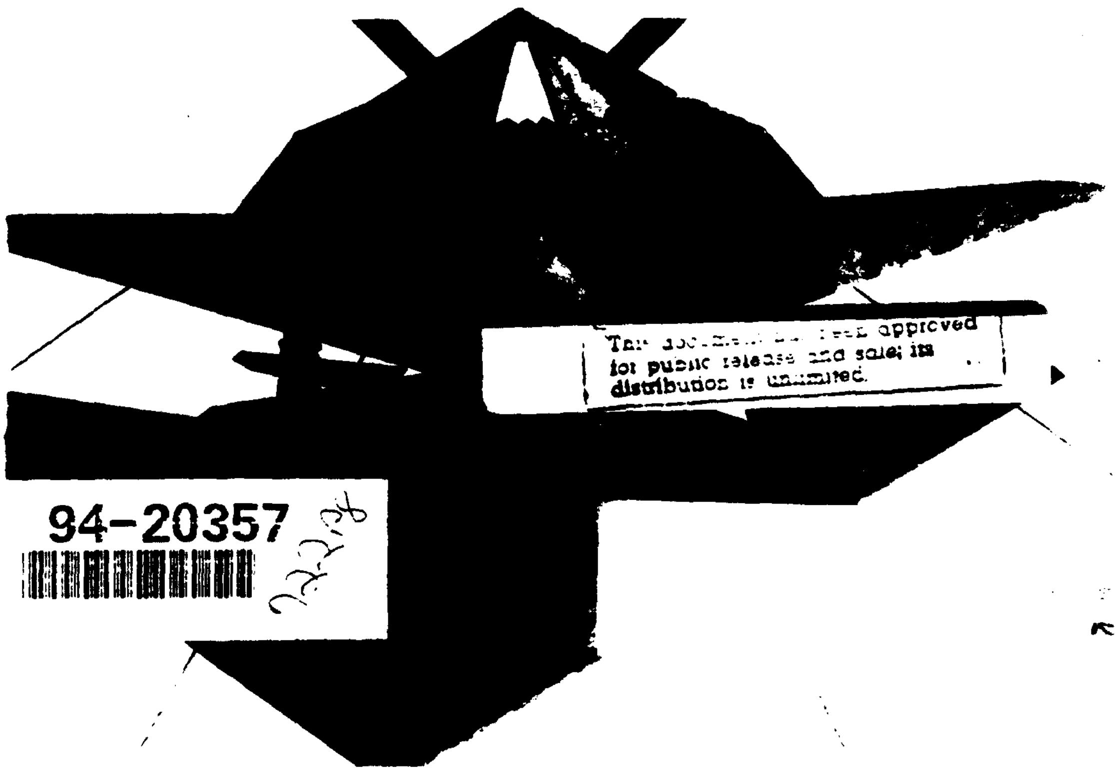
McClellan Air Force Base

Basewide Groundwater Operable Unit

Groundwater Operable Unit Remedial Investigation / Feasibility Study Report

Delivery Order 5066

Volume 2 of 3



DEPARTMENT OF THE AIR FORCE
HEADQUARTERS SACRAMENTO AIR LOGISTICS CENTER (AFMC)
McCLELLAN AIR FORCE BASE, CALIFORNIA

JUN 2 3 1994

MEMORANDUM FOR SEE DISTRIBUTION

FROM: SM-ALC/EMR
5050 Dudley Blvd, Suite 3
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SUBJECT: Groundwater (GW) Operable Unit (OU) Final Remedial Investigation/Feasibility Study (RI/FS) Document

1. Attached is the GW OU Final RI/FS. This document will be in the repository for public review on 1 Jul 94. The public comment period for the subject document and the GW OU Proposed Plan is 5 Jul - 6 Aug 94. The public meeting to discuss the Proposed Plan is scheduled for 20 Jul 94.

2. If you have any questions or comments, please contact me or Doris Varnadore at (916) 643-0830.

for KENDAL R. TANNER, P.E.
Remedial Program Manager
Environmental Restoration Division
Environmental Management Directorate

Attachment:
GW OU Final RI/FS

cc:
McClellan Admin Record

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Groundwater Operable Unit
Remedial Investigation/Feasibility Study Report

Volume 2 of 3

Prepared for

McClellan Air Force Base
Contract No. F04699-90-D-0035

Delivery Order 5066

Line Item 0014

Prepared by

CH2M HILL
2485 Natomas Park Drive, Suite 600
Sacramento, California 95833

SWE28722.66

June 1994

Notice

This report has been prepared for the Air Force by CH2M HILL for the purpose of aiding in the implementation of a final remedial action plan under the Air Force Installation Restoration Program (IRP). Because the report relates to actual or possible releases of potentially hazardous substances, its release prior to an Air Force final decision on remedial action may be in the public's interest. The limited objectives of this report and the ongoing nature of the IRP, along with the evolving knowledge of site conditions and chemical effects on the environment and health, must be considered when evaluating this report, since subsequent facts may become known that may make this report premature or inaccurate. Acceptance of this report in performance of the contract under which it is prepared does not mean that the Air Force adopts the conclusions, recommendations, or other views expressed herein, which are those of the contractor only and do not necessarily reflect the official position of the Air Force.

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Located in Other Volumes

CONTENTS—Volume 2 of 3 (Continued)

Located in Other Volumes (continued)

Response to Comments

Comments were received by McClellan Air Force Base on the March 1994 Draft Final Remedial Investigation/Feasibility Study for the Basewide Groundwater Operable Unit from the following agency:

- Department of Toxic Substances Control, May 4, 1994
- Department of Toxic Substances Control, May 6, 1994

Those comments, together with responses, are presented in this section.

SUBJECT: Draft Final Groundwater Operable Unit RI/FS
McClellan Air Force Base

PROJECT: SWE28722.66.FS

DATE: June 13, 1994

Mark Malinowski
Department of Toxic Substances Control

General Comments

1. **The RI/FS report should provide a summary or listing of the PGOURI recommendations.**

Response: A summary of the main PGOURI recommenoations is provided in Chapter 2 of the Final report.

2. **Chapter 1, Introduction, has a good introduction that helps the reader understand the organization of the chapter. Unfortunately the remaining Chapters did not incorporate the same approach or philosophy.**

Response: Comment noted.

3. **As discussed on April 28, 1994, in a teleconference between McAFB, U.S. EPA, and Cal-EPA, the following comments need to be addressed if an IROD can be completed for the proposed groundwater actions.**

   Innovative technologies should not be considered as the sole action for "hot spots".

   a. **Chapter 9 - Ground Water Treatment Options - A specific recommendation for a single treatment technology should be presented.**

   b. **Chapter 10 - Innovative Technologies - Prior to initiating in field in-situ treatment technologies, a containment system, that has been approved by the regulatory agencies must be in place and operating in the treatment area. The Department supports "long term" - up to two years - treatability studies for the air treatment innovative technologies. Innovative ex-situ treatment technologies should be evaluated as a "slipstream" as was done with the Purus system in OU-D.**

Response: The hot spots will be remediated using groundwater extraction wells to contain the contamination. Hot spots will not be remediated solely by the innovative technologies. All the groundwater containment alternatives include extraction wells in the hot spots. No further change to the feasibility study is necessary.

a. Selection of a single treatment technology in Chapter 9 is not appropriate because detailed evaluation of the three most promising technologies is necessary to select a single treatment technology. Chapter 13 now recommends a single treatment technology following detailed evaluation.

b. The Air Force agrees that the containment system must be functioning properly for initiation of the in situ treatability studies and has identified containment of the hot spots as a high priority. The Air Force also agrees with the DTSC comments on the air treatment and ex situ treatment technologies and will plan the treatability studies accordingly.

Primary Specific Comments

1. **Executive Summary. Include a base map (half-page) showing the OUs.**

The ground water priorities should be presented, in a tabular format as indicated in the Response to Comments (DTSC Primary Specific Comment 2).

Table ES-1 indicates that five of six "End Use" alternatives are "Purvey to local water districts," and implies a preference for distributing treated water to the water districts. Injection of the treated water is the preferred alternative.

The sentence describing the preferred interim remedial action currently "buried" in the last paragraph on page ix - "The preferred interim remedial.... and (re)injection of the treated water." - should also be the second paragraph of the Executive Summary (page iii).

Response: The alternatives have been restructured to remove the implication of a preference for the water purveyor end use. The description of the preferred interim remedial action has been moved up as suggested.

2. **Page 1-11, Section 1.4 (Repeat of previous DTSC comment)**

Bullet 1. The statement suggests that it is McAFB's intent and commitment to remediate all groundwater contamination that has migrated off-base. Remediation of all off-base contamination is neither prudent or appropriate.

Response: Text has been revised to reflect that the priorities for the remediation of specific areas of contamination will be developed with the regulatory agencies.

3. **Page 2-21, Section 2.3.2 (Repeat of previous DTSC comment)**

Since the PGOURI is the foundation of the RI/FS report present a summary or listing of the PGOURI recommendations.

Response: A summary of the PGOURI recommendations has been added to Chapter 2 of the Final report.

4. **Figures 3-2 through 3-8.**

The "Channel Migration Pattern" arrows and lines and "Extent of Contamination" lines do little to aid the reviewer in evaluating the cross sections.

Response: Channel migration lines and arrows have been removed as recommended.

5. **Page 4-64, Section 4.5.7.**

Paragraph 1. Add a reference to Figure 4-40. Line 5, The AdZa Well?

Response: The following text has been added to Section 4.5.6 after the first reference to Figure 4-40:

"Almost all base well locations were obtained from the Revised Final Well Closure Methods and Procedures Report (CH2M HILL, 1993). This report is presented in Appendix O." The reference to "AdZa" was a typographical error and has been corrected in the text.

6. **Page 4-105, Section 4.8 Paragraph 2.**

Monitor wells were not "removed" from the monitoring program. The Department and RWQCB staff met with McAFB to evaluate and establish "reasonable" sampling intervals given a wells past history (contaminant concentration) and proximity to ground water plumes.

Response: The paragraph has been modified in the following manner:

"Between 1991 and 1993, several wells were not sampled through the GSAP monitoring program. Sample intervals were selected based primarily on the wells' past contaminant concentration history and proximity to groundwater plumes. Some wells were not sampled because results measured from these wells had consistent nondetect VOC results. Spacial and temporal data gaps were not created. Other wells have VOC results above detectable levels, but were still not sampled. Temporal data gaps were created from not sampling these wells since the extent of contamination was unbound."

7. **Figure 4-41.**

The Caltrans well CT-2 location on the map is not correct.

Response: The location of CT-2 on Figure 4-41 has been moved to agree with Figure 4-40.

8. **Page 7-1, Section 7.1.1 (Repeat of previous DTSC comment)**

Bullet 1 specifies "Extent of offbase contamination...." The Department suggests that "offbase" be removed, since further work will be required both on and off-base, prior to design of the remedy.

Response: The text has been modified to incorporate the comment.

9. **Page 8-19 through 21. Figure 8-22, 23 and 24.**

The Figures did not make the transition from color to black and white well enough to differentiate the "Hot Spots" from "Background". The Department suggests either returning to color for these figures, or a different type of shading. The ground water elevation contours should also be labeled.

Response: Figures 8-22 through 8-24 will be returned to color to allow improved differentiation between the target volumes presented.

10. **Page 8-8, Section 8.3.1 (Refer to Prior DTSC Secondary Comment #18.)**

The response to the Departments comment was acceptable, however, the response should be incorporated in the text of the report. (Original Comment) The text describes dewatering in OU-A, and Figure 8-5 shows OUs G&H as being susceptible. Explain why, based on available data, modeling parameters used, etc., the area is more susceptible to dewatering.

Response: The text in the second paragraph has been revised to include the discussion on why areas of OU G and OU H are particularly susceptible to dewatering.

11. **Page 13-17, Section 13.1.1.**

Baseline requirement #10 should also include prevention of off-base contamination when BW 18 is decommissioned.

Response: The text has been modified to incorporate the comment.

12. **Page 13-18, Section 13.1.1.**

The Department suggests that preventing further off-base migration of contamination from OU-B is a higher priority than containing the existing off-base plume. The Department staff, at previous RPM meeting and discussions and in comments on the draft RI/FS report, have suggested that McAFB and the regulatory agencies meet with the City to discuss possible alternatives to remediating the OU-B off-base plume.

Response: The Air Force concurs with the priority suggested by DTSC and has arranged for meetings with the City. The Air Force will need to balance the DTSC priorities with the opinions of the public and other regulating agencies during the implementation of the remedial action.

13. **Page 13-21, Section 13.1.1, Bullet 4**

The final design packages for the treatment and end use systems will require approval by the regulatory agencies.

Response: It is the intent of the Air Force to have regulatory view and approval of all planning and design documents associated with the groundwater remedy.

14. **Page 13-25, Section 13.2.3, Figure 13-9**

Text should be added to explain Figure 13-9. It would appear the chart is trying to compare the ground water Target Volume risks to existing risks of breathing Sacramento air. Provide an explanation of "Ambient Background Risk".

Response: The following sentence was added to the second paragraph:

> Figure 13-9 is a comparison of the average risk of contracting cancer for American adults, the risk of contracting cancer as a result of Sacramento's current air quality, and the risks from consumption of the groundwater after the remedial action is in place (residual risk).

15. **Page 3-42, Section 13.3.1**

The recommendation that "Any remedy selected should be based on the MCL target volume." is inconsistent with comments submitted by the Department and the Central Valley Regional Water Quality Control Board and Section 13.3.3.

Response: The text has been modified to recommend the risk target volume.

16. **Following is a list of the Departments Geological Support Unit's (GSU) comments. "Editorial" comments not addressed in the Report include:**

Page RC-3, GSU editorial comment A-1.

Response: The following sentence has been added to the text:

"The OU boundaries are presented in Figure 2-1 of the Study Area Investigations chapter."

Page RC-3, GSU editorial comment C-1.

Response: The reader has been referred to Figures 4-43, 4-44, 4-45, and 4-46 for the well locations. The zones that the wells are screened in have been mentioned in the text.

Page RC-4, GSU editorial comment C-2.

Response: The text has been clarified to refer to OU B/C and not just OU C. The wells in questions are on the border between the two OUs.

Page RC-30, GSU editorial comment I-2.

Response: Table K-6, erroneously referred to as Table K-7, has been resorted.

Page RC-36, GSU editorial comment L-4.

Response: The wording in the text was changed, and any reference to flow rates was eliminated. The comparison was made between concentrations and volume of aquifer, and all references to the subject were moved to be in one paragraph (paragraph 3, page K-11) in which Figures K-11 through K-16 were referenced.

The five (5) GSU comments noted above should be addressed in the final Report, or McClellan should justify why they are not addressed.

17. **Page RC-2, GSU general editorial comment 2. The Report now places some figures (11 by 17 and larger) at the end of each chapter, and some figures (8 by 11) interspersed among the text. We appreciate McClellan's attempt to accommodate GSU's recommendation. However, when searching for a particular figure cited in the text, unless the list of figures in the table of contents is consulted first, it is unclear whether the figure will be found within the body of the chapter or at the end of the chapter. The original recommendation intended that <u>all</u> figures be placed into a single sequence at the end of each chapter. Unfortunately, to implement our recommendation would entail reprinting the entire Report merely to ensure correct pagination. Unless reprinting the**

Report becomes necessary on more substantive grounds, we do not advocate reprinting the Report merely to accommodate this recommendation. If it is necessary to completely reprint the Report, GSU recommends placing <u>all</u> figures into a single sequence at the end of each chapter.

Response: Chapter 4, Chapter 8, and Appendix J were the only sections with 11 x 17 and larger figures placed at the end of the section. At the beginning of each of these chapters, the following statement was provided instructing the reader on where to find the figures:

"As a convenience to the reader, all oversized figures (11" by 17" or larger) have been located at the end of the chapter."

18. Page RC-5, GSU significant comment D-2.

Both the stated response to this comment and the actual revision of the Report are inadequate. Although GSU believes that Section 4.2.2 <u>(Aquifer Properties)</u> should more fully discuss details, including limitations, of the aquifer tests performed at McClellan, the response merely defers to Appendix J. GSU focused on the need to discuss data from multiple-well aquifer tests. The response discussed slug test results. (The GSU comment made no reference to slug test results.) Section 4.22 (page 4-7) was revised to merely indicate that both "single-well and multiple-well aquifer tests" were evaluated, essentially treating our comment as an "editorial" comment. Even this minor revision is flawed, because the first paragraph of Section 4.2.2 (page 4-7) was revised to merely indicate that both "single-well and multiple-well aquifer tests" were evaluated, essentially treating our comment as an "editorial" comment. Even this minor revision is flawed, because the first paragraph of Section 4.2.2 (page 4-7) closes by stating, "No observation wells were monitored during these tests, preventing the use of distance-drawdown analysis or other analytical methods that provide data free of well inefficiency influences." Presumably, "these tests" refers to both single- and multiple-well tests. GSU recommends that the aquifer test results be more fully discussed in section 4.2.2, including the possible effects of partial well penetration on analytical results. Appropriate literature references should be cited in Section 4.2.2 for the Jacob and Papadopolus-Cooper analytical methods.

Response: Section 4.2.2 has been expanded to provide a more complete discussion of all single-well and multiple-well aquifer tests performed at the Base to date.

19. Page RC-10, GSU significant comment D-11.

Despite the response's reference to the response to GSU's significant comment D-8, describing the data set used to estimate volatile organic compound (VOC) target volumes, the text (page 4-100, paragraph 1) still

characterizes the data set as spanning the period January 1992 to January 1993. Rather than referring to the analytical data set as spanning the period January 1992 to January 1993, the Report should refer to Section 4.6.1 and Table 4-9, where it is made clear that the data set includes data older than January 1992.

Response: The test has been revised to refer to data set presented in Section 4.6.1.

20. Page RC-11, GSU editorial comment D-1.

The Report now incorrectly states that the Eocene Epoch approximately spans the period from "23 to 5 million years before the present." The Eocene Epoch represents the period 55 to 38 million years before present. The Report states that the Pleistocene Epoch represents the period "11,000 to 1.6 million years ago," which indicates that the Pleistocene spans nearly 11 billion years. In fact, the Pleistocene represents the period 1.6 million years to 11,000 years before present. The Report should be revised for accuracy.

Response: The text has been revised as recommended.

21. Page RC-13, GSU editorial comment D-8.

Table 4-4 cites "U.S. EPA, 1992" as a reference. The list of references (Chapter 14), indicates the EPA report was published in 1990, not 1992. This ambiguity should be resolved.

Response: The table has been corrected to incorporate the comment.

22. Page RC-17, GSU editorial comment D-23.

Figures 4-50, 4-52, and 4-54 should be revised to indicate the range of dates of analytical data upon which the contours are based. Regarding the fact that dates of sample data contoured on Figures 4-50, 4-52, and 4-54 (formerly Figures 2-53, 2-54, and 2-55), the fact that dates are indicated on the corresponding larger figures (Figures 4-51, 4-53, and 4-55) is irrelevant. Clearly the smaller figures are too small and cluttered for each date and data values to be posted, nor were such postings recommended by GSU. The GSU comment indicated that the small figures "should indicate the ... range of dates of sample data." intending that such information would be concisely shown in the explanation. Contour maps always have the potential to be re-presented out of context. As such the maps should indicate the date (or range of dates) of sample data. In this case, GSU believes it is important to indicate the relatively large span of sampling dates (up to 11 years in the draft version - nearly 3 years in the current version).

Response: The following statement has been added to Figures 4-50, 4-52, 4-56, 4-70, 4-71, and 4-72:

"Contours based on representative concentrations that were measured from 1988 to 1994. Selection of representative concentrations is discussed in Section 4.6.1."

23. Page RC-19, GSU editorial comment D-30.

The comment noted that the method of derivation of K_d values shown in Table 4-14 (formerly Table 2-10) was not discussed in the Report. Although the response and Table 4-14 cites U.S. EPA, 1990 as the source of K_{oc} values, it is still unclear how K_d values were derived. The comment should be addressed more substantially.

Response: The following equation has been added to Table 4-14 to explain how K_d was calculated: $K_d=f_{oc}*K_{oc}$.

24. Page RC-29, GSU editorial comment H-1.

GSU disagree with the response - "The collection of new data in areas where interpolation is currently used to define the target volume boundaries can indeed significantly reduce the volume extent." GSU reiterates that it is only fair to predict that such additional data can serve to reduce the uncertainty of the target volume. In other words, new data points could either reduce or increase the volume extent, depending on whether the new well penetrates contamination that is less concentrated or more concentrated than that predicted by the interpolation method. The sentence quoted in our original comment should be clarified.

Response: The text of Appendix E has been modified to state that additional monitoring wells will reduce the uncertainty in the location of the target volume boundaries.

25. Page RC-34, GSU significant comment L-1.

GSU reflects that the original comment be addressed more effectively. McAFB's response indicates that linear interpolation was not used and implies that contouring the target volumes by hand somehow precludes the use of linear interpolation. GSU believes this is an invalid implication. Perhaps linear interpolation really was not used, but in defense of the original comment, GSU provides the following quotes, from page K-5 of the draft Report: "Linear interpolation between known data points was used to estimate the spatial distribution of VOC contamination in the aquifers at McClellan AFB.... Linear interpolation was used to estimate the location of the VOC concentration isopleths between known data points ...." The Report then indicates that linear

interpolation of target volumes in areas of low concentration "... may be overestimated."

Response: McClellan AFB does not understand why the comment is quoting the Draft RI/FS. The response to the comment explains that linear interpolation was not used in the Draft Final RI/FS, in any way, to delineate the extent of contamination. A single contouring program could not be used to contour the concentrations because so many factors influence estimating the contours (e.g., knowledge of source areas, groundwater flow directions, contaminant properties and monitoring history at wells).

For example, the OU G and OU H A zone plume was drawn as one large contamination plume because the industrial waste line is located in this area and is considered a source of contamination. VOCs have consistently been measured in MW-185, at two times in MW-226, and only once, during the last sampling period, in MW-194. The OU G and OU H A zone target volume was extended north of MW-102 (which was nondetect) because VOCs were measured in the B zone in MW-103. Additional monitoring in this area has been recommended in Chapter 13.

The eastern OU A target volume was extended southward because high concentrations of TCE were measured in MW-158 and MW-1067 in the fourth quarter of the 1993 sampling period. These data were not fully incorporated into the data set because at the time of the target volume generation, the data were not available in electronic format (as discussed in Section 4.6.1).

In cases where a detect result was measured on the outer edge of the monitoring network, the extent of contamination was estimated by considering proximity to source areas, evaluating the groundwater flow directions, and monitoring history of the area of interest. For example, the western offbase plume was drawn as one large plume oriented in a northwest-southeast direction. The source of the contamination in this area is believed to be OU D. Historically, groundwater from OU D flowed southwest, and a plume from OU D could have extended southwest with the groundwater flow. It is possible after the operation of the OU D extraction wells, this offbase plume "broke off" from the main OU D plume. Groundwater in this offbase area now flows in a southeast direction towards the production wells south of the Base. Therefore, the plume has a northwest-southeast orientation. Concentrations in MW-1019 have been declining with time, and it is close to the boundary of the target volume. Concentrations in MW-1029 and MW-111 have been constant, and the edges of the target volumes were not drawn as close. There is still uncertainty with the true extent of contamination in this area and additional data points could change the interpretation of the extent of contamination.

Great care was taken to incorporate all possible data and all factors in creating the data set, delineating the extent of contamination, and generating the target volumes. Almost all the thinking processes have been discussed in the Draft Final report. Contours were drawn by hand because there is no other way to consider so much information with computer interpolation packages. Linear interpolation was not used to delineate the contours. Although linear interpolation was used in the Draft report, the Draft Final report and the Final report are different.

26. **Page RC-36, GSU editorial comment L-3.**

Despite the response's assurance that "Figures K-2, K-3, and K-4 will resemble the extent of prevalent contamination figures presented in the Conceptual Model [Figures 4-50, 4-52, and 4-54)," the two sets of figures are just as different from each other in the draft final as they were in the draft. The appendix figures should not merely "resemble" the primary figures? GSU again requests that the appendix figures "explicitly indicate on which primary figures they are based, and....indicate the date(s) of sample data on which they are based." In the case of Figures 4-50, 4-52, and 4-54 (see comment A-7, above), Figures K-2, K-3, and K-4 should also indicate (e.g., in the explanation) the range of dates of data upon which each figure is based. GSU's original comment should be more effectively addressed.

Response: The following statement has been added to Figures K-2, K-3, and K-4:

"These figures are based on target volume Figures 4-70, 4-71, and 4-72 presented in the Conceptual Model. The extent of contamination contours are based on representative concentrations that were measured from 1988 to 1994. Selection of the representative concentrations data set is discussed in Section 4.6.1."

27. **Page RC-36, GSU editorial comment L-5.**

There are new discrepancies between Tables K-2 and K-5 (formerly Table K-5). (See "Total Mass" values for TCE and PCE). The discrepancies should be corrected.

Response: The discrepancies have been corrected.

c. **Additional comments**

1. **Table K-1. Of the four prevalent VOCs that have been selected as compounds of concern (Table 4-10), three have a maximum nondetected value greater than the maximum concentration level (Table K-1). Of the 22 VOC species included in Table K-1, 15 have a maximum nondetected value greater than the maximum detected value. The greatest disparity is in the case of trichlorofluoromethane, for which the maximum nondetected value is 1,100 $\mu g/l$, compared to its**

maximum detected value of 15 μg/l. Although it is not practical for us to determine the proportion of analyses conducted with elevated detection limits, we must state our concern that many "non-detects" may be invalid. We recommend that every effort be made in the future to keep detection limits at or below the MCL for analytes that have an MCL. We also recommend that Appendix K or some other section of the Report be revised to evaluate and discuss the significance of the elevated detection limits documented in Table K-1.

Response: The reference to detection limits has been changed in the table to refer to reporting limits. The following paragraph was included in the text to explain the difference:

"Some discrepancy may be noted with the maximum nondetected reporting limit when compared to the detected values. The reporting limit was raised because of sample dilutions. Sample dilutions are necessary when there is a high concentration of one or more compounds in the given sample. The reporting limit is increased as a function of the dilutions, and all compounds are reported at the values detected in the final dilution and qualified using the final reporting limit value. Procedures to keep the reporting limits at or below MCLs, for contaminants with MCLs, are included in the Basewide RI/FS QAPP Update (Radian, 1994)."

2. **Page K-9, top of page. The Report states, "only ____ [sic] wells were sampled within the last 2 years." Obviously this paragraph is in draft form and needs revision. Appendix K should be revised for accuracy.**

Response: The revision has been made in the Final version of the report.

3. **Figures 4-7, 4-8, and 4-9. The contouring of transmissivity values shown in these figures is greatly improved over the draft version figures. However, each figure displays a minor mismatch between a posted transmissivity value and nearby contours. In Figure 4-7, MW-175 (T = 965 ft^2/day) is closer to the 500 contour than the 1000 contour. In Figure 4-8, MW-195 (T = 275 ft^2/day) is closer to the 500 contour than the 250 contour. In Figure 4-9, MW-1063 (T = 613 ft^2/day) is situated between the 1000 and 1500 contours. GSU recommends that the contours in these figures be adjusted to better honor posted transmissivity values.**

Response: The contours have been revised in the Final version of the report.

4. **Figures 4-14 and 4-15. Ground surface is indiscernible in these profile illustrations of the vadose and saturated zones. The figures should be revised to graphically depict ground surface.**

Response: The ground surface elevations have been explicitly added to these figures.

5. **Page 4-77, paragraph 3, and Figure 4-42. The Report indicates that Figure 4-42 includes a time-series graph for "cis-1,2-DCE", but the graph in Figure 4-42 to which the Report probably refers actually shows "Total 1,2-DCE". This minor discrepancy should be resolved.**

Response: The minor discrepancy has been resolved.

6. **Page 4-79, Table 4-11. The table mistakenly indicates that there are a total of 115 extraction wells in the monitoring network. There are in fact only 15 extraction wells. Table 4-11 should be revised for accuracy.**

Response: The typographical error has been corrected.

7. **Page 4-85, bottom of page. The Report indicates that "maximum VOC results collected from January 1992 to January 1993" were used to estimate the extent of VOCs. However, this statement contradicts with Section 4.6.1, in which it is shown that analytical data older than 1992 were also used. The Report should be revised for accuracy. See Comment A-4.**

Response: The text has been revised to incorporate the comment.

8. **Table 4-9 and Table K-6. These tables are improperly sorted, such that, for example, MW-102 occurs between MW-1019 and MW-1020. The table should be re-sorted. Also see Comment A-1.**

Response: These tables will be sorted numerically.

9. **Cross sections in Chapter 3. Several cross sections include graphic elements which purport to indicate "channel migration pattern." We submit that such indications are highly speculative and should not be included on the cross sections.**

Response: Channel migration arrows and lines have been removed as recommended.

Response to Comments

Comments were received by McClellan Air Force Base on the November 1993 Draft Remedial Investigation/Feasibility Study for the Basewide Groundwater Operable Unit from the following agencies:

- Regional Water Quality Control Board
- Department of Toxic Substances Control
- U.S. Environmental Protection Agency

Those comments, together with responses, are presented in this section. The Chapters in the Draft copy have been renumbered in the Draft Final as indicated in the Table of Contents.

SUBJECT: Draft Final Groundwater Operable Unit RI/FS
McClellan Air Force Base

PROJECT: SWE28722.66.FS

DATE: March 28, 1994

Alexander MacDonald
Regional Water Quality Control Board

Letter dated January 13, 1994

1. **Regional Board staff cannot accept a target volume of less than 10^{-6} risk target volume. Any reduction from this would not be protective of the aquifer as a drinking water source.**

Response:

The Air Force concurs with the establishment of a 10^{-6} risk target volume as the goal of the interim groundwater remedy. Discussion of the preferred alternative has been changed to reflect this comment.

2. **Target volumes may differ between plumes, either a 10^{-6} risk or background target volume. This is due to the complexity of capturing/treating various plumes. It may be easy with little increase in cost to capture all concentrations above background for a particular plume. Given the uncertainties in target volumes at this time, staff cannot recommend a relaxation from containment and treatment of concentrations exceeding background concentrations.**

Response:

This comment appears to conflict with Comment 1 above. Given the approach of developing an Interim Record of Decision (ROD) for the Groundwater Operable Unit (OU) in 1994, followed by a Basewide ROD (final) in the future, it appears the 10^{-6} risk target volume is appropriate at this time, given the uncertainty in estimating the background target volume. It is important to note that each target volume has areas of uncertainty that will require further data collection, either through Hydropunch sampling or monitoring wells, and the estimation of the difference between capture of the 10^{-6} risk target volume and the background target volume will improve as additional data are collected. There are administrative vehicles to change target volumes in the future, particularly an Explanation of Significant Differences to amend the Interim Groundwater ROD or the Basewide ROD.

3. **Plumes should be prioritized and remediated accordingly. Staff does not recommend attacking the very low concentrations in the off-Base plume to the west at first. Eliminating the flux of contaminants off-Base should be done before funds are spent on remediating that off-Base plume. The only off-Base plume that might have a high priority would be that off of OU A. Off-Base flux and hot spot remediation on-Base should be where dollars are spent.**

Response:

The priorities have been revised according to the comment. The commentor suggests that the OU A offbase plume should be the only offbase plume to receive high priority. However the plume moving offbase south from OU B should also receive a high priority.

4. **Conducting additional remedial investigation (plume definition) should be done in phases with hydropunch or depth-specific sampling done prior to placement of monitor wells. Monitor well construction would then follow and the plumes and target volumes refined. Then extraction systems would be installed in a phased approach to allow a more efficient extractions system to be designed.**

It is understood that the extraction/treatment proposal presented in the report assumes no new information had been gathered prior to monitor and extraction well installation, and treatment plant design. In reality, the target volumes will be smaller than that presented in the report after additional sampling is done.

Response:

It is the intent of the Air Force to implement the project in a phased approach, as defined in the schedules in Appendix S. The phasing of the implementation has been more clearly illustrated in the new Chapter 13 (formerly Chapter 11). With respect to the use of Hydropunch or depth-specific sampling prior to placement of monitoring wells, it is important to match the data collection technique to the data collection need. In many cases the use of a monitoring well without further water quality data is appropriate because the function of the well is to provide water level data to evaluate the capture zone of the interim remedy. If the only need is a one-time water quality value, then indeed the Hydropunch will be used.

The commentor noted the alternatives were developed assuming no additional data were collected prior to design and that is correct, with the exception that the decision analysis model was used to evaluate if the best strategy would change if the flow was considerably lower than estimated from the current data set. The conclusion was the strategy did not change until the flow on the east side was reduced to less than 100 gpm; the decision on the treatment technology is relatively insensitive to changes in flow from 100 to 700 gpm. The target volumes should be smaller for the A, B, and C zones, but the data set did not allow calculation of a target volume for the D/E zones so the total flow may be similar or greater than estimated today.

5. **McClellan should not rely on selling of the extracted and treated ground water to the water purveyors. With the current Department of Health Services (DHS) philosophy, there is plenty of "clean" water which the purveyors can use as a water source. McClellan is encouraged to pursue the matter with DHS and if they reverse their current position and allow the chosen reuse, staff recommends the water be used on-Base, to the extent possible, to off-set the loss of BW-18.**

Response:

The Air Force prefers the use of reinjection as the preferred alternative for water end use, given the DHS policy and philosophy. Reinjection testing is slated to take place in 1994.

Memorandum Dated 13 January 1994

I. VOLUME I

A. SUMMARY

1. Significant Comments

a. **Page viii, Table S-1. At this time, staff does not believe it is wise to place a good deal of faith in the ability to sell extracted and treated ground water to the water purveyors. This is the chosen alternative for the end-use option and Department of Health Services (DHS) policies do not allow for this end-use given the current availability of uncontaminated water sources. Staff encourages McClellan to pursue the concept of the chosen option with DHS. Alternately, injection of the treated water would preferred to discharge to Magpie Creek. The first choice should be to use the water on-Base as much as possible. The treated ground water could be all, or a portion of, the replacement supply for the closure of BW-18. It is not clear whether the DHS policy would apply to the reuse of the water on-Base.**

Response:

The Air Force is pursuing reinjection as the preferred alternative, and the testing of reinjection will take place in 1994. The issue of reuse onbase as potable or non-potable supply will continue to be pursued in parallel with the testing of reinjection's technical feasibility.

2. **Editorial Comments**

a. **Page v, first paragraph. It is stated that ground water contamination under OU D appears to be declining with time due to biodegradation and response to remedial actions. Declining concentration levels are also due to the temporary attenuation of the contaminants in the vadose zone as the ground water has declined 1-to-2 feet per year.**

Response:

The text has been changed to incorporate the comment.

b. **Page v, paragraph 3, last sentence. It is stated that contamination under McClellan Air Force Base represents a potential threat to the quality and useability of ground water as defined by State of California policies. The contamination in vadose zone *is* a threat to the quality and useability of the ground water beneath the Base. In addition, the ground water has already been degraded sufficiently to effect the useability of the ground water.**

Response:

The comment has been incorporated.

B. INTRODUCTION

1. **Editorial Comment**

a. **Page 1-10, first paragraph. The second sentence of this paragraph states that the OU C and OU B extractions systems currently produce approximately 90 gpm. Does this flow include all of the flow from the three extraction wells installed under the OU B EE/CA?**

Response:

The 90 gpm does include the flow of the OU C extraction wells.

C. CHAPTER 2, CONCEPTUAL MODEL

1. **Significant Comments**

a. **Page 2-33, physical properties of the aquifer. The moisture content is listed to be 15 to 25 percent. What is the purpose of moisture**

content in a saturated aquifer? Does this mean that the soils with a porosity of 35 to 45 percent will have 10-20 percent air by volume, potentially exceeding the percent water by volume in the soil matrix.

Response:

Moisture content equals the weight of water divided by the weight of the soil matrix. In a saturated media, the voids are filled completely with water. The saturated and unsaturated moisture content are listed in the text as follows:

- Moisture content from vadose zone soils: 0.15 to 0.25 percent
- Saturated moisture content: 0.30 to 0.35 percent

Vadose zone moisture content, total porosity and dry bulk density were sampled for during field activities. The saturated moisture content was calaculated as follows:

$w_{sat}\% = W_w/W_{soil} = (V_{total} * n_{total})/(V_{total} * \text{dry bulk density})$. The total volume cancels.

b. **Page 2-70, Water Balance. It is stated that 2.5 inches of rainfall percolate to recharge the aquifer. One cannot assume that percolation takes place over the entire Base. A significant portion of the Base is paved, or contains buildings and other less pervious surfaces. In addition, the percolation rate is not high at the Base as evidenced by the failure to reclaim wastewater at Base by land application. Samples analyzed for moisture content during RI activities do not indicate much recharge.**

The third paragraph discusses the flow through monitor zones A, B, and C close to BW-18 and gives values of 27, 67, and 262 acre-feet, respectively. How were these values developed? Through what vertical plane did this volume of water pass? Was it a plane or cylinder around the well? What distance from the well was the surface through which the given volume of water passed? Do the latter sentences discussing water losses/withdrawals deal with the same plane around BW-18? The loss of 55 acre-feet/year from the A-zone is from near BW-18? Throughout the Base? All of OU B?

The last paragraph discusses vertical flow between monitor zones A, B, and C. Do the volumes given represent vertical flow across the whole Base?

These are listed as significant comments since they impact calculations on which the model is based. A separate appendix may have been appropriate to detail how the water balance was developed and the calculations presented.

Response:

The water budget section has been completely rewritten to address the concerns stated in this comment. Please refer to the revised water budget section in Chapter 4 of the revised RI/FS Report.

c. **Page 2-90, paragraph 3. This paragraph discusses the concentrations of nickel in ground water and states that it is above MCLs in certain locations on-Base but is not a contaminant of concern. How can a metal above MCLs not be a contaminant of concern? Concentrations of metals may effect the water end-use options. Even if metals are not above MCLs, the discharge of the extracted ground water will have metal limitations placed on it if the discharge is to a surface water or injected into the ground water aquifers. The metal concentrations should be closely scrutinized and compared to the effluent limitations for the GWTP discharge and background concentrations in ground water to assess potential treatment options if necessary.**

Response:

No metals can be selected as contaminants of concern (COCs) until a detailed evaluation of metals is performed. An evaluation of metals cannot be performed in this interim RI/FS for the following two reasons:

- Background groundwater metals concentrations have not been established for groundwater beneath McClellan AFB. Hence, it is not possible to differentiate between metals in groundwater that occur naturally because of mineral dissolution and metals contamination from Base activities.

- A variety of field procedures have been used and it is not possible to distinguish between results from different sampling procedures. Historically, both filtered and unfiltered samples have been collected at low, and possibly high flow rates. Turbid samples are generally collected at high flow rates that may overestimate groundwater metals concentration.

Background concentrations must be established and field sampling techniques must be standardized before the extent of metals concentrations can be evaluated. A discussion of metals as a data gap is presented in the conceptual model.

Metals concentrations in the influent to the groundwater treatment plant have been addressed in the FS. The cost of adjusting the treatment system to treat potentially elevated concentrations has been evaluated and is discussed in the FS Approach and the Implementation plan chapters.

d. **Figures 2-65, 2-66, and 2-66. The extent of contamination defined by background, 10^{-6} risk level, and MCLs are presented using a linear extrapolation. This method greatly exaggerates the extent of contamination, especially in the upgradient direction. Since these target volumes are used to generate the number of wells, volumes of water to extract, treatment volumes, end-use options, and time to cleanup, and the costs associated with them, further refinement is necessary. If it is desired to demonstrate that the cost to capture and cleanup to background concentrations is unacceptably high, then the target values must be more realistic. The current volumes will exacerbate the cost differential between remediating the three target volumes.**

The new data from the southern OU A plume should be incorporated to the extent possible.

Response:

Revised target volumes are presented in the Draft Final Remedial Investigation/Feasibility Study (RI/FS). They were delineated from groundwater samples from 267 monitoring wells and 5 extraction wells, and hydropunch samples from 7 borings. Extraction wells with screened intervals greater than 20 feet long were not included in the target volume generation. Data from the following sources were examined to delineate the target volumes:

- Data from the Radian Groundwater Sampling and Analysis Program (GSAP) data base up to third quarter 1993. Risk values were calculated for these samples.
- Groundwater data from the OU D RI Summer/Fall 1993 Sampling effort
- Data from five southern OU A wells

Few wells in the A Zone of OU G and H, the eastern edge of the OU A plume, and the southern OU B plume have groundwater concentrations that fluctuate above and below maximum containment levels (MCLs). Data from the fourth quarter 1993 sampling was studied to determine how most recent concentrations affect target volumes. For example, trichloroethene (TCE) was measured at 8.1 $\mu g/l$ in August 1993 in MW-194 in OU G, but at 3.0 $\mu g/l$ October 1993. This is the only well in the region that an MCL target volume would or would not exist depending on which concentration was used. The target volume was presented because concentrations are fluctuating. These fluctuations will be discussed in the report. The more conservative target volume was selected.

Linear interpolation was not used. With significantly more data points, especially from wells that were measured consistently non-detect and thus dropped from the sampling program, target volumes were realistically bound. In areas where the extent was unbound, information about groundwater flow directions and distance from source areas were used to delineate the target volumes. Unbound conditions will be shown in dashed lines and bound condition will be shown in solid lines.

e. **Page 2-136, third bullet. How was this information used to alter the extent of contamination? Show the difference between before using the information and using the information.**

Response:

Monitoring Well MW-194, MW-185 and MW-226 in OUs G and H all measured volatile organic compound (VOC) concentrations above detectable levels but are located 2,000 to 5,000 feet apart. These wells were used to define a single plume because it is believed that the Industrial Waste Line (IWL) is the primary source of contamination in this area. Over time and under groundwater flow, the leakage from the IWL has merged into one low contamination plume. If the IWL was not a potential source, several smaller target volumes would have been delineated with OU-specific activities as the primary source of contamination. This will be discussed in the text.

f. **Page 2-137, paragraph 1. It is stated that linear approximation does not overestimate the mass because most of the mass is located in the hot spot areas. The mass will still be overestimated, just that the degree of overestimation will not be as great.**

Response:

Comment noted. Linear interpolation was not used in the mass estimates or the generation of the target volumes.

g. **Page 2-137, paragraph 4. It is stated that the wells that had measured VOC results above detection levels that had been removed from the monitor network created temporal data gaps. The past values for those wells, trends in concentration, location relevant to the plume, and professional judgement should be used to bring the data point onto the plot if it helps define the extent of contamination. In general, most of the wells that had detectable concentrations and were removed from monitoring, at least temporarily, were due to the constant low concentrations, known ground water flow direction, and redundancy. Many of the wells are scheduled for sampling and analysis a minimum of once every two years.**

Response:

To generate the revised target volumes, 267 groundwater wells, 7 hydropunch samples from OU D, and 5 extraction wells were used (versus approximately 161 wells that were used to generate the original target volumes). Several wells that were not included in the original data set were added to the revised data set to create the revised target volumes. These wells were sampled prior to 1992, at consistent concentrations (mostly nondetect), and thus were dropped from the monitoring program because no concentration changes were observed. These data points were brought back onto the plots. Data from the Radian GSAP program up to and including 3Q93 was used to delineate target volumes. Risk calculations were performed on this data set. The 4Q93 concentration data was also examined, but was not incorporated fully into the target volumes because it is not available in electronic form and risk calculations cannot be performed (see response to Comment d on how 4Q93 data was used). New data from Jacobs and the OU D RI were also used to further delineate the southern OU A plume and the OU D plume, respectively. Concentrations for each well were selected in the following manner:

- Wells that were last sampled prior to 1988 were not included in the data set. Actually, the last time these wells were sampled was in 1986.

- If a well was sampled in 1992 or 1993, the most recent concentration was selected, because this time period is considered representative of current conditions.

- If a well was sampled prior to 1992 (but after 1988), the time series of the well was examined in an attempt to extrapolate current conditions. In many cases the wells were consistently measured to nondetect (ND) levels and thus ND levels were assigned. For wells that observed fluctuating conditions, 4Q93

GSAP data was used if available, otherwise an average was taken.

This analysis is presented in the RI/FS.

h. **Page 2-138, paragraph 3. It is stated that no additional C Zone monitor wells need to be added in OU A to the sampling program because only two C Zone wells have ever had samples that exceeded the MCL. Were these wells located in the best areas to detect if concentrations in the C Zone exceed MCLs? The wells and delineated plume layer should be reviewed to make sure that no additional C Zone wells are needed in OU A.**

Response:

The last sentence of paragraph 3 has been deleted. Additional wells in the C Zone of OU A are proposed for water quality, hydraulic control, and/or to perform aquifer testing. These wells will assist in confirming the presence or absence of elevated levels of VOCs in the A Zone of OU A.

i. **Page 2-142, last paragraph. Adding additional wells to the north of OUD is of questionable value. The trend for MW-1026 is not indicative of a source from OU D.**

Response:

At least one well to the northeast of the OU D source areas should be installed to determine the northeastern extent of contamination and the northeastern extent of hydraulic control of the OU D extraction wells. Hydropunch samples from C2, collected during the summer 1993 RI sampling, yielded ND for all groundwater VOCs and hence, bound the northern extent of the plume. Discussion of OU D as a source of contamination at MW-1026 has been deleted from the text.

2. **Editorial Comments**

a. **Where is Page 2-8?**

Response:

Figures that are 11 inches by 17 inches take up two pages. Page 2-8 is the second half of Figure 2-3 that started on page 2-7. In the Draft Final, 11-inch by 17-inch figures will be put in the back of the chapter.

b. **Page 2-13, Stiff and Piper Diagrams. Stiff and Piper diagrams should be developed for the D and E aquifers since ground water injection into to those and deeper aquifers is a potential end-use option for disposal of treated ground water. Similar water quality values are required for both the injected water and the water of the zone into which the injection is to take place.**

Response:

Inorganic water quality information is currently not available for groundwater monitoring wells in the D and E Zones. Therefore Stiff and Piper diagrams for wells in the Monitoring Zones D and E cannot be prepared at this time. As part of Phase I of the remedy, constituents in native groundwater will be compared with constituents in treated reinjection water to ensure the compatibility between the two types of waters and to satisfy regulatory requirements. The recommended analytes for reinjection evaluation included the following:

- TPH, EPA 418.1
- Metals, SW 6010
- Arsenic, SW 7060
- Lead, SW 7421
- Mercury, SW 7470
- Selenium, SW 7440
- Semivolatile Organics, SW 8270
- BOD, EPA 405.1
- COD, EPA 410.4
- Alkalinity, EPA 403
- Hardness, EPA 130.1
- Nitrogen, Kjeldahl, EPA 351.2
- TOC, EPA 415.1
- TDS, EPA 160.1
- TSS, EPA 160.2
- Inorganic Anions, EPA 300.0
- Purgeable Hydrocarbons, SW 6010 and Purgeable Aromatics Volatiles, SW 8020

Concentrations in the reinjected water must be equal to or less than the concentrations in the native groundwater. Native groundwater will be collected from Base wells or nearby municipal supply wells, or from a newly installed deep monitoring well at the proposed injection location (to obtain site-specific water quality information).

c. **Figure 2-9. This figure presents transmissivity value contours for the A Zone. Several of the individual data points are significantly outside of the values of the contour lines on either side of the data**

point. This is readily apparent for monitor well MW-12. It should also be noted that the transmissivity values will be dependent upon the type of sediments into which the screened intervals for the monitor wells were completed. Some A zone wells may not have been completed in permeable materials, while others were. Contouring values from different aquifer tests completed in differing materials may not provide a good indication of changes in transmissivity across the Base. In addition contour lines are developed well past any plotted data points. How far can the data be extrapolated? Staff recommends deleting the contour lines from the figure.

Response:

The data presented in Figure 2-9 will be recontoured.

d. **Figure 2-10. The comments for Figure 2-9 apply to this figure also.**

Response:

The data presented in Figure 2-10 will be recontoured.

e. **Figure 2-11. The comments for Figure 2-9 apply to this figure also.**

Response:

The data presented in Figure 2-11 will be recontoured.

f. **Page 2-33, Table 2-4. The maximum detected value of TCE is 68,000 μg/l in MW-128 in OU C. Is the mean concentration value including all non-detects? If so, what value is assigned to the non-detect concentration used in determining the mean.**

Response:

The mean concentrations were calculated with a value of 0 (zero) assigned to NDs. The detection limit, or a fraction of the detection limit, was not used because, in several instances, the detection level was higher than several of the detected values. A footnote has been added to Table 2-4 to explain how the means were calculated.

g. **Page 3-47, first paragraph. The last sentence says that the only discharge of ground water is by pumping of irrigation and supply wells. Ground water extraction is occurring on-Base as part of remedial actions.**

Response:

The last sentence of the first complete paragraph has been revised as follows, "At the present time, the only discharge of groundwater is by pumping of irrigation and supply wells and by the pumping of onbase extraction wells as part of the remedial actions."

h. **Figure 2-23. This figure presents historical ground water flow directions. Are these directions good for any point on the Base? Wouldn't local influences produce potentially different flow directions, since this figure uses data from surrounding supply wells in the Sacramento Area?**

Response:

Figure 2-33 has been deleted. The flow vectors presented in the figure are in the vicinity of OU D only. This was mentioned in the original text.

i. **Where are Figures 2-31 and 2-32?**

Response:

These figures are C-sized figures that are located in pockets at the back of the chapter. The text indicates the location of these figures.

j. **Page 2-59, paragraph 2. It is stated that the 1993 water levels for the A-one were obtained from the PGOURI. The PGOURI was completed well before 1993. I believe the data came from the GSAP.**

Response:

The source of the 1993 water levels has been corrected to reference the GSAP.

k. **Figure 2-42. The horizontal flow values are different in the Figure than those presented in Table 2-5. In addition, if a water balance is applied to the values shown on the Figure for the A monitor zone, then there should be a net yearly increase in the volume of water in the A zone beneath the Base. With 600 acre-feet of recharge from the vadose zone, 60 acre-feet removed by extraction, and 400 acre-feet moving from the A zone to the B zone (horizontal flow is assumed to enter and exit the Base boundaries at the same volume), there would be a net increase of 140 acre-feet per year. How is this possible with declining water table? The same thing can be said using the values presented in Table 2-5.**

Response:

The water budget section has been completely rewritten to address the concerns stated in this comment. Please refer to the revised water budget section in Chapter 4 of the revised RI/FS Report.

l. **Page 2-80, paragraph 4. It is stated that different recharge mechanisms supply water for the various water purveyors. In reality, the recharge from the foothills and the rivers combine to supply the water to the aquifers from which the water purveyors obtain their water.**

Response:

Comment noted. Text will be revised to reflect this comment.

m. **Page 2-81, Figure 2-43. Several of the Base wells that are shown to be either active or inactive have actually been abandoned. BW-8, and BW-13 are examples.**

Response:

The figure has been revised to show wells that were abandoned between December 1993 to August 1993.

n. **Page 2-82, Figure 2-44. Many of the supply wells on-Base are shown to have no available pumping information for them. There is pumping information available for BW-18 (See appendices) and most of the other wells should be shown as abandoned or inactive. There is data available from the pumping of the Base supply wells. This information, along with off-Base municipal supply wells, is compiled by Radian for the Base.**

Response:

The pumping rate of BW-18 has been added to Figure 2-44. The wells that are abandoned or that will be abandoned in Phase III of the well abandonment program have also been distinguished on this figure.

o. **Page 2-85, paragraph 4. The four supply wells listed as being abandoned are not so designated on Figures 2-43 and 2-44. BW-8 has been abandoned.**

Response:

All wells decommissioned from January 1992 through January 1994 have been so noted in Table 2-6, and Figures 2-43 and 2-44.

p. **Page 2-88, paragraph 2. In addition to the removal of contaminants by ground water extraction and plume migration, the reason for the reasons for the increasing numbers of detections and decreasing concentrations can be attributed to the addition of wells to define plumes. Many new wells have been placed to define the extent of plumes and to determine ground water quality in previously undefined regions. This has led to the addition of numerous wells in relatively low ground water contamination areas.**

Response:

Comment noted. The text has been revised in the following manner, "For most contaminants, the frequency of detections has been increasing with time, but their maximum and mean concentrations have been decreasing. This may be the result of the following:

- Because of regional, Base, and extraction well pumpage, contaminant plumes have been migrating.
- Contaminant mass has been removed by extraction wells installed for remedial actions.
- Several wells that have been sampled consistently at non-detect levels have been dropped from the monitoring program.
- New wells have been added to the program to further define the plumes. This has led to the addition of numerous wells in relatively low groundwater contamination areas.

Hence, compounds have been detected in more sampled wells, but at lower concentrations."

q. **Page 2-88, paragraph 5. Although vinyl chloride has not been detected in any of the monitor wells sampled in 1992, vinyl chloride has been detected in the extraction wells in OU D and at the influent to the GWTP in 1992 and 1993.**

Response:

Text has been added to the section discussing natural attenuation at McClellan AFB that states vinyl chloride was detected in the influent to the groundwater treatment plant in 1992 and 1993.

r. **Page 2-89, Figure 2-45. The histogram for T-1,2-DCE year axis should be corrected.**

Response:

All the time axes in this figure will be revised.

s. **Page 2-90, paragraph 2. Background has not been established for metal concentrations in ground water. Thus, the last sentence is not accurate.**

Response:

We agree with the comment. The discussion of background metals concentrations has been revised in the RI/FS.

t. **Page 2-90, Table 2-8. The number of extraction wells should include the three completed under the OU B EE/CA.**

Response:

Extraction Wells EW-246, EW-63 and EW-247 in the A, B and C Zones, respectively, have been added to figures presenting well locations and have been included in the well count presented in Table 2-8. No water quality or water level information from these wells is currently available.

u. **Page 2-91, paragraph 2 and Figure 2-50. The last sentence of the paragraph should state that the blue line shows the extent if the data from the listed wells were not available, not the green line. All well data should be used to define plumes, with professional judgement eliminating the use of certain data. The concentration of TCE in MW-1068 should be 1.5 μg/l not 1500 μg/l.**

Response:

The text and figures have been revised as suggested.

v. **Page 2-91, fourth bullet. Who concluded that off-Base wells may present a public health hazard? If this an ATSDR conclusion, then it should be so stated.**

Response:

The fourth bullet has been deleted from the text.

w. **Page 2-104, paragraph 1. The first two sentences of the paragraph contradict each other. The first states that no water quality data is available from municipal wells downgradient of BW-18 during 1990-1992. The second sentence states that several municipal wells downgradient from BW-18 have been sampled from 1991-1993.**

Response:

The first statement regarding no water quality information being available downgradient of BW-18 has been deleted.

x. **Page 2-105, paragraph 3. The last sentence states that the IWL may be a source of contaminants due to leakage. In previous text it is stated that it is a source.**

Response:

Comment noted. The text has been revised.

y. **Page 2-106, paragraph 2. The second sentence should delete the reference to monitor zone D since no wells are screened in the D Zone in OU A.**

Response:

The text has been revised to incorporate the comment.

z. **Page 2-106, paragraph 4. The plume is not bounded on the southeast side as the new data from OU A, south plume, demonstrates.**

Response:

The new Jacobs data was obtained in December 1993 and January 1994 from five wells located in the in the southeast section of the OU A plume near Site 24. Four were A Zone wells and one was a B Zone well. TCE was measured in two of the A Zone onbase wells, MW-289 and MW-291, at 140 μg/l and 70 μg/l, respectively. TCE was measured at the two offgas A Zone monitoring wells at nondetectable levels. TCE was measured in the onbase B Zone at nondetectable levels. On the basis of current information, this section of the OU A plume is considered bound. These wells should continue to be monitored to determine the extent of offbase contamination.

aa. **Page 2-123, paragraph 3. Staff disagrees that the extent of contamination from the source is limited. The plume extending from OU C1 southward is significant horizontally.**

Response:

The text has been revised to incorporate the comment.

ab. **Page 2-123, paragraph 4. What is the significance of PRL P-10? If one looks at the definition of PRL P-10, it should be much larger than that described in the OU C PA/SI. Looking at the history of the site, what is the potential for significant ground water contamination from this PRL?**

Response:

References to PRL P-10, Magpie Creek, have been deleted because Magpie Creek is unlikely to be a major source of contamination in OU C. Site 22, a burn pit and landfill for priority pollutants, has been discussed as a primary source of the northern extent of the OU B/C plume.

ac. **Page 2-123, paragraph 5. It is stated that the upper zone of TCE is located near Study Area 15. The upper zone contamination is concentrated in OU C1 near the IWTP. Study Area 15 is significantly downgradient of the main sources.**

The plume in the B zone has not migrated northward from Study Area 15, but has migrated south from OU C1.

Response:

The text has been revised.

ad. **Figures 2-53a. 2-54a, and 2-55a. There is a high concentration ground water plume extending from OU C1 in the A Zone and one slightly south located in the C Zone. However, there is no such plume located in the B zone. Additional wells will need to be supplied in the B zone to define the extent of the plume.**

Response:

The high contamination that appeared in C Zone of OU C in the Draft RI/FS was because of high contamination in EW-144. Extraction Well EW-144 was originally assigned in the data base to the C Zone, but upon review of water quality and depth of screened intervals, EW-144 has been reassigned to the B Zone. The screened interval of EW-144 is within the B Zone (depths defined in the Preliminary GW OU RI) and is similar in depth and water quality to other B Zone wells. Nevertheless, C Zone well may still need to be installed to estimate the lateral extent of the deeper contamination.

ae. Page 2-124, paragraph 3. It is stated that TCE is significantly higher in concentration than other VOCs in OU D. 1,1-DCE is the VOC with the highest concentration in the ground water in the extraction field in OU D.

Response:

According to the GSAP, up to and including data from January, 1993, TCE is the highest concentration sampled in groundwater monitoring wells in OU D. The maximum concentration ever detected of TCE was 26,000 μg/l, whereas the maximum total 1,2-DCE concentration was 7,020 μg/l. The average TCE concentration measured in all wells is 371.3 μg/l, whereas the corresponding average total 1,2-DCE concentration is 67.21 μg/l. The average TCE concentration measured in the extraction wells is 550.96, whereas the corresponding average total-1,2-DCE concentration is 240.39. Averages were calculated with ND equal to zero.

af. Page 2-128, fourth bullet. An f_{oc} was previously stated to be in the range of 0.1 to 0.3 percent. A value of 0.3 percent was used in calculating mass in the aquifer. Are there any actual analyses performed for organic carbon content? A 0.3 percent value appears to be a bit high for the Central Valley.

Response:

Yes, total organic carbon was analyzed for during the Summer 1993 field effort for the OU D Remedial Investigation. Nine samples were taken with a minimum value of .000930, a maximum value of .006320, and an average value of .00274.

ag. Page 2-137, paragraph 5. It is stated that the A Zone contamination appears to be higher than the B Zone contamination due to the large unsampled vertical distance between the screened intervals since most of the wells are screened in the bottom of the two zones. The upper A Zone mass would similarly be unaccounted for. Cannot the data from the two zones be interpolated and a concentration estimated for the upper B zone be calculated? Additional wells may be necessary in the upper B Zone in areas where there is a high concentration in the A Zone but a low to non-detect concentration in the lower B Zone.

Response:

The contamination in the top of the A Zone is not unaccounted for in the same manner that the top of the B Zone is. Water levels have declined Basewide, leaving a shallow A Zone with approximately 10-foot thicknesses in OU A and thicknesses of no more the 40 to 50 feet in OUs B, C, and D. Some A Zone monitoring wells have gone dry, as water levels decline below screened intervals. Yes, data from the bottom of the A Zone and bottom of the B Zone can be interpolated to estimate the concentration of the top of the B Zone. During the installation of new monitoring wells, vertical hydropunching will be performed to determine a vertical contaminant profile and to optimize the placement of screened intervals.

ah. **Page 2-138, paragraph 1. Will samples be collected as described in the last sentence of this paragraph?**

Response:

It has been recommended in the Draft Final RI/FS that techniques for collecting groundwater samples for metals analyses be standardized. It is beyond the scope of this RI/FS to establish sampling procedures. Procedures will be determined as part of post RI/FS activities.

ai. **Page 2-138, paragraph 6. These wells already sampled in 2nd and 3rd Quarter 1993. Check the GSAP sample results and schedule.**

Response:

Comment noted. The 2Q93 and 3Q93 GSAP data from these wells have been used to delineate the target volumes.

aj. **Page 2-142, first sentence. MW-173 was already added to the monitoring program. Check GSAP sampling schedule.**

Response:

Comment noted. The 2Q93 and 3Q93 GSAP data from MW-173 has been used to delineate the target volumes.

ak. **Page 2-142, paragraph 3. The wells proposed for sampling have been sampled during 3rd and 4th Quarter 1993. Extraction Wells EW-233 and EW-234 may be screened below the contamination, but they are screened in the A Zone. A well was screened in a permeable unit just below the extraction well screened in the A Zone and the results showed much lower concentrations. In addition, MW-201, located just downgradient of the hot spot and screened in the B Zone has not shown any detectable concentrations. Figure 2-54a should not show the results of EW-233 and EW-234 since they are not screened in the B Zone.**

Response:

Comment noted. The 2Q93 and 3Q93 GSAP data from MW-120, MW-143 and MW-207 have been used to delineate the target volumes. Extraction Well EW-233 and EW-234 have been assigned to the A Zone because their screened intervals are located between the A Zone water table and the bottom of the A Zone (as delineated in the Preliminary GW OU RI). The observations discussed in the comment will also be discussed in the text of the Draft Final.

al. **Page 2-143, paragraph 3. Sampling of the extraction wells in OU D for vinyl chloride is already being performed. See Metcalf and Eddy for the results. Vinyl chloride is consistently found in the influent to the treatment plant.**

Response:

Comment noted. The extraction wells were also sampled during the OU D Summer RI sampling effort. This data will be presented in the Draft Final of the RI/FS.

am. **Page 2-143, paragraph 6. See comment C.2.p, above.**

Response:

The text has been revised as described in the Response to Comment C.2.p.

D. CHAPTER 3, RISK ASSESSMENT AND ARARs

1. Significant Comments

a. **Page 3-2, first sentence. The Non-Degradation Policy, State Water Resources Control Board Resolution 68-16, prohibits the degradation of the ground water body to the extent that affects the beneficial use or potential beneficial use of the aquifer. In addition, the high quality waters (background concentrations) will be maintained unless it can be demonstrated to be in the best interests of the people of the State of California.**

Response:

Comment noted. The reference to the Non-Degradation Policy has been deleted from the chapter.

b. **Page 3-9, paragraph 4. It is stated that the risks associated with OU A ground water are relatively low when compared to OUs B, C, and D, and this suggests that a significant fraction of the VOC mass in soil within OU A has not reached the ground water. This statement assumes that the mass released initially to the vadose zone at each OU is the same. This not the case. Different sources of contaminants and volumes/masses of contaminants are found in each OU.**

Response:

Comment noted. This statement is a reflection of the summary statistics of risks in groundwater as presented in the box plots that show median risks at OU A to be lower compared with the other OUs. Also, as discussed in the conceptual model, the largest VOC mass is likely to be present in OU A. We agree with the commentors's statement that different sources of contaminants and volumes/masses of contaminants are found in each OU; however, this interpretation seems reasonable given the existing availability of data on the relationship between vadose zone and groundwater data. Revision to Chapter 3 is not forseen to be required in response to this comment.

c. **Page 3-11, Figure 3-4. *How can the risks associated with the ground* water in OU C be greater in the C and D zones when the concentrations of contaminants is one-to-two orders of magnitude greater in the A Zone?**

Response:

The risk assessment standardizes contaminant concentrations in terms of exposure and toxicity; higher concentrations of low toxicity compounds could show lower risks than lower concentrations of higher toxicity compounds. Also note that risks have been aggregated into summary statistics for each OU. While concentrations in groundwater in certain areas of OU A may be greater than than in OU C, the median risks across wells in OU C is greater than the median risks in wells in OU A. Revision to Chapter 3 is not forseen to be required in response to this comment.

d. **Pages 3-9 (last sentence) and 3-12, first paragraph. The first sentence sates that the risks associated with the ground water in the B Zone is higher than that associated with the C and D zones, indicating that vertical migration of contaminants from the vadose zone has more significantly impacted shallow aquifers rather than the deeper aquifers. This statement goes without saying. The next sentence talks about the median risks in OU C with the greater risks**

being associated with the C and D zones, suggesting that contaminants in soils are not a significant contributor of contaminants to the ground water. The sentence goes on to state that the deeper zone contamination is likely lateral migration from OUs B and D. This idea should be eliminated from the report. One only has to look at the available ground water concentration data and ground water elevation data, and soils data from OU C1 to see that this statement is far from the truth.

Response:

We agree that vertical migration of VOCs from OU C1 have resulted in contaminant impacts to groundwater. However, a review of the available vadose zone data, compared with the groundwater contaminant data, in OU C (performed during the OU C Preliminary Assessment) to see that sites in OU C are not likely to represent significant sources of groundwater contamination under OU C. Revision to Chapter 3 is not forseen to be required in response to this comment.

e. **Page 3-12, paragraph 2. It is stated that in OU B, that little variability in risk is seen with the various monitor zones, suggesting that contamination is fairly consistent with increasing depth. Concentrations in the upper water zones is much greater than that in the lower aquifers. The difference is that the lateral extent is less in the upper aquifers. Close to sources the associated risk is much greater in the upper aquifer than the lower aquifer. The statement made in the report is much too general. The basis of comment 2.1.d, above, also applies to this paragraph.**

Response:

See the response to Significant Comment D.1.c.

f. **Page 3-12, paragraph 3. This paragraph states that risks less than $1x10^{-6}$ are generally not of concern to regulatory agencies. Our agency is concerned with risk levels down to the background risk value.**

Response:

The intent of this statement was to attempt to place increased lifetime cancer risk estimates into perspective, not to make a statement about appropriate risk levels for selection of remedial actions. Revision to Chapter 3 is not forseen to be required in response to this comment.

g. **Page 3-17, ARARs. Title 23, Division 3, Chapter 15 CCR is an ARAR. The regulations contained in Chapter 15 requires cleanup to background or an alternate value protective of beneficial uses.**

Background is not defined as 0.5 μg/l for all VOCs. It is site specific if there are VOCs in the upgradient direction. In McClellan's case, there should be no detectable concentrations of VOCs using a reliable/reproducible analytical method. In most cases, this can be met using EPA Method 601 and 602 with a 0.5 μg/l detection level.

Response:

The sentence in the fourth paragraph defining "background" has been deleted. The text has been modified to include a discussion of the cleanup requirements contained in Title 23, Division 3, Chapter 15. Also included is a discussion on how cleaning up to background means that there should be no detectable concentrations of VOCs, using a reliable analytical method such as EPA Method 601 and 602, which have a detection level of 0.5 μg/l.

E. CHAPTER 4, FEASIBILITY STUDY APPROACH

1. Significant Comments

a. **Page 4-1, paragraph 4. This paragraph states that ground water contamination underlying the Base poses a threat to ground water quality, as defined by State of California policies. The ground water beneath the site *is* contaminated and the waters of the State have been degraded. The remaining threat remains from contaminants within the vadose zone.**

Response:

The text has been changed to incorporate the comment.

F. CHAPTER 5, DATA COLLECTION AND MANAGEMENT

1. Significant Comments

a. **Page 5-1, last paragraph. It is stated that the extent of the ground water contamination off-Base will be determined by hydropunch sampling of the A Zone. Where in the schedule is time allotted for hydropunch sampling? No proposed hydropunch sample locations are provided, however, ground water monitor well installation locations are provided.**

Response:

The purpose of providing the potential locations of the monitoring wells instead of Hydropunch locations and the monitoring wells is that the monitoring wells will form the long-term monitoring network for the remedy, whereas the Hydropunch samples will not be part of the long-term remedy. The use of hydropunched samples to better place the monitoring wells has been added to the implementation schedules in Appendix S and the locations of any Hydropunch samples will be included in the Phase I Sampling and Analysis Plan (SAP) for the remedy.

2. **Editorial Comments**

a. **Page 5-5, paragraph 2. The current compliance reports do not include an interpretation of the capture zone of the well field.**

Response:

The text has been changed to incorporate the comment.

G. **CHAPTER 6, GROUND WATER CONTAINMENT OPTIONS**

1. ***Significant Comments***

a. **The proposed containment volumes are the same as those provided in Chapter 2. The comments regarding development of those containment (target) volumes apply to this chapter also.**

Response:

The target volumes are being reevaluated on the basis of groundwater sampling data collected from 1st quarter 1988 through 3rd quarter 1993. Refer to the response to comments from Chapter 2, significant Comments d and g. The revised target volumes will be presented in Chapter 4 of the revised RI/FS Report.

b. **Page 6-55, second paragraph. It is stated that several areas of low concentration will reach cleanup much quicker than those in the higher concentration areas. Was this taken into account during development of cost estimation?**

Response:

The cost estimates were not adjusted to include zone areas cleaning up faster than others. The cleanup of low concentration areas sooner does not affect the capital cost estimate. It would affect the long-term operations and monitoring costs of the remedy in terms of annual cost, but the present worth calculations are not significantly affected by a reduction in annual cost 20 years from now.

2. **Editorial Comments**

a. **Page 6-18, Table 6-1. The text prior to the table states that extraction rates of 10, 15, and 20 gpm for the A, B, and C zone extraction wells were used. If these values are used, even taking into consideration the special A Zone cases, the total extraction rates in the tables cannot be generated. Given the variability of transmissivities previously stated in the report, one cannot use equal flow rates from wells across the Base that are screened in the same zone.**

Response:

Table 6-1 will be revised to reflect the new extraction estimates on the basis of revised target volumes.

The objective of the groundwater modeling analysis is to determine the approximate total groundwater extraction rate that will be required to contain a given volume of contaminated groundwater for the purposes of developing cost estimates for treatment and end use. The numerical model is based on a very limited number of aquifer transmissivity estimates (32 points in 3 zones across the Base) and therefore contains significant uncertainty regarding the actual distribution of transmissivity across the Base. The number of extraction wells required to contain a given target volume will be a function of this uncertain transmissivity distribution, but the total extraction flow rate will depend more on the water budget components at the site (distribution and rate of recharge, etc.). For the purposes of estimating a total extraction rate, we felt it was more appropriate to assume a conservative well yield estimate for each monitoring zone rather than attempting to calculate a well yield on the basis of assumed transmissivities that are not available at most planned extraction well locations. During remedial design, additional aquifer test information will be collected, and the numerical model will be modified to incorporate these additional estimates of transmissivity and vertical leakance.

b. **Page 6-52, Figure 6-28. EW-233 and EW-234 are depicted to be screened in the C Zone when they are actually screened in the A zone. EW-144 has one section of screen in the A Zone.**

Response:

The monitoring zones where each of the existing extraction wells at the Base are screened have been adjusted in the numerical model to reflect revised construction information. This revised information is presented in the revised Chapter 4 and Appendix J.

H. CHAPTER 7, GROUND WATER TREATMENT OPTIONS

1. Significant Comments

a. **General Comment. Was consideration made for having modular treatment systems that can be reduced/increased as extraction and concentration rates change with time?**

Response:

The groundwater treatment options were evaluated and screened on several criteria, including robustness. In the consideration of the robustness of a treatment option the ability to "turn up or turn down" was an important factor. The ability to turn up reflects the treatment option's ability to treat a higher range of flows than planned, and conversely the ability to turn down reflects the treatment option's ability to be effective at lower than planned flows or concentrations. The availability of modular systems for any treatment option affects their ability to turn up or turn down, but it is not the only factor. It could be stated that in general, a treatment option that can be implemented in modules will be easier to turn up or turn down, and the screening performed in the feasibility study accommodated this factor.

Furthermore, the selection of modular construction or single units is a design detail that will be addressed at the time the treatment facilities are being designed. Given the phased implementation approach, the designers will have a better idea of the influent concentrations and flows after the extraction and monitoring networks are substantially complete than is available for the FS.

b. **General Comment. It is proposed to treat the extracted ground water from the off-Base extraction wells with wellhead treatment. Where will the discharge from those treatment units go?**

Response:

The wellhead treatment is a short-term (approximately 3 years) solution that is necessary to begin capture of the offbase contamination without waiting for the complete water end use to be in place.

Once the water end use is in place, the water from any offbase extraction wells would be piped on to the Base, treated in one of the two treatment plants, and piped to the end use. The short-term well head treatment and end use of the water is not anticipated to be an obstacle to the implementation of the interim remedy, given the small flows and the temporary nature of the arrangement. The question of whether the FS should evaluate the end use of the temporary well head treated water could be posed and the reason it does not is that the end use will be specific to each well, given the logistics and constraints. The end use will be discussed with the Agencies as part of the Groundwater Work Plan.

c. **Page 7-13, Table 7-3. How were the influent concentrations determined?**

Response:

A complete discussion of how the influent concentrations were estimated is included in Appendix M.

2. **Editorial Comments**

a. **Page 7-11, paragraph 1. The first sentence states that $470,000 dollars could be saved in future labor costs per year assuming a 15% decrease in future operations. That would place labor at $3,100,000/year. This is not currently the case.**

Response:

The $470,000 is the new O&M labor cost, not the savings. The text has been clarified.

I. CHAPTER 8, INNOVATIVE TECHNOLOGIES

1. **Editorial Comments**

a. **Figure 8-2. It should be noted that the potential innovate technology application sites are only preliminary and that additional sites may be identified under remedial investigations of the vadose zone in the various OUs.**

Response:

The text has been changed to incorporate the comment.

b. **Figure 8-4. There should be an arrow from the block to the far right to the smaller block above it labeled "New Potentially Applicable Technology".**

Response:

The figure has been corrected.

c. **Page 8-12, Table 8-2. The technology limitations should also include byproduct cleanup in the aquifer. A stated disadvantage is the production of water quality problems such as reduced iron and manganese, fermentation products, and sulfide.**

Response:

The disadvantage of potentially requiring the cleanup of by-products has been added.

J. CHAPTER 9, WATER END-USE OPTIONS

1. Significant Comments

a. **General Comment. Staff does not recommend placing such an emphasis on the end-use of supplying the water purveyors with the extracted and treated ground water until two major hurdles can be overcome. Those two hurdles being DHS allowance of putting the water into the public water supply and public acceptance of using that water for domestic purposes. If it is possible to sell the water to the water purveyors, then it should be possible to place a good portion of the water in the McClellan distribution system. This water could replace that lost when BW-18 is abandonded.**

Response:

Agree. Technically it is feasible to supply treated groundwater as a drinking water source to the water utilities. In the discussions with McClellan AFB, CH2M HILL, and the neighboring water utilities on August 10, 1993, the water utilities stated their desire for the treated groundwater and they felt they could sell the idea to their users. Currently McClellan AFB has decided to pursue the issue of using treated groundwater to replace a portion of the drinking water supply it currently receives from BW-18 while also testing reinjection as the preferred option.

b. **Page 9-7, first bullet. The reason for off-site ground water injection rejection is that it would be hard for McClellan to manage and**

conveyance costs would be too high. Distribution costs for supplying the water to water purveyors should be similar.

Response:

The distribution costs were assumed to be high for offsite groundwater reinjection because the participants at the August 10, 1993, workshop felt there were no areas adjacent to McClellan AFB where groundwater reinjection could be done cost-effectively. The distribution costs are comparatively low for supplying water to the water utilities (Arcade Water District and Rio Linda Water District) that are adjacent to McClellan AFB.

c. **Page 9-7, second bullet. The concept of having to maintain an established riparian habitat once ground water extraction and discharge to Magpie Creek had been terminated should be discussed with the various wildlife agencies. McClellan has already established the practice of providing water from its ground water treatment system for establishment of a wildlife habitat.**

Response:

McClellan AFB currently discharges approximateiy 200 gallons per minute (gpm) into Magpie Creek from the existing groundwater treatment plant. Apparently, McClellan AFB has been notified by wildlife agencies that since additional wildlife habitat has been created with this water, the agencies expect McClellan to maintain the flow of water for wildlife even after cleanup has been completed. Therefore McClellan AFB does not want to commit to additional long-term discharge to Magpie Creek.

d. **Page 9-7, third bullet. Recharge basins are not feasible due to a hard pan layer, but recharge from rainfall at 2.5 inches per year is used in the water balance? Was the hardpan layer considered in determining the recharge rate.**

Response:

Recharge basins are usually placed in areas where the soils and geology can support a long-term recharge rate of 1 to 3 feet per day. This required recharge rate is far higher then the precipitation recharge rate of 2.5 inches per year as reported in Section 2.5.5 of the Draft RI/FS. The precipitation recharge rate of 2.5 inches per year is based on the calibrated groundwater model and professional experience working on similar projects in the Sacramento area and has been revised in Section 2.5.5.

e. **Page 9-7, fourth bullet. Dropping discharge to the POTW as an option should have discussed the potential cost for that option.**

Response:

Discharge to the publicly owned treatment works (POTW) was dropped as a result of the August 10, 1993, workshop because the existing sewer lines near McClellan AFB are at capacity and discharge to a POTW was not considered to be a beneficial use of the treated groundwater. Therefore no costs were developed for this option.

f. **Page 9-7, fifth bullet. Discharge to local golf courses could have been considered in conjunction with injection and discharge to surface waters.**

Response:

Seasonal use of treated groundwater at golf courses was dropped as a result of the August 10, 1993, workshop because turfgrass has a seasonal water demand and the conveyance costs would be high compared to the use of water. Typically a golf course with 100 to 125 acres of turf would use approximately 350 to 450 acre-feet of irrigation water per year. If a golf course was adjacent to or on McClellan AFB it would have been a good reuse option.

g. **Page 9-8, Section 9.3.1. Is there a demand for treated water on the east side of the Base? Consideration should be made for supplying the on-Base users with water from the eastside treatment facility.**

Response:

There may be a demand on the east side of McClellan AFB for reclaimed water; however, McClellan AFB personnel stated that the existing greywater piping to the east side was unreliable, had low capacity, and was in need of repair.

h. **Page 9-9, Section 9.3.4. The geology of the area which will contain the injection wells should be checked to determine the appropriate depths at which injection should occur.**

Response:

The corrected depth of the reinjection wells, taking into account the hydrogeology of the area, is approximately 600 feet. Each well is assumed to have a recharge capacity of 750 gpm and each recharge well will have a backup standby well. This correction has been made in the text and tables.

2. **Editorial Comments**

a. **Pages 9-10 and 9-11, and Table 9-4. The text states that capitol costs for end-use systems 1 and 2 range from $112,000 to $689,000 for system 1 and $1.6 million to $2.5 million for system 2. The ranges should be for low flow from both the east and west plants for the low end, and the high flows for both plants for the high-end cost. The same can be said for Table 9-5 and the cost ranges presented in the text on Page 9-12.**

Response:

Editorial comment accepted and changes have been made in the text.

K. CHAPTER 11, IMPLEMENTATION PLANS AND DETAILED EVALUATION

1. **Significant Comments**

a. ***General Comment on Scheduling. Staff believes that under any of* the target volumes, capture and extraction of the ground water contamination plume to the west of the Base should be a low priority. Capturing the more significant concentrations off-Base and arresting the flux of additional contaminants from the Base are higher on the priority scale.**

Response:

The establishment of priorities has been refined to address the concern. The Air Force is in agreement that the areas to the west should be of a lower priority.

b. **General Comment. Staff recommends phasing of ground water monitor wells and hydropunch up front to better define the target volumes. The current schedule calls for placing the proposed extraction wells and monitor wells to remediate the off-Base target volumes as the first phase. After refining the target volumes, construction of extraction wells should also be phased so that necessary extraction rates and zones of capture can be further delineated. Additional extraction wells will be placed using the gathered information.**

Response:

The schedules have been adjusted to include Hydropunch sampling; however, the sequence does not have to be refinement of the target volumes prior to installation of the extraction wells. In many situations at McClellan AFB, the extraction wells can be installed in areas of definite contamination and used to perform long-term (at least 72-hour) aquifer tests to improve the information on transmissivity and storage, as well as measure the potential capture zones. The Air Force would prefer to attack the uncertainties related to the extraction wells performance (T, S, leakance, and zone of capture) in parallel with the refinement of the target volumes by Hydropunch or monitoring wells. For the purposes of the FS it is adequate to simply show the installation of the monitoring and extraction wells as part of the first phase of work, given that a detailed schedule will be developed in the Groundwater OU Work Plan and Phase I SAP.

c. **General Comment. Given funding limitations plumes, should be defined and prioritized. Some plumes may be required to be captured and remediated to background concentrations and some only to the 10^{-6} risk concentration.**

Response:

The Air Force agrees with the comment that the plumes cannot be addressed all at once due to funding limitations, and the revised discussion of priorities reflects this concept. However a single goal for the interim remedy of 10^{-6} risk is preferred to attempting to establish separator goals for each target volume. If the information collected during the implementation of the interim remedy indicates the goals should be changed, then an Explanation of Significant Difference can be prepared or the goal can be included in the Basewide ROD.

d. **Page 11-21, paragraph 2. It is stated that treated water would achieve discharge requirements under the Clean Water Act and California's Inland Surface Waters Plan (ISWP). No information was supplied for how the treated water would achieve the metals limitations specified in the ISWP. Treatment of volatiles will easily achieve compliance with the alternatives. Is there any estimate on the concentrations of metals in the treated ground water?**

Response:

The estimated influent for metals has been added to Appendix M. The treatment of the metals is inherent in each alternative as a contingency measure if the metals need to be removed to meet the discharge requirements of the selected end use.

e. **Page 11-36, Recommended Target Volume. Selection of the MCL target volume does not meet ARARs. The minimum target volume that can be used is the 10^{-6} risk target volume. That protects the ground water as a water supply. The decision to not remediate to background concentrations cannot be made at this time until the target volumes are better delineated. It is believed that the current volumes are an over-estimate of the volumes requiring remediation under the three target volumes, with the background volume being the one subject to the greatest over-estimation.**

In addition, staff believes that target volumes should be made on a plume-by-plume basis. It may not take much to capture and cleanup one plume to background, but may necessitate a very large increase in cost to capture and treat a plume to background concentrations instead of the risk based target volume.

Response:

The preferred alternative now includes the 10^{-6} target volume rather than the MCL target volume.

2. **Editorial Comments**

a. **Figure 11-2. Under the statistics listing the treatment system has a capacity of 800 gpm, but there is an allowance of discharge to Magpie Creek of 1000 gpm for the west treatment. A similar discrepancy is found in the east treatment facility.**

It is stated that remedial objectives are achieved by the year 2110. What are the objectives?

Response:

The allowance of discharge to Magpie Creek is independent of the treatment flow. It is important that the discharge to Magpie Creek be greater than the treatment flow. The reference to meeting the remedial action objective has been removed because of the phased approach to the remedy.

b. **Figure 11-3. An allowance for emergency discharge to Magpie Creek is listed as 1000 gpm and the treatment capacity is 1700 gpm. What will be done with the remaining treated ground water in the event that the water purveyors or the injection system cannot accept the water.**

Response:

The comment refers to an important operational consideration. To respond to the comment from today's information is inappropriate because the emergency discharge requirements are a function of the total flow to the treatment system. The total flow is, of course, an estimate, and the estimate will improve as the system is installed. The phasing of the remedy will allow the designers to accommodate the emergency discharge requirements when the appropriate information is available. Today there are a number of options available, including discharge greater than 1,000 gpm to Magpie Creek, standby reinjection wells, or turning down the extraction systems to a minimal flow, or any combination of these.

c. **Table 11-1, third line. Does this line refer to abandonment of production wells?**

Response:

The cost referred to the development of contingency measures for the offbase production wells, and the planning of the BW-18 abandonment and replacement. Well abandonment is an ongoing effort and its cost is not included in the remedy.

d. **Page 11-30, paragraph 3. If there is a concern for dewatering of the A Zone, then extraction wells can be made to be deepened or they can be constructed with a larger screen interval as long as they do not remain unused for extended periods of time or concentrations in ground water are similar with depth.**

Response:

The comment will be used in the design of the extraction wells.

e. **Page 11-30, paragraph 5. Conversion of ground water extraction wells to soil vapor extraction wells if the wells run dry would only be appropriate in areas with high concentrations of VOCs in ground water or near sources so that a mass in the vadose zone that required remediating would be there.**

Response:

The Air Force agrees that not every extraction well need be converted to an SVE well if it becomes dry. The comment will be used during the preparation of the remedial design. The text of the FS has been revised to remove any ambiguity on the use of dry extraction wells.

f. **Page 11-33, paragraph 3. Why is there a question mark near the end of the third sentence? What is a "stipper"?**

Response:

Typographical error.

L. **Appendix A, GROUND WATER TREATMENT PLANT EVALUATION**

1. **Editorial Comments**

a. **Page 8, last paragraph. Actual effluent limitations for VOCs are the detection limits for the EPA 500 series which can be less than 0.1 μg/l.**

Response:

The text has been revised to incorporate the comment.

b. **Page 11, paragraph 1. The GAC is also necessary to remove SVOCs and some portion of the metals found in the influent. There is no activated sludge process to remove ketones. No specific ketone removal equipment has been required since influent concentrations of ketones dropped below the effluent limitations for the ketones. Prior treatment was by a fixed-film process on a device similar to an RBC, but with plates placed horizontally instead of vertically.**

Response:

The text has been revised to incorporate the comment.

c. **Page 23, first paragraph. It is stated that a potential drawback of the direct treatment by using liquid phase GAC would be an increase in the emission rate of vinyl chloride. Is the release due to passive emission as the water passes through the treatment train? Under this scenario there is not an active mechanism to strip the vinyl chloride out of the water column.**

Response:

The concern is the air emissions at the point of discharge of the treated water. The vinyl chloride would not be removed by the GAC prior to discharge.

II. VOLUME II

A. APPENDIX C, RISK EVALUATION OF REMEDIAL ACTION ALTERNATIVES

1. Significant Comments

a. **Page C-2, paragraph 3. Carbon polishing may be required for alternatives other than discharge to the water purveyors in order to reliably meet effluent limitations for injection or discharge to Magpie Creek.**

Response:

Comment noted. Carbon polishing for injection or surface-water discharge would not affect the findings from the risk evaluation of remedial action alternatives. No changes in Appendix C are foreseen to respond to this comment.

b. **Page C-3, paragraph 1. Comment II.A.1.a applies to this paragraph also. In addition, it may be required to get below the detection limits using the EPA 500 Series methods for discharge to surface waters.**

Response:

Comment noted. See the Response to Comment II.A.1.a. No changes in Appendix C are foreseen to respond to this comment.

B. APPENDIX D, ARARs ANALYSIS

1. Significant Comments

a. **Page D-19, paragraph 5. The *Inland Surface Waters Plan* should be included as ARARs for the discharge of treated ground water to surface waters. This Plan contains receiving water limitations for specific organics and inorganic pollutants.**

Response:

The Inland Surface Waters Plan receiving water limitations are included later in the appendix in the "Applicable or Relevant and Appropriate Requirements (ARARs) and To-Be-Considered Criteria (TBCs) Regulating Groundwater Discharge" section.

b. **Page D-29, paragraph 5. The limitations for VOCs in the current permit for the GWTP are the detection limits for the EPA 500**

Methods. For most of the VOCs he limit is well below 0.5 µg/l. There are also limitations for inorganics found in the permit and these could also be applied to a discharge to surface waters.

Response:

This paragraph has been changed to reflect that the National Pollutant Discharge Elimination System (NPDES) permit is an ARAR for the discharge of treated groundwater and that the permit limitations found in the current permit will likely be applied to any additional groundwater treatment plants.

c. **Page D-29, paragraph 6. The point of compliance for ground water cleanup will be any point in the aquifer. In determining if a release from a waste management unit has occurred, the point of compliance is that as stated in the paragraph. The stated point of compliance is not applicable to surface waters. Points of compliance will be established by the Regional Board. Limitations will be placed on the effluent and the receiving water.**

Response:

The concept of "point of compliance" has been discussed in more detail and the fact that it pertains to groundwater only is included. This paragraph has been moved to the "ARARs and TBCs Affecting Groundwater Remedial Goals" section because the point of compliance ensures compliance with groundwater remedial goal ARARs.

d. **Page D-37, paragraph 4. The surface water of "sufficient size" is the Sacramento River, not the American River. The first water body of concern for the potential discharge will be Magpie Creek and effluent and receiving water limitations will be established to protect the creek.**

In addition, if any work is done within the streambed, or even below the streambed, a 404 permit from the U.S. Army Corps of Engineers, 401 Water Quality Certification from our office, and a 1603 Streambed Alteration Agreement from the Department of Fish and Game could all be required.

Response:

This sentence has been changed to read "...the surface water of sufficient size to be considered a navigable water is the Sacramento River." A sentence has been added to state that Magpie Creek is the first water body of concern when considering water quality protection. This discussion has been moved and incorporated into the "ARARs and TBCs Regulating Groundwater Discharge" section.

A discussion on the permits and agreements needed to conduct work within or below a streambed has been added.

e. **Page D-54, paragraph 1. 23 CCR, Division 3, Chapter 15 applies to the cleanup of the contaminated aquifer. This establishes that background concentrations need to be considered initially when determining cleanup levels. Alternative cleanup levels will be established based on technical feasibility and cost, but will be protective of the beneficial uses and potential beneficial uses of the aquifer.**

Response:

A paragraph has been added to discuss the groundwater protection standards and cleanup criteria provided in 23 CCR, Division 3, Chapter 15.

f. **Page D-54, paragraph 3. Chapter 15 requires a corrective action for the release of wastes, not just hazardous wastes.**

Response:

The word "hazardous" has been deleted from the sentence. It now reads, "In addition to the federal requirements, 23 CCR 2550.10 requires the discharger to implement a corrective action program to remediate releases of wastes."

2. **Editorial Comments**

a. **Table D-2. The column labeled "TBC Value for Compounds Without MCLs" should be labeled "TBC Values". There may be cases where a TBC value is lower than an MCL and would apply. An example would be an agricultural limit for zinc of 2000 μg/l and an MCL of 5000 μg/l. IRIS, CAL EPA Cancer Potency Factors, and PROP 65 values should be included in the TRB column.**

Response:

The California EPA Cancer Potency Factors, the IRIS Reference Doses, and the Proposition 65 criteria and have been added to Table D-2.

b. **Table D-6, Page 4. For the second action alternative under the citation section, 23 CCR, Division 3, Chapter 15 is listed. The**

requirements found in those regulations do not apply to proposed surface water discharge listed for this action.

Response:

This citation has been deleted.

c. **Table D-6, Page 5. For both actions listed on this page, California Water Code, Division 7, Section 1300 et seq and the Basin Plan for the Central Valley Region are also ARARs for the actions. Injection of wastes into the subsurface will require the submittal of a report of waste discharge and the development of limitations for the quality of water for the injection.**

Water will be required to meet non-detection levels for VOCs for injection into a clean aquifer and meet background concentrations for inorganic species of pollutants.

Response:

The California Water Code citation and the Basin Plan for the Central Valley Region have been added to the table.

d. **Page D-47, table D-7, item 8. Chapter 15 does not apply to the discharge to surface waters.**

Response:

This citation has been deleted.

e. **Page D-48, table D-7, item 11. See Comment II.B.2.c, above.**

Response:

The California Water Code citation and the Basin Plan for the Central Valley Region have been added to the citations listed on the table.

C. APPENDIX E, PROPOSED GROUND WATER MONITORING PROGRAM

1. Significant Comments

a. **Page E-1, paragraph. It is stated that the monitor program is highly variable. It should be noted that the program has been modified several times over the last ten years. Ground water flow direction, plume boundaries, history of analyses from each well were taken into account in developing the current monitor scheme. The**

schedule in the GSAP should be checked and it will be seen that most of the wells that should be sampled, have been sampled recently, or will be in the near future.

Response:

We acknowledge that groundwater flow directions, plume boundaries, and historic analyses were considered in the development of the Groundwater Sampling and Analysis Program (GSAP) program. This information will be added to the text.

b. **Page E-1, paragraph 2. It is stated that almost half the A Zone monitor wells have not been sampled since January 1992, and nearly 25 percent of the wells have not been sampled since 1986. What portion of those wells are dry and can no longer be sampled? In addition, many of the wells not sampled recently were eliminated due to redundancy, trends, ground water flow direction, and professional judgement. There should be few wells that need to be sampled that have not been within the past two years.**

Response:

We acknowledge that many of the A-Zone wells that have not been sampled recently may have gone dry. However, these wells still represent data gaps unless regional water levels begin to rise. We will state in the text that many of the wells were omitted from the sampling network because of redundancy, trends, and groundwater flow directions.

c. **Page E-1, paragraph 2. It is stated that Figures E-2 and E-3 suggest that fewer B and C Zone monitor wells have been dropped from the monitor program. That is likely due to the fact that none of those wells have gone dry and many were recently added during plume definition and PGOURI development. They were likely added in spots that necessitated continued monitoring.**

Response:

Comment noted.

d. **Page E-6, paragraph 3. The last sentence states that a significant potion of the currently defined target volumes can be eliminated with additional ground water monitor points at strategic locations. Good point. It justifies not accepting the costs for containment and treatment of the background target volume at this time. As ground water plumes are better defined the incremental cost increases associated with the various target volumes will be reduced. The**

MCL target volume will be the least effected by the refinement and the background target volumes the most.

Response:

We agree with this statement.

e. **Page E-7, paragraph 2. This paragraph eludes to the fact that as additional ground water quality information is gathered, the target volume definitions may change and that the associated hydraulic monitoring system would need to be adjusted. When and how will these determinations be made. Placement of hydropunch and monitor wells should be the initial phase prior to placement of extraction and hydraulic monitor wells, and prior to acceptance of which target volume should be remediated.**

Response:

These issues will be addressed in the work plan and the sampling and analysis plan developed for each phase of the remedy.

f. **Figures for proposed water quality monitor well, hydraulic control monitor well, and extraction wells. These figures are based on linear interpolation of the existing ground water quality data and ground water flow data. Staff believes that the target volumes in all but the downgradient direction are overly conservative, especially for the background and risk target volumes. Staff recommends hydropunch, as feasible in the A Zone, and deeper if possible to help define the plume. Ground water monitor locations would then be established. Afterwards, ground water extraction wells and hydraulic control monitor wells can be located. Staff will not comment on the current placement of the wells since a locations will likely be altered.**

Response:

The target volumes in the revised report have been refined with respect to the concerns noted. We agree that the monitoring well locations will change as the remedy proceeds.

D. APPENDIX J, GROUND WATER MODEL DEVELOPMENT

1. Significant Comments

a. **Page J-17, paragraph 1. Table J-1 is missing so the various extraction rates for hot spots versus low concentration cannot be reviewed.**

What does it mean that these wells will be included in alternatives requiring hotspot injection? Won't the proposed wells be needed for plume control, extraction and treatment?

The report uses a flow rate of 20 gpm, stating that this has been estimated for the C Zone extraction wells based on existing extraction wells on-Base. The C Zone extraction well completed as part of the OU B EE/CA produces a much greater flow than that. The B Zone may also produce more than 15 gpm.

Response:

This table was omitted in error from the Regional Water Quality Control Board (RWQCB) copy. Table J-1 will be included in the Draft Final Copy of the RI/FS Report.

The information regarding reinjection wells presented in Appendix J was incomplete. The statement provided regarding hot spot reinjection was meant to refer only to the reinjection well locations in the hot spots, not all of the extraction wells located in the hot spots. The hot spot extraction wells were included in all of the groundwater containment simulations. The text has been revised accordingly.

The objective of the groundwater modeling analysis is to determine the approximate total groundwater extraction rate that will be required to contain a given volume of contaminated groundwater for the purposes of developing cost estimates for treatment and end use. The numerical model is based on a very limited number of aquifer transmissivity estimates (32 points in 3 zones across the Base) and therefore contains significant uncertainty regarding the actual distribution of transmissivity across the Base. The number of extraction wells required to contain a given target volume will be a function of this uncertain transmissivity distribution, but the total extraction flow rate will depend more on the water budget components at the site (distribution and rate of recharge, etc.). For the purposes of estimating a total extraction rate, we felt it was more appropriate to assume a conservative well yield estimate for each monitoring zone rather than attempting to calculate a well yield on the basis of assumed transmissivities that are not available at most planned extraction well locations. During remedial design, additional aquifer test information will be collected, and the numerical model will be modified to incorporate these additional estimates of transmissivity and vertical leakance.

b. **Page J-34, Table J-2. If the given flow rates of 10, 15, and 20 gpm are used for the A Zone, B Zone, and C Zone extraction rates for each extraction well, the numbers presented in the table are not**

produced. Flow rates vary from 5.4 to 7 gpm for the A Zone, 7.2 to 15.5 gpm for the B Zone, and 17.5 to 20.7 gpm for the C Zone.

Response:

Table J-2 will be revised to reflect the new extraction estimates on the basis of revised target volumes.

E. APPENDIX K, VOC MASS ESTIMATES

1. Significant Comments

a. **Page K-5, last paragraph. Staff agrees that linear interpolation overestimates the extent of contamination in areas where few wells exist. Staff also believes that this is true in the upgradient and side gradient directions from the plume source. The mass will be overestimated by using the linear interpolations and will thus overestimate the cost to capture, treat, and dispose of the ground water containing the mass.**

Response:

We agree with the comment. Linear interpolation was not used to delineate the extent of contamination for the mass estimates presented in the Draft Final RI/FS.

b. **Page K-9, third sentence. This sentence states that in low concentration areas where linear extrapolation results in a large estimated extent of contamination, extent was reduced by examining the probable source areas and the historical and current ground water flow directions. The linear interpolation with and without the reduction should be presented to show where and why the reductions were made. Staff believes that additional reductions could have been made. An example is the C zone plume extending south from OU C. With little data in C Zone north of the IWTP, and little contamination in the upper zones there, it does not seem reasonable to extend the plume so far to the north.**

Response:

We agree with the comment. Linear interpolation was not used to delineate the extent of contamination for the mass estimates presented in the Draft Final RI/FS.

c. **Page K-9, first paragraph. It is stated that generally at high concentrations the results of linear and logarithmic interpolations were similar, but not so at lower concentrations, confirming that linear**

interpolation is accurate in high concentration areas and conservative in low concentration areas. The comparison in the upgradient and side gradient directions was not comparable in the high concentration areas unless there were sufficient wells in the upgradient and side gradient direction to provide control. This is supported by the second to last sentence in this paragraph.

Response:

We agree with the comment. Linear interpolation was not used to delineate the extent of contamination for the mass estimates presented in the Draft Final RI/FS.

d. **Page K-19, paragraph 3. It states that the thickness of the zones varies Basewide and significantly affects the volume of the contaminated aquifer and the estimation of VOC mass. How was the variation accounted for in developing the mass estimates?**

Response:

The contours of the bottom of the A, B and C Zones were presented in the Preliminary GW OU RI (Radian, 1992). We digitized them and used them to interpolate surfaces of zone bottoms. We used the January 1993 water levels to determine the top of the A-Zone surface. The difference in surfaces were used to calculate the zone thickness.

2. **Editorial Comments**

a. **Page K-12, Table K-2. The table lists a mass of PCE of 5,310.19 kg in the B Zone. What area on the Base does a majority of this mass reside. From scanning Table K-7 it appears that most of this mass should be attributed to the A zone.**

Response:

The mass estimates have been revised and will be presented in the Draft Final RI/FS. In the revised mass estimates, the majority of the tetrachloroethene (PCE) mass resides in the A Zone.

b. **Table K-7. Data for the water quality is samples from the OU D extraction wells should be available for 1992 and 1993. Metcalf and Eddy collects samples from the extraction wells.**

What are OU B2, OU B3, OU BC, OU A1, OU AB, OU A2, and OU C2?

MWs-194, 195, and 196 are in OU G not OU E.

Too many wells are placed in OU B1. Most of those wells so designated are actually in OU B.

Response:

The OU D extraction wells were not used in the mass estimates because their screened intervals are 120 feet long and extend from the vadose zone through the A Zone to the middle of the B Zone. The water quality is not representative of either the A Zone or the B Zone. Samples from surrounding monitoring wells in the A and B Zones were contoured and contamination in this area was included in the mass estimates. The wells have been reassigned to operable units.

F. APPENDIX L2, IN SITU ANAEROBIC BIOTREATMENT IMPLEMENTATION PLAN

1. Significant Comments

a. **Page L2-7, last bullet. This bullet states that water quality problems such as reduced iron and manganese, methane, fermentation products, and sulfide can result from anaerobic conditions. How will these problems be dealt with? This may not be a topic for this report, but this will be an issue if this process is to be used at the Base.**

Response:

The comment will be used in the development of any testing plans for this technology if the Air Force chooses to pursue its development.

b. **Page L2-13, last bullet. It is stated that the extracted ground water is treated to MCLs at a single treatment system at the target location and the treated ground water is amended and injected. How does the treatment affect the study since VOC mass will be removed by processes other than the anaerobic decomposition?**

Response:

The measurement of concentrations will be established so that the removal caused by aboveground treatment will not be mistaken for in situ destruction of the VOCs.

G. APPENDIX L3, IN SITU COMETABOLIC BIOTREATMENT IMPLEMENTATION PLANT

1. Significant Comments

a. **Page L3-6, fourth bullet. This states that the technology is effective at degrading the anaerobic transformation products of PCE and TCE. 1,1-DCE is an anaerobic decomposition product of PCE and TCE and the second bullet says that this process will not work on 1,1-DCE.**

Response:

The text has been corrected. The process is effective on some of the TCE degradation products, but not 1,1-DCE.

b. **Page L3-6, eighth bullet. Why is it that vinyl chloride is not formed during the transformation process? A schematic would help of the changes from PCE and TCE to the final end products.**

Response:

The degradation chain for biodegradation is not as simple as the loss or removal of chlorides, and in many cases the degradation chains have not been fully mapped.

c. **Page L3-13, Figure L3-2. This layout shows no aboveground treatment to remove VOCs as specified in text elsewhere in this appendix.**

Response:

The figure has been corrected.

d. **Page L3-19, seventh bullet. How is it determined that 600 lbs of contaminants will be removed during the test?**

Response:

The 600 pounds is based on the following calculation:

1 mg/l concentration
5 treatment modules (9 extraction wells, 9 injection wells)
27 gpm/module

$$\left(1\ \frac{mg}{l}\right)\left(\frac{28\ gpm}{module}\right) 5\ modules \left(\frac{3.785\ l}{gal}\right)\left(\frac{1{,}440\ \min}{d}\right)\left(\frac{365}{yr}\right)$$

$$= 268{,}568{,}460\ \frac{mg}{yr}\left(\frac{1\ g}{10^3\ mg}\right)\left(\frac{116}{454\ g}\right) = 592\ lbs$$

$$\approx 600\ lbs$$

H. APPENDIX L4, DUAL PHASE EXTRACTION IMPLEMENTATION PLAN

1. Significant Comments

a. Figure L4-2, Why are injection wells required or desired in dual phase extraction?

Response:

A key benefit of DPE systems is the ability to remediate the capillary fringe, which might otherwise be unavailable for treatment. This is achieved through the lowering of the water table, dewatering the soil further through the application of a high vacuum (to restore its air permeability), and inducing airflow through the former capillary fringe. A wellfield using a multiple well dual-phase extraction (DPE) configuration would experience intermediate pockets where the water table would not be drawn down as much as at the well. Also, in these pockets, the applied vacuums in the soil gas would be lower than at the wells. Therefore, these zones would be less likely to desaturate sufficiently to achieve the remediation benefit described above.

An intermediate injection well would have two benefits. First, it could be operated within the insufficiently desaturated zone to remove moisture from the soil through the injection of dried and/or heated air. This would have the effect of extending the zone over which DPE could have its maximum effectiveness beyond the immediate vicinity of the high-vacuum wells. Secondly, the injected air would tend to promote a greater proportion of airflow through the former capillary fringe than would occur with an extraction only well system, by inducing primarily horizontal flow parallel to the water table. This allows for advective vapor transport to be more uniformly applied as the contaminant removal mechanism within the former capillary fringe.

I. APPENDIX L6, ELECTRON BEAM TREATMENT IMPLEMENTATION PLAN

1. Editorial Comment

a. **Figure L6-2. The diagram has an arrow labeled discharge. Discharge to where?**

Response:

The discharge is to the end use of the water. If additional treatment is necessary to meet the discharge requirements, it would be at this point.

J. **APPENDIX L7, COMETABOLIC BIOFILTRATION IMPLEMENTATION PLAN**

1. **Significant Comments**

a. **Figure L7-1. How will the biosolids produced in the process effect the ground water treatment plant? Will filtration be provided?**

Response:

Filtration would probably be necessary. The mass of biosolids would not be so great that thickeners and clarifiers would be necessary.

b. **Figure L7-2. Where will the treated water from the air stripper go?**

Response:

The discharge would be to the end use of the water.

K. **APPENDIX M, INFLUENT VOC CONCENTRATION ESTIMATE**

1. **Significant Comments**

a. **Page M-3, Table M-1. The estimated concentrations presented in this table use average concentrations within a given contour interval and a weighted average developed. Will equal flow rates come from each of the contour intervals?**

Response:

For the estimates, the same flow rate was used for a specific plume in a specific zone, as presented in Table M-2. In reality, the extraction rates will be determined on the basis of aquifer testing.

b. **Page M-7, paragraph 2. The last se[illegible]ce is unclear. The isolation of the hotspots will still require [illegible]val and treatment of the extracted ground water from those [illegible] spots so how are the cost**

estimates for treatment different depending on budget-level and order-of-magnitude estimations.

Response:

The paragraph has been revised to clarify this discussion. It reads as follows, "The order of magnitude estimates isolated hotspots from the MCL and Risk target volume. For example, order of magnitude influent concentrations from the MCL target volume from regions where TCE concentration were greater than 5 μg/l and less than 500 μg/l. Conversely, budget level influent concentrations from the MCL target volume came from regions where TCE concentrations were greater than 5 μg/l, including the hotspots."

2. Editorial Comments

a. **Page M-4, Table M-2. Does this table assume a target area of background, MCLs, or risk based?**

Response:

The table assumes a background target area. A column heading has been appended to "Background Plume" to make this clear to the reader.

b. **Table M-7. Why are the maximum detected values different in the background target volume from the MCL and risk based target volumes? All the options require containment and treatment of the highest concentrations. Maximum concentrations should be consistent throughout.**

Response:

The tables have been revised and are incorporated into the RI/FS.

L. APPENDIX Q, EVALUATION OF END-USE OPTIONS

1. Significant Comments

a. **Page Q-17, last paragraph. McClellan should not dismiss a discharge to Magpie Creek due to potential responsibility for creating/ maintaining a riparian habitat. This issue should be discussed with the various wildlife agencies for their input. It should be noted that a surface water discharge is the least preferred alternative for disposal of the treated ground water.**

Response:

So noted. See Chapter 9 Water End-Use Options, Response 1c.

b. **Page Q-18, third sentence. What is meant by the statement that no additional sampling will be required prior to discharge of any new treated water? This would be true for the existing treatment plant if the ground water from a new extraction field has been adequately characterized prior to being discharged to the treatment plant. Any new treatment facilities will be required to do performance testing prior to discharge.**

Response:

So noted. Changes have been made to the text.

2. **Editorial Comments**

a. **Page Q-6, last sentence. Less than 400-feet of pipe should be required to connect the west ground water treatment plant to the storage tank. A line is currently connected but may need to be increased in size or supplemented.**

Response:

It may take less then 400 feet of pipeline to connect the west groundwater treatment plant to the storage tank. However, at this level of investigation and the relatively minor impact on the overall cost, the 400-foot assumption will remain.

b. **Page Q-16, last sentence. The Report of Waste Discharge will be used to develop injection limitations and requirements since EPA will not require a permit for injection of non-hazardous waste into a useable aquifer. Those types of wells are permitted by EPA by default at this time.**

Response:

So noted. Changes have been made to the text.

c. **Page Q-29, paragraph 1, and Table Q-9. The text discussing cost ranges should take the two low flows for each treatment plant as the low-end cost and the two highest anticipated flows for the high-end cost. The range should be $26,000 to $82,000 for system 1 and $73,000 to $128,000 for system 2.**

Response:

So noted. Changes have been made to the text and tables.

M. APPENDIX R, METHODOLOGY FOR BUDGET-LEVEL COST ESTIMATES

1. Significant Comments

a. **Page R-17, first sentence. It is stated that a chlorination system is assumed to be used to disinfect TCE-ladened ground water. In the case of discharge of the ground water to the water purveyors the chlorine addition should come after the treatment processes to remove VOCs.**

Response:

Agreed, it was intended to be added at the completion of the VOC treatment to avoid loss of the residual chlorine to air stripping or GAC.

2. Editorial Comments

a. **Page R-13, second bullet. This sentence does not make sense. What is "internals (?)"?**

Response:

Internals refers to the packing and distribution piping within the tower. The question mark was a typographical error.

b. **Table R-17. Consistency in numbers should be checked between alternatives that have the same basic requirements. For example, abandonment of BW-18 should have a consistent cost amongst all the alternatives.**

Response:

All the cost tables have been checked for consistency.

N. APPENDIX S, TASKS AND SCHEDULES FOR IMPLEMENTATION PLANS

1. Significant Comments

a. **Page S-2, Priority Based on Risk. Staff believes the priorities should be plume specific. For example, the low level concentration**

plume located off-Base to the west would be one of the first priorities according to those listed in the report. Staff thinks that money would be better spent preventing off-Base migration of additional contaminants to attacking this low level plume. Preventing further off-Base migration should be as important as remediating the low concentration off-Base plumes. In fact, by extracting off-Base without controlling on-Base plumes will only accelerate the off-Base migration.

Response:

The priorities have been revised to reflect the comment and to be consistent with Chapter 13.

b. **General Comment. Target volumes may vary with each plume. It may required to contain/remediate one plume to background because it is reasonable to do so, while 10^{-6} risk may the containment/cleanup value for another plume. This cannot be determined until the plume extends are better defined along with the associated costs for remediation.**

Response:

The Air Force agrees with the comment that the plumes cannot be addressed all at once because of funding limitations; the revised discussion of priorities reflects this concept. However, a single goal for the interim remedy of 10^{-6} risk is preferred to attempting to establish separate goals for each target volume. If the information collected during the implementation of the interim remedy indicates the goals should be changed, then an Explanation of Significant Difference can be prepared or the goal can be included in the Basewide ROD.

c. **Page S-3, Sequence of Tasks. Hydropunch sampling, followed by monitor well installation and sampling, should be the first tasks performed. Costs for the newly refined plume boundaries can then be developed and the plume cleanup determinations made. Then extraction and hydraulic control monitor wells can be constructed. This last item should also be done in phases to determine what the aquifer can actually yield and refine the design of the extraction system accordingly.**

Preliminary and final design packages will want to be reviewed by our office as time allows.

Consideration of construction of modular treatment units that allow expansion and reduction of treatment capacity should be considered.

Response:

The schedules have been adjusted to include Hydropunch sampling; however, the sequence does not have to be refinement of the target volumes prior to installation of the extraction wells. In many situations at McClellan AFB, the extraction wells can be installed in areas of definite contamination and used to perform long-term (at least 72-hour) aquifer tests to improve the information on transmissivity and storage, as well as measure the potential capture zones. The Air Force would prefer to attack the uncertainties related to the extraction wells performance (T, S, leakance, and zone of capture) in parallel with the refinement of the target volumes by Hydropunch or monitoring wells. For the purposes of the FS, it is adequate to simply show the installation of the monitoring and extraction wells as part of the first phase of work, given that a detailed schedule will be developed in the Groundwater OU Work Plan and Phase I SAP.

The Groundwater OU Work Plan and Phase I SAP will include the necessary design details and will be submitted to RWQCB for review.

Modular treatment units will be considered in the design of the treatment system.

d. **Time Schedules. It was noted that on alternative 1 under Task Order 3 that 134 wells are proposed to be constructed in 180 days. Staff considers this too ambitious of a schedule and does not incorporate any data from wells as they are installed into subsequent wells.**

Response:

The time schedule was based on several drilling operations being performed in different areas of the Base. By the time the third Task Order (now considered the third phase of the remedy) is put in place, the work will be predominantly onbase and within the defined target volumes. Two factors make 180 days more reasonable than initially appears. First, the number of wells in a given area is far less than the 134, and there will be time to incorporate the data into the understanding of that area. The second factor is that the understanding of the entire groundwater system does not need to be revisited for each new data point at that stage of the implementation. For example, data from OU A are not necessary to understand OU C. The schedule for Task Order 3 is certainly an estimate that will be revised as the results from the earlier phases are interpreted.

SUBJECT: Draft Final Groundwater Operable Unit RI/FS
McClellan Air Force Base

PROJECT: SWE28722.66.FS

DATE: March 28, 1994

Department of Toxic Substances Control
November 1993

General Comments

1. **Based on the Department of Health Services, Office of Drinking Water (DHS-ODW) response (letter dated December 6, 1993, enclosed) to the "draft" proposed plan, the Department does not support, at this time, the emphasis placed on supplying treated groundwater to the local water purveyors as an end use option.**

Response:

The Air Force will pursue reinjection as the preferred alternative for the end use of the treated groundwater.

2. **The RI/FS report should provide a summary of the PGOURI findings and recommendations.**

Response:

The Preliminary Groundwater Operable Unit Remedial Investigation (Preliminary GW OU RI) findings and recommendations have been summarized in Chapter 4, Conceptual Model.

3. **The RI/FS report should: 1) describe how this RI/FS will integrate further investigations to define the extent (vertical and horizontal) of groundwater contamination; 2) identify specific sites that can be tied to groundwater plumes; and 3) identify and prioritize specific plumes requiring remediation.**

Response:

The integration of further investigations is reflected in the conclusions of the Conceptual Model where the data gaps are identified, in the Feasibility Study (FS) approach (Chapter 6) where the basis for preparing the FS without complete information on the extent of the action is provided, in Chapter 13 where the phasing of the implementation of the alternatives is presented, and in Appendix E where the potential monitoring network is presented at the conceptual level of detail. The identification of specific sites that can be tied to groundwater plumes is, in most cases, not possible because of the sparcity of source data in Operable Units (OUs) A, C, and E through H. The conceptual model has included the probable known sources of groundwater contamination, but this is only applicable to today's information and will need to be updated as the Remedial Investigations (RIs) for the OUs are completed and reported. The identification and prioritization of the specific plumes has been performed and is included in Chapter 13.

4. **Groundwater contamination plumes have not been fully defined. The RI report should clearly identify that additional investigation will be necessary and will be carried out in focused RD/RAs. Use of in-situ sampling techniques followed by data evaluation and installation of monitoring/extraction wells is recommended.**

Response:

The Draft Final report does clearly identify where data gaps exist and identifies the process for filling the data gaps during the remedial design/remedial action (RD/RA). In situ sampling techniques such as Hydropunch will be used as appropriate; however, the sequence does not have to be in situ sampling followed by data interpretation, followed by installation of monitoring/extraction wells in all cases. For many areas of McClellan AFB, extraction wells can be installed without further characterization, or the extraction wells need to be installed in parallel with further refinement of the target volumes to provide much needed transimissivity and capture zone information. Another example of the need to install monitoring wells is to provide water level data to demonstrate hydraulic control of the plume. The Air Force agrees with the fact that in situ sampling is capable of providing vertical profiling at a greater definition than monitoring wells or is capable of providing lateral definition in the shallow groundwater faster than monitoring wells, and these techniques will be used to the full extent necessary to implement the interim groundwater remedy.

5. **The focused RD/RAs for specific groundwater plume actions must clearly define the geology and hydrogeology (cross sections, groundwater contour maps, etc.)**

Response:

The Draft Final Remedial Investigation/Feasibility Study (RI/FS) includes a discussion of the upcoming documents for the implementation of the interim remedy. The first document for Agency review will be the Groundwater OU Work Plan which will include the overall plan for implementation of the interim groundwater remedy, the phasing of the project (including investigation, treatability studies, and construction of the remedy) and the detailed plans/ designs/sampling and analysis plans (SAPs) for the first phase of the implementation. The details of the focused RD/RAs will be presented in this Groundwater OU Work Plan, and the appropriate cross sections and contour maps will be included to explain the rationale for the scope and phasing of the project. The Draft Final RI/FS includes an extensive presentation of the cross sections for the Base in Chapter 3, and makes use of the information in development of the conceptual model and the remedial action alternatives.

6. **All references to the groundwater Record of Decision (ROD) should indicate this is an interim ROD (IROD). It is still unclear to the Department whether the groundwater IROD will use a "plug in" approach. If a "plug in" approach will be used, describe the process. Given that implementation of actions will occur over the next 5-7 years, the RPMs should consider an approach that allows maximum flexibility.**

Response:

The references to the decision document have been changed to Interim Record of Decision (ROD). The Interim ROD is not a "plug-in" ROD, and has sufficient flexibility because the decision being made revolves around the remediation of a particular target volume related to maximum contaminant levels (MCLs), risk or background. The ROD will clearly state that there are areas where the extent of the target volume is uncertain and investigation is necessary; however, changes in the understanding of the spatial distribution of the contamination does not change the requirements of the ROD. The remedy will need to adjust to the changed conditions.

Primary Specific Comments

1. **Page 1-6, Section 1.4**

Bullet 1. The statement suggests that it is McAFB's intent to remediate all groundwater contamination that has migrated off-base. Department staff does not believe that capture and remediation of all off-base contamination is prudent or appropriate. Capturing highly contaminated on-base groundwater plumes and preventing further contamination of groundwater by major sources should be considered a higher priority.

Response:

The Air Force agrees with the comment, and the priorities of the various projects that will make up the interim remedy reflect this concept. The priorities are discussed in detail in Chapter 13.

2. **Page 1-6, Section 1.4**

Section 1.4 should identify (or reference a section) the priority ranking for specific plumes (Table format is suggested).

Response:

The presentation of the priorities in Chapter 1 seems premature because the reader is not fully familiar with the plumes or the remedy strategy. Reference to Chapter 13 will be added to Chapter 1, and a table of the priorities is included there. The executive summary will also include the priorities in tabular format.

3. **Section 1**

Include text indicating that additional investigative work will be necessary. The Department recommends that investigatory work be carried out under focused RD/RAs for the specific plumes.

Response:

The comment has been incorporated.

4. **Section 2**

Since the PGOURI is the foundation of the RI/FS document present a summary of the PGOURI investigation and recommendations.

Response:

Chapter 2, Study Investigation, and Chapter 3, Physical Characteristics of the Study Area, will be added to the Draft Final Remedial Investigation/Feasibility Study. A summary of the Preliminary GW OU RI investigations and recommendations will be presented in these chapters.

5. **Page 2-6, Section 2.2.2**

Include a section on background (inorganic) water quality. Describe how monitor wells will be selected for determining background and how the data will be evaluated.

Response:

Determining background metals concentrations in the groundwater is beyond the scope of this RI/FS. It will be performed as a post-RI/FS activity. This has been discussed in the Conceptual Model.

6. **Figure 2-5**

The groundwater contours to the southeast of the base indicate a flow directly toward McAFB. Radian's quarterly GSAP maps indicate a total lack of data points to substantiate the contours presented in this figure.

Response:

Figure 2-5 was contoured from January 1993 water levels which are presented in Figures 2-38 through 2-40. McClellan AFB does not know which Radian Groundwater Sampling and Analysis Program (GSAP) maps DTSC is referring to. In the southeast portion of the Base, flow directly toward the Base is due to the head differences between the higher offbase water levels and the lower onbase water levels. In the A Zone, offbase Wells MW-1037, MW-1061, MW-197, and MW-28D have water level elevations of -31.53, -36.88, and -34.22 feet mean sea level (msl), respectively. Conversely, onbase Wells MW-175, MW-68, and MW-186 have water elevations of -41.1, -41.5, and -38.03 feet msl, respectively. Thus, groundwater flows from offbase to onbase. The same behavior is observed in the B Zone and in the C Zone. The contours presented in the figures extend out to the wells furthest from the Base; these wells are MW-1037, MW-1038, and MW-1039 in the A Zone, B Zone, and C Zone, respectively. Although data are available for these points, it does not appear that Radian has extended the contours out to the furthest points. There are data to substantiate these figures.

