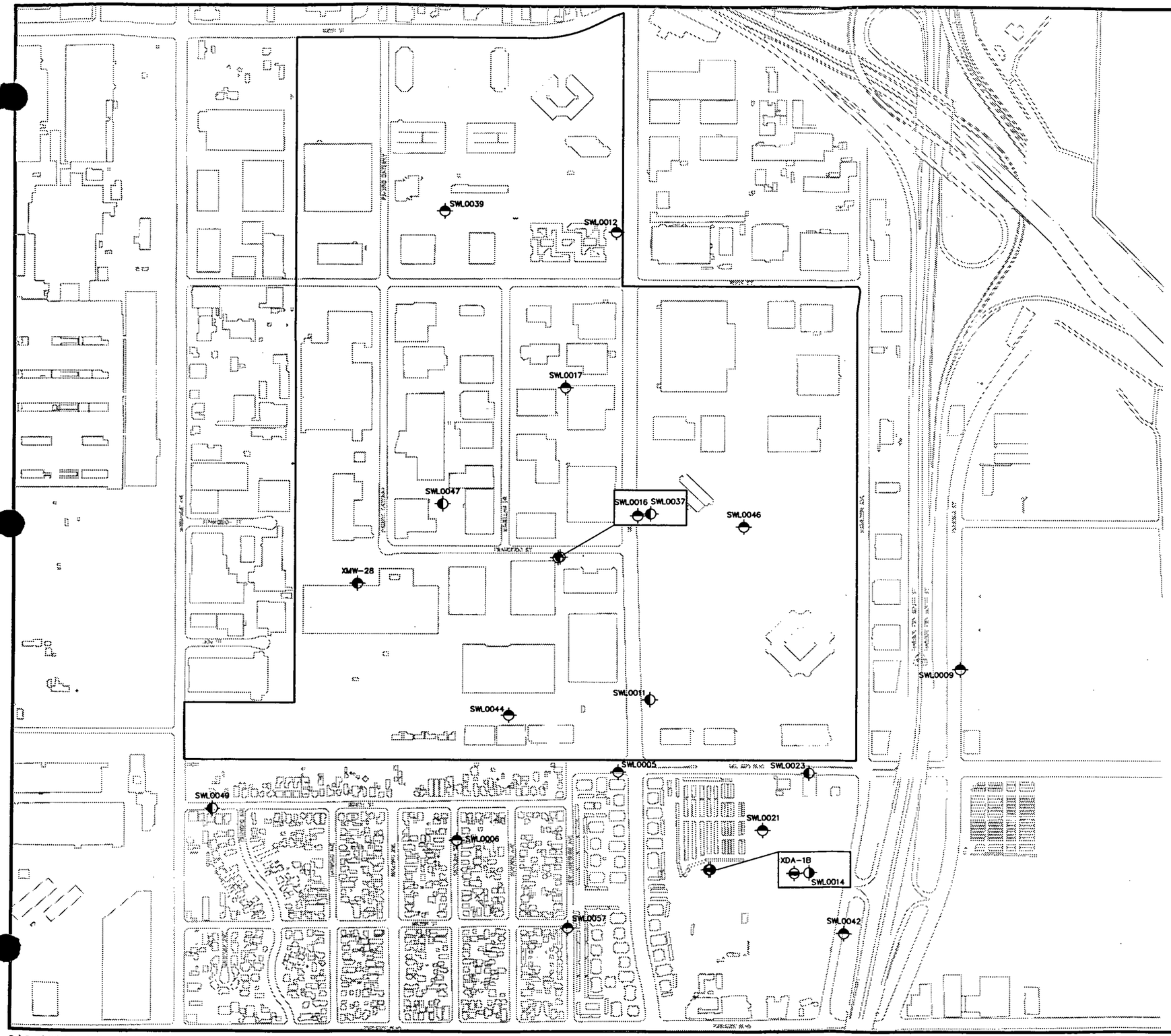
FIGURE 2.2-5

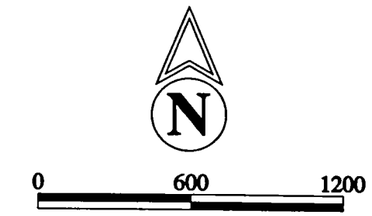
Groundwater Monitoring Locations

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

S:\DJD\NT_DWGS\22221, 10/03/96 at 15:50





EXPLANATION

SWL0012	Well screened in Upper Bellflower Aquitard
SWL0037	Well screened in Middle Bellflower B Sand
XMW-28	Well screened in both Upper Bellflower Aquitard and Middle Bellflower B Sand
SWL0014	Well screened in Middle Bellflower C Sand
XDA-1B	Well screened in Gage Aquifer

FIGURE 2.2-6

Aquifer Test Locations

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

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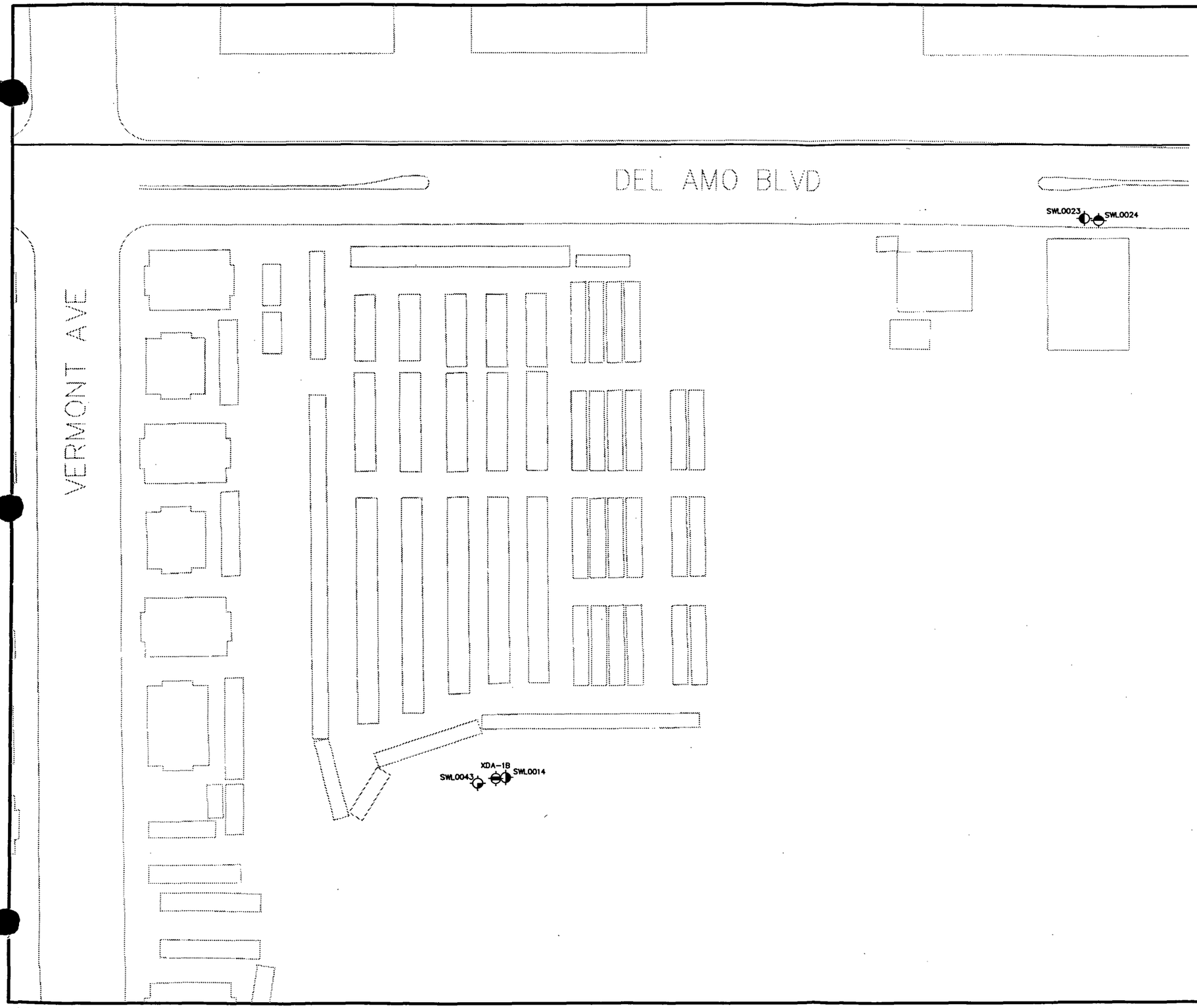

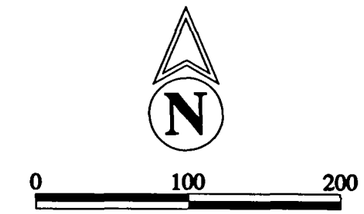

EXPLANATION

SWL0024	Well screened in Upper Bellflower Aquitard
SWL0023	Well screened in Middle Bellflower B Sand
SWL0014	Well screened in Middle Bellflower C Sand
SWL0043	Well screened in Lower Bellflower Aquitard
XDA-1B	Well screened in Gage Aquifer

FIGURE 2.2-7

Ratio Test Method Locations

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

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3.0 CONCEPTUAL HYDROSTRATIGRAPHIC MODEL

Presented in this section are discussions of regional and study area hydrostratigraphy and the conceptual hydrostratigraphic model for the study area. Section 3.1 discusses the regional physiographic and hydrostratigraphic settings. Section 3.2 discusses the local hydrostratigraphy, defines the conceptual hydrogeologic model for the study area, and describes the hydrostratigraphic units. Section 3.3 discusses the results of soil properties testing conducted during the hydrostratigraphic investigation. Section 3.4 correlates the local conceptual hydrogeologic model to nomenclature from regional studies the neighboring Montrose Plant Property. Section 3.5 is a discussion of sedimentology, depositional environments and geologic structure.

3.1 REGIONAL PHYSIOGRAPHIC AND HYDROSTRATIGRAPHIC SETTING

The physiographic and stratigraphic setting provides a framework for understanding the distribution of hydrostratigraphic units beneath the study area. The following sections briefly describe the regional geology of the Los Angeles basin and study area vicinity, identify the important stratigraphic and hydrostratigraphic units and describe their occurrence beneath the study area.

3.1.1 Physiographic Setting

The Del Amo study area lies in the Torrance Plain, a physiographic province within the broad coastal plain of the greater Los Angeles area (Figure 3.1-1). The broad coastal plain is bordered on the west and south by the Pacific Ocean, on the north by the Santa Monica Mountains, on the east by the Puente Hills, and on the southeast by the Santa Ana Mountains and the San Joaquin Hills (CDWR, 1961). The Torrance Plain is an older geomorphic surface which is west of and parallel to the belt of hills that occurs along the Newport-Inglewood structural zone, and is bounded on the southwest by the El Segundo Sand Hills and Palos Verdes Hills. The Newport-Inglewood structural zone is a composite faulted anticlinal belt which transects the coastal plain in a northwest-southeast direction and extends from Beverly Hills in the north to Seal Beach in the south. The belt of hills is the surface expression of deformation along the Newport-Inglewood fault zone and includes, from north to south, the Beverly, Baldwin, Rosecrans, Dominguez, Signal, Bixby Ranch, and Landing Hills. The Torrance Plain is a broad featureless area only slightly dissected by local streams.

The Torrance Plain is located within the West Coast groundwater basin, a northwest-southeast trending sub-basin of the Los Angeles coastal groundwater basin (Figure 3.1-1). The physiographic boundaries of the West Coast basin are the Ballona Escarpment on the north; the Baldwin, Rosecrans and Dominguez Hills on the east; and the Pacific Ocean on the south and west. The Palos Verdes Hills bound the southwest corner of the basin (Poland and others, 1959; CDWR, 1961).

3.1.2 Regional Hydrostratigraphic Setting

The West Coast basin is underlain by a thick sequence (up to 13,000 feet thick) of middle Miocene through Holocene-age marine and continental sediments deposited in a broad synclinal depression that overlies a basement complex of igneous and metamorphic rocks. The synclinal depression is locally interrupted by two series of anticlinal domes formed in Pliocene and older rocks which extend from Gardena to Playa Del Rey and through Wilmington to Torrance (CDWR, 1961). The underlying rock units of hydrogeologic interest are, from oldest to youngest: (1) the Pico formation; (2) the San Pedro formation; (3) the Lakewood formation; (4) Older Dune Sand; (5) Alluvium; and, (6) Active Dune Sand. Active Dune Sand and Older Dune Sand are not present within the study area.

Tertiary-age marine sediments in the West Coast basin underlie the Pleistocene-age deposits and include the Pliocene-age Pico and Repetto formations and the Miocene-age Puente and Monterey formations. These formations consist of sandstone, siltstone, mudstone, diatomite and siliceous shale and are of marine origin (CDWR, 1961).

The lower Pleistocene San Pedro formation unconformably overlies the Pliocene Pico formation and consists of unconsolidated to semi-consolidated gravel, sand, silt, and clay. Sediments are marine and continental in origin and attain a maximum thickness of about 1,000 feet.

The upper Pleistocene Lakewood formation unconformably overlies the San Pedro formation and consists of gravel, sand, sandy silt, silt, and clay. Sediments are marine and continental in origin and attain a thickness of about 400 feet. Pleistocene Old Dune Sand conformably overlies the Lakewood formation. Holocene deposits conformably overlie the Lakewood formation and consist of alluvium and active dune sand which are typically present at surface outcrops throughout the West Coast basin (Poland and others, 1959). Older Dune Sand and Active Dune Sand are not present within the study area.

CDWR (1961) reports the general depositional setting for the units in the study area vicinity as marine to continental. Within this general transitional setting are several depositional environments, including alluvial fans, deltas, and estuaries that contain complex and lithologically heterogeneous deposits. Known sea level fluctuations and tectonic activity (CDWR, 1961) may also affect the vertical and lateral distribution of geologic units in the study area vicinity.

The study area lies on the southwest limb of the Gardena syncline (CDWR, 1961). At the study area, hydrostratigraphic units appear to dip at about 1° to the east to northeast, consistent with the regional geologic structure. Kennedy/Jenks/Chilton (1991) suggest that beds in the upper Pleistocene to Holocene section may dip similarly.

The study area is underlain by marine and continental deposits of the Lakewood and San Pedro formations. These formations consist of sand, sandstone, and silty sandstone aquifers separated by silt and/or clay aquitards, and have a cumulative thickness of greater than 800 feet in the study area vicinity. Based on published well logs and interpretive cross sections, significant aquitards are present within the Lakewood and San Pedro formations in the study area vicinity (CDWR, 1961). From shallowest to deepest, the regional hydrostratigraphic units are: (1) Old Dune Sand aquifer; (2) Bellflower aquitard; (3) Gage aquifer; (4) Gage-Lynwood aquitard; (5) Lynwood aquifer; (6) an unnamed aquitard; (7) Silverado aquifer; (8) Redondo Beach aquitard; and (9) lower San Pedro aquifer. The Old Dune Sand aquifer is not present in the study area vicinity.

The Bellflower aquitard is the shallowest regional hydrostratigraphic unit and is not considered a groundwater resource (CDWR, 1961). As further discussed in Section 7.0, the underlying Gage aquifer is not utilized as a source of drinking water by the major water purveyor in this area (Dominguez Water Company, personal communication, 1993, 1996a, 1996b). However, limited groundwater is apparently produced by the City of Torrance from several municipal supply wells completed partially in the lower portion of Gage Aquifer. These wells are located approximately two miles southwest of the plant site in a cross gradient position. Beneath the Lakewood formation, regionally extensive hydrostratigraphic units in the lower Pleistocene San Pedro formation form the primary groundwater resources in the basin (CDWR, 1961). The shallower of these hydrostratigraphic units, the Lynwood aquifer, is separated from the Gage aquifer by the Gage-Lynwood aquitard, which is composed of interbedded silts and clays up to 40 feet thick in the study area vicinity (CDWR, 1961; Hargis + Assoc., 1990d and 1992). The deeper Silverado aquifer is separated from the Lynwood aquifer by a regionally extensive

aquitard, which attains a thickness of approximately 175 feet beneath the study area (CDWR, 1961).

3.2 STUDY AREA HYDROSTRATIGRAPHY

The conceptual hydrostratigraphic model for the study area was developed through an understanding of the regional and site-specific stratigraphic and structural framework to evaluate the distribution of principal hydrostratigraphic units in the shallow subsurface beneath the area (including approximately the upper 200-250 feet).

3.2.1 Conceptual Hydrostratigraphic Model

The analysis of detailed hydrostratigraphic data discussed below has led to development of a conceptual hydrostratigraphic model for the study area. Figure 3.2-1 is a block model illustrating the simplified distribution of principal hydrostratigraphic units beneath the study area. The relatively detailed and high quality character of hydrostratigraphic data collected during this investigation allowed both the verification of the published regional hydrostratigraphy and the further subdivision into study area-specific hydrostratigraphic units, as follows: 1) the upper Bellflower aquitard (UBF); 2) the middle Bellflower sand (MBF); 3) the lower Bellflower aquitard (LBF); 4) the Gage aquifer; (5) the Gage-Lynwood aquitard (GLA); and, (6) the Lynwood aquifer. The middle Bellflower sand can locally be subdivided into three members: (1) the middle Bellflower B sand (MBFB); (2) the middle Bellflower mud (MBFM); and, (3) the middle Bellflower C sand (MBFC).

There are generally two types of hydrostratigraphic units present within the study area including predominantly coarser grained sands and finer grained muds. The terms sand and mud are used in this report to describe the dominant character of the two types of hydrostratigraphic units. A sand is defined as a laterally continuous hydrostratigraphic body dominated by fine to medium sand and are named sands or aquifers. A mud is defined as a laterally continuous hydrostratigraphic body dominated by clay, silt, and very fine sand, and are named muds or aquitards. Sands can contain local "muddy" zones and muds can contain local "sandy" zones, especially at the upper and lower boundary of the units.

Study area-wide hydrostratigraphic cross sections were developed to show the vertical and lateral distribution of the hydrostratigraphic units. These cross sections are included as Plates 3-1 through 3-10. The location of these cross sections are shown in Figure 3.2-2. Structural contour maps were developed to illustrate in plan view the relative elevations of the base of hydrostratigraphic units and the general east to northeast-dipping geologic structure (Figures 3.2-3 through 3.2-7). Thicknesses of each hydrostratigraphic unit are presented on isopach maps (Figures 3.2-8 through 3.2-15).

The block model, cross sections, and contour maps shown on the figures and plates were based on the best quality soil boring data available within the study area. While all available data was reviewed and considered, the interpretations of the hydrostratigraphic contacts between hydrostratigraphic units were developed from: (1) soil boring locations drilled deep enough to encounter hydrostratigraphic contacts; and, (2) locations where data regarded of high quality and confidence was available. The quality of the data available was viewed with regard to objectivity, such as geophysical and CPT data, supplemented by subjective descriptions of lithology by field geologists. The potential subjectiveness of the lithologic descriptions was minimized where core photographs were utilized to verify field descriptions. Hydrostratigraphic control locations were selected where data of sufficient quality was available. Tables 3.2-1 and 3.2-2 summarize the elevations of the base of hydrostratigraphic units and thicknesses of hydrostratigraphic units at the selected locations. Soil boring logs are presented in Appendix B, geophysical logs are presented in Appendix D, and CPT logs are presented in Appendix E.

The principal hydrostratigraphic units are laterally continuous on a study area-wide scale and can be correlated between borings. The nature and distribution of small-scale hydrostratigraphic features can be inferred from the interpreted depositional setting and from information obtained during completion of other investigative borings, CPT logs, and monitoring well borings. As discussed in following report sections, heterogeneities inherent among these small-scale hydrostratigraphic features have a significant effect on groundwater flow and contaminant transport.

3.2.2 Hydrostratigraphic Unit Definition and Descriptions

Published stratigraphic nomenclature for the study area and vicinity is very generalized. All the sediments encountered in this study are identified as being part of the upper Pleistocene Lakewood formation. CDWR hydrostratigraphic nomenclature (1961) is used to identify the

major hydrostratigraphic units within the Lakewood formation; these units include the Bellflower aquitard and Gage aquifer. The Bellflower aquitard is a dominantly muddy portion of the Lakewood formation that lies in the shallow subsurface. The Gage aquifer is defined as a dominantly sandy interval of the Lakewood Formation that lies directly underneath the Bellflower aquitard.

The Bellflower aquitard is between 160 and 185 feet thick and consists of sand and mud intervals of variable thickness. The Bellflower aquitard can generally be divided into three discrete and laterally continuous stratigraphic subunits based on the predominance of muddy or sandy lithotypes, including: (1) the upper Bellflower, which is predominantly muddy; (2) the middle Bellflower, which is predominantly sandy; and, (3) the lower Bellflower, which is predominantly muddy.

Beneath the study area, the Bellflower aquitard contains a significant sandy interval that formed in a similar depositional environment as the Gage aquifer. As a result, the Bellflower aquitard was further divided into subunits that reflect distinct depositional settings which affect hydrogeologic conditions beneath the area. Depositional settings are discussed in Section 3.5.2.

Previous studies in the vicinity suggest that Holocene-age surficial deposits beneath the study area extend to depths of approximately 30 feet below ground surface and are distinct from the underlying Bellflower aquitard (Hargis + Assoc., 1990d and 1992). However, data collected during the present study indicate that the sediments in the upper 30 feet are indistinguishable from the sediments in the Bellflower aquitard.

Following the established framework of regional hydrostratigraphy and hydrostratigraphic nomenclature, and focusing on the stratigraphic data collected during this investigation, the hydrostratigraphic units defined for the study area are described in the following sections.

3.2.2.1 Upper Bellflower Aquitard

The uppermost hydrostratigraphic unit within the Del Amo study area is the UBF. The upper Bellflower consists of laminated to massive yellowish brown muds up to 30 feet thick, with local sands and fossiliferous zones. Lithologic descriptions from soil borings and interpretation of CPT curves completed during the RI and related investigations (such as those completed at the Waste Pit Area and the MW-20 area) show that the sands within the upper Bellflower are discontinuous. The sand layers can be from one to greater than 10 feet thick and can extend laterally greater than 1000 feet.

The UBF ranges in thickness from 41 feet in the southwest corner of the study area to a maximum observed thickness of 97 feet in the northeast corner of the study area. The average thickness of the UBF is 74 feet. Elevations of the base of the UBF range from 15 to 71 feet below mean sea level.

A particularly distinctive feature of the UBF is a laterally extensive fossiliferous layer found at depths ranging from about 40 to 50 feet below ground surface (5 feet below to 5 feet above mean sea level). A layer of dark brown clayey fill from 2 to 7 feet thick overlies the UBF across most of the study area. Typically underlying the fill is an approximately 20- to 30-foot thick massive very fine sandy silt to silty very fine sand. Beneath this sandy silt/silty sand are stratified muds and sands extending the base of the UBF. Some zones in the upper Bellflower appear to contain fossil roots, suggesting subaereal exposure at the time of deposition.

CPT logs were very useful in evaluating the distribution of sediments of the UBF. Relative grain size was found to be proportional to CPT tip resistance, and these data were a good indicator of sandy versus muddy layers. The use of geophysical logs was limited by unpredictable fluctuations of resistivity response in the unsaturated zone and suppression of response due to high dissolved mineral content at the water table. Gamma logs were somewhat helpful in interpretations of the internal stratigraphy of the UBF.

3.2.2.2 Middle Bellflower Sand

Underlying the generally muddy UBF is the MBF sand. The MBF is a massive, light yellowish brown, fine to medium sand with local muddy zones. The average approximate thickness of the MBF is 65 feet. A significant and laterally extensive mud layer from 1 to 25 feet thick is present within the MBF beneath a portion of the study area. This mud layer is absent in the central and south central portions of the study area. The MBF is therefore divided into three distinct members, including: (1) the upper MBF B Sand (MBFB); (2) the MBF mud itself (MBFM); and, (3) the lower MBF C sand (MBFC). Where the MBFM is absent, the sand packages of the MBF are merged and collectively referred to as the MBFB/C sand on the cross sections presented on Plates 3-1 through 3-10.

<u>Middle Bellflower B Sand</u>

The MBFB sand is generally an olive colored fine sand. Locally, the MBFB can contain minor muddy layers and laminations. Sedimentary structures observed in the MBFB include planar stratification, cross-stratification, bioturbation, and massive sand. Local mud drapes and mud rip-up clasts are also observed.

Based on soil boring information penetrating the MBFB where the MBFM is present, available core data indicate a 15-foot average thickness for the MBFB, a minimum observed thickness of 4 feet and a maximum observed thickness of 34 feet. The elevation of the base of the MBFB ranges from 13 feet below mean sea level in the southwest corner of the study area at soil boring XMW-22 to 91 feet below mean sea level at soil boring SBL0034 in the northeast corner of the study area. Geophysical logs indicate relatively high resistivity, low gamma counts, and low spontaneous potential in the MBFB sediments. The MBFB is defined on CPT logs by a very pronounced peak indicating a sharp increase in grain size upon contact with the MBFB. The CPT probe often encountered refusal at the top of the MBFB.

Middle Bellflower Mud

The MBFM is a muddy unit comprised of laminated and layered silts and very fine sands. The MBFM is the only hydrostratigraphic unit that is not present throughout the study area. Figure 3.2-10 is an isopach map illustrating the area in the central and southeastern portion of the study area where the MBFM pinches out and is not present. The transition from the MBFB downward into the MBFM is typically gradational, where the appearance of mud layers and laminations in the MBFB grade to a predominantly muddy MBFM with sand layers and laminations.

Based on soil boring information within the study area penetrating the unit where the MBFM is present, available core data indicate a 7-foot average thickness for the MBFM and a maximum observed thickness of 43 feet. The MBFM pinches completely in the central and southern portion of the study area, as discussed above. The elevation of the base of the MBFM ranges from minus 36 feet msl in the southwest corner of the study area at soil boring XMW-16 to minus 103 msl feet at soil boring SBL0027 in the north central portion of the study area. Geophysical logs indicate relatively low resistivity, high gamma counts, and high spontaneous potential in the MBFM sediments.

Middle Bellflower C Sand

The MBFC sand is a thick body of fine to medium sand with local muddy layers and lenses. The transition from the MBFM to the MBFC is sharp to gradational, marking the transition from mud and muddy sand to predominantly clean fine sand. A distinctive coarsening of sand size occurs near the base of the MBFC, in most cases the medium sand contains fossiliferous layers of mostly shell fragments in a sand matrix. Sedimentary structures observed in the

MBFC include large and small scale cross-stratification, burrows, bioturbation, mud rip-ups, and mud drapes. Much of the MBFC is massive and structureless, suggesting bioturbation.

Based on soil boring information penetrating the MBFC where the MBFM is present, available core data indicate a 43-foot average thickness for the MBFC, a minimum observed thickness of 9 feet and a maximum observed thickness of 60 feet. The elevation of the base of the MBFC ranges from minus 72 feet in the southwest corner of the study area at soil boring SBL0020, to minus 129 feet as soil boring SBL0028 in the northern portion of the study area. Geophysical logs indicate relatively high resistivity, low gamma counts, and low spontaneous potential in the MBFC sediments. The base of the MBFC typically shows a pronounced high geophysical resistivity signature.

Where the MBFM is absent, the merged MBFB/C is a virtually uninterrupted sand unit with inferred greater hydraulic interconnection relative to where the mud is present. Even where the mud is absent, the upper "MBFB" portion can typically be distinguished from the basal "MBFC" portion within the merged unit based on the subtle lithologic and geophysical variations described herein. Therefore, while the MBFB and MBFC are merged over a significant portion of the site, monitoring wells that penetrate the merged unit are still classified as being either MBFB or MBFC depending on whether they are screened in the upper or basal portions of the MBFB/C. For this reason, figures presented later in this report illustrating study area groundwater water elevation contours and contaminant distributions are always specific to either the MBFB or MBFC rather than being presented for a merged MBFB/C for a portion of the study area.

3.2.2.3 Lower Bellflower Aquitard

The LBF is an overall muddy hydrostratigraphic unit, and is present throughout the study area. The fine-grained deposits consist of laminated to massive muds and interbedded fine sands and muds. The sandy intervals consist of planar laminated to cross-stratified fine to medium-grained sands. The transition from the MBF to the LBF is sharp to gradational, marked in most cases by the presence of bluish gray and greenish gray muds beneath the sand and shell fragments of the base of the MBFC. The top and bottom contacts can be sharp or gradational depending on location.

The LBF averages 27 feet in thickness, ranging from a minimum of five feet to a maximum 25 feet over the study area. While overall a muddy unit with hydraulic properties representative of an aquitard, the LBF is comprised of complex and heterogenous interval of

layered sediments. Analysis of lithologic data indicates that the layering is grouped into three general packages; an upper muddy package, a middle sandier package, and a lower muddy package. The thicknesses of the respective units varies and the predominantly sandy middle layer is locally discontinuous. Good examples of the LBF layering are seen on cross section G-G′ at soil borings SBL0078, SBL0107, and SBL0077. Geophysical logs indicate relatively low resistivity, high gamma counts, and high spontaneous potential in the LBF sediments.

3.2.2.4 Gage Aquifer

The transition from the LBF to the Gage aquifer is generally gradational with the muddy layers grading into clean fine to medium sands. The Gage aquifer is predominantly a sandy hydrostratigraphic unit showing sedimentary structures and packages that are similar to those observed in the sands of the MBF.

The Gage aquifer averages 66 feet in thickness over the study area, and ranges from a minimum of 40 to an observed maximum of 78 feet thick. The elevation of the base of the Gage aquifer ranges from 186 feet below mean sea level in the southwest corner of the study area to 216 feet below mean sea level in the northeast corner.

Massive to cross-stratified clean sands appear to be packaged in 10- to 20-foot thick fining upward sequences. A particularly distinctive feature near the base of the Gage aquifer is a fossiliferous layer containing whole shells and shell fragments. The fossil assemblage includes gastropods, bi-valves, and echinoderms (sand dollars). Geophysical logs indicate relatively high resistivity, low gamma counts, and low spontaneous potential in the Gage aquifer sediments.

3.2.2.5 Gage-Lynwood Aquitard

The Gage-Lynwood aquitard is an overall muddy hydrostratigraphic unit showing similar character to that observed in the LBF. The fine-grained deposits consist of laminated to massive muds and interbedded fine sands and muds. The sandy intervals consist of planar laminated to cross-stratified fine to medium-grained sands. Available data indicate that the GLA is present throughout the study area with an estimated thickness of about 26 feet. The elevation of the base of the GLA ranges from 172 feet below mean sea level at XEB-06 to 228 feet below mean sea level at XEB-09. No borings penetrated the total thickness of the GLA in the northern portion of the study area.

Exploratory soil borings for this investigation did not completely penetrate the total thickness of the GLA; however, partial thicknesses were explored at seven locations, including SBL0021, SBL0027, SBL0033, SBL0077, SBL0078, SBL0080, and SBL0081. Investigations by others within the study area provide further data on the sediment grain-size and geophysical properties but lack observations of primary sedimentary structures. Soil boring locations XDA-1A (EPA, 1989); and XEB-2A, XEB-05, XEB-09, and XEB-12 (Hargis + Associates borings) were used as supplementary data to characterize the presence and thickness of the GLA. These borings are considered adequate to characterize and verify the presence and general character of the GLA in the study area.

3.2.2.6 Lynwood Aquifer

Soil Borings completed in the Lynwood aquifer in 1989 and 1990 by Hargis + Associates reveal laminated fine- to coarse-grained sands with local gravel beds. The Lynwood aquifer reportedly occurs at depths of approximately 220 feet to 250 feet bgs (CDWR, 1961; Hargis + Assoc., 1992) and extends to a depth of approximately 375 feet bgs within the study area vicinity (CDWR, 1961).

3.3 MATERIAL PROPERTIES

As part of the hydrostratigraphic evaluation of the study area, selected soil samples were collected during the drilling and logging of exploratory soil borings for laboratory testing of physical soil properties. Representative samples of each HSU were collected from a broad geographic area to develop an understanding of soil physical properties variation within each unit. The distribution of soil properties data availability is illustrated in Figure 2.2-3. The various soil properties tests conducted included determination of the following parameters: grain-size distribution; bulk density; moisture content; vertical and horizontal hydraulic conductivity; vertical and horizontal air permeability; and, plasticity (Atterberg limits). The availability of soil properties data is summarized in Table 2.2-3.

A summary of the results of soil properties testing is presented in Appendix F. The Appendix includes three sections: (1) a summary table of physical test results; (2) sediment grain-size distribution graphs; and, (3) a summary table and discussion of results of consolidation tests conducted on selected soil samples of aquitard sediments.

Soil properties data were collected primarily to assist in monitoring well design and construction and to fulfill the data requirements of the Groundwater FS and the groundwater flow and transport model.

3.4 CORRELATION WITH LOCAL AND REGIONAL NOMENCLATURE

Hydrostratigraphic unit designations were assigned to merge the study area-specific hydrostratigraphy with established local and regional nomenclature. This objective was accomplished to a large degree, and direct correlations were made whenever possible. The Gage aquifer, the Gage-Lynwood aquitard, and the Lynwood aquifer reported here correlate directly to published CDWR (1961), Hargis + Associates (1990d, 1992), and EPA (1989) terminology.

The Bellflower aquitard reported by CDWR is consistent with The UBF/MBF/LBF described in Section 3.2.2. Some differences are noted between the Bellflower aquitard hydrostratigraphy reported at the Montrose Plant Property at the southwest corner of the study area and the UBF/MBF/LBF used in this study. The Bellflower aquitard hydrostratigraphic units at the Montrose Plant Property were described by Hargis + Associates from land surface down as: (1) Playa; (2) the Palos Verdes Sand; (3) a fossil layer; (4) the upper Bellflower aquitard; (5) the Bellflower sand; and, (6) the lower Bellflower aquitard. The UBF of the Del Amo study area is correlative to the Playa, Palos Verdes Sand, fossil layer and a portion of the upper Bellflower aquitard at the Montrose Plant Property. The MBFB of the Del Amo study area is correlative to a sandy interval of the Montrose upper Bellflower aquitard. The MBFM of the Del Amo study area is correlative to the base of the Montrose upper Bellflower aquitard. The MBFC and the LBF of the Del Amo study area are correlative to the Bellflower sand and lower Bellflower, respectively, of the Montrose Plant Property. These similarities and differences are illustrated in Figure 3.4-1.

A regional groundwater flow and transport model (model) is currently under joint development by representatives of Shell, Dow, and Montrose. The results of this modeling effort will be presented in the joint Montrose/Del Amo Groundwater FS report. The stratigraphic layering used for this model was developed based on the conceptual hydrostratigraphic model presented in this section. The flow and transport model is comprised of thirteen layers, numbered 1 through 13, based on the hydrostratigraphic units presented in Section 3.2.2. Each hydrostratigraphic unit is represented by one or more model layers. The MBFC was subdivided into two model layers based on the description of an upper fine sand and lower

medium sand with fossil layers (Section 3.2.2.2). The LBF was subdivided into three model layers based on observed layering (Section 3.2.2.3). While there is limited data available from the GLA, it was also subdivided into three model layers based on observed similarities to the LBF and to facilitate modeling objectives. The correlation of model layers to study area hydrostratigraphic units is shown in Figure 3.4-1.

3.5 SEDIMENTOLOGY, DEPOSITIONAL SETTING, AND STRUCTURE

This section presents a interpretive summaries of sedimentology, depositional setting, and structure based on the data collected during this investigation. Section 3.5.1 discusses the sedimentology. Section 3.5.2 discusses depositional environments which associate observed sedimentary structures and grain size ranges to specific depositional settings. Section 3.5.3 discusses the basic geologic structure of the study area sediments.

3.5.1 Sedimentology

Deposits of the Bellflower aquitard and Gage aquifer consist of interbedded sands and muds, with the sands fining upward into muds, either gradually or with a sharp contact. Overall, the Bellflower is dominated by muds. The Gage and the middle subunit of the Bellflower are dominated by sands and are separated stratigraphically by 15 to 35 feet of lower Bellflower muds. Specific sedimentary features of these units are described below.

The basal contact of the upper Bellflower is generally sharp, with upper Bellflower muds directly overlying sands of the middle Bellflower. Evaluation of continuous soil cores and geophysical logs indicates that sands within the middle Bellflower are packaged in 5- to 15-foot thick fining upward cycles. The sands at the base of the middle Bellflower are generally medium- to coarse-grained and display large-scale cross-stratification to planar lamination. Sand packages of the middle Bellflower locally contain fossil assemblages and fine upward through interlaminated fine sand and mud to laminated mud. The sands and muds commonly show sharp contacts, suggesting that flow velocities within the depositional system changed rapidly. Overall, the middle Bellflower appears to be fining upward into the mud-dominated upper Bellflower. The general upward-fining trend reflects the general decrease in depositional energy from the active tidal channel to the tidal flats of a coastal estuary. Rapid fluctuation in flow velocity caused by tidal influences should produce sharp contacts between sand and mud within the overall fining upward sequence.

The lower Bellflower is similar to the upper Bellflower, with massive to laminated mud deposits containing thin sandy and fossiliferous zones. Muds of the lower Bellflower were encountered in all borings that penetrated to sufficient depths, indicating that the unit is laterally continuous beneath the study area. Sand deposits 2 to 5 feet thick are locally developed within the lower Bellflower (see geologic log of SBL0027 at 140 to 155 feet bgs, Appendix and on Plate 3-6).

The Gage aquifer consists of two or possibly three cycles of fining upward sands. Overall, the sand packages fine upward, culminating in the muddy deposits of the lower Bellflower. The contact between the lower Bellflower and Gage appears gradational with thin mud laminae becoming more and more prevalent in the uppermost part of the Gage. Muds one to three feet thick are locally developed in the uppermost portion of the Gage. The central portion of the Gage contains medium-to coarse-grained sand with large-scale cross-stratification, that fines upward into medium to fine sand showing cross-stratification, planar lamination, slump structures and burrows. Locally, bedding appears to be cyclic (see for example core of SBL0021 at 176 to 177 feet bgs, Appendix B), suggesting regular changes in flow conditions. The basal fining upward cycle in the Gage begins with an approximately 1- to 5-foot thick lag deposit consisting of a fossiliferous zone of bivalve, gastropod (snail), and echinoderm fossils in a matrix of medium to coarse sand, overlain by a generally massive to bioturbated medium- to fine-grained sand with local bivalve fossils in life position.

3.5.2 Depositional Setting

Sedimentology of the Bellflower aquitard and Gage aquifer suggests these units were deposited in a coastal estuarine environment. Coastal estuaries form where rivers enter the ocean and fluvial processes are modified by tidal and marine processes. The primary depositional processes within estuaries are a mixture of fluvial, tidal, and marine. Important depositional features within the estuary include large tidal channels flanked by tidal flats and supra-tidal marshes. Small tidal channels, known as tidal runoff creeks, cut across the tidal flat and provide drainage into the main channels (Clifton, 1982). Figure 3.5-1 is a schematic representation of the interpreted paleogeographic setting and illustrates the various depositional environments reflected in the shallow sediments underlying the study area.

Flows within the large tidal channels and tidal runoff creeks alternate as tides flood and ebb in the estuary. Deposition occurs on channel banks during both flood and ebb tides, in a manner similar to deposition on point bars in a wholly fluvial environment. Within the estuary,

lateral shifting of the tidal channels produces an overall fining upward sequence as channel deposits are overlain by finer-grained tidal flat deposits and capped by supra-tidal marsh deposits (Clifton, 1982). Typically at the base of the channel deposits are lag deposits of coarse sand to fine gravels (often shells and shell fragments), where the finer-grained material has been winnowed away by currents (Blatt et al., 1980). Rapid changes in flow velocity caused by tidal fluctuations may produce local sharp contacts between sands and muds. Tidal fluctuations may also produce local cyclic bedding.

The large channel deposits are expected to form thick, laterally continuous sand bodies that result from lateral migration of the tidal channel across the estuarine basin. On a regional scale, these large tidal channel deposits should be oriented perpendicular to the paleocoastline. The smaller tidal runoff creeks cut into the finer-grained tidal flat deposits and produce small sand bodies that may be laterally discontinuous. The geometry of these smaller sand bodies depends on the amount of mud within the tidal flat deposits. If the tidal flats are mud dominated, lateral migration of these tidal runoff creeks may be limited, as the cohesive muddy banks hinder erosion (Clifton, 1982). Sand-dominated tidal flats may allow greater lateral migration of the tidal runoff creeks. Depending on the dominant material, tidal runoff creek deposits could potentially be linear and ribbon-like in a muddy setting, or planar and sheet-like in a sandier setting. Because these smaller tidal runoff creeks drain into the larger tidal channels, they are typically oriented at a high angle closer to the larger channels and at varying angles farther away from the main channel.

Within the context of a coastal estuarine environment, the muddy deposits of the upper and lower Bellflower are interpreted to have resulted from deposition on tidal flats and subareal supra-tidal marshes. The presence of interbedded muds and sands, bioturbated sands, and local root structures supports this interpretation. Sands within the upper and lower Bellflower are interpreted as deposits of tidal runoff creeks. Because the upper and lower Bellflower are mud dominated, the sands contained within them are expected to be linear, ribbon-like bodies. These sands are expected to be best developed perpendicular to the main tidal channel axis. Along a given tidal runoff creek, the amount of sand may vary and locally diminish to the point of isolating the sand from other parts of the channel. Slumping of muddy point bars could also locally isolate sands accumulating in tidal runoff creeks.

The thick and laterally continuous sand deposits of the middle Bellflower and Gage within the study area are interpreted to reflect deposition in tidal channels. The presence of cross-stratified sands, slump structures, bioturbated zones, lag deposits, and cyclic bedding are consistent with this interpretation.

Preliminary evaluation of core from soil borings drilled in 1989 and 1990 by Hargis + Associates suggests that deposits of the Lynwood aquifer may reflect deposition in a shallow marine-to-beach setting. The overlying muddy deposits of the Gage-Lynwood aquitard likely represent some type of back-beach/coastal estuary setting. Progradation of a beach into a marine basin could produce an extensive sheet sand, as described for the Lynwood aquifer by CDWR (1961) and Hargis + Associates (1990d and 1992).

Rooted horizons suggest that deposition must have occurred in an environment transitional from continental (subareal) to marine, likely in an estuarine setting.

3.5.3 Structure

Data from this investigation and from investigations conducted by others in adjacent areas were used to generate the structural contour maps (Figures 3.2-3 through 3.2-7). A contour interval of 10 feet was selected to show the slight east to northeast dipping structure. Based on the contour sets, average structural gradients for hydrostratigraphic units range from 8 to 12 feet per thousand, translating to structural dips from 0.5° to 1°, generally to the east to northeast. The lack of linearity of the structural contours generally reflects the gradational nature of the transition from one environment of deposition to the next and the expected topographic relief which existed at the time of transition.

This structure appears consistent with the regional structural interpretation that places the study area on the southwest limb of the Gardena syncline and at the southwestern margin of the Newport-Inglewood structural zone (Figure 3.1-2). The slight structural dip is not expected to substantially impact groundwater flow in the vicinity of the study area. As discussed in Section 4.1.2, the structural dip does cause the water table to intersect the contact between the UBF and the MBFB in the southwest portion of the study area.

TABLE 3.2-1
Summary of Hydrostratigraphic Control Data:
Elevations of Base of Hydrostratigraphic Units at Available Control Locations
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				Elevations of Base of Hydrostratigraphic Units (Feet Mean Sea Level)						
Location	Easting	Northing	Reference Elevation	UBF	MBFB*	MBFM	MBFC	LBF	Gage	GLA
CPL0005	198505	57792	37.5	-33						
CPL0009	199559	57676	32.8	-44						
CPT-1	199266	56201	33.5	-34						
CPT-11	199532	56718	34.2	-42						
CPT-12	199448	56533	34.0	-38						
CPT-13	199181	56520	34.5	-34						
CPT-14	199030	56521	35.0	-34						
CPT-15	198879	56516	35.5	-34						
CPT-16	198729	56518	35.8	-33						
CPT-17	199084	56721	36.3	-36						
CPT-18	198939	56720	36.8	-33						
CPT-2	198211	56172	38.0	-17						
CPT-3	199594	56220	27.3	-42						
CPT-4	198847	56449	32.2	-33						
CPT-5	199712	56474	30.4	-41						
CPT-6	199910	56420	29.8	-46						
CPT-7	199333	56521	33.5	-37						
CPT-8	199532	56510	32.6	-40						
SBL0013	199584	58732	36.4	-39	-47	-47	-101	-144		
SBL0014	198063	56984	38.4	-21	-44	-47	-96			
SBL0015	198907	58894	37.2	-34	-54	-60	-115	-131		
SBL0016	198842	56885	35.7	-34	-53	-53	-109			
SBL0019	201224	57883	21.3	-61	-84	-84	-105	-141		
SBL0020	197440	56537	42.4	-15	-35	-58	-72	-100		
SBL0021	198037	59262	42.7	-30	-46	-57	-92	-115	-182	
SBL0022	200338	57885	32.0	-50	-66	-66	-113	-149		
SBL0023	199215	56525	34.8	-33	-51	-51	-101			
SBL0024	198585	56524	36.4	-27	-56	-56	-104			
SBL0025	201300	59096	23.6	-68	-82	-82	-112			
SBL0026	200391	56456	31.5	-58	-71	-71	-124			
SBL0027	198428	60735	40.4	-49	-79	-103	-116	-138	-216	
SBL0028	201141	56416	26.8	-60	-73	-73	-129			
SBL0029	198634	58107	39.7	-32	-36	-36	-105			
SBL0030	198030	59899	42.2	-33	-54	-63	-95			
SBL0031	201301	57135	24.0	-66	-73	-73	-105	-136		
SBL0032	199326	60737	36.7	-57	-87	-97	-120			
SBL0033	199890	60401	35.7	-79	-100	-104	-133	-149	-221	
SBL0034	199336	60109	40.1	-57	-91	-97	-120	-141		
SBL0035	200685	58611	28.7	-56	-69	-69	-106	-135		
SBL0050	198271	58410	40.9	-30						
SBL0051	201891	57040	23.6	-71	-76	-76	-112	-146		
SBL0052	200097	56873	33.9	-54	-78	-78	-117	-144		
SBL0053	200451	55844	20.2	-54	-78	-78	-112	-146		
SBL0054	201078	55866	21.1	-61	-69	-69	-125	-156		
SBL0059	199423	56862	34.8	-40	-51	-51	-107	-136		
SBL0065	198400	56617	38.9	-21						
SBL0077	200260	54982	23.2	-42	-60	-60	-108	-130	-190	
SBL0078	197954	58850	42.3	-32	-46	-57	-90	-116	-182	
SBL0079	198261	58275	42.3	-33	-43	-50				
SBL0080	198562	56183	36.2	-47	-58	-58	-108	-117	-176	
SBL0081	199553	57684	33.2	-46	-59	-59	-104	-139		
SBL0084	199556	56522	32.7	-41	-57	-57	-104			

TABLE 3.2-1
Summary of Hydrostratigraphic Control Data:
Elevations of Base of Hydrostratigraphic Units at Available Control Locations
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				Elevations of Base of Hydrostratigraphic Units (Feet Mean Sea Level)						
Location	Easting	Northing	Reference Elevation	UBF	MBFB*	MBFM	MBFC	LBF	Gage	GLA
SBL0097	198884	57958	36.3	-42	-47	-47	-100			
SBL0099	198445	57717	39.5	-34	-43	-49	-105			
SBL0101	199100	57244	36.8	-41	-45	-45	-100			
SBL0103	198993	56528	35.4	-35	-39	-39	-97			
SBL0106	199976	56155	23.7	-49	-54	-54	-108			
SBL0107	199614	55494	29.4	-40						
SBL0108	198515	56928	38.5	-33	-46	-48	-108			
XBF-18	196366	58108	51.4	-19	-33	-57	-94			
XBF-32A	194857	55589	54	7						
XDA-1A	200434	55845	21.6						-200	-250
XDM-3	198869	56467	32.0	-34						
XEB-01	196227	57561	49.1	3	-19	-41	-74	-90	-152	
XEB-03	197791	57207	40.9	-14	-38	-49	-90	-112	-174	-200
XEB-04	197706	56869	42.7	-16	-32	-43	-81	-106	-167	-189
XEB-05	197394	56505	41.5						-158	-178
XEB-06	196937	56497	44.0	-8	-29	-43	-80	-96	-150	-172
XEB-08	196877	57820	49.3	-2	-18	-47	-88	-99	-171	-189
XEB-09	199639	56482	31.1	-40	-56	-56	-106	-140	-191	-228
XEB-10	198999	56480	35.4	-40						
XEB-11	198585	55652	37.8	-26	-41	-41	-84	-113	-173	
XEB-12	199599	55474	31.0	-38	-43	-49	-100	-149	-189	-219
XEB-13	200059	54027	25.0	-37	-50	-50	-97	-123	-185	-205
XEB-14	198540	54420	32.0	-36	-48	-59	-93	-110	-168	-180
XEB-15	197240	54950	40.5	-38	-44	-54	-84	-89	-159	-172
XEB-16	199540	52130	25.3	-23	-43	-59	-90	-99	-153	-203
XEB-17	194718	52814	37.1	-21	-33	-33	-70	-91	-155	-193
XEB-2A	197200	56890	44.6	-3	-28	-59	-81	-95	-155	-178
XG-08	197974	55531	23.9	-44	-51	-51	-99	-109		
XG-10	196470	57900	49.9	-4	-33	-46	-83	-105		
XG-12	198949	56036	27.0	-40	-57	-77	-108	-122		
XG-16	197573	55518	38.2	-42	-52	-52	-93	-105		
XS-302	196835	57286	48.0	4	-16	-61	-81			
XLW-01	196897	57220	45.5	5	-25	-64	-85	-96	-164	-179
XLW-03	197827	57929	41.4	-25	-47	-63	-92	-117	-172	-195
XMW-01T	197965	58543	41.8	-29						
XMW-02T	197845	58641	42.8	-27						
XMW-03	196252	57308	47.4	1	-19					
XMW-16	196283	55732	42.0	-1	-13	-17				
XMW-22	196753	55480	41.1	-2	-27					
XMW-29	198349	56813	39.2	-32						
XMW-30	198216	56157	37.9	-17						
XP-1	199266	56202	33.4	-34						
XP-3	199902	56422	29.8	-46						

* Where the elevation of the base of the MBFB and MBFM are equal, the MBFB and MBFC are merged and are designated the MBFB/C. Splitting the MBFB/C into discrete intervals was required for construction of the joint groundwater model. Assignment of the elevation of the base of the MBFB at these locations was based on data from boring logs, core photographs, and geophysical logs. Where data indicated no discernible break within the MBFB/C, depth to the base of the MBFB was assigned based on the site-wide proportioned average thickness of the MBFB and MBFC.

TABLE 3.2-2
Summary of Hydrostratigraphic Control Data:
Thicknesses of Hydrostratigraphic Units at Available Control Locations
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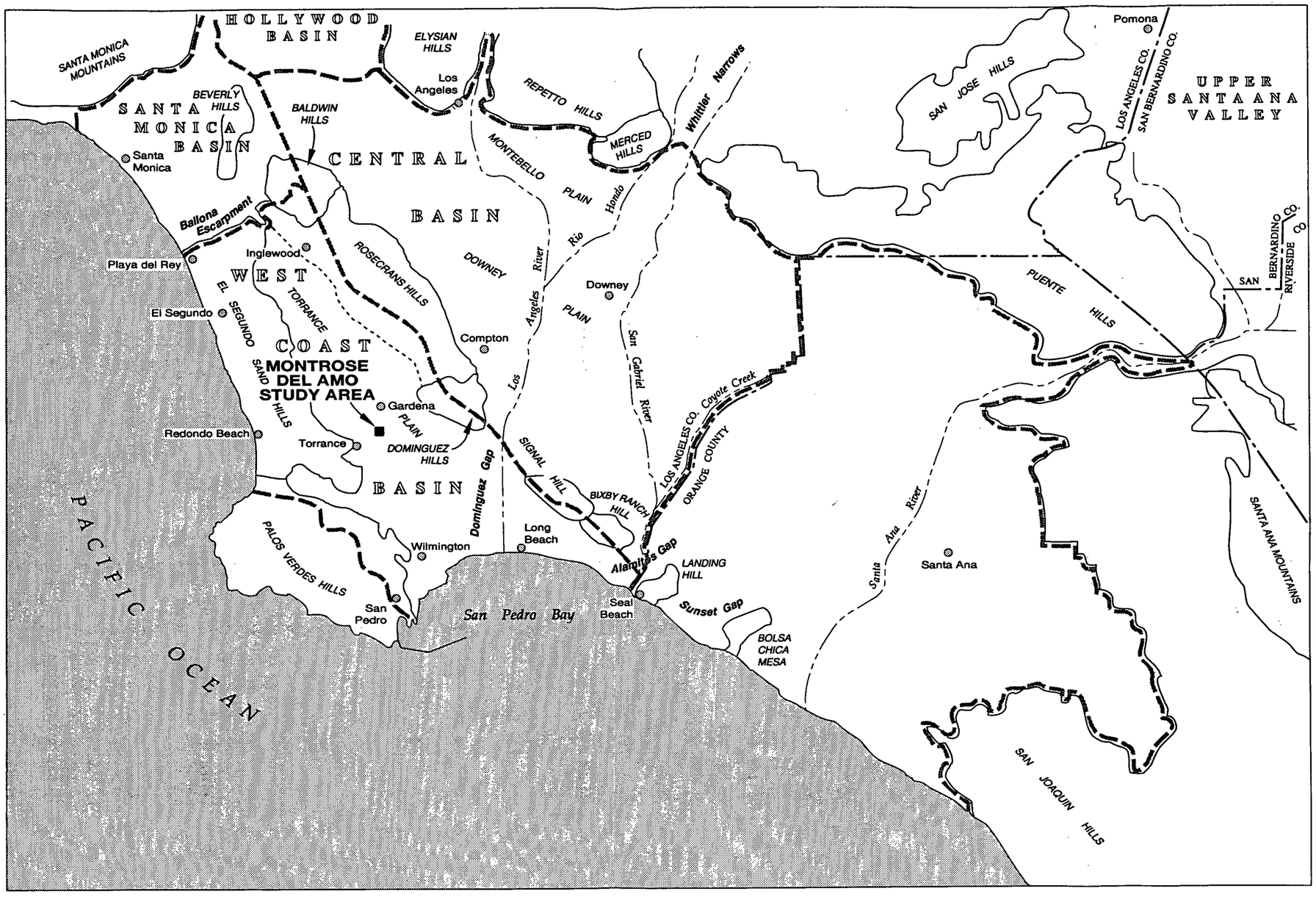
				Thicknesses of Hydrostratigraphic Units (Feet)						
Location	Easting	Northing	Reference Elevation	UBF	MBFB*	MBFM	MBFC*	LBF	Gage	GLA
CPL0005	198505	57792	37.5	70						
CPL0009	199559	57676	32.8	77						
CPT-1	199266	56201	33.5	67						
CPT-11	199532	56718	34.2	76						
CPT-12	199448	56533	34.0	72						
CPT-13	199181	56520	34.5	68						
CPT-14	199030	56521	35.0	69						
CPT-15	198879	56516	35.5	70						
CPT-16	198729	56518	35.8	69						
CPT-17	199084	56721	36.3	72						
CPT-18	198939	56720	36.8	70						
CPT-2	198211	56172	38.0	55						
CPT-3	199594	56220	27.3	69						
CPT-4	198847	56449	32.2	65						
CPT-5	199712	56474	30.4	71						
CPT-6	199910	56420	29.8	76						
CPT-7	199333	56521	33.5	71						
CPT-8	199532	56510	32.6	73						
SBL0013	199584	58732	36.4	75	8	0	54	43		
SBL0014	198063	56984	38.4	59	23	3	49			
SBL0015	198907	58894	37.2	71	20	6	55	16		
SBL0016	198842	56885	35.7	70	19	0	56			
SBL0019	201224	57883	21.3	82	23	0	21	36		
SBL0020	197440	56537	42.4	57	20	23	14	28		
SBL0021	198037	59262	42.7	73	16	11	35	23	67	
SBL0022	200338	57885	32.0	82	16	0	47	36		
SBL0023	199215	56525	34.8	68	18	0	50			
SBL0024	198585	56524	36.4	63	29	0	48			
SBL0025	201300	59096	23.6	92	14	0	30			
SBL0026	200391	56456	31.5	90	13	0	53			
SBL0027	198428	60735	40.4	89	30	24	13	22	78	
SBL0028	201141	56416	26.8	87	13	0	56			
SBL0029	198634	58107	39.7	72	4	0	69			
SBL0030	198030	59899	42.2	75	21	9	32			
SBL0031	201301	57135	24.0	90	7	0	32	31		
SBL0032	199326	60737	36.7	94	30	10	23			
SBL0033	199890	60401	35.7	115	21	4	29	16	72	
SBL0034	199336	60109	40.1	97	34	6	23	21		
SBL0035	200685	58611	28.7	85	13	0	37	29		
SBL0050	198271	58410	40.9	71						
SBL0051	201891	57040	23.6	95	5	0	36	34		
SBL0052	200097	56873	33.9	88	24	0	39	27		
SBL0053	200451	55844	20.2	74	24	0	34	34		
SBL0054	201078	55866	21.1	82	8	0	56	31		
SBL0059	199423	56862	34.8	75	11	0	56	29		
SBL0065	198400	56617	38.9	60						
SBL0077	200260	54982	23.2	65	18	0	48	22	60	
SBL0078	197954	58850	42.3	74	14	11	33	26	66	
SBL0079	198261	58275	42.3	75	10	7				
SBL0080	198562	56183	36.2	83	11	0	50	9	59	

TABLE 3.2-2
Summary of Hydrostratigraphic Control Data:
Thicknesses of Hydrostratigraphic Units at Available Control Locations
Groundwater Remedial Investigation Report
Del Amo Study Area

				Thicknesses of Hydrostratigraphic Units (Feet)						
Location	Easting	Northing	Reference Elevation	UBF	MBFB*	MBFM	MBFC*	LBF	Gage	GLA
SBL0081	199553	57684	33.2	79	13	0	45	35		
SBL0084	199556	56522	32.7	74	16	0	47			
SBL0097	198884	57958	36.3	78	5	0	53			
SBL0099	198445	57717	39.5	74	9	6	56			
SBL0101	199100	57244	36.8	78	4	0	55			
SBL0103	198993	56528	35.4	70	4	0	58			
SBL0106	199976	56155	23.7	73	5	0	54			
SBL0107	199614	55494	29.4	69						
SBL0108	198515	56928	38.5	72	13	2	60			
XBF-18	196366	58108	51.4	70	14	24	37			
XBF-32A	194857	55589	54	47						
XDA-1A	200434	55845	21.6							50
XDM-3	198869	56467	32.0	66						
XEB-01	196227	57561	49.1	46	22	22	33	16	62	
XEB-03	197791	57207	40.9	55	24	11	41	22	62	26
XEB-04	197706	56869	42.7	59	16	11	38	25	61	22
XEB-05	197394	56505	41.5							20
XEB-06	196937	56497	44.0	52	21	14	37	16	54	22
XEB-08	196877	57820	49.3	51	16	29	41	11	72	18
XEB-09	199639	56482	31.1	71	16	0	50	34	51	37
XEB-10	198999	56480	35.4	75						
XEB-11	198585	55652	37.8	64	15	0	43	29	60	
XEB-12	199599	55474	31.0	69	5	6	51	49	40	30
XEB-13	200059	54027	25.0	62	13	0	47	26	62	20
XEB-14	198540	54420	32.0	68	12	11	34	17	58	12
XEB-15	197240	54950	40.5	79	6	10	30	5	70	13
XEB-16	199540	52130	25.3	48	20	16	31	9	54	50
XEB-17	194718	52814	37.1	58	12	0	37	21	64	38
XEB-2A	197200	56890	44.6	48	25	31	22	14	60	23
XG-08	197974	55531	23.9	68	7	0	48	10		
XG-10	196470	57900	49.9	54	29	13	37	22		
XG-12	198949	56036	27.0	67	17	20	31	14		
XG-16	197573	55518	38.2	80	10	0	41	12		
XS-302	196835	57286	48.0	44	20	45	20			
XLW-01	196897	57220	45.5	41	30	39	21	11	68	15
XLW-03	197827	57929	41.4	66	22	16	29	25	55	23
XMW-01	197965	58543	41.8	71						
XMW-02	197845	58641	42.8	70						
XMW-03	196252	57308	47.4	46	20					
XMW-16	196283	55732	42.0	43	12	4				
XMW-22	196753	55480	41.1	43	25					
XMW-29	198349	56813	39.2	71						
XMW-30	198216	56157	37.9	55						
XP-1	199266	56202	33.4	67						
XP-3	199902	56422	29.8	76						

792/174E



EXPLANATION

- Boundary Between Physiographic Features (Dotted where approximately located or poorly defined)
- Boundary of Groundwater Basin
- County Line
- River or Creek

Note: Modified After CDWR, 1961.

N

0 5 10

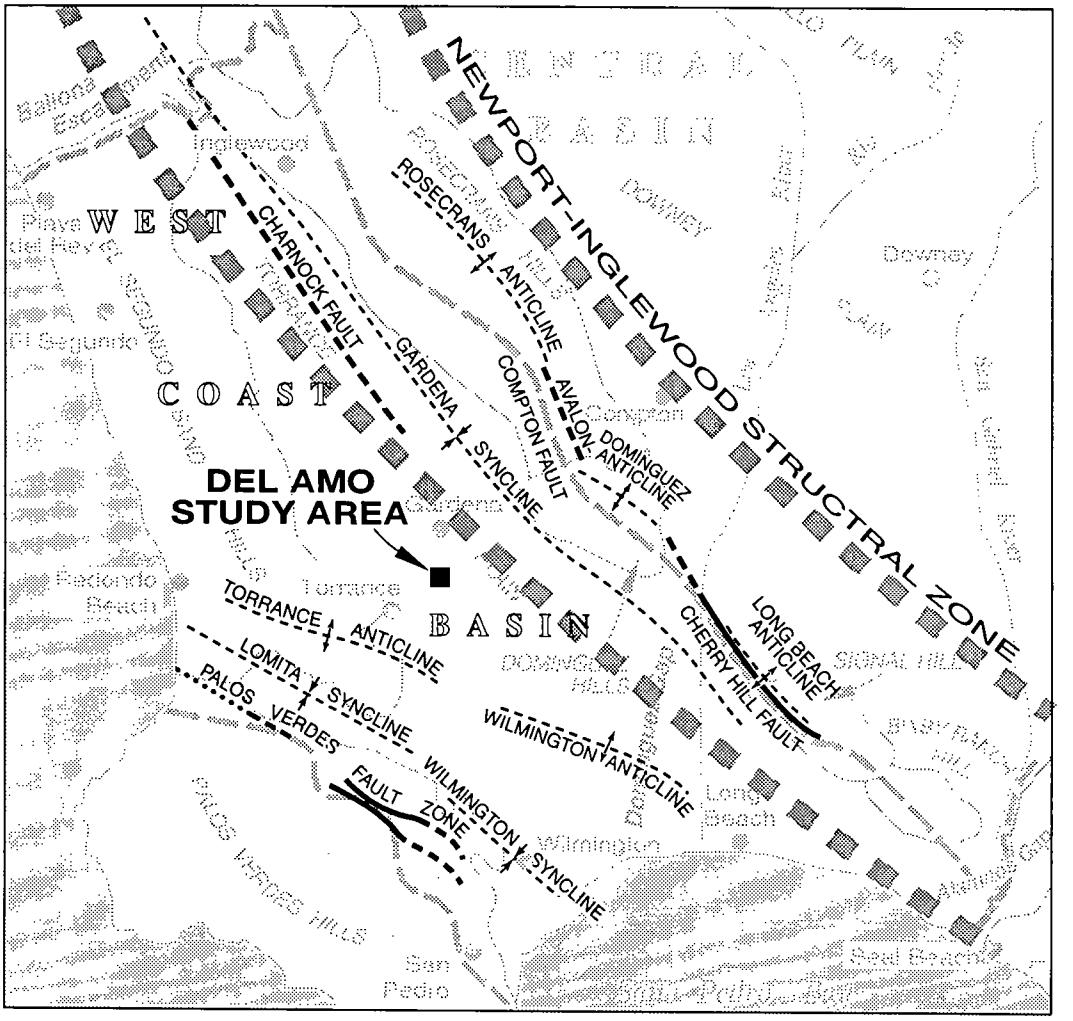
SCALE IN MILES

FIGURE 3.1-1

Regional Physiography and Groundwater Basins

Groundwater Remedial Investigation Report
Del Amo Study Area

792/174C



EXPLANATION

- Fault (Dashed where approximately located)
- Concealed Fault
- Anticline (Dashed where approximately located)
- Syncline (Dashed where approximately located)
- Boundary of West Coast Basin
- Newport-Inglewood Structural Zone

Note: Modified After CDWR, 1961.

FIGURE 3.1-2

Major Geologic Structures West Coast Groundwater Basin

Groundwater Remedial Investigation Report Del Amo Study Area

DAMES & MOORE

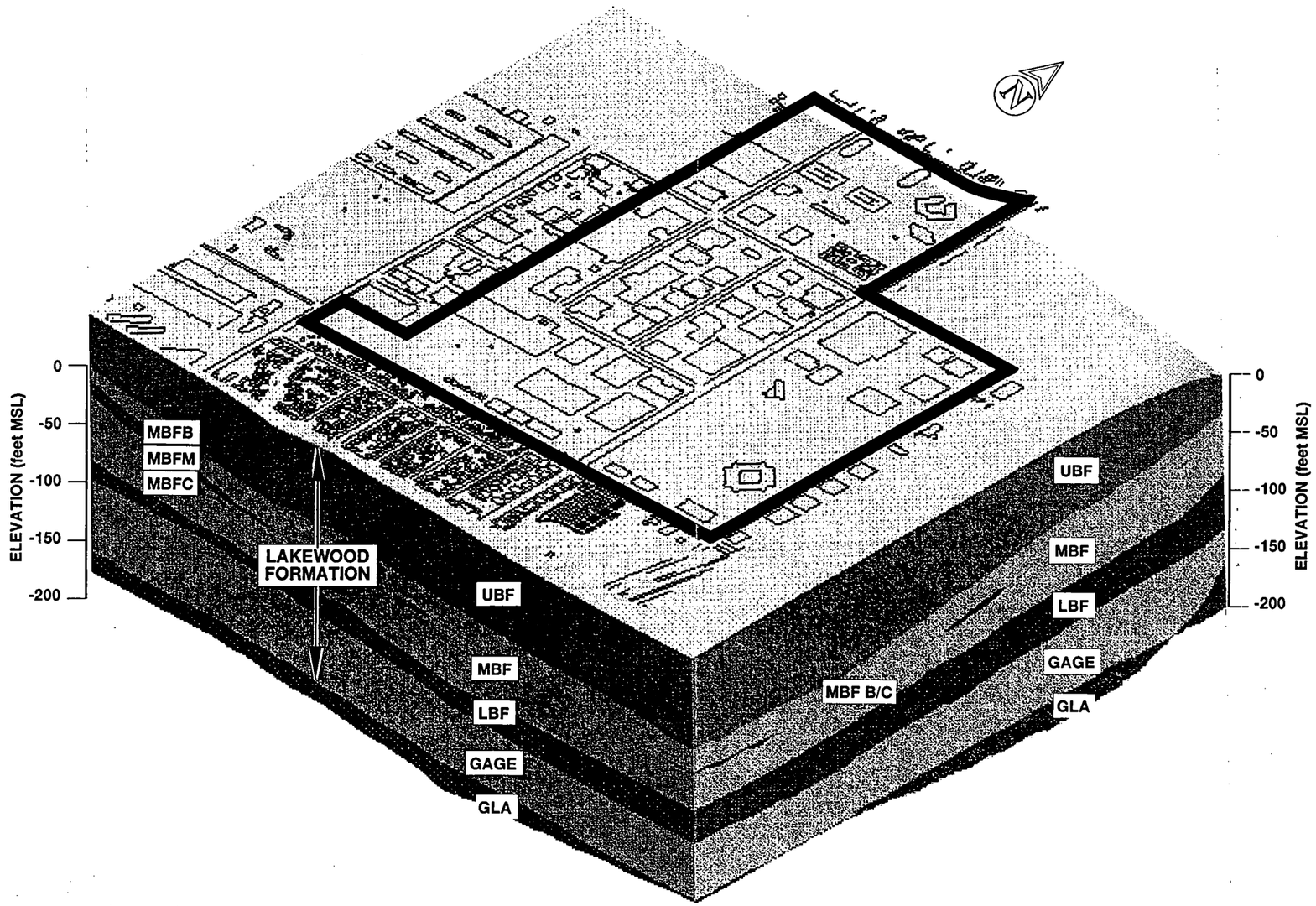


FIGURE 3.2-1

Hydrostratigraphic Units in the Lakewood Formation

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

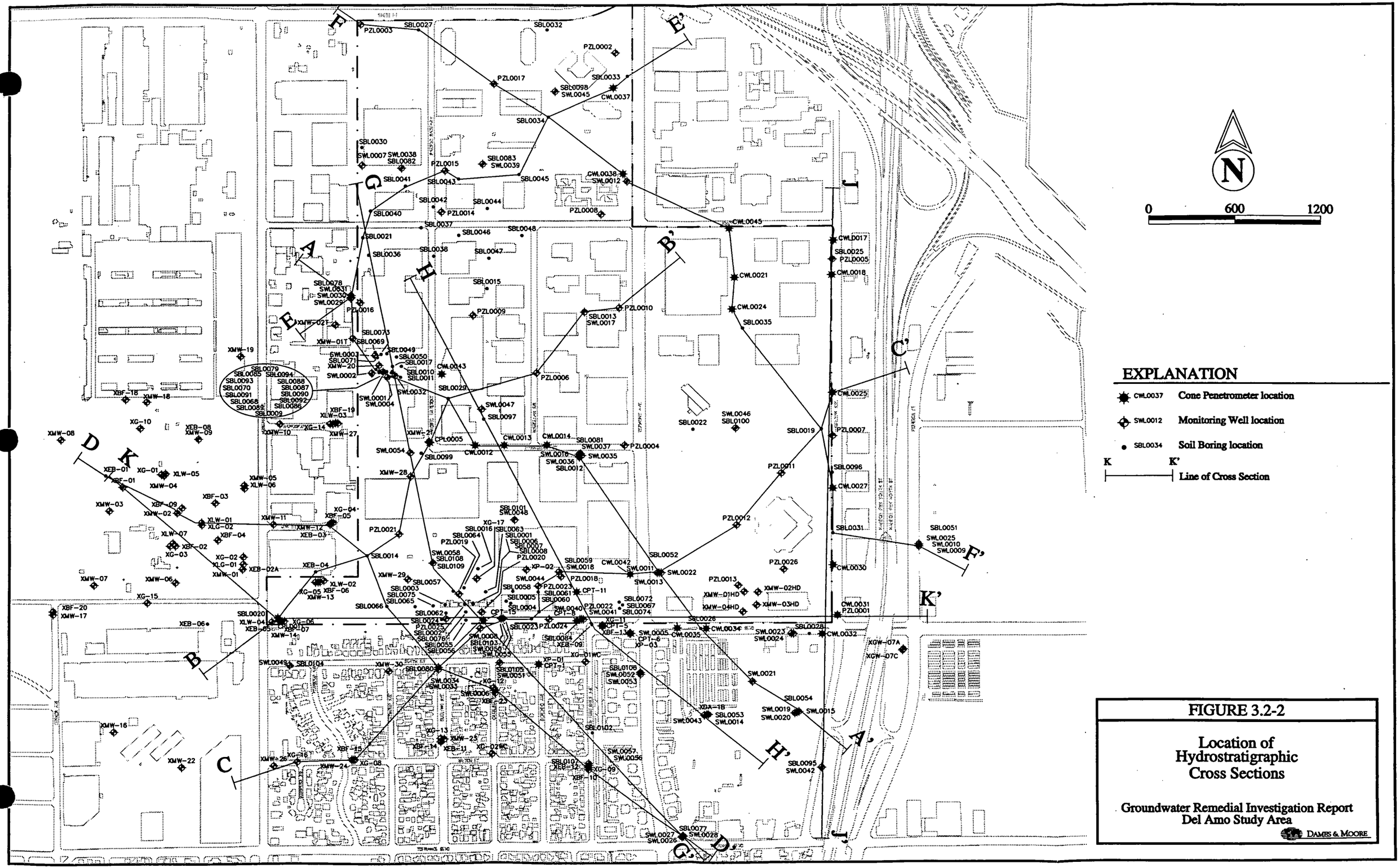


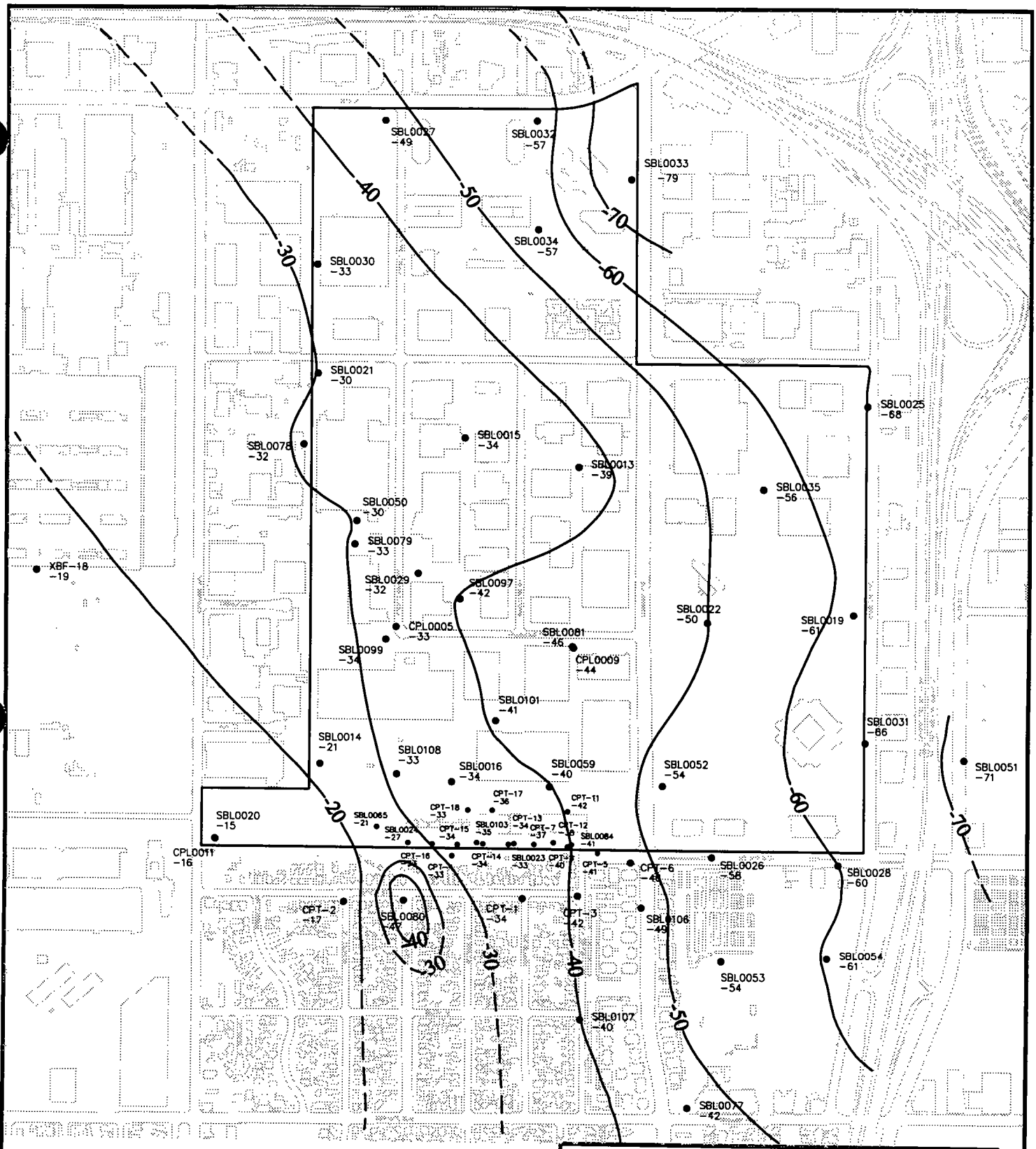
FIGURE 3.2-2

Location of Hydrostratigraphic Cross Sections

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

S:\DJD\NT_DWGS\INDXXSEC, 10/01/96 at 14:31



EXPLANATION

CPT-6 ● -46 — Control point indicating elevation of base of hydrostratigraphic unit

-20 — Elevation contour, dashed where inferred (feet MSL).