7. **Page 2-13, Section 2.2.2, Paragraph 1**

Since injection is a viable alternative for treated water disposal, and since injection in the D and E zones is more likely than injection into the A, B and or C zones, Piper and Stiff diagrams for D and E zone wells would be appropriate. The diagrams would aid in evaluating water quality and the viability of injecting the treated groundwater.

Response:

Inorganic water quality information is currently not available for groundwater monitoring wells in the D and E Zones. Thus, Stiff and Piper diagrams for wells in Monitoring Zones D and E cannot be prepared at this time. As part of Phase I of the remedy, constituents in native groundwater will be compared with constituents in treated reinjection water to ensure the compatibility between the two types of waters and to satisfy regulatory requirements. The recommended analytes for reinjection evaluation include the following:

- TPH, EPA 418.1
- Metals, SW 6010
- Arsenic, SW 7060
- Lead, SW 7421
- Mercury, SW 7470
- Selenium, SW 7440
- Semivolatile Organics, SW 8270
- BOD, EPA 405.1
- COD, EPA 410.4
- Alkalinity, EPA 403

- Hardness, EPA 130.1
- Nitrogen, Kjeldahl, EPA 351.2
- TOC, EPA 415.1
- TDS, EPA 160.1
- TSS, EPA 160.2
- Inorganic Anions, EPA 300.0
- Purgeable Hydrocarbons, SW 6010 and Purgeable Aromatic Volatiles, SW 8020

Concentrations in the reinjected water must be equal to or less than the concentrations in the native groundwater. Native groundwater will be collected from Base wells or nearby municipal supply wells, or from a newly installed deep monitoring well at the proposed injection location (to obtain site-specific water quality information).

8. Figures 2- 9-11

Given the limited aquifer testing duration, testing locations, and the heterogeneity previously described, the figures showing "T" mean little and provide only limited use.

Response:

For the purposes of evaluating remedial alternatives, it was necessary to estimate the distribution of aquifer properties across the Base for input into the groundwater model (described in Chapter 6). We have presented these assumed distributions in the Conceptual Model.

9. Pages 2-22/29, Section 2.3

Describe the likely sources (sites) of the groundwater plumes (i.e., OU-B, former plating facility - Bldg 666/CS 47, now IC-1, OU-C1, former waste ponds at the IWTP - CS-42, etc.)

Response:

The likely sources of contamination are discussed in the section describing hot spot target volumes.

10. Page 2-47, Section 2.5.1

The Department recommends incorporating two subsections, regional and local, in the Historical Movement of Groundwater section. On-base production wells would have a pronounced effect on contaminant migration, more so than the regional effects.

Response:

The local groundwater movement and regional groundwater movements will be presented Chapter 3, Physical Characteristics of the Study Area.

11. **Page 2-69, Section 2.5.4, Paragraph 1**

The text attributes drawdown in OU-A as likely being caused by BW-20. BW-20 was decommissioned by CH2M Hill in 1993. If BW-20 was recently (prior to 1993) operational, than base Civil Engineering should have data. Reference and provide BW-20 pumping rate and frequency.

Response:

Reference to BW-20 as the cause of drawdown in the northern section of OU A has been deleted from the text.

12. **Page 2-81, Figure 2-43**

Base Wells 8,13,17,20 and 28, as well as City Well 150, were decommissioned in 1992 and 1993. All the above mentioned wells should be identified as "ABANDONED" in Figure 2-43. BW-15 (identified on page 2-86) is not identified in the figure and the actual existence of Caltrans Well 3 (CT-3) at the identified location is questionable. Enclosed is a memo from Caltrans regarding well locations and estimated pumping rates (for Figure 2-44.)

Response:

All Base wells decommissioned during January 1992 to January 1994 have been so noted in Table 2-6 and Figures 2-43 and 2-44. A note has been added to Figure 2-43 indicating that CW-150 has been decommissioned. Additional Caltrans Wells were identified from the memorandum.

13. **Page 2-88, Section 2.6.1, Paragraph 1**

The OU-D RI/FS report indicates that there are metals in the groundwater. A figure similar to Figure 2-45 should be prepared for metals.

Response:

A figure showing frequency of metals detections and mean concentrations with time would not be conclusive because a variety of field sampling methods have been used historically. Comparisons between unfiltered and filtered results or samples collected at high or low purge rates would not be valid.

14. **Page 2-90, Section 2.6.1, Paragraph 2**

Background for inorganics has not been established for McAFB. It is inappropriate to discount nickel and manganese as COCs.

Response:

No metals can be evaluated as contaminants of concern (COCs) until a detailed evaluation of metals is performed. Yet an evaluation of metals cannot be performed in this interim RI/FS for the following two reasons:

- Background groundwater metals concentrations have not been established for groundwater beneath McClellan AFB. Hence, it is not possible to differentiate the difference between metals in groundwater that occur naturally due to mineral dissolution and metals contamination from Base activities.

- A variety of field procedures have been used and it is not possible to distinguish between results from different sampling procedures. Historically, both filtered and unfiltered samples have been collected at low, and possibly high flow rates. Turbid samples are generally collected at high flow rates that may overestimate groundwater metals concentration.

Background concentrations must be established and field sampling techniques must be standardized before the extent of metals concentrations can be evaluated. A discussion of metals as a data gap is presented in the conceptual model.

15. **Page 2-104, Section 2.6.3, Par. 1**

The Department recommends that McAFB have a contingency action available for rapid installation of well head treatment for CW-132, if CW-132 is used. The Department also recommends holding a meeting with McAFB, EPA, RWQCB, DHS-ODW and the City to discuss implementation of an action, if necessary.

Response:

A discussion of the contingency plan for CW-132 is presented in Chapter 13, Implementation Plans.

16. **Section 2.6.4**

The sections on OU plumes must make a stronger link to specific sites within the appropriate OU.

Response:

Comment noted.

17. **Page 2-106, Section 2.6.4**

The Department believes there is a high potential for vertical migration of contamination due to improperly abandoned base wells (e.g., BW-7). The Department requests that McAFB ensure proper abandonment of the remaining non-operational base wells for all the OUs.

Response:

McClellan concurs and has selected contractors to continue proper abandonment of Base wells.

18. **Page 2-106, Section 2.6.4, Paragraph 4**

Given the off-base plume located under site 24 in OU-A, confidence in bounding the south and southeast sides of the OU-A plume should be limited.

Response:

The new Jacobs data were obtained in December 1993 and January 1994 from five wells located in the southeast section of the OU A plume near Site 24. Four were A Zone wells and one was a B Zone well. TCE was measured in two of the A Zone onbase wells, MW-289 and MW-291, at 140 $\mu g/l$ and 70 $\mu g/l$, respectively. TCE was measured at the two offbase A Zone monitoring wells at nondetectable levels and TCE was measured in the onbase B Zone well at nondetectable levels. From current information, this section of the OU A plume is considered bound. These wells should continue to be monitored to determine the extent of offbase contamination.

19. **Page 2-123, Section 2.6.4**

OU-B/C While the lateral extent of TCE groundwater plumes from areas like Building 666 appear to be limited, the plume(s) that extend from OU-C1 to BW-18 and beyond do not appear to be limited in lateral extent. Given that there are at least four "TCE plumes" the Department recommends that the text be more specific when discussing "bounds" and "confidence." The text should also discuss the need to further delineate the TCE plume, in OU-C, on the far west side of the base (MW-111).

Response:

Comment noted.

20. **Page 2-124, Section 2.6.4**

OU E-H Groundwater monitoring, based on limited monitoring points (10 A-Zone wells), has detected three wells with TCE above MCLs (8.1, 7.5, 6.8 ppb), two wells with TCE contamination below MCLs (4.2 and 3.5 ppb) and five Non Detects (Radian July-Sept., 1993, GSAP). OU-E-H has plating shops, degreasing and wash racks, as well as aircraft maintenance facilities. That no confirmed sites exist is true, but the statement does not accurately depict the OUs being described.

Response:

Comment noted.

21. **Page 2-129, Figure 65-7**

Both the A and C zones have plumes above MCLs that extend from OU-C1 to the southern portion of OU-B. However, the B zone figure does not indicate a plume above MCLs extending from OU-C1 to OU-B. It would appear that additional monitoring wells in the B zone are warranted.

Response:

The high contamination noted in the C Zone of OU C in the Draft RI/FS was due to high contamination in EW-144. Extraction Well EW-144 was originally assigned to the C Zone in the data base, but upon review of water quality and depth of screened intervals, EW-144 has been reassigned to the B Zone. The screened interval of EW-144 is within the B Zone (depths defined in the Preliminary GW OU RI) and is similar in depth and water quality to other B Zone wells. The C Zone well may still need to be installed to estimate the lateral extent of the deeper contamination.

22. **Page 2-138, Section 2.8**

The Department strongly supports additional definition of the zone between the bottom of the A zone and bottom of the B zone.

Response:

Comment noted.

23. **Page 2-138, Section 2.8, Paragraph 1**

Use of filtered samples must be coordinated with both ATSDR and toxicologist (representing McAFB and the regulatory agencies).

Response:

Comment noted.

24. **Page 2-138, Section 2.8, Paragraph 5**

The Department recommends that McAFB monitor (or obtain data from Northridge) the pumping rate and frequency of the Northridge Water District wells in the area.

Response:

McClellan AFB will attempt to obtain the Northridge pumping information.

25. **Page 2-142, Section 2.8**

OU-B&C It appears that MW-61 in OU-C may be within a separate plume that joins with the larger OU-C1 plume. Further delineation of the MW-61 plume should be considered.

Response:

Monitoring Well MW-61 was included in the larger OU B/C plume which included OU C1 and IC 1 and IC 2.

26. **Page 2-159, Section 2.8, Paragraph 2**

The Department's recommendation for decommissioning BW-18 was based on the assumption that BW-18 would not be "turned off" until an adequate extraction system to contain migration of contamination off-base was in place. Department staff assumed that the BW-18 decommissioning would not be accomplished for three to five years. The Future Conditions section should consider that BW-18 will be operating until the 1997-1998 timeframe.

Response:

Comment noted.

27. **Page 3-17, Section 3.5**

See General Comment #1. Based on discussions between DHS-ODW and the Department, it does not appear that the local water purveyors will be able to obtain the treated water from McAFB. The Department recommends that McAFB add a paragraph discussing the ODW policy.

Response:

This chapter provides a brief introduction to ARARs. A detailed discussion of the ARARs that apply to each alternative, including end-use options, is provided in Appendix D. The Office of Drinking Water policy on new water supply sources has been added to the Appendix.

28. **Page 4-1, Section 4.1**

Section 4.1 should be placed in the Introduction section.

Response:

Moving the section was considered, and it was decided that the section needed to be included in Chapter 6 (formerly Chapter 4) because the uncertainties cannot be understood by individuals unfamiliar with the project until they have read the Conceptual Model and the Risk Assessment.

29. **Page 4-6, Section 4.4.1, Paragraph 2**

The iROD for the groundwater OU must also address the need for additional characterization work.

Response:

The comment has been incorporated.

30. **Page 4-11, Section 4.5.1**

The Department recommends that the list of uncertainties, for both the RI and FS, be included in the Introduction.

Response:

The list of uncertainties has been included in the Executive Summary.

31. **Page 5-1, Section 5.1.1**

Bullet 1 and the last paragraph specify "uncertainties" regarding "contamination offbase." The Department suggests that "offbase" be removed, since further work will be required both on and off-base, prior to design of the remedy.

Response:

The comment has been incorporated.

32. **Page 5-2, Section 5.1.1, Paragraph 1**

The Department recommends that the aquifer tests be conducted for 24 to 48 hours.

Response:

The Air Force concurs, and future aquifer tests from extraction wells will be scoped to be up to 72 hours and monitor wells from multiple depths if appropriate.

33. **Pages 5-3/4, Section 5.1.5**

The monitoring well network must also serve to evaluate hydrogeologic flow for areas where contamination may exist, but no remedial actions are proposed.

Response:

The comment has been incorporated.

34. **Page 5-5, Section 5.2.3**

The compliance report must also show the capture zone(s), provide evaluation of the extraction system(s) effectiveness and recommend modifications, as appropriate.

Response:

The comment has been incorporated.

35. **Page 6-52, Fiure 6-28**

Provide the extent of capture in the A and B zones for BW-18. Extraction wells 233 and 234 are lower A zone (ID'd as "B" in the Specific Data Report) extraction wells. Include the three OU-B "EE/CA" wells capture zone.

Response:

The capture zone presented for Base Well 18 includes the capture in Monitoring Zones A and B attributable to vertical movement into the lower aquifers. Significant uncertainty exists as to the extent of this capture zone because it was estimated from the groundwater model containing uncertainty regarding the distribution of transmissivity across the Base.

The screened intervals for Extraction Wells 233 and 234 have been corrected.

Insufficient information regarding the OU B engineering evaluation/cost analysis (EE/CA) wells is available at this time to definitively estimate their zone of capture.

36. **Page 9-1.**

See General Comment 1.

Response:

The end-use evaluation reflects the findings of DTSC-ODW with respect to sale of the water to the utilities.

37. **Page 9-9, Section 9.3.4, Paragraph 1**

The Department questions the viability of being able to inject water at a rate of 1600 GPM into three wells, all screened above 100 feet BGS. Further evaluation of injection zones should be identified as a requirement. Water quality evaluations must be made as well. The results must be evaluated and approved by the regulatory agencies prior to injection.

Response:

The reinjection depth was an error and has been corrected to 600 feet. The water quality of the reinjection zone will be tested as well as the reinjection zones capacity to receive water. The actual number of wells will depend on the capacity calculated from the reinjection testing, and will be adjusted appropriately during remedial design.

38. **Page 9-9, Section 9.3.4, Paragraph 3**

The text indicates that the RI report is evaluating the potential effects of injecting treated groundwater. Reference the section(s) where the evaluation is being conducted.

Response:

The reinjection of treated groundwater is evaluated in Chapter 8 (formerly Chapter 6) for two situations: reinjection as an end use on the north end of the Base, and reinjection of a portion of the water in the hot spots per EPA's comments. Detailed results are available in Appendix J also.

39. **Page 11-1, Section 11, Paragraph 1**

The preferred alternative may not be the same for each, or all, plumes. As identified in General Comment #2, the report should identify and prioritized

specific plumes that will require remediation. At a minimum, the remedial actions should meet the 10^{-6} risk.

Response:

The preferred alternative has been revised to reflect the plume-specific priorities; however, a consistent remedial action goal of containment of the 10^{-6} risk target volume is applied. If a specific area of groundwater contamination is found to need a more or less stringent requirement, then an Explanation of Significant Difference can amend the Interim ROD or the requirement can be incorporated into the Final ROD.

40. Page 11-15, Section 11.1.1

The bullet identifying Priority 1, is misleading. Not all off-base contamination should be considered high priority. See Primary Specific Comment #1.

Response:

The priorities discussion is revised and the comment incorporated.

41. Page 11-29 Section 11.2.9

State acceptance is determined by the State signing of the iROD or ROD.

Response:

The comment has been incorporated.

42. Page 11-29, Section 11.2.10

Community Acceptance does not occur until they have made comment on the Proposed Plan.

Response:

The comment has been incorporated.

43. Page 11-33, Section 11.3.3

The minimum acceptable target volume is the 10^{-6} target volume.

Response:

The preferred remedy has been adjusted to reflect the comment.

44. **Figure 11-8**

The flow sequence suggests that all off-base work will be complete prior to initiating on-base work. In reviewing the Department's and RWQCB's (agencies) comments, that is not the sequencing that the agencies recommend. While some further off-base work is necessary, the agencies recommend that the on and off-base high priority efforts be performed simultaneously. The Department also recommends including the off-base production well contingency, identified in Primary Specific Comment 15.

Response:

The comment has been incorporated into the priorities.

45. **Page D-19**

The DHS-ODW policies and regulations have significant impacts on the groundwater end use options and should be discussed.

Response:

A discussion of the DHS-ODW policy on new water supply sources and how it effects the end-use options has been added to Appendix D.

46. **Appendix E**

Include a section discussing the need to monitor hydraulic flow conditions across the base and in areas where contamination may be present, but remedial actions are not in place.

Response:

The existing monitoring network is adequate to monitor the overall hydraulic flow conditions across the Base. In areas where additional contamination is discovered, additional monitoring wells will be installed as necessary to better define the hydraulic conditions in that area.

47. **Appendix E**

Figures E-8 and E-9. The text described the need to monitor between the A and B zones in OU-C. Neither figure proposes additional wells suggested by the text. The figures do not indicate additional wells to further define the plume emanating from OU-C1 in the B zone. The maps do not identify the OU-B EE/CA wells, or indicate the need for extraction wells around the OU-B base perimeter to prevent off-base migration when BW-18 is decommissioned.

Response:

The design issues referred to will be addressed in the work plan and sampling and analysis plan developed for each phase of the remedy.

48. **Appendix N**

Table N-3. The data indicates that BW-10, located on the east side of the base, is a major operational on-base production well. The influence of the well should be discussed in the text. Verify the pumpage rate for BW-10 for 1993. BW-18 pumpage volume for 1993 appears to be significantly reduced or only reflects pumping for a partial year. If data for 1993 is partial (1st qtr.), identify the ending date of data collection. BW-20 has no data available, yet the text indicates that it has significant influence. How was the determination of influence made? The Table should also indicate the year a production well was decommissioned or shut down due to contamination.

Response:

The well abandonment program is an ongoing program, and as such will incorporate more current information as it becomes available. Appendix N was a reprint of the most recent well abandonment report available at the time of submission of the Draft RI/FS report. A more recent report has become available and is included in Appendix N.

49. **Appendix S**

As previously indicated (General Comment # 3 et.al.), specific plumes should be prioritized for definition and RD/RA implementation.

Response:

The schedules have been revised to reflect the priorities. The level of detail will be expanded for each phase of the remedy during the preparation of the Groundwater OU Work Plan, and the schedule will be presented there. The sequencing of specific data collection-vs-extraction well installations issues is best addressed in the Groundwater OU Work Plan, and the schedule in Appendix S has sufficient detail for the FS purposes of comparing alternatives.

50. **Groundwater Well Specific Data Report**

During review of the Time Trend Analyses charts, it became apparent that, for volatile compounds, the log scale graph would provide the resolution to help the Department evaluate trends. The Department suggests that the 0-100, 0-1000 and 0-10000 be replaced by the log scale graph using the full page.

Response:

The Groundwater Well Specific Data Report will be reissued with data up to January 1994. The concentration time series will be plotted in the log scale as suggested.

Secondary Specific Comments

1. **Page 1-3, Section 1.3.1, Paragraph 1**

The ROD should be identified as an "interim" ROD.

Response:

The comment has been incorporated.

2. **Page 1-5, Section 1.3.2**

Delete Bullet 4.

Response:

The section is based on the objectives stated in the Management Action Plan, therefore the bullet was not deleted.

3. **Page 1-9, Section 1.6, Paragraph 2**

The GWTP also receives water from OU-B extraction wells.

Response:

The comment was incorporated.

4. **Figure 2-1**

Under the different topics (Site Characterization, Source Area Information etc.) identify the section where the discussion is presented.

Response:

The sections where different topics are located will be included in the figure, as recommended.

5. **Page 2-20, Section 2.2.3, Paragraph 1**

The phrase "conservative design of an extraction system..." needs further clarification. Does the statement mean that the actual zone of capture will be larger

than expected, or that more wells than actually necessary would be installed, or both?

Response:

This discussion has been clarified in the following manner, "Based on the current data, transmissivities were estimated to be lower than those estimated by the Jacob Method. This approach will result in a conservative design of the extraction system that will be effective at containing contamination, even in such low transmissivity conditions. This design will address the uncertainty that exists in actual aquifer characteristics at the site because it will be effective in all but worst-case conditions. Additional aquifer tests will be performed. If transmissivities are found to be higher that those originally estimated, fewer extraction wells will be needed for capture."

6. **Page 2-20, Table 2-1**

Include the depth range, (since it varies across the base) below the ground surface, for the three zones identified in Table 2-1.

Response:

Zone depths in mean sea level and below ground surface have been added to the table as recommended.

7. **Page 2-30, Section 2.3**

IWL - Pgph 2. The depth of the IWL was generally not the reason repairs could not be implemented on the IWL. More likely reasons included small diameter pipe and elbows in the pipe.

Response:

The following sentences have been added to the text, "Repairs were not made on all detected leaks because access to some sections was limited by small-diameter pipes, small-diameter elbows, or depth of the pipe below the ground surface. The Industrial Wastewater Line (IWL) is located 3 to 20 feet bgs."

8. **Page 2-51, Figure 2-23**

The vector direction for 1958 is not supported by Fig 2-21 (west). The vector magnitudes are also inconsistent with Fig. 2-21 e.g. 1978 gradient is greater than 1968 in Fig. 2-21.

Response:

Figure 2-23 has been deleted.

9. **Page 2-70, Section 2.5.5, Paragraph 4**

The text does not reflect what is presented in Figure 2-42 or Table 2-5.

Response:

The text, figure, and table regarding the water table have been revised in the Draft Final RI/FS.

10. **Page 2-85, Section 2.5.7, Paragraph 2**

BW-8 is completely decommissioned. BW-7 is still not decommissioned.

Response:

Well BW-8 will be presented as "decommissioned" in the Draft Final. Well BW-7 will be decommissioned during Phase III of the well abandonment program; this will be presented in the Draft Final.

11. **Page 2-90, Table 2-8**

The two extraction wells (233 & 234) located near Building 666 are screened in the lower A zone.

Response:

Extraction Wells EW-233 and EW-234 have been moved to the A Zone in all figures and for the target volume generation.

12. **Page 2-101, Figure 2-50**

Verify the concentration of TCE for MW-1068.

Response:

The concentration of MW-1068 has been corrected to be 1.5 μg/l.

13. **Page 2-103, Section 2.6.3, Paragraph 2**

Add a sentence indicting when CW-150 was decommissioned.

Response:

The following sentence has been added to the text, "The well (CW-150) was put out of operation in April 1989 and decommissioned in April 1991."

14. **Page 2-117, Figure 2-58**

Cut A2 does not adequately depict the two contaminant plumes in OU-A.

Response:

The vertical profiles will be revised and recontoured to represent current water quality conditions more accurately.

15. **Page 2-125, Section 2.7**

Provide the mass estimates in gallons also.

Response:

The volumes will not be presented in gallons. The volumes calculated are not of contaminated groundwater, but of contaminated aquifer, which includes both soil and groundwater.

16. **Page 2-142, Paragraph 2**

edit. We assume you meant the east side of the OU-C plume, not OU-A.

Response:

The text has been corrected to reference OU B/C.

17. **Figure 2-77-79**

The Figures represent Risk, not concentration.

Response:

The titles of Figures 2-76 through 2-79 have been changed to Risk Trend Analyses for Wells in Monitoring Zones A (or B, C, or D and E).

18. **Page 6-9, Section 6.3.1, Paragraph 2**

The Text describes de-watering in OU-A, and Figure 6-5 shows OUs G&H as being susceptible. Explain why, based on available data, modeling parameters used, etc., the area is more susceptible to de-watering.

Response:

This area of the Base is especially susceptible to dewatering for two reasons. The first is that it is a low-transmissivity area and groundwater extraction will create more drawdown in this area than in adjacent higher transmissivity areas.

The second reason is that the base of Monitoring Zone A is at a shallower depth in this area, providing less saturated thickness from which to extract groundwater. See Figure 3-29 in the Preliminary GW OU RI for the base elevation of the A Zone across the site.

SUBJECT: Draft Final Groundwater Operable Unit RI/FS
McClellan Air Force Base

PROJECT: SWE28722.66.FS

DATE: March 28, 1994

Marvin Woods
Department of Toxic Substances Control

General Significant Comment

1. **The Report proposes the installation of several new monitor wells and extraction wells in order to implement the remedial action and to monitor its performance. The existing monitoring network provi.les clear, but relatively gross, evidence that ground water contamination is stratified. In particular, in the OU B/C area, near and down-gradient of the Industrial Waste Treatment Plant (IWTP), we suspect that contamination is more strongly stratified than the existing monitoring network can resolve. With better vertical resolution of the VOC plume(s), new monitor and extraction wells can be better designed and the extraction of contaminated ground water would be more efficient. We strongly recommend that, prior to construction of additional monitor and extraction wells, the vertical distribution of contamination be defined more precisely with depth-discreet *in situ* ground water sampling methods (e.g., BAT or HydroPunch).**

Response:

The Air Force supports the appropriate delineation of the vertical profile of contaminant concentrations. With respect to the use of Hydropunch or depth-specific sampling prior to placement of monitoring wells, it is important to match the data collection technique to the data collection need. In many cases the use of a monitoring well without further water quality data is appropriate because the function of the well is to provide water level data to evaluate the capture zone of the interim remedy. If the only need is a one-time water quality value, then indeed the Hydropunch will be used. In several areas of the Base there is sufficient information to install efficient extraction wells and obtain good estimates of aquifer parameters to fill significant data gaps.

General Editorial Comments

1. **It is confusing to allot two page numbers to a single ledger-size (11" x 17") figure.**

Response:

It is common printing practice to always have even pages on the left and odd pages on the right when printing two-sided copies. To alleviate the inconvenience for the figures that are 11 by 17 or C-size, plates are placed at the end of the chapter in the Draft Final.

2. **The Report is necessarily lengthy and complex. To facilitate its review and use, we recommend separating tables and figures from the rest of the text. For example, figures (most of which are ledger-size) could be bound unfolded in a separate comb binder. In that case, assigning page numbers to the figures is unnecessary and comment 1, above, becomes moot.**

Response:

The document has a wide audience, and it would be difficult for the public to review a document with the tables and figures bound separately.

3. **The Report has numerous occurrences of typographical and grammatical errors as well as cases of omitted, superfluous, or inappropriate words. This is to be expected in a draft version, and these errors have not been enumerated in this memorandum. However, we have highlighted these occurrences in our copy and would be happy to share the information with CH2M HILL.**

Response:

We appreciate the offer to provide a markup with editorial errors; however, the changes in Chapters 4, 8 (formerly Chapters 2 and 6), and Appendix J, (where this reviewer focused) were quite extensive, and the usefulness of the editorial markup would have been minimal. It is expected that the changes from the Draft Final to the Final RI/FS will be primarily editorial, and we would appreciate the opportunity to review any editorial errors you may find.

4. **It is our understanding that the GWDSR is part of the Report. However, the GWDSR does not have a title page showing who prepared it and when, nor is the GWDSR ever cited in the Report. Please provide an appropriate title page for the GWDSR and some brief explanatory text either within the Report or at the beginning of the GWDSR itself.**

Response:

It was not intended that the Groundwater Well Specific Data Report be part of the Remedial Investigation/Feasibility Study (RI/FS). It was prepared independently in response to concerns, particularly EPAs, that the data were not available, and it was prepared in accordance with the DTSC/EPA/RWQCB guidelines for presenting hydrogeologic data. The Groundwater Well Specific Data Report will be reissued soon to include data through January 1994. At that time the title page will be incorporated and the time series will have only log scale.

A. Summary

Editorial Comment

1. **Page iv, last paragraph. This paragraph discusses operable units (OUs) at McClellan. The Report should provide a suitable map or perhaps refer to Figure 2-12.**

Response:

The comment has been incorporated by reference to Chapter 4 (formally Chapter 2).

B. Glossary of Terms

Editorial Comment

1. **The *list of abbreviations* and acronyms is incomplete. Although "Preliminary GW OU RI" is listed, "PGOURI" is not. "TIS" is also not listed. "TIS" and "PGOURI", which is used several times in the Report, should be included in the list.**

Response:

These acronyms have been added to the list.

C. Chapter 1, Introduction

Editorial Comments

1. **Page 1-9, last paragraph. In discussing extraction wells, please either provide a map that shows their locations or refer to an appropriate existing map. Also, please indicate the depths or monitoring zones from which the wells pump.**

Response:

The comment has been incorporated by referring the reader to Chapter 4.

2. **Page 1-10, paragraph 1. It is stated that four extraction wells currently operate within OU C. However, according to *Management Action Plan* (McClellan AFB, July 1993) (Figure 3-9), OU C encompasses only two of the four wells, the other**

two being in OU B. The distribution of extraction wells with respect to OUs should be clarified.

Response:

The text has been corrected.

D. Chapter 2, Conceptual Model

Significant Comments

1. **Page 2-6, last paragraph, and Figure 2-3. This paragraph states that the lithology at McClellan is highly heterogenous, and refers to cross section N-N' shown in Figure 2-3. Although Figure 2-3 does support the statement, it is not clear that all cross sections developed show such heterogeneity. The Report needs to either refer more frequently and explicitly to the PGOURI or to re-present essential illustrations of the PGOURI (i.e., all of the cross sections A-A' through S-S'). At the very least, the Report needs to provide a map showing cross sections that have been developed. GSU does not wish to promote unnecessary duplication of effort and reportage, but a Remedial Investigation/ Feasibility Study Report needs to be able to stand alone better than this Report. Although we have tied this comment to the paragraph stated above, it really applies to all of Chapter 2 (*Conceptual Model*).**

Response:

Two chapters, Chapter 2, Study Area Investigation, and Chapter 3, Physical Characteristics of the Study Area, will be added to the Draft Final RI/FS. Eight cross sections have been prepared for the Draft Final of the RI/FS and will be presented in Chapter 3. These cross sections will show lithology, contaminant concentrations, and water levels. A map showing where Preliminary Groundwater Operable Unit Remedial Investigation (Preliminary GW OU RI) cross sections and these new cross sections are located will be added to Chapter 4.

2. **Page 2-13, paragraph 3. This section discusses aquifer properties as determined through 28 single-well aquifer tests. The Report once again fails to cite the PGOURI, where several multiple-well aquifer tests are described and interpreted. Furthermore, the Report does not present for review the data generated by the 28 single-well tests. The Report should discuss how the transmissivity (T) values estimated by the single-well tests compare with values provided by multiple-well tests. If CH2M HILL deems the previous multiple-well tests to be inadequate, the Report should discuss this. In that case, the single-well T estimates should be confirmed by at least two thoroughly-designed multiple-well aquifer tests.**

The Report should provide a brief mathematical development of the Papadopolus-Cooper analytical method and cite an appropriate reference. The Report should discuss the probable effects of partial well penetration on the analytical method and resulting T estimates. Finally, the Report should discuss the meaning of T estimates based on aquifer tests conducted within a highly heterogeneous hydrogeologic system that displays a great amount of hydraulic connection.

Response:

The revised Appendix J presents all of the T values incorporated into the numerical groundwater model. All of the single-well tests presented in the Preliminary GW OU RI were used in the model as were the results of four multiple-well tests. References for these aquifer test results are included in Appendix J. The results of the slug tests presented in the Preliminary GW OU RI were not used as input to the model. Slug test results reflect the aquifer properties of a very small portion of the aquifer directly around the well bore, and produced permeability results an order-of-magnitude lower than those obtained from the pumping test performed at the site. Pumping tests are clearly the more appropriate source of transmissivity data when the data is to be used to estimate the aquifer response to groundwater extraction.

Transmissivity values derived from aquifer tests performed in a leaky heterogeneous aquifer reflect the average transmissivity of the aquifer in response to groundwater extraction. This is the information necessary to evaluate the response of this type of aquifer system to groundwater extraction. It is not clear from the comment what other source of data would be used to develop a conceptual design of an extraction system at the Base if aquifer test data were ignored.

A complete discussion of the Papadopolus-Cooper method can be found in Kruseman and de Ridder, 1991.

3. **Pages 2-17 through 2-19 (Figures 2-9 through 2-11). We observe that T contours shown in the figures do not honor posted data values in many instances, and that the contours are completely unconstrained by data in large areas (e.g., the northwest quadrant of the Base in Figure 2-9). While individual T values may be subject to implicit "adjustment" during the contouring process (based on professional judgement), such practice needs to be fully explained in the Report, and the Report should include complete justifications for any adjustments made to data values. In a larger sense, however, because of the large uncertainty associated with these T estimates, we believe that these three maps should viewed with great circumspection in any case.**

Response:

The transmissivity values in these figures have been recontoured and will be presented in the Draft Final RI/FS.

4. **Page 2-20, top of page. It is stated that using the lower T estimates yielded by the Papadopolus-Cooper method results in a conservative design of the extraction system. If the Report means conservative in the temporal sense, we concur. However, lower T estimates result in a larger predicted capture zone. If the remedial design assumes relatively low T, and T turns out to be higher, then this is not a conservative design. A conservative design should be biased toward assuming relatively *high* T, which implies smaller capture zones. This issue should be more carefully considered and discussed in the final version of the Report.**

Response:

The term "conservative" was intended to reference the total number of extraction wells required to capture the plumes at the site. Lower assumed transmissivities will result in a larger number of extraction wells at lower flow rates being required to capture the plumes. Higher assumed transmissivities will result in a smaller number of extraction wells pumping at higher flow rates to capture the same plume.

5. **Page 2-31, paragraph 1. After pointing out that "no detailed assessments or investigations have been performed for OUs E, F, G, or H," the paragraph nevertheless concludes that "the extent of contamination in these areas is considered minimal" compared to that of OUs A, B, C, and D. While this may prove to be true, the conclusion is apparently unfounded at this time. The Report should be revised to accurately reflect this situation.**

Response:

The reference to contamination at OUs E, F, G and H being minimal has been deleted.

6. **Page 2-90, top of page and paragraph 3. At the top of this page, the Report states that it will discuss why nickel is not considered a compound of concern (COC) even though it is detected above Maximum Contaminant Levels (MCLs). In paragraph 3, after noting that elevated nickel concentrations may be the result of the use of nickel in metal plating activities, the Report then merely states, "Nickel is not considered a COC." The Report does not explain why nickel is not considered a COC. Furthermore, even though nickel-contaminated ground water may be effectively extracted along with the targeted volatile organic compound (VOC) plumes, the Report does not indicate how groundwater treatment will accommodate nickel. Obviously, although nickel will be extracted along with VOCs, it cannot receive the same treatment as VOCs. The Report needs to discuss how nickel will be treated.**

Response:

No metals can be evaluated as contaminants of concern (COC) until a detailed evaluation of metals is performed. An evaluation of metals cannot be performed in this interim RI/FS for the following two reasons:

- Background groundwater metals concentrations have not been established for groundwater beneath McClellan AFB. Hence, it is not possible to differentiate the difference between metals in groundwater that occur naturally due to mineral dissolution and metals contamination from Base activities.

- A variety of field procedures have been used and it is not possible to distinguish between results from different sampling procedures. Historically, both filtered and unfiltered samples have been collected at low, and possibly high flow rates. Turbid samples are generally collected at high flow rates that may overestimate groundwater metals concentration.

Background concentrations must be established and field sampling techniques must be standardized before the extent of metals concentrations can be evaluated. A discussion of metals as a data gap is presented in the conceptual model.

Metals concentrations in the influent to the groundwater treatment plant has been addressed in the FS. The cost of adjusting the treatment system to treat potentially elevated concentrations has been evaluated and is discussed in the FS Approach and the Implementation plan chapters.

7. **Page 2-90, paragraph 5 and Table 2-8. It is stated that "over 300 monitor wells and 14 extraction wells have been installed Basewide," and that since 1986, "almost every well has been sampled at least once." Table 2-8 indicates that the monitoring network consists of a total of 279 monitor wells and 12 extraction wells. The list of wells provided at the front of the GWSDR indicates that a total of 306 monitor wells and 16 extraction wells have been installed at McClellan AFB. Table K-7 (*GSAP Results For COCs*) provides sample results for a total of 282 monitor wells and 12 extraction wells. If Table K-7 is a complete listing of all COC analytical results, the comparison shows that 24 monitor wells and 4 extraction wells have never been sampled. Furthermore, the most recent sample date is older than 1986 on at least 14 monitor wells. Inasmuch as this section of the Report is entitled *Groundwater Monitoring History*, it should provide a more thorough account of the sampling history, and explain why so many wells have apparently never been sampled. It should also state how long the monitoring network represented by Table 2-8 has been in effect.**

Response:

A more complete well count will be performed and a summary of recent sampling information available in the Groundwater Sampling and Analysis Program (GSAP) will be presented.

8. **Page 2-104, *Extent of Contamination*. It is stated that the nature and extent of VOC contamination is estimated on the basis of "maximum VOC results from January 1992 to January 1993." However, Table K-7 indicates that most-recent-sample dates range from March 1982 to January 1993. Likewise, several contaminant isopleth maps (e.g., 2-53a, 2-54a, 2-55a, and 2-56) show posted sample values ranging in age from March 1982 to January 1993. In some cases it is clear that contour lines are partially constrained by the old data values. It is evident that the maps listed form the basis for target volume maps (Figures 2-65 through 2-67). The Report is either correct in claiming to use only recent (January 1992 to January 1993) VOC data (i.e., older data were in fact not used, even though they are posted on isopleth maps), or the extent of contamination has been improperly determined, by contouring analytical data sets that span over a decade. If the former case is true, relevant maps need to be revised to make a clear distinction between data that constrain contours and data that do not. If the latter case is true, the entire basis for the feasibility study is in question and a thorough re-examination of the data analysis methodology must be conducted. We can approve the practice of contouring a data set that spans a year or two, but we cannot approve the contouring of a data set spans nearly 11 years. This issue must be addressed or the text and figures appropriately clarified in the final version of the Report.**

Response:

The target volumes have been revised and are presented in the Draft Final RI/FS. They were delineated from samples from 267 groundwater monitoring wells, 5 extraction wells, and hydropunch samples from 7 borings. Only 5 extraction wells were incorporated because their screened intervals were less than 20 feet long; the 7 other wells had screened interval ranging from 65 to 120 feet long. Data from the following sources were examined to delineate the target volumes:

- Data from the Radian GSAP database up to third quarter 1993. Risk values were calculated for these samples.
- Groundwater data from the OU D RI Summer/Fall 1993 Sampling effort
- Data from five southern OU A wells

Data from the fourth quarter 1993 sampling was studied to determine how most recent concentrations affect target volumes. This data was not incorporated fully into target volume generation because it is not currently available in electronic format and thus complete risk assessment calculations cannot be performed.

The original target volumes were created with only maximum concentrations collected between January 1992 to January 1993. Therefore, wells that were dropped from the monitoring program were not included. Several of these wells have been added to the revised dataset to create the revised target volumes. These wells were sampled prior to 1992, at consistent concentrations (mostly non-detect) and thus were dropped form the monitoring program because no concentration changes were observed. These data points were brought back onto the plots. Concentrations for each well were selected in the following manner:

- Wells that were last sampled prior to 1988 were not included in the data set. Actually, the last time these wells were sampled was in 1986.
- If a well were sampled in 1992 or 1993, the most recent concentration was selected, because this time period is considered representative of current conditions.
- If a well was sampled prior to 1992 (but after 1988) the time series of the well was examined to attempt to extrapolated to current conditions. In many cases the wells were consistently measured to nondetect (ND) levels and thus ND levels were assigned. For wells that observed fluctuating conditions, 4Q93 GSAP data was used if available, otherwise an average was taken.

This analysis will be presented in the text.

9. **Page 2-124, paragraph 2. It is stated that TCE concentrations decrease steeply from the A monitoring zone to the C monitoring zone, indicating that the extraction system is effective. However, we note that there is only one C-zone monitor well (MW-190) in OU D. Therefore, with regard to the C zone, it is currently unknown whether the OU D extraction system is completely effective at limiting downward migration of TCE. We recommend that C-zone ground water of OU D be sampled with either depth-discrete sampling methods (e.g., BAT) or with new monitor wells, to confirm the hypothesis that the C zone is uncontaminated.**

Response:

Comment noted. A monitoring well has been proposed to be installed in the C Zone of OU D. In addition, vertical hydropunching will be performed in conjunction with well installation to establish a vertical contamination profile.

10. **Page 2-125, paragraph 1. It is stated that mass estimates were based on "maximum detected results from the January 1992 to January 1993 sampling period." See comment 8 above.**

Response:

The concentrations used to perform the mass estimates were selected in the manner outlined in the response to Comment 8.

11. **Page 2-128, last paragraph. It is stated that hot spots are based on maximum VOC concentrations from the January 1992 to January 1993 sampling period. See comment 8 above.**

Response:

Hot spots defined as a target volume from the same data set that the maximum containment level (MCL), Risk and Background target volumes were defined from (see response to comment 8).

12. **Page 2-135, *Hot Spots*. The first sentence states, "The hot spot target volumes are defined as the regions where TCE concentrations are greater than 500 μg/l." However, target volumes based on MCLs, 10^{-6} cancer risk, and background are defined on the basis of total VOC concentrations. We believe that hot spot target volumes should also be based on total VOC concentrations. The Report (and hot spot target volumes) should be revised or the Report should explain why TCE concentrations are used rather than total VOC concentrations to define hot spots.**

Response:

Concentrations of all volatile organic compounds (VOCs) were considered when delineating the hotspots. For most wells, non-TCE VOC compounds were detected above 500 μg/l only in wells that also detected trichloroethene (TCE) above 500 μg/l. For wells and compounds where this was not true (elevated non-TCE compounds were detected in wells that did not detect TCE above 500 μg/l), the compound concentration was included in the target volume. This will be discussed further in the text of the Draft Final.

Editorial Comments

1. **Page 2-4, paragraphs 3 and 4. Reference to ages of stratigraphic units is confusing. Paragraph 3 refers to the "Mio-Pliocence (25 to 2 million years ago [Ma]) Mehrten Formation," and paragraph 4 refers to the "Pliocence (4 to 3 million year [sic] ago) Laguna Formation," which overlies the Mehrten Formation. Does the Pliocene end at 2 MA or 3 Ma? On the other hand, if the stated age ranges refer to stratigraphic units as opposed to epochs, then how**

can a 4 to 3 Ma unit overlie a 25 to 2 Ma unit? These apparent conflicts should be resolved.

Response:

The conflicts cited have been resolved.

2. **Page 2-13, paragraph 1, and Figure 2-8. Although the last sentence states that Figure 2-8 shows profile views, Figure 2-8 is in fact only a map. The text should be revised.**

Response:

The text has been revised to state the following: "Figure 2-8 shows the Stiff diagrams for several A-zone, B-zone and C-zone wells in plan view."

3. **Table 2-1. There are several inaccuracies in the table, which summarizes aquifer test results. Assuming that hydraulic conductivity and zone thickness values provided are accurate, most of the stated T values are inaccurate. In OU A, zone A T values actually range from 38 to 965 ft^2/day (not 30 to 75 ft^2/day). In OU B/C, zone A T is 791 ft^2/day (not 100 to [illegible]00 ft^2/day), zone B T is 258 ft^2/day (not 250 to 500 ft^2/day), and zone C T is [illegible]2 ft^2/day (not 500 to 2000 ft^2/day). In OU D, zone A T is 1390 ft^2/day (not 800 to 900 ft^2/day), zone B/C T is 2226 to 6617 ft^2/day (not 100 to 1100 ft^2/day), and zone D T cannot be calculated (not 23.7 to 26.2 ft^2/day) because no zone thickness is provided. Table 2-1 should be revised.**

Response:

Table 2-1 has been revised. Aquifer parameters for OU G have been added to the table.

4. **Figure 2-13. Several graphical problems exist on Figure 2-13.**

   - **The figure should show OU boundaries (text implies that it does).**
   - **The industrial waste line (IWL) should be shown more prominently and be included in the legend.**
   - **What are the areas labeled "IC1" and "IC7?" They are not referred to in Chapter 2, are presumably irrelevant, and should probably be deleted from the map.**
   - **What are the five areas shown with dashed line in the eastern and south-eastern part of the base? If they are relevant, the legend should indicate what they represent.**

Response:

OU boundaries have been added to Figure 2-13. The Industrial Waste Line (IWL) will be displayed more prominently. The following text has been added to explain the significance of "IC1" and "IC7," "The IWL has been divided into 9 individual sections. Seven of the IWL sections and 32 other sites have been combined into 8 Investigation Clusters (ICs). The 8 ICs are presented in Figure 4-13". The five dashed-line sections have been removed from the graphic.

5. **Figures 2-13, 2-31, 2-32, 2-53a, 2-54a, 2-55a. These "figures" are actually plates, and should be labeled and treated as such. Where referred to in the Report, it should be made clear that they are located in a pocket at the end of chapter.**

Response:

These figures will continue to be called "figures." They are an integral part of the conceptual model presentation. The figures are linked to the text, and it would be awkward to not treat them as figures because of their large size. Readers are encouraged to study the figures as they read the text. It has been made clear that these figures are located in pockets at the end of the Chapter 2. It is stated in the Figures list in the content section of the report. On page 2-22, it is stated that Figure 2-13 is located in a pocket at the end of Chapter 2. On page 2-60, it is stated that Figures 2-31 and 2-23 are located in pockets at the end of the chapter. On page 2-105, it is stated that Figure 2-53a, 2-54a and 2-55a are located in pockets at the back of the chapter.

6. **Page 2-30, paragraph 3. Reference to "Figure 2-12" is incorrect. The Report actually refers to Figure 2-13.**

Response:

The text has been revised to reference Figure 2-13.

7. **Page 2-33, *Henry's Constant*. The last sentence mistakenly gives Henry's constant for TCE as $9x10^3$ atm -m^3/mol, instead of the correct value of $9x10^{-3}$ atm -m^3/mol.**

Response:

The text has been revised.

8. **Table 2-4. The table provides partition coefficients for COCs, but the Report fails to document how these values were derived. The Report should discuss more completely this important issue.**

Response:

The partition coefficients provided in this table were obtained from EPA Guidance document No. EPA/540/2-90/011, *Subsurface Contamination Reference Guide*.

9. **Page 2-34, paragraphs 1 and 2. The Report should state the temperature at which stated partition coefficients and vapor pressures are correct.**

Response:

Footnotes that state the temperature that the vapor pressures, water solubilities, Henry's constants, and partition coefficients for the contaminants of concern (COCs) were reported at have been added to Table 2-4.

10. **Page 2-34, paragraph 3. "Solubilized" is not a word. We recommend that "dissolved" be used instead.**

Response:

The text has been revised.

11. **Page 2-36, paragraph 1. It is stated that "subsurface materials" at McClellan AFB are about 25 percent saturated. The Report should make it clear that this statement applies to the vadose zone only.**

Response:

The test has been revised to state the following: "The percent saturation of the McClellan AFB vadose zone soils is 25%."

12. **Page 2-40, paragraph 1. In the last sentence, the second occurrence of "solubility" should be replaced with "concentration."**

Response:

The choice of the second occurrence of the word "solubility" in the following sentence was specific and intended: "Usually, the solubility limit of a compound is not a limiting factor except at the source, as the solubility is generally very high compared to the concentrations found in groundwater." Generally, the concentration of a contaminant in the groundwater does not reach its water solubility limit. For example, although the maximum recorded TCE concentration sampled at a monitoring well is 68,000 μg/l, the water solubility of TCE is approximately 1,000,000 μg/l, which is well above the maximum detected concentration.

13. **Figure 2-17. The figure illustrates the concept of retardation as caused by adsorption. While it is effective at illustrating this concept, it graphically implies that with sufficient time all contaminant will be adsorbed. The second footnote attempts to correct this erroneous conclusion by stating that, at equilibrium, the ratio of concentrations in ground water and soil remain constant. However, this statement confuses more than it clarifies because the illustration shows that the ratio is constantly changing. The illustration should be revised to illustrate the effect of both adsorption and desorption, and the footnote should indicate that the ratio remains constant because of an equilibrium between adsorption and desorption.**

Response:

The ratio between contaminant particles in solution to contaminant particles sorbed remains constant in all three time steps and is not constantly changing. In T_o, 16 particles appear in solution and 5.33 particles appear sorbed. The ratio of particles in solution to particles sorbed is 16:5.33 or 3:1. In T_1, the ratio is 12:4 or 3:1. In T_2, the ratio is 9:3 or 3:1. The second footnote has been modified to state the following: "The ratio of concentration in the groundwater/porewater to concentration os the soil matrix remains constant for a given contaminant because of equilibrium between adsorption and desorption. This process is known as Equilibrium Sorption."

14. **Figure 2-23. Clearly, the horizontal hydraulic gradient vectors shown in the figure cannot be correct for all points on McClellan AFB. The Report should present data used to construct the figure.**

Response:

This figure has been omitted from the Draft Final RI/FS. The flow vectors presented in the figure present in the Draft RI/FS are in the vicinity of OU D only. This was discussed in the text.

15. **Figure 2-37. The hydrograph provides a vertical grid with alternating 16- and 17-month spacing. Given the awkward vertical grid spacing, it is difficult to discern the annual cycles cited by the text. The grid spacing should be changed to 12 months.**

Response:

The horizontal spacing of the hydrographs have been changed to 12-month cycles. The horizontal and vertical axes in all six hydrographs will span the same ranges for comparability between the hydrographs.

16. **Figure 2-44. The figure indicates that the only Base well for which pumping information is known is BW-29. We find it difficult to believe that McClellan AFB does not keep records for its pumping wells. Elsewhere in the Report and**

in Table 2-6, Base well BW-18 is reported to have a pumping rate of 1200 gallons per minute (gpm). The figure should be updated.

Response:

Figure 2-44 has been updated.

17. **Page 2-85, paragraph 4. In discussing wells to be decommissioned, the Report refers to "*the* [our emphasis] triox hole" (in Table 2-6, it is listed as "Triax Hole"). By using the definite article, the Report apparently assumes that the reader is already familiar with this well. This is an invalid assumption. Clarification is needed.**

Response:

The following text has been added to the text to clarify the presence of the Triax Hole: "Four additional wells are located at Camp Kohler, which is located 1 mile east of the Base on Roseville Road. Two are former laundry wells, LW-1 and LW-2; and two were constructed as part of a seismic survey... The four wells at Camp Kohler, LW-1, LW-2, the seismic well and the triax hole were decommissioned during Phase III. The latter two wells are seismic survey wells and not water wells." The location the Camp Kohler wells are located on Figure 2-43.

18. **Table 2-6 and Figures 2-43 and 2-44. In the table, Base well B-18 is shown to pump at 1200 thousand gallons per day (tgpd). Elsewhere, BW-18 is reported to pump at 1200 gpm, which equals 1728 tgpd. Pumping rates should be verified, and Table 2-6 (and presumably the ground water flow model) should be revised. Also, the table reports that BW-20 was decommissioned during Phase 2, in 1993. However, Figure 2-43 indicates that BW-20 is "active" and Figure 2-44 indicates "no pumping information available," as opposed to "not in service." These inconsistencies should be resolved.**

Response:

Quarterly Production Well reports were consulted for BW-18 pumping rates. BW-18 was pumped at a rate of 800 to 1490 thousand gallons per day (gpd) between 1990 to 1992. Figures and tables have been updated to reflect a consistent BW-18 pumping rate and a consistent status for BW-20.

19. **Page 2-88, paragraph 2. It is stated that 1992 sample data were used to select VOCs of concern because "1992 was the last year of sampling." However, sampling has occurred in 1993, including an apparently complete round in January 1993, as indicated in Table K-7 (Appendix K). Figure 2-45 shows time-series plots for selected VOCs that include the January 1993 data. The Report should either correct this inaccuracy or more fully discuss why 1992 data were used despite the existence of 1993 data.**

Response:

The data set described in the response to significant comment 8 was used to select the prevalent contaminants presented in the Draft Final. The COCs will be called "prevalent contaminants" in the Draft Final. 1Q93, 2Q93, and 3Q93 data was used in the data set where available. The generation of the dataset will be discussed fully in the Conceptual Model.

20. **Page 2-88, paragraph 2, and Figure 2-45. The Report states that Figure 2-45 shows "histograms" of VOC summary statistics for "TCE and 1,2-DCA." In fact, the figure shows line graphs (not histograms) for TCE, PCE, DCE, total 1,2-Dichloroethene, carbon tetrachloride, and chloroform. A plot of 1,2-DCA statistics is not shown. Is "DCE" a subset of "Total 1,2-Dichoroethene"?**

    Figure 2-45 contains some graphical errors.

    - **In the "frequency of detection" graph for carbon tetrachloride, the 1983 and 1985 data points are missing.**
    - **The time axis for the "Total 1,2-Dichloroethene" plot is mangled.**
    - **The symbol color for the "mean concentration" graph for TCE is blue and red. This is also true for the 1985 "mean concentration" data point for PCE. The symbols are supposed to be red.**
    - **In the legend, "Frequency of Dects" should be changed to "Frequency of Detections".**

Response:

The text has been revised to refer to Figure 2-45 as line graphs and not histograms. The "DCE" line graphs in Figure 2-45 have been replaced with "1,2-DCA" line graphs. cis-1,2-DCE is a subset to "Total-1,2-Dichloroethene". The graphical errors listed in the comment have been corrected.

21. **Table 2-50. The map should indicate the date of sample results.**

Response:

The following note has been added to Figure 2-50: "Maximum concentrations measured between January 1992 to January 1993 are posted."

22. **Page 2-103, paragraph 4. The paragraph discusses the sample results and history of city well CW-150, which is screened from 144 feet to 372 feet below ground surface. The last sentence claims, "The sample record also indicates that contamination is mainly confined to the uppermost groundwater zones ...." We are extremely incredulous at such a claim, and cannot imagine how such a**

conclusion could be reached, considering the long screened interval of CW-150. This statement should be reconsidered and either deleted or clarified.

Response:

The last sentence in paragraph 4 has been deleted.

23. **Figures 2-53 through 2-60. Contouring anomalies and other graphical errors are apparent in these figures.**

- **Maps and profiles should indicate the date or range of dates of sample data.**

- **Source areas indicated on maps are barely distinguishable from base map features. A more distinct color should be used to indicate source areas.**

- **Some solid contour lines should be dashed where they are poorly constrained by data (e.g., the northeast portion of the 1.0 ppb TCE contour in OU D on Figures 2-53 and 2-53a).**

- **Especially apparent in the profiles, many contours appear to have little relationship with posted data, and many contours are inadequately labeled. Some contours appear to have no basis (e.g., in *Cut A1*, the 50 ppb vinyl chloride and 0.1 PCE contours centered about the blank casing of monitor well MW-178). The data should be re-examined and probably re-contoured.**

- **On the southeast end of *Cut West Perimeter* (Figure 2-60), the third well from the left is labeled "MW-1050" and (inaccurately) posts MW-1050 data for 1/22/93, but the well actually depicted is probably MW-1052 (no contamination detected on 1/22/93). Although the figure indicates a cis-1,2-DCA concentration of 4.7 $\mu g/l$ on 1/22/93, the concentration reported in Table K-7 is 0.47 $\mu g/l$. This figure should be revised.**

Response:

First Bullet in Comment: The year that the sample data was collected for Figures 2-53, 2-54, and 5-55 are presented in Figures 2-53a, 2-54a, and 2-55a respectively, which are located in pockets at the end of the chapter. Figures 2-53, 2-54, and 2-55 contain water levels, source areas, well locations, and extent of COC concentration for the A Zone, B Zone and C Zone, respectively. They were too cluttered to include analytical data, so the analytical data and year of sampling was included in companion Figures 2-53a, 2-54a, and 2-55a. Because there are few wells in the D/E Zones, Figure 2-56 presents the analytical data from those D/E Zone wells, the horizontal extent of contamination that is based on that data, and the year the data was collected. The date of sample collection is provided for each well on the vertical profiles in Figures 2-58, 2-59 and 2-60.

Second Bullet in Comment: The source area color will be changed so that it is more distinguishable.

Third Bullet in Comment: Areas where the extent of contamination is unbound will be shown with a dashed line.

Fourth Bullet in Comment: The data in the profile figures will be reexamined and recontoured so that the contours adhere to the posted concentration values.

Fifth Bullet in Comment: Corrections will be made as advised.

24. **Page 2-106, paragraph 5. Although the Report indicates that Base wells in OU A are shown on Figures 2-53 through 2-56, Base wells are apparently not shown. Either the text or the figures should be revised.**

Response:

The locations of active base wells and CW-132 have been added to the figure. The text has been revised to state that only groundwater contours, source areas, groundwater monitoring wells and the location of active base wells and CW-132 are shown in Figures 2-53 to 2-56.

25. **Page 2-123, paragraph 5. The Report should clarify what is meant by the "upper zone of TCE."**

Response:

The text has been revised to state the following: "TCE and other contamination are located underneath Study Area 15 in Monitoring Zone A."

26. **Page 2-123, last paragraph. The last sentence states that although "wells on the southeast end of BC4 and the [south] end of BC2 show higher concentrations in the lower zones," these wells are nevertheless "at the edge of the TCE plume and do not represent the conditions within the plume." This statement demonstrates inverted logic and surely should be revised or otherwise clarified.**

Response:

The text has been revised to state the following: "Wells located on the southeast end of BC4 and the southeast end of BC2 and screened in the top of Monitoring Zone C measured TCE concentrations above MCLs. This suggests that in some areas of the B/C plume, contamination has migrated from the bottom of Monitoring Zone B to the top of Monitoring Zone C."

27. **Page 2-125, paragraph 3. The Report should clarify and describe more fully the methodology used to determine volumes.**

Response:

A more thorough discussion of the methodology followed to create the target volumes will be included in the Draft Final.

28. **Page 2-126, Figure 2-61. At the left end of the plot, the "total TCE" graph lies below the "A Zone TCE" graph, which is illogical. The Report should provide some explanatory text. Also, the legend contains some typographical errors and inconsistencies relative to companion figures 2-62 through 2-64 (e.g., use of commas instead of semicolons; and "5 to 1" instead of "1 to 5").**

Response:

The plots in which the total contaminant lay below the A Zone contaminant line have been corrected. The inconsistency was due to the graphics program connecting each point with a straight line. The inconsistencies in the legend have been corrected.

29. **Page 2-128, third bullet. In determining contaminant mass, dry bulk density is here assumed to be 1.45 g/cm^3. However, on page 2-33 (fourth bullet), bulk density (wet) is reported to be 1.2 to 1.3 g/cm^3. It is impossible for a dry bulk soil density to be greater than a wet bulk soil density. The Report should explain this apparent discrepancy. Furthermore, the reported wet density range seems to be rather low. The Report should discuss and suggest an explanation for these low bulk density values.**

Response:

The dry and saturated bulk densities have been changed. The wet bulk density used in the mass estimates was 1.8 g/cm^3; this was calculated from a dry bulk density if 1.4 g/cm^3 and a saturated moisture content of 34 percent.

30. **Table 2-10. The table provides values for K_{oc}, f_{oc}, and K_d, but the Report does not indicate how K_d values were derived. As there are numerous methods for deriving K_d, the Report should provide appropriate explanatory text and justify the chosen method.**

Response:

The partition coefficients provided in this table were obtained from EPA Guidance document No. EPA/540/2-90/011, *Subsurface Contamination Reference Guide.*

31. **Page 2-135, last paragraph. It is stated that in OU D, no monitor wells are screened below zone B. However, according to Table K-7, zone C is monitored by one well, MW-190 (last sampled in July 1991). The distribution of monitor wells with respect to OUs and monitoring zones needs to be verified and accurately represented in the Report.**

Response:

The wells have been reassigned to the operable units. The new designations will be presented in the RI/FS. There are no C Zone monitoring wells in OU D.

32. **Page 2-137, paragraph 1. It is stated that contaminant mass estimations based on linear interpolation "are not overestimated." The statement would be more accurate to say "not *significantly* overestimated."**

Response:

The discussion on linear interpolation has been omitted from the text. Linear interpolation was not used in the delineation of the target volumes or the VOC mass estimates.

33. **Page 2-138, paragraph 2. The Report refers to Figures 2-57 through 2-60 to illustrate "current well locations." However, these figures are profiles that do not include all wells, nor do they in any way show well locations. Perhaps the Report should cite Figures 2-53 through 2-56.**

Response:

Figures 2-46 to 2-49, which show monitoring well locations, have been referenced in the text.

34. **Page 2-138, paragraph 3. The last sentence claims that in OU A, "No additional C-zone monitoring wells need to be added to the sampling program because only two C-zone wells, once each, have ever been sampled for contaminant concentration above MCLs." The statement is ambiguous, but it appears to indicate inverted logic. If only two ground water samples have ever been taken from the C zone in OU A, then it seems clear that more C-zone wells *should* be added to the sampling program.**

Response:

The last sentence has been deleted.

35. **Page 2-142, paragraph 2. The first sentence mistakenly refers to the east side of the "OU A" plume. Because the next sentence refers monitor well MW-61, we believe that the statement actually refers to the "OU B" plume.**

Response:

The text has been corrected to reference OU B.

36. **Page 2-142, paragraph 6. The Report should describe the arrangement of wells currently in the D and E zones as lying in a *north-south* line, not a "vertical" line.**

Wells recommended for continued monitoring should be kept in the program not only to monitor for VOCs, but to provide regular measurements of hydrostatic head.

Response:

The text has been revised to state the following: "The wells that are currently in the D and E Zones are oriented north to south. The east and west extent of contamination in the D and E zones would be better defined with the installation and sampling of wells on the east and west sides of existing wells in the D and E zones. The extent of horizontal and vertical hydraulic control could also be monitored with the installation of additional wells."

37. **Page 2-143, paragraph 2. Although it is stated that no monitor wells are screened in the C and D zones of OU D, according to Table K-7, monitor well MW-190 is located in the southeastern corner of OU D and is screened within the C zone. The Report should be revised or otherwise clarified. Also see Editorial Comment D-31, above.**

Response:

According to OU boundaries, MW-190 is actually located in OU C. The wells have been reassigned to OUs. The new designations will be presented in the Draft Final.

38. **Page 2-143, paragraph 4. The third sentence includes "capping of the OU [sic] source pits" in its list of remedial actions performed. This typographical omission needs to be corrected.**

Response:

The text has been revised to incorporate the comment.

39. **Figures 2-71 through 2-75. These time-series plots are difficult to compare because virtually every graph has a different horizontal scale and a different vertical scale. To facilitate meaningful comparison of data trends, all graphs should be presented at the same scale.**

Response:

Figures 2-71 to 2-73 present contaminant time trend for selected wells. Each figure presents a different observation. The time scales of the trends will be the same by figure so that the behaviors of wells presented in a single figure could be compared.

40. **Figures 2-76 through 2-79. For each figure, the title is *Concentration Trend Analyses ...*, whereas it should be *Risk Trend Analyses ....* Also, the title of Figure 2-79 is ... *Monitoring Zone D*, whereas it should be ... *Monitoring Zones D and E*. The figure titles should be revised.**

Response:

The text has been revised to incorporate the comment.

41. **Page 2-159, paragraph 1. The Report suggests that "groundwater impacts within the deeper monitoring zones are relatively localized." One reasonable explanation for such trends is that several deeper wells have incompetent annular seals that leak and allow shallow contaminated ground water to migrate down to deeper zones along the well annulus. The Report should address this idea.**

Response:

This suggestion has been incorporated into the text.

E. Chapter 5. Data Collection and Management

Editorial Comment

1. **Page 5-7, paragraph 1. The Report recommends that water levels be recorded daily from transducers in wells that are "critical to monitoring hydraulic control." However, it is unclear how many or which wells will be fitted with such transducers. The Report should provide an estimate of which wells should be fitted with transducers. The Report should also explain by what means pressure data will be transmitted to the receiving station.**

Response:

The details of which wells should be fitted with transducers will be provided in the Groundwater OU Work Plan. The signals will be collected and transmitted via a Supervisory Control and Data Acquisition system (SCADA). The Groundwater OU Work Plan will have the design of the SCADA system included because it needs to be sized up front to accommodate the complete remedy.

F. **Chapter 6. Groundwater Containment Options**

Significant Comments

1. **Page 6-6, paragraph 1. The Report claims, "Since all of the evaluations are based on the same set of assumptions, all of the alternatives [extraction networks] will be affected equally by any discrepancies between the site conceptual model and actual site conditions." We disagree with this statement for the following reason. The ground water flow model may be apparently calibrated to acceptable tolerances, but the calibration is probably not a unique solution. For example, the effect of a faulty transmissivity specification may be masked by another incorrectly specified model parameter, such as vertical leakance. In the various scenarios (involving three different extraction networks with and without reinjection of treated ground water), various parts of the hydrogeologic system are stressed unequally. For example, if in one scenario, extraction wells are not present in a part of the system whose transmissivity has been incorrectly specified, the error in model-calculated heads in that particular part of the system may be low. However, if in another scenario, extraction wells are simulated in the same part of the system, model-calculated heads may be incorrect by a significant amount. Unfortunately, the only way to detect this kind of error is via real-world monitoring after the extraction wells are actually pumping. This concept should be reconsidered and the Report revised accordingly.**

Response:

The calculations presented here support an interim remedy at the Base. The objective of the groundwater modeling analysis is to determine the approximate total groundwater extraction rate that will be required to contain a given volume of contaminated groundwater. These representative flow rates were then used for treatment and end-use selection and cost-estimating. The numerical model is based on a very limited number of aquifer transmissivity estimates (32 points in 3 zones across the Base) and therefore contains significant uncertainty regarding the actual distribution of transmissivity across the Base. Additional aquifer testing will be performed prior to remedial design, and the performance of each individual extraction well will be evaluated as it is added to the extraction system. The conceptual model of the site will also be revised as new data become available. The groundwater model will be revised as improved estimates of the aquifer characteristics are obtained.

2. **Page 6-6, paragraph 3. The Report claims that if actual transmissivities are greater than those assumed by the model, "less wells will be needed to achieve capture." This notion is restated at the end of the next paragraph, where the Report claims that the "extraction system will be effective, even if aquifer properties in certain areas result in higher well capacities than expected." We disagree with this interpretation on the grounds that capture zone dimensions are inversely proportional to transmissivity. In our opinion, if effectiveness is**

considered in the spatial sense, capture zone dimensions should be the criteria for comparison. Because higher transmissivities would result in narrower capture zones (but more elongated in the up-gradient direction), more extraction wells would be required. This concept should be reconsidered and the Report revised accordingly.

Response:

The actual design of the extraction network installed at the Base will be based on the results of additional aquifer testing performed at the site. The conceptual model and groundwater model will be continually revised, as new data become available.

3. **Page 6-7, paragraph 2. In considering the likelihood that A-zone extraction wells may eventually go dry, the Report notes that such wells will be converted to vapor extraction wells to assist in remediation of the vadose zone. We recommend that McClellan AFB consider designing and building A-zone extraction wells as dual-phase, or vacuum-enhanced extraction wells from the beginning.**

Response:

We concur with this recommendation. The decision of which wells are to be selected for vacuum extraction will be made during remedial design.

4. **Page 6-51, paragraph 3. The Report lists the most significant components of the extraction system: available saturated thickness, ground water flow direction and gradient, and hydraulic conductivity in the vicinity of extraction wells. We feel that a fourth component, extraction well efficiency, is equally important, especially in the case of the A-zone. The model assumes extraction wells that are 100 percent efficient; this is probably a dangerous assumption to actually make. Although in the model the discharge of these wells was constrained to allow drawdown of at most 75 percent of initial saturated thickness (top of page 6-18), this constraint may be too liberal. This problem may prove to be a serious one, and the Report needs to discuss it thoroughly.**

Response:

The actual efficiency of the groundwater extraction wells to be installed at the Base is unknown but will likely fall between 60 and 80 percent. This level of uncertainty is dwarfed by the uncertainty in the assumed transmissivity distribution and vertical leakances. The installation of extraction wells at the Base will progress in a phased manner, allowing adjustment to the remedial design in response to detailed design issues such as well efficiency.

Editorial Comments

1. **Page 6-1, paragraph 1. The introductory paragraph claims that Chapter 6 "briefly describes the construction and calibration of the groundwater flow model," noting that Appendix J contains more detailed information. In fact, however, Chapter 6 is limited to a presentation of the main results of the modelling effort. Model construction is summarized in five sentences (page 6-7, last paragraph), and calibration of the model is not discussed in Chapter 6. The simple solution of this error would be to simply revise the sentence to be more accurate. However, Chapter 6 and Appendix J combined do not provide adequate documentation of the model or its development. To correct the problem fully, Appendix J should be extensively revised to provide thorough documentation of the model and its construction, calibration, and sensitivity analysis.**

Response:

Additional documentation, more fully describing the model construction and calibration, will be included in Appendix J of the revised RI/FS Report.

2. **Page 6-3. The Report describes the effect of extraction wells with relatively short screens at depths above or below zones of contaminated ground water. The Report should also consider and discuss the effect that very long extraction screen intervals would have on the withdrawal of contaminated ground water. If an extraction well is screened across both contaminated and uncontaminated water-bearing zones and the uncontaminated zone is more transmissive, the efficiency of the well in terms of its ability to extract contaminated ground water is correspondingly reduced. The Report does in fact provide a good discussion of this concept, where it discusses the use of base well BW-18 as an extraction well (top of page 6-53). However, the Report should include discussion of this concept in this section. Also, see our General Significant Comment 1.**

Response:

The option of constructing extraction wells with screened intervals that extend through all contaminated zones was discussed in several meetings with the State agencies. The State was firm in the position that all extraction wells should only be screened in a single monitoring zone. The basis cited was that the system would be more flexible and that portions of the system could be turned off as areas with lower levels of contamination cleaned up. It was in response to this position that longer screened intervals were not evaluated.

3. **Page 6-5, *Chemical Factors*. Although the Report discusses the effects of various chemical factors on the extraction remedy, the model does not simulate mass transport, nor does it account for "dead-end" porosity, described in the preceding section. The Report should make it clear that the model is limited in these respects.**

Response:

The model does not account for these processes, and this fact will be clearly stated in the revised Chapter 6. However, the approximate time for cleanup estimates presented in this chapter do account for the effects of dead-end porosity by incorporating flushing factors in the concentration decay curves.

4. **Figures 6-6, 6-8, 6-16, and 6-18. Figure 6-16 shows A-zone extraction wells relative to the MCL target volume. Figure 6-6 shows calculated flow lines for the same configuration, but does not depict the western-most extraction well. The situation is similar in Figures 6-8 and 6-18, except that Figure 6-8 does not depict the eastern-most extraction well. The Report should explain these apparent discrepancies or the figures should be revised.**

Response:

These figures were in error in the draft report. These figures will be revised in the Draft Final Report as the target volumes have been revised.

5. **Page 6-17, bullets 3, 5, and 7. The extraction alternatives involving injection wells, though mentioned in the bullets, are not discussed further, nor are they illustrated in Chapter 6. The Report should be revised to properly document these scenarios.**

Response:

The results of the simulations including hot spot reinjection previously presented in Appendix J have been more extensively evaluated and the results presented in Chapter 6 and Appendix J.

6. **Page 6-17, 6-18, and 6-31. In discussing the selection of extraction wells for the three target volumes, the Report does not describe the rationale or process. The Report should briefly discuss how the number and location of extraction wells were determined and refined.**

Response:

The process used to select extraction well locations will be discussed briefly in the revised Chapter 6.

7. **Page 6-31, last paragraph, and Figures 6-22, 6-23, and 6-24. In discussing the baseline simulation (no-action alternative), the Report refers to figures that show contours representing calculated heads for monitoring zones A, B, and C. However, the Report provides no evidence as to the accuracy of the model-based contours. The Report should discuss the calibration process, summarize model error, and provide contour maps of the observed water elevation data that the**

model is attempting to match. Such crucial information would allow the reader to assess the degree to which the model results resemble reality.

Response:

The calibration of the model was evaluated by comparing the simulated to actual water levels in groundwater monitoring wells at the Base. A more complete discussion of the calibration procedure and the accuracy of the simulated water levels will be provided in the revised Appendix J.

8. **Figure 6-25, *Location of Hypothetical Future Municipal Wells.* The ground water elevation contours on this map are irrelevant and misleading. In fact, the entire figure is unnecessary because the only pertinent information on the map, namely locations of the three hypothetical production wells, is shown clearly on the next two figures. Figure 6-25 should be deleted.**

Response:

This section has been omitted from the Draft Final version of the Report.

9. **Page 6-51, last paragraph, and Figure 6-28. The figure depicts the effect of the existing extraction system. However, the figure and the text that refers to it are both flawed. The text says that the figure depicts the effectiveness of extraction in the A and B zones, and that it shows areas of greatest contamination in the A zone. In fact, the figure apparently shows extraction in zones A, B, and C, and the extent of contamination is not depicted. On the figure, extraction well EW-73 is mislabeled "EW-173." Extraction well EW-141, which we understand is an active extraction well, is not shown. These textual and graphical errors should be corrected.**

Finally, there is apparently some confusion regarding the monitoring zone in which extraction wells in OUs B and C are screened. Figure 6-28 indicates that EW-144 is completed in zone BC, and the rest are completed in zone C. However, the GWSDR indicates that EW-233 and EW-234 are completed in zone B. However, on recent quarterly monitoring maps produced by Radian Corporation, EW-233 and EW-234 are reportedly completed in the A-zone, EW-144 is reportedly completed in the AB zone, and EW-137 and EW-140 are reportedly completed in the B zone. This Report, which we expect to represent the ultimate state of knowledge of the RI at McClellan AFB, should resolve these uncertainties.

Response:

These figure errors have been corrected in the revised Chapter 6.

The monitoring zones where each of the existing extraction wells at the Base are screened have been adjusted in the numerical model to reflect revised construction information. This revised information is presented in Chapter 4 and Appendix J.

10. **Page 6-53, last paragraph. The Report recommends that, in the event that additional contamination is discovered, the problem will be addressed by installing additional extraction wells. It may be possible to achieve the same results by pumping peripheral extraction wells at a greater discharge rate. The Report should discuss this alternative.**

Response:

The revised Chapter 6 will discuss this option.

11. **Page 6-55, top of page. The Report discusses analysis of the time required to achieve aquifer cleanup. Several factors are involved in this technical analysis, yet the Report only presents the results of the analysis in broad, general terms. The Report should document the analysis in one or more tables and graphs.**

Response:

The time to cleanup analysis will be discussed in more detail in the revised version of Chapter 6.

12. **Page 6-55, last paragraph, and Table 6-2. The Report indicates that operations and maintenance costs, summarized in Table 6-2, "include pumping and power costs." We are concerned that no consideration has been given to the costs associated with monitor and extraction well maintenance, redevelopment, and possible replacement and/or abandonment. The Report should discuss these costs.**

Response:

The maintenance of the extraction system is included in the cost estimates. Appendix R has the details of the cost estimates.

G. Works Cited

Editorial Comments

1. **The list of works cited is incomplete. Throughout the Report, numerous reports are cited that do not appear in the list. The "Works Cited" list should be completed.**

Response:

The Works Cited section has been corrected so that all of the reports cited in the text are included.

2. **Some references listed are incomplete. For example, for the work *DNAPL Site Evaluation*, only the authors and year are provided (Cohen, Robert M. and James W. Mercer, 1993). Please provide more complete reference information on works cited.**

Response:

Complete references have been included in the Draft Final.

3. **Although some authors have two or more references in the same year (e.g., Radian Corporation, 1991), citations of these reports throughout the Report are not differentiated. Citations within the Report should indicate by letter (e.g., "1991a", "1991b") exactly which work is being cited.**

Response:

These citations have been corrected.

H. Appendix E. Proposed Groundwater Monitoring Program

Editorial Comment

1. **Page E-6, *Groundwater Quality Wells*. The Report states, "a significant portion of the currently identified target volumes can be eliminated with additional groundwater monitoring points ...." The only thing that can be eliminated with additional monitoring points is some of the *uncertainty* associated with target volumes. The sentence should be clarified.**

Response:

We disagree with this statement. The current interpretation of the target volumes is based on existing data and relies on interpolation between the existing data points to determine the location of target volume boundaries where no data are available. The collection of new data in areas where interpolation is currently used to define the target volume boundaries can indeed significantly reduce the volume extent.

I. Appendix F. Data Management

Editorial Comments

1. **Figure F-1. The flowchart makes reference to the "Wyckoff OU" and the "Wyckoff Database." These terms are not defined or discussed elsewhere in Appendix F, nor in the rest of the Report. The Report should provide appropriate definition of these terms.**

Response:

The figure had an error. Wyckoff should have been Groundwater OU. The figure has been corrected.

2. **Page F-4, *Station ID*. This section of the Report discusses the importance of ensuring that sorting keys (e.g., well names) in data tables have the same number of characters so that the table will be sorted logically. We agree completely with this recommendation. However, it is disappointing that this recommendation was not followed in the case of Table K-7 (Appendix K), where, for example, entries for well MW-15 appear between entries for MW-149 and MW-150. We recommend that Table K-7 be re-sorted for the final version of the Report.**

Response:

Appendix K has been resorted.

J. Appendix G. Interactions of the Vadose Zone ....

Editorial Comments

1. **Page G-5, top of page, and Figures G-2 through G-5. The text states that the figures show the "lateral extent of ground water contamination" for the four potential target volumes. However, the figures illustrate the extent of contamination only within monitoring zone A, not the maximum extent within all monitoring zones. This discrepancy should be corrected.**

Response:

The lateral extent of the groundwater contamination that is relevant to the interactions with the vadose zone is only the shallow contamination.

2. **Page G-5, paragraphs 2 and 3. Because the vadose zone is expanding at McClellan AFB (i.e., the water table is dropping), the Report recommends taking this trend into account when designing the soil vapor extraction (SVE) system. Likewise, the Report recommends that in the case of a rising water table, dual-phase extraction wells would need to be designed. We submit that dual-phase wells should be designed in both cases. In the former case, the well will initially be screened across the water table, and because the ground water beneath a highly contaminated vadose zone is likely to also be highly contaminated, such a well should be used to extract contaminated ground water in addition to soil gas. Furthermore, application of a vacuum on A-zone ground water extraction wells would help minimize drawdown and maximize well yield. We recommend that McClellan fully consider designing and building dual-phase extraction wells wherever practical and appropriate.**

Response:

The comment will be incorporated into the design of the remedy.

K. Appendix J. Groundwater Model Development

Significant Comments

1. **Despite the title of this appendix, the appendix is little more than a reiteration of Chapter 6 (*Groundwater Containment Options*) (or vice versa). There are less than eight pages of material beyond what is already presented in Chapter 6. In these eight pages (J-2 through J-11), the appendix provides only abbreviated documentation of the model's construction, calibration, and sensitivity analysis. Generally, the appendix provides only brief narrative synopses of crucial components of the model that should be fully presented in narrative, tabular, and graphical form. The narrative presentation should provide justifications for all significant model input values. Considering the complexity of the model (and its predecessor, the Papadopolus regional model) and the amount of effort expended and expense incurred in its development, full documentation is a necessity. We consider that documentation is just as much a part of the model as the simulations produced by the model. In the final version of the Report, Appendix J should be extensively revised to provide much more detail.**

Response:

Additional documentation more fully describing the model construction and calibration will be included in Appendix J of the revised RI/FS Report.

Editorial Comments

1. **Page J-2, paragraph 3. The Report refers the reader to the MicroFem computer program documentation (Hemker and Van Elburg, 1989) for more detailed description of the MicroFem model. Presumably, this documentation can be acquired only through purchase of the program and is thus not readily available. The Report should summarize the capabilities and limitations of the model, and provide a brief presentation of the mathematical approach the model takes.**

Response:

A more complete description of the rational for selecting MicroFem for use at McClellan AFB, the capabilities of the model, its availability, and information supporting model verification are included in Appendix J of the revised RI/FS Report.

2. **Page J-3, fourth bullet. The model apparently incorporates "the Regional Aquifer" as the bottom model layer. This aquifer is not described in the**

Appendix nor anywhere else in the Report. The Report should discuss this aquifer and how the monitoring zones at McClellan AFB relate to it. Presumably, this discussion should be provided in Chapter 2.

Response:

A more complete description of how the regional aquifer was incorporated into the groundwater model and the physical characteristics of the aquifer will be included in Appendix J and Chapter 4, respectively.

3. **Page J-4, bottom of page. The appendix discusses the distribution of transmissivity as implemented in the model. There are no figures or tables showing the basic field data, nor does the text refer to figures or tables in the main part of the Report. The appendix should provide a table showing hydraulic conductivity, saturated thickness, and transmissivity determined at various points through field activities, and the appendix should discuss and assess the quality of these data. Contour maps of transmissivity should also be presented.**

Response:

The revised Appendix J will include transmissivity contour maps, along with a table summarizing transmissivity and hydraulic conductivity at locations of field measurements.

4. **Page J-7, last paragraph. The appendix reports that the model was deemed "calibrated" based on visual inspection. The configuration of the calibrated model is not presented in any form in the appendix, nor does the appendix provide comparative potentiometric surface maps (observed versus calculated) for review. The appendix should present in tabular form all model input parameters, which represent the construction of the model. The accuracy of the calibrated model should be indicated in a table that shows observed head versus calculated head and percent error at each monitor well. The appendix should provide potentiometric surface maps (observed and calculated) for each model layer.**

Response:

Additional documentation more fully describing the model construction and calibration will be included in Appendix J of the revised RI/FS Report. This will include comparisons of observed versus simulated water levels.

5. **Page J-8 and Table J-1. The appendix claims that sensitivity analysis indicated that heads did not change significantly when transmissivity and vertical leakance values were halved and doubled. The results of 14 separate sensitivity analysis runs are shown in Table J-1. However, there is no indication of the specific changes to the calibrated model represented by each individual sensitiv-**

ity run. Calculated head distributions are not expected to change at all if *all* transmissivity values are halved or doubled simultaneously. The appendix should provide, in a separate table, a "key" to runs 1 through 14, documenting the altered model parameters and their values for each run.

Response:

More detail will be provided in revised Appendix J on the sensitivity analyses performed on the groundwater model.

6. **Table J-1. The table shows that, in the calibrated model, between node 500 and node 1000, there is a head difference of approximately 45 feet. According to available basewide water elevation maps, this amount of relief on the water table or any of other potentiometric surface does not exist. The Report should discuss this obvious anomaly. The model results should be checked for errors.**

Response:

The original Table J-1 contained water level information from Model Node Number 500, well outside the area of interest (McClellan AFB). This nodal information will be omitted from revised Table J-1 to avoid confusion.

7. **Pages J-17 and J-18, and Figures J-10 through J-15, J-22 through J-27, and J-34 through J-39. The text refers to the figures to illustrate the flow lines associated with extraction wells and reinjection wells. However, we cannot readily discern the effects of reinjection in any of the figures, either through direct observation or comparison with corresponding figures showing extraction alone. The hydraulic effects of reinjection of treated water should be more clearly illustrated in the figures and more fully discussed in the text.**

Response:

The absence of any noticeable effects from reinjection was the purpose of performing the simulations. The reinjection is to occur into the regional aquifer, and results suggest that this reinjection will not appreciably influence the containment resulting from extraction well pumping in the A-, B- and C-Monitoring Zones.

8. **Page J-50, paragraphs 2 and 3. The appendix refers to "recovery" and "delivery" wells. We assume that these terms are synonymous with "extraction" and "injection", respectively. We recommend that the relatively obscure terms "recovery well" and "delivery well" be avoided in favor of the terms used elsewhere in the Report, "extraction well" and "injection well."**

Response:

The term delivery well refers to a groundwater reinjection well. The term recovery well refers to a groundwater extraction well. The terms delivery and recovery have been removed from the revised Appendix J and replaced with the more familiar terms injection and extraction.

9. **Page J-50, paragraph 5. This one-sentence paragraph notes that "variation of transmissivity caused by the variation in saturated thickness was not accounted for in the modeling effort." Is this a limitation of MicroFem, or was it simply a choice made during model development? We note that other three-dimensional numerical flow models (e.g. MODFLOW) have the capability to recalculate transmissivity in unconfined aquifers at every numerical iteration. The appendix should clarify this point and provide additional justification.**

Response:

9. This statement was included in the Appendix in error. MicroFem does include the capability of adjusting the transmissivity during each calculational time step on the basis of the saturated thickness at each model node. This option was used in the simulations to ensure that the pumping rates in areas with small saturated thickness, such as OU A, would be sustainable. The viability of extraction well pumping in these areas will be further evaluated during remedial design through aquifer testing, and alternative technologies will be considered.

L. Appendix K. VOC Mass Estimates

Significant Comment

1. **Page K-9, top of page. The appendix downplays the significance of contaminant mass overestimation in areas of low contaminant concentration, emphasizing the fact that most of the contaminant mass is located within the high-concentration areas. However, although contaminant mass overestimation may be small, volume overestimation is probably quite large. Consequently, the number of extraction wells and thus the overall cost of containment and extraction are also significantly overestimated. It is unclear why CH2M HILL insists on using linear interpolation and extrapolation in low-concentration areas even when they concede that logarithmic interpolation and extrapolation is more appropriate in low-concentration areas. In preparation of the revised Report, this issue should be revisited and perhaps target volumes should be refined based on more accurate contouring methodology.**

Response:

The extent of contamination and delineation of target volumes were not performed using lienar interpolation. They were contoured by hand. Water quality samples from 279 wells and boring were used. Several wells have measured nondetect consistently and those samples delineated the bound conditions. In areas were extent was unbound, source area information and groundwater flow directions were used to delineate the extent so as not to overestimate the extent of contamination.

Editorial Comments

1. **Page K-2, paragraph 3. Noting that for most contaminants, frequency of detection has increased with time but maximum and mean concentrations have decreased with time, the appendix attributes these phenomena to contaminant migration resulting from ground water extraction. However, increase in frequency and decrease in mean concentration may also be an artifact of the large increase in number of monitor wells (many placed in low concentration areas) with time. This concept should be considered and discussed in the Report.**

Response:

The text has been revised in the following manner, "For most contaminants, the frequency of detections has been increasing with time, but their maximum and mean concentrations have been decreasing. This may be the result of the following:

- Because of regional, Base, and extraction well pumpage, contaminant plumes have been migrating.
- Contaminant mass has been removed by extraction wells installed for remedial actions.
- Several wells that have been sampled consistently at non-detect levels have been dropped from the monitoring program.
- New wells have been added to the program to further define the plumes. This has led to the addition of numerous wells in relatively low groundwater contamination areas.

Hence, compounds have been detected in more sampled wells, but at lower concentrations."

2. **Table K-1, *Summary Statistics of 1992 VOC Sampling Results*. Columns are allotted for both "Minimum Non-Detect" and "Maximum Non-Detect" values, yet both columns report zero for all compounds. The non-detect values should be reported in Table K-1.**

Response:

Table K-1 has been revised.

3. **Page K-5, paragraph 2, and Figures K-2, K-3, and K-4. The figures purport to illustrate areal extent of COCs in monitoring zones A, B, and C. However, in general, they bear little resemblance to the primary figures upon which they are presumably based: Figures 2-53, 2-54, and 2-55. These discrepancies should be resolved or otherwise clarified. In addition, the figures should explicitly indicate on which primary figures they are based, and they should indicate the date(s) of sample data on which they are based.**

Response:

Figures K-2, K-3 and K-4 will resemble the extent of prevalent contamination figures presented in the Conceptual Model.

4. **Page K-9, last paragraph. The appendix notes, "Cumulative mass versus cumulative volume graphs show that the groundwater concentrations and flow rates from the high concentration areas are significantly different than the concentrations and flow rates from the low concentration areas." This sentence is nonsensical. First, it is obvious that concentrations in the high-concentration areas would be different from concentrations in the low-concentration areas. Second, it is unclear how such graphs could contain any information regarding flow rates, much less flow rates within high-concentration areas versus flow rates within low-concentration areas. The entire paragraph should be clarified, and presumably should refer to Figures K-11 through K-14 (*Cumulative Mass ... Versus Volume*).**

Response:

Comment noted. The text will be clarified.

5. **Tables K-2 and K-6. The two tables report different values for total mass of TCE and cis-1,2-DCE and for total volume of TCE-impacted ground water. All other quantities common to the two tables are equal in value. These discrepancies should be corrected.**

Response:

The masses of TCE and cis-1,2-DCE have been corrected in Table K-2.

6. **Page K-20, equations. In the equation describing "mass sorbed," the soil bulk density is denoted "ρ_{bulk}", but in the explanation of this term, it is denoted "ρ_{soil}." In the equation describing "mass total," contaminant concentration in water is denoted "CW." Elsewhere on this page, concentration in water is correctly denoted "C_w." These minor textual errors should be corrected.**

Response:

The typographical errors have been corrected.

SUBJECT: Draft Final Groundwater Operable Unit RI/FS
McClellan Air Force Base

PROJECT: SWE28722.66.FS

DATE: March 28, 1994

Joseph B. Healy, Jr.
United States Environmental Protection Agency

GENERAL COMMENTS

1. **This report does not meet EPA's minimum expectations for an RI. The Conceptual Model does not replace the suggested chapters 2 and 3 from the Table 3-13 of Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA. This was a topic of discussion during several agency meetings in 1993. It is my understanding that the Air Force suggested following the guidance recommended format, but would present the chapters in a different sequence. It is also my understanding that McAFB and the regulators reached consensus on how the PGOURI was to be summarized in the RI/FS. This is completely missing.**

   Response:

   Chapters 2 and 3 have been added.

2. **It is evident from reading the RI/FS that the Air Force is not providing their contractors with sufficient guidance. The extensive use of color graphics and inclusion of unnecessary information is a waste of time and money. If the Air Force wants to do something that exceeds expectations, then the Air Force and their contractor(s) should focus their efforts on acceleration, streamlining, and cost reduction, especially if the McAFB has intentions of becoming a "model" base.**

   Response:

   The Air Force does not share EPA's opinion.

3. **All graphics should be in black and white. The revised RI/FS should not contain any color Figures, Tables, or Charts.**

Response:

The figures that can be black and white will be changed to black and white. Where it is appropriate to use color, it will be used.

4. **Details in the conceptual model regarding hydrology and chemistry which are not specific to McAFB should be deleted. It is more appropriate to refer to published literature.**

Response:

The Remedial Investigation/Feasibility Study (RI/FS) report is a public document, and the explanation of the processes that are taking place is important. The public may not have other access to the information the commentor wants deleted.

5. **The northeastern OUs (E, F, G, and H) have not been investigated but are suspected to contain contamination. If this report is intended to be a basewide Groundwater RI/FS, it should include all OUs and contaminants found in the groundwater. It may be more appropriate to title this as an interim or focused report.**

Response:

The report does include all contaminants found in the groundwater. This RI/FS does support an Interim Record of Decision (ROD), and the document has been revised to make this point clear.

6. **Background concentration levels for inorganic chemicals in groundwater has not been established. Background must be established for inorganic chemicals to complete the RI/FS. A method similar to that used to establish background for inorganic chemicals in subsurface soils is suggested.**

Response:

The Air Force is proceeding with establishment of background levels for inorganics in the groundwater.

7. **The report does not present recent groundwater data (latest is from January 1993). At least two more quarters of groundwater sampling data could be made available in the draft final report, especially unfiltered metals data. It is our understanding that unfiltered metals samples have been collected since approximately 1993.**

Response:

Data through the third quarter of 1993 has been incorporated into the Draft Final report.

8. **It is unclear how the vadose zone will be incorporated into the basewide RI/FS for McClellan Air Force Base (McAFB); it is apparent most of the contamination at McAFB is contained in the "smear zone." The Groundwater OU RI/FS Report does not evaluate remediation of the basewide smear zone and, apparently, so far none of the OU specific vadose zone RI/FSs do either. It seems that the most appropriate way to deal with contamination at McAFB would be to devise an overall plan for addressing the entire contaminant problem (in all media), then to subdivide the problem into manageable units. The overall plan should also address how these units will be managed from a basewide prospective to timely completion. The plan must provide a mechanism for efficient implementation of all administrative and CERCLA requirements so that a basewide ROD is completed in a cost-effective and timely manner. Ideally, detailed breakout of the steps should be agreed to by all parties before work starts.**

Response:

The Remedial Project Management (RPM) team is working to develop the overall framework for following the CERCLA process at McClellan, from which a plan similar to that described could be developed.

9. **The 15-year time period for contaminants to be captured by proposed extraction wells may be unnecessarily short. Additionally, the number of wells necessary to meet this constraint during groundwater flow modeling is, in our opinion, excessive. Removal or relaxation of this time constraint could allow for a treatment scenario with fewer wells, reducing capital and, potentially, O&M costs. The Air Force should re-examine the appropriateness of the 15-year constraint. Further, it is recommended that model runs be performed to analyze if the number of extraction and injection wells can be reduced, while maintaining contaminant plume capture. Chapter 6 refers to hundreds of years of contaminant persistency. How does this relate to the 15-year capture and the optimization of extraction well placement?**

Response:

Additional simulations were performed to investigate the option of including fewer extraction wells in a given groundwater containment option and accepting longer travel times for contamination to reach a particular extraction well. The results of these simulations performed on the risk target volume suggest that with such a sparse well arrangement, the extraction network is unable to overcome the downward hydraulic gradient that exists in areas between the extraction wells, and contamination migrates downward into lower strata. Since

A-zone contamination overlies uncontaminated portions of the B and C monitoring zones in many areas of the Base, this extraction network was considered unacceptable.

10. **The report frequently reads like a textbook educating the reader on very basic items but often lacking details on site specific subjects. It has the flavor of a teaching tool rather than a technical report on the groundwater Operable Unit RI/FS at McAFB. The revised report should provide more detail for the many broad-sweeping, partially substantiated statements presented in this document. Several specific comments contained herein provide examples of the lack of detail.**

Response:

The Air Force views the public as a customer and needs to provide a report that allows them to understand the complex issues at McClellan. A considerable amount of detail has been added to the report.

11. **The Air Force should evaluate, as a remedial alternative, the option of aggressively reducing hot spot mass contamination using existing technologies. The time and cost factors should be considered when presenting this alternative with the six alternatives currently evaluated.**

Response:

The results of the simulations including hot spot re-injection previously presented in Appendix J have been more extensively evaluated, and the results presented in Chapter 6 and Appendix J.

Chapter 1 – Introduction

SPECIFIC COMMENTS

1. **p. 1-3**

Third full paragraph, last sentence. The text references Figure 1-2 for a graphic representation of the RI/FS/ROD process but fails to adequately explain it. Additionally, the figure is confusing and consequently provides little direct benefit to the report: the overuse of color and stealth cartoons detracts from the overall effectiveness of the illustration. A much simpler, well-explained black and white graphic is required.

Response:

The graphic has been removed.

2. **p. 1-6**

Second paragraph. The text outlines McAFB goals and objectives for the IRP and provides potential resource constraints. While we recognize that McAFB may face future resource challenges, we are concerned that such resource constraints do not cause delays in the investigation and remediation of this NPL Site. The discussion on priorities should include reference to risk reduction.

Response:

The Air Force is in the process of developing a risk reduction prioritization model for McClellan. Chapter 13 has a detailed discussion of the priorities for the implementation of the interim groundwater remedy, and risk reduction was considered.

3. **p. 1-7**

Figure 1-3 does not need to be in color or include extensive graphics. A simple black and white flow chart is sufficient.

Response:

The graphic is necessary and remains in the report.

4. **p. 1-9**

Figure 1-4 adds nothing to the discussion or the readers edification of how existing remedial actions are integrated into the groundwater remedy. Remove this figure.

Response:

The graphic is necessary and remains in the report.

Chapter 2—Conceptual Model

SPECIFIC COMMENTS

1. **p. 2-2**

Figure 2-1. The Air Force should remove cartoonish graphics. This figure adds nothing to the readers understanding of the conceptual model. If the Air Force determines that a figure is necessary for this information, then a simple black and white flow chart could be used.

Response:

The purpose of this figure is to explain the idea of a Conceptual Model to readers who are unfamiliar with Conceptual Models. The figure shows how the following components make up the framework of the Conceptual Model:

- Site Characteristics
- Source Area Information
- Fate and Transport
- Physical Transport Mechanisms

With the above information, existing conditions could be proposed and future conditions could be predicted. It is believed that this figure assists in explaining the structure of the Conceptual Model.

2. p. 2-5

Although Figure 2-2 is pretty, it is not necessary to produce this in color. Especially since the RI is mostly devoid of site specific geology.

Response:

Geologic maps are generally in color and were originally in color. No additional effort was made to generate this geologic map in color. It would be difficult and ineffective to present the various outcrops in black and white, especially since the figure is already presented. The discussion of geology is essential in describing the alluvial and fluvial deposits that make up the subsurface units.

3. p. 2-7

Section 2.2.2. This is a very weak discussion of site geology and hydrogeology. The Air Force has spent considerable effort investigating the base, yet very little is even summarized here. One purpose of the RI is to report and present information collected during site characterization. One cross-section is not sufficient. Figure 2-3 would be easier to read if it were in black and white. The Air Force should add more cross-sections and fence diagrams. The cross-sections should be in black and white, depict lithology, water levels, vertical gradients and chemistry.

Response:

Two chapters, Study Area Investigations (Chapter 2) and Physical Characteristics of the Study Area (Chapter 3) will be added to the RI/FS. Eight cross sections showing boring lithology, contaminant concentrations, water levels, and geophysical logs will be presented in Chapter 3. A thorough discussion of the geology will be presented.

4. p. 2-9

Second paragraph. The text states that if significant aquitards separate the monitoring zones beneath McAFB, the water level responses to regional pumping in each monitoring zone would be dampened. It should be noted that the degree of dampening would also be related to the locations of the pumping well screen intervals; wells with intervals screened over most of the monitoring zones could produce similar water level responses.

Response:

Although it is true that water level responses would be similar in wells that are screened through the zones that the pumping wells are screened in, few such scenarios exist in the present well network. Generally, pumping wells are screened significantly deeper than the Monitoring Zones D and E, whereas most of the monitoring wells are in Monitoring Zones A, B, and C.

5. p. 2-9

Figure 2-6, Gradient between OU A well clusters. The figure contains data through December 1992. Please update the figure in the revised report to include available 1993 data. This figure does not benefit from use of color and should be changed to black and white.

Response:

The last horizontal axis label was incorrectly labeled as "Dec-92"; it has been corrected to "Jan-93." This figure does include January 1993 data. This figure will be a black and white in the Draft Final version.

6. p. 2-10

Figure 2-4, Hydrographs of wells in the A and B zones of OU A, OU B/C, and OU D. The figure contains data through January 1993. Please update the figure in the revised report to include more recent available data. This figure does not benefit from use of color and should be changed to black and white.

Response:

Post January 1993 water level information is currently not available in electronic format and will not be updated into these hydrographs.

7. p. 2-11

Figure 2-5 does not benefit from the use of color and should be in black and white. Add data to support contours.

Response:

Figure 2-5 will be presented in black and white. The January 1993 data used to generate these figures is presented in Figures 2-38, 2-39, and 2-40. The data in these figures will be referenced on Figure 2-5.

8. **p. 2-13**

Second paragraph. The text states the necessity to divide the saturated zone into two-dimensional layers even though the groundwater system behaves more as one unit. It is unclear, based on the provided rationale, why the system was subdivided into several two-dimensional systems. The last sentence of the paragraph indicates that the conceptual model was developed, in part, based on constraints of the groundwater investigation tools (numerical modeling and contouring) instead of site data. Please revise the text to more clearly explain why the groundwater system beneath McAFB was divided into several two-dimensional systems. Please include a discussion as to the advantage of studying the groundwater system as discrete two dimensional systems as opposed to one three dimensional system.

Response:

The text explains that the subsurface was divided into zones for interpretation according to geophysical logs, but that the subsurface is believed to behave more as one unit than as separate units. There is no advantage to studying the system as a two-dimensional system not a three-dimensional system. The second paragraph on page 2-13 appears to have been confusing and has been omitted.

9. **p. 2-13**

Third paragraph. The text states that aquifer test data from 28 single-well aquifer tests were evaluated to estimate the distribution of aquifer transmissivity across McAFB. It is unclear why data from only 28 of the 41 single-well tests were used for this evaluation (Final PGOURI Report p. 2-19, last paragraph). It is also unclear why test data from multiple-well tests were not used (Final PGOURI Report p-19, Second paragraph). Please provide additional text to clarify the aquifer parameter evaluation in this report.

Response:

All of the single-well and multiple-well aquifer test results contained in the Preliminary Groundwater Operable Unit Remedial Investigation (GW OU RI) were considered when constructing the three-dimensional groundwater model to support the Groundwater Operable Unit Remedial Investigation/Feasibility Study (GW OU RI/FS) Report. It was the opinion of CH2M HILL that the results of the single- and multiple-well aquifer tests were more representative of the aquifer characteristics than were the slug-test results. The slug-test results consistently resulted in transmissivity estimates that were a full order of magnitude lower than the estimates obtained by standard continuous-rate aquifer tests. Slug tests do not stress the hydrologic system to the extent that pumping tests do, and as a result provide transmissivity estimates from the aquifer materials extremely close to the well. It is our opinion that aquifer tests that include pumping of significant quantities of water are a more appropriate source of information when constructing a groundwater model to compare various groundwater extraction scenarios.

10. **p. 2-14/18**

Figures 2-7 through 2-11 do not benefit from the use of color.

Response:

Figures 2-7 and 2-8 will remain in color because the colors used in these figures distinguish between wells screened in Monitoring Zones A, B, and C. Figures 2-9, 2-10, and 2-11 will be presented in black and white in the next version of the report.

11. **p. 2-18**

Figures 2-10 and 2-11. The figures show transmissivity contours in the B and C Monitoring Zones. Considering the amount of investigative work completed, little or no OU C transmissivity or hydraulic conductivity data were presented in these figures. If supplemental data exist, they should be added to the figures to improve contouring control.

Response:

Of the 27 single-well aquifer tests conducted during the Preliminary GW OU RI, the only OU C wells that were monitored were the MW-206/MW-207/MW-208 cluster. The transmissvities from the Papadopolus-Cooper method are presented on Figures 2-9, 2-10, and 2-11. The transmissivity values have been recontoured to honor the data.

12. **p. 2-20**

First partial sentence. The sentence states that Table 2-1 presents transmissivities and hydraulic conductivities for Monitoring Zones A, B, and C for each OU. Table 2-1 does not include the above information for OU G. Please include the data from OU G (MW-195 and MW-196) as depicted on Figures 2-10 and 2-11, respectively.

Response:

The OU G aquifer parameters have been added to Table 2-1.

13. **p. 2-29**

Third full paragraph. Please reference the source for the historical information presented in this section.

Response:

The reference for the OU C source area history has been added to the text.

14. **p. 2-30**

First paragraph. Please reference the source for the historical information presented in this section.

Response:

The reference for the OU D source area history has been added to the text.

15. **p. 2-30**

Second paragraph. Please reference the source for the historical information presented in this section.

Response:

The information on the Industrial Waste Line (IWL) was obtained from various Preliminary Assessment (PA), sampling and analysis plan (SAP), and RI reports on the different OUs that the IWL runs through.

16. **p. 2-30**

Third paragraph. Second to last sentence. The text states that Figure 2-12 depicts the route of the IWL: Figure 2-12 does show approximate boundaries of OUs at McAFB, but does not show the IWL. Please revise the figure to include the location of the IWL or reference another figure.

Response:

The text has been revised to reference Figure 2-13, which does show the IWL.

17. **p. 2-31**

First complete paragraph. The text states that no detailed assessments or investigations have been performed for OUs, E, F, G, or H but that the extent of contamination in these OUs is considered minimal when compared to OUs A through D. Please clarify why the extent of contamination is considered minimal when no investigations have been conducted in the former OUs.

Response:

Although detailed analysis on OUs E, F, G, and H have not been performed, several source areas in these OUs have been identified and are referenced in the text. In addition, several monitoring wells have been installed in these OUs to monitor the water quality and water levels. The contamination in OUs E, F, G, and H are considered less of a priority than OUs A, B, C, and D for the following reasons:

- The groundwater concentrations measured from wells in OUs E, F, G, and H are orders-of-magnitude less than groundwater concentrations measured in OUs A, B, C, and D.
- Because groundwater currently flows in a southwesterly direction, the likelihood is small that contamination from OUs E, F, G, and H will migrate offbase and pose a threat to municipalities. Conversely, plumes from OUs A, B, C, and D are believed to be migrating offbase.

Because of funding constraints, the OU remediation of the groundwater plumes will have to be performed in phases. Priority has been given to the OU A, B, C, and D plumes because of the high concentrations and potential for offbase migration.

18. p. 2-31

Third complete paragraph. The text lists five primary COCs at McClellan AFB. Chemicals of concern are normally established after all investigative data on Site contaminants are presented. The COCs are normally identified early in the Risk Assessment. It seems premature to list these chemicals as COCs in the section dealing with conceptual model development. Additionally, several of the OUs have not been investigated and metal COCs have not been addressed. (This is due to the fact that background concentration levels for metals have not been established). It is suggested that a different term be used for these contaminants or provide reference for this designation. (For further information, please reference page 3-22, Section 3.4.2.2 of Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, dated October 1988.)

Response:

The term "prevalent contaminants" has been used to describe compounds in the Conceptual Model that were once called "contaminants of concern."

19. **p. 2-32**

Table 2-3, Summary of Wastes and Contaminants by Operable Unit. The table summarizes types of wastes and contaminants in the OUs. It does not include PCBs and dioxin/furan compounds confirmed in OU B1 and OUD. Additionally, OUs E, F, G, and H should be included. Please update the table accordingly.

Response:

PCBs and dioxin/furan compounds have been added to the lists of contaminants found in OU B and OU D in Table 2-3. OUs E, F, G, and H have also been added to Table 2-3.

20. **p. 2-33**

Table 2-4, Physical and Chemical Properties of VOCs of Concern. The table lists physical properties of several VOCs, including their mean, frequency, and maximum detections. It is unclear to what the mean, frequency, and maximum detect refer (VOCs in soil or water? Does frequency refer to the number of locations with positive analytical results?). Please provide footnotes or additional text to clarify these columns in the table.

Response:

The title of Table 2-4 has been changed to "Physical and Chemical Properties of Groundwater VOCs of Concern." The third column, "Mean," has been footnoted with the following, "Mean calculated with non-detects as zero." The fourth column heading has been changed to "Frequency of Detects" to clarify the information presented in the table.

21. **p. 2-33**

The color cartoons for Henry's Constant, Solubility in Water, Partition Coefficient, and Vapor Pressure are not necessary. Each are almost illegible due to the extensive use of color and unneeded graphics.

Response:

These pull-out figures are intended to explain to the lay reader the range of partitioning tendencies of the volatile organic compounds (VOCs) of concern, depending on their Henry's constant, water solubility, vapor pressure and coefficient of distribution. The partitioning tendencies and mobility of contaminants is essential in understanding the current site conditions and extent of contamination. The colors in these pull-out figures will be removed to make them more like charts and more easily read.

22. p. 2-35

Figure 2-14 should be in black and white without the use of cartoons.

Response:

This figure is intended to explain to the lay reader the multiphase partitioning of contaminants in the vadose zone and in the groundwater. The figure shows how nonaqueous phase liquids (NAPLs) exist as free product and contaminants sorb to the organic carbon site on soil particles. The figure shows the four phases in the vadose zone and the three phases in the groundwater zone. This figure is intended to visualize a complex topic for the reader.

23. p. 2-36

First paragraph and Figure 2-15. Why was foc = 0.002 used? This discussion needs a summary. There is no value added by use of color.

Response:

Typical organic carbon fractions (f_{oc}) range from 0.001 to 0.003. Soil sampling collected during Summer 1993 at OU D confirms that f_{oc} values range from 0.0009 to 0.006, with an average of 0.00274. An f_{oc} of 0.002 was selected because it fell within the range of typically accepted values confirmed by field sampling. The intention of the figure was not to demonstrate how contaminants partition differently because of their partition coefficients. The following summary has been added to the discussion: "At a given organic carbon content, contaminants would ideally partition differently under equilibrium conditions. Their tendency to partition is related to their partition coefficient, K_{oc}." The figure will be presented in black and white in the Draft Final RI/FS.

24. p. 2-39

Second full paragraph, second sentence. The sentence states that dissolution of DNAPLs in a saturated environment can take decades or centuries. Please provide support for this statement. The entire discussion on DNAPLs should end with a recommendation for source removal.

Response:

The source of the statement is provided in the first sentence of the subsection, "Presence, Implications, and Mass Movement of DNAPLs." The information on DNAPLs was obtained mainly from *DNAPL Site Investigation* by Robert M. Cohen and James Mercer. The recommendation for source removal was made in the Basewide engineering evaluation/cost analysis (EE/CA) and was mentioned in the Feasibility Study Approach Chapter.

25. **p. 2-39**

The discussion on transport mechanisms is far too detailed for this document. This entire section can be briefly summarized with references to text books where needed. The cartoons are not necessary and should be deleted from the revised version. Figure 2-19 can be used if it is changed to black and white.

Response:

It is of the opinion of the Air Force that the RI/FS must be understood by the general public. The public does not have access to textbooks discussing contaminant transport mechanisms. Hence, the section discussing contaminant transport mechanisms will remain the Conceptual Model.

26. **p. 2-46**

Figure 2-20 does not benefit from use of color. The revised figure could use different symbols instead of color.

Response:

The figure has been revised and will be presented in black and white in the next version of the report.

27. **p. 2-50**

Figure 2-22 does not benefit from the use of color. The revised figure should be in black and white. The text in the discussion on page 2-47 should provide reference for the data used to construct this figure and Figure 2-23.

Response:

Figure 2-22 will be presented in black and white in the revised version of the RI/FS. The following sentence has been added to the text to reference the source, "These gradients were measured from groundwater elevation contour maps prepared by the County of Sacramento Department of Public Works (presented in Figure 2-21)."

28. **p. 2-52/57**

The figures on these pages do not need to be in color. How were the cross-sections determined? Are these representative of each OU? Figure 2-29 and 2-30 are appropriate for a work plan, where little is know of a site or base. Site and/or base specific information should be added to these two figures. On Figure 2-30 the text box titled Regional Production and Base Wells, fourth bullet should be changed from "contaminant moss" to "contaminant mass."

these wells is depicted on Figure 2-54 as contaminated

Response:

The figures showing the decline of the water table will be presented in color because in some areas the lines overlap and it is difficult to distinguish between the differences. Figure 2-29 and Figure 2-30 are necessary to explain to the general public the impacts that the historical base activities had on the creation of the smear zone and contamination of the groundwater. The typographical error will be corrected.

29. p. 2-60

First partial paragraph, fourth sentence. Please define the term "conservative particle."

Response:

The following sentence has been incorporated into the text: "The term "conservative particle" describes a particle that does not transform and is not retarded by sorption."

30. p. 2-60

First complete paragraph. Figure 2-31 and 2-32 should be checked by hand. The text introduces Figures 2-33 through 2-36 as depictions of estimated smear zones in cross-section. The text does not discuss the cross-sections. What is the purpose of these cross-sections? Will they be used to develop additional information in subsequent reports? Does the information depicted on the cross-sections compare with field observations? Please provide a brief discussion of the implications which might be derived from these figures, particularly the differences in extent of smear zones and extent of estimated 1993 TCE contamination data in groundwater. For example, can conclusions be made for why the estimated 1993 TCE groundwater contamination extent correlates with the 1968 OU A smear zone, while the 1993 groundwater contamination correlates with the 1950 OU B smear zone? Also provide a reference of data used to construct these figures. It appears from the discussion provided in the text and the precision of the drawings that these figures are not necessary.

Response:

The purpose of the cross sections is to show the extent of smear zone contamination in profile view. They present literally the interface between the groundwater and the vadose zone. Comparisons between these cross sections and field data could be performed by subsequent reports. The assumptions made in preparing these figures are presented in the text.

31. p. 2-60

Last paragraph. The text states that BW-18 has a large radius of influence, hence groundwater locally moves toward BW-18 from all directions. Apparently, BW-18 (and BW-20) are not located on Figures 2-38 through 2-41. For completeness, please add them to these figures. In addition, it would aid the reader if all extraction/pumping wells were highlighted on these figures. Please review them, as appropriate.

Response:

The locations of BW-10, BW-18, and BW-29 will be presented in Figures 2-38 through 2-41. All extraction wells will be labeled with a different symbol to aid the reader.

32. p. 2-69

Last paragraph. Last sentence. The sentence states that the observed downward hydraulic gradient beneath McAFB is necessary to drive water from the recharge area to the discharge area. It should be noted that this gradient is a measurement of the head differences between the recharge and discharge areas. Consequently, a gradient cannot drive anything. It is a term to describe the apparent difference between two locations of differing groundwater head values. Please revise the sentence accordingly.

Response:

The text has been revised in the following manner to incorporate the comment: "The vertical hydraulic gradients that exist at the Base are predominantly downward, except on areas where shallow extraction is occurring. This downward gradient is a result of hydraulic level differences between recharge areas and discharge areas. Surface infiltration is the major source of recharge. Regional pumping is the major component of discharge. Consequently, water moves from the recharge area (ground surface) of higher hydraulic head to the discharge area (regional aquifer) of lower hydraulic head."

33. p. 2-69

Figure 2-37 does not benefit from the use of color and should be revised as black and white.

Response:

The figure has been revised and will be presented in black and white in the next version of the report.

34. p. 2-70

Third paragraph. This paragraph assumes an annual recharge rate of 2.5 inches (15 percent of precipitation). Please reference the source of the assumed recharge rate.

Response:

This assumed recharge rate was estimated from a combination of professional judgement and experience with other projects in the Sacramento area. This value is also supported by the calibrated groundwater model presented in Appendix J. Site-specific recharge studies have not been performed at the Base to independently verfiy this recharge rate. Please refer to the discussion of the recharge rates selected for the groundwater model presented in the revised Appendix J.

36. p. 2-79

Figure 2-42 does aid the text and should not be included in the revised text.

Response:

This figure shows where all the production, municipal, and Base wells are located within the vicinity of McClellan AFB. By presenting this dense network of pumping wells, this figure shows that the groundwater aquifers in this area are heavily pumped and used by municipalities.

37. p. 2-81

Figure 2-43. The three Caltrans wells identified as CT-1, 2, and 3 each have a Base Well symbol, please clarify.

Response:

The Caltrans well symbols have been changed to district well symbols.

38. p. 2-85

Second paragraph. This paragraph states that pumping rates for the City of Sacramento, Caltrans, and Citizens Utilities wells are not anticipated to change. Information included on Figure 2-44 indicates that no pumping information was available for the Caltrans wells. How can a statement be made about the future pumping rates for the Caltrans wells if no information is available? Please clarify.

Response:

Caltrans pumping data has been added to Figure 2-44. The last paragraph in Section 2.5.6 has been deleted.

39. p. 2-85

Fourth paragraph, fifth sentence. The sentence identifies the "triox hole," please define as to which well this refers. Also, a reference is made on Table 2-6 to the "Triax hole." Please clarify.

Response:

The triax hole is one of two seismic survey wells located at Camp Kohler. It is not a water supply well. The text has been modified to explain this. The location of this well and the other three Camp Kohler wells have been added to Figure 2-43. The spelling of "triax" has been corrected in the text.

40. p. 2-85

Fourth paragraph, last sentence. This sentence states that LW-1 and LW-2 will be redrilled and decommissioned. Please expand the discussion and cite the location of the relevant redrilling and decommissioning process. (Additionally, is this offbase area considered part of the NPL site? Is any investigation going to be performed in the area of the fuel tank farm?)

Response:

Well LW-1 was uncovered by backhoe and has been filled with concrete. It has been agreed upon by the agencies that there is no need to abandon this well. Well LW-2 was decommissioned in January 1994. The locations of these wells are presented on Figure 2-43.

41. p. 2-86

The information in 2.6 is not a sufficient summary of existing and observed conditions identified by the RI. This section needs to be extensively revised to summarize all data and all decisions made during the RI.

Response:

Two chapters will be added to the Draft Final of the report. The first will provide a summary of previous investigation findings. The second will provide a summary of the major conclusion of the Preliminary GW OU RI (Radian, 1992). The chapters are entitled Study Area Investigation and Physical Characteristics of the Study Area.

41. **p. 2-86**

Last paragraph. Please correct the text in this paragraph that lists VOCs of concern. These are inconsistent with the COCs listed on page 2-31. Please clarify.

Response:

The four prevalent contaminants are TCE, PCE, 1,2-DCA, and cis-1,2-DCE. All text and/or tables on these pages will present and discuss only four VOCs as contaminants of concern (COCs).

42. **p. 2-87**

Table 2-6. Table column titles should either be footnoted for abbreviations, or provide full explanations (e.g., Inst. Date - Installation Date).

Response:

Complete titles have been added to the column headings.

43. **p. 2-88**

First paragraph, first sentence. Text in this sentence should identify the sources (state or federal) or MCLs and background levels.

Response:

The sources of the MCL levels have been footnoted in Table 2-7. The background levels have been removed from the table. The following sentences have been incorporated into the text to discuss background conditions, "Background conditions exist when there are no detectable concentrations of VOCs using reliable analytical methods. In most cases, this can be met by using EPA Method 601 and 602 with a 0.5 μg/l detection level."

44. **p. 2-88**

Second paragraph, second sentence. The sentence states that the histograms in the referenced figure (Figure 2-45) contain information on TCE and 1,2-DCA. However, the histograms presented in Figure 2-45 include histograms for carbon tetrachloride, chloroform, DCE, 1,2-DCE, PCE, and TCE but not 1,2-DCA. What is the purpose of this figure? It does not adequately summarize the data collected during the RI.

Response:

1,2-DCA was mislabeled as "DCE." The correction has been made. As discussed in the text, the purpose of this figure is to show how the average concentrations and frequency of detections have changed with time. All data from the Groundwater Sampling and Analysis Program (GSAP) program, up to the January 1993 sampling period, was used to create this figure.

45. p. 2-88

Last paragraph. The text states that nickel and manganese have been consistently detected above MCLs in filtered groundwater samples. It is EPA Region 9 current policy that only unfiltered groundwater samples may be used for risk assessment purposes. The use of filtered samples to identify COCs is, therefore, not appropriate. Please refer to the attached article by Puls and Powell (1992) for a technical discussion of collecting groundwater samples for metals. It may be inappropriate to dismiss metals as COCs since they have not been compared to background concentration levels.

Response:

We agree with the comment. McClellan is aware that only unfiltered metals samples can be used in risk assessment. No metals can be selected or dismissed as COCs until a detailed evaluation of metals is performed. Yet an evaluation of metals cannot be performed in this interim RI/FS for the following two reasons:

- Background groundwater metals concentrations have not been established for groundwater beneath McClellan AFB. Hence, it is not possible to differentiate the difference between metals in groundwater that occur naturally due to mineral dissolution and metals contamination from Base activities.

- A variety of field procedures have been used and it is not possible to distinguish between results from different sampling procedures. Historically, both filtered and unfiltered samples have been collected at low, and possibly high flow rates. Turbid samples are generally collected at high flow rates that may overestimate groundwater metals concentration.

Background concentrations must be established and field sampling techniques must be standardized before the extent of metals concentrations can be evaluated. A discussion of metals as a data gap is presented in the conceptual model.

46. p. 2-90

First complete paragraph. The text states that results from 1991 were selected because 1991 was the most recent year that filtered metal samples were collected. As previously commented (see specific comment 31), filtered groundwater samples cannot be used for risk assessment purposes. Please re-evaluate inorganic results by using unfiltered groundwater samples to establish COCs.

Response:

It is currently not possible to distinguish between filtered and unfiltered samples. It has been recommended in Draft Final RI/FS that techniques for sampling groundwater for metals be standardized before a detailed evaluation of metals in the groundwater be performed to establish COCs.

47. p. 2-90

Second complete paragraph. The text presents a Sacramento Basin background concentration level for manganese. While this reference may be appropriate when considering basin wide manganese concentrations, the basin wide value is not appropriate for use at McAFB. Defensible background concentration ranges for inorganic chemicals in groundwater beneath McAFB must be established in order to adequately assess the need for remediation of these chemicals. The process for establishing the background concentration ranges should make use of the appropriate statistical methods, given the available data. The methods could be similar to those used to establish background concentration ranges for inorganic chemicals in subsurface soils at McAFB.

Response:

McClellan agrees with the comment. It has been recommended in the Draft Final RI/FS that background metals concentrations in the groundwater be established before a detailed evaluation of metals in the groundwater be performed. Establishing background concentrations is beyond the scope of this RI/FS. It should be performed as a post RI/FS activity. Once background is established, the conceptual model regarding metals concentrations can be refined.

48. p. 2-90

Third complete paragraph. Third sentence. The sentence states that nickel is not considered a COC in groundwater at McAFB. It is unclear why nickel should not be considered a COC, particularly since the previous sentence states that elevated nickel concentrations may be related to past activities at the contaminant source areas. An adequate and defensible rationale for removing nickel from consideration as a COC has not been, in our opinion, presented in this report. Please revise the report to consider nickel as a COC or present detailed discussions supporting the decision to eliminate it from consideration

(e.g., it occurs consistently below Site-specific background concentration ranges). Additionally, Section 7.6.1 references the presence of acetone and MEK. Please evaluate these compounds for inclusion into the list of COCs.