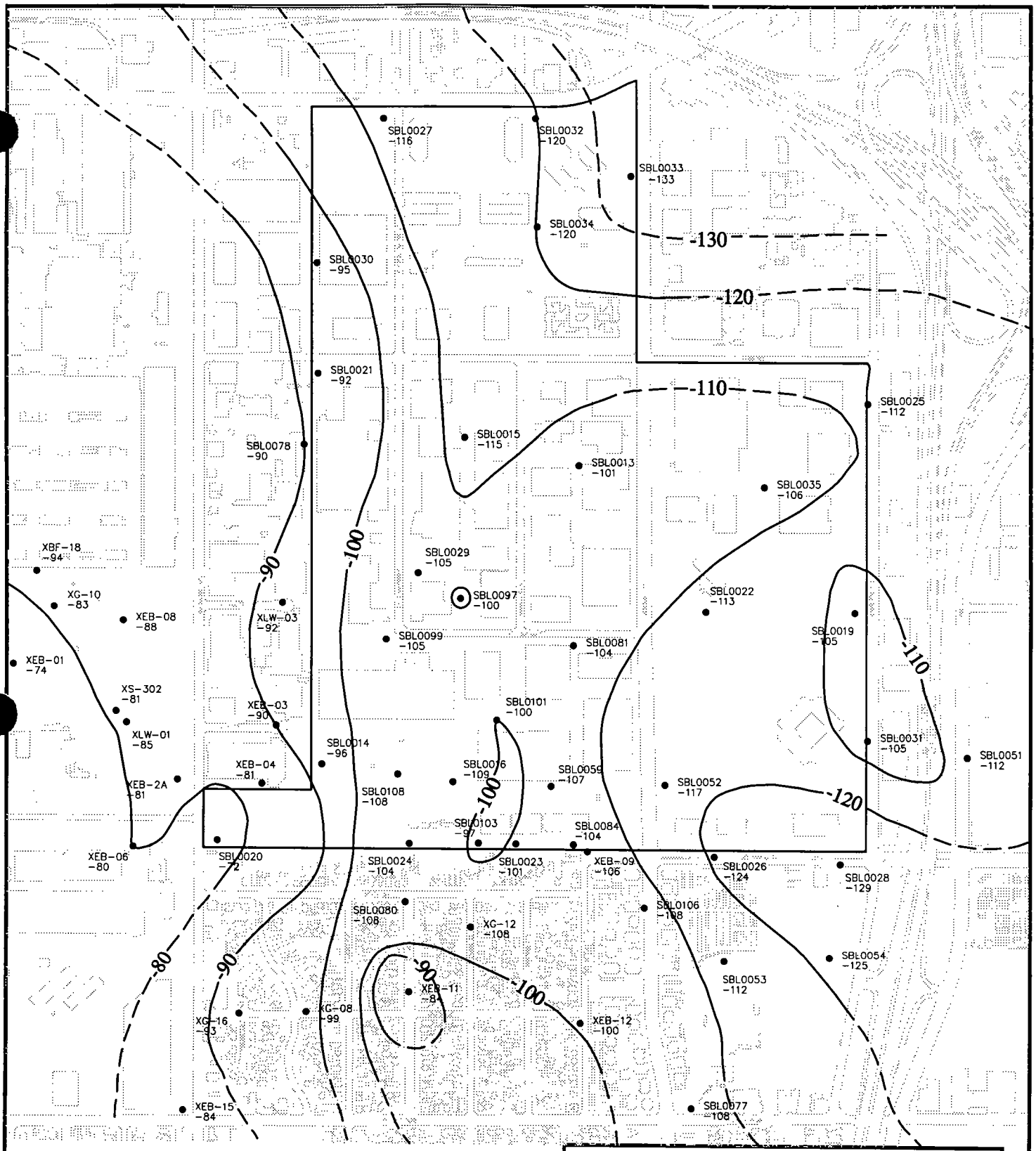
FIGURE 3.2-3

Contour Map Base of Upper Bellflower Aquitard

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

D:\DJD\RI\SEC3\6ZUF3203, 04/14/98 at 13:31



EXPLANATION

CPT-6 ● -46 — Control point indicating elevation of base of hydrostratigraphic unit

-20 — Elevation contour, dashed where inferred (feet MSL).

FIGURE 3.2-4

Contour Map Base of Middle Bellflower Aquitard

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

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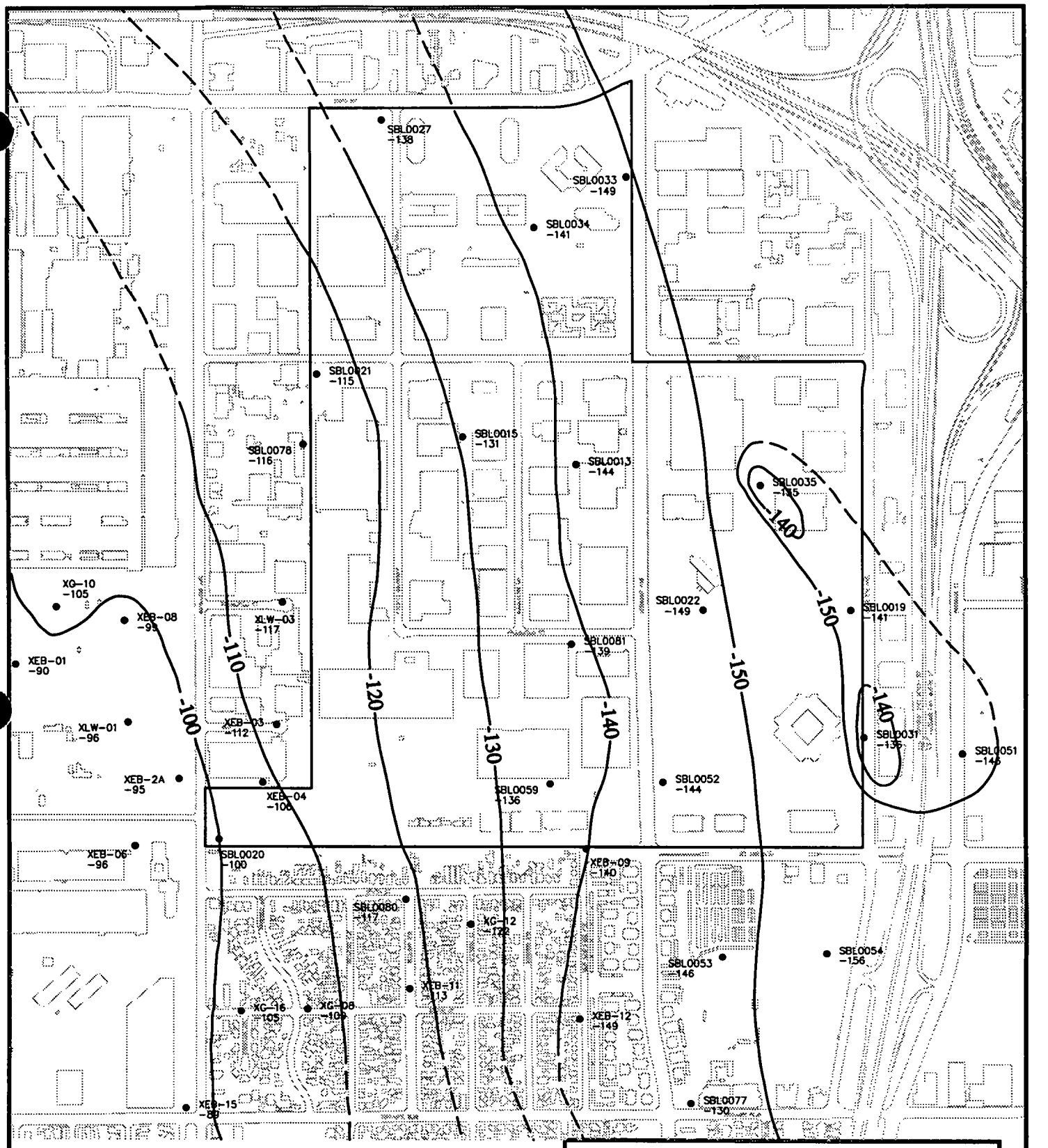

EXPLANATION

CPT-6 ● -46 — Control point indicating elevation of base of hydrostratigraphic unit

-20 — Elevation contour, dashed where inferred (feet MSL).

FIGURE 3.2-5

Contour Map Base of Lower Bellflower Aquitard

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

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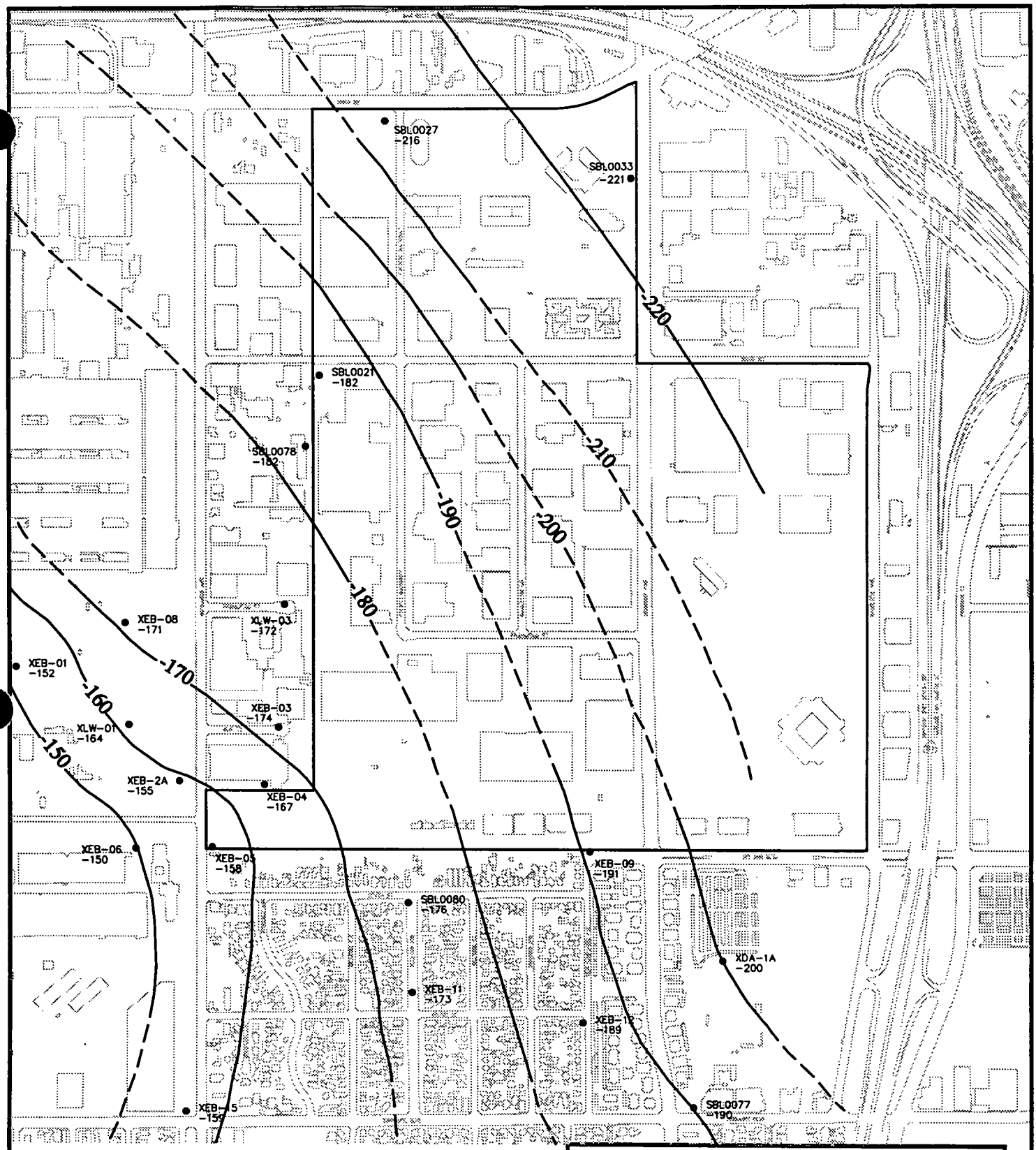

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N

EXPLANATION

CPT-6 ● -46 — Control point indicating elevation of base of hydrostratigraphic unit

-20 — Elevation contour, dashed where inferred (feet MSL).

FIGURE 3.2-6

Contour Map Base of Gage Aquifer

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

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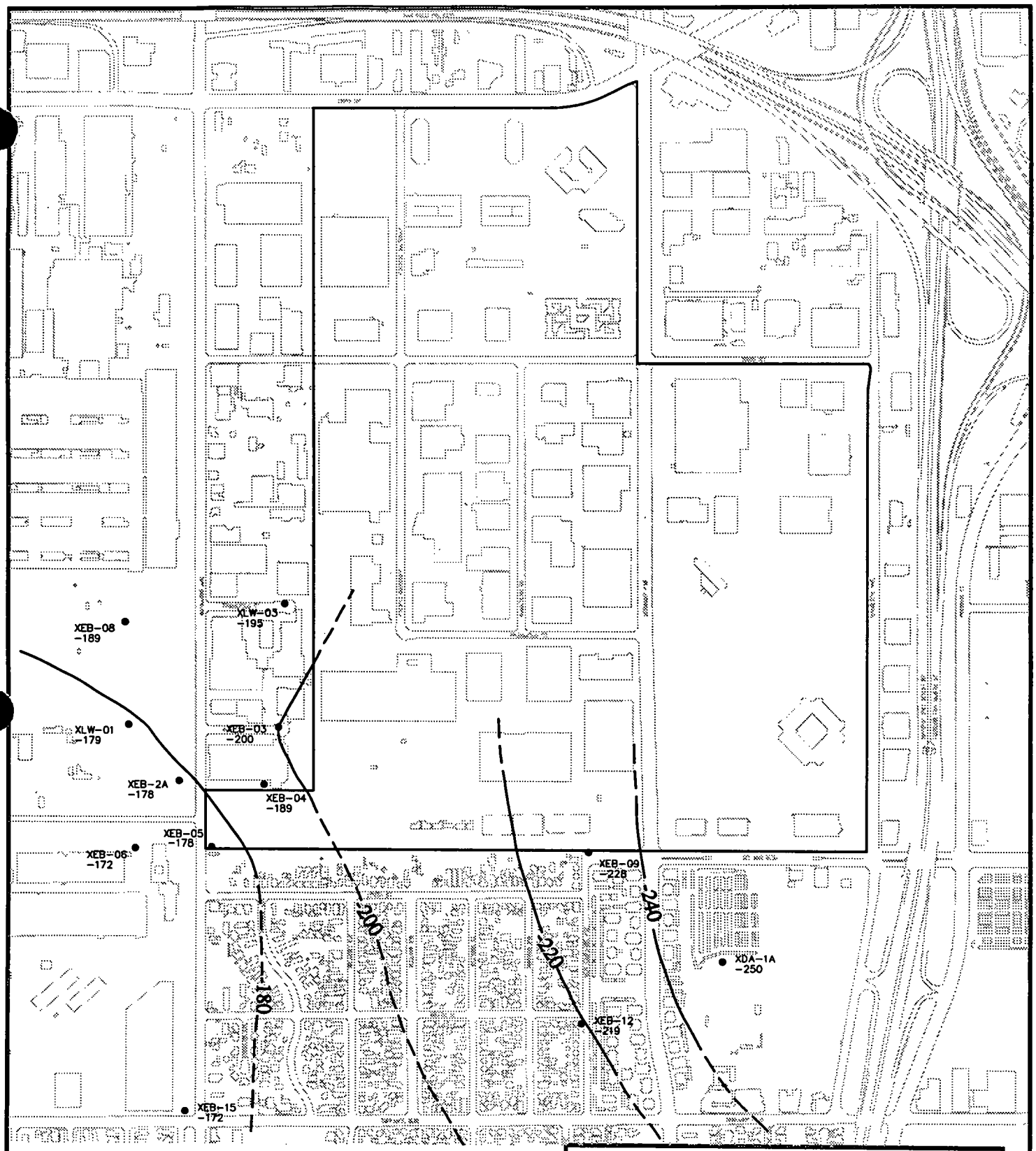

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N

EXPLANATION

CPT-6 ● -46 — Control point indicating elevation of base of hydrostratigraphic unit

-20 — Elevation contour, dashed where inferred (feet MSL).

FIGURE 3.2-7

Contour Map Base of Gage-Lynwood Aquitard

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

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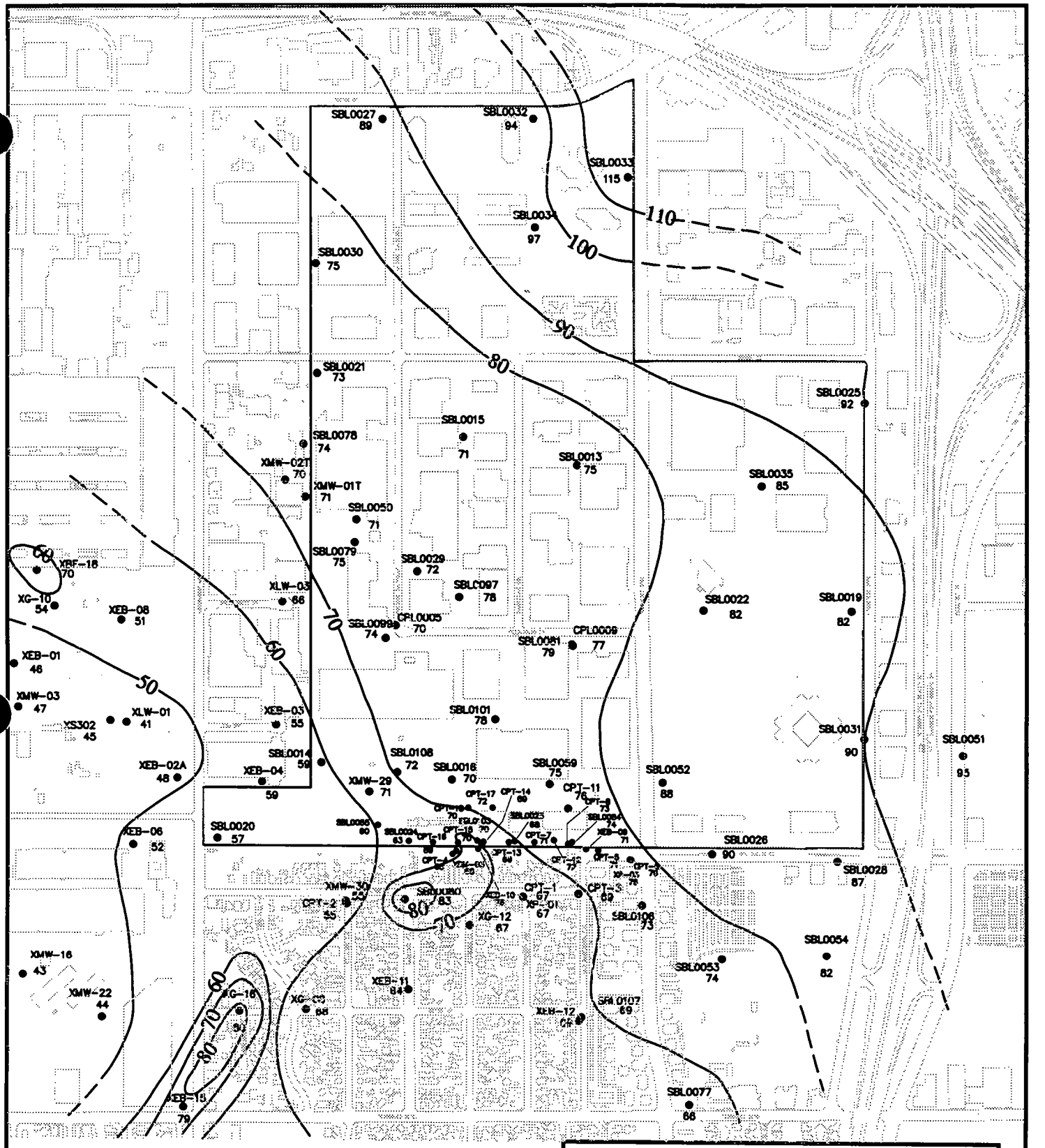

EXPLANATION

XEB-15 ● 79 — Control point indicating thickness of hydrostratigraphic unit (usually measured from base of current unit to base of unit above)

20 — Isopach contour, dashed where inferred (feet).

FIGURE 3.2-8

Isopach Map
Upper Bellflower Aquitard

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

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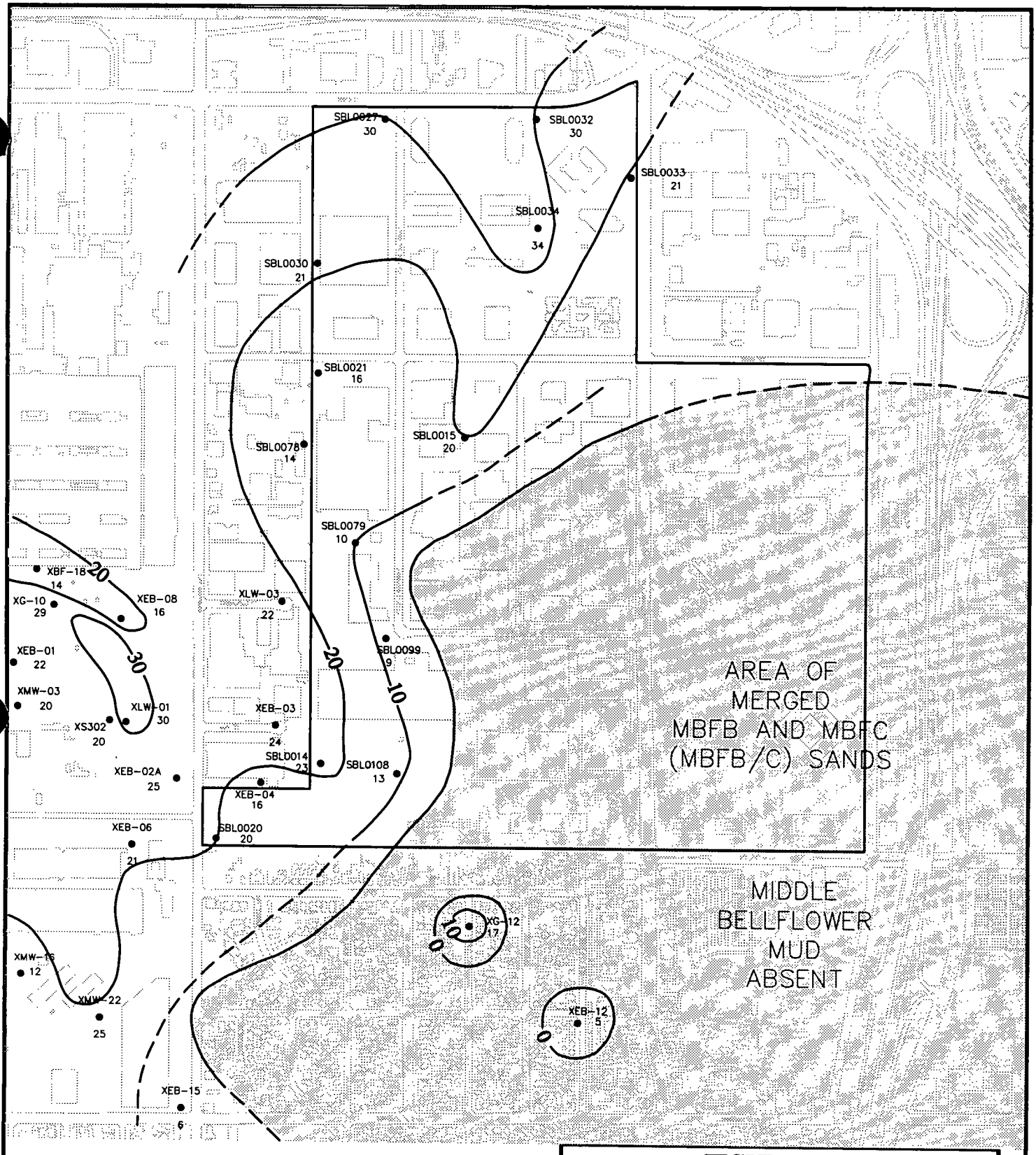

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N

EXPLANATION

XEB-15 ● 10 — Control point indicating thickness of hydrostratigraphic unit in feet

20 — Thickness contour, MBF Mud Dashed where inferred

FIGURE 3.2-9

Isopach Map
Middle Bellflower B Sand

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

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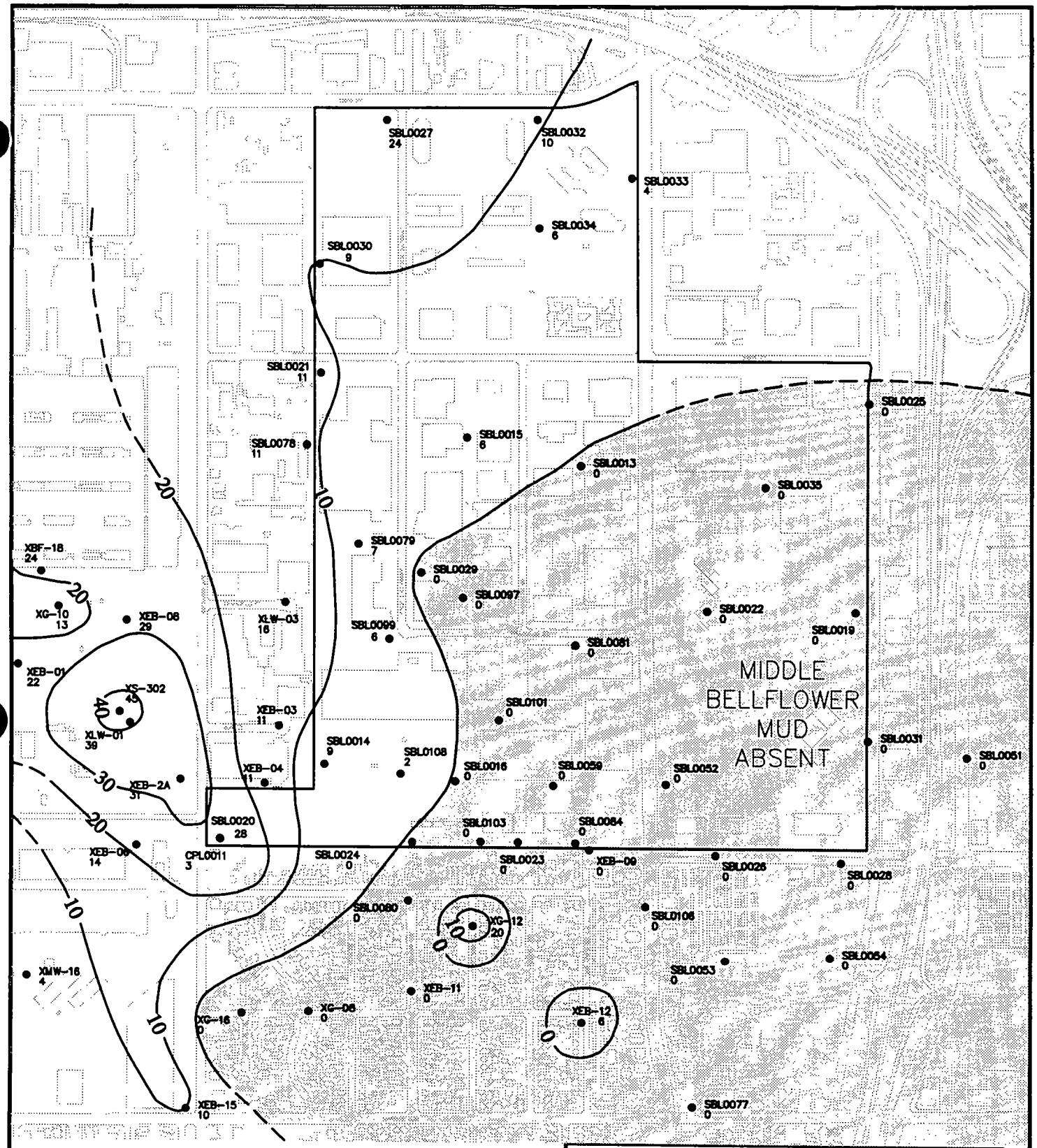

EXPLANATION

XEB-15 ● 10 — Control point indicating thickness of hydrostratigraphic unit in feet

20 — Thickness contour, MBF Mud Dashed where inferred

FIGURE 3.2-10

Isopach Map Middle Bellflower Mud

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

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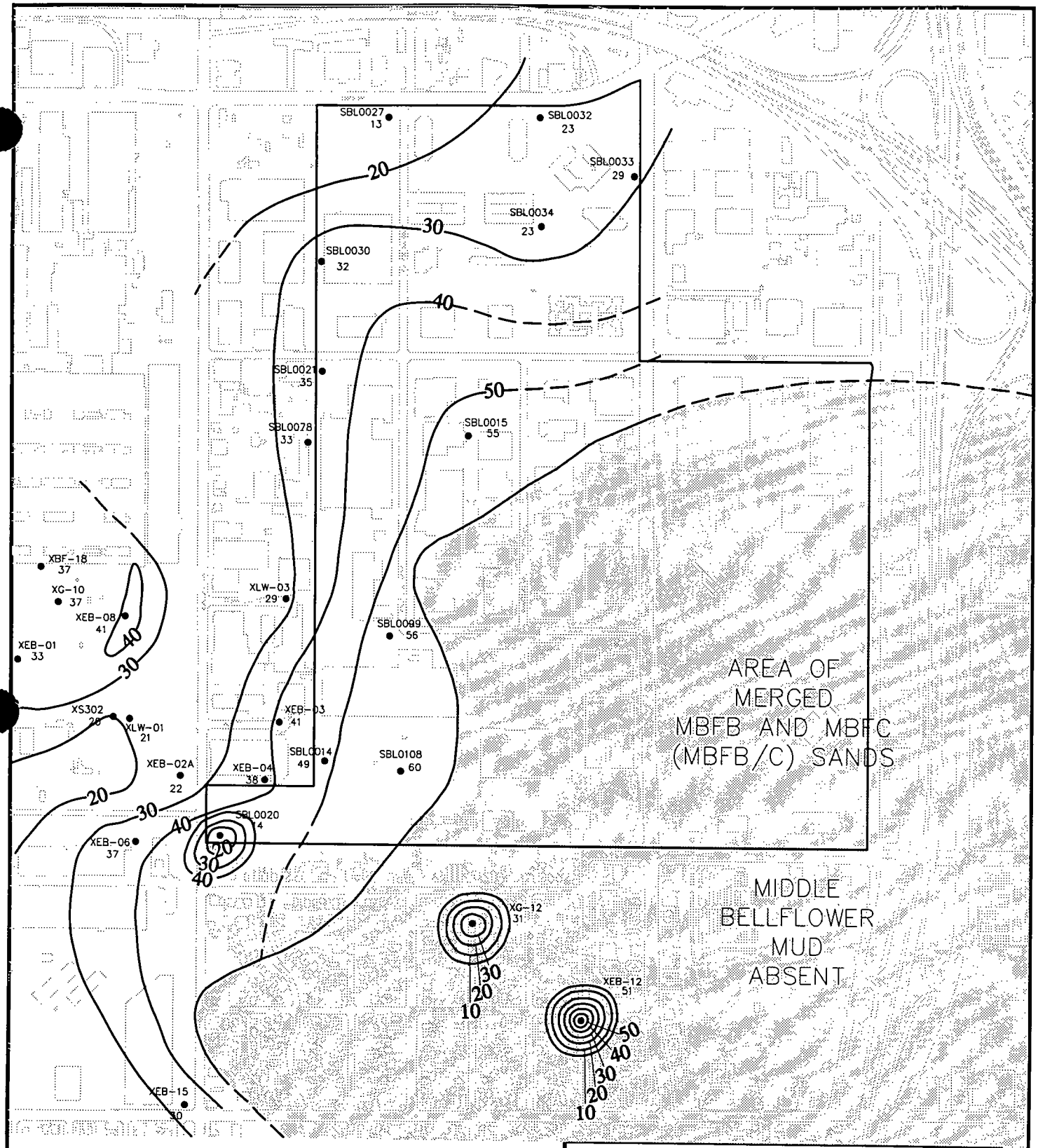

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N

EXPLANATION

XEB-15 • 10 — Control point indicating thickness of hydrostratigraphic unit in feet

20 — Thickness contour, MBF Mud Dashed where inferred

FIGURE 3.2-11

Isopach Map
Middle Bellflower C Sand

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

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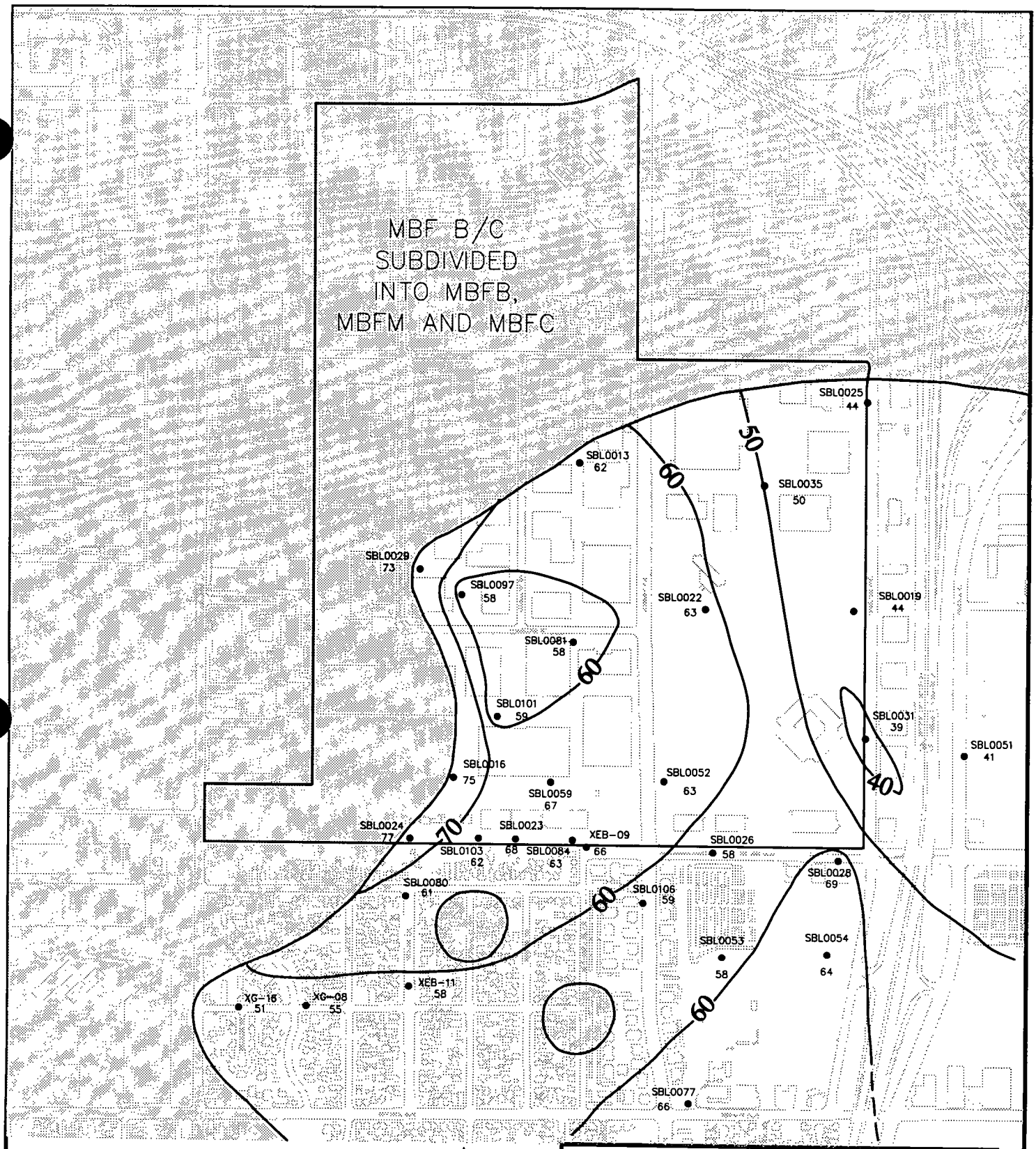

0 800 1600

N

EXPLANATION

XEB-15 • 30 — Control point indicating thickness of hydrostratigraphic unit (usually measured from base of current unit to base of unit above)

20 — Isopach contour, dashed where inferred (feet).

Area where MBF B/C is subdivided into MBFB, MBFM and MBFC

FIGURE 3.2-12

Isopach Map
Middle Bellflower B/C Sand

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

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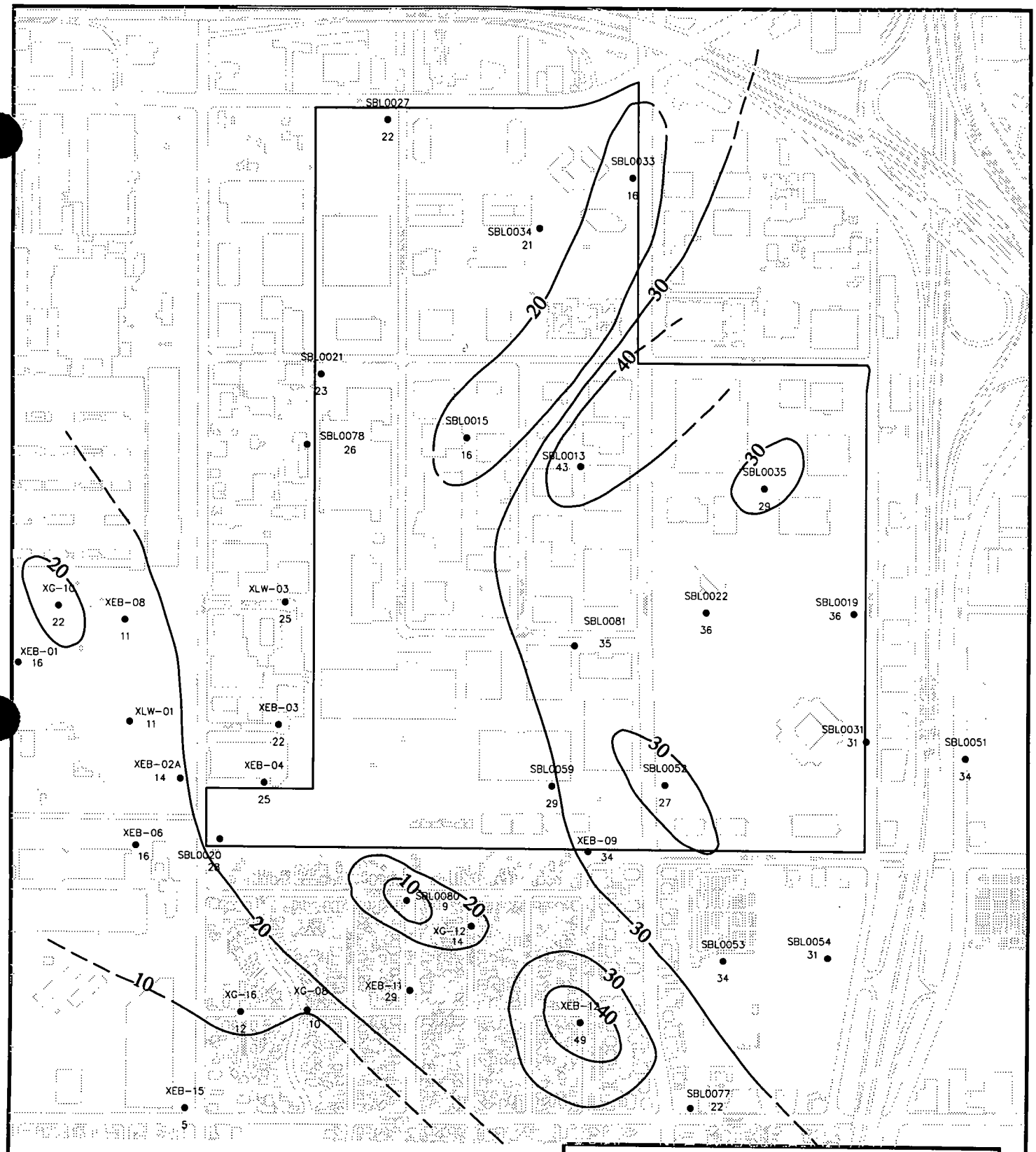

EXPLANATION

XEB-15 ● 5 — Control point indicating thickness of hydrostratigraphic unit (usually measured from base of current unit to base of unit above)

20 — Isopach contour, dashed where inferred (feet).

FIGURE 3.2-13

Isopach Map
Lower Bellflower Aquitard

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

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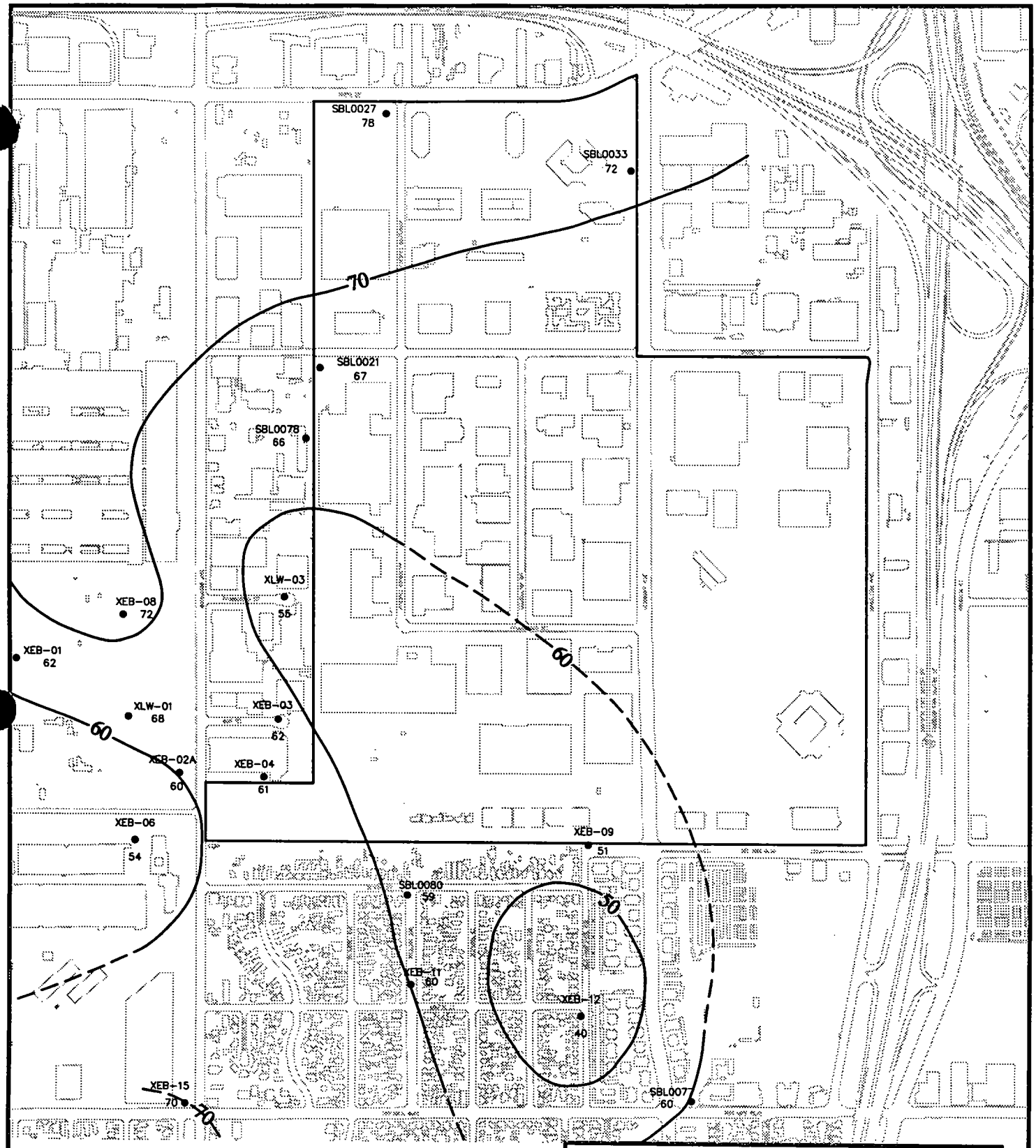

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N

EXPLANATION

XEB-15 • 30 — Control point indicating thickness of hydrostratigraphic unit (usually measured from base of current unit to base of unit above)

20 — Isopach contour, dashed where inferred (feet).

FIGURE 3.2-14

Isopach Map
Gage Aquifer

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

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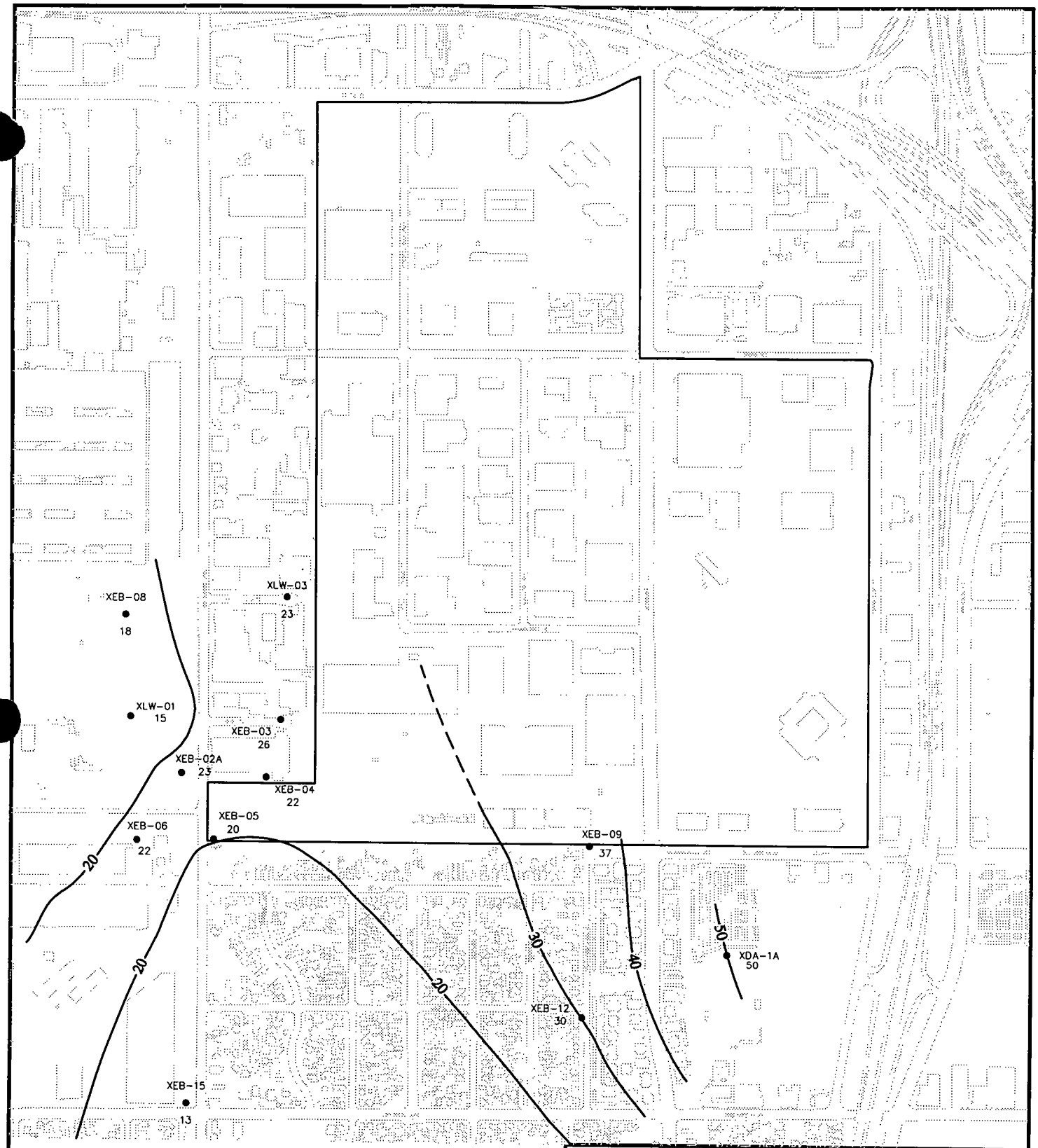

EXPLANATION

XEB-15 • 13 — Control point indicating thickness of hydrostratigraphic unit (usually measured from base of current unit to base of unit above)

20 — Isopach contour, dashed where inferred (feet).

FIGURE 3.2-15

Isopach Map
Gage-Lynwood Aquitard

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

D:\DJD\RI\SEC3\iso-gla, 06/16/97 at 11:16

696/045D

PUBLISHED REGIONAL HYDROSTRATIGRAPHY①		REGIONAL GW MODEL LAYER NUMBER	MONTROSE HYDRO-STRATI-GRAPHY②	DEL AMO STUDY AREA HYDROSTRATIGRAPHY③		AVERAGE THICKNESS (ft)	BASE ELEV. RANGE (ft/msl)
UPPER PLEISTOCENE LAKEWOOD FORMATION	BELLFLOWER AQUITARD	1	UPPER BELLFLOWER AQUITARD	UPPER BELLFLOWER AQUITARD		74	-15 to -71
		2		MIDDLE BELLFLOWER	B-SAND	15	-35 to -91
		3			MUD	7	-36 to -103
		4	BELLFLOWER SAND		C-SAND	43	-70 to -129
		5					
		6	LOWER BELLFLOWER AQUITARD	LOWER BELLFLOWER AQUITARD		27	-100 to -156
		7					
		8					
	GAGE AQUIFER	9	GAGE AQUIFER	GAGE AQUIFER		66	-186 to -216
LOWER PLEISTOCENE SAN PEDRO FORMATION	GAGE/ LYNWOOD AQUITARD	10	GAGE/ LYNWOOD AQUITARD	GAGE/LYNWOOD AQUITARD		20②	-170 to -230②
		11					
		12					
	LYNWOOD AQUIFER	13	LYNWOOD AQUIFER	NOT REACHED		36④	-240④
	UNNAMED AQUITARD	NOT APPLICABLE	LYNWOOD-SILVERADO AQUITARD	NOT REACHED		208④	-440④
	SILVERADO AQUIFER	NOT APPLICABLE	NOT REACHED	NOT REACHED		>240④	BASE NOT REACHED

EXPLANATION

① California Department of Water Resources Bulletin 104, 1961. Planned Utilization of the Groundwater Basins of the Coastal Plain of Los Angeles County. Appendix A – Groundwater Geology, June 1961.

Poland, J.F., A.A. Garrett and A. Sinnott, 1959. Geology, Hydrology and Chemical Character of Ground Waters in the Torrance – Santa Monica Area, California. U.S. Geological Survey Water Supply Paper 1461.

② Hargis + Associates 1992. Final Draft Remedial Investigation, Montrose Site, Torrance, CA. Volumes I through IV, October 29.

③ Current study.

④ Drillers Log, LACDPW Well No 795.

FIGURE 3.4-1

Comparison of Stratigraphic Nomenclature

Groundwater Remedial Investigation Report
Del Amo Study Area

901/966

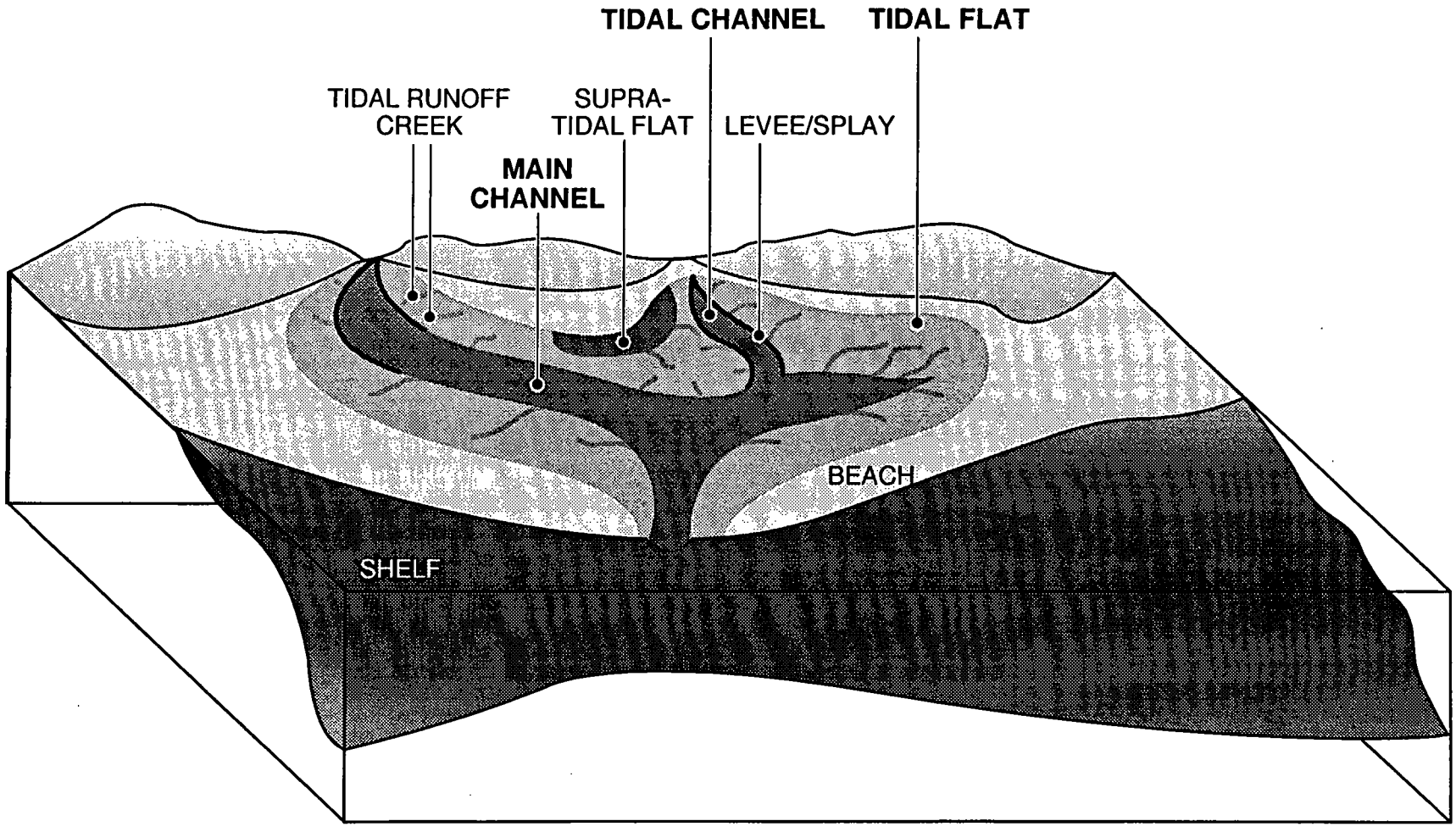

FIGURE 3.5-1

Schematic Representation of Estuarine Depositional Environments

Groundwater Remedial Investigation Report
Del Amo Study Area

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PARTIALLY SCANNED
OVERSIZE ITEM(S)

See document # 2259656
for partially scanned image(s).

PLATES 3-1 TO 3-10
(3 OF 20 TO 12 OF 20)

For complete hardcopy version of the oversize document
contact the Region IX Superfund Records Center

4.0 GROUNDWATER CONDITIONS

4.1 GROUNDWATER LEVELS AND FLOW CONDITIONS

4.1.1 Historical Groundwater Levels

Groundwater levels in the vicinity of the Del Amo Plant site are believed to have been rising for approximately the last thirty years. Evidence for this is presented on the hydrograph in Figure 4.1-1, showing trends in groundwater elevations for representative monitoring wells screened in the water table, MBFB, MBFC, Gage aquifer, and Lynwood aquifer units. The locations of the wells included on the hydrograph are illustrated in Figure 4.1-2. As shown on the hydrograph, groundwater elevations in all units have risen at a rate of approximately one foot per year, and data for well 806-C suggests that this trend has continued since 1965. Although groundwater elevation data for years prior to 1956 are not available, the hydrograph suggests that groundwater elevations were at least 15 to 20 feet lower than current conditions during much of the operational period of the former rubber plant.

Additional evidence of long-term rising groundwater levels is provided by observed LNAPL conditions in the vicinity of plant site monitoring well MW-20. As described in Sections 5.1 and 6.2 of this report, rather than occurring in a single floating layer, LNAPL in the MW-20 area is submerged in isolated ganglia over an approximately 30-foot interval beneath the water table. This mode of occurrence is consistent with conditions that can be expected after an LNAPL has migrated through the vadose zone, intercepted the water table, and then been influenced by a rising groundwater table. The fact that the LNAPL is observed over a 30-foot interval indicates that groundwater has risen at least 30 feet since the LNAPL first intercepted the water table, and further supports hydrograph data indicating a relatively long term trend of rising groundwater.

Rising groundwater levels may be associated with adjudication of the West Coast Basin, which occurred in 1961. The adjudication date slightly precedes the observed onset of rising groundwater levels in 1965, which might be expected given the time necessary to implement controls on groundwater pumping and affect corresponding changes in groundwater levels.

4.1.2 Water Table Zone Groundwater Elevations and Flow Velocities

Due in part to the consistent, low angle structural dip toward the northeast observed in all hydrostratigraphic units (see Section 3.5.3), the groundwater table crosses the stratigraphic boundary between the UBF and MBFB near the western boundary of the plant site. The water table resides within the UBF to the east of a demarcation line near the western plant site boundary, and within the MBFB to the west of the line. Groundwater conditions are therefore described with respect to the water table zone (UBF/MBFB), and the underlying coarse grained water-bearing units, including the MBFB and the MBFC, the Gage aquifer, and the Lynwood aquifer. For the reason stated above, the water table zone and MBFB are separate units east of the demarcation line, while to the west, they are identical.

Time-series groundwater elevations for the water table zone during the period of investigation are presented in Table 4.1-1. This table also indicates the total change in elevation and the average change in elevation per year for each monitoring location. As indicated by the table, water table groundwater elevations have been rising since the inception of groundwater monitoring, at an average rate of approximately one foot per year.

October 1995 groundwater elevation data and interpretive contours are presented in Figure 4.1-3. Flow direction in the water table zone is inferred from the contours to be toward the south-southwest over much of the plant site, but a radial flow pattern associated with groundwater mounding is inferred in the vicinity of the waste pits and near the southeast corner of the site. The cause of the mounding is unknown. It is speculated that the mounding may be the result of infiltration of water from unknown artificial recharge sources, possibly leaking water supply pipelines and/or sewer pipelines. No additional information is known by which this can be verified or that would suggest other possible mechanisms for the mounding.

An approximate average horizontal flow velocity for the water table zone is calculated using the formula

$$V = \frac{K(i)}{n}$$

where V = velocity (ft/day);
K = hydraulic conductivity (ft/day);
I = gradient (unitless); and
n = effective porosity

A value of 3.0 ft/day is used for K. This is the mean value derived from recovery data for 11 constant discharge pumping tests and one slug test conducted for UBF monitoring wells. The tests are discussed in Section 4.2, with results summarized in Table 4.2-2. As indicated in the table, UBF K values ranged from 0.1 to 5.2 feet/day.

A value of 0.0025 is used for the gradient, which is derived from the October 1995 groundwater elevation contours (Figure 4.1-3). This gradient is an average value for the plant site as a whole. The reader should note that there are large variations in the gradient for the water table, and for short distances, the gradient may be much higher or lower. Relatively high gradient values exist where contours are closely spaced, such as near the Waste Pit Area (0.0193 between SWL0051 and SWL0006) and near the southeast corner of the plant site (0.0320 between XMW-04HD and XMW-03HD), while relatively low gradients exist where contours are spaced further apart, such as near the central portion of the plant site (0.0003 between SWL0017 and PZL0006) and near the southwest corner of the plant site (0.0004 between XMW-11 and XMW-26).

A value of 0.15 is used for effective porosity. This is the mean effective porosity value for 56 upper Bellflower soil samples for which physical testing analyses were conducted. Effective porosity data is included in Appendix F1.

Substituting the above values,

$$V = \frac{3.0\ (0.0025)}{0.15}$$

$$= 0.050 \text{ ft/day}$$

$$= 18.3 \text{ ft/yr}$$

A time-series summary of water table groundwater elevation contours is presented in Figure 4.1-4, through which apparent changes in flow direction through time can be evaluated. It is important to note that the groundwater elevation contours presented in Figure 4.1-4 are inferred based on the data available at the times indicated. Therefore, some of the variation in contour geometry apparent between events is likely due to changes in interpretation as more water level data become available from wells added to the network, rather than changes in groundwater elevations.

4.1.3 Middle Bellflower B Sand Groundwater Elevations and Flow Velocities

Time-series groundwater elevations for the MBFB are presented in Table 4.1-1, and indicate that ground water elevations have risen at an average rate of approximately one foot per year over the duration of groundwater monitoring (since February 1994). October 1995 groundwater elevation data and interpretive contours are presented in Figure 4.1-5. As inferred from the contours, flow direction in the MBFB is toward the south to south-southeast over the plant site. A time-series summary of groundwater elevation contours is presented in Figure 4.1-6, demonstrating a relatively consistent flow direction over the monitoring period.

The average horizontal flow velocity for the MBFB, calculated by the method described in Section 4.1.2 above, is 0.1 ft/day or 36.5 ft/yr. This value is based on a hydraulic conductivity of 20 ft/day (mean value; range = 9 to 50 feet/day; see Table 4.2-2), a gradient of 0.0008 (October 1995 groundwater contours, Figure 4.1-5), and an effective porosity of 0.15 (mean physical testing value, 11 samples). The reader should note that while not as dramatic as for the water table, the gradient for the MBFB is also variable, ranging from 0.0004 (between XMW-11 and XMW-26) to 0.002 (between SWL0010 and XGW-07C).

4.1.4 Middle Bellflower C Sand Groundwater Elevations and Flow Velocities

Time-series groundwater elevations for the MBFC are presented in Table 4.1-1. As was the case for the water table and MBFB, ground water elevations have risen at an average rate of approximately one foot per year. October 1995 groundwater elevation data and interpreted contours are presented in Figure 4.1-7, and indicate a south-southeasterly flow at the plant site. The time-series summary of groundwater elevation contours for the MBFC presented in Figure 4.1-8 indicates a relatively consistent flow pattern over the monitoring period.

The horizontal flow velocity for the MBFC is estimated to be 0.87 feet per day, or 317 ft/yr. This value is based on a hydraulic conductivity of 163 feet/day (mean value; range = 27 to 400 feet/day; see Table 4.2-2), a gradient of 0.0008 (Figure 4.1-7), and an effective porosity of 0.15 (mean physical testing value, 32 samples).

4.1.5 Gage Aquifer Groundwater Elevations and Flow Velocities

Time-series groundwater elevations for the Gage aquifer are presented in Table 4.1-1, and are consistent with data for the overlying units, indicating ground water elevations rising at an average rate of approximately one foot per year. Groundwater elevation data and contours for October 1995 are presented in Figure 4.1-9 and indicate a southeasterly flow direction. The time-series groundwater contours presented in Figure 4.1-10 suggest that the southeasterly flow direction has been consistent through time.

The horizontal flow velocity for the Gage aquifer is estimated to be 0.17 feet per day, or 61 ft/yr. This value is derived from a hydraulic conductivity of 31 feet/day (mean value; range = 23 to 36 feet/day; see Table 4.2-2), a gradient of 0.0007 (Figure 4.1-9), and an effective porosity of 0.13 (mean physical testing value, 11 samples).

4.1.6 Lynwood Aquifer Groundwater Elevations and Flow Velocities

Time-series groundwater elevations for the Lynwood aquifer are presented in Table 4.1-1. As shown, groundwater elevations have risen at a rate of approximately two feet per year. It is noteworthy that the Lynwood groundwater elevations are approximately 11 feet lower than all the other units.

The small number of Lynwood aquifer monitoring locations for which data are available, the small range in their respective groundwater elevations, and the relatively close proximity of the monitoring locations make evaluation of representative groundwater contours and flow direction difficult. For this reason, figures illustrating groundwater elevation contours and flow direction are not presented, and an estimated flow velocity is not calculated.

4.1.7 Hydraulic Head, Vertical Gradient, and Flow Conditions

The hydraulic head between HSUs can be evaluated by inspection of hydrographs for co-located wells completed in different HSUs (Plate 4-1) and from cross sections with interpretive potentiometric contours. The three cross sections selected for presentation of potentiometric contours are sections G-G′, J-J′, and K-K′ (Plates 4-2, 4-3 and 4-4). The potentiometric contours presented on these plates are based on groundwater elevation data from the February 1996 sampling event.

The hydrographs of Plate 4-1 show that in general, groundwater elevations decrease with depth and each successive HSU. Exceptions to this occur at co-located wells SWL0050/SWL0055 (MBFB/MBFC), near the southern boundary of the plant site, and at SWL0011/SWL0013 (MBFB/MBFC), in the southern portion of the Butadiene plant. At these two locations, the MBFC groundwater elevation is slightly higher (0.22 and 0.02 feet, respectively) than the MBFB. The reason for the anomaly at these locations is not known.

With the exception of locations where groundwater table elevations are anomalously high, (SWL0009, SWL0057, SWL0028) the hydrographs of Plate 4-1 indicate that groundwater elevations for the water table, MBFB, and MBFC are typically within approximately 1.5 feet of each other, with Gage aquifer groundwater elevations being an additional two feet or less below the MBFC. Additionally, changes in groundwater elevations through time are typically mirrored between the water table, MBFB, MBFC and Gage aquifer. These conditions are in contrast to the Lynwood aquifer, where groundwater elevations are approximately 11 feet below the Gage aquifer, and for which changes in groundwater elevations through time appear to be independent of the overlying HSUs.

Vertical gradients between the major water-bearing HSUs are presented in Table 4.1-2. The vertical gradients were calculated for each well cluster in the study area. Well clusters are co-located monitoring wells that are screened in different HSUs. The vertical gradients are calculated by dividing the difference in the groundwater elevations at two respective monitoring locations by the difference in their respective screened interval mid-points. Groundwater elevation data for the third sampling period 1995 monitoring event were used for the vertical gradient calculation (see Table 4.1-1). Well screen midpoints are indicated in Table 4.1-2. Negative gradients imply a potential for groundwater to flow downward, while positive values indicate a potential for upward flow. As can be seen from Table 4.1-2, the vertical gradients between the water table and MBFB, between the MBFB and MBFC, and the between the MBFC and Gage are small relative to the vertical gradient between the Gage and Lynwood.

It is important to understand that decreasing hydraulic head with depth indicates only a *potential* for downward groundwater flow. While interpretive, the potentiometric groundwater elevation contours (Plates 4-2 through 4-4) more effectively illustrate groundwater flow direction in the vertical plane than discussion of hydraulic head or vertical gradients. Groundwater flow is perpendicular to the potentiometric contours on Plates 4-2 through 4-4, and the relative spacing of the contours gives an indication of the gradient. The effectiveness of the Gage-Lynwood aquitard in isolating the Lynwood aquifer from the overlying units is apparent from cross section K-K´, where groundwater elevations in the Lynwood at XLW-04

are approximately 11 feet lower than at the co-located Gage well XG-06. This is in contrast to the water table and MBFC wells at the same locations, which have groundwater elevations within 0.5 feet of each other, even though their screened intervals are separated by more than 20 feet.

As illustrated by the contours on the cross sections, groundwater flow is generally vertical in finer grained units, and generally horizontal in coarser grained units. Furthermore, because of typically large differences between vertical hydraulic conductivities in the fine grained aquitards and horizontal hydraulic conductivities in the coarser grained aquifers (up to several orders of magnitude; see Section 4.2 and associated tables), the velocity of the horizontal flow in the coarser units typically greatly exceeds the velocity of the vertical flow in the finer grained units.

The cross sections indicate that flow direction and gradient near the water table is variable. The presence of local recharge and mounding of the water table near the Waste Pit Area and near the southeast corner of the plant site is inferred to be largely responsible for this observation.

Based on the similarity of their groundwater elevations and their fluctuations in groundwater elevations through time, the water table, MBFB, and MBFC are likely hydraulically interconnected. The Gage aquifer is reported to be merged with the overlying units approximately ½ mile west of the plant site. The hydraulic interconnection between the Gage aquifer and overlying units is likely significantly decreased in the plant site vicinity by the presence of the LBF aquitard, and it is therefore believed that the distal area of merging is largely responsible for the mirrored water level fluctuations in the Gage aquifer and overlying units at the plant site. It is important to keep in mind that while some degree of hydraulic interconnection across the LBF aquitard beneath the site likely exists, vertical flow of ground water across the aquitard is small compared to the horizontal flow in the adjacent MBFC and Gage aquifers.

The Lynwood aquifer is relatively isolated from the overlying units. This judgement is based on the observed presence of the Gage-Lynwood aquitard, the approximately 11 foot difference in groundwater levels between the Lynwood and Gage aquifers, and fluctuations in Lynwood aquifer ground water elevations through time that are not observed mirrored in overlying units.

4.2 AQUIFER PROPERTIES

Aquifer testing was conducted during the Del Amo RI to develop spatially distributed hydraulic conductivity values for each hydrostratigraphic unit. Hydraulic conductivity data for the MBFC and Gage aquifers obtained by Hargis + Associates during the Montrose RI/FS were supplemented with limited testing during the Del Amo RI. Locations of constant rate discharge tests are shown in Figure 2.2-6. In addition, vertical hydraulic conductivity of aquitards was estimated through a combination of aquifer testing via the ratio method (Neuman and Witherspoon, 1972) and physical testing (Appendix F). Locations of ratio method tests are shown in Figure 2.2-7.

Aquifer testing during the Del Amo RI included 19 constant rate discharge tests, one slug test, and three ratio method tests. Aquifer test data analysis methods are described in Appendix H1. Well construction schematics are presented in Appendix H2. Theis recovery plots and recovery data for each constant rate discharge test are included in Appendices H3 and H4, respectively.

4.2.1 Purpose and Objectives

Aquifer testing was performed to obtain estimates of transmissivity and hydraulic conductivity in the UBF, and MBFB. Results for the MBFC and Gage aquifers obtained by Hargis + Associates were supplemented by limited testing in these units during the Del Amo RI. These estimates were obtained by analyzing late-time recovery data from constant discharge pumping tests conducted at 19 wells and a slug test in one well. In addition, three tests were conducted to obtain estimates of vertical hydraulic conductivity of aquitards using the ratio method (Neuman and Witherspoon, 1972 and CDWR, 1971). One ratio method test was conducted to provide vertical hydraulic conductivity estimates for the upper Bellflower aquitard and two ratio method tests were conducted to provide vertical hydraulic conductivity estimates for the lower Bellflower aquitard.

Hydraulic conductivity values obtained from analyses of aquifer testing data were used primarily as input to the groundwater flow and transport model (discussed in the Groundwater Feasibility Study Report). Recovery test data collected by Hargis + Associates as part of the Montrose RI/FS for the MBFC and Gage aquifers were also used as input to the groundwater model. These results will be used to support feasibility study activities and future remedial alternative design.

Aquifer testing locations were selected to develop representative ranges of transmissivity and hydraulic conductivity values and provide spatial distribution of aquifer transmissivity and hydraulic conductivity in areas of contaminant plumes for the UBF, MBFB, and MBFC. Aquifer testing was conducted in areas near or overlain by contaminants to provide geographic distribution of control points for the groundwater model.

Ranges for transmissivity and hydraulic conductivity for the MBFC and Gage aquifers, previously obtained by Hargis + Associates, were supplemented with one test in the MBFC and one test in the Gage aquifer during this investigation.

4.2.2 Constant Rate Discharge and Slug Tests

Twelve-hour (nominal) constant discharge pumping tests were conducted in 11 upper Bellflower aquitard monitoring wells (SWL0005, SWL0006, SWL0009, SWL0012, SWL0016, SWL0017, SWL0021, SWL0039, SWL0042, SWL0046 and SWL0057), six middle Bellflower B sand monitoring wells (SWL0011, SWL0023, SWL0037, SWL0047, SWL0049 and XMW-28), one middle Bellflower C sand well (SWL0014), and one Gage aquifer monitoring well (XDA-1B) during the Del Amo RI. The pumping recovery data from each well were analyzed using the Theis recovery method (Theis, 1935) to estimate aquifer transmissivity. Table 4.2-1 presents a summary of constant rate discharge tests, including test dates, pumping rate, and total pumping time. Schematic diagrams of each well tested are included in Appendix H2.

One slug test was conducted to provide data from a very low-yield Upper Bellflower aquitard well (SWL0044) that could not support a 12-hour pumping test. A schematic well construction diagram of SWL0044 is included in Appendix H2. As indicated in Table 4.2-1, a few of the aquifer pumping tests were less than 12 hours in duration. This was due to drawdown being greater than predicted, requiring the tests to be terminated early to avoid drawing the water level in the pumping well below the pump intake.

Hydraulic conductivity, K, estimates were obtained by dividing transmissivity, T, results by the aquifer thickness, b ($K = T/b$). Aquifer thickness values used for water table wells were equal to the distance from the static water level immediately prior to pumping to the base of the filter pack or to the base of the aquifer unit, whichever was most appropriate based on the lithologic log. Aquifer thickness values used for MBFB, MBFC and Gage aquifer were dictated by the stratigraphy recorded for the pumping well or nearest control boring based on the lithologic log (in some cases, the b value used was less than that of the entire aquifer, as dictated by

stratigraphy). Schematics for each well tested showing the aquifer thickness used to calculate hydraulic conductivity are presented in Appendix H2.

Table 4.2-2 is a summary of aquifer testing results (including Hargis + Associates data for the MBFC and Gage aquifers) presenting transmissivity, aquifer thickness and derived hydraulic conductivity values. Plots of Theis recovery analyses for constant rate discharge tests and Cooper, Bredehoeft, Papadopulos head-ratio match for the slug test are presented in Appendix H3.

4.2.2.1 Upper Bellflower Aquitard Properties

Transmissivity values for the UBF based on Theis recovery analyses for 11 constant discharge tests, and the match to the head-ratio data from one slug test (Cooper et al., 1967), ranged from 0.001 to 0.13 ft^2/minute (1.4 to 190 ft^2/day). Hydraulic conductivity values for the UBF ranged from 0.1 to 10 feet/day (Table 4.2-2). Hydraulic conductivity values for each UBF well tested are shown in Figure 4.2-1.

4.2.2.2 Middle Bellflower B Sand Aquifer Properties

Transmissivity values for the MBFB from Theis recovery analyses for six constant discharge pumping tests ranged from 0.11 to 0.96 ft^2/minute (140 to 1,400 ft^2/day). Hydraulic conductivity values for the MBFB ranged from 9 to 50 feet/day (Table 4.2-2). Hydraulic conductivity values for each MBFB well tested are shown in Figure 4.2-2.

4.2.2.3 Middle Bellflower C Sand Aquifer Properties

The transmissivity values for the MBFC, based on the Theis recovery analyses conducted at Del Amo and Montrose, ranged from 1.1 to 5.5 ft^2/minute (1,600 to 7,900 ft^2/day). Hydraulic conductivity values for the MBFC ranged from 27 to 400 feet/day (Table 4.2-2). Hydraulic conductivity values for each MBFC well tested, including data from Hargis + Associates tests, are shown in Figure 4.2-3.

4.2.2.4 Gage Aquifer Properties

Transmissivity values for the Gage aquifer, based on the Theis recovery analyses conducted

for the Del Amo RI and the Montrose RI/FS, ranged from 0.92 to 1.5 ft^2/minute (1,300 to 2,200 ft^2/day). Hydraulic conductivity values for the Gage aquifer ranged from 23 to 36 feet/day (Table 4.2-2). Hydraulic conductivity values for each Gage well tested, including data from Hargis + Associates tests, are shown in Figure 4.2-4.

4.2.3 Results of Ratio Method Analyses

Three pump tests were conducted at the Del Amo Study Area to estimate the vertical hydraulic conductivity (K_v') of the UBF and LBF aquitards. These three well pairs included a MBFB pumping well with an UBF monitoring well (SWL0023 and SWL0024, respectively), a MBFC pumping well with a LBF monitoring well (SWL0014 and SWL0043, respectively), and a Gage aquifer pumping well with a LBF monitoring well (XDA-1B and SWL0043, respectively). The locations of the well clusters tested are shown in Figure 2.2-7. The ratio method (Neuman and Witherspoon, 1972) was the procedure followed to estimate K_v' of the aquitard materials. This procedure is described in Appendix H1.

The vertical hydraulic conductivity of the lower portion of the UBF was estimated by pumping SWL0023, which is screened in the MBFC and monitoring the response in the UBF at SWL0024. K_v' of the lower portion of the LBF was estimated by pumping XDA-1B which is screened in the Gage aquifer and monitoring the drawdown at LBF well SWL0043. K_v' of the upper portion of the LBF was estimated by pumping SWL0014, which is screened in the MBFC and monitoring the response at SWL0043. Figures H1-2 and H1-3 in Appendix H1 summarize well completion details and generalized hydrostratigraphy for each ratio method pump test well cluster.

The results of the aquifer/aquitard ratio method tests are summarized in Table 4.2-3. Results for each test are discussed in Appendix H1. Based on results of the ratio method analyses, vertical hydraulic conductivity for the upper Bellflower aquitard was estimated to range from 1.4×10^{-1} to 4.9×10^{-1} feet/day. Estimates of vertical hydraulic conductivity for the lower Bellflower aquitard ranged from 9×10^{-3} to 9.6×10^{-1} feet/day. The lower Bellflower aquitard consists of complex and heterogeneous layers of materials that result in this wide range of K_v' values between tests conducted for the upper and lower portions of the aquitard.

4.3 GENERAL GROUNDWATER CHEMISTRY

General groundwater chemistry for each hydrostratigraphic unit is summarized on trilinear Piper diagrams and discussed below. The Piper diagrams illustrate relative percentages of the major cations (calcium, magnesium, and sodium plus potassium) and anions (chloride, sulfate, and carbonate). There are no water quality standards for these naturally occurring compounds. Relative total dissolved solids content for each sampling location can be judged by the diameter of the circle presented in the upper part of the Piper diagrams. The distribution of total dissolved solids concentrations is also illustrated on individual figures for each HSU. There is a secondary (nonrisk-based) maximum contaminant level for total dissolved solids of 1,000 mg/l. Figures illustrating the distribution of nitrate (NO_3) concentrations at Del Amo monitoring locations are presented and discussed in Section 6.

4.3.1 Water Table

The general mineral character for 35 Del Amo water table monitoring locations tested during the third sampling period 1995 are summarized on a trilinear Piper diagram, Figure 4.3-1. Following the classification system used by Freeze and Cherry (1979), groundwater in the water table zone tends to be calcium dominated to non-dominated with respect to cations, and bicarbonate dominated to chloride-dominated with respect to anions. The pH of groundwater in the water table zone ranged from 6.4 (PZL0025) to 7.9 (SWL0045) during the October 1995 sampling event.

The distribution of Total Dissolved Solids (TDS) concentrations are illustrated on Figure 4.3-2. TDS concentrations are typically in excess of 1,000 mg/l, although detected concentrations range from as low as 240 mg/l (SWL0045) to 2,800 mg/l (PZL0024) at Del Amo monitoring locations. The minimum value at SWL0045 is anomalous relative to other water table monitoring locations, and is most likely indicative of an influx of water from a leaking potable water pipeline or other source. Further evidence of this is provided from the anomalously high groundwater elevation at SWL0045 (-4 feet msl) and elevated chloroform concentrations (82 µg/l, October, 1995). Chloroform is commonly present at low concentrations in potable water supplies as a result of water treatment.

4.3.2 Middle Bellflower B Sand

A trilinear Piper diagram for the 17 MBFB locations tested for general minerals is presented in Figure 4.3-3. As shown, groundwater in the MBFB tends to be calcium dominated to non-dominated with respect to cations, and is highly variable with respect to anions, ranging from

bicarbonate dominated to chloride dominated. The pH for Del Amo MBFB monitoring locations ranged from 6.6 (XMW-28) to 7.9 (XG-02WC) during the October 1995 sampling event.

The distribution of TDS concentrations for the MBFB is presented on Figure 4.3-4. TDS concentrations at Del Amo monitoring locations range from 410 mg/l (SWL0037) to 4,200 mg/l (SWL0041). TDS concentrations are mostly in excess of 1,000 mg/l, and range from 410 mg/l (SWL0037) to 4,200 mg/l (SWL0041). The relatively high TDS at SWL0041 coincides with an elevated surfactant concentration relative to other MBFB locations. TDS, surfactants, and VOCs are all present at elevated concentrations in the underlying MBFC (well SWL0040) at this location as well.

4.3.3 Middle Bellflower C Sand

General minerals analyses were conducted for 16 MBFC monitoring locations during the October 1995 sampling event. Results for these analyses are summarized on the trilinear Piper diagram presented in Figure 4.3-5. As illustrated, groundwater in the MBFC tends to be calcium dominated to non-dominated with respect to cations, and bicarbonate dominated to chloride dominated with respect to anions. The pH of groundwater samples from the MBFC ranged from 6.6 (XBF-13) to 7.7 (SWL0018).

TDS concentrations for the MBFC are presented on Figure 4.3-6. In general, TDS concentrations tend to be lower for the MBFC than in overlying units. Excepting locations SWL0040 and XBF-13, TDS for the MBFC ranged from 290 mg/l (SWL0035) to 1,500 mg/l (XBF-15) for the October 1995 sampling event. TDS concentrations at SWL0040 and XBF-13 (7600 and 6800 mg/l), located near the southern boundary of the plant site, are elevated relative to other MBFC monitoring locations, and not judged to be representative of natural conditions. The high TDS concentrations in the vicinity of SWL0040 and XBF-13 may be associated with elevated surfactant and VOC concentrations at these locations, as discussed in Section 5.3.

4.3.4 Gage Aquifer

The general mineral character for samples from seven Gage aquifer locations are summarized in Figure 4.3-7. Groundwater in the Gage aquifer tends to be non-dominated with respect to cations, and bicarbonate dominated to non-dominated with respect to anions. The pH of groundwater samples from the Gage ranged from 7.6 (XG-12) to 7.9 (XG-09).

Gage aquifer TDS concentrations are illustrated on Figure 4.3-8. All Gage aquifer TDS concentrations are less than 1,000 mg/l. TDS concentrations ranged from 320 mg/l (SWL0036) to 810 mg/kg (SWL0034) during the October 1995 sampling event.

Table 4.1-1
Time Series Summary of Groundwater Elevations
Del Amo Monitoring Locations

HSU	Location	1994 Feb	1994 May	1994 Jul	1994 Oct	1995 Mar	1995 Jun	1995 Oct	1996 Feb	Change In Level Over Period of Record (ft)	Average Rate of Change in Level /Year (ft/yr)
Water Table	PZL0001	-20.62	-19.91	-20.05	-20.32	-19.19	-18.65	-18.97	-18.41	2.21	1.1
	PZL0002	-13.58	-13.42	-13.49	-13.56	-12.78	-12.44	-12.31	-12.06	1.52	0.8
	PZL0003	-14.00	-13.85	-13.92	-14.01	-13.38	-12.97	-12.82	-12.37	1.63	0.8
	PZL0004	-19.05	-17.00	-17.05	-17.23	-16.12	-15.61	-15.92	-15.58	3.47	1.7
	PZL0005	-13.32	-12.14	-12.00	-12.09	-11.67	-11.14	-11.37	-10.92	2.40	1.2
	PZL0006	-18.83	-17.81	-17.72	-17.94	-17.06	-16.47	-16.82	-16.60	2.23	1.1
	PZL0007	-19.34	-18.60	-18.74	-18.98	NA	-17.58	-17.65	-17.10	2.24	1.1
	PZL0008	-15.21	NA	-14.59	-14.51	-13.81	-13.35	-13.08	-12.68	2.53	1.3
	PZL0009	-18.18	-17.62	-17.47	-17.48	-17.00	-16.42	-16.34	-15.95	2.23	1.1
	PZL0010	-18.34	-17.64	-17.76	-17.87	-16.95	-16.57	-16.60	-16.30	2.04	1.0
	PZL0011	-17.54	-17.16	-17.16	-17.10	-16.88	-15.88	-15.92	-15.83	1.71	0.9
	PZL0012	-19.71	-19.49	-19.61	-18.70	-18.47	-17.71	-18.04	-17.46*	2.25	1.1
	PZL0013	-15.83	-29.01	-15.96	-16.04	-15.93	-15.44	-15.48	-15.58	0.25	0.1
	PZL0014	-16.47	-15.97	-16.04	-15.98	-15.27	-14.90	-14.64	-14.33	2.14	1.1
	PZL0015	-15.22	-14.74	-14.72	-14.73	-14.25	-13.65	-13.48	-13.14	2.08	1.0
	PZL0016	-18.57	-17.99	-17.91	-17.81	-17.46	-16.90	-16.79	-16.50	2.07	1.0
	PZL0017	-13.43	-13.07	-13.10	-13.11	-12.62	-12.07	-11.82	-11.49	1.94	1.0
	PZL0018	-20.08	NA	-19.44	-19.64	-17.57	-17.31	-17.98	-17.84	2.24	1.1
	PZL0019	-19.32	-18.71	-18.73	-18.64	-18.16	-16.88	-16.78	-16.67	2.65	1.3
	PZL0020	-17.70	-17.51	-17.42	-17.63	-16.78	-15.16	-15.45	-15.27	2.43	1.2
	PZL0021	NA	-20.03	-20.01	-20.19	-19.22	-18.98	-18.88	-18.58	1.45	0.9
	PZL0022	-18.88	-18.85	-18.95	-18.88	-19.25	-18.83	-18.73	-18.87	0.01	0.0
	PZL0023	-19.71	-18.83	-18.88	-17.30	-17.47	NA	NA	NA	2.24	2.1
	PZL0024	-18.68	-18.33	-18.71	-18.27	-18.62	-16.26*	-16.13	-16.28*	2.40	1.2
	PZL0025	-19.37	-19.27	-19.24	-17.81*	-18.03	-16.86	-17.11	-16.99	2.38	1.2
	PZL0026	-14.62	NA	-14.58	-14.61	-14.57	-14.21	-14.18	-14.16	0.46	0.2
	SWL0002	-19.23	-18.46	-18.43	-18.43	-18.07	-17.44	-17.31	-17.06	2.17	1.1
	SWL0003	-19.03	-18.41	-18.97	-18.33	-17.91	-17.25	-17.14	-16.90*	2.13	1.0
	SWL0004	-19.24	-18.44	-18.47	-18.51	-18.10	-17.57	-17.45	-17.07	2.17	1.1
	SWL0005	-18.80	-18.11	-18.13	-18.51	-16.80	-16.16	-16.61	-16.37	2.43	1.2
	SWL0006	-20.68	-20.06	-20.04	-19.81	-19.15	-18.62*	-18.73	-18.38	2.30	1.2
	SWL0007	-17.29	-16.72	-16.65	-16.64	-16.29	-15.87	-15.49	-15.27	2.02	1.0
	SWL0008	-17.50	-17.37	-17.42	-17.42	-15.86	-15.06	-15.18	-15.40	2.10	1.1
	SWL0009	-15.95	-15.28	-15.34	-15.44	-12.87	-12.38	-12.89	-12.91	3.04	1.5
	SWL0012	-14.02	-13.32	-13.27	-13.29	-12.69	-12.30	-12.07	-11.87	2.15	1.1
	SWL0015	-21.33	-20.55	-20.76	-20.89	-19.93	-19.19	-19.46	-18.75	2.58	1.3
	SWL0016	-19.15	-18.42	-18.28	-18.50	-17.27	-16.83	-17.26	-18.93	0.22	0.1
	SWL0017	-18.36	-17.71	-17.75	-17.75	-17.01	-16.55	-16.64	-16.27	2.09	1.1
	SWL0021	-21.05	-20.39	-20.34	-20.61	-19.55	-19.00	-19.24	-18.61	2.44	1.2
	SWL0024	-21.28	-19.77	-19.86	-20.11	-19.04	-18.49	-18.85	-18.22	3.06	1.5
	SWL0028	-18.17	-17.77	-17.86	-17.99	-17.17	-16.06	-15.82	-15.84	2.33	1.2
	SWL0038	-15.79	-15.53	-15.69	-15.72	-15.20	-14.77	-14.49	-14.18	1.61	0.9

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Table 4.1-1
Time Series Summary of Groundwater Elevations
Del Amo Monitoring Locations

HSU	Location	1994 Feb	1994 May	1994 Jul	1994 Oct	1995 Mar	1995 Jun	1995 Oct	1996 Feb	Change In Level Over Period of Record (ft)	Average Rate of Change in Level /Year (ft/yr)
Water Table	SWL0039	NA	-14.16	-14.37	-14.18	-13.75	-12.13	-12.90	-12.56	1.60	1.0
	SWL0042	NA	NA	-21.47	-21.72	-20.83	-19.99	-20.43	-19.59	1.88	1.2
	SWL0044	NA	NA	NA	NA	NA	-16.81	-17.26	-17.08	-0.27	-0.4
	SWL0045	NA	NA	NA	NA	NA	NA	-4.05	-4.14	-0.09	-0.3
	SWL0046	NA	NA	NA	NA	NA	NA	-17.47	-17.08	0.39	1.3
	SWL0049	NA	NA	NA	NA	NA	NA	-18.85	-18.52	0.33	1.1
	SWL0051	NA	NA	NA	NA	NA	NA	-14.87	-16.76	-1.89	-6.2
	SWL0057	NA	NA	NA	NA	NA	NA	-14.36*	-14.28	0.08	0.4
	XDM-01	NA	-22.38	NA	NA	NA	NA	NA	NA	---	---
	XDM-02	NA	-18.10	NA	NA	NA	NA	NA	NA	---	---
	XGW-07A	NA	-21.31	-21.58	-19.82	-17.94*	-18.11	-18.46	-17.86	3.45	2.1
	XMW-01	-20.24	-19.82	-19.75	-19.49	-19.27	-18.76	-18.48	-18.27	1.97	1.0
	XMW-01HD	-16.59	-16.09	-16.06	-16.15	-15.78	-15.41	-15.36	-15.19	1.40	0.7
	XMW-01T	-18.97	-18.32	-18.36	-18.39	-17.80	-17.43	-17.29	-16.98	1.99	1.0
	XMW-02HD	-14.99	-14.87	-14.93	-15.10	-14.92	-14.40	-14.57	-14.52	0.47	0.2
	XMW-02T	-18.88	-18.46	-18.52	-18.54	-17.98	-17.31	-17.41	-17.09	1.79	0.9
	XMW-03	-19.64	NA	NA	-19.10	NA	NA	-18.17	-17.74	1.90	1.0
	XMW-03HD	-15.57	-15.41	-15.41	-15.54	-15.26	-14.68	-14.92	-14.78	0.79	0.4
	XMW-04	NA	-18.99	-18.89	-18.79	-18.64	-18.14	-17.84	-17.47	1.52	0.9
	XMW-04HD	-19.65	-19.24	-19.36	-19.57	-18.62	-17.83	-18.34	-18.68	0.97	0.5
	XMW-05	NA	-19.08	-18.98	-18.77	-18.58	-18.06	-17.79	-17.57	1.51	0.9
	XMW-06	NA	-18.65	-19.56	-19.40	-19.12	-18.77	-18.61	-18.03	0.62	0.4
	XMW-07	-20.48	NA	NA	NA	NA	NA	-18.49	NA	1.99	1.2
	XMW-08	NA	NA	NA	NA	NA	NA	NA	NA	---	---
	XMW-09	NA	-19.04	-18.87	-18.77	-18.45	-18.15	-17.93	-17.56	1.48	0.9
	XMW-10	-19.51	-18.90	-18.91	-18.76	-18.45	-18.02	-17.73	-17.48	2.03	1.0
	XMW-11	-19.87	-19.47	-19.33	-19.32	-19.06	-18.53	-18.24	-18.05	1.82	0.9
	XMW-12	NA	-19.25	-19.20	-19.52	-19.11	-18.52	-18.35	-18.18	1.07	0.6
	XMW-13	-20.36	-19.74	-19.79	-19.62	-19.28	-18.57	-18.48	-18.17	2.19	1.1
	XMW-14	-20.33	-19.80	-19.71	-19.70	-19.42	-18.86	-18.68	-18.36	1.97	1.0
	XMW-15	NA	-19.91	-19.81	NA	NA	NA	NA	NA	0.10	0.8
	XMW-16	NA	-19.98	NA	-19.96	-19.66	NA	-19.05	-18.71	1.27	0.8
	XMW-17	NA	NA	NA	NA	NA	NA	-18.49	NA	---	---
	XMW-18	NA	-18.90	NA	NA	NA	NA	-18.00	-17.41	1.49	0.9
	XMW-19	NA	-18.45	-18.34	-18.14	-17.94	-17.59	-17.38	-17.02	1.43	0.9
	XMW-21	-19.59	-22.89	-18.62	-18.84	-18.29	-18.37	-17.91	-17.48	2.11	1.1
	XMW-22	NA	-20.16	-19.99	-20.02	-19.75	-19.20	-18.97	-18.49	1.67	1.0
	XMW-23	-20.76	-20.28	-20.19	-20.25	-19.49	-18.67	-18.71	-18.42	2.34	1.2
	XMW-24	-20.19	-19.80	-19.83	-19.81	-19.12	-18.35	-18.41	-18.21	1.98	1.0
	XMW-25	-21.72	-20.98	-21.03	-21.04	-20.38	-19.77	-19.93	-19.40	2.32	1.2
	XMW-26	NA	-20.16	-20.09	-19.95	-19.74	-19.17	-18.84	-18.52	1.64	1.0
	XMW-27	-19.43	-18.68	-18.70	-18.65	-18.27	-17.90	-17.71	-17.42	2.01	1.0

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HSU	Location	1994 Feb	1994 May	1994 Jul	1994 Oct	1995 Mar	1995 Jun	1995 Oct	1996 Feb	Change In Level Over Period of Record (ft)	Average Rate of Change in Level /Year (ft/yr)
Water Table	XMW-28	-19.95	-19.29	-19.17	-19.33	-18.67	-18.61	-18.23	-17.98*	1.97	1.0
	XMW-29	-20.47	-19.73	-19.79	-19.76	-19.12	-18.56	-18.69	-18.29	2.18	1.1
	XMW-30	-20.55	-19.89	-19.89	-19.83	-19.25	-18.28	-18.44	-18.07	2.48	1.2
	XP-02	-20.19	-19.34	-19.43	-19.64	-17.50	-17.96	-18.08	-17.74	2.45	1.2
MBFB	PZL0021	NA	-20.03	-20.01	-20.19	-19.22	-18.98	-18.88	-18.58	1.45	0.9
	SWL0002	-19.23	-18.46	-18.43	-18.43	-18.07	-17.44	-17.31	-17.06	2.17	1.1
	SWL0003	-19.03	-18.41	-18.97	-18.33	-17.91	-17.25	-17.14	-16.90*	2.13	1.0
	SWL0004	-19.24	-18.44	-18.47	-18.51	-18.10	-17.57	-17.45	-17.07	2.17	1.1
	SWL0010	-20.66	-19.88	-20.10	-20.38	-19.07	-18.78	-18.94	-18.10	2.56	1.3
	SWL0011	-20.77	-20.06	-20.19	-20.44	-19.25	-18.86	-19.05	-18.33	2.44	1.2
	SWL0019	-22.30	-21.55	-21.77	-22.07	-20.99	-20.55	-20.67	-19.49	2.81	1.4
	SWL0023	-21.64	-20.95	-21.08	-21.36	-20.08	-19.88	-19.99	-19.05	2.59	1.3
	SWL0029	-18.72	-18.02	-18.05	-18.10	-17.51	-17.10	-16.97	-16.66	2.06	1.0
	SWL0037	-19.23	-19.01	-19.13	-19.33	-18.28	-17.94	-17.98	-17.58	1.65	0.9
	SWL0041	-21.04	-21.13	-21.25	-21.68	-20.10*	-19.10	-19.21	-18.64	2.40	1.3
	SWL0047	NA	NA	NA	NA	NA	NA	-17.77	-17.43	0.34	1.1
	SWL0048	NA	NA	NA	NA	NA	NA	-18.43	-18.01	0.42	1.4
	SWL0049	NA	NA	NA	NA	NA	NA	-18.85	-18.52	0.33	1.1
	SWL0050	NA	NA	NA	NA	NA	NA	-18.85	-18.35	0.50	1.6
	SWL0052	NA	NA	NA	NA	NA	NA	-19.15	-18.33	0.82	2.7
	SWL0056	NA	NA	NA	NA	NA	NA	-19.77*	-19.09	0.68	3.3
	XDM-02	NA	-18.10	NA	NA	NA	NA	NA	NA	---	---
	XG-01WC	NA	NA	NA	NA	-22.36*	-18.21*	-19.23	-18.63	3.73	4.4
	XG-02WC	NA	NA	NA	NA	-19.59*	-19.38*	-19.97	-18.95	0.64	0.7
	XGW-07C	NA	-20.52	-19.69	-20.93	-19.62	-20.26	-20.52	-19.55*	0.97	0.6
	XMW-01	-20.24	-19.82	-19.75	-19.49	-19.27	-18.76	-18.48	-18.27	1.97	1.0
	XMW-01T	-18.97	-18.32	-18.36	-18.39	-17.80	-17.43	-17.29	-16.98	1.99	1.0
	XMW-02T	-18.88	-18.46	-18.52	-18.54	-17.98	-17.31	-17.41	-17.09	1.79	0.9
	XMW-03	-19.64	NA	NA	-19.10	NA	NA	-18.17	-17.74	1.90	1.0
	XMW-04	NA	-18.99	-18.89	-18.79	-18.64	-18.14	-17.84	-17.47	1.52	0.9
	XMW-05	NA	-19.08	-18.98	-18.77	-18.58	-18.06	-17.79	-17.57	1.51	0.9
	XMW-06	NA	-18.65	-19.56	-19.40	-19.12	-18.77	-18.61	-18.03	0.62	0.4
	XMW-07	-20.48	NA	NA	NA	NA	NA	-18.49	NA	1.99	1.2
	XMW-08	NA	NA	NA	NA	NA	NA	NA	NA	---	---
	XMW-09	NA	-19.04	-18.87	-18.77	-18.45	-18.15	-17.93	-17.56	1.48	0.9
	XMW-10	-19.51	-18.90	-18.91	-18.76	-18.45	-18.02	-17.73	-17.48	2.03	1.0
	XMW-11	-19.87	-19.47	-19.33	-19.32	-19.06	-18.53	-18.24	-18.05	1.82	0.9
	XMW-12	NA	-19.25	-19.20	-19.52	-19.11	-18.52	-18.35	-18.18	1.07	0.6
	XMW-13	-20.36	-19.74	-19.79	-19.62	-19.28	-18.57	-18.48	-18.17	2.19	1.1
	XMW-14	-20.33	-19.80	-19.71	-19.70	-19.42	-18.86	-18.68	-18.36	1.97	1.0
	XMW-15	NA	-19.91	-19.81	NA	NA	NA	NA	NA	0.10	0.8
	XMW-16	NA	-19.98	NA	-19.96	-19.66	NA	-19.05	-18.71	1.27	0.8

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HSU	Location	1994 Feb	1994 May	1994 Jul	1994 Oct	1995 Mar	1995 Jun	1995 Oct	1996 Feb	Change In Level Over Period of Record (ft)	Average Rate of Change in Level /Year (ft/yr)
MBFB	XMW-17	NA	NA	NA	NA	NA	NA	-18.49	NA	---	---
	XMW-18	NA	-18.90	NA	NA	NA	NA	-18.00	-17.41	1.49	0.9
	XMW-19	NA	-18.45	-18.34	-18.14	-17.94	-17.59	-17.38	-17.02	1.43	0.9
	XMW-21	-19.59	-22.89	-18.62	-18.84	-18.29	-18.37	-17.91	-17.48	2.11	1.1
	XMW-22	NA	-20.16	-19.99	-20.02	-19.75	-19.20	-18.97	-18.49	1.67	1.0
	XMW-26	NA	-20.16	-20.09	-19.95	-19.74	-19.17	-18.84	-18.52	1.64	1.0
	XMW-27	-19.43	-18.68	-18.70	-18.65	-18.27	-17.90	-17.71	-17.42	2.01	1.0
	XMW-28	-19.95	-19.29	-19.17	-19.33	-18.67	-18.61	-18.23	-17.98*	1.97	1.0
	XMW-29	-20.47	-19.73	-19.79	-19.76	-19.12	-18.56	-18.69	-18.29	2.18	1.1
	XMW-30	-20.55	-19.89	-19.89	-19.83	-19.25	-18.28	-18.44	-18.07	2.48	1.2
	XP-02	-20.19	-19.34	-19.43	-19.64	-17.50	-17.96	-18.08	-17.74	2.45	1.2
	XP-03	NA	NA	NA	NA	-19.20*	-19.29	-19.22	-18.53	0.67	0.8
MBFC	SWL0013	-20.77	-20.09	-20.20	-20.48	-19.28	-18.88	-19.03	-18.37	2.40	1.2
	SWL0014	-22.16	-26.36	-21.56	-21.82	-20.71	-20.27	-20.42	-19.00	3.16	1.6
	SWL0018	-20.54	-19.84	-19.89	-20.12	-19.23	-19.03	-18.74	-18.25	2.29	1.2
	SWL0027	NA	-21.78	-21.95	-22.15	-20.97	-20.62	-20.77	-19.67	2.11	1.3
	SWL0030	-18.71	-18.09	-18.09	-18.13	-17.53	-17.14	-17.03	-16.67	2.04	1.0
	SWL0033	-20.61	-20.14	-20.18	-20.34	-19.48	-18.95	-19.00	-18.52	2.09	1.1
	SWL0035	-19.36	-19.12	-19.19	-19.41	-18.38	-18.02	-18.08	-17.64	1.72	0.9
	SWL0040	-20.59	-20.40	-20.49	-20.25	-19.31*	-19.22	-19.35	-18.75	1.84	1.0
	SWL0043	NA	NA	-22.31	-21.79	-20.66	-20.26	-19.58	-18.48	3.83	2.5
	SWL0053	NA	NA	NA	NA	NA	NA	-19.09	-18.24	0.85	2.8
	SWL0054	NA	NA	NA	NA	NA	NA	-17.87*	-17.67	0.20	0.8
	SWL0055	NA	NA	NA	NA	NA	NA	-18.63*	-18.23	0.40	1.7
	SWL0058	NA	NA	NA	NA	NA	NA	NA	-18.17	---	---
	XBF-01	NA	-19.26	-19.37	-19.45	-18.90	-18.48	-18.32	-17.71	1.55	0.9
	XBF-02	-19.67	-19.39	-19.39	-19.43	-19.03	-18.66	-18.57	-18.00	1.67	0.8
	XBF-03	NA	-19.30	-19.42	-19.36	-18.93	-18.57	-18.36	-17.92	1.38	0.8
	XBF-04	NA	-19.41	-19.37	-19.52	-19.01	-18.63	-18.45	NA	0.96	0.7
	XBF-05	-19.87	-19.21	-19.30	-19.78	-19.02	-18.57	-18.52	NA	1.35	0.8
	XBF-06	-19.88	-19.24	-19.29	-19.98	-19.32	-18.82	-18.78	-18.36	1.52	0.8
	XBF-07	-20.50	-19.86	-19.91	-20.16	-19.55	-19.02	-18.99	-18.55	1.95	1.0
	XBF-08	NA	-19.72	-19.79	NA	NA	NA	NA	NA	-0.07	-0.5
	XBF-09	NA	-19.28	-19.41	-19.46	-18.93	-18.55	-18.18	-17.87	1.41	0.8
	XBF-10	-21.96	-21.19	-21.32	-21.48	-20.44	-19.99	-20.12	-19.12*	2.84	1.4
	XBF-11	NA	NA	NA	NA	NA	NA	NA	NA	---	---
	XBF-12	-23.07	-22.36	-22.50	-22.62	-21.63	-21.20	-21.34	-20.28	2.79	1.4
	XBF-13	-21.04	-20.44	-20.53	-20.67	-19.57	-19.18	-19.27	-18.66	2.38	1.2
	XBF-14	-21.20	-20.45	-20.59	-20.64	-19.83	-19.34	-19.35	-18.84	2.36	1.2
	XBF-15	-21.52	-20.82	-20.93	-21.01	-20.27	-19.76	-19.72	-19.25	2.27	1.1
	XBF-16	NA	NA	NA	NA	NA	NA	NA	NA	---	---
	XBF-17	NA	-21.33	-21.40	-21.58	-20.69	-20.21	-20.29	-19.55	1.78	1.1

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HSU	Location	1994 Feb	1994 May	1994 Jul	1994 Oct	1995 Mar	1995 Jun	1995 Oct	1996 Feb	Change In Level Over Period of Record (ft)	Average Rate of Change in Level /Year (ft/yr)
MBFC	XBF-18	NA	-19.20	-19.43	-19.69	NA	NA	NA	-17.84	1.36	0.8
	XBF-19	-19.84	-19.18	-19.29	-19.33	-18.59	-18.28	-18.16	-17.82	2.02	1.0
	XBF-21	NA	-20.45	-20.54	-20.69	-19.94	-19.56	-19.50	-19.09	1.36	0.8
	XBF-22	NA	NA	NA	NA	NA	NA	-55.30	NA	---	---
	XBF-23	-21.05	-20.34	-20.40	-20.52	-19.66	-19.16*	-19.18	-18.77	2.28	1.1
	XBF-24	-21.84	-21.14	-21.19	-21.31	NA	-19.95	-20.05	-19.90	1.94	1.0
	XBF-27	NA	NA	NA	NA	NA	NA	-46.36	NA	---	---
	XBF-29	NA	-20.54	-20.58	-20.77	-20.06	-19.76	-19.62	-19.22	1.32	0.8
Gage	SWL0020	-23.86	-23.05	-23.62	-24.21	-22.40	-22.52	-22.76	-21.93	1.93	1.0
	SWL0022	-22.70	-21.95	-22.47	-23.04	-21.33	-21.42	-21.41	-20.98	1.72	0.9
	SWL0025	-23.85	-23.02	-23.63	-24.30	-22.42	-22.50	-22.77	-21.96	1.89	0.9
	SWL0026	-23.53	-22.74	-23.17	-23.63	-21.98	-22.08	-22.18	-21.37	2.16	1.1
	SWL0031	-20.35	-19.76	-20.10	-20.54	-19.27	-19.23	-19.08	-18.49	1.86	0.9
	SWL0034	-21.98	-21.27	-21.62	-22.03	-20.67	-20.66	-20.64	-20.10	1.88	0.9
	SWL0036	NA	-21.36	-21.97	-22.39	-20.77	-20.98	-20.91	-20.34	1.02	0.6
	XDA-1B	-23.30	-22.38	-22.90	-23.46	-21.82	-21.85	-21.97	-20.95	2.35	1.2
	XG-01	NA	-18.72	-19.01	-19.37	-19.25	-19.10	-18.89	-18.32	0.40	0.2
	XG-02	NA	-20.10	-20.41	-20.75	-19.65	-19.57	-19.41	-18.86	1.24	0.7
	XG-03	-20.27	-19.90	-20.17	-20.49	-19.49	-19.35	-20.15	-18.49	1.78	0.9
	XG-04	-20.87	-20.37	-20.70	-21.14	-19.89	-19.00	-19.66	-19.18	1.69	0.9
	XG-05	-20.64	-20.48	-20.81	-21.19	-20.01	-19.90	-19.79	-19.28	1.36	0.7
	XG-06	-21.23	-20.53	-20.86	-21.25	-20.03	-19.89	-19.90	-19.31	1.92	1.0
	XG-07	NA	-20.28	-20.57	NA	NA	NA	NA	NA	-0.29	-2.3
	XG-08	-21.88	-21.11	-21.48	-21.89	-20.60	-20.57	-20.54	-19.98	1.90	1.0
	XG-09	NA	NA	-22.74	-23.17	-21.64	-21.70	-21.77	NA	0.97	0.8
	XG-10	NA	-19.35	-19.68	-20.02	-19.01	NA	NA	-18.08	1.27	0.8
	XG-11	-22.67	-21.91	-22.36	-22.86	-21.23	-21.35	-21.40	-20.84	1.83	0.9
	XG-12	-22.37	-21.62	-22.03	-22.49	-20.99	-20.97	-21.06	-20.43	1.94	1.0
	XG-13	-22.39	-21.62	-22.02	-22.53	-21.03	-21.01	-21.05	-20.47	1.92	1.0
	XG-14	-20.78	-20.12	-20.45	-20.85	-19.61	-19.60	-19.43	-18.87	1.91	1.0
	XG-15	NA	-20.01	-20.30	-20.59	-19.68	-22.13	-19.32	-18.74	1.27	0.8
	XG-16	NA	-21.23	-21.59	-22.00	-20.74	-20.70	-20.65	-20.12	1.11	0.7
	XG-17	-21.90	-21.17	-21.55	-21.95	-20.56	-20.58	-20.59	-20.01	1.89	0.9
	XG-18	-23.38	-22.62	-23.00	-23.38	-24.09	-21.90	-22.03	-21.23	2.15	1.1
	XG-19	-23.09	-22.33	-22.74	-23.07	-21.67	-21.63	-21.73	-21.09	2.00	1.0
	XLG-01	NA	-20.05	-20.42	-20.75	-19.66	-19.58	-19.41	-18.87	1.18	0.7
	XLG-02	NA	-19.87	-20.18	-20.53	-19.51	-19.36	-19.22	-18.63	1.24	0.7
Lynwood	XLW-01	NA	NA	NA	-33.57	-28.64	-30.90	-31.01	-30.54	3.03	2.3
	XLW-02	NA	NA	NA	-33.46	-28.64	-30.86	-31.07	-30.65	2.81	2.1
	XLW-03	NA	NA	NA	-33.33	-28.40	-29.66	-30.70	-30.29	3.04	2.3
	XLW-04	NA	NA	NA	-33.33	-28.37	-30.64	-30.86	-30.45	2.88	2.2
	XLW-05	NA	NA	NA	-33.38	-28.48	-30.69	-30.72	-30.29	3.09	2.3

NA = Not available. * = Measurement taken before purging during sample round. All elevations in feet Mean Sea Level.

Table 4.1-1
Time Series Summary of Groundwater Elevations
Del Amo Monitoring Locations

HSU	Location	1994 Feb	1994 May	1994 Jul	1994 Oct	1995 Mar	1995 Jun	1995 Oct	1996 Feb	Change In Level Over Period of Record (ft)	Average Rate of Change in Level /Year (ft/yr)
Lynwood	XLW-06	NA	NA	NA	-33.34	-28.42	-30.64	-30.71	-30.31	3.03	2.3
	XLW-07	-29.70	NA	NA	-33.36	-28.42	-30.66	-30.74	-30.33	-0.63	-0.3

NA = Not available. * = Measurement taken before purging during sample round. All elevations in feet Mean Sea Level.

TABLE 4.1-2
VERTICAL GRADIENTS

HSU Pair	Monitoring Location Pair	Well Screen Midpoint Elevations (ft msl)	Vertical Gradient	Average Vertical Gradient
Water Table/MBFB	PZL0016/SWL0029	-23.01 / -42.04	-0.0095	-0.0234
	SWL0016/SWL0037	-22.73 / -56.70	-0.0212	
	SWL0015/SWL0019	-26.08 / -60.15	-0.0355	
	SWL0057/SWL0056	-21.95 / -50.61	-0.1888*	
	SWL0009/SWL0010	-24.66 / -85.03	-0.1002*	
	SWL0024/SWL0023	-26.12 / -67.94	0.0273	
MBFB/MBFC	SWL0029/SWL0030	-42.04 /- 68.53	-0.0023	-0.0027
	XMW-12/XBF-05	-27.63 / -86.42	-0.0029	
	XMW-27/XBF-19	-25.76 / -89.22	-0.0071	
	SWL0037/SWL0035	-56.70 / -95.42	-0.0026	
	SWL0050/SWL0055	**-41.95 / -87.15**	**+0.0049**	
	SWL0011/SWL0013	**-66.18 / -105.69**	**+0.0005**	
	XMW-13/XBF-06	-26.60 / -77.20	-0.0059	
	XMW-14/XBF-07	-24.56 / -68.65	-0.0071	
	SWL0052/SWL0053	-62.56 / -99.86	-0.0016	
MBFC/Gage Aquifer	SWL0030/SWL0031	-68.53 / -128.75	-0.0340	-0.0304
	XBF-05/XG-04	-86.42 / -133.56	-0.0242	
	XBF-19/XG-14	-89.22 / -133.62	-0.0286	
	SWL0035/SWL0036	-95.42 / -152.79	-0.0493	
	SWL0013/SWL0022	-105.69 / -153.29	-0.0500	
	XBF-06/XG-05	-77.20 / -127.65	-0.0200	
	XBF-07/XG-06	-68.65 / -126.21	-0.0158	
	XBF-14/XG-13	-78.72 / -139.78	-0.0192	
	SWL0040/XG-11	-92.15 / -166.59	-0.0275	
	SWL0027/SWL0026	-104.14 / -144.50	-0.0349	
Gage Aquifer/Lynwood Aquifer	XLG-02/XLW-01	-149.73 / -194.49	0.2634	-0.1870
	XG-01/XLW-05	-103.62 / -192.91	0.1325	
	XG-06/XLW-04	-126.21 / -192.54	0.1652	

Groundwater elevations used in vertical gradient calculaton from third sampling period, 1995 monitoring event (Table 4.1-1). Bolded Locations have an upward (positive) vertical gradient; all others are downward.

* Gradient values at these locations may not reflect natural conditions; water table elevations are anomalously high, possibly due to recharge from leaking water pipelines, sewers, or other unknown sources. Gradient values at these locations are not used in calculation of average value.

TABLE 4.2-1
SUMMARY OF CONSTANT RATE DISCHARGE TESTS
DEL AMO AQUIFER TESTING

Well ID	Test Date(s)	Pumping Rate, Q (gpm)	Time Pump On	Time Pump Off	Total Pumping Time (minutes)
Upper Bellflower Aquitard					
SWL0005	2/29/96	0.7	13:31:20	19:14:00	341
SWL0006	3/6/96	0.35	9:21:00	21:33:00	732
SWL0009	3/5/96	0.29	9:10:00	22:30:00	800
SWL0012	3/13/96	0.86	9:45:00	15:38:00	353
SWL0016	2/20/96	0.8	9:01:00	21:35:00	754
SWL0017	3/19/96	0.4	12:25:00	0:30:00	725
SWL0021	3/22/96	0.2	8:43:00	20:43:00	720
SWL0039	1/19/96	1.8	9:39:00	21:53:00	734
SWL0042	3/20/96	1.0	9:40:00	21:51:00	731
SWL0046	1/18/96	0.9	10:34:00	22:50:30	737
SWL0057	2/21/96	0.75	9:09:00	21:26:00	737
Middle Bellflower B Sand					
SWL0011	3/15/96	10.8	10:00:00	22:20:00	740
SWL0023	4/25/96-4/26/96	9.9	09:40:00	13:00:00	1,640
SWL0037	3/23/96	4.8	8:35:00	20:36:00	721
SWL0047	3/12/96	4.6	9:47:35	21:50:00	722
SWL0049	2/28/96	5.0	10:22:00	23:00:00	758
XMW-28	3/24/96	4.0	10:40:00	21:25:00	645
Middle Bellflower C Sand					
SWL0014	4/22/96	4.8	12:00:02	17:56:00	356
Gage					
XDA-1B	5/3/96	25.0	10:33:00	21:30:00	657

TABLE 4.2-2
SUMMARY OF AQUIFER TESTING RESULTS
THEIS RECOVERY METHOD
DEL AMO AQUIFER TESTING
Page 1 of 2

Well ID	Transmissivity, T (ft^2/minute)	Aquifer Thickness, b (feet)	Hydraulic Conductivity, K (feet/day)
Upper Bellflower Aquitard			
SWL0005	0.02	17.6	1.6
SWL0006	0.025	21.6	1.7
SWL0009	0.004	24.1	0.2
SWL0012[1]	0.059	16.5	5.2
SWL0016	0.046	13.4	4.9
SWL0017	0.016	16.7	1.4
SWL0021	0.02	16	1.8
SWL0039	0.13	19.3	10
SWL0042	0.02	16.1	1.8
SWL0044[2]	0.001	13.8	0.1
SWL0046	0.023	11.4	2.9
SWL0057	0.053	16.3	4.7
Middle Bellflower B Sand			
SWL0011	0.77	63	18
SWL0023	0.96	65	21
SWL0037	0.50	61	12
SWL0047	0.35	58	9
SWL0049	0.42	12.1	50
XMW-28[3]	0.11	16.1	10

TABLE 4.2-2
Page 2 of 2

Well ID	Transmissivity, T (ft^2/minute)	Aquifer Thickness, b (feet)	Hydraulic Conductivity, K (feet/day)
Middle Bellflower C Sand			
SWL0014	1.1	58	27
XBF-5[4]	5.5	20	400
XBF-7[4]	1.3	10	190
XBF-9[4]	3.5	19.5	260
XBF-11[4]	2.8	65.1	62
XBF-13[4]	1.3	59.5	32
XBF-15[4]	5	43.5	170
Gage			
XDA-1B	0.98	62	23
XG-5[4]	1.5	61	35
XG-11[4]	1.3	52	31
XG-13[4]	0.92	36.5	36

1 Short pumping time; pumping was terminated at 353 minutes to avoid drawing water level below pump intake.

2 Results for match to head-ratio data from falling-head slug test

3 Well XMW-28 is a water table well that is screened partially in the upper Bellflower and partially in the middle Bellflower B Sand

4 Results from Hargis + Associates' reanalysis of constant discharge aquifer test data collected during Montrose RI/FS using the Theis recovery method (Hargis + Assoc., 1996b)

TABLE 4.2-3
SUMMARY OF AQUITARD VERTICAL HYDRAULIC CONDUCTIVITY RATIO METHOD TEST RESULTS
Page 1 of 1

Aquifer/ Well	Aquitard/ Well	Time (minutes)	Upper-End Average K_v' (feet/day)	Lower-End Average K_v' (feet/day)
MBFB	UBF	170	4.9×10^{-1}	2.6×10^{-1}
SWL0023	SWL0024	500	2.5×10^{-1}	1.4×10^{-1}
		Average	3.7×10^{-1}	2×10^{-1}
MBFC	LBF	60	9.6×10^{-1}	3.6×10^{-1}
SWL0014	SWL0043	210	6.1×10^{-1}	2.3×10^{-1}
		Average	7.9×10^{-1}	3×10^{-1}
Gage	LBF	72	5×10^{-2}	2×10^{-2}
XDA-1B	SWL0043	312	2×10^{-2}	9×10^{-3}
		Average	3.5×10^{-2}	1×10^{-2}

K_v' = vertical hydraulic conductivity of aquitard

796/061

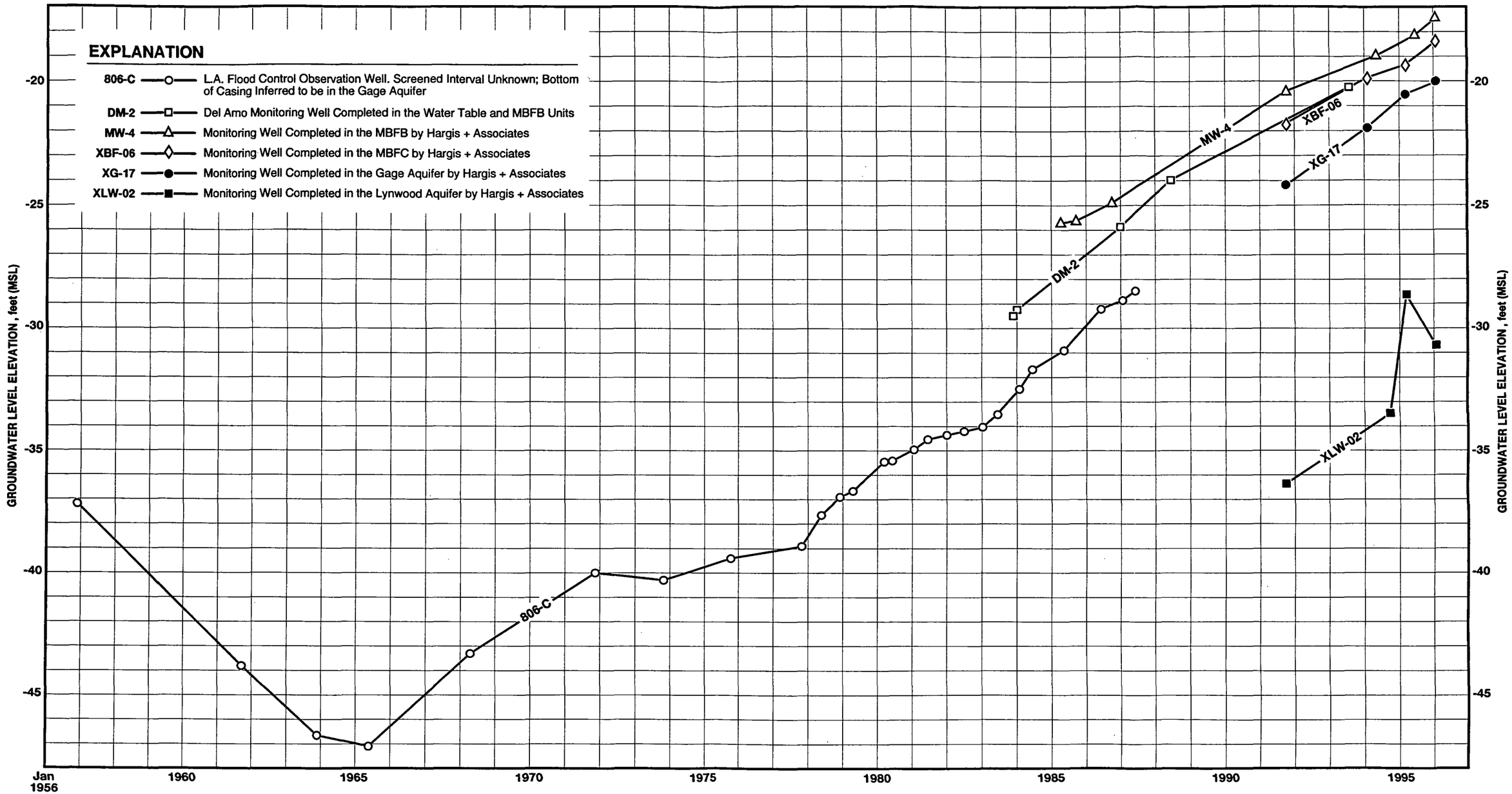


FIGURE 4.1-1

Historical Hydrograph

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

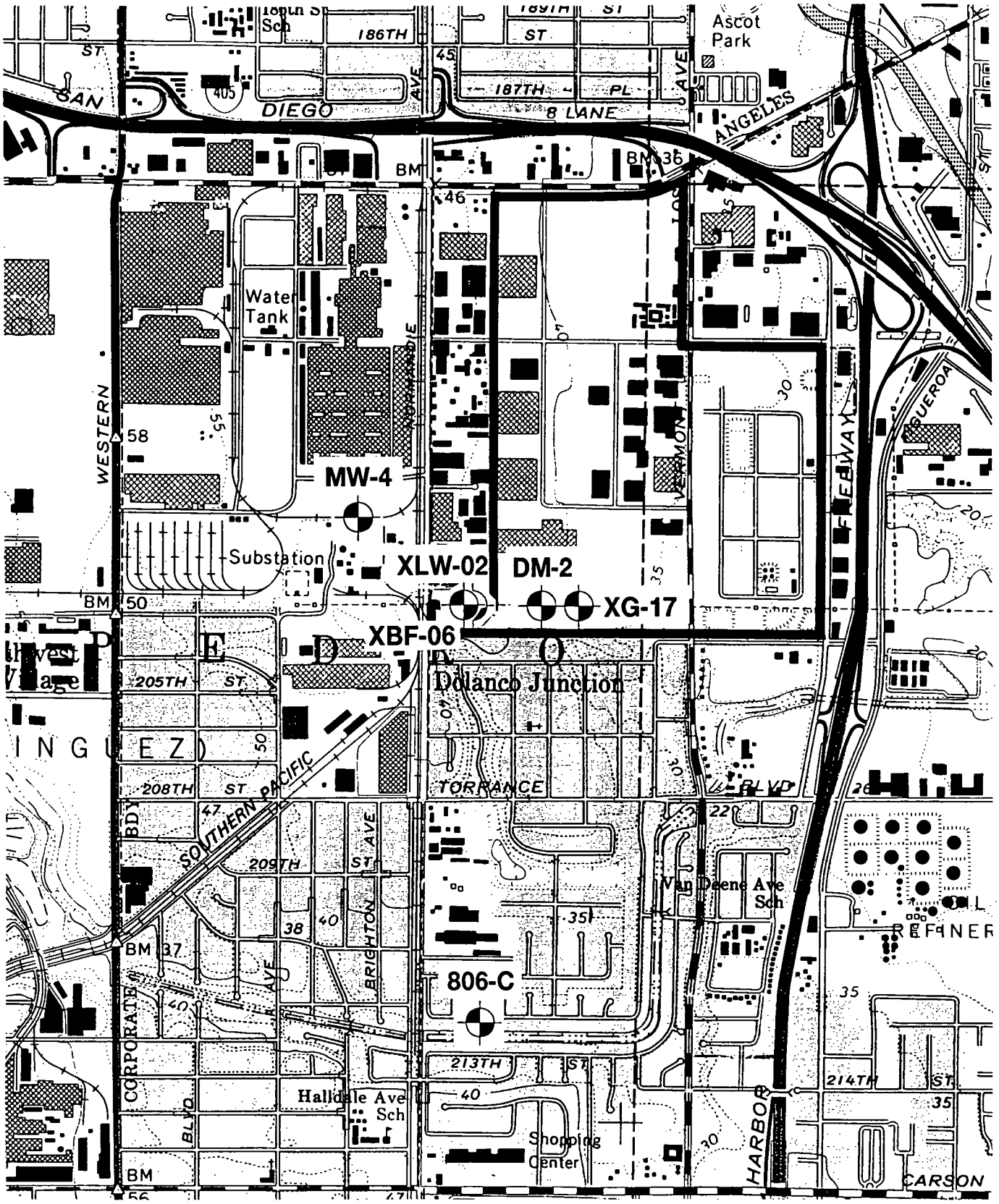


FIGURE 4.1-2

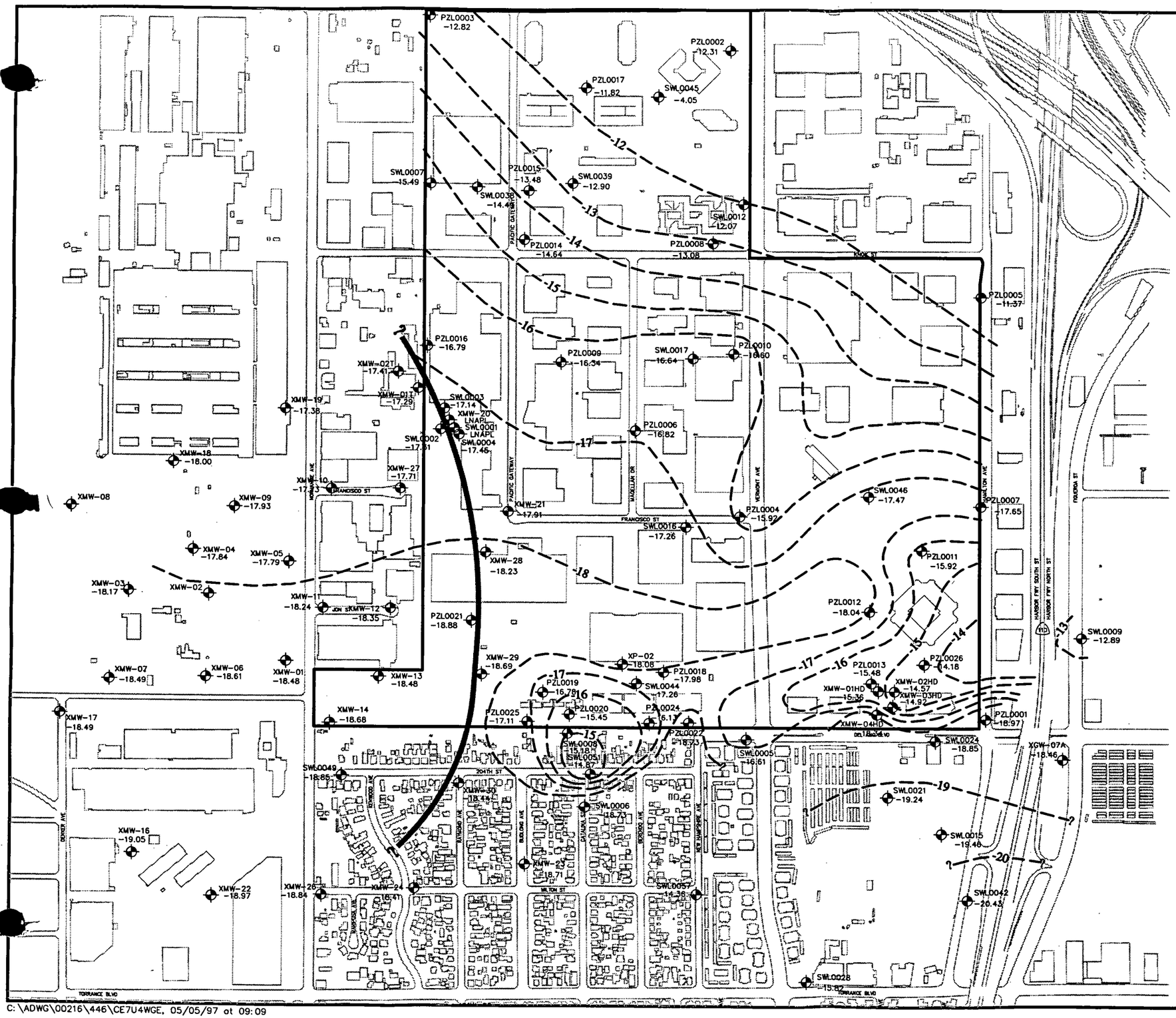
Monitoring Well Location Map

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

0 1/4 1/2
Scale in Miles

Base Map: USGS Topographic Quadrangle: Torrance, CA 1964; photorevised 1981



EXPLANATION

PZL0007 -17.65 — Water table zone monitoring location and groundwater elevation in feet MSL

-17 — Groundwater elevation contour (Feet MSL)

? ? — Inferred intersection of water table surface with top of middle Bellflower B sand. The overlying upper Bellflower aquitard is unsaturated west of the inferred intersection

FIGURE 4.1-3

October 1995 Groundwater Elevations Water Table Zone

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

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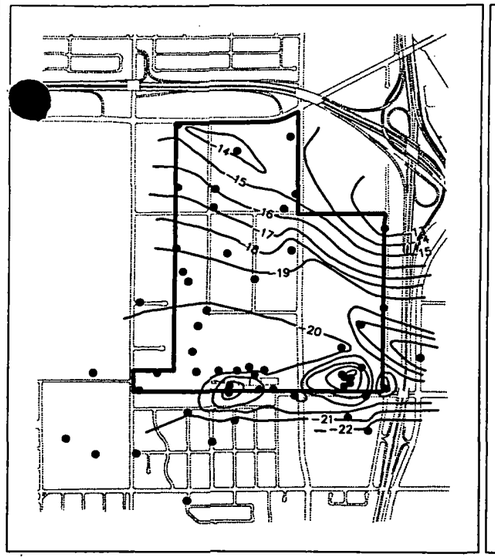

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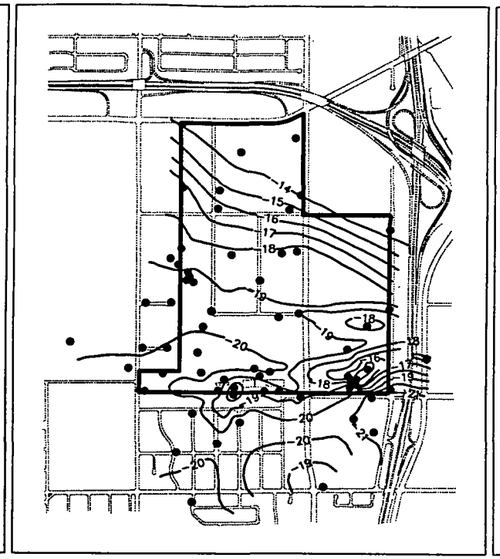
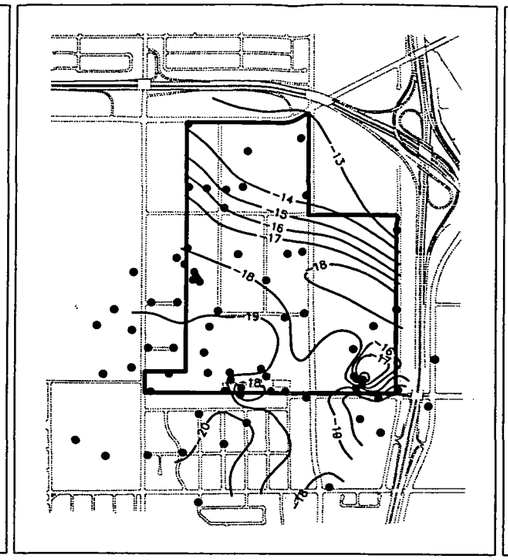


February 1994



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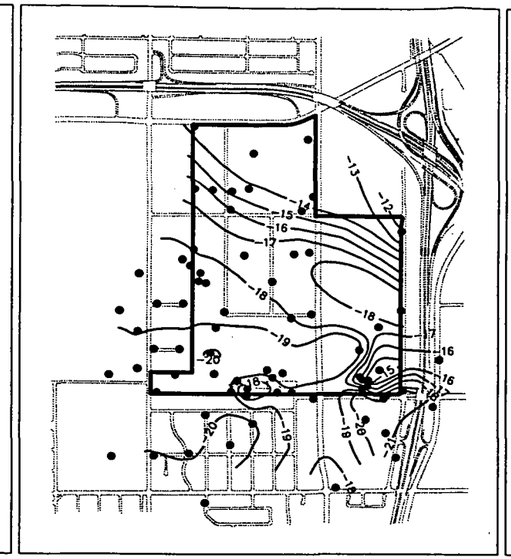
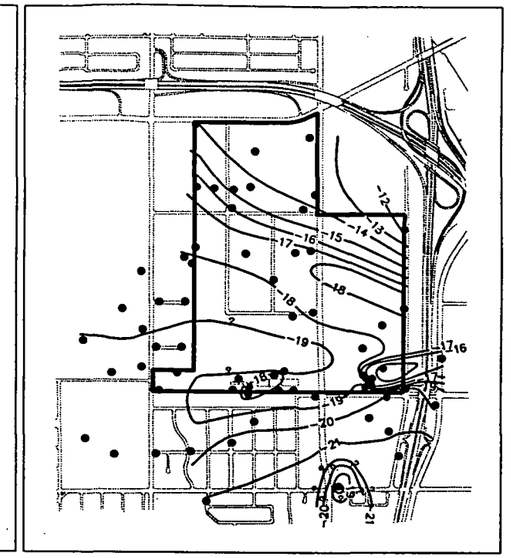


July 1994



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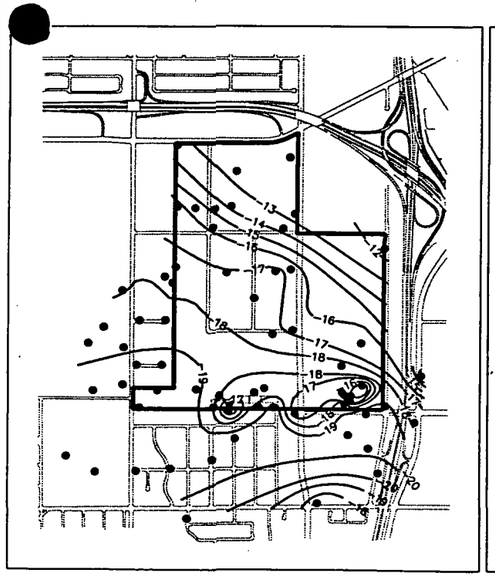

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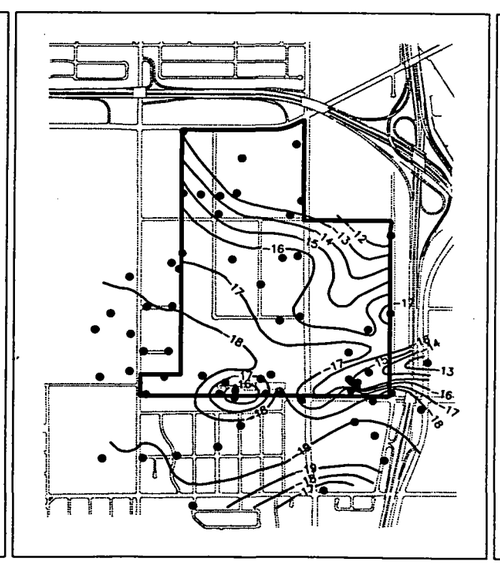
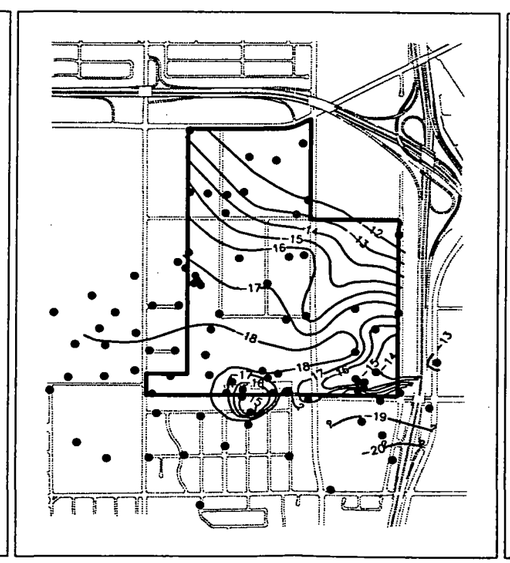