Response:

No metals can be selected as COCs until background metals concentrations in groundwater are established for the groundwater beneath McClellan AFB. This has been discussed in the Draft Final RI/FS. Acetone and MEK are parameters that impact treatment processes, but were not selected as COCs because their current groundwater concentration do not pose a health risk.

49. p. 2-91

Second complete paragraph, last sentence. The text describes the hypothetical uncertainty associated with contaminant data interpretations if data were missing. It is unclear why this statement is included in the report.

Response:

As stated in the text, the scenario of missing wells demonstrates how interpretation of groundwater water quality data and extent of contamination are dependant on the monitoring well network. This uncertainty is not purely hypothetical. In almost all cases Basewide, understanding of the extent of contamination is limited to the location of monitoring wells. The extent could only be bound with confidence in areas where wells have consistently measured nondetect. Conversely, plumes could only be identified in areas where wells have consistently measured detects.

50. p. 2-95

Figures 2-47, 2-48, and 2-49. Please add extractions wells to the legend.

Response:

The extraction wells have been differentiated from the monitoring wells in the figures and in the legend.

51. p. 2-101

Figure 2-50. This figure does not benefit from the use of color. The proposed new well is not needed. How was uncertainty determined?

Response:

The use of color helps to distinguish between the differences in extent of contamination for different monitoring well networks (see Response to Comment 49). The intent of this figure is not to propose new well locations but to demonstrate the idea that the northern extent of the OU A Monitoring Zone B plume could be delineated further with the installation of a well north of MW-225. Uncertainties were initially identified in the Strawman ROD in November 20, 1992, and are presented in Table 4-2 of the Feasibility Study Approach. Uncertainty in the monitoring well network is a reason why the full extent of contamination is not known (second uncertainty in Table 4-2).

52. p. 2-102

Figure 2-51. The figure is inaccurate. Please update the scheduled completion of the final GW OU RI/FS. This figure does not require the use of color.

Response:

Figure 2-51 will presented as a black and white timeline. The final GWOU RI/FS will be shown to be completed in 1994.

53. p. 2-104

Figure 2-52 does not require the use of color

Respose:

Figure 2-52 will be presented in black and white.

54. p. 2-103

Fourth paragraph. It should be noted in this paragraph that CW-150 was abandoned in April 1991 (see Appendix O, pages 10-15).

Response:

The text has been modified to incorporate the comment.

55. p. 2-104

Last paragraph. The text states that the estimated contaminant extent for VOCs will be based on groundwater sampling results obtained from January 1992 and January 1993, but the estimated contaminant extent for metals will be based on sampling results obtained prior to 1992. It is assumed that the data prior to 1992 is from filtered groundwater and cannot be used for risk assessment purposed. Since unfiltered sampling data must be used for risk

assessment, please revise the report accordingly. Additionally, sampling data for metals from the same time period as those for VOCs should be used, if possible.

Response:

Four figures have been prepared showing the lead, nickel, chromium, manganese, and aluminum concentration results in wells in the A, B, C, D, and E Zones that were sampled in the second and third quarter of 1993. It is currently not possible to distinguish between filtered and unfiltered samples. It has been recommended in Draft Final RI/FS that techniques for sampling groundwater for metals be standardized before a detailed evaluation of metals in the groundwater be performed to establish COCs any risk assessments.

56. p. 2-106

The figures showing the extent of contamination (Figures 2-53, 2-54, 2-55, and 2-66) should include all COCs (see comments 31 and 34). Additionally, a figure(s) showing extent of metals contamination should also be included.

Response:

See response to comment 55. The extent of metals concentrations cannot be delineated at this time because background concentrations have not been established. It is currently not possible to distinguish between metals that occur naturally in the groundwater from mineral dissolution and metals contamination due to Base activities.

57. p. 2-106

Last paragraph, last sentence, Figures 2-53, 2-54, and 2-55. The text states that contaminant concentrations generally decrease from the A Zone to the D Zone. While this is probably true, Figures 2-53, 2-54, and 2-55 show a decrease in TCE concentrations from approximately 3,000 μg/l to 1 μg/l from the A to B Monitoring Zones and then an increase in TCE to greater than 1,000 μg/l in the C Monitoring Zone within what appears the vicinity of OU C1. An explanation for this would be appropriate in this section. McAFB should consider installing a monitoring well(s) in the area to delineate the complete vertical distribution of contaminants (throughout Monitoring Zones A, B, C, and D).

Response:

The >1,000 μg/l contour interval presented in Figure 2-55, Extent of Contamination in Monitoring Zone C, is the result of a sample collected in EW-144 that measured 1,300 μg/l. In the data base, EW-144 was assigned to Monitoring Zone C. But by comparing screened interval depths with monitoring zone depths, EW-144 is actually screened in Monitoring Zone C. Hence, TCE concentrations appear to decrease from approximately 3,000 μg/l to greater than 1,000 μg/l from the A to B Monitoring Zones, and then from greater than 1,000 μg/l to greater than 1 μg/l from the B to C Monitoring Zones. This will be incorporated into the text and figures of the Draft RI/FS.

58. p. 2-106

Last paragraph. What is the significance of the cross-section used. Why is there not a cross-section normal to groundwater flow for OU A plume? Figure 2-58, 2- and 2-60 need to have contours checked by hand. It would be helpful if lithology were included in these sections.

Response:

Eight cross sections have been included in Chapter 3, Site Characteristics. They will show lithology. Three of the cross sections in OU A are perpendicular to groundwater flow.

59. p. 2-124

Fourth full paragraph. The paragraph should be edited to include language indicating that the Conceptual Model will be expanded as investigations of OUs E, F, G, and H are completed.

Response:

The following text has been incorporated to address the comment: "As detailed investigations of OUs E, F, G and H are performed, the data collected will be incorporated into the conceptual model. Information regarding source areas, the industrial waste line, and the vadose zone coupled with water level and water quality data will help delineate further the extent of contamination in those operable units."

60. p. 2-125

First paragraph. The section presents calculated VOC mass dissolved in groundwater and adsorbed to the soil matrix. For completeness, please provide calculations used to determine total mass.

Response:

The following sentence has been added to the text: "The assumptions made and performed to calculate VOC mass and volume are presented in Appendix K, VOC Mass Estimates."

61. p. 2-127/8

The figures on these pages do not require the use of color.

Response:

Figures 2-61 through 2-64 will be presented in black and white.

62. p. 2-128

Second paragraph. The sections presenting the rationale for assigning hot spot, MCL, risk, and background target volumes seems to be inconsistently applied. A detailed explanation of the development of each type of target volume developed for each zone (A, B, and C) should be presented. The following three figure sets were compared for continuity with respect to projected extent of contamination, target volume development, and proposed MCL target volume groundwater extraction:

- **A Zone Figure 2-53; 2-65; 6-16;**
- **B Zone Figures 2-54; 2-66; 6-17;**
- **C Zone Figures 2-55; 2-67; and, 2-18.**

A Zone: **Figure 2-53 shows concentration contours for both TCE (>1.0 μg/l) and cis- 1, 2-DCE (> 1.0 μg/l) in the vicinity of MW-295 (OU-H). Figure 2-65 indicates that a concentration of 10.0 μg/l TCE was reported in groundwater samples collected from MW-295 in 1982. This location appears to qualify for the development of an MCL target volume, based on the reported 1982 TCE concentration; however, no extraction wells are proposed for this area on Figure 6-16. This does not seem to be a result of the age of the data since 1982 data is used to qualify a hot spot target volume at MW-8 (OU-A, figure 2-65) approximately 4000 feet south of MW-295.**

Figure 2-65 contains an area designated as a background target volume in the eastern portion of OU-G. The figure indicates that TCE concentrations below laboratory detection limits were recorded in 1991 water samples collected from MW-102 on the northeast boundary of the projected background target volume. Text on page 2-135 describing how background target volumes are developed states that this target volume type is "defined as an area where total VOC concentrations are greater that 0.5 μg/l." Figure 2-53 does not show any chemical concentration contours in this area and, since no chemical concentration information other than the non-detected level of TCE from MW-102 samples were presented on Figure 2-65, it is unclear why this background target volume was developed. Please clarify.

B Zone: Contaminant contours for PCE (concentration not identified) and TCE (> 1.0 μg/l) are depicted on Figure 2-54 in the vicinity of MW-195 (OU-G). Figure 2-66 includes an MCL target volume in this area with a reported TCE concentration below laboratory detection limit from a 1990 groundwater sample. It is unclear why a target volume on Figure 2-66 and the proposed extraction well on Figure 6-17 were developed for this area since the reported contamination does not exceed the MCL for TCE, and the PCE concentration is not identified. Please clarify.

Figure 2-54 also includes an area of contamination in OU-D with depicted concentrations of 1,2-DCA (>100 μg/l) and TCE (> 10 μg/l). Both these concentrations are in excess of their respective MCLs of 0.5 and 5 μg/l. Figure 2-66 presents analytical data from groundwater sampling activities completed during 1985 which include a reported TCE concentration of 296.0 μg/l from MW-38D. An MCL target volume was not developed for this area and the area around the well is not included in either the risk or background target volumes. Additionally, this figure indicates that the six extraction wells in OU-D all contained groundwater with TCE concentrations greater than the MCL as reported during 1991. The wells are located within or near the background target volume created for this area and, according to the text on page 2-135, the areas around MW-38D and the extraction wells should have an associated MCL target volume. Further, Figure 6-17 shows six OU-D extraction wells without an associated MCL target volume. Please explain these inconsistencies.

Figure 2-66 shows a risk and background target volume in an area off base, directly west of OU-C. No supporting data on the presence or concentration of chemicals in this area is included in Figure 2-66 or 2-54. Please clarify.

Figure 6-17 includes an extraction well within OU-C. Figure 2-54 indicates that concentrations of TCE (>1.0 μg/l) and cis-1,2-DCE (>0.5 μg/l) are present in the groundwater around MW-207. Figure 2-66 shows a 1991 TCE concentration of 2.7 μg/l in water samples from MW-207. The above data suggest that this area does not fulfill the criteria established for the assignment of an MCL target volume. However, as previously stated, Figure 6-17 Extraction Well Locations, B Monitoring Zone, MCL Target Volume shows an extraction well in this area. Please address this inconsistency.

TCE concentrations of 5,400.0 μg/l and 800.0 μg/l were detected in 1993 water samples collected from EWs -233 and -234, respectively, as shown on Figure 2-66. Although the area around

these wells is depicted on Figure 2-54 as contaminated, no associated MCL target volume has been depicted on Figure 2-66. Additionally, this area is not included on Figure 6-17.

C Zone: **Figure 2-55 indicates that there is a concentration of TCE within the area around MW-69 (OU-A) of >1.0 μg/l. Although Figure 2-67 shows an MCL target volume for the area around MW-69, the supporting TCE concentration included on this figure is 1.2 μg/l, considerably less than the TCE MCL of 5.0 μg/l. Additionally, the corresponding extraction well location figure (Figure 6-18) for C zone shows one extraction well for this area at the same location as MW-69. The development of this MCL target volume does not appear to follow the criteria set forth in the text. Please clarify this issue.**

Response:

The target volumes have been revised and will be presented in the RI/FS. The inconsistencies and confusion described in the comment will be clarified. There will be agreement between the extraction well layout, extent of contamination, and target volume figures. Data older than 1988 will not be used in the target volume generation. If the data do not agree with the delineated target volumes, the rationale will be explained.

63. p. 2-135

Third paragraph. The section should be expanded and more explanatory, especially the discussions dealing with Zone B of OUD.

Response:

A discussion of the B Zone of OU D is presented in the extent of OU D contamination. The discussion of the target volumes has been expanded.

64. p. 2-136

Second complete paragraph. The text states that a Preliminary Assessment of OU G has not been performed. It is unclear how this RI/FS Report can address basewide groundwater contamination when several OUs have not been investigated. Based on the text, at least one OU (OU G) has not even had a Preliminary Assessment performed on it. The Basewide Groundwater RI/FS therefore cannot be completed until all areas beneath the Base have been investigated and evaluated (see General Comment 1, p. 1).

Response:

Response:

The Basewide Groundwater Operable Unit RI/FS is interim. A final RI and final FS will be prepared when more detailed information basewide is available.

65. p. 2-138

First complete paragraph. The text states that all groundwater samples collected for metals analysis should be filtered to remove sediments and that analysis of unfiltered samples misrepresents and overestimates the groundwater chemistry. EPA Region 9 does not agree with this assertion and will not accept data from filtered groundwater samples for risk assessment purposes.

Acquisition for representative groundwater quality samples for metals was investigated by Puls and Powell (1992). Several wells at a Superfund Site were sampled using low flow rate purging and sampling techniques after a contractor had previously sampled the groundwater and recovered elevated turbidity samples. The authors found from their study no significant differences in arsenic concentrations, whether the samples were filtered or not. Further, using the same purging and sampling techniques for metals at three separate sites, Puls and Powell (1992) have repeatedly demonstrated no significant differences between filtered and unfiltered metal samples. In addition, low flow rate purging and sampling techniques for metals in groundwater have recently been demonstrated to provide consistently low turbidity samples at McAFB.

Unfiltered samples should be used to characterize the groundwater beneath the site because it is reasonable that potential users would be exposed to unfiltered water. In addition, the contamination beneath McAFB is contained in the entire aquifer, not just the dissolved portion. Remediation of the aquifer should therefore recognize and attempt to address the whole problem, not just the dissolved phase.

In addition, domestic, poorly constructed, or damaged wells could produce sandy or turbid waters. Receptors who drink water from these wells could potentially be exposed to metal concentrations that are, in part, derived from colloidal and adsorbed sources. Problematic wells (those consistently yielding turbid or sandy samples) should be redeveloped and carefully sampled to reduce turbidity. If this does not work, then consideration should be given to modifying or replacing the wells.

Response:

Comment noted. Please refer to responses to Comments 45, 46, and 55. Techniques for collecting groundwater samples have been discussed in the RI/FS.

135 feet bgs. A Zone wells, such as MW-11, MW-72, and MW-15 have screened

66. p. 2-138

Third complete paragraph. Last sentence. The text states that no additional C-zone monitoring wells are needed because only two C-zone wells have ever been sampled. It is unclear from this statement why no additional monitoring wells would be needed since it is implied that C-zone contamination is undefined. Please review and clarify the text.

Response:

Comment noted. The last sentence of the third complete paragraph has been deleted.

67. p. 2-144

First bullet. This is an observation, not a conclusion. What is the reason for the increase? The date scale should be the same for each well in Figure 2-71. This figure, and the subsequent ones through to 2-75, does not benefit by the use of color.

Response:

The text has been revised to refer to these bullets as "observations and conclusions." The following sentence has been added to the text to attempt to explain the observation, "This may be due to increased concentrations gradients from higher groundwater flow rates. Contaminants that were sorbed to the soil matrix or trapped in porewater were mobilized by increased concentration gradients and extracted by the extraction wells." The date scales in Figure 2-71 will be revised to be the same for each time series plot. Figures 2-71 through 2-75 will be presented in black and white in the Draft Final.

68. p. 2-144

Third bullet. The grammar and sentence structure is awkward. The discussion is very dogmatic. Could the presence of DNAPL have the same effect?

Response:

The text has been revised as follows, "Monitoring wells that are screened within the source areas do not experience a sharp decline in TCE concentrations after extraction wells are put into operation. This may be due to the DNAPLs in the source areas or a large mass of contamination adsorbed to the aquifer materials, or both. Concentration gradients are induced by groundwater extraction that drive adsorbed mass into the groundwater or induces DNAPLs to dissolve into the grou ¦water and replace the aqueous phase contamination removed by the extractio wells. Time series plots of A-zone monitoring wells screened directly thorough the source ares are presented in Figure 2-73."

Response:

69. **p. 2-144**

Last bullet. Last sentence. The text states that vinyl chloride has not been detected in any OU D monitoring wells since May 1990. A previous sentence (p. 2-143, third complete paragraph, last sentence) states that vinyl chloride in OU D has not been detected in any other wells since April 1990. Please revise the report to consistently state when vinyl chloride was last detected in OU D wells.

Response:

The last sentence of the first paragraph has been deleted.

70. **p. 2-150**

Fourth paragraph. The paragraph is awkward and confusing, please restate it in simpler terms.

Response:

The text in this paragraph will be restated in simple terms.

71. **p. 2-152/5**

The figures on these pages do not require the use of color.

Response:

These figures will remain in color because the color helps differentiate between wells that are located close together, for example, in OU B in the A-zone. The colors also help to identify, at a glance, wells with similar risk trends.

Chapter 3—Risk Assessment and Arars

GENERAL COMMENTS

1. **While McClellan has undertaken a fairly good ARARs analysis, McClellan seems to lack a fundamental understanding of the roles of ARARs in remedy selection, ARAR waivers, and, potentially, the ROD process. McClellan, as represented by its statements on pages D55-58 appears to believe that compliance with ARARs is not essential, and moreover, should compliance prove difficult that the ARARs will be re-evaluated and/or waived post-ROD. This misunderstanding requires immediate attention.**

   McClellan has obviously spent a lot of money producing a draft copy in full color. Perhaps the money spent in generating draft documents in color could be better spent elsewhere.

Response:

Response:

McClellan AFB recognizes that compliance with ARARs is one of the nine evaluation criteria used during the detailed analysis of remedial alternatives which must be met by the selected alternative. The discussion about post-ROD activities relates to Interim RODs. This discussion has been expanded to indicate that ARARs may be modified after the Interim ROD to account for new information about the site or new regulations that may affect the remedial action (RA) or remedial goals. The ARARs identified in the Interim ROD will serve as goals for the interim remedy. The final Basewide ROD will update and incorporate all of the Interim RODs and will establish fixed standards for all of the RAs.

Any waivers that may be needed will be sought at the time of the Interim ROD. However, if new site information or regulations indicate that a waiver may be needed after the Interim ROD, the waiver will be sought at the time of the Basewide ROD. Waivers will not be pursued after the signing of the Basewide ROD.

SPECIFIC COMMENTS

1. **page 3-1**

Section 3.1 asserts that "[r]emedial actions performed by McClellan AFB have reduced the likelihood that contaminated groundwater is being used in and around the Base."

This should be rephrased as a response action.

Response:

This sentence has been rephrased as requested.

2. **page 3-2**

Section 3.1. The RI/FS asserts that in response to the RWQCB antidegradation policy the RI/FS has assumed residential use of groundwater. There is no explanation in the RI/FS to link these two concepts. I do not understand the basis for any such association.

Response:

The statement asserting a relationship between the antidegradation policy and residential use of groundwater has been deleted from the risk assessment

Response:

3. **page 3-2**

The suggestion that contaminant risk can be "standardized" should be reviewed with EPA's risk assessors.

Response:

The comment that contaminant risk can be standardized is inaccurate. What the text states is that concentrations of different contaminants in groundwater can be standardized in terms of exposure and toxicity (exposure and toxicity are combined in a risk assessment to provide numerical estimates of health risk). Revision of the text in response to this comment is not foreseen to be required.

4. **page 3-6**

The RI/FS appears to assert that both ARARs and PRGs are <u>only</u> health based. This is incorrect.

The RI/FS states that [s]amples with cancer risks or noncancer hazard indexes exceeding a defined cut-point of acceptable levels may then be mapped to spatially define areas requiring either treatment or no further action." This statement appears to imply that response actions will be implemented only due to risk levels. As noted above, other considerations may necessitate a response action (i.e., compliance with non-risk based ARARs). Further there is no indication how McClellan will determine "a defined cut-point." McClellan notes that is mapped 10^{-6}, 10^{-4}, and 10^{-2} risk levels, it is unclear what basis is used for the last risk level or if the regulatory agencies have accepted a 10^{-4} risk level.

Response:

The first sentence in Section 3.2.2 has been revised to include the phrase, ". . . to distinguish areas requiring remediation from areas *with concentrations that do not exceed ARARs or* that do not pose unacceptable health risks," to clarify that certain ARARs may not be health risk-based.

The purpose of a "defined cut-point" (i.e., a specified level of increased lifetime cancer risk or hazard index) is only for mapping contaminant data in terms of health risk estimates. No risk management decisions or selection of an acceptable risk level for purposes of determining the need for remedial action is implied in selection of these risk levels. The 10^{-6}, 10^{-4}, and 10^{-2} increased lifetime cancer risk levels for developing groundwater contours had been specified in the Groundwater Operable Unit RI/FS Work Plan. Presentation of the data in this fashion permits the Remedial Project Managers (RPMs) to visualize the extent of groundwater contamination at McClellan AFB in terms of risks to human health. Further revision text in response to this comment is not foreseen to be required.

5. **page 3-7**

Section 3.3.1. The sample-specific risk assessment methodology should be reviewed.

Response:

Comments on the sample-specific risk assessment methodology have been provided by Dan Stralka, EPA Region IX toxicologist in a January 28, 1994, memorandum to Joe Healy, EPA RPM.

6. **page 3-9**

Section 3.3.2. Please clarify the statement "[s]elected VOCs were not excluded as COPCs based on concentrations detected in blanks."

Response:

EPA *Risk Assessment Guidance for Superfund* (RAGS) states that if blanks contain detectable levels of common laboratory contaminants (such as methylene chloride, acetone, methyl ethyl ketone, or toluene) then sample results should be considered as positive results only if the concentrations in the sample exceed 10 times the maximum concentration detected in any blank. The sample-specific risk assessment methodology deviated slightly from RAGS in that contaminant concentrations in groundwater samples were not compared with concentrations detected in blanks. In particular, this resulted in methylene chloride concentrations that were possibly related to laboratory contamination being included in the sample-specific risk calculations. This approach probably resulted in a very slight overestimation of health risks associated with groundwater contaminants. Further revision of the text in response to this comment is not foreseen to be required.

7. **page 3-9**

Section 3.3.3. Why SVOCs were excluded from the risk assessment. The RI states that SVOCs are associated with elevated risks in localized areas.

Response:

The text has been revised to state that risks from SVOCs were not incorporated into the risk contours. The SVOCs were included as contaminant of potential concern (COPCs), and health risks were estimated for these contaminants in groundwater. Increased lifetime cancer risks (ILCR) were calculated for SVOCs in 495 samples collected between 1986 and 1993. The ILCR exceeded 10^{-2} in one sample (collected 24 October 1987 from EW-85); the ILCR exceeded 10^{-4} in one sample (collected 16 October 1989 from MW-161); and ILCR exceeded 10^{-6} in 91 samples.

8. page 3-12

Section 3.4.1. The risk assessment summarily states that action is not required for risks falling within 10^{-4} to 10^{-6} range. There is no discussion about past practices at this site to indicate if action is anticipated within this range. Further, there is no indication that action may be necessitated due to other factors. i.e., ARARs.

The RI states that certain wells indicate that the risk level may be a high as 10^{-2}, but that these wells are located "within contaminant source areas." This explanation is circular, concern should include source areas and the location of wells within source areas should not be used as justification to exclude the results from these wells.

Response:

The text presents a summarized version of the following statement from OSWER Directive 9355.0-30, "Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions," April 22, 1991: "[g]enerally, where the baseline risk assessment indicates that a cumulative site risk to an individual using reasonable maximum exposure assumptions for either current or future land use exceeds the 10^{-4} lifetime excess cancer risk end of the risk range, action under CERCLA is generally warranted at the site. For sites where the cumulative site risk to an individual based on reasonable maximum exposure for both current and future land use is less than 10^{-4}, action generally is not warranted, but may be warranted if a chemical specific standard that defines acceptable risk is violated or unless there are noncarcinogenic effects or an adverse environmental impact that warrants action. A risk manager may also decide that a lower level of risk to human health is unacceptable and that remedial action is warranted where, for example, there are uncertainties in the risk assessment results. *Records of Decision for remedial actions taken at sites posing risks within the 10^{-4} to 10^{-6} risk range must explain why remedial action is warranted.*"

The purpose of this section in the risk assessment is not to comment on any risk management decisions that may be made in regard to groundwater contaminants at McClellan AFB, or on the selection of acceptable risk levels for purposes of risk management. It is offered simply as a means of placing estimates of ILCR into perspective by describing the risk levels where remedial action is generally considered to be warranted. The text has been reworded for clarification to state that "[a]ction is not *specifically* required for risks falling within 1 x 10^{-4} to 1 x 10^{-6}. . . ."

Wells with contaminants associated with ILCR exceeding 10^{-2} have not been excluded. These risks have been presented, and remedial action alternatives have been developed to address these contaminant hot spots in groundwater. The text has been clarified by placing the statement starting with, "[t]he numerical results presented in the previous section do not reflect expected pathways of exposure under either current or future conditions," in a separate paragraph.

9. **page 3-14**

Section 3.4.2. The RI implies that it only due to public pressure that regulatory agencies have established certain risk factors for VOCs.

Response:

This paragraph has been deleted from the text.

10. **page 3-16**

Table 3-1 This table is too broad to be useful for ARARs analysis. To a certain extent this deficiency is remedied in Appendix D. The text asserts that this is a list of "potential and probable ARARs." Yet Appendix D excludes many of these provisions from application to this OU, as such, they are not "potential and probable ARARs."

Response:

Table 3-1 has been deleted.

Chapter 4—Feasibility Study Approach

SPECIFIC COMMENTS

1. **p. 4-4**

Figure 4-1. Remove the cartoons. This figure does not require the use of color.

Response:

The figure is now black and white.

2. **p. 4-7/8**

Figures 4-2 and 4-3 are not necessary.

Response:

The graphic is necessary and remains in the report.

3. p. 4-9

Section 4.4.2. The cleanup strategies listed by bullet in the second paragraph should include offbase contamination.

Response:

Offbase contamination is already included in the cleanup strategies. For example, if there is offbase contaminated groundwater from McClellan at concentrations greater than maximum contaminant levels (MCLs), it is part of the MCL target volume.

Chapter 5 – Data Collection and Management

GENERAL COMMENTS

1. **Chapter 5 discusses a number of proposed data collection procedures and data type modification suggestions, yet is does not clearly define whether these modifications have already been made, will be recommended in the future, are critical to providing a quality data collection program or are merely suggestions. These types of modifications, if not currently related to the groundwater RI/FS effort, are more appropriate for an organized data collection improvements technical memorandum. Including this information in the report detracts from what and how work was already completed.**

Response:

The management of the information and data collected during the groundwater remedy is a considerable effort and needs to be considered in the feasibility study. It is crucial to the McClellan program that data be turned around and interpreted as quickly as possible, particularly in the implementation of a phased remedy.

SPECIFIC COMMENTS

1. **P. 5-5**

Section 5.2.2. This section should, at a minimum, reference the procedures that are used to evaluate, qualify, and generally ensure the quality of the field and analytical data collected prior to entry into a database.

Response:

The procedures are included in the quality assurance project plan (QAPP).

2. p. 5-6

Section 5.2.4. To improve clarity, references should be made to the sections that include sample collection and system monitoring frequency rather than including these details in this section. This section should focus on the data collection, processing, and quality assurance procedures rather than on collection rationale and frequency details.

Response:

The details necessary to prepare a cost estimate and schedule for this component of the remedy are included.

Chapter 6—Groundwater Containment Options

GENERAL COMMENTS

1. p. 6-6

First full paragraph. The text states that since all of the model scenario evaluations are based on the same set of assumptions: All of the potential remedial alternatives will be affected equally by any discrepancies between the site conceptual model and actual site conditions. While this statement is reasonable, it should be noted that the preferred alternative might not be optimal if significant discrepancies exist between the groundwater flow model and actual site conditions. In addition, while the apparently correct alternative could be differentiated, the actual costs to design, construct, and operate the remedial alternative could be significantly different that those predicted. The greater the difference between actual site conditions and those used in the groundwater flow model, the greater the potential for design and cost variances.

Response:

The objective of the groundwater modeling simulations was to determine whether groundwater containment was a viable alternative at McClellan AFB, and to determine the approximate groundwater extraction rate that will be required to contain a given volume of contaminated groundwater.

It is acknowledged that significant uncertainty exists regarding actual site conditions, and that discrepancies likely exist between the conceptual model developed in the RI Report and actual site conditions.

However, this feasibility study is intended to support an Interim ROD at the Base. Activities scheduled prior to remedial design include the collection and analysis of additional site-specific data, along with the associated improvement of the conceptual model. While we acknowledge that uncertainties exist in the current understanding of actual site conditions, we feel that the current numerical model is an appropriate tool for the objectives stated above.

2. **Insufficient data were presented in this section to allow for evaluation of the model: there is no documentation of model setup; model cells containing pumping were not indicated; and it appears that all available regional pumping data were not utilized in development of the model (see figures in Appendix N).**

Response:

Additional documentation more fully describing the model construction and calibration will be included in Appendix J of the revised RI/FS Report.

SPECIFIC COMMENTS

1. **p. 6-2**

Figure 6-1. This cartoon is not necessary.

Response:

One of the primary purposes of this report is to inform the public about the evaluation of remedial alternatives that were considered for cleanup of the Base. Groundwater extraction is a basic component of all remedial alternatives considered, and the color provided in this figure helps distinguish the dissolved contamination from the groundwater and the soil particles.

2. **p. 6-3**

Figure 6-2. This cartoon is not necessary.

Response:

One of the primary purposes of this report is to inform the public about the evaluation of remedial alternatives that were considered for cleanup of the Base. Groundwater extraction is a basic component of all remedial alternatives considered, and the color provided in this figure helps distinguish the dissolved contamination from the groundwater and the soil particles.

3. **p. 6-3**

Fifth sentence. The text states that "careful" monitoring of the aquifer response to pumping is required to ensure that the desired aquifer target volume is captured. What method(s) of monitoring aquifer response to pumping is proposed to track capture of the target volume? Please refer the reader to the section of the report that describes the monitoring approach.

Response:

The proposed approach to monitoring the effectiveness of the groundwater containment system is presented in Appendix E. The proposed approach includes the installation of additional monitoring wells to allow collection of sufficient water level data to evaluate the horizontal and vertical gradients in the vicinity of the containment system. This gradient information will be used to confirm that three-dimensional capture is being achieved by the containment system.

4. **p. 6-4**

Figure 6-3. This cartoon is not necessary.

Response:

This figure is intended to inform the public about the relationship between stratigraphy and the success of groundwater extraction as a remedial action. The color included in the figure helps distinguish the contaminated zones from the uncontaminated zones of the hydrologic system, and accentuates the layering of the strata.

5. **p. 6-5**

Third paragraph, fifth sentence. The text states that the presence of DNAPLs will sustain groundwater contaminant concentrations of 10 to 20 percent of the contaminant solubility for hundreds of years. Please provide a reference or supporting documentation in the text.

Response:

A complete discussion of the influence of dense nonaqueous phase liquids (DNAPLs) on site remediation is contained in the reference "DNAPL Site Evaluation" written by Robert Cohen and James Mercer, 1993. This reference will be included in the revised RI/FS Report.

6. **p. 6-6**

Fourth full paragraph, first sentence. It is assumed that the existing extraction wells at the McAFB refers only to wells installed for the remedial program and not include McAFB production wells (such as Base Well 18). Please clarify.

Response:

The term "existing extraction wells" only refers to wells installed for the remedial program with the intended purpose of extracting contaminated groundwater. It does not refer to groundwater production wells installed for water supply purposes.

7. p. 6-7

Section 6.3, Groundwater Flow Model. The text does not supply appropriate background information related to chosing the groundwater model. Why was MicroFem chosen? What are its attributes which make it appropriate to use at McAFB? Is this model in the public domain? How is it available? The statement that the model has been fully verified is vague, provide reference and citation for model verification.

Response:

A more complete description of the rational for selecting MicroFem for use at McClellan AFB, the capabilities of the model, its availability, and references supporting model verification are included in Appendix J of the revised RI/FS Report.

8. p. 6-8

Figure 6-4. The figure does not portray a three-dimensional interpretation as described in the supporting text and has no scale. The two-dimensional product presented lacks considerable detail, such as identifying surface features (major roadways, highways, rivers) for the reader to evaluate the magnitude of the area which the figure represents. Please revise the figure to include a scale (approximate, if necessary) and legend.

Response:

Figure 6-4 will be revised to include geographical features and an approximate scale.

9. p. 6-11

Second bullet. The bullet identifies one of the main elements of groundwater extraction strategy used during extraction scenario modeling. It seems that the reported 15-year limit for travel time of contaminants within the target volume to reach extractions wells is too short. Successful accomplishment of this criterion requires a large number of wells at this site. Successful containment might be accomplished with fewer wells over a longer time period (e.g., 30-year travel time). In addition, utilization of injection wells to optimize cleanup and minimize treatment system flow rates could have been modeled. Please provide rationale in the revised document for establishing the 15-year contaminant travel time or perform additional model runs to minimize the number of extraction and injection wells.

12. Page D-39

Response:

Additional simulations were performed to investigate the option of including fewer extraction wells in a given groundwater containment option and accepting longer travel times for contamination to reach a particular extraction well. The results of these simulations performed on the risk target volume suggest that with such a sparse well arrangement, the extraction network is unable to overcome the downward hydraulic gradient that exists in areas between the extraction wells, and contamination migrates downward into lower strata. Since many areas of the Base A-zone contamination overlie uncontaminated portions of the B and C monitoring zones, this extraction network was considered unacceptable.

10. p. 6-13

Figure 6-7. It is unclear if the green flow lines represent B or C zone information. It appears that no attempt is being proposed to capture B zone contaminants in OU D (compare Figures 2-54 (PCE >100 μg/l, TCE > 10 μg/l) and 6-7 area around OU D). This discrepancy must be explained or corrected. Since the Air Force developed a three dimensional flow model please provide three dimensional capture areas. The A, B, C, D, etc. nomenclature for 'monitoring' zones is purely contrived. The Air Force should prepare a <u>detailed</u> conceptual site model (see specific comments on Tech Memo J) which presents the <u>data</u> and <u>interpretations</u> of the hydrogeology form the RI. Since the RI has stated previously that the entire saturated thickness is one hydrologic unit it would be appropriate to model it as such. The use of color does not provide a positive benefit to the capture zone figures.

Response:

Figure 6-7 will be revised so that the flow lines presented for each aquifer are more easily distinguishable.

Monitoring Well MW-38D was presented in Figure 5-54 with elevated PCE and TCE hits. An MCL target volume was not defined in the B Zone for concentrations from this well because this well was last sampled in 1985, as indicated on the figure. Data from 198 is not representative of current groundwater conditions and could not be used in the target volumes. Monitoring Well MW-38D was sampled during the OU D RI field effort in Summer 1993, and has been included in the revised target volumes.

In the data base, MW-38D was considered an "AB" well. In the revised target volumes, MW-38D was placed in the A Zone because its screened interval, 120 to 130 feet below ground surface (bgs), falls within the A Zone and not within the B Zone. According to the Preliminary GW OU RI, the bottom of the A Zone is approximately -70 to -75 mean sea level (msl). The ground surface in OU D is approximately 60 feet msl. Hence, the bottom of the A Zone is 130 to

135 feet bgs. A Zone wells, such as MW-11, MW-72, and MW-15 have screened intervals ranging from 96 feet bgs to 131 ft bgs. Conversely, B Zone wells, such as MW-58 and MW-51, have screened intervals ranging from 172 to 191 feet bgs. Monitoring Well MW-38D has been included in the revised target volumes and contamination from this area will be captured.

The capture zones developed using the numerical model are three-dimensional capture zones. The evaluation of capture includes tracking particles from the target volume boundaries to the extraction wells. These particles are free to migrate between model layers according to local vertical gradients and the assumed hydraulic conductivity distribution. In our opinion, this process demonstrates three-dimensional contaminant capture.

The results of the RI state that the saturated sediments at the Base cannot be grouped into distinct horizontal layers in which groundwater flow is isolated from adjacent layers. This is not to say that the sediments cannot be discretized for the purposes of numerical analysis, as long as vertical interaction between these assumed "layers" is accounted for. It would not be appropriate to model the saturated system at the Base as a single layer, as resolution regarding the distribution of contamination with depth would be lost. This is an extremely critical site feature that must be preserved in any analysis of potential remedial options at the Base.

The flow line figures do benefit by the use of color, as the colors represent the aquifers thorough which the particles move, and this information is necessary to demonstrate three-dimensional capture.

11. p. 6-14

Figure 6-8. It is also unclear on this figure if the green flow lines represent B or C zone information (see above). Please increase the scale for clarity.

Response:

Figure 6-8 will be revised so that the flow lines presented for each aquifer are more easily distinguishable, and the scale will be increased for clarity.

12. p. 6-15

Figure 6-9. The figure apparently presents more proposed extraction well locations than those proposed for the A monitoring zone hot spots, as implied by the figure title. Please revise the title to reflect that the figure shows all proposed A zone extraction wells, if appropriate.

Response:

Figure 6-9 has been revised to eliminate the A-zone extraction wells that fall outside of the hot spots.

13. p. 6-17

First paragraph. The text states that injection of end-use water with injection wells around hot spots was not quantitatively evaluated because "injection is considered incompatible with innovative technologies." It is unclear why injection is considered incompatible with innovative technologies, especially for the stated example of in-situ biodegradation. Injection of treated, nutrient-laden groundwater is not uncommon at in-situ biodegradation sites. It is also puzzling why this potentially time-reducing injection scenario was dismissed because it might interfere with an innovative technology study. It is our opinion that the fastest, least expensive groundwater cleanup method should be considered for McAFB; therefore, elimination of a potentially beneficial and cost-saving scenario (injection of end-use water around hot spots) because it might interfere with an innovative technology study is, in our opinion, not appropriate. Please revise the text to further justify the stated approach or include a quantitative evaluation of reinjection around hot spots.

Response:

The results of the simulations including hot spot re-injection previously presented in Appendix J have been more extensively evaluated; the results are presented in Chapter 6 and Appendix J.

14. p. 6-19

Figures 6-10 through 6-15 to do require the use of color.

Response:

Figures 6-10 through 6-15 will be presented without color in the revised RI/FS Report.

15. p. 6-31

Table 6-2. Extraction System Costs. The calculations for estimating capital and O&M costs (including length of O&M activities) should be referenced in a footnote and included in Appendix J. The information in Table 6-2 can not currently be evaluated without additional backup. This table should include costs for reinjection.

Response:

The calculations for estimating capital and O&M costs are included in Appendix R.

16. p. 6-32

The discussion of Figure 6-22 through 6-24 is confusing. What data were used to assemble these figures? What is the purpose of these figures? If it is to demonstrate that the no action alternative is not appropriate then use real data. EPA recommends that these figures be replaced with figures showing existing extent of contamination.

Response:

The no-action simulations were performed to evaluate the hydrologic system that would result from no further remedial action at the Base and the scheduled abandonment of Base Well 18. "Real" data currently collected at the Base necessarily includes the influences of Base Well 18 pumpage. The existing extent of contamination is presented in Chapter 4 of the RI/FS Report.

17. p. 6-32

First full paragraph, fifth sentence. Please reference the source or rationale for the assumed 1,200 gpm pumping rate.

Response:

The Base Well 18 pumping rate used in the model calibration simulations has been revised to approximately 975 gpm. This rate reflects an average annual rate based on 1992 pumping records presented in the Quarterly Monitoring Reports for Areas B, C, and D produced by Metcalf & Eddy, Consultants.

18. p. 6-32

Second full paragraph, first sentence. The sentence should be edited to read "Figures 6-26 and 6-27 show the effects of this simulated municipal..." Also, these figures do not benefit by the use of color (6-16/18). The entire discussion on future water production is not necessary. The discussion only addresses one area and one impact, increase contaminant movement into the C zone. We already know that this will occur through observations made at base well 18. Suggest that this discussion and figures be eliminated.

Response:

This evaluation has been omitted from the revised report.

19. p. 6-51

Section 6.4 Model Accuracy. Without adequate presentation of conceptual model and application of the numeric model to the conceptual model, this discussion can not be evaluated (see specific comments Tech Memo J).

Response:

Refer to Chapter 4 of the revised RI/FS Report for a discussion of the site conceptual model. Refer to Appendix J of the revised RI/FS Report for an expanded discussion of groundwater model construction as it relates to the conceptual model.

20. p. 6-51

Section 6.5, first paragraph. The five most contaminated areas of the A zone are not shown in Figure 6-28. This figure does not require the use of color.

Response:

This information has been added to the revised figure.

21. p. 6-53

First paragraph. The text correctly states that use of base well BW-18 as a contaminant extraction well would be inefficient. However, even though it is reported that well BW-18 produces much if its water from relatively uncontaminated Monitoring Zone D, it is unclear why a contaminant extraction well screened over Monitoring Zones A, B, and C (or a combination of wells screened in these zones) located near well BW-18 could not reasonably achieve similar control over the OU B and OU C plume(s). It seems that a modeling scenario to test this possibility should be been attempted. In simple terms, it seems odd that 123 extraction wells are needed to replace and augment what base well BW-18 has partially accomplished in the past. Please provide an explanation in the text detailing why base well BW-18 could not be replaced with a minimal number of contaminant extraction wells, or perform additional modeling runs to test this hypothesis.

Response:

The placement and construction of the proposed extraction wells was constrained by State concerns that extraction wells be screened in individual monitoring zones, and that the downward movement of contamination from upper contaminated aquifers into lower uncontaminated zones was unacceptable. The result of these constraints is that a large number of extraction wells screened in individual zones were required to contain the target volumes. We disagree that Base Well 18 is capturing all of the OU B and OU C plumes; it is certainly not addressing contamination that resides in OUs east of the runway. It should be further noted, that the current pumping rate of BW-18 is almost 90 percent of the estimated total pumpage required to contain the entire MCL target volume at the Base.

22. p. 6-55

First full paragraph, last sentence. The text states that innovative technologies will reduce the time required for remediation in the hot spot areas. This optimistic statement seems unfounded given that innovative technologies are usually not off-the-shelf, tested technologies and great uncertainty in their success rates exist. This report has not presented the innovative technologies that are proposed for hot spot remediation so there is no way to evaluate their potential for success, let alone whether their use could speed remediation. Please remove this sentence from the report.

Response:

The reference to innovative technologies has been deleted from the text.

23. p. 6-55

Second full paragraph. Calculations used to develop the order-of-magnitude cost estimates and cost curves should be included in Appendix J.

Response:

Detailed cost information and assumptions used to develop the budget level costs to construct and operate the extraction system are included in Appendix R.

Chapter 7—Groundwater Treatment Options

GENERAL COMMENTS

1. **Figure 7-1 is not necessary.**

Response:

The figure is necessary to provide the public with a picture of the potential treatment systems.

2. **Figure 7-2 does not require the use of color.**

Response:

The figure has been changed to black and white.

3. **Figure 7-3 does not require the use of color.**

Response:

The figure has been changed to black and white.

4. **Figure 7-4/13 do not require the use of color.**

Response:

The figures have been changed to black and white.

Chapter 8 – Innovative Technologies

GENERAL COMMENTS

1. **Figure 8-1 is not necessary.**

Response:

The figure is necessary and remains in the text. It has been changed to black and white.

2. **It is EPA Region 9's position that innovative technologies <u>not</u> impede the application of existing technologies. The Air Force should proceed with existing technologies for hot spot reduction.**

Response:

The Air Force does not plan on impeding the application of existing technologies because of the evaluation of innovative technologies. It is important to note that existing technologies will only be effective in containing the hot spots. The Air Force is committed to remediation in the fastest and least expensive manner possible, and the evaluation of innovative technologies is a possible means to that end.

3. **Dual phase extraction can be considered an existing technology and a variant of pump and treat.**

Response:

The high-vacuum, dual-phase extraction system is commonly considered an innovative technology and is defined as such by the EPA SITE program.

4. **The Air Force should consider use of horizontal air sparging wells in conjunction with vertical sve wells.**

Response:

The Air Force will consider the use of combinations of horizontal and vertical wells for air sparging. Horizontal wells are being considered for numerous applications across the Base.

5. **Figure 8-3 does not require the use of color.**

Response:

The figure is now black and white.

6. **From review of this chapter it appears that this activity is a boondoggle for the Air Force's contractors.**

Response:

The Air Force has expended considerable effort into developing the Public/Private Partnership for the evaluation of innovative technolgies for application at McClellan, other DOD facilities, and in private sector cleanups. The USEPA has been part of this partnership from its inception and is still very involved through the SITE program. There is considerable scientific review of innovative technology evaluations through the Air Force, DTSC, the private partners, and the SITE program. There is considerable and adequate review of the priority of funding innovative technology projects. The innovative technologies which survived the screening in the feasibility study are not automatically funded as projects unless they are high priority enough for the McClellan program as a whole.

7. **Figure 8-4 does not require the use of color.**

Response:

Figure 8-4 is now black and white.

Chapter 10—Assembly and Screening of Alternatives

GENERAL COMMENTS

1. **Figure 10-1 does not require the use of color.**

Response:

Figure 10-1 is now black and white.

Chapter 11—Implementation Plans and Detailed Evaluation

GENERAL COMMENTS

1. **An implementation plan is not necessary for <u>each</u> alternative, only the selected one. Therefore Figure 11-1 is not necessary. Only one of the 11-2/7 is necessary, and that one should not have cartoons or color.**

Response:

In planning the feasibility study, the effort for preparation of cost estimates of various levels of accuracy was discussed with the Agencies. It was EPA's decision to pursue budget level cost estimates for the alternatives. To prepare budget level cost estimates, it is necessary to do sufficient planning to reach a cost estimate accuracy of +30 to -15 percent.

2. **Schedules are not necessary for each alternative. Therefore Appendix S should be modified accordingly.**

Response:

The preparation of present worth costs needs a cash flow diagram for each alternative. The cash flow diagram cannot be prepared without scheduling.

3. **Figures 11-9 through 11-13 do not require the use of color.**

Response:

The figures have been changed to black and white.

SPECIFIC COMMENTS

1. **p. 11-35**

Innovative Technologies. Why is the application of innovative technologies a "prime target" of the McClellan remedial effort? The Air Force would be better

served by using existing technologies in an aggressive manner to address hot spot reduction.

Response:

See Response to Comment 1 of Chapter 8.

2. **p. 11-37**

Preferred Remedy. EPA agrees with Alternative 4 with the following modifications, the Air Force will use existing technologies, air sparging, dual phase, <u>and</u> reinjection within hot spots to accelerate mass reduction.

Response:

The suggestions by EPA for the preferred alternative will be discussed with DTSC and RWQCB. Both DTSC and RWQCB prefer a more stringent target volume definition of 10^{-6} risk, and the DTSC Office of Drinking Water does not agree with the sale of water to the utilities, so reinjection is the preferred water end use. The Air Force will work closely with the Agencies to develop the preferred remedy and the proposed plan.

APPENDIX D

1. **Fold-Out Page: "How do the regulations apply to the design criteria for the McClellan Air Force Base Groundwater Remedial Action"**

In discussion chemical specific ARARs the RI implies that ARARs are useful in determining the levels of VOCs released during construction and are contractors at risk of exposure. This issue cannot be resolved by ARARs. ARARs <u>may</u> be useful in determining responses to answers to this query; but ARARs will not provide the answer themselves. The RI also seeks an ARAR determination to the level at which contaminants in groundwater are hazardous. It is unclear how the term "hazardous" is being used in this context. It appears, however, that this query is best resolved by the risk assessment not be ARARs analysis. Finally, the RI seeks an ARAR determination to the "maximum reinjection pressure to ensure that reinjection does not cause movement of fluids into another aquifer." While a specific ARAR may preclude reinjection if such reinjection will result in the movement of fluids into another aquifer, the ARAR will, most probably, not set the specific reinjection pressure.

In discussing action-specific ARARs the RI seeks to learn the permits needed for end-use alternatives. It is unclear what is really sought by this inquiry. Permits are not needed for an on-site response action.

Response:

The questions on the figure regarding exposure limits to workers have been changed. The question now reads, "What are the limits on fugitive dust generation during construction of extraction well?"

The term "hazardous" has been deleted from the third question. The question now reads, "What are limits of contaminants in groundwater before the beneficial uses of the aquifer have been degraded?"

The questions regarding reinjection pressure and required permits have been deleted from the figure.

2. **Page D-5**

The RI's definition of ARARs does not coincide with the CERCLA definition. The RI adds "duly" to "promulgated" and changes "facility siting" to "public health." To avoid confusion, the CERCLA definition should be used if possible.

Response:

The CERCLA definition has been included.

3. **Page D-6**

The RI states that to be an ARAR the regulation must be applied consistently "statewide." The sentence should be worded that the state must apply the regulation consistently. This rewording allows: (1) for potential variation among the regional boards while still acknowledging the state is apply the regulation consistently; and (2) for individual regional boards to have additional requirements not implemented by other boards.

Response:

The wording in the text has been changed to "The State must apply the regulation consistently."

4. **Page D-7**

The RI implies that EPA is the actor, i.e., "EPA need meet only the ..." In this RI, such statements may be more appropriately stated "McClellan AFB ..."

The RI states that "[l]egally binding ARARs ..." If something is an ARAR, it is legally binding so the extent ARARs are legally binding. The RI implies that there are non-legally binding ARARs.

Response:

The reference to EPA in this paragraph and the term "legally binding" used to describe ARARs have been deleted.

5. **Page D-9**

The discussion of ARAR waivers would be more complete if the RI noted that because this is not a fund action, the fund balancing waiver is not available to this action.

Response:

The fact that the fund balancing waiver is not available to McClellan AFB has been included.

6. **Page D-10**

The RI states that "[s]ome of the earlier OU remedial actions will be reviewed 5 years after each of their respective ROD dates." I don't understand why all previous RODs are not getting 5 year review? Are there previous RODs where no hazardous substances were left in place?

Response:

This sentence has been rephrased to state that the OU re[illegible]al actions that result in hazardous substances being left in place will be reviewed 5 years after their respective Interim ROD.

7. **Page D-11**

The ARARs Process figure asserts that "ARARs Established as Standards" only takes place in the year 2003 when a basewide ROD is signed. The NCP specifies that while ARARs may not be legally required for interim measures, they should be met during RD/RA activities.

Response:

The figure remains unchanged. Additional text has been added to clarify the ARARs process. The ARARs identified in the Interim ROD will be met during the remedial design/remedial action (RD/RA) phase and will be closely aligned to the ARARs presented in the final Basewide ROD. The Basewide ROD will allow for new information acquired at the site or new or updated regulations to be applied to the remedial actions as they become available. The ARARs presented in the Interim ROD will serve as goals for the RA, where the Basewide ROD ARARs will be fixed standards for the remedial actions.

8. **Page D-13**

Is hydrochloric acid a toxic substance? The RI states that it is nontoxic.

Response:

The word "nontoxic" has been deleted when referring to offgas treatment by-products that include hydrochloric acid.

9. **Page D-27**

There are only two minor criteria that make groundwater in California Class II. This classification should be affirmed with the state.

Response:

The text remains unchanged. No comments regarding the groundwater classification discussed in this section were received by the State agencies.

10. **Page D-29**

What else besides a domestic use or municipal water supply could the Magpie Creek be classified? When will an ecological assessment be performed to allow the determination to apply/not apply human health criteria for the consumption of aquatic life?

Response:

The promulgated water quality standards established under the authority of Section 303(c)(2)(B) are applicable to specific pollutants in specific states in accordance with the use classifications presented in 57 Federal Register 60847, 22 December 1992. Although California may have several use designations for waters of the State, the standards discussed in the text are applied from only the presence in all waters of some aquatic life designation and the presence or absence of the municipal and domestic water supply (MUN) use designation.

11. **Page D-37**

Any response action offsite must comply with "laws." There are no ARARs for offsite response actions.

Response:

The sentence has been changed to read, "However, for offsite treatment or disposal, all hazardous waste laws and regulations must be complied with."

12. **Page D-39**

The contained-in policy applies to listed wastes contained in groundwater. EPA guidance, and EPA ARAR training, allows an additional determination that if the groundwater contains the listed waste below a "health based level" than the groundwater need not be treated as a hazardous waste.

Response:

The phrase "above a health-based level" has been added to the last column of the container storage section.

13. **Page D-40**

Offsite shipment of wastes would not be analyzed by ARARs.

Response:

The transportation requirements have been deleted from Table D-6.

14. **Page D-42**

Please explain why "reasonable precautions" is sufficient to comply with SMAQMD rules (other than 403).

Response:

"Reasonable precautions" are sufficient to comply with Rule 403. Text has been added to clarify what is needed to comply with other Sacramento Metropolitan Air Quality Management District (SMAQMD) Rules.

15. **Page D-43**

The RI notes certain permitting requirements for UIC and then dismisses them as procedure. Why continue to note permits when discussing ARARs?

Response:

The discussion on permitting has been deleted.

16. **Page D-53**

Potential conflict with previous explanation of "contained in" policy. Does it merely need to contain a listed waste or contain a listed waste above a risk level?

Response:

The discussion on the "contained-in" policy has been deleted from the text. This policy applies to nonsolid wastes that contain listed wastes. It is not likely that environmental medium at the Base will contain a listed waste because the contaminants originate from many different sources and processes.

17. Page D-56

ARARs are frozen at ROD unless health based. The discussion that post-ROD activities are necessary to fully select ARARs is confusing.

The remedy must meet all non-waived ARARs. The RI is incorrect in asserting that the "remedial action does not necessarily have to meet all ARARs, but it does need to provide the best balance of protectiveness, cost, and implementability." The RI appears to be confusing some of the nine criteria used in remedy selection and also forgetting that compliance with ARARs is a threshold criteria.

Further a waiver of an ARAR is done at time of the ROD. The RI implies that after the fact, if RA activities indicate ARAR compliance will be difficult that a waiver can be sought.

Response:

The discussion about post-ROD activities relates to Interim RODs. This discussion has been expanded to indicate that ARARs may be modified after the Interim ROD to account for new information on the site or new regulations that may affect the RA or remedial goals. The ARARs identified in the Interim ROD will serve as goals for the interim remedy. The final Basewide ROD will update and incorporate all of the Interim RODs and will establish fixed standards for all of the RAs.

Any waivers that may be needed will be sought at the time of the Interim ROD. However, if new site information or regulations indicate that a waiver may be needed after the Interim ROD, the waiver will be sought at the time of the Basewide ROD. Waivers will not be pursued after the signing of the Basewide ROD.

APPENDIX E (Technical Memorandum E) – Proposed Groundwater Monitoring Program

GENERAL COMMENTS

1. **The proposed Monitoring Program, as presented, lacks detail pertinent to the rationale and criteria used to develop the monitoring networks, especially when**

considering that the program proposes the installation of 289 new wells. Rationale for each monitoring well should be clearly identified.

Response:

The rationale for the placement of each monitoring well will be addressed in the work plan and SAP developed for each phase of the remedy. It should be noted that a maximum of 116 new monitoring wells is proposed for the background target volume (smaller numbers for risk and MCL), not the 289 indicated in the comment.

2. **The Proposed Program should evaluate the potential for eliminating (abandoning) wells from the base monitoring network that are of limited or no value as monitoring extraction or hydraulic containment control points.**

Response:

The potential to eliminate monitoring wells from the GSAP program will be evaluated in the work plan and SAP developed for each phase of the remedy.

3. **The proposed Monitoring Program should include a discussion of how each proposed well or group of wells addresses the "two major objectives" presented in the first paragraph on page E-6. Specifically, justification for proposed well placements should be presented which states how a proposed well or group of wells: will better define spacial distribution of contamination; allow refinement of the remedial action target volumes; and/or how a location will add to the effectiveness of monitoring the extraction network for containing contaminated groundwater.**

Response:

The rationale for the placement of each monitoring well will be addressed in the work plan and SAP developed for each phase of the remedy.

4. **All proposed wells should be sequentially numbered so discussion of proposed well locations can be more easily addressed.**

Response:

The designation of each monitoring well will be included in the work plan and SAP developed for each phase of the remedy.

5. **The number of monitoring wells proposed in this technical memorandum is very large. The use of multiple completion wells (e.g., Waterloo System™) may be considered to minimize the number of new monitoring wells proposed. This method for monitoring well installation potentially maximizes data collection while minimizing actual borehole installation.**

Response:

The potential use of multiple completion wells will be evaluated in the work plan and SAP developed for each phase of the remedy.

SPECIFIC COMMENTS

1. p. E-1

Second paragraph. The text should include a brief discussion of the current groundwater monitoring network, and the frequency of sampling, to explain the variability associated with sampling frequency. Please also include a table in the revised report which lists all monitoring wells and their sampling frequency.

Response:

This discussion will be provided in the work plan and SAP developed for each phase of the remedy.

2. p. E-6

Second paragraph, last sentence. The text states existing monitoring wells that fail to provide critical monitoring data will be dropped from the water quality monitoring network. Please provide the criteria that will be used in determining when a well fails to provide critical monitoring data.

Response:

This criteria will be provided in the work plan and SAP developed for each phase of the remedy.

3. p. E-6

Third paragraph. The set of groundwater quality monitoring wells should be presented before discussing any associated details. The second sentence of the paragraph should reference or state what design criteria were used for improving the understanding of the spatial distribution of contamination at McAFB. The paragraph should reference where in the report the "current understanding of the extent of the remedial action target volumes" is discussed. What criteria were used to "evaluate" and what "monitoring data" were used to develop the target volumes (see comment 43, chapter 2)? The paragraph should state what uncertainties in the target volume extent exist, as addressed in the fifth sentence.

What is the specific rationale for the placement of monitoring wells in "strategic locations," so the intended elimination of significant portions of the currently

identified target volumes can be attained? What are the "strategic locations" and which "areas" are referred to in the last sentence?

Response:

This criteria will be provided in the work plan and SAP developed for each phase of the remedy. The objective of this appendix is to determine the approximate number of additional monitoring wells that would be required to adequately monitor each of the proposed extraction networks. This information was used to develop budget level cost estimates for each of the extraction networks, and to provide a basis for the costs presented. We feel that the level of detail provided is appropriate to support budget level cost estimates.

A plume-by-plume description of why each monitoring well is located at a particular location will be provided in the work plan and SAP developed for each phase of the remedy.

4. p. E-6

Fourth paragraph. The set of hydraulic containment monitoring wells should be presented before discussing any associated details. What were the criteria and or rationale used to develop the hydraulic containment monitoring network?

Response:

This criteria will be provided in the work plan and SAP developed for each phase of the remedy.

5. p. E-7

First full paragraph. The paragraph indicates that a method was developed to determine the number of wells required to monitor the hydraulic gradients present along the perimeter of each target volume. It also implies that the number developed was impractical because it was so large. No rationale or criteria for developing a total number of perimeter target volume monitoring wells were included for consideration. Please include this information in the revised report.

Response:

This criteria will be provided in the work plan and SAP developed for each phase of the remedy.

6. p. E-7

Second full paragraph, first sentence. Please reference the section of report which discusses "current interpretation of the target volume extent."

Response:

The current interpretation of the target volume extent is discussed in Chapter 4.

7. p. E-7

Last paragraph. The text introduces the approximate locations of the proposed new groundwater monitoring wells to monitor MCL target volumes, but it does not provide justification for the new wells. Justification for installing additional wells at McAFB is necessary, particularly since a large number of new wells are proposed to augment a substantial number of existing monitoring wells. The rationale and criteria used to develop the MCL Monitoring Network should be presented in detail. The presentation should include justification for each proposed well or group of wells. Figures E-5 through E-7 should have capture zones depicted. What is the recommended monitoring frequency?

Response:

Most of the monitoring wells at McClellan are located in source areas and other areas of known groundwater contamination. Very few wells are located on the boundaries of the target volumes. The rationale for the placement of each monitoring well will be addressed in the work plan and SAP developed for each phase of the remedy.

8. p. E-8

First paragraph. The text introduces the approximate locations of the proposed new groundwater monitoring wells to monitor risk target volumes, but it does not provide justification for installing these additional wells. The rationale and criteria used to develop the Risk Monitoring Network should be presented in detail. The presentation should include justification for each proposed well or group of wells.

Figure E-9 shows that 18 locations were identified as Hydraulic Containment Monitoring Wells (HCMWs) and 12 locations were identified as Water Quality Monitoring Wells (WQMWs). However, Table E-1 indicates that 17 wells were intended as HCMWs and 13 wells were proposed as WQMWs. Please clarify this apparent inconsistency.

Response:

The rationale for the placement of each monitoring well will be addressed in the work plan and SAP developed for each phase of the remedy.

The discrepancy between the figures and table will be corrected in the revised appendix.

9. **p. E-8**

Second paragraph. The text introduces the approximate locations of the proposed new monitoring wells to monitor background target volumes, but does not provide justification for installing additional wells. The rationale and criteria used to develop the Background Monitoring Network should be presented in detail. The presentation should include justification for each proposed well or group of wells.

Response:

The rationale for the placement of each monitoring well will be addressed in the work plan and SAP developed for each phase of the remedy.

10. **p. E-8**

Table E-1. The table should include a line at the bottom showing the total number of proposed HCMWs and WQMWs.

Response:

We will include this information in the revised table.

11. **p. E-9**

First paragraph. The text introduces the approximate locations of the proposed new Monitoring Zone D wells, but does not provide justification for installing them. The rationale and criteria used to develop the Monitoring Zone D Well Network should be presented in detail. The presentation should include justification for each proposed well.

Response:

The rationale for the placement of each monitoring well will be addressed in the work plan and SAP developed for each phase of the remedy.

Appendix F – Data Management Overview

SPECIFIC COMMENTS

1. **p. F-2**

   Last two bullets. These bullets are said to represent tasks and procedures that will be performed for all data before they are entered. It is unclear what level of data entry, data verification, and data presentation and analysis is required prior to "entering" data into what is assumed to be the computerized database.

Response:

The sentence introducing the bullets contained an error and has been corrected.

2. **p. F-7**

   Electronic Data Interchange. The Air Force should use the Draft EPA Region 9 electronic file formats. These were developed in conjunction with the DTSC and RWQCB. These are included with the comments.

Response:

The data management system should be capable of exporting the data into the file formats specified in the draft protocol. There are several protocols the data management system needs to interface with, and it is simplest to develop exporting routines to satisfy the protocols.

Appendix G (Technical Memorandum G) – Interactions of the Vadose Zone and Groundwater Remedial Action Alternatives

GENERAL COMMENTS

1. **The memorandum briefly raises issues that must be resolved before an efficient remedial effort that addresses all phases of contamination at McAFB can be conducted. The memorandum does not, however, specifically identify how the smear zone will be remediated. It is assumed that SVE would be the most appropriate remedial strategy for the smear zone. The memorandum does not address how SVE would be applied in a uniform manner basewide if SVE remedial actions are performed independently in hot spots.**

   It seems that the most appropriate way to deal with contamination at McAFB would be to devise an overall plan for addressing the entire contaminant problem (in all media), then to subdivide the problem into manageable units. The overall plan should also address how these units will be managed from a basewide prospective to timely completion. Ideally, detailed breakout of the

steps should be agreed to by all parties before work starts (see General Comment 4, p. 1).

Response:

McClellan is currently developing a strategy for implementation of soil vapor extraction (SVE) at full scale. Integration of the SVE removal actions is part of the proposed strategy. See Response to Comment 4.

SPECIFIC COMMENTS

1. **p. G-3**

Third paragraph, last sentence. The text states that Figure G-1 shows the locations of the sites selected for SVE remediation at McAFB. It would aid the reader if these locations were highlighted on the figure. Please revise the figure as appropriate.

Response:

The figure has been modified appropriatly.

Appendix J (Technical Memorandum J) – Groundwater Model Development

SPECIFIC COMMENTS

1. **p. J-2**

Site Conceptual Model. This section is woefully lacking in site specific details. The conceptual model does not even describe the type of aquifer system modeled! The conceptual model should contain all known details of the site specific and regional hydrogeology. The appropriate data sets should be presented. The initial conditions must be presented.

Response:

The revised Appendix J provides expanded documentation about the construction of the groundwater model and how the conceptual model was integrated into the numerical model. It is not clear what "initial conditions" are requested. Initial head values are irrelevant, as this is a steady-state model which, by definition, does not require a set of initial heads.

1. **p. J-3**

First full paragraph, second sentence. The text states that the net recharge rate applied to the top of Monitoring Zone A is 2.5 inches per year. Please provide a reference or explanation for how the recharge rate was determined. The

recharge should not be applied as an annual phenomenon, but monthly since this most accurately represents the recharge (assume to be from precipitation, must be specific).

Response:

As is clearly stated in Appendix J, the analysis performed here is a steady-state analysis. Precipitation recharge cannot be entered on a monthly basis in a steady-state simulation. We feel that a steady-state analysis is appropriate for the current modeling activities because the objective is to evaluate the long-term effectiveness of groundwater extraction systems at containing contaminated groundwater.

2. **p. J-3**

Last paragraph. The text introduces MicroFem as the computer program selected for groundwater flow modeling, but does not adequately present a rationale for implementing this program at McAFB. Other computer programs that also meet the stated selection criteria ("capable of simulating transient and steady-state flow in combinations of confined, unconfined, and semiconfined aquifers with a variety if boundary conditions") are publicly available and well documented. Please provide in the revised report a discussion of how MicroFem was selected, with rationale for why this program is applicable to McAFB groundwater flow. Also, provide references as to how it is well documented. Who considers it to be highly reliable?

Response:

A more complete description of the rationale for selecting MicroFem for use at McClellan AFB, the capabilities of the model, its availability, and information supporting model verification are included in Appendix J of the revised RI/FS Report.

3. **p. J-4**

First paragraph, second sentence. The text indicates that the computer model was constructed as four-layers, but does not present the vertical dimensions of the layers. Please add a brief statement to the text that presents the depths or thicknesses of the model layers and compare them to the conceptual model as presented in Subsection 2.2.1, Depositional Environment, p. 2-4.

Response:

The requested information on model layering will be provided in the revised Appendix J.

4. p. J-4

Second paragraph. The text very briefly introduces the boundary conditions used in the computer model. The text states observed water levels were specified for initial conditions along the lateral boundaries, but does not indicate the type of lateral boundary conditions. Please indicate the type of lateral boundary conditions used in this model (e.g., constant head, no-flow).

Response:

The assumed boundary conditions will be more fully described in the revised Appendix J.

5. p. J-4

Site-Specific Aquifer Properties. Aquifer properties used must be presented. Were interpolated values for transmissivity checked against site data?

Response:

The aquifer transmissivities used in the model were identical to those presented in the conceptual model for the site (Figures 4-7 through 4-9). The transmissivity values estimated from aquifer tests performed at the site were contoured, digitized, and input directly into the model. The interpolated transmissivity values assigned to each of the model nodes was checked by contouring the final transmissivity field and comparing these results to the figures presented in Chapter 4. A more complete description of the model construction methodology is the included in the revised Appendix J. The transmissivity distribution of the regional aquifer was obtained directly from the calibrated Papadopulos model referenced in the RI/FS Report.

6. p. J-6

First paragraph. The text references a groundwater flow model developed by S.S. Papadopulos for McAFB in 1987; however, the final PGOURI Report (Radian 1992) cites the Papadolupos report date as May 1986. Please revise the apparent discrepancy, if appropriate.

Response:

The complete reference for the Papadopulos model is: Installation Restoration Program Phase II - Confirmation/Quantification, *Stage 2-3, Subregional Groundwater Flow Modeling, McClellan AFB, California*. Final Report. August 1987. The report was submitted by Radian but the preface states that the modeling was performed by Papadopulos and Associates under subcontract.

7. **p. J-8**

Second full paragraph. The text states that calibrated computer model simulated heads within 2 feet of the measured heads in Monitoring Zones A, B, and C in the PGOURI report, but does not present data or graphics which illustrate the calibrated state of the model. Please provide graphics or other preferred method in the revised report which demonstrate the calibration state of the model. Additionally, please provide input files used in the final calibration model run.

Response:

The calibration of the model was evaluated by comparing simulated to actual water levels in groundwater monitoring wells at the Base. The revised Appendix J will provide additional information describing the calibration of the groundwater model.

8. **p. J-8**

Last paragraph. The text indicates that model layer transmissivities and vertical conductances between the layers have the greatest uncertainty compared to other model parameters. A sensitivity analysis was therefore performed to test the impact of varying these model parameters. The results of the sensitivity analysis indicated that the model was not overly sensitive to layer transmissivities or leakances. The report does not state whether other model parameters (e.g., layer thicknesses) were tested since the model was not sensitive to those parameters with the greatest uncertainty. Please state in the revised report what other model parameters (if any) were tested during the sensitivity analysis.

Response:

More detail will be provided in the revised Appendix J for the sensitivity analyses performed on the groundwater model.

9. **p. J-13**

First paragraph, last bullet. The bullet indicates one of the constraints on the extraction system alternatives was to include enough extraction wells so that the travel time between the majority of the target volume and the extraction wells would not exceed 15 years. It is unclear why this constraint was placed on the extraction system, since a large number of extraction wells is needed for success. It is also puzzling why 15 years was used since it has been previously stated in the report that aquifer cleanup could potentially take hundreds of years.

One other approach to plume containment could involve perimeter extraction (and/or injection) to arrest contaminant migration. Hot spot extraction and treatment would also occur. Treatment of contaminated groundwater utilizing a minimum number of wells would be an integral constraint on this system. A slower rate of contaminant plume shrinkage would result from this scenario but the cost-benefit comparison should be made available to the decision makers. Please provide rationale in the revised report for using the 15 year travel time constraint on the extraction alternatives. Additionally, it has been intimated at several agency meetings that the purpose of this system is only to arrest the flow of contaminated groundwater and other options will be explored for hot spot removal.

Response:

Additional simulations were performed to investigate the option of including fewer extraction wells in a given groundwater containment option and accepting longer travel times for contamination to reach a particular extraction well. The results of these simulations performed on the risk target volume suggest that, with such a sparse well arrangement, the extraction network is unable to overcome the downward hydraulic gradient that exists in areas between the extraction wells, and contamination migrates downward into lower strata. Since many areas of the Base A-zone contamination overlie uncontaminated portions of the B and C monitoring zones, this extraction network was considered unacceptable.

10. p. J-14

Second paragraph. The paragraph introduces ten extraction alternatives that were evaluated using the groundwater flow model. It should be noted that, not counting the no-action alternative, only three significantly different extraction alternatives are listed in the text:

<u>Containment</u>

Containment with treated groundwater reinjection surrounding contamination hot spots.

Containment with reinjection of treated groundwater into the regional aquifer through an injection well located northwest of the runway.

The remaining seven alternatives listed are variations of these and are only dependent on the size of the target volume.

Response:

We agree that three main extraction alternatives were evaluated under various target volume assumptions.

11. **p. J-17**

First paragraph, fourth sentence. The text cites Table J-1 as summarizing those extraction wells predicted to contain contaminated groundwater. It appears that Table J-2 is the proper citation. Please revise the text accordingly.

Response:

The draft report contained an erroneous table reference regarding Table J-2. This has been corrected in the Draft Final version.

12. **p. J-17**

Second paragraph, last sentence. The text introduces several figures (Figures J-13 through J-15) that present predicted pathlines for the basic containment alternative, combined with reinjection end use of all treated groundwater into the regional aquifer. It is difficult for the reader to determine the location of the reinjection well on the figures. Please revise the figures in this appendix to clearly depict the location of the regional aquifer reinjection well.

Response:

The location of the re-injection well will be added to the appropriate Appendix J figures.

13. **p. J-50**

Third paragraph, first sentence. The term "delivery" well first appears in this sentence without a clear definition. It is assumed that this is an alternate term for injection well. Please revise the text to clarify the definition of "delivery" well.

Response:

The term "delivery well" refers to a groundwater re-injection well. The term "recovery well" refers to a groundwater extraction well. The terms delivery and recovery have been removed from the revised Appendix J and replaced with the more familiar terms injection and extraction.

14. **p. J-50**

Last paragraph. The text states that variation of transmissivity caused by the variation in saturated thickness was not accounted for in the modeling effort. Please amend the text to explain why this potentially significant effect was not simulated. For completeness, also discuss in the revised text the potential problems associated with not accounting for the transmissivity variation.

Response:

The report misstated that the model analysis did not account for the reduction in transmissivity resulting from a decrease in aquifer saturated thickness. The MicroFem model does account for this reduction in transmissivity.

Appendix N

GENERAL COMMENTS

1. **It appears that a large percentage (approximately 40%) of the data from pumping wells (see Figure N-2) within the model boundaries (see Figure J-1) was not used in the model simulations. What are the potential effects of this unaccounted-for pumpage on the model? Please address this issue in the revised report.**

Response:

(need input from pete lawson)

Appendix O – Summary of McClellan AFB Well Abandonment Program

Appendix O, Summary of McClellan AFB Well Abandonment Program, is a previously prepared document as part of the ongoing Basewide well abandonment program and was included in the RI/FS report for *completeness of the document.* The document has been previously submitted to the Agencies. McClellan's well abandonment efforts are ongoing and a new summary report has been prepared which brings the program up to date. Additional well abandonment activities are planned, and the comments received from EPA will be incorporated into future efforts and well abandonment reports. Responses to each comment on Appendix O are not appropriate because the document was previously submitted to the Agencies. The Air Force will accommodate the reviewers comments in future well abandonment work and reports.

GENERAL COMMENTS

1. **All documents submitted to EPA for review must be complete and include all associated appendices. The document included in this appendix does not include any of its appendices and, therefore, could not be adequately reviewed.**

Response:

The subject document was previously submitted to EPA in complete form.

2. **Figures included in the report depicting grouting operations do not include the size of the perforations installed prior to grout installation. Also, "grouting operations" figures for McAFB Wells 1, 2, 12, and 27 show existing perforations as being installed with the Mills tool. No information regarding what sources**

of information were utilized to obtain this information, including the perforation size, was referenced in the report.

Response:

See general response to Appendix O comments above.

3. **A complete description, including figures, of the "downhole squeeze" method of grout installation and subsequent pressurization to induce grout migration through well screens and perforations should be included in the report. The report describes portions of the process, and associated equipment used in the process, throughout its text without providing a detailed narrative of the procedure. This information may have been included in the Well Closure Methods and Procedures plan, however as noted above (General Comment 1), the "plan" was not included for review with this appendix.**

Response:

See general response to Appendix O comments above.

4. **Volumes of cement per foot of rise for assumed porosity percentages were developed for each well. It is not stated how these volume estimates were used. Were historic geologic and/or geophysical data used to estimate formation porosity, or were the ranges presented based on possible porosities of filter pack material?**

Response:

See general response to Appendix O comments above.

5. **Considering the problems encountered during attempts to abandon the wells included in this report, each initial closed circuit video survey should have been accompanied by a well diameter caliper survey. Caliper surveys would have identified any changes in hole diameters, and potentially identified major breaks or separations in casing/screen material.**

Response:

See general response to Appendix O comments above.

6. **During instances where less cement than calculated was used, what assurances are there that the gravel pack was sufficiently invaded by cement?**

Response:

See general response to Appendix O comments above.

SPECIFIC COMMENTS

1. **p. 1**

   Fifth paragraph, second sentence. What efforts or measures were conducted to located McAFB Wells 3, 6, 16, and 19? If these wells were considered potential conduits for contaminants, why has the effort to locate them been apparently abandoned?

Response:

   See general response to Appendix O comments above.

2. **p. 9**

   Third full paragraph, third sentence. How is the "external pressure" developed and applied downhole?

Response:

   See general response to Appendix O comments above.

3. **p. 10**

   Second paragraph. What source was used to determine the specific well construction data included in this paragraph?

Response:

   See general response to Appendix O comments above.

4. **p. 10**

   Third paragraph. What method was used to install the perforations, and what size and configuration of perforations were installed (e.g., number of vertical rows and perforations per foot per row)?

Response:

   See general response to Appendix O comments above.

5. **p. 13**

   Figure 4. No size, configuration, or amount is shown on the figure for the Mills Knife Perforations. Please provide this information.

Response:

See general response to Appendix O comments above.

6. **p. 15**

Third paragraph, second sentence. It should be noted that the Well Drillers Report is a California Department of Water Resources document (DWR Form 188) and that the completion interval (screened or perforated area) of a well is included on the 188 form. This information should be presented in this paragraph. Please edit this paragraph.

Response:

See general response to Appendix O comments above.

7. **p. 18**

Figure 6. No size, configuration, or amount is shown on the figure for the new Mills Knife Perforations. Please provide this information. How was it determined that the existing perforations were installed with the Mills Knife tool? What is the size, configuration, and amount of the existing perforations?

Response:

See general response to Appendix O comments above.

8. **p. 19**

Third full paragraph, fourth sentence. The sentence is awkward and confusing. Please edit for clarity.

Response:

See general response to Appendix O comments above.

9. **p. 19**

Fourth full paragraph, second sentence. The sentence poses the possibility that perforating operations may or may not have been completed. This is not supported by the text which indicates that all wells included in the abandonment operation received perforations. Please edit this sentence to conform with the text or state the criteria used in perforating the casing.

Response:

See general response to Appendix O comments above.

10. **p. 20**

Second full paragraph. The comments included in this paragraph belong at the end of this report. Please make the appropriate changes.

Response:

See general response to Appendix O comments above.

11. **p. 20**

Third full paragraph. What source was used to determine the specific well construction data included in this paragraph?

Response:

See general response to Appendix O comments above.

12. **p. 21**

Figure 7. The figure does not include a legend. Please provide one in the revised report.

Response:

See general response to Appendix O comments above.

13. **p. 23**

Figure 8. No size, configuration, or amount is shown on the figure for the new Mills Knife Perforations. Please provide this information. How was it determined that the existing perforations were installed with the Mills Knife tool? What is the size, configuration, and amount of the existing perforations?

Response:

See general response to Appendix O comments above.

14. **p. 24**

Fifth full paragraph, eighth sentence. Why was the borehole diameter assumed to be 24 inches?

Response:

See general response to Appendix O comments above.

15. **p. 27**

Figure 10. No size, configuration, or amount is shown on the figure for the new Mills Knife Perforations. Please provide this information. How was it determined that the existing perforations were installed with the Mills Knife tool? What is the size, configuration, and amount of the existing perforations?

Response:

See general response to Appendix O comments above.

16. **p. 28**

Second full paragraph, sixth and seventh sentences. What head pressures were developed by the column of water in the well, and what criteria were used to judge if the "goals for grout placement" were achieved?

Response:

See general response to Appendix O comments above.

17. **p. 29**

Sixth paragraph, fourth sentence. Again, the size, configuration and amount of perforations installed should be included.

Response:

See general response to Appendix O comments above.

18. **p. 31**

Second full paragraph. What source was used to determine the specific well construction data included in this paragraph?

Response:

See general response to Appendix O comments above.

19. **p. 31**

Third full paragraph. The process described in the paragraph fails to note how the grout was introduced into the well. It is assumed that tremie pipe was used. Please edit this paragraph to include this information.

Response:

See general response to Appendix O comments above.

20. p. 34

Figure 12. No size, configuration, or amount is shown on the figure for the new Mills Knife Perforations. Please provide this information. How was it determined that the existing perforations were installed with the Mills Knife tool? What is the size, configuration, and amount of the existing perforations?

Response:

See general response to Appendix O comments above.

21. p. 35

Second paragraph, fourth sentence. The sentence should be edited to add the components and mixture ratio of a seven-sack sand cement mixture (seven sacks of cement to 1,316 pounds of sand to between 6 and 8 gallons of water per cubic yard).

Response:

See general response to Appendix O comments above.

22. p. 36

First paragraph, first sentence. Information presented in Table 2-6 of the RI/FS identifies this well as possibly being located at the corner of Whitney and Eastern Avenues.

Response:

See general response to Appendix O comments above.

23. p. 36

Second paragraph, third sentence. Information presented in Table 2-6 of the RI/FS identifies this well as being recently located near BW-7, please address the inconsistencies in Table 2-6, this comment, and the previous comment.

Response:

See general response to Appendix O comments above.

24. p. 38

Second paragraph. Data gathered during research should also include the type and size of screen slots, or perforations, and the casing and screen construction material used. Also, during research gathering activities at the California Department of Water Resources (DWR), efforts should be made to find any existing geophysical data which may have been submitted with each individual 188 Well Driller Report.

Response:

See general response to Appendix O comments above.

Appendix P—Budget Estimate/Technical Proposal for Horizonal Extraction Wells at McClellan Air Force Base

GENERAL COMMENTS

1. **What is the purpose of enclosing this proposal? This proposal was obviously generated based on specific well design criteria at McAFB. Where is the prospective application of this drilling and well construction technique proposed to be used?**

Response:

The horizontal well proposal was developed to obtain costs and schedules for application of horizontal drilling at McClellan AFB. The prospective applications include the OU A areas with lower permeabilties and small saturated thickness, as well as air sparging or containment of the hot spots and other vadose zone applications.

SUBJECT: Review of the Draft Base-Wide Groundwater Operable Unit RI/FS Report for McClellan AFB dated November 1993.

PROJECT: SWE28722.66.FS

DATE: March 28, 1994

Daniel Stralka, Ph.D
United States Environmental Protection Agency

SPECIFIC COMMENTS

1. **Section 3.2.2, page 3-6, second paragraph.**

   Where is mapping of the risk volumes corresponding to the three risk isopleths?

Response:

The risk volumes were presented in the conceptual model, which is the chapter following the risk assessment. These risk volume figures now have been added to Appendix B, which contains the detailed presentation of the risk assessment.

2. **Section 3.3.3, page 3-9, first paragraph.**

   The elimination of SVOCs as a class is not warranted and should be evaluated further.

Response:

This text has been revised to state that risks from semivolatile organic compounds (SVOCs) were not incorporated into the risk contours. The SVOCs were included as contaminants of potential concern (COPCs), and health risks were estimated for these contaminants in groundwater. Further discussion of health risks associated with SVOCs in groundwater is presented on page B-42 in Appendix B. Further revision of the text in response to this comment is not foreseen to be required.

3. **Section 3.3.3, page 3-9, third paragraph.**

The suggestion that vadose zone contamination presents an increasing hazard to ground water in OU A should be put into context of where this information will be addressed.

Response:

This information has generally been addressed in the Groundwater Operable Unit Remedial Investigation/Feasibility Study (GWOU RI/FS) through the development of a target volume for remedial action that includes groundwater underlying OU A. Chapter 1 of the GWOU RI/FS provides a discussion of how the RI/FS will result in an Interim Record of Decision (Interim ROD), with contaminant sources to groundwater to be addressed elsewhere, such as in the Vadose Zone FS and Interim ROD for the Vadose Zone. Further revision of the text in response to this comment is not foreseen to be required.

4. **Figure 3-4, page 3-11.**

Define the groundwater zones in descriptive terms including depth.

Response:

Descriptive terms have been added to this figure, as requested. Description of the different monitoring zones, along with cross-section figures have been presented in the hydrogeology section of a new site description chapter for the RI/FS report.

5. **Tech Memo B, page B-5, Data Sources.**

It is not clear all the data or specific time increments were used in the risk assessment calculations. Please clarify.

Response:

The 29 time increments used to group groundwater data for risk assessment calculations are presented in Attachment B-1, "Monitoring Well History." The time series of increased lifetime cancer risk (ILCR) in each well, presented in Attachment B-4, documents the temporal range of data considered in the risk assessment calculations.

6. **Page B-11, Water Uses.**

Are the results of the off-base municipal sampling results incorporated into the overall calculations of risk and/or the extent of contamination?

Response:

Offbase municipal sampling data are not incorporated into the Groundwater Sampling and Analysis Program (GSAP), hence they were not incorporated into the risk calculations. Offbase monitoring wells, that cover the areas where offbase municipal sampling was performed, are included in the calculations of risk and evaluation of the extent of contamination.

7. **Page B-13, Data Evaluation, Second Bullet.**

It is not clear in the data presentation that the results were grouped by time period except in the well time courses. How was this done for the risk calculations?

Response:

Discussion of how the data were grouped is discussed on page B-26, first paragraph. For purposes of evaluating trends in health risks over time, a time scale of 29 intervals, ranging from 2 to 5 months, was superimposed over the volatile organic compound (VOC) sampling event history. The width of the intervals was chosen to place sampling events into different time intervals for the largest number of monitoring wells. The event in which the highest concentrations of each parameter were reported was used in the risk assessment for cases where two sampling events from a single well fell into the same time interval.

8. **Page B-13, COPC.**

A risk based screen of the metals concentration should be presented to demonstrate the lack of risk.

Response:

It is the intent of the RI/FS to compare concentrations of metals in groundwater with background as an initial basis for identifying metals as COPCs. However, background concentration data for metals in groundwater is a data gap in the RI/FS that prevents further evaluation of metals as COPCs. Further evaluation of metals in the risk assessment will be performed following collection of background metals data.

9. **Tables B-3 thru B-5, Summary Statistics.**

For ranges of detection the lower limit should the range of detection limits or if the information is lacking then left blank.

Response:

These tables have been revised as requested. In cases where the lower limit of the range of detection limits was not available in the GSAP, in these tables the value was left blank.

10. Page B-42, COPC, second paragraph.

The elimination of SVOCs is not appropriate for the sample-specific risk methodology. If a chemical detected presented a low risk it will fall out in the presentation of the total risk map. The current presentation looses the spatial component of the data.

Response:

Elevated risks (i.e., risks greater than 10^{-6}) associated with SVOCs are present in a relatively limited number of samples. Not including these samples within the calculation of risk contours is not likely to perceptibly change the distribution of risks in groundwater. Any loss in spatial presentation of risk will be relatively minor, and would not change the use of the risk contours in the development of areas for remedial action. Further revision of the text in response to this comment is not foreseen to be required.

11. Figure B-9, page B-48.

The scatter plots do not support the conclusion that only cancer endpoints should be addressed. All risks for the sample need to be presented such that a complete assessment cane be easily presented in the base-wide documents with a minimum of recalculation. This line of reasoning should be deleted.

Response:

This figure and the associated text have been deleted from Appendix B.

PREPARED FOR: McClellan Air Force Base

PREPARED BY: Jeff Obert/CH2M HILL/CVO
George Combes/CH2M HILL/BOS

COPIES: Starr Dehn/CH2M HILL/SAC
John Lucero/CH2M HILL/RDD

DATE: March 23, 1994

SUBJECT: Groundwater Treatment Plant Evaluation

PROJECT: SAC28722.66.TP

Introduction

This memorandum presents an evaluation of the existing groundwater treatment plant (GWTP) at McClellan Air Force Base (AFB). Since CH2M HILL is currently developing the basewide groundwater Operable Unit (OU) Feasibility Study (FS), the main purpose of this document is to develop estimates of capital and operations and maintenance (O&M) costs for future flow scenarios. These estimates can then be used to compare other treatment options for future groundwater treatment. As a secondary purpose, this memorandum addresses plant modifications (both equipment and operation) that may be implemented for the existing plant throughput and treatment requirements.

At the time of the writing of this document, preliminary estimates of groundwater flows and concentrations have been developed for the site-wide groundwater OU FS. These flows and concentrations are preliminary in that additional work is currently underway that will refine the estimates. Although there is a level of uncertainty in these estimates, they are the best available at this time. In addition, these estimates are the basis for preliminary sizing and cost estimates of other standard and innovative treatment technologies being considered for future water treatment.

The primary purpose of this document is to allow a comparison of alternatives for future groundwater treatment that integrate the existing GWTP. Accordingly, the available flow and concentration estimates are used to develop capital and O&M costs for three scenarios in the following sections of this document. As part of the FS, similar estimates on other technologies such as advanced oxidation, grass-roots air stripping facilities, and innovative *ex situ* and *in situ* technologies are also being developed at this time. The FS effort will use these estimates on other technologies, as well as the information developed in this memorandum, to assemble alternatives for comparison.

The level of accuracy of the cost estimates developed in this memorandum will be order of magnitude approximately +50 to -30 percent. This level is consistent with that of other technologies and is adequate in developing treatment alternatives that integrate the GWTP for comparison in the FS.

Background

Treatment Plant

Several plumes of groundwater contaminated with various volatile organic compounds (VOCs) have been identified at McClellan AFB. In 1985, a groundwater extraction and treatment system was designed to treat a portion of the extracted groundwater. The technologies considered for the treatment plant included air stripping with offgas treatment using either vapor-phase activated carbon or thermal incineration. No catalysts suitable for chlorinated vapors were available at that time; thus, catalytic oxidation was not considered. The presence of vinyl chloride, methylene chloride, acetone, and methyl ethyl ketone in the groundwater steered the design to warm-water air stripping with thermal incineration offgas treatment. Liquid-phase activated carbon and activated sludge were included to remove phenol and ketones from the air stripper effluent.

Flow Rate, VOC Concentration

The initial estimated extraction flow rate was 1,000 gallons per minute (gpm); this formed the design basis for the plant. When the groundwater extraction system and GWTP went online, lower flows were experienced. Recent flows have averaged approximately 125 gpm. This is below the minimum required air stripper flow rate of 250 gpm; thus, about 125 gpm have been recycled through the plant since it began operation. The air flow rate was reduced to about 1,200 cubic feet per minute (cfm) to maintain good VOC removal in the air stripping system while reducing the energy cost of combustion. Figure 1 shows recent reported data on the GWTP flow rate.

The VOC concentration in the extracted groundwater feeding the plant has dropped since the plant was brought online. Figure 2 shows the concentration of VOCs over the last 6 years. Extracted VOC concentration has dropped from a high of approximately 60 parts per million (ppm) or milligrams per liter (mg/L) in 1987 to the current level of approximately 1 ppm.

Historical data on this chart were provided by the United States Air Force (USAF). Current data points were developed from analytical results presented in "Quality Control Review of Groundwater Treatment Plant Data" for May 1992 to the present. This report is submitted monthly by the USAF to the California Regional Water Quality Control Board (RWQCB).

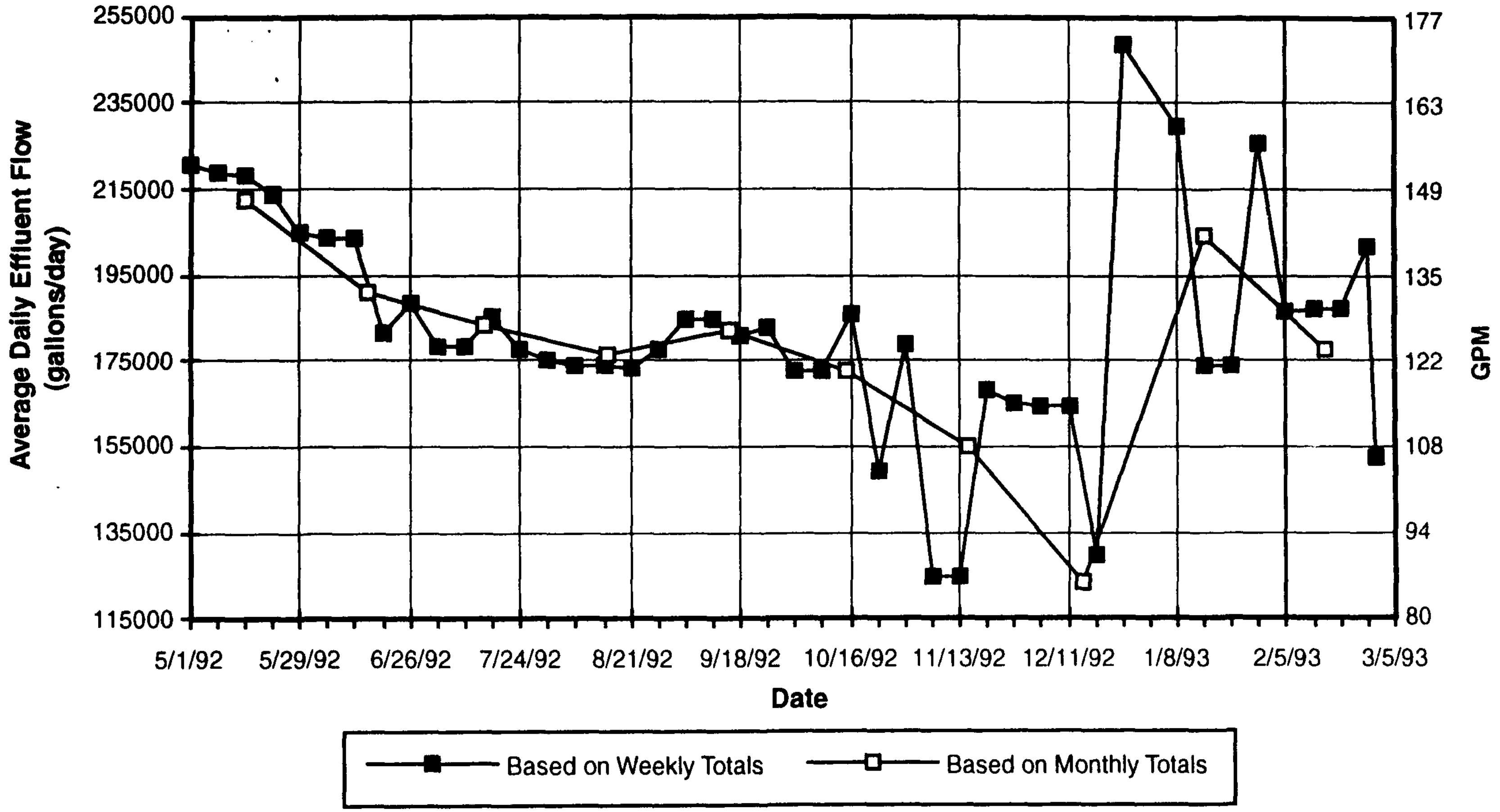

FIGURE 1
McCLELLAN AFB
GROUNDWATER TREATMENT PLANT
EFFLUENT FLOWS

CH2M HILL

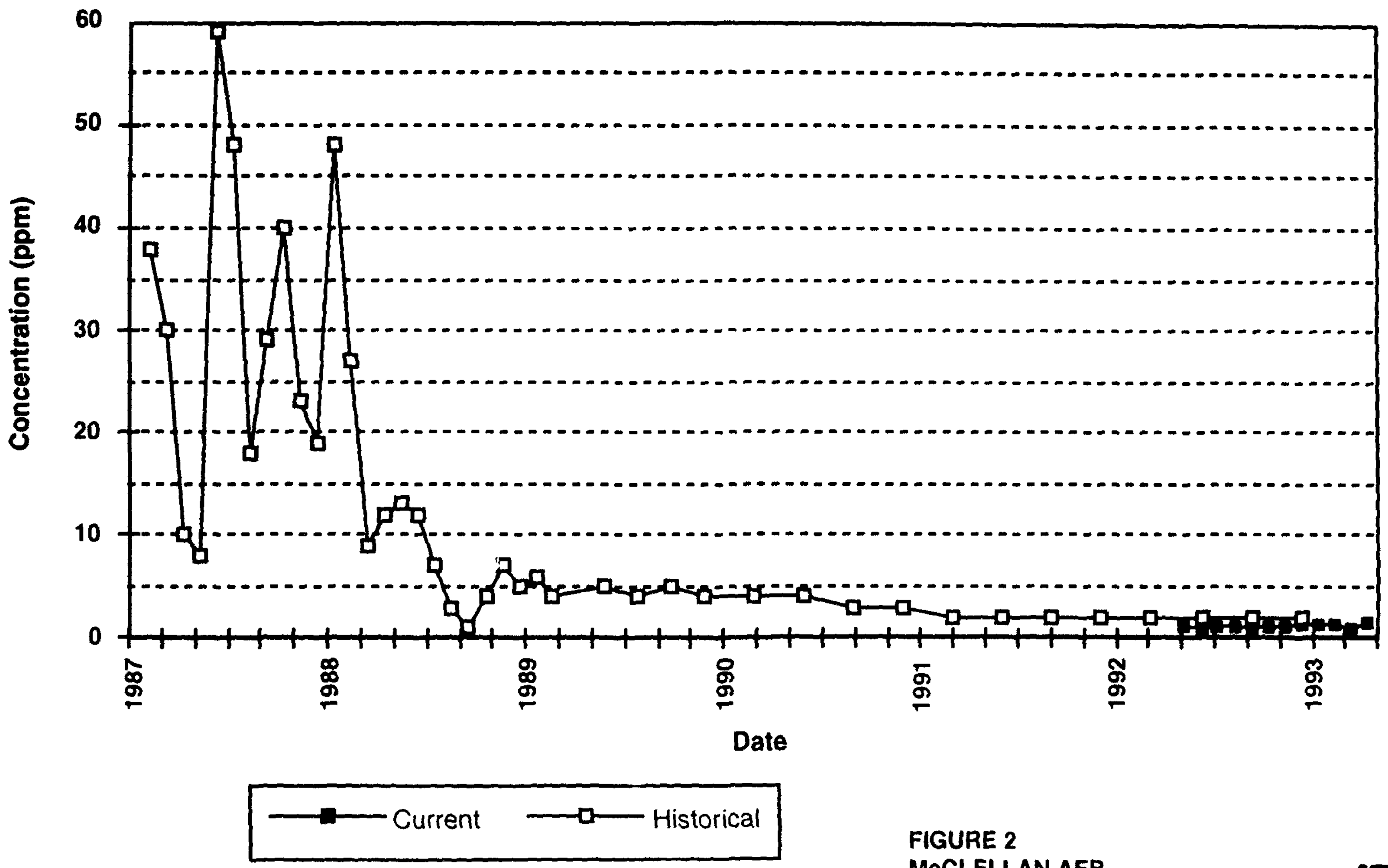

FIGURE 2
McCLELLAN AFB
GROUNDWATER TREATMENT PLANT
TOTAL VOC CONCENTRATIONS

Regulatory Constraints

Air-Related Requirements

It has not been determined at this time if the proposed modifications would result in emission changes of sufficient magnitude to trigger regulatory requirements as a "major" modification. A major modification is defined as "modification to a major stationary source which results in an increase in the potential to emit greater than: 25 tons per year of nitrogen oxides, 25 tons per year of reactive organic compounds, 100 tons per year of carbon monoxide, or 15 tons per year of PM10 aggregated with all other increases in potential to emit over the period of five consecutive years before the application for modification, and including the calendar year of the most recent application." This applicable or relevant and appropriate requirements (ARARs) analysis has been prepared with the worst case assumption that the proposed changes will meet the regulatory definition of a "major" modification, although this likely is not the case. Groundwater treatment rates would increase, but the concentrations of contaminants in the water to be treated are significantly less than those concentrations considered in the original "permitting" analysis of the facility. The stack flow rate for the existing thermal treatment system is not expected to increase, and the exhaust gas concentrations are not expected to increase from concentrations originally evaluated for the facility. For these reasons, significant emission changes are not expected to result from the proposed modifications.

If the modifications *are not deemed* "major" based on further study, many of the ARARs described in the following will not be applicable.

ARARs are site specific and are typically grouped into three categories:

- Ambient or chemical-specific
- Performance-, design-, or other-action-specific
- Location-specific

Ambient Air Quality Standards and New Source Review

Both the national (federal) and California governments have established ambient air quality standards (NAAQS and CAAQS, respectively) for a number of air pollutants, referred to as criteria pollutants. The criteria pollutants include:

- Carbon monoxide (CO)
- Lead
- Oxides of nitrogen (NO_x) as nitrogen dioxide (NO_2)
- Ozone (Reactive organic gases [ROG] and NO_x are precursors to ozone formation)

- Particulate matter less than 10 microns in aerodynamic diameter (PM1O)

- Sulfur dioxide (SO_2)

These standards would be considered ambient or chemical-specific ARARs.

A project cannot cause or contribute to an exceedance of the applicable NAAQS or CAAQS. To insure this, new or modified sources of air pollutants are required to comply with new source review (NSR) regulations. Sources **other than remedial actions** are required to obtain an authority to construct (ATC) permit and a permit to operate (PTO). NSR regulations are promulgated and permits are issued by the local air pollution control districts in California. In the case of McClellan AFB, the local regulatory agency is the Sacramento Metropolitan Air Quality Management District (SMAQMD).

SMAQMD has proposed new NSR rules (Rule 202). These rules require that proposed emissions units or modifications with a potential to emit ROG, NO_x, or CO must provide offsets for the affected pollutant. Offsets for PM10 and SO_2 must be provided only if cumulative emission changes exceed 80 pounds per day (lb/day) for PM10 or 150 lb/day for SO_x. Applicants are also required to apply Best Available Control Technology (BACT) to any new emissions unit or modification of an existing unit that has the potential to emit ROG, NO_x, SO_2, PM10, or CO. BACT requirements may be considered performance-, design-, or other-action-specific ARARs.

Other ARARs were identified by SMAQMD for the soil vapor extraction (SVE) Pilot System at McClellan AFB in a January 7, 1992, letter from Jorge DeGuzman to Mark Malinowski, Department of Toxic Substances Control. These ARARS would also be applicable to a major modification of the GWTP operations, and include the following:

- SMAQMD Rule 401 - Ringelmann Chart: No person shall discharge into the atmosphere from any single source of emissions whatsoever any air contaminant, other than uncombined water vapor, for a period or periods aggregating more than three minutes in any one hour which exceeds 20 percent in opacity or a No. 1 on the Ringelmann Chart, as published by the United States Bureau of Mines.

- SMAQMD Rule 402 - Nuisance: The project should not create a public nuisance. This includes a nonacceptable health risk. Risk assessment must be conducted using SMAQMD's "Permit Procedure Regarding Criteria for Calculating an Excess Cancer Risk to the Public Who May be Exposed to Carcinogenic Air Contaminants from a New/ Modified Toxic Air Emission Source," September 9, 1991.

- SMAQMD Rule 403 - Fugitive Dust: All reasonable precautions should be taken not to cause or allow the emissions of fugitive dust from being airborne beyond the property line from which the emission originates.

New Source Performance Standards

The federal Environmental Protection Agency (EPA) establishes standards of performance for new sources (NSPS). These standards reflect the degree of emission limitation and the percentage reduction achievable through the application of the best technological system of continuous emission reduction that EPA determines is adequately demonstrated for each particular source category. EPA must consider the cost of achieving emission reductions and energy requirements when drafting NSPS.

NSPS are not applicable to any of the new equipment proposed at the GWTP, and the only NSPS source category that might be considered applicable to the existing thermal fume incinerator is Subpart E of 40 Code of Federal Regulations (CFR), Part 60. These standards are only applicable to incinerators with charging rates greater than 50 tons per day. The existing fume incinerator is not expected to exceed a charging rate of approximately 2.0 lb/day, far less than that regulated by the incinerator NSPS.

RCRA Requirements

Resource Conservation and Recovery Act of 1976 (RCRA) requirements do not apply to the fume incinerator, as the contaminants combusted do not meet the RCRA definition of solid waste (40 CFR, Part 261.20, Subpart C, Appendix I).

Requirements for Noncriteria Pollutants—Toxic Air Contaminants

In addition to the criteria pollutants discussed above, there has been increasing concern about toxic air contaminants (TACs) in recent years. TACs include airborne inorganic and organic compounds that can have both short-term (acute) and long-term (carcinogenic, chronic, and mutagenic) effects on human health. Vinyl chloride is one of the TACs potentially emitted from the GWTP. Chlorinated solvents such as trichloroethylene and methylene chloride are others.

Prior to the 1990 amendments to the Clean Air Act, the EPA conducted a program to establish National Emission Standards for Hazardous Air Pollutants (NESHAPs). NESHAPs were established for benzene, vinyl chloride, radionuclides, mercury, asbestos, beryllium, inorganic arsenic, radon 222, and coke oven emissions. The 1990 Clean Air Act amendments require EPA to set standards for categories and subcategories of sources that emit hazardous air pollutants, rather than for the pollutants themselves. The deadline for the first set of EPA standards is November 1994. NESHAPs set before 1991 will remain applicable.

Under Assembly Bill (AB) 1807, California has a program for identifying and developing emissions control and reduction methods for TACs. The California Air Resources Board (ARB) has identified 15 compounds as TACs; these are dioxins/ furans, ethylene dibromide, ethylene dichloride, benzene, hexavalent chromium, cadmium, asbestos, vinyl chloride, chloroform, trichloroethylene, methylene chloride, inorganic arsenic, ethylene oxide, carbon tetrachloride, and formaldehyde. Other compounds are being studied for possible identification as TACs. Control measures for TACs are being developed by the ARB. None of the control measures developed to date for the identified TACs are applicable to the proposed GWTP modifications, the existing thermal oxidizer, or their emissions.

In addition to AB 1807, California has implemented AB 2588, the Air Toxics "Hot Spots" Information and Assessment Act of 1987. Under AB 2588, industrial and municipal facilities must inventory and report emissions of listed toxic substances. High priority facilities must conduct risk assessments. McClellan AFB has prepared and submitted a health risk assessment based on 1989 facility-wide emissions, including the GWTP. Follow-on legislation requires pollution control planning and implementation for sources with risks greater than 10 theoretical excess lifetime cancer cases per million individuals, but McClellan's estimated risks were below this level.

SMAQMD's a "Permit Procedure Regarding Criteria for Calculating an Excess Cancer Risk to the Public Who May be Exposed to Carcinogenic Air Contaminants from a New/Modified Toxic Air Emission Source," (September 9, 1991), requires screening and potentially refined risk assessment of human health effects associated with exposure to TACs from new or modified sources. Both residential and workplace exposures must be evaluated. Cancer risks are considered acceptable if risks do not exceed one theoretical excess lifetime cancer case per million individuals. If the applicant applies Toxic Best Available Control Technology (TBACT), risks are acceptable if they do not exceed 10 theoretical excess lifetime cancer cases per million individuals.

The existing GWTP has previously conducted a risk assessment and demonstrated acceptable risks. If modifications to the facility operations or equipment are proposed, the previous risk assessment will need to be modified and the results compared to acceptable levels, as mentioned previously in the discussion of SMAQMD Rule 402—Nuisance.

The original conditions for construction for the GWTP are listed in Appendix A. This list was issued by the County of Sacramento Air Pollution Control District (CSAPCD) (now SMAQMD). The list states frequency for air sampling and analyses, specific operating conditions, and documentation required by the CSAPCD's control officer for start-up and operation.

Water-Related Requirements

The RWQCB National Pollutant Discharge Elimination System (NPDES) requirements for waste discharge from the GWTP are listed in Appendix A. This list presents the operating conditions of the plant, frequency of sampling for a list of specified constituents, and effluent limitations on discharge into Magpie Creek and into receiving water or watercourses.

The primary treatment requirements of the NPDES permit are that the plant remove acetone, methyl ethyl ketone, and methyl isobutyl ketone to less than 1 mg/L, and all other VOCs to less than the detection limits for the EPA Method 500 series, or 0.1 μg/L.

Equipment

Original Design

The GWTP has been significantly modified since it was initially installed. This section will describe the initial design, and the next section will discuss the modifications and the current plant configuration.

There are two main streams in the GWTP, the groundwater and the air stream. The following paragraphs describe how the groundwater and the air stream travel through the process.

Figure 3 is a process schematic of the GWTP as originally designed.

Groundwater

Water is pumped from the wells into an influent tank, which provides mixing of recycle flows and storage time for process upsets. The water is then pumped from the influent tank through the primary water-water heat exchanger, recovering heat from treated water from the air stripper.

After leaving the primary water-water heat exchanger, the groundwater travels through the secondary water-water heat exchanger and the air-water heat exchanger, and flows back through the other side of the secondary water-water heat exchanger. This circular arrangement of the heat exchangers was developed to raise the water temperature in the air-water heat exchanger to above the dew point of the hydrochloric acid in the combustor offgas and thus avoid corrosion in the air-water exchanger.

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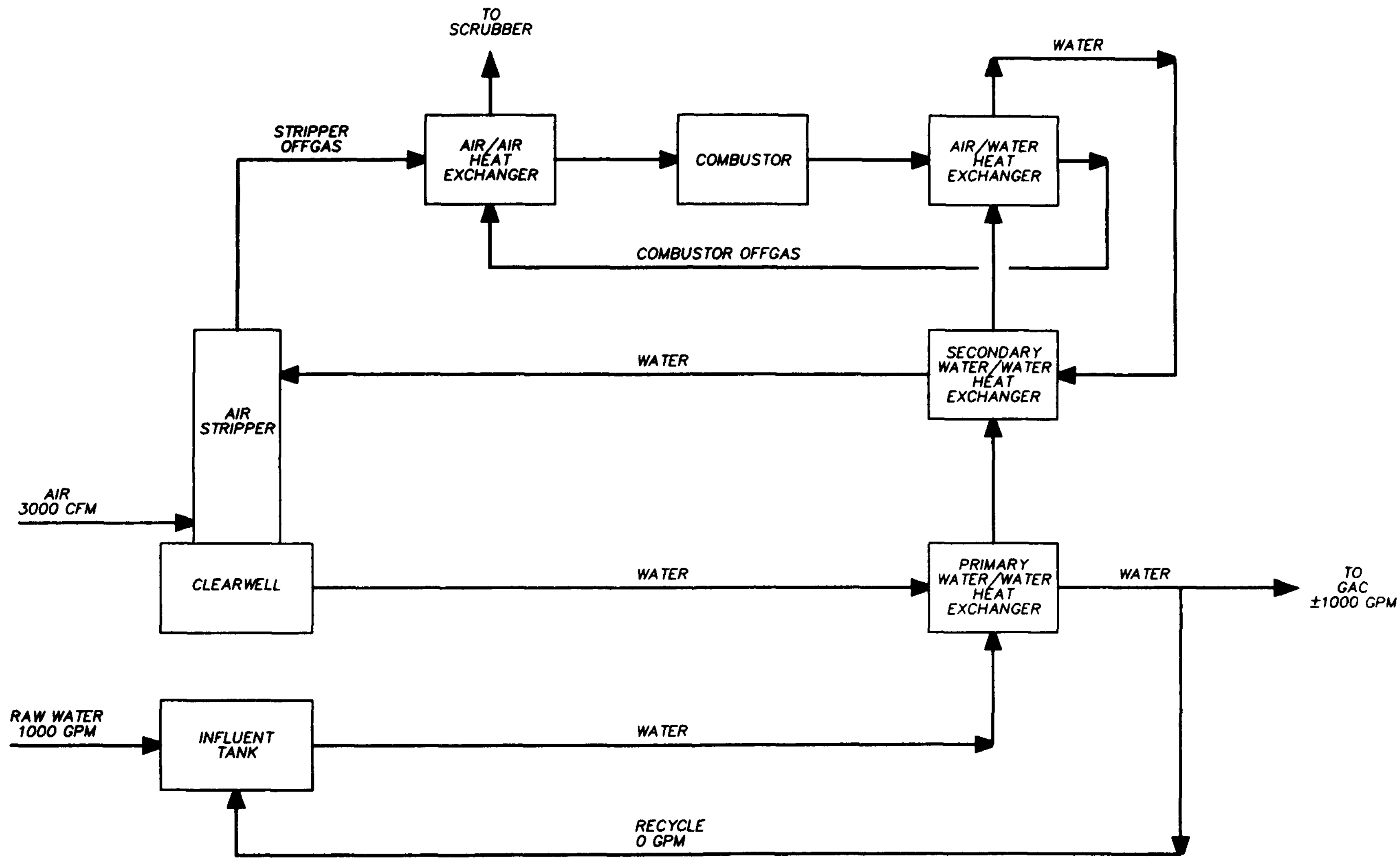

FIGURE 3
McCLELLAN AFB
GROUNDWATER TREATMENT PLANT
ORIGINAL FLOW DIAGRAM

CH2M HILL

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After the heat exchange loop, the water enters the top of the packed tower air stripper at a temperature of about 125°F. The water contacts air in a counter-current fashion to allow the VOCs to volatilize into the air phase. The tower is sized to reduce the VOC concentration for the majority of compounds present to below each compound's detection limit. The design of the tower is based on the initial extracted groundwater concentration.

The stripper effluent, pumped through the primary water-water heat exchanger, recovers its heat value and then flows to either the granular activated carbon (GAC) vessels or the influent tank via the recycle line.

The GAC is required in order to remove phenol and if necessary SVOCs and a portion of the metals. After the GAC, the water flows through an activated sludge process to remove the ketones that were not completely removed earlier in the treatment. The effluent from this system is then discharged to Magpie Creek.

The recycle line maintains a minimum water flow rate through the air stripper of about 250 gpm. This minimum flow rate is required for proper water distribution over the packing through the spray nozzles in the top of the tower.

Air

Air is sent to the air stripper by a constant-speed high pressure blower. The flow rate is controlled by manual adjustment of a bleed damper, which dumps a fraction of the flow to the atmosphere. Air flows into the bottom of the air stripper and out the top as air stripper offgas. As the air travels through the stripper, it absorbs VOCs, ketones, water vapor, and heat from the water. Water droplets are removed with a mist eliminator. Since the stripper offgas cannot be discharged directly to the atmosphere because of regulatory requirements, a thermal incinerator is used to oxidize the VOCs to carbon dioxide, water vapor, and hydrochloric acid.

The air stripper offgas flows through the air-air heat exchanger where it recovers heat from the combustor offgas and passes to the combustor. In the combustor, natural gas is burned to raise the air stripper offgas temperature to 1,800°F. The combustor offgas then travels through the air-water heat exchanger, providing the heat that elevates the groundwater temperature for air stripping. After passing through the air-air heat exchanger, the combustor offgas flows to the bottom of the packed tower caustic scrubber. The scrubber cools the combustor offgas to about 155°F and converts the hydrochloric acid vapors to sodium chloride dissolved in water. The sodium chloride is discharged through the scrubber blowdown where it is mixed with the plant effluent prior to its discharge into Magpie Creek. The scrubber offgas is discharged into the atmosphere.

Design Modifications

Over the history of the GWTP, numerous modifications have been performed. This section describes only those major modifications that exist in the current plant configuration. During the early operation of the GWTP, it became apparent that scaling was going to be a significant problem for the heat exchangers. This was due to water hardness and elevated temperatures in the exchangers, which caused the precipitation of calcium and magnesium salts on the heat exchange surfaces. The decision was made to rearrange the heat exchangers as shown in Figure 4. This arrangement allowed decreased flow rates, lower feed VOC concentrations, and improved internal recycling, thereby decreasing the temperature of the water. The maximum water temperature of the system decreased from 188°F to about 120°F. However, the lower temperatures caused the gas-side exchanger surfaces to be more susceptible to corrosion from acid gas condensation. It was reported that the original carbon-steel air-water heat exchanger was replaced with an Inconel heat exchanger after 3 years of operation. In addition, scale eventually fouled the original 5/8-inch-diameter Pall Rings packing in the air stripper. This packing was replaced with 2-inch-diameter Tripacks. The original packing had been chosen because it has a higher mass transfer coefficient than Tripacks. Tripacks were used as the replacement media because they have a larger void space than the Pall Rings and should not foul as quickly.

Figure 4 is a process schematic of the current configuration.

This configuration has been in use for all but a few months of the GWTP's operation. The plant has treated groundwater for more than 6 years and has met its discharge limits. As shown in Figure 2, the groundwater concentration was very high and variable for the first 2 years of operation, but has since become relatively low and stable at about 1 mg/L. The activated sludge system has been deactivated and removed because the ketone concentrations dropped to levels that could be treated using the air stripping and GAC system alone. Recent operating data indicate that VOC removal is occurring across the air stripping system for all compounds except occasionally dibromochloromethane. This compound was not included in the design basis of the stripper. It has not been detected in the plant effluent and is probably adsorbed by the GAC system.

Operations and Maintenance (O&M)

Existing Plant Operations

The GWTP operates 24 hours per day, 365 days per year. It is equipped with full spare backup air stripper feed pumps, GAC feed pumps, and blowers. In addition, with the low flow rate of 250 gpm, the system also has a full spare GAC system and three spare water-water heat exchangers. This equipment redundancy helps ensure

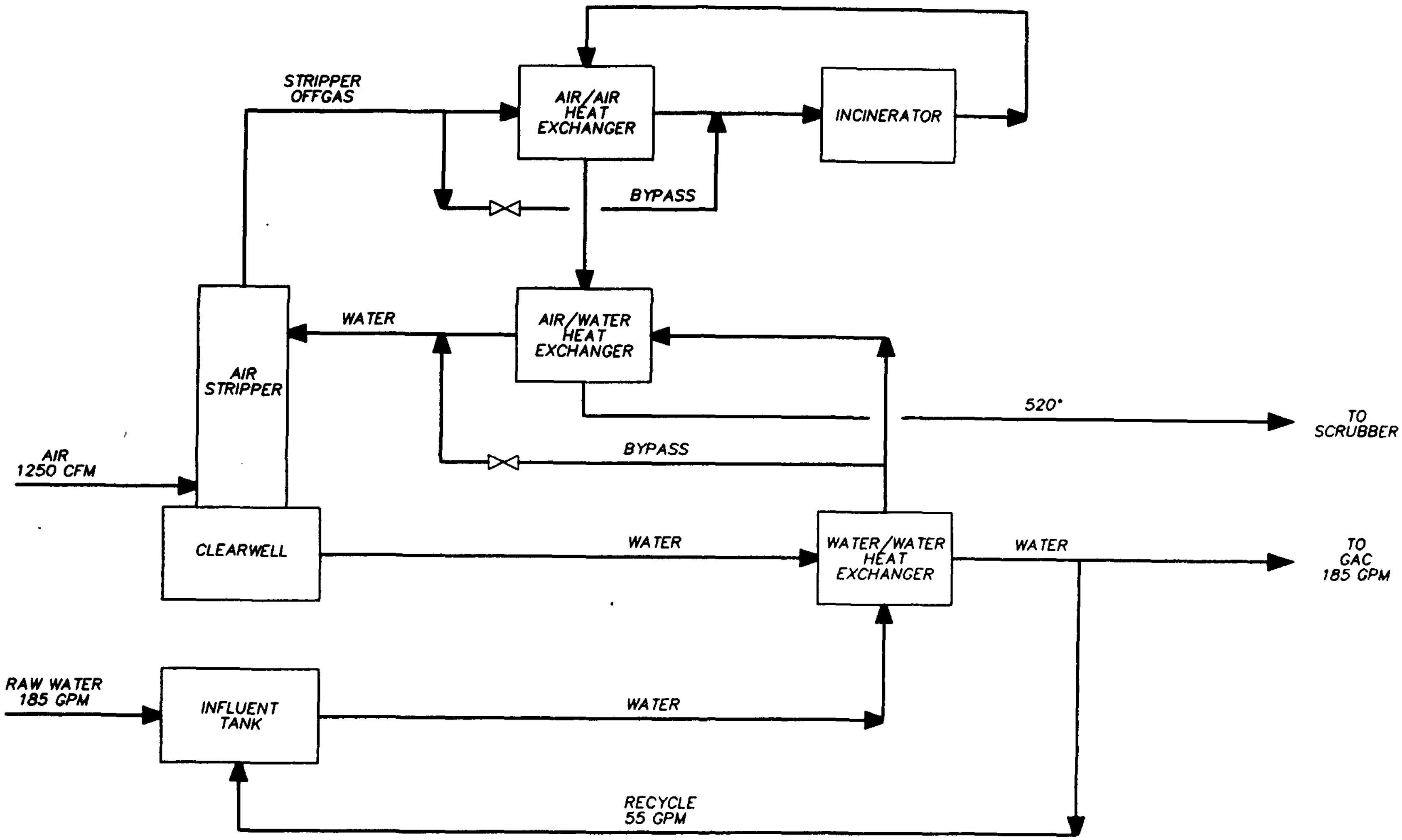

FIGURE 4
McCLELLAN AFB
GROUNDWATER TREATMENT PLANT
CURRENT FLOW DIAGRAM

30-Aug-...

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the continuous operation of the system. The system is shutdown for a few hours a few times a year to descale the heat exchangers.

The GWTP is operated by a staff of six full-time employees and one part-time secretary. The general staffing plan is to have at least one operator onsite at all times. The remainder of the staff are onsite during the dayshift on weekdays. The staff perform preventive maintenance on both the GWTP and the extraction well system, record data, take water samples, generate reports, and meet with other McClellan personnel.