June 1995



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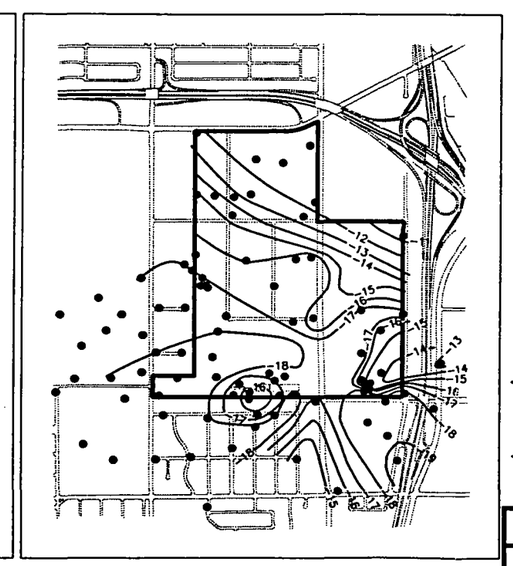

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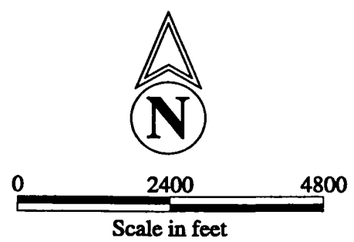

EXPLANATION

- Water Table monitoring location
- Groundwater elevation contour (ft MSL)

FIGURE 4.1-4

Time - Series Groundwater Contours Water Table Zone

Groundwater Remedial Investigation
Del Amo Study Area

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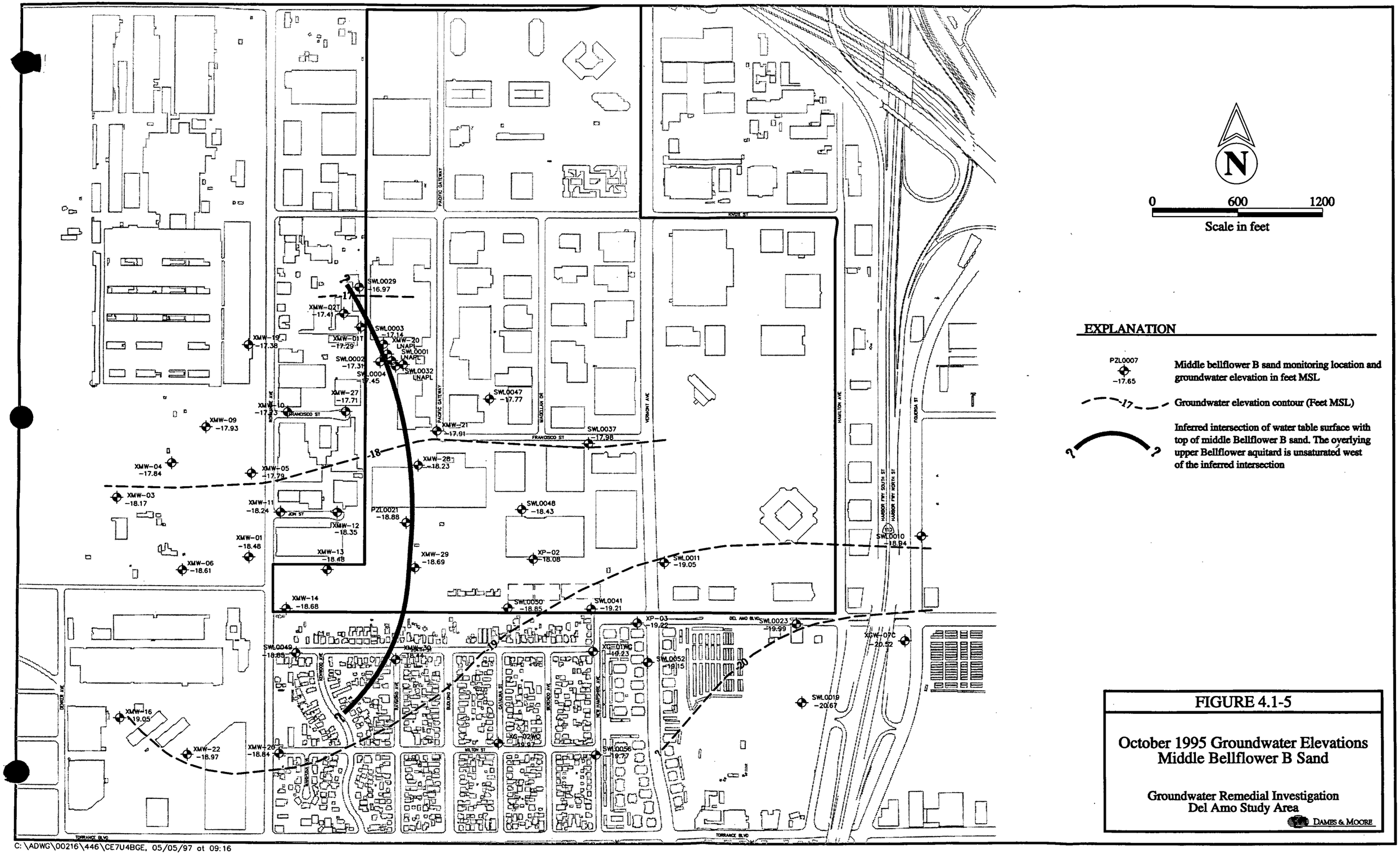

FIGURE 4.1-5

October 1995 Groundwater Elevations
Middle Bellflower B Sand

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

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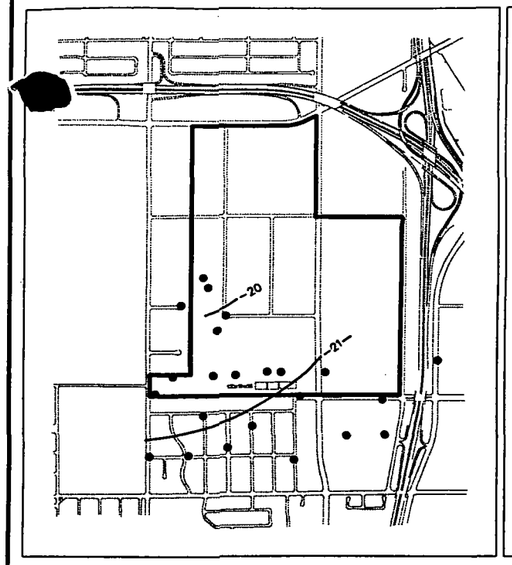

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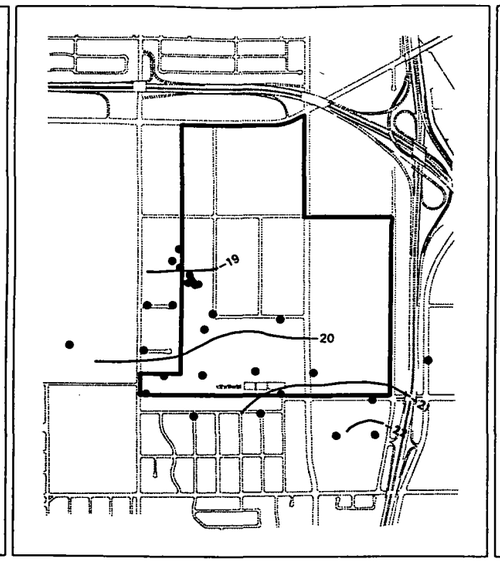

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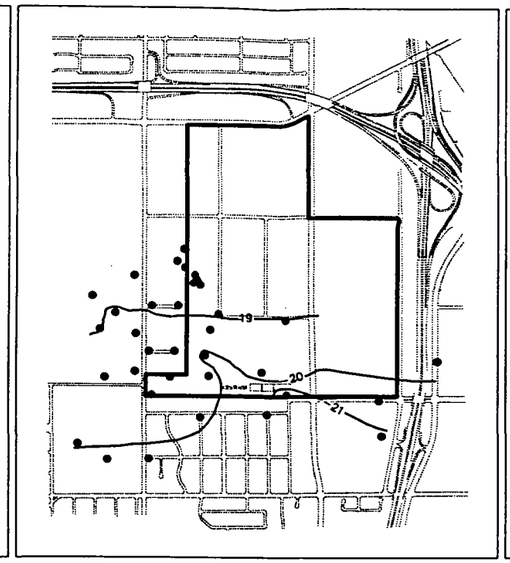

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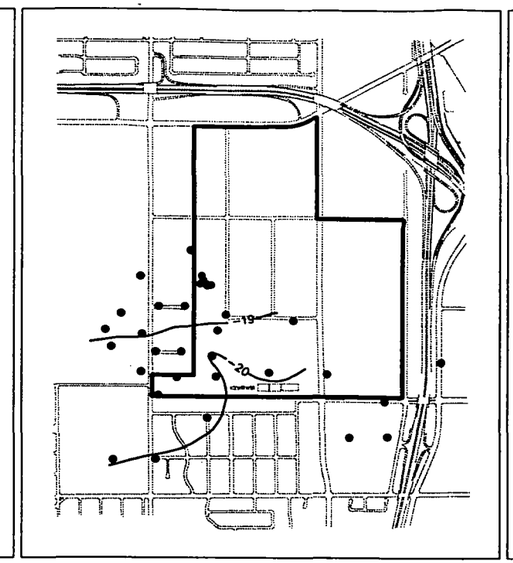

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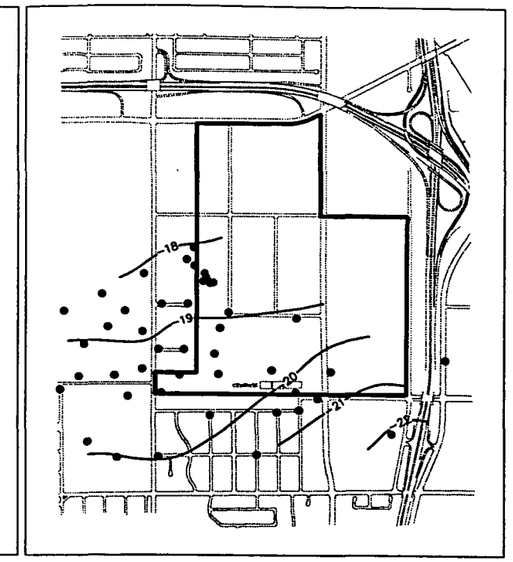

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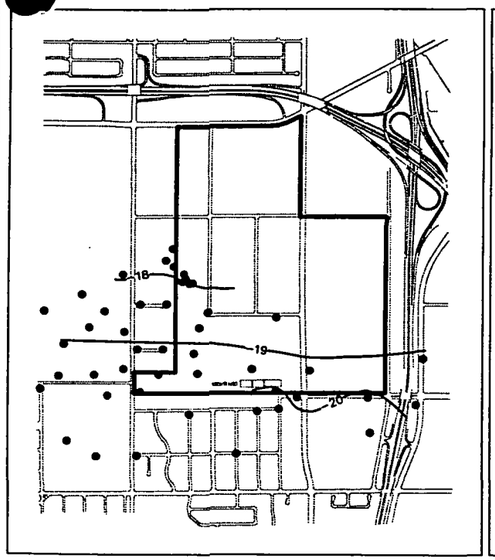

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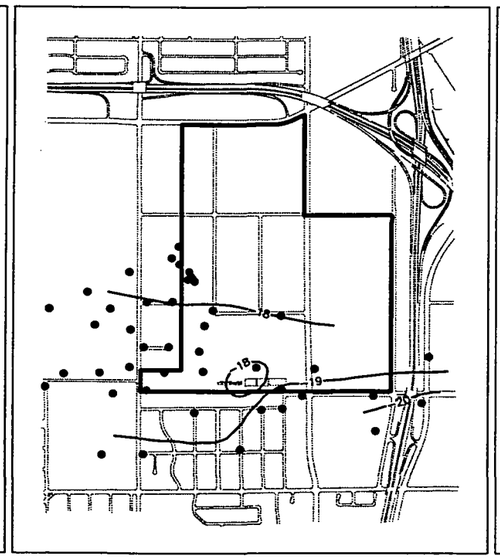

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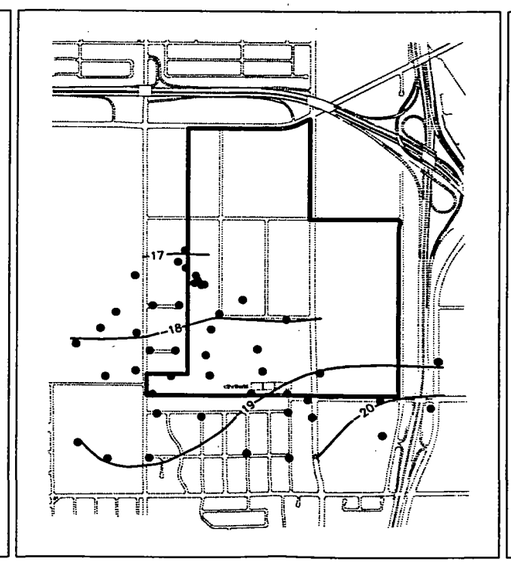

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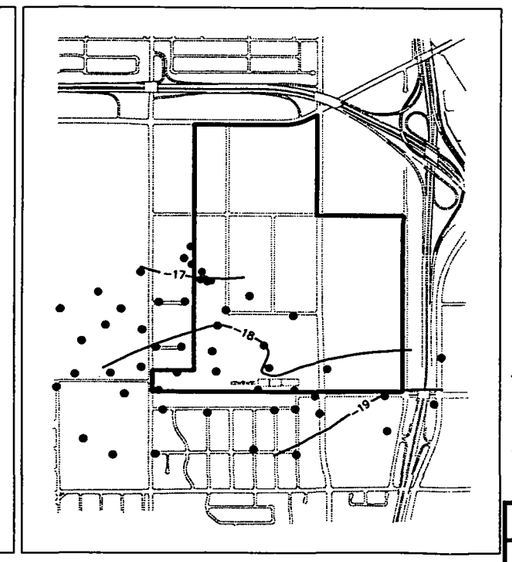
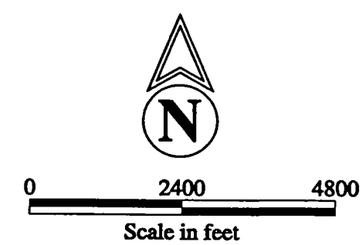


February 1996



EXPLANATION

- MBFB monitoring location
- Groundwater elevation contour (ft MSL)

FIGURE 4.1-6

Time - Series Groundwater Contours
Middle Bellflower B Sand

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

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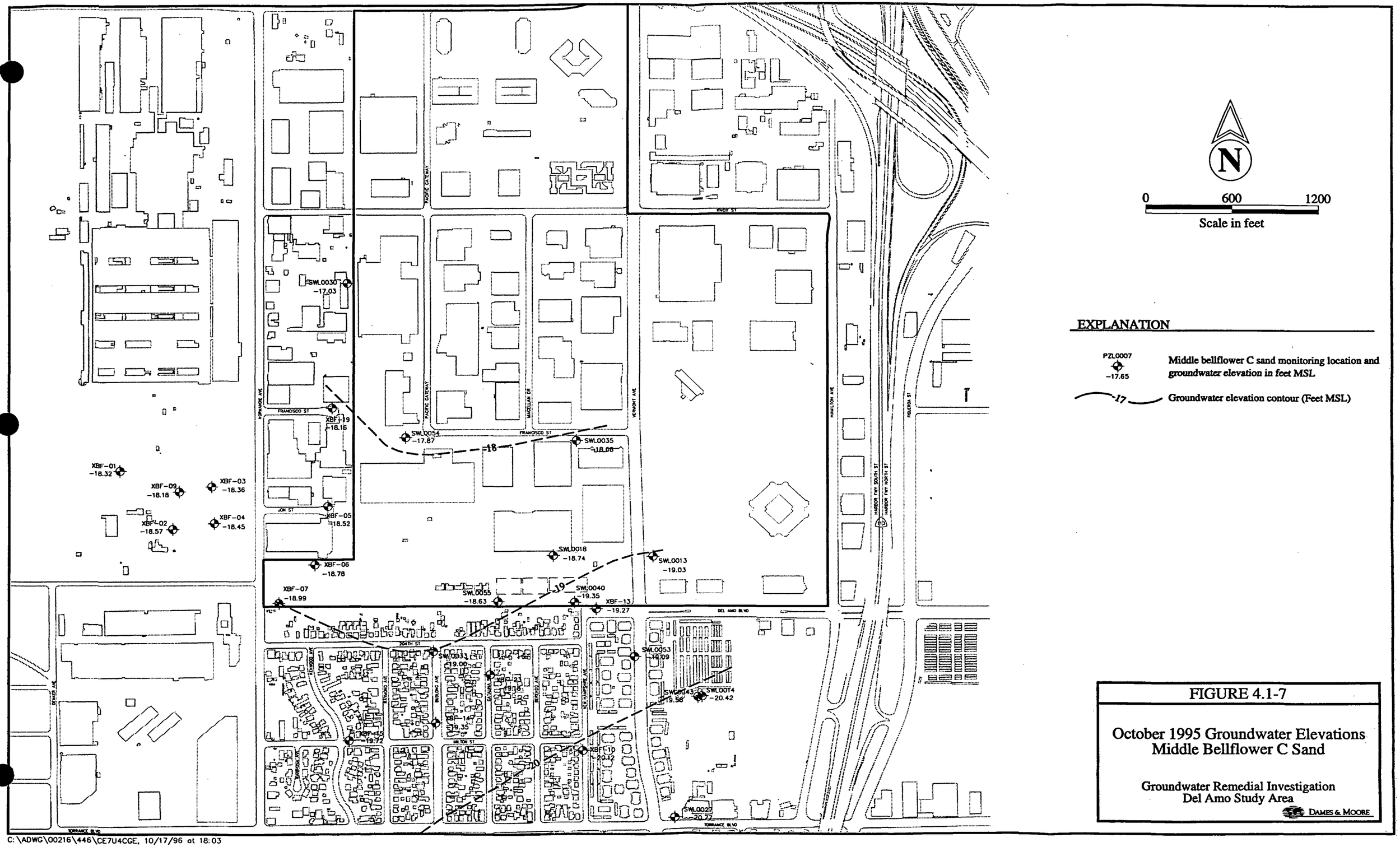


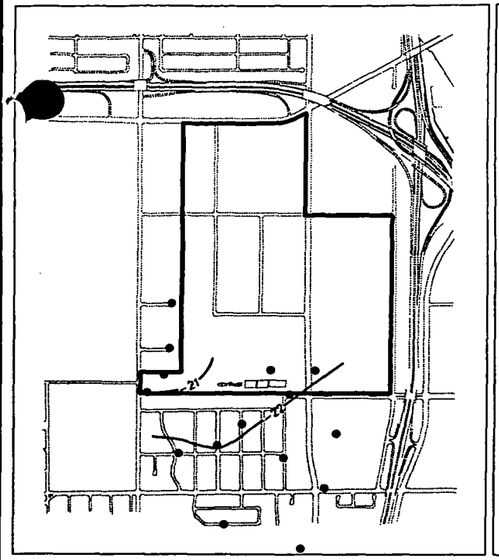
C:\ADWG\00216\446\CE7U4CGE, 10/17/96 at 18:03

FIGURE 4.1-7

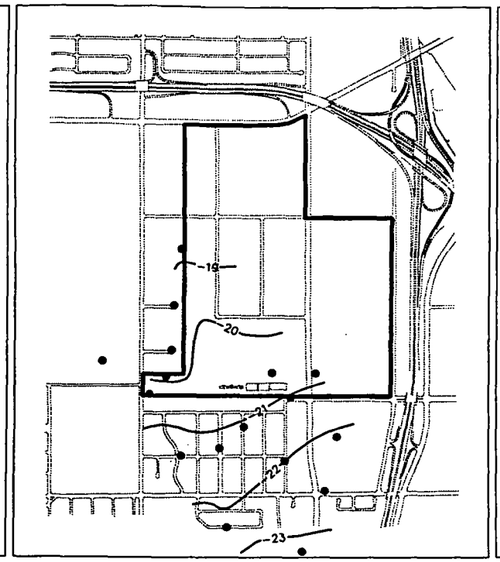
October 1995 Groundwater Elevations
Middle Bellflower C Sand

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE



July 1993



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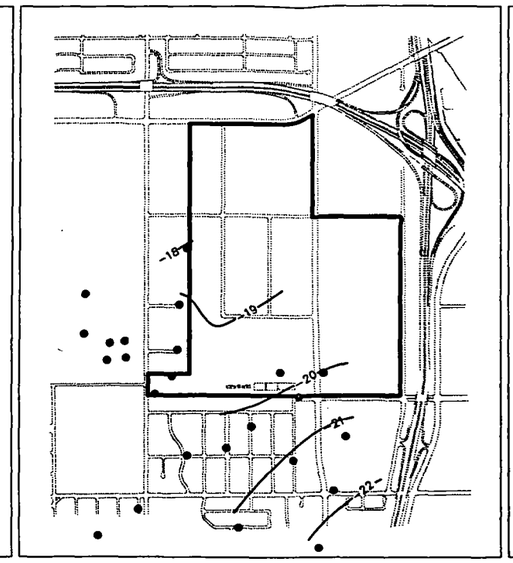
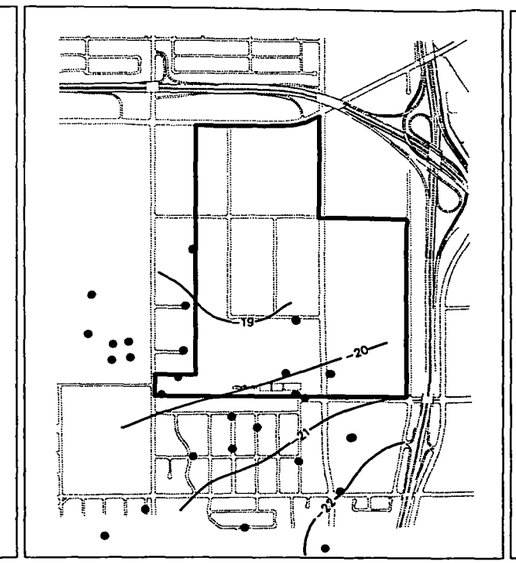
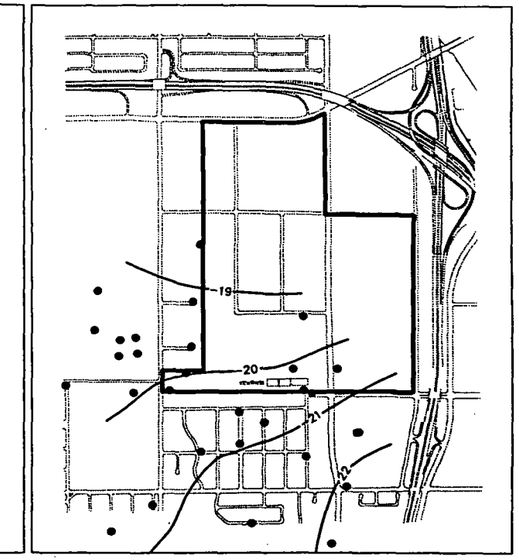


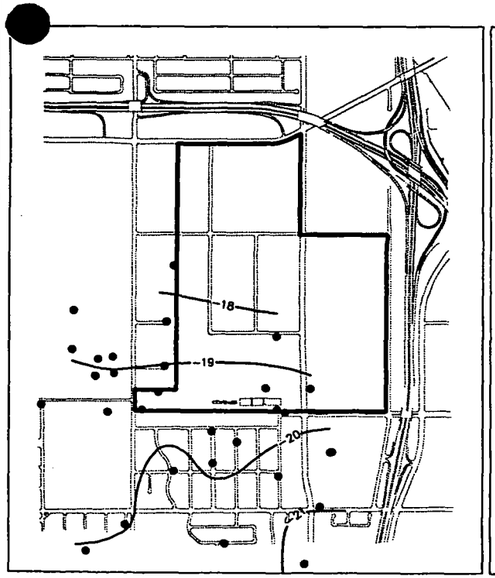
May 1994



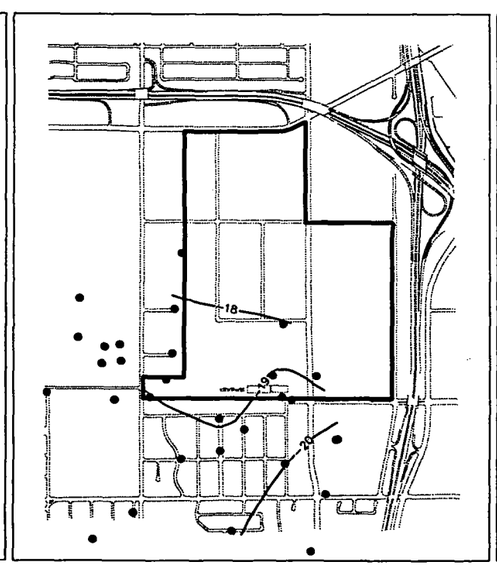
July 1994



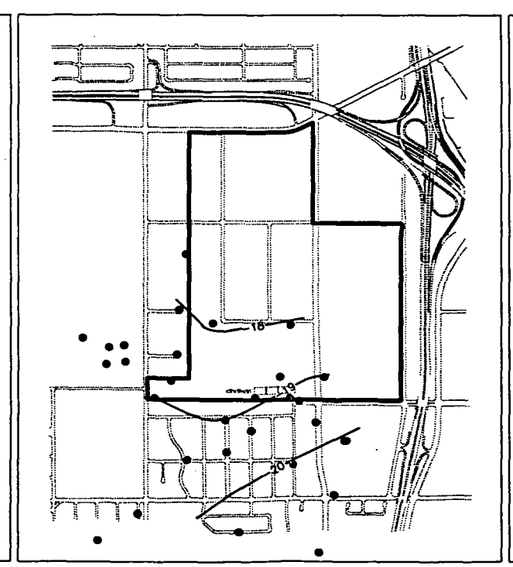
October 1994



March 1995



June 1995



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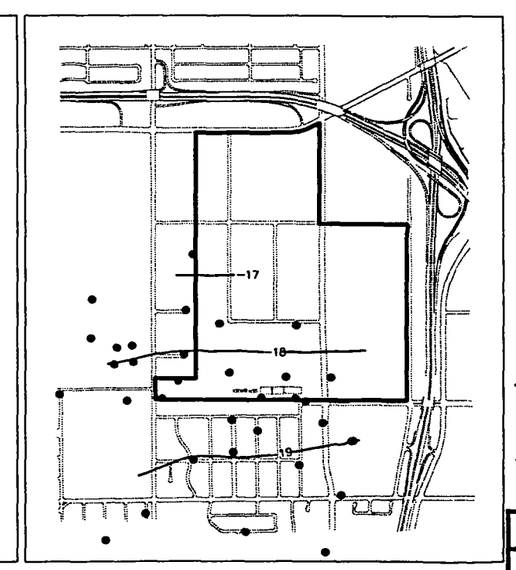

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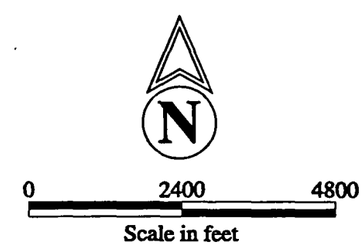

EXPLANATION

- MBFC monitoring location
- Groundwater elevation contour (ft MSL)

FIGURE 4.1-8

Time - Series Groundwater Contours Middle Bellflower C Sand

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

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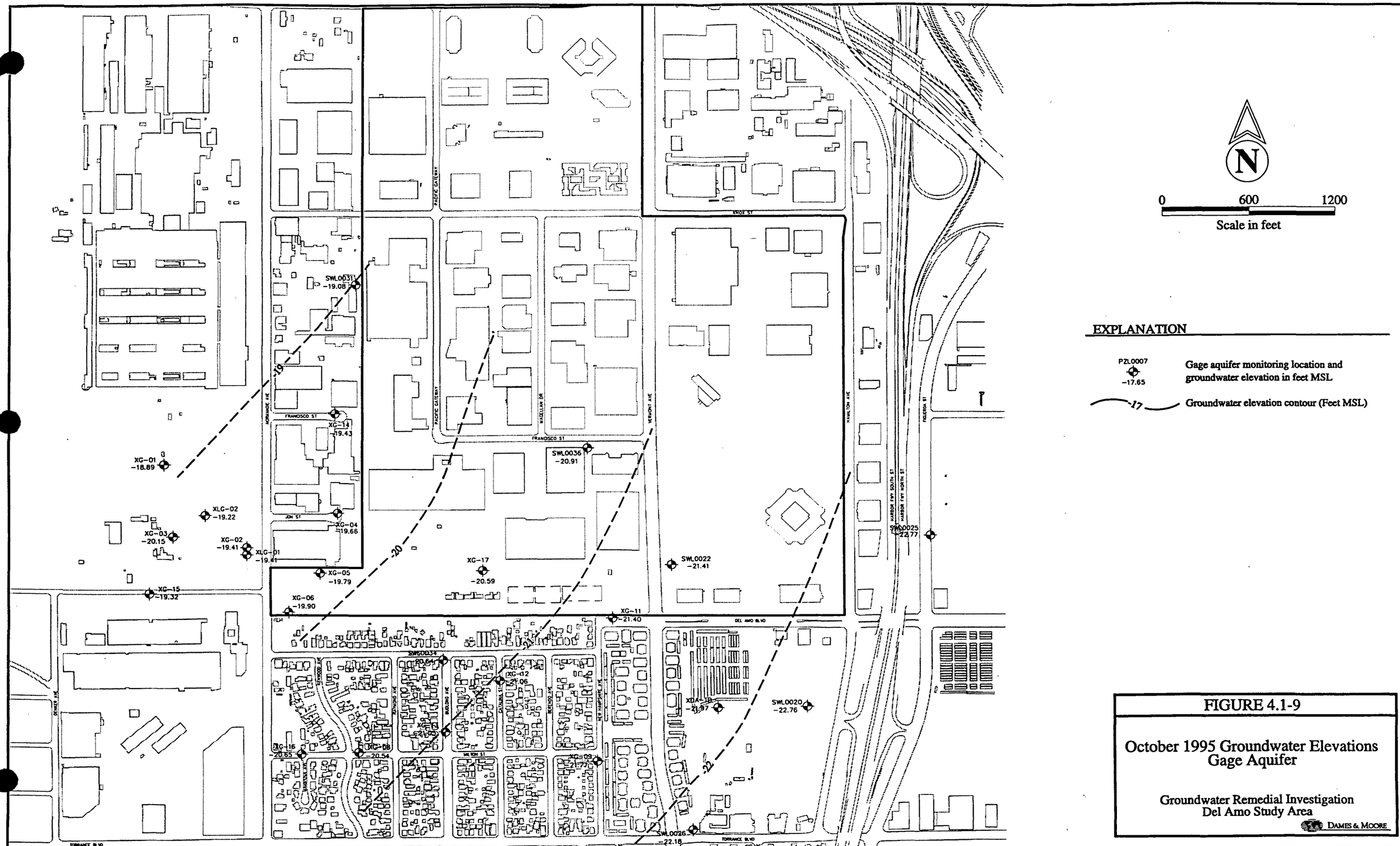


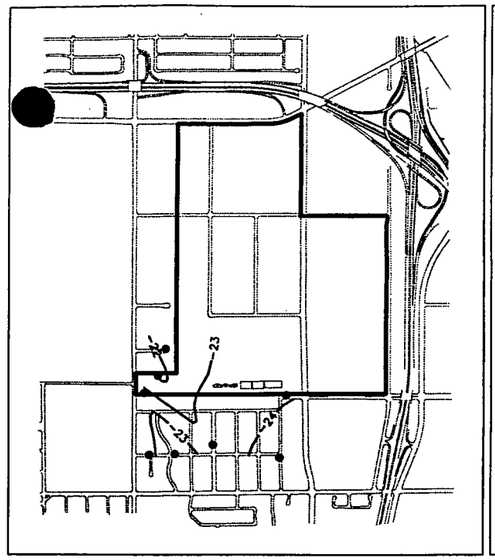
FIGURE 4.1-9

October 1995 Groundwater Elevations
Gage Aquifer

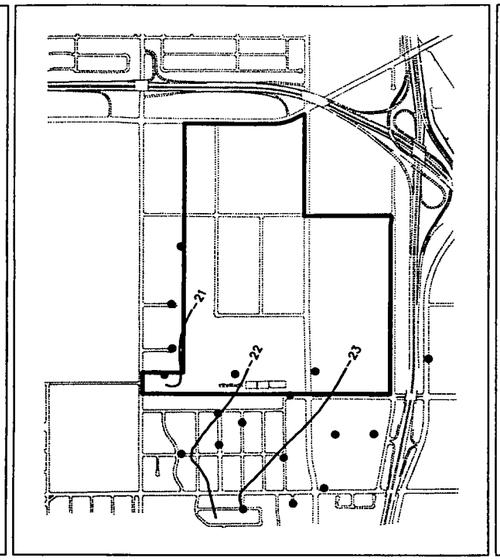
Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

C:\ADWG\00216\446\CE7U4GGE, 10/17/96 at 18:08



May 1993



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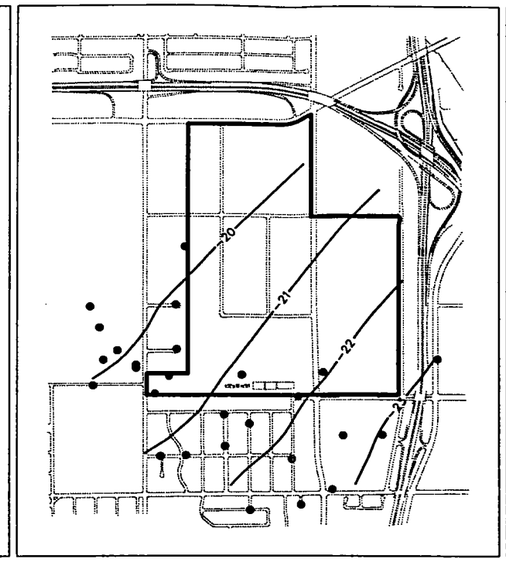

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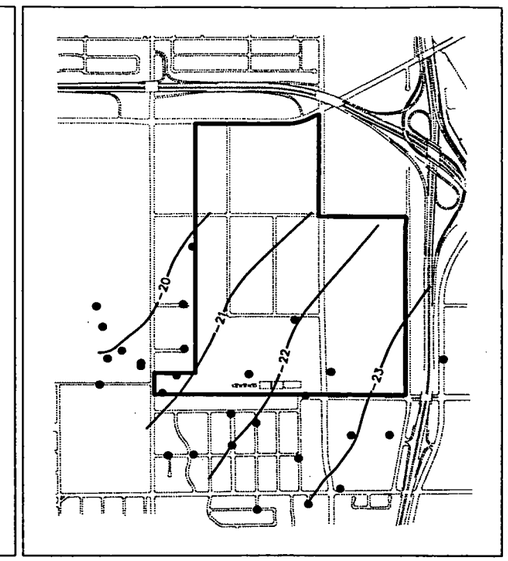
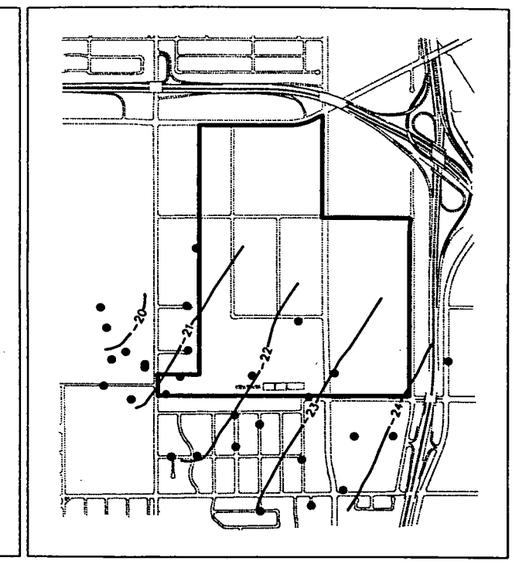
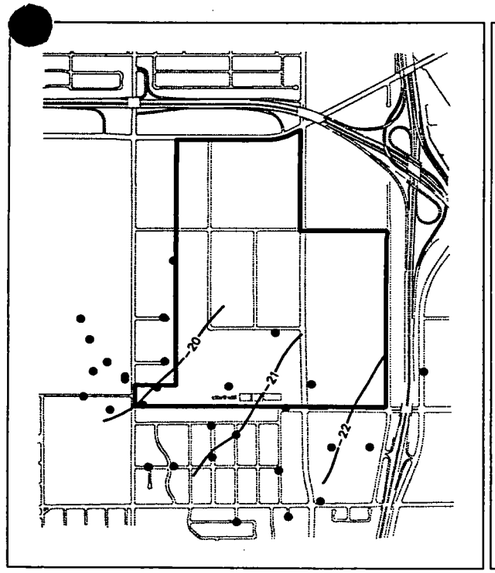


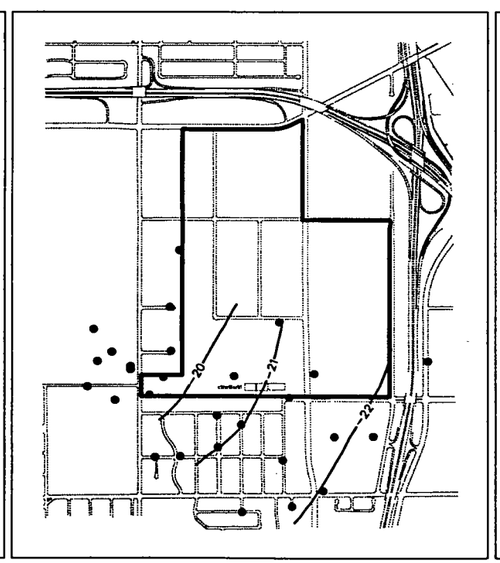
July 1994



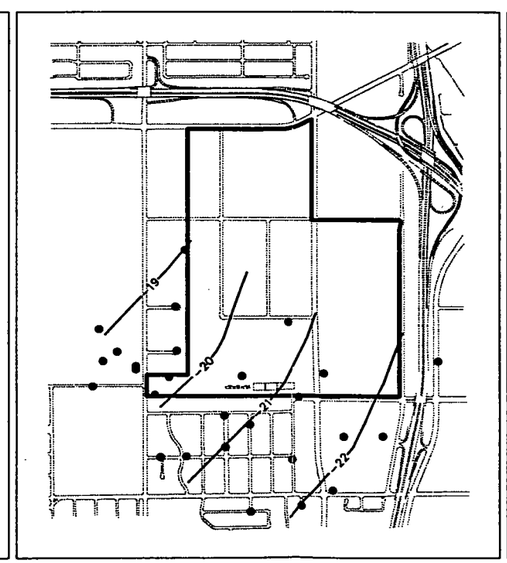
October 1994



March 1995



June 1995



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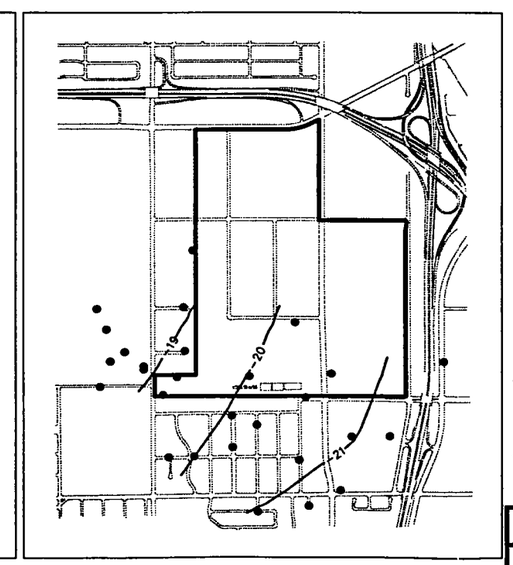
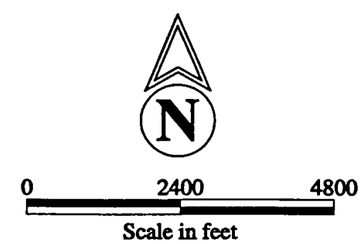


February 1996



EXPLANATION

- ● Gage monitoring location
- Groundwater elevation contour (ft MSL)

FIGURE 4.1-10

Time - Series Groundwater Contours Gage Aquifer

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

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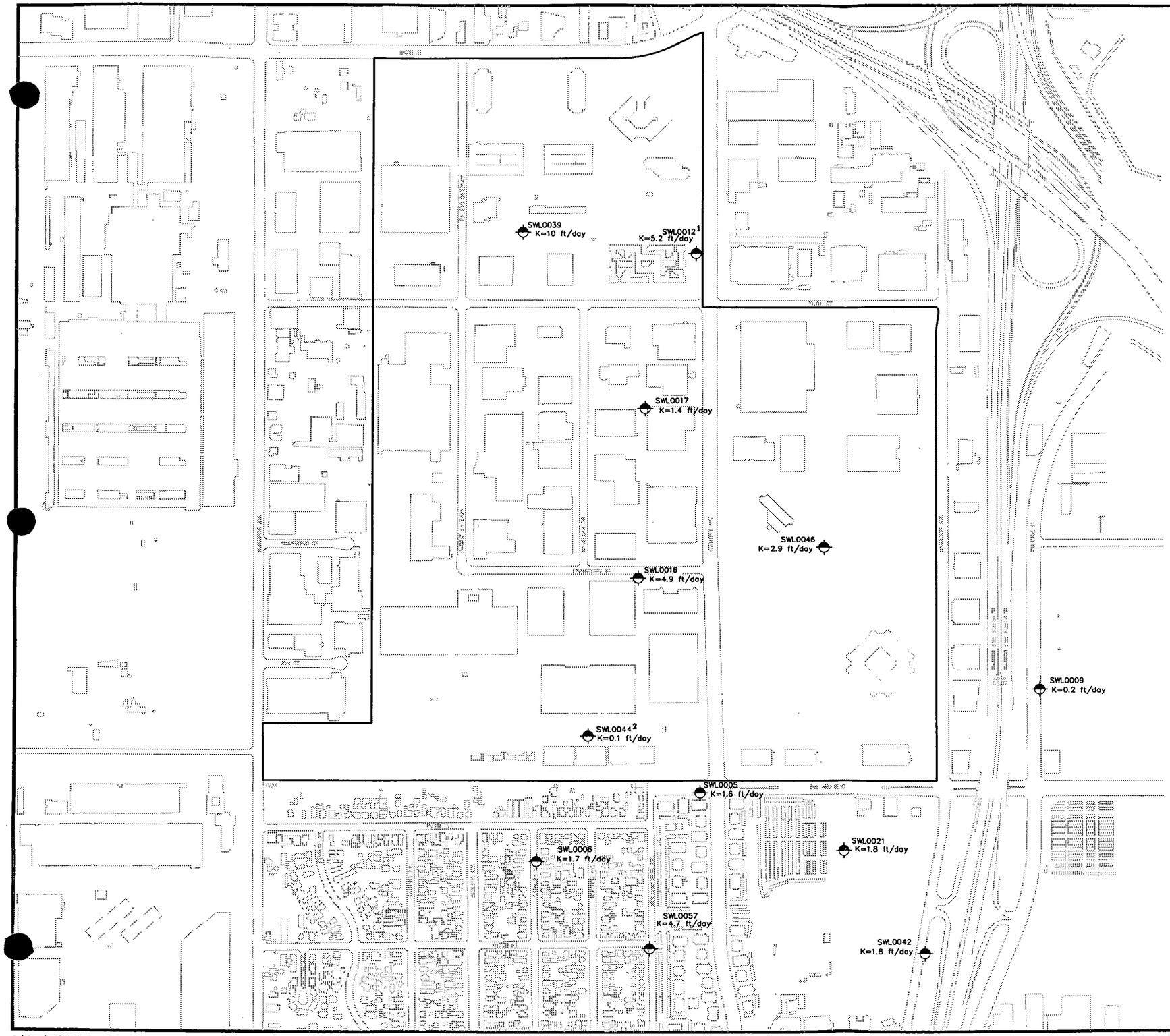

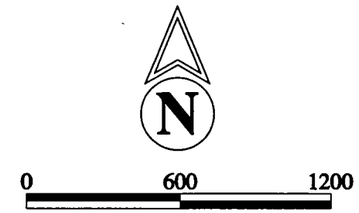

EXPLANATION

SWL0012 — Well screened in Upper Bellflower Aquitard

Notes: 1) Short pumping time; pumping was terminated at 353 minutes to avoid drawing water level below pump intake.

2) Results for match to head-ratio data from falling-head slug test.

FIGURE 4.2-1

Hydraulic Conductivity Results Upper Bellflower Aquitard

Groundwater Remedial Investigation Report Del Amo Study Area

DAMES & MOORE

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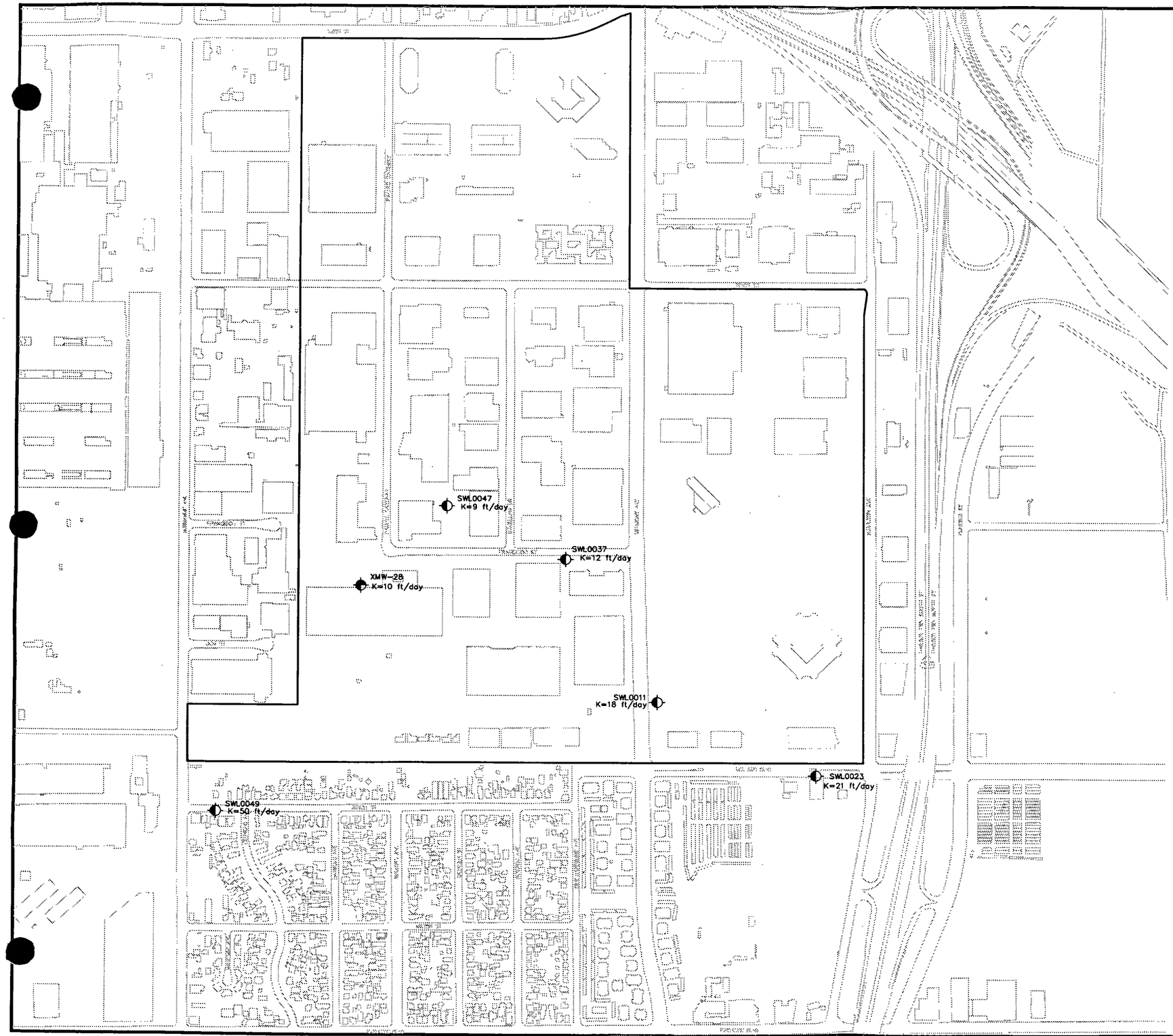

N

0 600 1200

EXPLANATION

SWL0037 — Well screened in Middle Bellflower B Sand

XMW-28 — Well screened in both Upper Bellflower Aquitard and Middle Bellflower B Sand

FIGURE 4.2-2

Hydraulic Conductivity Results Middle Bellflower B Sand

Groundwater Remedial Investigation Report Del Amo Study Area

DAMES & MOORE

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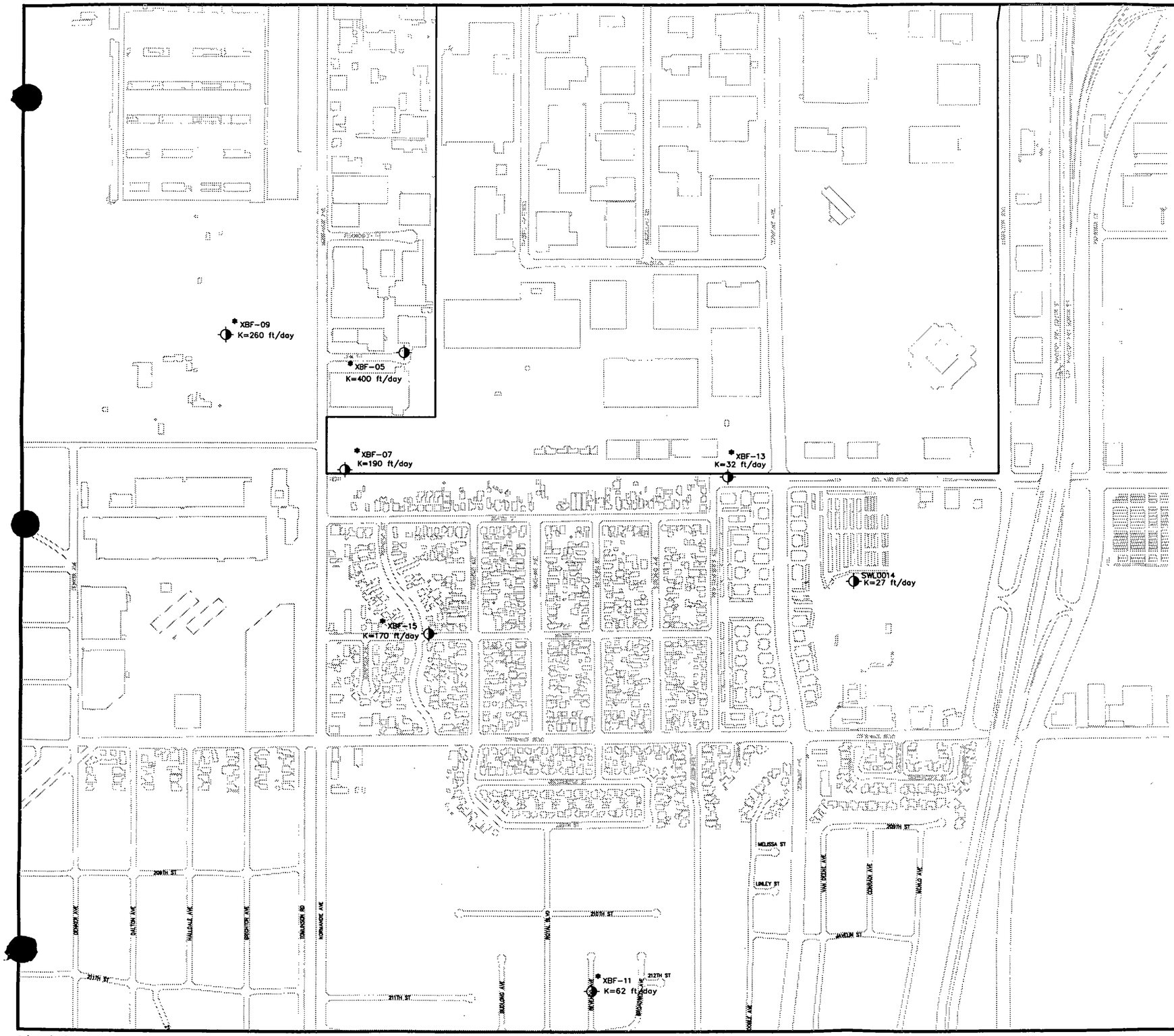

EXPLANATION

SWL0014 — Well screened in Middle Bellflower C Sand

* Aquifer test and analysis conducted by Hargis + Associates

FIGURE 4.2-3

Hydraulic Conductivity Results
Middle Bellflower C Sand

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

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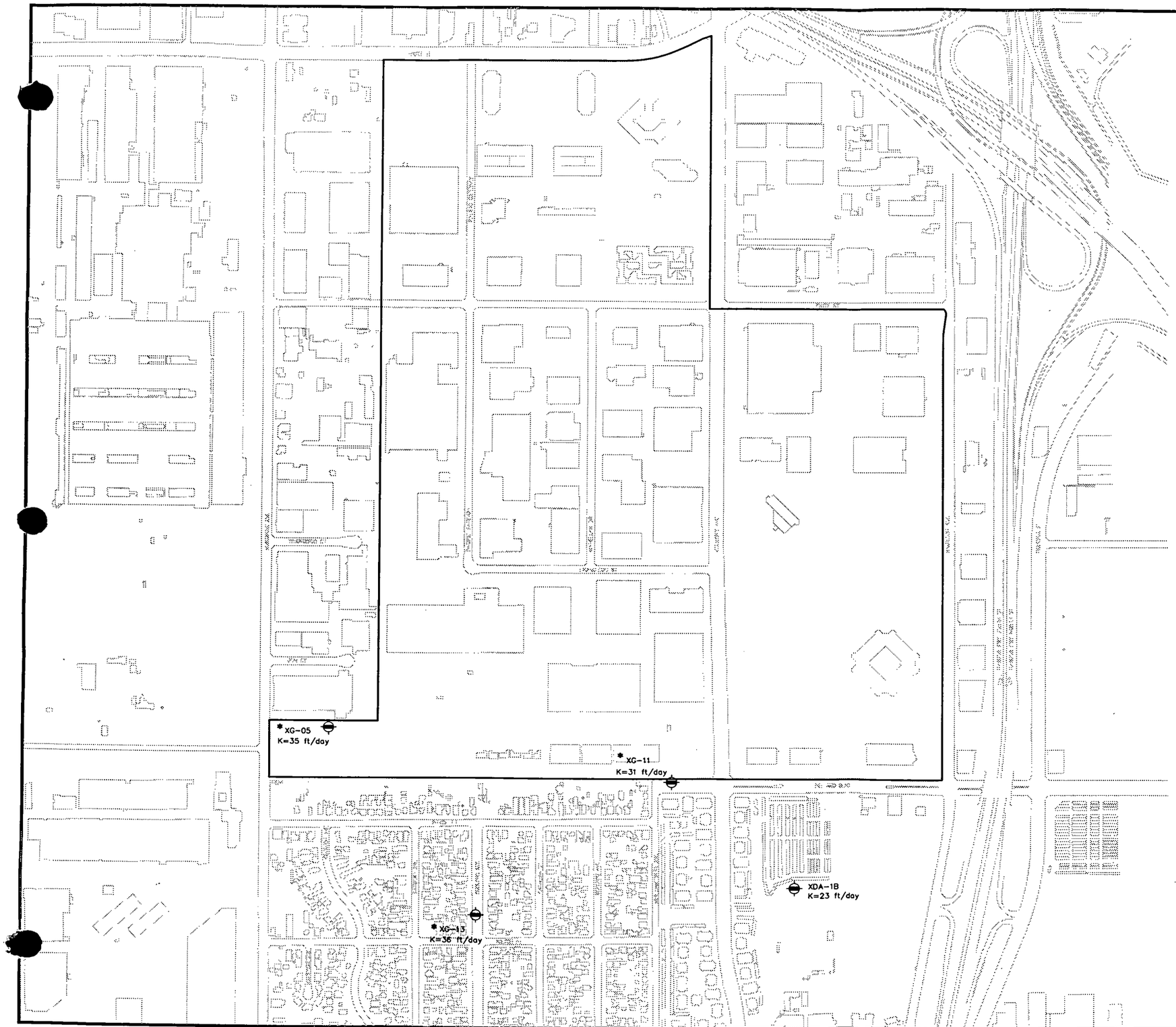

FIGURE 4.2-4

Hydraulic Conductivity Results
Gage Aquifer

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

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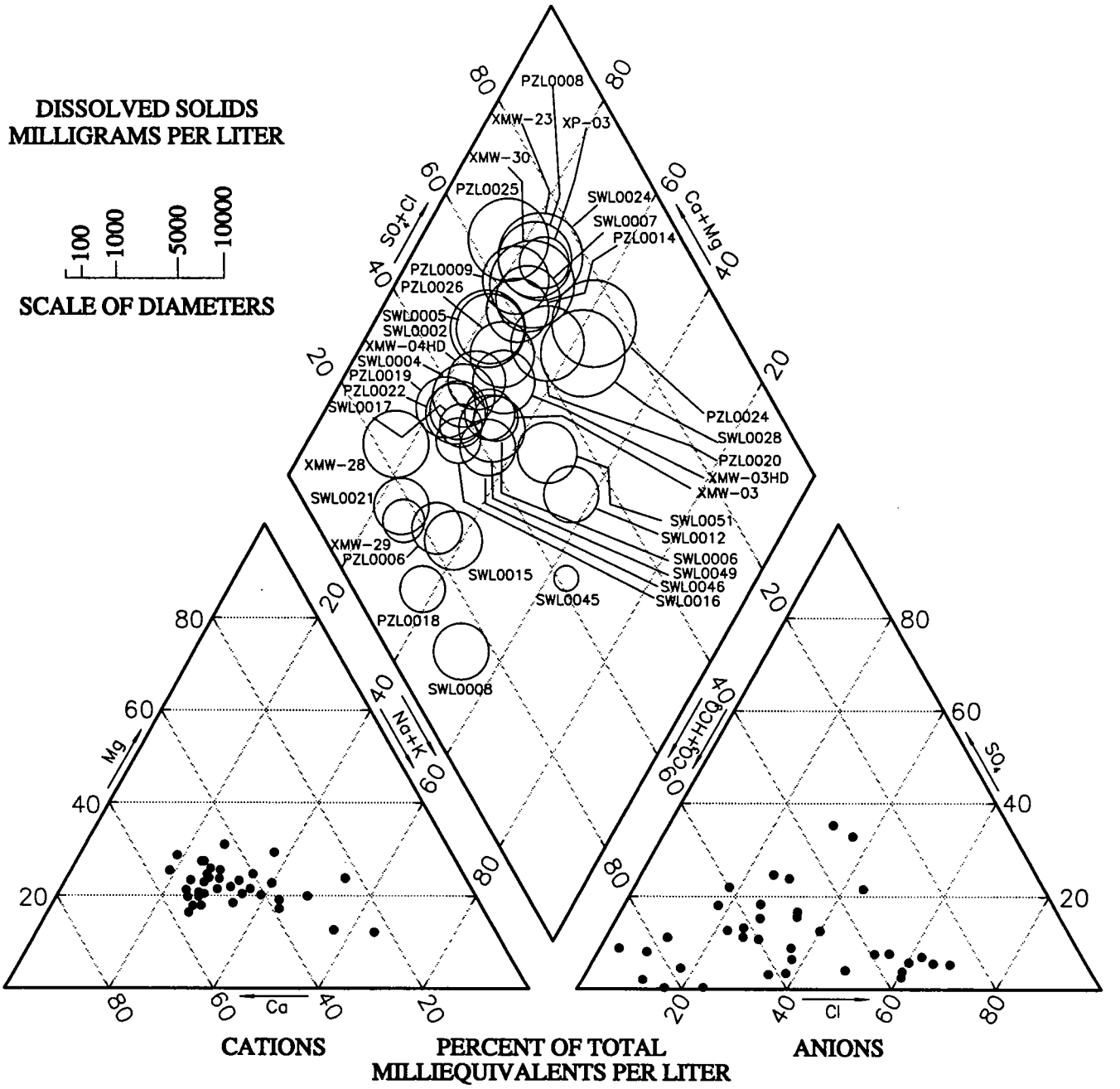


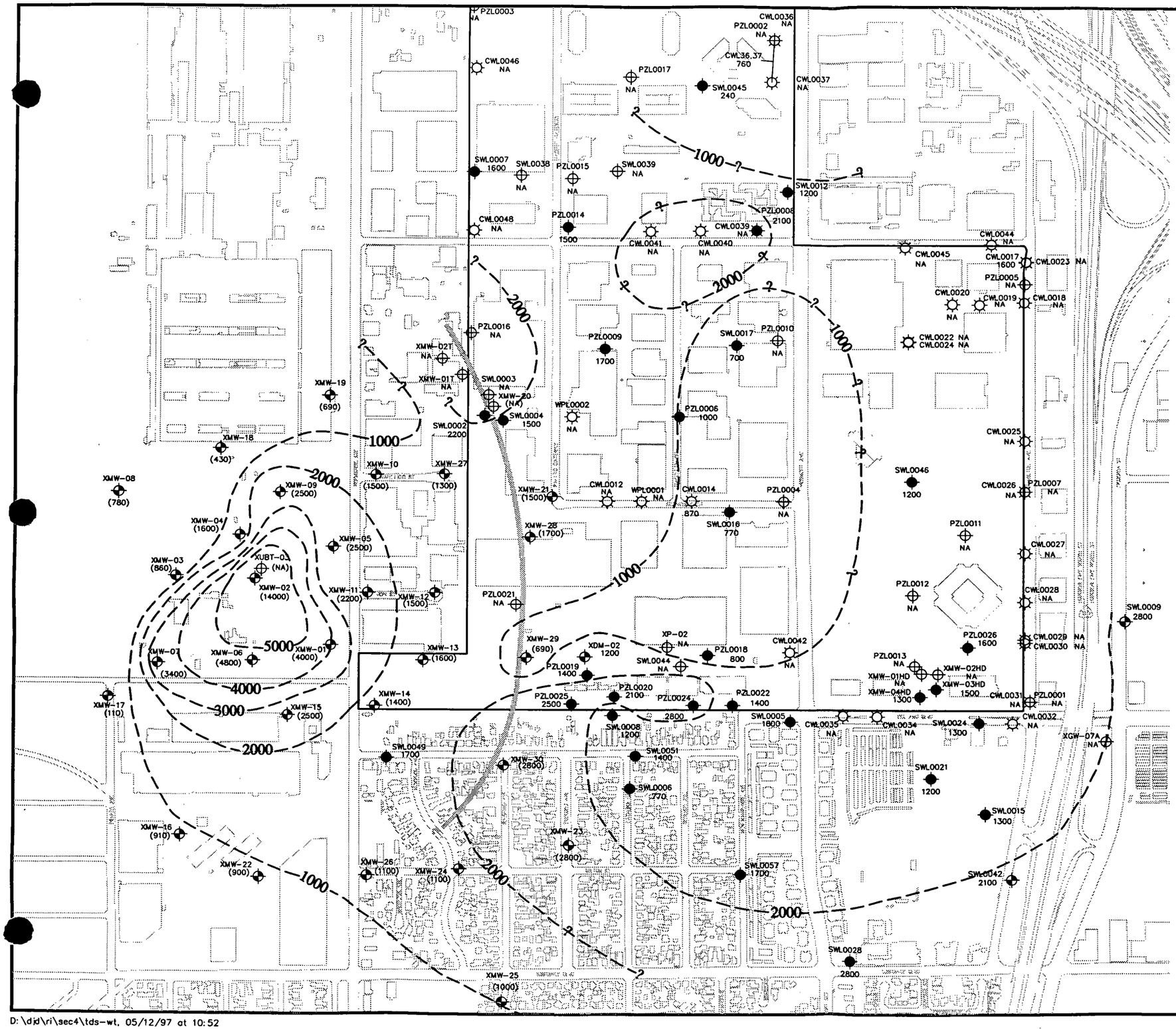
FIGURE 4.3-1

Trilinear Piper Diagram
Water Table

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

D:\DJD\RI\SEC4\tlp-w, 05/08/97 at 16:18



D:\did\ri\sec4\tds-wt, 05/12/97 at 10:52

N

0 600 1200

Scale in Feet

EXPLANATION

SWL0012 1200	Monitoring location with Third Sampling Period 1995 TDS concentration (mg/L)
PZL0026 1600	Monitoring location with historical TDS concentration (Third Sampling Period 1995 data not available)
CWL0017 1600	Temporary well point with one-time historical TDS data (Third Sampling Period 1995 data not available)
CWL36,37 760	Composite sampling location with one-time historical TDS data (Third Sampling Period 1995 data not available)
XMW-20 NA	Monitoring location where TDS was not analyzed for
1000	TDS concentration isopleth (mg/l), queried where uncertain
	Inferred intersection of water table surface with top of middle Bellflower B sand. The overlying upper Bellflower aquitard is unsaturated west of the inferred intersection

Notes: Data collected by Hargis + Associates for Montrose monitoring program in parentheses

TDS Secondary MCL = 1,000 mg/l

FIGURE 4.3-2

Total Dissolved Solids Water Table Zone

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

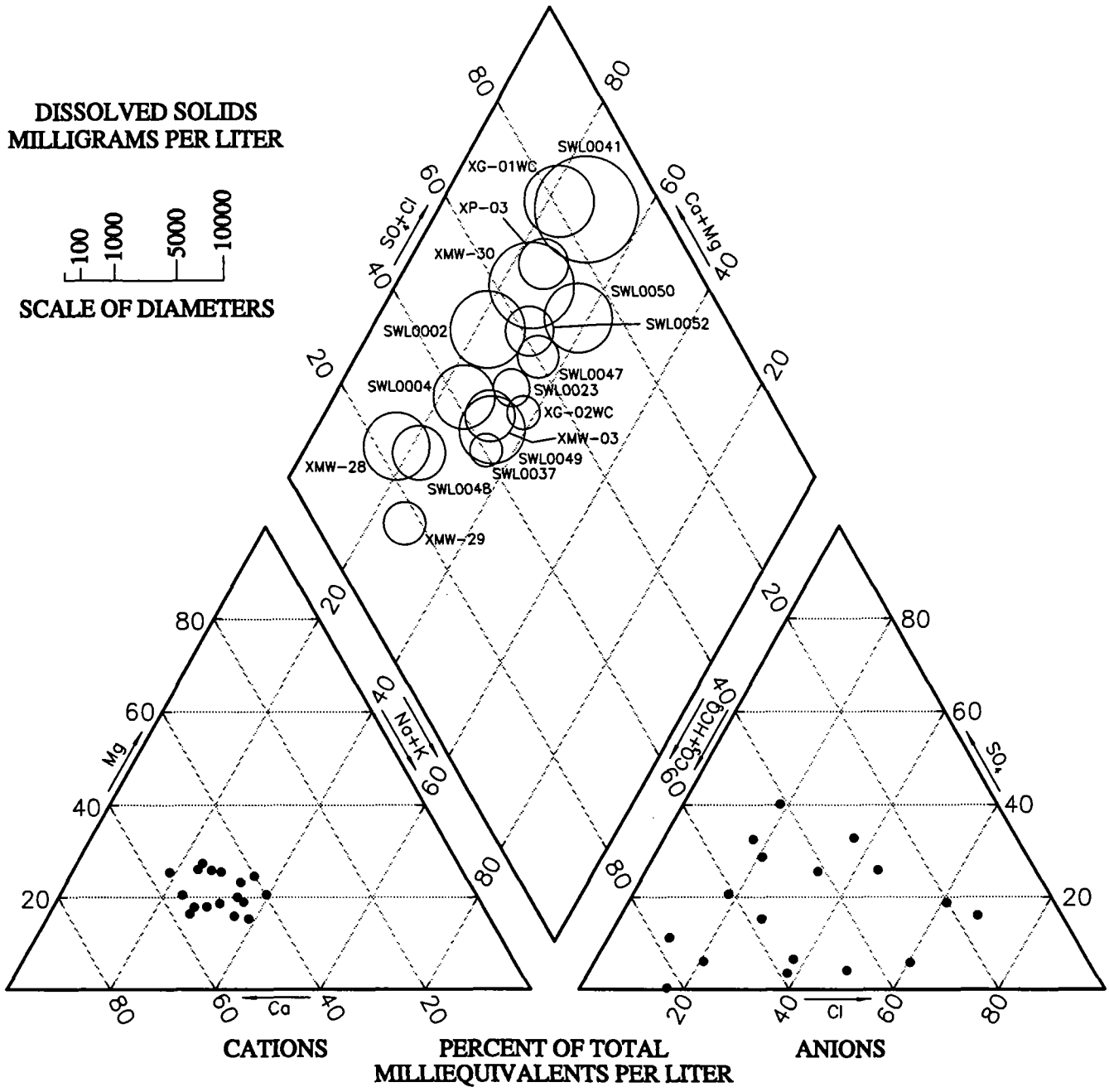


FIGURE 4.3-3

Trilinear Piper Diagram
Middle Bellflower B Sand

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

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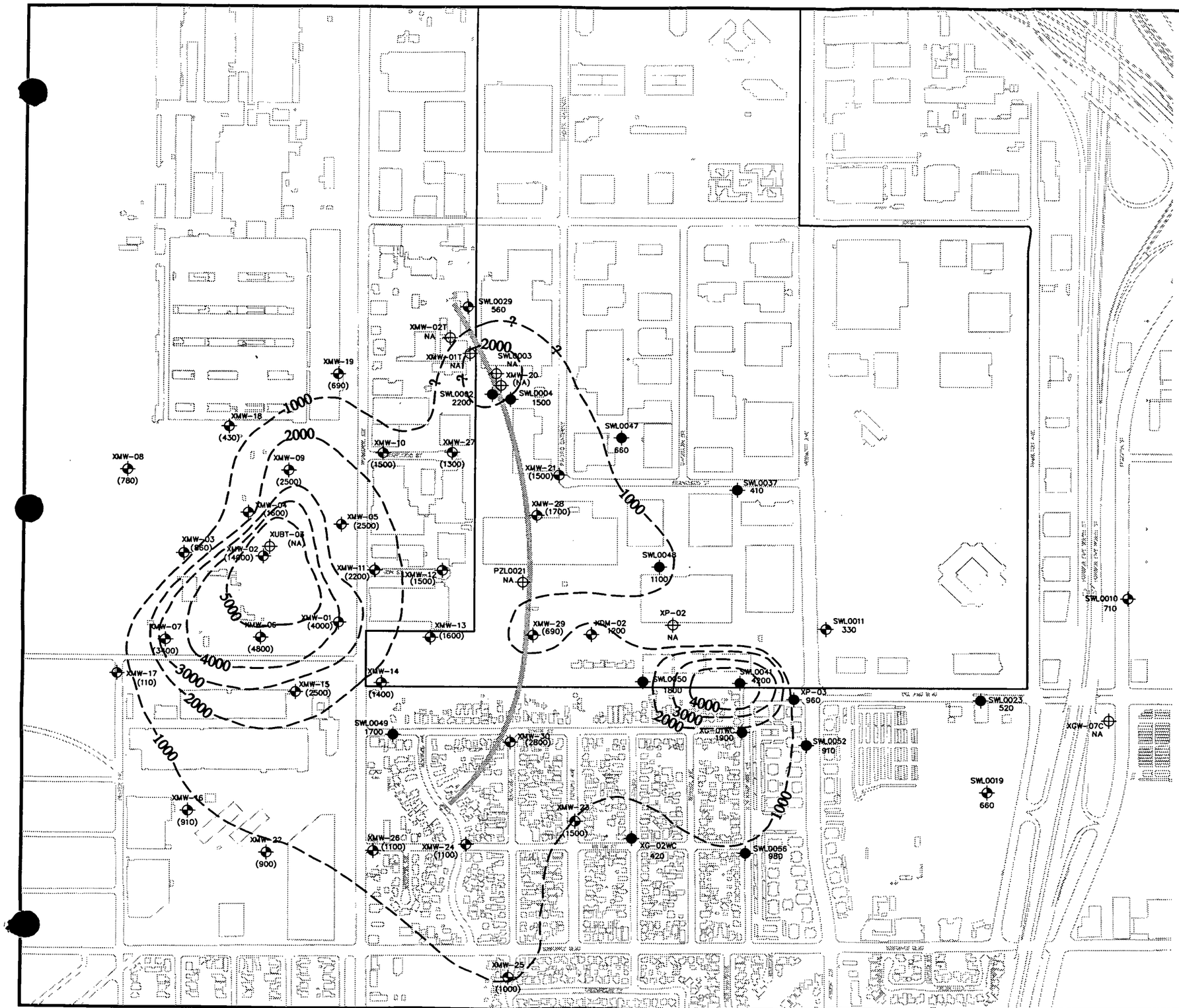

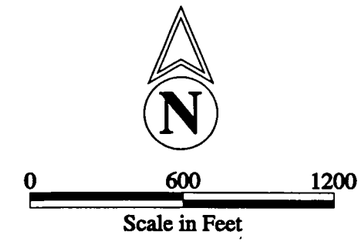

EXPLANATION

SWL0002 2200	Monitoring location with Third Sampling Period 1995 TDS concentration (mg/L)
SWL0029 560	Monitoring location with historical TDS concentration (Third Sampling Period 1995 data not available)
XMW-20 NA	Monitoring location where TDS was not analyzed for
1000	TDS concentration isopleth (mg/l), queried where uncertain
? ?	Inferred intersection of water table surface with top of middle Bellflower B sand. The overlying upper Bellflower aquitard is unsaturated west of the inferred intersection

Notes: Data collected by Hargis + Associates for Montrose monitoring program in parentheses

TDS Secondary MCL = 1,000 mg/l

FIGURE 4.3-4

Total Dissolved Solids
Middle Bellflower B Sand

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

D:\did\ri\sec4\tds-b, 05/12/97 at 10:55

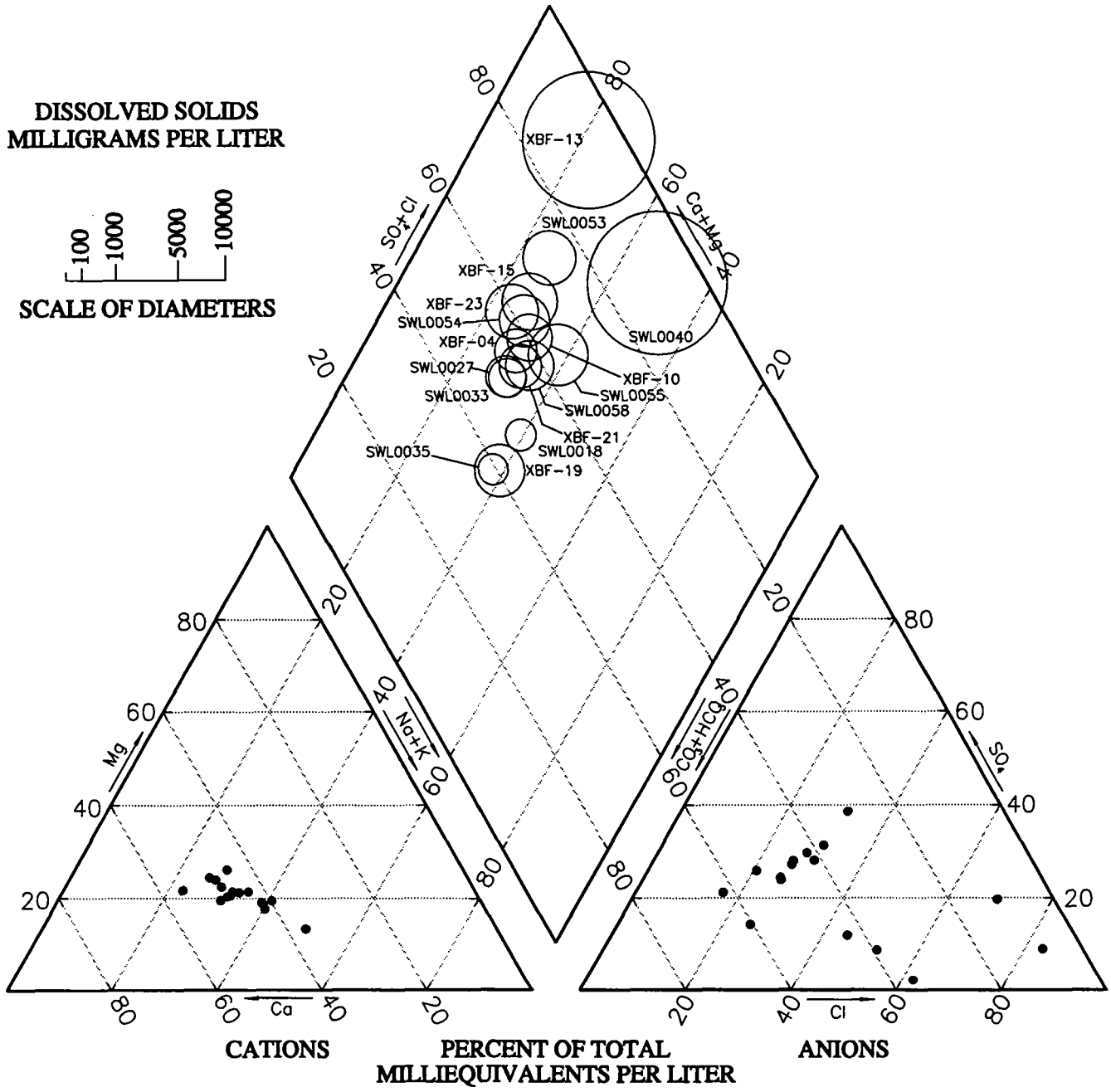

FIGURE 4.3-5

Trilinear Piper Diagram
Middle Bellflower C Sand

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

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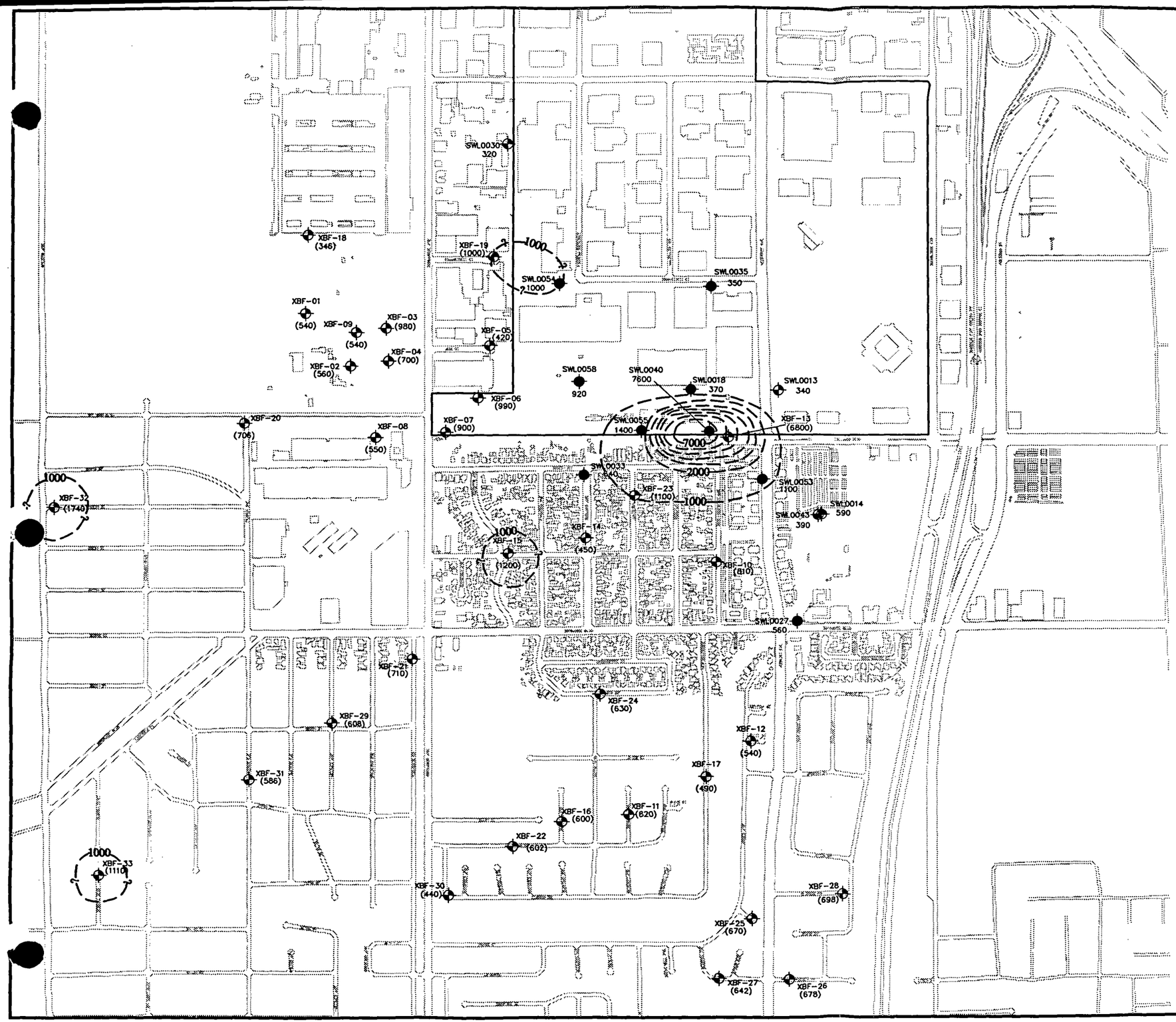

N

0 600 1200

Scale in Feet

EXPLANATION

SWL0040 7600 — Monitoring location with Third Sampling Period 1995 TDS concentration (mg/L)

SWL0013 340 — Monitoring location with historical TDS concentration (Third Sampling Period 1995 data not available)

1000 — TDS concentration isopleth (mg/l), queried where uncertain

Notes: Data collected by Hargis + Associates for Montrose monitoring program in parentheses

TDS Secondary MCL = 1,000 mg/l

FIGURE 4.3-6

Total Dissolved Solids
Middle Bellflower C Sand

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

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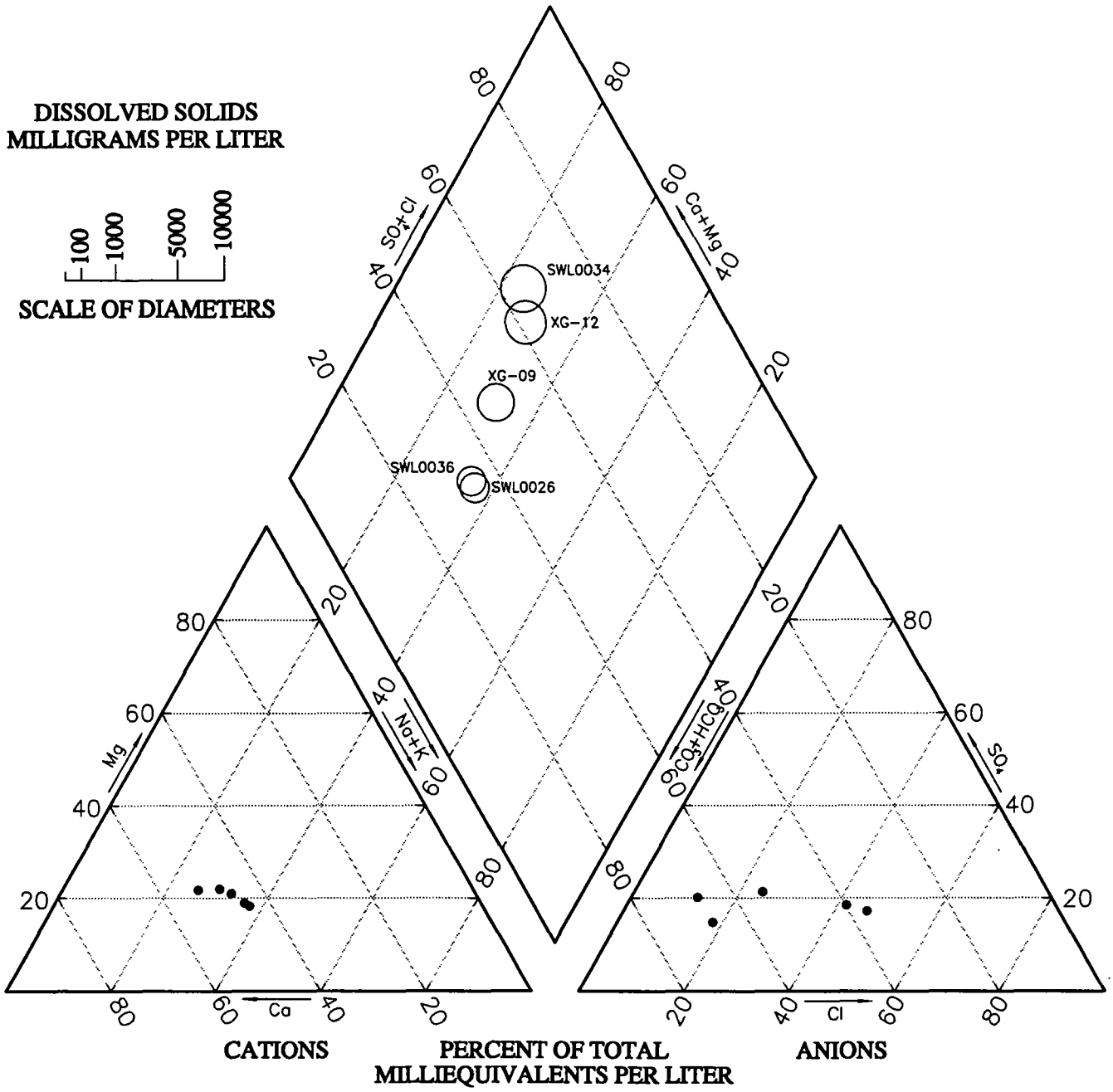

FIGURE 4.3-7

Trilinear Piper Diagram
Gage Aquifer

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

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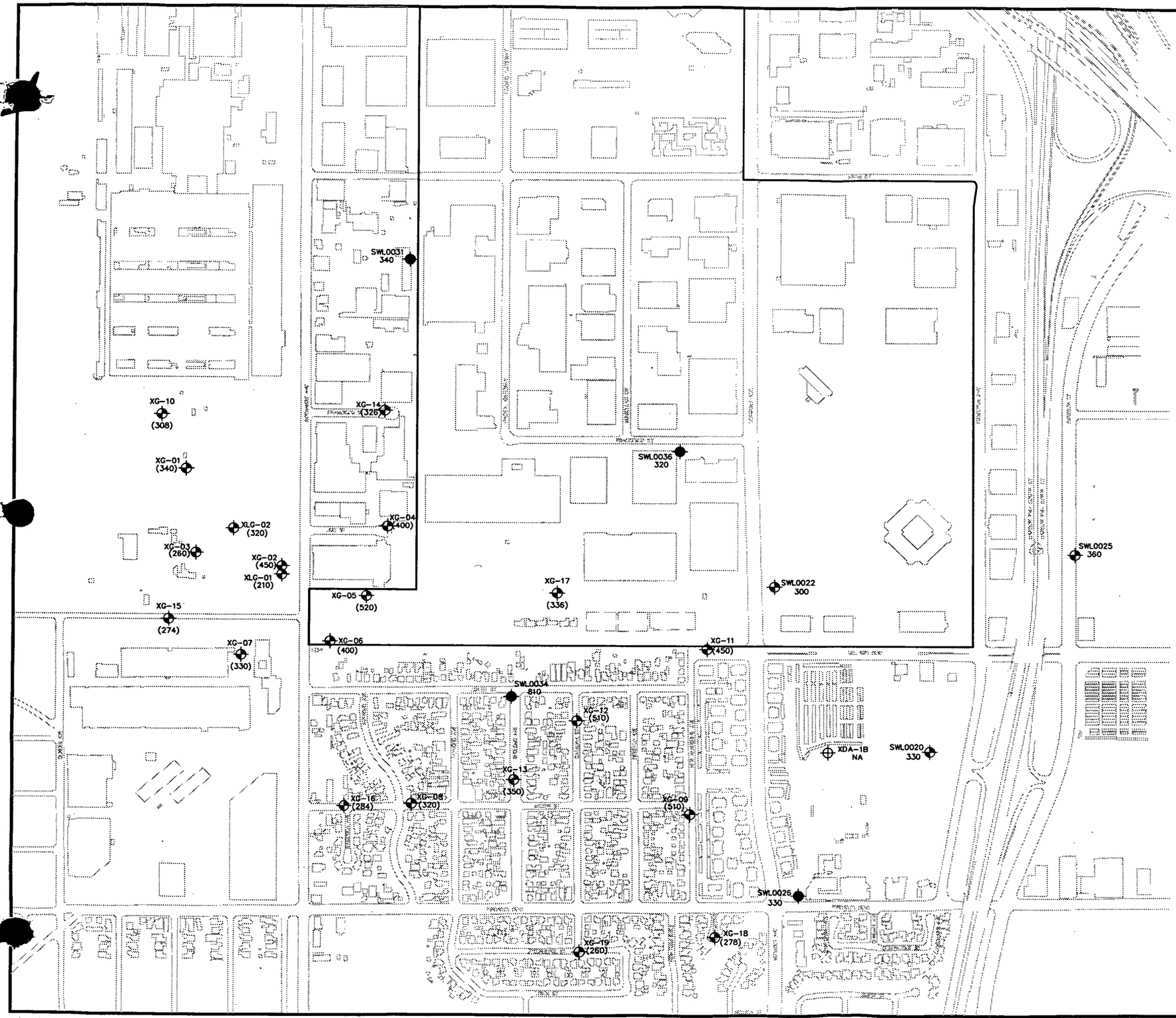

N

0 600 1200

Scale in Feet

EXPLANATION

SWL0026 330	Monitoring location with Third Sampling Period 1995 TDS concentration (mg/L)
SWL0022 300	Monitoring location with historical TDS concentration (Third Sampling Period 1995 data not available)
XDA-1B NA	Monitoring location where TDS was not analyzed

Notes: Data collected by Hargis + Associates for Montrose monitoring program in parentheses

TDS Secondary MCL = 1,000 mg/l

FIGURE 4.3-8

Total Dissolved Solids Gage Aquifer

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

D:\did\ri\sec4\tds-g, 05/12/97 at 11:04

PARTIALLY SCANNED
OVERSIZE ITEM(S)

See document # 2259656
for partially scanned image(s).

PLATE 4-1 TO 4-4
(13 OF 20 TO 16 OF 20)

For complete hardcopy version of the oversize document
contact the Region IX Superfund Records Center

5.0 NATURE AND EXTENT OF GROUNDWATER CONTAMINATION

5.1 DISTRIBUTION OF NAPL

Areas of known and suspected Non-Aqueous Phase Liquid (NAPL) in the plant site vicinity are identified on Figure 5.1-1. Areas of known NAPL are identified based on direct observation of NAPL at groundwater monitoring locations and/or reaction of a hydrocarbon specific dye ("Sudan Red") with soil core. Areas where NAPL is suspected, but not observed, are subjectively identified taking into account the following lines of evidence:

- Historical information indicating the former presence of facilities where large volumes of pure chemicals were stored, processed, or disposed of;

- Dissolved concentrations of a compound that are both elevated with respect to surrounding monitoring locations, and represent a significant fraction of the solubility of the compound; and,

- Deep soil gas (near the water table) concentration profiles similar to those measured in the vicinity of a known NAPL

Known and suspected NAPL areas are all located at groundwater contamination source areas, which are identified and discussed in Section 5.3.

5.1.1 LNAPL Areas

LNAPL has been observed at one Del Amo plant site location and three offsite locations in the vicinity of the plant site (Figure 5.1-1). LNAPL is suspected of being present at five additional plant site areas.

Plant site areas at which LNAPL has been observed are limited to the MW-20 area near the western plant site boundary. A measurable thickness of LNAPL is consistently present in monitoring wells XMW-20, SWL0001, and SWL0032 in this area. The LNAPL is composed almost entirely (>95%) of benzene, and extends laterally over an area of approximately 17,500 square feet (0.4 acre), as documented in the "Focused Investigation, Nature and Extent of NAPL, Monitoring Well MW-20" (Dames & Moore, 1993b), and the Phase I RI report (Dames & Moore, 1993d). Based on investigations described in these reports and subsequent data

detailed in Section 6.2 of this document, the LNAPL is limited to the saturated zone, and is discontinuously present through an approximately 30-foot interval extending downward from the water table.

Known LNAPL areas outside of, but in close proximity to the former plant site, include the following:

- The P-1 LNAPL (at well XP-01) at 204th Street and Berendo Avenue;
- In the vicinity of soil boring SBL0102, located on New Hampshire Avenue between 204th Street and Milton Street; and,
- In the vicinity of well XMW-07, near the Jones Chemical site, west of the southwest corner of the Del Amo plant site.

The P-1 LNAPL is a complex petroleum product likely associated with one or more petroleum pipelines in the vicinity, and unrelated to the Del Amo plant site. The extent of the P-1 LNAPL has not been fully evaluated. Additional information regarding the P-1 LNAPL is presented within Dames & Moore's "Focused Investigation of Non-Aqueous Phase Liquid, Monitoring Well P-1" (Dames & Moore, 1992b) and letters to Mr. Tom Dunkelman of EPA dated January 23, 1992, and April 15, 1993 (Dames & Moore, 1992a and Shell, 1993).

The LNAPL at boring SBL0102 was encountered during drilling of this boring. This LNAPL is in close proximity to active petroleum transmission pipelines located beneath New Hampshire Avenue and is suspected to be a petroleum hydrocarbon product similar in character, mode of occurrence and origin to the P-1 LNAPL. The extent of this LNAPL has not been evaluated. Field observations regarding the LNAPL are described on the boring log for SBL0102 (Appendix B) and further detailed in an August 18, 1995 letter from the Respondents to EPA (Shell, 1995c). No monitoring wells have been completed at this location.

Little information is available regarding the LNAPL at well XMW-07. The XMW-07 LNAPL is also believed to be a petroleum product, and has not been fully evaluated with respect to its extent. Additional investigation of the LNAPLs at well XP-01, soil boring SBL0102 and well XMW-07 is considered outside the scope of the Del Amo RI since they are located outside the plant site and are not believed to be associated with plant site operations.

Locations where LNAPL is suspected, but not known to be present, include the following plant site areas:

- A former VOC storage tank area southeast of the MW-20 LNAPL;
- A former ethylbenzene production area in the styrene plant;
- A portion of the Waste Pit Area;
- Along a section of a benzene pipeline that is suspected of leaking, in an area referred to as the Hamilton-Dutch area; and
- In the vicinity of a former laboratory along the eastern plant site boundary.

The areas of suspected LNAPL indicated on Figure 5.1-1 take into account not only the groundwater sampling locations where the elevated dissolved concentrations were detected, but also the location of former facilities where pure products were stored and likely to have been released from.

If present, the suspected LNAPLs at the above areas are likely to be composed primarily of benzene and/or ethylbenzene based on the specific dissolved compounds detected and their respective concentrations. The suspected LNAPL along the eastern plant site boundary would likely be composed primarily of benzene and toluene.

The possibility of additional areas of LNAPL not shown on Figure 5.1-1 cannot be ruled out. However, if present, additional LNAPL areas are likely coincident with one or more of the groundwater contamination source areas discussed in Section 5.3, as is the case for the known and suspected LNAPL areas identified above. Additional investigations to evaluate the potential presence of LNAPL in areas where it has not already been confirmed are currently under consideration by the Respondents and EPA.

5.1.2 DNAPL

Observed DNAPLs are limited to an area at the Montrose Plant Property, west of the Del Amo plant site (Figure 5.1-1). This DNAPL is composed primarily of chlorobenzene and DDT and has been investigated by Hargis + Associates as part of the Montrose remedial investigation (Hargis + Assoc., 1992).

Dense non-aqueous phase liquid has not been observed in any monitoring wells or borings at the Del Amo plant site. However, DNAPL is suspected along the western plant site boundary, northwest of the MW-20 LNAPL (Figure 5.1-1), where elevated concentrations of TCE and

PCE have been measured in both Del Amo monitoring wells and at offsite wells sampled by other investigators in the past. It is not certain from the available data whether the high concentrations along the western plant site boundary are associated exclusively with operations at facilities unrelated to the plant site, or whether there has been an additional contribution from the plant site "pits and trenches area" (see Plate 1-2). The pits and trenches area was identified from evaluation of historical aerial photographs of the plant site, but their history of use is unknown.

5.2 DISTRIBUTION OF DISSOLVED CONTAMINANTS

Dissolved contaminants tested for in the study area include VOCs, SVOCs, p-CBSA, metals, pesticides and PCBs, and cyanide. The compounds tested for were selected in accordance with the "Technical Memorandum, Data Quality Objectives for Risk Assessment, Del Amo Superfund Site" (Bechtel/Clement, 1992). Tables 2.2-4 and 2.2-5 indicate the locations at which each type of analysis has been conducted one or more times as part of the Del Amo monitoring program. Biodegradation indicator compounds and most general mineral testing parameters are not considered dissolved contaminants, and are discussed in Sections 6.1 and 4.3 , respectively, of this document.

Contaminant distribution information is presented largely in a graphic format within this document. VOC, SVOC, metals, and pesticide/PCB summary figures are presented for the water table, MBFB, MBFC, and Gage hydrostratigraphic units with concentrations of detected compounds listed for each location. For key compounds in each hydrostratigraphic unit, (those with relatively high concentrations and large distributions), individual maps are presented with concentration values posted at each location and interpretive concentration isopleths drawn to show the dissolved plumes and areas of maximum concentrations. Graphs presenting BTEX concentrations through time at Del Amo monitoring wells for each unit are included on plates.

Drinking water MCLs are referenced and discussed with respect to figures illustrating the distribution of key compounds to put the concentrations in perspective. The cited MCL for each compound is the lower of either the federal EPA or the state Department of Health Services MCL.

Del Amo groundwater monitoring included nine specific sampling events conducted during the period from February 1993 through February 1996. This data set is collectively referred to as the "time-series data". A summary of the time-series data that includes results for all detected compounds at each monitoring location is presented in Appendix G1. A disk containing the

complete time-series data set for primary samples (does not include duplicate samples or other QA/QC analytical data) in electronic format is provided in Appendix G3. A summary of QA/QC results and data validation issues is presented in Appendix I.

Summary figures presented in this report present third sampling event (October through December) 1995 data where available. Third sampling period 1995 data were selected for presentation to maintain consistency with the groundwater modeling effort and because this event is relatively recent and comprehensive with respect to the number of locations and analytes for which there are data. Where third sampling event 1995 data for a specific location and/or analyte are not available, the most recent historical concentrations are posted. Detailed summaries of groundwater data for each sampling event through the first sampling period 1996, are provided within the respective groundwater monitoring reports. First sampling period 1996 monitoring data are discussed within the June 17, 1996 Groundwater Monitoring Report.

Data collected by Hargis + Associates for the adjacent Montrose Plant Property are not included in the time-series data of Appendix G1 because the two data sets have not been collected and maintained in similar formats. However, the Montrose data are presented on the summary figures for completeness. The Montrose data are identified as such on the figures, and are also from the third sampling period 1995, except where not available. The reader is referred to the Montrose RI Report for further information regarding the Montrose data set (Hargis + Assoc., 1992).

For some locations and/or analytes, use of third sampling event 1995 data may result in concentrations that are not representative of the time-series data as a whole. This can occur when the compound concentration is anomalous with respect to the time-series data as a whole, when the single sampling event has elevated detection limits relative to other sampling events, or when a trend of increasing or decreasing concentrations through time exists. For this reason, the time-series data as a whole for each monitoring location were taken into consideration when evaluating the position of concentration isopleths for figures illustrating individual compound distributions. Third sampling period 1995 data that may not be representative of the time-series data in accordance with the above criteria are indicated on the figures.

Del Amo monitoring locations with trends of increasing or decreasing concentrations for one or more compounds were identified using a statistical program. A least-squares linear fit was applied to the time-series data for each compound and location, followed by a two-tailed Students T test to identify those locations where the linear fit exhibits a significant slope. The trends were identified using a default setting of 99% confidence, meaning that 99 out of every

100 identified trends are in fact "real" and not due to random variation in the data. The confidence level takes into account both the number of concentration values used and the scatter of the points relative to the best fit (least squares regression) line. In this way, if relatively few concentration values are available, the scatter about a best fit line must be very low to achieve the 99% confidence level necessary for trend identification. Monitoring locations and key compounds for which statistically significant concentration trends are identified in the text below, and graphs illustrating the trends are included in Appendix G2. The reason why trends exist for the identified locations and compounds is typically unknown or speculative, and therefore not discussed in the sections below.

The reader should recognize that identification of trends is limited to those monitoring locations and compounds for which it can be said with a high degree of certainty that the slope of the best-fit line is not zero, or flat. Statistical identification of locations and compounds for which concentrations are "stable" cannot be conducted by the same statistical method as for trends, as a best fit line through the data points that has a slope of exactly zero would be exceedingly rare, and a very restrictive definition of stability. Statistical identification of wells and compounds with stable concentrations is not conducted in this RI. An intuitive, non-statistical evaluation of contaminant plume stability is presented in Section 6.

For the purposes of this report, VOCs are considered to be all compounds on the project-specific EPA Method 8240 analyte list. Compounds that are tested for under both Methods 8240 and 8270, such as naphthalene, are listed as VOCs, and are not repeated under the SVOC heading in either the time-series data table (Appendix G1) or in the figures.

Metals data are summarized on the figures in a different format than other compound classes. Because many metals occur naturally in groundwater, the data posted on metals summary figures are limited to those metals with a concentration in excess of state or federal MCLs. For those metals with both total (unfiltered samples) and dissolved (filtered samples) concentration data, the highest of the two values is presented in the figures.

Because data for some metal compounds (aluminum, for example) originates from both "metals" and "general mineral" testing, the list of metals analyzed for at some locations (those analyzed for "metals") can be substantially different than the list for other locations (those where only general minerals testing was conducted, or where neither general minerals nor "metals" testing was conducted). For the same reason, metals data for a single monitoring location can also originate from a mix of the third sampling period 1995 event and historical data. For the above reasons, metals summary figures are limited to showing locations at which exceedances of one

or more MCLs occurred during the most recent sampling event (third sampling event 1995 or earlier) for each compound that was tested for. Therefore, the full list of metals compounds was not necessarily analyzed for at every location for which data are summarized on the figures, and the metals data posted for a location may be from more than one sampling event. Del Amo monitoring locations for which a full metals analysis was conducted are indicated in Tables 2.2-4 and 2.2-5.

5.2.1 Water Table Zone

5.2.1.1 VOCs

VOCs detected in samples from Del Amo and Montrose water table zone monitoring locations are presented in Figure 5.2-1. One or more VOCs were detected at 59 of the 64 Del Amo water table monitoring locations tested during the third sampling period, 1995. A total of 31 specific VOCs were detected at one or more sampling locations. These detected VOCs are listed in Table 5.2-1 with the maximum concentration and the monitoring location at which the maximum concentration occurred. VOCs for which individual water table distributions are illustrated include benzene, ethylbenzene, chlorobenzene, PCE, TCE, and naphthalene. Graphs of BTEX concentrations through time at Del Amo water table monitoring locations are presented on Plate 5-1.

Benzene is considered the dominant VOC contaminant in the water table by virtue of its detection at 42 of 64 Del Amo monitoring locations[1] sampled during the third sampling period 1995, far more than any other compound. The distribution of benzene is illustrated in Figure 5.2-2. The benzene concentration exceeds the MCL for this compound within the 10^0 (1 μg/l) isopleth. While the circular 1 μg/l concentration isopleth at CWL0041 is interpreted to be distinct from the 1 μ/l isopleth of the main benzene plume to the south, an alternative interpretation is that these isopleths are continuous.

Trends of increasing benzene concentration through time are limited to well XMW-28, in the former tank farm area in the western portion of the plant site. Trends of decreasing benzene concentration are apparent at locations SWL0021 (offsite in a former landfill area, south of the southeast corner of the plant site), and SWL0008 (offsite, immediately south of the Waste Pit

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1 Citations regarding the number of monitoring locations at which a compound is detected are restricted to monitoring locations sampled as part of the Del Amo groundwater monitoring program during the third sampling period 1995. Figures may indicate detections at a greater number of locations than stated in the text since the data presented on the figures is a composite of Del Amo and Montrose data, and third sampling period 1995 and historical data.

Area). Graphs of benzene concentrations through time at each of these locations are included in Appendix G2.

Review of the time-series data presented in Appendix G1 and the graphs on Plate 5-1 suggests that water table benzene concentrations as a whole have been relatively stable over the duration of the groundwater monitoring program. Figure 5.2-3 shows interpretive time-series benzene concentration isopleths for sampling events in 1993, 1994, 1995 and 1996. Comparison of the maps of Figure 5.2-3 indicates no significant expansion or retreat of the benzene plumes over the monitoring period. The time series data together with the extreme rarity of monitoring locations for which trends of increasing benzene concentration have been identified is consistent with an hypothesis of benzene plume stability. A more detailed evaluation of benzene plume stability is presented in Section 6.1.

The ethylbenzene distribution is illustrated in Figure 5.2-4. The area for which ethylbenzene exceeds the MCL of 680 μg/l is approximately bounded by the 10^3 (1,000 μg/l) isopleth. Although at much lower concentrations, the ethylbenzene distribution pattern is similar in appearance to benzene, implying similar origins. The exception to this is the area west of the plant site, where ethylbenzene is confined within a much more limited area than benzene. A trend of decreasing ethylbenzene concentrations is identified at XMW-13 (panhandle area, southwest corner of plant site).

Chlorobenzene concentrations are presented in Figure 5.2-5. The area where dissolved chlorobenzene concentrations exceed the MCL of 70 μg/l is approximately bounded by the 10^2 (100 μg/l) isopleth. The main chlorobenzene plume is centered at the former Montrose Plant Property west of the Del Amo plant site, where chlorobenzene was used in the manufacturing of DDT. A trend of decreasing chlorobenzene concentrations is identified at XMW-11 (west of the plant site).

Tetrachloroethene and trichloroethene (PCE and TCE) distributions are illustrated in Figures 5.2-6 and 5.2-7, respectively. The areas for which concentrations in excess of the MCL (5 μg/l for both PCE and TCE) exist are approximated by the 10^0 (1 μg/l) isopleth. The distributions of PCE and TCE are similar, with the highest concentrations in the vicinity of PZL0016 (central portion of the western plant site boundary). Historical data collected by other investigators indicate concentrations similar or higher than those observed at PZL0016 have been detected at monitoring locations outside of the plant site at the adjacent Amoco facility. TCE and PCE plumes distinct from that observed in the PZL0016 area, and with lesser maximum concentrations, are apparent in the vicinity of wells XMW-06 (near the Jones Chemical site,

west of plant site), SWL0016 (central plant site), and former offsite landfills south and east of the southeast corner of the plant site. A trend of increasing PCE concentration is identified at XP-02 (central-southern portion of plant site). TCE concentrations have decreased through time at PZL0016 (central portion of western plant site boundary) and increased at adjacent well XMW-02T.

While dichlorinated compounds have been detected at the Del Amo plant site and vicinity, their distribution is closely related to the PCE and TCE distributions. For this reason, no figures or additional discussion of dichlorinated compounds is provided.

Figure 5.2-8 illustrates naphthalene concentrations, and indicates four distinct naphthalene plumes. There is no federal or state MCL for naphthalene. Groundwater data collected prior to this RI indicate maximum naphthalene concentrations are present at well XP-01 (offsite, south of the plant site), where a petroleum hydrocarbon LNAPL that includes naphthalene is present. Analytical data regarding the composition of P-1 LNAPL and concentrations of dissolved constituents were presented in Dames & Moore's "Focused Investigation of Non-Aqueous Phase Liquid, Monitoring Well P-1" (Dames & Moore, 1992b). The extent of the naphthalene plume in the central portion of the plant site cannot be well defined due to elevated detection limits associated with interference from high benzene concentrations, but where detected in this area, naphthalene concentrations are low relative to benzene and other VOCs detected.

5.2.1.2 p-CBSA

Para-chlorobenzene sulfonic acid is a compound associated with the manufacturing of DDT, which occurred at the Montrose Plant Property, west of the former Del Amo plant site. While no MCLs have been established for p-CBSA, plotting its distribution is useful because of its close association with the Montrose Plant Property and because of its high mobility. The distribution of p-CBSA can in some cases provide an indication of the migration of other dissolved contaminants with a common source area. The p-CBSA distribution may also be of interest with respect to treatment and remedy selection implications, which are considered within the Groundwater Feasibility Study.

The water table distribution of p-CBSA is illustrated in Figure 5.2-9. While p-CBSA concentrations are generally higher, the plume is similar to that for chlorobenzene, with the main plume centered at the former Montrose Plant Property. No trends are identified for p-CBSA at the four Del Amo water table locations where p-CBSA was detected.

5.2.1.3 SVOCs

SVOC analytical data for Del Amo and Montrose water table monitoring locations are summarized in Figure 5.2-10. One or more SVOCs were detected at eight Del Amo water table monitoring locations sampled during the third sampling event, 1995. As illustrated in Figure 5.2-10, SVOCs are primarily limited to the southern portion of the Del Amo plant site and the offsite area west of the plant site, entirely within the benzene distribution. The only detected SVOC with an MCL exceedance is bis(2-ethylhexyl)phthalate (MCL of 4 μg/l exceeded at CWL0040, XMW-06, and WPL0001). However, phthalates are also common laboratory contaminants. SVOC data for CWL0040, WPL001, and XMW-06 are limited to a single sampling event, so the validity of the bis(2-ethylhexyl)phthalate detections cannot be fully evaluated for these locations.

The most commonly detected SVOC at Del Amo monitoring locations is phenol (six locations during the third sampling event 1995; Table 5.2-1). The areas of local phenol concentration maxima coincide with plant site areas of maximum benzene concentration, suggesting an association between these compounds. Identified SVOC concentration trends are limited to SWL0008 (south of the Waste Pit Area) and XMW-14 (southwest corner of plant site), where a trend of decreasing 2-methylnaphthalene concentrations for both locations is apparent from the time-series data.

5.2.1.4 Metals

Analytical data for those metals with MCL exceedances at Del Amo and Montrose monitoring locations are presented in Figure 5.2-11 along with their respective MCLs. The metal most frequently detected at a concentration in excess of its MCL at Del Amo monitoring locations is arsenic (eight locations; MCL=50 μg/l). Aluminum was detected in excess of the MCL (1,000 μg/l) at seven locations. Remaining metals detected in excess of their MCLs were limited to three or fewer locations, and include nickel (three locations; MCL=100 μg/l), chromium (two locations; MCL=50 μg/l), barium (one location; MCL=1,000 μg/l), lead (one location; MCL=50 μg/l), and cadmium (one location; MCL=5 μg/l).

Samples from the seven locations at which aluminum exceeded the MCL were unfiltered, (referred to as "total metals" in Appendix G1) and where available, time-equivalent filtered samples ("dissolved metals") do not exceed MCLs. Similarly, the samples for the two locations where chromium exceeded the MCL were also unfiltered.

Metal concentration trends were limited to decreasing concentrations of total aluminum at SWL0008 (all results less than MCL) and increasing concentrations of barium at SWL0017 (maximum concentration of 160 μg/l; MCL=1,000 μg/l). Monitoring location SWL0008 is located just south of the Waste Pit Area, while SWL0017 is near the center of the Del Amo plant site.

5.2.1.5 Pesticides and PCBs

Pesticide and PCB analytical data are summarized in Figure 5.2-12. Analyses for pesticides and PCBs at Del Amo monitoring locations were limited to the first sampling event (Phase I RI), during which tests were conducted for 34 water table locations. PCBs were not detected in any samples. Detected pesticides were limited to isomers of DDT and BHC in the area west and south of the Del Amo plant site. BHC was produced at the former Stauffer Chemical Company pilot plant, located at the southeast corner of the Montrose Plant Property. The only detected pesticide for which there is an MCL is γ-BHC (a.k.a. Lindane). The MCL for this compound of 0.2 μg/l was exceeded at XMW-01, XMW-05, XMW-06, and XMW-12, all west of the Del Amo plant site.

5.2.1.6 Cyanide

Analyses for cyanide were limited to 27 Del Amo water table monitoring locations during the first sampling event (Phase I RI). A list of locations tested is provided in Tables 2.2-4 and 2.2-5. Cyanide was not detected at any of the monitoring locations tested.

5.2.2 Middle Bellflower B Sand

A summary of the distribution of contaminants in the MBFB is presented below. The reader is reminded that the water table intersects the MBFB near the western margin of the Del Amo plant site. East of this demarcation, the water table zone and MBFB are considered separate units, while to the west, they are identical. For this reason, the distribution of contaminants west of the demarcation line is identical for the water table and MBFB, and differences in compound distributions between the two units are limited to the area from the central plant site eastward. Similarly, water table monitoring locations west of the demarcation line are also considered MBFB installations, and are included on contaminant distribution maps for both the water table and MBFB units. Monitoring locations that are east of the demarcation line but were

constructed with their screen opposite both the water table and MBFB units are also considered to be both water table and MBFB installations.

5.2.2.1 VOCs

MBFB concentration data for VOCs are summarized in Figure 5.2-13. One or more VOCs were detected at 27 of the 33 Del Amo MBFB monitoring locations tested. A total of 25 individual VOCs were detected at one or more sampling locations (Table 5.2-1). VOCs for which distributions are illustrated include benzene, ethylbenzene, chlorobenzene, PCE, TCE, and naphthalene. Graphs of BTEX concentrations through time at Del Amo monitoring locations are presented on Plate 5-2.

Benzene is considered the dominant VOC contaminant in the MBFB based on its consistent detection at 18 of the 33 Del Amo MBFB locations. The distribution of benzene is illustrated in Figure 5.2-14. For the area in which the water table and MBFB zones are distinct, benzene concentrations for the MBFB are generally reduced relative to the water table. An exception to this occurs southeast of the Waste Pit Area, where benzene at MBFB location SWL0041 (8,100 μg/l, third sampling event 1995) is consistently elevated relative to colocated water table monitoring location PZL0022 (6.3 μg/l). While benzene is present at relatively high concentrations in the overlying water table near the southeastern corner of the plant site, it is not clear from the available data whether it extends into the MBFB in this area. However, if present, benzene has not extended significantly beyond the southern plant site boundary in this area, as evidenced by the lack of benzene detections at SWL0023, SWL0019, and SWL0052.

Ethylbenzene, chlorobenzene, PCE, and TCE distributions are illustrated in Figures 5.2-15, 5.2-16, 5.2-17, and 5.2-18, respectively. The distributions and concentrations of these compounds in the MBFB are generally reduced relative to the overlying water table for the area in which the water table and MBFB are distinct. An exception to this occurs for ethylbenzene, which has an elevated concentration relative to the water table zone at SWL0041, as was the case for benzene.

Figure 5.2-19 illustrates the MBFB concentration distribution for naphthalene. For the areas with MBFB monitoring locations, the distribution and detected concentrations of naphthalene in the MBFB are very similar to the water table zone. As noted for the water table, naphthalene detection limits are elevated at some locations due to interference from high concentrations of benzene.

Benzene and other VOC concentrations at Del Amo MBFB monitoring locations are typically relatively stable over the period for which monitoring has been conducted. All MBFB monitoring locations with concentration trends for one or more VOCs are located in the area where the water table and MBFB are merged, and were therefore previously identified in Section 5.2.1 above. These locations and compounds include benzene at XMW-28 (increasing), ethylbenzene at XMW-13 (decreasing), chlorobenzene at XMW-11 (decreasing), and TCE at XMW-02T (increasing).

5.2.2.2 p-CBSA

The MBFB distribution of p-CBSA is illustrated in Figure 5.2-20. Since p-CBSA is largely limited to the area for which the water table and MBFB zones are identical, the distribution is also identical to that for the water table. No trends are identified for p-CBSA at MBFB locations.

5.2.2.3 SVOCs

MBFB monitoring locations at which SVOCs were tested for are indicated in Figure 5.2-21 along with concentrations of detected compounds. One or more SVOCs were detected in samples from three of the 11 Del Amo monitoring locations for which analyses were conducted during the third sampling event 1995. As illustrated in Figure 5.2-21, SVOCs are primarily limited to the southern portion of the plant site and the offsite area west of the plant site. Detection of SVOCs in excess of MCLs was limited to bis(2-ethylhexyl)phthalate at XMW-06, west of the plant site. The reliability of this detection is in question since SVOCs were only analyzed for once at this location (by Hargis + Associates for the Montrose Plant Property), and phthalates are common laboratory contaminants.

The most commonly detected SVOC was phenol, which was detected at two Del Amo MBFB monitoring locations during the third sampling event 1995. Trends for SVOCs at MBFB locations were limited to decreasing concentrations of 2-methylnaphthalene at XMW-14 (southwest corner of plant site).

5.2.2.4 Metals

Data for metals with concentrations in excess of MCLs at MBFB monitoring locations are presented in Figure 5.2-22. Metals concentrations that exceeded MCLs at one or more Del Amo monitoring locations included arsenic (XMW-13, XMW-28, and XMW-29; MCL=50 μg/l),

cadmium (XGW-07C; MCL=5 μg/l), and aluminum (SWL0002; MCL=1,000 μg/l). No trends for metal concentrations were identified from the time-series data for Del Amo monitoring locations.

5.2.2.5 Pesticides and PCBs

A single round of testing for pesticides and PCBs was conducted for 12 Del Amo MBFB sampling locations. Analytical results are summarized in Figure 5.2-23 along with recent and historical data for Montrose MBFB monitoring locations. Detected pesticides are limited to isomers of DDT and BHC in the area west of the Del Amo plant site, and the data are therefore identical to that presented for the water table. PCBs have not been detected at any Del Amo MBFB monitoring locations.

5.2.2.6 Cyanide

Testing for cyanide at Del Amo MBFB locations was limited to one sampling event at locations SWL0010, SWL0019, and XMW-28. Cyanide was not detected at these locations.

5.2.3 Middle Bellflower C Sand

5.2.3.1 VOCs

VOC concentrations at MBFC monitoring locations are summarized in Figure 5.2-24. One or more VOCs were consistently detected at 15 of the 24 Del Amo MBFC monitoring locations tested during the third sampling period 1995. A total of 15 specific VOCs were detected at one or more sampling locations (Table 5.2-1). Figures illustrating the distribution of individual VOCs are presented for benzene, ethylbenzene, chlorobenzene, PCE, and TCE. All other VOCs are either detected at only a few MBFC locations or none at all. Graphs of BTEX concentrations through time at Del Amo MBFC monitoring locations are presented on Plate 5-3.

The distribution of benzene is illustrated in Figure 5.2-25. Maximum benzene concentrations are present in the vicinity of the Waste Pit Area at SWL0040 (110,000 μg/l; see Table 5.2-1). The benzene concentration at this location is an exception to the general case of decreasing concentrations with successively deeper units, since the benzene concentration at colocated monitoring location SWL0041 in the overlying MBFB was only 8,100 μg/l. Possible explanations accounting for this are discussed in Section 5.3.2.

The MBFC benzene distribution is distinct from the overlying units in that the downgradient extent of the western portion of the plume is much greater than in the overlying units. Furthermore, benzene concentrations within the western portion of the plume are relatively low compared to the eastern portion of the plume near the Waste Pit Area, which does not extend nearly as far. Likely mechanisms for this distribution are discussed in Section 6.

The time-series data (Appendix G1) indicate that benzene and other VOC concentrations at most Del Amo MBFC monitoring locations have been relatively stable over the duration of the monitoring program. A trend of increasing benzene concentration is identified at SWL0040. Benzene concentrations have decreased through time at SWL0033, south of the plant site and the Waste Pit Area.

Ethylbenzene concentrations are presented in Figure 5.2-26. As illustrated, ethylbenzene is primarily limited to the immediate vicinity of the Waste Pit Area, with the maximum concentration occurring at SWL0040. The ethylbenzene detection limit is elevated near the southwestern corner of the plant site (XBF-07, XBF-06) due to interference from high concentrations of chlorobenzene, and could conceivably mask the presence of relatively low (<MCL) concentrations of ethylbenzene in this area. Trends for ethylbenzene concentrations were not identified for any Del Amo MBFC monitoring locations.

Chlorobenzene concentrations are presented in Figure 5.2-27. Chlorobenzene is the dominant dissolved VOC in the MBFC based on its consistent detection at 12 Del Amo monitoring locations, and its wide distribution and high concentrations relative to other VOCs. Maximum chlorobenzene concentrations occur within a relatively narrow band extending from the former Montrose Plant Property to XBF-24, approximately 0.7 miles to the southeast. A trend of decreasing chlorobenzene concentrations is identified at well XBF-05, near the southeast corner of the former Del Amo plant site.

The distribution of PCE and TCE concentrations are presented on Figures 5.2-28 and 5.2-29. As illustrated, elevated concentrations of these compounds persist near the western plant site boundary, and are inferred to have migrated a considerable distance down gradient along the direction of flow. PCE and TCE detection limits are elevated within the southern plume area due to interference from high concentrations of chlorobenzene.

5.2.3.2 p-CBSA

The distribution of p-CBSA is illustrated in Figure 5.2-30. The distribution is similar to that for chlorobenzene, although p-CBSA tends to be present at higher concentrations and over a slightly larger area. A trend of decreasing p-CBSA concentration through time is identified at XBF-06, at the southwest corner "panhandle" area of the Del Amo plant site.

5.2.3.3 SVOCs

MBFC monitoring locations at which SVOCs were tested for are presented in Figure 5.2-31 along with concentrations of detected compounds. As shown, detected SVOCs at Del Amo MBFC monitoring locations are limited to a historical detection of bis(2-ethylhexyl)phthalate at SWL0030 (18 μg/l; MCL=4 μg/l), near the western plant site boundary. This compound was not detected (<7 μg/l) at this location in three prior sampling events, and thus the detection is suspected to result from laboratory contamination. No concentration trends are identified for SVOCs at Del Amo MBFC monitoring locations.

5.2.3.4 Metals

MBFC locations where one or more metals have been tested for are indicated in Figure 5.2-32. Metals detected at concentrations exceeding MCLs are limited to cadmium at SWL0027 (12 μg/L, MCL=5 μg/L), which is located well south of the plant site, adjacent to an inactive landfill. Monitoring locations with identified concentration trends are limited to SWL0030 (near western plant site boundary), where the barium concentration has increased through time, although it remains much less than the MCL (maximum concentration 53 μg/l, MCL=1,000 μg/l).

5.2.3.5 Pesticides and PCBs

Analyses for pesticides and PCBs at Del Amo monitoring locations were limited to a single sampling event at five locations. Analytical results for pesticide and PCBs in the MBFC are summarized in Figure 5.2-33. As illustrated, detections of pesticides and PCBs at Del Amo MBFC monitoring locations are limited to β-BHC at XBF-06 (0.1 μg/l; no MCL). Other detections of pesticides are entirely associated with monitoring locations sampled as part of the Montrose monitoring program.

5.2.3.6 Cyanide

Analyses for cyanide were limited to one sampling event at XBF-06. Cyanide was not detected.

5.2.4 Gage Aquifer

5.2.4.1 VOCs

VOC concentrations at Del Amo and Montrose Gage aquifer monitoring locations are summarized in Figure 5.2-34. One or more VOCs were detected at 14 of the 18 Del Amo monitoring locations that were sampled during the third sampling event 1995. A total of nine individual VOCs were detected at one or more sampling locations (Table 5.2-1). Individual compounds for which distributions are illustrated include benzene, ethylbenzene and chlorobenzene. Graphs of BTEX concentrations through time for Del Amo Gage monitoring locations are presented on Plate 5-4.

Benzene was detected at six of the 14 Del Amo Gage aquifer monitoring locations. The distribution of benzene is illustrated in Figure 5.2-35, and indicates substantially reduced concentrations relative to the overlying MBFC. Benzene concentrations at Del Amo monitoring locations have been relatively stable over the duration of the monitoring program. Identified benzene concentration trends are limited to XG-09, where benzene concentrations have decreased over time.

Ethylbenzene concentrations at Gage monitoring locations are summarized in Figure 5.2-36. As shown, ethylbenzene is limited to a single detection of 4 μg/l at XG-09. A trend of decreasing ethylbenzene concentrations is also identified for this location.

Chlorobenzene concentrations are presented in Figure 5.2-37. Chlorobenzene concentrations are elevated relative to benzene, but the lateral distribution is similar in appearance. As was the case for other VOCs, the Gage chlorobenzene distribution is markedly reduced from that for the overlying MBFC with respect to both concentrations and extent. No trends are identified for chlorobenzene concentrations in the Gage aquifer at Del Amo monitoring locations.

PCE was not detected any Del Amo Gage aquifer monitoring locations, while detection of TCE was limited to XG-14 (54 μg/l) west of the plant site. Figures illustrating the distributions of these compounds are therefore not presented. A distribution figure is similarly not included for naphthalene, as it was detected at only two location (1.1 μg/l at XDA-1B; 13 μg/l at XG-12)

during the third sampling event 1995. Naphthalene was not detected in all other sampling events at both of these locations.

5.2.4.2 p-CBSA

The Gage aquifer p-CBSA distribution is illustrated in Figure 5.2-38. Although similar to the benzene and chlorobenzene distributions, the dissolved plume for p-CBSA is slightly larger than either chlorobenzene or benzene, and concentrations are generally higher. Like the VOCs, the Gage p-CBSA plume is substantially reduced relative to the overlying MBFC with respect to concentrations and extent. A trend of decreasing p-CBSA concentration through time is identified at XG-17, just north of the Waste Pit Area.

5.2.4.3 SVOCs

Gage aquifer locations for which SVOC testing has been conducted are indicated in Figure 5.2-39. Detected SVOCs at Del Amo monitoring locations are limited to historical (Phase I RI sampling event) concentrations of 2-chlorophenol, di-n-octylphthalate, and bis(2-ethylhexyl)-phthalate at XG-05. Concentration trends are not identified for any SVOCs at Del Amo Gage aquifer monitoring locations. MCL exceedances are noted for bis(2-ethylhexyl)phthalate at XG-01 and XG-02 (Montrose monitoring locations) as well as XG-05 (Del Amo monitoring location), although the single round of SVOC data at these locations is not sufficient to evaluate whether these detections represent in-situ conditions or have more likely resulted from laboratory contamination of the samples.

5.2.4.4 Metals

Gage aquifer monitoring locations where one or more metals have been tested for are indicated in Figure 5.2-40. All metals concentrations are below MCLs. Monitoring locations at which a complete metals list has been tested for are indicated in Tables 2.2-4 and 2.2-5.

5.2.4.5 Pesticides and PCBs

Monitoring locations where pesticides and PCBs have been analyzed for are indicated in Figure 5.2-41. Analyses for pesticides and PCBs at Del Amo Gage monitoring locations were limited to one sampling event at locations XG-04, XG-05, XG-11, and XG-17. As illustrated, pesticides and PCBs were not detected at each of these four locations, although there have been historical detections of DDT isomers at a few Montrose Gage aquifer monitoring locations.

5.2.4.6 Cyanide

Analyses for cyanide were limited to a single sampling event (Phase I RI) at XG-17. Cyanide was not detected at this location.

5.3 GROUNDWATER CONTAMINATION SOURCE AREAS

5.3.1 Regional Source Areas

Regional groundwater contamination source areas outside of, but in the vicinity of the Del Amo plant site, are identified on Figure 5.3-1. The regional source areas were identified largely on the basis of groundwater analytical data in publicly available reports from regulatory agency files indicating elevated concentrations of one or more VOCs at water table monitoring locations relative to surrounding areas. There is also information in the files for most of the source areas indicating a history of land use consistent with the observed VOC contamination and/or data indicating elevated VOC concentrations in soil. Water quality data are generally not available for deeper zones below the water table at the regional source areas.

The facilities listed as being associated with the regional source areas in Figure 5.3-1 are included only to indicate the name of the existing business in the area at the time the data was generated, and may not reflect responsibility for the detected contaminants in all cases. The extent of the identified regional source areas is not known, and outside the scope of the Del Amo RI.

In support of the identification of the depicted regional source areas, concentration distribution maps at a regional scale for benzene, tri-chlorinated and tetra-chlorinated compounds (primarily PCE and TCE), and dichlorinated compounds are presented on Figures 5.3-2, 5.3-3, and 5.3-4 respectively. Most of the identified source areas exhibit elevated concentrations of one or more of the classes of compounds considered in these figures, although other VOCs may be dominant for some areas.

5.3.2 Plant Site Source Areas

Twelve groundwater contamination source areas associated with the former Del Amo plant site have been identified, as shown on Figure 5.3-5. Past releases of VOCs from plant site facilities or operations are inferred to have impacted groundwater at each of these locations. Source area 3 (the MW-20 LNAPL) has been extensively investigated, as described in Dames & Moore's "Focused Investigation, Nature and Extent of Non-Aqueous Phase Liquid, Monitoring Well MW-20" dated March 5, 1993, and "Draft Report and Work Plan, Laboratory Data and Analysis and Hydraulic Extraction Work Plan, MW-20 Pilot Program, Del Amo Study Area," dated September 29, 1995. Additional investigation of other source areas is currently under consideration by the Respondents and EPA.

The plant site source areas have been identified based on two or more of the following lines of evidence:

- Observation of LNAPL in a well or boring;
- Water table analytical data indicating compound concentrations elevated relative to surrounding monitoring locations;
- Historical information indicating the presence of facilities where large volumes of chemicals were stored, processed, or disposed of;
- Shallow soil gas data indicating elevated concentrations of VOCs.

With the exception of plant site source areas 1 and 2, which are associated with cyclohexane and TCE/PCE respectively, the identified plant site source areas are all associated with elevated concentrations of dissolved benzene. This fact is illustrated in Figure 5.3-6, which overlays third sampling period 1995 benzene concentrations with source areas from the plant site and near vicinity.

5.3.3 Interpretation of Contaminant Distributions with Respect to Plant Site Source Areas

5.3.3.1 VOCs

Benzene

VOCs, specifically benzene and chlorobenzene, are concluded to be the dissolved contaminants of principal interest within the study area based on their relatively broad distributions, high concentrations, and known toxicity. Multiple plant site and regional source areas are inferred

to have contributed to the observed benzene distribution, as indicated in Figures 5.3-1 and 5.3-5. The majority of the benzene sources are located within the former styrene plant area at the Del Amo plant site, where benzene was used in the production of styrene. The individual plumes from the benzene sources are interpreted to have largely merged over time, resulting in two primary water table plumes at the plant site, referred to as the eastern and western plume areas. A third plume area exists west of the plant site, in the vicinity of the Montrose Plant Property, and is partially merged with the western plant site plume. The benzene in this area may be attributable to one or more of the following potential sources:

- releases of chlorobenzene feedstock at the Montrose manufacturing plant that contained benzene as a contaminant;
- Possible releases of benzene from the Stauffer BHC manufacturing operations in which benzene feedstock was chlorinated to make BHC; and
- releases of benzene from long-distance conveyance pipelines at the southern edge of the Montrose facility.

The presence of an area between the Montrose and Del Amo plant areas where benzene is consistently at very low or non-detectable concentrations (well XMW-11) indicates that the Montrose area benzene plume cannot be attributable to the Del Amo plant site without significant deviations from groundwater gradients observed over the duration of the groundwater monitoring program. There is no indication from the dissolved VOC plume configurations in any other areas that such deviations have occurred.

As discussed in Section 5.2.3.1, the elevated benzene concentrations in the MBFC at monitoring location SWL0040 are not typical of plant site conditions in that they are consistently higher than for the overlying MBFB and water table zones. Benzene was detected at 110,000 μg/L at MBFC location SWL0040, while being detected at 8,100 μg/L and 1.3 μg/L at colocated monitoring points SWL0041 (MBFB) and PZL0022 (water table), respectively. For most sampling events, ethylbenzene, TDS, and surfactant concentrations are elevated at this location relative to other MBFC and overlying MBFB monitoring locations. The reason(s) for the apparent inverted concentration gradient (increasing concentrations with successively deeper HSUs) are not well understood. Several explanations are possible, including the following:

(1) At the time of the contaminant release, the water table may have been within the MBFC in the vicinity of SWL0040. The contaminants migrated downward through the vadose zone until intercepting the water table, where the contaminant spread out. Subsequently, the groundwater table rose, and the majority of the contaminant mass became trapped in the saturated zone, submerged beneath the water table. Residual contamination that was

originally present in the vadose zone was largely removed by biodegradation, volatilization, or other processes before becoming submerged, resulting in an inverted concentration profile, where contaminant concentrations are higher in the MBFC than in the overlying units. LNAPL is unlikely to be present at the base of the MBFC where well SWL0040 is screened since the water table is unlikely to have been this deep during operation of the plant site,.

(2) Surfactants and/or high TDS concentrations in the contaminant solution may have influenced contaminant mobility in this area.

(3) A dry well or other unknown conduit may exist in the vicinity of SWL0041 by which concentrated contaminant solutions have been introduced directly to the MBFC and/or B/C sand in the past without significantly impacting the overlying zones.

(4) Contamination associated with the Waste Pit Area may have migrated down into the MBFC in some areas when groundwater elevations were lower (see number 1 above). Given a higher hydraulic conductivity/lower biodegradation rate for the MBFC (see Section 6 of this document), higher VOC concentrations in the MBFC relative to the overlying units downgradient from the Waste Pit Area could result.

(5) A naturally occurring, preferential flow path is locally present through which relatively high concentrations of contaminants associated with the Waste Pit Area enter the MBFC in the vicinity of well SWL0040.

Chlorobenzene

Unlike benzene, chlorobenzene appears to be primarily associated with one source area based on its concentration distribution pattern. The highest water table chlorobenzene concentration and the inferred source area for the chlorobenzene is located west of the Del Amo plant site at the Montrose Plant Property. Chlorobenzene was formerly used at the Montrose Plant Property in the production of DDT.

The chlorobenzene distribution is also distinct from benzene in that the extent of the dissolved plume is greatest at depth, in the MBFC rather than in the water table. This is likely explained by the observed presence of a chlorobenzene DNAPL at the Montrose Plant Property. The presence of a DNAPL increases the likelihood of downward vertical migration of the product and subsequent spreading of dissolved contamination at depth. The relatively greater hydraulic conductivity of the MBFC relative to the water table zone results in an expanded lateral extent of the dissolved plume.

Ethylbenzene

Ethylbenzene, which was also used in production of styrene at the plant site, shares many of the same source areas as benzene. Consequently, the resulting ethylbenzene distribution is similar to benzene (Figure 5.2.4), and is interpreted to have formed in a similar manner.

PCE and TCE

The distribution of the chlorinated solvents PCE and TCE are considered important to study area conditions in that they are present at relatively high concentrations in plumes that overlap with both the benzene and chlorobenzene plumes. The PCE and TCE distributions are distinct from the chlorobenzene and benzene plumes however, and are generally not attributed to the same source areas. PCE and TCE are present in two distinct primary plumes that are centered west of the southwest corner of the Del Amo plant site, and along the western plant site boundary (Figures 5.2-6 and 5.2-7). The origin of the plume near the southwestern corner of the plant site is not known, but is unlikely to be associated with the plant site based on the location of the maximum concentrations and the groundwater flow direction. Multiple sources are likely to have contributed to the more northerly PCE/TCE plumes along the western plant site boundary, including two existing businesses adjacent to the plant site where chlorinated solvent contamination has been detected in both soil borings and water table monitoring wells. An additional PCE/TCE contribution from the Del Amo plant site cannot be ruled out however, given elevated PCE/TCE concentrations in soil gas samples from the plant site area and historical photographs indicating the former presence of "pits and trenches" of unknown usage.

The PCE and TCE plumes south and east of the southeast corner of the plant site are at much lower concentrations than the plumes near the western plant site boundary. These plumes are inferred to be associated with inactive landfills known to be present in these areas, (see Figure 5.3-1) and are not believed to be associated with the plant site.

5.3.3.2 p-CBSA

p-CBSA is associated with the production of DDT, and has a distribution very similar to chlorobenzene, although larger for some hydrostratigraphic units. p-CBSA is inferred to originate from outside of the Del Amo plant site, in the same area as the chlorobenzene and DDT sources.

5.3.3.3 SVOCs

SVOCs have been detected primarily within the southern plant site area and the area west of the southwest corner of the plant site. While an SVOC contribution from the plant site is likely, SVOCs are judged to be of secondary importance relative to VOCs based on their limited lateral extent, low mobility, and relatively low concentrations. The most prevalent SVOC at the plant

site, phenol, has been detected only in areas with high benzene concentrations, and may originate from the natural degradation of this compound (see Section 6).

5.3.3.4 Metals

Several metals, primarily arsenic and aluminum, have been sporadically detected at concentrations in excess of MCLs within the water table and MBFB. MCL exceedances for aluminum and chromium are associated with unfiltered samples, and corresponding data for filtered samples indicates a concentration less than the MCL. This suggests that the MCL exceedances for aluminum and chromium are due to suspended sediment in the samples rather than dissolved concentrations, and are therefore more a function of well construction, well development, and sampling technique than the intrinsic water quality.

Taking into account the likely explanation for the aluminum and chromium MCL exceedances, relatively few instances of MCL exceedances for metals exist relative to VOCs. Unlike benzene and other VOCs, comparison of the distribution of metal MCL exceedances (Figures 5.2-11 and 5.2-22) with historic areas of chemical storage and use (Plate 1-2) reveals no correlation. The metals figures do indicate that a cluster of five monitoring locations with exceedances for arsenic exist near the southwest corner of the site (XMW-13, XMW-28, XMW-29, PZL0025, and SWL0008). A sixth location, XMW-14, could also be considered part of this cluster since time-series data show that while the most recent arsenic result (49 μg/l) was slightly below the MCL (50 μg/l), all previous arsenic concentrations exceed the MCL.

While the aluminum and chromium exceedances discussed above are attributed to sediment in the groundwater samples, the origin of the arsenic and other metal exceedances is not known with any certainty. Excepting the arsenic cluster, the metal exceedances appear to be scattered, with no consistent patterns. Review of the time-series data indicates that aside from the noted disparity between total and dissolved concentrations for aluminum and chromium, most metal concentrations are relatively stable through time.

The metal exceedances could be associated with either natural and/or anthropogenic sources from on or offsite areas. The metals are not interpreted to be associated with the Del Amo plant site given the poor correlation between the distribution of MCL exceedances and former plant facilities, and the lack of any evidence for the storage or use of concentrated solutions or substances containing the metals of concern.

5.3.3.5 Pesticides

Detected pesticides at the Del Amo plant site are limited to isomers of DDT and BHC in the extreme southwest corner of the plant site. These detections are part of a larger pesticide plume that underlies and extends downgradient of the Montrose Plant Property.

Table 5.2-1
Summary of Detected Compounds at Del Amo Monitoring Locations
Third Sampling Period 1995

HSU	Compound Class	Compound	Number of Locations Tested	Number of Locations With Detections	Maximum Concentration (ug/l)	Location with Maximum Concentration	MCL*
Water Table	VOCs	Benzene	64	42	1200000	SWL0004	1
		Toluene	64	8	44000	PZL0011	1000
		Ethylbenzene	64	12	23000	XMW-21	700
		Trichloroethene	64	21	9400	PZL0016	5
		Tetrachloroethene	64	19	6300	PZL0016	5
		Chlorobenzene	64	10	4500	XMW-13	70
		1,1-Dichloroethane	64	6	4000	XMW-01T	5
		Xylenes (Total)	64	6	3600	PZL0011	1750
		Acetone	64	5	2700	XMW-13	None
		cis-1,2-Dichloroethene	64	11	2500	PZL0016	6
		1,2,4-Trimethylbenzene	64	4	850	XMW-13	None
		Chloroform	64	13	600	XMW-13	100
		1,1-Dichloroethene	64	8	570	XMW-01T	6
		Naphthalene	64	12	510	XMW-13	None
		1,2-Dichloroethane	64	8	490	XMW-14	0.5
		Cyclohexane	64	7	430	SWL0038	None
		Methylene chloride	64	4	280	PZL0021	None
		1,1,1-Trichloroethane	64	1	280	XMW-01T	200
		trans-1,2-Dichloroethene	64	3	110	PZL0016	5
		Vinyl chloride	64	2	90	XMW-01T	0.5
		Freon 12	64	5	46	SWL0042	None
		n-Propylbenzene	64	2	18	SWL0057	None
		Isopropylbenzene	64	2	17	SWL0049	None
		1,4-Dichlorobenzene	64	4	13	SWL0042	5
		Freon 11	64	2	10	SWL0039	None
		1,2-Dichloropropane	64	3	8.6	SWL0021	5
		Methyl Ethyl Ketone	64	1	5.0	PZL0003	None
		sec-Butylbenzene	64	4	4.9	PZL0012	None
		1,2-Dichlorobenzene	64	1	1.9	SWL0042	600
		1,1,2,2-Tetrachloroethane	64	2	0.90	SWL0017	1

MCL = Lower of the US or California Maximum Contaminant Level for the given compound.

Table 5.2-1
Summary of Detected Compounds at Del Amo Monitoring Locations
Third Sampling Period 1995

HSU	Compound Class	Compound	Number of Locations Tested	Number of Locations With Detections	Maximum Concentration (ug/l)	Location with Maximum Concentration	MCL*
Water Table	VOCs	Dichlorobromomethane	64	1	0.58	SWL0045	100
	SVOCs	Phenol	30	6	320	PZL0019	None
		2-Methylnaphthalene	30	1	47	SWL0057	None
		Diethylphthalate	30	1	25	SWL0042	None
		Pentachlorophenol	30	1	5.1	SWL0024	None
	PCBSA	PCBSA	21	4	47000	XMW-13	None
MBFB	VOCs	Benzene	33	18	1200000	SWL0004	1
		Ethylbenzene	33	8	23000	XMW-21	700
		Trichloroethene	33	12	6400	XMW-01T	5
		Toluene	33	2	6300	XMW-13	1000
		Chlorobenzene	33	6	4500	XMW-13	70
		1,1-Dichloroethane	33	2	4000	XMW-01T	5
		Acetone	33	4	2700	XMW-13	None
		Xylenes (Total)	33	3	2400	XMW-13	1750
		Tetrachloroethene	33	12	1200	XMW-02T	5
		1,2,4-Trimethylbenzene	33	3	850	XMW-13	None
		Chloroform	33	5	600	XMW-13	100
		1,1-Dichloroethene	33	5	570	XMW-01T	6
		Naphthalene	33	5	510	XMW-13	None
		1,2-Dichloroethane	33	5	490	XMW-14	0.5
		Methylene chloride	33	2	280	PZL0021	None
		1,1,1-Trichloroethane	33	1	280	XMW-01T	200
		cis-1,2-Dichloroethene	33	5	270	XMW-01T	6
		Cyclohexane	33	2	210	SWL0049	None
		Vinyl chloride	33	1	90	XMW-01T	0.5
		Isopropylbenzene	33	3	17	SWL0049	None
		1,4-Dichlorobenzene	33	1	13	SWL0049	5
		n-Propylbenzene	33	3	13	SWL0049	None
		sec-Butylbenzene	33	3	12	SWL0047	None
		Freon 12	33	1	12	SWL0052	None

MCL = Lower of the US or California Maximum Contaminant Level for the given compound.