The GWTP has several control loops to help maintain continuous satisfactory operation of the treatment system and provide for safe shutdown of the facility. It is designed for manual startup and establishment of the proper temperature profile in all the equipment. Once the proper temperature profile has been reached, the system can be placed in automatic mode. In this state, the following control loops exist:

- The system will automatically switch to backup pumps or blowers if the lead equipment fails.
- Failure of backup equipment will result in the automatic safe shutdown of the treatment system, without operator intervention.
- Loss of setpoint temperatures in the combustor, scrubber, or air stripper will result in the automatic safe shutdown of the system, without operator intervention.
- Shutdown of the system will cause the closure of valves on the discharge to minimize the discharge of possibly undertreated groundwater.
- Shutdown of the system will cause the closure of a float-actuated valve on the plant influent to prevent the possible spillage of contaminated groundwater.
- Critical alarms and shutdown signals will activate an auto dialer system to contact the appropriate staff offsite in the unlikely event that there are no staff onsite during a system failure.

Existing Plant O&M Costs

Cost data was assembled based on actual 1992 data provided by the USAF. Table A-1 summarizes these 1992 costs.

Table A-1
McClellan AFB Groundwater Treatment Plant
O&M Costs for 1992

Category	Annual Cost ($/yr)
Contractor Labor*	$552,000
McClellan Labor	$72,000
Electricity	$48,000
Natural Gas	$36,000
Analyses	$36,000
Maintenance Reimbursables**	$103,000
Total	$847,000

*Includes GWTP O&M, database upkeep, and reporting; does not include wellfield O&M and other activities.
**Includes liquid-phase carbon replacement (2 beds replaced in 1992 at about $25,000 each), one new heat exchanger (about $29,000), and miscellaneous maintenance parts.

The labor costs to operate the plant are borne mostly by an outside contractor. The outside contractor is also responsible for operating, monitoring, and maintaining the groundwater extraction system, the estimated costs of which are not included in the labor costs in Table A-1. Additional labor is expended by McClellan staff to oversee plant O&M and coordinate plant activities with other base activities.

The plant uses electricity to operate all the pump and blower motors, the controls, the lighting, and the general electrical needs of the plant. The bulk of the electricity is used by the 60-horsepower (hp) air stripper feed pump, the 40-hp GAC feed pump, and the 40-hp air stripper blower.

The offgas combustor uses natural gas to burn the organic chemicals and raise the air stripper offgas to a temperature of 1,800°F. Minimizing the air stripper offgas flow rate minimizes the cost of natural gas consumption, which is generally proportional to it.

Maintenance reimbursable expenses are incurred during the repair or replacement of faulty equipment or the replacement of activated carbon. These expenses include only the purchase cost of these items and not the labor to install them.

The groundwater is sampled and analyzed for VOCs, ketones, metals, and occasionally other standard water-quality parameters. These samples are taken at several places in the plant, including the plant influent, the air stripping influent, the GAC influent and the plant effluent. Sampling is usually performed on a weekly basis.

Basis for Evaluations

Anticipated Groundwater Flows and Concentrations

As stated earlier, the existing GWTP is currently treating groundwater from OUs C and D at approximately 180 gpm. The three scenarios developed in this document estimate future GWTP costs of treating 330 gpm, 1,000 gpm, and 2,400 gpm, respectively. The concentration estimates for these three flow cases are developed based on various data as described hereafter.

Scenario 1

Based on Figure 1, the maximum current flow from OUs C and D into the plant is approximately 180 gpm. McClellan staff are currently in the process of adding flow from OU B, expected to be approximately 150 gpm, to the existing flows from OUs C and D. In Scenario 1, monitoring well data from OU B are used to estimate the concentrations of the significant VOCs that will be present at the combined flow rate of 330 gpm. These concentrations are shown in Table A-2.

Table A-2
McClellan AFB Groundwater Treatment Plant - Scenario 1
Flow and Concentrations

Parameter	Combined OUs B, C, and D Total Flow: 330 gpm *Concentrations (μg/L)*
1,1,1-TCA	35
1,1,2-TCA	1
1,1-DCA	17
1,1-DCE	282
1,2-DCA	4
c-1,2-DCE	17
Chloroform	2
PCE	2
t-1,2-DCE	1
TCE	164
Toluene	3
Vinyl Chloride	40
Total Concentration	**568**

Scenario 2

As a midpoint of the anticipated range of flows that may require treatment from the west side of the AFB (OUs B, C, and D), 1,000 gpm has been selected for Scenario 2. Current FS estimates of concentrations from additional combined hot spot and groundwater containment target volumes on the west side of the AFB are combined with the Scenario 1 flows to give flow-weighted averages of contaminant concentrations. These concentrations are shown in Table A-3.

Table A-3
McClellan AFB Groundwater Treatment Plant - Scenario 2
Flow and Concentrations

Parameter	**Combined West Side** **Total Flow: 1,000 gpm** ***Concentrations (μg/L)***
1,1,1-TCA	25
1,1,2-TCA	0
1,1-DCA	6
1,1-DCE	93
1,2-DCA	9
c-1,2-DCE	6
Chloroform	1
PCE	1
t-1,2-DCE	0
TCE	251
Methylene Chloride	13
Toluene	1
Vinyl Chloride	13
Total Concentration	**419**

Scenario 3

Based on the packed tower dimensions and packing type, a maximum estimated flow for the GWTP in Scenario 3 is 2,400 gpm. As in the case of Scenario 2, concentration estimates from additional west side flows and Scenario 1 flows are combined to give the estimated Scenario 3 concentrations. These are shown in Table A-4.

Table A-4 McClellan AFB Groundwater Treatment Plant - Scenario 3 Flow and Concentrations	
Parameter	**Combined West Side** **Total Flow: 2,400 gpm** ***Concentrations (µg/L)***
1,1,1-TCA	22
1,1,2-TCA	0
1,1-DCA	2
1,1-DCE	39
1,2-DCA	10
c-1,2-DCE	2
Chloroform	0
PCE	0
t-1,2-DCE	0
TCE	277
Methylene Chloride	16
Toluene	0
Vinyl Chloride	5
Total Concentration	**373**

Changes in Concentration with Time

Over time, concentration from the extraction target volumes is expected to decrease. As a basis for estimating O&M costs in the future, it is assumed that additional flows from any sources other than OUs C and D will decrease to approximately 50 percent of their initial values sometime in the future. Figure 2 illustrates the trend in extracted groundwater concentrations from the OU C and D sources, which are expected to remain fairly constant. Since the additional target volumes are initially at much lower concentrations and cover larger geographical volumes, it is assumed that the typical concentration of VOCs will not decrease as much with time as was seen in Figure 2, and that 50 percent of the initial concentration is a reasonable basis for comparison.

Performance Estimation

Method

CH2M HILL used several computer programs and performed engineering calculations to estimate the performance of the GWTP under the various scenarios. This approach was used because the infrastructure does not currently exist to deliver the groundwater to the GWTP under each scenario so that its performance can be directly measured during field testing. In addition, there are concerns about operating the GWTP under unknown conditions that may result in the discharge of effluent water in possible violation of McClellan's NPDES discharge permit or with possible damage to the existing equipment.

The computer programs used during this project include STRIPR (an air stripping model), a liquid GAC model, and a temperature profile model to give stream temperatures in the GWTP under varying water flows and air flows. All the models were developed internally by CH2M HILL.

Air Stripping Model

STRIPR estimates the performance of counter-current-flow packed tower air strippers. The model uses Henry's Law and mass transfer correlations to estimate tower performance. Although STRIPR provides Henry's Law corrections for elevated temperatures, there are potential inaccuracies at significantly elevated temperatures. Because the temperatures evaluated for the three scenarios are relatively close to ambient (90°-113°F), the performance estimates should be suitable for evaluation of alternative uses of the existing system, but may not be sufficiently accurate for design purposes. STRIPR output and air stripping performance summaries are provided in Appendix B.

Liquid GAC Model

The liquid GAC model estimates the carbon usage rate that results when groundwaters containing a mixture of contaminants are treated. The algorithms are based on a survey of several operating systems as reported by Speth, et al. ("EPA Research Program in Granular Activated Carbon," in Design and Use of GAC, AWWA/EPA Technology Transfer Conference, May 9, 1989, Cincinnati, Ohio). This information can then be used to estimate the operating cost of GAC as a result of carbon replacement. Activated carbon usage estimates are provided in Appendix C.

Temperature Profile Model

The temperature profile model is based on operating data taken during a site visit on June 30, 1993, and on data taken during testing conducted by the contract operator during July 1993 and reported by Alec Elgal on July 28, 1993 (Appendix D). Information provided by Alec Elgal concerning the heat transfer areas of the heat exchangers was also used in the development of the model. The model estimates the heat balances and temperature profiles resulting under each scenario. This model allows users to evaluate the performance of the heat exchange networks and to estimate both the effects of recycle loops and the size of additional heat exchangers. The air stripper operating temperature predicted by this model can then be used as an input to STRIPR to estimate the VOC-removal efficiency of the air stripper.

Engineering Calculations

Engineering calculations were performed to estimate pump and blower sizing. Pump curves provided by vendors were used to estimate the performance and energy consumption rates of the existing and proposed replacement pumps. Current field data were used to estimate the energy consumption of the blower. Blower curves provided by vendors were used to estimate the energy consumption of a proposed replacement blower.

Evaluation of the Scenarios

Operations and Maintenance

As shown in Table A-1, current O&M costs are dominated by contractor labor at 65 percent of the 1992 expenditure. Numerous factors influence this cost, including staffing plans, maintenance requirements, and the degree of plant automation. While many of the staffing requirements are dictated by the contract under which the contractor operates, CH2M HILL estimates that through alternative staffing methods that satisfy the contract, this cost could be reduced by approximately 10 to 20 percent. A reduction in contractor labor of 15 percent is used as a basis in developing O&M costs for options under future flow scenarios later in this memorandum. This equates to $470,000 per year for operation of the GWTP in its current capacity and configuration.

Significant operating labor savings can be achieved if the contract is modified to not require 24-hour-per-day operation. As described earlier, automatic shutdown control systems are in place to safely shut down the plant under most situations. While capital improvements may be necessary to integrate wellfield shutdown with the plant shutdown, savings on the order of 50 percent of operating labor (roughly $275,000 per year) could be realized with this option.

Maintenance reimbursables are also a major factor at 12 percent of the total cost. The major contributing factors here are carbon usage and the new heat exchanger. The heat exchanger replacement is not expected to be an annual cost and is omitted from reimbursable estimates used for developing the options in later sections of this memorandum. The reimbursable cost used as a basis in developing options is $74,000 per year.

Electrical power and gas consumption are calculated for the treatment options developed under higher flow rates that are presented in later sections. These costs will rise with increasing GWTP flow rates.

Annual McClellan labor and analytical costs are assumed to remain constant for all future options.

Scenario 1

Three options have been developed for treating the flows and concentrations of Scenario 1. The first option presupposes continued operation of the GWTP with no capital investment or change in operating strategy. The second and third options involve improving the operating costs of the existing system and modifying the treatment system, respectively.

Option 1 — Continued Operation of the Existing GWTP

CH2M HILL used the temperature profile model to estimate an air stripper feedwater temperature of 113°F. Next, STRIPR was used to estimate the air flow rate required in the air stripper to meet the existing performance level of this unit, which is generally below the detection limits for each VOC compound.

This evaluation estimates that the GWTP could operate with an air flow rate of 1,200 cfm and produce an air stripper effluent with VOC concentrations below the detection limits. Based on this information, the only cost change from the 1992 costs would be a small increase in the cost of electricity because of a change in the pumping rate from 240 to 330 gpm. Carbon usage is estimated to increase slightly. This cost is reflected under maintenance reimbursables. No capital costs would be incurred by this option. The costs of this option are presented in Table A-5.

Initial costs and future costs illustrate the effect of decreased carbon usage because of the estimated decrease in future extracted water contaminant concentration, as discussed earlier.

Option 2 — Existing GWTP Treatment Technologies with Minor Modifications

In this option, the existing treatment technologies and the general treatment strategy would remain the same. The changes proposed include installing smaller pumps and a smaller blower to more efficiently treat the low flow rates of 330 gpm and 1,000 to 1,200 cfm, respectively.

Site-visit observations indicated that the discharge valves on the 60-hp air stripper feed pump and the 40-hp GAC feed pump were throttled more than 50 percent. Significant power savings would be achieved by the installation of pumps with smaller motors designed to efficiently deliver water at 330 gpm.

Table A-5 McClellan AFB Groundwater Treatment Plant Scenario 1, Option 1 Costs			
	Base Case	**Option 1 Initial**	**Option 1 Future**
Total Capital ($)	**$0**		
Annual O&M ($/yr)			
Labor:			
Contractor	$552,000	$470,000	$470,000
McClellan Staff	72,000	72,000	72,000
Power	48,000	50,000	50,000
Natural Gas	36,000	36,000	36,000
Maintenance Reimbursables	74,000	80,000	75,000
Analyses	36,000	36,000	36,000
Total O&M	**$818,000**	**$744,000**	**$739,000**

The blower was observed to be discharging a significant flow rate of air to the atmosphere. Proposed changes to the tower packing and the air-side heat exchange loops would lower the required blower discharge pressure from about 30 inches of water column (in. wc) to about 3 in. wc. This would greatly reduce the power requirements of the system. Unfortunately, the only way to reduce the inlet pressure of the existing blower is to close the blower's inlet vane damper. Although this would reduce the blower discharge pressure, it would only slightly decrease the power drawn by the blower motor. Since the blower motor is rated at 40 hp, significant power savings would be achieved by installing a blower with a smaller motor.

The anticipated power savings are shown in Table A-6.

In developing costs for this option, the use of variable frequency drives (VFDs) was considered. The option presented was chosen over VFDs for three reasons. Cost research showed that a VFD for an existing pump was more expensive than buying a new, smaller pump and motor. Existing pump operation at low RPMs was not as efficient as operation with a new, smaller pump, and high-flow capacity for each pump set and the blowers can be maintained by leaving one of each equipment pair in place.

Option 3 — Direct Treatment Using Liquid Phase GAC

In this option, the groundwater would be treated directly using the existing GAC system. The air stripper and thermal oxidation system would be bypassed and mothballed for possible use again under Scenarios 2 or 3. The logic behind this option is that the groundwater concentration has decreased over the last several years to a level where it may be more economical to operate the plant using only GAC.

Table A-6 McClellan AFB Groundwater Treatment Plant Scenario 1, Option 2 Costs			
Capital ($)	**Base Case**	**Option 2 Initial**	**Option 2 Future**
Air Stripper Pump	$4,400		
GAC Pump	4,270		
Blower	1,250		
Installation (50%)	5,000		
Total Capital	**$14,920**		
Annual O&M ($/yr)			
Labor:			
Contractor	$552,000	$470,000	$470,000
McClellan Staff	72,000	72,000	72,000
Power	48,000	27,000	27,000
Natural Gas	36,000	36,000	36,000
Maintenance Reimbursables	74,000	80,000	75,000
Analyses	36,000	36,000	36,000
Total O&M ($/yr)	**$818,000**	**$721,000**	**$716,000**

This option would increase the cost of carbon replacement but should gain the credit of eliminating the power costs associated with the air stripper feed pumps and the air stripper blower, and the fuel costs associated with the thermal oxidizer. Because this equipment, as well as the heat exchangers, would not be functioning under this option, there should be the additional benefit of significantly less need for plant maintenance. Thus, a reduction in operating staff would be justified. For estimating purposes, a staffing level of 0.4 full-time equivalent employees has been chosen.

A major potential drawback to this option is that it might increase the emissions rate of vinyl chloride, an air toxic compound. As previously mentioned, SMAQMD will require TBACT for any new toxic emissions because the entire McClellan facility is over the toxics threshold cancer risk. SMAQMD determines what control technology constitutes TBACT on a case-by-case basis by evaluating several factors. Economic considerations are not taken into account in the selection of TBACT. Since the GWTP already has thermal destruction capability, SMAQMD may require its continued use regardless of its cost if other treatment alternatives will result in increased air emissions of vinyl chloride or other toxic compounds.

If the GAC was used to remove vinyl chloride, then the carbon usage rate would be approximately 20,000 lb every 12 days. If the GAC system was operated to allow breakthrough of the vinyl chloride but capture of all the other compounds, then the carbon usage rate would be approximately 20,000 lb every 60 days. The carbon supplier estimates the cost of replacing the carbon with nonregenerated carbon at $1 per pound plus freight. There would be no cost to regenerate the carbon. The vendor recommends the continued use of nonregenerated carbon at the site in order to assure compliance with the low discharge limits.

Table A-7 presents a summary of the costs of Option 3 for carbon that is capable of treating vinyl chloride to the discharge standards.

Table A-7
McClellan AFB Groundwater Treatment Plant
Scenario 1, Option 3 Costs

	Base Case	Option 3 Initial	Option 3 Future
Total Capital ($)		**$0**	
Annual O&M ($/yr)			
Labor:			
Contractor	$552,000	$30,000	$30,000
McClellan Staff	72,000	72,000	72,000
Power	48,000	21,000	21,000
Natural Gas	36,000	0	0
Maintenance Reimbursables	74,000	774,000	774,000
Analyses	36,000	36,000	36,000
Total O&M	**$818,000**	**$933,000**	**$933,000**

Scenario 2

In this scenario, the highest water flow rate that could be treated without changing any of the existing equipment is evaluated. A new GAC system would need to be installed. The water and air flow rates have been chosen at 1,000 gpm and 1,750 cfm, respectively. These flow rates, along with the existing heat exchange network, should produce an air stripper feed temperature of approximately 90°F and a scrubber gas inlet temperature of about 650°F. Higher flow rates would result in higher inlet temperatures. Based on testing performed in July 1993 (Appendix D), higher inlet temperatures could melt the plastic media inside the scrubber or the FRP scrubber itself. Therefore the flow rate chosen for this scenario is 1,750 cfm.

Estimates of removal efficiency under these conditions indicate that the air stripper would no longer remove all of the VOCs to below their detection limits. For example, only about 63 percent of the 1,2-dichloroethane (1,2-DCA) would be removed by the air stripper. The GAC system would need to provide the rest of the

VOC removal. The GAC usage rate would thus be about 60,000 lb every 56 days. The increased air flow rate would increase the natural gas consumption of the combustor to a heat consumption rate of about 2.56 million Btu per hour.

The costs of this scenario are summarized in Table A-8.

Table A-8
McClellan AFB Groundwater Treatment Plant
Scenario 2 Costs

Capital ($)	**Base Case**	**Scenario 2 Initial**	**Scenario 2 Future**
Carbon System		$165,000	
Installation (20%)		33,000	
Total Capital		**$198,000**	
Annual O&M ($/yr)			
Labor:			
Contractor	$552,000	$470,000	$470,000
McClellan Staff	72,000	72,000	72,000
Power	48,000	73,000	73,000
Natural Gas	36,000	48,000	48,000
Maintenance Reimbursables	74,000	439,000	256,000
Analyses	36,000	36,000	36,000
Total O&M	**$818,000**	**$1,138,000**	**$955,000**

The major increase in O&M cost in this scenario over Scenario 1 is carbon usage. Evaluation of the existing system indicates that 1,2-DCA is the key compound for stripper performance. The stripper feedwater temperature is the critical variable in removing 1,2-DCA. At temperatures less than approximately 100°F, 1,2-DCA removal is estimated to decrease dramatically in a nonlinear fashion. This decrease in removal efficiency causes the stripper effluent concentration of 1,2-DCA to increase, which subsequently increases liquid-phase carbon usage. Heat balance calculations indicate that this temperature corresponds to a water flow rate of 600 to 700 gpm with existing equipment. While numerous scenarios have not been fully developed over the possible range of water flows between 330 and 1,000 gpm, it is apparent that additional heat exchangers that could maintain a stripper feedwater temperature of 100°F should be considered in future designs for flows above approximately 700 gpm.

Scenario 3

In this scenario, it is assumed that the existing GWTP would be upgraded to hydraulically treat 2,400 gpm without increasing the air stripper air flow rate above the design capacity of the existing combustor system. Treating this water flow rate would require the addition of the following equipment:

- Air stripper and GAC feed pumps capable of providing 2,400 gpm at the new line pressures
- Three plate and frame heat exchangers in parallel to the existing ones
- Five GAC adsorption systems
- An air-water heat exchanger made of Inconel and operated in series with the existing one to prevent melting of the scrubber by reducing the scrubber inlet gas temperature and to increase the air stripper feedwater temperature by recovering additional heat
- Replacement of liquid distributor nozzles with a trough-type distributor to allow 2,400 gpm of flow

In this scenario, the air stripper feed temperature and the scrubber gas inlet temperature would be about 90°F and 450°F, respectively, the latter because 450°F is the original design temperature of the scrubber inlet, based on an offgas flow rate of 3,000 standard cfm (scfm). The air flow rate has been chosen at 3,000 cfm because this is the maximum design air flow rate for the incinerator and the scrubber, and is believed to be the maximum that could be used without incurring substantial costs related to upgrading the combustor and the scrubber systems. In addition to substantial cost, the modifications required to allow greater than 3,000 cfm would likely trigger regulatory action limits. These triggers, and the likely negative public perception of additional incineration equipment installation, form the basis for limiting the air flow to 3,000 cfm in this scenario. The heat duty of the combustor is estimated to be about 4.82 million Btu per hour. The flow conditions predicted to occur in the air stripper would not result in complete removal of some of the VOCs. For example, the air stripper is estimated to remove only 47 percent of the 1,2-dichloroethane. Therefore, the GAC system would be used to achieve final compliance with the effluent criteria. It is estimated that the lead beds on all seven GAC systems, or 140,000 lb, would need to be replaced every 57 days. The costs of this scenario are summarized in Table A-9.

Scenario 3 includes replacing the existing air-water heat exchanger, which has a heat exchange area of 774 ft^2, with a larger unit of 1,135 ft^2. This process change, as well as the inclusion of new water-water heat exchangers, provides a stripper inlet temperature of 90°F. As discussed earlier, this results in poor removals of 1,2-DCA. Additionally, cis-1,2-DCE and methylene chloride are not estimated to be removed to less than 0.5 parts per billion (ppb) in the stripper effluent. These compounds cause the carbon usage to increase dramatically in this scenario. While Scenario 3 provides a reasonable basis for comparison with other technologies, further study could optimize O&M costs through the examination of heat exchange networks that could raise the stripper feedwater temperature to greater than 100°F. Given the uncertainties in the extracted groundwater contaminant concentrations at the time of preparation of this memorandum, more detailed scenarios are not developed here.

Table A-9 McClellan AFB Groundwater Treatment Plant Scenario 3 Costs			
Capital ($)	**Base Case**	**Scenario 3 Initial**	**Scenario 3 Future**
3 Water-Water Heat Exchangers		$150,000	
5 Carbon Skids		825,000	
2 Stripper Pumps		29,500	
2 GAC Pumps		25,100	
1 Liquid Distribution System		10,000	
1 Inconel Air-Water Exchanger		152,000	
Installation (50%)		600,000	
Piping (installed)		395,000	
Total Capital		**$2,186,600**	
Annual O&M ($/yr)			
Labor:			
Contractor	$552,000	$542,000	$542,000
McClellan Staff	72,000	72,000	72,000
Power	48,000	105,000	105,000
Natural Gas	36,000	91,000	91,000
Maintenance Reimbursables	88,000	1,121,000	585,000
Analyses	36,000	36,000	36,000
Total O&M	**$832,000**	**$1,967,000**	**$1,431,000**

Alternative Technologies

As part of the FS, standard technologies, including advanced oxidation processes, air stripping at ambient conditions, and liquid phase carbon treatment trains, are being evaluated in a similar fashion to those presented in this memorandum. In addition, innovative technologies are also being investigated. Based on the groundwater data available at this time, most containment target volumes contain concentrations of 1,2-DCA above 0.5 ppb. This compound, as discussed above, is difficult to remove from water by air stripping. Unfortunately, it is also relatively difficult to treat with advanced oxidation processes. Nevertheless, air stripping and advanced oxidation can be effective, though costly, at removing 1,2-DCA. The effectiveness and costs associated with these alternative technologies and the GWTP (existing and modified under the scenarios presented) will be compared in the FS.

Summary

The existing GWTP at McClellan was originally designed to treat 1,000 gpm of extracted groundwater. In its 8 years of operation, the plant has undergone numerous physical changes to accommodate operational problems and lower flow rates from the extraction system. Currently, the plant treats approximately 125 gpm of extracted groundwater to nondetectable levels (<0.5 ppb) of the targeted compounds.

Current O&M costs are examined, and contractor labor is identified as the major constituent. Potential changes to operations staffing are identified, some of which require changes to the existing operations contract. Potential savings of up to $275,000 per year in O&M cost are identified if 24-hour-per-day, 7-day-per-week operator presence is not required.

Three future flow scenarios are examined: 330 gpm, 1,000 gpm and 2,400 gpm. These scenarios use information on groundwater contaminant concentration from the current base-wide groundwater OUFS being developed by CH2M HILL.

Under Scenario 1, three options are developed. Option 1 describes the operation of the GWTP without equipment modifications. Resulting O&M costs of $744,000 per year are estimated with minor operational changes. Option 2 describes replacement of two pumps and one blower to achieve more efficient energy usage. The capital costs are estimated at about $15,000, and provide an anticipated O&M cost of $721,000 per year. Option 3 describes shutting down the air stripper and incinerator, and treating the groundwater flow with carbon alone. Vinyl chloride removal is estimated to require frequent carbon replacement and results in an O&M cost of $933,000 per year, even though operating labor, power, and natural gas costs can be significantly decreased.

Under Scenario 2, one option is developed. With a capital investment of approximately $200,000 for additional carbon vessels, an initial O&M cost of $1,170,000 per year is estimated. Given that contaminant concentrations will decrease with time as they are shown to do in the historical data from the GWTP influent flow, future O&M costs will decrease, because of lowered carbon costs, to approximately $955,000.

Under Scenario 3, one option is also developed. Significant capital investment, including heat exchangers, pumps, and piping, is required, resulting in a capital cost of about $2,200,000. The accompanying O&M costs are estimated at $1,967,000 per year initially, dropping to $1,431,000 in the future.

Conclusions

The primary purpose of this memorandum is to provide cost information to allow comparison of the GWTP with other technologies as part of the groundwater OUFS. These costs are developed for three scenarios in this memorandum.

In developing this information, various potential methods of decreasing O&M cost in the near future are identified, such as replacement of pumps and blowers and staffing modifications.

Evaluation of Scenarios 2 and 3 indicates that certain compounds, most notably 1,2-DCA, drive the O&M cost because of increasing carbon usage. Increased carbon usage is due to low stripper removal efficiencies at cooler water temperatures, which result with increased water flow rates. An approximate breakthrough point of 100°F is indicated. This temperature correlates with an approximate water flow rate of 700 gpm in the existing GWTP. While the options developed under the scenarios within this memorandum are sufficient for comparison of the GWTP with other technologies, potential optimization of carbon usage can be performed during design activities by adding heat exchange capacities at higher flow rates.

Attachment A-1
NPDES Permit and
Authority to Construct

COUNTY OF SACRAMENTO
AIR POLLUTION CONTROL DISTRICT

NORM COVELL
AIR POLLUTION CONTROL OFFICER
9323 Tech Center Drive, Suite 600
Sacramento, California 95826
(916) 366-2107

September 8, 1986

J. Thomas Lawell, Colonel, USAF
Director, Environmental Management
Department of the Air Force
Headquarters Sacramento Air Logistics Center (AFLC)
McClellan AFB, CA 95652

Dear Colonel Lawell:

Please refer to your application to construct the following equipment located at Area D, McClellan AFB.

APPLICATION NO. A/C 8392: VOC STRIPPING PROCESS
A/C 8393: FUME INCINERATOR

AUTHORITY TO CONSTRUCT

Authorization to construct is hereby granted with the following conditions:

1. Groundwater entering the influent sump shall be sampled and analyzed at least once in any 14 day period to determine the concentrations of the compounds in Table 3 of the "Environmental Risk Assessment of Volatile Organics" (July 1986) and the concentration of total organic compounds. Whenever two samples in succession yield concentrations for any of the aforementioned compounds or total organic compounds in excess of the influent concentration listed in Table 2 of the "Environmental Risk Assessment of Volatile Organics" (July 1986), the groundwater shall be sampled and analyzed twice weekly until the concentrations no longer exceed the Table 2 listings.

2. In the event that twice-weekly sampling is required per condition no. 1, if 10 successive samples yield concentrations for any of the aforementioned compounds or total organic compounds in excess of the Table 2 influent listings, the Air Pollution Control Officer may deem the operating conditions to be out of compliance with the specifications submitted with the application. Upon a finding of non-compliance, the Air Pollution Control Officer may require the Department of the Air Force to apply for a modified permit or take other appropriate action.

3. The Air Pollution Control Officer shall be notified within 7 days of the time that any two successive groundwater samples yield concentrations for any of the aforementioned compounds or total organic compounds in excess of the Table 2 influent listings.

SEP 10 REC'D

4. The Department of the Air Force shall operate an ambient air monitoring station in the vicinity of Bldg. 704 to monitor for 1,1-dichloroethylene, trichloroethylene, methylene chloride, and 1,1,1-trichloroethane. A second monitoring station shall be operated by the Department of the Air Force as close as possible to a point such that if a line segment was drawn between the two stations, the emission point would bisect the line segment. The Department of the Air Force shall submit a monitoring plan for approval by the Air Pollution Control Officer, specifying sampling technique, sample duration, analytical technique, and monitoring project duration. Operation of the groundwater treatment system shall not begin until the Air Pollution Control Officer has approved a monitoring plan.

5. Quarterly reports shall be submitted to the Air Pollution Control Officer within the 30 days following March 31, June 30, September 30, and December 31, summarizing the ambient air monitoring results, the groundwater concentrations of the aforementioned organic compounds (condition no. 1) and including an estimate of average daily emissions for the quarter.

6. All sampling, analytical, and operational data shall be made available for inspection by the Air Pollution Control Officer upon request.

7. Combustion temperature and oxygen concentration in the combustion exhaust shall be continuously monitored.

8. A temperature of at least 1300°F shall be maintained in the combustion zone whenever the air stripper is venting organic compounds to the incinerator.

9. Water flow rate to stripping column shall be continuously monitored.

10. Within the 30 days following completion of the performance test program, the incinerator exhaust shall be tested for the emission rate and destruction efficiency of the compounds in Table 3, 1,1,1-trichloroethane, acetone, and total organic compounds. The destruction efficiency test shall include the use of an appropriate surrogate compound. The incinerator exhaust shall also be tested to determine the emission rate for oxides of nitrogen.

11. At least 30 days prior to the emissions test, the Department of the Air Force shall submit a test plan to the Air Pollution Control Officer. The plan shall specify the test method, analytical technique, a schedule of periodic retesting, and any other appropriate information. The test shall not take place until the Air Pollution Control Officer has approved a test plan and has received at least a 7 day advance notification of the test.

12. In accordance with California Health and Safety Code Section 39660e, the Department of the Air Force shall cooperate with the Air Pollution Control District and the California Air Resources Board in evaluating the potential emissions of chlorinated dioxins and dibenzofurans. In the event the Air Pollution Control Officer determines that emissions

of chlorinated dioxins and/or dibenzofurans pose an unacceptable public health risk, the Department of the Air Force shall take appropriate steps to mitigate the health impact.

13. The Air Pollution Control Officer shall be notified in writing of the anticipated date of initial start-up of the source not more than 60 days or less than 30 days prior to such date and shall be notified in writing of the actual date of commencement of construction and start up within 15 days after such date.

14. All equipment, facilities, and systems installed or used to achieve compliance with the terms and conditions of this Authority to Construct shall at all times be maintained in good working order and be operated as efficiently as possible so as to minimize air pollutant emissions.

15. Sample ports and test platforms, as necessary, shall be constructed per applicable EPA and OSHA requirements, and shall be permanent.

16. Access, facilities, utilities and any necessary safety equipment for source testing and inspection shall be provided upon request of the Air Pollution control officer.

17. Notify the Air Pollution Control Officer of any malfunctions of the continuous monitoring system or breakdown of the air pollution control equipment as required by Rule 602-Breakdown Conditions; Emergency Variance.

18. Start-up and operation of the facility shall not begin until the Department of the Air Force provides written notification of the means by which emissions of oxides of nitrogen from the facility will be offset in accordance with Rule 202. Such notification must be forwarded to the Air Pollution Control Officer for approval.

Commencing work under this authority to construct shall be deemed acceptance of all the conditions specified.

This, however, does not constitute a permit to operate nor does it guarantee that the proposed equipment will comply with air pollution control regulations.

You are requested to notify this office when construction has been completed. A final inspection will then be made to determine whether the equipment has been constructed according to the plans approved by this District. At that time, operation will be observed and permission to operate will be granted upon compliance with the rules and regulations of the Sacramento County Air Pollution Control District.

Sincerely,

Eric P. Skelton

ERIC P. SKELTON
Air Toxics Manager

ES:jb

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

ORDER NO. 91-171

NPDES NO. CA0081850

WASTE DISCHARGE REQUIREMENTS
FOR
UNITED STATES DEPARTMENT OF THE AIR FORCE
MC CLELLAN AIR FORCE BASE
GROUND WATER EXTRACTION AND TREATMENT SYSTEM
SACRAMENTO COUNTY

CONTAMINANTS AND TREATMENT PROCESSES

The Report of Waste Discharge describes the proposed discharge as follows:

Average flow: 0.33 million gallons per day (mgd)

Design flow: 1.44 mgd

Average temperature: 81 °F Summer; 72 °F Winter

Constituent	Concentration	
Suspended Matter	<5 mg/l	
pH	minimum 7.4	maximum 8.5

IT IS HEREBY ORDERED, that Order No. 87-194 be rescinded, and that the Department of the Air Force, McClellan Air Force Base, in order to meet the provisions contained in Division 7 of the California Water Code and regulations adopted thereunder, and the provisions of the Clean Water Act and regulations and guidelines adopted thereunder, shall comply with the following:

A. Effluent Limitations:

1. The discharge of effluent in excess of the following limits is prohibited:

Constituents	Units	Daily Maximum	Monthly Average
Acetone	mg/l	1.0	1.0
Methyl Ethyl Ketone	mg/l	1.0	1.0
Methyl Isobutyl Ketone	mg/l	1.0	1.0
Other Volatile Organics	µg/l	Nondetectable[1]	---
Base Neutral and Acid Extractable	µg/l	Nondetectable[2]	---
Pesticides	µg/l	Nondetectable[3]	---

Receiving Water Limitations:

1. The discharge shall not cause the dissolved oxygen concentration in Magpie Creek to fall below 5.0 mg/l.

2. The discharge shall not cause visible oil, grease, scum, or foam in the receiving waters or watercourses.

3. The discharge shall not cause concentrations of any materials in the receiving waters which are deleterious to human, animal, aquatic, or plant life.

4. The discharge shall not cause esthetically undesirable discoloration of the receiving waters.

5. The discharge shall not cause fungus, slimes or other objectionable growths in the receiving waters.

6. The discharge shall not cause bottom deposits in the receiving waters.

7. The discharge shall not increase the turbidity of the receiving waters more than 10% over background levels

8. The discharge shall not alter the normal ambient pH of the receiving water more than 0.5 units.

9. The discharge shall not increase the normal ambient temperature of the receiving water more than 5°F (3°C).

10. The discharge shall not increase the temperature of the receiving waters above 90°F (32.2°C).

11. The discharge shall not cause the concentrations of acetone, methyl ethyl ketone, or methyl isobutyl ketone to exceed 1.0 mg/l in Magpie Creek.

12. The discharge shall not cause a violation of any applicable water quality standard for receiving waters adopted by the Board or the State Water Resources Control Board as required by the Clean Water Act and regulations adopted thereunder. If more stringent applicable water quality standards are approved pursuant to Section 303 of the Clean Water Act, or amendments thereto, the Board will revise and modify this order in accordance with such more stringent standards.

Constituent	Units	Type of Sample	Sampling Frequency
Volatile Organics	µg/l	Grab	Weekly
Acetone	µg/l	Grab	Weekly
Methyl Ethyl Ketone	µg/l	Grab	Weekly
Methyl Isobutyl Ketone	µg/l	Grab	Weekly
Total Cadmium	µg/l	24-hour Composite	Monthly
Total Nickel	µg/l	24-hour Composite	Monthly
Total Chromium	µg/l	24-hour Composite	Monthly
Total Zinc	µg/l	24-hour Composite	Weekly
Total Lead	µg/l	24-hour Composite	Monthly
Total Selenium	µg/l	24-hour Composite	Monthly
Total Antimony	µg/l	24-hour Composite	Monthly
Total Mercury	µg/l	24-hour Composite	Monthly
Temperature	°F/°C	Grab	Weekly
pH	pH units	Grab	Weekly
Specific Conductivity	µmhos/cm	24-hour Composite	Weekly
Sodium	mg/l	Grab	Weekly
Chloride	mg/l	Grab	Weekly
Pesticides	µg/l	Grab	Twice per year
Base Neutral and Acid Extractable Compounds	µg/l	Grab	Twice per year
Suspended Solids	mg/l	Grab	Weekly
Dissolved oxygen	mg/l	Grab	Weekly
Turbidity	Turbidity Units	Grab	Weekly

McClellan Air Force Base
Ground Water Treatment Plant

ATTACHMENT 3

Contaminant	Average Influent Concentration (µg/l)	Average Effluent Concentration (µg/l)	Detection Limit (µg/l)
Benzene	Not Detected	Not Detected	0.02[1]
Bromodichloromethane	Not Detected	Not Detected	0.002[1]
Bromoform	0.37	Not Detected	
Carbon Tetrachloride	Not Detected	Not Detected	0.003[1]
Chlorobenzene	0.06	Not Detected	0.001[1]
Chloroethane	Not Detected	Not Detected	
Chloroform	1.3	Not Detected	
Chloromethane	Not Detected	Not Detected	0.01[1]
1,2-Dichlorobenzene	1.3	Not Detected	0.02[1]
1,3-Dichlorobenzene	0.06	Not Detected	0.006[1]
1,4-Dichlorobenzene	Not Detected	Not Detected	0.006[1]
1,1-Dichloroethane	46.7	Not Detected	0.002[1]
1,2-Dichloroethane	9.0	Not Detected	0.002[1]
1,1-Dichloroethylene	369	Not Detected	0.003[1]
T-1,2-Dichloroethylene	1.6	Not Detected	0.002[1]
Dichloromethane	Not Detected	Not Detected	0.02[1]
1,2-Dichloropropane	Not Detected	Not Detected	0.006[1]
T-1,3-Dichloropropylene	Not Detected	Not Detected	0.05[1]
Ethylbenzene	Not Detected	Not Detected	0.002[1]
1,1,2,2-Tetrachloroethane	Not Detected	Not Detected	0.01[1]
Tetrachloroethylene	2.4	Not Detected	0.001[1]
Toluene	10.4	Not Detected	0.01[1]
1,1,1-Trichloroethane	40.7	Not Detected	0.003[1]
1,1,2-Trichloroethane	3.3	Not Detected	
Trichloroethylene	275	Not Detected	0.001[1]
Trichlorofluoromethane	Not Detected	Not Detected	
Vinyl Chloride	72.0	Not Detected	0.006[1]
Xylenes	Not Detected	Not Detected	0.004[1]
Pesticides	Not Detected	Not Detected	[2]
Base Neutral and Acid Extractable Compounds	Not Detected	Not Detected	[3]

[1] EPA Method 502.1 and 503.1 detection limits.
[2] See EPA SW846 for detection limits for EPA Method 608.
[3] See EPA SW846 for detection limits for EPA Method 625.

Attachment A-2
Air Stripper
Performance Estimates

McClellan GWTP
Effluent Characterization Estimates
by: JSO
Project: SAC28722.66.TP
Date 8/18/93

	SCENARIO 1			SCENARIO 2			SCENARIO 3		
Parameter	Influent ug/l	Treatment %R	Effluent ug/l	Influent ug/l	Treatment %R	Effluent ug/l	Influent ug/l	Treatment %R	Effluent ug/l
1,1,1-TCA	35.0	99.99%	0.0	22.0	99.99%	0.0	24.9	99.96%	0.0
1,1,2-TCA	1.0	99.85%	0.0	0.1	74.92%	0.0	0.3	59.32%	0.1
1,1-DCA	16.8	99.99%	0.0	2.3	99.85%	0.0	5.5	99.08%	0.1
1,1-DCE	281.9	99.99%	0.0	38.8	99.99%	0.0	93.0	99.97%	0.0
1,2-DCA	3.6	99.72%	0.0	10.0	70.14%	3.0	8.6	54.27%	3.9
c-1,2-DCE	17.4	99.99%	0.0	2.4	96.05%	0.1	5.7	87.92%	0.7
Chloroform	1.7	99.99%	0.0	0.2	99.30%	0.0	0.5	96.78%	0.0
PCE	2.1	99.99%	0.0	0.3	99.98%	0.0	0.7	99.89%	0.0
t-1,2-DCE	0.9	99.99%	0.0	0.1	99.83%	0.0	0.3	99.00%	0.0
TCE	163.5	99.99%	0.0	276.5	99.97%	0.1	251.3	99.87%	0.3
Methylene Chloride	0.0	99.99%	0.0	16.4	97.41%	0.4	12.7	90.78%	1.2
Toluene	2.8	99.99%	0.0	0.4	99.85%	0.0	0.9	99.15%	0.0
Vinyl Chloride	39.6	99.99%	0.0	5.4	99.99%	0.0	13.1	99.99%	0.0
Total	566.2		0.1	374.9		3.6	417.5		6.4
Flowrate (gpm)			335			1000			2400

```
AIR STRIPPER SIZE/PERFORMANCE -- CH2M HILL, INC.; VERSION NUMBER: 2.15

CLIENT  MCCLELLAN AFB                     DATE          18-AUG-93
JOB NO.          USR$PRID                 TIME          16:22:08
DESCRIPTION EXISTING STRIPPER             BY            CVO_OBERT

     OPERATING CONDITIONS   ('*' INDICATES USER-PROVIDED DATA)
COLUMN DIAMETER, FEET                                     8.0(*)
PACKED DEPTH, FEET  (FACTOR-OF-SAFETY 1.25 INCLUDED)     23.0(*)
PACKING TYPE           2.000" Jaeger Tri-Packs          plastic   (*)
WATER TEMPERATURE, T IN DEGREES F                       111.0(*)
WATER FLOW, GPM @ T                                     330.0(*)
AIR FLOW, SCFM @ 60 F                                  1250.0(*)
AIR:WATER (VOL @ 60 F:VOL @ T)                           28.3

     COLUMN PERFORMANCE  ('*' INDICATES USER-PROVIDED DATA)
COMPOUND          111TCA     112TCA     1,1DCA     1,1DCE     1,2DCA
% REMOVAL          99.99      99.85      99.99      99.99      99.72
PRESSURE DROP, INCHES OF WATER:      0.001/FOOT          0.01 TOTAL
For pressure drop correlation curve, X-   0.96283, Y-   0.00352.

     PHYSICAL PROPERTIES OF CONTAMINANTS  ('*' INDICATES USER-PROVIDED)
COMPOUND          111TCA     112TCA     1,1DCA     1,1DCE     1,2DCA
H,ATM/MOLFRC     3840.9      166.6      762.8     2742.1      138.7
DL, SQFT/HR    5.51E-05   5.51E-05   6.21E-05   6.53E-05   6.21E-05
DG, SQFT/HR      0.3521     0.3521     0.3945     0.4037     0.3945
MOL WT            133.4      133.4       98.9       96.9       98.9

PHASE                                       AIR          WATER
DENSITY, LB/CUFT                          0.0695          61.8
VISCOSITY, CP                            0.01907        0.6108
SURF. TENSION, DYN/CM                                     68.3

     MASS TRANSFER PROPERTIES FOR EACH CONTAMINANT
COMPOUND            111TCA     112TCA     1,1DCA     1,1DCE     1,2DCA
STRIPPING FACT     83.00       3.60      16.48      59.26       3.00
LOCAL kL         10.4805    10.4805    11.1280    11.4075    11.1280
LOCAL kG         0.04384    0.04384    0.04730    0.04803    0.04730
kL/kG             239.06     239.06     235.29     237.53     235.29
OVERALL KL        9.8664     4.3049     8.5047    10.4981     4.1277
WETTED A, FT2/FT3  19.5        19.5       19.5       19.5       19.5
KLA               192.73      84.09     166.14     205.07      80.63
HTOL, FEET          0.94       2.15       1.09       0.88       2.24
NTOL               19.60       8.55      16.89      20.85       8.20
(KL, kL, AND kG ARE IN LBMOL/HR-SQFT-MOLFRAC)

     PACKING PARAMETERS  ('*' INDICATES USER-PROVIDED DATA)
     ------- ----------
SURFACE AREA, SQFT/CUFT                                  48.0
EFFECTIVE DIAMETER, FEET                                0.202
PACKING FACTOR, SQFT/CUFT                                 16.
SURFACE TENSION, DYNES/CM                                 33.
PACKED DEPTH SAFETY FACTOR                               1.25
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AIR STRIPPER SIZE/PERFORMANCE -- CH2M HILL, INC.; VERSION NUMBER: 2.15

CLIENT  MCCLELLAN AFB                         DATE          18-AUG-93
JOB NO.          USR$PRID                     TIME          16:23:29
DESCRIPTION EXISTING STRIPPER                 BY            CVO_OBERT

     OPERATING CONDITIONS    ('*' INDICATES USER-PROVIDED DATA)
COLUMN DIAMETER, FEET                                          8.0(*)
PACKED DEPTH, FEET  (FACTOR-OF-SAFETY 1.25 INCLUDED)          23.0(*)
PACKING TYPE            2.000" Jaeger Tri-Packs                plastic    (*)
WATER TEMPERATURE, T IN DEGREES F                             111.0(*)
WATER FLOW, GPM @ T                                           330.0(*)
AIR FLOW, SCFM @ 60 F                                        1250.0(*)
AIR:WATER (VOL @ 60 F:VOL @ T)                                 28.3

     COLUMN PERFORMANCE  ('*' INDICATES USER-PROVIDED DATA)
COMPOUND          cisDCE      ClForm      PCE
% REMOVAL          99.99       99.99       99.99       0.00        0.00
PRESSURE DROP, INCHES OF WATER:      0.001/FOOT            0.01 TOTAL
For pressure drop correlation curve, X-   0.96283, Y-   0.00352.

     PHYSICAL PROPERTIES OF CONTAMINANTS  ('*' INDICATES USER-PROVIDED)
COMPOUND          cisDCE      ClForm      PCE
H,ATM/MOLFRC       323.2       525.2       3405.9       0.0         0.0
DL, SQFT/HR     6.53E-05    6.26E-05    4.30E-05    0.00E+00    0.00E+00
DG, SQFT/HR       0.4037      0.3923      0.3280      0.0000      0.0000
MOL WT              96.9       119.4       165.8         0.0         0.0

PHASE                                          AIR           WATER
DENSITY, LB/CUFT                             0.0695           61.8
VISCOSITY, CP                                0.01907         0.6108
SURF. TENSION, DYN/CM                                         68.3

     MASS TRANSFER PROPERTIES FOR EACH CONTAMINANT
COMPOUND             cisDCE      ClForm      PCE
STRIPPING FACT         6.98       11.35       73.60        0.00        0.00
LOCAL kL            11.4075     11.1751      9.2576      0.0000      0.0000
LOCAL kG            0.04803     0.04711     0.04182     0.00000     0.00000
kL/kG                237.53      237.20      221.38        0.00        0.00
OVERALL KL           6.5752      7.6982      8.6926      0.0000      0.0000
WETTED A, FT2/FT3      19.5        19.5        19.5        19.5        19.5
KLA                  128.44      150.38      169.81        0.00        0.00
HTOL, FEET             1.41        1.20        1.07        0.00        0.00
NTOL                  13.06       15.29       17.27        0.00        0.00
(KL, kL, AND kG ARE IN LBMOL/HR-SQFT-MOLFRAC)

     PACKING PARAMETERS  ('*' INDICATES USER-PROVIDED DATA)
     ------- ----------
SURFACE AREA, SQFT/CUFT                                        48.0
EFFECTIVE DIAMETER, FEET                                       0.202
PACKING FACTOR, SQFT/CUFT                                      16.
SURFACE TENSION, DYNES/CM                                      33.
PACKED DEPTH SAFETY FACTOR                                     1.25
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AIR STRIPPER SIZE/PERFORMANCE -- CH2M HILL, INC.; VERSION NUMBER: 2.15

CLIENT  MCCLELLAN AFB                          DATE          18-AUG-93
JOB NO.          USR$PRID                      TIME          16:24:15
DESCRIPTION EXISTING STRIPPER                  BY            CVO_OBERT

     OPERATING CONDITIONS   ('*' INDICATES USER-PROVIDED DATA)
COLUMN DIAMETER, FEET                                          8.0(*)
PACKED DEPTH, FEET  (FACTOR-OF-SAFETY 1.25 INCLUDED)          23.0(*)
PACKING TYPE              2.000" Jaeger Tri-Packs              plastic   (*)
WATER TEMPERATURE, T IN DEGREES F                             111.0(*)
WATER FLOW, GPM @ T                                           330.0(*)
AIR FLOW, SCFM @ 60 F                                        1250.0(*)
AIR:WATER (VOL @ 60 F:VOL @ T)                                 28.3

     COLUMN PERFORMANCE  ('*' INDICATES USER-PROVIDED DATA)
COMPOUND          trDCE        TCE         Tol        VinCl
% REMOVAL         99.99        99.99       99.99      99.99        0.00
PRESSURE DROP, INCHES OF WATER:     0.001/FOOT               0.01 TOTAL
For pressure drop correlation curve, X-   0.96283, Y-   0.00352.

     PHYSICAL PROPERTIES OF CONTAMINANTS  ('*' INDICATES USER-PROVIDED)
COMPOUND          trDCE        TCE         Tol        VinCl
H,ATM/MOLFRC      742.3       1299.3       860.2     ********        0.0
DL, SQFT/HR     6.53E-05     5.74E-05     5.44E-05    7.68E-05    0.00E+00
DG, SQFT/HR      0.4037       0.3590       0.3464      0.4760      0.0000
MOL WT             96.9        131.4         92.2        62.5         0.0

PHASE                                          AIR           WATER
DENSITY, LB/CUFT                              0.0695          61.8
VISCOSITY, CP                                 0.01907        0.6108
SURF. TENSION, DYN/CM                                         68.3

     MASS TRANSFER PROPERTIES FOR EACH CONTAMINANT
COMPOUND             trDCE       TCE         Tol        VinCl
STRIPPING FACT       16.04       28.08       18.59     21825.74       0.00
LOCAL kL           11.4075     10.6953     10.4135      12.3781     0.0000
LOCAL kG           0.04803     0.04441     0.04336      0.05360    0.00000
kL/kG               237.53      240.83      240.15       230.94       0.00
OVERALL KL          8.6422      9.0228      8.1408      12.3753     0.0000
WETTED A, FT2/FT3  19.5         19.5        19.5         19.5         19.5
KLA                 168.82      176.26      159.03       241.74       0.00
HTOL, FEET            1.07        1.03        1.14         0.75       0.00
NTOL                 17.17       17.92       16.17        24.58       0.00
(KL, kL, AND kG ARE IN LBMOL/HR-SQFT-MOLFRAC)

     PACKING PARAMETERS  ('*' INDICATES USER-PROVIDED DATA)
     ------- ----------
SURFACE AREA, SQFT/CUFT                                      48.0
EFFECTIVE DIAMETER, FEET                                     0.202
PACKING FACTOR, SQFT/CUFT                                     16.
SURFACE TENSION, DYNES/CM                                     33.
PACKED DEPTH SAFETY FACTOR                                   1.25
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MeCl2
99.99 %

AIR STRIPPER SIZE/PERFORMANCE -- CH2M HILL, INC.; VERSION NUMBER: 2.15

CLIENT	MCCLELLAN AFB	DATE	18-AUG-93
JOB NO.	USR$PRID	TIME	16:25:59
DESCRIPTION	EXISTING STRIPPER	BY	CVO_OBERT

OPERATING CONDITIONS ('*' INDICATES USER-PROVIDED DATA)

COLUMN DIAMETER, FEET		8.0(*)
PACKED DEPTH, FEET (FACTOR-OF-SAFETY 1.25 INCLUDED)		23.0(*)
PACKING TYPE	2.000" Jaeger Tri-Packs	plastic (*)
WATER TEMPERATURE, T IN DEGREES F		90.0(*)
WATER FLOW, GPM @ T		1000.0(*)
AIR FLOW, SCFM @ 60 F		1750.0(*)
AIR:WATER (VOL @ 60 F:VOL @ T)		13.1

COLUMN PERFORMANCE ('*' INDICATES USER-PROVIDED DATA)

COMPOUND	111TCA	112TCA	1,1DCA	1,1DCE	1,2DCA
% REMOVAL	99.99	74.90	99.85	99.99	70.14

PRESSURE DROP, INCHES OF WATER: 0.000/FOOT 0.00 TOTAL
For pressure drop correlation curve, X- 2.12805, Y- 0.00677.

PHYSICAL PROPERTIES OF CONTAMINANTS ('*' INDICATES USER-PROVIDED)

COMPOUND	111TCA	112TCA	1,1DCA	1,1DCE	1,2DCA
H,ATM/MOLFRC	2209.2	95.3	450.1	1568.6	83.7
DL, SQFT/HR	4.27E-05	4.27E-05	4.81E-05	5.05E-05	4.81E-05
DG, SQFT/HR	0.3297	0.3297	0.3695	0.3781	0.3695
MOL WT	133.4	133.4	98.9	96.9	98.9

PHASE	AIR	WATER
DENSITY, LB/CUFT	0.0722	62.1
VISCOSITY, CP	0.01854	0.7644
SURF. TENSION, DYN/CM		70.2

MASS TRANSFER PROPERTIES FOR EACH CONTAMINANT

COMPOUND	111TCA	112TCA	1,1DCA	1,1DCE	1,2DCA
STRIPPING FACT	21.96	0.95	4.47	15.59	0.83
LOCAL kL	13.3752	13.3752	14.2016	14.5582	14.2016
LOCAL kG	0.05502	0.05502	0.05935	0.06027	0.05935
kL/kG	243.11	243.11	239.27	241.55	239.27
OVERALL KL	12.0492	3.7674	9.2721	12.6155	3.6800
WETTED A, FT2/FT3	25.9	25.9	25.9	25.9	25.9
KLA	312.21	97.62	240.25	326.89	95.36
HTOL, FEET	1.76	5.64	2.29	1.68	5.78
NTOL	10.43	3.26	8.03	10.92	3.19

(KL, kL, AND kG ARE IN LBMOL/HR-SQFT-MOLFRAC)

PACKING PARAMETERS ('*' INDICATES USER-PROVIDED DATA)

SURFACE AREA, SQFT/CUFT	48.0
EFFECTIVE DIAMETER, FEET	0.202
PACKING FACTOR, SQFT/CUFT	16.
SURFACE TENSION, DYNES/CM	33.
PACKED DEPTH SAFETY FACTOR	1.25

```
AIR STRIPPER SIZE/PERFORMANCE -- CH2M HILL, INC.; VERSION NUMBER: 2.15

CLIENT  MCCLELLAN AFB                          DATE          18-AUG-93
JOB NO.          USR$PRID                      TIME          16:26:38
DESCRIPTION EXISTING STRIPPER                  BY            CVO_OBERT

     OPERATING CONDITIONS   ('*' INDICATES USER-PROVIDED DATA)
COLUMN DIAMETER, FEET                                         8.0(*)
PACKED DEPTH, FEET  (FACTOR-OF-SAFETY 1.25 INCLUDED)         23.0(*)
PACKING TYPE            2.000" Jaeger Tri-Packs               plastic   (*)
WATER TEMPERATURE, T IN DEGREES F                            90.0(*)
WATER FLOW, GPM @ T                                        1000.0(*)
AIR FLOW, SCFM @ 60 F                                      1750.0(*)
AIR:WATER (VOL @ 60 F:VOL @ T)                               13.1

     COLUMN PERFORMANCE  ('*' INDICATES USER-PROVIDED DATA)
COMPOUND          cisDCE     ClForm     PCE
% REMOVAL         96.05      99.30      99.98       0.00        0.00
PRESSURE DROP, INCHES OF WATER:     0.000/FOOT           0.00 TOTAL
For pressure drop correlation curve, X-   2.12805, Y-   0.00677.

     PHYSICAL PROPERTIES OF CONTAMINANTS  ('*' INDICATES USER-PROVIDED)
COMPOUND          cisDCE     ClForm     PCE
H,ATM/MOLFRC      184.9      300.4      1870.7       0.0         0.0
DL, SQFT/HR     5.05E-05   4.85E-05   3.33E-05   0.00E+00    0.00E+00
DG, SQFT/HR     0.3781     0.3673     0.3072     0.0000      0.0000
MOL WT            96.9       119.4      165.8        0.0         0.0

PHASE                                          AIR          WATER
DENSITY, LB/CUFT                             0.0722          62.1
VISCOSITY, CP                                0.01854        0.7644
SURF. TENSION, DYN/CM                                        70.2

     MASS TRANSFER PROPERTIES FOR EACH CONTAMINANT
COMPOUND            cisDCE     ClForm     PCE
STRIPPING FACT       1.84       2.99      18.60       0.00        0.00
LOCAL kL          14.5582    14.2616    11.8146     0.0000      0.0000
LOCAL kG          0.06027    0.05912    0.05248    0.00000     0.00000
kL/kG              241.55     241.22     225.13       0.00        0.00
OVERALL KL         6.3118     7.9103    10.5455     0.0000      0.0000
WETTED A, FT2/FT3  25.9       25.9       25.9        25.9        25.9
KLA                163.55     204.97     273.25       0.00        0.00
HTOL, FEET           3.37       2.69       2.02       0.00        0.00
NTOL                 5.46       6.85       9.13       0.00        0.00
(KL, kL, AND kG ARE IN LBMOL/HR-SQFT-MOLFRAC)