Table 5.2-1
Summary of Detected Compounds at Del Amo Monitoring Locations
Third Sampling Period 1995

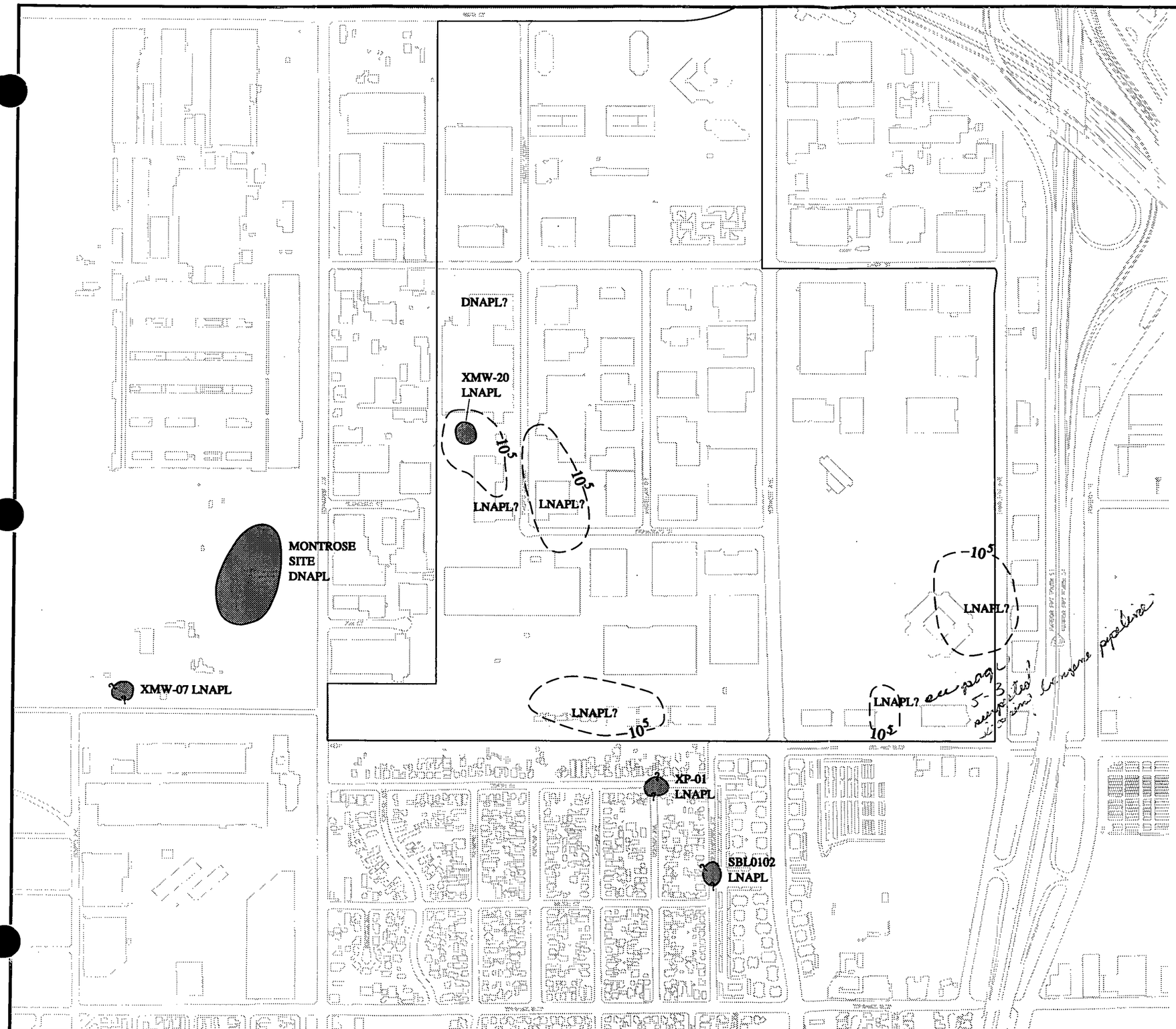
HSU	Compound Class	Compound	Number of Locations Tested	Number of Locations With Detections	Maximum Concentration (ug/l)	Location with Maximum Concentration	MCL*
Gage	PCBSA	PCBSA	14	10	38000	SWL0034	None

M[illegible] = Lower of the US or California Maximum Contaminant Level for the g[illegible] compound.

Table 5.2-1
Summary of Detected Compounds at Del Amo Monitoring Locations
Third Sampling Period 1995

HSU	Compound Class	Compound	Number of Locations Tested	Number of Locations With Detections	Maximum Concentration (ug/l)	Location with Maximum Concentration	MCL*
MBFB	VOCs	Carbon disulfide	33	1	3.0	SWL0010	None
	SVOCs	Phenol	12	2	130	XMW-29	None
		2-Methylnaphthalene	12	1	14	SWL0050	None
		2,4-Dimethylphenol	12	1	9.0	SWL0048	None
	PCBSA	PCBSA	14	4	47000	XMW-13	None
MBFC	VOCs	Benzene	24	11	110000	SWL0040	1
		Chlorobenzene	24	10	30000	XBF-15	70
		Acetone	24	3	18000	XBF-07	None
		Ethylbenzene	24	3	1500	SWL0040	700
		Trichloroethene	24	1	1200	SWL0054	5
		Naphthalene	24	2	550	SWL0040	None
		Tetrachloroethene	24	2	510	SWL0054	5
		1,4-Dichlorobenzene	24	3	47	XBF-15	5
		1,1-Dichloroethene	24	1	16	SWL0054	6
		cis-1,2-Dichloroethene	24	1	16	SWL0054	6
		1,2-Dichloroethane	24	1	12	SWL0058	0.5
		1,2-Dichlorobenzene	24	2	7.1	XBF-15	600
		Chloroform	24	1	6.2	SWL0054	100
		Methylene chloride	24	1	1.2	SWL0035	None
		Toluene	24	1	0.51	XBF-06	1000
	PCBSA	PCBSA	19	10	110000	XBF-15	None
Gage	VOCs	Chlorobenzene	18	8	8800	SWL0034	70
		Acetone	18	5	240	XG-12	None
		Methyl Ethyl Ketone	18	1	55	SWL0034	None
		Trichloroethene	18	1	54	XG-14	5
		Benzene	18	6	19	XG-12	1
		Naphthalene	18	3	13	XG-12	None
		Carbon disulfide	18	1	9.5	SWL0025	None
		Ethylbenzene	18	1	4.0	XG-09	700
		Methylene chloride	18	1	2.1	SWL0036	None

MCL = Lower of the US or California Maximum Contaminant Level for the given compound.



N

0 600 1200

Scale in Feet

EXPLANATION

Approximate area of known LNAPL/DNAPL (dashed and queried where extent is undefined)

LNAPL? Approximate area of suspected LNAPL/DNAPL

10^5 Benzene concentration isopleth (100,000 µg/l)

Note:
This map is not intended to accurately portray the limits of known or suspected areas of NAPL. With the exception of the XMW-20 LNAPL, the extent of the NAPL areas has not been fully evaluated.

FIGURE 5.1-1

Areas of Known or Suspected NAPL

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

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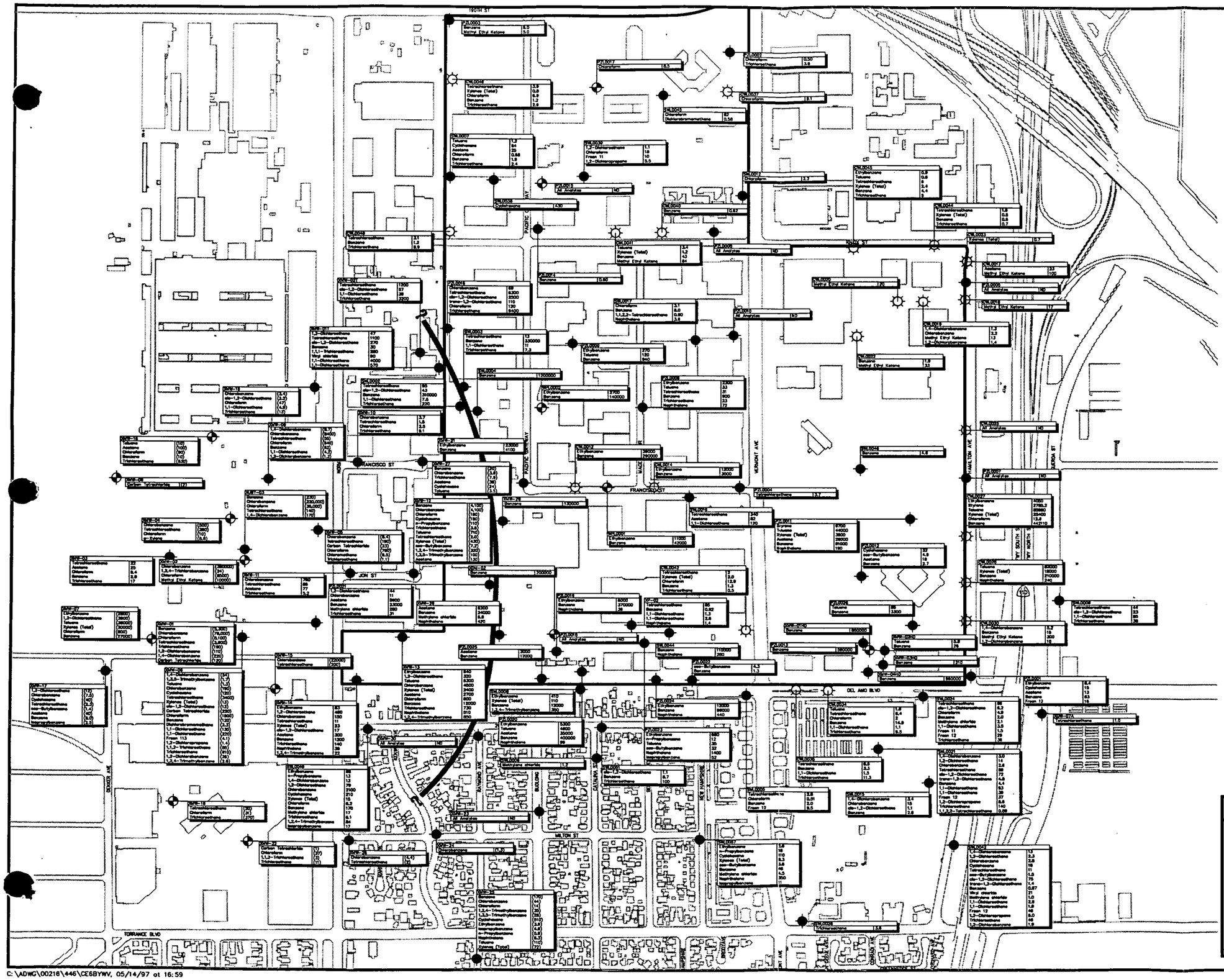

0 300 600

Scale in feet

EXPLANATION

Monitoring Location With Third Sampling Period 1995 VOC Concentration

XMW-03HD	
Benzene	210

Monitoring Location With Historical VOC Concentration (third sampling period 1995 data not available)

XMW-08	
Carbon Tetrachloride	(2)

Temporary Well Point With One-Time Historical Data (third sampling period 1995 data not available)

CWL0025	
All Analytes	ND

Inferred intersection of water table surface with top of middle Bellflower B sand. The overlying upper Bellflower aquitard is unsaturated west of the inferred intersection

NOTE: Data collected by Hargis + Associates for Montrose monitoring program in parentheses.

FIGURE 5.2-1

VOC Concentrations
Water Table Zone

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

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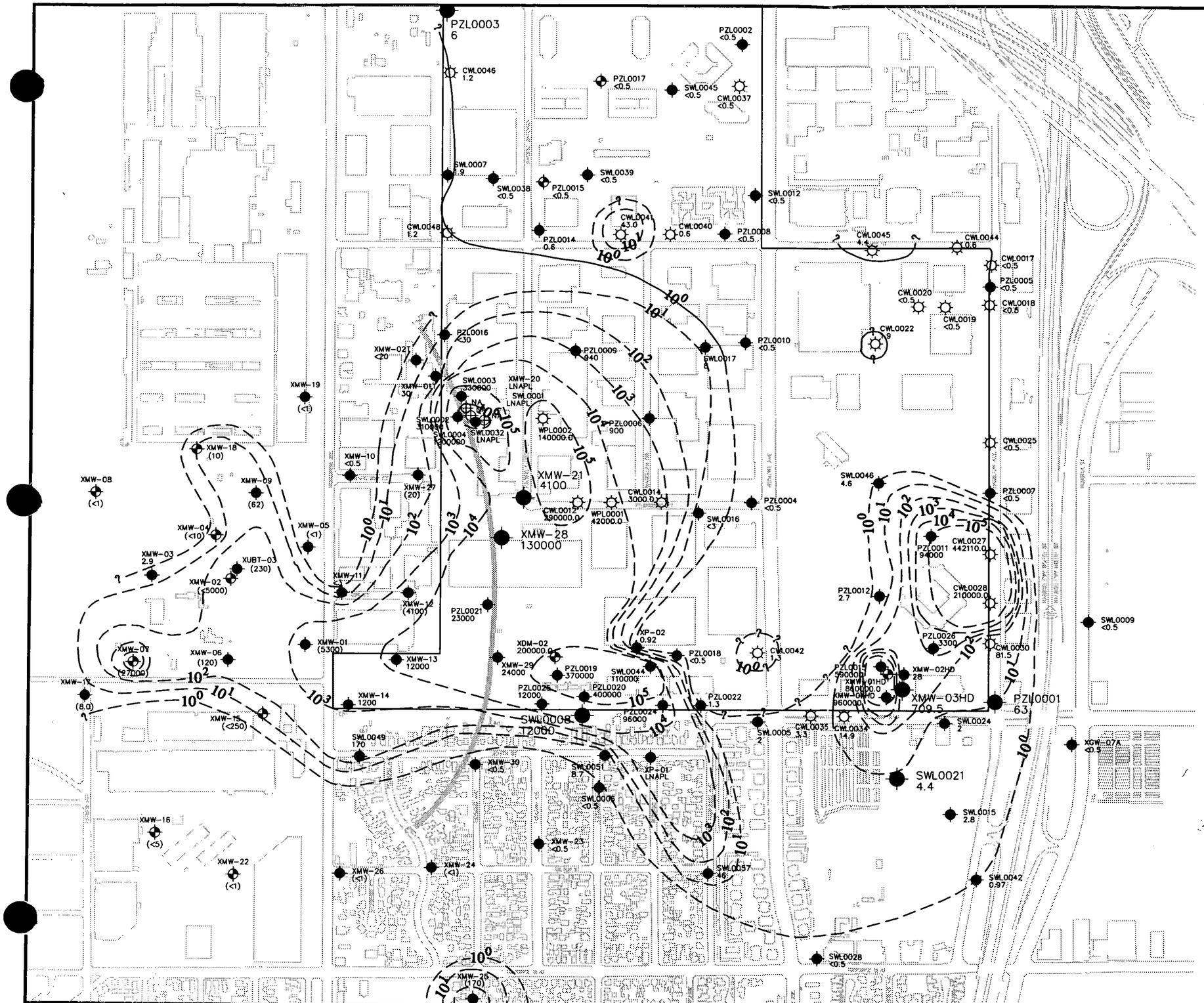

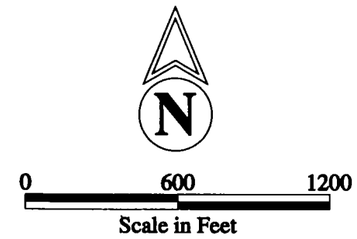

EXPLANATION

PZL0003 6	Monitoring location with Third Sampling Period 1995 benzene concentration (µg/L)
PZL0017 (<0.5)	Monitoring location with historical benzene concentration (Third Sampling Period 1995 data not available)
CWL0045 4.4	Temporary well point with one-time historical data (Third Sampling Period 1995 data not available)
XMW-20 N/A	Monitoring location where benzene was not analyzed for
XMW-11 780	Monitoring location where posted data may not be representative of time-series data or be reflected by concentration isopleths due to anomalous Third Sampling Period 1995 data, elevated detection limit, or a concentration trend
10^2	Benzene concentration isopleth (µg/L)
	Inferred intersection of water table surface with top of middle Bellflower B sand. The overlying upper Bellflower aquitard is unsaturated west of the inferred intersection

Notes: 1) Data collected by Hargis + Associates for Montrose monitoring program in parentheses

2) Benzene MCL = 1 µg/l

FIGURE 5.2-2

Benzene Concentrations Water Table Zone

Groundwater Remedial Investigation Report Del Amo Study Area

DAMES & MOORE

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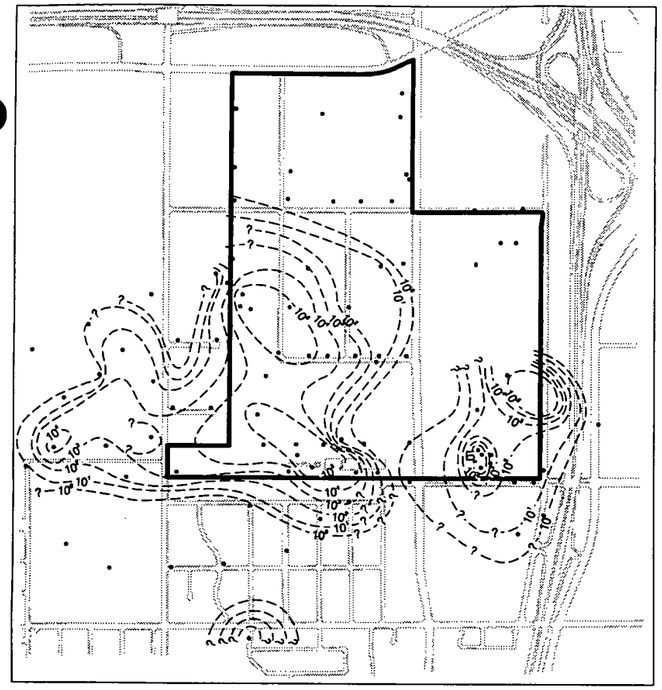
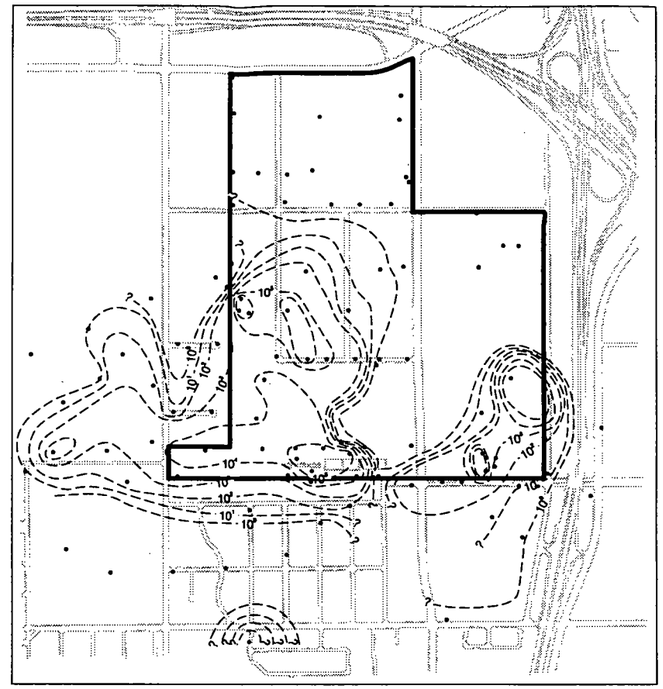


Phase I RI
February-August, 1993



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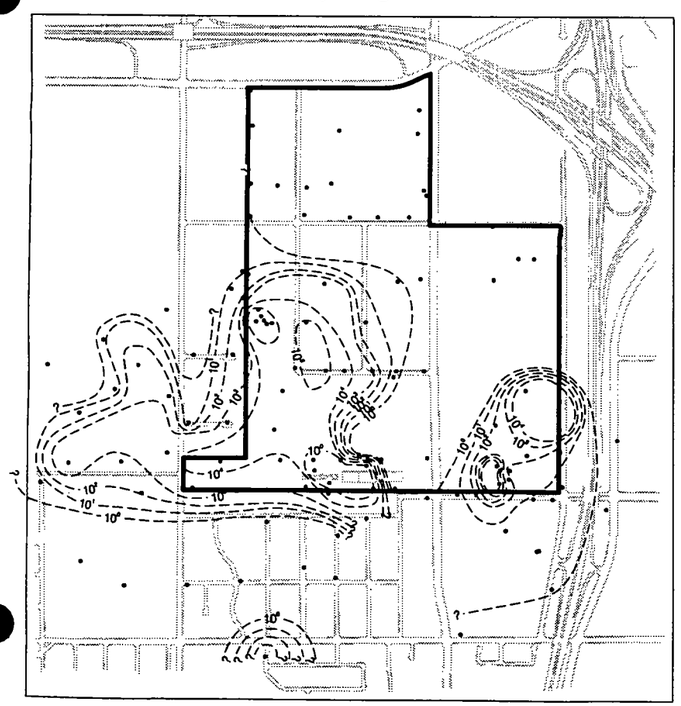

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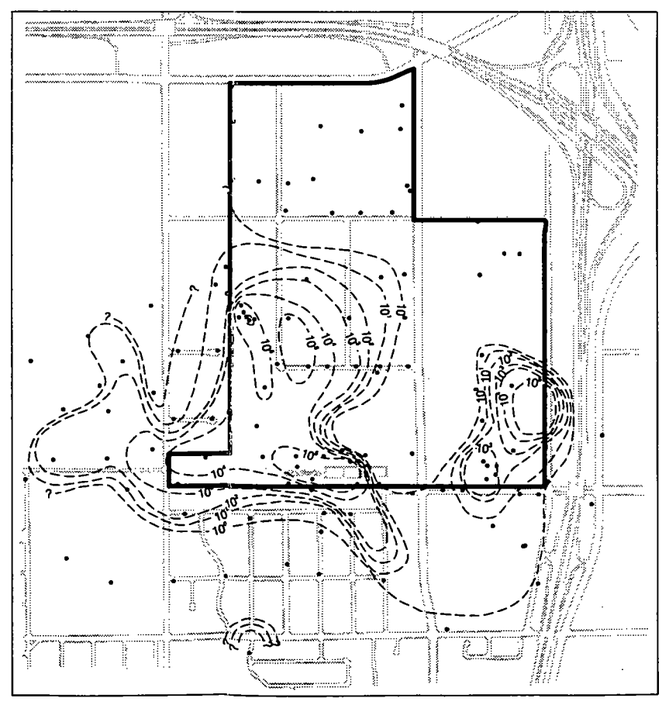

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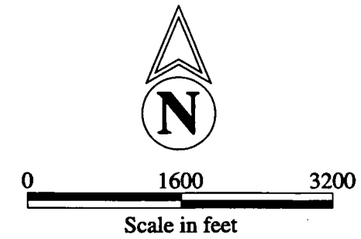


EXPLANATION

- Water Table monitoring location
- Benzene concentration isopleth (µg/L)

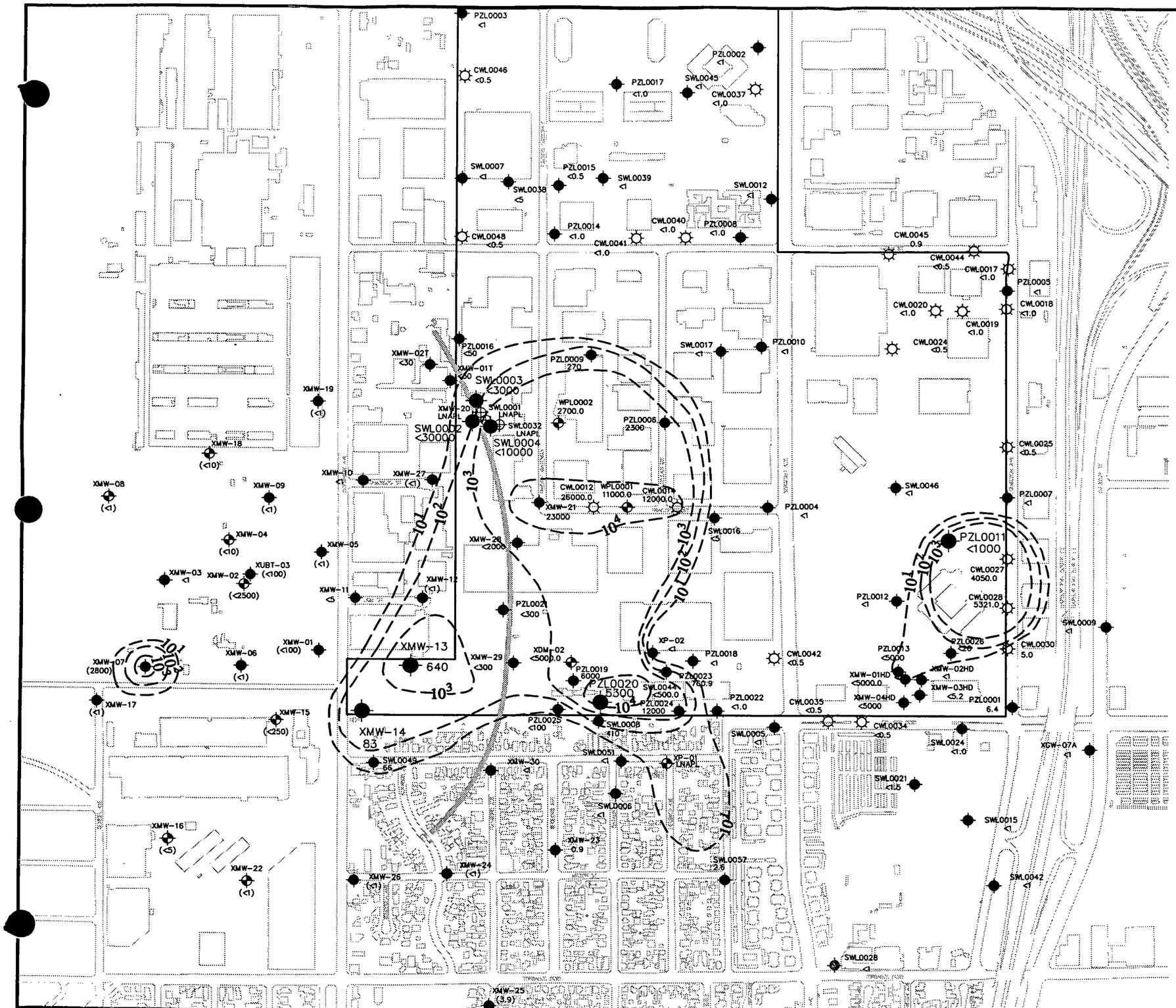
FIGURE 5.2-3

Time - Series Benzene Concentrations
Water Table Zone

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

J:\00216\446\CE76IF01, 05/14/97 at 12:33



EXPLANATION

XMW-23 0.9	Monitoring location with Third Sampling Period 1995 ethylbenzene concentration (µg/L)
XMW-04 (<10)	Monitoring location with historical ethylbenzene concentration (Third Sampling Period 1995 data not available)
CWL0045 0.9	Temporary well point with one-time historical data (Third Sampling Period 1995 data not available)
XMW-11 780	Monitoring location where posted data may not be representative of time-series data or be reflected by concentration isopleths due to anomalous Third Sampling Period 1995 data, elevated detection limit, or a concentration trend
10^2	Ethylbenzene concentration isopleth (µg/L)
? ?	Inferred intersection of water table surface with top of middle Bellflower B sand. The overlying upper Bellflower aquitard is unsaturated west of the inferred intersection

Notes: 1) Data collected by Hargis + Associates for Montrose monitoring program in parentheses

2) Ethylbenzene MCL = 680 µg/l

FIGURE 5.2-4

Ethylbenzene Concentrations Water Table Zone

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

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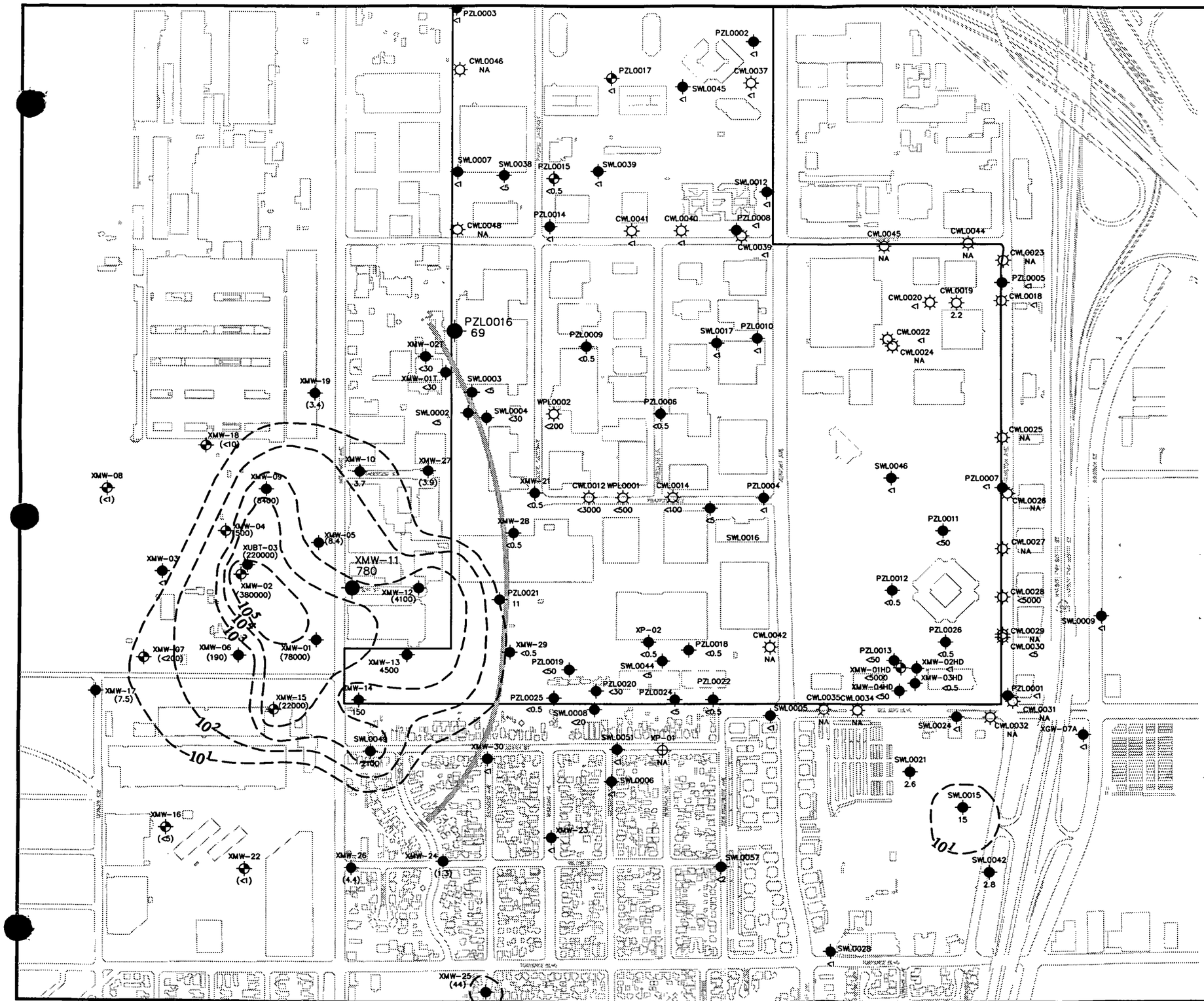

N

0 600 1200

Scale in Feet

EXPLANATION

PZL0003 6	Monitoring location with Third Sampling Period 1995 chlorobenzene concentration (µg/L)
PZL0017 (<0.5)	Monitoring location with historical chlorobenzene concentration (Third Sampling Period 1995 data not available)
CWL0045 4.4	Temporary well point with one-time historical data (Third Sampling Period 1995 data not available)
XMW-20 NA	Monitoring location where chlorobenzene was not analyzed for
XMW-11 780	Monitoring location where posted data may not be representative of time-series data or be reflected by concentration isopleths due to anomalous Third Sampling Period 1995 data, elevated detection limit, or a concentration trend
10²	Chlorobenzene concentration isopleth (µg/L)
	Inferred intersection of water table surface with top of middle Bellflower B sand. The overlying upper Bellflower aquitard is unsaturated west of the inferred intersection

Notes: 1) Data collected by Hargis + Associates for Montrose monitoring program in parentheses

2) Chlorobenzene MCL = 70 µg/l

FIGURE 5.2-5

Chlorobenzene Concentrations Water Table Zone

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

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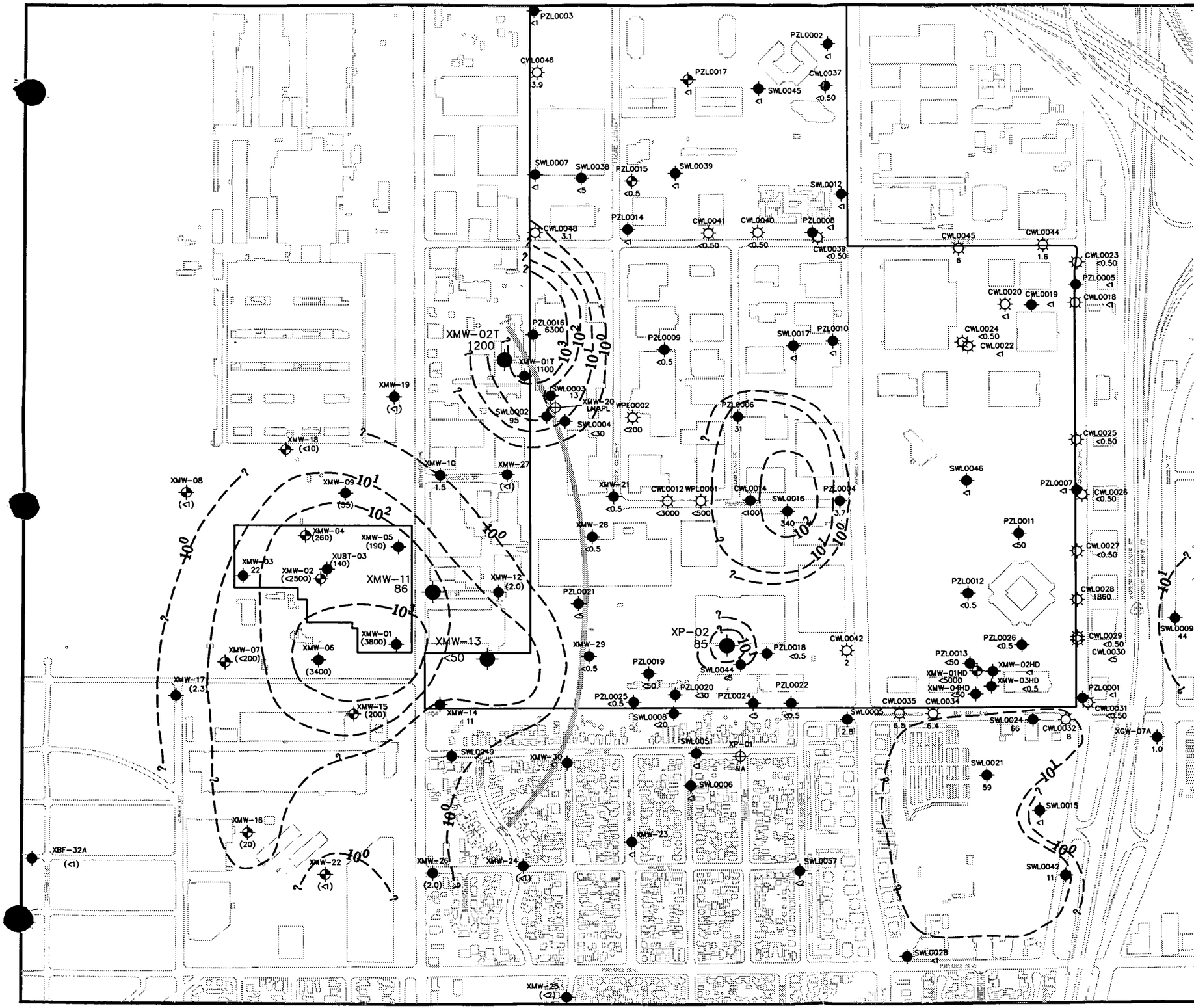

EXPLANATION

PZL0003 <1	Monitoring location with Third Sampling Period 1995 tetrachloroethene concentration (µg/L)
XMW-18 (<10)	Monitoring location with historical tetrachloroethene concentration (Third Sampling Period 1995 data not available) (µg/l)
CWL0045 6	Temporary well point with one-time historical data (Third Sampling Period 1995 data not available) (µg/l)
XMW-20 NA	Monitoring location where tetrachloroethene was not analyzed for
XMW-11 86	Monitoring location where posted data may not be representative of time-series data or be reflected by concentration isopleths due to anomalous Third Sampling Period 1995 data, elevated detection limit, or a concentration trend (µg/l)
10^2	Tetrachloroethene concentration isopleth (µg/L)
	Inferred intersection of water table surface with top of middle Bellflower B sand. The overlying upper Bellflower aquitard is unsaturated west of the inferred intersection

Notes: 1) Data collected by Hargis + Associates for Montrose monitoring program in parentheses

2) Tetrachloroethene MCL = 5 µg/l

FIGURE 5.2-6

Tetrachloroethene Concentrations Water Table Zone

Groundwater Remedial Investigation Report Del Amo Study Area

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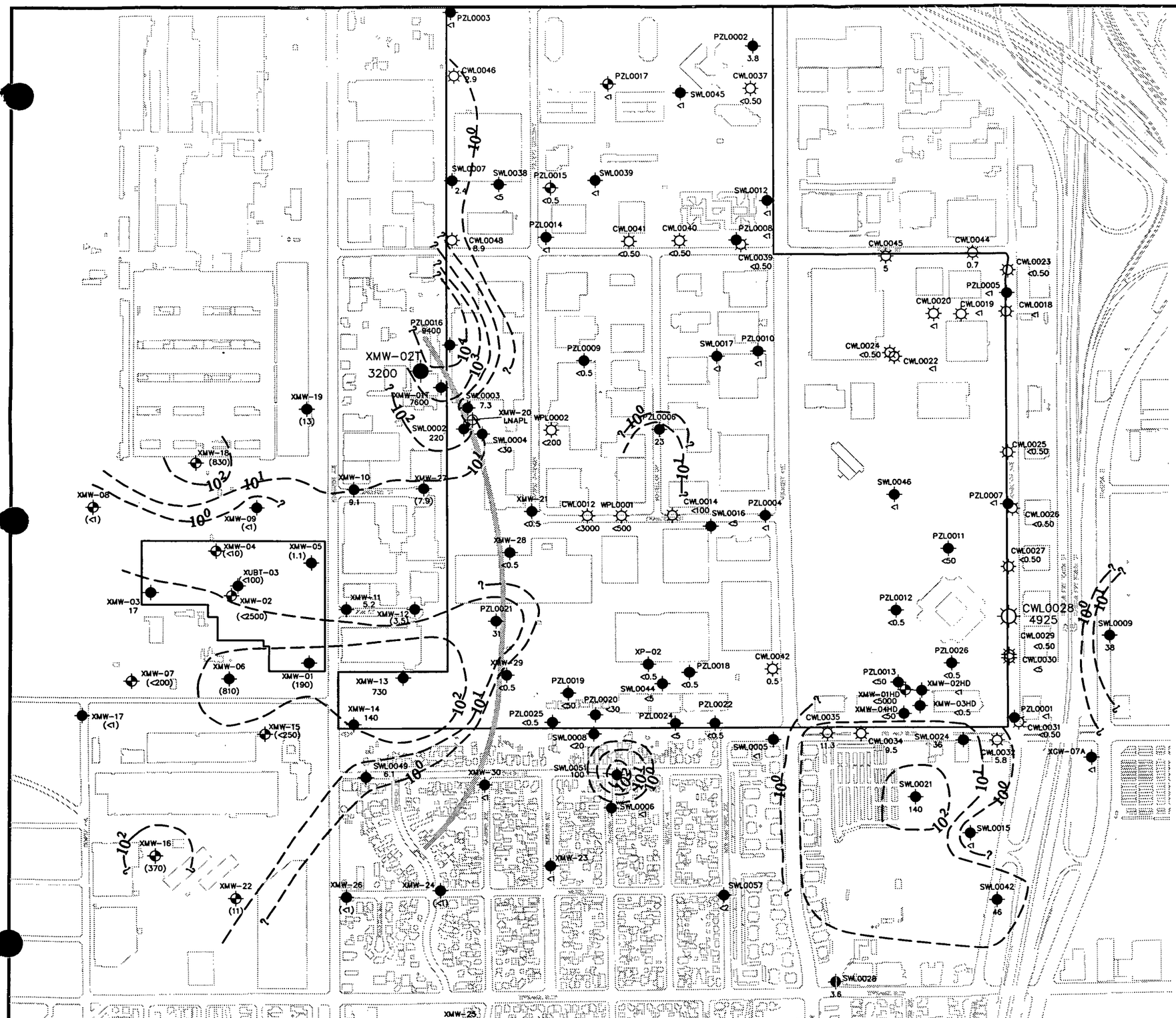

EXPLANATION

PZL0003 <1	Monitoring location with Third Sampling Period 1995 trichloroethene concentration (µg/l)
XMW-18 (830)	Monitoring location with historical trichloroethene concentration (Third Sampling Period 1995 data not available) (µg/l)
CWL0045 5	Temporary well point with one-time historical data (Third Sampling Period 1995 data not available) (µg/l)
XMW-20 NA	Monitoring location where trichloroethene was not analyzed for
XMW-02T 3200	Monitoring location where posted data may not be representative of time-series data or be reflected by concentration isopleths due to anomalous Third Sampling Period 1995 data, elevated detection limit, or a concentration trend (µg/l)
10^2	Trichloroethene concentration isopleth (µg/L)
?	Inferred intersection of water table surface with top of middle Bellflower B sand. The overlying upper Bellflower aquitard is unsaturated west of the inferred intersection

Notes: 1) Data collected by Hargis + Associates for Montrose monitoring program in parentheses

2) Trichloroethene MCL = 5 µg/l

FIGURE 5.2-7

Trichloroethene Concentrations Water Table Zone

Groundwater Remedial Investigation Report Del Amo Study Area

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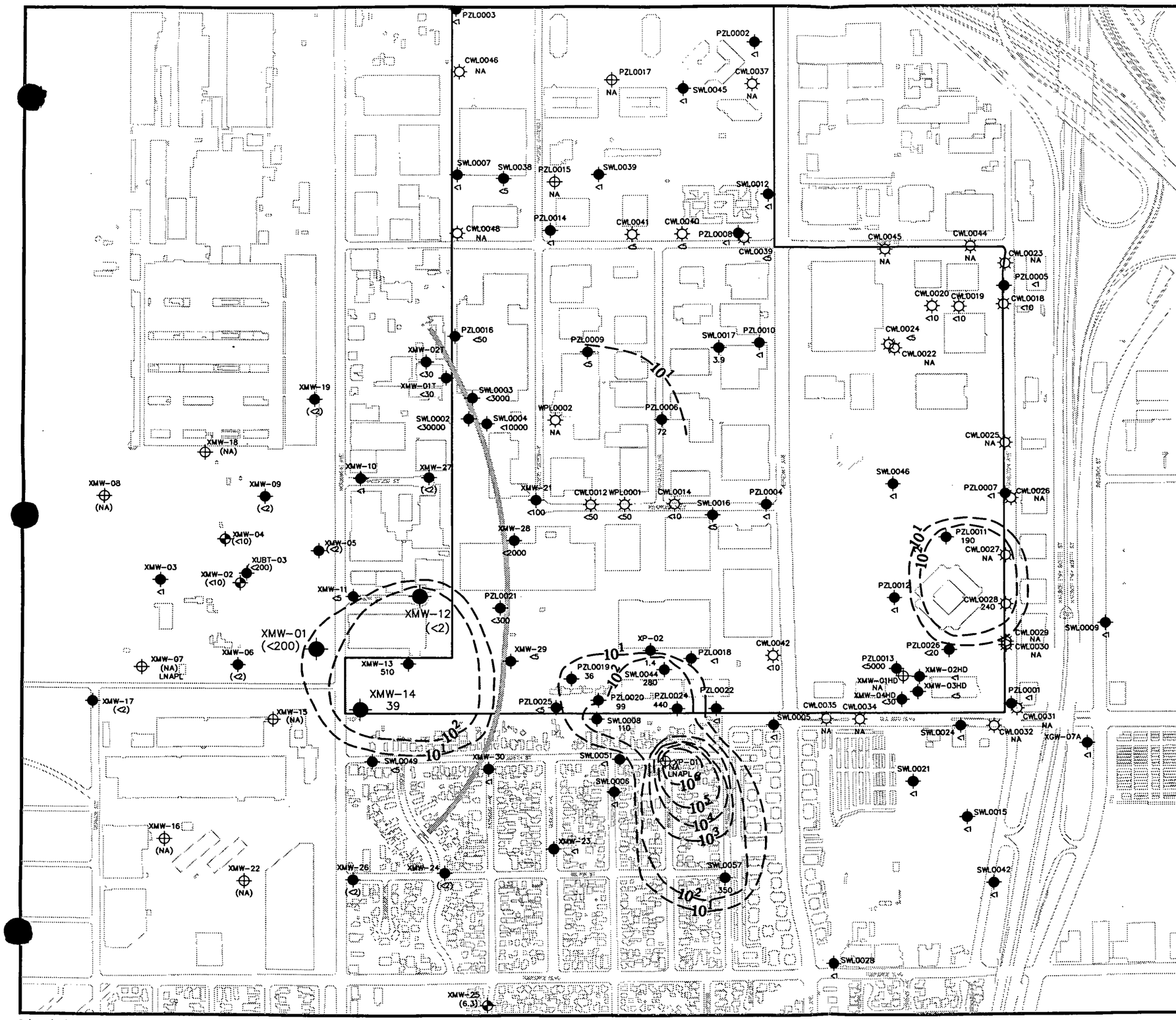

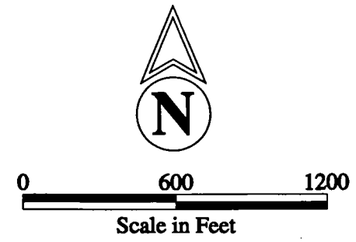

EXPLANATION

PZL0003 6	Monitoring location with Third Sampling Period 1995 naphthalene concentration (µg/L)
PZL0017 (<0.5)	Monitoring location with historical naphthalene concentration (Third Sampling Period 1995 data not available)
CWL0045 4.4	Temporary well point with one-time historical data (Third Sampling Period 1995 data not available)
XMW-20 NA	Monitoring location where naphthalene was not analyzed for
XMW-11 780	Monitoring location where posted data may not be representative of time-series data or be reflected by concentration isopleths due to anomalous Third Sampling Period 1995 data, elevated detection limit, or a concentration trend
10^2	Naphthalene concentration isopleth (µg/L)
	Inferred intersection of water table surface with top of middle Bellflower B sand. The overlying upper Bellflower aquitard is unsaturated west of the inferred intersection

Notes: 1) Data collected by Hargis + Associates for Montrose monitoring program in parentheses

2) There is no MCL for naphthalene

FIGURE 5.2-8

Naphthalene Concentrations Water Table Zone

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

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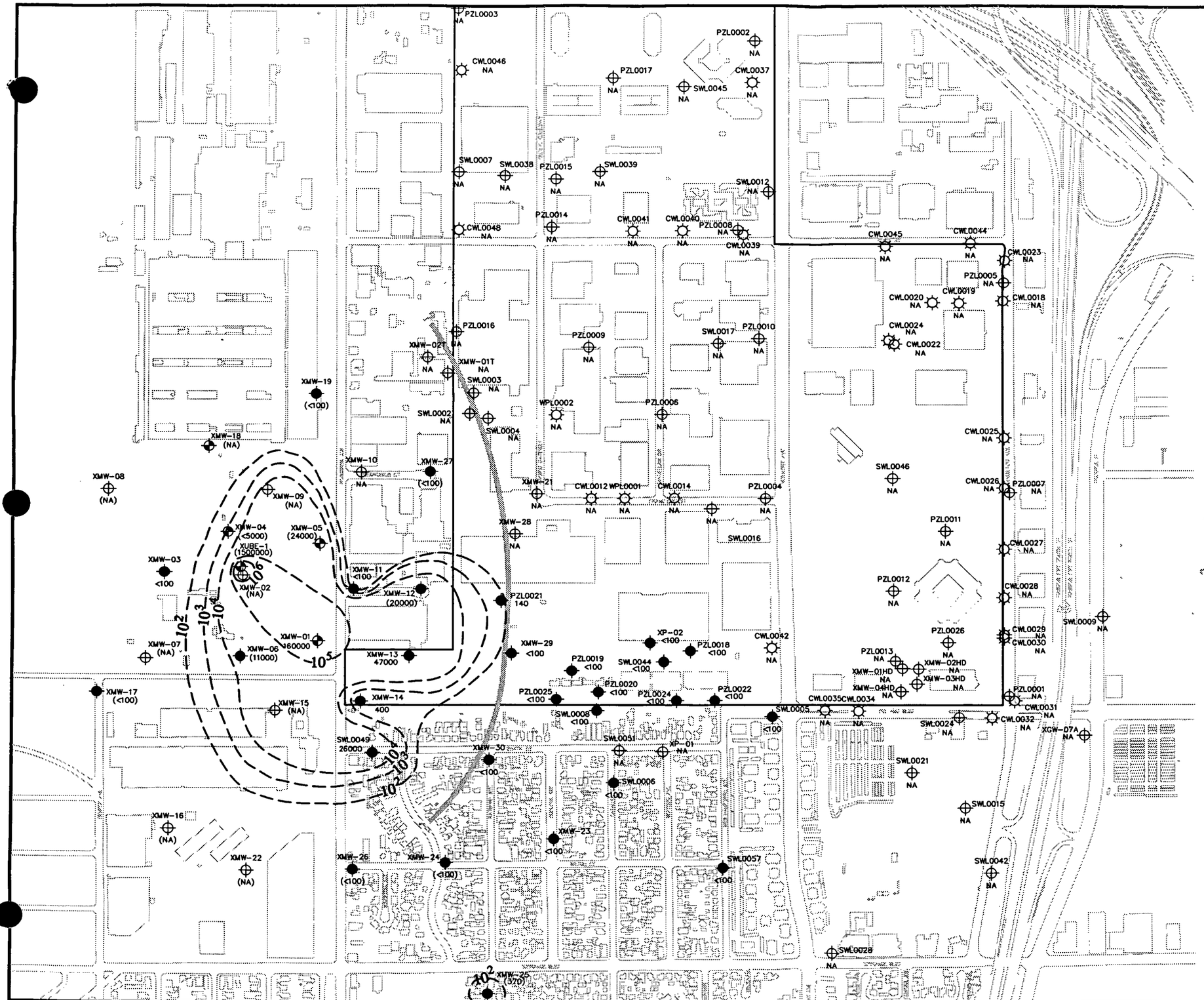

EXPLANATION

PZL0003 6	Monitoring location with Third Sampling Period 1995 p-CBSA concentration (µg/L)
PZL0017 (<0.5)	Monitoring location with historical p-CBSA concentration (Third Sampling Period 1995 data not available)
CWL0045 4.4	Temporary well point with one-time historical data (Third Sampling Period 1995 data not available)
XMW-20 NA	Monitoring location where p-CBSA was not analyzed for
10^2	p-CBSA concentration isopleth (µg/L)
?	Inferred intersection of water table surface with top of middle Bellflower B sand. The overlying upper Bellflower aquitard is unsaturated west of the inferred intersection

Notes: 1) Data collected by Hargis + Associates for Montrose monitoring program in parentheses

2) There is no MCL for p-CBSA

FIGURE 5.2-9

p-CBSA Concentrations Water Table Zone

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

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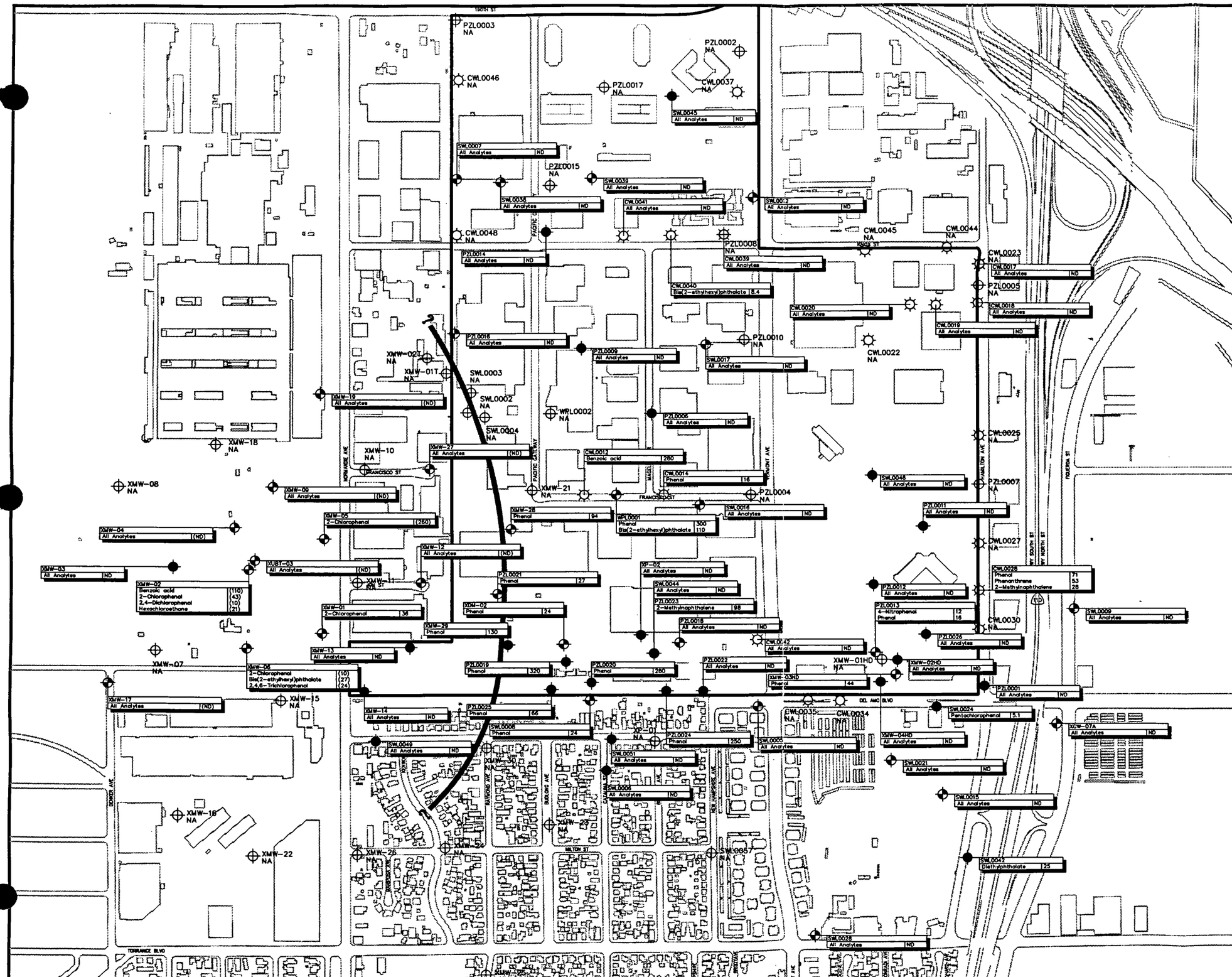

EXPLANATION

- Monitoring Location With Third Sampling Period 1995 VOC Concentration (SWL0046 All Analytes ND)
- Monitoring Location With Historical VOC Concentration (third sampling period 1995 data not available) (XMW-09 All Analytes (ND))
- Temporary Well Point With One-Time Historical Data (third sampling period 1995 data not available) (CWL0016 All Analytes ND)
- NA — Monitoring Location Where VOCs Were Not Analyzed For
- Inferred intersection of water table surface with top of middle Bellflower B sand. The overlying upper Bellflower aquitard is unsaturated west of the inferred intersection

NOTES:

Data collected by Hargis + Associates for Montrose monitoring program in parentheses.

MCLs

Bis(2-ethylhexyl)phthalate: 4 µg/L

No MCLs for all other detected SVOCs

FIGURE 5.2-10

SVOC Concentrations Water Table Zone

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

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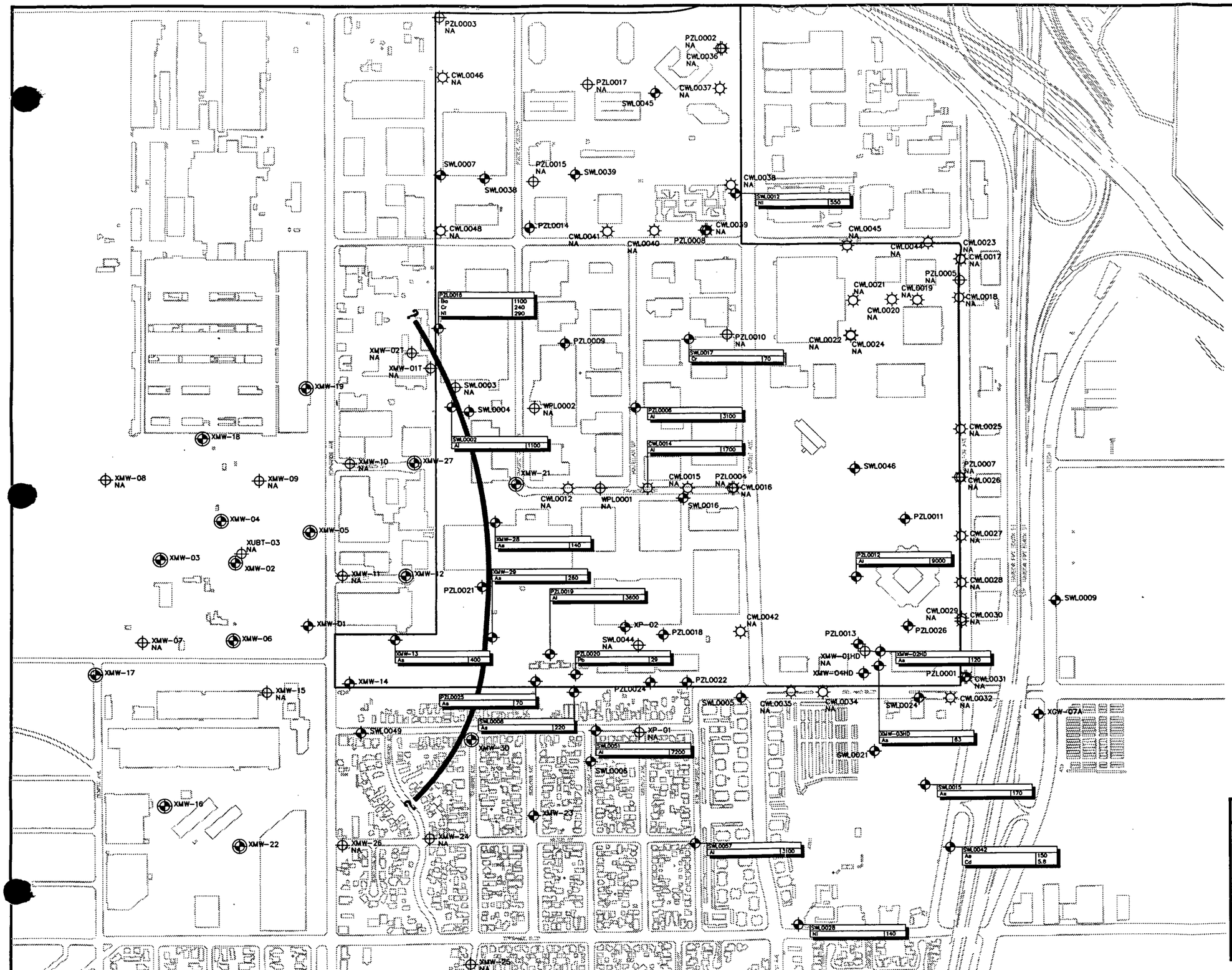

EXPLANATION

Monitoring location with one or more metals concentrations in excess of MCLs

SWL0012 Ni 550

Temporary well point with one-time metals data and concentrations in excess of MCLs

CWL0014 Al 1700

SWL0025 Monitoring location where no metals were detected at concentrations in excess of MCLs.

XMW-06 Monitoring location where no metals were detected at concentrations in excess of MCLs. Data collected by Hargis + Associates, Inc. for Montrose Monitoring Program.

NA Monitoring location where metals were not analyzed for.

Inferred intersection of water table surface with top of middle Bellflower B sand. The overlying upper Bellflower aquitard is unsaturated west of the inferred intersection

MCLs (µg/l)

Al	1,000
As	50
Cd	5
Cr	50
Ni	100
Pb	15

FIGURE 5.2-11

Metals Concentrations Water Table Zone

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

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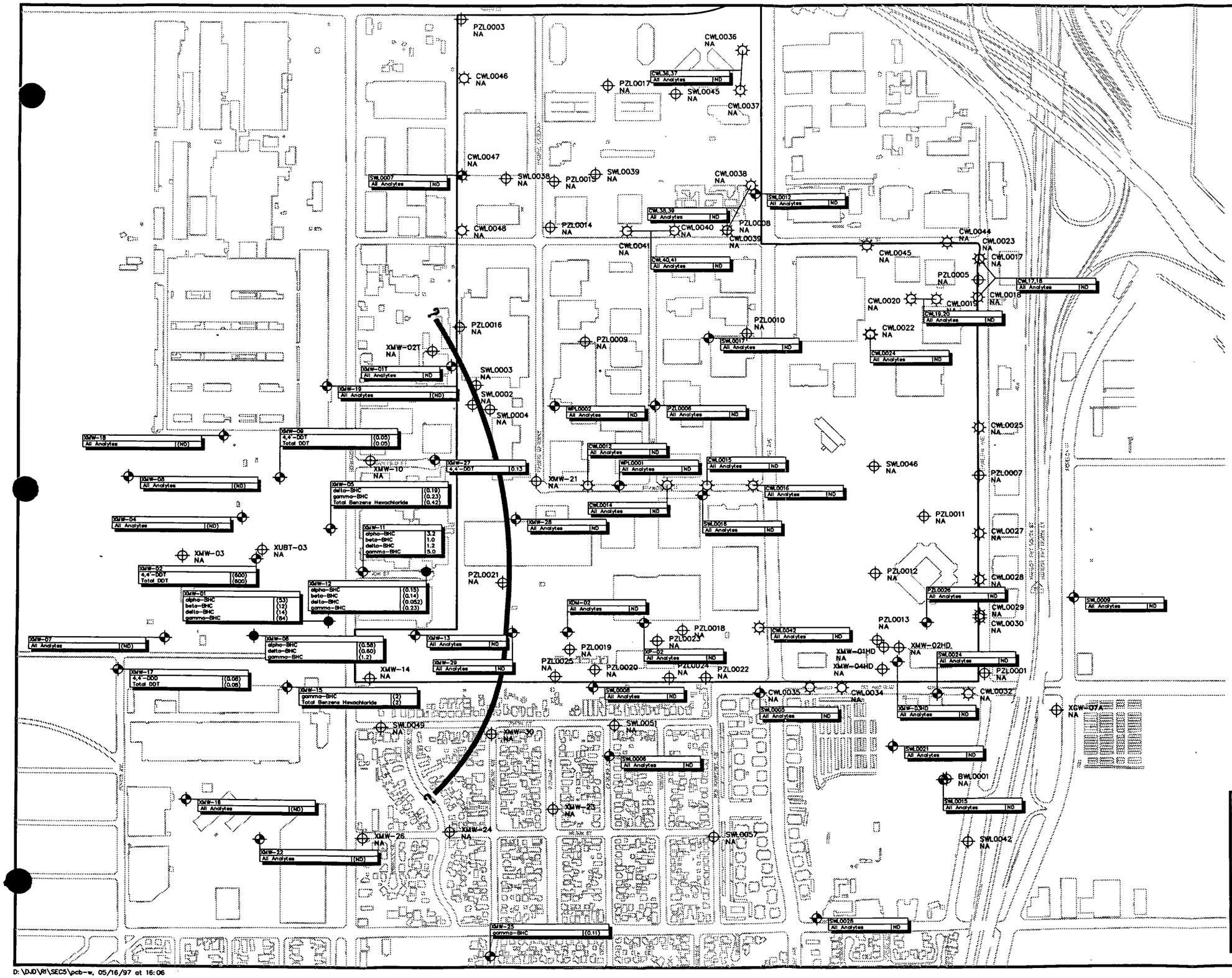

EXPLANATION

Monitoring Location With Third Sampling Period 1995 Pesticide and PCB Concentrations

XMW-08
alpha-BHC (0.58)
delta-BHC (0.60)
gamma-BHC (1.2)

Monitoring Location With Historical Pesticide and PCB Concentrations (third sampling period 1995 data not available)

SWL0009
All Analytes ND

Temporary Well Point With One-Time Historical Data (third sampling period 1995 data not available)

CWL0024
All Analytes ND

Composite Sampling Location With Third Sampling Period 1995 Pesticide and PCB Concentrations

CWL17,18
All Analytes ND

NA — Monitoring Location Where Pesticides and PCBs Were Not Analyzed For

Inferred intersection of water table surface with top of middle Bellflower B sand. The overlying upper Bellflower aquitard is unsaturated west of the inferred intersection

NOTES: Data collected by Hargis + Associates for Montrose monitoring program in parentheses.

MCLs
gamma-BHC: 4 µg/l
No MCLs for all other detected pesticides/PCBs

FIGURE 5.2-12

Pesticide and PCB Concentrations
Water Table Zone

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

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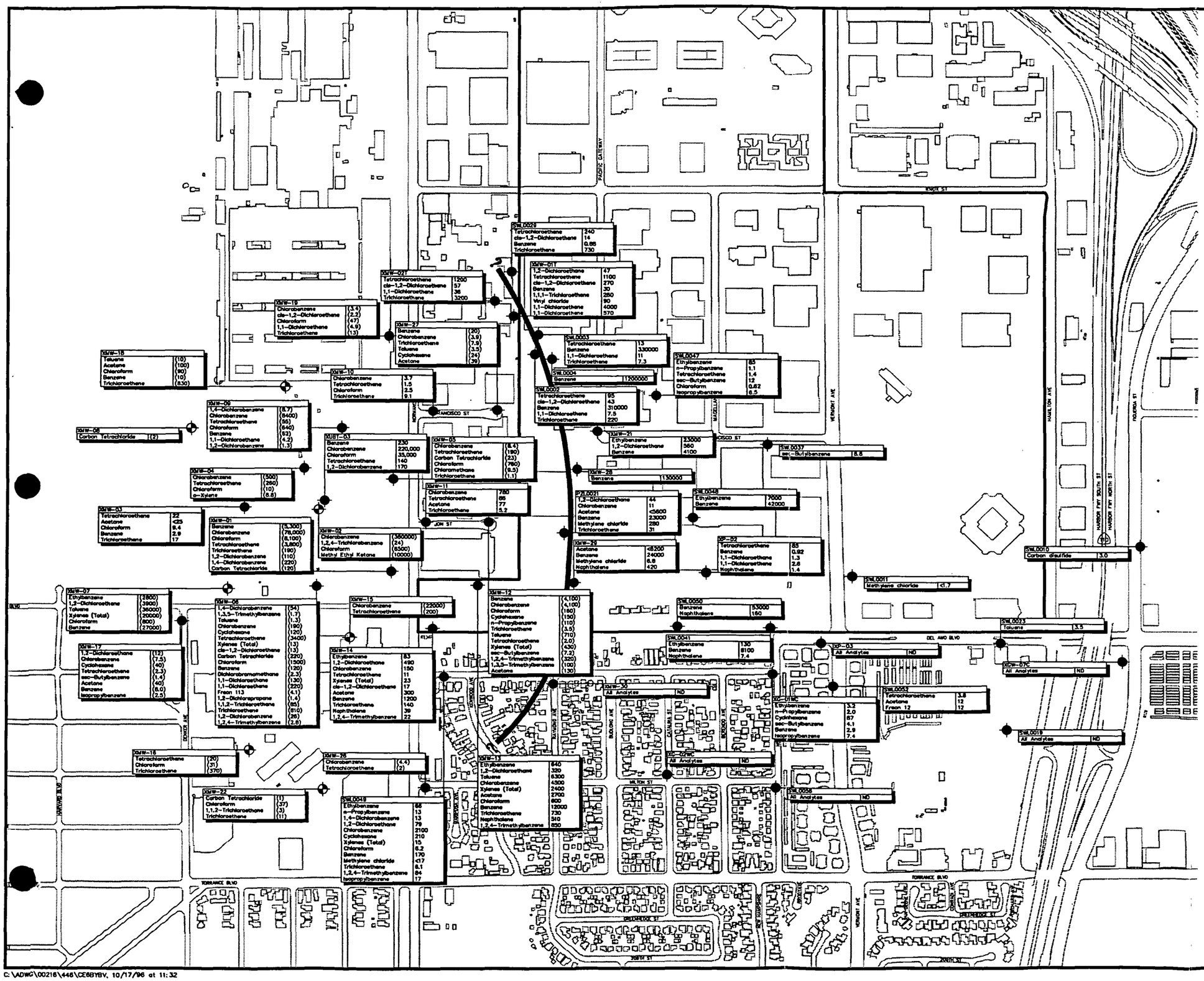

N

0 600 1200

Scale in feet

EXPLANATION

Monitoring Location With Third Sampling Period 1995 VOC Concentration

SWL0023
Toluene 3.5

Monitoring Location With Historical VOC Concentration (third sampling period 1995 data not available)

XMW-08
Carbon Tetrachloride (2)

Inferred intersection of water table surface with top of middle Bellflower B sand. The overlying upper Bellflower aquitard is unsaturated west of the inferred intersection

NOTE: Data collected by Hargis + Associates for Montrose monitoring program in parentheses.