     PACKING PARAMETERS  ('*' INDICATES USER PROVIDED DATA)
     ------- ----------
SURFACE AREA, SQFT/CUFT                                      48.0
EFFECTIVE DIAMETER, FEET                                    0.202
PACKING FACTOR, SQFT/CUFT                                     16.
SURFACE TENSION, DYNES/CM                                     33.
PACKED DEPTH SAFETY FACTOR                                   1.25
```

AIR STRIPPER SIZE/PERFORMANCE -- CH2M HILL, INC.; VERSION NUMBER: 2.15

CLIENT	MCCLELLAN AFB	DATE	18-AUG-93
JOB NO.	USR$PRID	TIME	16:27:14
DESCRIPTION	EXISTING STRIPPER	BY	CVO_OBERT

OPERATING CONDITIONS ('*' INDICATES USER-PROVIDED DATA)

COLUMN DIAMETER, FEET		8.0(*)
PACKED DEPTH, FEET (FACTOR-OF-SAFETY 1.25 INCLUDED)		23.0(*)
PACKING TYPE	2.000" Jaeger Tri-Packs	plastic (*)
WATER TEMPERATURE, T IN DEGREES F		90.0(*)
WATER FLOW, GPM @ T		1000.0(*)
AIR FLOW, SCFM @ 60 F		1750.0(*)
AIR:WATER (VOL @ 60 F:VOL @ T)		13.1

COLUMN PERFORMANCE ('*' INDICATES USER-PROVIDED DATA)

COMPOUND	trDCE	TCE	Tol	VinCl	
% REMOVAL	99.83	99.97	99.85	99.99	0.00

PRESSURE DROP, INCHES OF WATER: 0.000/FOOT 0.00 TOTAL

For pressure drop correlation curve, X- 2.12805, Y- 0.00677.

MeCl2
97.41

PHYSICAL PROPERTIES OF CONTAMINANTS ('*' INDICATES USER-PROVIDED)

COMPOUND	trDCE	TCE	Tol	VinCl	
H,ATM/MOLFRC	424.6	807.1	514.7	577751.4	0.0
DL, SQFT/HR	5.05E-05	4.44E-05	4.21E-05	5.95E-05	0.00E+00
DG, SQFT/HR	0.3781	0.3362	0.3244	0.4458	0.0000
MOL WT	96.9	131.4	92.2	62.5	0.0

PHASE	AIR	WATER
DENSITY, LB/CUFT	0.0722	62.1
VISCOSITY, CP	0.01854	0.7644
SURF. TENSION, DYN/CM		70.2

MASS TRANSFER PROPERTIES FOR EACH CONTAMINANT

COMPOUND	trDCE	TCE	Tol	VinCl	
STRIPPING FACT	4.22	8.02	5.12	5743.28	0.00
LOCAL kL	14.5582	13.6493	13.2897	15.7969	0.0000
LOCAL kG	0.06027	0.05573	0.05442	0.06726	0.00000
kL/kG	241.55	244.91	244.21	234.85	0.00
OVERALL KL	9.2797	10.4718	9.0129	15.7905	0.0000
WETTED A, FT2/FT3	25.9	25.9	25.9	25.9	25.9
KLA	240.45	271.34	233.54	409.16	0.00
HTOL, FEET	2.29	2.03	2.36	1.35	0.00
NTOL	8.03	9.07	7.80	13.67	0.00

(KL, kL, AND kG ARE IN LBMOL/HR-SQFT-MOLFRAC)

PACKING PARAMETERS ('*' INDICATES USER-PROVIDED DATA)

SURFACE AREA, SQFT/CUFT	48.0
EFFECTIVE DIAMETER, FEET	0.202
PACKING FACTOR, SQFT/CUFT	16.
SURFACE TENSION, DYNES/CM	33.
PACKED DEPTH SAFETY FACTOR	1.25

AIR STRIPPER SIZE/PERFORMANCE -- CH2M HILL, INC.; VERSION NUMBER: 2.15

CLIENT	MCCLELLAN AFB	DATE	18-AUG-93
JOB NO.	USR$PRID	TIME	16:32:37
DESCRIPTION	EXISTING STRIPPER	BY	CVO_OBERT

OPERATING CONDITIONS ('*' INDICATES USER-PROVIDED DATA)

COLUMN DIAMETER, FEET		8.0(*)
PACKED DEPTH, FEET (FACTOR-OF-SAFETY 1.25 INCLUDED)		23.0(*)
PACKING TYPE	2.000" Jaeger Tri-Packs	plastic (*)
WATER TEMPERATURE, T IN DEGREES F		72.0(*)
WATER FLOW, GPM @ T		2400.0(*)
A. FLOW, SCFM @ 60 F		1750.0(*)
AIR:WATER (VOL @ 60 F:VOL @ T)		5.5

COLUMN PERFORMANCE ('*' INDICATES USER-PROVIDED DATA)

COMPOUND	111TCA	112TCA	1,1DCA	1,1DCE	1,2DCA
% REMOVAL	99.14	23.09	81.84	98.88	21.42

DUBIOUS RESULTS: X VALUE TOO HIGH TO CALCULATE PRESSURE DROP!
For pressure drop correlation curve, X= 5.20022, Y= 0.00667.

PHYSICAL PROPERTIES OF CONTAMINANTS ('*' INDICATES USER-PROVIDED)

COMPOUND	111TCA	112TCA	1,1DCA	1,1DCE	1,2DCA
H,ATM/MOLFRC	1328.1	57.0	277.0	938.3	52.6
DL, SQFT/HR	3.32E-05	3.32E-05	3.74E-05	3.93E-05	3.74E-05
DG, SQFT/HR	0.3111	0.3111	0.3486	0.3567	0.3486
MOL WT	133.4	133.4	98.9	96.9	98.9

PHASE	AIR	WATER
DENSITY, LB/CUFT	0.0746	62.3
VISCOSITY, CP	0.01808	0.9528
SURF. TENSION, DYN/CM		71.9

MASS TRANSFER PROPERTIES FOR EACH CONTAMINANT

COMPOUND	111TCA	112TCA	1,1DCA	1,1DCE	1,2DCA
STRIPPING FACT	5.49	0.24	1.14	3.88	0.22
LOCAL kL	15.6005	15.6005	16.5644	16.9803	16.5644
LOCAL kG	0.05461	0.05461	0.05891	0.05982	0.05891
kL/kG	285.69	285.69	281.18	283.85	281.18
OVERALL KL	12.8387	2.5957	8.2199	13.0364	2.6089
WETTED A, FT2/FT3	31.3	31.3	31.3	31.3	31.3
KLA	401.64	81.20	257.14	407.82	81.61
HTOL, FEET	3.30	16.32	5.15	3.25	16.24
NTOL	5.58	1.13	3.57	5.66	1.13

(KL, kL, AND kG ARE IN LBMOL/HR-SQFT-MOLFRAC)

PACKING PARAMETERS ('*' INDICATES USER-PROVIDED DATA)
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SURFACE AREA, SQFT/CUFT	48.0
EFFECTIVE DIAMETER, FEET	0.202
PACKING FACTOR, SQFT/CUFT	16.
SURFACE TENSION, DYNES/CM	33.
PACKED DEPTH SAFETY FACTOR	1.25

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AIR STRIPPER SIZE/PERFORMANCE -- CH2M HILL, INC.; VERSION NUMBER: 2.15

CLIENT  MCCLELLAN AFB                          DATE          18-AUG-93
JOB NO.            USR$PRID                    TIME          16:34:26
DESCRIPTION EXISTING STRIPPER                  BY            CVO_OBERT

     OPERATING CONDITIONS   ('*' INDICATES USER-PROVIDED DATA)
COLUMN DIAMETER, FEET                                         8.0(*)
PACKED DEPTH, FEET  (FACTOR-OF-SAFETY 1.25 INCLUDED)         23.0(*)
PACKING TYPE           2.000" Jaeger Tri-Packs                plastic    (*)
WATER TEMPERATURE, T IN DEGREES F                            90.0(*)
WATER FLOW, GPM @ T                                        2400.0(*)
AIR FLOW, SCFM @ 60 F                                      3000.0(*)
AIR:WATER (VOL @ 60 F:VOL @ T)                                9.4

     COLUMN PERFORMANCE  ('*' INDICATES USER-PROVIDED DATA)
COMPOUND          111TCA     112TCA     1,1DCA     1,1DCE     1,2DCA
% REMOVAL          99.96      59.32      99.08      99.97      54.27
PRESSURE DROP, INCHES OF WATER:      0.000/FOOT          0.01 TOTAL
For pressure drop correlation curve, X-   2.97928, Y-   0.01989.

     PHYSICAL PROPERTIES OF CONTAMINANTS  ('*' INDICATES USER-PROVIDED)
COMPOUND          111TCA     112TCA     1,1DCA     1,1DCE     1,2DCA
H,ATM/MOLFRC     2209.2       95.3      450.1     1568.6       83.7
DL, SQFT/HR    4.27E-05   4.27E-05   4.81E-05   5.05E-05   4.81E-05
DG, SQFT/HR     0.3297     0.3297     0.3695     0.3781     0.3695
MOL WT           133.4      133.4       98.9       96.9       98.9

PHASE                                          AIR          WATER
DENSITY, LB/CUFT                             0.0722          62.1
VISCOSITY, CP                                0.01854        0.7644
SURF. TENSION, DYN/CM                                        70.2

     MASS TRANSFER PROPERTIES FOR EACH CONTAMINANT
COMPOUND            111TCA     112TCA     1,1DCA     1,1DCE     1,2DCA
STRIPPING FACT       15.69       0.68       3.20      11.14       0.59
LOCAL kL           20.8074    20.8074    22.0930    22.6477    22.0930
LOCAL kG           0.08023    0.08023    0.08656    0.08789    0.08656
kL/kG               259.33     259.33     255.24     257.67     255.24
OVERALL KL         18.6214     5.5928    14.0977    19.4523     5.4552
WETTED A, FT2/FT3  32.0         32.0       32.0       32.0       32.0
KLA                 596.78     179.24     451.80     623.41     174.83
HTOL, FEET            2.21       7.37       2.93       2.12       7.56
NTOL                  8.31       2.50       6.29       8.68       2.43
(KL, kL, AND kG ARE IN LBMOL/HR-SQFT-MOLFRAC)

     PACKING PARAMETERS  ('*' INDICATES USER-PROVIDED DATA)
     ------- ----------
SURFACE AREA, SQFT/CUFT                                      48.0
EFFECTIVE DIAMETER, FEET                                    0.202
PACKING FACTOR, SQFT/CUFT                                     16.
SURFACE TENSION, DYNES/CM                                     33.
PACKED DEPTH SAFETY FACTOR                                   1.25
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AIR STRIPPER SIZE/PERFORMANCE -- CH2M HILL, INC.; VERSION NUMBER: 2.15

CLIENT	MCCLELLAN AFB	DATE	18-AUG-93
JOB NO.	USR$PRID	TIME	16:35:13
DESCRIPTION	EXISTING STRIPPER	BY	CVO_OBERT

OPERATING CONDITIONS ('*' INDICATES USER-PROVIDED DATA)

COLUMN DIAMETER, FEET		8.0(*)
PACKED DEPTH, FEET (FACTOR-OF-SAFETY 1.25 INCLUDED)		23.0(*)
PACKING TYPE	2.000" Jaeger Tri-Packs	plastic (*)
WATER TEMPERATURE, T IN DEGREES F		90.0(*)
WATER FLOW, GPM @ T		2400.0(*)
AIR FLOW, SCFM @ 60 F		3000.0(*)
AIR:WATER (VOL @ 60 F:VOL @ T)		9.4

COLUMN PERFORMANCE ('*' INDICATES USER-PROVIDED DATA)

COMPOUND	cisDCE	ClForm	PCE		
% REMOVAL	87.92	96.78	99.89	0.00	0.00

PRESSURE DROP, INCHES OF WATER: 0.000/FOOT 0.01 TOTAL
For pressure drop correlation curve, X- 2.97928, Y- 0.01989.

PHYSICAL PROPERTIES OF CONTAMINANTS ('*' INDICATES USER-PROVIDED)

COMPOUND	cisDCE	ClForm	PCE		
H,ATM/MOLFRC	184.9	300.4	1870.7	0.0	0.0
DL, SQFT/HR	5.05E-05	4.85E-05	3.33E-05	0.00E+00	0.00E+00
DG, SQFT/HR	0.3781	0.3673	0.3072	0.0000	0.0000
MOL WT	96.9	119.4	165.8	0.0	0.0

PHASE	AIR	WATER
DENSITY, LB/CUFT	0.0722	62.1
VISCOSITY, CP	0.01854	0.7644
SURF. TENSION, DYN/CM		70.2

MASS TRANSFER PROPERTIES FOR EACH CONTAMINANT

COMPOUND	cisDCE	ClForm	PCE		
STRIPPING FACT	1.31	2.13	13.28	0.00	0.00
LOCAL kL	22.6477	22.1864	18.3796	0.0000	0.0000
LOCAL kG	0.08789	0.08622	0.07653	0.00000	0.00000
kL/kG	257.67	257.32	240.16	0.00	0.00
OVERALL KL	9.4613	11.9507	16.2885	0.0000	0.0000
WETTED A, FT2/FT3	32.0	32.0	32.0	32.0	32.0
KLA	303.22	382.99	522.01	0.00	0.00
HTOL, FEET	4.36	3.45	2.53	0.00	0.00
NTOL	4.22	5.33	7.27	0.00	0.00

(KL, kL, AND kG ARE IN LBMOL/HR-SQFT-MOLFRAC)

PACKING PARAMETERS ('*' INDICATES USER-PROVIDED DATA)
------- ----------

SURFACE AREA, SQFT/CUFT	48.0
EFFECTIVE DIAMETER, FEET	0.202
PACKING FACTOR, SQFT/CUFT	16.
SURFACE TENSION, DYNES/CM	33.
PACKED DEPTH SAFETY FACTOR	1.25

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AIR STRIPPER SIZE/PERFORMANCE -- CH2M HILL, INC.; VERSION NUMBER: 2.15

CLIENT  MCCLELLAN AFB                          DATE          18-AUG-93
JOB NO.          USR$PRID                      TIME          16:35:51
DESCRIPTION EXISTING STRIPPER                  BY            CVO_OBERT

     OPERATING CONDITIONS   ('*' INDICATES USER PROVIDED DATA)
COLUMN DIAMETER, FEET                                      8.0(*)
PACKED DEPTH, FEET  (FACTOR-OF-SAFETY 1.25 INCLUDED)      23.0(*)
PACKING TYPE            2.000" Jaeger Tri-Packs           plastic   (*)
WATER TEMPERATURE, T IN DEGREES F                         90.0(*)
WATER FLOW, GPM @ T                                     2400.0(*)
AIR FLOW, SCFM @ 60 F                                   3000.0(*)
AIR:WATER (VOL @ 60 F:VOL @ T)                             9.4

     COLUMN PERFORMANCE  ('*' INDICATES USER-PROVIDED DATA)
COMPOUND          trDCE       TCE         Tol        VinCl
% REMOVAL         99.00       99.78       99.15      99.99        0.00
PRESSURE DROP, INCHES OF WATER:      0.000/FOOT            0.01 TOTAL
For pressure drop correlation curve, X=   2.97928, Y=   0.01989.

     PHYSICAL PROPERTIES OF CONTAMINANTS  ('*' INDICATES USER PROVIDED)
COMPOUND          trDCE       TCE         Tol        VinCl
H,ATM/MOLFRC      424.6       807.1       514.7    577751.4        0.0
DL, SQFT/HR    5.05E-05    4.44E-05    4.21E-05    5.95E-05    0.00E+00
DG, SQFT/HR      0.3781      0.3362      0.3244      0.4458      0.0000
MOL WT             96.9       131.4        92.2        62.5         0.0

PHASE                                          AIR          WATER
DENSITY, LB/CUFT                             0.0722          62.1
VISCOSITY, CP                                0.01854         0.7644
     TENSION, DYN/CM                                         70.2

     MASS TRANSFER PROPERTIES FOR EACH CONTAMINANT
COMPOUND           trDCE       TCE         Tol        VinCl
STRIPPING FACT      3.02        5.73        3.65     4102.34        0.00
LOCAL kL         22.6477     21.2337     20.6744     24.5748      0.0000
LOCAL kG         0.08789     0.08128     0.07936     0.09809     0.00000
kL/kG             257.67      261.26      260.51      250.53        0.00
OVERALL KL       14.0950     16.0415     13.7263     24.5641      0.0000
WETTED A, FT2/FT3  32.0        32.0        32.0        32.0         32.0
KLA               451.72      514.10      439.90      787.23        0.00
HTOL, FEET          2.93        2.57        3.00        1.C8        0.00
NTOL                6.29        7.16        6.12       10.96        0.00
(KL, kL, AND kG ARE IN LBMOL/HR-SQFT-MOLFRAC)

     PACKING PARAMETERS  ('*' INDICATES USER-PROVIDED DATA)
     ------- ----------
SURFACE AREA, SQFT/CUFT                                  48.0
EFFECTIVE DIAMETER, FEET                                 0.202
PACKING FACTOR, SQFT/CUFT                                16.
SURFACE TENSION, DYNES/CM                                33.
PACKED DEPTH SAFETY FACTOR                               1.25
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MeCl2
90.78

Attachment A-3
Activated Carbon
Performance Estimates

CARBON USAGE ESTIMATES
Filename:GACMCS1.XLS

Compound	Isotherm Constants(1) K (mg/g)	Isotherm Constants(1) 1/n	Max Eff (ug/L)	Maximum Influent Conc(ug/L)	% Removal Required	X/M (mg/g)	Carbon Usage Rate: Isotherm Est. (lb/1,000gal)	Carbon Usage Rate: Safety Factor(2)	Carbon Usage Rate: Predicted(3) (lb/1,000gal)	Replacement Frequency(4) (Days)
Benzene	50	0.533	0.5	0	#DIV/0!	0.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Toluene	97	0.43	0.5	2.88	82.64	7.84	0.00	12.73	0.05	800
Ethylbenzene	176.69	0.53	0.5	0	#DIV/0!	0.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Xylene	584.3	0.55	0.5	0	#DIV/0!	0.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Trichloroethylene	55.9	0.48	0.5	164	99.70	23.47	0.08	3.03	0.24	177
Tetrachloroethylene	143	0.52	0.5	2.1	76.19	5.79	0.00	12.81	0.05	805
1,1,1-Trichloroethane	13.0	0.53	0.5	35	98.57	2.20	0.18	2.03	0.36	116
1,2-Dichloroethane	1.2	0.533	0.5	3.6	86.11	0.06	0.67	1.06	0.71	59
cis-1,2-Dichloroethylene	15	0.526	0.5	17.4	97.13	1.78	0.11	2.57	0.28	149
Chloroform	2.9	0.73	0.5	1.7	70.59	0.03	0.69	1.05	0.72	58
1,1,2 TCA	5.8	0.6	0.5	1	50.00	0.09	0.12	2.44	0.30	141
1,1 DCA	2.4	0.53	0.5	16.9	97.04	0.28	0.68	1.05	0.72	58
1,1 DCE	35	0.54	0.5	281.9	99.82	17.67	0.18	2.02	0.36	116
1,2 DCBENZENE	129	0.43	0.5	0	#DIV/0!	0.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
T 1,2 DCE	3.1	0.51	0.5	0.9	44.44	0.09	0.12	2.50	0.29	144
VINYL CHLORIDE	2.7	0.95	0.5	39.6	98.74	0.13	3.50	1.00	3.50	12
Bromodichloromethane	7.9	0.61	100	11	-809.09	0.50	0.24	1.74	0.42	99

GAC SYSTEM SIZING	
Flowrate(MGD):	0.482
EBCT(minutes):	16
Volume of GAC(ft:	716
GAC Density(lb/f	28
Weight of GAC(lb:	20048

Notes:
(1) - From Speth, et.al. "EPA's Research Program In Granular Activated Carbon," in Design and Use of GAC, AWWA/EPA Tech Transfer Conf. May 9-10, 1989, Cincinnati, Ohio
(2) - From "Developing Carbon Usage Rate Estimates for Synthetic Organic Chemicals"
(3) - Predicted = Isotherm * Safety Factor
(4) - Based on continuous operation at the given influent conditions
vinyl chloride freundlich constarts estimated from chloroethane (1/n) factor and calgon estimate of 20,000 lbs lasting 30 days
11 DCE , chloroform and 11 DCA Kf factors adjusted to match calgon prediction of 60 days at 20000 lbs of carbon

CARBON USAGE ESTIMATES
Filename:GACMCS2.xls

Compound	Isotherm Constants(1) K (mg/g)	Isotherm Constants(1) 1/n	Max Eff (ug/L)	Maximum Influent Conc(ug/L)	% Removal Required	X/M (mg/g)	Carbon Usage Rate: Isotherm Est. (lb/1,000gal)	Carbon Usage Rate: Safety Factor(2)	Carbon Usage Rate: Predicted(3) (lb/1,000gal)	Replacement Frequency(4) (Days)
Benzene	50	0.533	0.5	0	#DIV/0!	0.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Toluene	97	0.43	0.5	0.0006	-83233.3	0.20	0.00	134.27	0.00	9510
Ethylbenzene	176.69	0.53	0.5	0	#DIV/0!	0.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Xylene	584.3	0.55	0.5	0	#DIV/0!	0.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Trichloroethylene	55.9	0.48	0.5	0.08295	-502.8	0.61	0.00	20.74	0.03	1336
Tetrachloroethylene	143	0.52	0.5	6E-05	########	0.03	0.00	148.32	0.00	10558
1,1,1-Trichloroethane	13.0	0.53	0.5	0.0022	-22627.3	0.01	0.00	18.61	0.03	1192
1,2-Dichloroethane	1.2	0.533	0.5	2.208	77.4	0.05	0.53	1.18	0.63	66
cis-1,2-Dichloroethylene	15	0.526	0.5	0.0948	-427.4	0.11	0.01	8.58	0.08	528
Chloroform	2.9	0.73	0.5	0.0014	-35614.3	0.00	0.10	2.67	0.27	155
1,1,2 TCA	5.8	0.6	0.5	0.02508	-1893.6	0.01	0.03	5.01	0.14	300
1,1 DCA	2.4	0.53	0.5	0.00345	-14392.8	0.00	0.01	7.36	0.09	450
1,1 DCE	35	0.54	0.5	0.00388	-12786.6	0.04	0.00	24.92	0.03	1620
1,2 DCBENZENE	129	0.43	0.5	0	#DIV/0!	0.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
T 1,2 DCE	3.1	0.51	0.5	0.00017	########	0.00	0.00	19.36	0.03	1243
VINYL CHLORIDE	2.7	0.95	0.5	0.00054	-92492.6	0.00	2.00	1.00	2.00	21

GAC SYSTEM SIZING	
Flowrate(MGD):	0.482
EBCT(minutes):	16
Volume of GAC(ft3):	716
GAC Density(lb/ft3)	28
Weight of GAC(lbs):	20048

Notes:
(1) - From Speth, et.al. "EPA's Research Program In Granular Activated Carbon," in Design and Use of GAC, AWWA/EPA Tech Transfer Conf. May 9-10, 1989, Cincinnati, Ohio
(2) - From "Developing Carbon Usage Rate Estimates for Synthetic Organic Chemicals"
(3) - Predicted = Isotherm * Safety Factor
(4) - Based on continuous operation at the given influent conditions
vinyl chloride freundlich constants estimated from chloroethane (1/n) factor and calgon estimate of 20,000 lbs lasting 30 days
11 DCE , chloroform and 11 DCA Kf factors adjusted to match calgon prediction of 60 days at 20000 lbs of carbon

CARBON USAGE ESTIMATES
Filename:GACMCS3.xls

Compound	Isotherm Constants(1) K (mg/g)	1/n	Max Eff (ug/L)	Maximum Influent Conc(ug/L)	% Removal Required	X/M (mg/g)	Carbon Usage Rate: Isotherm Est. (lb/1,000gal)	Safety Factor(2)	Predicted(3) (lb/1,000gal)	Replacement Frequency(4) (Days)
Benzene	50	0.533	0.5	0	#DIV/0!	0.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Toluene	97	0.43	0.5	0.00765	-6435.9	0.61	0.00	66.18	0.01	4522
Ethylbenzene	176.69	0.53	0.5	0	#DIV/0!	0.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Xylene	584.3	0.55	0.5	0	#DIV/0!	0.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Trichloroethylene	55.9	0.48	0.5	0.32669	-53.1	1.19	0.00	14.65	0.04	927
Tetrachloroethylene	143	0.52	0.5	0.00091	-54845.1	0.10	0.00	78.49	0.01	5409
1,1,1-Trichloroethane	13.0	0.53	0.5	0.00996	-4920.1	0.03	0.00	13.16	0.05	829
1,2-Dichloroethane	1.2	0.533	0.5	3.93278	87.3	0.06	0.70	1.04	0.72	57
cis-1,2-Dichloroethylene	15	0.526	0.5	0.68856	27.4	0.33	0.02	5.42	0.13	326
Chloroform	2.9	0.73	0.5	0.0161	-3005.6	0.00	0.19	1.93	0.38	110
1,1,2 TCA	5.8	0.6	0.5	0.12204	-309.7	0.03	0.05	3.68	0.19	217
1,1 DCA	2.4	0.53	0.5	0.0506	-888.1	0.01	0.04	3.98	0.18	236
1,1 DCE	35	0.54	0.5	0.0279	-1692.1	0.12	0.00	16.01	0.04	1018
1,2 DCBENZENE	129	0.43	0.5	0	#DIV/0!	0.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
T 1,2 DCE	3.1	0.51	0.5	0.003	-16566.7	0.00	0.01	9.75	0.07	605
VINYL CHLORIDE	2.7	0.95	0.5	0.00131	-38067.9	0.00	2.09	1.00	2.09	20

GAC SYSTEM SIZING	
Flowrate(MGD):	0.482
EBCT(minutes):	16
Volume of GAC(ft3):	716
GAC Density(lb/ft3)	28
Weight of GAC(lbs):	20048

Notes:
(1) - From Speth, et.al. "EPA's Research Program In Granular Activated Carbon," in Design and Use of GAC, AWWA/EPA Tech Transfer Conf. May 9-10, 1989, Cincinnati, Ohio
(2) - From "Developing Carbon Usage Rate Estimates for Synthetic Organic Chemicals"
(3) - Predicted = Isotherm * Safety Factor
(4) - Based on continuous operation at the given influent conditions
vinyl chloride freundlich constants estimated from chloroethane (1/n) factor and calgon estimate of 20,000 lbs lasting 30 days
11 DCE , chloroform and 11 DCA Kf factors adjusted to match calgon prediction of 60 days at 20000 lbs of carbon

Attachment A-4
Field Testing Results

GWTP WATER FLOW RATE TEST BY M & E

Alec Elgal / EMR / July 93

A series of three tests were run on the GWTP to observe the performance of the plant at higher than current flow rates. The primary objective was in support of the anticipated increased flow rate resulting from the water to be pumped from OUB wells EW-63, 246, 247, which would raise it to approximately 350 GPM. However, the opportunity was used to obtain additional data for higher flow rates.

	INCINERATOR	GAS-TO-GAS HEAT EXCHANGER	SPACE	GAS-TO-WATER HEAT EXCHANGER	TRANSITION	SCRUBBER
RUN 1 Water 250 GPM Air 850 CFM A/W 25/1	1800 F	1210 F (T Drop=590 F)	1020 F	500 F (T Drop=520 F)		Water 150 F
RUN 2 Water 500 GPM Air 1020 CFM A/W 15/1	1800 F	1230 F (T Drop=570 F)	1040 F	520 F (T Drop=520 F)		Water 155 F
RUN 3 Water 750 GPM Air 1700 CFM A/W 17/1	1800 F	1260 F (T Drop=540 F)	1080 F	680 F (T Drop=400 F)		Water 159 F

The critical parameter is considered to be the temperature inside the scrubber at the bottom screen supporting the packing which is desired to be kept below boiling point of water 212 F. This screen is about four feet above the transition inlet to the scrubber. The scrubber was originally designed for double the air flow capacity, that is, 3200 CFM and as it can be noticed for 750 GPM water flow rate the air flow rate was 1700 CFM or half the capability. It should also be noted that for obtaining variation in data progression 1020 CFM was used instead of 1200 CFM for the 500 GPM flow rate.

Raising the flow rate of the plant from 250 to 750 GPM resulted in an increase in temperature of the water temperature inside of the scrubber from 150 F to 159 F. This is a satisfactory performance. From a view point of trying to determine whether there is a need to modify the plant by installing a secondary heat exchanger it can be concluded that there is no need at this time. The secondary heat exchanger was removed in May due to rusting and with cost of replacement considerations it was not replaced due to the current anticipated relatively low flow rates.

It is concluded that even for 750 GPM the focus should be on the scrubber temperature and not the consideration of a need for a secondary heat exchanger. If needed the scrubber recirculation can be increased slightly to accommodate 750 GPM with an addtional margin of safety for keeping the temperature down. More importantly for the current anticipated flow rates of 350 GPM for the added support of OU8 we have an ample margin of safety.

As a historical note, the plant was designed for 1000 GPM and tested for acceptance. Subsequently, numerous modifications were made with convenience in mind rather than maintaining the 1000 GPM capability, particularly that such high flow rates were not being anticipated. One significant modification was the removal of the water-to-gas heat exhanger from just down stream of the incinerator and installing in its present position of just upstream of the scrubber. This decision was made due to observation of the tendency for condensation of halides and the resulting rust and corrosion. Thus, the 1000 GPM capability was compromised somewhat. The present system hardware is capable of 750 GPM as it stands now.

PREPARED FOR: McClellan Air Force Base

DATE: March 23, 1994

SUBJECT: Risk Assessment Methodology
Groundwater Operable Unit RI/FS
Delivery Order No. 5066

PROJECT: SAC28722.66.RA

Introduction

The risk assessment addresses two primary needs in the Groundwater Operable Unit (GW OU) Remedial Investigation/Feasibility Study (RI/FS) for McClellan AFB. First, it provides some of the necessary interpretations and calculations to support the development of target volumes for remedial actions. Target volumes represent volumes of groundwater with contaminants that could pose unacceptable risks to users, should that water be used. Once established, these target volumes are then used in the development of remedial action alternatives. Second, the risk assessment addresses the requirement for a baseline risk assessment in an RI/FS, as required by the National Contingency Plan (NCP) (40 CFR 300.430 (d)(1)). The primary purpose of the baseline risk assessment is to provide risk managers with an understanding of the actual and potential risks to human health and the environment posed by the site and any uncertainties associated with the assessment. This information may be useful in determining whether a current or potential threat to human health or the environment exists that warrants remedial action (U.S. EPA, 1990a; 1991a).

Remedial actions performed by McClellan AFB have rendered remote the likelihood that contaminated groundwater is being used in and around the base. Therefore, the existing understanding of site conditions indicates there probably are no exposure pathways to human populations from groundwater contamination. However, this understanding is not complete. In particular, the lateral and vertical extent of contamination in OU A is inadequately defined, and contamination possibly extends offbase, potentially threatening nearby municipal and industrial supply wells. No remedial action is in place in OU A for controlling potential exposures to groundwater contaminants. Also, it is uncertain if risks could increase with future use of groundwater. For example, there are few institutional controls on placement of a private domestic well within a contaminated aquifer (there are, however, several regulatory constraints prohibiting a municipal water purveyor from using contaminated groundwater). Finally, California requirements (specifically the aquifer antidegradation policy enforced by the Regional Water Quality Control Boards) prohibit degradation of water quality such that it affects the designated use of the aquifer.

In response to this state requirement, and for calculation of target volumes, the risk assessment has used the assumption that residential use of groundwater and residential exposure pathways (ingestion, inhalation of VOCs, and dermal contact with groundwater) were possible at any location within the contaminant plumes, regardless of the constraints on groundwater use or reasonable consideration of the pathways of exposure. It must be strongly emphasized that numerical estimates of health risks used to support development of target volumes do not reflect the magnitude of potential health risks to the surrounding public, but simply represent a convenient method for characterizing the nature and extent of groundwater contamination within a standardized public health context. This means that different types and concentrations of contaminants can be standardized in terms of exposure and toxicity to allow comparison of groundwater contamination in different areas, and in setting priorities. For example, risk assessment can be used to compare relatively higher concentrations of a lower-toxicity substance such as trichloroethene (TCE) alongside relatively lower concentrations of a higher-toxicity substance such as vinyl chloride.

Approach to the Risk Assessment

This baseline risk assessment was based on exposure scenarios that estimated the reasonable maximum exposure (RME). The RME is defined as the highest exposure that is reasonably expected to occur at a site. RMEs are estimated for individual exposure pathways. If a population is exposed via more than one pathway, the combination of exposures across pathways must also represent an RME. The intent of the RME is to develop a conservative estimate of exposure (i.e., well above the average case) that is still within the range of possible exposures (U.S. EPA, 1989).

Elements of Risk Assessment

The elements of the risk assessment are as follows:

- Identification of the chemicals of potential concern (COPCs)
- Exposure assessment
- Toxicity assessment
- Risk characterization

These elements are presented in Figure B-1.

As described below, COPCs consist of any contaminant detected in groundwater with available U.S. Environmental Protection Agency (EPA) or California Environmental Protection Agency (Cal-EPA) toxicity criteria.

Exposure refers to the potential contact of an individual with a chemical. Exposure assessment is the estimation of the magnitude, frequency, duration, and routes of exposure to a chemical. Human exposure to chemicals is typically evaluated by estimating the amount of a chemical which could come into contact with the lungs, gastrointestinal tract, or skin during a specified period of time. This exposure assessment is based on scenarios that define human populations potentially exposed to

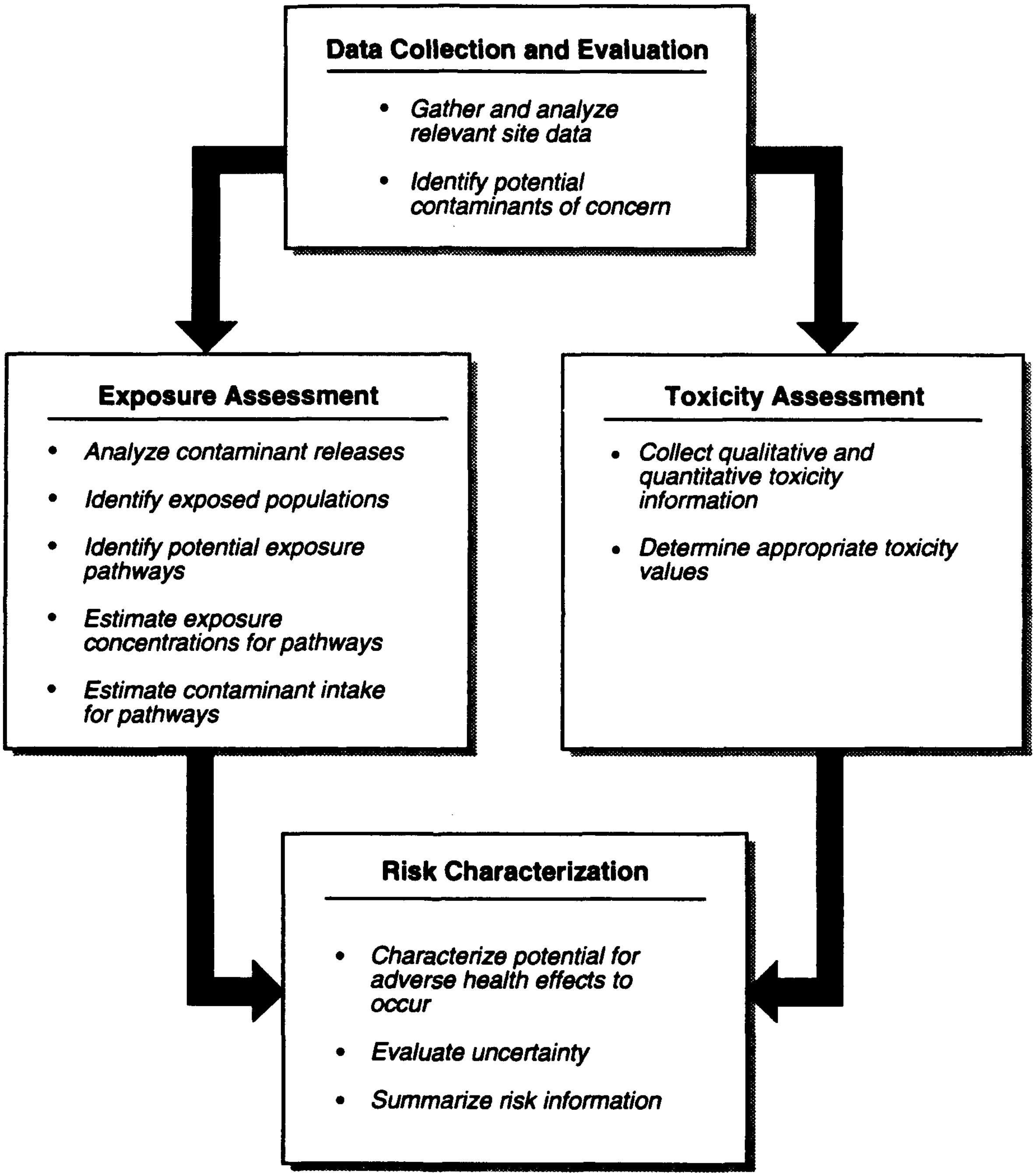

FIGURE B-1
ELEMENTS OF RISK ASSESSMENT
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

RDD1454_101

CH2M HILL

contaminants of concern (COCs) originating from the site. The potential pathways of exposure; frequency and duration of potential exposures; rates of contact with air, water, and soil; and the concentrations of chemicals in air, groundwater, or soil are evaluated in the assessment of human intake of COPCs. Chemical intakes and associated risks have been quantified for all exposure pathways considered potentially complete.

Chemical intakes are expressed as the amount of chemical at the exchange boundary (i.e., skin, lungs, or gastrointestinal tract) and available for absorption. Please note that in keeping with EPA guidance, intakes for dermal exposure pathways are estimated in terms of absorbed dose and not quantity of chemical at the exchange boundary. Estimates of chemical intakes based on RME scenarios are presented in this section. Chemical intakes were estimated for both adults and children and for both current and future land use. Calculations and input parameters used for estimating intake rates through the inhalation, soil ingestion, groundwater ingestion, and dermal contact with soil and groundwater pathways were obtained from EPA (U.S. EPA, 1989; 1990b; 1991a). The calculated intake rates are combined with toxicity criteria values (discussed in Section 4.3) to characterize potential health risks.

The calculations used to estimate exposure or intake from contact with chemicals in soil have the same general components: (1) a variable representing chemical concentration, (2) variables describing the characteristics of the exposed population, and (3) an assessment-determined variable that defines the time frame over which exposure occurs. The general mathematical relationship between these variables and chemical intake in humans is:

$$I = \frac{C \times CR \times EF \times ED}{AT \times BW} \qquad (1)$$

where:

I = Intake (mg/kg-day)

C = Average concentration in the contaminated medium contacted over the exposure period (mg/kg, mg/l, or mg/m^3)

CR = Contact rate; the quantity of contaminated medium contacted per unit time (e.g., mg/day)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

AT = Averaging time; period over which exposure is averaged (days)

BW = Body weight (kg)

The calculated intake rates are combined with toxicity criteria values (discussed in Section 4.3) in order to characterize potential health risks.

The toxicity assessment determines the relationship between the magnitude of exposure to a chemical and the adverse health effects. This assessment provides, where possible, a numerical estimate of the increased likelihood and/or severity of adverse effects associated with chemical exposure (U.S. EPA, 1989).

For purposes of the toxicity assessment, the COPCs have been classified into two broad categories: noncarcinogens and carcinogens. This classification has been selected because health risks are calculated quite differently for carcinogenic and noncarcinogenic effects, and separate toxicity values have been developed for them. These toxicity values represent the potential magnitude of adverse health effects associated with exposure to chemicals, and are developed by EPA and Cal-EPA. Toxicity studies with laboratory animals or epidemiological studies of human populations provide the data used to develop these toxicity values. These values represent allowable levels of exposure based upon the results of toxicity studies or epidemiological studies. The toxicity values are then combined with the exposure estimates in the risk characterization process to estimate adverse effects from chemicals potentially originating from groundwater contaminants.

Risk characterization involves estimating the magnitude of the potential adverse health effects under study. This is accomplished by combining the results of the dose-response and exposure assessments to provide numerical estimates of potential health effects. These values represent comparisons of exposure levels with appropriate toxicity threshold values and estimates of excess cancer risk. Risk characterization also considers the nature of and weight of evidence supporting these estimates, as well as the magnitude of uncertainty surrounding such estimates.

Although the risk assessment produces numerical estimates of risk, these numbers do not predict actual health outcomes. The estimates are calculated to overestimate risk, and thus any actual risks are likely to be lower than these estimates, and may even be zero.

Data Sources

Groundwater monitoring data used to develop risk-based target volumes were taken from the Groundwater Sampling and Analysis Program (GSAP) maintained by Radian. Data from the quarterly monitoring program from 1986 to 1993 were used to develop target volumes. Data from these years were selected because they represent a reasonable number of wells and parameters monitored to plot concentration contours, and provide a relatively long period to evaluate the changes in the spatial extent of estimated health risks over time.

Introduction to Sample-Specific Risk Assessment Methodology

For the case where there is a single contaminant in groundwater, the contaminant levels in different wells can be compared to a contaminant-specific ARAR or preliminary remediation goal (PRG) to distinguish areas that require remediation from areas that do not pose unacceptable health risks. However, for the case of multiple contaminants detected in groundwater (as is present at McClellen AFB), the approach used is to integrate individual contaminant concentrations into cumulative increased lifetime cancer risks or hazard indices, based on contaminant levels reported from each sample. Samples with cancer risks or noncancer hazard indices exceeding a defined cut-point of acceptable levels may then be mapped to spatially define areas requiring either treatment or no further action. This approach is referred to as a sample-specific risk assessment methodology. Attributes of the sample-specific risk assessment methodology are:

- Characterizes health risks associated with chemical contaminants detected **in each sample**
- Uses reasonable maximum exposure assumptions for each sample
- Sums risks across chemicals and pathways for each sample
- Represents only a small modification of current risk assessment guidelines
- Has been accepted for use by U.S. EPA Region X

How the sample-specific risk assessment methodology integrates within current EPA risk assessment guidelines is presented in Table B-1. The benefits that the sample-specific methodology provide to the risk assessment for the GW OU FS are presented in Table B-2.

The risk-based target volumes developed through sample-specific risk assessment then identify areas of groundwater that could pose unacceptable health risks should that water be used in the future. Target volumes representing 10^{-6}, 10^{-4}, and 10^{-2} increased lifetime cancer risks and a noncancer hazard index exceeding 1.0 will be mapped using groundwater monitoring data collected at McClellan AFB and risk calculations documented in this technical memorandum.

Note that the calculations and assumptions used to prepare the risk-based target volumes represent health risks associated with a hypothetical future land use scenario, but do not address health risks potentially associated with current conditions in groundwater at McClellan AFB.

Table B-1 Integration of Sample-Specific Methodology within Current Risk Assessment Guidelines	
Current Risk Assessment Guidelines	**Sample-Specific Methodology**
• Assumes simultaneous exposure to multiple chemicals detected across an entire site	• Retains information on spatial distribution of risks throughout the site
• Develops a point estimate of exposure and risk (often a 95 percent UCL of the mean) from the variable contaminant concentrations detected	• Uses all of the same exposure and toxicity parameters
• Most useful for identifying sites where the no-action alternative is feasible	• Estimates exposures and risks for each contaminant detected in each sample • Provides useful input to an FS by identifying portions of a site where remedial action may be required

Table B-2 Benefits of the Sample-Specific Methodology	
Retains spatial information	Retains spatial information inherent in site characterization data. Provides information on how spatially discrete risks could be. The methodology can discriminate site areas that exceed target *risk levels.*
Reduces assumptions	Avoids use of the assumption that UCL exposure concentrations are co-located at the exposure point. Maximum risks are predicted at locations identified by site characterization.
Improves visualization of site risks	Improves visualization of variability in groundwater risks across several sampling rounds using time series and box plots. Facilitates contouring of risks; risk and chemical contours can be compared to identify major contributors to site risks.
Improves RI/FS integration	Allows FS efforts to be focused on specific areas with elevated risks. Facilitates development of volume estimates. Facilitates evaluation of risk reduction associated with remedial action alternatives.
Cost savings	Facilitates potential cost savings in FS and remedial action by identifying discrete areas of unacceptable risks and by streamlining FS analyses.

Site Background

This section provides a description of the land uses surrounding McClellan AFB and uses of groundwater both onbase and offbase.

Land Use

Land use in the vicinity of McClellan AFB (Figure B-2) consists of a combination of military, industrial, commercial, residential, and agricultural zones. Much of the land use around McClellan AFB is residential. In the Rio Linda area northwest of McClellan AFB, most of the land is categorized as agricultural-industrial. This land category identifies areas reserved for large-lot rural residential uses where livestock and crops may be raised. Many of these residences use private well water for nonpotable uses. Much of the land use to the southwest and east consists of low density residential units. While some of these residences may have private wells, the majority have municipal water supplies. To the southwest and east are parcels designated for commercial and office uses, including shopping, office complexes, and strip commercial development.

Water Uses

Onbase Water Uses

McClellan AFB obtains water from three onbase supply wells. Other onbase supply wells have been abandoned, due to the groundwater contamination. Base Well 18, the principal supply well, has been equipped with wellhead treatment using activated carbon for removal of groundwater contaminants. During times of high water demand, McClellan AFB obtains supplemental water from the Northridge Water District.

Offbase Water Uses

The communities in the vicinity of McClellan AFB receive water from private wells and municipal water supplies. Most of the water for North Highlands (to the east of the Base) is supplied by the Arcade Water District. The Rio Linda Water District and Northridge Water District also supply water to the North Highlands community. North Sacramento receives water from the City of Sacramento Water Department. Many private wells are still in use in the area north of El Camino Boulevard in North Sacramento.

Offbase Remedial Action

Groundwater samples have been collected between 1979 and 1989 from nearly 240 residential wells located in the Rio Linda, Elverta, and North Sacramento areas to the west and the south of McClellan AFB. These samples were analyzed for volatile organic compounds (VOCs), and selected samples were analyzed for metals, pesticides/PCBs, and/or semivolatile organic compounds (SVOCs). A total of 195 wells have been sampled at least once, without detecting groundwater contaminants. The contaminants detected were VOCs, principally TCE.

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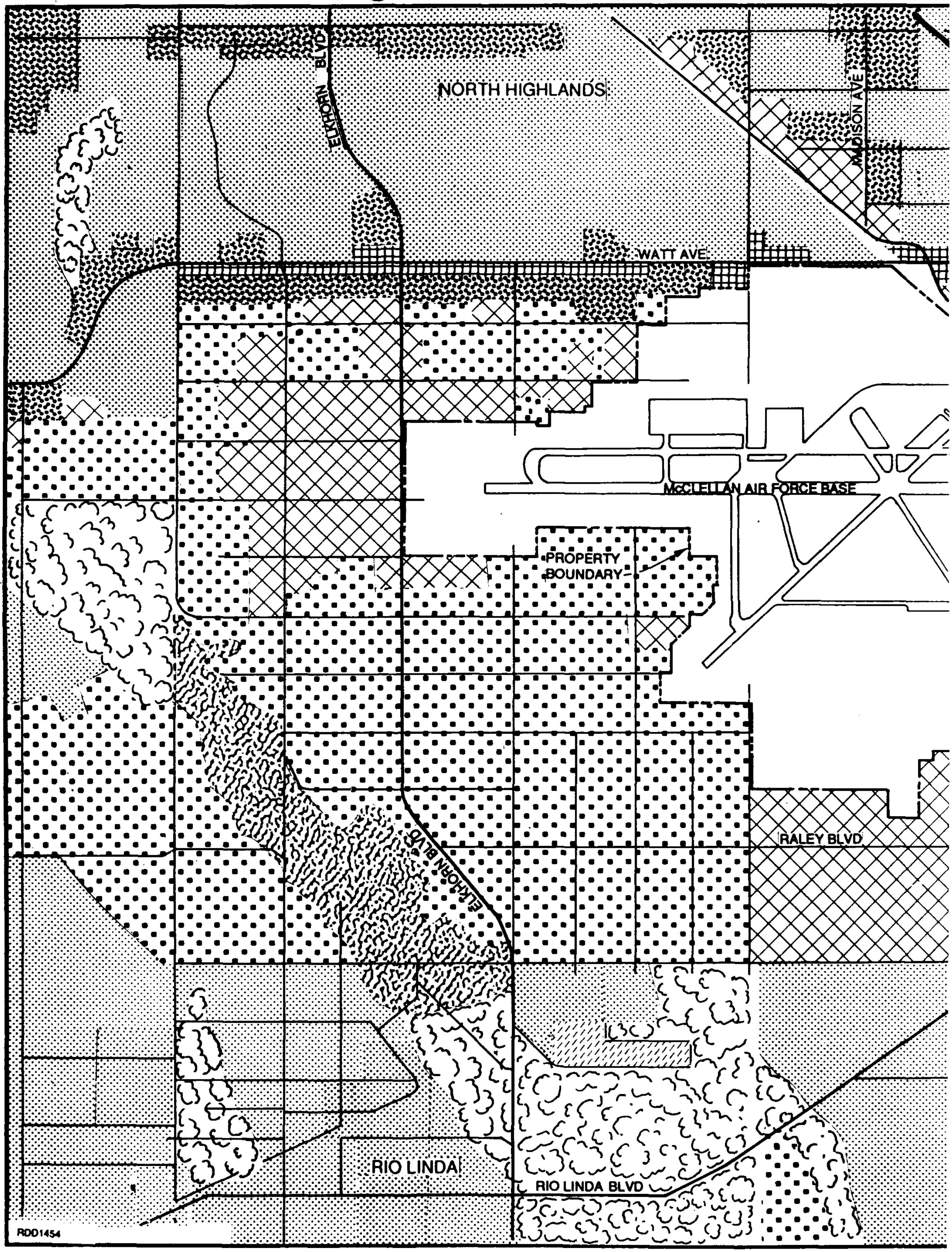
NORTH HIGHLANDS
ELKHORN BLVD
MADISON AVE
WATT AVE
McCLELLAN AIR FORCE BASE
PROPERTY BOUNDARY
RALEY BLVD
ELKHORN BLVD
RIO LINDA
RIO LINDA BLVD
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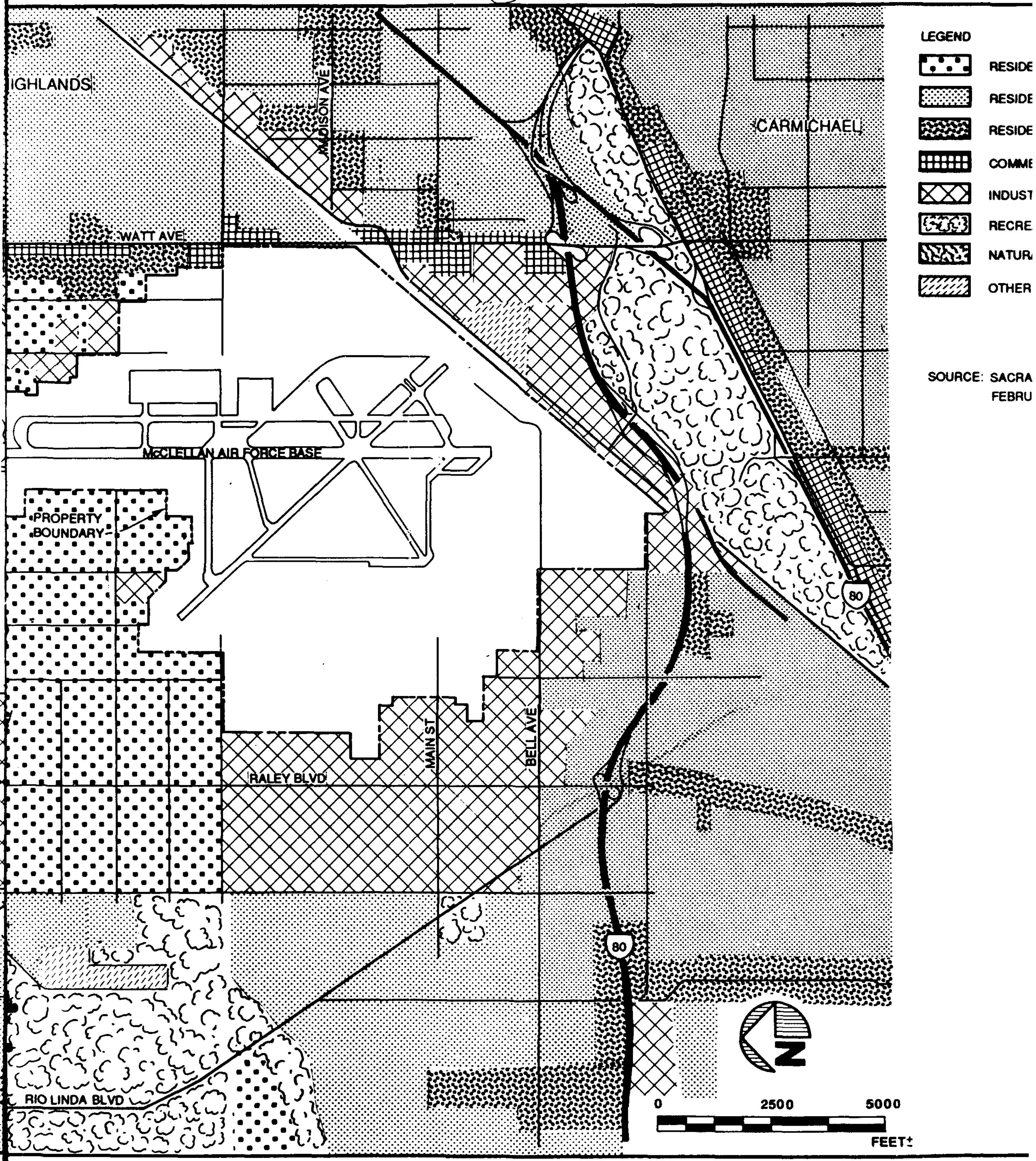

LEGEND
RESIDE
RESIDE
RESIDE
COMME
INDUST
RECREA
NATURA
OTHER
SOURCE: SACRA
FEBRU
IGHLANDS
MADISON AVE
CARMICHAEL
WATT AVE
McCLELLAN AIR FORCE BASE
PROPERTY BOUNDARY
80
MAIN ST
BELL AVE
RALEY BLVD
RIO LINDA BLVD
0
2500
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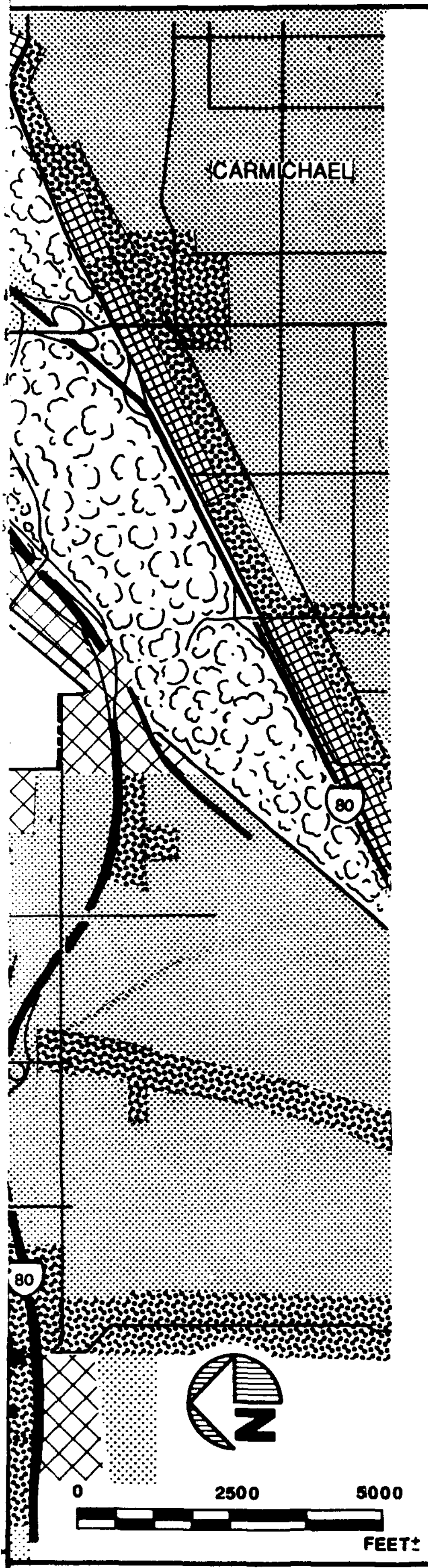
FEET±



LEGEND

- RESIDENTIAL - AGRICULTURAL
- RESIDENTIAL - LOW DENSITY
- RESIDENTIAL - MEDIUM TO HIGH DENSITY
- COMMERCIAL
- INDUSTRIAL
- RECREATIONAL
- NATURAL PRESERVE
- OTHER PUBLIC /QUASI-PUBLIC

SOURCE: SACRAMENTO COUNTY PLANNING DEPARTMENT, FEBRUARY 8, 1991.

FIGURE B-2
LAND USE MAP OF THE VICINITY OF McCLELLAN AIR FORCE BASE
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

CH2M HILL

During 1986-1987, McClellan AFB performed an offbase remedial action in which 550 homes to the west and south of McClellan AFB were connected to the municipal water supply system. The remedial action area included residences with contaminated private wells and properties that could be in the plume pathway. The remedial action area is presented in Figure B-3. Property owners were given the choice of abandoning their wells or continuing to use them for irrigation; if not abandoned, the wells were disconnected from the homes. Backflow valves (to prevent any possible contamination of the municipal water) were attached to the municipal water system at the homes where occupants elected to continue to use their wells for irrigation. Those valves are checked and maintained annually. The northern portion of the residential area receives water from the Rio Linda Water District and wells, and the southern portion receives water from the City of Sacramento Water District. After connection to the municipal supply was complete, McClellan AFB discontinued groundwater sampling of private wells. McClellan AFB continues to sample offbase groundwater monitoring wells; municipal production wells are sampled by other agencies.

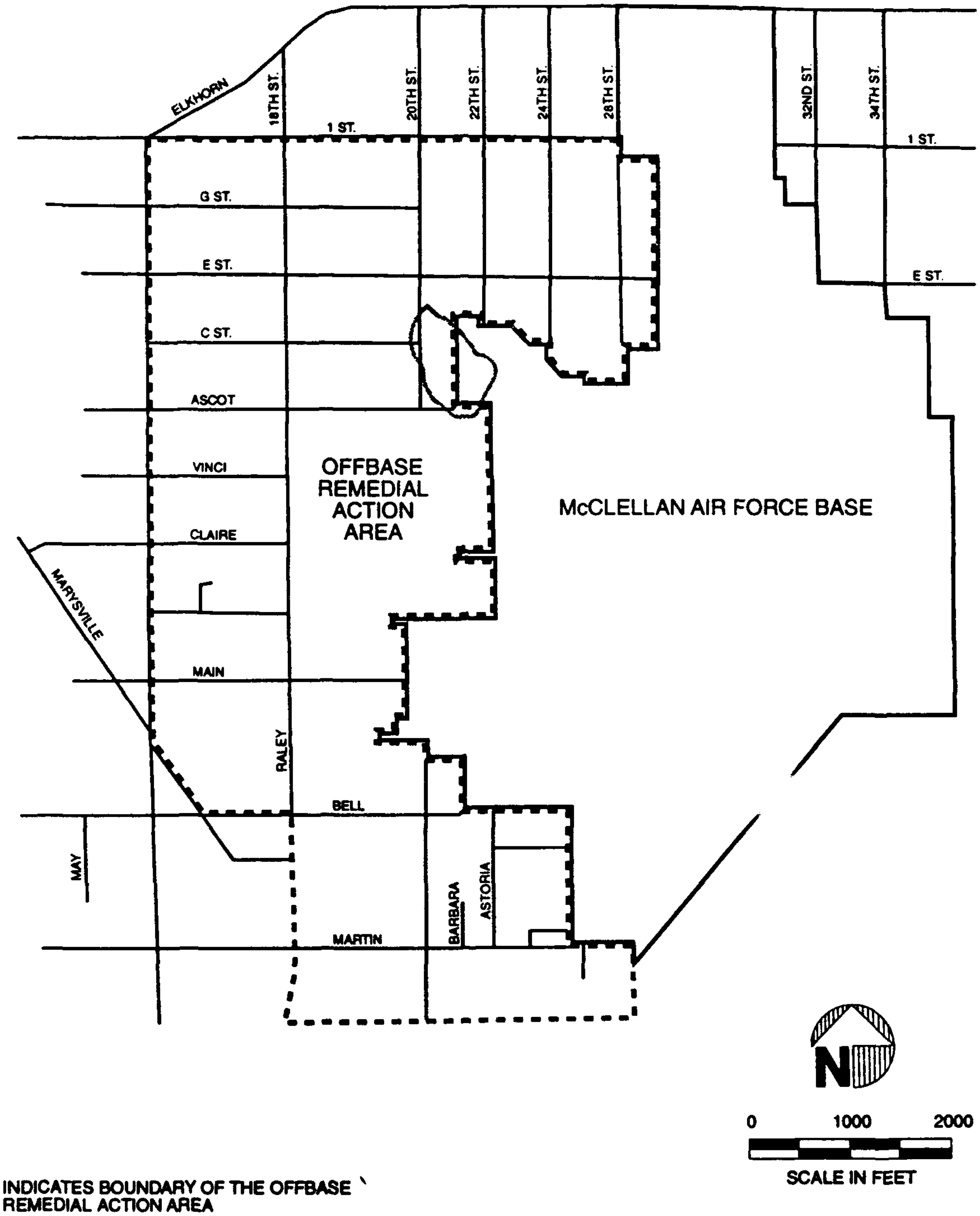
Exposure and Risk Calculation Methodology

This section presents the exposure and risk calculation methodology used by the sample-specific risk assessment for developing risk-based target volumes. Identification of exposure pathways for future uses of groundwater is based on the assumption that all groundwater near McClellan AFB could be used for residential purposes regardless of the actual or anticipated use. This assumption corresponds to the groundwater antidegradation policy for the State of California by assuming that groundwater is suitable for residential use. This assumption also meets or exceeds the definition of an RME scenario presented in the U.S. Environmental Protection Agency's *Risk Assessment Guidance for Superfund* (U.S. EPA, 1989). Another assumption implied by the development of risk-based target volumes is that each monitoring well at McClellan AFB represent an exposure point, regardless of the actual or anticipated use of the water. Exposure pathways associated with a residential use scenario may include ingestion of contaminants in groundwater, inhalation of VOCs emitted from indoor water use, and absorption of contaminants from dermal contact with groundwater.

Data Evaluation

Data from the GSAP were evaluated for use in performing exposure and risk calculations. As described previously, data collected from 1986 to 1993 were selected because they represent a reasonable number of wells and parameters monitored to plot concentration contours, and provide a relatively long period to evaluate the changes in the spatial extent of estimated health risks over time. The steps involved with the data evaluation were:

- Identification and selection of COPCs



LEGEND

INDICATES BOUNDARY OF THE OFFBASE REMEDIAL ACTION AREA

APPROXIMATE EXTENT OF OFFBASE GROUNDWATER PLUME

NOTE:

ALL RESIDENTS WITHIN THE OFFBASE REMEDIAL ACTION AREA HAVE BEEN SUPPLIED WITH MUNICIPAL WATER HOOKUPS.

Source: Radian, 1990
CH2M HILL, 1993

ROO 1454_23

FIGURE B-3
OFFBASE REMEDIAL ACTION AREA
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

CH2M HILL

- Evaluation, grouping, and selection of data based on qualifiers
- Grouping of sampling rounds from each well into monitoring zones and time periods for purposes of evaluating trends in risk over depth in groundwater and time

Contaminants of Potential Concern

The purpose of identifying and selecting for inclusion into the risk assessment those chemicals of greatest potential health concern (COPCs) (*i.e.*, the chemicals that are most toxic, mobile, persistent, or prevalent of those detected at the site) from among the entire set of chemicals associated with groundwater at McClellan AFB is to focus the risk assessment on the most important chemicals (i.e., those chemicals presenting 99 percent of the total risk) detected at the site.

COPCs in groundwater at McClellan AFB were grouped as VOCs, SVOCs, and pesticides/PCBs. Summary tables presenting the numbers of samples collected between 1986 and 1993, numbers of samples with detected concentrations, minimum and maximum concentrations, and detection limits are presented for these parameters in Tables B-3 (VOCs), B-4 (SVOCs), and B-5 (pesticides/PCBs). Metals have not been identified at this time as chemicals of potential concern for purposes of developing risk-based target volumes. A review of the available data indicated a consistent low-level presence of metals in groundwater resulting from naturally occurring dissolution of metals from rocks and sediments. Elevated concentrations were detected sporadically and inconsistently (Radian, 1991).

VOCs have the largest extent in groundwater at McClellan. VOCs that were detected in groundwater during the GSAP, and that had toxicity values developed either by EPA or the California Environmental Protection Agency (Cal-EPA) were considered in the development of target volumes. The extent of SVOCs and pesticides/PCBs in groundwater is limited when compared with VOCs. While there may be health risk concerns for selected SVOCs and pesticides (PCBs have not been detected in groundwater), there is insufficient extent in groundwater for the purposes of developing risk-based target volumes. Health risks were calculated for SVOCs, pesticides, and PCBs; however, risk-based target volumes were not developed for these contaminants.

Factors typically considered in selecting COPCs for risk assessment (U.S. EPA, 1989) include:

- Evaluation of the analytical methods
- Evaluation of data quality with respect to sample quantitation limits
- Evaluation of data quality with respect to qualifiers and codes
- Evaluation of data quality with respect to blanks

Table B-3
Summary Statistics of Volatile Organic Compounds in Groundwater (1986 - 1993)
McClellan AFB Groundwater Operable Unit

Parameter	Number of Detects	Number of Samples	Frequency of Detects	Range of Detection Limits		Range of Detected Concentrations	
				Minimum	Maximum	Minimum	Maximum
1,1,1,2-TETRACHLOROETHANE		2567			25,000		
1,1,1-TRICHLOROETHANE	453	4532	0.10		1,500	0.17	6,900
1,1,2,2-TETRACHLOROETHANE	20	4539	0.00		750	0.22	27
1,1,2-TRICHLOROETHANE	33	4540	0.01		1,000	0.7	220
1,1-DICHLOROETHANE	522	4532	0.12		2,500	0.1	1,700
1,1-DICHLOROETHENE	678	4534	0.15		1,400	0.1	40,000
1,2,3-TRICHLOROPROPANE		2034		1.6	25,000		
1,2-DIBROMO-3-CHLOROPROPANE		48		6.9	520		
1,2-DIBROMOETHANE		58		4.8	360		
1,2-DICHLOROBENZENE	85	7037	0.01		2,500	0.27	220
1,2-DICHLOROETHANE	419	4537	0.09		500	0.1	7,000
1,2-DICHLOROPROPANE	20	4540	0.00		550	0.11	23
1,3-DICHLOROBENZENE	34	7037	0.00		1,600	0.1	14
1,4-DICHLORO-2-BUTENE (TOTAL)		112		2.6	550		
1,4-DICHLOROBENZENE	36	7036	0.01		1,200	0.27	57
1-CHLOROHEXANE		2093		2	25,000		
2-BUTANONE	24	342	0.07		5,000	8.4	15,000
2-CHLOROETHYLVINYLETHER		4513			4,000		
2-HEXANONE	12	345	0.03		2,500	1.5	340
4-METHYL-2-PENTANONE	22	342	0.06		2,500	1.2	6,100
ACETONE	111	335	0.33		5,000	1.5	22,000
ACETONITRILE		57		6.5	490		
ACROLEIN		149			8,200		
ACRYLONITRILE		149			8,800		
ALLYL CHLORIDE		49		3.7	280		
BENZENE	110	3202	0.03		400	0.1	1,600
BENZYL CHLORIDE		1798		2.2	50,000		
BIS(2-CHLOROISOPROPYL)ETHER		1798		2.1	50,000		
BIS-CHLOROMETHYLETHER		2			0		

Table B-3
Summary Statistics of Volatile Organic Compounds in Groundwater (1986 - 1993)
McClellan AFB Groundwater Operable Unit

Parameter	Number of Detects	Number of Samples	Frequency of Detects	Range of Detection Limits		Range of Detected Concentrations	
				Minimum	Maximum	Minimum	Maximum
BROMOBENZENE		2090		1.6	25,000		
BROMODICHLOROMETHANE	13	4540	0.00		500	0.11	1
BROMOFORM		4540			4,000		
BROMOMETHANE		4535			5,900		
CARBON DISULFIDE	6	342	0.02		550	1.1	340
CARBON TETRACHLORIDE	147	4540	0.03		600	0.12	480
CHLOROBENZENE	49	7392	0.01		1,300	0.1	24
CHLOROETHANE	2	4535	0.00		2,600	1.5	2
CHLOROFORM	572	4535	0.13		500	0.1	970
CHLOROMETHANE	40	4535	0.01		2,200	0.31	47
CIS-1,2-DICHLOROETHENE	101	302	0.33	0.2	120	0.47	570
CIS-1,3-DICHLOROPROPENE	3	4540	0.00		1,000	2.2	17
DIBROMOCHLOROMETHANE	8	4540	0.00		1,000	0.22	67
DIBROMOMETHANE		2240		1.6	25,000		
DICHLORODIFLUOROMETHANE	3	149	0.02		1,000	9.2	61
ETHYL METHACRYLATE		147		5	1,900		
ETHYLBENZENE	21	3207	0.01		550	0.1	360
IODOMETHANE		147		5	630		
METHYL METHACRYLATE		58		28	2,100		
METHYLENE CHLORIDE	318	4479	0.07		2,000	0.4	2,000
O-XYLENE		1		5	5		
PROPANENITRILE		58		43	3,200		
STYRENE		342			550		
TETRACHLOROETHENE	468	4534	0.10		500	0.1	16,000
TOLUENE	218	3149	0.07		600	0.2	1,300
TOTAL 1,2-DICHLOROETHENE	996	3580	0.28		1,000	0.1	4,000
TOTAL CHLOROTOLUENE		1798		1.8	130,000		
TOTAL XYLENES	82	1862	0.04		400	0.2	160
TRANS-1,2-DICHLOROETHENE	1	959	0.00	0.2	550	2.1	2

Table B-3
Summary Statistics of Volatile Organic Compounds in Groundwater (1986 - 1993)
McClellan AFB Groundwater Operable Unit

Parameter	Number of Detects	Number of Samples	Frequency of Detects	Range of Detection Limits		Range of Detected Concentrations	
				Minimum	Maximum	Minimum	Maximum
TRANS-1,2-DICHLOROPROPENE		49		5	380		
TRANS-1,3-DICHLOROPROPENE	4	4540	0.00		1,700	0.25	2
TRANS-1,4-DICHLORO-2-BUTENE		35		10	500		
TRICHLOROETHENE	2170	4520	0.48		100	0.2	68,000
TRICHLOROFLUOROMETHANE	102	4504	0.02		2,200	0.11	150
TRICHLOROPROPANE		206		2	4,000		
VINYL ACETATE		342			760		
VINYL CHLORIDE	109	4535	0.02		1,000	0.34	2,700

Note: Blank in the "Number of Detects" column indicates that parameter was not detected in any sample.

Table B-4
Summary Statistics of Semivolatile Organic Compounds in Groundwater (1986 - 1993)
McClellan AFB Groundwater Operable Unit

Parameter	Number of Detects	Number of Samples	Frequency of Detects	Range of Detection Limits		Range of Detected Concentrations	
				Minimum	Maximum	Minimum	Maximum
1,2,4,5-TETRACHLOROBENZENE		124		1.4	15		
1,2,4-TRICHLOROBENZENE	3	479	0.006		19	2	2
1,2-DICHLOROBENZENE	29	479	0.061		28	1.3	170
1,2-DIPHENYLHYDRAZINE		166			100		
1,3-DICHLOROBENZENE	22	479	0.046		28	1.6	13
1,3-DINITROBENZENE		3		2.6	2.6		
1,4-DICHLOROBENZENE	16	479	0.033		44	2.3	18
1,4-NAPHTHOQUINONE		3		1.2	1.2		
1-CHLORONAPHTHALENE		124		2	21		
1-METHYLNAPHTHALENE		3		3.9	3.9		
1-NAPHTHYLAMINE		124		5.4	57		
2,3,4,6-TETRACHLOROPHENOL		124		6.5	68		
2,3,7,8-TCDD		72			0		
2,4,5-TRICHLOROPHENOL		407			50		
2,4,6-TRICHLOROPHENOL		484			31		
2,4-DICHLOROPHENOL		484			29		
2,4-DIMETHYLPHENOL	4	484	0.008		28	1.4	2.1
2,4-DINITROPHENOL		484			420		
2,4-DINITROTOLUENE		479			57		
2,6-DICHLOROPHENOL		124		6.5	68		
2,6-DINITROTOLUENE		479			23		
2-ACETYLAMINOFLUORENE		3		6.4	6.4		
2-CHLORONAPHTHALENE		479			19		
2-CHLOROPHENOL		484			38		
2-METHYLNAPHTHALENE	6	407	0.015		40	0.6	2.1
2-METHYLPHENOL (O-CRESOL)	3	407	0.007		50	1.7	3.8
2-NAPHTHYLAMINE		124		9.4	130		
2-NITROANILINE		404			55		
2-NITROPHENOL		484			43		
2-PICOLINE		124		2.3	24		
3,3'-DICHLOROBENZIDINE		479			170		

Table B-4
Summary Statistics of Semivolatile Organic Compounds in Groundwater (1986 - 1993)
McClellan AFB Groundwater Operable Unit

Parameter	Number of Detects	Number of Samples	Frequency of Detects	Range of Detection Limits		Range of Detected Concentrations	
				Minimum	Maximum	Minimum	Maximum
3,3'-DIMETHYLBENZIDINE		3		8.2	8.2		
3-METHYLCHOLANTHRENE		98		3.3	35		
3-METHYLPHENOL		3		13	13		
3-NITROANILINE		404			55		
4,6-DINITRO-2-METHYLPHENOL		484			240		
4-AMINOBIPHENYL		124		2.8	30		
4-BROMOPHENYL-PHENYLETHER		479			22		
4-CHLORO-3-METHYLPHENOL		407			30		
4-CHLOROANILINE		404			50		
4-CHLOROPHENYLPHENYLETHER		479			42		
4-METHYLPHENOL (P-CRESOL)	7	406	0.017		50	1.5	38
4-NITROANILINE		404			55		
4-NITROPHENOL	4	484	0.008		55	3.8	7.9
5-NITRO-O-TOLUIDINE		3		2.6	2.6		
7,12-DIMETHYLBENZ(A)ANTHRACENE		124		1.3	28		
A,A-DIMETHYLPHENETHYLAMINE		124		7.1	75		
ACENAPHTHENE		479			19		
ACENAPHTHYLENE		479			35		
ACETOPHENONE	3	124	0.024	2.7	28	1.3	4.4
ANILINE	2	364	0.005		50	2.1	5.9
ANTHRACENE	1	479	0.002		19	1.3	1.3
BENZIDINE	1	442	0.002		440	3.2	3.2
BENZO(A)ANTHRACENE		479			78		
BENZO(A)PYRENE		479			25		
BENZO(B)FLUORANTHENE		479			48		
BENZO(G,H,I)PERYLENE	4	479	0.008		41	1.4	3.5
BENZO(K)FLUORANTHENE		479			28		
BENZOIC ACID	10	404	0.025		500	2.4	350
BENZYL ALCOHOL	2	404	0.005		75	6	23
BENZYL CHLORIDE		3		2.6	2.6		

Table B-4
Summary Statistics of Semivolatile Organic Compounds in Groundwater (1986 - 1993)
McClellan AFB Groundwater Operable Unit

Parameter	Number of Detects	Number of Samples	Frequency of Detects	Range of Detection Limits		Range of Detected Concentrations	
				Minimum	Maximum	Minimum	Maximum
BIS(2-CHLOROETHOXY)METHANE		479			53		
BIS(2-CHLOROETHYL)ETHER		479			57		
BIS(2-CHLOROISOPROPYL)ETHER	2	479	0.004		57	1.2	1.2
BIS(2-ETHYLHEXYL)PHTHALATE	230	443	0.519		10	1	1400
BUTYLBENZYLPHTHALATE	10	478	0.021		25	2.3	13
CHLOROBENZILATE		3		4.1	4.1		
CHRYSENE		479			25		
DI-N-BUTYLPHTHALATE	98	430	0.228		25	0.29	67
DI-N-OCTYL PHTHALATE	14	479	0.029		25	1.4	6
DIBENZ(A,J)ACRIDINE		124		2.1	22		
DIBENZO(A,H)ANTHRACENE	3	479	0.006		65	1.5	4.1
DIBENZOFURAN		404			20		
DIETHYLPHTHALATE	2	479	0.004		19	0.94	2.9
DIMETHYL PHTHALATE		479			16		
DIPHENYLAMINE	1	97	0.010	1.9	20	1.3	1.3
ETHYLMETHANESULFONATE		124		3.2	34		
FLUORANTHENE	1	479	0.002		22	1.4	1.4
FLUORENE		479			19		
HEXACHLOROBENZENE		479			19		
HEXACHLOROBUTADIENE		479			28		
HEXACHLOROCYCLOPENTADIENE		479			60		
HEXACHLOROETHANE		479			25		
HEXACHLOROPROPENE		3		5.7	5.7		
INDENE		3		4.3	4.3		
INDENO(1,2,3-C,D)PYRENE	3	479	0.006		50	1.3	1.8
ISOPHORONE	2	479	0.004		22	4	13
ISOSAFROLE		3		1.5	1.5		
METHAPYRILENE		3		12	12		
METHYLMETHANESULFONATE		124		4.7	49		
N-NITROSO-DI-N-BUTYLAMINE		124		2.9	31		

Table B-4
Summary Statistics of Semivolatile Organic Compounds in Groundwater (1986 - 1993)
McClellan AFB Groundwater Operable Unit

Parameter	Number of Detects	Number of Samples	Frequency of Detects	Range of Detection Limits		Range of Detected Concentrations	
				Minimum	Maximum	Minimum	Maximum
N-NITROSODI-N-PROPYLAMINE		479			50		
N-NITROSODIETHYLAMINE		3		2.7	2.7		
N-NITROSODIMETHYLAMINE		442			100		
N-NITROSODIPHENYLAMINE	7	478	0.015		19	1.5	10.3
N-NITROSOMETHYLETHYLAMINE		3		3.5	3.5		
N-NITROSOMORPHOLINE		3		3.4	3.4		
N-NITROSOPIPERIDINE		124		2.8	29		
N-NITROSOPYRROLIDINE		3		4.2	4.2		
NAPHTHALENE	18	479	0.038		16	0.69	19
NITROBENZENE		479			19		
O-TOLUIDINE		3		2.5	2.5		
P-ACETOPHENETIDINE		98		2	21		
P-CHLORO-M-CRESOL		77			0		
P-DIMETHYLAMINO-AZOBENZENE		124		3.2	34		
PENTACHLOROBENZENE		124		1.5	100		
PENTACHLOROETHANE		3		1.9	1.9		
PENTACHLORONITROBENZENE		100		2.5	26		
PENTACHLOROPHENOL	3	484	0.006		36	1.2	7.8
PHENANTHRENE	1	479	0.002		54	1.3	1.3
PHENOL	77	476	0.162		26	1.1	12
PRONAMIDE		124		1.7	18		
PYRENE	1	477	0.002		21	1.2	1.2
PYRIDINE	1	3	0.333	2.4	2.4	9.2	9.2
QUINOLINE		3		3.1	3.1		
SAFROLE		3		2.5	2.5		

Note: Absence of value in the "Number of Detects" column indicates contaminant was not detected in any sample.

Table B-5
Summary Statistics of Pesticides/PCBs in Groundwater (1986 - 1993)
McClellan AFB Groundwater Operable Unit

Parameter	Number of Detects	Number of Samples	Frequency of Detects	Range of Detection Limits		Range of Detected Concentrations	
				Minimum	Maximum	Minimum	Maximum
2,4,6-TRICHLOROPHENOL	1	127	0.008			1.2	1.2
2,4-DICHLOROPHENOL		127					
2,4-DIMETHYLPHENOL	3	127	0.024			0.32	1.1
2,4-DINITROPHENOL		127					
2-CHLOROPHENOL	3	127	0.024			0.35	0.8
2-NITROPHENOL		127					
4,4'-DDD		236					
4,4'-DDE		236					
4,4'-DDT		236					
4,6-DINITRO-2-METHYLPHENOL		127					
4-CHLORO-3-METHYLPHENOL	1	127	0.008			0.57	0.57
4-NITROPHENOL		127					
ALDRIN		236					
ALPHA CHLORDANE		236					
ALPHA-BHC		236					
BETA-BHC		236					
DELTA-BHC		236					
DIELDRIN		236					
ENDOSULFAN I		236					
ENDOSULFAN II		236					
ENDOSULFAN SULFATE		236					
ENDRIN		236					
ENDRIN ALDEHYDE		236					
ENDRIN KETONE		155					
GAMMA CHLORDANE		155					
GAMMA-BHC (LINDANE)		236					
HEPTACHLOR		236					
HEPTACHLOR EPOXIDE		236					
METHOXYCHLOR		157					
PCB-1016		236					

Table B-5
Summary Statistics of Pesticides/PCBs in Groundwater (1986 - 1993)
McClellan AFB Groundwater Operable Unit

Parameter	Number of Detects	Number of Samples	Frequency of Detects	Range of Detection Limits		Range of Detected Concentrations	
				Minimum	Maximum	Minimum	Maximum
PCB-1221		236					
PCB-1232		236					
PCB-1242		236					
PCB-1248		236					
PCB-1254		236					
PCB-1260		236					
PENTACHLOROPHENOL		127					
PHENOL	61	127	0.480			0.24	5
TOXAPHENE		236					

Note: Absence of value in the No. of Detects column indicates contaminant was not detected in any sample. Detection limits not reported in the GSAP database.

- Evaluation of tentatively identified compounds

- Comparison of potential site-related compounds with background (primarily for inorganic compounds)

Since sample-specific risk calculations are performed within a relational database, it is possible to calculate health risks associated with each contaminant in each sample. Therefore, each contaminant detected in groundwater (as shown in Tables B-3 through B-5) with an EPA or Cal-EPA toxicity value was considered a COPC.

Evaluation of Data Qualifiers

Much of the data in the GSAP was collected prior to the development of consistent guidelines for determining data usability for risk assessments (i.e., the *EPA Guidance for Data Usability in Risk Assessment* [U.S. EPA, 1992b]). Data in the GSAP were flagged with quality assurance/quality control (QA/QC) qualifiers; however, many of these qualifiers do not conform with current EPA guidelines for data QA/QC evaluation. Table B-6 presents the qualifiers identified in the GSAP, along with a series of classifications for the qualifiers. The 32 GSAP data qualification flags were categorized as:

- Not Applicable (3 flags)–N
- Reject (8 flags)–R
- Detect (20 flags)–D
- Nondetect (1 flag)–U

Individual records within the GSAP database were coded as N, R, D, or U based on the qualifier for that record within the database. Records coded as D or U were retained in the risk calculations and mapping of target volumes. In order to retain as much data as possible, data were retained unless the meaning of the flag clearly indicated rejection of that record. The database contained various combinations of these different flags (for example, there are 143 different combinations for flags for VOC records). Records with combinations of flags that included one categorized as R were rejected.

Development of Data Groupings

Monitoring wells in the GSAP database were grouped by depth in which each well is screened (monitoring zones) and by OU to permit evaluation of differences in risks within different aquifers and areas onbase. Monitoring zones and OUs both are referred to by letters (monitoring zones from A to D, OUs from A to H). To minimize confusion between monitoring zones and OUs, the following terminology was used in the risk assessment to designate monitoring zones:

- A-zone = Shallow zone
- B-zone = Mid-shallow zone

Table B-6
Decision Rules for Groundwater Sampling and Analysis Program Qualifiers

Data Classification for Risk Assessment	Data Code in GSAP	Comment
Reject (R)	BL	Blank.
	E	(Organic) Analyte exceeds the calibration range for that specific analysis.
	M	Problem related to accuracy based on matrix or surrogate spike analysis.
	N/A	Not Applicable.
	NA	Not Analyzed.
	NR	Not Requested or Not Required.
	U	Unusable result because multiple or critical QC criteria were not met.
	UNK	Unknown.
Detect (D)	2a	Results obtained from secondary column due to coelution.
	2b	Results obtained from secondary column due to interferences.
	@ or *	Detected at less than 5 times the reporting limit ("reporting limit" is not defined, so the significance of this qualification is unknown. The impact in rejecting such data would, however, be substantial (e.g. approximately 1,700 VOC records would be rejected).
	B	Found in associated blank; sample result not corrected for amount detected in blank.
	C	Second column or GC/MS confirmation.
	D	This flag identifies all analytes at a secondary dilution factor.
	DL	Dilution.
	E	(Inorganic) Estimated value due to interferences, i.e., CN or color interference.
	G	Estimated value due to possible GC interference and/or coelution.
	I	Result modified since last issue of this report.
	J	Estimated value.

Table B-6
Decision Rules for Groundwater Sampling and Analysis Program Qualifiers

Data Classification for Risk Assessment	Data Code in GSAP	Comment
Detect (D) (continued)	NC	The RPD or spike recovery was not calculated. This spike amount was not significantly above what was found in the sample.
	NE	Threshold not established.
	O	Contamination associated with other types of blanks.
	P	Problem related to laboratory or field precision, or reproducibility, based on duplicate sample or duplicate spike results. Note: Radian does not have criteria defining how extensive the "problem" is. Given that they defined a qualifier which indicates data are unusable ("U"), it is assumed that these problems are not substantive enough to warrant rejection. Rejecting records flagged P would have resulted in a substantial loss of information (approximately 1,850 VOC records) for a problems of unknown magnitude
	R	Reagent blank contamination. Note: As with the "P" qualifier, data are assumed to be within the acceptable ranges of data validation and are retained in the risk assessment.
	S	Indicated that a specific result from the analysis has been obtained using the Method of Standard Addition.
	V	Second column confirmation not requested.
	Y	This is a general purpose flag for those situation for those flags not covered by the standard flags. The specific definition of this flag is described in the comments summary or case narrative.
	Z	(Inorganics) Found in associated blank; sample result not corrected for amount in blank
Not Detect (U)	ND	Not detected at or above specific reporting limit.
Not Applicable (N)	NA	(a) (b) See Specific Work Order. (c)

Note: Samples with parameters (i.e., contaminants) classified as "Detect" (D) or "Not Detect" (U) were included in the risk assessment. Samples with parameters classified as "Reject" (R) or "Not Applicable" (N) were rejected from consideration in the risk assessment.

- C-zone = Mid-deep zone
- D-zone = Deep zone

Because of logistical considerations and data requirements, all monitoring wells were not sampled at the same time interval at McClellan AFB. For purposes of evaluating trends in health risks over time, a time scale of 29 intervals ranging from 2 to 5 months, was superimposed over the VOC sampling event history. The width of the intervals was chosen to place sampling events into different time intervals for the largest number of monitoring wells. The event in which the highest concentrations of each parameter were reported was used in the risk assessment for cases where two sampling events from a single well fell into the same time interval. The VOC sampling history with the time scale is presented in Attachment B-1.

Exposure Assessment

This section presents the methodology for quantifying exposure to contaminants detected in groundwater, and associated carcinogenic risks and noncancer health effects. As discussed previously, a residential exposure scenario is assumed in the exposure calculations. Exposures and health risks are based on reasonable maximum exposure parameters.

Residential exposure to contaminants in groundwater could occur through the use of groundwater for domestic purposes. In residences, people can be exposed to contaminants in groundwater from ingestion of water used for drinking and cooking. They can also be exposed through dermal absorption of contaminants, primarily during bathing and showering, and inhalation of VOCs released from the water into household air during showering, bathing, cooking or by use of household appliances such as washing machines.

Exposure/Risks from Ingestion of Contaminants in Groundwater

Individuals could potentially be exposed to contaminants in groundwater through the ingestion of drinking water. The magnitude of exposure to contaminants through ingestion depends on the amount of water ingested on a daily basis. This assessment assumes that adult residents consume 2 liters of water per day, 350 days per year for 30 years (U.S. EPA, 1991b). The 2-liters-per-day value is close to the 90th percentile for drinking water ingestion (U.S. EPA, 1990b). The 30-year exposure duration is considered to be a 90th percentile value for time spent at one residence (U.S. EPA, 1991b; 1990b). The other parameters used in this intake equation also represent reasonable maximum values.

The following equation is used to calculate the intake associated with the ingestion of contaminants in groundwater:

$$Intake = \frac{C_W \times IR_w \times EF \times ED}{BW \times AT \times 365\,days/year} \tag{2}$$

The parameters are in Table B-7.

Table B-7
Parameters for Estimating Chemical Intake from Ingestion of Contaminants in Groundwater

Parameter	Description	Units	Value
Intake	Chemical intake rate	mg/kg-day	calculated from Eq. 2
C_w	Chemical concentration in water	mg/l	modeled or measured value
BW	Body weight	kg	70
AT	Averaging time	years	70 (cancer effects) 30 (noncancer effects)
EF	Exposure frequency	days/year	350
ED	Exposure duration	years	30
IR_w	Daily water ingestion rate	l/day	2

Source: U.S. EPA, 1991b.

A lifetime average intake of a chemical is estimated for carcinogens. This acts to prorate the total cumulative intake over a lifetime. An averaging time of a lifetime of 70 years is used for carcinogens. Chemical intake rates for noncarcinogens are calculated using an averaging time that is equal to the exposure duration.

The estimated lifetime cancer risk from potential exposure to a carcinogenic VOC through ingestion of groundwater is calculated as follows:

$$Risk = Intake \times SF_o \tag{3}$$

where SF_o is the oral slope factor in units of $(mg/kg\text{-}day)^{-1}$. A description of the SF_o and the contaminant-specific values for this parameter are presented below in the toxicity assessment. Estimated lifetime cancer risks for all carcinogenic contaminants are then summed to obtain the total risk associated with ingestion of contaminants in groundwater. If risks could exceed 10^{-2}, the exponential form of this equation should be used:

$$Risk = 1 - \exp(-Intake \times SF_o) \tag{4}$$

A hazard quotient (HQ) for potential exposure to a noncarcinogenic contaminant through ingestion of groundwater is calculated as follows:

$$HQ = \frac{Intake}{RfD_o} \tag{5}$$

where RfD_o is the oral Reference Dose in units of mg/kg-day. The HQs estimated for all noncarcinogenic contaminants are then summed to compute a Hazard Index (HI) associated with ingestion of contaminants in groundwater. Descriptions of the RfD_o, HQ and HI, and contaminant-specific values for the RfD_o are presented below in the toxicity assessment.

Exposures/Risks from Inhalation of VOCs in Groundwater

Individuals can be exposed to VOCs transferred from tap water to the air from showers, baths, toilets, dishwashers, washing machines, and cooking. Using a simple predictive equation based on a one-compartment indoor air model, Andelman (1990) predicted the relationship between the concentration of VOCs in water and the concentration in air. This equation is used to estimate the range of average indoor air concentrations that are likely to be encountered from a chemical volatilizing at an average rate of 50 percent from all water uses. The equation is based on data indicating 30 to 90 percent volatilization of radon from water, depending upon water use (Prichard and Gesell, 1981). The transfer efficiencies (percent volatilization) among the different water uses are presented in Table B-8.

Table B-8
Transfer Efficiencies for Radon for Various Water Uses in a Typical House

Water Use	Daily Quantity (l)	Transfer Efficiency (%)
Showers	150	63
Tub baths	150	47
Toilet	365	30
Laundry	130	90
Dishwasher	55	90
Drinking and kitchen	30	30
Cleaning	10	90
Total	890	

Source: Prichard and Gesell, 1981.

From these data, Andelman concluded that the volume use-weighted mean percent volatilization was about 50 percent.

The relationship of indoor air concentration to water concentration obtained from this model is (Andelman, 1990; Andelman et al., 1987):

$$C_a \approx 0.1 \times 10^{-4} C_w$$

to

$$C_a = 5 \times 10^{-4} C_w$$

where C_a is the average indoor air concentration (mg/l) generated by the corresponding average water concentration, C_w (mg/l). Thus, a water concentration of 1 mg/l would be expected to generate a concentration between 0.00001 and 0.0005 mg/l in air in the home (Andelman, 1990). A correction factor of 1,000 l/m^3 converts the concentration in air to mg/m^3. Other studies (McKone, 1987) have predicted similar estimated household air concentrations for different VOCs, with values of C_a ranging from 0.00002 to 0.00012 mg/l for a C_w of 1 mg/l (Andelman, 1990). EPA has selected the highest value to represent the amount of chemical volatilized into air from water (U.S. EPA, 1991b). This provides a conservative estimate of the amount of VOCs that would volatilize during domestic use of water.

Exposure to VOCs in air in a residential exposure scenario is based on an inhalation rate of 15 m^3/day. This inhalation rate considers the potential for exposure during household water uses, such as cooking, laundry, bathing, and showering. Activity-specific inhalation rates were combined with time/activity level data for populations that spend a majority of their time at home to derive daily inhalation values. The inhalation rate of 15 m^3/day was found to represent a reasonable upper-bound value for daily, indoor residential activities (U.S. EPA, 1991a).

The following equations is used to calculate the intake associated with the inhalation of chemicals volatilized from groundwater:

$$C_a = C_w(mg/l) \times 0.0005 \times 1{,}000(l/m^3) \tag{8}$$

Equation 8 converts the concentration in groundwater (C_w) to a corresponding concentration in ambient air (C_a). This concentration in air is then used to calculate chemical intake as follows:

$$Intake = \frac{C_a \times IR_a \times EF \times ED}{BW \times AT \times 365\, days/year} \tag{9}$$

The parameters are presented in Table B-9.

Table B-9 Parameters for Estimating Chemical Intake from Inhalation of VOCs in Groundwater			
Parameter	**Description**	**Units**	**Value**
Intake	Chemical intake rate	mg/kg-day	calculated from Eq. 9
C_a	Chemical concentration in air	mg/m^3	modeled value (Eq. 8)
BW	Body weight	kg	70
AT	Averaging time	years	70 (cancer effects) 30 (noncancer effects)
EF	Exposure frequency	days/year	350
ED	Exposure duration	years	30
IR_a	Daily inhalation rate	m^3/day	15
Source: U.S. EPA, 1991b.			

A lifetime average intake of a chemical is estimated for carcinogens. This acts to prorate the total cumulative intake over a lifetime. An averaging time of a lifetime of 70 years is used for carcinogens. Chemical intal rates for noncarcinogens are calculated using an averaging time value that is equal to the exposure duration.

Estimated lifetime cancer risk from potential exposure to a carcinogenic VOC in air is calculated as follows:

$$Risk = Intake \times SF_i \tag{10}$$

where SF_i is the inhalation slope factor in units of $(mg/kg\text{-}day)^{-1}$. A description of the SF_i and the contaminant-specific values for this parameter are presented below in the toxicity assessment. Estimated lifetime cancer risks for all carcinogenic VOCs are then summed to obtain the total risk associated with inhalation of VOCs in air at the site. If risks could exceed 10^{-2}, the exponential form of this equation should be used:

$$Risk = 1 - \exp(-Intake \times SF_i) \tag{11}$$

An HQ for potential exposure to a noncarcinogenic VOC in air is calculated as follows:

$$HQ = \frac{Intake}{RfD_i} \tag{12}$$

where RfD_i is the inhalation Reference Dose in units of mg/kg-day. The HQs estimated for all noncarcinogenic VOCs are then summed to compute an HI associated with inhalation of VOCs in air at the site. Descriptions of the RfD_i, HQ and HI, and contaminant-specific values for the RfD_i are presented below in the toxicity assessment.

Exposure/Risks from Dermal Contact with Contaminants in Groundwater

Individuals can become exposed through dermal absorption of contaminants in water. The magnitude of potential exposure through this pathway is related to the concentration in water, surface area of exposed skin, the ability of the contaminant to penetrate through the skin, and frequency and duration of exposure. The absorbed dose from dermal contact with contaminants in groundwater is based on a calculation recommended by Cal-EPA (Cal-EPA, 1992a), and is estimated as follows:

$$AbsorbedDose = \frac{C_w \times SA \times K_p \times ET \times EF \times ED \times 0.001\, l/cm^3}{BW \times AT \times 365\, days/year} \qquad (13)$$

The parameters are presented in Table B-10.

Table B-10
Parameters for Estimating Chemical Absorption from Dermal Contact with Groundwater

Parameter	Description	Units	Value
Absorbed dose		mg/kg-day	calculated from Eq. 13
C_w	Concentration in water	mg/l	modeled or measured value
SA	Exposed skin surface area	cm^2/event	23,000
ET	Exposure time	hour/day	0.25
EF	Exposure frequency	event/year	350
ED	Exposure duration	years	30
BW	Body weight	kg	70
AT	Averaging time	years	70 (cancer effects) 30 (noncancer effects)
K_p	Dermal permeability coefficient	cm/hour	chemical-specific

Source: Cal-EPA, 1992a.

Values for K_p can be estimated using an equation provided by EPA (U.S. EPA, 1992a):

$$\log K_p = -2.72 + 0.71 \log K_{ow} - 0.0061 MW \quad (14)$$

where MW is the molecular weight of the chemical and log K_{ow} is the log octanol/ water partition coefficient. These values were obtained either from Howard, 1989, 1990, 1992, 1993 or U.S. EPA, 1979.

All contaminant-specific parameter values (SF_o, SF_i, RfD_o, RfD_i and log K_{ow}) are tabulated in Attachment B-2.

Toxicity Assessment

The toxicity assessment determines the relationship between the magnitude of exposure to a chemical and the adverse health effects. This assessment provides, where possible, a numerical estimate of the increased likelihood and/or severity of adverse effects associated with chemical exposure (U.S. EPA, 1989).

For purposes of the toxicity assessment, the chemicals of potential concern have been classified into two broad categories: noncarcinogens and carcinogens. This classification has been selected because health risks are calculated quite differently for carcinogenic and noncarcinogenic effects. Separate toxicity values have been developed for carcinogenic and noncarcinogenic effects. These toxicity values represent the potential magnitude of adverse health effects associated with exposure to chemicals, and are developed by EPA and DTSC. Toxicity studies with laboratory animals or epidemiological studies of human populations provide the data used to develop these toxicity values. These values represent allowable levels of exposure based upon the results of toxicity studies or epidemiological studies. The toxicity values are then combined with the exposure estimates (as presented in the previous section) to develop the numerical estimates of carcinogenic risk and noncancer health risks. These numerical estimates are then used in the risk characterization process to estimate adverse effects from chemicals potentially originating in groundwater.

Sources of Toxicity Values

Toxicity values (cancer slope factors and Reference Doses) used in the risk assessment were obtained from these sources:

- The Integrated Risk Information System (IRIS), a database available through by the EPA Environmental Criteria and Assessments Office (ECAO) in Cincinnati, Ohio. IRIS, prepared and maintained by EPA, is an electronic database containing health risk and EPA regulatory information on specific chemicals.

- The Health Effects Assessment Summary Tables (HEAST), provided by the EPA Office of Solid Waste and Emergency Response (OSWER) (U.S. EPA, 1992). HEAST is a compilation of toxicity values published in health effects documents issued by EPA. HEAST is for use in Superfund and RCRA programs.

- California cancer potency factors compiled by the Cal-EPA Standards and Criteria Work Group (Cal-EPA, 1992b).

The most health conservative (i.e. highest) value was selected in cases where both state and federal agencies have developed slope factors.

Toxicity Values for Noncancer Effects

Noncarcinogenic effects were evaluated using either Reference Doses (RfDs) or Reference Concentrations, developed by EPA. The RfD is a health-based criterion, expressed as chemical intake rate in units of mg/kg-day, used in evaluating noncarcinogenic effects. The RfD is based on the assumption that thresholds exist for certain toxic effects such as liver or kidney damage, but may not exist for other toxic effects such as carcinogenicity. In general, the RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime of exposure (U.S. EPA, 1989). RfDs are developed for oral routes of exposure. The RfC, expressed as a concentration in air with units of mg/m^3, is used to evaluate adverse effects from inhalation exposure.

Potential health risks associated with exposure to noncarcinogenic compounds were evaluated by calculating an HQ. The potential hazard quotient was calculated as the ratio of the intake to the RfD, as follows:

$$HQ = \frac{Intake}{RfD} \tag{15}$$

If the estimated daily intake for any single chemical is greater than its reference dose, the hazard quotient will exceed unity. A hazard quotient that exceeds unity indicates that there is a potential for adverse health effects associated with exposure to that chemical.

An HI is calculated to assess the potential for noncarcinogenic effects posed by more than one chemical. The hazard index approach assumes that simultaneous subthreshold exposures to several chemicals could result in an adverse health effect. It also assumes that the magnitude of the adverse effect will be proportional to the sum of the ratios of the subthreshold exposures to the acceptable exposure (the RfD). The hazard index is equal to the sum of the hazard quotients, and is calculated as follows:

$$HI = \frac{E_1}{RfD_1} + \frac{E_2}{RfD_2} + \cdots + \frac{E_i}{RfD_i} \qquad (16)$$

where E_i is the exposure level (or intake) for the i^{th} chemical, and RfD_i is the reference dose for the i^{th} chemical. E and RfD are expressed in the same units (mg/kg-day), and represent the same exposure period (i.e. chronic, subchronic, or short-term).

Exposures to contaminants in air were estimated in units of mg/kg-day (see Appendix G). Therefore, RfCs were converted to inhalation RfDs as follows:

$$RfD_i = RfC(mg/m^3) \times \left(\frac{20m^3/day}{70kg}\right) \qquad (17)$$

where RfD_i is the inhalation reference dose, 20 m^3/day is the daily inhalation rate and 70 kg is body weight.

Toxicity Values for Carcinogenic Effects

Evidence of carcinogenicity of a chemical comes from two sources: lifetime studies with laboratory animals and human studies where excess cancer risk is associated with exposure to the chemical. Unless evidence to the contrary exists, if a carcinogenic response occurs at the exposure levels studied (typically high doses), it is assumed that responses will occur at all lower doses. Exposure to any level of a carcinogen is then considered to have a finite risk of inducing cancer.

Since risks at low levels of exposure cannot be quantified directly by either animal or epidemiological studies, mathematical models are used to extrapolate from high to low doses. The linearized multistage model for low dose extrapolation is recommended by regulatory agencies (U.S. EPA, 1986). Use of the linearized multistage model leads to a conservative upper bound estimate of risk. The linearized multistage model incorporates a procedure for estimating the largest possible slope at low doses that is consistent with experimental dose-response data (use of a large slope tends to produce a higher estimate of cancer risk). The most sensitive species of animal is used for extrapolation to humans (i.e., the assumption being that man is as sensitive as the most sensitive animal species). The true risk is not likely to be higher than the estimate, is most likely lower, and could even be zero.

Numerical estimates of cancer potency are presented as Slope Factors (SFs). Under an assumption of dose-response linearity at low doses, the SF defines the cancer risk due to continuous constant lifetime exposure to one unit of carcinogen (in units of risk per mg/kg/day). Individual cancer risk was calculated as the product of exposure to a chemical (in mg/kg/day) and the SF for that chemical (in $mg/kg/day)^{-1}$, as follows:

$$\textit{Risk} = \textit{Intake} \times \textit{SF} \tag{18}$$

Cancer risks from exposure to multiple carcinogens and multiple pathways were assumed to be additive, based on the EPA carcinogen risk assessment guidelines (U.S. EPA, 1986).

Each SF is accompanied by a weight-of-evidence classification. The weight-of-evidence classification considers the available data for a chemical to evaluate the likelihood that the chemical is a potential human carcinogen. The evidence is characterized separately for studies in humans and studies in laboratory animals as sufficient, limited, inadequate, no data, or evidence of noncarcinogenicity. EPA recommends that cancer risk estimates should always be accompanied by a weight-of-evidence classification to indicate the strength of evidence that a chemical is a human carcinogen (U.S. EPA, 1986; 1989). A description of the weight-of-evidence classification is presented in Table B-11.

Table B-11
EPA Weight-of-Evidence
Classification System for Carcinogenicity

Group	Description
A	Human carcinogen, based on evidence from epidemiological studies.
B1 or B2	Probable human carcinogen. B1 indicates that limited human data are available. B2 indicates sufficient evidence in animals and inadequate or no evidence in humans.
C	Possible human carcinogen, based on limited evidence in animals.
D	Not classifiable as to human carcinogenicity.
E	Evidence of noncarcinogenicity for humans.

Source: U.S. EPA, 1986.

Chemicals Without Available Toxicity Values

Toxicity values are not available for all of the chemicals of potential concern at the site. RfCs were not available for acetone, benzene, chloroform, cis-1,2-dichloroethene, tetrachloroethene, trichloroethene, vinyl chloride, and xylenes. Characterization of health risks for benzene, trichloroethene, and vinyl chloride were based solely on carcinogenic effects. In the other cases, noncancer health risks associated with inhalation exposures were characterized by comparison with the oral RfD.

Another uncertainty in the toxicity assessment is whether to assess cancer risks potentially associated with 1,1-dichloroethene (1,1-DCE). 1,1-DCE is a Group C (possible) human carcinogen. EPA guidelines suggest characterizing cancer risks for Group C carcinogens on a case-by-case basis (U.S. EPA, 1989). Several animal studies with 1,1-DCE have been negative for carcinogenicity. The EPA has judged these studies to not be adequate for detecting a carcinogenic effect (according to the IRIS profile for 1,1-DCE, dated January 20, 1992). However, the single positive study judged adequate by EPA did not unequivocally show a carcinogenic dose-response relationship (one important factor in judging whether or not a chemical does cause cancer). 1,1-DCE is mutagenic and is structurally similar to vinyl chloride, a known human carcinogen. Based on this information, EPA classified 1,1-DCE as a Group C or possible human carcinogen. Since the weight of evidence for carcinogenicity is less for 1,1-DCE, it is less certain that this chemical is carcinogenic in humans. Including risks from 1,1-DCE may then overestimate total cancer risks associated with chemicals at the site.

EPA Region IX recommends evaluation of the risks associated with 1,1-DCE using a modified-RfD approach (as opposed to the SFs for this chemical). This approach involves including an additional tenfold safety factor to the published RfD for this chemical to account for potential carcinogenicity of this chemical. EPA Region IX has stated that the number of negative cancer studies for 1,1-DCE is "notable." Five oral carcinogenicity studies have been conducted on 1,1-DCE including a lifetime joint study by the National Cancer Institute and National Toxicology Program. All of these oral cancer studies were negative. Eleven studies on 1,1-DCE evaluated carcinogenic potential via inhalation; ten of these studies were negative. One study, by Maltoni, did produce evidence of carcinogenic potential in mice, although this interpretation is blurred by the lack of a clear dose-response relationship. A similar study by the same group of investigators did not produce cancer in rats, even though doses up to six-fold greater were administered. Thus, the evidence supporting the classification of 1,1-DCE as a "carcinogen" is especially weak (U.S. EPA, 1990c).

Data Interpretation

This section presents interpretations of the sample-specific risk assessment calculations used to develop risk-based target volumes. The results from these interpretations provide some indication of the uncertainties associated with the risk-based target volumes, and an evaluation of the spatial variability in risks in groundwater at McClellan AFB. Note that risk estimates presented in this section are based on the assumption that monitoring well location represents an exposure point. As discussed previously, there is a low likelihood of complete exposure pathways to groundwater contaminants at McClellan under current conditions. Pathways could potentially exist in the future, particularly in OU A, where there are nearby supply wells, and where the lateral extent of contamination is not defined.

Sample-Specific Risk Assessment Methodology

Health risks were characterized by spatially defining the area where groundwater contaminants were associated with risks that exceeded specified risk thresholds. The risk characterization approach typically used for Superfund risk assessments has assumed that exposures can occur simultaneously to all chemicals detected over a relatively large geographic area, sometimes sitewide. Exposure point concentrations have been assumed to be the upper 95 percent confidence limit on the arithmetic mean concentrations (U.S. EPA, 1989). The result of such an assessment is a boiled-down point estimate of risk for the predefined "area of concern" in which concentrations were averaged. While this conservative "shorthand" approach might serve well for risk screening, or as a risk management tool for cases which require no remediation, for sites at which the no-action alternative is unlikely, the approach yields no information about the spatial distribution of risks within the predefined "area of concern" or data grouping. The information provided by a risk assessment using the conventional approach is not in a form directly usable to the GW OU FS.

Rather than generating a single point estimate of risk sitewide, risks associated with groundwater contaminants were characterized by evaluating sample-specific risks. This approach retains information on the spatial distribution of risk in groundwater. Sample specific risk or hazard index calculations use the same equations to estimate RME risks as defined in RAGS (U.S. EPA, 1989). Exposure parameter values and toxicity values are the same as those used in a conventional, sitewide calculation. The only structural difference in calculating sample-specific versus sitewide risk lies in the concentration values used. Where the conventional, sitewide approach uses the 95 percent upper confidence limit (UCL) of the mean concentration for all contaminants of concern, sample-specific risk calculations use concentrations reported from each individual site characterization sample of the relevant medium. However, the sample-specific risks are still considered to be a reasonable maximum due to the use of conservative assumed exposure parameters in the calculation of intake, including upper bound medium intake rates (e,g,. 2 liters/day for drinking water), exposure frequencies (e.g., 350 days/year), exposure durations (e.g., 30 years), and averaging times (e.g., 70-year lifetime). These parameters are still applied in a multiplicative manner (as in the conventional approach), and risks from multiple pathways of exposure are summed. Therefore, the risk calculations retain their conservative nature.

Figure B-4 presents the differences in these two different types of risk calculations. *N*-samples are collected from onsite locations and analyzed for *P*-parameters. The conventional risk calculation (upper panel) applies the exposure assumptions and toxicity values to a point estimate (such as a mean or UCL) from the data set. Parameter-specific cancer risks or hazard quotients are then cumulated, resulting in a single estimate of cancer risk or hazard index applicable to the entire site. The sample-specific method uses the same exposure assumptions and toxicity values, but applies these values to each parameter concentration in each sample. Parameter-specific risks or hazard quotients are cumulated for each sample, providing *N* calculated risks or hazard indices.

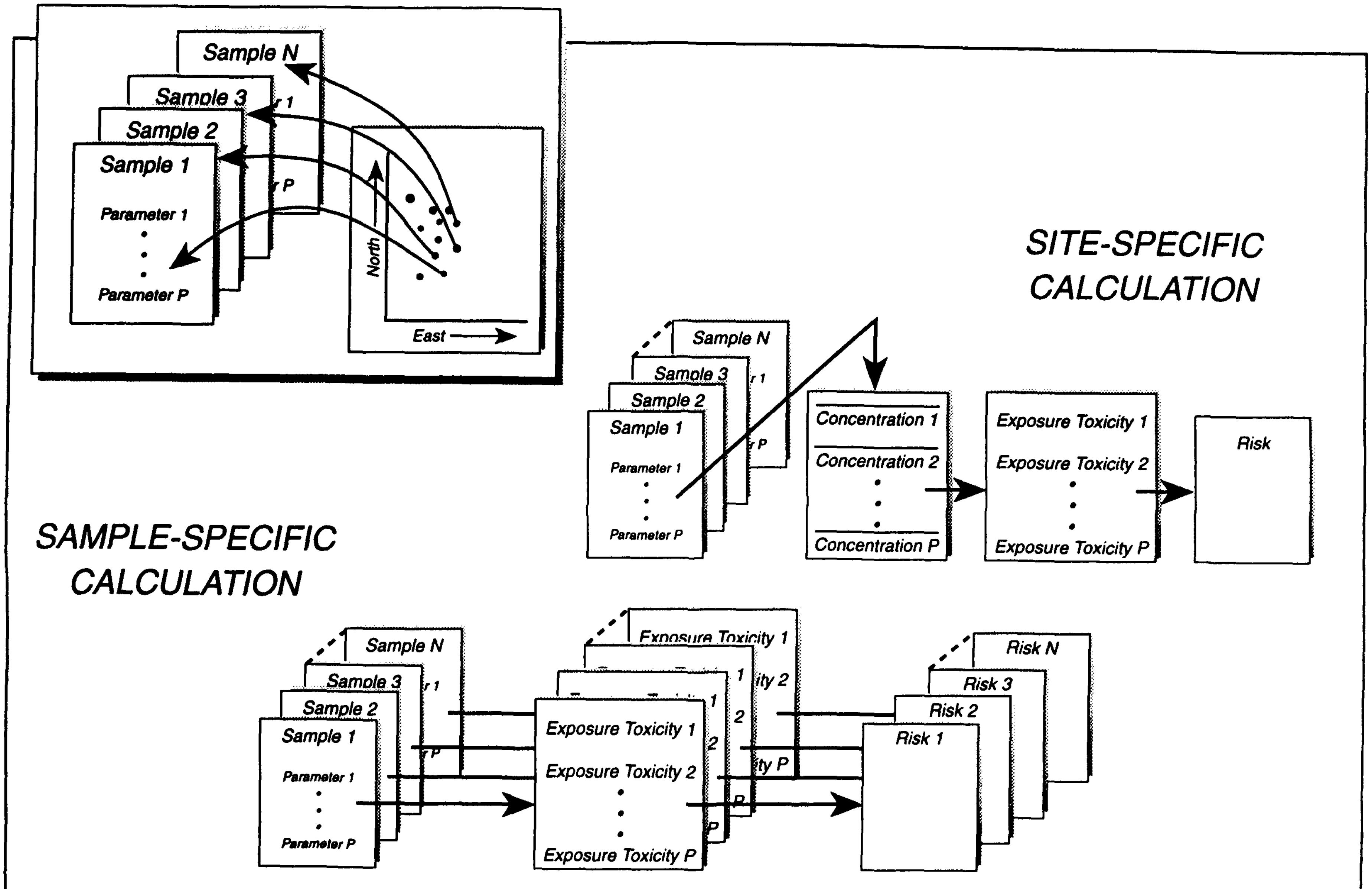


FIGURE B-4
SAMPLE-SPECIFIC RISK ASSESSMENT METHODOLOGY
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

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Since spatial information has been retained, the estimated cancer risks or hazard indices with specific locations can be mapped. Based on agreed-upon risk levels (in this case, 10^{-2}, 10^{-4}, 10^{-6} increased lifetime cancer risks and HI = 1.0), maps or kriged results can differentiate areas that may require remediation from areas requiring no further action. Specific parameters driving the risks can be identified from an intermediate data file generated during the risk calculations, that contains the *N*-sets of *P*-parameter-specific risks or HQs, which then can be queried to map or evaluate contaminant-specific risks. Finally, summary statistics of sitewide risks can be generated from the *N*-sets of risk estimates.

The advantage of the sample-specific methodology is greatest when risks are attributable to multiple contaminants. An assumption inherent in the sitewide risk calculation is spatial covariance of contaminant concentrations (i.e. the UCL concentrations of all contaminants detected at the site coincide spatially). Such spatial covariance is rarely observed at complex sites. Applying sitewide risk calculations to a data set would yield higher risk estimates than the sample-specific risk estimates, unless the elevated concentrations did indeed coincide spatially.

Groundwater Monitoring Data Assumptions

Several assumptions were applied to the groundwater monitoring data for developing the risk calculations and mapping the risk estimates. For purposes of generating risk contours, groundwater samples collected between 1986 and 1993 were grouped into periods corresponding generally to the monitoring periods in the quarterly monitoring program. Selected VOCs were not excluded as chemicals of potential concern based on concentrations detected in blanks. Samples identified as field duplicates were excluded from the data prior to performing sample-specific risk calculations. Finally, parameters reported as not detected were assumed to be zero for purposes of contouring risks. Use of a surrogate concentration such as one-half of the detection limit would arbitrarily inflate risks, when *P*-parameter-specific risks were cumulated in a sample. This would result in estimated risk in samples where contaminants had never been detected.

Identification of Contaminants of Potential Concern

VOCs represented the primary contaminants of concern in groundwater at McClellan AFB. Table B-12 presents for each VOC mean estimates of increased lifetime cancer risk and HQ (summed across ingestion, inhalation, and dermal exposure pathways) for all OUs and monitoring zones across McClellan AFB. Table B-12 also presents the number of individual samples with contaminant concentrations associated with a risk exceeding 1×10^{-6} or an HQ > 1.0. On the basis of the mean estimates of increased lifetime cancer risks or HQs, and the number of samples exceeding the 1×10^{-6} risk or HQ > 1.0 thresholds, the COPCs in groundwater appear to be TCE, chloroform, PCE, 1,2-DCA (based on increased cancer risk), and 1,1-DCE (based on noncancer effects).

Table B-12
McClellan Air Force Base Groundwater OU
Sample-Specific Risk Assessment
Parameter Summary
(All Wells/All OUs/All Monitoring Zones)

Parameter	Mean Risk	Sample Count $>10^{-6}$
Estimated Cancer Risks		
TRICHLOROETHENE	0.8E-04	1,295
CHLOROFORM	1.8E-05	270
TETRACHLOROETHENE	1.7E-04	263
1,2-DICHLOROETHANE	1.6E-04	251
METHYLENE CHLORIDE	3.4E-05	120
CARBON TETRACHLORIDE	6.3E-05	98
VINYL CHLORIDE	1.5E-02	95
BENZENE	3.9E-04	63
1,1,2-TRICHLOROETHANE	7.2E-05	27
1,1,2,2-TETRACHLOROETHANE	1.8E-05	21
1,2-DICHLOROPROPANE	7.5E-06	9
DIBROMOCHLOROMETHANE	4.3E-05	8
BROMODICHLOROMETHANE	2.0E-06	8
CHLOROMETHANE	5.8E-07	3
BROMOFORM	2.8E-07	--
Parameter	**Mean HI**	**Sample Count >1.0**
Noncancer Effects (Hazard Index)		
1,1-DICHLOROETHENE	99.8	352
TETRACHLOROETHENE	0.4	28
1,1,1-TRICHLOROETHANE	0.2	26
CARBON TETRACHLORIDE	0.7	12
4-METHYL-2-PENTANONE	2.9	9
METHYLENE CHLORIDE	0.1	7
ACETONE	0.3	6
CHLOROFORM	0.0	5
1,1,2-TRICHLOROETHANE	0.4	2
1,1-DIC[illegible]ROETHANE	0.1	2
CARBON DISULFIDE	0.8	1

Table B-12 McClellan Air Force Base Groundwater OU Sample-Specific Risk Assessment Parameter Summary (All Wells/All OUs/All Monitoring Zones)		
Parameter	**Mean Risk**	**Sample Count $>10^{-6}$**
2-BUTANONE	0.3	1
CIS-1,2-DICHLOROETHENE	0.1	1
1,2-DICHLOROPROPANE	0.2	--
TOLUENE	0.0	--
CHLOROBENZENE	0.0	--
DICHLORODIFLUOROMETHANE	0.0	--
ETHYLBENZENE	0.0	--
TRANS-1,2-DICHLOROETHENE	0.0	--
BROMOFORM	0.0	--
TOTAL XYLENES	0.0	--
DIBROMOCHLOROMETHANE	0.0	--
BROMODICHLOROMETHANE	0.0	--

Methylene chloride and carbon tetrachloride showed higher mean risks compared with chloroform. However chloroform has a wide extent in groundwater. Also, methylene chloride is a common laboratory contaminant (EPA, 1989). Samples associated with blank contamination were not rejected from the risk assessment; therefore, it is likely that a portion of the methylene chloride risks reflect laboratory contaminants rather than groundwater contaminants. Vinyl chloride provides the highest mean risk. However, relatively few samples contained vinyl chloride concentrations associated with risks exceeding 1 x 10^{-6}, suggesting that vinyl chloride contamination is highly localized.

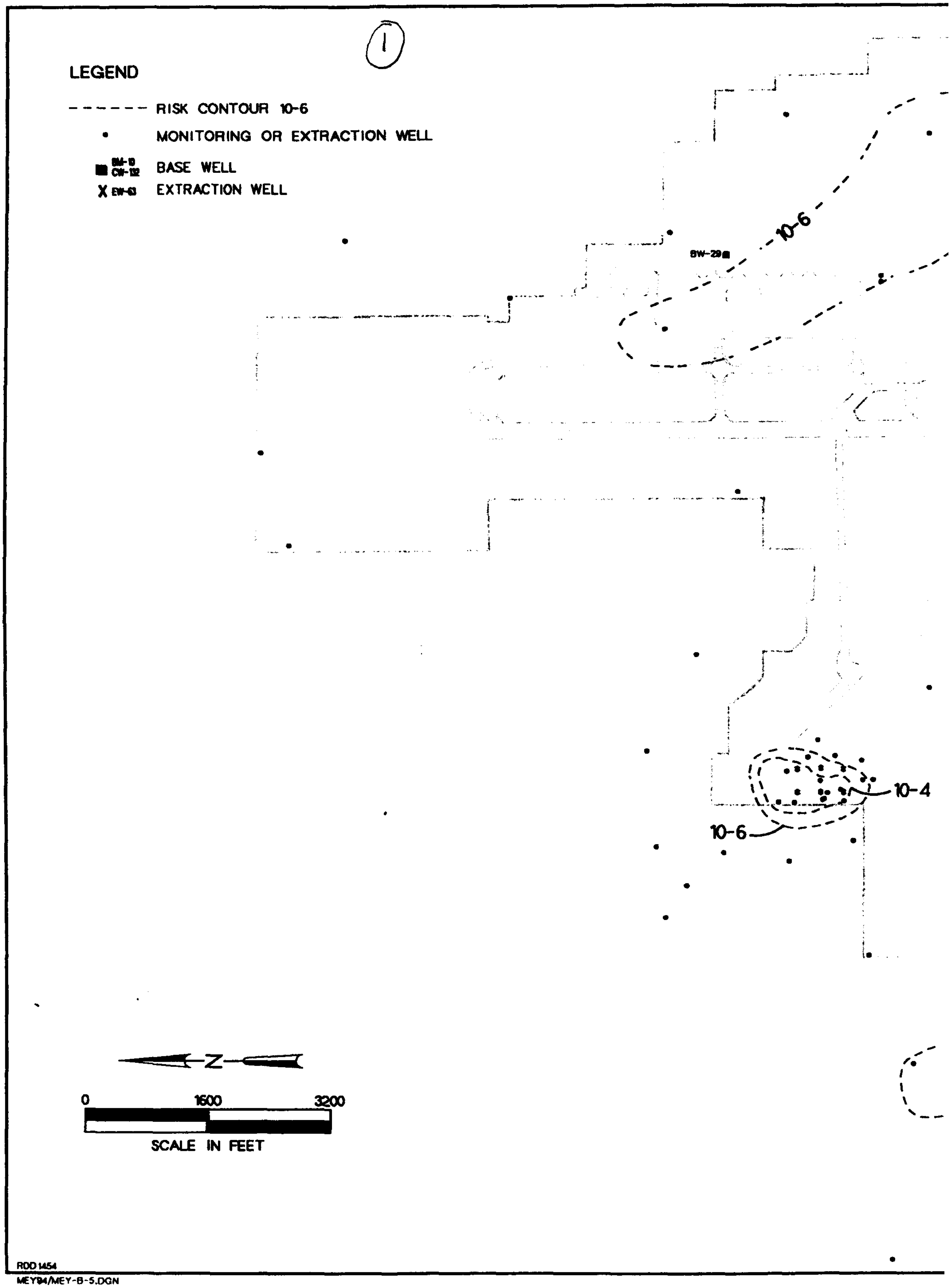
The mean estimated lifetime cancer risk summed across SVOCs in each sample was 1.7 x 10^{-4}, suggesting that SVOCs should be considered as COPCs. However, the risks exceeded 10^{-6} in only 91 of 495 samples, and exceeded 10^{-5} in only 12 samples. The mean risk is skewed by a limited number of chemicals in a limited number of samples, such as a 10.3 μg/l concentration of N-nitrosodiphenylamine in a single sample. N-nitrosodiphenylamine is a Category B2 carcinogen with an oral slope factor of 150 (mg/kg-day)$^{-1}$. It was detected in only seven of 478 samples (1.5 percent) collected between 1986 and 1993. While SVOCs may provide elevated risks in localized areas, they generally are a much lower concern than VOCs. HIs associated with SVOCs exceeded 1.0 in only a single sample.

Data Presentation

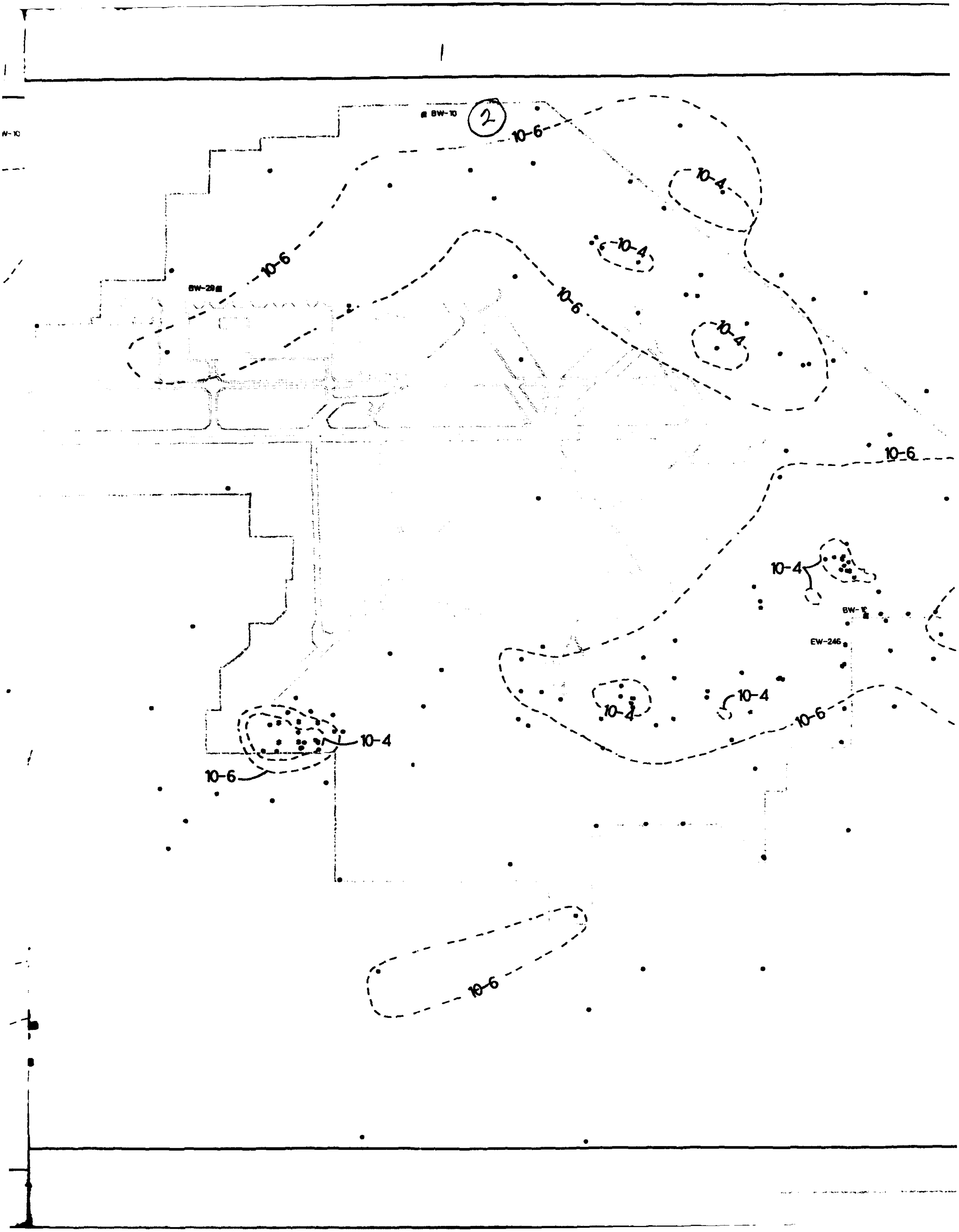
Data developed from the sample-specific risk calculations are presented graphically in Figures B-5 through B-7 and Attachments B-3 and B-4. Figures B-5 through B-7 presents 10^{-6}, 10^{-4}, and 10^{-2} increased lifetime cancer risk contours in the A-zone (shallow), B-zone (mid-shallow) and C-zone (mid-deep) groundwater. An insufficient number of wells in the D-zone (deep) were available to develop risk contours. These figures present the distributions of risks in groundwater across McClellan AFB. Attachment B-3 presents a series of box plots of cancer risks from each well within each OU and each monitoring zone. Attachment B-4 presents time series that depict how cancer risk varies over the monitoring history of each well. The following sections provide information on how to interpret data presented in box plots, and some summary inferences from the sample-specific risk calculations.

Description of Box Plots

Variability of risks in each well was presented graphically using box plots. A generic box plot is presented in Figure B-8. A box plot identifies the median (50th percentile value), the lower and upper quartiles (25th and 75th percentile values) and the extreme spread of the data. The edges of the box demark the 25th and 75 percentiles, and so represent the middle 50 percent range (or interquartile range) of the parameter values. The line within the box is the median. The lines extending outward from the box demark the range of data, excluding outliers. Two outliers are defined, based on their distance from the nearest edge of the box (and relative to the range of the box). Outside values lie 1.5 to 3 interquartile ranges from the nearest box edge, and far-out values lie 3 or more interquartile ranges from the nearest box edge. The notch represents the approximate 95 percent confidence interval around the median.



1
LEGEND
RISK CONTOUR 10-6
MONITORING OR EXTRACTION WELL
BASE WELL
EXTRACTION WELL
10-6
BW-29
10-4
10-6
N
0
1600
3200
SCALE IN FEET
ROD 1454
MEY94/MEY-B-5.DGN



BW-10
10-6
10-4
BW-29
BW-1
EW-246

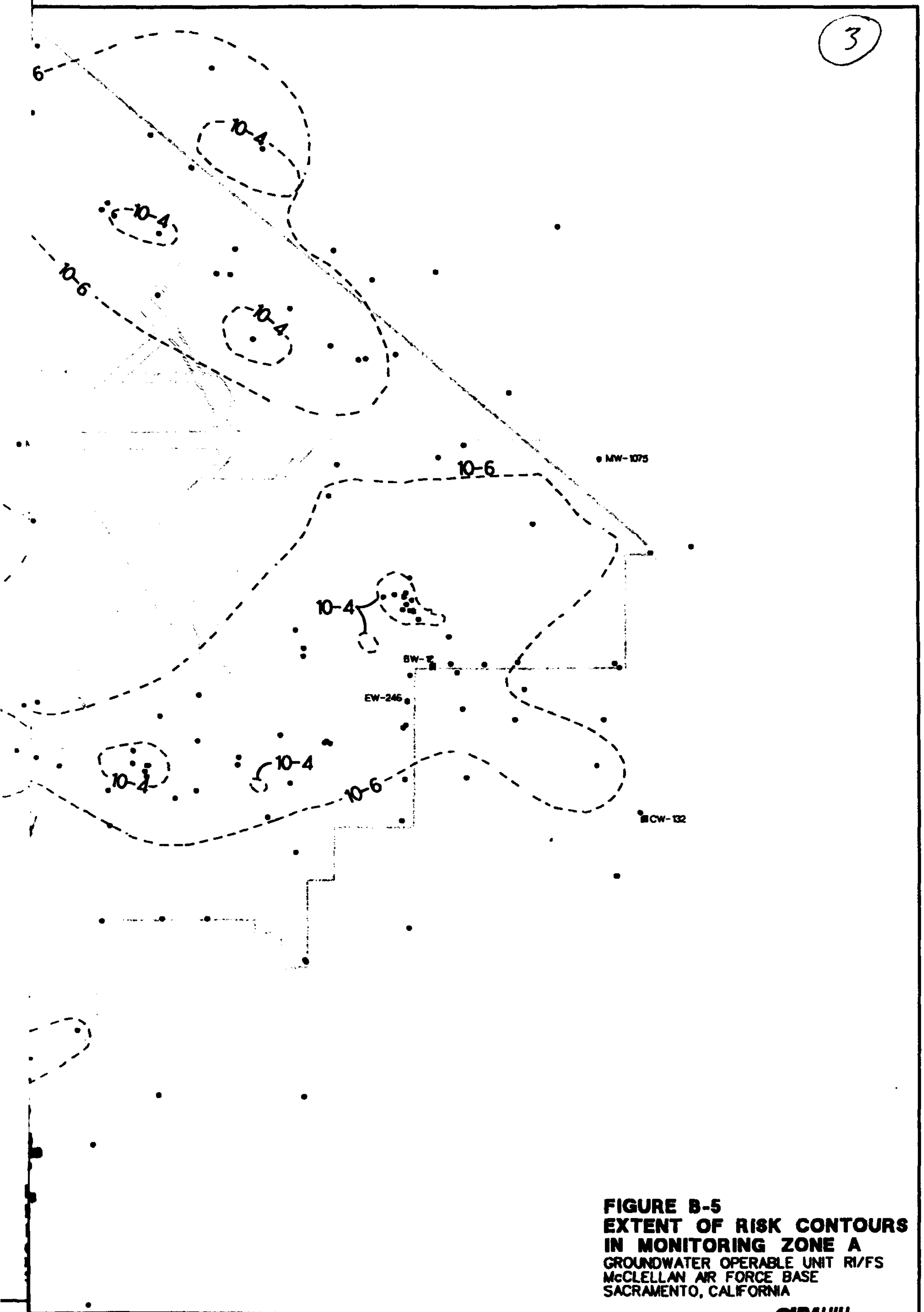
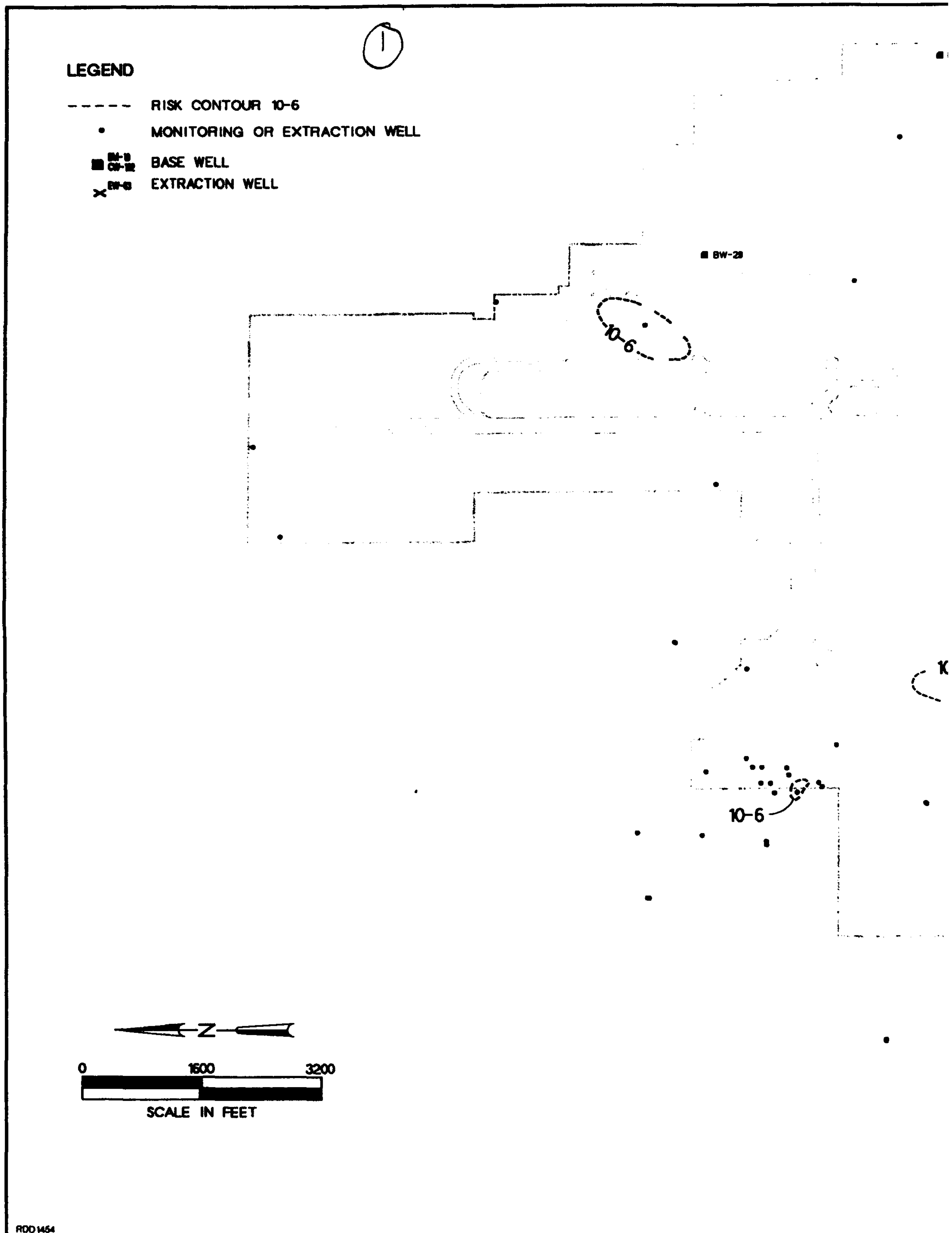
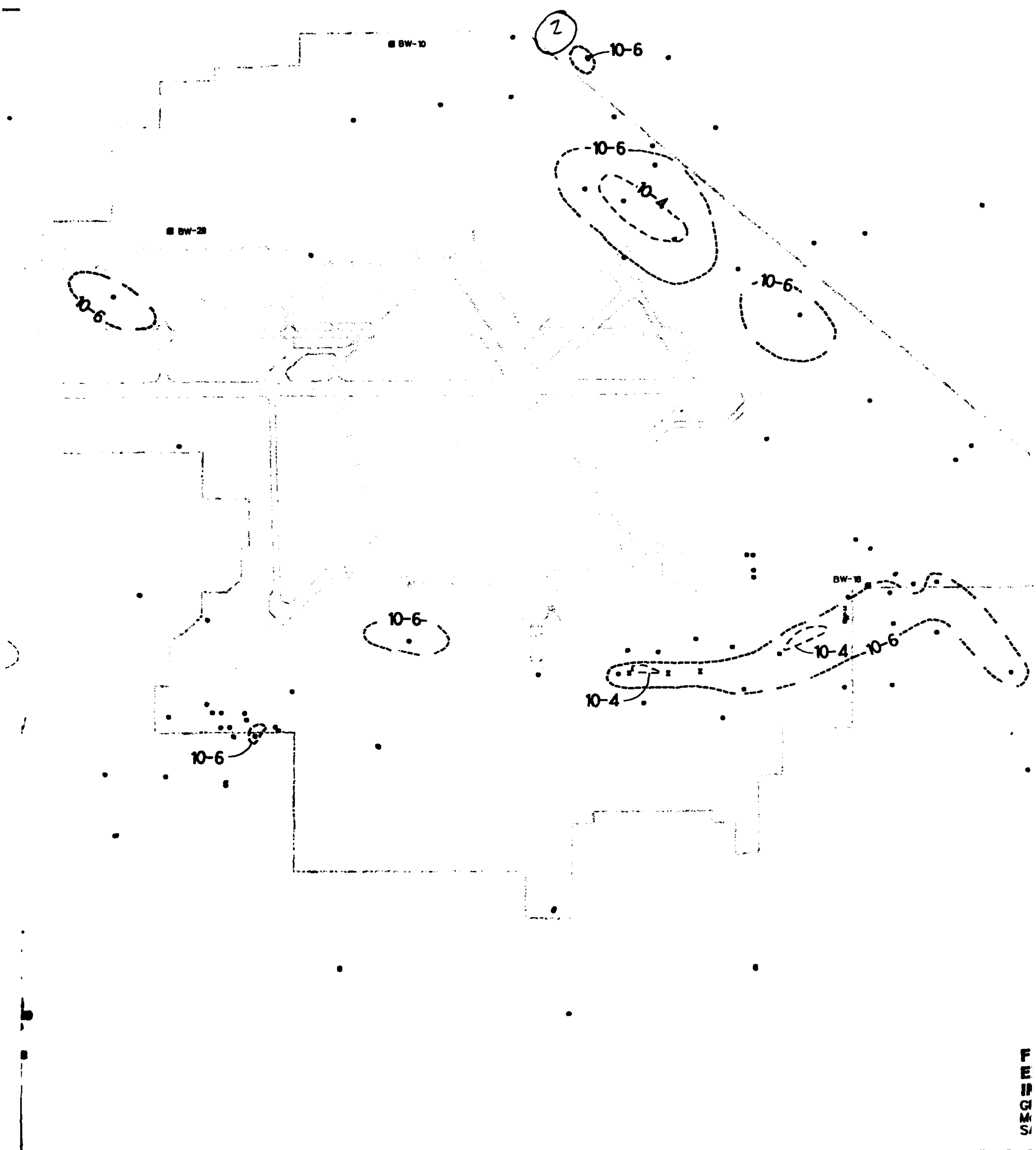


FIGURE B-5
EXTENT OF RISK CONTOURS IN MONITORING ZONE A
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA
CH2M HILL



RDD 1454
MEY94/MEY-B-6.DGN


2
BW-10
10-6
10-6
10-4
BW-28
10-6
10-6
10-6
BW-18
10-4
10-6
10-4
10-6

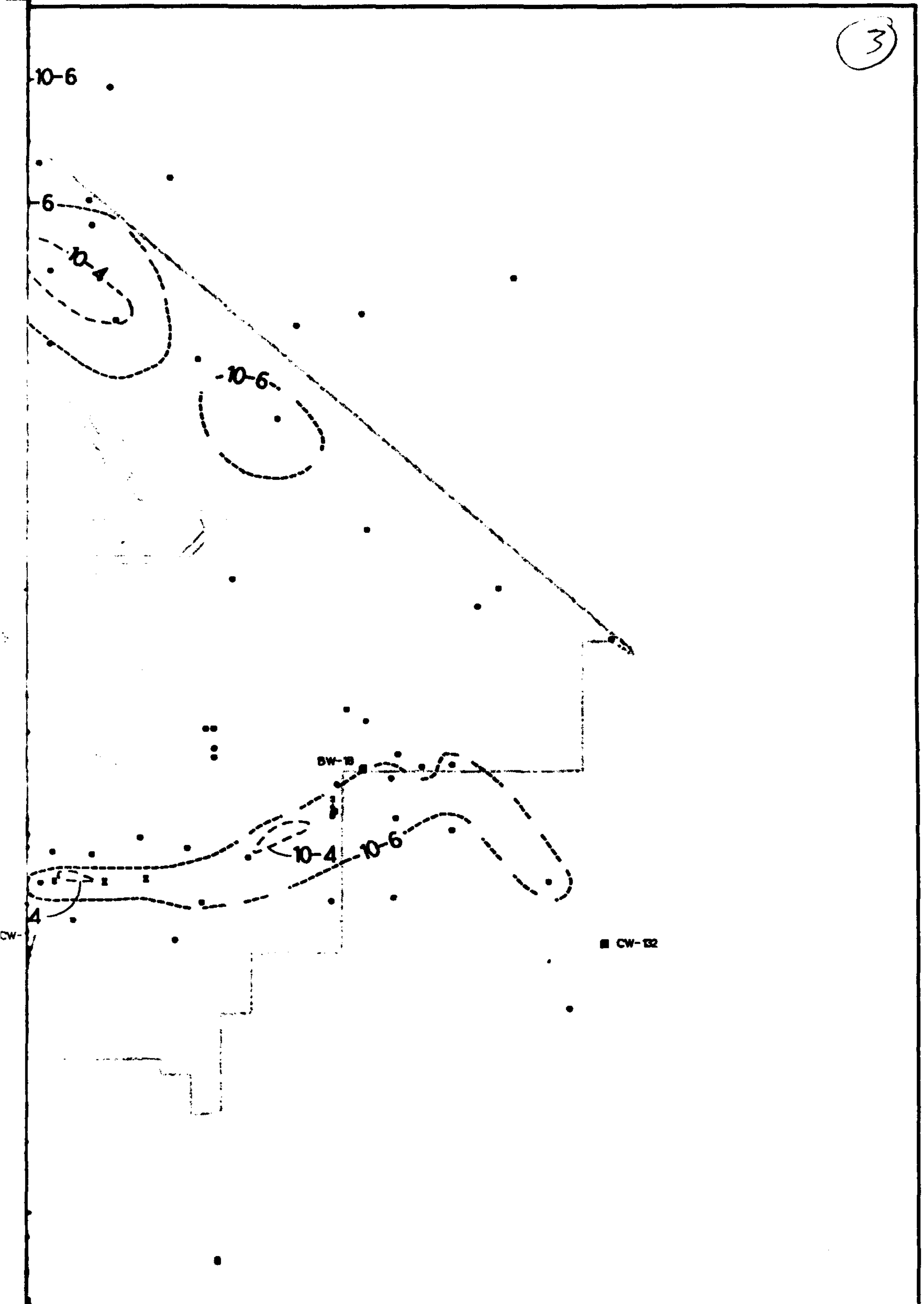
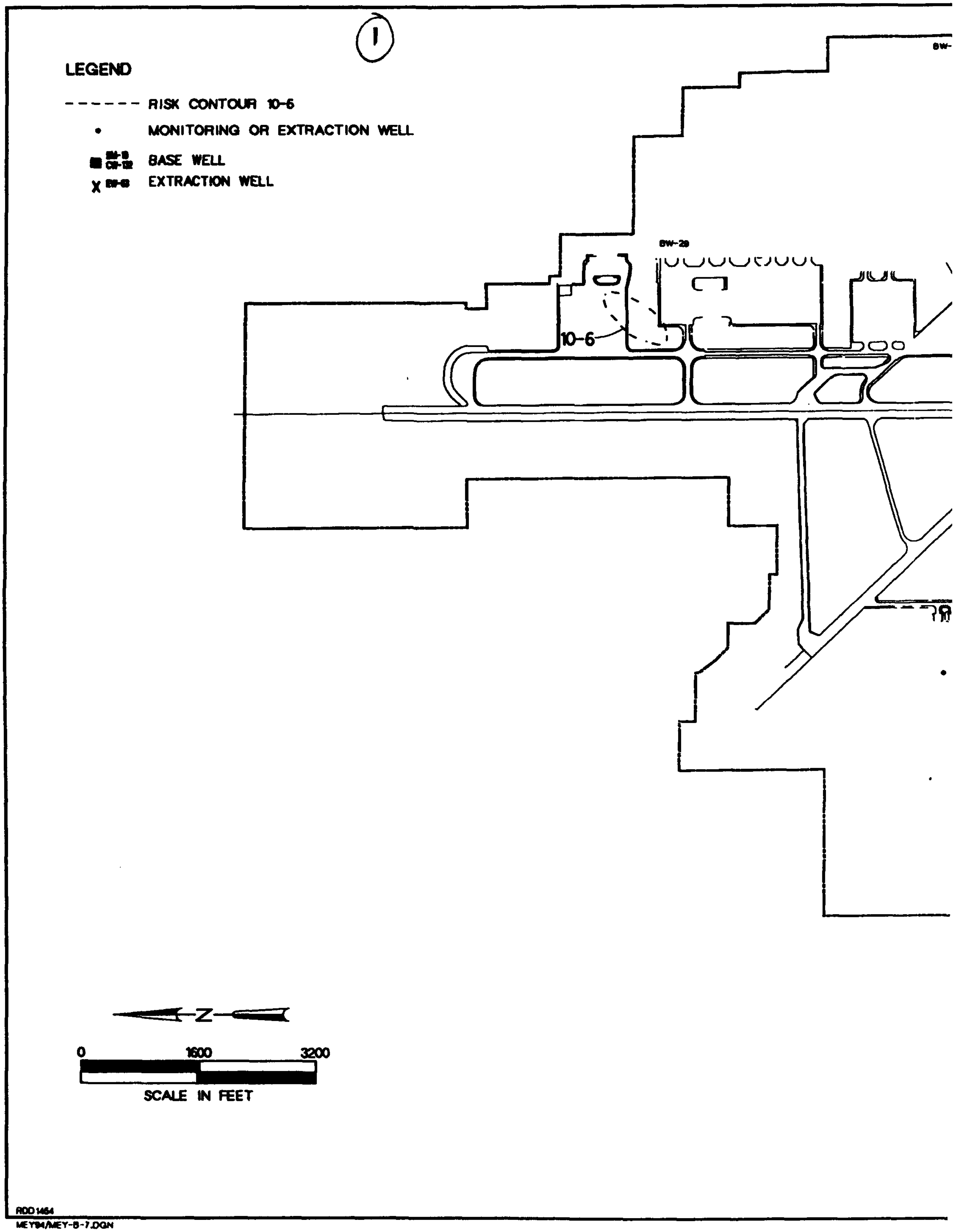


FIGURE B-6
EXTENT OF RISK CONTOURS IN MONITORING ZONE B
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA
CH2M HILL


1
LEGEND
RISK CONTOUR 10-6
MONITORING OR EXTRACTION WELL
BASE WELL
EXTRACTION WELL
BW-29
10-6
N
0
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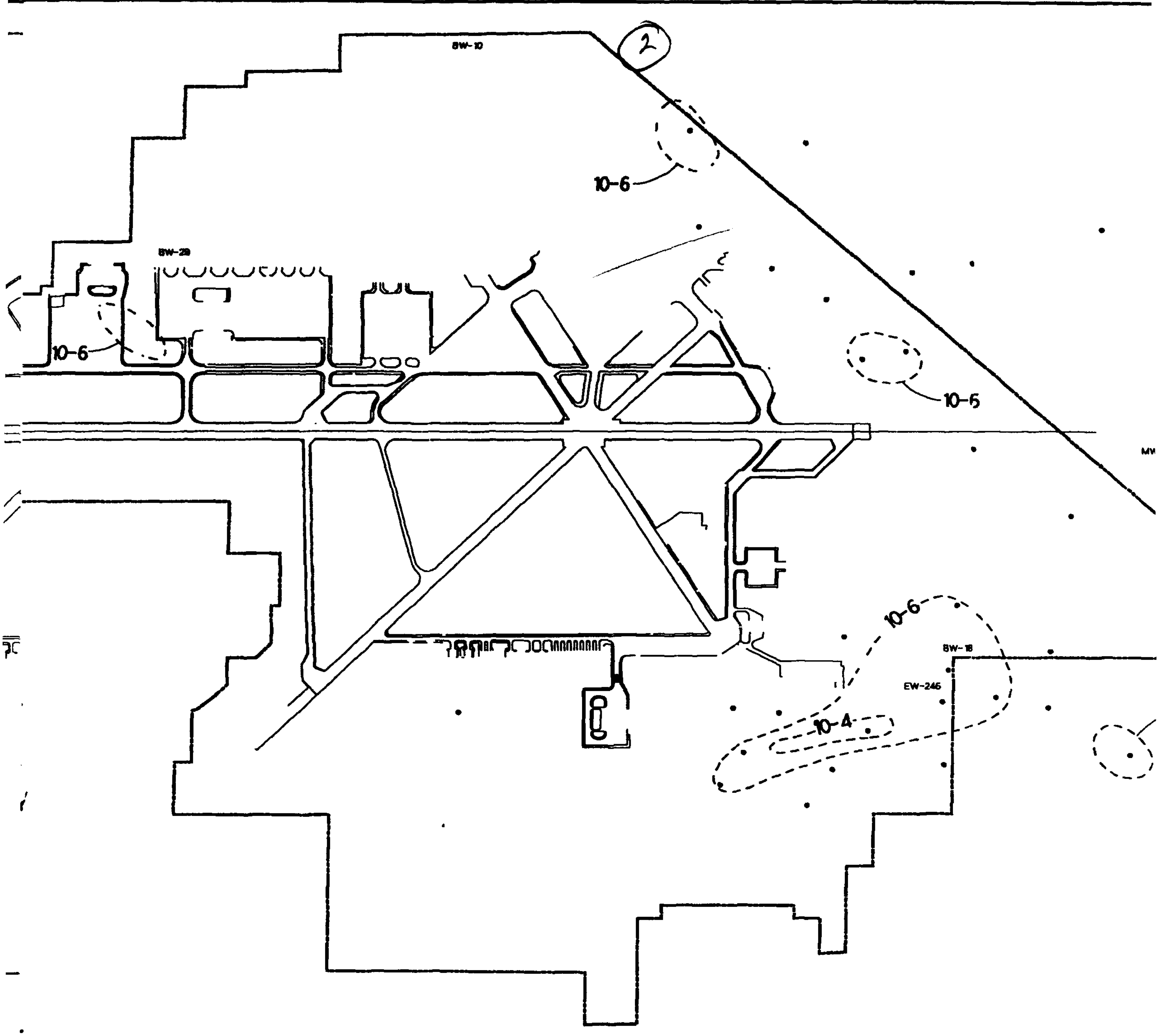
SCALE IN FEET
RDD 1464
MEY94/MEY-8-7.DGN



BW-10
10-6
BW-29
10-6
10-6
10-6
BW-18
EW-246
10-4

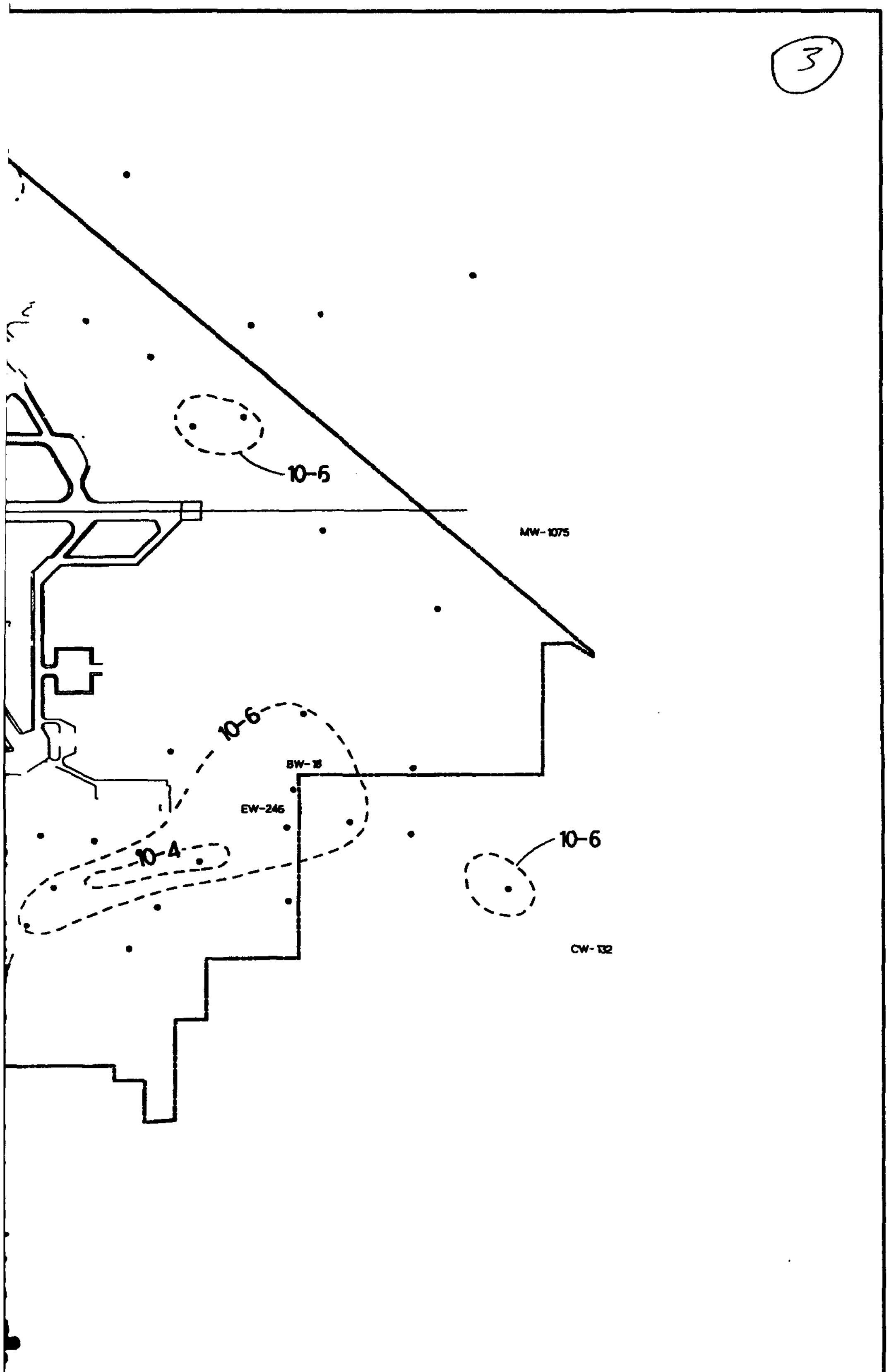
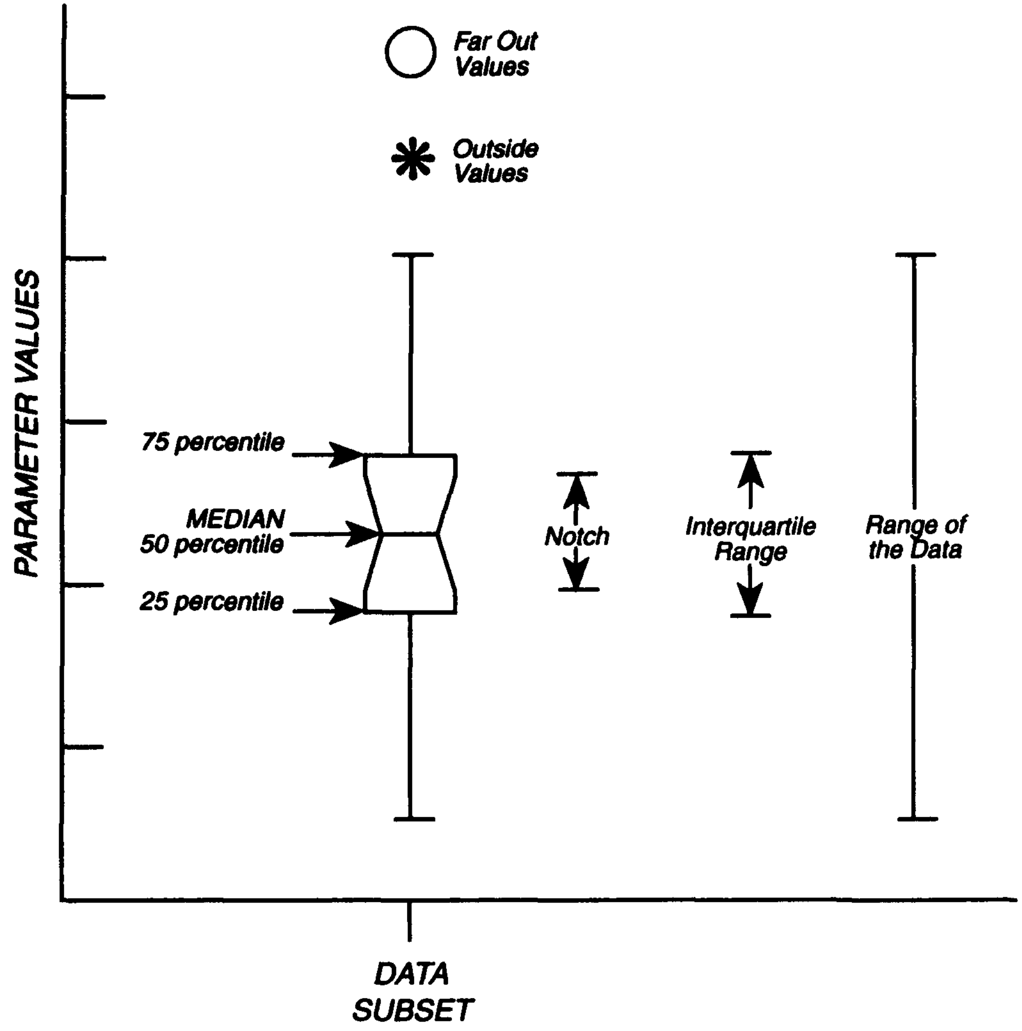


FIGURE B-7
EXTENT OF RISK CONTOURS IN MONITORING ZONE C
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

CH2M HILL



A box plot identifies the median (50 percentile value), the lower and upper quartiles (25 and 75 percentile values), and the extreme spread of the data.

The edges of the box demark the 25 and 75 percentiles, and so represent the middle 50 percent range (or interquartile range) of the range of values. The line within the box is the median.

The lines extending outward from the box demark the range of data, excluding outliers. Two outliers are defined, based on their distance from the nearest edge of the box (and relative to the range of the box).

Outside values lie 1.5 to 3 interquartile ranges from the nearest box edge, and far out values lie 3 or more interquartile ranges from the nearest box edge.

The notch represents the appoximate 95 percent confidence interval around the median.

FIGURE B-8
BOX PLOT
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

CH2M HILL

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Overall Inferences

A summary of the increased lifetime cancer risk estimates from the monitoring well data, grouped by OU and by monitoring zone, is presented in Figure B-9. Figure B-9 presents median estimates of risks associated with VOCs across all samples within each operable unit. Median risks in groundwater under OU A are relatively low, compared with OUs B, C, and D. This suggests that a significant fraction of the VOC mass in soil within OU A has not yet been released to groundwater. Median risks within the B-zone in OU B are noticeably greater than risks within the underlying C- and D-zones, suggesting that vertical migration of contaminants from soil has more significantly impacted shallow aquifers rather than the deeper aquifers. One significant finding from this analysis is that median risks in OU C are noticeably greater in the deeper monitoring zones compared with the shallow monitoring zones. This suggests that contaminants in soils within OU C are not a significant contributor to groundwater contamination, and that contaminants in the deeper zones reflect lateral migration in groundwater, possibly from OUs B and D. Figure B-10 presents the box plots of risks across all samples grouped by OU and monitoring zone. The A-zone (shallow zone) results presented in Figure B-10 indicate median risks generally between 10^{-6} to 10^{-5} with selected wells containing VOC concentrations associated with risks up to 10^{-2}, with little variability between OUs A through D. Results across the different monitoring zones for OU B show relatively little variability, suggesting that contamination is fairly consistent with increasing depth. Results for OU C show the higher median risks within deeper monitoring zones, suggesting that observed risks (hence contamination) have not originated from vertical migration of contamination from soils within OU C. The results for OU D show significant outliers with elevated risks within the B-zone (mid-shallow zone); these elevated contaminant levels appear to be relatively confined to the B-zone, based on the results presented for the C-zone (mid-deep zone). Table B-13 presents the contaminants associated with those observed distributions of risks across McClellan AFB groundwater. Attachments B-3 and B-4 provide detailed presentation of the sample-specific risk calculations based on estimated cancer risks.