FIGURE 5.2-13

VOC Concentrations Middle Bellflower B Sand

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

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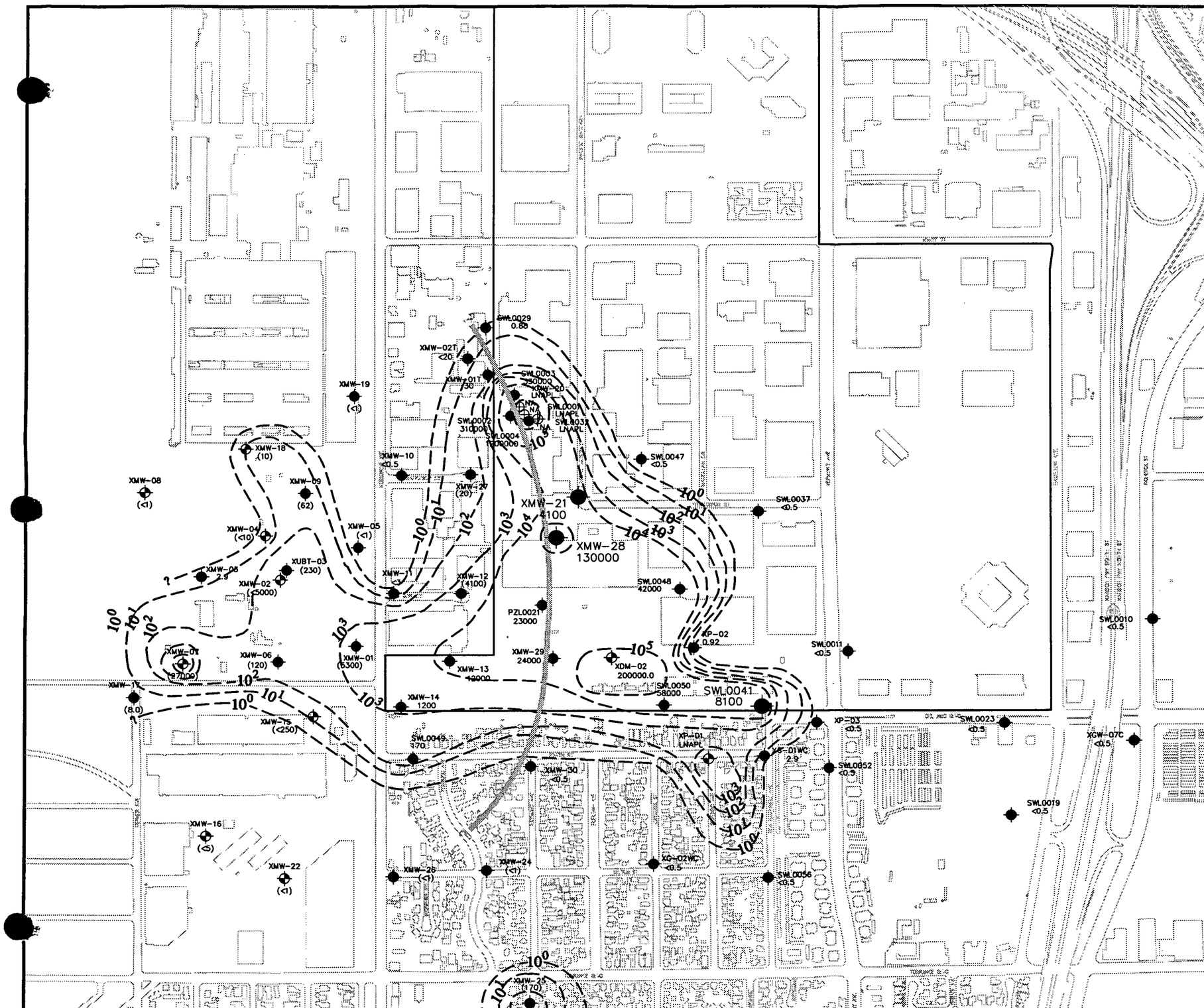

N

0 600 1200

Scale in Feet

EXPLANATION

XMW-09 62 — Monitoring location with Third Sampling Period 1995 benzene concentration (µg/L)

XMW-18 (<10) — Monitoring location with historical benzene concentration (Third Sampling Period 1995 data not available)

XMW-11 780 — Monitoring location where posted data may not be representative of time-series data or be reflected by concentration isopleths due to anomalous Third Sampling Period 1995 data, elevated detection limit, or a concentration trend

10^2 — Benzene concentration isopleth (µg/L)

? — Inferred intersection of water table surface with top of middle Bellflower B sand. The overlying upper Bellflower aquitard is unsaturated west of the inferred intersection

Notes: 1) Data collected by Hargis + Associates for Montrose monitoring program in parentheses

2) Benzene MCL = 1 µg/l

FIGURE 5.2-14

Benzene Concentrations Middle Bellflower B Sand

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

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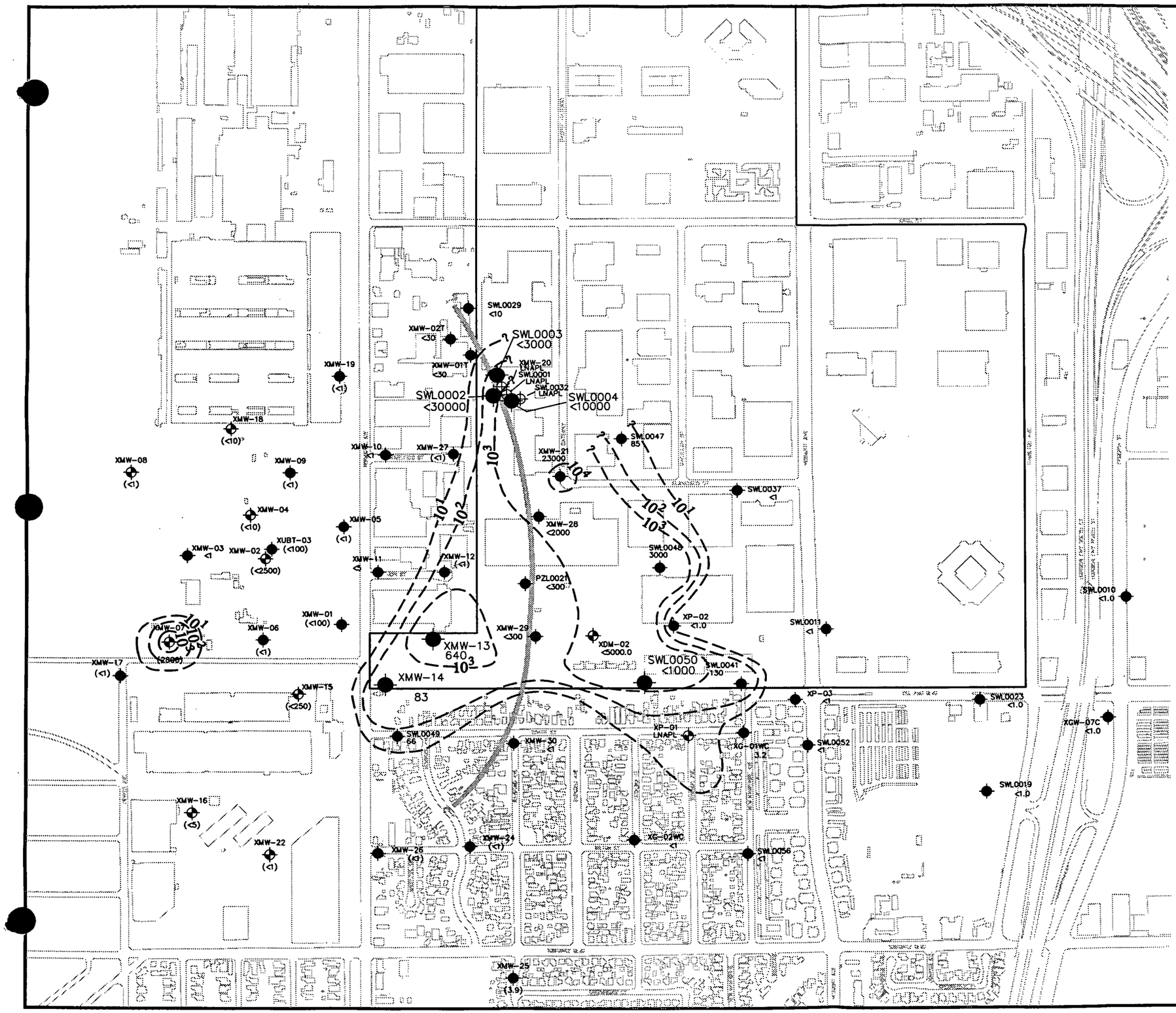

N

0 600 1200

Scale in Feet

EXPLANATION

XMW-19 (<1) — Monitoring location with Third Sampling Period 1995 ethylbenzene concentration (µg/L)

XMW-18 (10) — Monitoring location with historical ethylbenzene concentration (Third Sampling Period 1995 data not available)

XMW-11 780 — Monitoring location where posted data may not be representative of time-series data or be reflected by concentration isopleths due to anomalous Third Sampling Period 1995 data, elevated detection limit, or a concentration trend

10^2 — Ethylbenzene concentration isopleth (µg/L)

Inferred intersection of water table surface with top of middle Bellflower B sand. The overlying upper Bellflower aquitard is unsaturated west of the inferred intersection

Notes: 1) Data collected by Hargis + Associates for Montrose monitoring program in parentheses

2) Ethylbenzene MCL = 700 µg/l

FIGURE 5.2-15

Ethylbenzene Concentrations Middle Bellflower B Sand

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

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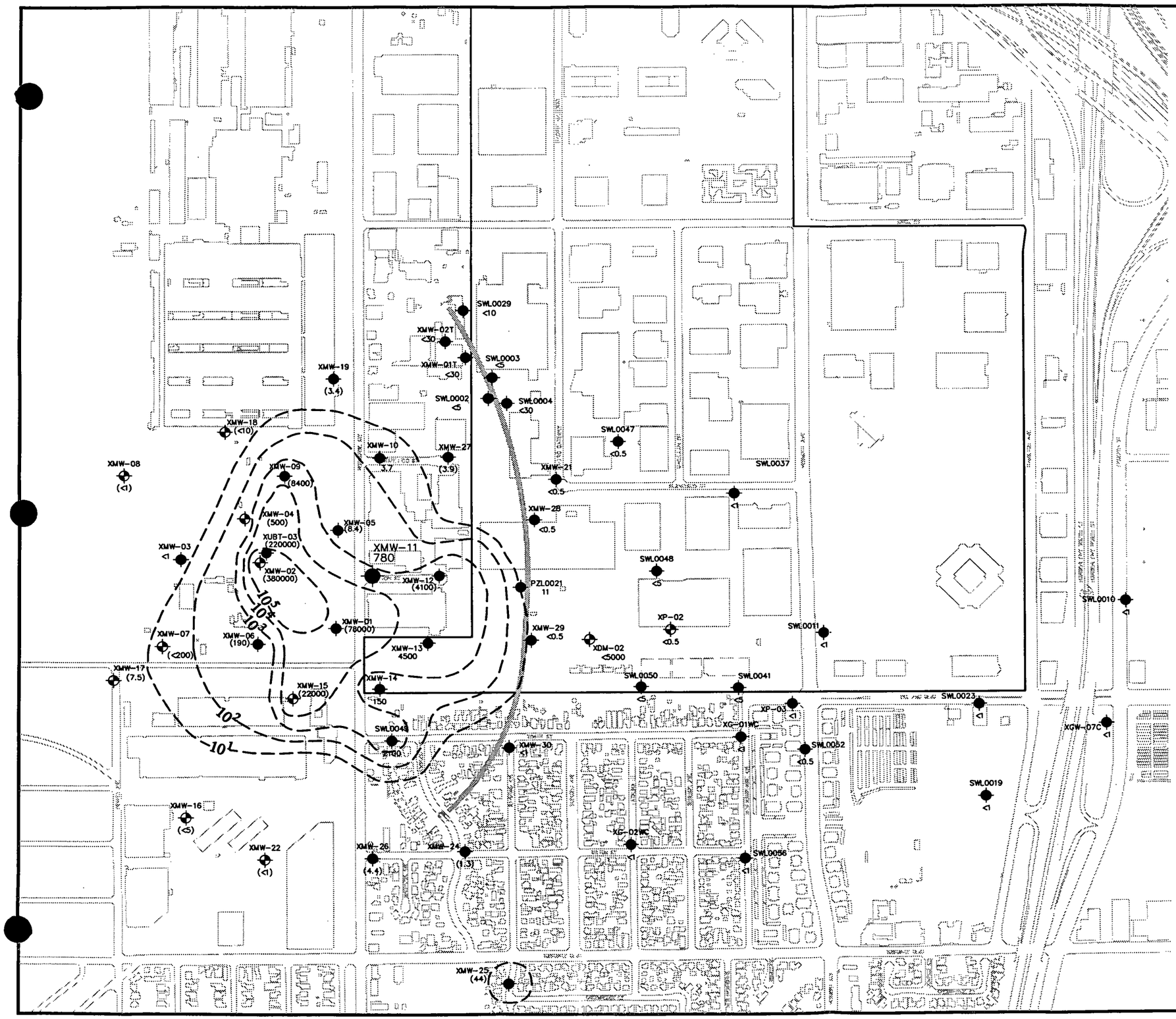

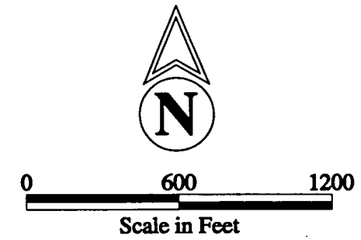

EXPLANATION

XMW-19 (<1) — Monitoring location with Third Sampling Period 1995 chlorobenzene concentration (µg/L)

XMW-18 (10) — Monitoring location with historical chlorobenzene concentration (Third Sampling Period 1995 data not available)

XMW-11 780 — Monitoring location where posted data may not be representative of time-series data or be reflected by concentration isopleths due to anomalous Third Sampling Period 1995 data, elevated detection limit, or a concentration trend

10² — Chlorobenzene concentration isopleth (µg/L)

Inferred intersection of water table surface with top of middle Bellflower B sand. The overlying upper Bellflower aquitard is unsaturated west of the inferred intersection

Notes: 1) Data collected by Hargis + Associates for Montrose monitoring program in parentheses

2) Chlorobenzene MCL = 70 µg/l

FIGURE 5.2-16

Chlorobenzene Concentrations Middle Bellflower B Sand

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

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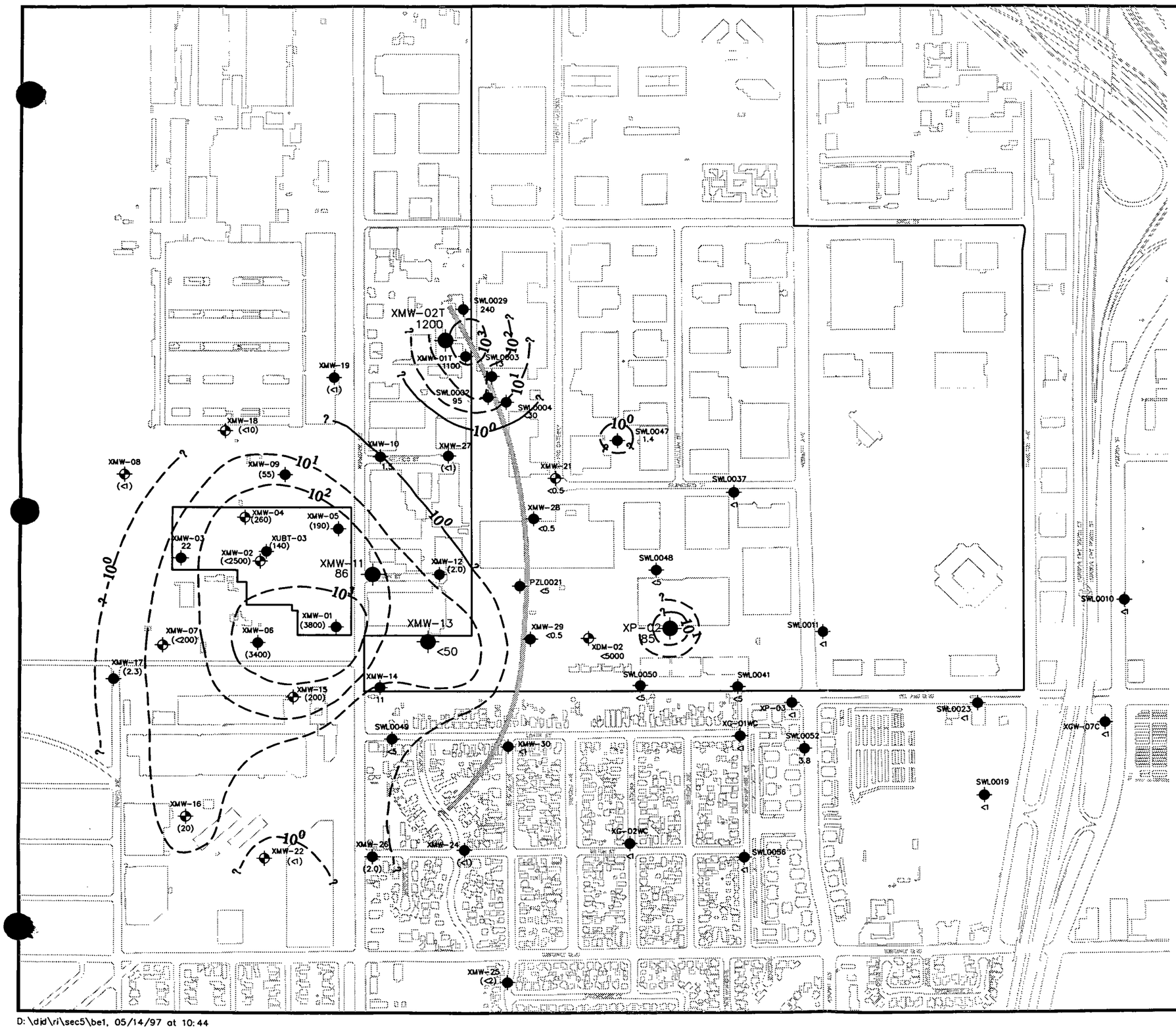

N

0 600 1200

Scale in Feet

EXPLANATION

SWL0047 1.4	Monitoring location with Third Sampling Period 1995 tetrachloroethene concentration (µg/l)
XMW-18 (<10)	Monitoring location with historical tetrachloroethene concentration (Third Sampling Period 1995 data not available) (µg/l)
XMW-20	Monitoring location where tetrachloroethene was not analyzed for (µg/l)
XMW-11 86	Monitoring location where posted data may not be representative of time-series data or be reflected by concentration isopleths due to anomalous Third Sampling Period 1995 data, elevated detection limit, or a concentration trend (µg/l)
10^2	Tetrachloroethene concentration isopleth (µg/l)
	Inferred intersection of water table surface with top of middle Bellflower B sand. The overlying upper Bellflower aquitard is unsaturated west of the inferred intersection

Notes: 1) Data collected by Hargis + Associates for Montrose monitoring program in parentheses

2) Tetrachloroethene MCL = 5 µg/l

FIGURE 5.2-17

Tetrachloroethene Concentrations Middle Bellflower B Sand

Groundwater Remedial Investigation Report
Del Amo Study Area

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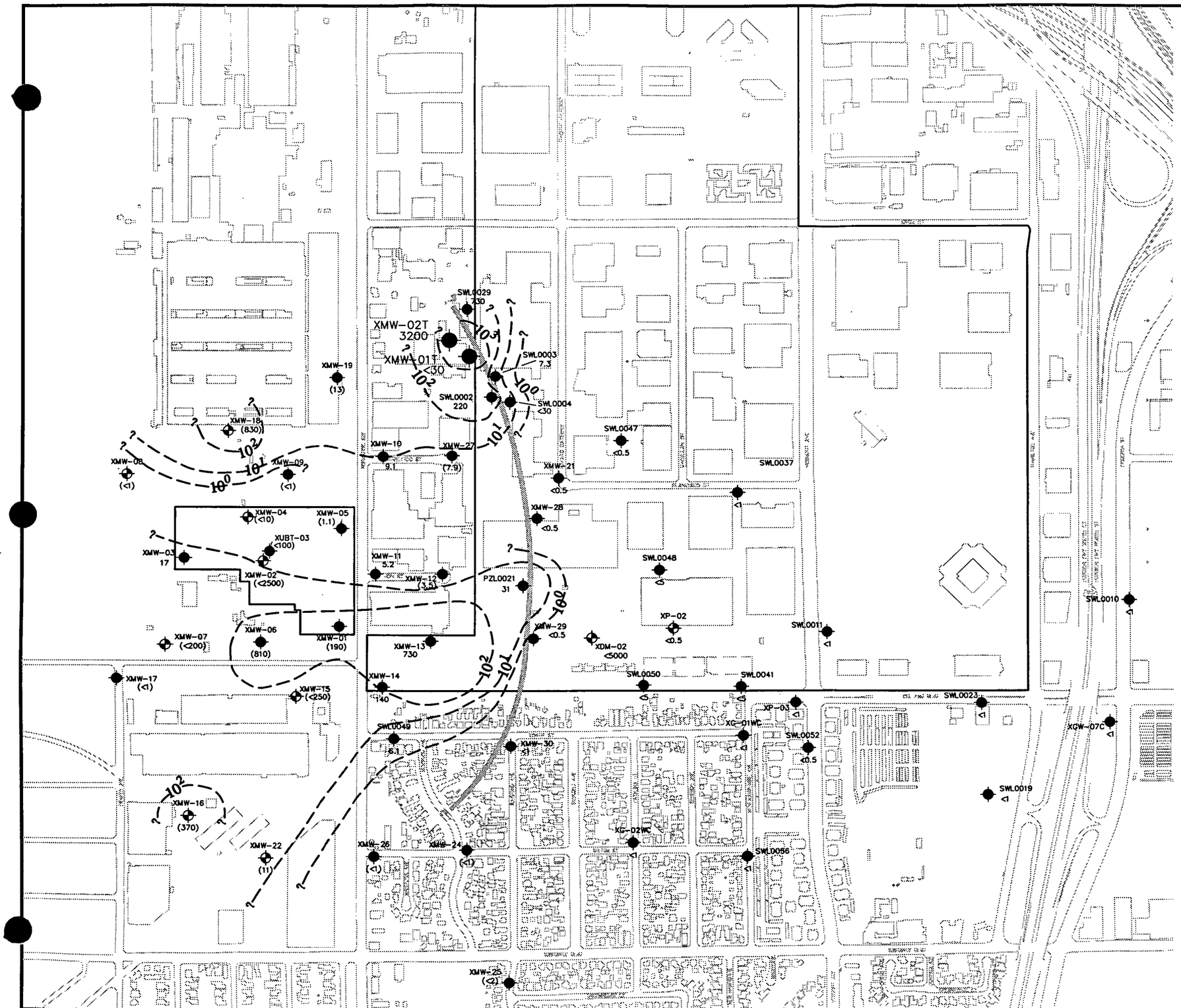

N

0 600 1200

Scale in Feet

EXPLANATION

SWL0047 <0.5	Monitoring location with Third Sampling Period 1995 trichloroethene concentration (µg/l)
XMW-18 (830)	Monitoring location with historical trichloroethene concentration (Third Sampling Period 1995 data not available) (µg/l)
XMW-20	Monitoring location where trichloroethene was not analyzed for
XMW-02T 3200	Monitoring location where posted data may not be representative of time-series data or be reflected by concentration isopleths due to anomalous Third Sampling Period 1995 data, elevated detection limit, or a concentration trend (µg/l)
10^2	Trichloroethene concentration isopleth (µg/l)
? ?	Inferred intersection of water table surface with top of middle Bellflower B sand. The overlying upper Bellflower aquitard is unsaturated west of the inferred intersection

Notes: 1) Data collected by Hargis + Associates for Montrose monitoring program in parentheses

2) Trichloroethene MCL = 5 µg/l

FIGURE 5.2-18

Trichloroethene Concentrations Middle Bellflower B Sand

Groundwater Remedial Investigation Report
Del Amo Study Area

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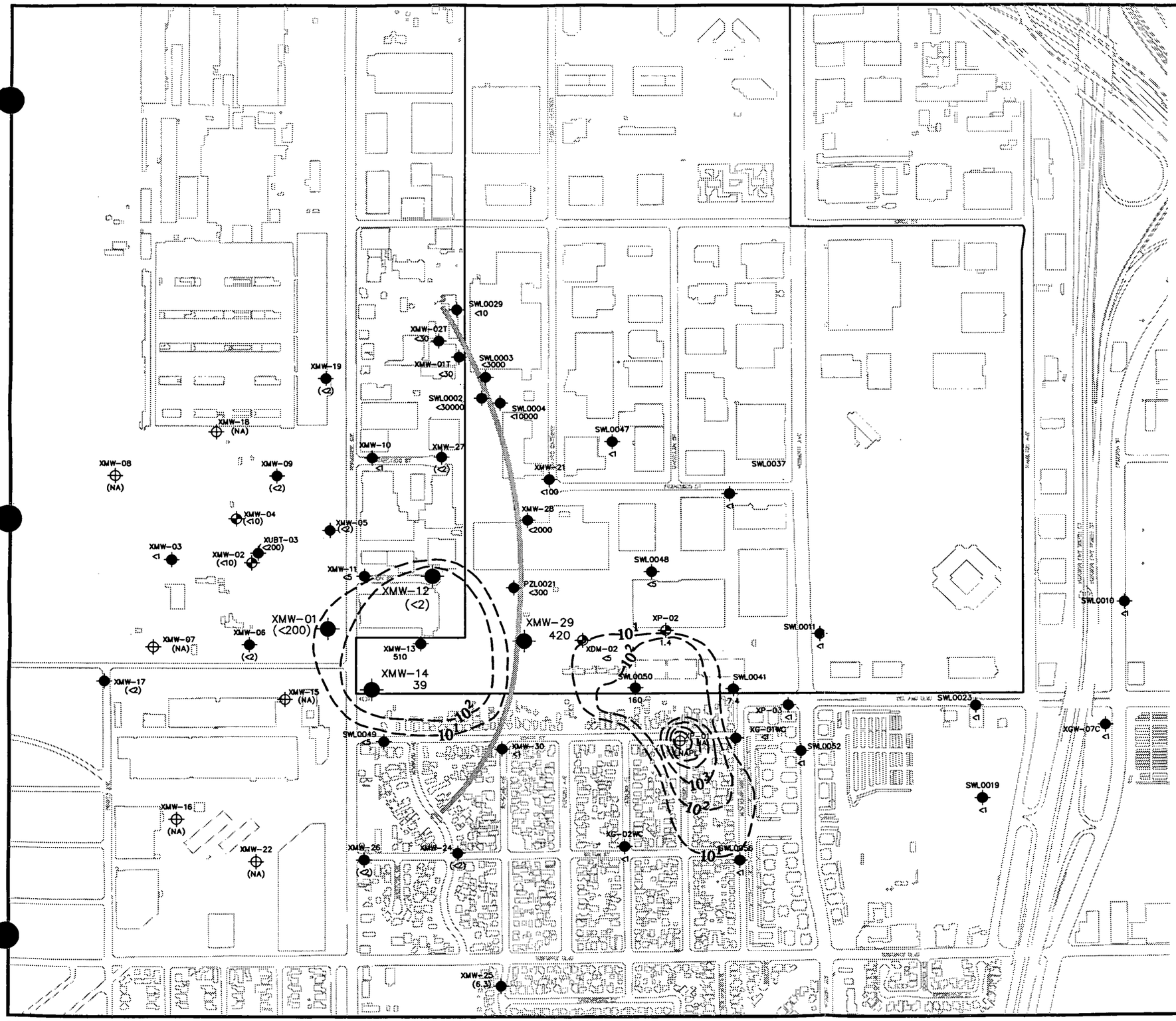

EXPLANATION

PZL0003 6	Monitoring location with Third Sampling Period 1995 naphthalene concentration (µg/L)
PZL0017 (<0.5)	Monitoring location with historical naphthalene concentration (Third Sampling Period 1995 data not available)
XMW-20	Monitoring location where naphthalene was not analyzed for
XMW-11 780	Monitoring location where posted data may not be representative of time-series data or be reflected by concentration isopleths due to anomalous Third Sampling Period 1995 data, elevated detection limit, or a concentration trend
10²	Naphthalene concentration isopleth (µg/L)
	Inferred intersection of water table surface with top of middle Bellflower B sand. The overlying upper Bellflower aquitard is unsaturated west of the inferred intersection

Notes: 1) Data collected by Hargis + Associates for Montrose monitoring program in parentheses

2) There is no MCL for naphthalene

FIGURE 5.2-19

Naphthalene Concentrations Middle Bellflower B Sand

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

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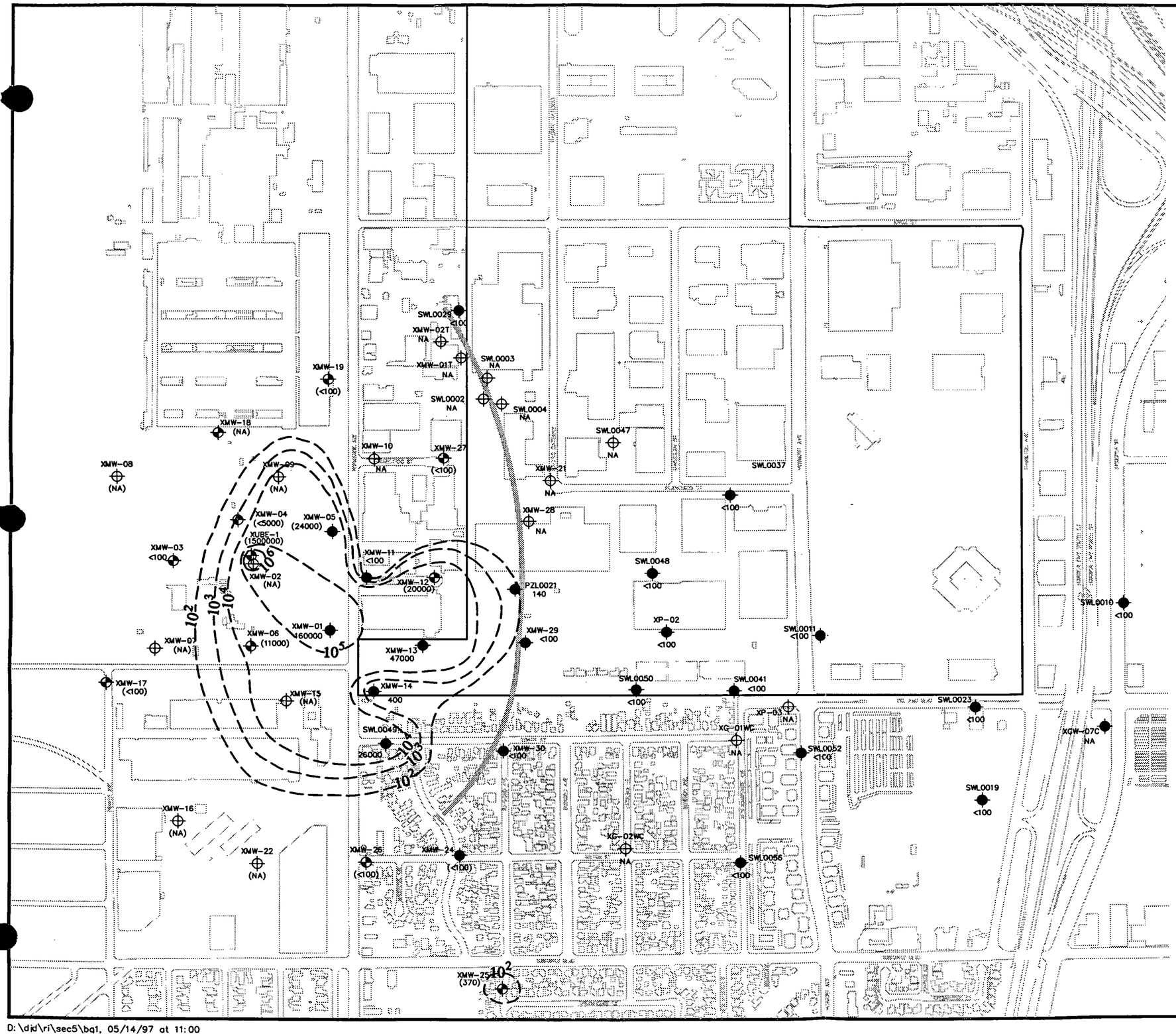


N

0 600 1200

Scale in Feet

EXPLANATION

PZL0003 6 — Monitoring location with Third Sampling Period 1995 p-CBSA concentration (µg/L)

PZL0017 (<0.5) — Monitoring location with historical p-CBSA concentration (Third Sampling Period 1995 data not available)

XMW-20 — Monitoring location where p-CBSA was not analyzed for

10^2 — p-CBSA concentration isopleth (µg/L)

Inferred intersection of water table surface with top of middle Bellflower B sand. The overlying upper Bellflower aquitard is unsaturated west of the inferred intersection

Notes: 1) Data collected by Hargis + Associates for Montrose monitoring program in parentheses

2) There is no MCL for p-CBSA

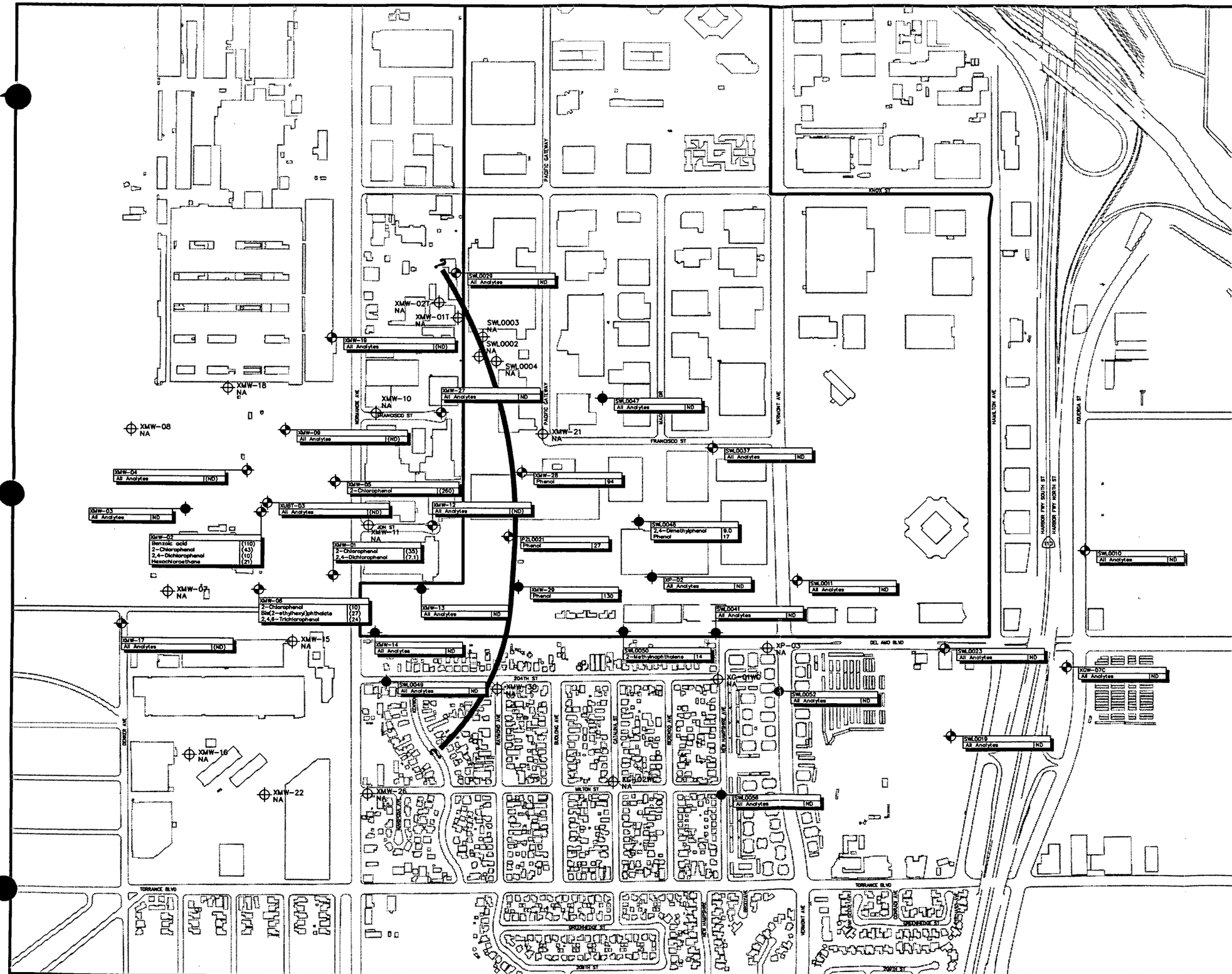
FIGURE 5.2-20

p-CBSA Concentrations Middle Bellflower B Sand

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

D:\did\ri\sec5\bq1, 05/14/97 at 11:00



EXPLANATION

Monitoring Location With Third Sampling Period 1995 SVOC Concentration (XMW-29, Phenol 130)

Monitoring Location With Historical SVOC Concentration (third sampling period 1995 data not available) (XMW-05, 2-Chlorophenol (260))

NA Monitoring Location Where SVOCs Were Not Analyzed For

Inferred intersection of water table surface with top of middle Bellflower B sand. The overlying upper Bellflower aquitard is unsaturated west of the inferred intersection

NOTES:

Data collected by Hargis + Associates for Montrose monitoring program in parentheses.

MCLs

Bis(2-ethylhexyl)phthalate: 4 µg/L

No MCLs for all other detected SVOCs

FIGURE 5.2-21

SVOC Concentrations Middle Bellflower B Sand

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

C:\ADWG\00216\446\CE6BYBS, 05/05/97 at 10:10

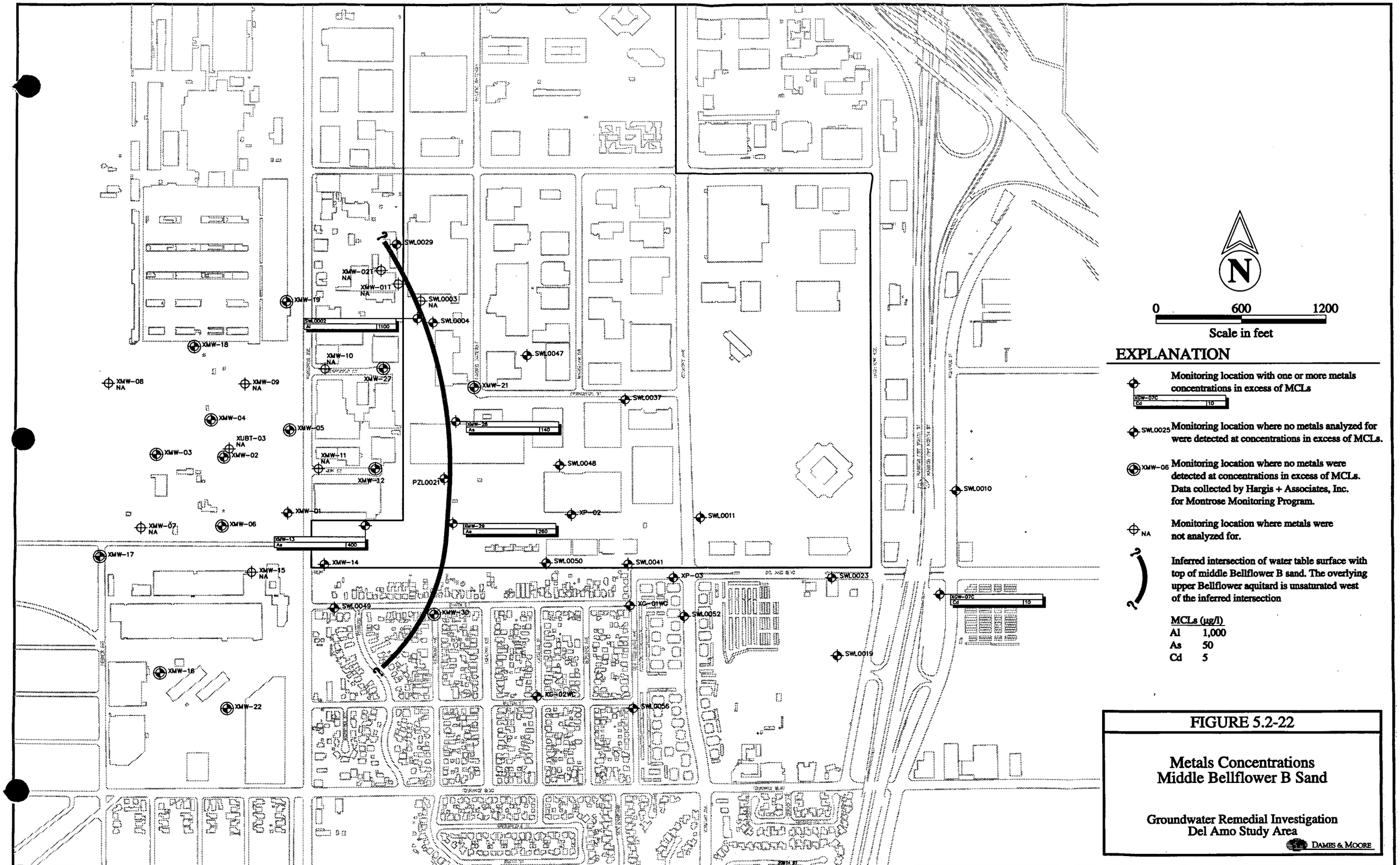


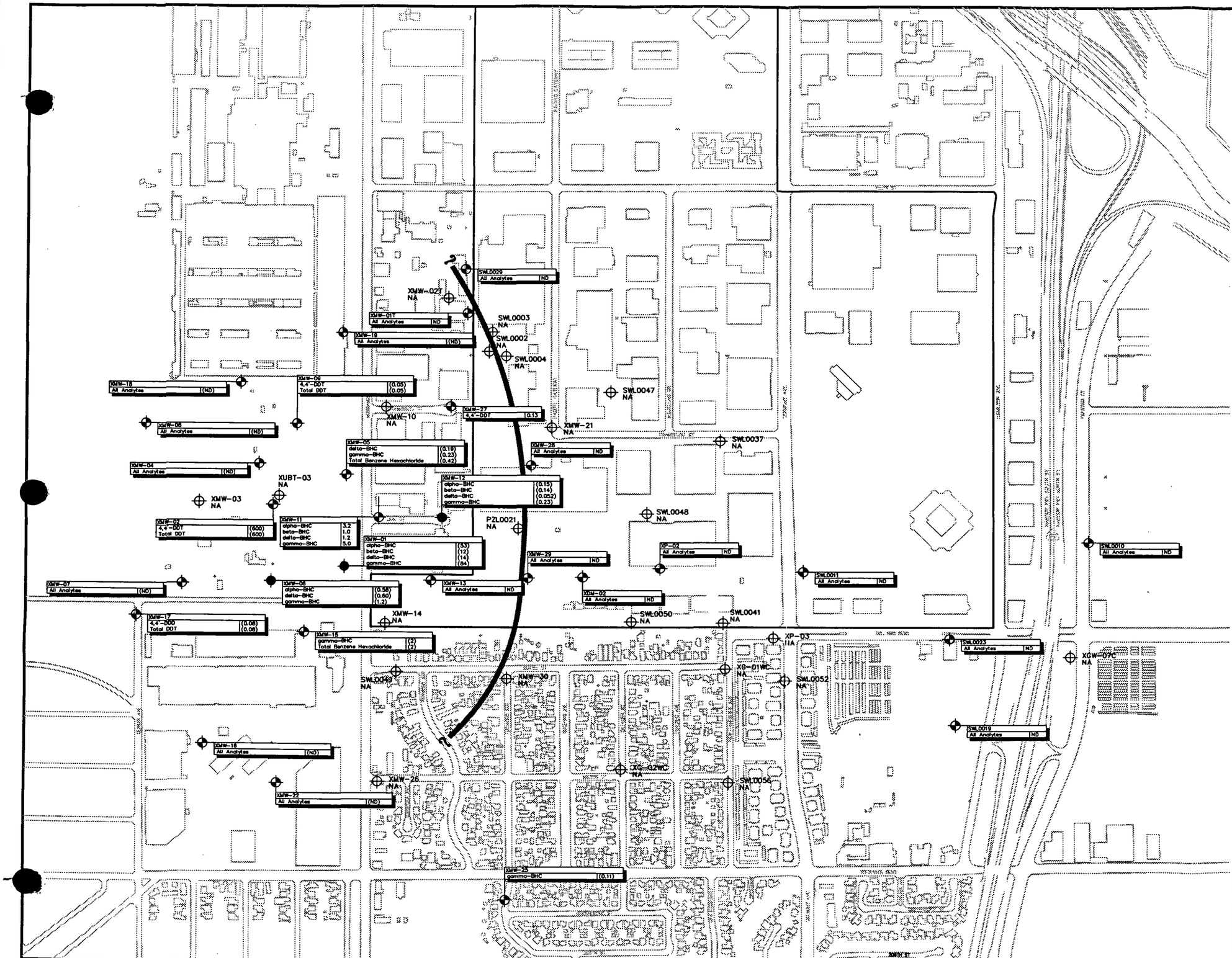
FIGURE 5.2-22

Metals Concentrations
Middle Bellflower B Sand

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

D:\DJD\R1\SEC5\met-b, 05/14/97 at 16:46



EXPLANATION

Monitoring Location With Third Sampling Period 1995 Pesticide and PCB Concentrations

XMW-08 alpha-BHC (0.58) delta-BHC (0.60) gamma-BHC (1.2)

Monitoring Location With Historical Pesticide and PCB Concentrations (third sampling period 1995 data not available)

XMW-13 All Analytes ND

SWL0025 NA Monitoring Location Where Pesticides and PCBs Were Not Analyzed For

Inferred intersection of water table surface with top of middle Bellflower B sand. The overlying upper Bellflower aquitard is unsaturated west of the inferred intersection

NOTES: Data collected by Hargis + Associates for Montrose monitoring program in parentheses.

MCLs

gamma-BHC: 4 µg/l

No MCLs for all other detected pesticides/PCBs

FIGURE 5.2-23

Pesticide and PCB Concentrations Middle Bellflower B Sand

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

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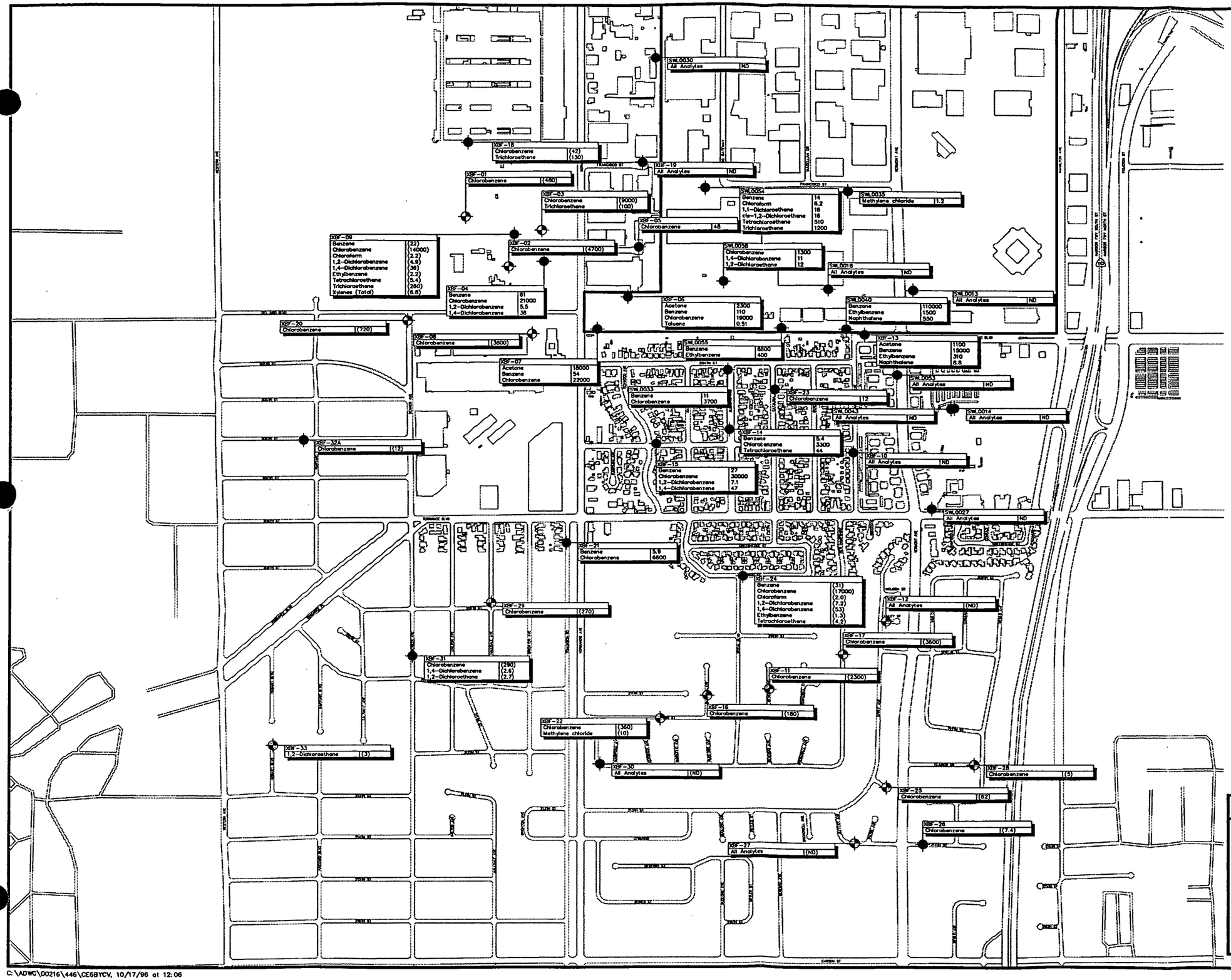

FIGURE 5.2-24

VOC Concentrations
Middle Bellflower C Sand

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

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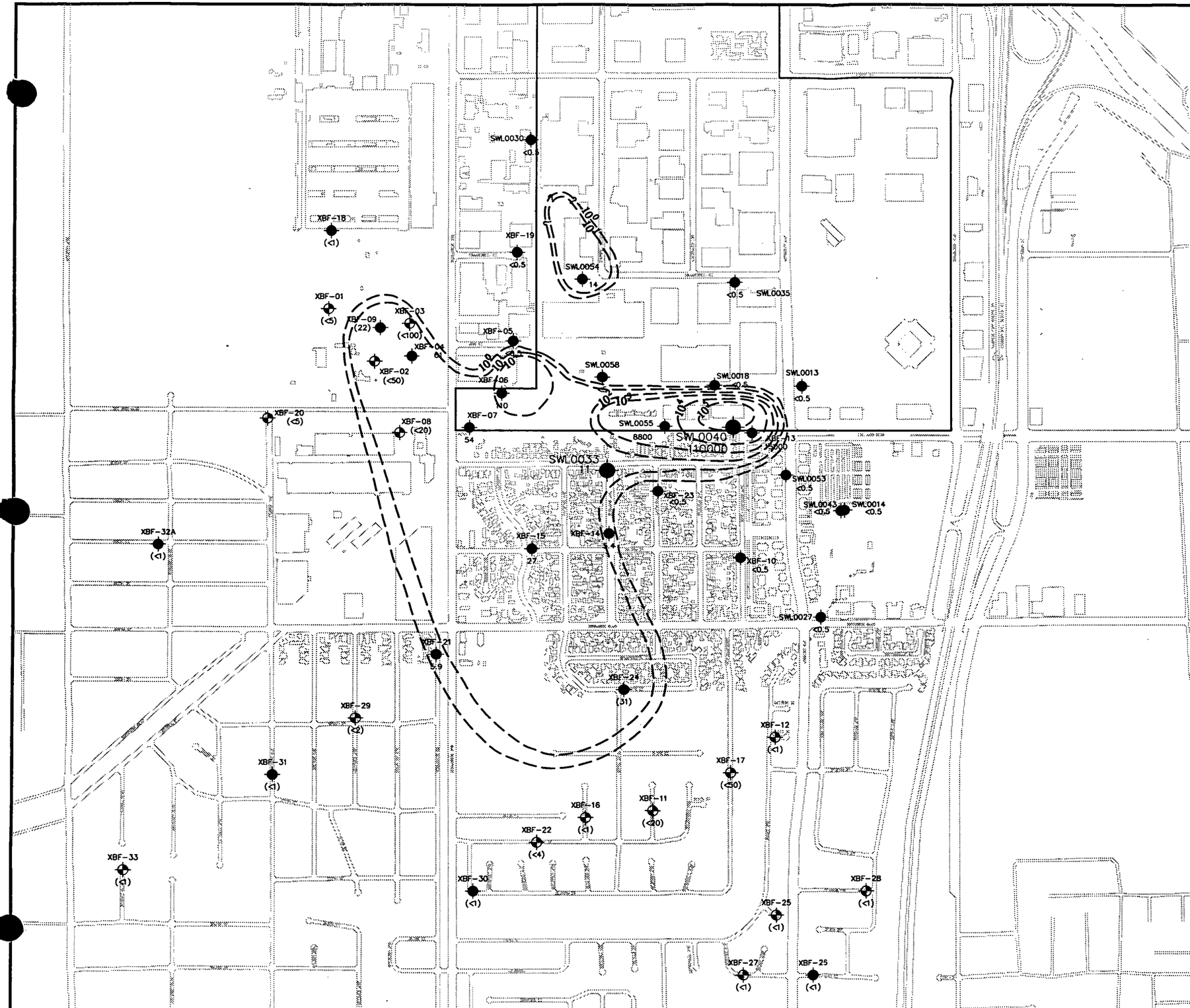


N

0 800 1600

Scale in Feet

EXPLANATION

PZL0003 6	Monitoring location with Third Sampling Period 1995 benzene concentration (µg/L)
FZL0017 (<0.5)	Monitoring location with historical benzene concentration (Third Sampling Period 1995 data not available)
XMW-11 780	Monitoring location where posted data may not be representative of time-series data or be reflected by concentration isopleths due to anomalous Third Sampling Period 1995 data, elevated detection limit, or a concentration trend
10^2	Benzene concentration isopleth (µg/L)

Notes: 1) Data collected by Hargis + Associates for Montrose monitoring program in parentheses

2) Benzene MCL = 1 µg/l

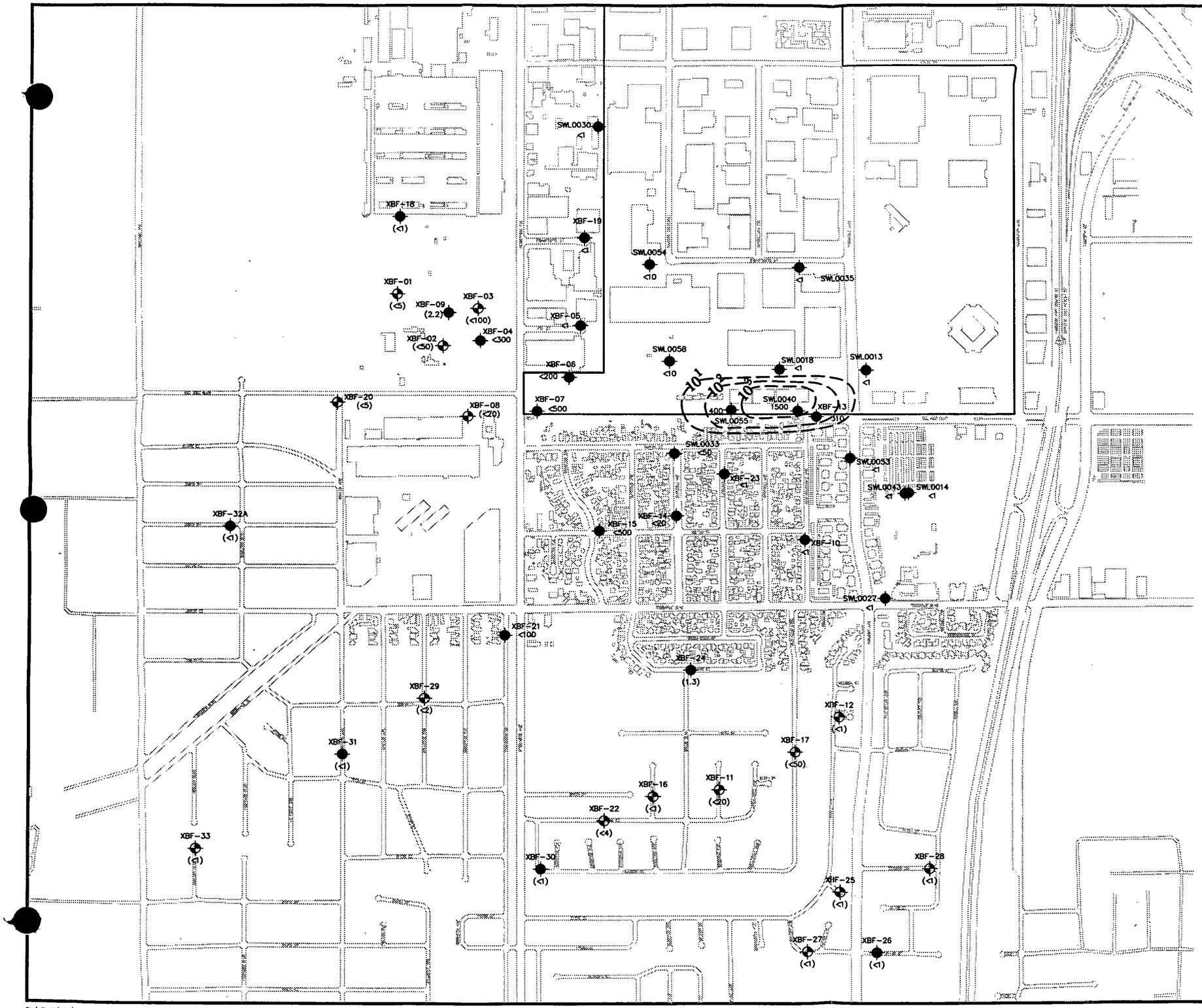
FIGURE 5.2-25

Benzene Concentrations Middle Bellflower C Sand

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

D:\did\ri\sec5\co1, 05/09/97 at 09:54



N

0 800 1600

Scale in Feet

EXPLANATION

PZL0003 6 — Monitoring location with Third Sampling Period 1995 ethylbenzene concentration (µg/L)

PZL0017 (<0.5) — Monitoring location with historical ethylbenzene concentration (Third Sampling Period 1995 data not available)

10^2 — Ethylbenzene concentration isopleth (µg/L)

Notes: 1) Data collected by Hargis + Associates for Montrose monitoring program in parentheses

2) Ethylbenzene MCL = 700 µg/l

FIGURE 5.2-26

Ethylbenzene Concentrations Middle Bellflower C Sand

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

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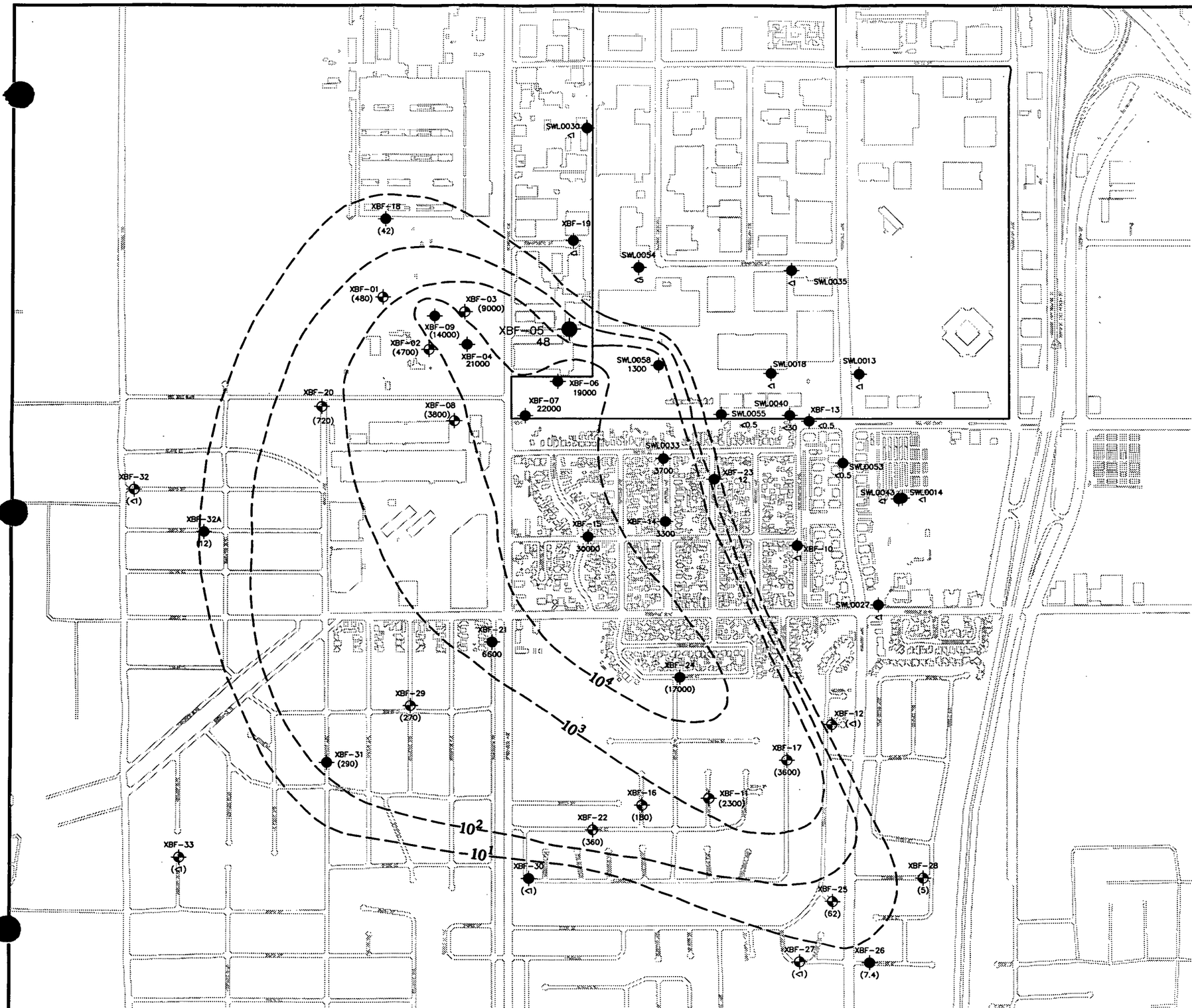
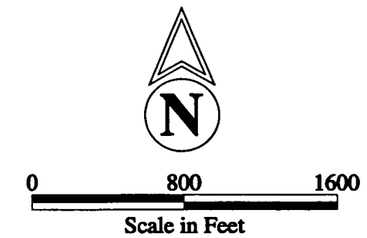




EXPLANATION

PZL0003 6	Monitoring location with Third Sampling Period 1995 PCBSA concentration (µg/L)
PZL0017 (<0.5)	Monitoring location with historical PCBSA concentration (Third Sampling Period 1995 data not available)
XMW-11 780	Monitoring location where posted data may not be representative of time-series data or be reflected by concentration isopleths due to anomalous Third Sampling Period 1995 data, elevated detection limit, or a concentration trend
10^2	PCBSA concentration isopleth (µg/L)

Notes: 1) Data collected by Hargis + Associates for Montrose monitoring program in parentheses

2) Chlorobenzene MCL = 70 µg/l

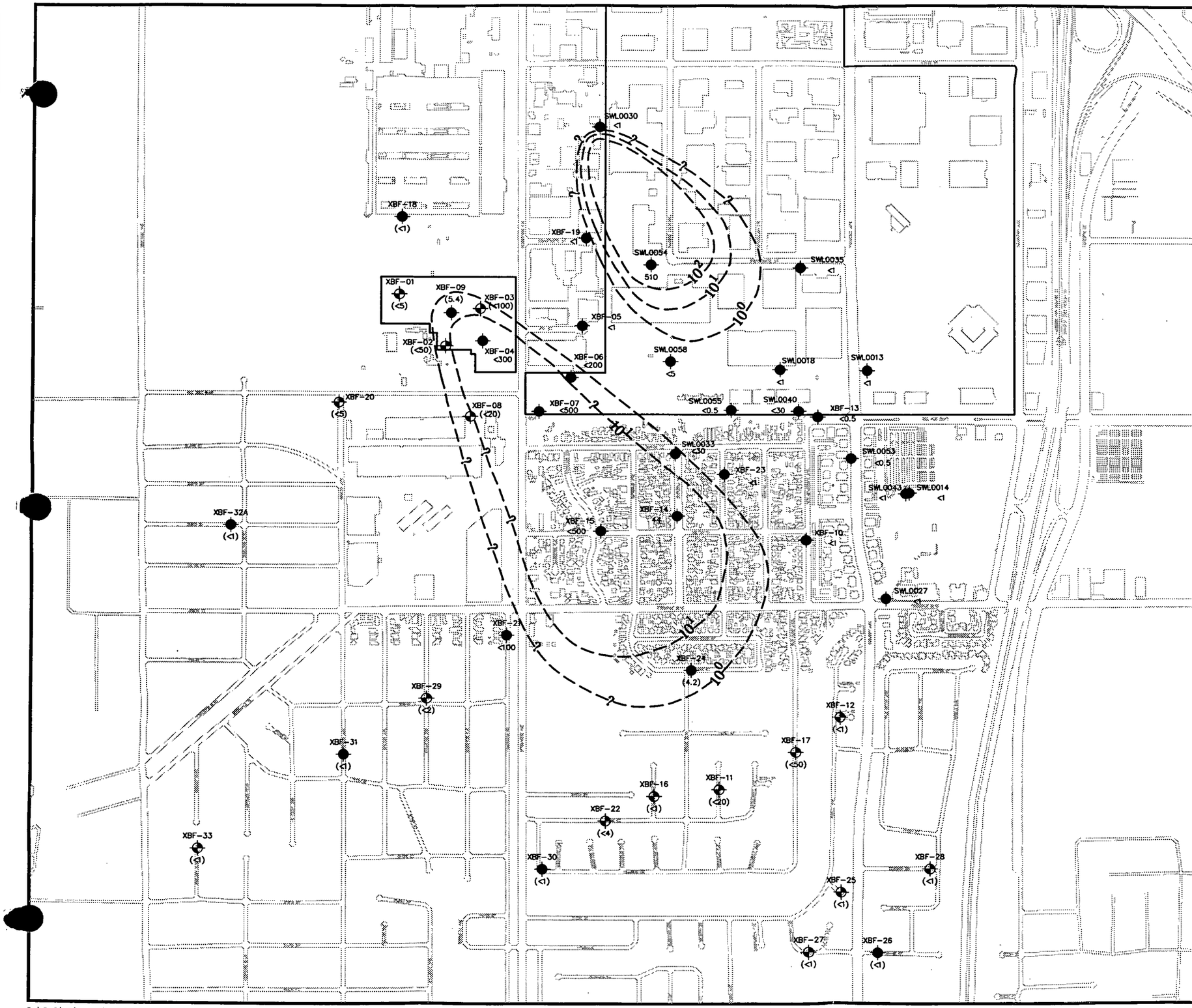
FIGURE 5.2-27

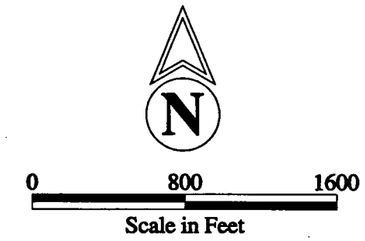
Chlorobenzene Concentrations Middle Bellflower C Sand

Groundwater Remedial Investigation Report Del Amo Study Area

DAMES & MOORE

D:\did\ri\sec5\cb1, 05/09/97 at 09:55





EXPLANATION

SWL0030 <1 — Monitoring location with Third Sampling Period 1995 PCE concentration (µg/l)

XBF-01 (<5) — Monitoring location with historical PCE concentration (Third Sampling Period 1995 data not available) (µg/l)

Notes: 1) Data collected by Hargis + Associates for Montrose monitoring program in parentheses

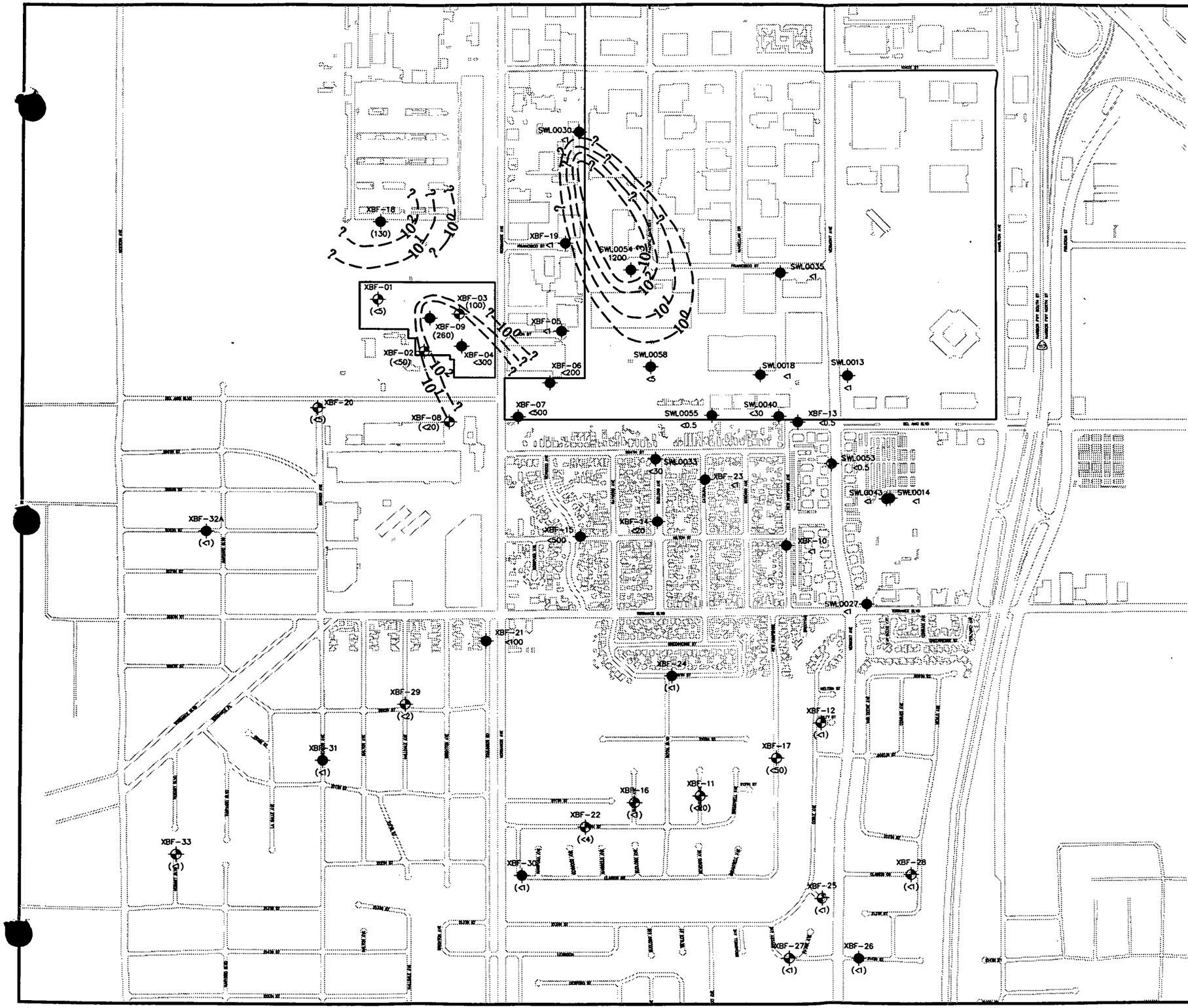
2) Tetrachloroethene MCL = 5 µg/l

FIGURE 5.2-28

Tetrachloroethene Concentrations Middle Bellflower C Sand

Groundwater Remedial Investigation Report Del Amo Study Area

D:\DJD\RI\SEC5\mbfc-pce, 05/20/97 at 16:41



EXPLANATION

SWL0054 1200 — Monitoring location with Third Sampling Period 1995 TCE concentration (µg/l)

XBF-01 (<5) — Monitoring location with historical TCE concentration (Third Sampling Period 1995 data not available) (µg/l)

Notes: 1) Data collected by Hargis + Associates for Montrose monitoring program in parentheses

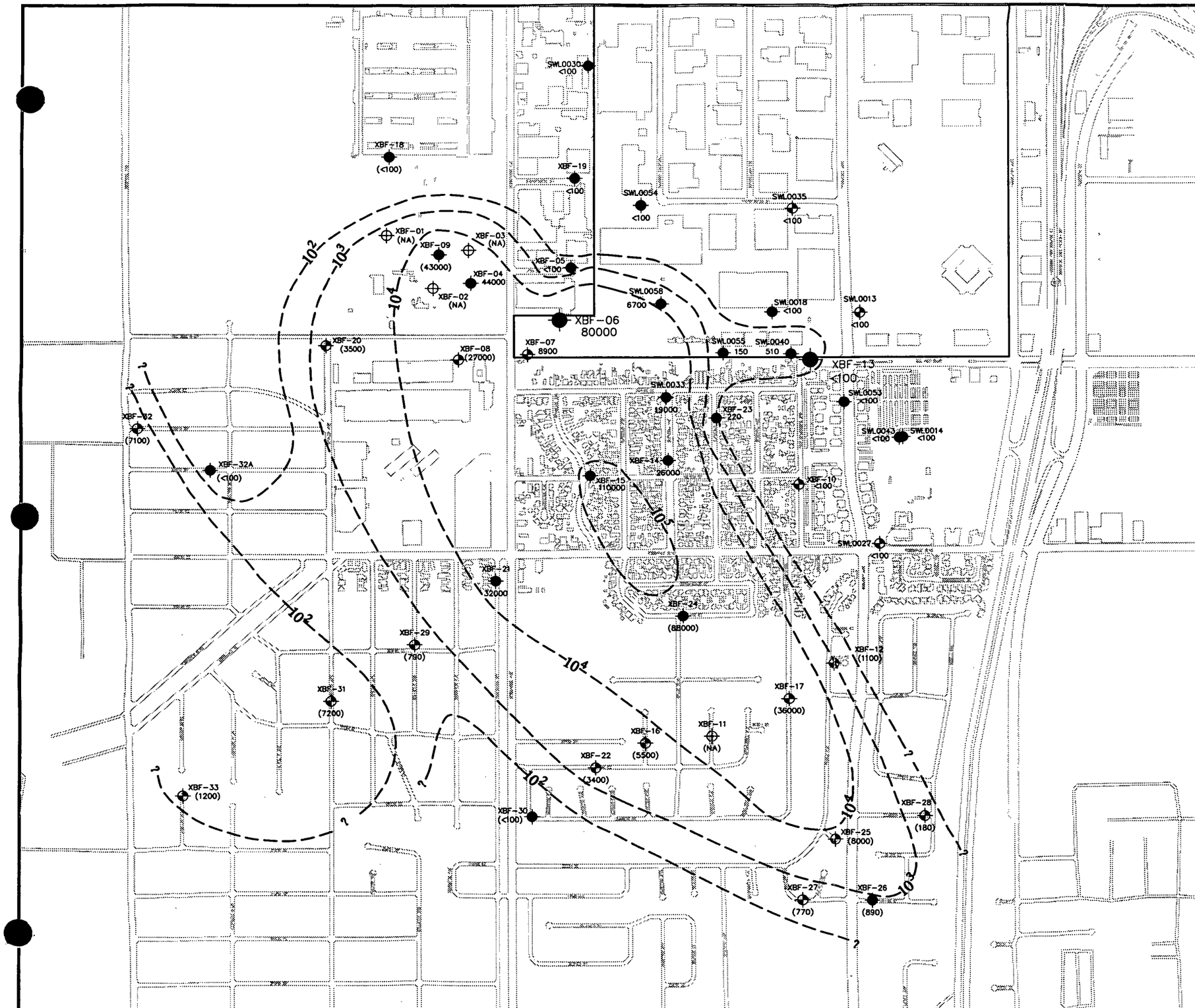
2) Trichloroethene MCL = 5 µg/l

FIGURE 5.2-29

Trichloroethene Concentrations Middle Bellflower C Sand

Groundwater Remedial Investigation Report Del Amo Study Area

D:\DJD\RI\SEC5\mbfc-tce, 05/20/97 at 16:46



N

0 800 1600

Scale in Feet

EXPLANATION

PZL0003 6	Monitoring location with Third Sampling Period 1995 p-CBSA concentration (µg/L)
PZL0017 (<0.5)	Monitoring location with historical p-CBSA concentration (Third Sampling Period 1995 data not available)
XMW-20 NA	Monitoring location where p-CBSA was not analyzed for
XMW-11 780	Monitoring location where posted data may not be representative of time-series data or be reflected by concentration isopleths due to anomalous Third Sampling Period 1995 data, elevated detection limit, or a concentration trend
10^2	p-CBSA concentration isopleth (µg/L)

Notes: 1) Data collected by Hargis + Associates for Montrose monitoring program in parentheses

2) There is no MCL for p-CBSA

FIGURE 5.2-30

p-CBSA Concentrations Middle Bellflower C Sand

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

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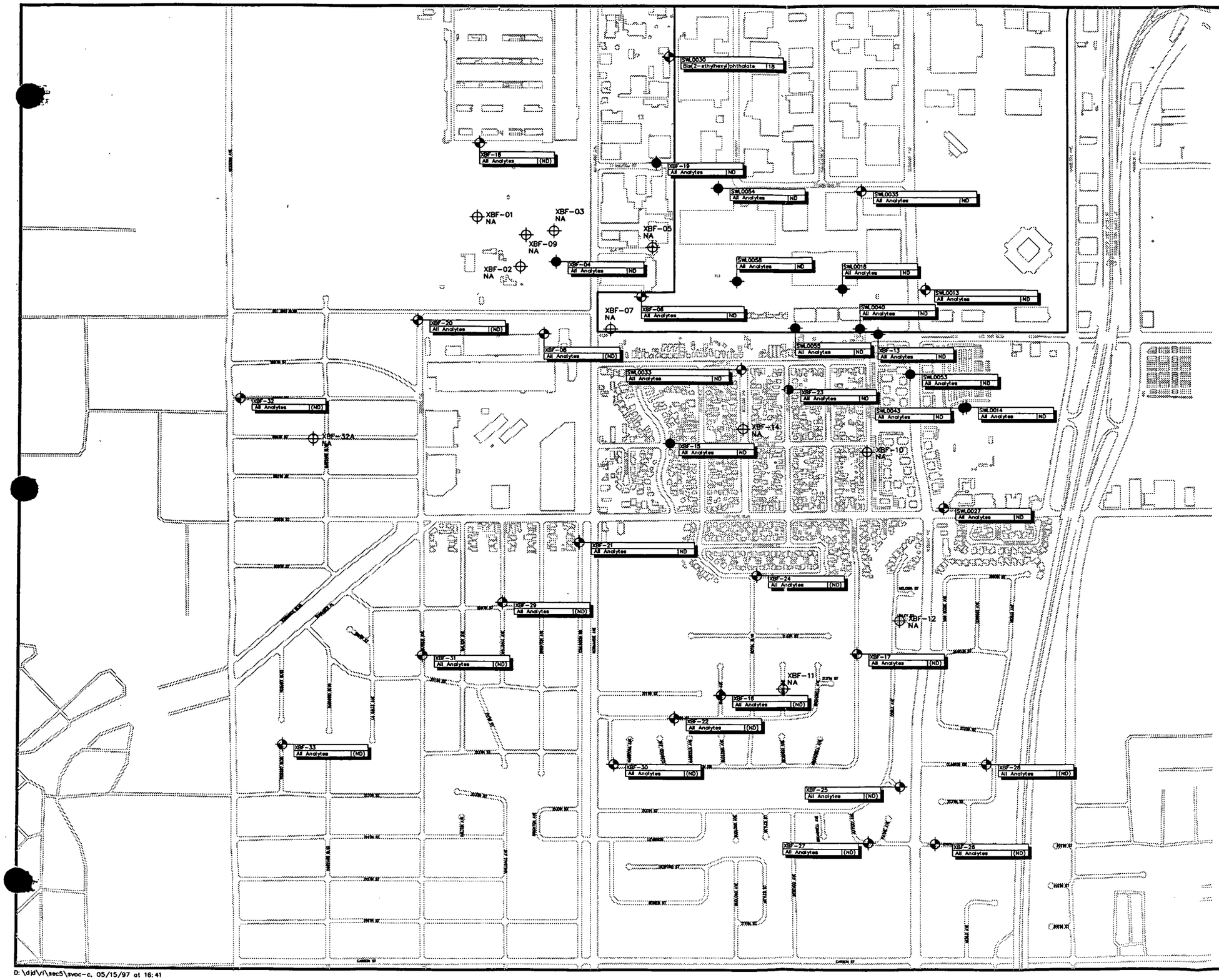


EXPLANATION

Monitoring Location With Third Sampling Period 1995 SVOC Concentration

SWL0014
All Analytes ND

Monitoring Location With Historical SVOC Concentration (third sampling period 1995 data not available)

SWL0013
All Analytes ND

NA Monitoring Location Where SVOCs Were Not Analyzed For

NOTES:

Data collected by Hargis + Associates for Montrose monitoring program in parentheses.