Figure B-11 presents the box plots for noncancer hazard indices. This analysis shows that increased noncancer health risks generally are confined to the A- and B-zones. The data from the sample-specific risk assessment represent approximately 3,000 paired increased lifetime cancer risk and hazard index calculations, which were log-transformed for graphical presentation. Not all samples had cancer risk and hazard index calculations. Where the groundwater contaminants provided risks but no hazard index, a value of zero was substituted for missing hazard index value in that sample, after log-transformation. Where groundwater contaminant provided a hazard index, but no risk, a value of 10^{-8} was substituted for the missing risk value.

Operable Unit A				B	A	C
Operable Unit B		A		C	B	
Operable Unit C	C, D			A		B
Operable Unit D			A			B, C
Operable Unit E,F						ALL
Log Median Cancer Risk	-4.5 (3.2×10^{-5})	-5.5 (3.2×10^{-6})	-6.0 (1×10^{-6})	-6.2 (6×10^{-7})	-6.7 (2×10^{-7})	-8 (1×10^{-8})

NOTES:

A–A Zone
B–B Zone
C–C Zone
D–D Zone

FIGURE B-9
OVERALL RISK RANKING OF OPERABLE UNITS AND GROUNDWATER MONITORING ZONES
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

1312_159

CH2M HILL

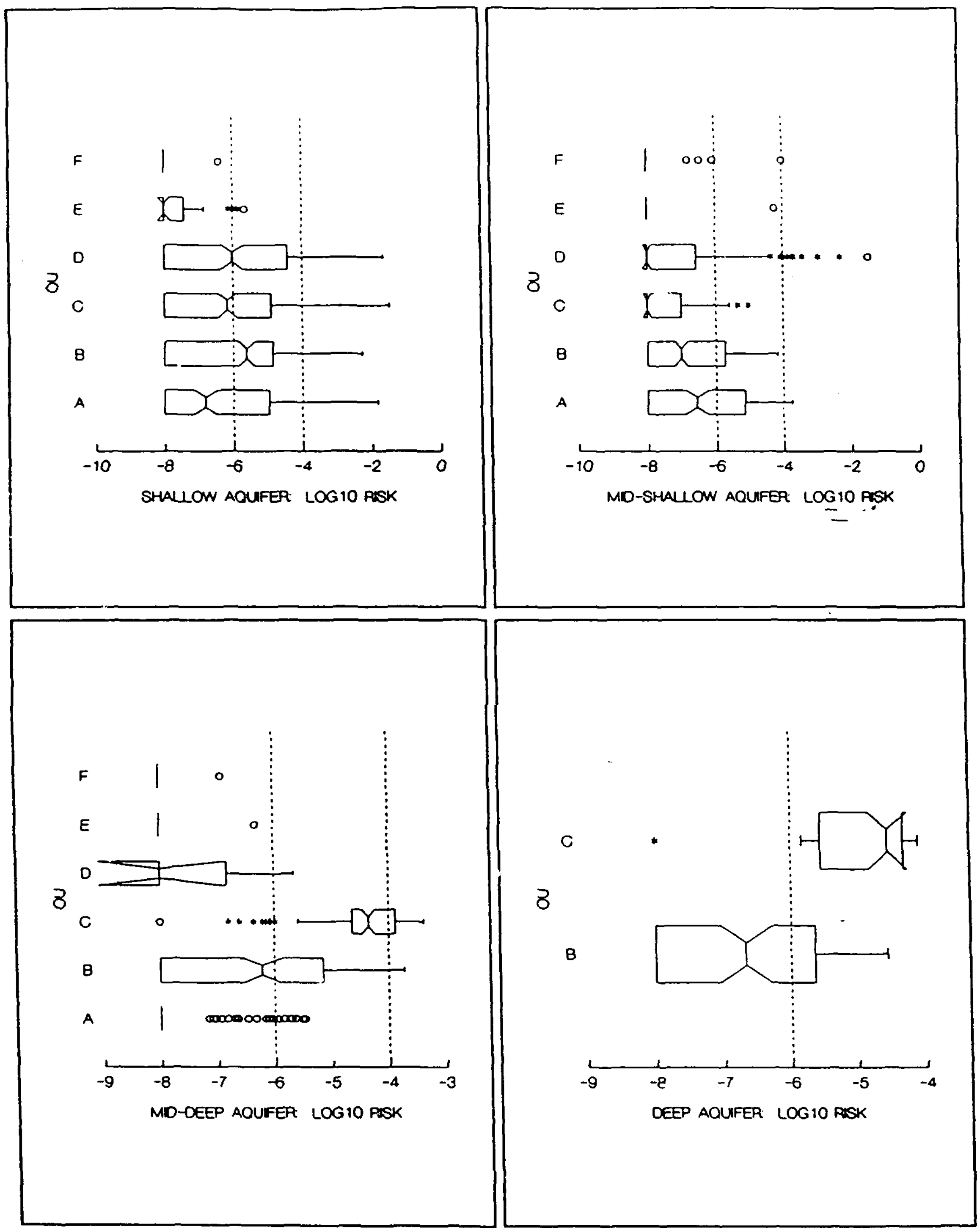

FIGURE B-10
CANCER RISK ACROSS MONITORING ZONES AND OPERABLE UNITS
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

RDD1454_103

CH2M HILL

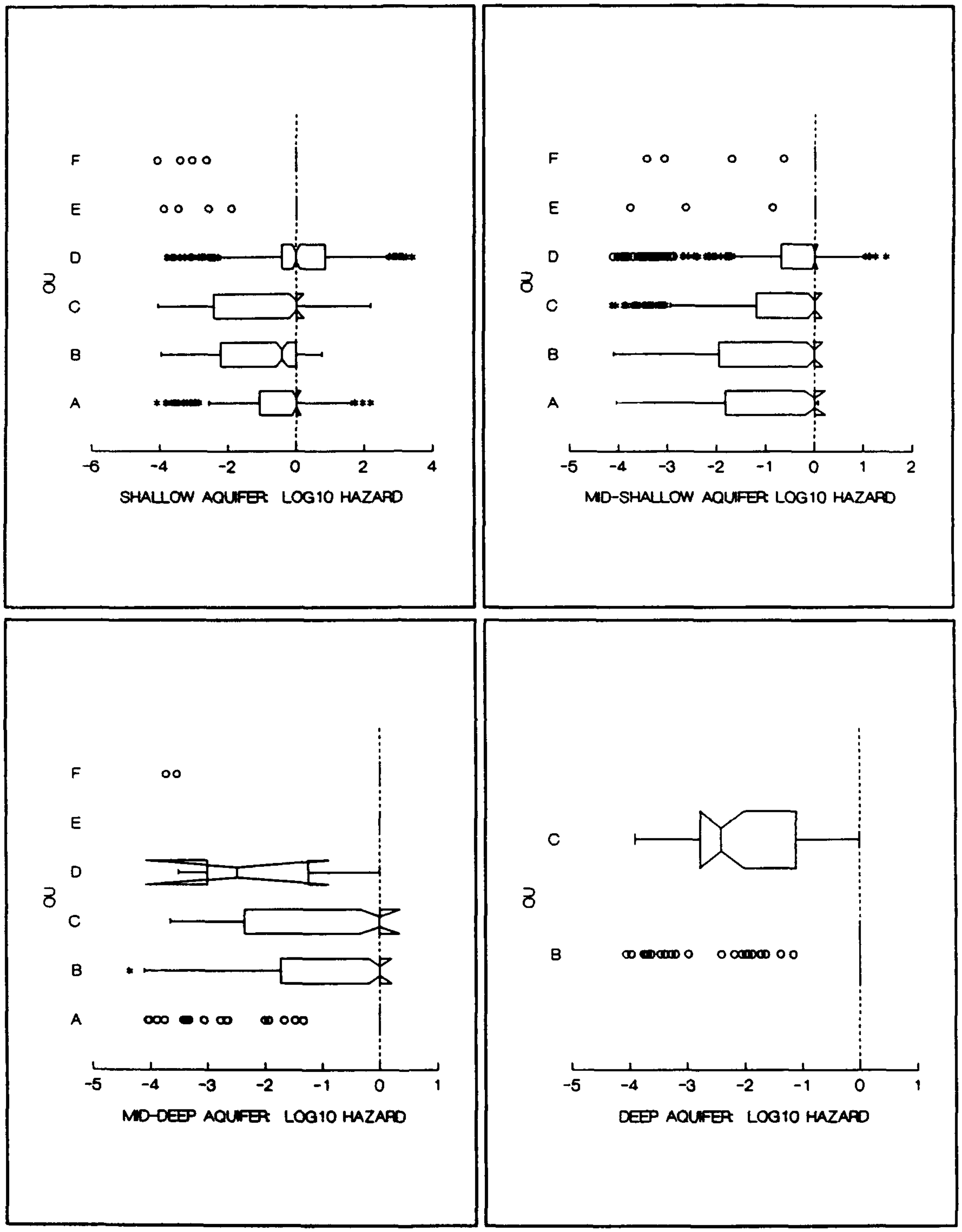

FIGURE B-11
HAZARD INDEXES ACROSS MONITORING ZONES AND OPERABLE UNITS
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

RDD1454_104

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Table B-13
McClellan Air Force Base Groundwater OU
Mean Estimated Lifetime Cancer Risks
by OU Within Monitoring Zones

Monitoring Zone	Parameter	Operable Units						
		All OUs	OU A	OU B	OU C	OU D	OU E	OU F
Shallow (A-Zone)	TRICHLOROETHENE	5.5E-04	5.4E-04	1.7E-04	1.2E-03	3.5E-04	1.4E-06	3.1E-06
	CHLOROFORM	2.9E-05	8.1E-05	3.0E-06	9.9E-06	9.6E-05	--	--
	TETRACHLOROETHENE	2.5E-04	1.4E-06	1.8E-04	1.1E-03	1.6E-04	--	--
	1,2-DICHLOROETHANE	1.9E-04	1.6E-05	1.4E-06	1.1E-04	5.3E-04	--	--
	METHYLENE CHLORIDE	8.2E-05	4.3E-05	4.3E-06	3.7E-05	2.1E-04	1.4E-07	4.4E-07
	CARBON TETRACHLORIDE	8.8E-05	1.3E-04	1.9E-06	4.1E-05	--	--	--
	VINYL CHLORIDE	2.5E-03	--	--	1.5E-04	3.5E-03	--	--
	BENZENE	8.2E-04	9.9E-04	3.5E-05	4.1E-07	1.5E-03	--	--
	1,1,2-TRICHLOROETHANE	7.5E-06	--	1.5E-06	--	9.0E-06	--	--
	1,1,2,2-TETRACHLOROETHANE	2.6E-05	1.8E-06	3.6E-05	4.4E-05	1.5E-06	--	--
	1,2-DICHLOROPROPANE	9.5E-06	4.2E-06	1.6E-07	1.2E-05	1.2E-06	--	--
	DIBROMOCHLOROMETHANE	5.3E-05	--	2.1E-05	--	1.5E-04	--	--
	BROMODICHLOROMETHANE	2.1E-06	3.4E-07	2.5E-06	4.3E-07	--	--	--
	CHLOROMETHANE	1.0E-06	3.3E-07	1.4E-07	2.3.E-06	--	1.4E-07	--
Mid Shallow (B-Zone)	TRICHLOROETHENE	1.1E-04	9.4E-06	1.7E-04	2.9E-06	1.2E-04	3.1E-06	5.9E-07
	CHLOROFORM	4.1E-06	5.3E-06	1.8E-06	4.0E-07	6.5E-06	--	--
	TETRACHLOROETHENE	1.2E-04	3.3E-06	3.0E-04	3.1E-06	2.3E-05	--	4.7E-05
	1,2-DICHLOROETHANE	2.2E-04	2.0E-06	1.7E-06	--	3.0E-04	--	7.1E-07
	METHYLENE CHLORIDE	2.5E-05	6.5E-07	1.8E-05	4.2E-06	3.5E-05	5.6E-05	4.1E-05
	CARBON TETRACHLORIDE	2.2E-05	2.6E-05	8.0E-07	5.8E-07	7.9E-07	--	--

Table B-13
McClellan Air Force Base Groundwater OU
Mean Estimated Lifetime Cancer Risks
by OU Within Monitoring Zones

Monitoring Zone	Parameter	Operable Units						
		All OUs	OU A	OU B	OU C	OU D	OU E	OU F
Mid Shallow (B-Zone) (continued)	VINYL CHLORIDE	2.0E-02	--	--	--	2.0E-02	--	--
	BENZENE	3.3E-05	1.2E-06	4.7E-06	1.7E-06	1.2E-04	--	--
	1,1,2-TRICHLOROETHANE	1.0E-04	--	2.0E-05	--	1.1E-04	--	--
	1,1,2,2-TETRACHLOROETHANE	1.5E-05	--	--	--	1.5E-05	--	--
	1,2-DICHLOROPROPANE	1.4E-7	--	9.0E-08	--	2.0E-07	--	--
	CHLOROMETHANE	3.4E-07	1.1E-07	6.9E-07	1.1E-07	1.9E-07	--	--
Mid Deep (C-Zone)	TRICHLOROETHENE	5.0E-05	5.9E-07	1.2E-05	9.2E-05	--	--	--
	CHLOROFORM	1.6E-06	1.3E-07	1.8E-06	8.7E-07	--	--	--
	TETRACHLOROETHENE	8.7E-06	5.3E-07	1.0E-05	6.4E-06	--	--	--
	1,2-DICHLOROETHANE	1.7E-06	--	1.7E-06	1.5E-06	--	--	--
	METHYLENE CHLORIDE	3.6E-06	2.0E-07	1.8E-06	5.9E-06	--	--	1.2E-07
	CARBON TETRACHLORIDE	1.9E-06	1.9E-06	2.0E-06	--	--	--	--
	BENZENE	1.2E-06	1.6E-06	9.1E-07	1.5E-06	--	4.8E-07	--
	1,1,2,2-TETRACHLOROETHANE	1.6E-06	--	--	--	1.6E-06	--	--
	1,2-DICHLOROPROPANE	2.3E-07	--	2.3E-07	--	--	--	--
	DIBROMOCHLOROMETHANE	1.9E-05	--	1.9E-05	--	--	--	--
	CHLOROMETHANE	3.1E-07	1.7E-07	4.5E-07	1.6E-07	--	--	--
Deep (D-Zone)	TRICHLOROETHENE	2.1E-05	2.4E-04	4.4E-06	3.0E-05	--	--	--
	CHLOROFORM	6.6E-06	3.2E-05	3.1E-07	3.6E-07	--	--	--
	TETRACHLOROETHENE	1.9E-06	--	1.7E-07	2.8E-06	--	--	--

Table B-13
McClellan Air Force Base Groundwater OU
Mean Estimated Lifetime Cancer Risks
by OU Within Monitoring Zones

Monitoring Zone	Parameter	Operable Units						
		All OUs	OU A	OU B	OU C	OU D	OU E	OU F
Deep (D-Zone) (continued)	1,2-DICHLOROETHANE	1.3E-06	--	1.3E-06	1.2E-06	--	--	--
	METHYLENE CHLORIDE	1.9E-06	--	1.5E-06	2.7E-06	--	--	--
	CARBON TETRACHLORIDE	8.7E-07	--	6.2E-07	1.1E-06	--	--	--
	BENZENE	2.5E-06	--	2.5E-06	--	--	--	--
	1,1,2,2-TETRACHLOROETHANE	2.8E-06	--	2.8E-06	--	--	--	--
	CHLOROMETHANE	1.1E-07	--	1.1E-07	--	--	--	--
Unspecified	TRICHLOROETHENE	9.6E-07	--	1.1E-06			--	--
	CHLOROFORM	4.7E-06	--	--	--	--	--	--
	TETRACHLOROETHENE	6.6E-07	--	--	--	--	--	--
	1,2-DICHLOROETHANE	8.0E-06	--	--	--	--	--	--
	METHYLENE CHLORIDE	6.9E-07	--	--	--	--	--	--
	CARBON TETRACHLORIDE	1.3E-06	--	--	--	--	--	--
	VINYL CHLORIDE	2.8E-04	--	--	--	--	--	--
	1,1,2-TRICHLOROETHANE	8.1E-07	--	--	--	--	--	--
	1,1,2,2-TETRACHLOROETHANE	9.8E-06	--	--	--	--	--	--
	DIBROMOCHLOROMETHANE	3.8E-05	--	--	--	--	--	--
	BROMODICHLOROMETHANE	1.7E-06	--	--	--	--	--	--
	CHLOROMETHANE	2.7E-07	--	--	--	--	--	--
	BROMOFORM	2.8E-07	--	--	--	--	--	--

Risk Characterization

Risk characterization involves estimating the magnitude of the potential adverse health effects under study. This is accomplished by combining the results of the dose-response and exposure assessments to provide numerical estimates of potential health effects. These values represent comparisons of exposure levels with appropriate RfDs and estimates of excess cancer risk. Risk characterization also considers the nature of and weight of evidence supporting these estimates, as well as the magnitude of uncertainty surrounding such estimates.

Although the risk assessment produces numerical estimates of risk, these numbers do not predict actual health outcomes. The estimates are calculated to overestimate risk, and thus any actual risks are likely to be lower than these estimates, and may even be zero.

Characterization of Numerical Results

Generally, EPA considers action to be warranted at a site when cancer risks exceed 1×10^{-4}. Generally, action is not specifically required for risks falling within 1×10^{-4} to 1×10^{-6}, however this is judged on a case-by-case basis. Risks less than 1×10^{-6} generally are not of concern to regulatory agencies. A hazard index (the ratio of chemical intake to the RfD) greater than one indicates that there is some potential for adverse noncancer health effects associated with exposure to the contaminants of concern (U.S. EPA, 1991a).

Interpretations of the data presented in the previous section indicate that the range of risks from contaminant concentrations fall between 10^{-4} to 10^{-6} in most of the monitoring wells. In selected wells, risks may be as high as 10^{-2}; generally these risks are found in wells that have been placed within contaminant source areas. Note that the numerical results presented in the previous section do not reflect expected pathways of exposure under either current or future conditions. These reflect a hypothetical scenario of a residence using contaminated groundwater that was developed for the purpose of estimating risk-based target volumes for remedial action. Under current conditions or foreseeable future conditions at McClellan AFB, it is not likely that there would be pathways of exposure to the contaminants in groundwater as measured in the GSAP.

Comparison with Health Assessment Findings

The results from the risk assessment were compared with the findings from the Health Assessment for McClellan AFB prepared by the Agency for Toxic Substances and Disease Registry (ATSDR). In preparation of the Health Assessment, ATSDR collected and reviewed relevant health and environmental data for activities across the entire base (ATSDR, 1993). ATSDR concluded that there have been complete exposure pathways in the past from groundwater contaminants to human populations, both onbase and offbase. The health assessment states that, while exposure pathways appear to be incomplete under current conditions, there is a lack of data to fully evaluate exposure pathways. In particular, ATSDR notes that there are no updated records on the current use of private wells by residents provided with the alternate water supply. ATSDR speculated that it is possible that some residents may have reconnected their private wells because of water restrictions during the drought, though none reported using their private wells for potable purposes in the ATSDR public availability sessions. Individuals using private wells for irrigation purposes could be exposed by inhalation of contaminants from droplets of water spray in the air and by ingesting biota that have bioaccummulated contaminants. Based on a survey of a limited number of residents, ATSDR noted that contaminant concentrations in offbase wells had decreased considerably from between 1985 and 1991.

ATSDR stresses the uncertainties concerning potential adverse health effects associated with exposure to low levels of multiple environmental contaminants in groundwater. In a fashion similar to that presented in this risk assessment, ATSDR provides a quantitative evaluation of health risks associated with groundwater contaminants, and in several cases, reported that potential exposures exceeded acceptable levels. However, these estimates operate under the same constraint in that they are calculated in a manner that overestimates risk, and thus any actual risks are likely to be lower than these estimates, and may even be zero.

The adverse effect principally of concern for contamination of groundwater is cancer. Cancer is of concern largely due to the scientific uncertainty over the existence of no-effect threshold for carcinogenic effects. Public concerns about carcinogens have mandated that regulatory agencies use extremely low acceptable risk levels in setting criteria levels for groundwater contaminants. Data evaluating potential human health risks from exposure to groundwater contaminants are limited and indirect. Epidemiological studies of the cancer incidence possibly due to exposure to trihalomethanes (THMs) originating from chlorination of water supplies best simulate the human exposure scenario, but do not correlate well exposure concentrations and observed cancer incidences.

These studies do not conclusively relate observed cancer incidences with THM concentrations (shown to average 83 $\mu g/l$ in previous studies), but are suggestive because they represent concentrations of chlorinated VOCs in groundwater at which elevations in cancer risk are barely detectable in several large epidemiological studies (Williamson, 1981; NRC, 1980; Shy, 1985). Relatively few studies have evaluated the incidence of adverse effects in populations living near disposal sites, and these often have several limitations. While these studies have played a role in shaping the public debate concerning groundwater contamination, they generally have added little to our understanding of trends between adverse effects and contamination (Upton et al., 1989). However, a limited number of studies provide a useful example of the extent of groundwater contamination with VOCs considered to be associated with adverse health effects. In one case, prompted by health complaints from residents in Hardeman County, Tennessee, groundwater samples were collected from wells near a landfill where 300,000 barrels of pesticide manufacturing wastes were stored. The population previously exposed to contaminated well water exhibited hepatomegaly and abnormally high levels of hepatic enzyme levels. These effects decreased upon cessation of exposure. Concentrations of carbon tetrachloride detected in private wells serving the exposed individuals ranged from 61 to 18,700 ug/l, with a median level of 1,500 ug/l. The authors concluded that the findings indicated transitory liver injury probably related to contaminated groundwater (Clark et al., 1982). Though there are limitations with the data, epidemiological studies of human exposure to groundwater contaminants provide some insight on the potential for adverse health effects at McClellan AFB. The studies of cancer incidences associated with exposures to THMs in chlorinated surface water indicate increased cancer risks that are barely detectable with epidemiological methods. While contaminant exposures were not quantified in these studies, a median THM concentration reported in U.S. surface water, during the time in which these studies were conducted, was 117 μg/l, with 83 μg/l of chloroform (Williamson, 1981). The NAS has concluded that the projected increases in mortality in these epidemiological studies are probably too small to distinguish in the presence of confounding factors, such as cigarette smoking (NRC, 1980). The human experience with exposure to groundwater contaminants, as it has been evaluated through epidemiological studies, combined with data characterizing the contaminant concentrations, suggest that there is a low likelihood of a perceptible association between adverse health effects and groundwater contamination at McClellan AFB.

Works Cited

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Attachment B-1
Monitoring Well History

Table B1-1
Well History By Zones
VOCs

Contouring Period		1				2							3			4			5				6			7			8			9			10			11			12			13			14		
Wellname	Zone	8601	8602	8603	8604	8605	8606	8607	8608	8609	8610	8611	8612	8701	8702	8703	8704	8705	8706	8707	8708	8709	8710	8711	8712	8801	8802	8803	8804	8805	8806	8807	8808	8809	8810	8811	8812	8901	8902	8903	8904	8905	8906	8907	8908	8909	8910	8911	8912
MW-16	A																						36						33			33			33			33			33				40				40
MW-1002	A				33					33					33			33			33		33			33			33			33			29			29			29			36					40
MW-1004	A			33						33				33				33			33		33			40			33			40			29			29			29				36		40		
MW-1005	A			33						33				33			40			33			33			33			33			33			29			29			29				36				40
MW-1008	A			33							33				33		33			33			33			33			33			40			29														
MW-101	A			33						33				33			33				40		33			33			33			33			29														40
MW-1011	A			33							33			33			33				33		33			33			40			33			29														
MW-1012	A			33						33				33				33		40			33			33			33			33			29														
MW-1013	A			33							33			33			40				33		33			33			33			33			29			29			29								
MW-1014	A			33							33			33			33				33		33			33			33			33			29			29			29								
MW-1015	A			33							33			33				33			33		33			33			33			33			29			29			29			36					40
MW-1016	A			33							33			33				33			33		33			33			33			33			29			29			29			36			40		
MW-1017	A			33						33				33			33			33			33			33			33			33			29														
MW-1018	A			33						33					33			33			33		40			33			33			33			29														
MW-1019	A				33					33				33			33				33		33			40			33			40			29			29			29			36					40
MW-102	A			33						33				33			33				40		33			33			33			33			29												40		
MW-1020	A			33							33			33			33				33		33			33			33			33			29			29			29			36			40		
MW-1021	A											33		33			33				33		33			33			33			33			29			33			29			36					40
MW-1023	A											33		33			33				33		33			33			33			33			29			29			29				36				40
MW-1024	A											33		33			33				33		33			33			33			33			29			29			29			36			40		
MW-1026	A											33		33			33				33		33			33			33			33			29														
MW-1028	A											33		33			33				33		33			40			33						29												40		
MW-1033	A											33		33			33				33		33			33			40			33			29														
MW-1036	A											33		33			33				33		33			40			33			40			29														
MW-1037	A										33			33				33			40		33			33			33			33			29			29			29			36					40
MW-1041	A											33		33				33			33		33			33			33			33			29														
MW-1044	A																																								29			61					40
MW-1049	A																																								29			61					40
MW-1053	A																																													40			
MW-1054	A																																														36		

Table B1-1
Well History By Zones
VOCs

Contouring Period		1				2							3			4			5			
Wellname	Zone	8601	8602	8603	8604	8605	8606	8607	8608	8609	8610	8611	8612	8701	8702	8703	8704	8705	8706	8707	8708	8709
MW-1059	A																					
MW-106	A			33						33				33			33			33		
MW-1061	A																					
MW-1064	A																					
MW-1067	A																					
MW-1069	A																					
MW-107	A				30					33				33			33			33		
MW-11	A																					
MW-110	A			33						33				33			33			33		
MW-111	A				33					30				33			33			33		
MW-114	A		30								33			33			30				33	
MW-115	A			33							33			33			33			33		
MW-116	A		30							30				30			33				30	
MW-117	A			6	33						33											
MW-12	A																					
MW-120	A			6	30						33			33			33				33	
MW-123	A			6	20						30											
MW-126	A												30	40			40				33	30
MW-128	A												30	40			33				33	
MW-131	A											33		33			33				33	
MW-135	A																					
MW-138	A																					
MW-14	A																					
MW-145	A																					
MW-15	A																					
MW-150	A																					
MW-153	A																					
MW-155	A																					
MW-157	A																					
MW-158	A																					

Contouring Period		6			7			8			9			10			11			12			13			14		
Wellname	Zone	8710	8711	8712	8801	8802	8803	8804	8805	8806	8807	8808	8809	8810	8811	8812	8901	8902	8903	8904	8905	8906	8907	8908	8909	8910	8911	8912
MW-1059	A																									41		
MW-106	A	33			33			30			33			20														40
MW-1061	A																											
MW-1064	A																											
MW-1067	A																											
MW-1069	A																											
MW-107	A	30			30			33			33			20														
MW-11	A	30						33			33						30			33				40				40
MW-110	A	33			33			33			30			20														40
MW-111	A	33			40			33			40																	40
MW-114	A	33			40			33			40			20			30			30								
MW-115	A	33			33			33			33			20			20			20			36			40		
MW-116	A	33			40			30			40			30												40		
MW-117	A																											
MW-12	A	36						33			33			33			30			30				40				40
MW-120	A	33			40			33			40			20			20			20			36					
MW-123	A																											
MW-126	A	33			40			33			40			30			33			33			36			40		
MW-128	A	33			40			33			40			20			20			30			30			40		
MW-131	A	33			33			33			33			20			20			20			36					
MW-135	A					30		20			30				20		20			30			30			40		
MW-138	A					33		20			33			20			20			20			36			40		
MW-14	A	36						33			33			33			30			30				40				40
MW-145	A																		20				36					
MW-15	A	36						33			33			33			30			33				40				40
MW-150	A																		20				40					40
MW-153	A																				20		40					40
MW-155	A																								40			
MW-157	A																								30			
MW-158	A																									40		

Table B1-1
Well History By Zones
VOCs

Contouring Period		1				2							3			4			5				6			7			8			9			10			11			12			13			14		
Wellname	Zone	8601	8602	8603	8604	8605	8606	8607	8608	8609	8610	8611	8612	8701	8702	8703	8704	8705	8706	8707	8708	8709	8710	8711	8712	8801	8802	8803	8804	8805	8806	8807	8808	8809	8810	8811	8812	8901	8902	8903	8904	8905	8906	8907	8908	8909	8910	8911	8912
MW-158	A																																																
MW-160	A																																																40
MW-164	A																																														39		
MW-168	A																																															40	
MW-172	A																																																
MW-176	A																																																
MW-178	A																																														41		
MW-182	A																																																
MW-185	A																																																
MW-188	A																																																
MW-189	A																																																
MW-191	A																																																
MW-194	A																																																
MW-197	A																																																
MW-198	A			39							39																																						
MW-200	A																																																
MW-202	A																																																
MW-203	A																																																
MW-204	A																																																
MW-209	A																																																
MW-206	A										39																																						
MW-210	A																																																
MW-212	A																																																
MW-214	A																																																
MW-217	A																																																
MW-210	A			33						33				33				33			33		33			33			33			33			29			29			29			36					40
MW-218	A			33						33				33				33			33		33			40			33			40			29			29											
MW-222	A																																																
MW-224	A																																																
MW-226	A																																																

Table B1-1
Well History By Zones
VOCs

Contouring Period		1				2							3			4			5				6			7			8			9			10			11			12			13			14		
Wellname	Zone	8601	8602	8603	8604	8605	8606	8607	8608	8609	8610	8611	8612	8701	8702	8703	8704	8705	8706	8707	8708	8709	8710	8711	8712	8801	8802	8803	8804	8805	8806	8807	8808	8809	8810	8811	8812	8901	8902	8903	8904	8905	8906	8907	8908	8909	8910	8911	8912
MW-228	A																																																
MW-235	A																																																
MW-238	A																																																
MW-25D	A																																		29			29			29				36				40
MW-28D	A																	33			33		33			40			33			40			29			33			29			36					40
MW-31S	A			33							33			33			33				33		33			33			40																				
MW-33S	A										33			40			40			40		33	33			40			33			40			33			33			33			40					40
MW-36S	A			33						33				33			40			33			33			33			33			33			29														
MW-41S	A			33								33		33			33				33		33			40			33			40			29			33			29			36			40		
MW-44S	A			33						33				40	8			33			33		33			33			33			33			29			29			29			36					40
MW-60	A										33			40			33				33		33			33			33			33			29			29			29			36			40		
MW-61	A			33									33	40				33			33		33			40			33			40			29			29			29				36				
MW-62	A																												40			33			29			29			29			36					40
MW-65	A																																								29			36					40
MW-67	A			33							33			33				33			33		33			33			33			33			29														
MW-68	A																	33			33		33			33			33			33			29														40
MW-7	A																																								56				36				40
MW-72	A																	33			33		40			40			40			40			29			29			29			36			40		
MW-75	A																												40			33			29			33			29			36					40
MW-88	A													40				33			33		40			33			40			33			29			29			29			36			40		
MW-89	A													40				33			33		40			33			40			33			29			33			29			36			40		
MW-90	A													40				33			33		40			33			40			33			29			29			29			36			40		
MW-91	A													40			33			33			40			33			40			33			29			33			29			36					40
MW-92	A													33			33			33			40			33			40			33			29			29			29			36			40		
MW-1000	AB			33							33			33			33				33		33			33			33			33			29			29			29				36		40		
MW-1003	AB			33							33			33				33			33		33			33			33			33			29			29			29				36		40		
MW-1010	AB				33						33			33				33		33			33			33			33			33			29														
MW-1034	AB											33		33			33				33		33			33			33			33			29														
MW-1042	AB											33		33				33			33		33			33			33			33			29												40		
MW-108	AB				33					33				33			33			33			33			33			33			33			29												40		

Table B1-1
Well History By Zones
VOCs

Contouring Period		1				2							3			4			5				6			7			8			9			10			11			12			13			14		
Wellname	Zone	8601	8602	8603	8604	8605	8606	8607	8608	8609	8610	8611	8612	8701	8702	8703	8704	8705	8706	8707	8708	8709	8710	8711	8712	8801	8802	8803	8804	8805	8806	8807	8808	8809	8810	8811	8812	8901	8902	8903	8904	8905	8906	8907	8908	8909	8910	8911	8912
MW-113	AB											33		33			33			33			33			33			33			33																	40
MW-121	AB		33								33			33			33				33		33			33			33			33			29			29			29			38			40		
MW-124	AB		33									33																																					
MW-128	AB			33																																													
MW-170	AB																	38			33		38			40			38			40			29														40
MW-52	AB											33		33				33		33			40			33			33			33			29			29			29			38			40		
MW-53	AB											33		33				38		33			40			33			40			40										29		38					
MW-54	AB											33		33			40				33		40			33			40			33			29			29			29			38			40		
MW-55	AB											33		33			40				33		40			33			33			40			29			29			29			38			40		
MW-57	AB											33		33			40			33			40			33			33			33			29			33			29				38		40		
MW-70	AB													40				33			33		40			33			40			38			38			38			38			38			40		
MW-74	AB																												40			33			29							29		38					40
MW-76	AB																												40			33			38							38		38					40
MW-1001	B				33						33			33				33			33		33			33			33			33			29			29			33				38		40		
MW-1022	B											33		33			33				33		40			33			33			33			29			29			29			38					
MW-1025	B											33		33			33				33		33			33			33			33			29			29			29			38			40		
MW-1027	B											33		33			33				33		33			33			33			33			29													40	
MW-1028	B																				33		40			33			33			33			29														
MW-183	B			33						33				33			33				40		33			33			33			33			38												40		
MW-1030	B											33		33			33				33		33			33			33						29												40		
MW-1031	B											33		33			38				38		38			33			38						38												40		
MW-1032	B											33		33				33			33		33			33			33			33			29														
MW-1035	B											33		33			33				33		29			33			33			33			29												40		
MW-1038	B											33		33			33				40		33			33			33			33			29			29			29			38			40		
MW-184	B			33							33			33				33		33			33			33			33			33			29			29				29		38					40
MW-1043	B											33		33				33			33		33			33			33			33			29												40		
MW-1045	B																																								38			40			40		
MW-105	B			33							33			33			33				33		33			33			33			33			29			29			29			38					40
MW-1050	B																																								29			40				44	40
MW-1055	B																																														38		

Table B1-1
Well History By Zones
VOCs

Contouring Period		1				2							3			4			5				6			7			8			9			10			11			12			13			14		
Wellname	Zone	8601	8602	8603	8604	8605	8606	8607	8608	8609	8610	8611	8612	8701	8702	8703	8704	8705	8706	8707	8708	8709	8710	8711	8712	8801	8802	8803	8804	8805	8806	8807	8808	8809	8810	8811	8812	8901	8902	8903	8904	8905	8906	8907	8908	8909	8910	8911	8912
MW-1058	B																																														41		
MW-1062	B																																																
MW-1065	B																																																
MW-1068	B																																																
MW-1069	B																																																
MW-109	B											33		33			33			33			33			33			33			33			29												40		
MW-112	B				30					33				33			33			33			33			33			33			33																	40
MW-118	B			33							33																																						
MW-130	B											33		40			33			33			33			33			33			33			29			29			29			36					40
MW-134	B																										33		33			33			29			29			29			36			40		
MW-142	B																										33		33						30			29			29			36					40
MW-143	B																										33		33			40			29			29			29			36			40		
MW-148	B																																							29				36					40
MW-151	B																																							29				36					40
MW-158	B																																													40			
MW-165	B																																															40	
MW-170	B																																																
MW-173	B																																																
MW-176	B																																														41		
MW-179	B																																																
MW-183	B																																																
MW-189	B																																																
MW-180	B			33							33			33			33				33		33			33			40			33			29												40		
MW-182	B																																																
MW-185	B																																																
MW-188	B																																																
MW-190	B																						36						33						29														
MW-201	B																																																
MW-204	B																																																
MW-207	B																																																

Table B1-1
Well History By Zones
VOCs

Contouring Period 1–6

Wellname	Zone	1: 8601	1: 8602	1: 8603	1: 8604	2: 8605	2: 8606	2: 8607	2: 8608	2: 8609	2: 8610	2: 8611	3: 8612	3: 8701	3: 8702	4: 8703	4: 8704	4: 8705	5: 8706	5: 8707	5: 8708	5: 8709	6: 8710	6: 8711	6: 8712
MW-20D	B										33			40				38		30			30		
MW-211	B																								
MW-213	B																								
MW-215	B																								
MW-218	B																								
MW-220	B																								
MW-223	B																								
MW-225	B																								
MW-227	B																								
MW-229	B																								
MW-22D	B										33			40				33			30		33		
MW-23D	B			33							33			33				33			33		33		
MW-24D	B			30						30				30				30			30		30		
MW-26D	B																								
MW-27D	B																	30			33		33		
MW-28D	B				33						33			30			33				40		33		
MW-51	B											33		33			33				33		40		
MW-56	B											33		30			33				30		40		
MW-59	B				30							30		30			40				33		40		
MW-63	B				33							30		30				33			33		33		
MW-64	B																								
MW-66	B																								
MW-71	B																								
MW-100	BC		33							33				30			33				33		33		
MW-99	BC											29		33				38			33		33		
MW-1039	C											30		30			33				40		30		
MW-1040	C											33		33				30		33			33		
MW-1046	C																								
MW-1051	C																								
MW-1054	C																								

Contouring Period 7–14

Wellname	Zone	7: 8801	7: 8802	7: 8803	8: 8804	8: 8805	8: 8806	9: 8807	9: 8808	9: 8809	10: 8810	10: 8811	10: 8812	11: 8901	11: 8902	11: 8903	12: 8904	12: 8905	12: 8906	13: 8907	13: 8908	13: 8909	14: 8910	14: 8911	14: 8912
MW-20D	B	33			30			33			29			29			30			38			40		
MW-211	B																								
MW-213	B																								
MW-215	B																								
MW-218	B																								
MW-220	B																								
MW-223	B																								
MW-225	B																								
MW-227	B																								
MW-229	B																								
MW-22D	B	33			33			33			29			29			29			38			40		
MW-23D	B	30			40			33			29			33			29			38					40
MW-24D	B	30			30			30			29			30			30			30					40
MW-26D	B										29			30			29				36				
MW-27D	B	40			38			40			29										61				40
MW-28D	B	30			33			33			29														40
MW-51	B	33			29			40			29			28			29			36			40		
MW-56	B	33			33			40			29			33			29			38					
MW-59	B	33			38			33			30			28			38				38		40		
MW-63	B	33			30			40			29			30			29			28			40		
MW-64	B										30			29			30			38					40
MW-66	B																28			38					40
MW-71	B				40			33			29			29			29			36					
MW-100	BC	33			40			33			29														40
MW-99	BC	38			33			33			28														40
MW-1039	C	40			33			33			29			29			29			30					40
MW-1040	C	38			30			38			29														40
MW-1046	C															29	29			61			40		
MW-1051	C																29			40					40
MW-1054	C																								40

Table B1-1
Well History By Zones
VOCs

Contouring Period		1				2							3			4			5				6			7			8			9			10			11			12			13			14		
Wellname	Zone	8601	8602	8603	8604	8605	8606	8607	8608	8609	8610	8611	8612	8701	8702	8703	8704	8705	8706	8707	8708	8709	8710	8711	8712	8801	8802	8803	8804	8805	8806	8807	8808	8809	8810	8811	8812	8901	8902	8903	8904	8905	8906	8907	8908	8909	8910	8911	8912
MW-1080	C																																														41		
MW-1083	C																																																
MW-118	C			30							33																																						
MW-122	C		30									30		30				33			30		30			30			30			33			20			20			20			36					40
MW-125	C		30																																														
MW-127	C			30							33																																						
MW-132	C											30		40				40		40			33			40			33			40			20			20			20			36			40		
MW-133	C																										30		30			30			20			20			20			36			40		
MW-136	C																											33	33			40			20			20			20			36			40		
MW-138	C																											30	30			33			20			20			20			36					40
MW-147	C																																							30				36					40
MW-152	C																																							30				36					40
MW-154	C																																									20		36					40
MW-161	C																																														80		40
MW-166	C																																															40	
MW-171	C																																																54
MW-174	C																																																46
MW-177	C																																														36		
MW-180	C																																																
MW-181	C																																																40
MW-184	C																																																
MW-187	C																																																
MW-189	C																																																
MW-193	C																																																
MW-196	C																																																
MW-199	C																																																
MW-205	C																																																
MW-209	C																																																
MW-216	C																																																
MW-218	C																																																

Table B1-1
Well History By Zones
VOCs

Contouring Period		1				2							3			4			5				6			7			8			9			10			11			12			13			14		
Wellname	Zone	9601	9602	9603	9604	9605	9606	9607	9608	9609	9610	9611	9612	9701	9702	9703	9704	9705	9706	9707	9708	9709	9710	9711	9712	9801	9802	9803	9804	9805	9806	9807	9808	9809	9810	9811	9812	9901	9902	9903	9904	9905	9906	9907	9908	9909	9910	9911	9912
MW-221	C																																																
MW-140	CD																																							20	20			30			44		40
MW-1047	B																																								20			40			40		
MW-1049	D																																								20			40			40		
MW-1052	B																																								20			40					40
MW-1057	D																																													30			
MW-149	B																																								20			30					40
MW-162	D																																																40
MW-163	D																																																
MW-167	D																																																40
MW-168	D																																																
MW-230	E																																																
MW-231	E																																																
MW-232	E																																																
EW-137																											33		30			33			20			30	30	30	30	30	30	61	35	35	40		40
EW-140																											33		33			33			20			33	33	33	30	33	33	40	30	35	40		40
EW-141																											33		30			33			26			33	33	33	30	30	33	40	30	30	40		40
EW-144																																						40	33	33	66	33	33	40	30	30	40		40
EW-233																																																	
EW-234																																																	
EW-73																							30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	66	30	30	61	40	40	62		40
EW-83																							30	33	33	30	33	33	30	33	33	30	33	33	20	20	20	20	20	20	20	20	20	30	35	35	62		40
EW-84																							30	30	30	30	33	33	30	30	33	30		33	33	20	20	30	20	20	20	20	20	30	30	30	62		40
EW-85																							30	33	33	30	33	33	30	33	33	30	33	33	20	20	20	20	20	20	20	20	20	30	30	35	62		40
EW-86																							30	33	33	30	33	33	30	33	33	30	33	33	20	20	20	20	20	20	20	20	20	30	35	35	62		40
EW-87																							30	33	33	30	33	33	30	33	33	30	33	33	20	20	20	20	20	20	20	20	20	30	35	35	62		40
MW-406																																30										66							

Table B1-1
Well History By Zones
VOCs

Contouring Period		15			16			17			18			19		20			21			22		23				24						25		26		27
Wellname	Zone	9001	9002	9003	9004	9005	9006	9007	9008	9009	9010	9011	9012	9101	9102	9103	9104	9105	9106	9107	9108	9109	9110	9111	9112	9201	9202	9203	9204	9205	9206	9207	9208	9209	9210	9211	9212	9301
MW-10	A		30		40												40															30						
MW-1002	A	30			40				30																													
MW-1004	A	30			40			30			40			37				40		30						40									30			
MW-1005	A		30		40				30		40			30				40		30						40												
MW-1009	A	40																40														30						
MW-101	A										40												40			40						30			30			30
MW-1011	A	40																																				
MW-1012	A	40									40												40															
MW-1013	A																																					
MW-1014	A																																					
MW-1015	A	30			54							40		8				53					40			40									30			
MW-1016	A	30			54				30			40		30				53		40			30			40									30			
MW-1017	A	40			30																																	
MW-1018	A	40			30									8			30									8	30											
MW-1019	A		30		40				40		30			40			30			40			30			40									30			30
MW-102	A							8					30							40																		
MW-1020	A		30		40				30			40		30			40			30			40									30						30
MW-1021	A		30		54				30		40			40			53				40		40			40						30						30
MW-1023	A	30			40						40			8						40			30			40									30			
MW-1024	A	30			40				30		40			30	8					40			30			40						30						30
MW-1026	A	40									40												40									34						30
MW-1029	A				30						40						30									40												
MW-1033	A																																					
MW-1036	A	40			30													40																				
MW-1037	A	30						40										40					40									30						30
MW-1041	A	40									40												40															30
MW-1044	A	30			54			40				40		40				53		40			30			40									34			30
MW-1049	A		30			40			40			40		40				53		30			40			30						30			30			30
MW-1053	A		30			40		40				40			40			30			40		30			40						30			34			34
MW-1054	A					40		40				40			40		30			40			40				40					34			30			

Table B1-1
Well History By Zones
VOCs

Contouring Period		15			16			17			18			19		20			21			22		23				24						25		26		27
Wellname	Zone	9001	9002	9003	9004	9005	9006	9007	9008	9009	9010	9011	9012	9101	9102	9103	9104	9105	9106	9107	9108	9109	9110	9111	9112	9201	9202	9203	9204	9205	9206	9207	9208	9209	9210	9211	9212	9301
MW-1058	A		40		40			40			40			40				30			40		30			40						34			36			34
MW-106	A																																					
MW-1061	A			40			40				40			40				40					40				40											
MW-1064	A					40	40					40		40			40						40															30
MW-1067	A								34	40					40		40			40			40			30						34			34			30
MW-1069	A								40	40				40			40			30			30									36						34
MW-107	A	40																																				
MW-11	A		36			40												40																				
MW-110	A								40											40																		
MW-111	A				30						40						40																					
MW-114	A																																					
MW-115	A	30									40																											
MW-116	A																																					
MW-117	A																																					
MW-12	A		35		40															40															30			
MW-120	A																																					
MW-123	A																																					
MW-128	A	40			40			36					40	38						40															30			
MW-129	A	36			40			38			40			38			40			30															30			
MW-131	A	36			40			36			40			38			40			38																		
MW-135	A	36			40			30			40			30			40			40															36			
MW-138	A	36			40			36				40	8	30			40			38															30			
MW-14	A		36			40														40																		30
MW-145	A	40			54				40			36		40				53		40																		
MW-15	A		36			40														40																		30
MW-150	A		40			40		40			36			40				38		40			40			40						30			38			30
MW-153	A		40			38		40			38			40				38			40		40			40						30			38			38
MW-155	A		38			40		40			40			38			40				30		40			40						30			30			38
MW-157	A		36	40	60			40			40			36				40			38		40			40						30			38			30
MW-158	A		38		40			40			40			8				40		38			40			8	38					30			30			30

Table B1-1
Well History By Zones
VOCs

Contouring Period		15			16			17			18			19		20			21			22		23				24						25		26		27
Wellname	Zone	9001	9002	9003	9004	9005	9006	9007	9008	9009	9010	9011	9012	9101	9102	9103	9104	9105	9106	9107	9108	9109	9110	9111	9112	9201	9202	9203	9204	9205	9206	9207	9208	9209	9210	9211	9212	9301
MW-159	A					40		40				40		36			40				30		40			40						30			30			30
MW-160	A	40		40		40			40		30			40			30			40															30			
MW-164	A						40				40			40			40			40																		
MW-169	A	54								40				40			40				30					8	30					30			30			30
MW-172	A		40	54				40				40		40			40				40																	
MW-175	A					40		40			40			40			30				40		40			40									34			
MW-179	A	34		40				40				40			40		30				40																	
MW-182	A		40	40				40				30		40			40			40																		
MW-185	A		46				40				40				40			40														56						
MW-186	A				40		40						40		40			40			30																	
MW-189	A			54			40				40			40			30			40																		34
MW-191	A			40			40				40			40				40			40																	
MW-194	A			50						8			30	40			40																					
MW-197	A				60		40					40		40				40			40														30			
MW-198	A																																					
MW-200	A				40		40					40		40			30				40		40			40						30			30			30
MW-202	A										40							40																				
MW-203	A				40		40				40			40			40			40																		
MW-204	A		40	40				40			30			40			40				30						40					34						34
MW-205	A									40	40			40			40				40																	
MW-206	A																																					
MW-210	A						54			40				40				40			40																	
MW-212	A								40		40				40		40																					
MW-214	A					40			40			40		40				40		30															34			
MW-217	A					54			40			40		46				40		30			40			8	30					8	34		30			30
MW-219	A	30			40			40			30			8						40																		
MW-218	A																																					
MW-222	A						54		40			40		40				40			30						40											
MW-224	A							54		40				40			40				40												30					
MW-226	A									40	40			40			40															8	34					

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Table B1-1
Well History By Zones
VOCs

Contouring Period		15			16			17			18			19		20			21			22		23				24						25		26		27
Wellname	Zone	8001	8002	8003	8004	8005	8006	8007	8008	8009	8010	8011	8012	8101	8102	8103	8104	8105	8106	8107	8108	8109	8110	8111	8112	8201	8202	8203	8204	8205	8206	8207	8208	8209	8210	8211	8212	8301
MW-228	A										40				40		40				40											30						
MW-235	A																				40		40			40						30						
MW-236	A																				40		40				40					30			30			30
MW-250	A	30			40			30			40			30			40			30																		
MW-280	A	30			54						40							53																				
MW-318	A																																					
MW-305	A	40			40																																	
MW-306	A																																					
MW-418	A	30			40			30			40			30						40			40			40						30			30			30
MW-448	A	30			40			30			40			30				40			30																	
MW-60	A	30			40						40									40																		
MW-61	A	40			40				30														40															30
MW-62	A	40			40			30			40				30		40				30																	
MW-65	A		30			40			30				40		30		40				30		40															
MW-67	A	40				54																																
MW-69	A					54					40							53																				
MW-7	A		30		54			30			40			30				53			40		40			40						30			30			30
MW-72	A		30		40													40														30						
MW-75	A		30			40		40			30			40				30			40														30			
MW-88	A	30			40						40									40																		30
MW-89	A	30			40													40														30						
MW-90	A		30		40												40															30						
MW-91	A	30				40		40									40															30						
MW-92	A	30			40			30			30		6	40						40																		30
MW-1000	AB		30						40					40			30						40									30						30
MW-1003	AB	30						40						40						40															30			
MW-1019	AB	40									40												40															30
MW-1034	AB	40			30												40																					
MW-1042	AB										40												40															30
MW-108	AB							40												40															30			

Table B1-1
Well History By Zones
VOCs

Contouring Period		16			18			17			18			19		20			21			22		23				24						25		26		27
Wellname	Zone	9001	9002	9003	9004	9005	9006	9007	9008	9009	9010	9011	9012	9101	9102	9103	9104	9105	9106	9107	9108	9109	9110	9111	9112	9201	9202	9203	9204	9205	9206	9207	9208	9209	9210	9211	9212	9301
MW-113	AB				36							40								36																		
MW-121	AB	36			40				36			40		36						40																		
MW-124	AB																																					
MW-126	AB																																					
MW-170	AB							40												40																		
MW-52	AB	36						40									40															36						
MW-53	AB	40			40													40														36						
MW-54	AB	36			40													40														36						
MW-55	AB	36			40			36			40			36			36			40																		36
MW-57	AB	36			40			36			40			36			36			40																		36
MW-70	AB	36												40												40												
MW-74	AB		40			40		40			40			40				36			40																	36
MW-76	AB		40		40			40				40		36				40			36																	36
MW-1001	B	36						40						40						40															36			
MW-1022	B	40	36		54				36		40			36			53				36		40			40						36			34			36
MW-1025	B	36			40				36		40			8				36		40			36			40						36			36			36
MW-1027	B										40												40															36
MW-1028	B	40									40												40			40						36						36
MW-103	B							40			36									40																		
MW-1030	B										40						36									40												
MW-1031	B										40												40															
MW-1032	B	40			36									8				36								40						36						
MW-1035	B				36												40															36						
MW-1038	B	36						40										40					40															36
MW-104	B	36							40					40						40															36			
MW-1043	B										40												40															36
MW-1045	B		40			54					40				40			53		36			40				36					34			36			36
MW-105	B	36				40					40									40															36			
MW-1050	B		36			40			36		36	8		36			40			36			40			36						34			34			36
MW-1055	B					40			40		36			40			36			40			40			36						34			36			

Table B1-1
Well History By Zones
VOCs

Contouring Period		15			16			17			18			19		20			21			22		23				24						25		26		27
Wellname	Zone	9001	9002	9003	9004	9005	9006	9007	9008	9009	9010	9011	9012	9101	9102	9103	9104	9105	9106	9107	9108	9109	9110	9111	9112	9201	9202	9203	9204	9205	9206	9207	9208	9209	9210	9211	9212	9301
MW-1059	B			40				40						40							40		38			40						34			38			36
MW-1062	B			40			40				40							40					40			40									34			
MW-1065	B								54	40				40			40			40			40									38						38
MW-1068	B								40	40					40		36			40			40									34						38
MW-1069	B								40	40					40		40			38			40				38					34			34			38
MW-109	B							40												40															34			
MW-112	B				38									6																								
MW-118	B																																					
MW-130	B	36			40			36			40			36			40			36															38			
MW-134	B	36			40			38			40			38			40			40																		
MW-142	B	38			40				40					40				40														38						
MW-143	B	38			40				40					40				40														38						
MW-148	B		40			54					40							60																				
MW-151	B		40		40			40			40			38			40			38			40			40									34			
MW-158	B		36			40			40		36			40			36				40		40			40						6			34			36
MW-165	B						40				40						36																					
MW-170	B	54				46		46						36							40		46			6	38											
MW-173	B	40				40		40			38			38				38			40																	
MW-176	B					40			40					40						40			40				40					34			36			34
MW-178	B	54				54		40			40			40				36			40																	
MW-183	B		40	40				40			38			40			40			40																		38
MW-189	B				58		40				40			40						40																		
MW-180	B							40												40			40				40											
MW-182	B		46				40				40			8			46				38																	
MW-185	B			58			40				46																											
MW-188	B				57		40					40		40			38			40																		
MW-190	B	40	38		40						40									40																		38
MW-201	B			46											40						40																	
MW-204	B				40		40				40			40			38			40												34						34
MW-207	B		40	40					40		36			40			36			40																		

Table B1-1
Well History By Zones
VOCs

Contouring Period		15			16			17			18			19		20			21			22		23				24						25		26		27
Wellname	Zone	9001	9002	9003	9004	9005	9006	9007	9008	9009	9010	9011	9012	9101	9102	9103	9104	9105	9106	9107	9108	9109	9110	9111	9112	9201	9202	9203	9204	9205	9206	9207	9208	9209	9210	9211	9212	9301
MW-200	B	36			40			40						40						40																		
MW-211	B						40			40				40				40			40																	
MW-213	B						40			40				40			40															36						
MW-215	B					40			40			40		40				40		36															34			
MW-218	B					40			8	40		40		36			40			36			40			40							36		34			36
MW-220	B							64		40				40			40				36																	
MW-223	B						40		40			40								40												36						
MW-225	B							40		40				40			40				40											36						
MW-227	B									40	40				40			40														36						
MW-229	B									40				40				40			36											34						
MW-220	B	36			40			40			36			36	8					40																		
MW-230	B	36						40						36	8						40		40			40						34			36			34
MW-240	B	36			64						40							60																				
MW-260	B	40			36			40			40			36				40		36																		36
MW-270	B				40			36			40			36				60		36																		34
MW-290	B										40																											
MW-51	B	36						40												40																		
MW-58	B	40			40			36			40			36			40			36																		36
MW-59	B	36			40			36				40		36				40														36						
MW-63	B	36			64				36			36		36				63			36		40				40					34			34			34
MW-64	B		36		40						40										40		40			8	36					36			36			36
MW-66	B		40			64			40		40				36		63				36		40				40					8			34			34
MW-71	B	40	40			64		40			40			40				63			40																	34
MW-100	BC										40												40			40									34			
MW-69	BC								40					40							40																	34
MW-1030	C	36						40										40					40															34
MW-1040	C										40												40															
MW-1046	C		36			64		36			40				36			63		36			40				36					34			34			36
MW-1051	C		36			40			36		40			40				36		40			40				60					34			34			34
MW-1056	C					40			40		36			40			36			40			40			36						34			34			

Table B1-1
Well History By Zones
VOCs

Contouring Period		15			16			17			18			19		20			21			22		23				24						25		26		27