MCLs

Bis(2-ethylhexyl)phthalate: 4 µg/L

No MCLs for all other detected SVOCs

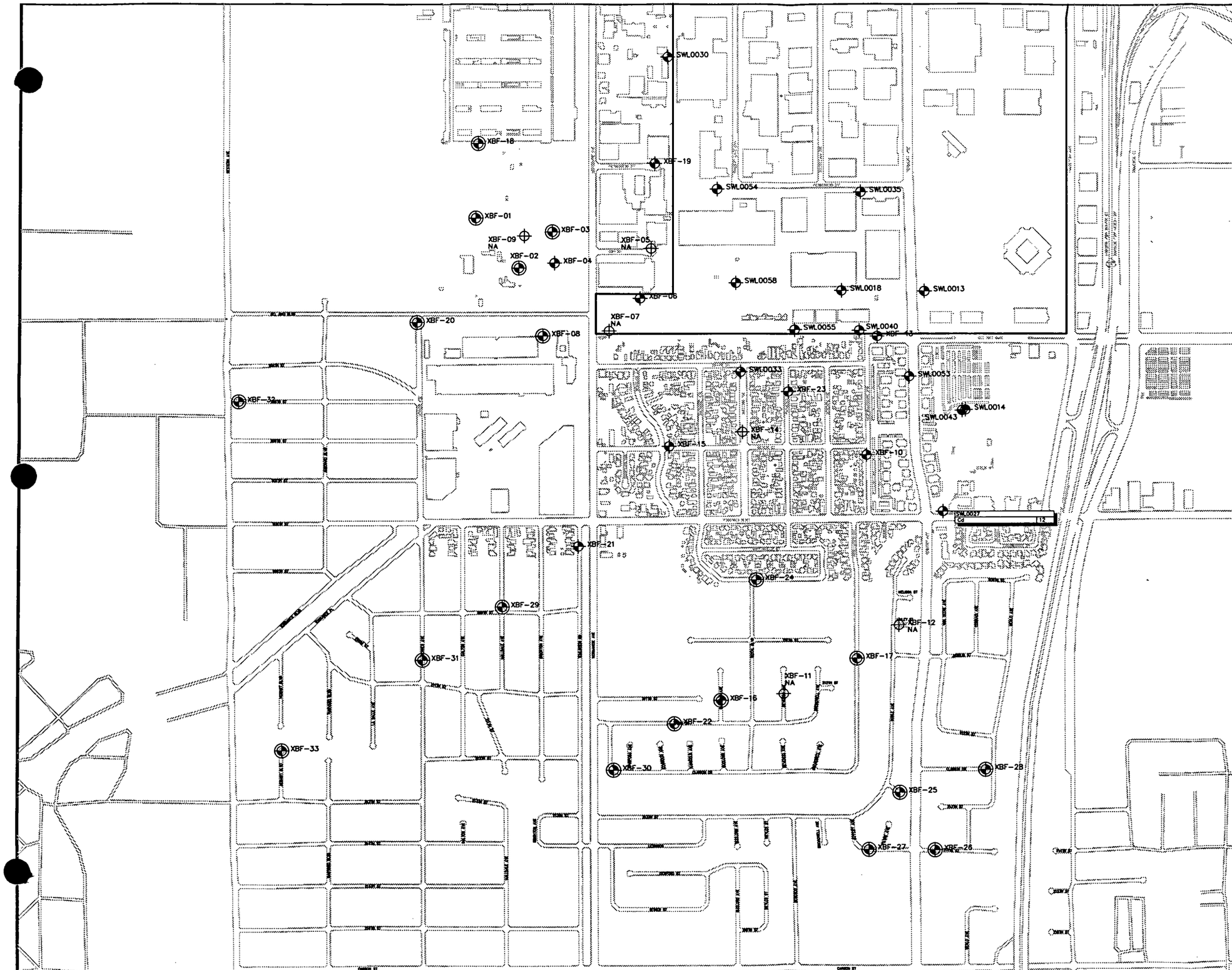
FIGURE 5.2-31

SVOC Concentrations
Middle Bellflower C Sand

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

D:\dd\vi\sec5\svoc-c, 05/15/97 at 16:41



N

0 800 1600

Scale in feet

EXPLANATION

SWL0025 — Monitoring location with one or more metals concentrations in excess of MCLs

SWL0027 Cd 12

SWL0025 NA — Monitoring location where metals were not analyzed for

SWL0053 — Monitoring location where no metals analyzed for were detected at concentrations in excess of MCLs.

XBF-24 — Monitoring location where no metals were detected at concentrations in excess of MCLs. Data collected by Hargis + Associates, Inc. for Montrose Monitoring Program.

Notes: 1) Data collected by Hargis + Associates for Montrose monitoring program in parentheses

2) MCLs (µg/l)
Cd 5

FIGURE 5.2-32

Metals Concentrations
Middle Bellflower C Sand

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

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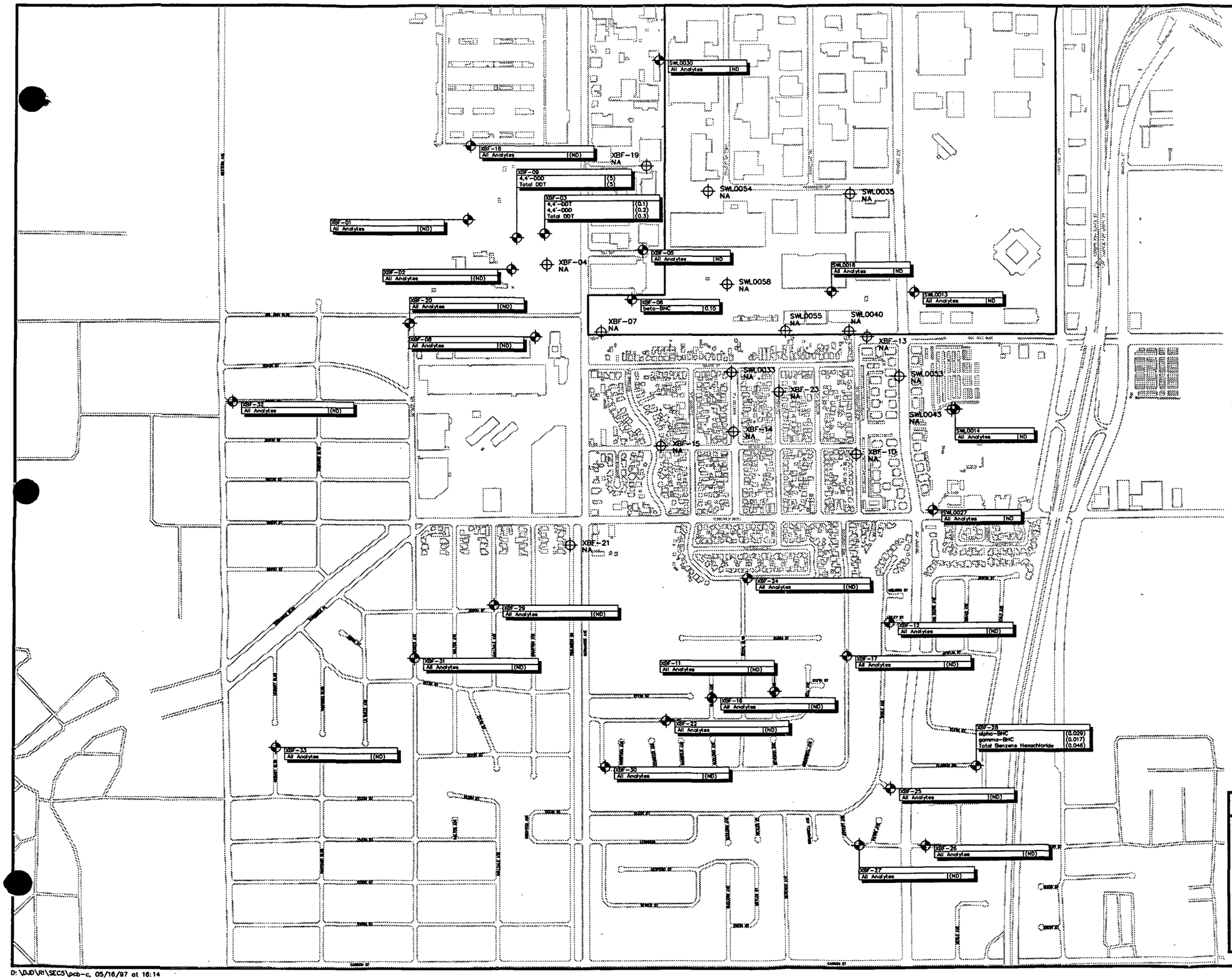

EXPLANATION

Monitoring Location With Historical Pesticide and PCB Concentrations (third sampling period 1995 data not available)

SWL0025 NA — Monitoring Location Where Pesticides and PCBs Were Not Analyzed For

NOTES: Data collected by Hargis + Associates for Montrose monitoring program in parentheses.

MCLs
gamma-BHC: 4 µg/l
No MCLs for all other detected pesticides/PCBs

FIGURE 5.2-33

Pesticide and PCB Concentrations
Middle Bellflower C Sand

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

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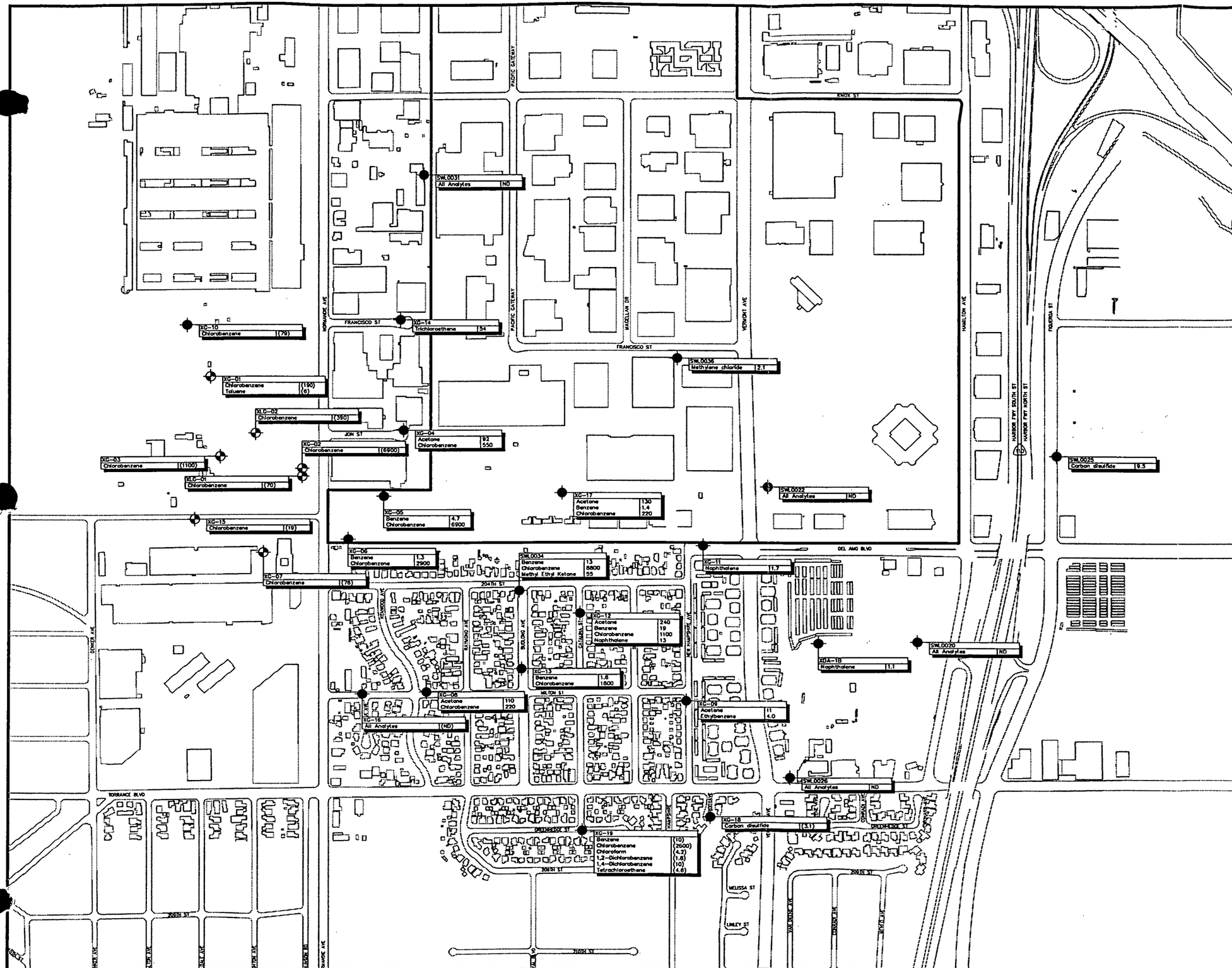


EXPLANATION

Monitoring Location With Third Sampling Period 1995 VOC Concentration

SWL0022
All Analytes ND

Monitoring Location With Historical VOC Concentration (third sampling period 1995 data not available)

XLC-01
Chlorobenzene (70)

NOTE: Data collected by Hargis + Associates for Montrose monitoring program in parentheses.

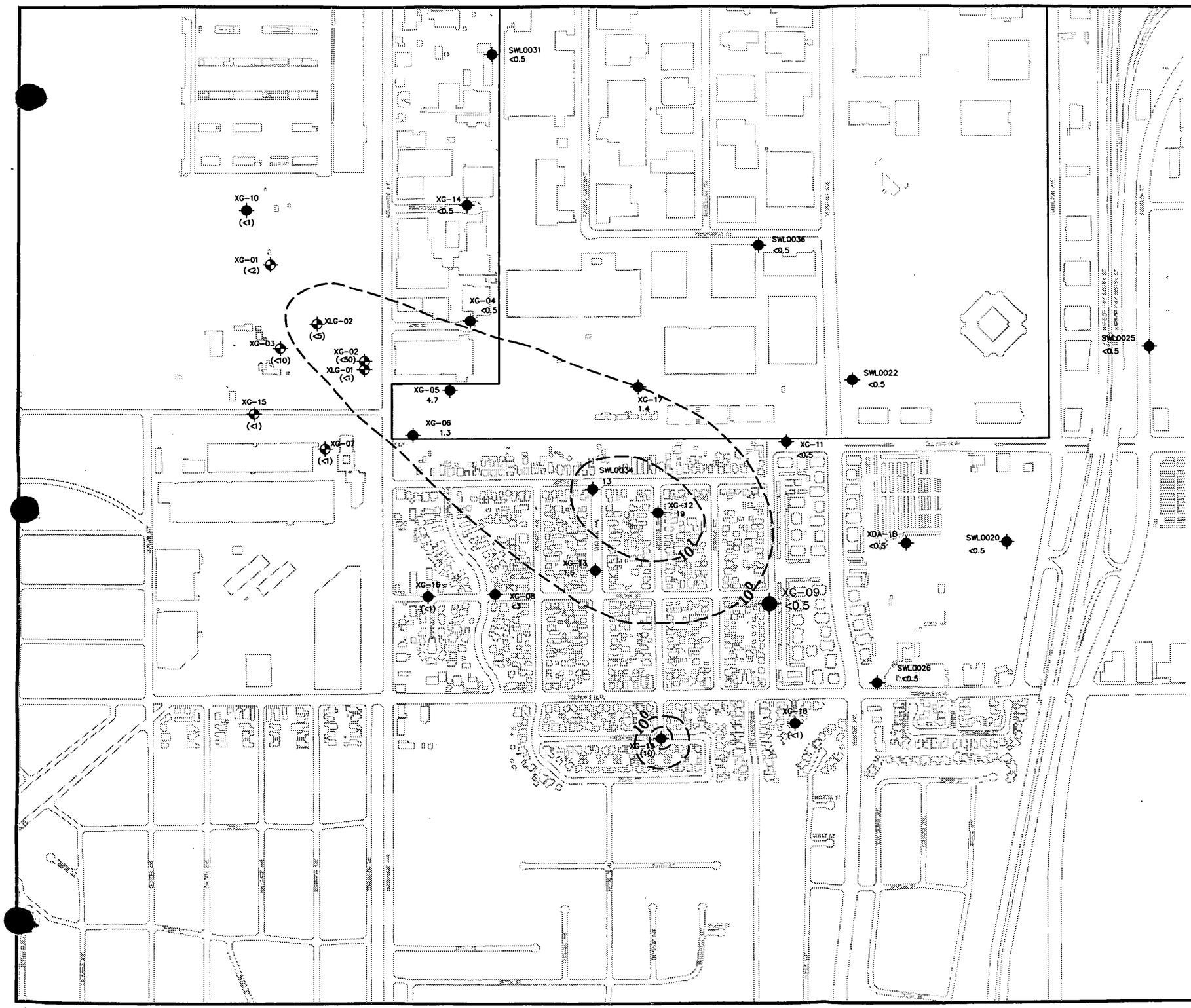
FIGURE 5.2-34

VOC Concentrations Gage Aquifer

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

C:\ADWG\00216\446\CE6BYGV, 10/17/96 at 14:17



EXPLANATION

XG-05 4.7 — Monitoring location with Third Sampling Period 1995 benzene concentration (µg/L)

XG-01 (<2) — Monitoring location with historical benzene concentration (Third Sampling Period 1995 data not available)

XMW-11 780 — Monitoring location where posted data may not be representative of time-series data or be reflected by concentration isopleths due to anomalous Third Sampling Period 1995 data, elevated detection limit, or a concentration trend

10 — Benzene concentration isopleth (µg/L)

Notes: 1) Data collected by Hargis + Associates for Montrose monitoring program in parentheses

2) Benzene MCL = 1 µg/l

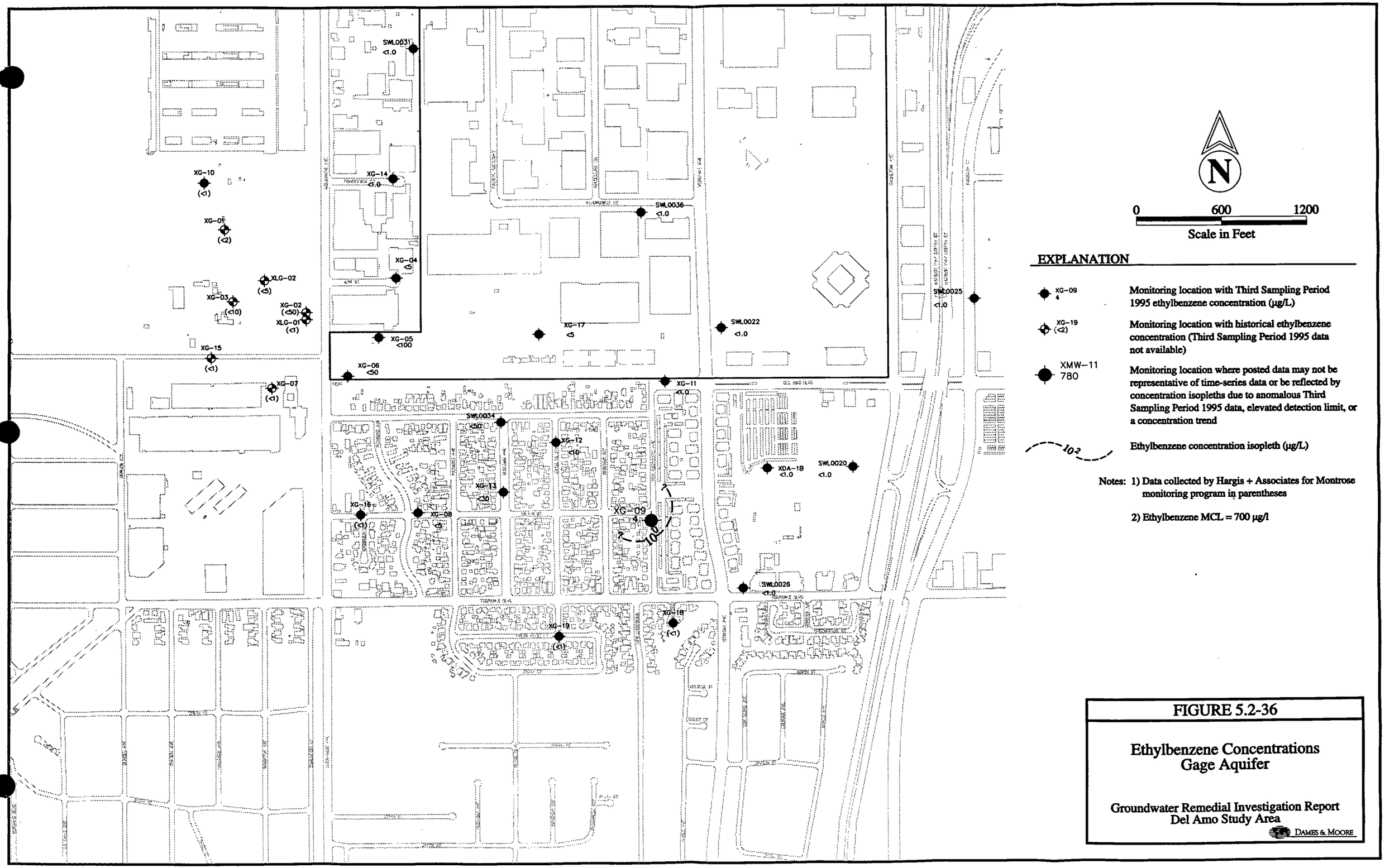
FIGURE 5.2-35

Benzene Concentrations Gage Aquifer

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

d:\djd\ri\sec5\qa1, 05/09/97 at 13:22



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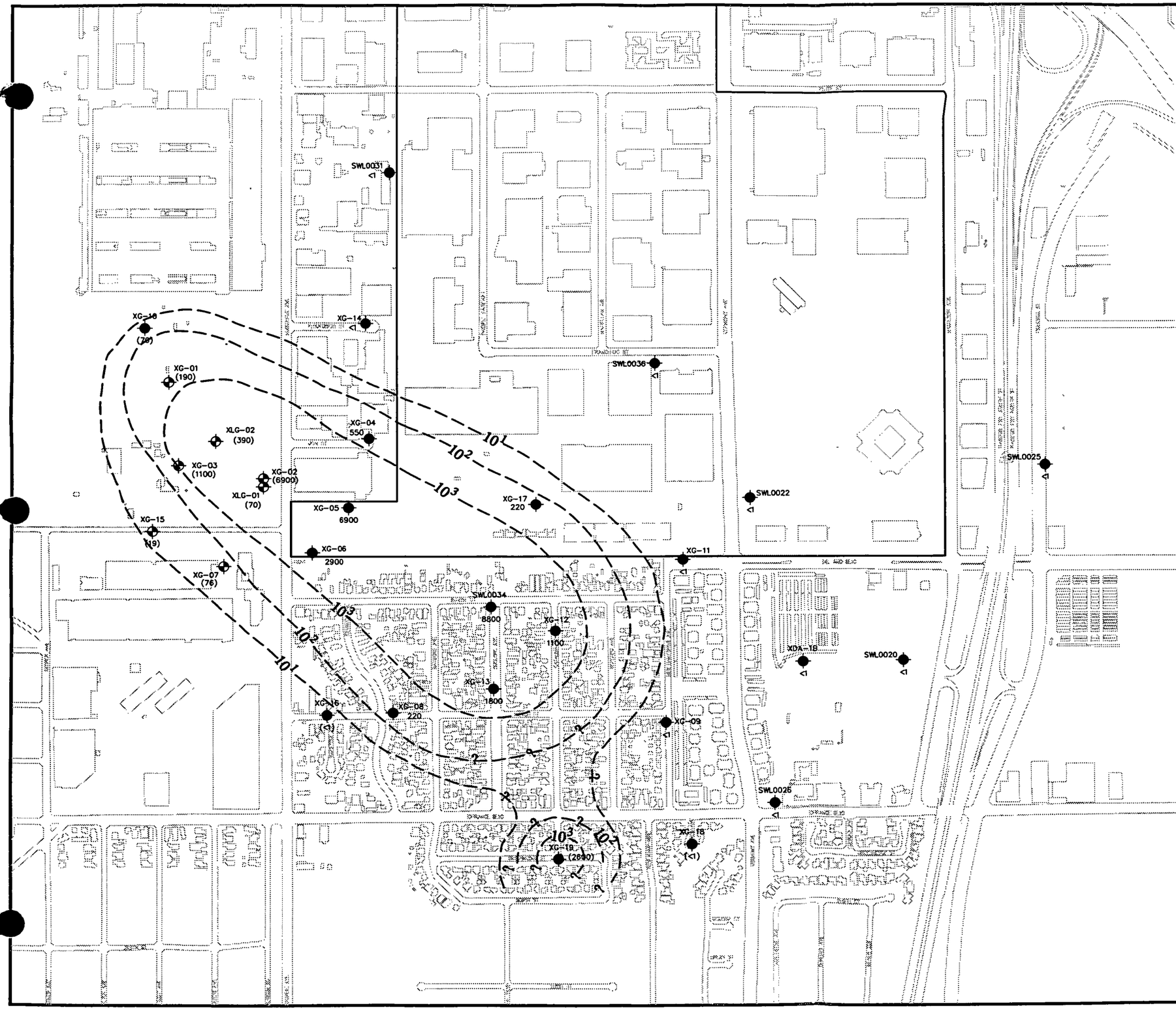

N

0 600 1200

Scale in Feet

EXPLANATION

PZL0003 6 — Monitoring location with Third Sampling Period 1995 chlorobenzene concentration (µg/L)

PZL0017 (<0.5) — Monitoring location with historical chlorobenzene concentration (Third Sampling Period 1995 data not available)

10^2 — Chlorobenzene concentration isopleth (µg/L)

Notes: 1) Data collected by Hargis + Associates for Montrose monitoring program in parentheses

2) Chlorobenzene MCL = 70 µg/l

FIGURE 5.2-37

Chlorobenzene Concentrations Gage Aquifer

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

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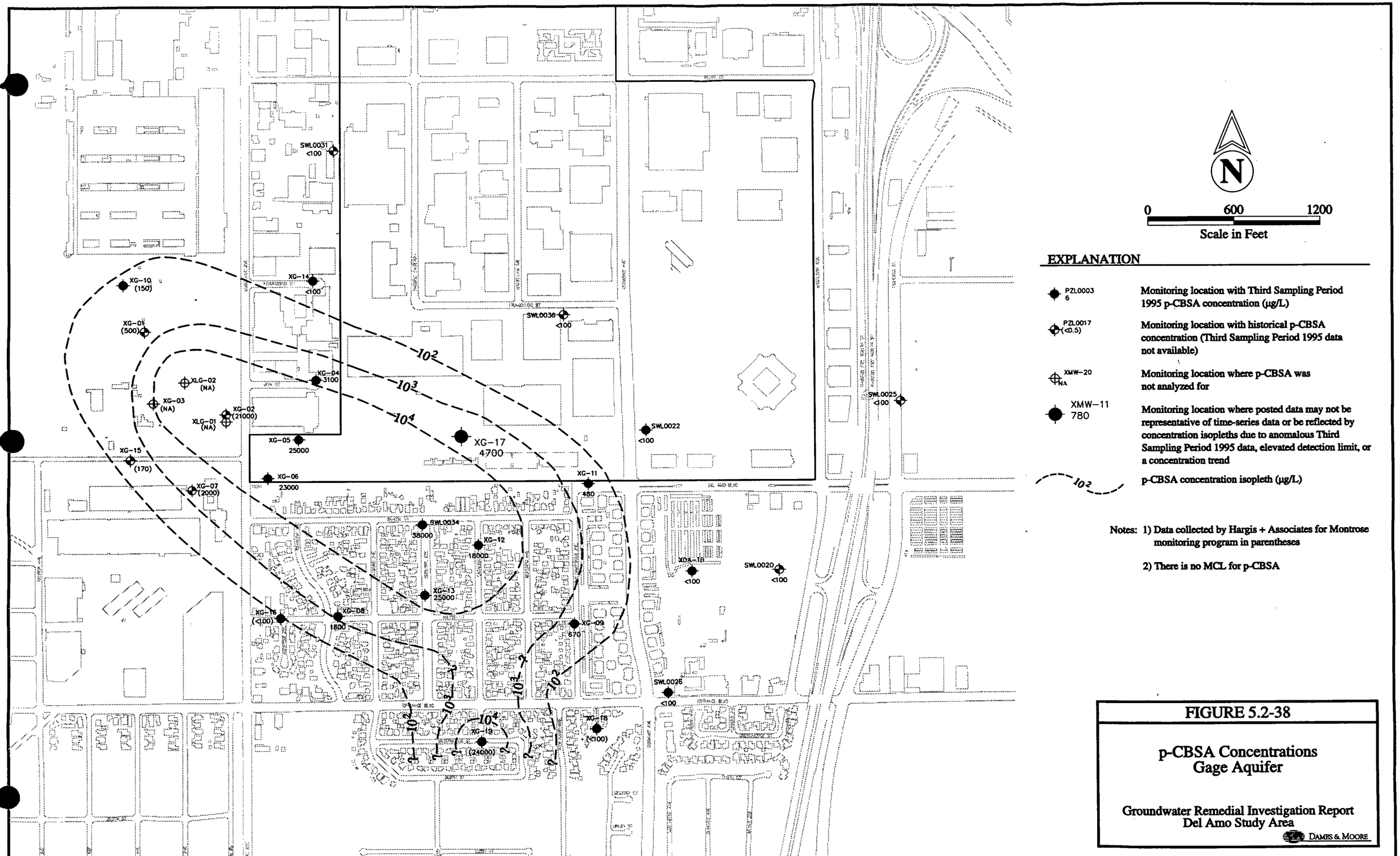

FIGURE 5.2-38

p-CBSA Concentrations
Gage Aquifer

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

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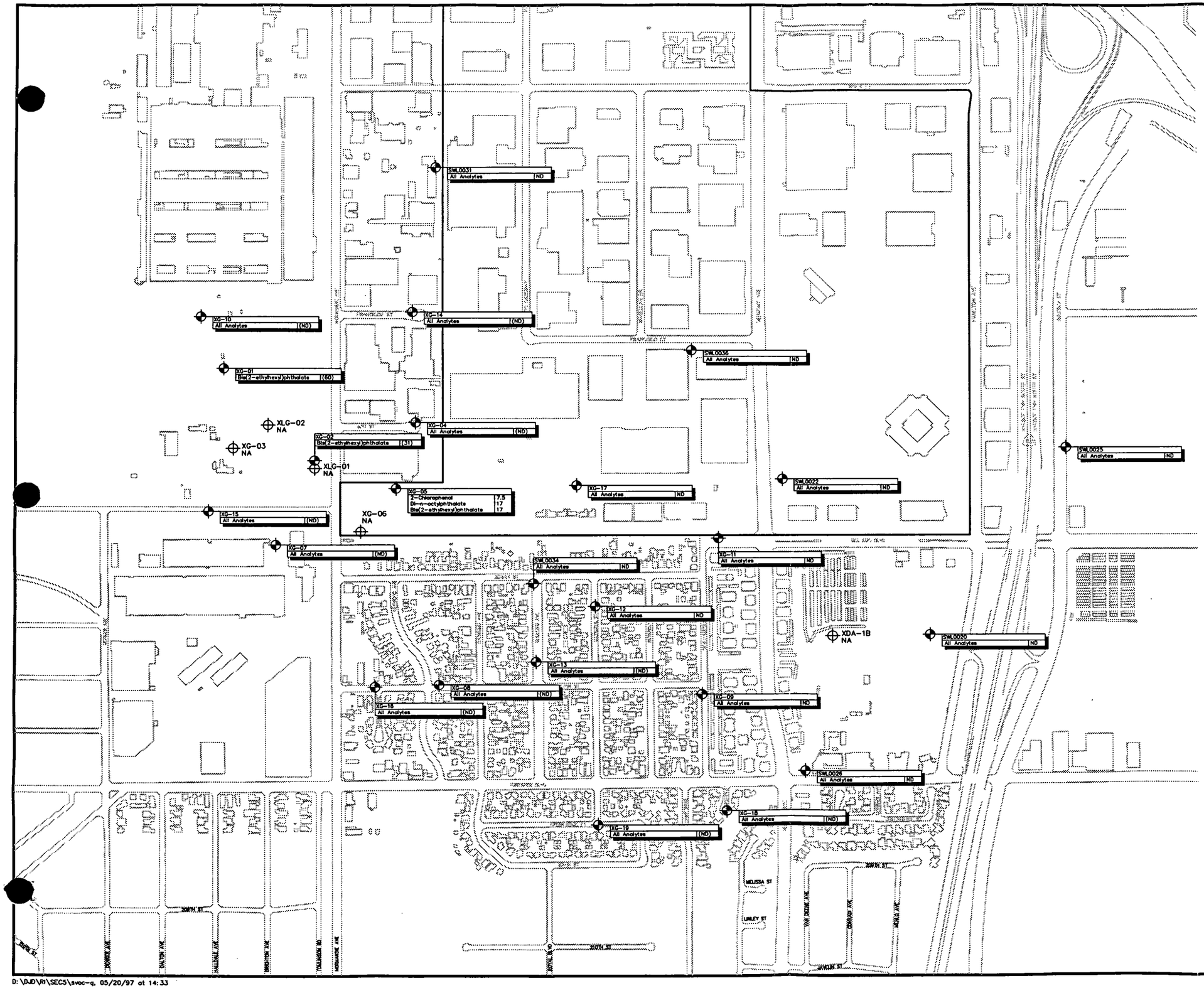


EXPLANATION

Monitoring Location With Historical SVOC Concentration (third sampling period 1995 data not available)

Monitoring Location Where SVOCs Were Not Analyzed For

NOTES:

Data collected by Hargis + Associates for Montrose monitoring program in parentheses.

MCLs

Bis(2-ethylhexyl)phthalate: 4 µg/L
No MCLs for all other detected SVOCs

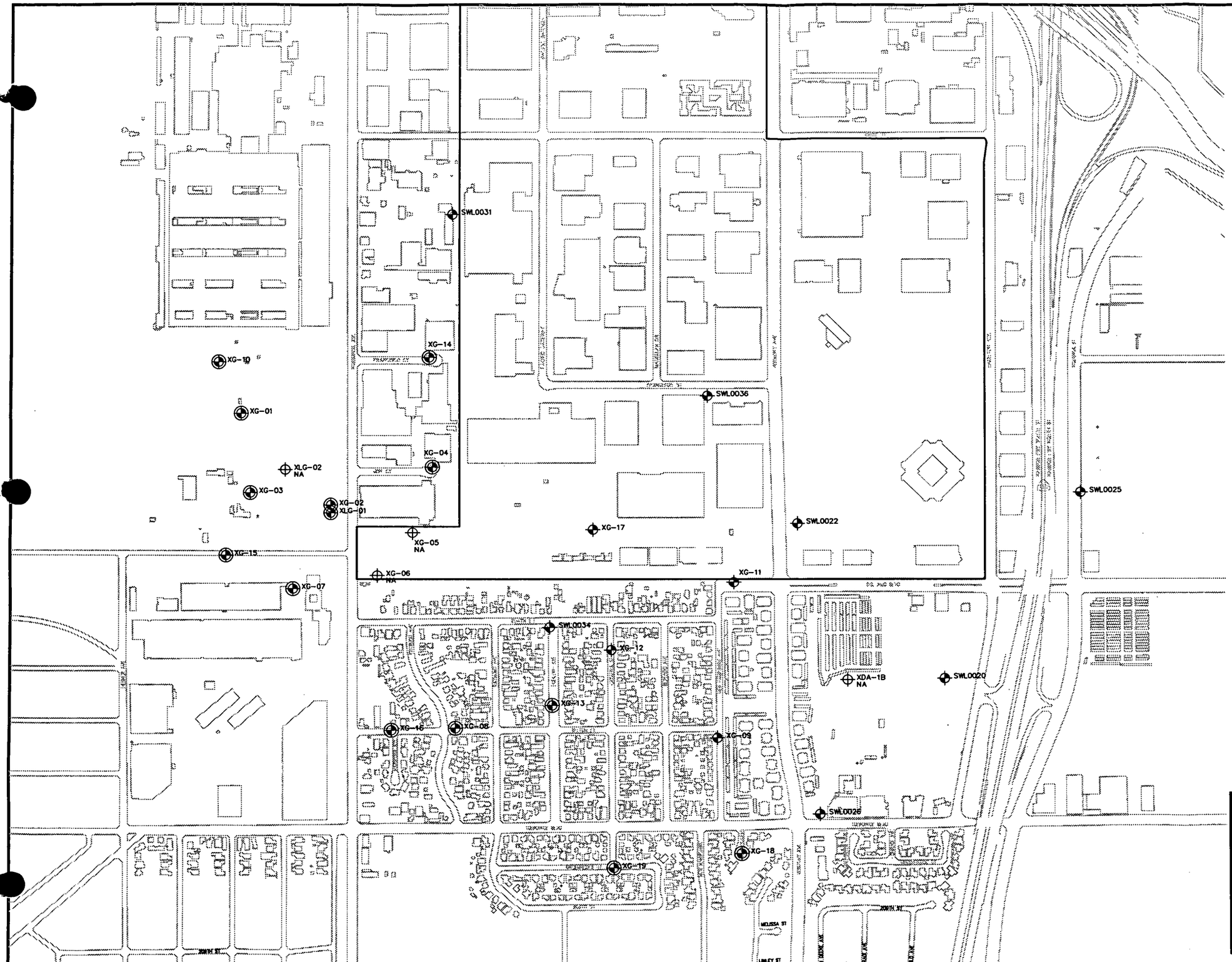
FIGURE 5.2-39

SVOC Concentrations Gage Aquifer

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

D:\DJD\R1\SEC5\svoc-g, 05/20/97 at 14:33



N

0 600 1200

Scale in feet

EXPLANATION

SWL0025 — Monitoring location where one or more metals were analyzed for, with all concentrations lower than MCLs

SWL0025 NA — Monitoring location where metals were not analyzed for

NOTE: Data collected by Hargis + Associates for Montrose monitoring program in parentheses.

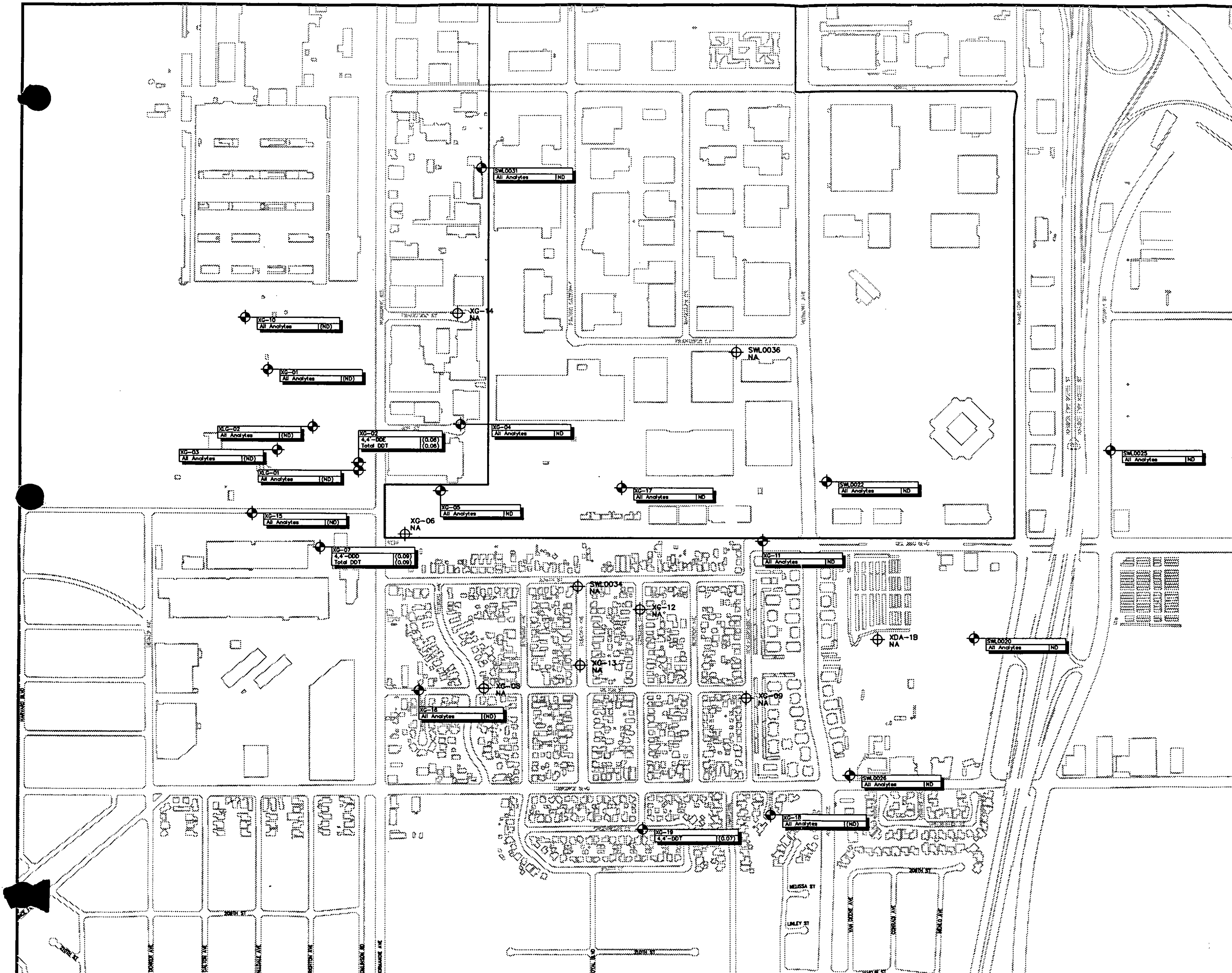
FIGURE 5.2-40

Metals Concentrations Gage Aquifer

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

d:\dja\vi\sec5\met-g, 05/15/97 at 16:33



N

0 600 1200

Scale in feet

EXPLANATION

XG-17 All Analytes ND — Monitoring Location With Historical Pesticide and PCB Concentrations (third sampling period 1995 data not available)

SWL0025 NA — Monitoring Location Where Pesticides and PCBs Were Not Analyzed For

NOTES: Data collected by Hargis + Associates for Montrose monitoring program in parentheses.

MCLs

gamma-BHC: 4 µg/l

No MCLs for all other detected pesticides/PCBs

FIGURE 5.2-41

Pesticide and PCB Concentrations
Gage Aquifer

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

D: \DJD\RI\SEC5\pcb-g, 05/16/97 at 16:15

Source	Local Facility*	VOCs with Elevated Concentrations in Groundwater
A	Amoco/Del Amo (?)	TCE, PCE, chloroform
B	International Light Metals	TCE
C	International Light Metals/ McDonnell Douglas	TCE
D	International Light Metals	TCE, PCE, 1,1-DCE, 1,1-DCA
E	McDonnell Douglas	1,1-DCE, toluene, benzene, TCE, 1,1,1-TCA
F	Trico	1,1-DCA, TCE, PCE, vinyl chloride
G	Penske Truck Leasing	benzene
H	Mobil Oil Refinery	BTEX
I	Allied Signal	1,1-DCE, 1,1-DCA, 1,1,1-TCA, benzene
J	Jones Chemical	TCE, PCE, 1,1-DCE
K	XMW-07 LNAPL	BTEX, 1,1-DCA
L	Jones Chemical	TCE, PCE, benzene, 1,1-DCE, 1,1-DCA
M	Montrose	chlorobenzene, p-CBSA, chloroform
N	unknown	BTEX, TCE, 1,2-DCA, 1,2,4-trimethylbenzene
O	unknown	benzene
P	P-1 LNAPL Pipeline leakage?	benzene, naphthalene
Q	Azko	toluene
R	Armco	BTEX, chlorobenzene, p-CBSA
S	Gardena Valley Landfill	benzene, PCE, TCE, vinyl chloride
T	Cal Compact Landfill	vinyl chloride, TCE, PCE, cis-1,2-DCE, benzene
U	Cal Compact Landfill	BTEX
V	Golden Eagle Refinery	BTEX
W	Golden Eagle Refinery	vinyl chloride, cis-1,2-DCE, TCE, PCE
X	Southwest Conservation Landfill	PCE, TCE, 1,1-DCA, vinyl chloride
Y	Boring SBL0102 LNAPL Pipeline leakage?	groundwater not tested

* Indicates only the name of the local facility at the time the analytical data was collected and does not necessarily reflect responsibility for the contamination present

FIGURE 5.3-1

Regional Groundwater Contamination Source Areas

Groundwater Remedial Investigation Report
Del Amo Study Area

DAMES & MOORE

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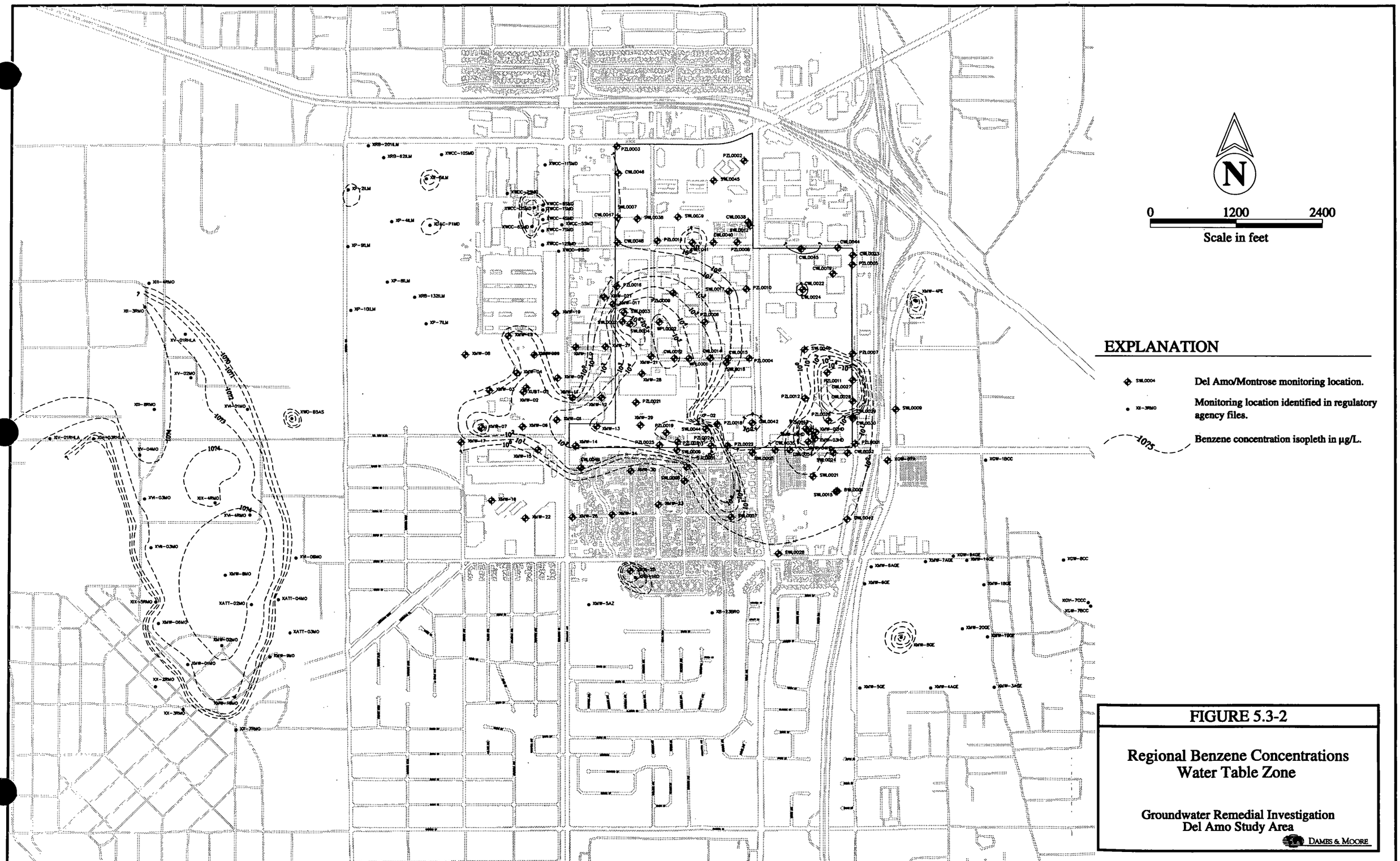

FIGURE 5.3-2

Regional Benzene Concentrations
Water Table Zone

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

D:\djd\RI\SEC5\ce7qiben, 04/06/98 at 14:06

N

0 1200 2400

Scale in feet

EXPLANATION

PZL0016 — Del Amo/Montrose monitoring location.

XWO-85AS — Monitoring location identified in regulatory agency files.

10* — Tri- and tetra- chlorinated compound concentration isopleth in µg/L.

NOTES:

Tri- and Tetra- Chlorinated Compounds include 111-TCA, TCE, PCE, 1,1,22-Tetrachloroethane, and 112-TCA. Concentration isopleths from input to groundwater model.

Concentration isopleths near southeast corner of plant site inferred from concentration data and boundaries of inactive landfills in this area.

FIGURE 5.3-3

Regional Tri- and Tetra-Chlorinated Compound Concentrations Water Table Zone

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

D:\djd\ri\sec5\CE7QIPCT, 04/07/98 at 9:06

EXPLANATION

- XMW-01T — Del Amo/Montrose monitoring location.
- XWCC-35MD — Monitoring location identified in regulatory agency files.
- 10^3 — Dichlorinated compound concentration isopleth in µg/L.

NOTES:

Dichlorinated Compounds include 1,1-DCA, 1,2-DCA, 1,1-DCE, and Trans-1,2-DCE. Concentration isopleths from input to groundwater model.

Concentration isopleths near southeast corner of plant site inferred from concentration data and boundaries of inactive landfills in this area.

FIGURE 5.3-4

Regional Dichlorinated Compound Concentrations Water Table Zone

Groundwater Remedial Investigation
Del Amo Study Area

DAMES & MOORE

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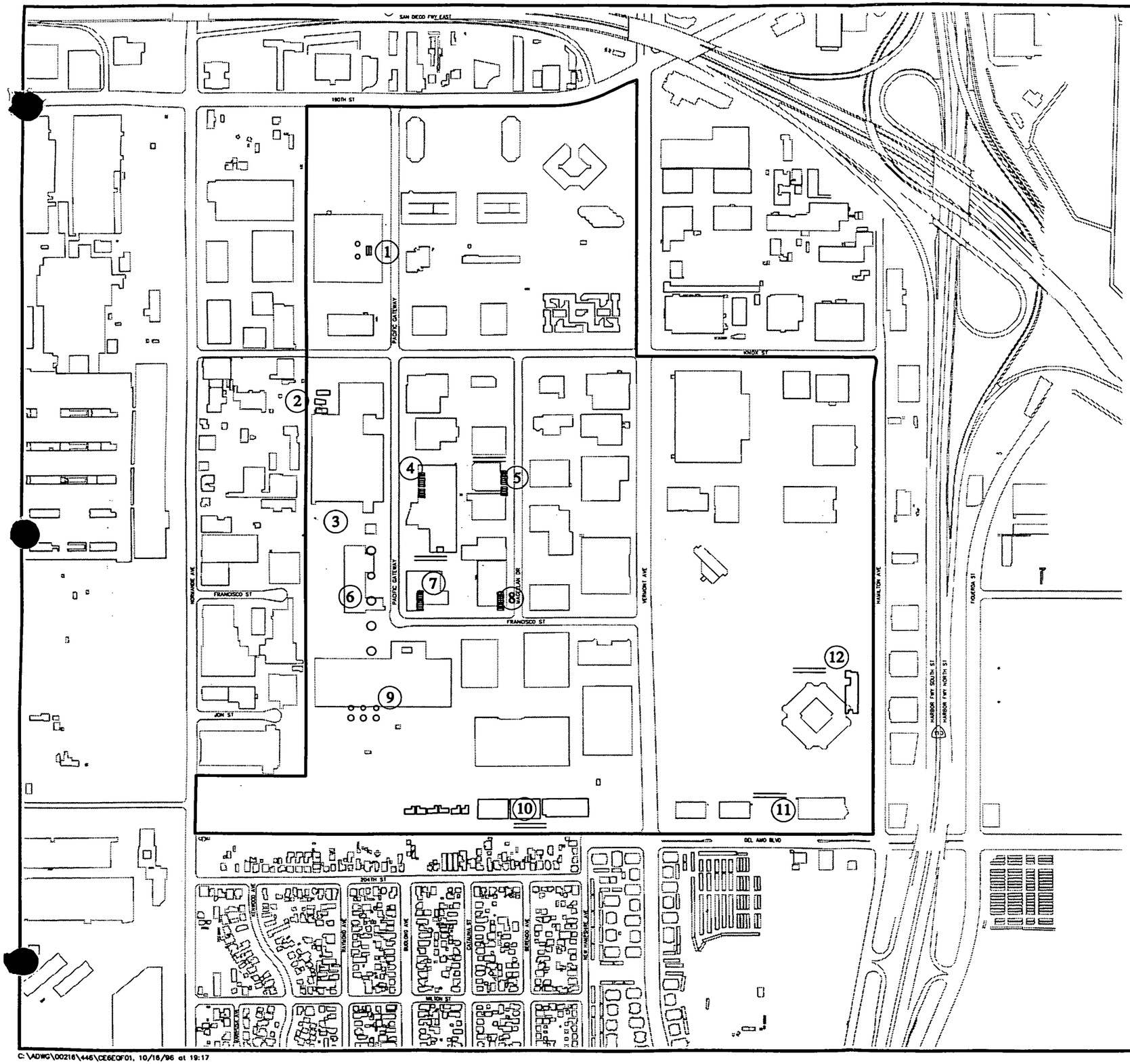

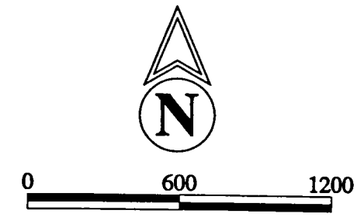

EXPLANATION

(9) Approximate location of groundwater contamination source areas

Source Area Number	Suspected Former Source Facility	Local Water Table Monitoring Locations	VOCs with Elevated Concentrations in Groundwater	VOCs with Elevated Concentrations in Soil Gas
1	cyclohexane tanks	SWL0038	cyclohexane	soil gas sampling not conducted (inaccessible)
2	offsite Amoco facility and/or onsite "pits and trenches"	PZL0016	TCE PCE chloroform	TCE PCE
3	XMW-20 LNAPL (benzene tank and/or pipeline)	XMW-20 SWL0001 SWL0002 SWL0003 SWL0004 SWL0032	benzene (LNAPL) toluene ethylbenzene	benzene toluene ethylbenzene styrene
4	VOC tanks in styrene finishing/benzene purification unit	WPL0002 PZL0009	benzene ethylbenzene cyclohexane	benzene cyclohexane
5	VOC tanks and/or underground pipelines in styrene finishing unit	PZL0006	BTEX styrene naphthalene	BTEX styrene cyclohexane
6	tank farm (VOC storage)	XMW-21 XMW-28	benzene ethylbenzene	benzene toluene ethylbenzene styrene
7	VOC storage tanks at ethylbenzene production unit #1	XMW-21 CWL0012	benzene ethylbenzene	BTEX cyclohexane
8	VOC storage tanks at ethylbenzene production unit #2	WPL0001	benzene ethylbenzene phenol	ethylbenzene
9	"utility tanks"	PZL0021	benzene toluene	none
10	Waste Pit Area and underground petroleum product pipelines	PZL0019 PZL0020 PZL0024 SWL0044	BTEX naphthalene phenol	soil gas sampling not conducted within waste pits
11	underground benzene pipeline	XMW-01HD XMW-04HD	benzene phenol(?)	benzene
12	laboratory, underground pipelines (?)	CWL0027 CWL0028 PZL0011	BTEX styrene cyclohexane naphthalene	benzene toluene ethylbenzene cyclohexane

FIGURE 5.3-5

Plant Site
Groundwater Contamination
Source Areas

Groundwater Remedial Investigation
Del Amo Study Area

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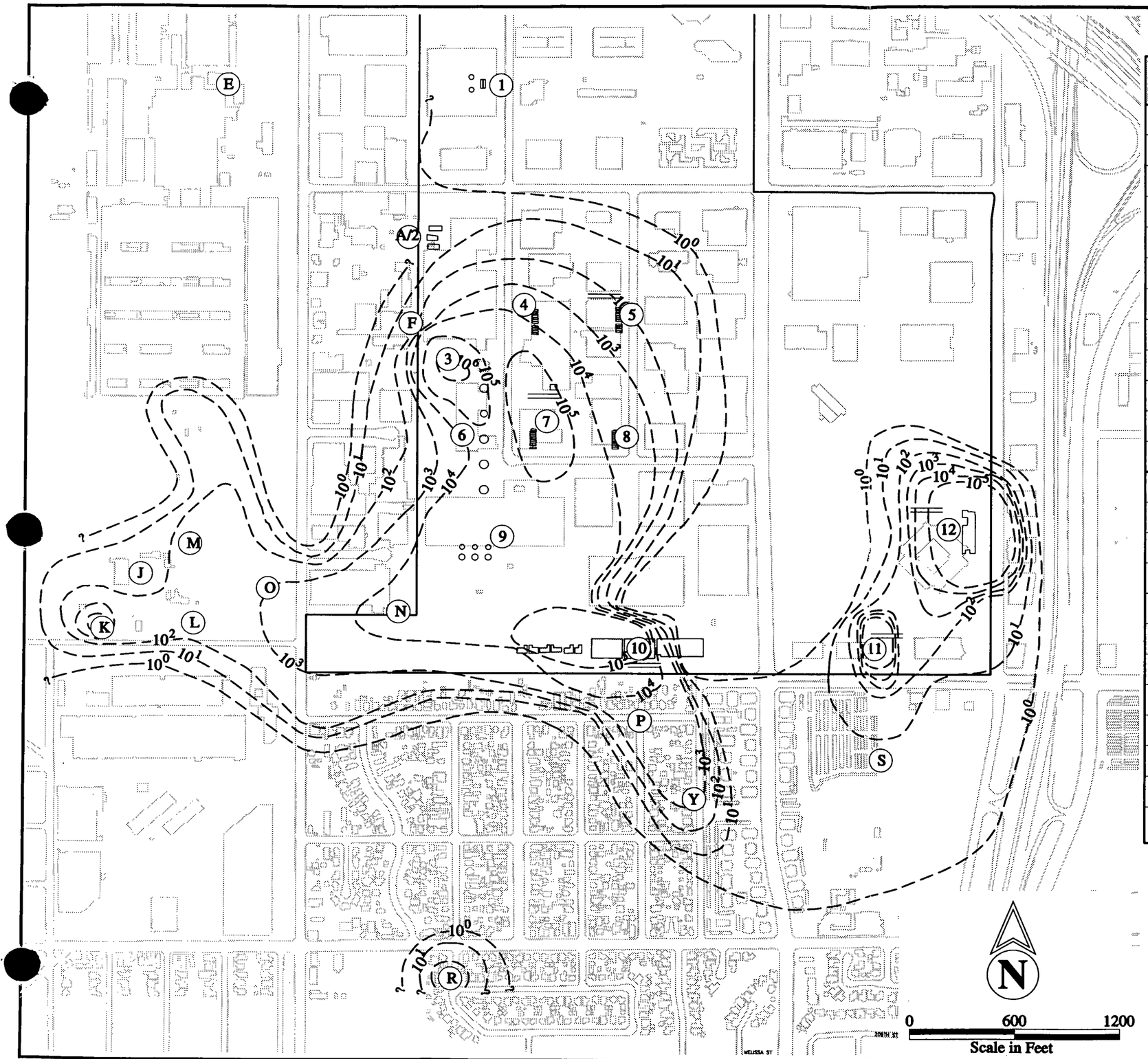

Source Area	Facility	VOCs with Elevated Concentrations in Groundwater
1	Del Amo plant site–cyclohexane tanks	cyclohexane
A/2	Amoco and possibly Del Amo plant site "pits and trenches" area	PCE, TCE, chloroform
3	Del Amo plant site–MW-20 LNAPL	benzene, toluene, ethylbenzene
4	Del Amo plant site–VOC tanks in styrene finishing/benzene purification unit	benzene, ethylbenzene, cyclohexane
5	Del Amo plant site–VOC tanks and/or underground pipelines at styrene finishing unit	BTEX, styrene, naphthalene
6	Del Amo plant site–tank farm (VOC storage)	benzene, ethylbenzene
7	Del Amo plant site–VOC storage tanks at ethylbenzene production unit #1	benzene, ethylbenzene
8	Del Amo plant site–VOC storage tanks at ethylbenzene production unit #2	benzene, ethylbenzene, phenol
9	Del Amo plant site–"utility tanks"	benzene, toluene
10	Del Amo plant site–Waste Pit Area and underground petroleum product pipelines	BTEX, naphthalene, phenol
11	Del Amo plant site–underground benzene pipeline	benzene, phenol (?)
12	Del Amo plant site–laboratory, underground pipelines	benzene, toluene, ethylbenzene, cyclohexane
E	McDonnell Douglas	1,1-DCE, toluene, benzene, TCE, 1,1,1-TCA
F	Trico	1,1-DCA, TCE, PCE, vinyl chloride
J	Jones Chemical	TCE, PCE, 1,1-DCE
K	XMW-07 LNAPL	BTEX, 1,1-DCA
L	Jones Chemical	TCE, PCE, benzene, 1,1-DCE, 1,1-DCA
M	Montrose	chlorobenzene, p-CBSA, benzene, chloroform
N	unknown	BTEX, TCE, 1,2-DCA, 1,2,4-trimethylbenzene
O	unknown	benzene
P	P-1 LNAPL–underground petroleum pipelines	benzene, naphthalene
R	Armco	BTEX, chlorobenzene, p-CBSA
S	Gardena Valley Landfill	benzene, PCE, TCE, vinyl chloride
Y	Boring SBL0102 LNAPL–underground petroleum pipeline?	groundwater not tested

FIGURE 5.3-6

Benzene Concentrations and Local Groundwater Contamination Source Areas

Groundwater Remedial Investigation
Del Amo Study Area

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PLATES 5-1 TO 5-4
(17 OF 20 TO 20 OF 20)

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