Wellname	Zone	9001	9002	9003	9004	9005	9006	9007	9008	9009	9010	9011	9012	9101	9102	9103	9104	9105	9106	9107	9108	9109	9110	9111	9112	9201	9202	9203	9204	9205	9206	9207	9208	9209	9210	9211	9212	9301
MW-1060	C			40				40			36			40				36			36		40			40						34			36			36
MW-1063	C			40			40				40							40					40			36						34			34			36
MW-119	C																																					
MW-122	C																																					
MW-125	C																																					
MW-127	C																																					
MW-132	C	36			54			36				40		36				53		36			40				40					8	34		36			36
MW-133	C	36			40			36			40			36						40															34			
MW-136	C	36			40				40			36			40			36		40															36			
MW-138	C	36			40			36				40		36						40															36			
MW-147	C		40			54					40							53																				
MW-152	C		40			36		40			36			40			36			40			40			40						34			34			34
MW-154	C		40			36		40			36			40			36				40		40			40						34			34			34
MW-161	C					40		36						40							40																	
MW-168	C						54				40			36			40			36																		
MW-171	C					40		40									40										40								34			
MW-174	C					40			40		36			8				36			40																	
MW-177	C	40			40			40													40		40			40						36			36			36
MW-180	C	54				40						40		36							40																	
MW-181	C									40				40						40																		36
MW-184	C		40	40				40			36			40			36			40																		
MW-187	C			40			40				40				40			36			40																	
MW-190	C			54			40				40			40						40																		
MW-193	C		40				40				40				8						40																	
MW-198	C			40			40				40																											
MW-199	C				54		40					40		36							40														36			
MW-205	C				42		40				40				40		40				40																	
MW-208	C	40		40				40			36			40			40			36																		
MW-216	C					40	40					40		40				36		40															34			
MW-219	C					40			40			40		40				40		36			40			40						8	34		36			36

Table B1-1
Well History By Zones
VOCs

Contouring Period		15			16			17			18			19		20			21			22		23				24						25		26		27
Wellname	Zone	9001	9002	9003	9004	9005	9006	9007	9008	9009	9010	9011	9012	9101	9102	9103	9104	9105	9106	9107	9108	9109	9110	9111	9112	9201	9202	9203	9204	9205	9206	9207	9208	9209	9210	9211	9212	9301
MW-221	C											54		40							40																	
MW-148	CD		40			40		40			40			40				36			40		40			40						38			38			38
MW-1047	D		36			54						40		36				44		40			40			40						34			34			34
MW-1048	D		36			54					40						63						40			40												
MW-1052	D		36						40					40						40			38				40					34			34			34
MW-1057	D					40			40					40						40			36				40					34			34			
MW-149	D		40			36		40			40			40				38			40		38			40						34			34			34
MW-162	D			40					40		38							40														34						
MW-163	D	40			40				40		36			8						40																		34
MW-167	D							40			40			36			40			38																		
MW-168	D	40			40						40																											
MW-230	E										54	54						40														34						
MW-231	E						54			40				36							40																	
MW-232	E						54				40							40																				
EW-137		40	36	40	40				36			36		40				40		40			40			40						38			38			38
EW-140		40	36	40	40				8			36		36				40			40		40			40						38			38			38
EW-141		40	36	40	40				40			36		40				40			40		40			40						38			38			38
EW-144		40	36	40	40				36			36		36				40		40			40			40						38			38			38
EW-233																		44			40		40			40						38			38			38
EW-234																		44			40					40						38			38			38
EW-73		36	40	40	40													40																				
EW-83		36	36	36	40													40																				
EW-84		36	36	36	40													40																				
EW-85		36	36	36	40													40																				
EW-86		36	36		40													40																				
EW-87		36	36	36	40													40																				
MW-49S																																						

Attachment B-2
Toxicity Values

Table B2-1
Toxicity Values

Chemical name	CAS registry number	SF- ingestion $(mg/kg\text{-}day)^{-1}$	RfD - ingestion (mg/kg-day)	SF - inhalation $(mg/kg\text{-}day)^{-1}$	RfC inhalation (mg/m^3)	RfD inhalation (mg/kg-day)	Kow	MW
ACENAPHTHENE	83-32-9		6.00E-02				4.33	154.21
ACENAPHTHYLENE	208-96-8						4.07	152.21
ACETONE	67-64-1		1.00E-01				-0.24	58.09
ACETONITRILE	75-05-8		6.00E-03		5.00E-02	1.43E-02	-0.34	41.05
ACETOPHENONE	98-86-2		1.00E-01				1.58	120.16
ACROLEIN	107-02-8		2.00E-02		2.00E-05	5.71E-06	-0.1	56.06
ACRYLONITRILE	107-13-1	1.00E+00		1.00E+00	2.00E-03	5.71E-04	0.25	53.06
ALDRIN	309-00-2	1.70E+01	3.00E-05	1.70E+01			1.13	304.93
ALLYL CHLORIDE	107-05-1	2.10E-02	5.00E-02	2.10E-02	1.00E-03	2.86E-04		
ANILINE	62-53-3	5.70E-03		5.70E-03	1.00E-03	2.86E-04	0.9	93.12
ANILINE, 4-CHLORO	106-47-8		4.00E-03				1.83	127.58
ANTHRACENE	120-12-7		3.00E-01				4.45	178.23
AROCLOR 1016	12674-11-2		7.00E-05					
AROCLOR 1221		7.70E+00						
AROCLOR 1232		7.70E+00						
AROCLOR 1242		7.70E+00						
AROCLOR 1248		7.70E+00						
AROCLOR 1254		7.70E+00						
AROCLOR 1260		7.70E+00						
BENZENE	71-43-2	1.00E-01		1.00E-01			2.13	78.11
BENZENE, 1,2,4-TRICHLORO	120-82-1		1.00E-02		9.00E-03	2.57E-03	4.02	181.46
BENZENE, 1,3-DINITRO	99-65-0		1.00E-04					
BENZIDINE	92-87-5	5.00E+02	3.00E-03	5.00E+02			1.34	184.23
BENZIDINE, 3,3'-DIMETHYL	119-93-7	9.20E+00						
BENZO(A)ANTHRACENE	56-55-3						5.61	228.28
BENZO(A)PYRENE	50-32-8	1.20E+01		1.20E+01			6.04	252
BENZO(B)FLUORANTHENE	205-99-2						6.57	252.32
BENZO(G,H,I)PERYLENE	191-24-2						7.23	276
BENZO(K)FLUORANTHENE	207-08-9						6.34	252.32
BENZOIC ACID	65-85-0		4.00E+00				1.87	122.13
BENZYL ALCOHOL	100-51-6		3.00E-01				1.1	108.13
BENZYL CHLORIDE	100-44-7	1.70E-01		1.70E-01			2.3	126.58
BIS(2-CHLOROETHOXY)METHANE	111-91-1						0.75	173.05
BROMOCHLOROMETHANE	74-97-5						1.41	129.38
BROMODICHLOROMETHANE	75-27-4	1.30E-01	2.00E-02	1.30E-01			2.1	163.83
BROMOFORM	75-25-2	7.93E-03	2.00E-02	3.90E-03			2.37	252.73
BROMOMETHANE	74-83-9		1.40E-03		5.00E-03	1.43E-03	1.19	94.95

Table B2-1
Toxicity Values

Chemical name	CAS registry number	SF- ingestion (mg/kg-day)^-1	RfD - ingestion (mg/kg-day)	SF - inhalation (mg/kg-day)^-1	RfC inhalation (mg/m^3)	RfD inhalation (mg/kg-day)	Kow	MW
BUTANONE, 2-	78-93-3		6.00E-01		1.00E+00	2.86E-01	0.29	72.1
BUTANONE, 2-	78-93-3		6.00E-01		1.00E+00	2.86E-01	0.29	72.1
BUTENE, 1,4-DICHLORO-2-	764-41-0			9.30E+00				
CARBON DISULFIDE	75-15-0		1.00E-01		1.00E-02	2.86E-03	4.16	76.13
CARBON TETRACHLORIDE	56-23-5	1.50E-01	7.00E-04	1.50E-01			2.83	153.84
CHLOROBENZENE	108-90-7		2.00E-02		2.00E-02	5.71E-03	2.84	112.56
CHLOROFORM	67-66-3	[illegible].10E-02	1.00E-02	8.10E-02			1.97	119.39
CHLOROMETHANE	74-87-3	1.30E-02		6.30E-03			0.91	50.49
CHLORONAPHTHALENE, BETA-	91-58-7		8.00E-02				4.12	
CHRYSENE	218-01-9						5.61	228.28
CRESOL, P-	106-44-5		5.00E-02				1.94	108.13
CRESOL, P-CHLORO-M-	59-50-7						2.95	142.59
DDD, 4,4'-	72-54-8	2.40E-01		2.40E-01			5.99	320
DDE, 4,4'-	72-55-9	3.40E-01		3.40E-01			5.69	318
DDT, 4,4'-	50-29-3	3.40E-01	5.00E-04	3.40E-01			6.19	354.5
DIBENZ(A,H)ANTHRACENE	53-70-3						5.97	278.36
DIBROMOCHLOROMETHANE	124-48-1	3.60E+00	2.00E-02	2.50E-01			2.24	208.28
DIBROMOETHANE, 1,2-	106-93-4	8.50E+01		7.60E-01				
DICHLOROBENZENE, 1,2-	95-50-1		9.00E-02		2.00E-01	5.71E-02	3.38	147.01
DICHLOROBENZENE, 1,3-	541-73-1						3.6	147.01
DICHLOROBENZENE, 1,4-	106-46-7	0.00E+00		0.00E+00	8.00E-01	2.29E-01	3.52	147.01
DICHLOROBENZIDINE, 3,3-	91-94-1	1.20E+00		1.20E+00			3.51	251.13
DICHLORODIFLUOROMETHANE	75-71-8		2.00E-01		2.00E-01	5.71E-02	2.16	129.91
DICHLOROETHANE, 1,1-	75-34-3		1.00E-01		5.00E-01	1.43E-01	1.79	98.96
DICHLOROETHANE, 1,2-	107-06-2	9.10E-02		9.10E-02			1.48	98.96
DICHLOROETHENE, 1,1-	75-35-4	0.00E+00	9.00E-04	0.00E+00		9.00E-04	2.13	96.95
DICHLOROETHENE, CIS-1,2-	156-59-2		1.00E-02				1.86	96.94
DICHLOROETHENE, TRANS-1,2-	156-60-5		2.00E-02				2.06	96.94
DICHLOROPHENOL, 2,4-	120-83-2		3.00E-03					
DICHLOROPROPANE, 1,2-	78-87-5	6.80E-02			4.00E-03	1.14E-03	1.99	112.99
DIELDRIN	60-57-1	1.60E+01	5.00E-05	1.60E+01			4.32	380.93
DIETHYLPHTHALATE	84-66-2		8.00E-01				2.47	222.26
DIOXIN (2,3,7,8-TCDD)	1746-01-6	1.50E+05		1.50E+05				
DIPROPYLAMINE, N-NITROSO-	621-64-7	7.00E+00						
ENDRIN	72-20-8		3.00E-04				4.56	380.9
ETHANE, 1,1,1-TRICHLORO	71-55-6		9.00E-02		1.00E+00	2.86E-01	2.49	133.42
ETHANE, 1,1,2-TRICHLORO	79-00-5	5.70E-02	4.00E-03	5.70E-02			2.07	133.42

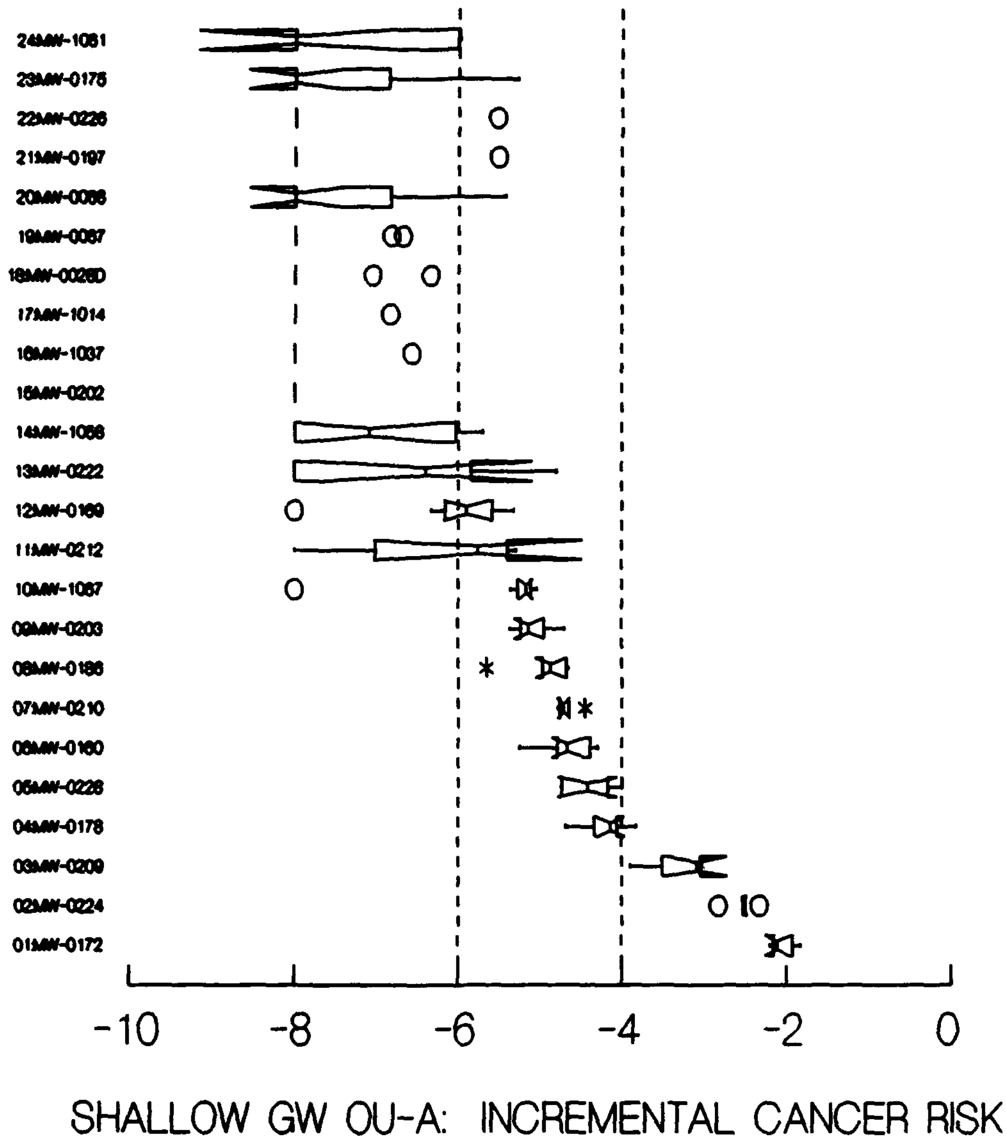
Table B2-1
Toxicity Values

Chemical name	CAS registry number	SF- ingestion (mg/kg-day)^-1	RfD - ingestion (mg/kg-day)	SF - inhalation (mg/kg-day)^-1	RfC inhalation (mg/m^3)	RfD inhalation (mg/kg-day)	Kow	MW
ETHANE, 1,1,2-TRICHLORO-1,2,2-TRIFLUORO	76-13-1		3.00E+01		2.70E+01	7.71E+00	3.16	187.38
ETHER, BIS(2-CHLOROETHYL)	111-44-4	1.10E+00		1.10E+00			1.29	143.02
ETHER, BIS(2-CHLOROISOPROPYL)	39638-32-9	7.00E-02	4.00E-02	3.50E-02				
ETHER, BIS(CHLOROMETHYL)	542-88-1	2.20E+02		2.20E+02			-0.38	114.96
ETHYLBENZENE	100-41-4		1.00E-01		1.00E+00	2.86E-01	3.15	106.16
FLUORANTHENE	206-44-0		4.00E-02				5.33	202.26
FLUORENE	86-73-7		4.00E-02				4.18	116.15
HEPTACHLOR	76-44-8	5.70E+00	5.00E-04	5.70E+00			5.27	373.35
HEPTACHLOR EPOXIDE	1024-57-3	1.30E+01	1.30E-05	1.30E+01			5.4	389.4
HEXACHLOROBENZENE	118-74-1	1.80E+00	8.00E-04	1.80E+00			5.31	284.8
HEXACHLOROBUTADIENE	87-68-3	7.80E-02		7.80E-02			4.9	260.76
HEXACHLOROCYCLOPENTADIENE	77-47-4		7.00E-03		7.00E-05	2.00E-05	3.99	272.22
HEXACHLOROETHANE	67-72-1	1.40E-02	1.00E-03	1.40E-02			3.82	236.74
HEXANONE, 2-	591-78-6						1.38	100.16
HYDRAZINE, 1,2-DIPHENYL	122-66-7	8.00E-01		8.00E-01			3.03	184.24
INDENO(1,2,3-CD)PYRENE	193-39-5						7.66	276.34
ISOPHORONE	78-59-1	9.50E-04	2.00E-01				2.22	138.23
METHACRYLATE, ETHYL	97-63-2		9.00E-02					
METHOXYCHLOR	72-43-5		5.00E-03	9.10E+00			5.08	345.65
METHYL METHACRYLATE	80-62-6		8.00E-02				1.38	100.13
METHYL TERT-BUTYL ETHER	1634-04-4				5.00E-01	1.43E-01	1.24	88.94
METHYLENE CHLORIDE	75-09-2	1.40E-02	6.00E-02	3.50E-03	3.00E+00	8.57E-01	1.25	84.94
METHYLPHENOL, 2-	95-48-7		5.00E-02				1.95	108.15
METHYLPHENOL, 3-	108-39-4		5.00E-02				1.96	108.15
NAPHTHALENE	91-20-3						3.3	128.16
NITROBENZENE	98-95-3		5.00E-04		2.00E-03	5.71E-04	1.85	123.11
NITROSO-DI-N-BUTYLAMINE, N-	924-16-3	1.10E+01		1.10E+01				
NITROSODIETHYLAMINE, N-	55-18-5	1.50E+02		1.50E+02				
NITROSODIMETHYLAMINE, N-	62-75-9	5.10E+01		5.10E+01				
NITROSODIPHENYLAMINE, N-	86-30-6	4.90E-03		9.00E-03				
NITROSOMETHYLETHYLAMINE, N-	10595-95-6	2.20E+01						
NITROSOPYRROLIDINE, N-	930-55-2	2.10E+00		2.10E+00				
PENTACHLOROBENZENE	608-93-5		8.00E-04					
PENTACHLOROPHENOL	87-86-5	1.20E-01	3.00E-02	1.80E-02			5.12	266.35
PENTANONE, 4-METHYL-2-	108-10-1		5.00E-02		8.00E-02	2.29E-02	1.19	100.16
PENTANONE, 4-METHYL-2-	108-10-1		5.00E-02		8.00E-02	2.29E-02	1.19	100.16
PHENANTHRENE	85-01-8						4.46	178.23

Table B2-1
Toxicity Values

Chemical name	CAS registry number	SF- ingestion (mg/kg-day)^-1	RfD - ingestion (mg/kg-day)	SF - inhalation (mg/kg-day)^-1	RfC inhalation (mg/m^3)	RfD inhalation (mg/kg-day)	Kow	MW
PHENOL	108-95-2		6.00E-01				1.46	94.11
PHENOL, 2,4,5-TRICHLORO	95-95-4		1.00E-01				3.72	197.46
PHENOL, 2,4,6-TRICHLORO	88-06-2	7.00E-02		7.00E-02			3.69	197.45
PHENOL, 2,4-DIMETHYL	105-67-9		2.00E-02				2.3	122.16
PHENOL, 2,4-DINITRO	51-28-5		2.00E-03				1.54	184.11
PHENOL, 2-CHLORO	95-57-8		5.00E-03				2.15	128.56
PHTHALATE, BIS(2-ETHYLHEXYL)	117-81-7	1.40E-02	2.00E-02				5.11	390.54
PHTHALATE, DI-N-BUTYL-	84-74-2		1.00E-01				4.72	278.34
PHTHALATE, DI-N-OCTYL-	117-84-0		2.00E-02				9.2	391
PHTHALATE, DIMETHYL	131-11-3		1.00E+01				1.56	194.2
PYRENE	129-00-0		3.00E-02				5.32	202
PYRIDINE	110-86-1		1.00E-03				0.65	79.1
QUINOLINE	91-22-5	1.20E+01						
STYRENE	100-42-5		2.00E-01		1.00E+00	2.86E-01	2.95	104.16
TETRACHLOROBENZENE, 1,2,4,5-	95-94-3		3.00E-04					
TETRACHLOROETHANE, 1,1,1,2-	630-20-6	2.60E-02	3.00E-02	2.60E-02			3.03	167.85
TETRACHLOROETHANE, 1,1,2,2-	79-34-5	2.00E-01		2.00E-01			2.39	167.86
TETRACHLOROET[illegible]	127-18-4	5.10E-02	1.00E-02	5.10E-02			3.4	165.82
TETRACHLOROPH[illegible], 2,3,4,6-	58-90-2		3.00E-02					
TOLUENE	108-88-3		2.00E-01		4.00E-01	1.14E-01	2.73	92.13
TOLUENE, 2,4-DINITRO	121-14-2	6.80E-01	2.00E-03	3.10E-01			1.98	182.14
TOLUENE, 2,6-DINITRO	606-20-2	6.80E-01					1.72	182.15
TOTAL XYLENE			2.00E+00			9.00E-02		
TOXAPHENE	8001-35-2	1.20E+00		1.20E+00			3.7	517
TRICHLOROETHENE	79-01-6	1.50E-02		1.00E-02			2.42	71.08
TRICHLOROPROPANE, 1,2,3-	96-18-4		6.00E-03				1.98	147.43
VINYL ACETATE	108-05-4		1.00E+00		2.00E-01	5.71E-02	0.73	86.09
VINYL CHLORIDE	75-01-4	1.90E+00		3.00E-01			1.38	62.5
XYLENE, O-	95-47-6		2.00E+00				3.12	106.16
XYLENE, P-	106-42-3						3.15	106.17

Attachment B-3
Increased Lifetime Cancer Risk
Box Plots
Individual Wells



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15MW-0202
14MW-1068
13MW-0222
12MW-0169
11MW-0212
10MW-1067
09MW-0203
08MW-0186
07MW-0210
06MW-0160
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04MW-0178
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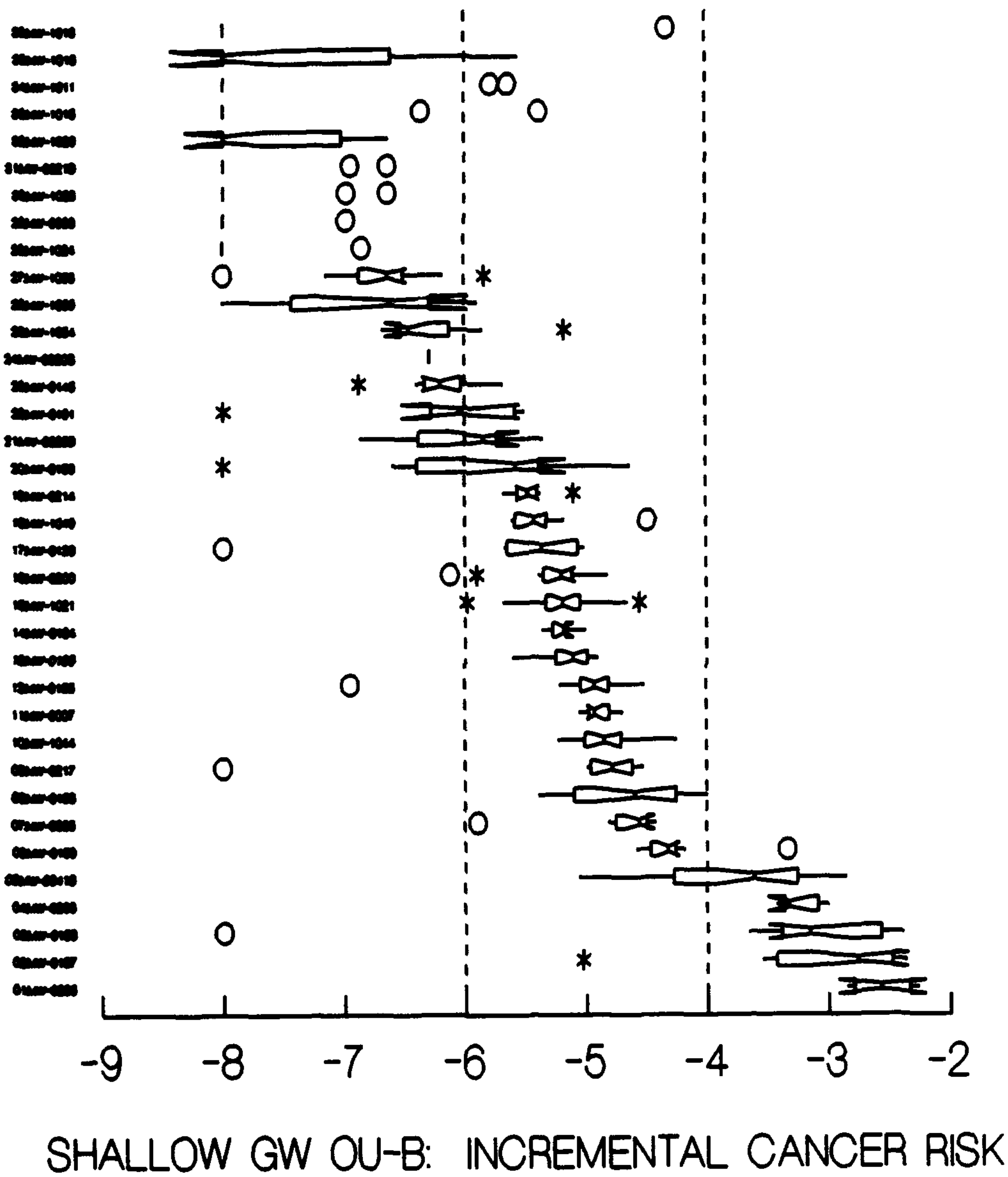
SHALLOW GW OU-A: INCREMENTAL CANCER RISK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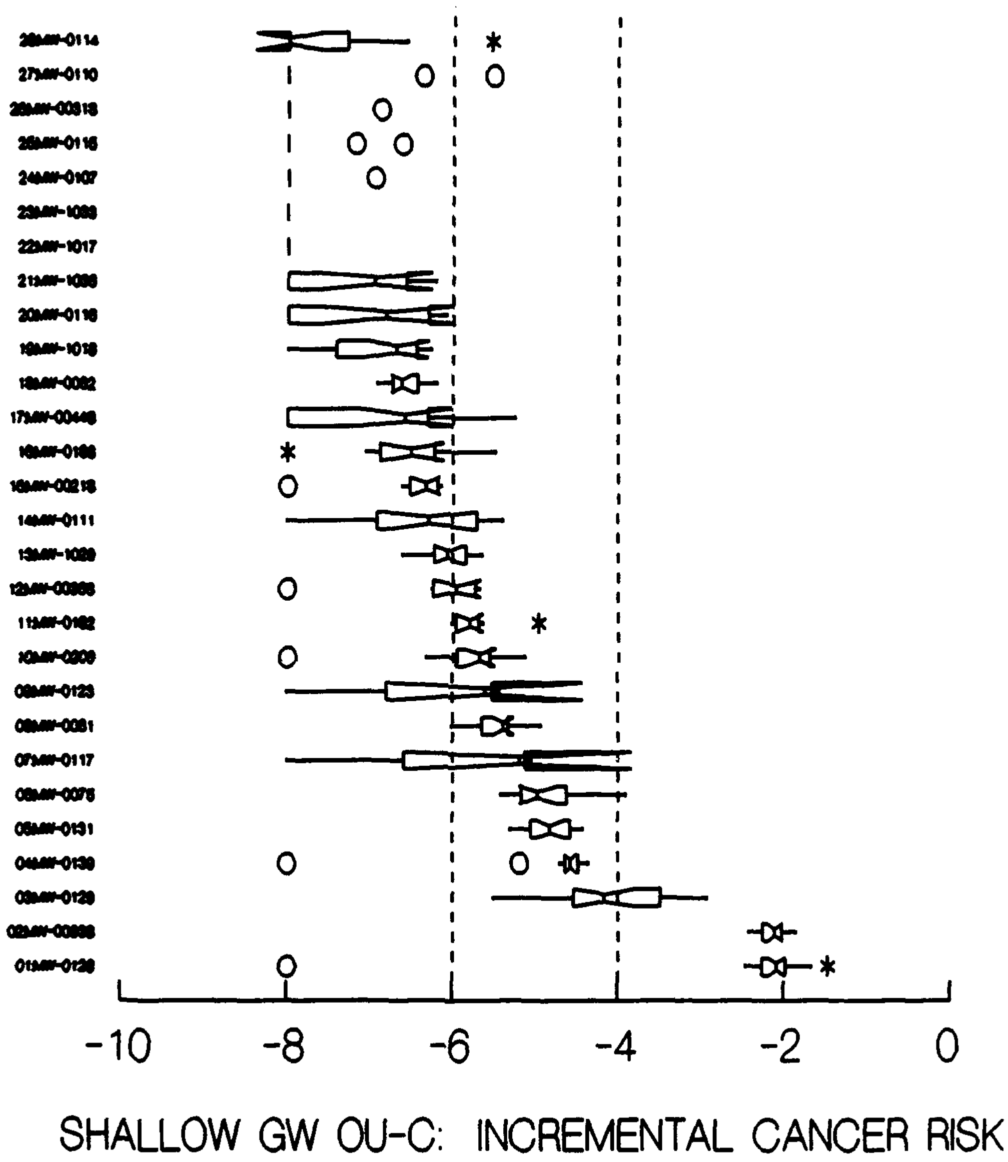

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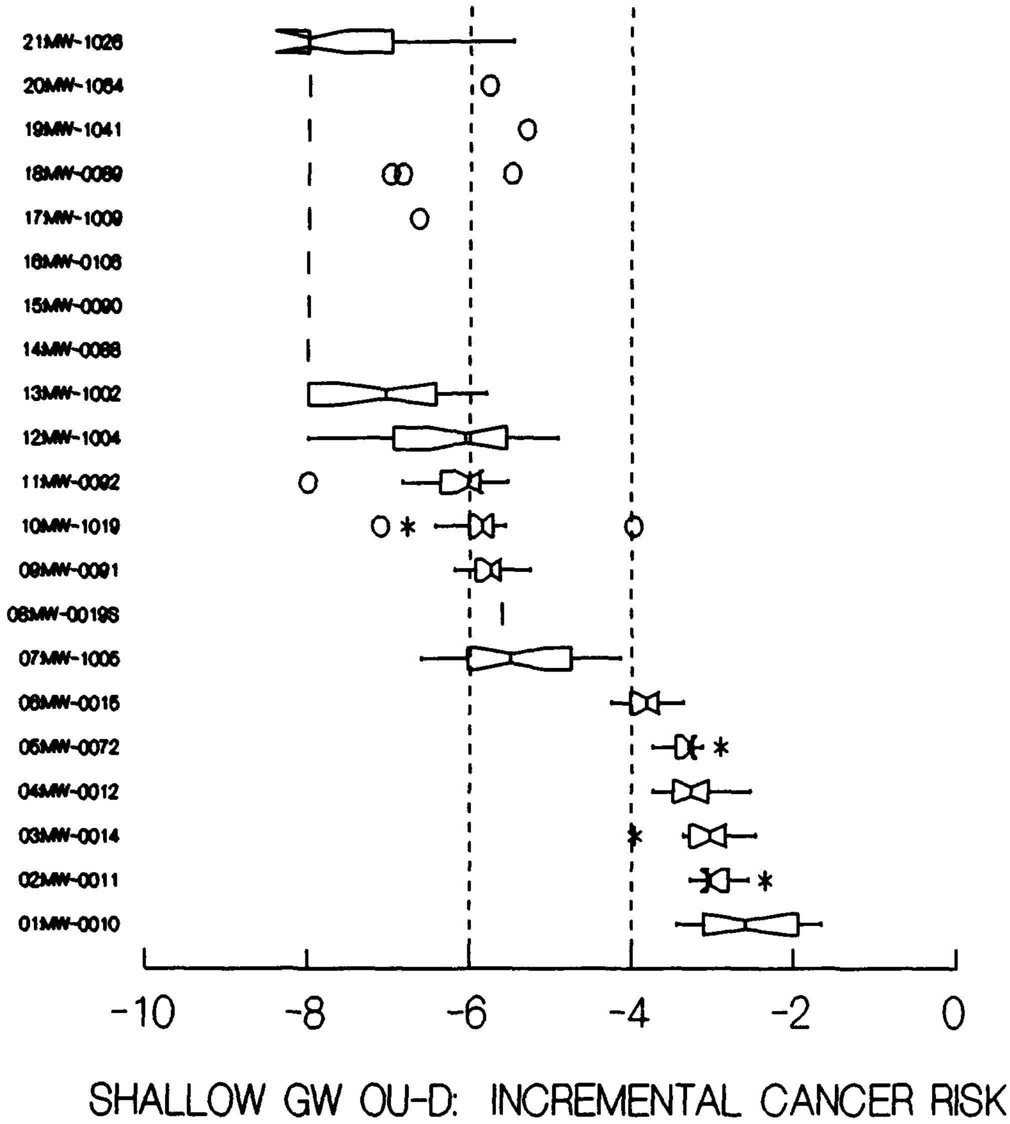
SHALLOW GW OU-C: INCREMENTAL CANCER RISK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11MW-0092
10MW-1019
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07MW-1005
06MW-0015
05MW-0072
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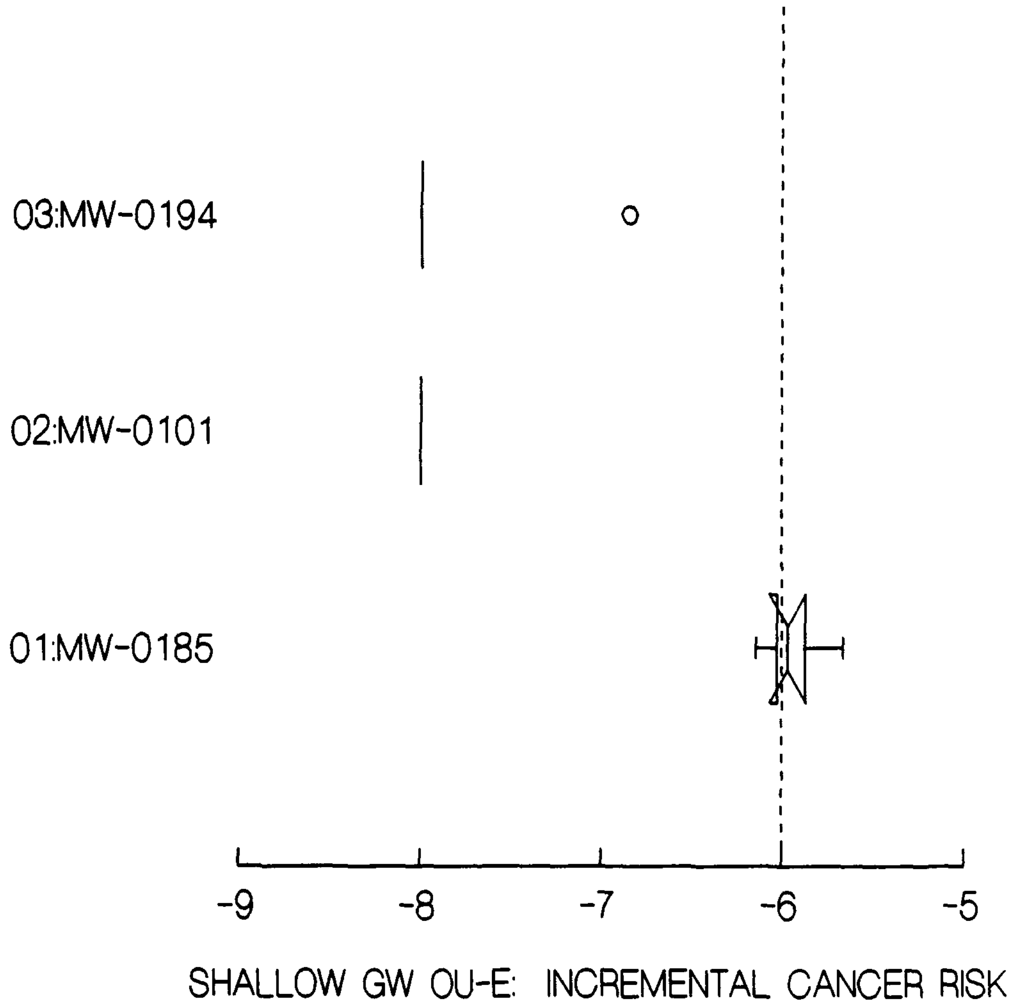
SHALLOW GW OU-D: INCREMENTAL CANCER RISK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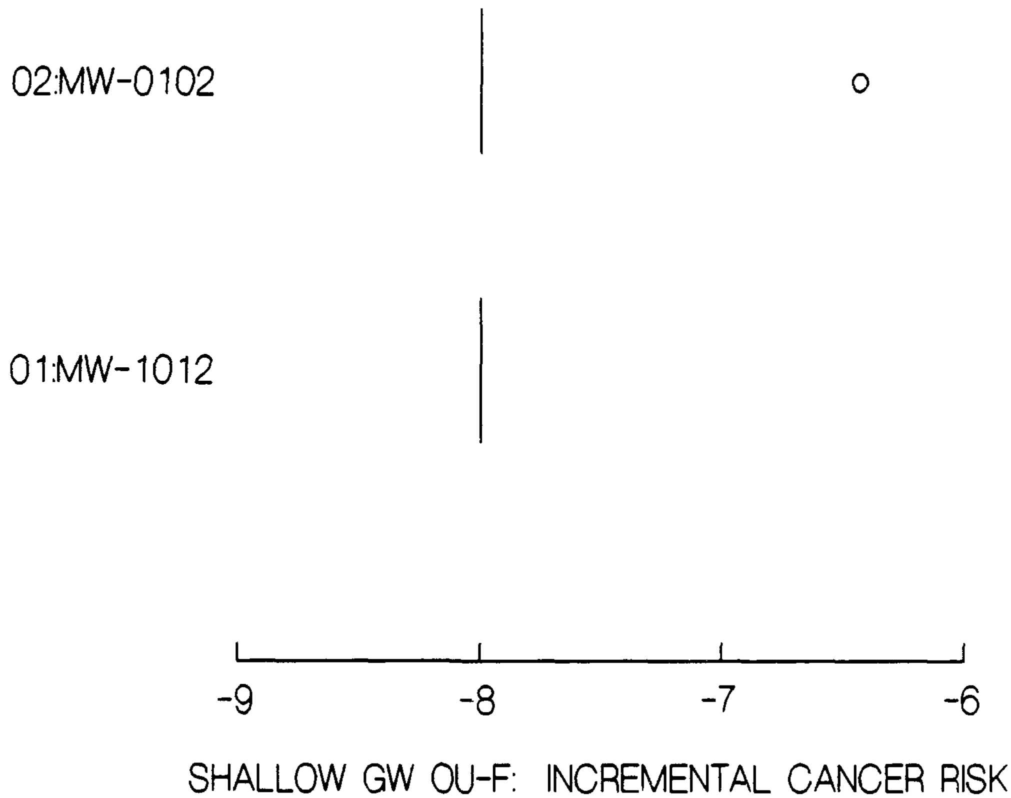
SHALLOW GW OU-E: INCREMENTAL CANCER RISK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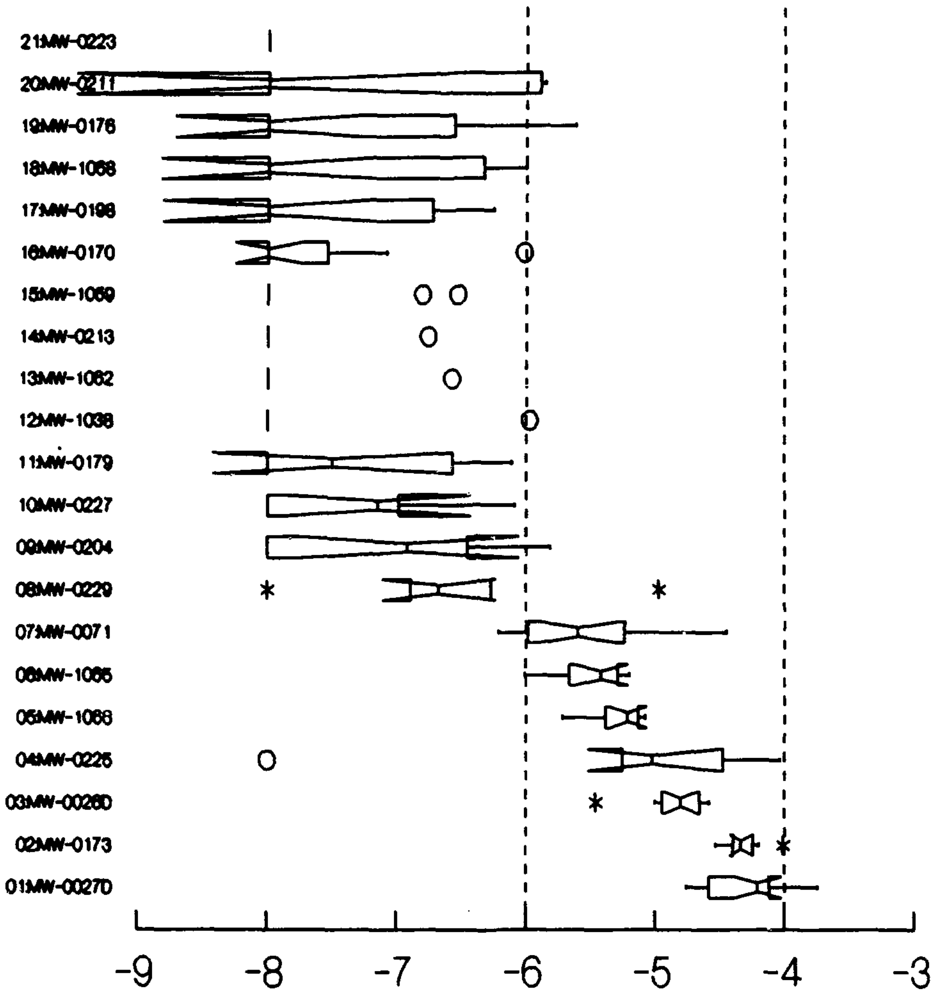
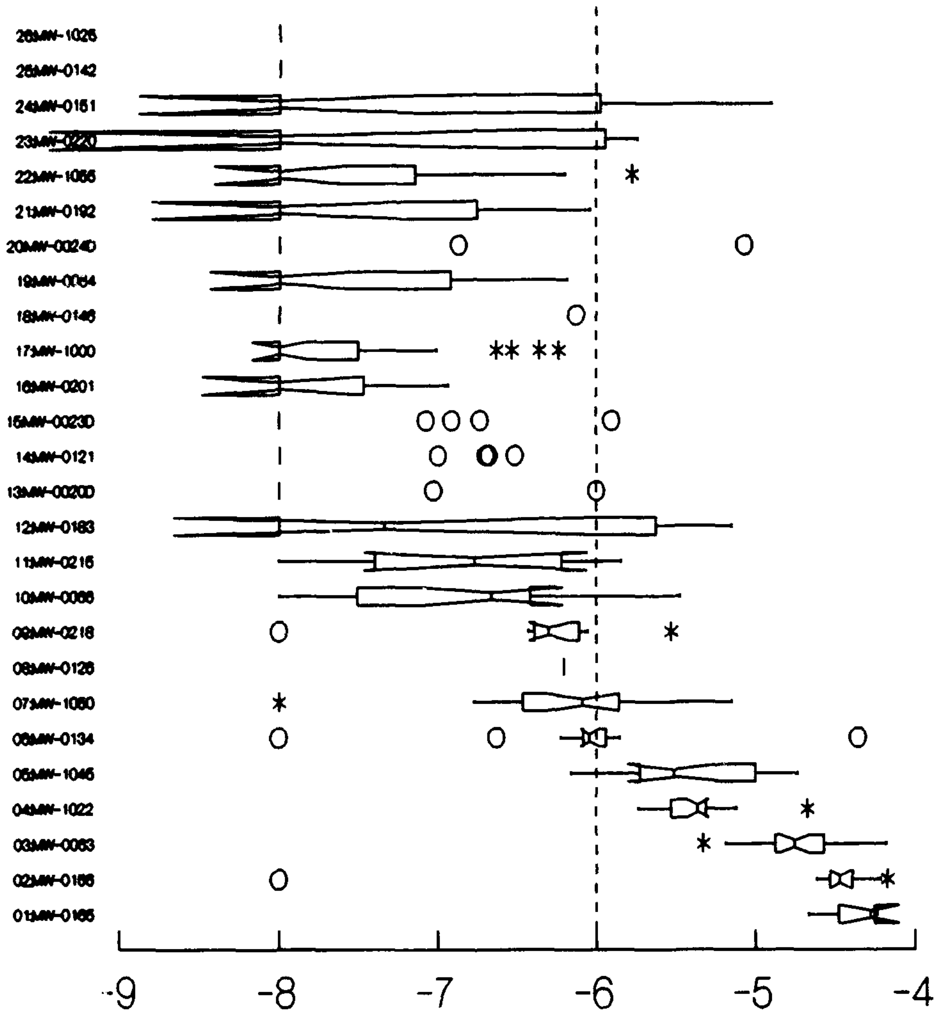


MID-SHALLOW GW OU-A: INCREMENTAL CANCER RISK



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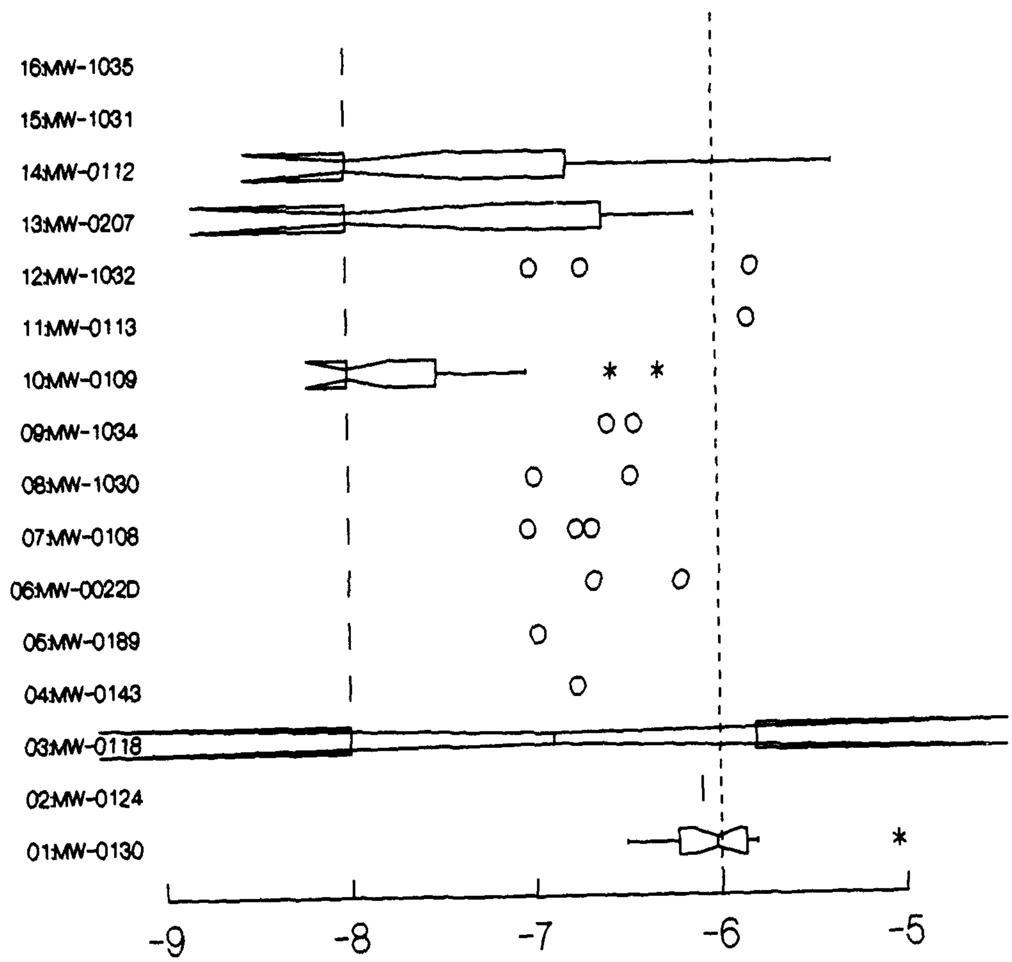
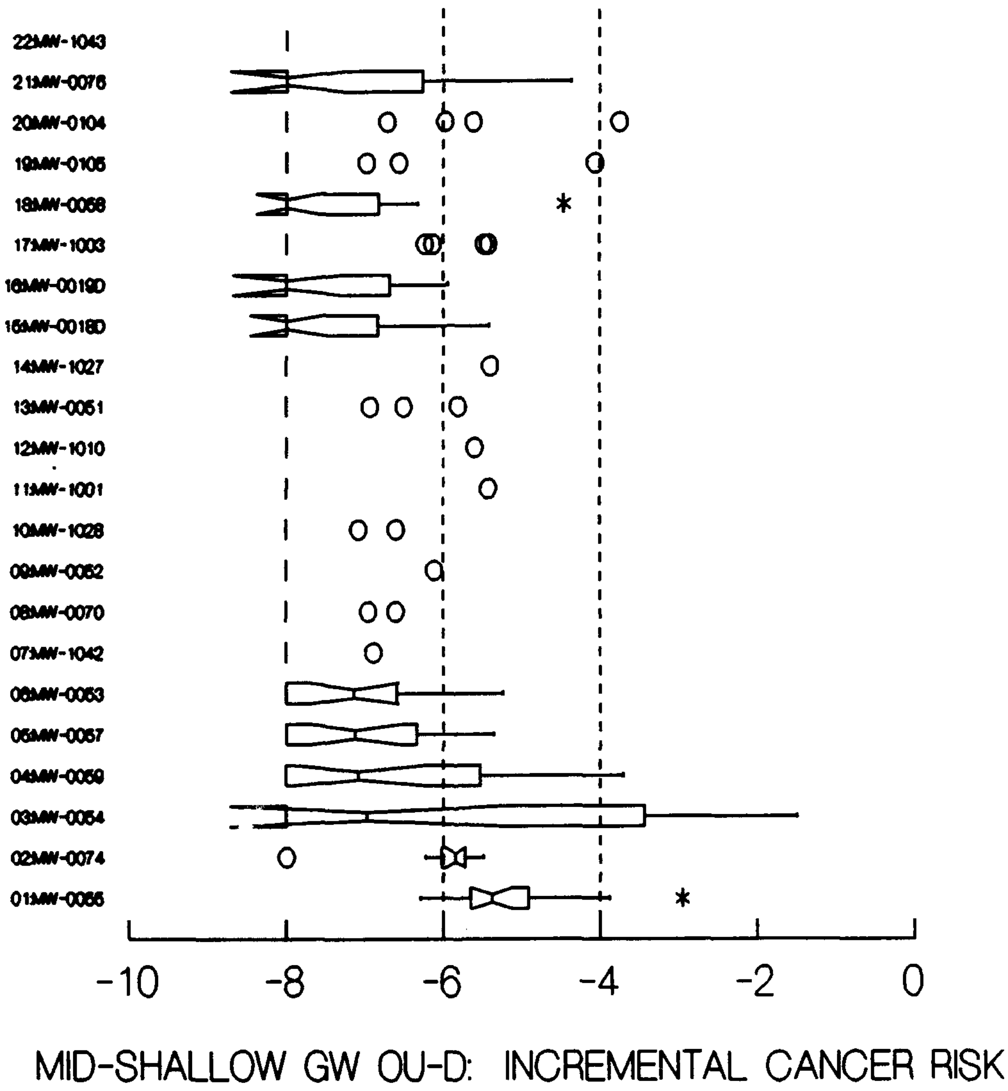


MID-SHALLOW GW OU-C: INCREMENTAL CANCER RISK



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12MW-1010
11MW-1001
10MW-1028
09MW-0052
08MW-0070
07MW-1042
06MW-0053
05MW-0057
04MW-0059
03MW-0054
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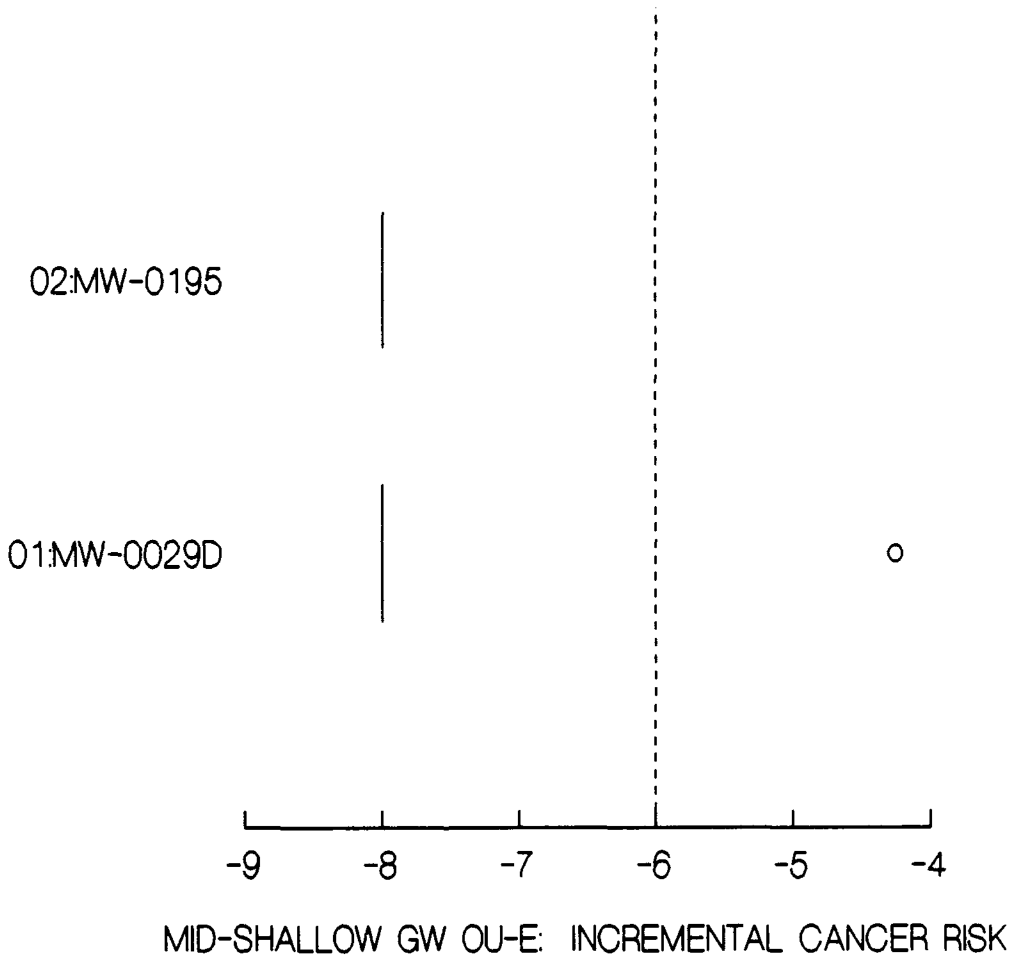
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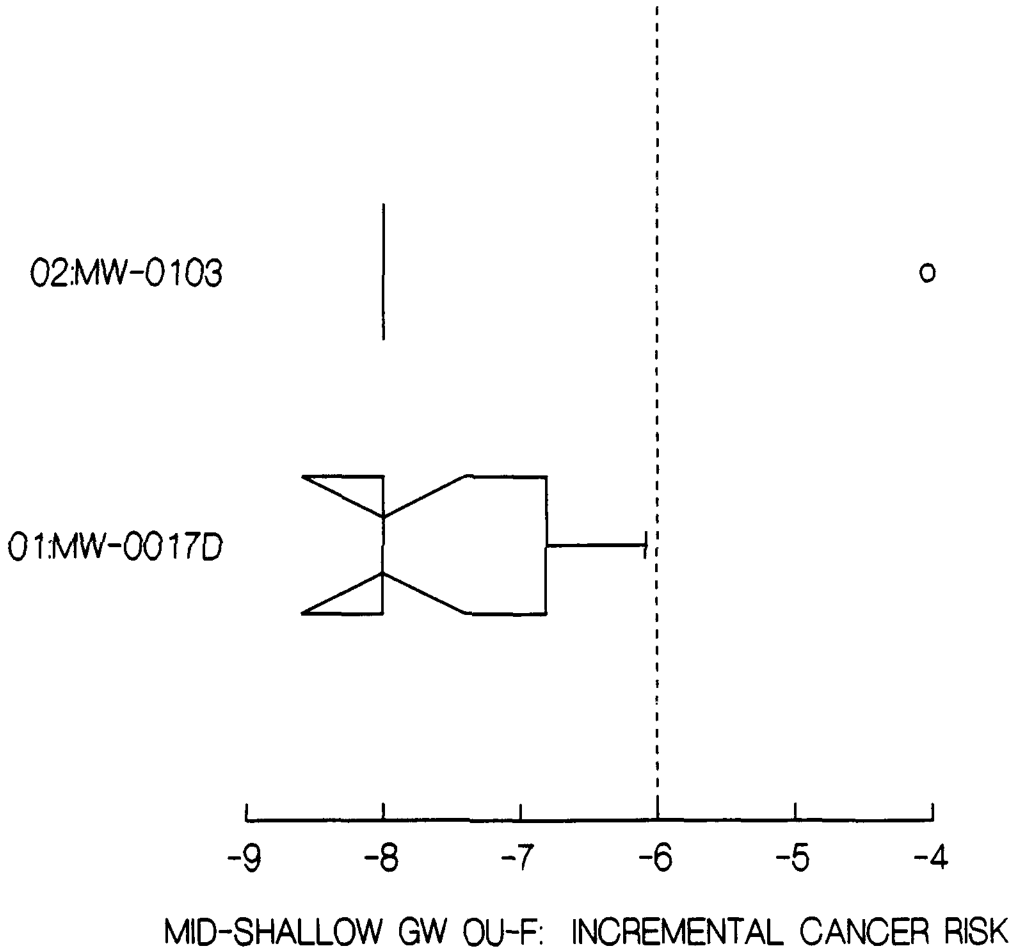
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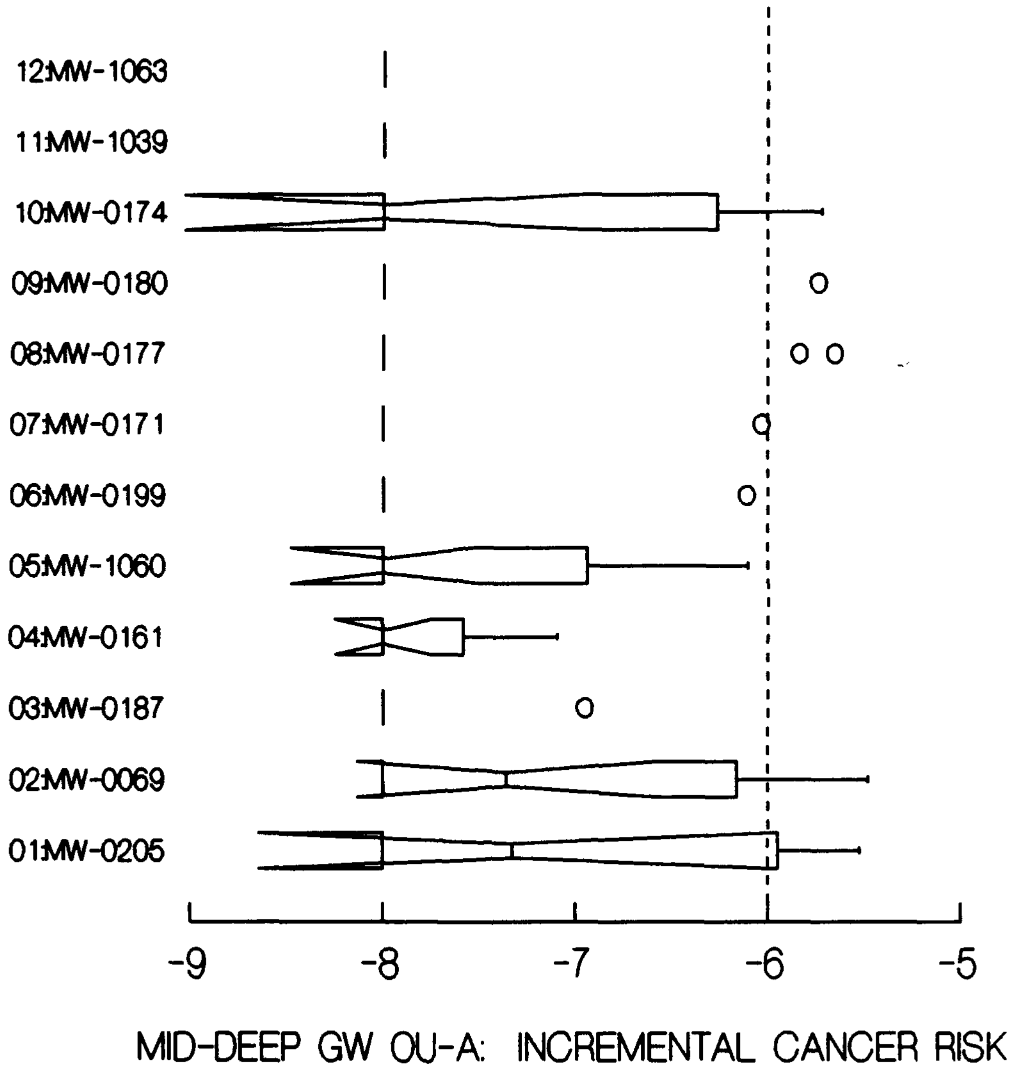

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04:MW-0161
03:MW-0187
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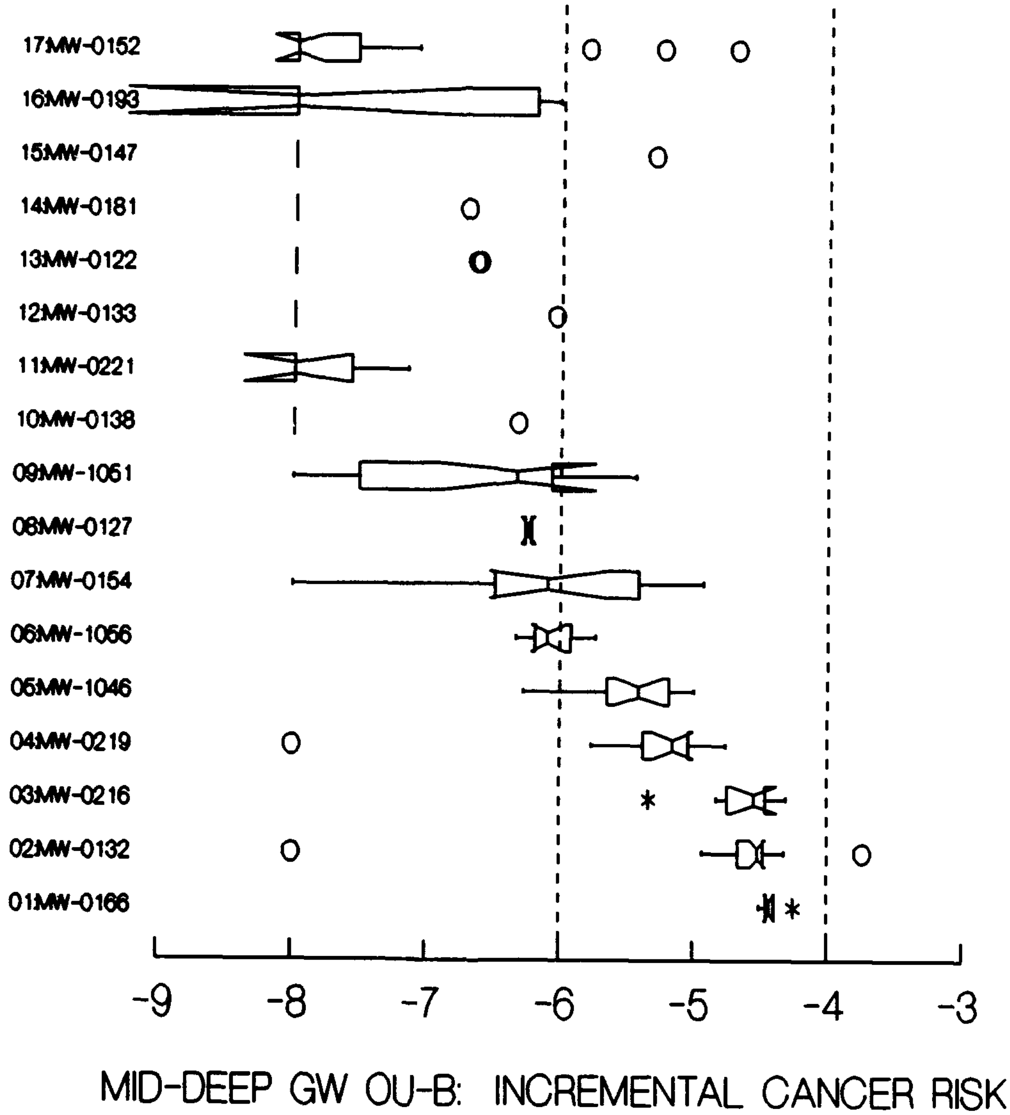
MID-DEEP GW OU-A: INCREMENTAL CANCER RISK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08MW-0127
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06MW-1056
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03MW-0216
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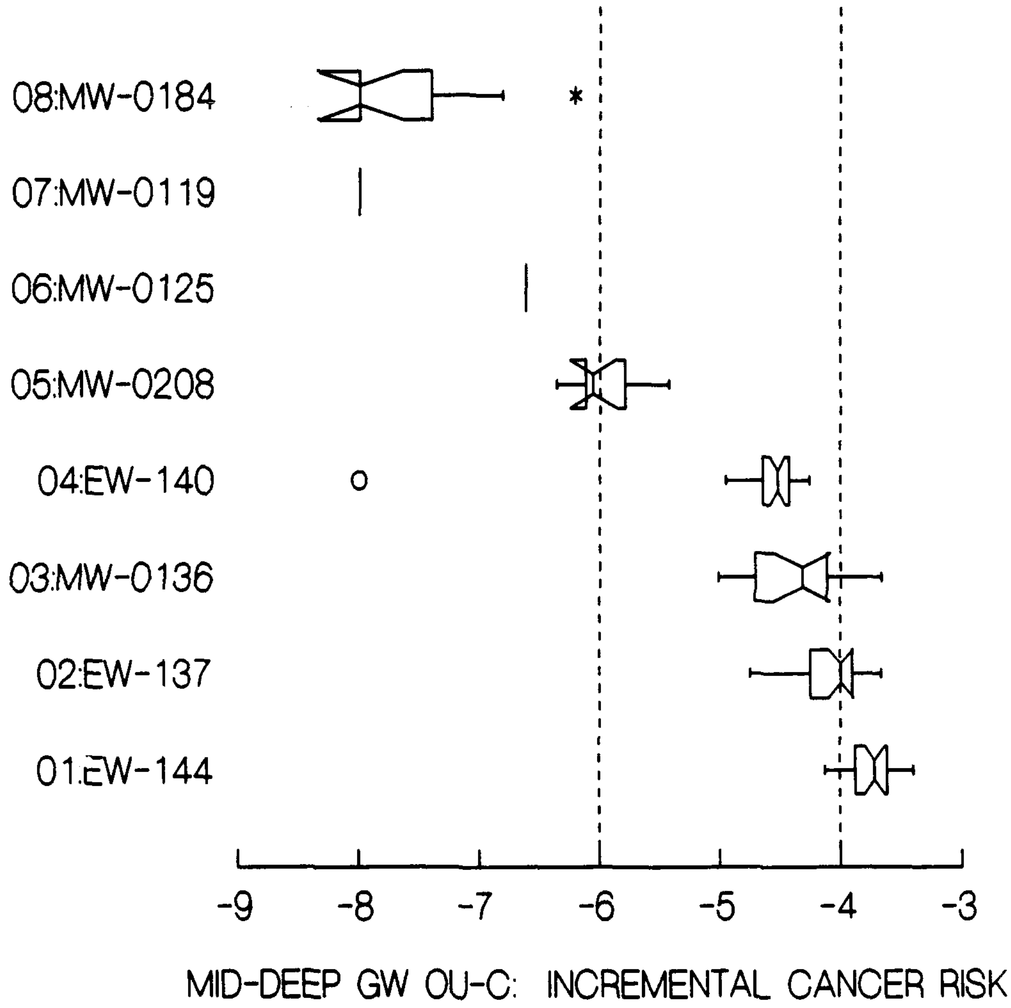
MID-DEEP GW OU-B: INCREMENTAL CANCER RISK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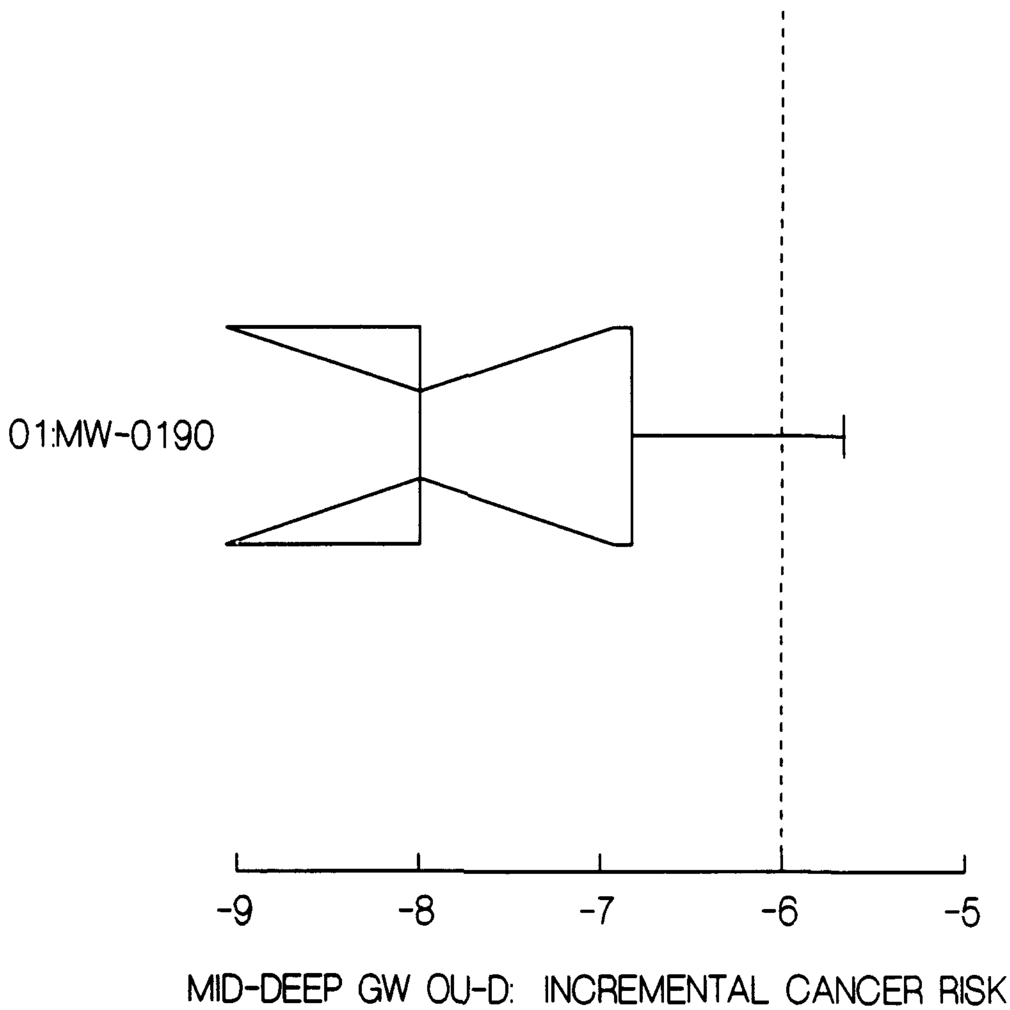
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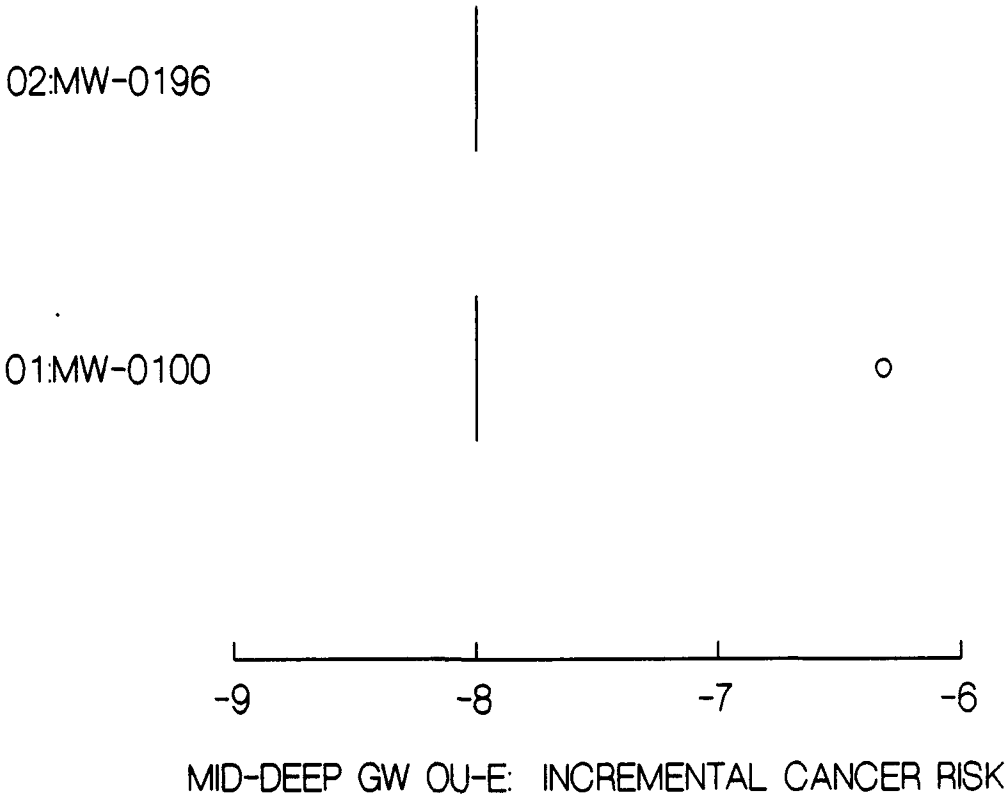
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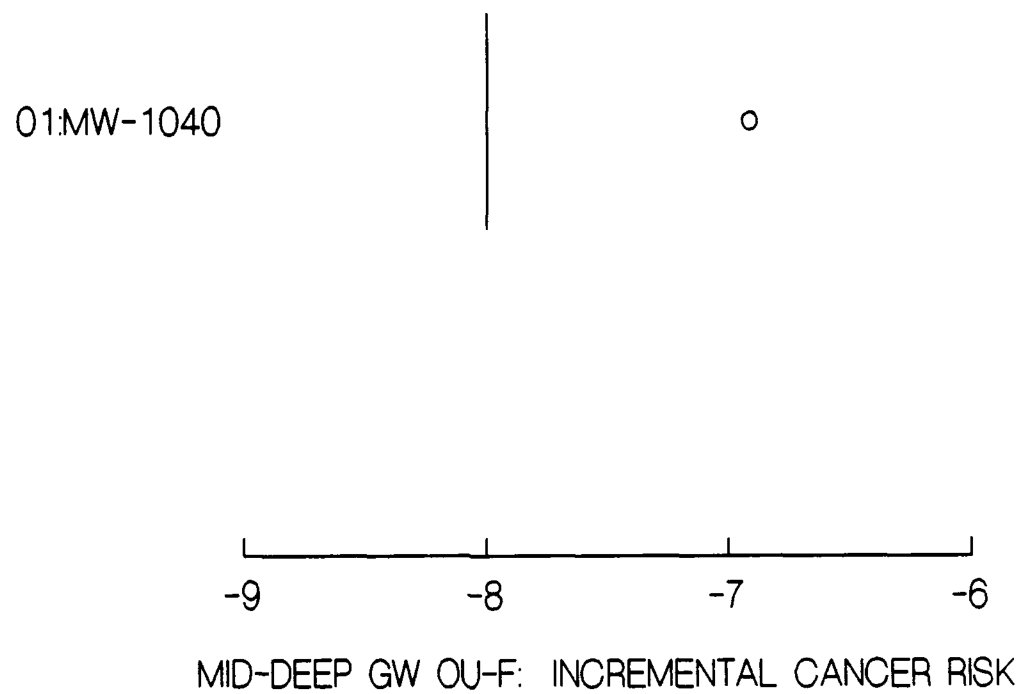
MID-DEEP GW OU-E: INCREMENTAL CANCER RISK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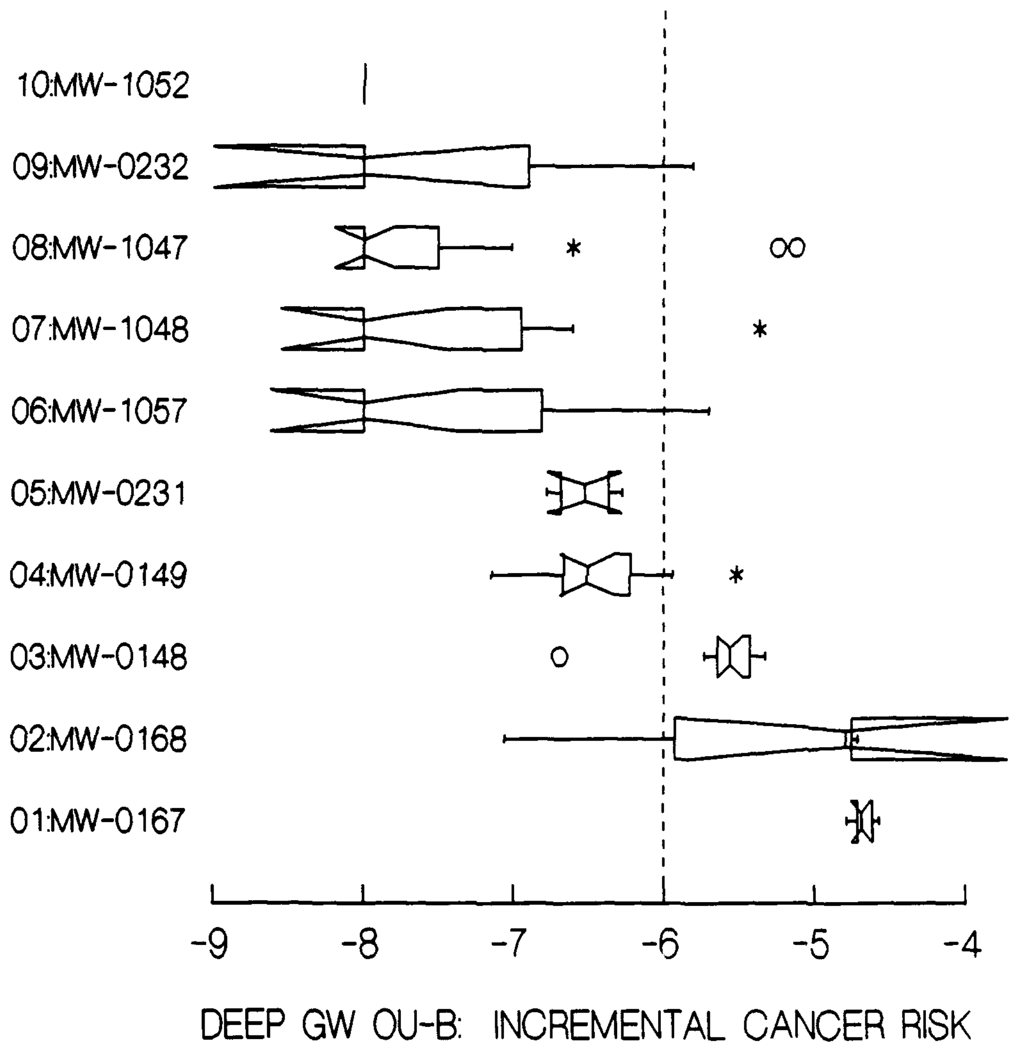
MID-DEEP GW OU-F: INCREMENTAL CANCER RISK



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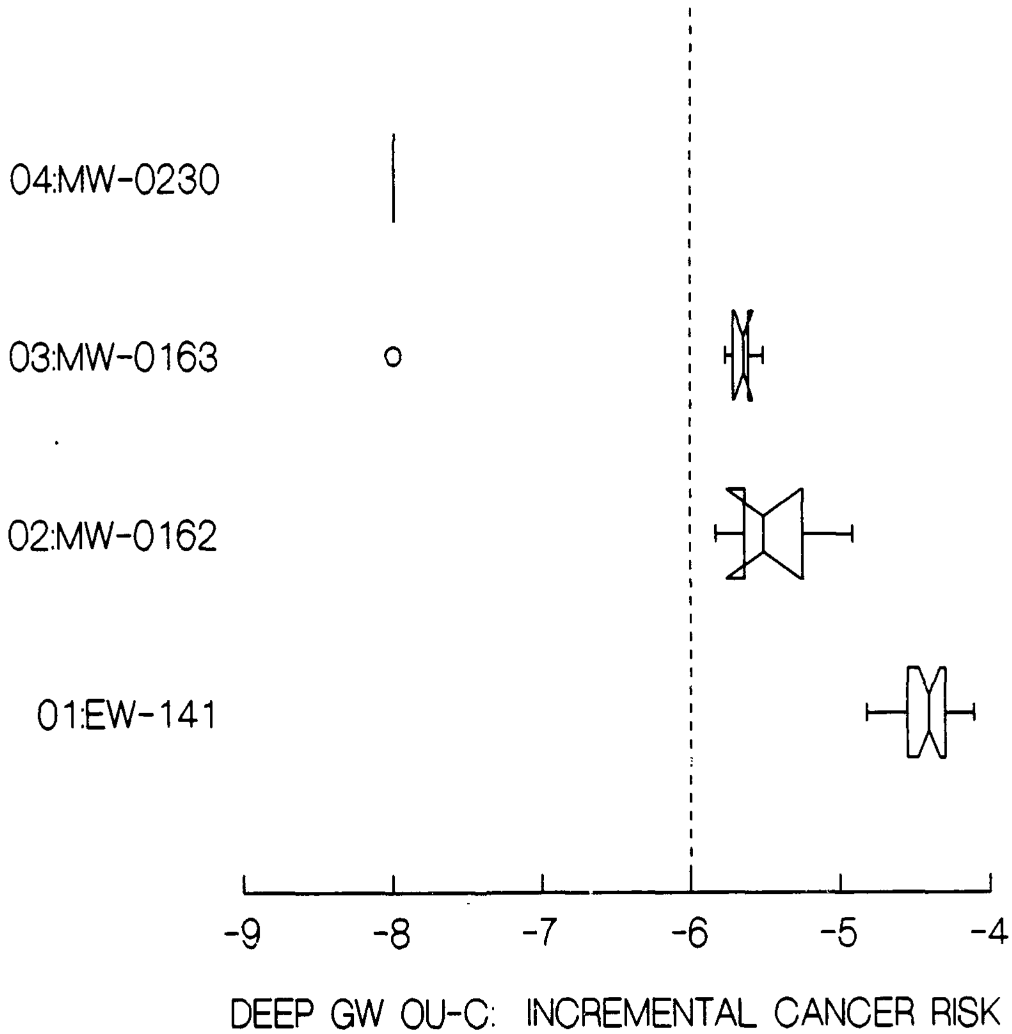
05:MW-0231
04:MW-0149
03:MW-0148
02:MW-0168
01:MW-0167
-9
-8
-7
-6
-5
-4
DEEP GW OU-B: INCREMENTAL CANCER RISK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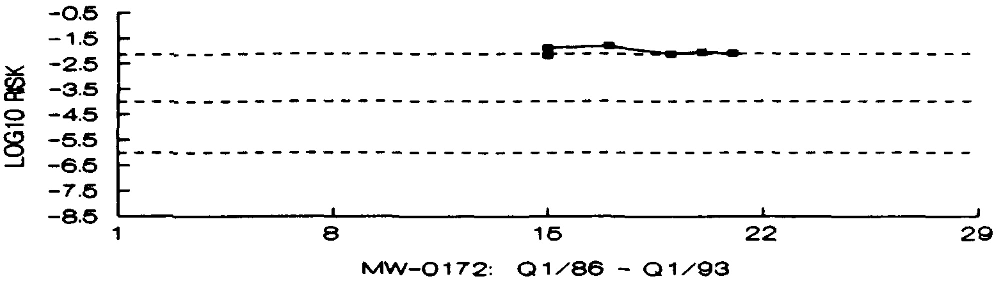
-4
DEEP GW OU-C: INCREMENTAL CANCER RISK

Attachment B-4
Increased Lifetime Cancer Risk
Time Series for
Individual Wells

Increased Lifetime Cancer Risk
Time Series
OU A, A-zone Wells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8
15
22
29
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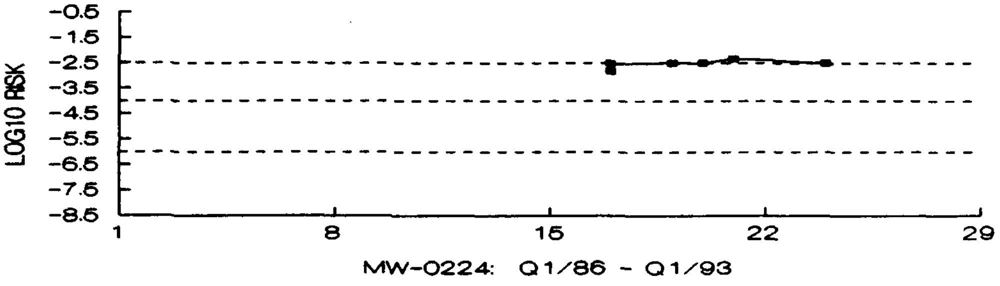
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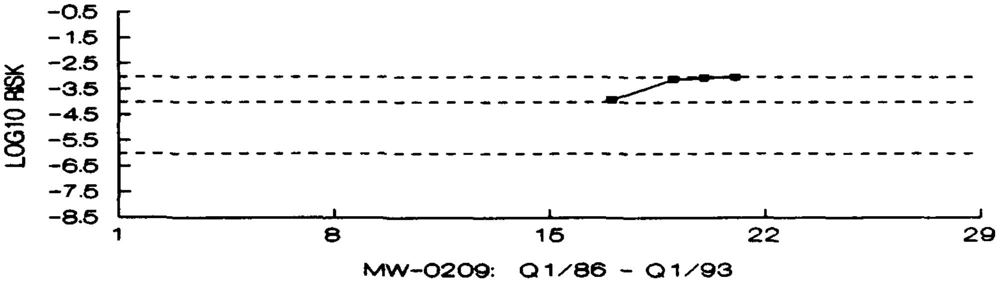
15
22
29
MW-0224: Q1/86 - Q1/93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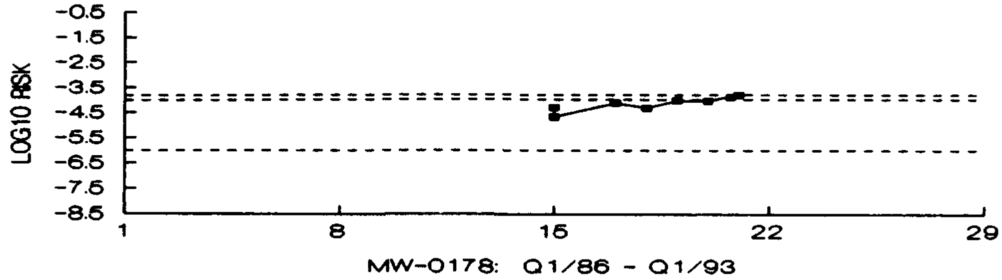
LOG10 RISK
1
8
15
22
29
MW-0209: Q1/86 - Q1/93



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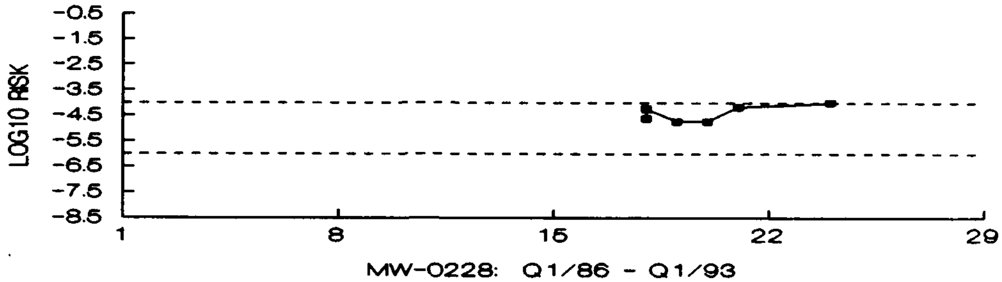
15
22
29
MW-0178: Q1/86 - Q1/93



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LOG10 RISK
1
8
15
22
29
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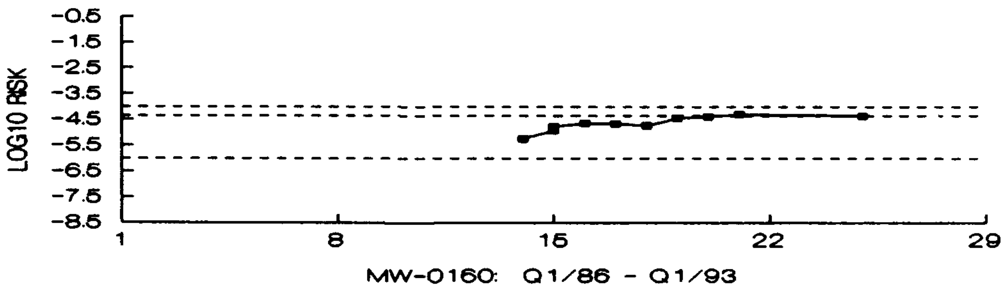

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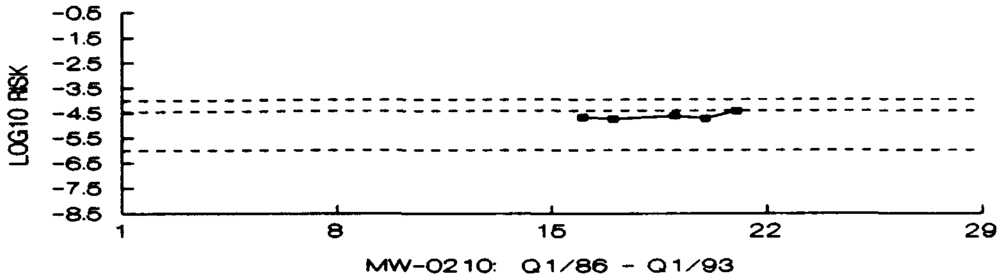
LOG10 RISK
1
8
15
22
29
MW-0160: Q1/86 - Q1/93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LOG10 RISK
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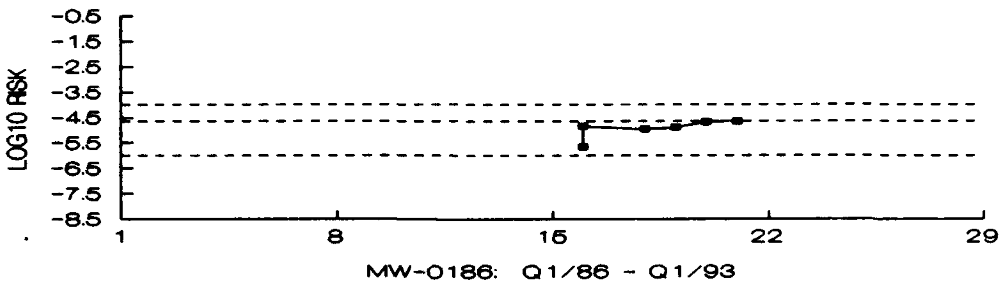
15
22
29
MW-0210: Q1/86 - Q1/93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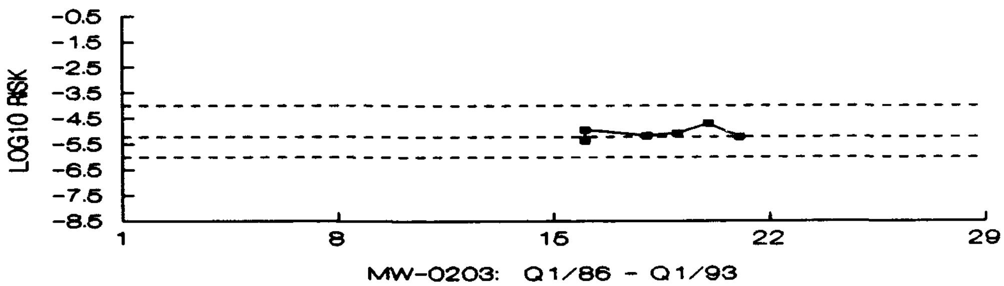
15
22
29
MW-0186: Q1/86 - Q1/93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LOG10 RISK
1
8
15
22
29
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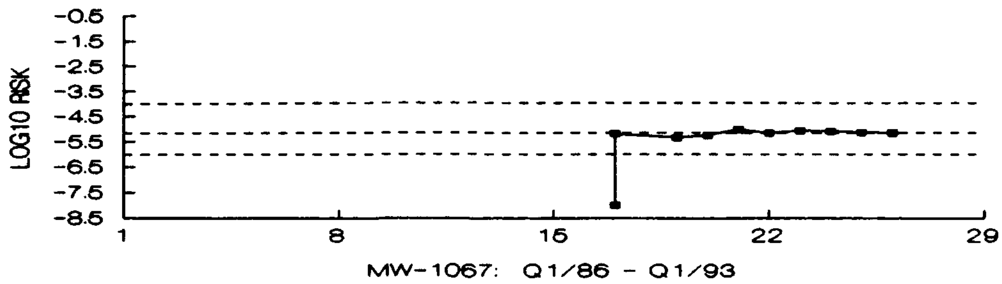

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LOG10 RISK
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15
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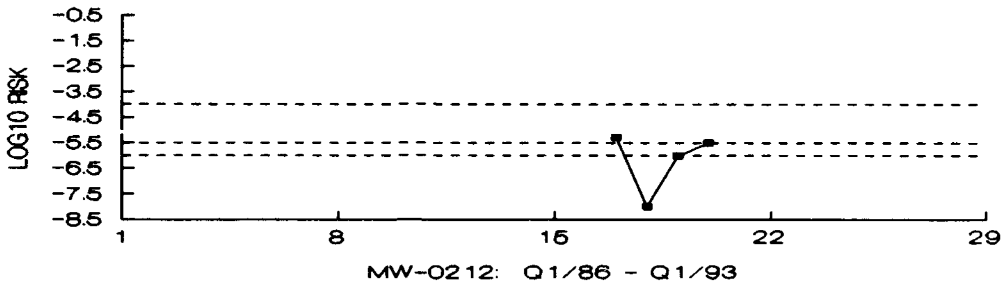

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LOG10 RISK
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15
22
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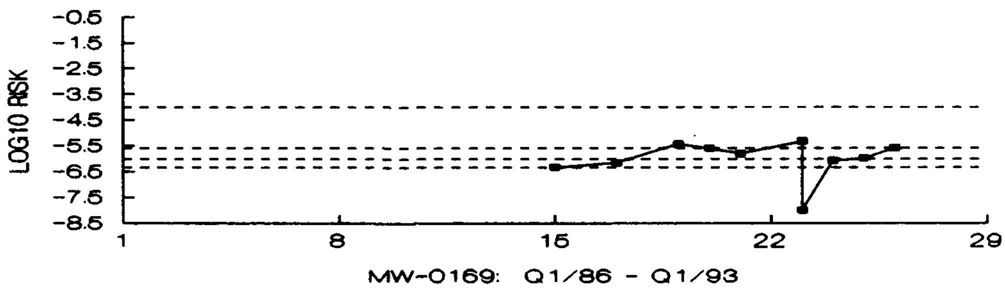

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-5.5
-6.5
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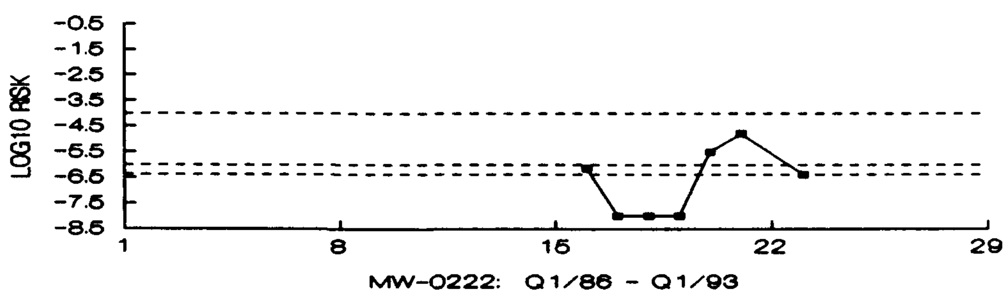
-8.5
LOG10 RISK
1
8
15
22
29
MW-0169: Q1/86 - Q1/93



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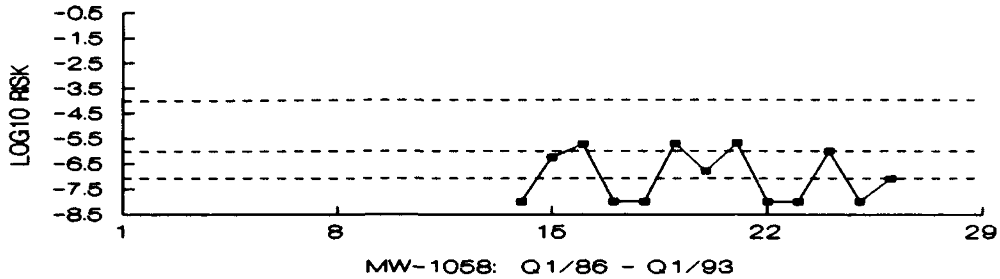
MW-0222: Q1/86 - Q1/93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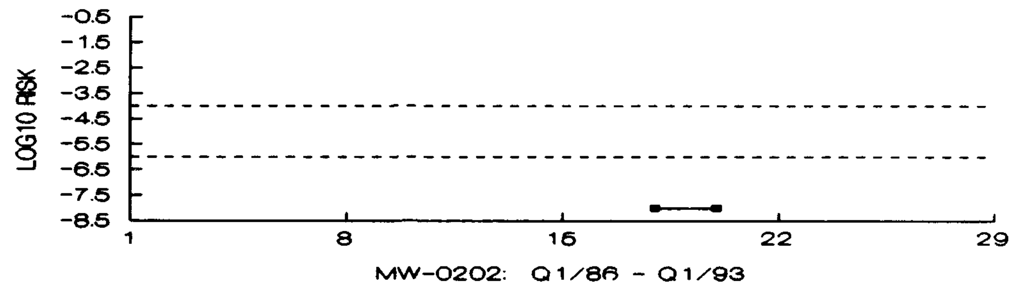
MW-1058: Q1/86 - Q1/93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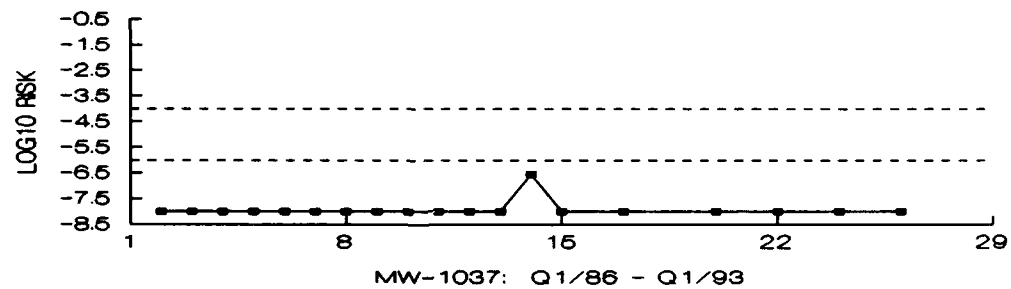
MW-0202: Q1/86 - Q1/93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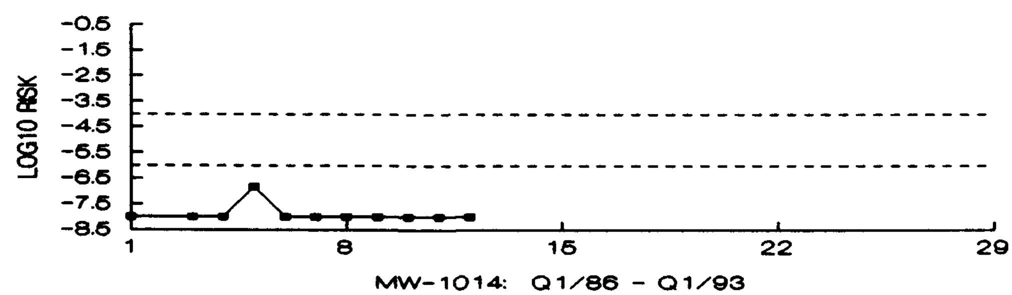
MW-1037: Q1/86 - Q1/93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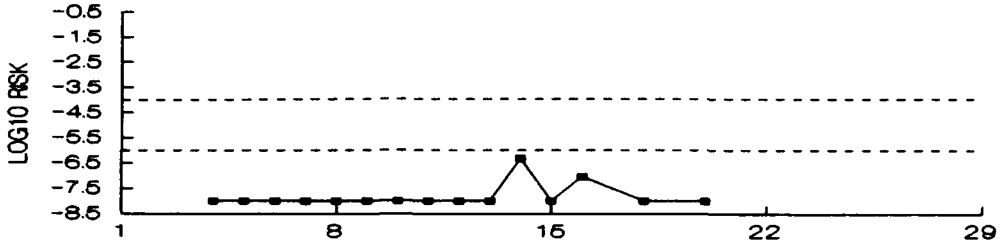
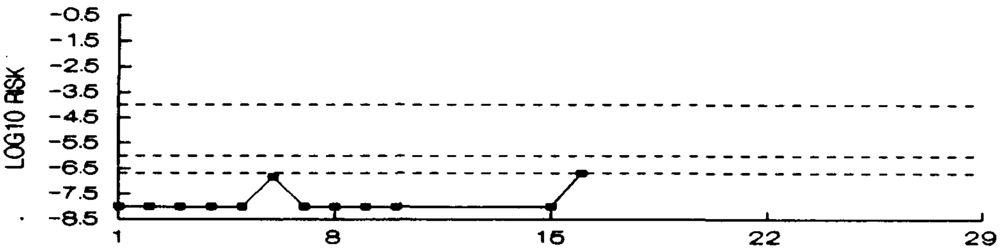
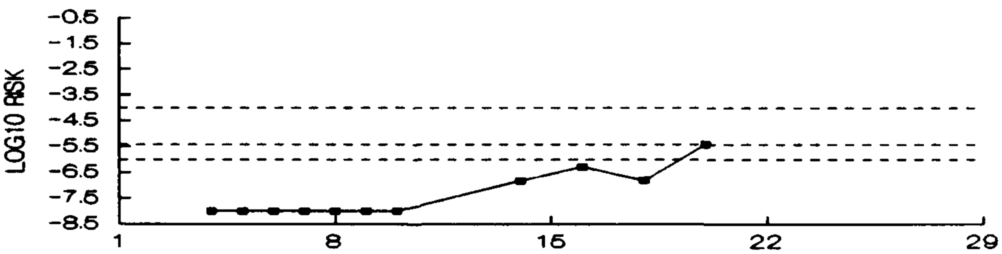
MW-1014: Q1/86 - Q1/93



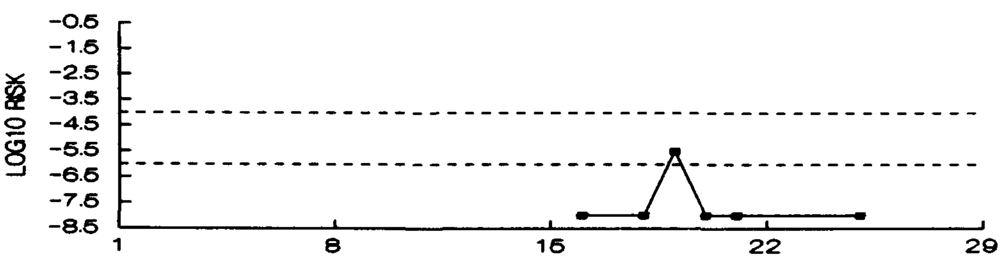
MW-0028D: Q1/86 - Q1/93



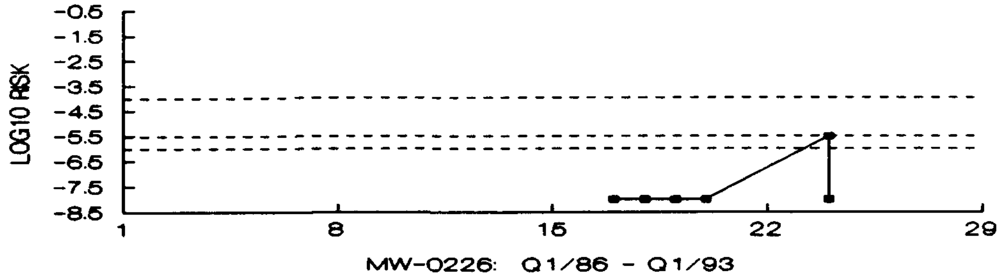
MW-0067: Q1/86 - Q1/93



MW-0068: Q1/86 - Q1/93



MW-0197: Q1/86 - Q1/93



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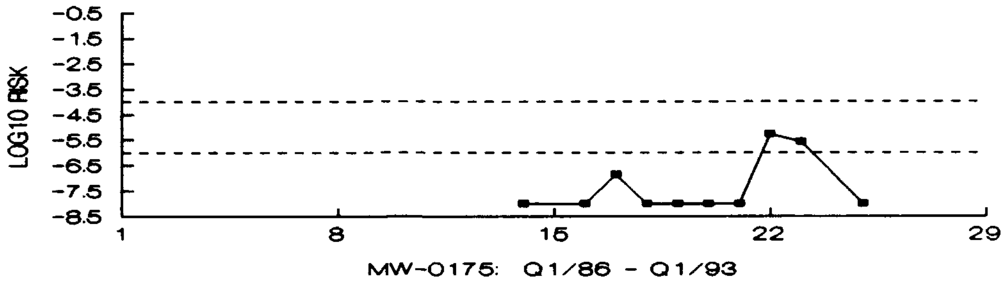
MW-0226: Q1/86 - Q1/93



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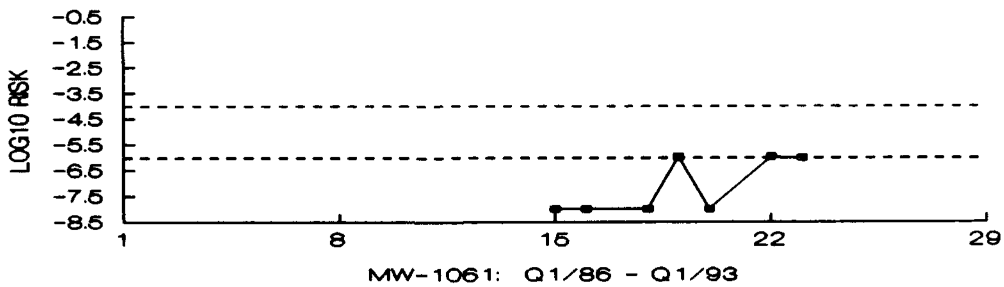
MW-0175: Q1/86 - Q1/93



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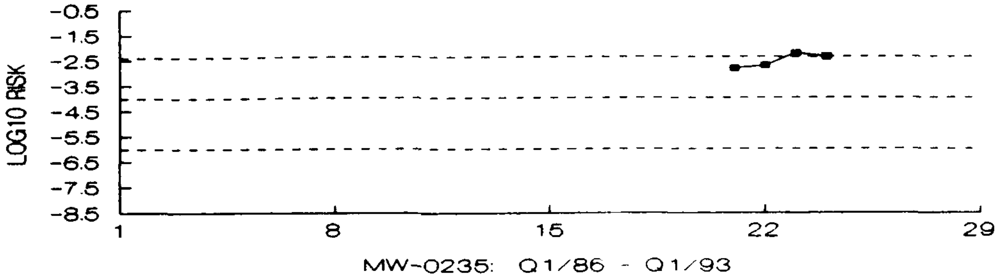
MW-1061: Q1/86 - Q1/93

Increased Lifetime Cancer Risk
Time Series
OU B, A-zone Wells



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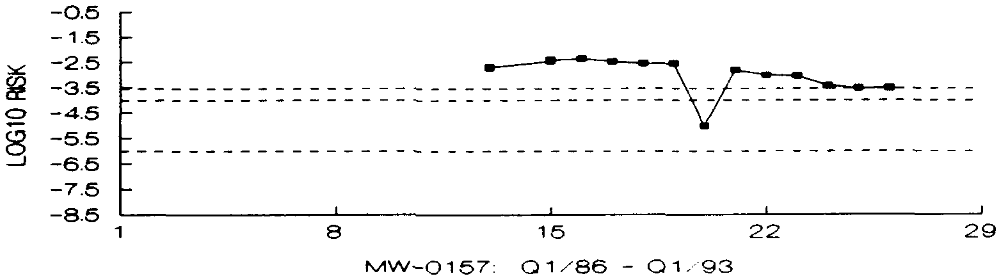
MW-0235: Q1/86 - Q1/93



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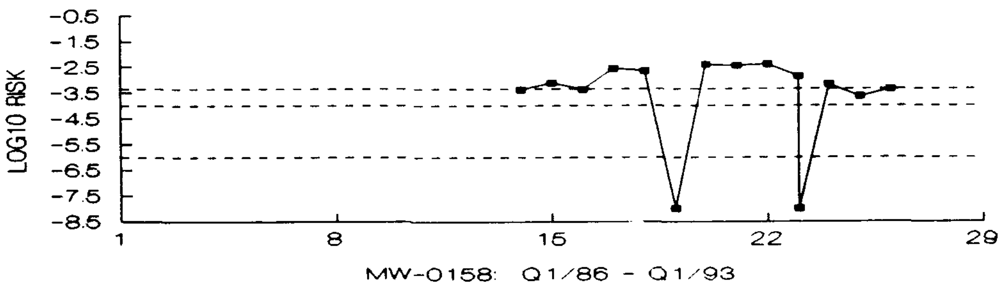
MW-0157: Q1/86 - Q1/93



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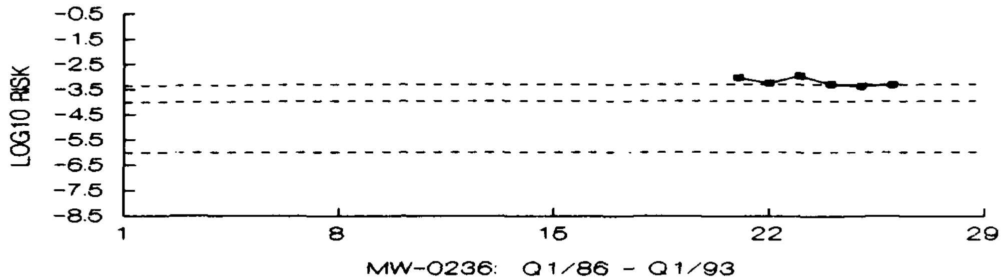
MW-0158: Q1/86 - Q1/93



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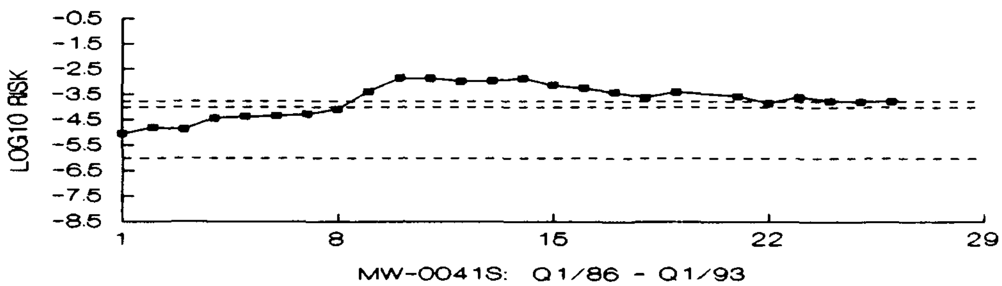
MW-0236: Q1/86 - Q1/93



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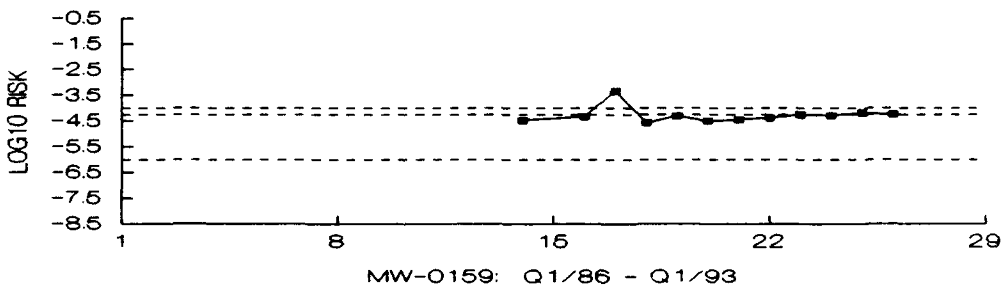
MW-0041S: Q1/86 - Q1/93



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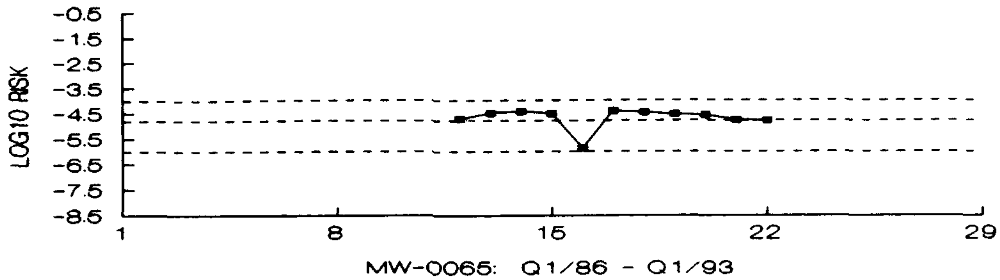
MW-0159: Q1/86 - Q1/93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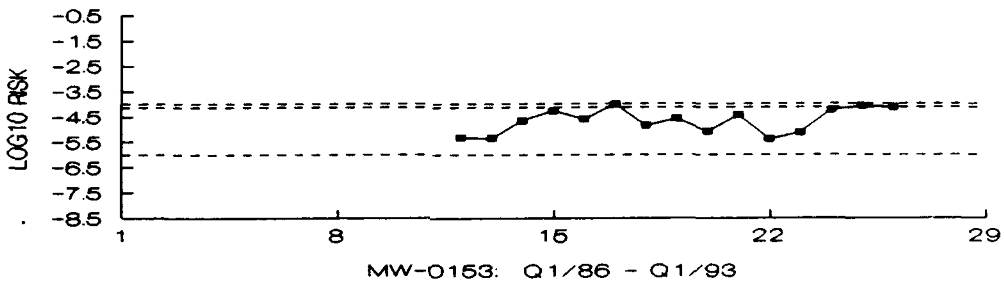
MW-0065: Q1/86 - Q1/93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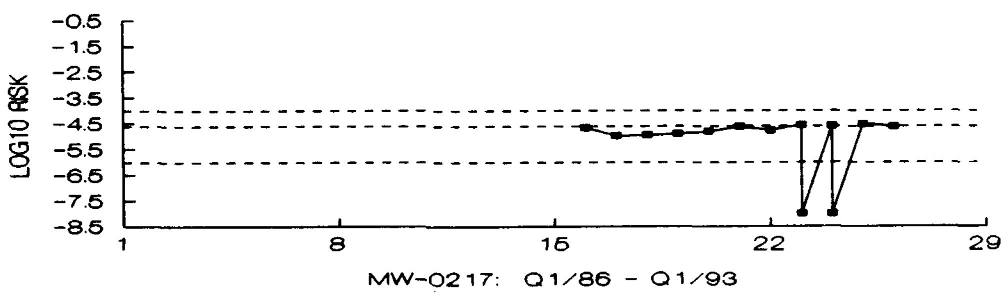
MW-0153: Q1/86 - Q1/93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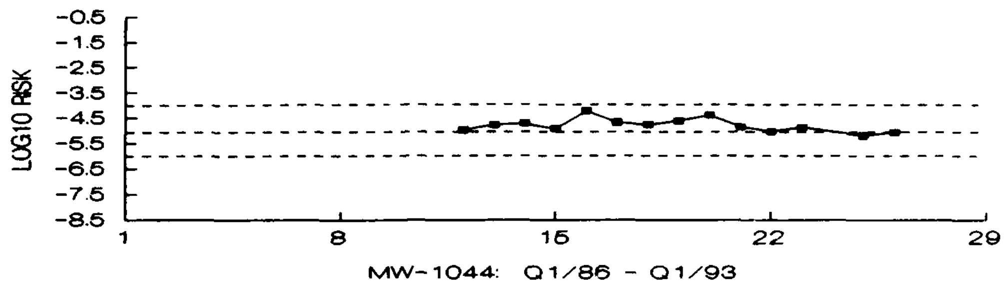
MW-0217: Q1/86 - Q1/93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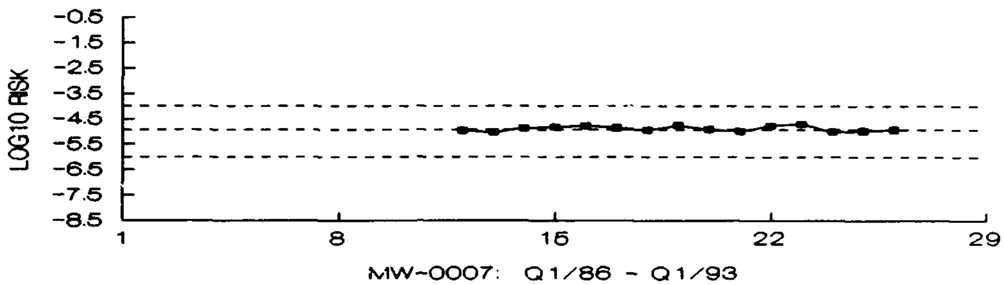
MW-1044: Q1/86 - Q1/93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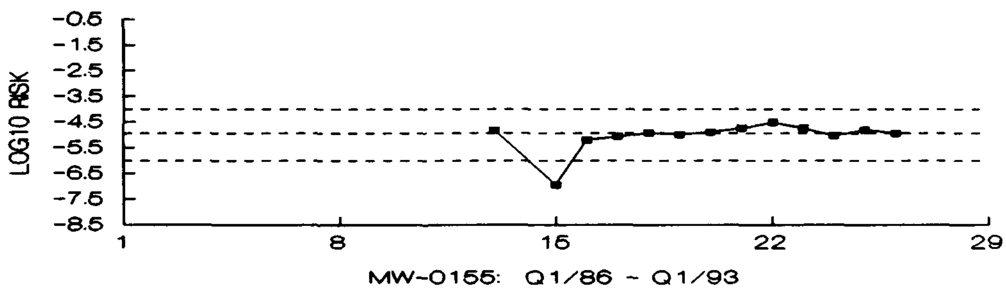
MW-0007: Q1/86 - Q1/93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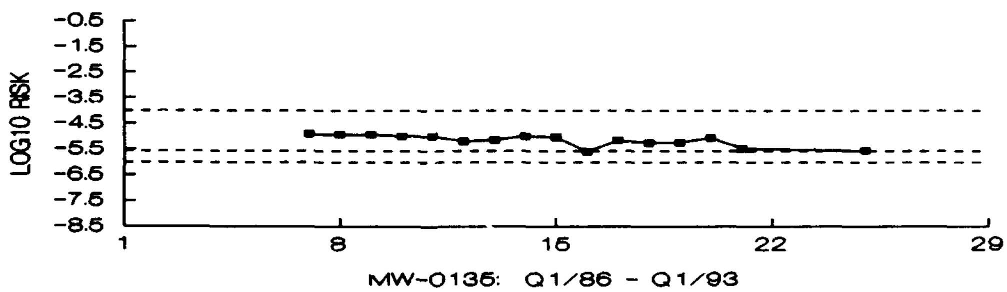
MW-0155: Q1/86 - Q1/93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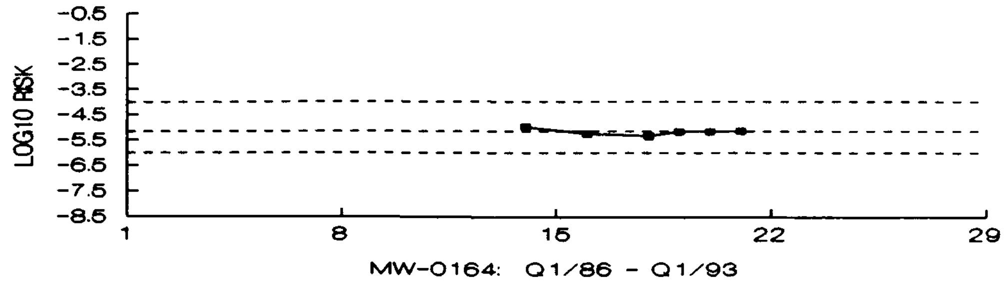
MW-0135: Q1/86 - Q1/93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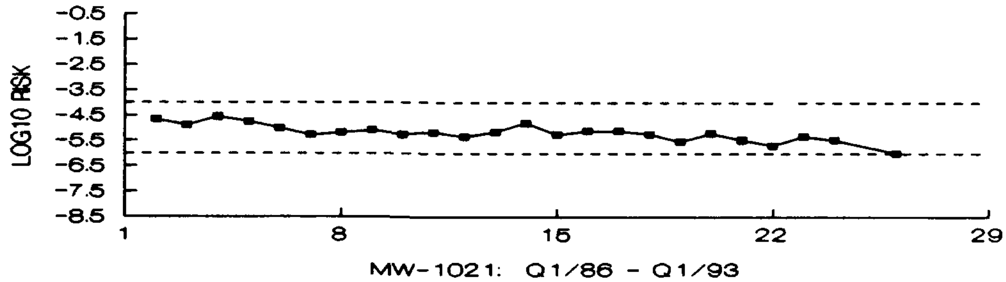
MW-0164: Q1/86 - Q1/93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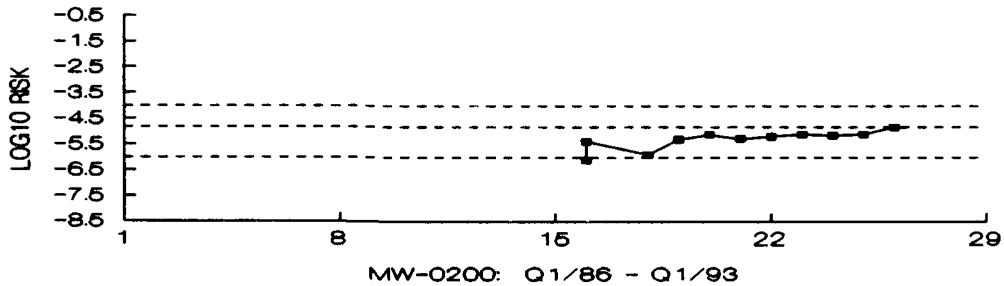
MW-1021: Q1/86 - Q1/93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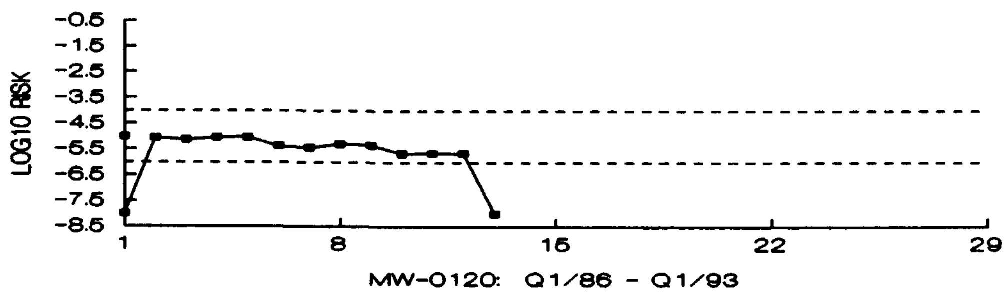
MW-0200: Q1/86 - Q1/93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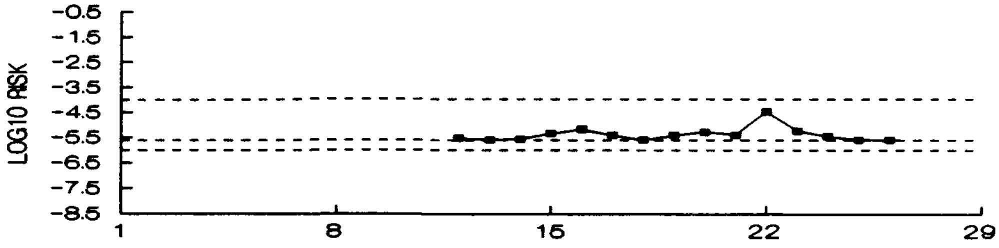
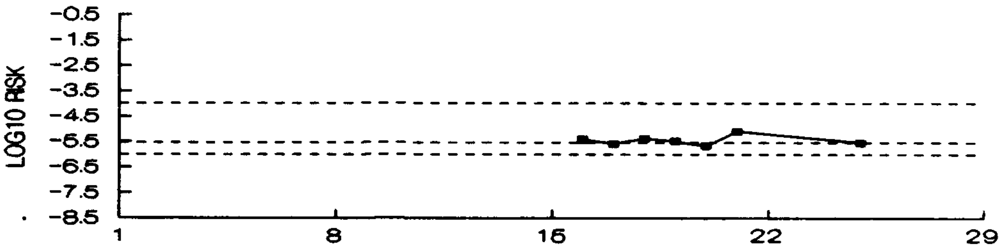
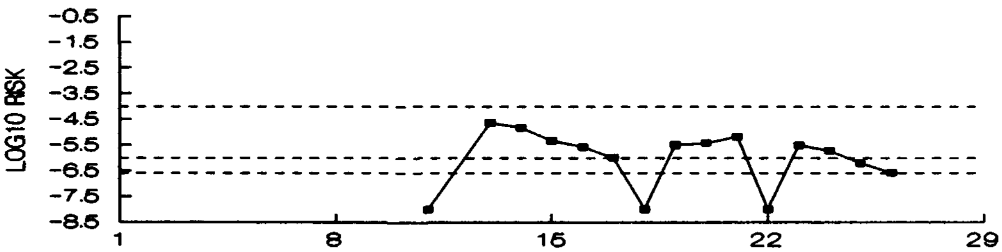
MW-0120: Q1/86 - Q1/93



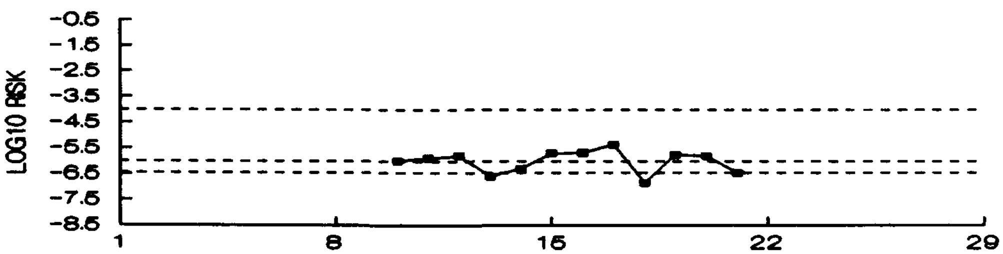
MW-1049: Q1/86 - Q1/93



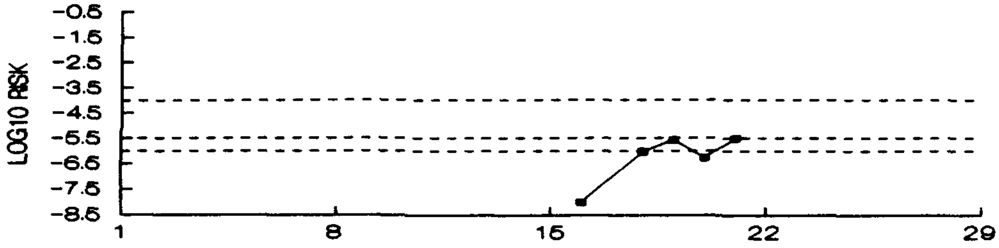
MW-0214: Q1/86 - Q1/93



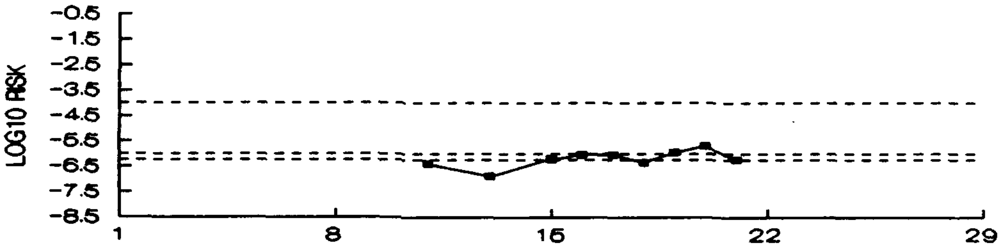
MW-0150: Q1/86 - Q1/93



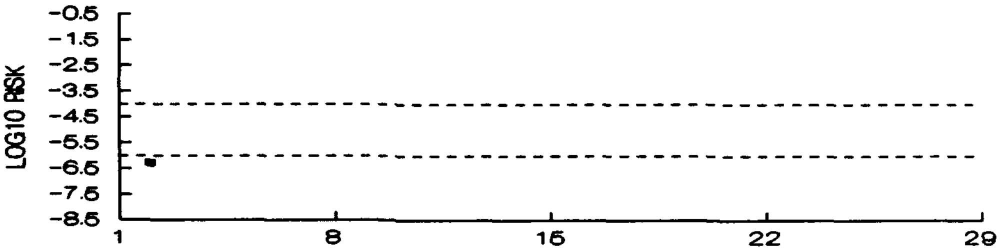
MW-0025D: Q1/86 - Q1/93



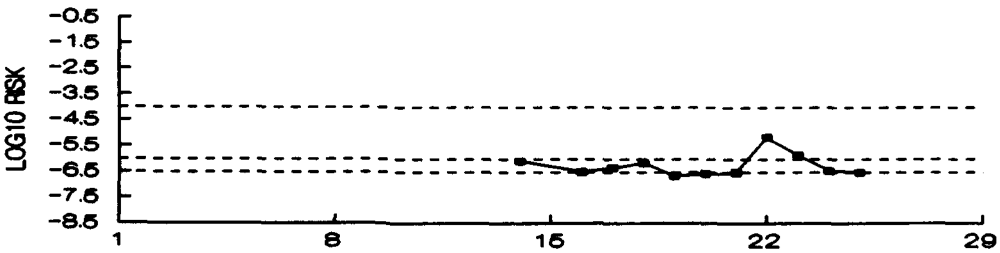
MW-0191: Q1/86 - Q1/93



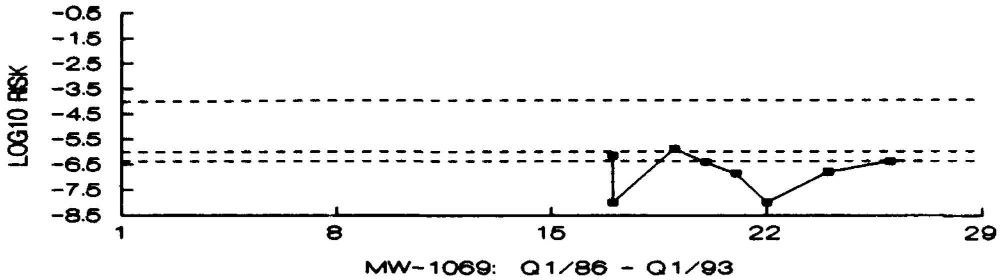
MW-0145: Q1/86 - Q1/93



MW-0020S: Q1/86 - Q1/93



MW-1054: Q1/86 - Q1/93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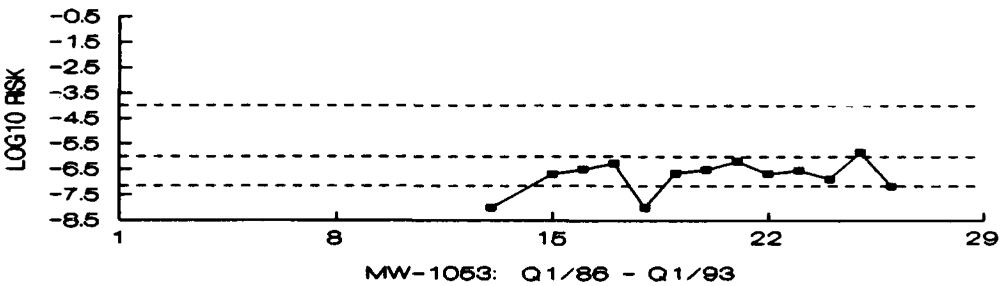
MW-1069: Q1/86 - Q1/93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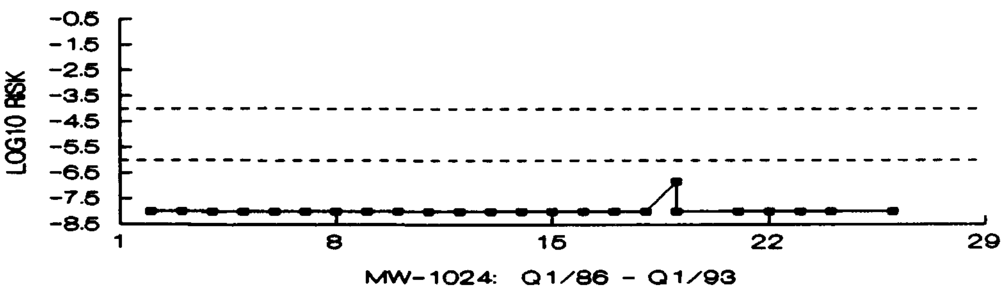
MW-1053: Q1/86 - Q1/93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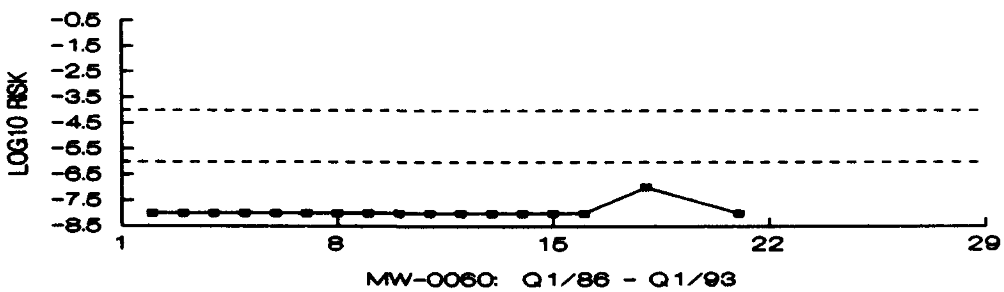
MW-1024: Q1/86 - Q1/93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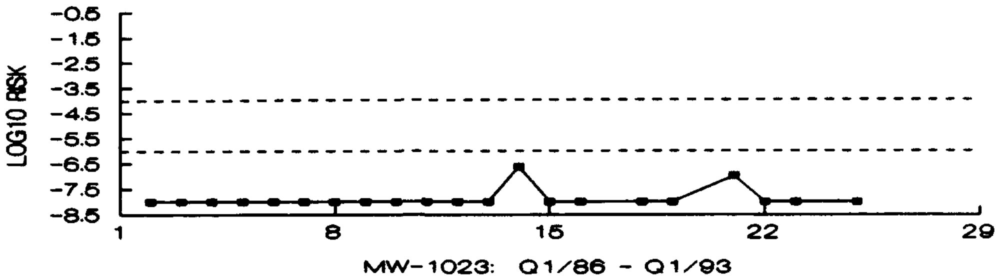
MW-0060: Q1/86 - Q1/93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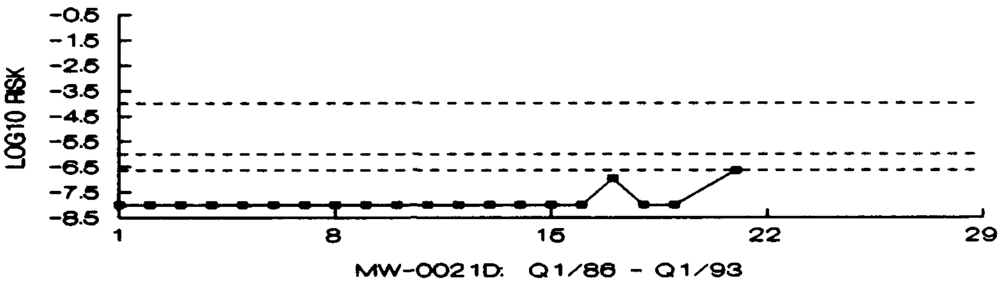
MW-1023: Q1/86 - Q1/93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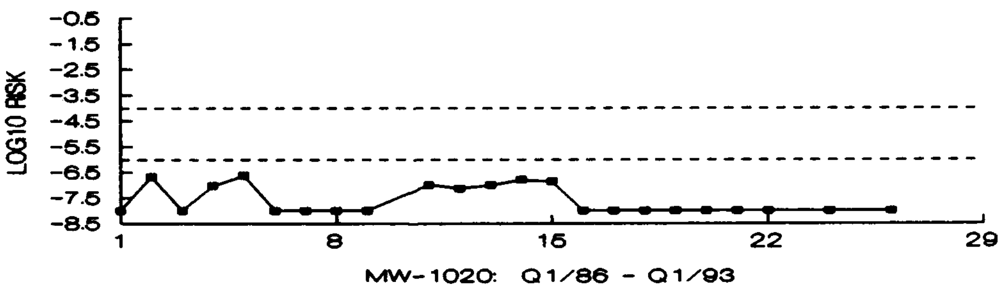
MW-0021D: Q1/86 - Q1/93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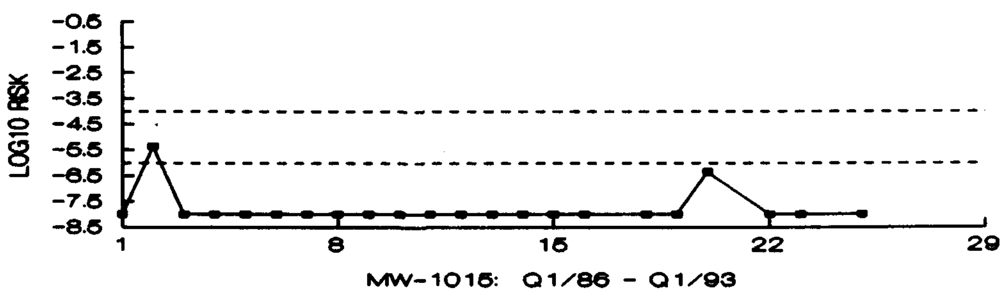
MW-1020: Q1/86 - Q1/93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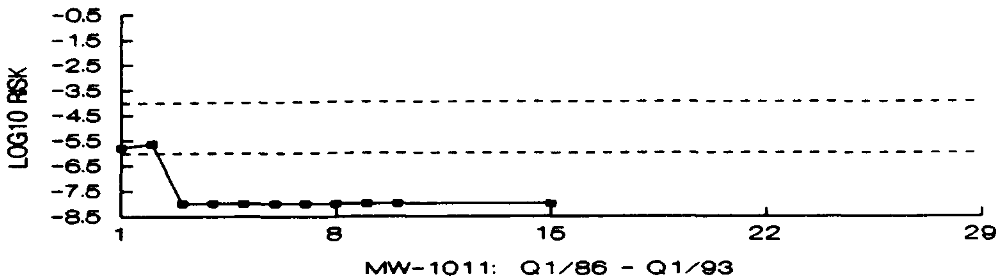
MW-1015: Q1/86 - Q1/93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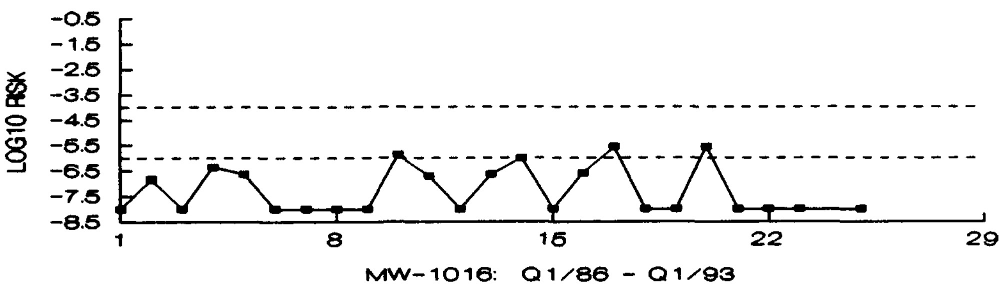
29
MW-1011: Q1/86 - Q1/93


LOG10 RISK
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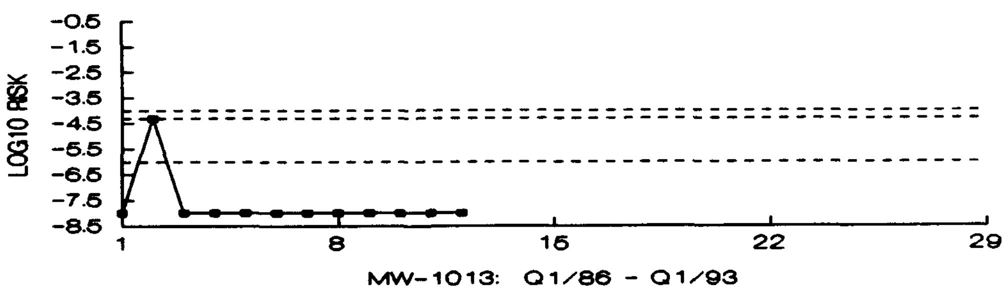
MW-1016: Q1/86 - Q1/93


LOG10 RISK
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15
22
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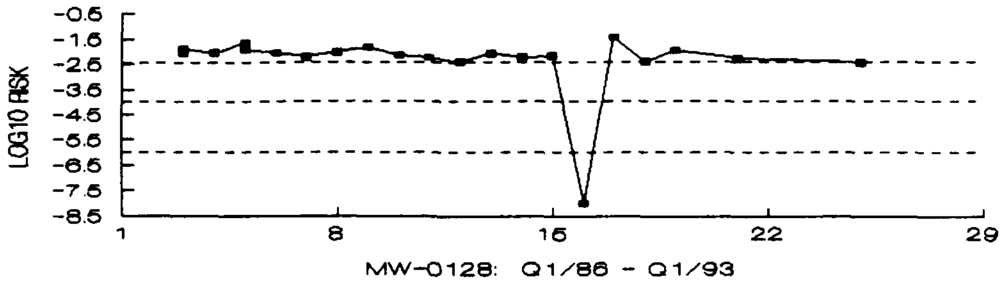
MW-1013: Q1/86 - Q1/93

Increased Lifetime Cancer Risk
Time Series
OU C, A-zone Wells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LOG10 RISK
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22
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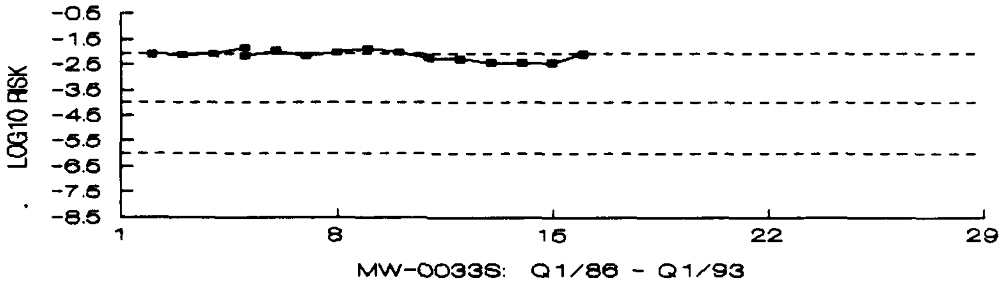
MW-0128: Q1/86 - Q1/93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LOG10 RISK
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22
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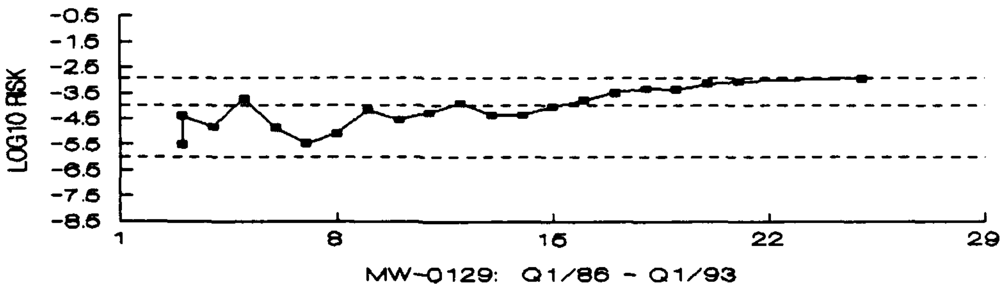
MW-0033S: Q1/86 - Q1/93


-0.5
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-5.5
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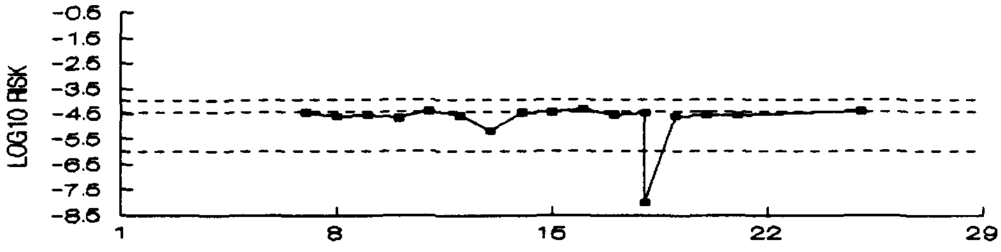
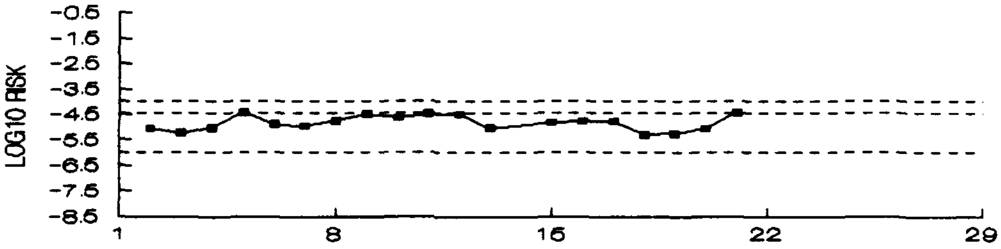
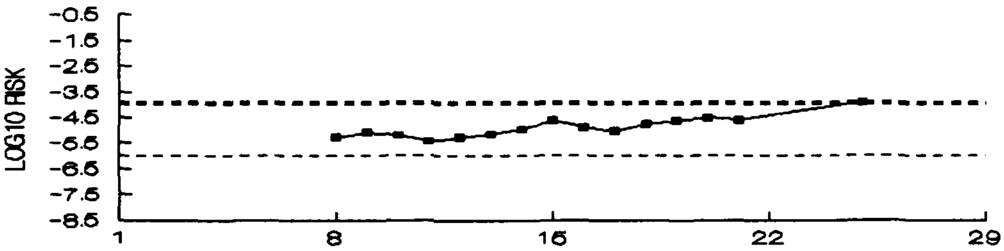
-8.5
LOG10 RISK
1
8
15
22
29
MW-0129: Q1/86 - Q1/93



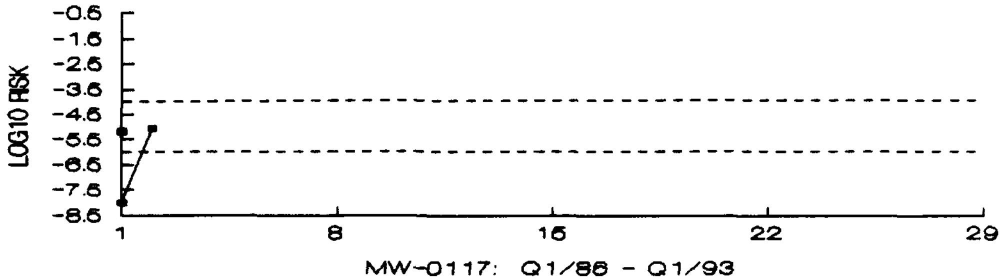
MW-0139: Q1/86 - Q1/93



MW-0131: Q1/86 - Q1/93



MW-0075: Q1/86 - Q1/93



-0.5
-1.5
-2.5
-3.5
-4.5
-5.5
-6.5
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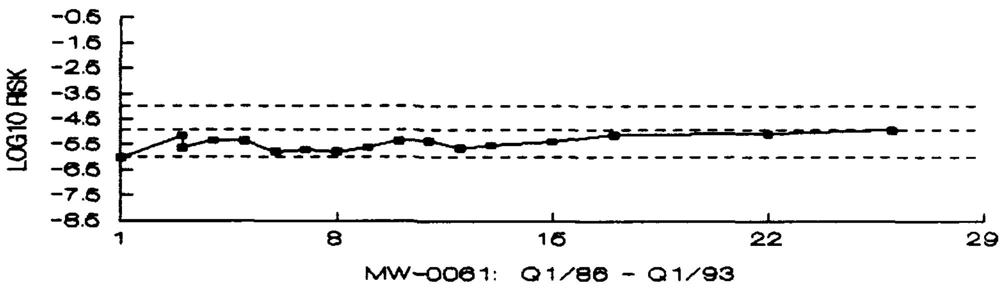
-8.5
LOG10 RISK
1
8
15
22
29
MW-0117: Q1/86 - Q1/93



-0.5
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-2.5
-3.5
-4.5
-5.5
-6.5
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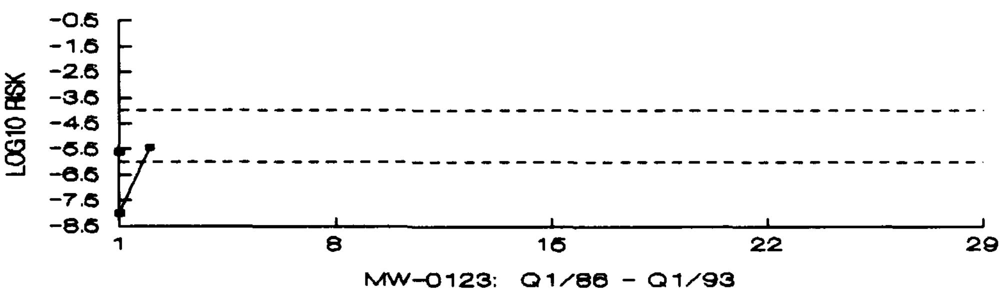
-8.5
LOG10 RISK
1
8
15
22
29
MW-0061: Q1/86 - Q1/93



-0.5
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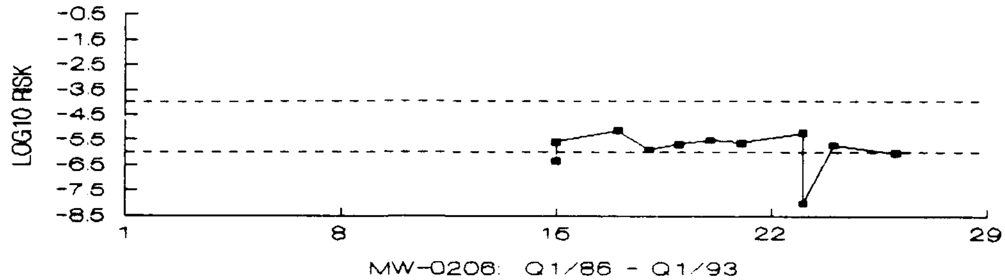
-2.5
-3.5
-4.5
-5.5
-6.5
-7.5
-8.5
LOG10 RISK
1
8
15
22
29
MW-0123: Q1/86 - Q1/93



LOG10 RISK
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-7.5
-8.5
1
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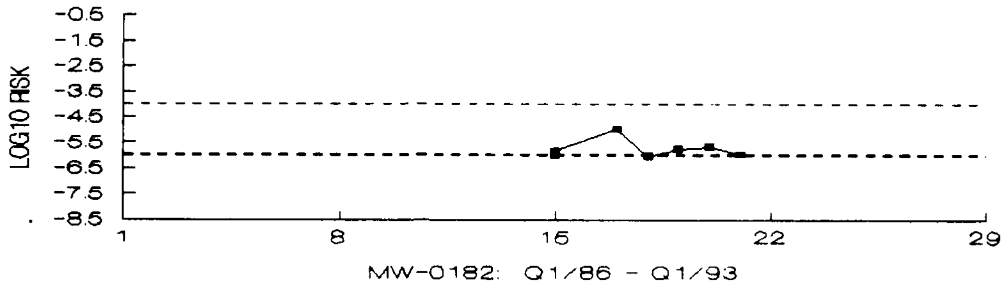
15
22
29
MW-0206: Q1/86 - Q1/93



LOG10 RISK
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-8.5
1
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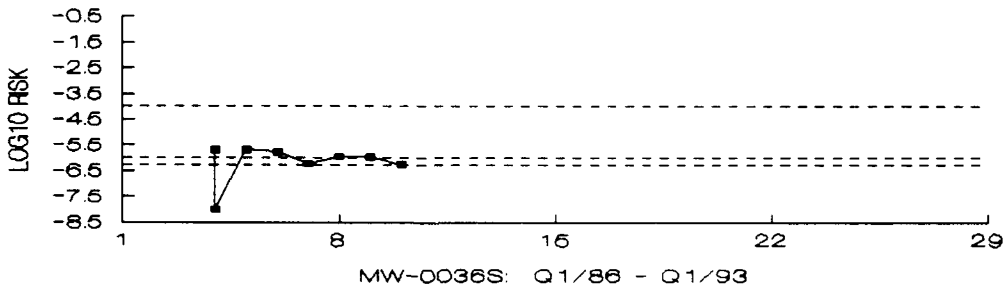
15
22
29
MW-0182: Q1/86 - Q1/93



LOG10 RISK
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-3.5
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-7.5
-8.5
1
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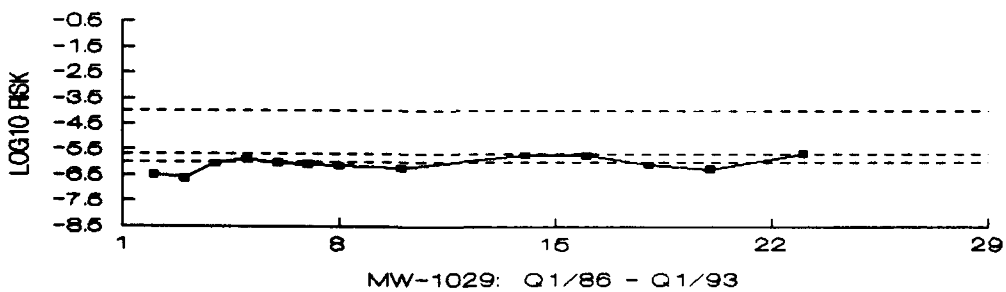
15
22
29
MW-0036S: Q1/86 - Q1/93



LOG10 RISK
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-7.5
-8.5
1
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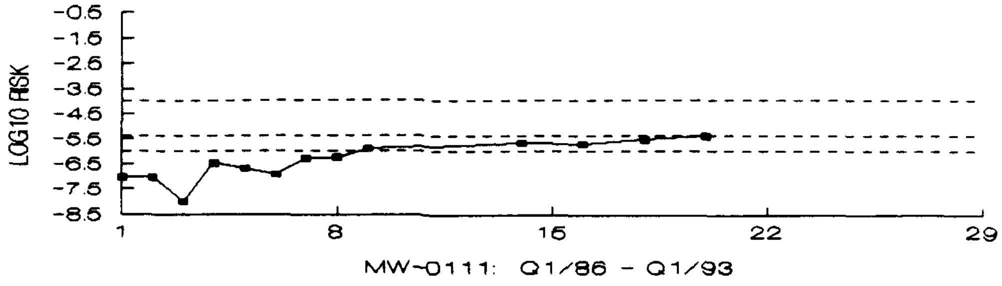
15
22
29
MW-1029: Q1/86 - Q1/93



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-8.5
LOG10 RISK
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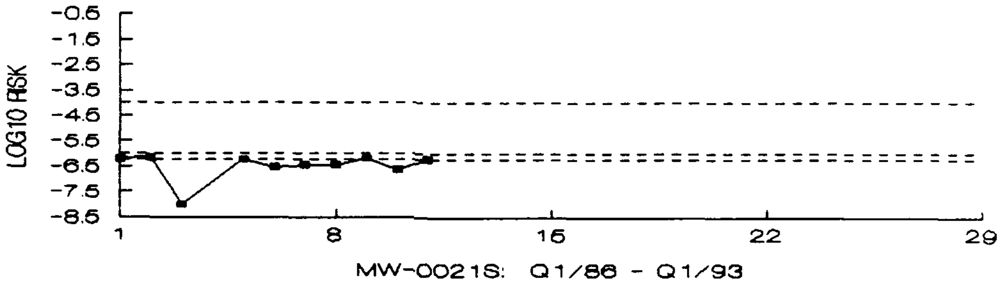
15
22
29
MW-0111: Q1/86 - Q1/93



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LOG10 RISK
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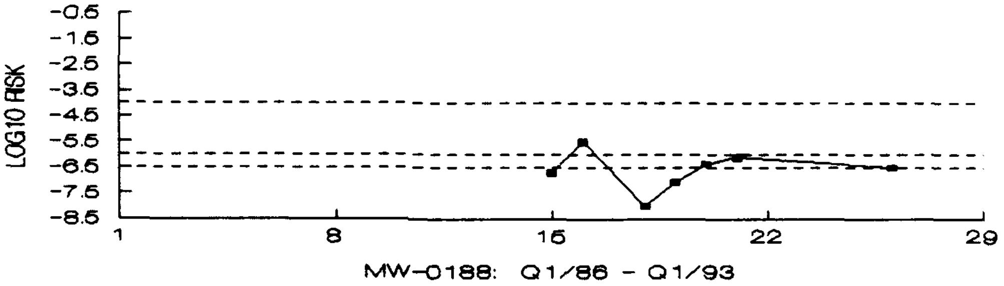
22
29
MW-0021S: Q1/86 - Q1/93



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LOG10 RISK
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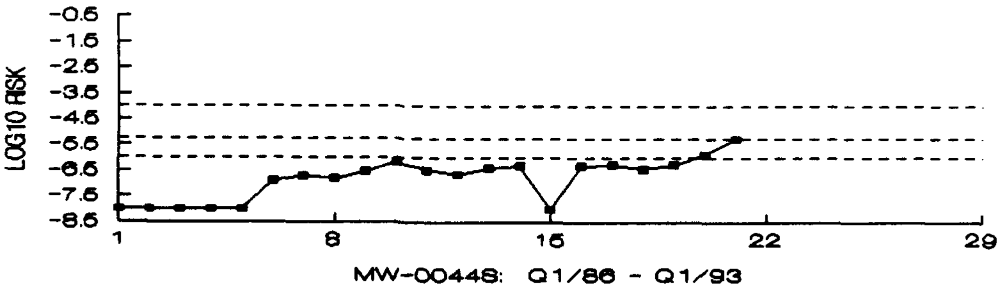
22
29
MW-0188: Q1/86 - Q1/93



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LOG10 RISK
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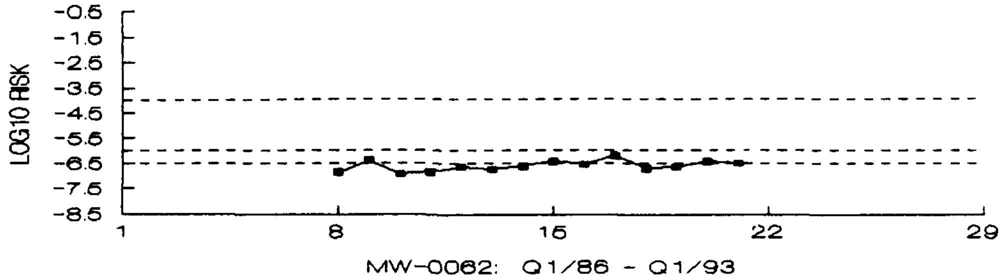
22
29
MW-0044S: Q1/86 - Q1/93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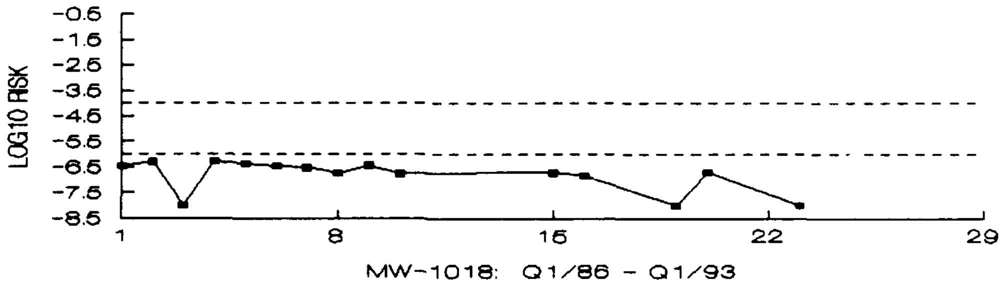
MW-0062: Q1/86 - Q1/93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15
22
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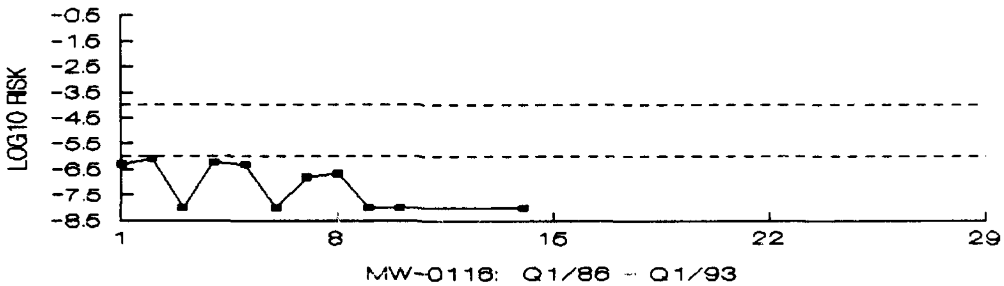
MW-1018: Q1/86 - Q1/93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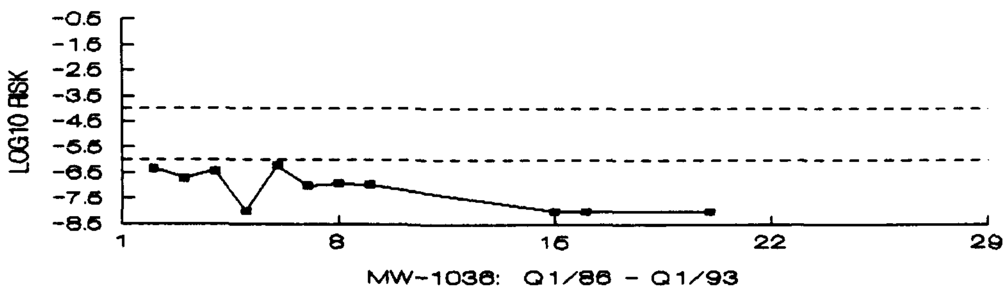
29
MW-0116: Q1/86 - Q1/93


LOG10 RISK
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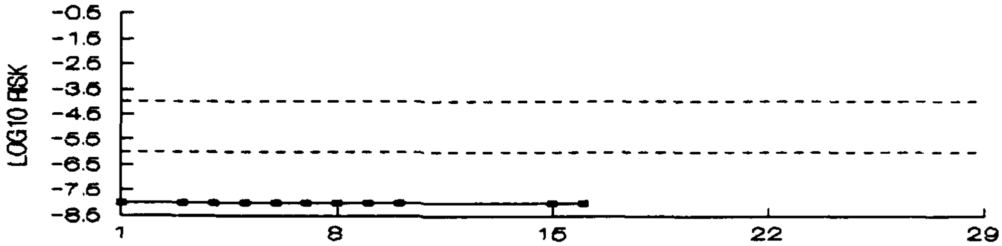
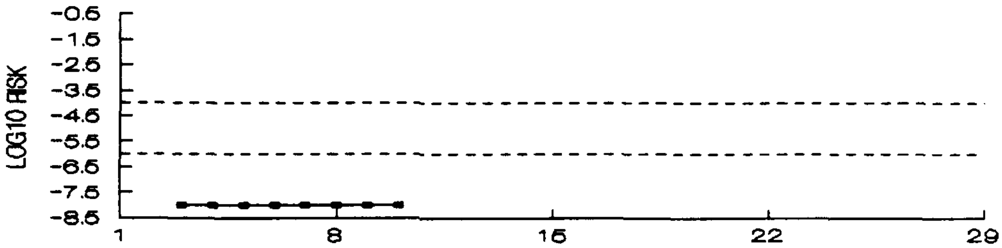
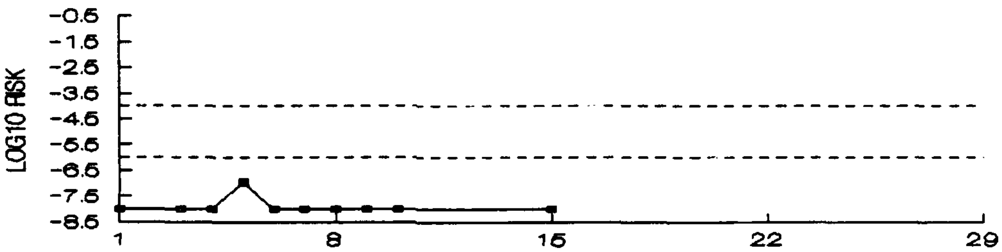
15
22
29
MW-1036: Q1/86 - Q1/93



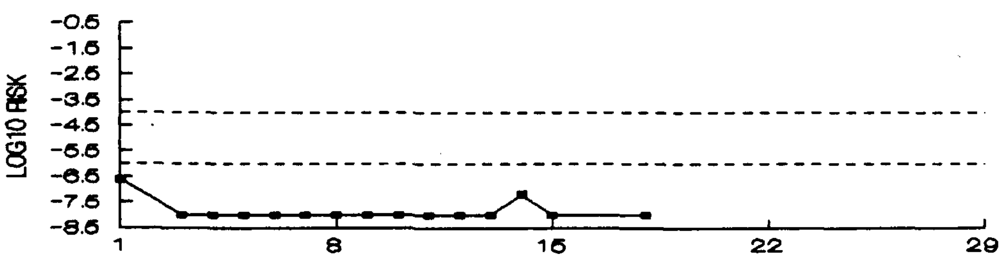
MW-1017: Q1/86 - Q1/93



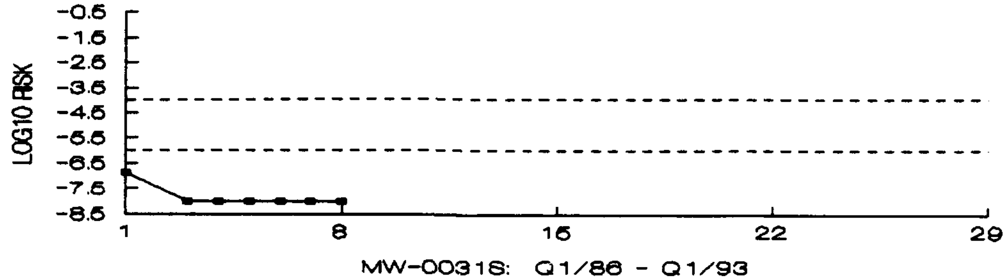
MW-1033: Q1/86 - Q1/93



MW-0107: Q1/86 - Q1/93



MW-0115: Q1/86 - Q1/93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LOG10 RISK
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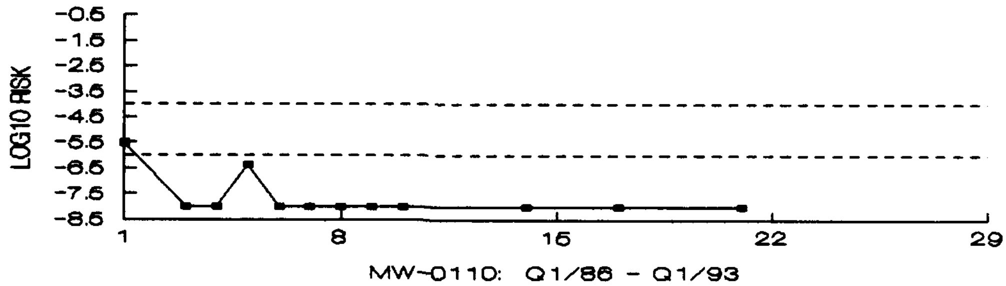
15
22
29
MW-0031S: Q1/86 - Q1/93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LOG10 RISK
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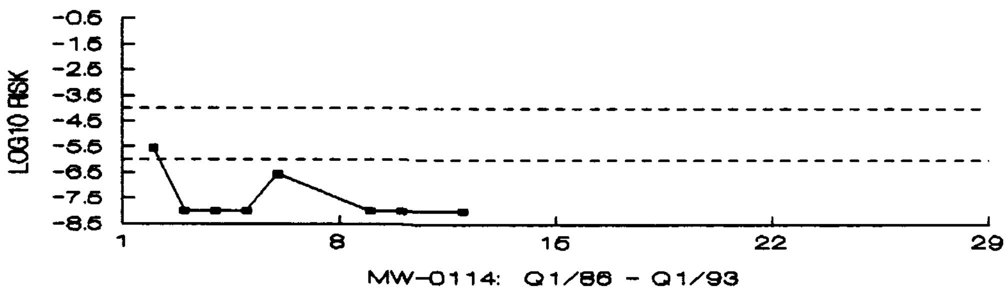
22
29
MW-0110: Q1/86 - Q1/93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LOG10 RISK
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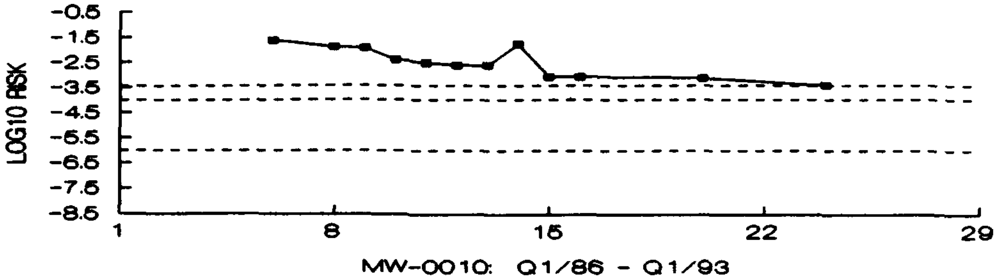
29
MW-0114: Q1/86 - Q1/93

Increased Lifetime Cancer Risk
Time Series
OUs D, E, F
A-zone Wells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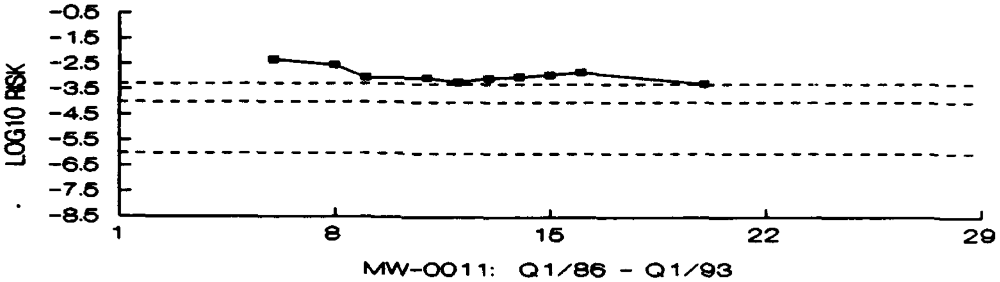
MW-0010: Q1/86 - Q1/93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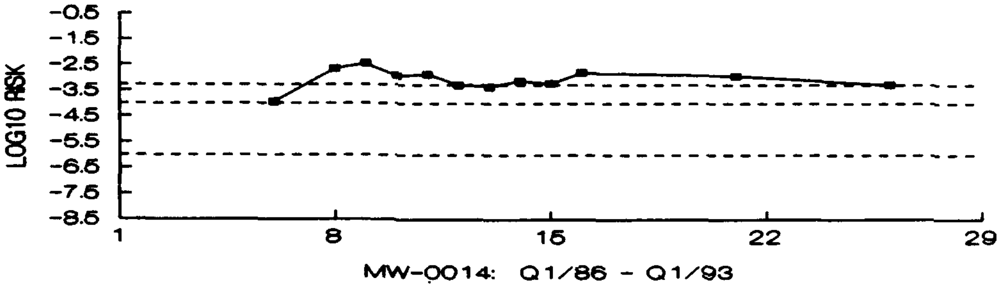
MW-0011: Q1/86 - Q1/93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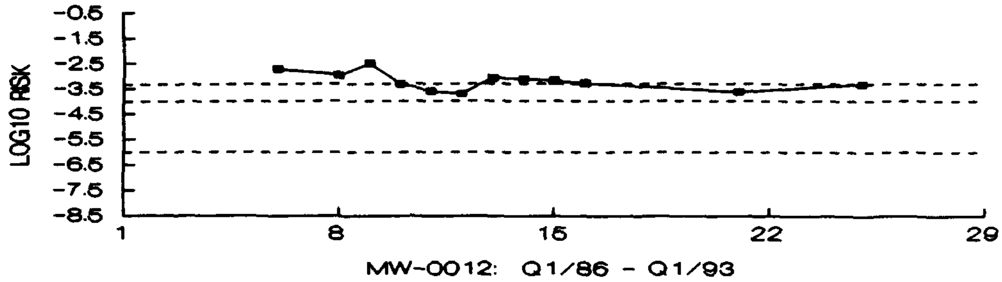
22
29
MW-0014: Q1/86 - Q1/93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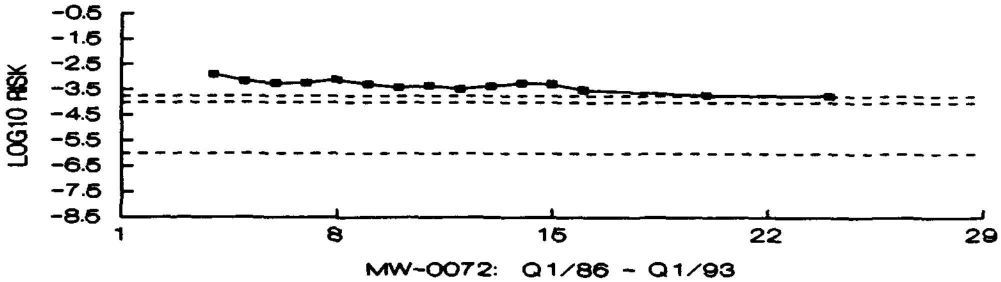
22
29
MW-0012: Q1/86 - Q1/93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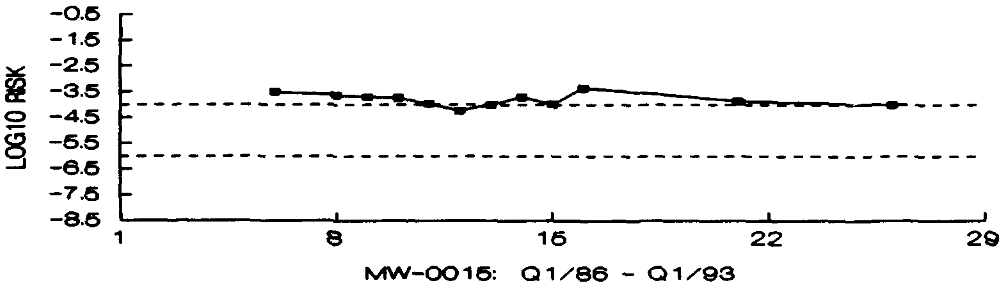
15
22
29
MW-0072: Q1/86 - Q1/93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LOG10 RISK
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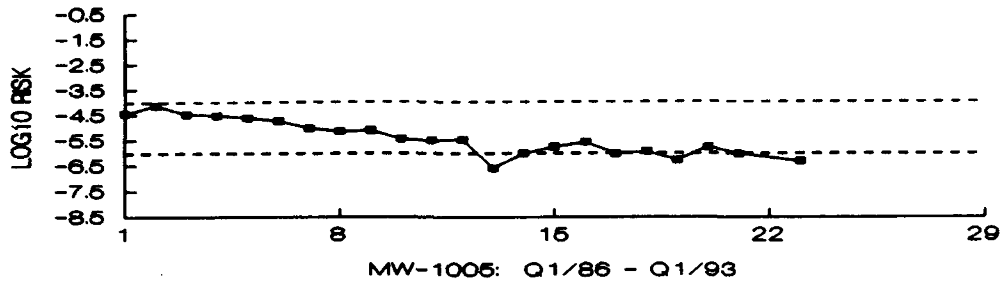
8
15
22
29
MW-0015: Q1/86 - Q1/93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LOG10 RISK
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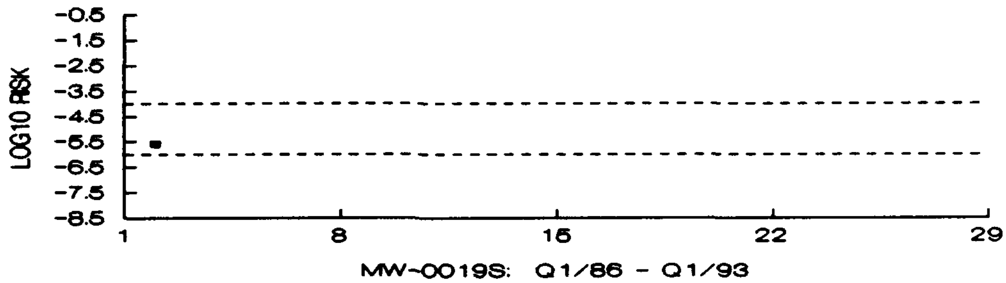
8
15
22
29
MW-1005: Q1/86 - Q1/93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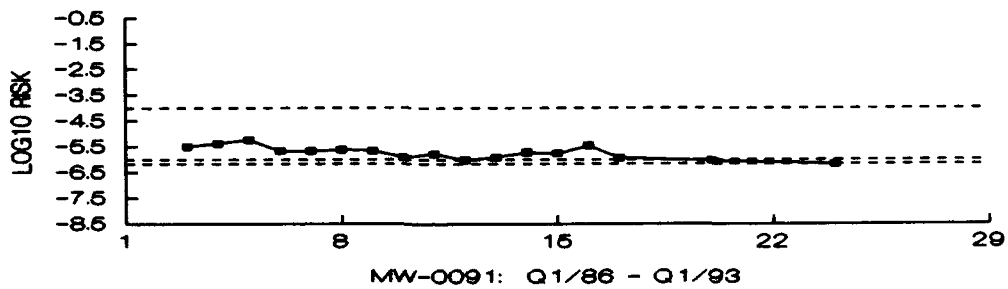
8
15
22
29
MW-0019S: Q1/86 - Q1/93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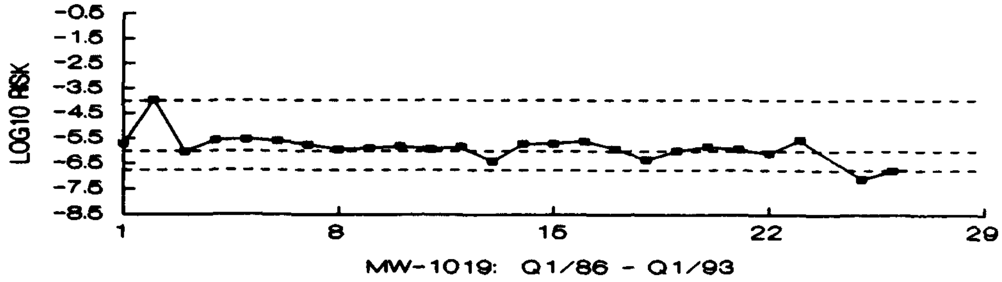
8
15
22
29
MW-0091: Q1/86 - Q1/93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LOG10 RISK
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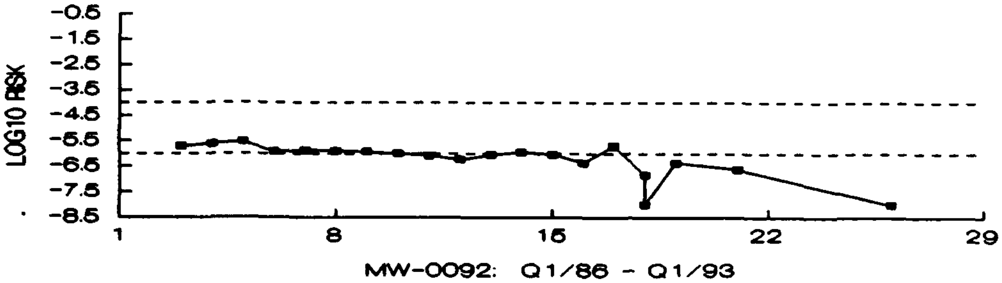
8
15
22
29
MW-1019: Q1/86 - Q1/93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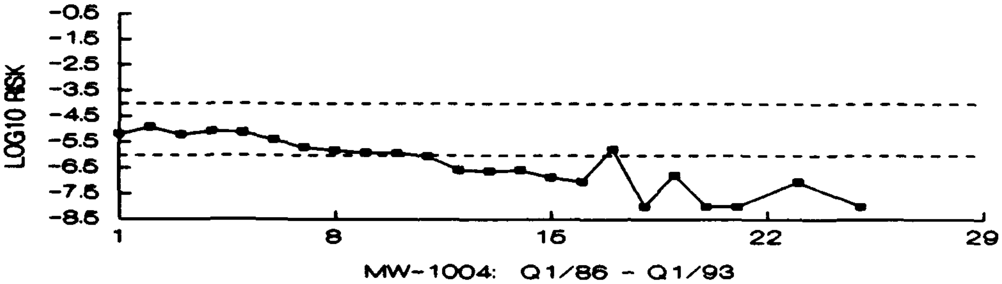
LOG10 RISK
1
8
15
22
29
MW-0092: Q1/86 - Q1/93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LOG10 RISK
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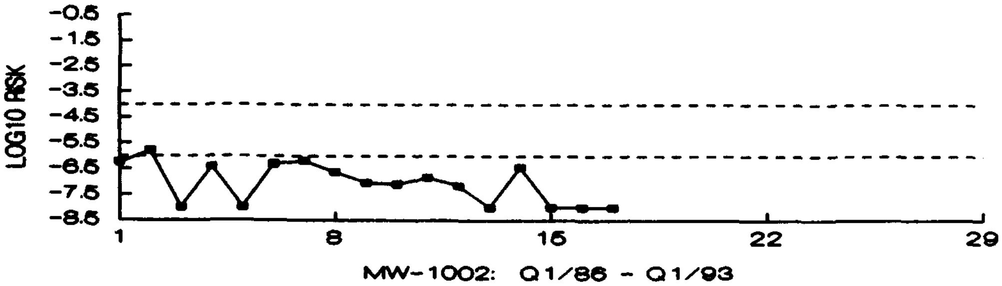
8
15
22
29
MW-1004: Q1/86 - Q1/93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LOG10 RISK
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8
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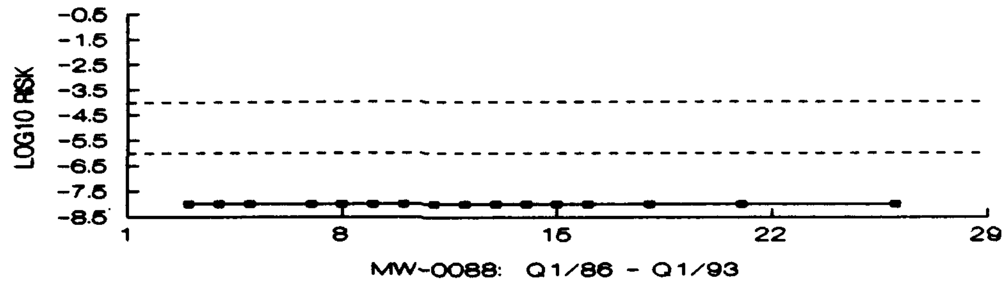
22
29
MW-1002: Q1/86 - Q1/93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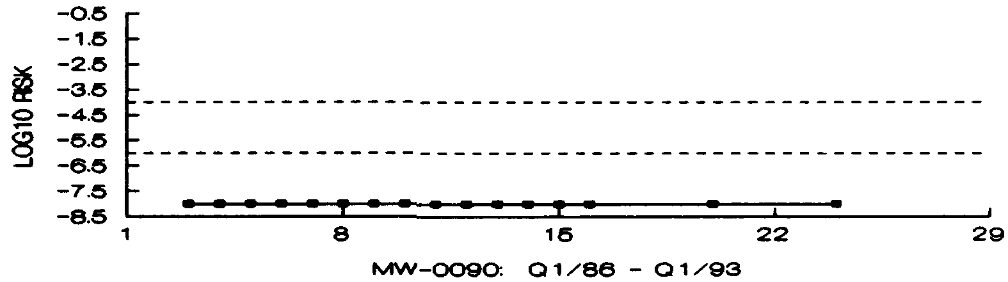
LOG10 RISK
1
8
15
22
29
MW-0088: Q1/86 - Q1/93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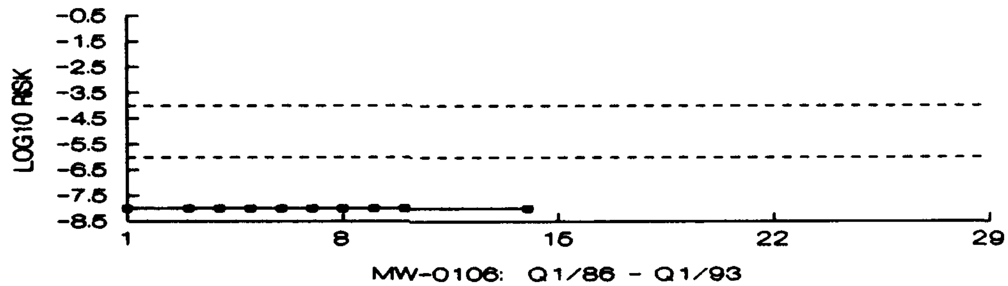
MW-0090: Q1/86 - Q1/93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22
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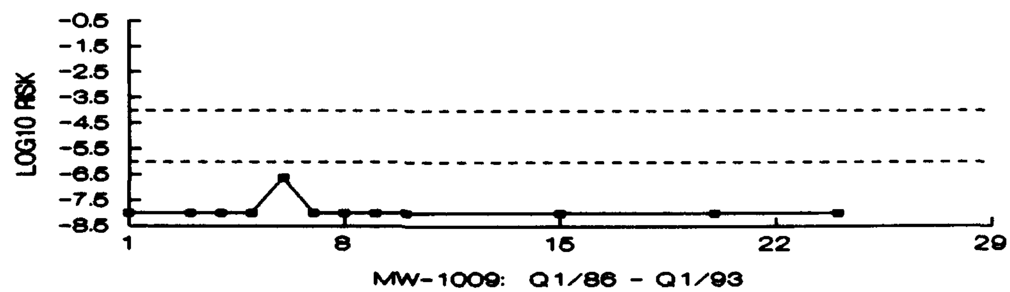
MW-0106: Q1/86 - Q1/93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LOG10 RISK
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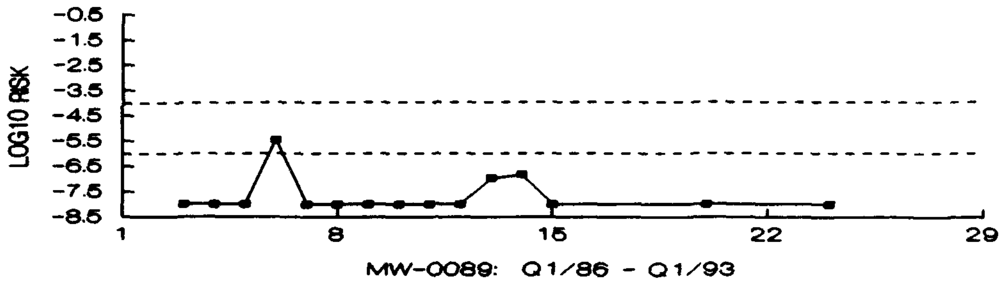
MW-1009: Q1/86 - Q1/93



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22
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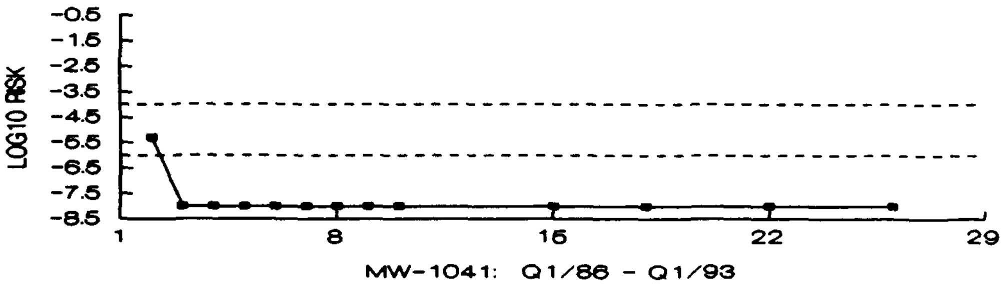
MW-0089: Q1/86 - Q1/93



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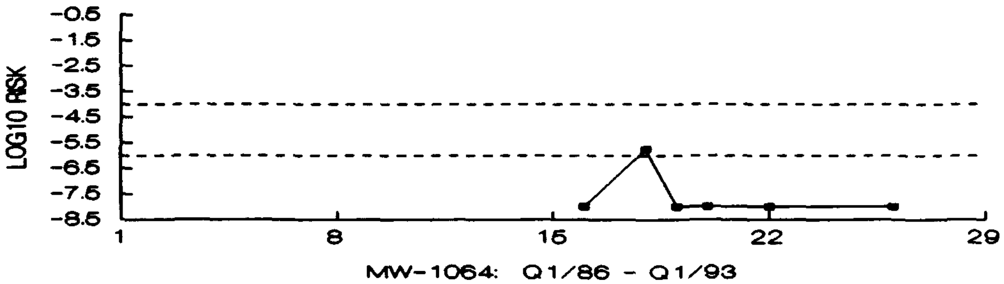
MW-1041: Q1/86 - Q1/93



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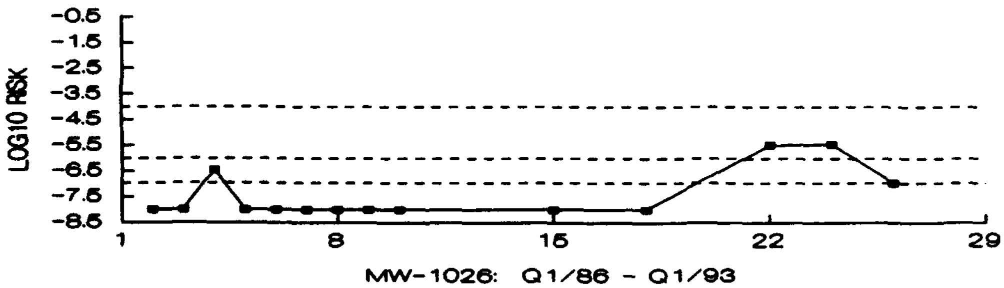
MW-1064: Q1/86 - Q1/93



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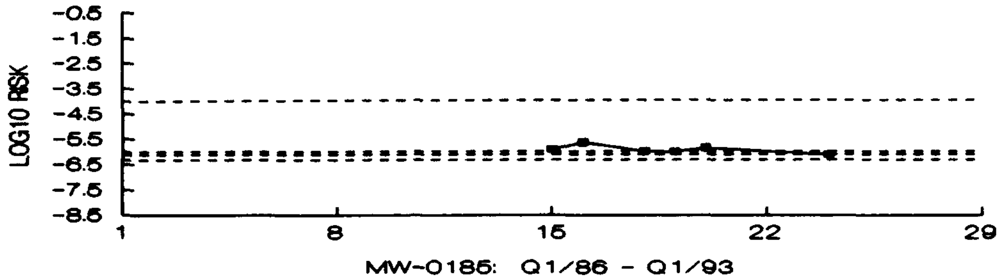
MW-1026: Q1/86 - Q1/93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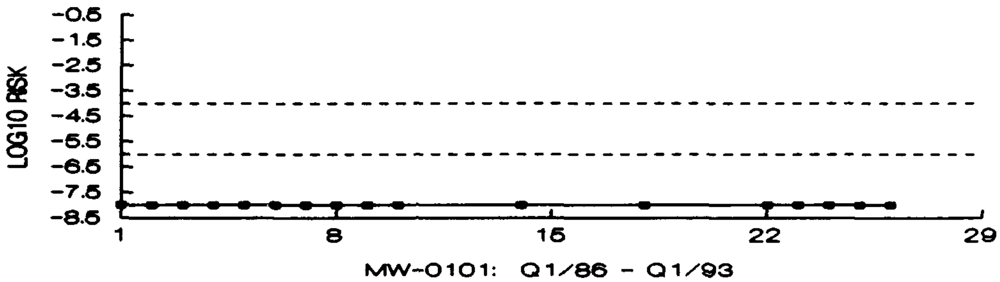
MW-0185: Q1/86 - Q1/93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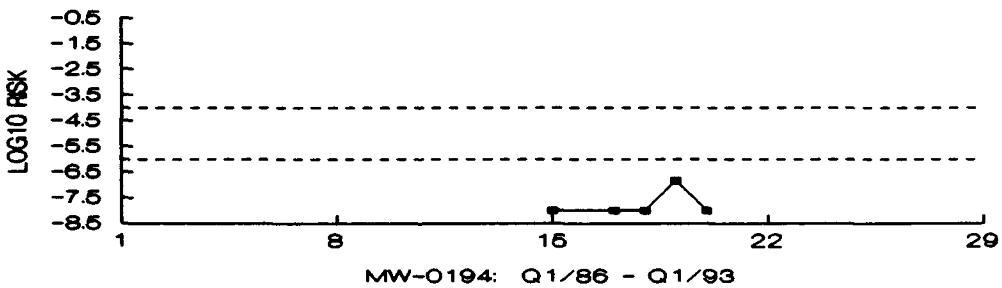
MW-0101: Q1/86 - Q1/93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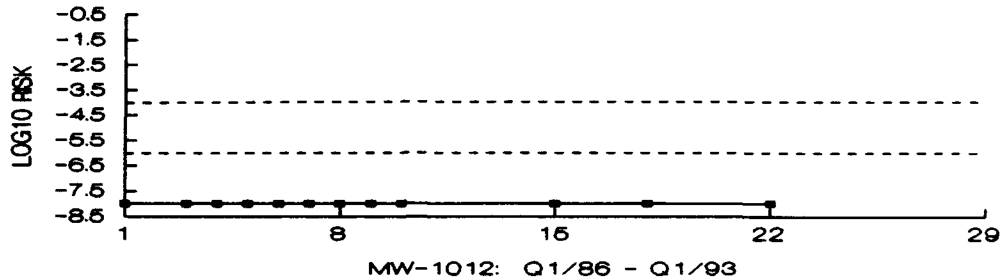
MW-0194: Q1/86 - Q1/93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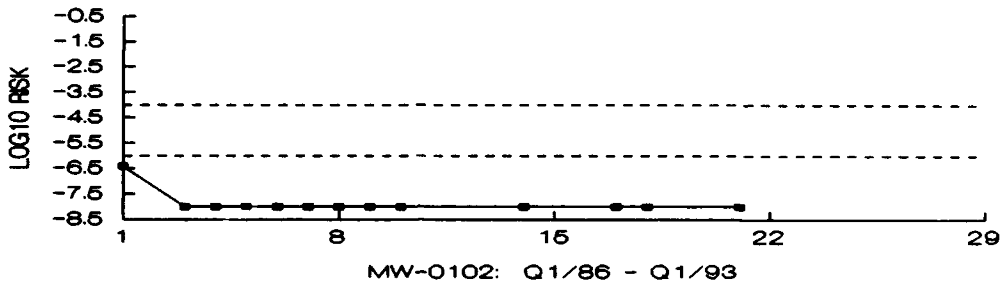
MW-1012: Q1/86 - Q1/93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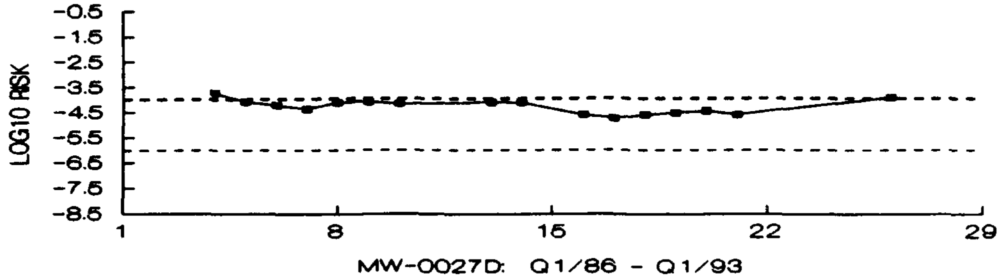
MW-0102: Q1/86 - Q1/93

Increased Lifetime Cancer Risk
Time Series
OU A, B-zone Wells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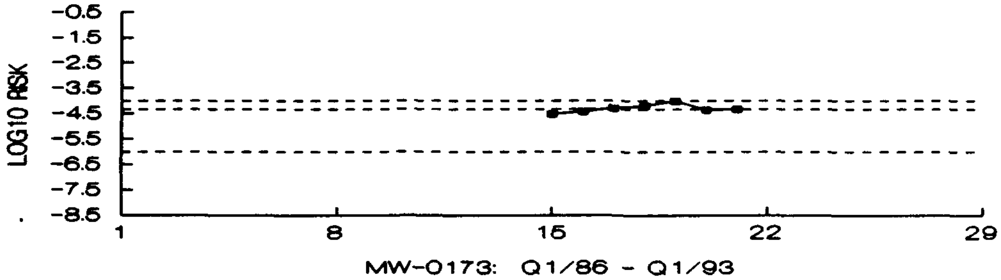
MW-0027D: Q1/86 - Q1/93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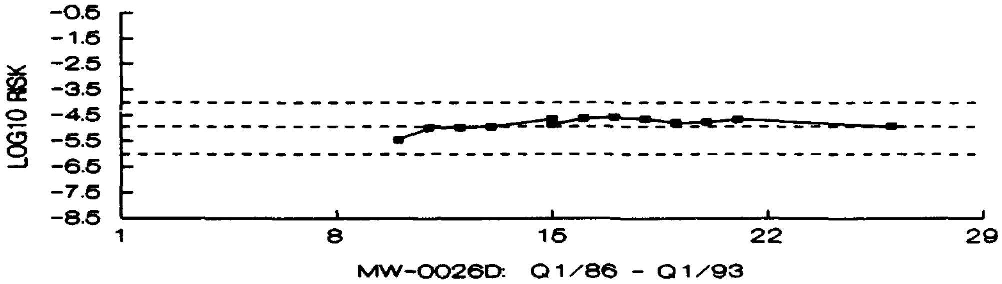
MW-0173: Q1/86 - Q1/93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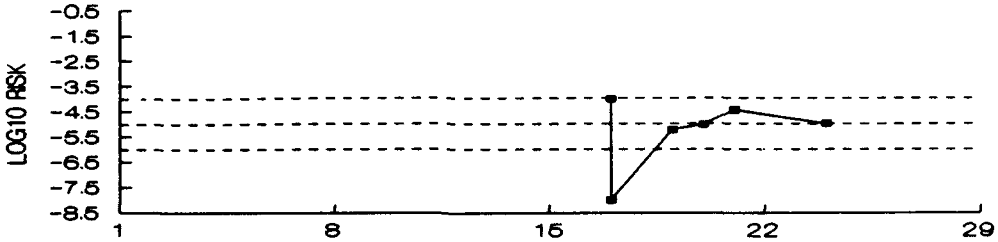
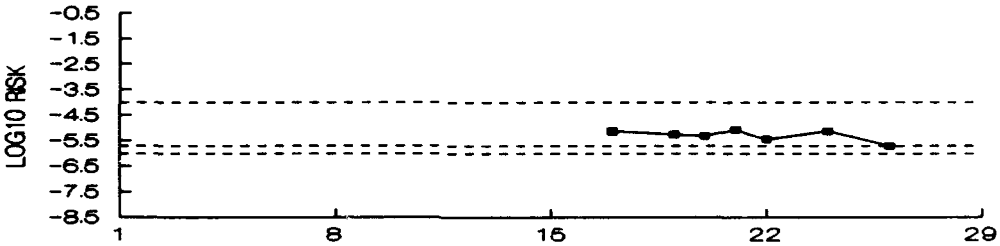
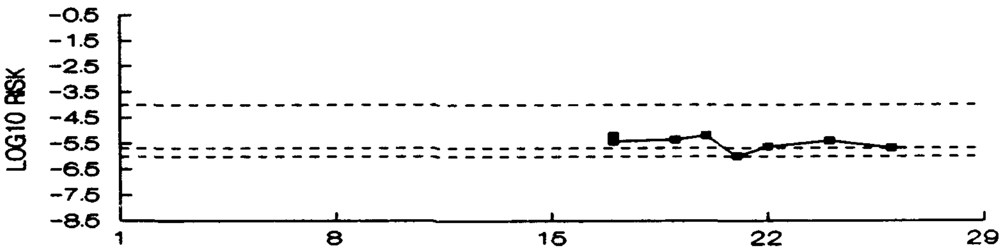
MW-0026D: Q1/86 - Q1/93



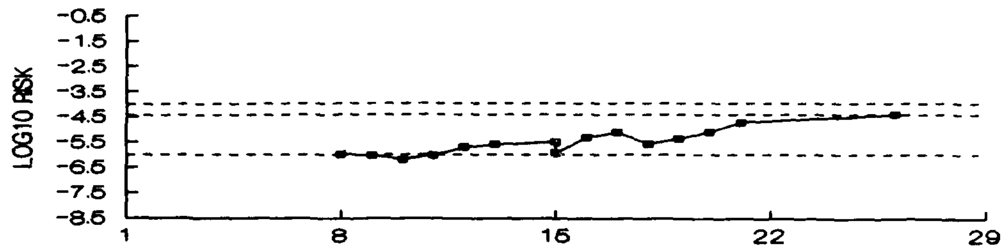
MW-0225: Q1/86 - Q1/93



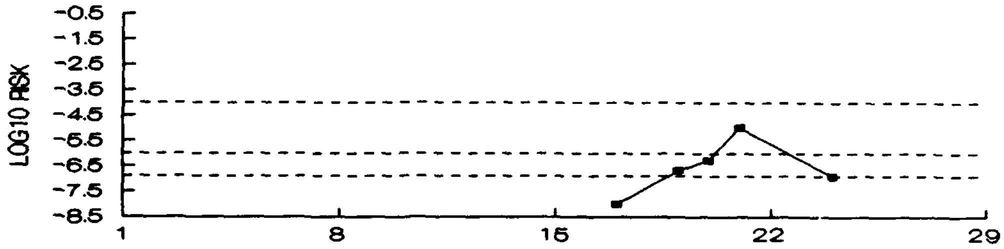
MW-1066: Q1/86 - Q1/93



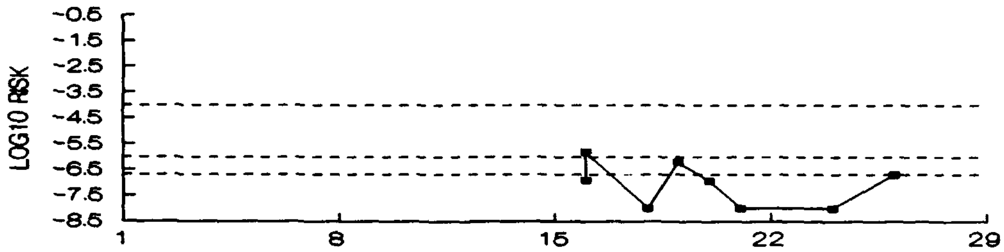
MW-1065: Q1/86 - Q1/93



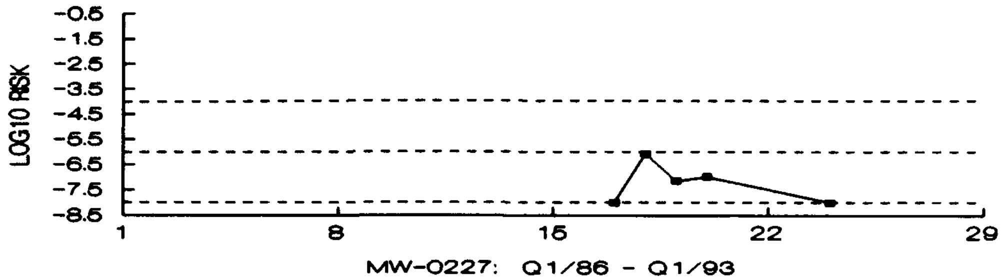
MW-0071: Q1/86 - Q1/93



MW-0229: Q1/86 - Q1/93



MW-0204: Q1/86 - Q1/93



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LOG10 RISK
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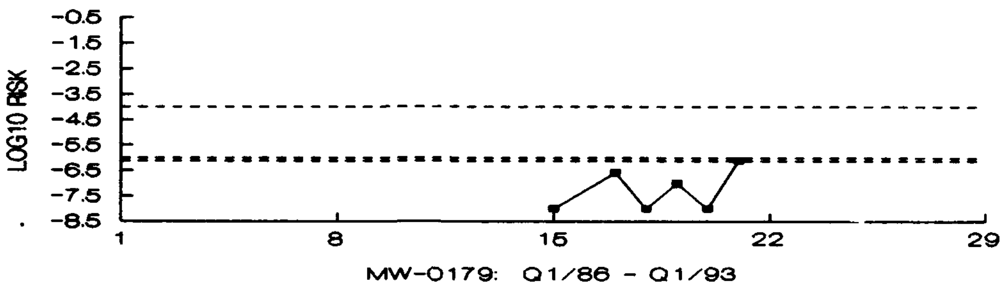
22
29
MW-0227: Q1/86 - Q1/93



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LOG10 RISK
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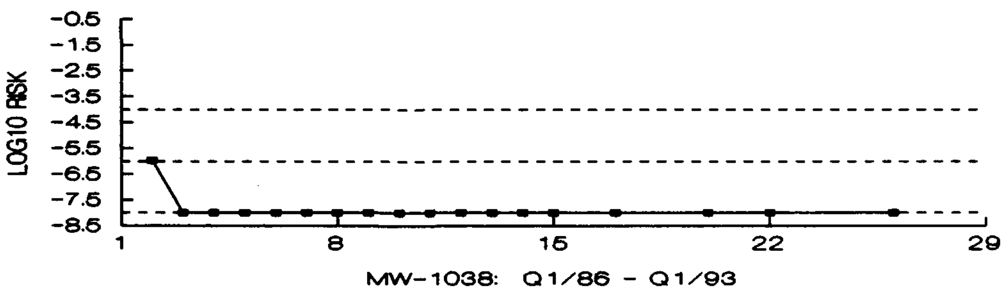
22
29
MW-0179: Q1/86 - Q1/93



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22
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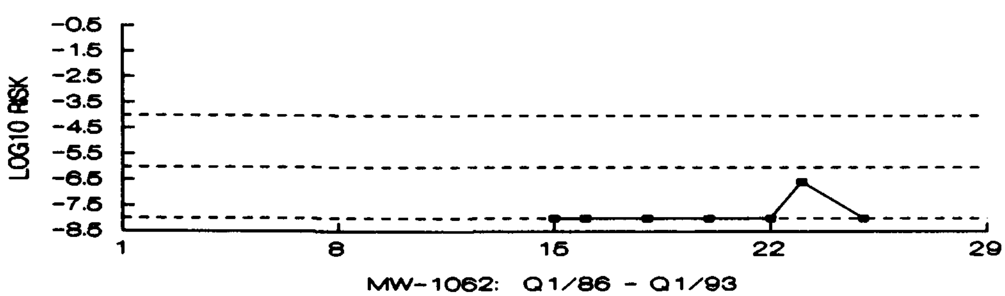
MW-1038: Q1/86 - Q1/93



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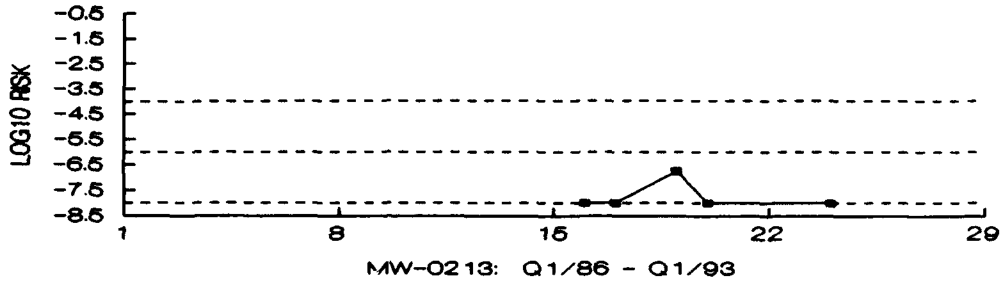
MW-1062: Q1/86 - Q1/93



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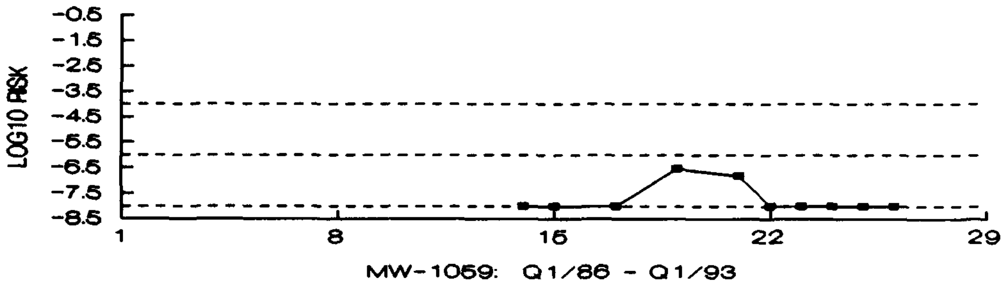
MW-0213: Q1/86 - Q1/93



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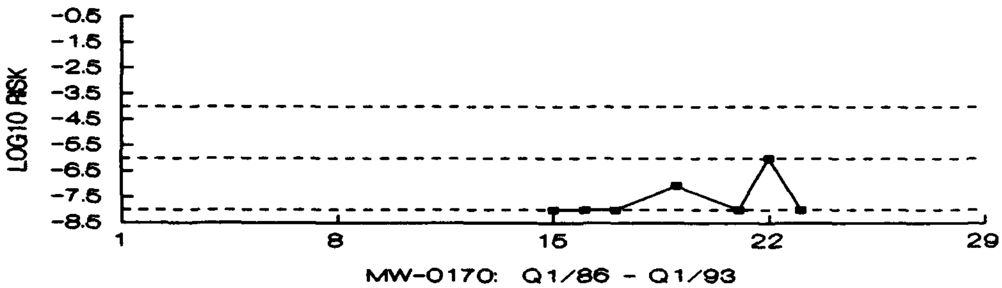
MW-1059: Q1/86 - Q1/93



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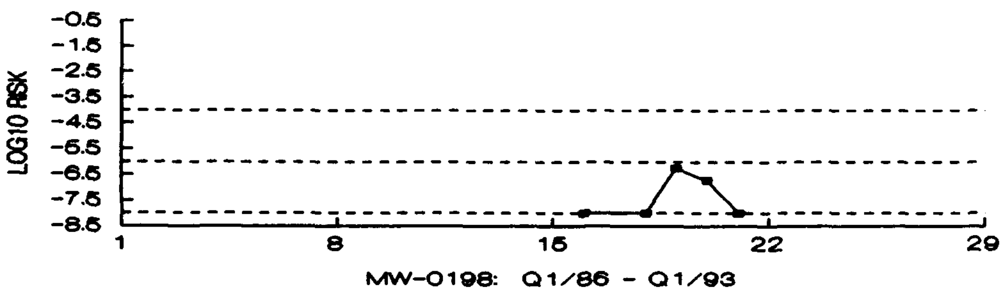
MW-0170: Q1/86 - Q1/93



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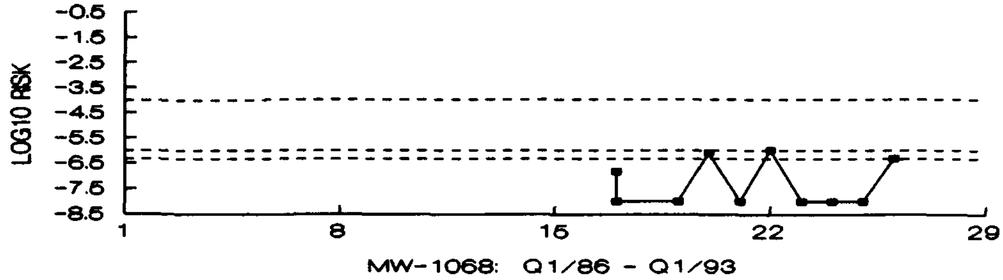
MW-0198: Q1/86 - Q1/93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22
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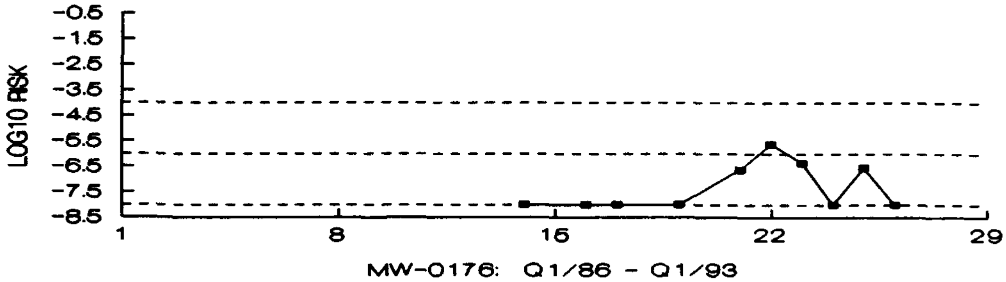
MW-1068: Q1/86 - Q1/93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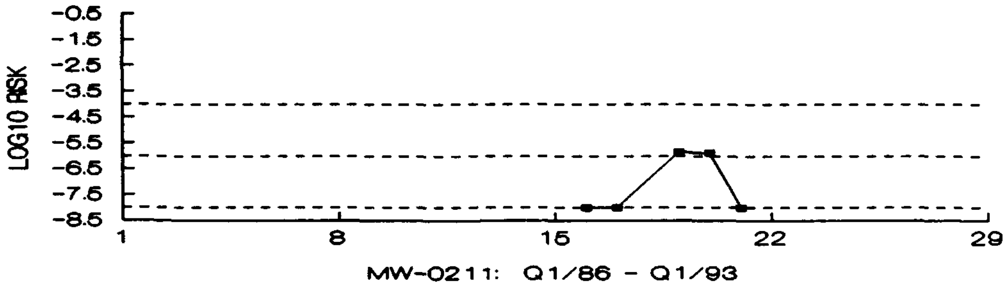
MW-0176: Q1/86 - Q1/93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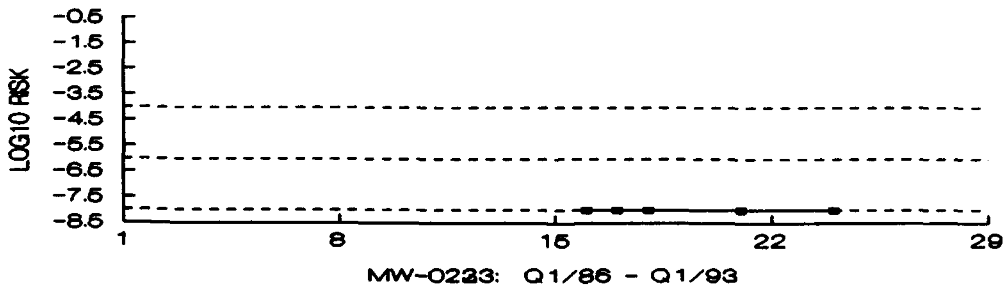
MW-0211: Q1/86 - Q1/93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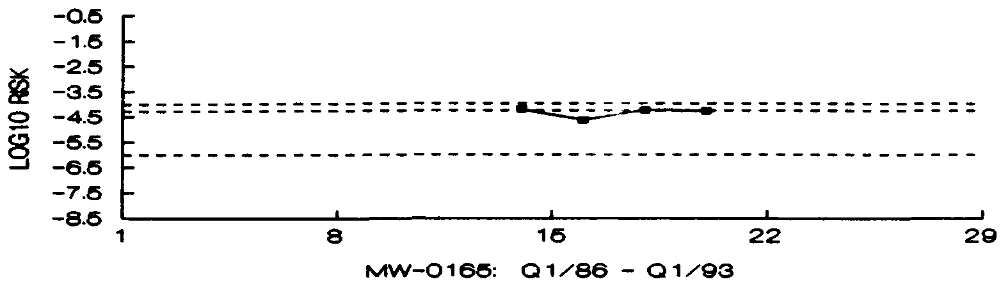
MW-0223: Q1/86 - Q1/93

Increased Lifetime Cancer Risk
Time Series
OU B, B-zone Wells



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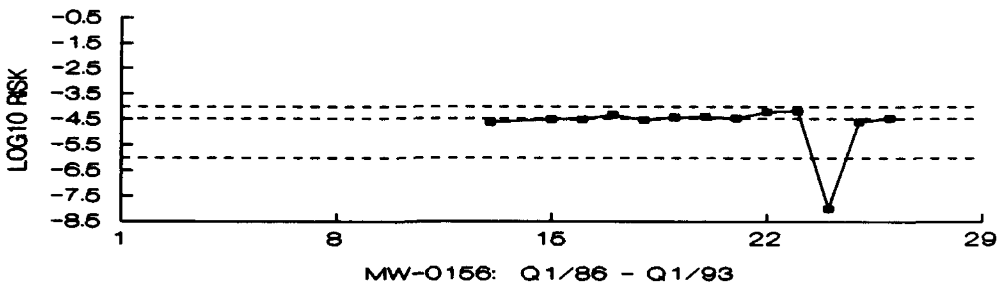
29
MW-0165: Q1/86 - Q1/93



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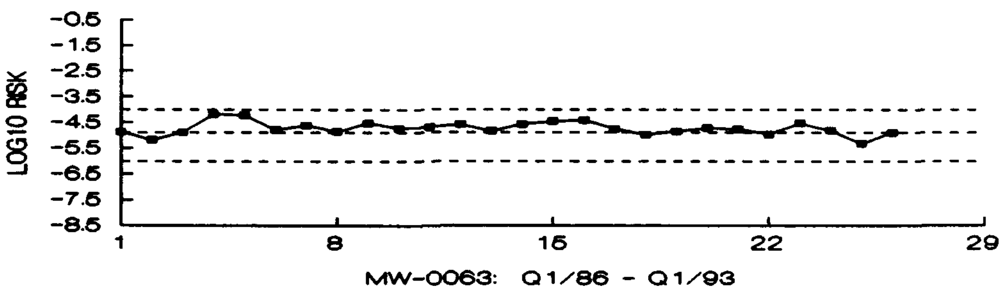
MW-0156: Q1/86 - Q1/93



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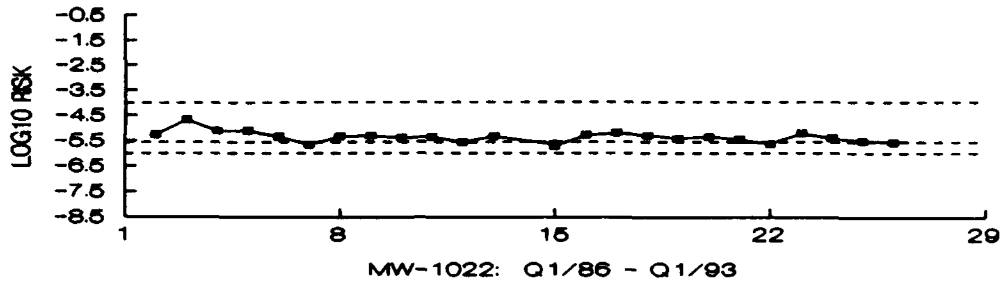
MW-0063: Q1/86 - Q1/93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22
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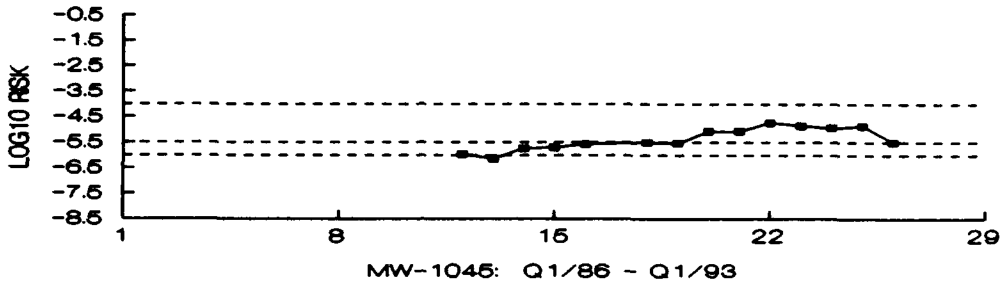
MW-1022: Q1/86 - Q1/93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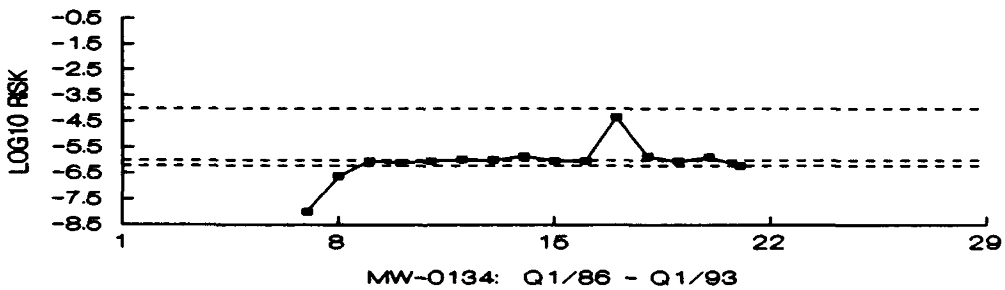
MW-1045: Q1/86 - Q1/93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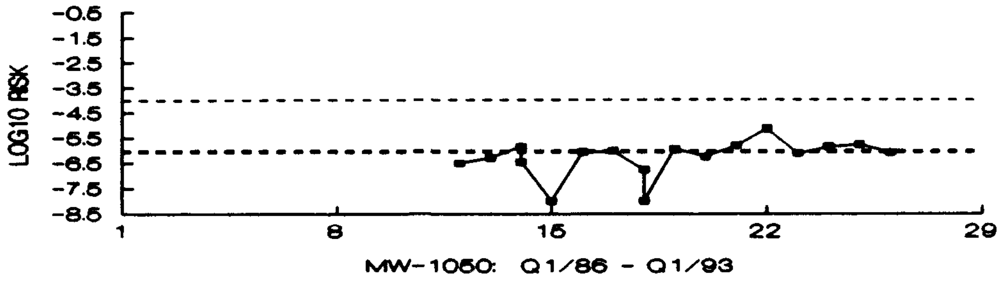
29
MW-0134: Q1/86 - Q1/93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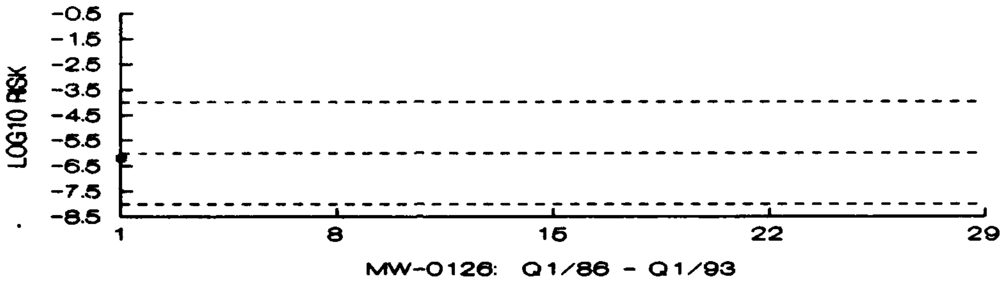
MW-1050: Q1/86 - Q1/93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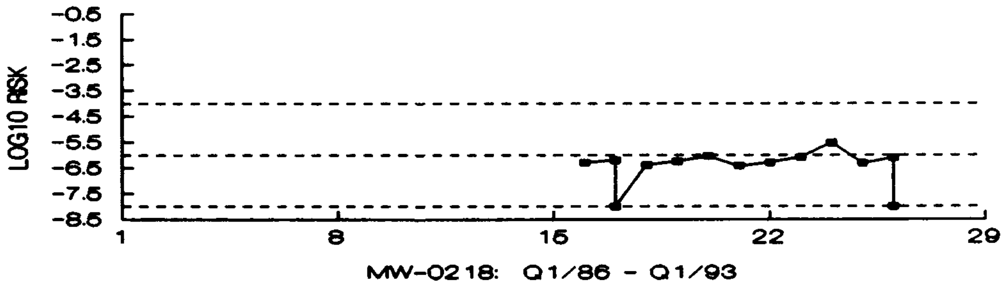
MW-0126: Q1/86 - Q1/93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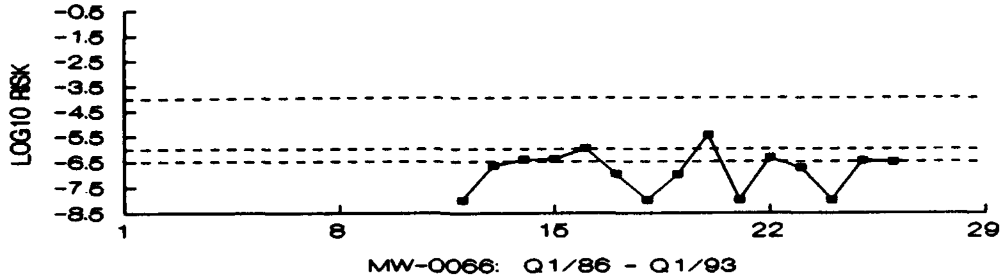
MW-0218: Q1/86 - Q1/93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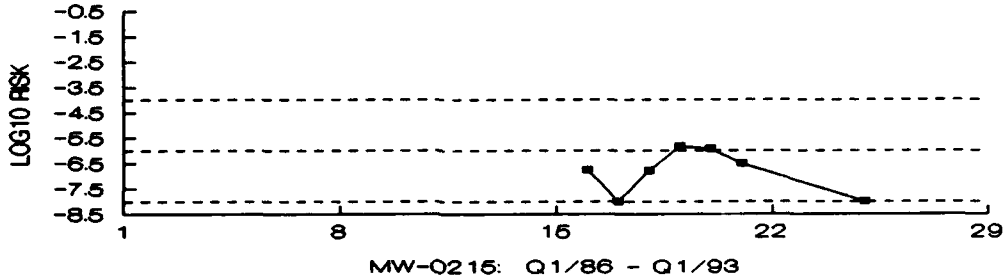
MW-0066: Q1/86 - Q1/93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LOG10 RISK
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8
15
22
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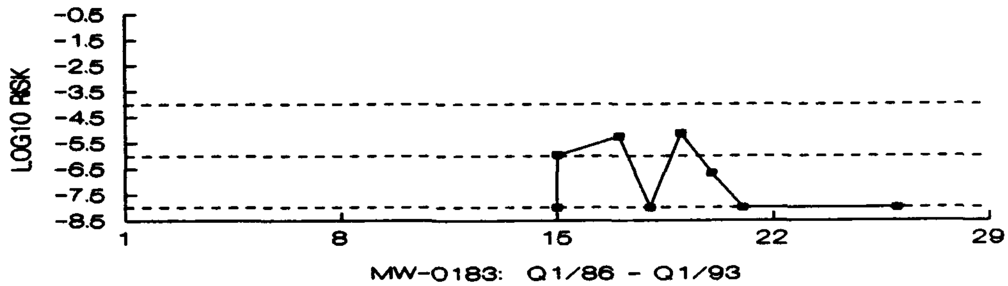
MW-0215: Q1/86 - Q1/93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LOG10 RISK
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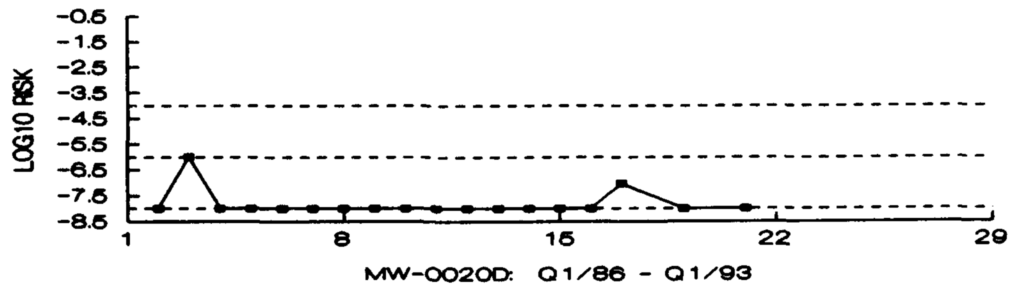
8
15
22
29
MW-0183: Q1/86 - Q1/93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-8.5
LOG10 RISK
1
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15
22
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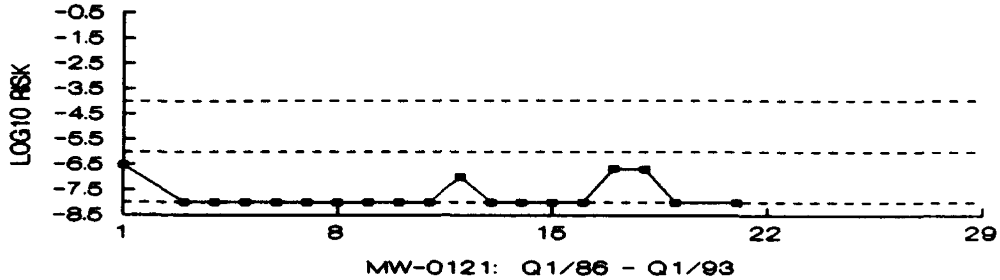
MW-0020D: Q1/86 - Q1/93



-0.5
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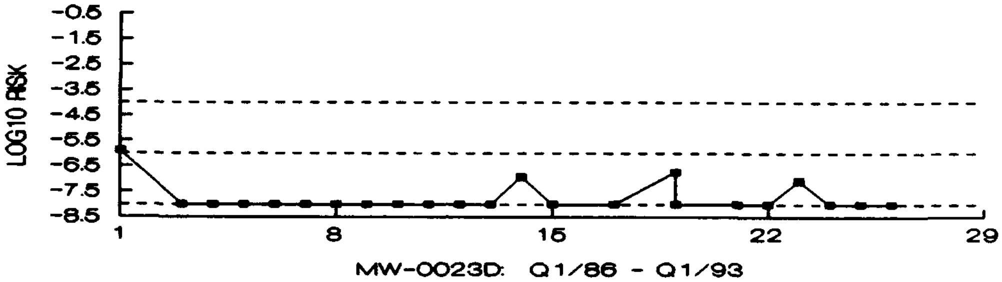
LOG10 RISK
1
8
15
22
29
MW-0121: Q1/86 - Q1/93



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LOG10 RISK
1
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15
22
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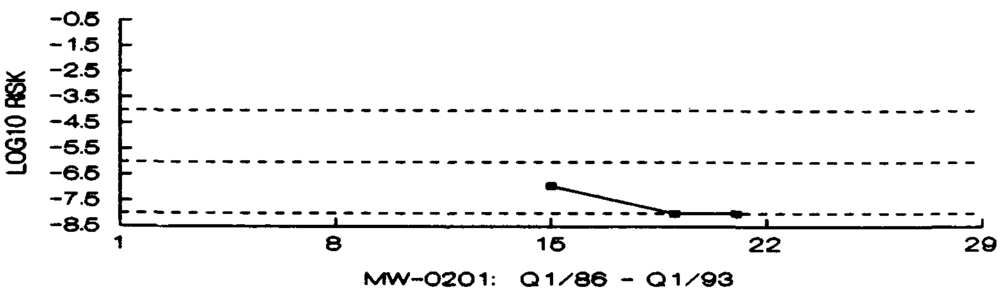
MW-0023D: Q1/86 - Q1/93



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LOG10 RISK
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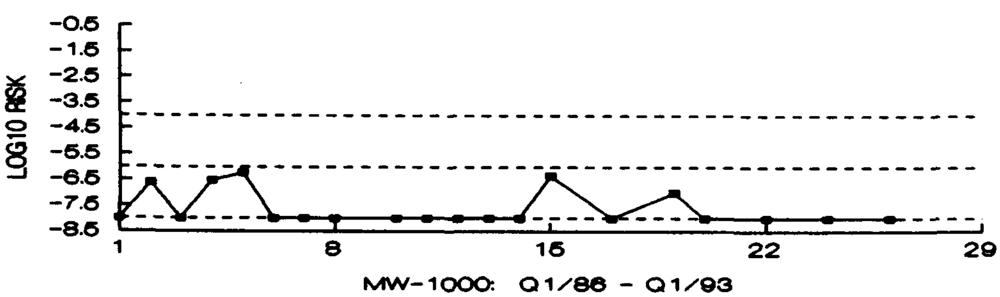
MW-0201: Q1/86 - Q1/93



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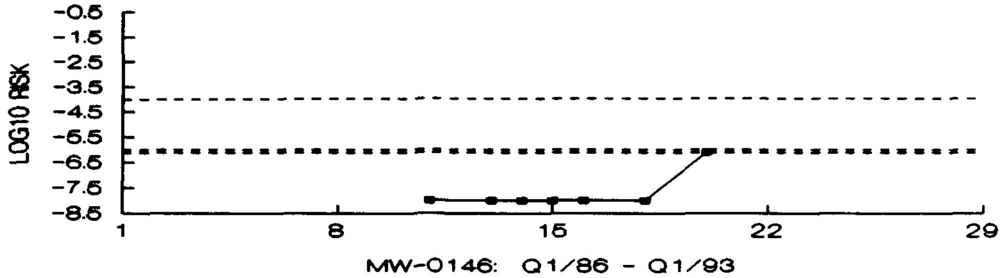
-8.5
LOG10 RISK
1
8
15
22
29
MW-1000: Q1/86 - Q1/93



LOG10 RISK
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-1.5
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-3.5
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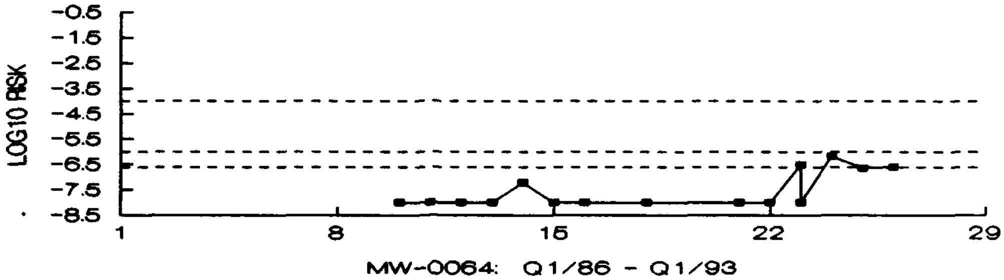
-7.5
-8.5
1
8
15
22
29
MW-0146: Q1/86 - Q1/93



LOG10 RISK
-0.5
-1.5
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-4.5
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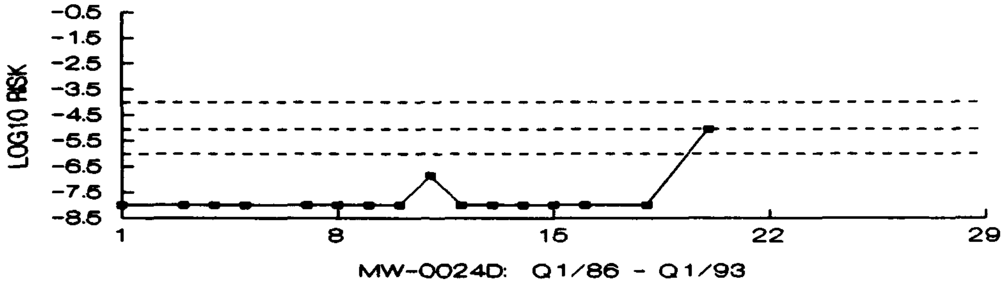
-7.5
-8.5
1
8
15
22
29
MW-0064: Q1/86 - Q1/93



LOG10 RISK
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-2.5
-3.5
-4.5
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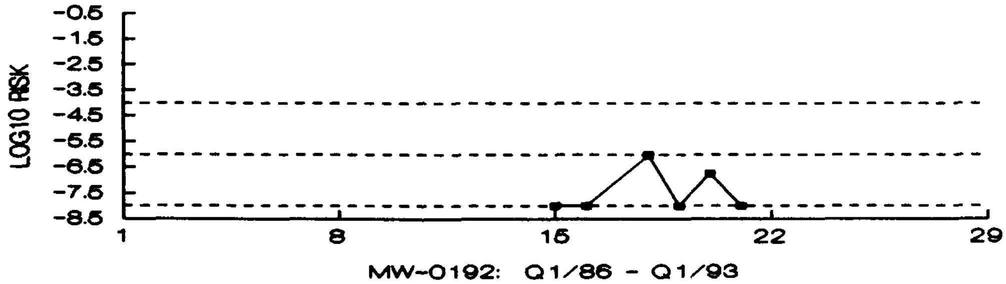
-7.5
-8.5
1
8
15
22
29
MW-0024D: Q1/86 - Q1/93



LOG10 RISK
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-3.5
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-8.5
1
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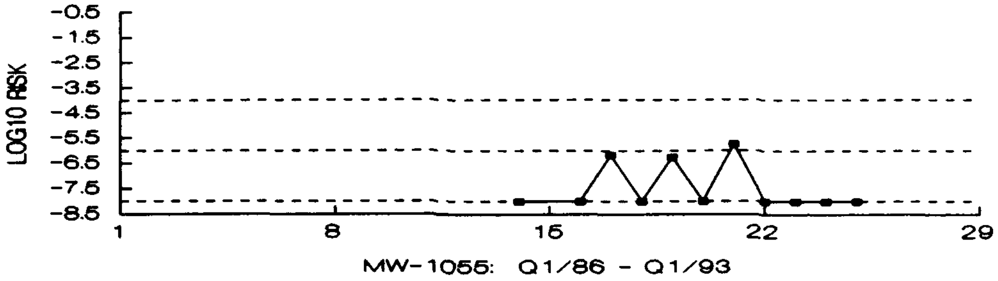
15
22
29
MW-0192: Q1/86 - Q1/93


LOG10 RISK
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-7.5
-8.5
1
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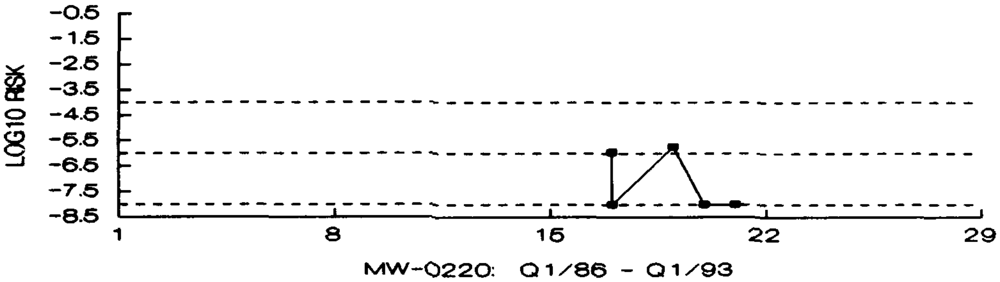
15
22
29
MW-1055: Q1/86 - Q1/93


LOG10 RISK
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-3.5
-4.5
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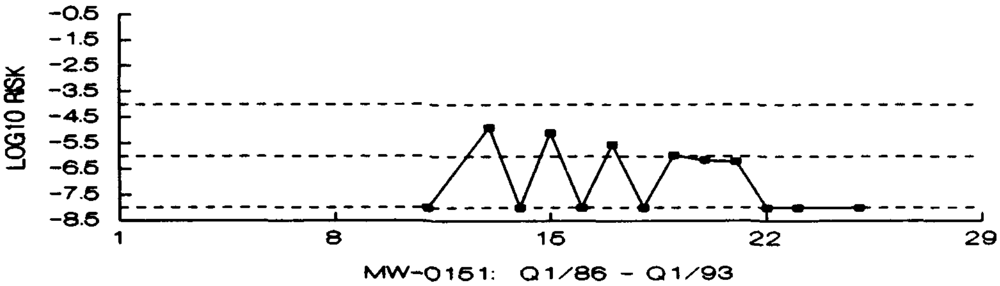
-7.5
-8.5
1
8
15
22
29
MW-0220: Q1/86 - Q1/93


LOG10 RISK
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-8.5
1
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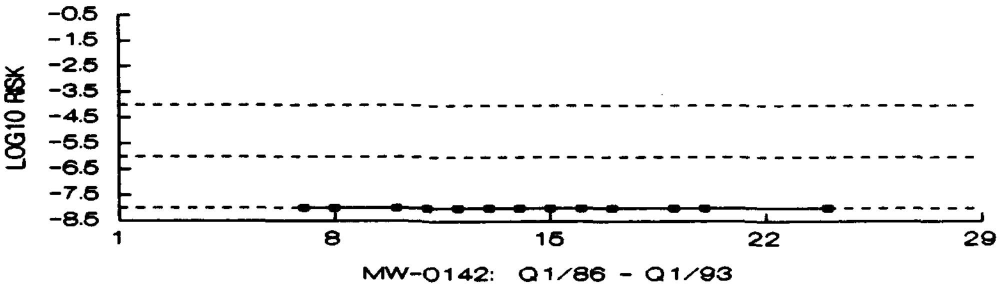
15
22
29
MW-0151: Q1/86 - Q1/93


LOG10 RISK
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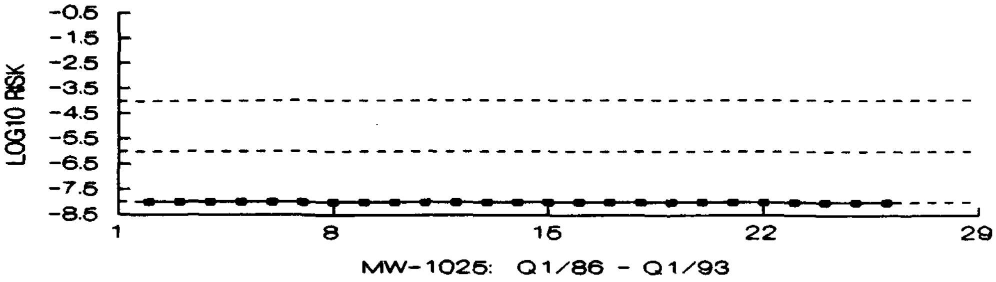
-8.5
1
8
15
22
29
MW-0142: Q1/86 - Q1/93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-5.5
-6.5
-7.5
-8.5
LOG10 RISK
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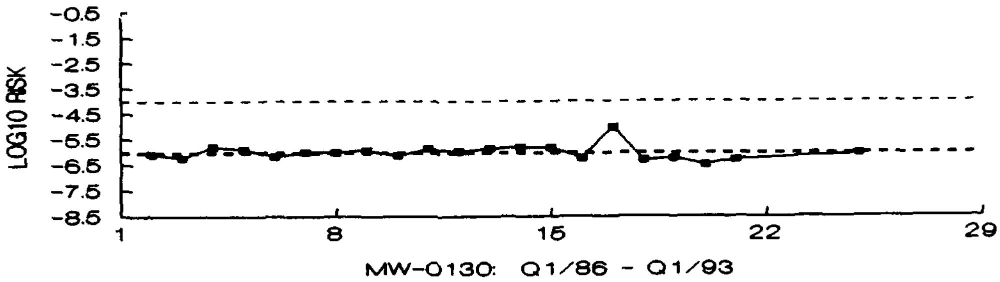
8
15
22
29
MW-1025: Q1/86 - Q1/93

Increased Lifetime Cancer Risk
Time Series
OU C, B-zone Wells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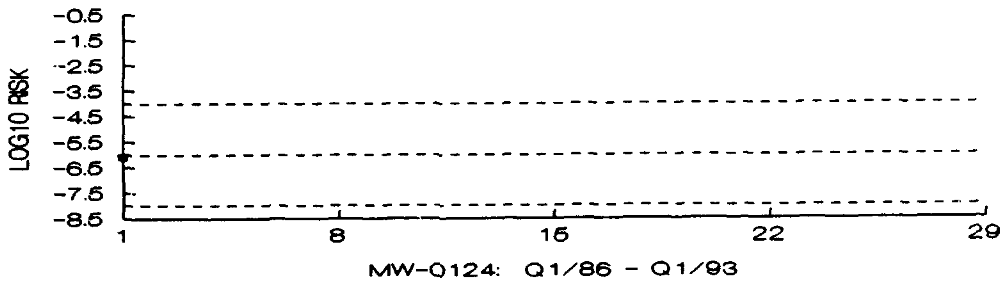
-8.5
LOG10 RISK
1
8
15
22
29
MW-0130: Q1/86 - Q1/93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LOG10 RISK
1
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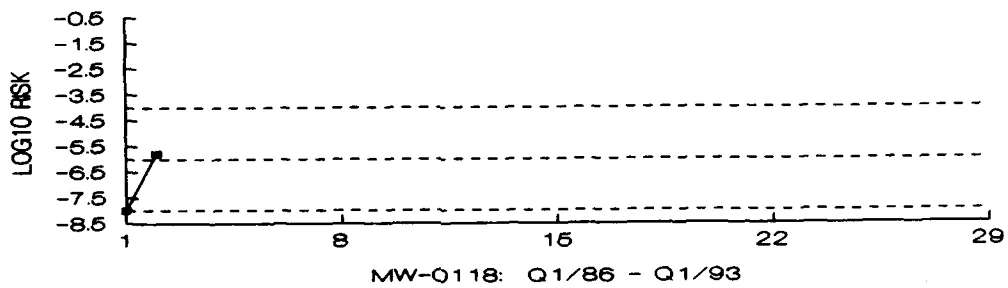
15
22
29
MW-0124: Q1/86 - Q1/93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-6.5
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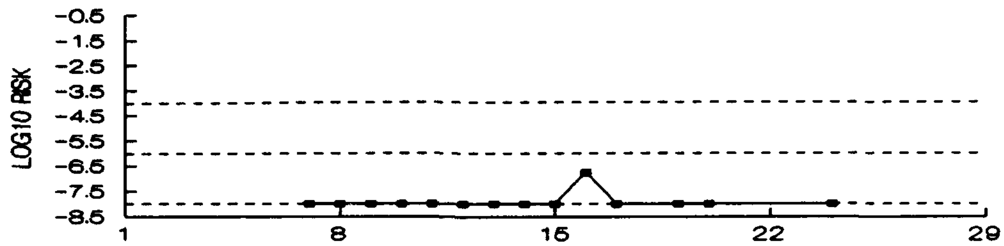
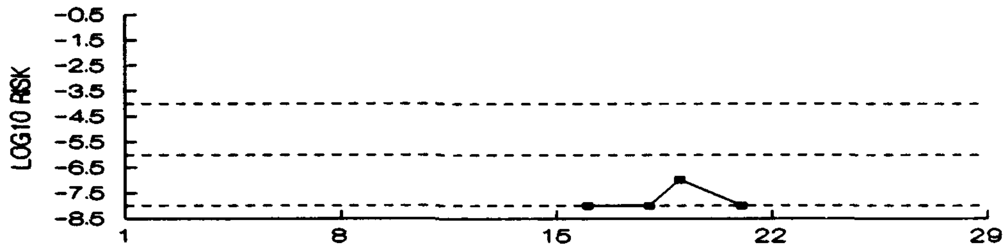
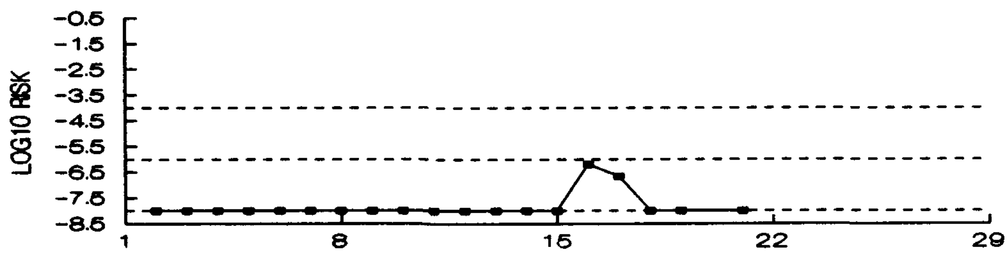
-8.5
LOG10 RISK
1
8
15
22
29
MW-0118: Q1/86 - Q1/93



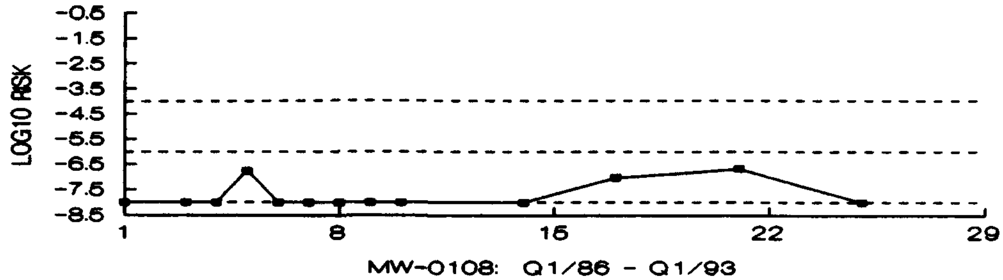
MW-0143: Q1/86 - Q1/93



MW-0189: Q1/86 - Q1/93



MW-0022D: Q1/86 - Q1/93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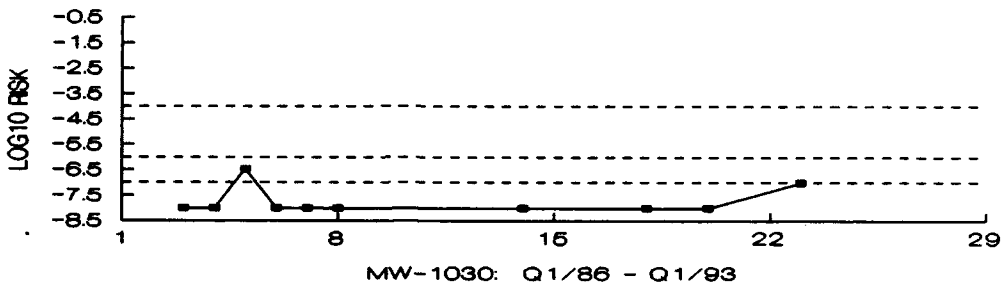
-8.5
LOG10 RISK
1
8
15
22
29
MW-0108: Q1/86 - Q1/93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-5.5
-6.5
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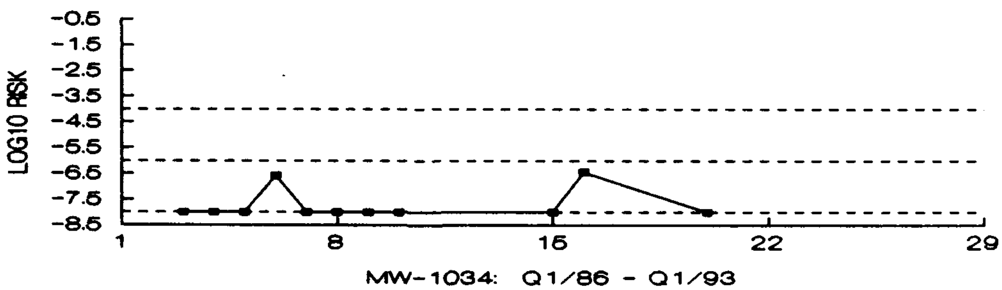
-8.5
LOG10 RISK
1
8
15
22
29
MW-1030: Q1/86 - Q1/93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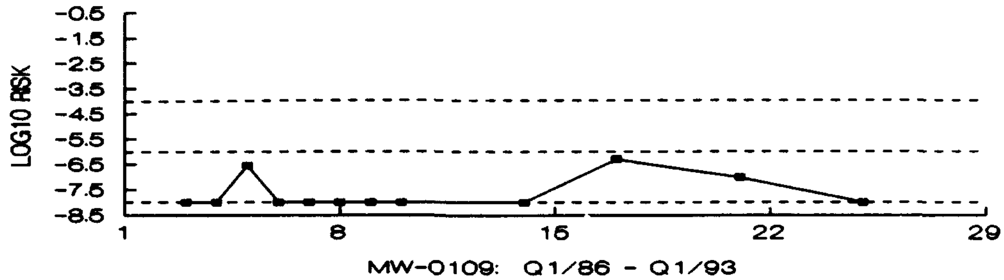
LOG10 RISK
1
8
15
22
29
MW-1034: Q1/86 - Q1/93


LOG10 RISK
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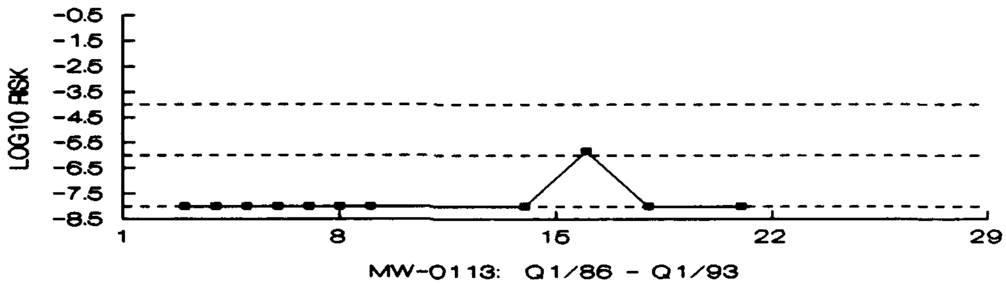
-7.5
-8.5
1
8
15
22
29
MW-0109: Q1/86 - Q1/93


LOG10 RISK
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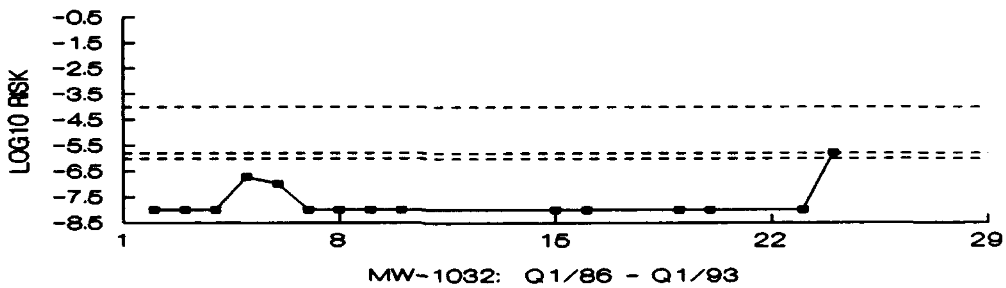
-8.5
1
8
15
22
29
MW-0113: Q1/86 - Q1/93


LOG10 RISK
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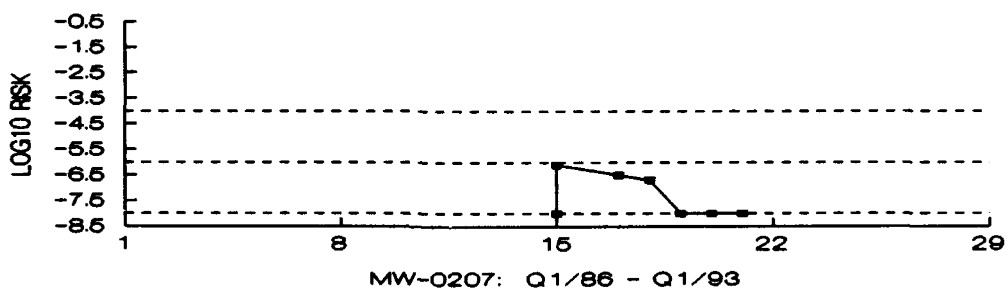
-8.5
1
8
15
22
29
MW-1032: Q1/86 - Q1/93


LOG10 RISK
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-8.5
1
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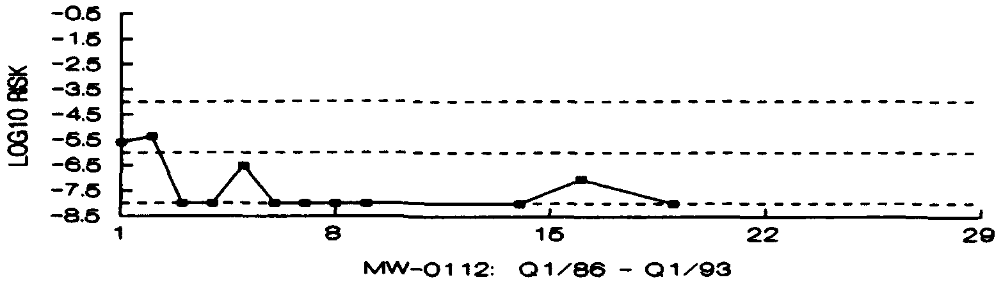
15
22
29
MW-0207: Q1/86 - Q1/93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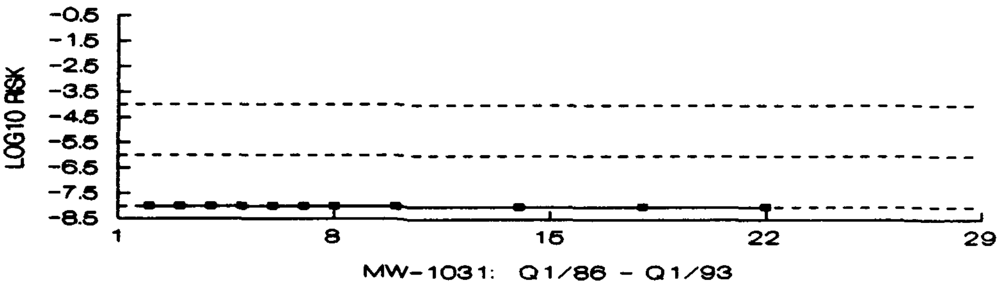
-8.5
LOG10 RISK
1
8
15
22
29
MW-0112: Q1/86 - Q1/93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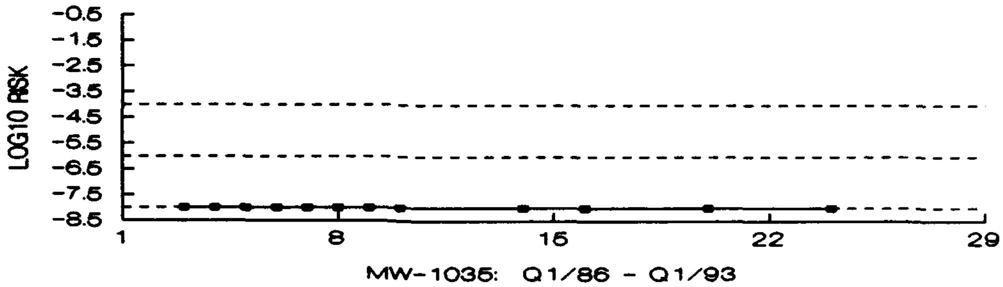
-8.5
LOG10 RISK
1
8
15
22
29
MW-1031: Q1/86 - Q1/93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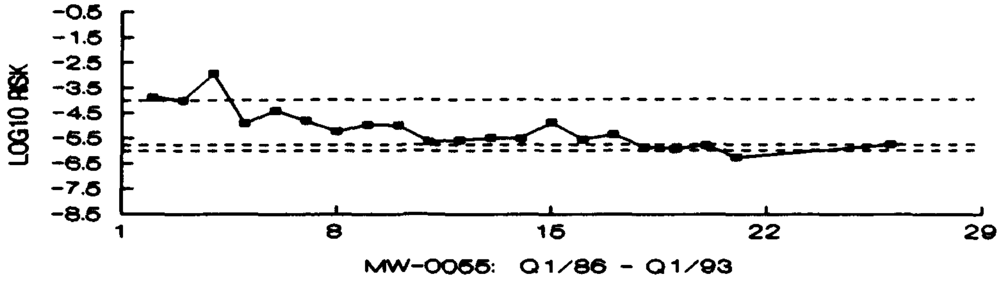
-5.5
-6.5
-7.5
-8.5
LOG10 RISK
1
8
15
22
29
MW-1035: Q1/86 - Q1/93

Increased Lifetime Cancer Risk
Time Series
OUs D, E, F
B-zone Wells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-2.5
-3.5
-4.5
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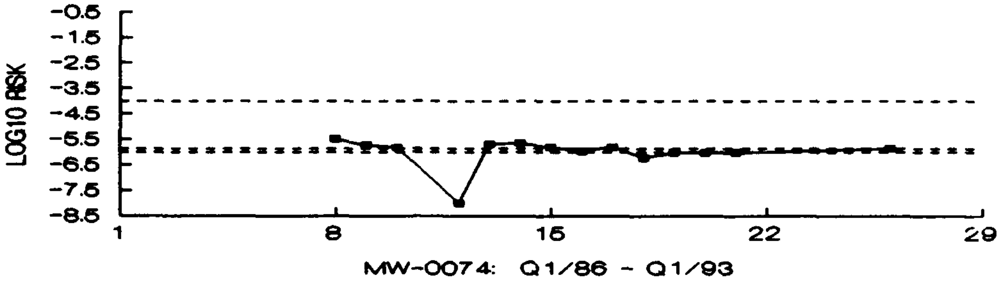
-6.5
-7.5
-8.5
LOG10 RISK
1
8
15
22
29
MW-0055: Q1/86 - Q1/93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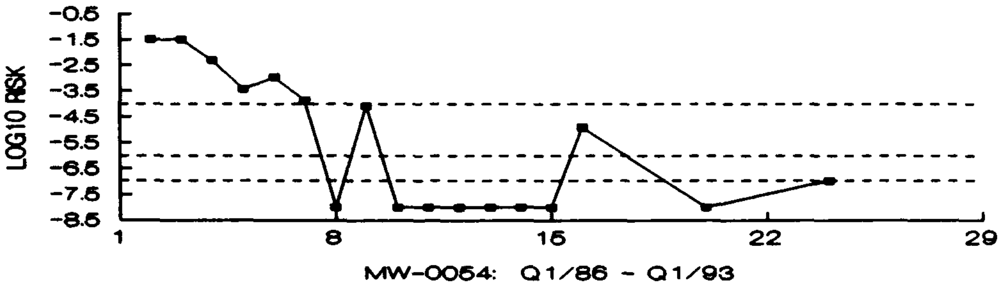
-8.5
LOG10 RISK
1
8
15
22
29
MW-0074: Q1/86 - Q1/93


-0.5
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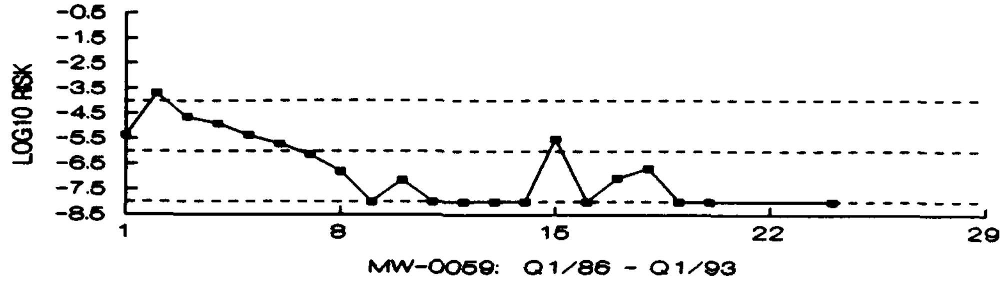
-8.5
LOG10 RISK
1
8
15
22
29
MW-0054: Q1/86 - Q1/93



LOG10 RISK
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-3.5
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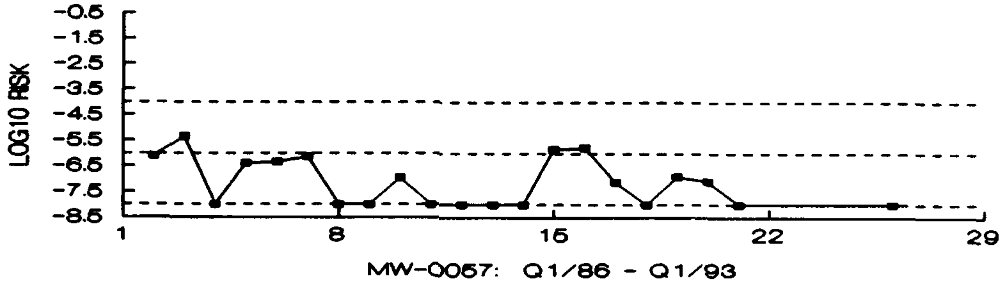
-6.5
-7.5
-8.5
1
8
15
22
29
MW-0059: Q1/86 - Q1/93



LOG10 RISK
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-6.5
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-8.5
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22
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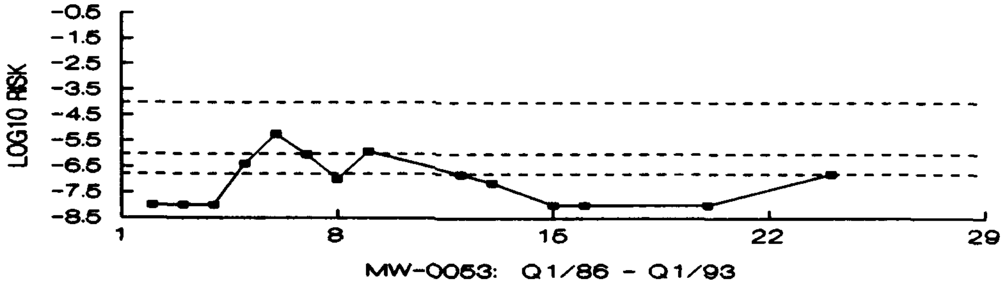
MW-0057: Q1/86 - Q1/93



LOG10 RISK
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-1.5
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-3.5
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-7.5
-8.5
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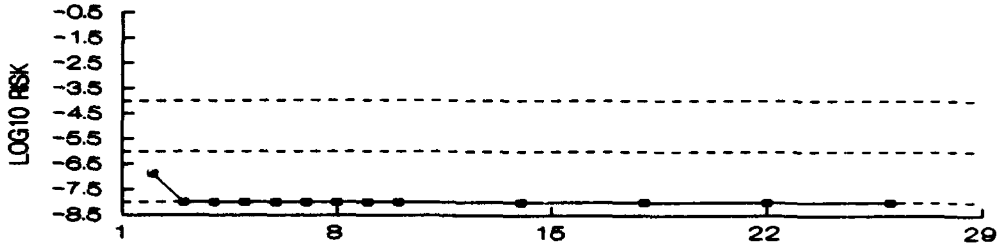
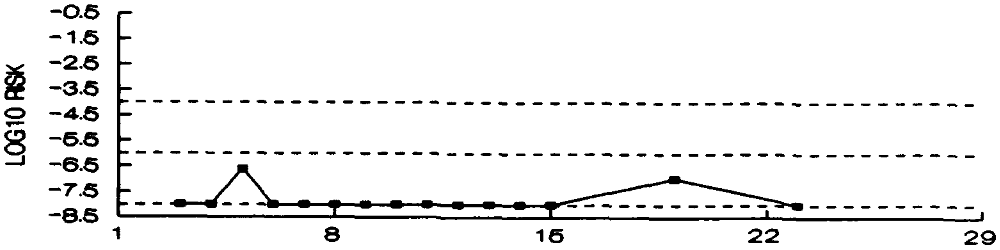
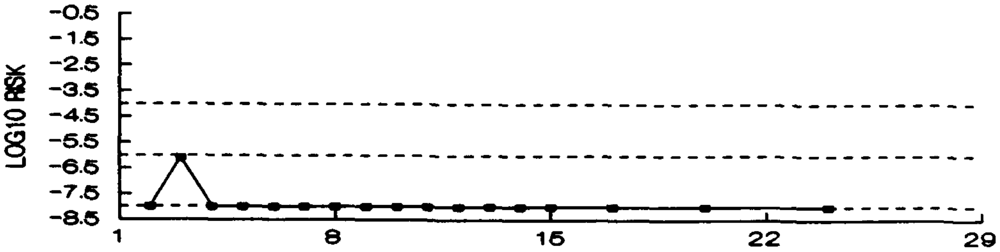
22
29
MW-0053: Q1/86 - Q1/93



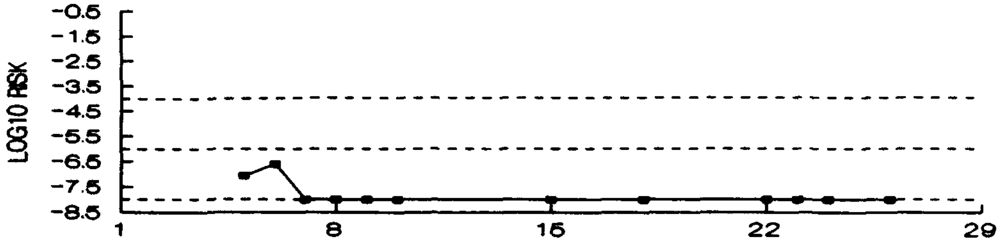
MW-1042: Q1/86 - Q1/93



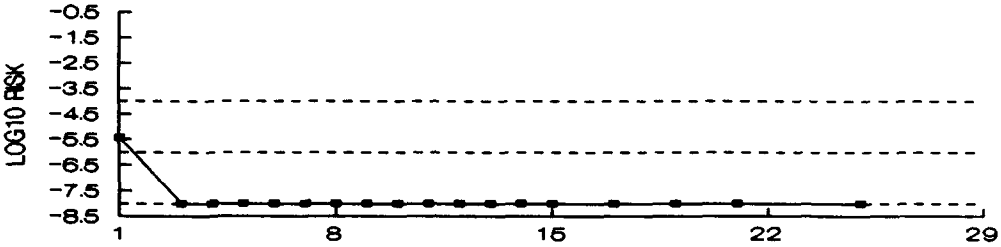
MW-0070: Q1/86 - Q1/93



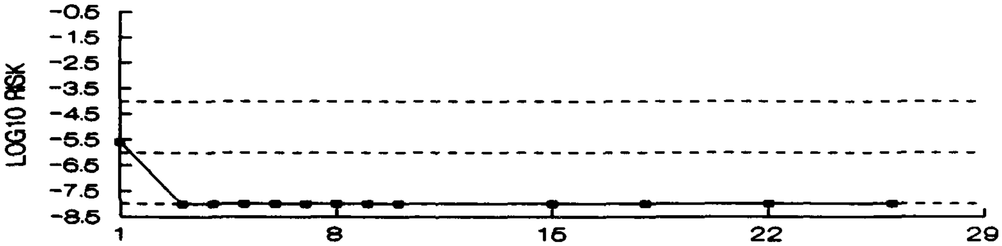
MW-0052: Q1/86 - Q1/93



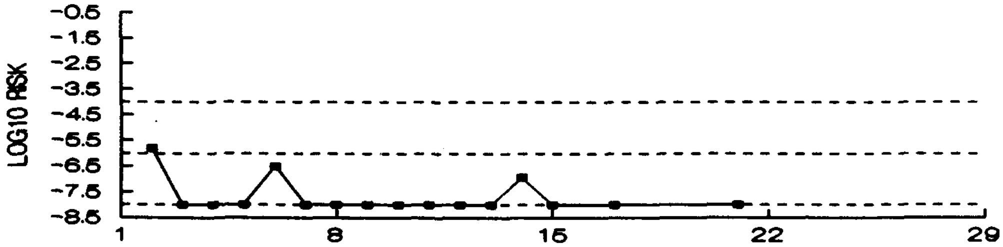
MW-1028: Q1/86 - Q1/93



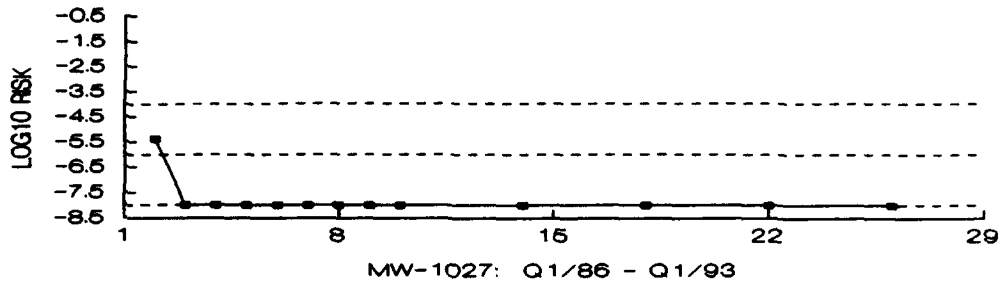
MW-1001: Q1/86 - Q1/93



MW-1010: Q1/86 - Q1/93



MW-0051: Q1/86 - Q1/93


LOG10 RISK
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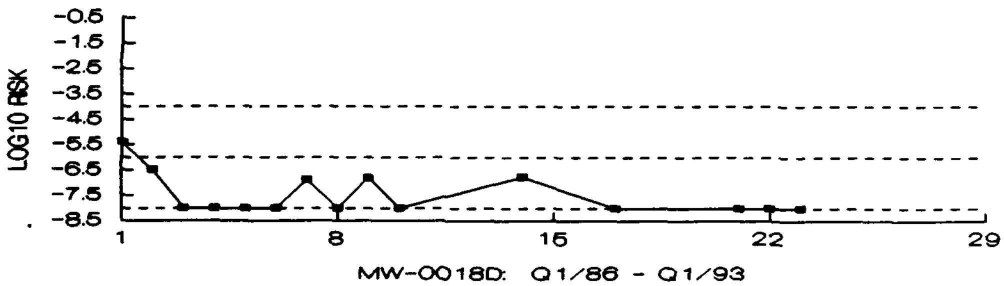
-3.5
-4.5
-5.5
-6.5
-7.5
-8.5
1
8
15
22
29
MW-1027: Q1/86 - Q1/93


LOG10 RISK
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-8.5
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22
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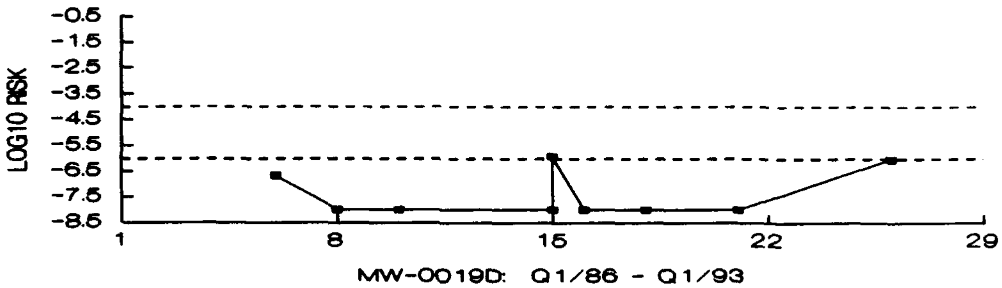
MW-0018D: Q1/86 - Q1/93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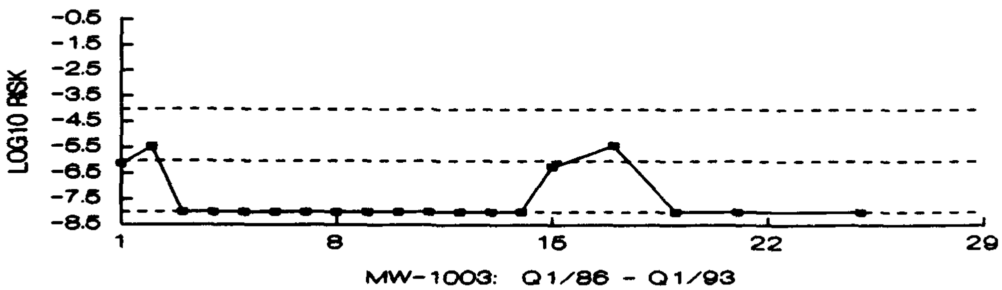
MW-0019D: Q1/86 - Q1/93


LOG10 RISK
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-3.5
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-8.5
1
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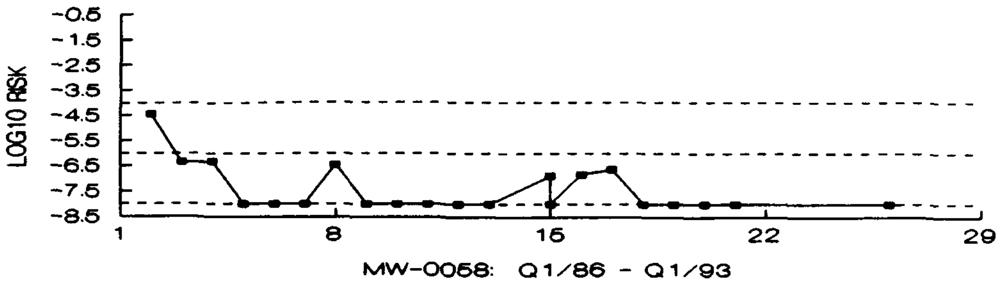
MW-1003: Q1/86 - Q1/93


LOG10 RISK
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-8.5
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22
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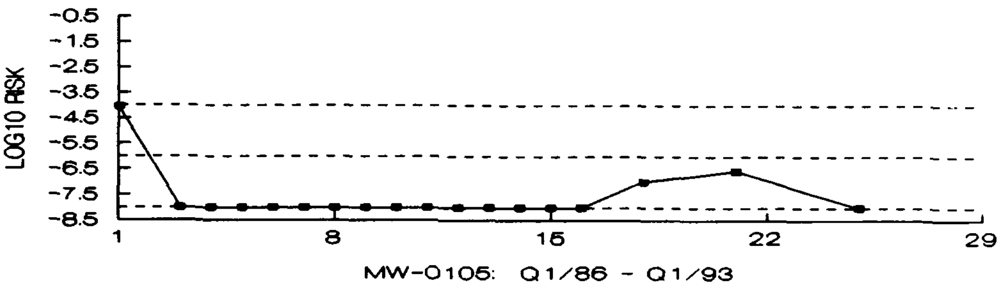
MW-0058: Q1/86 - Q1/93


LOG10 RISK
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-4.5
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22
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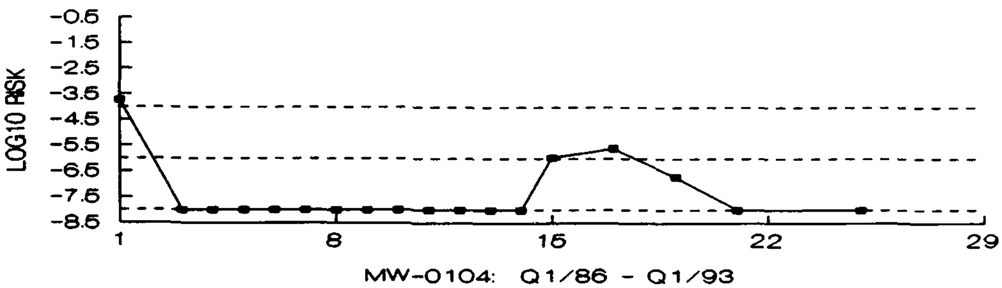
MW-0105: Q1/86 - Q1/93


LOG10 RISK
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-8.5
1
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15
22
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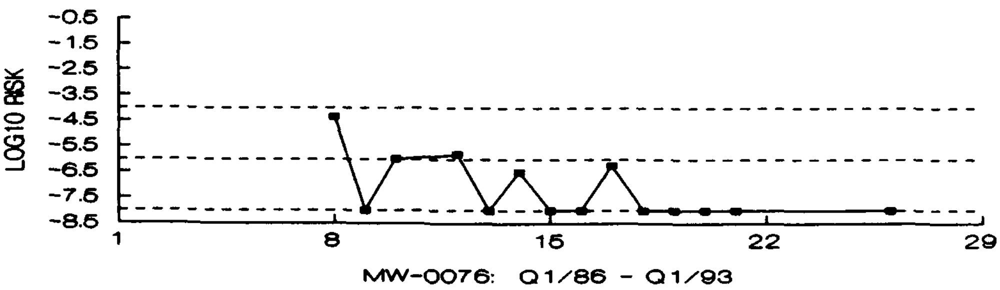
MW-0104: Q1/86 - Q1/93


LOG10 RISK
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-3.5
-4.5
-5.5
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-8.5
1
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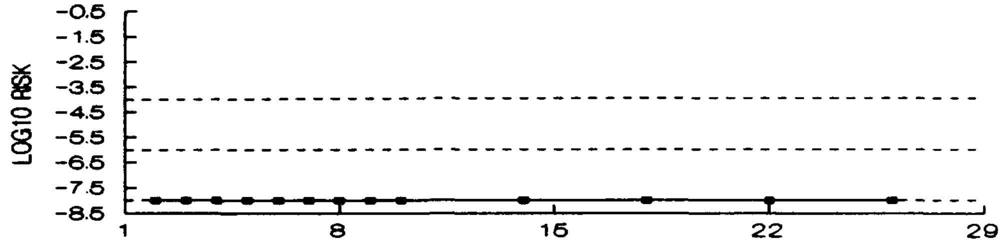
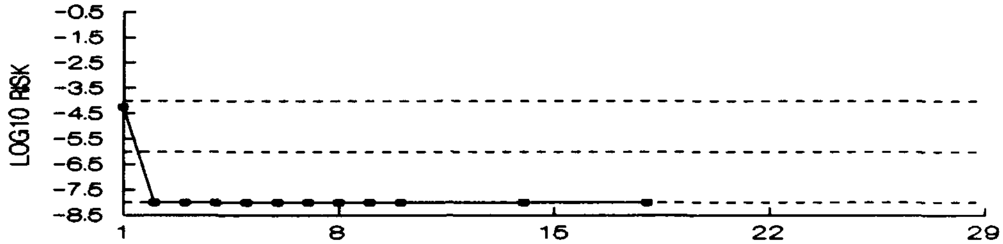
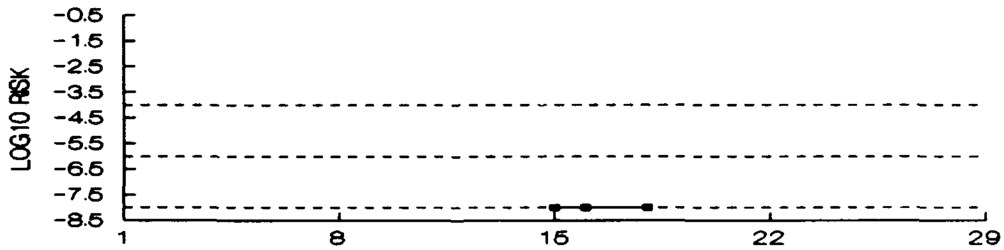
15
22
29
MW-0076: Q1/86 - Q1/93



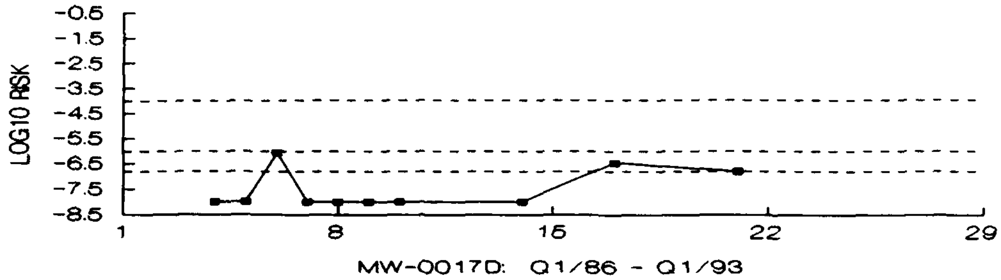
MW-1043: Q1/86 - Q1/93



MW-0029D: Q1/86 - Q1/93



MW-0195: Q1/86 - Q1/93



-0.5
-1.5
-2.5
-3.5
-4.5
-5.5
-6.5
-7.5
-8.5
LOG10 RISK
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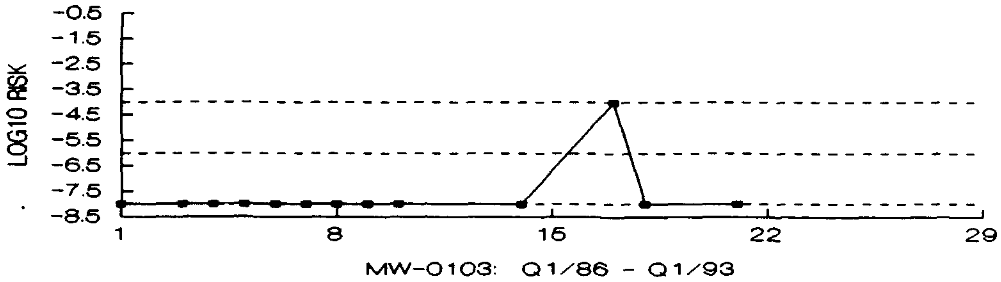
MW-0017D: Q1/86 - Q1/93



-0.5
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-2.5
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-5.5
-6.5
-7.5
-8.5
LOG10 RISK
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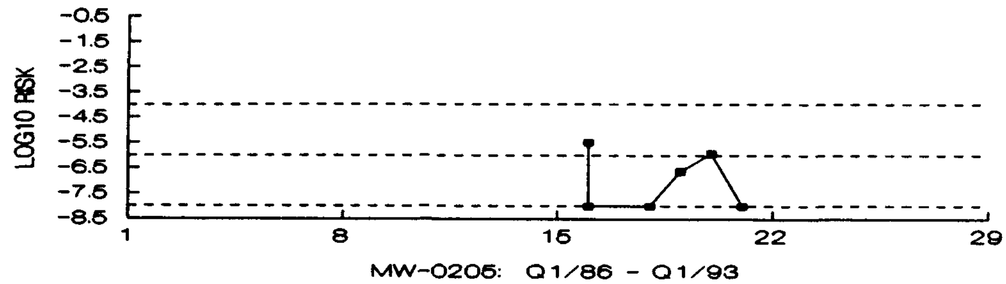
8
15
22
29
MW-0103: Q1/86 - Q1/93

Increased Lifetime Cancer Risk
Time Series
OU A, C-zone Wells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-8.5
1
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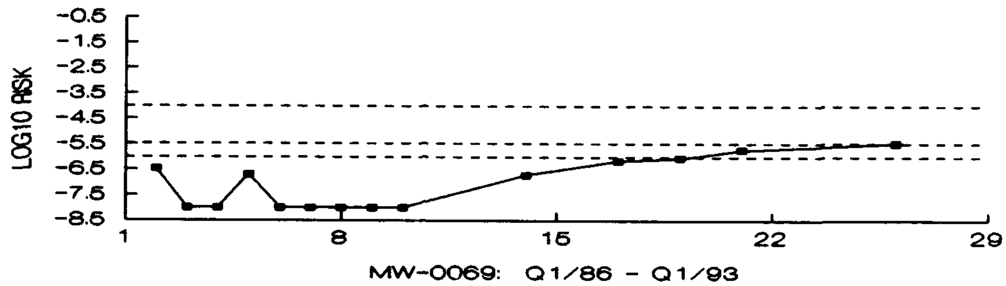
15
22
29
MW-0205: Q1/86 - Q1/93


LOG10 RISK
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-8.5
1
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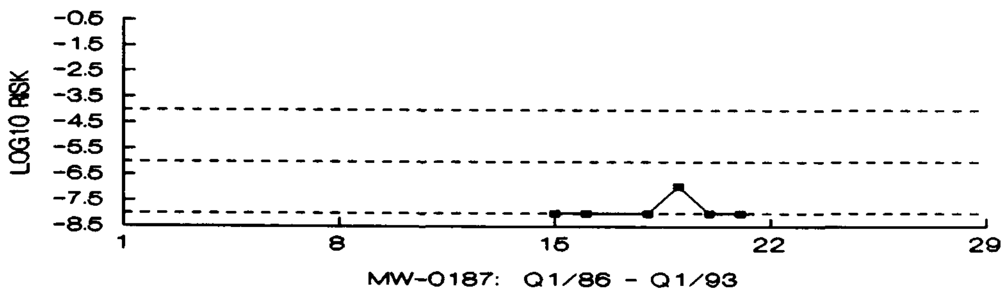
15
22
29
MW-0069: Q1/86 - Q1/93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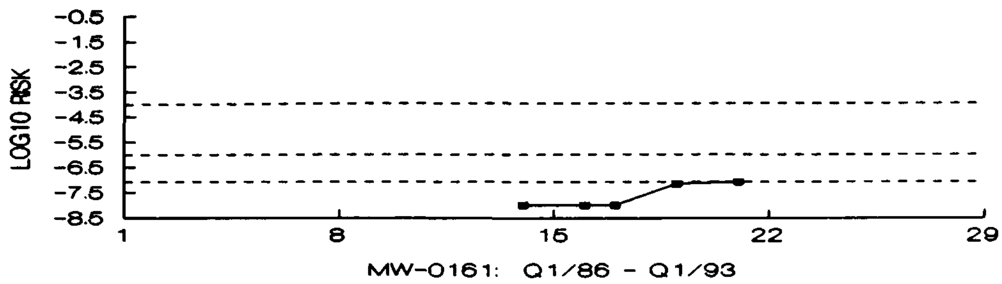
15
22
29
MW-0187: Q1/86 - Q1/93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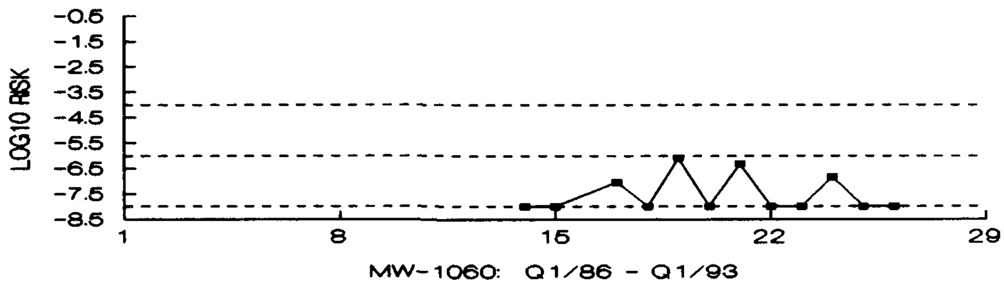
15
22
29
MW-0161: Q1/86 - Q1/93


LOG10 RISK
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-8.5
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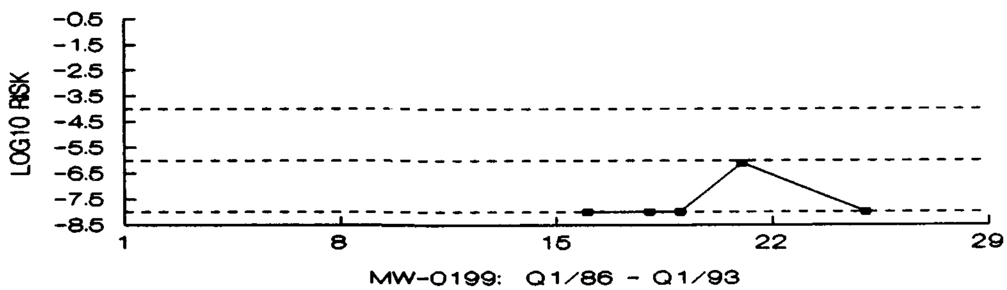
15
22
29
MW-1060: Q1/86 - Q1/93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-8.5
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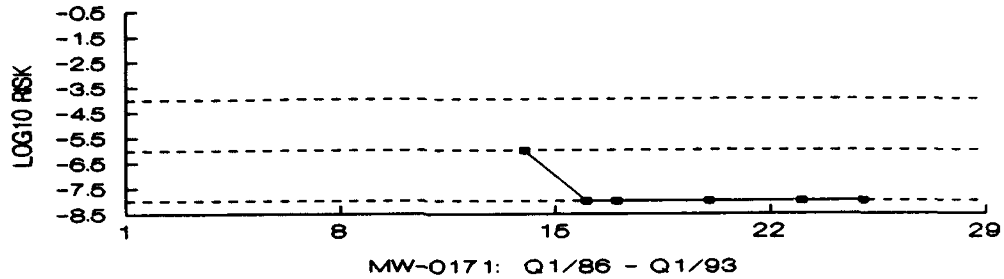
15
22
29
MW-0199: Q1/86 - Q1/93


LOG10 RISK
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1
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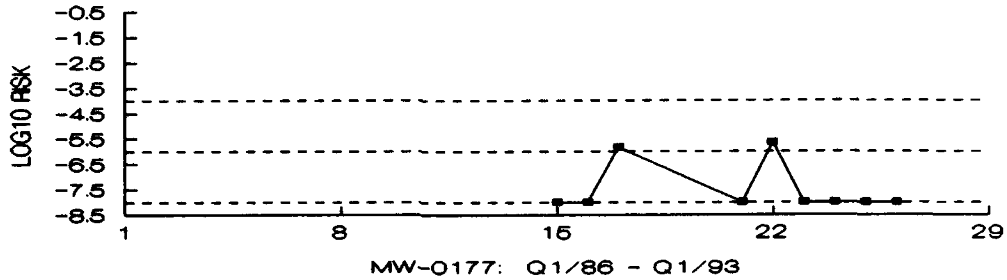
15
22
29
MW-0171: Q1/86 - Q1/93


LOG10 RISK
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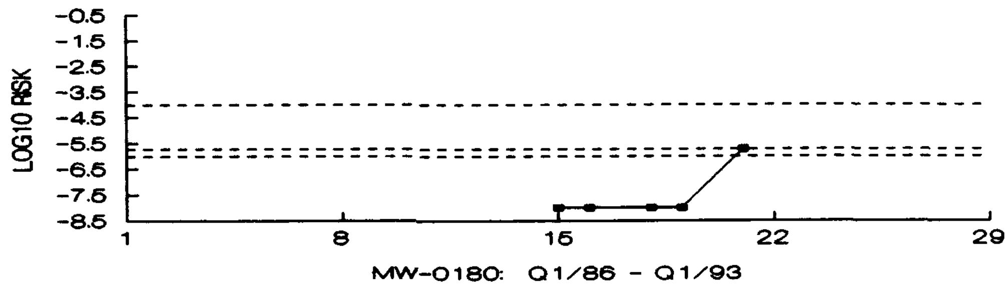
-7.5
-8.5
1
8
15
22
29
MW-0177: Q1/86 - Q1/93


LOG10 RISK
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-8.5
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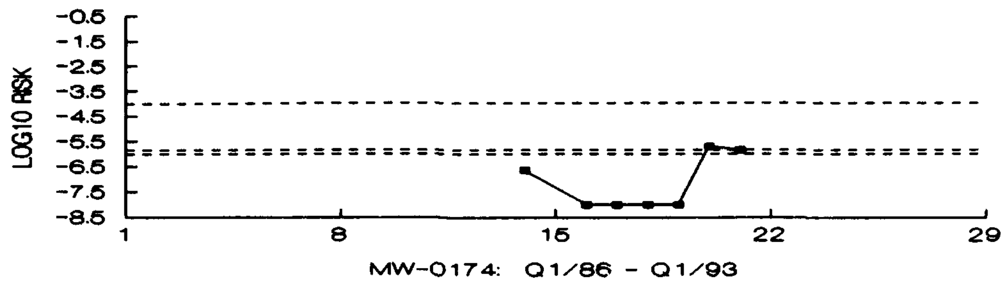
15
22
29
MW-0180: Q1/86 - Q1/93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LOG10 RISK
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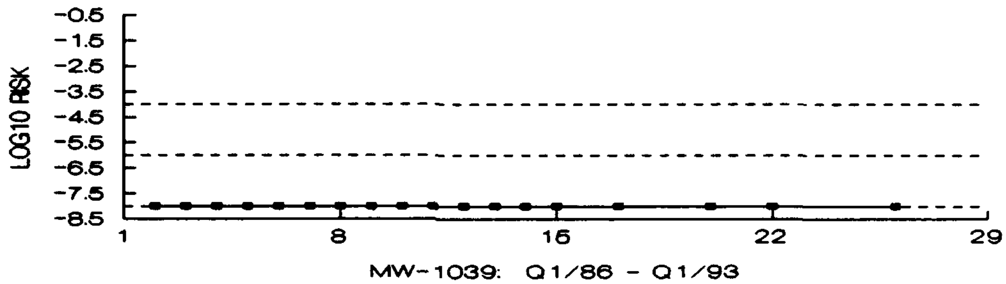
15
22
29
MW-0174: Q1/86 - Q1/93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LOG10 RISK
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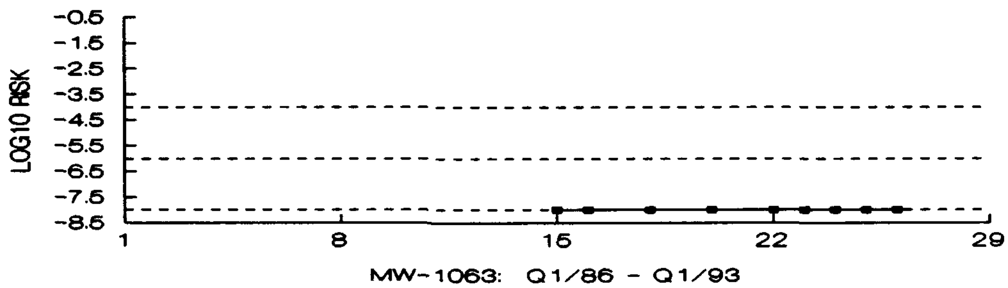
15
22
29
MW-1039: Q1/86 - Q1/93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-8.5
LOG10 RISK
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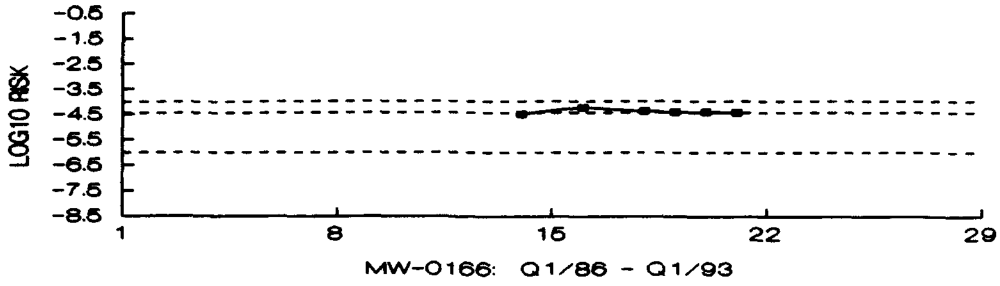
15
22
29
MW-1063: Q1/86 - Q1/93

Increased Lifetime Cancer Risk
Time Series
OU B, C-zone Wells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LOG10 RISK
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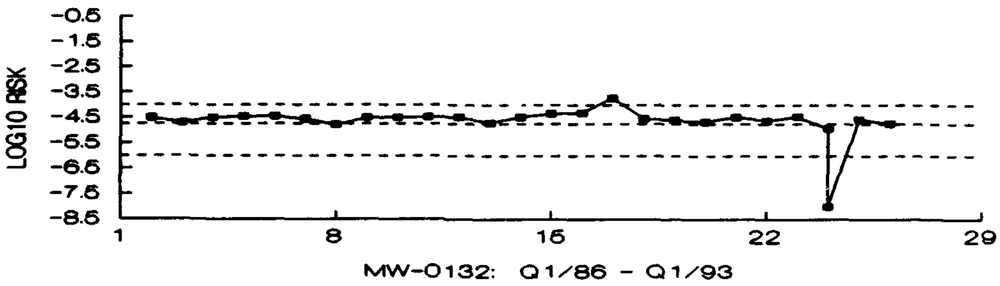
22
29
MW-0166: Q1/86 - Q1/93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LOG10 RISK
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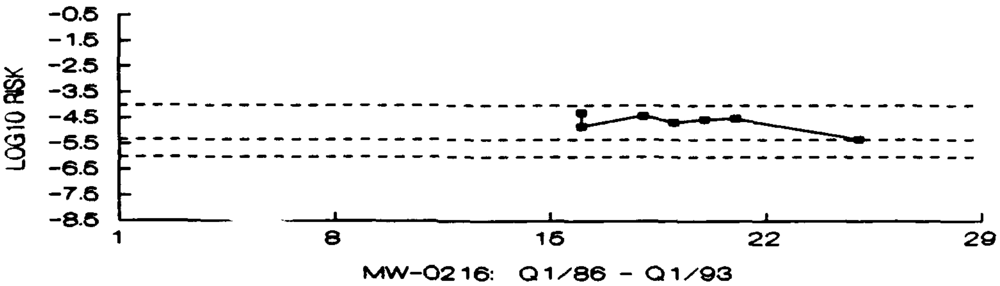
15
22
29
MW-0132: Q1/86 - Q1/93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LOG10 RISK
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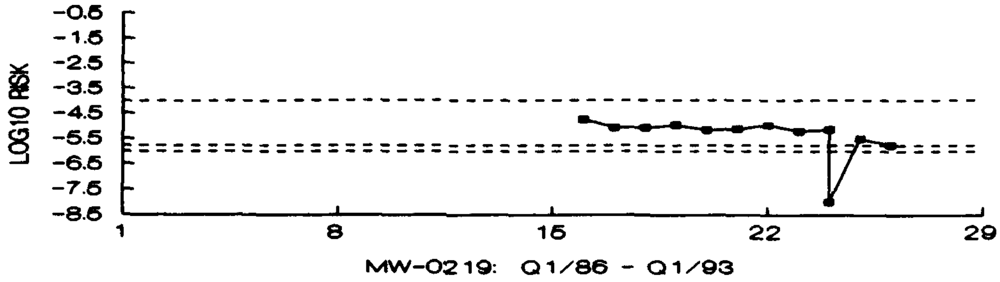
22
29
MW-0216: Q1/86 - Q1/93



LOG10 RISK
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1
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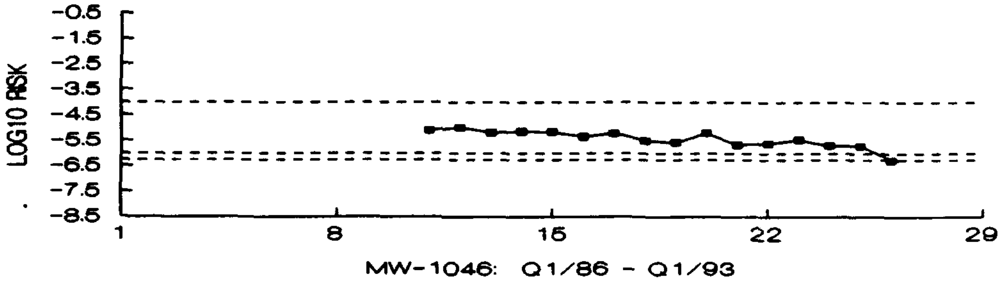
15
22
29
MW-0219: Q1/86 - Q1/93



LOG10 RISK
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-8.5
1
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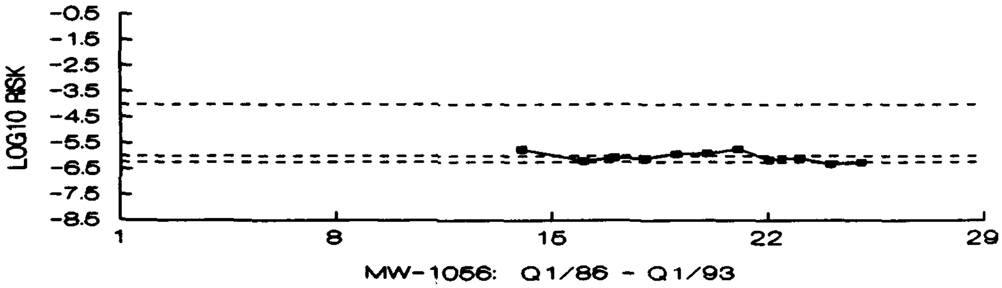
15
22
29
MW-1046: Q1/86 - Q1/93



LOG10 RISK
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-7.5
-8.5
1
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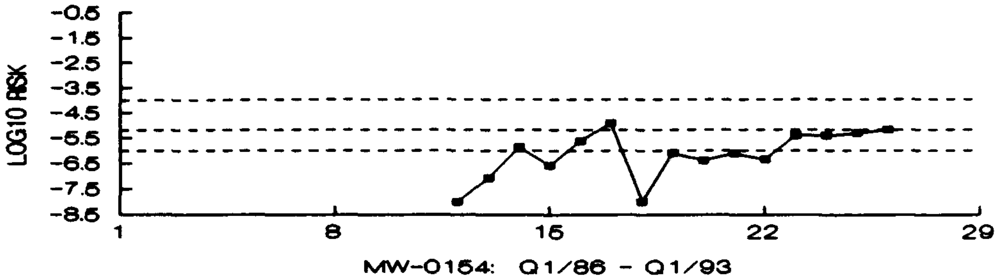
15
22
29
MW-1056: Q1/86 - Q1/93


LOG10 RISK
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-8.5
1
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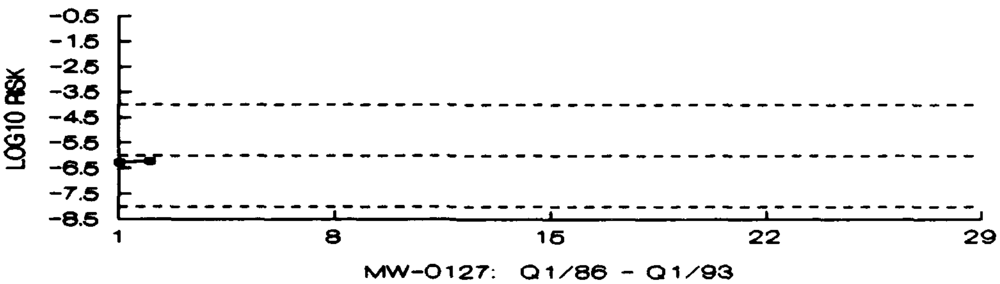
15
22
29
MW-0154: Q1/86 - Q1/93


LOG10 RISK
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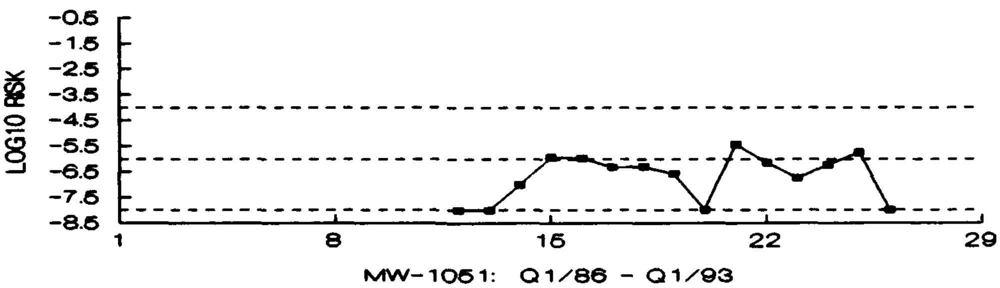
-8.5
1
8
15
22
29
MW-0127: Q1/86 - Q1/93


LOG10 RISK
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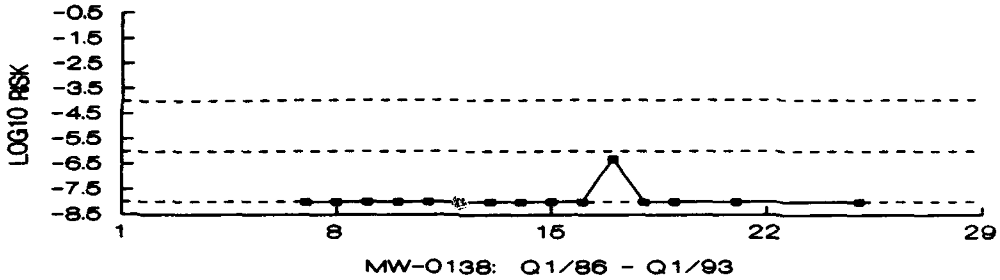
-7.5
-8.5
1
8
15
22
29
MW-1051: Q1/86 - Q1/93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-2.5
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-4.5
-5.5
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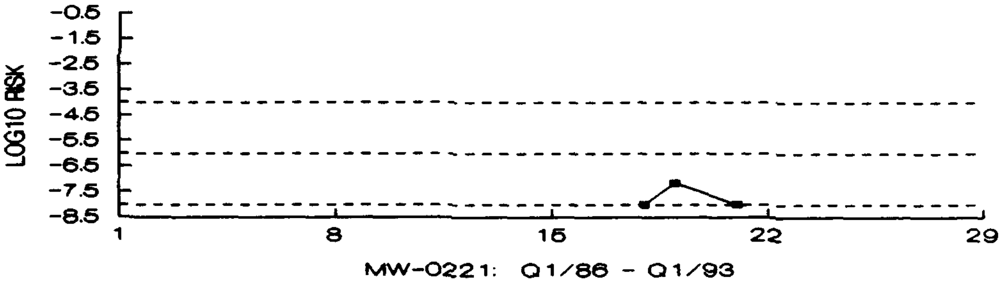
-8.5
LOG10 RISK
1
8
15
22
29
MW-0138: Q1/86 - Q1/93


-0.5
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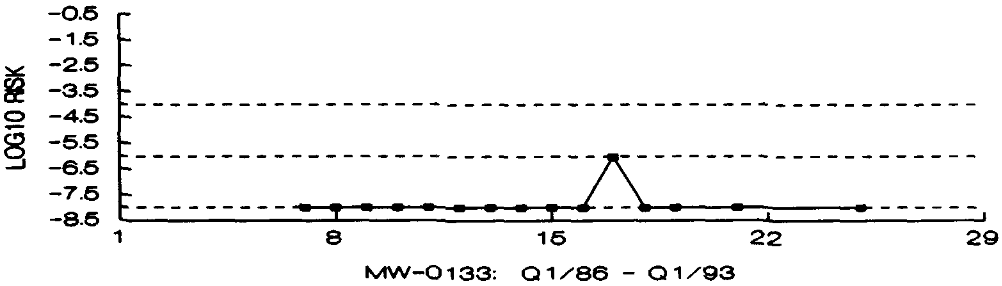
-8.5
LOG10 RISK
1
8
15
22
29
MW-0221: Q1/86 - Q1/93


-0.5
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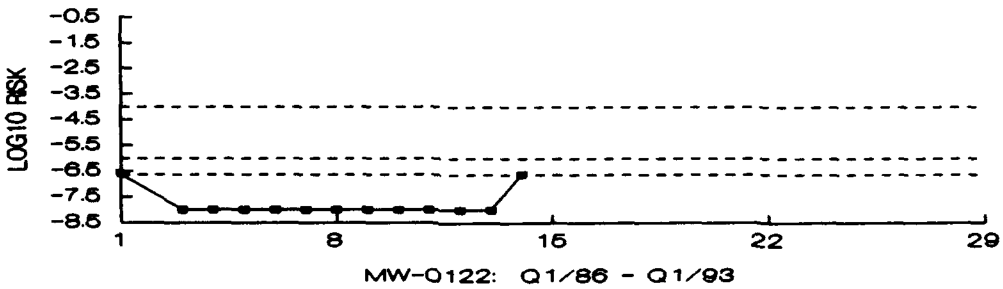
-8.5
LOG10 RISK
1
8
15
22
29
MW-0133: Q1/86 - Q1/93


-0.5
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-8.5
LOG10 RISK
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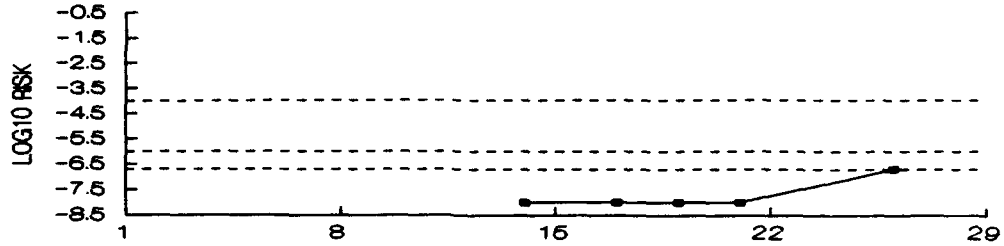
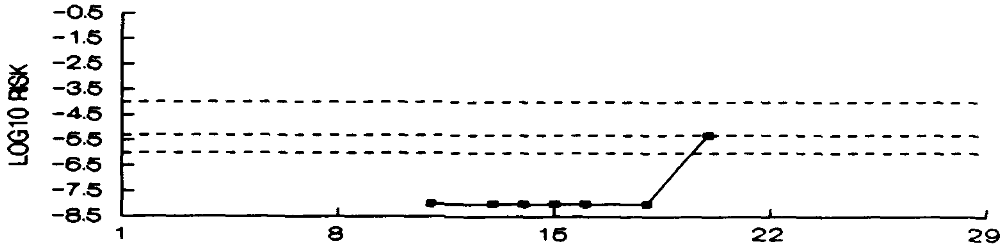
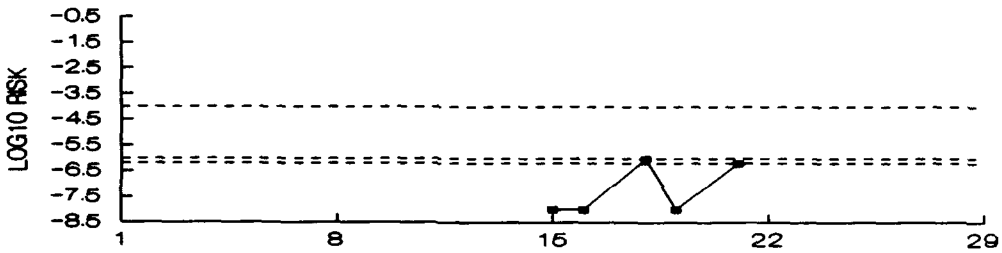
8
15
22
29
MW-0122: Q1/86 - Q1/93



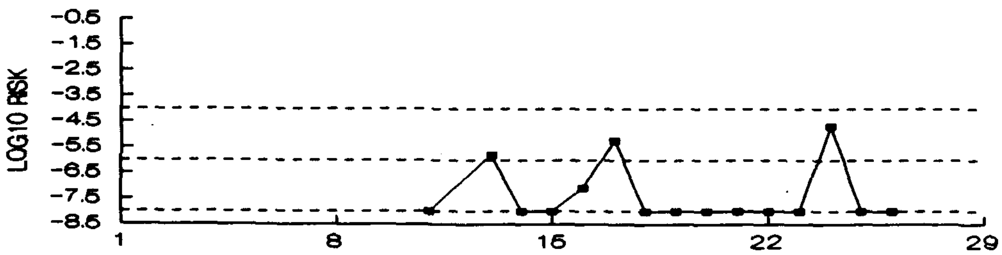
MW-0181: Q1/86 - Q1/93



MW-0147: Q1/86 - Q1/93

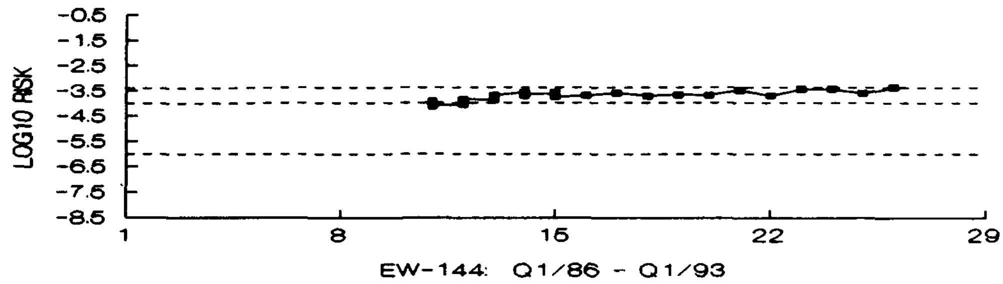


MW-0193: Q1/86 - Q1/93



MW-0152: Q1/86 - Q1/93

Increased Lifetime Cancer Risk
Time Series
OUs C, D, E, F
C-zone Wells



-0.5
-1.5
-2.5
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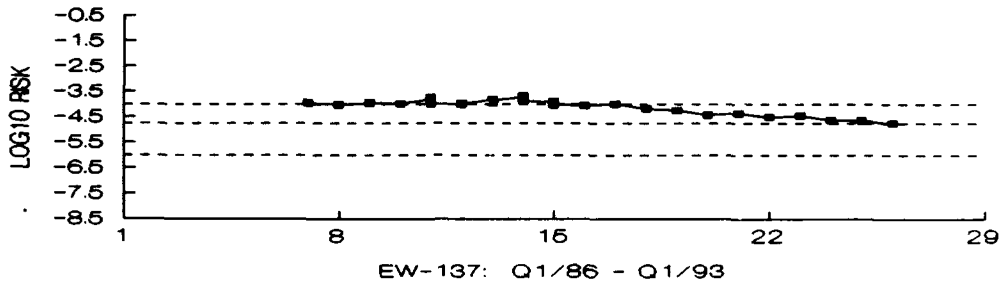
-7.5
-8.5
LOG10 RISK
1
8
15
22
29
EW-144: Q1/86 - Q1/93



-0.5
-1.5
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-8.5
LOG10 RISK
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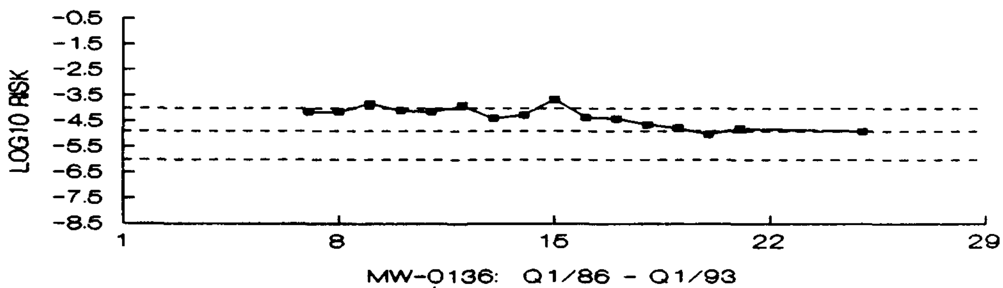
8
15
22
29
EW-137: Q1/86 - Q1/93



-0.5
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-8.5
LOG10 RISK
1
8
15
22
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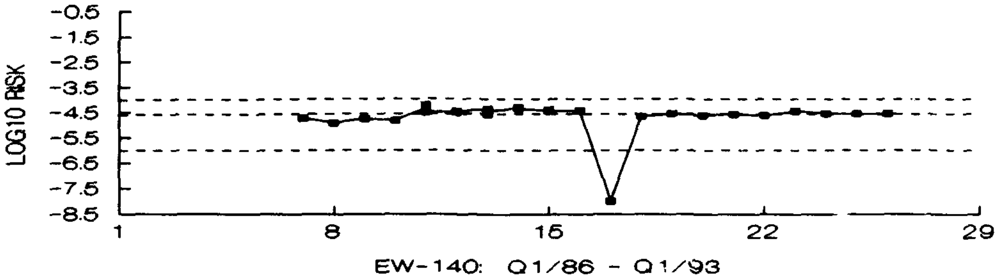
MW-0136: Q1/86 - Q1/93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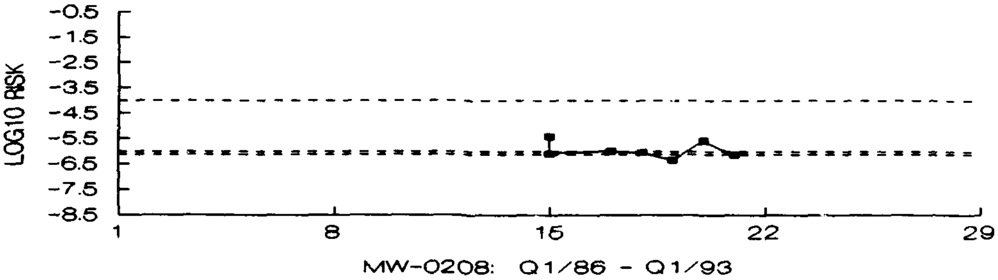
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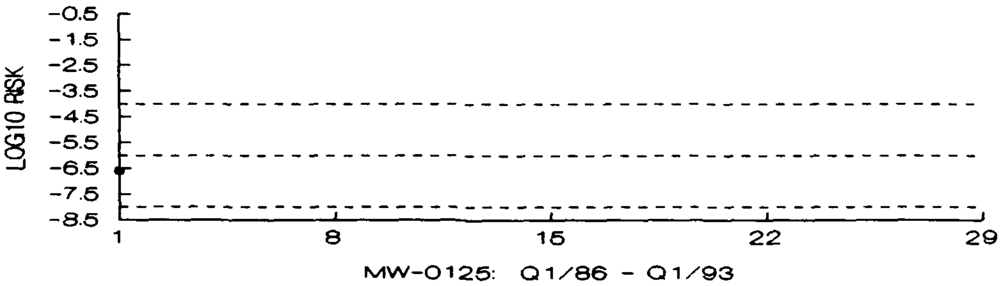
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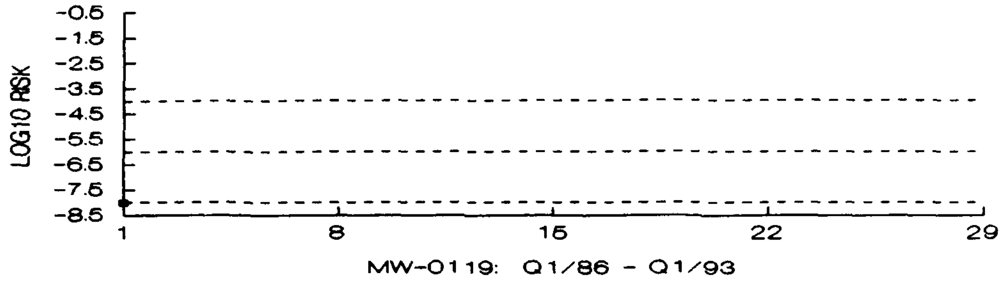
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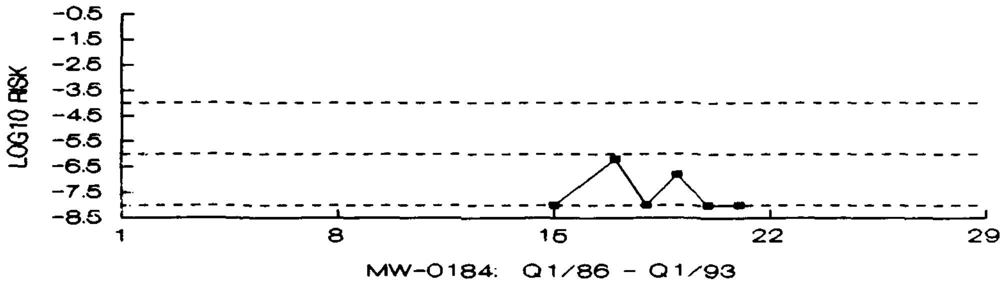
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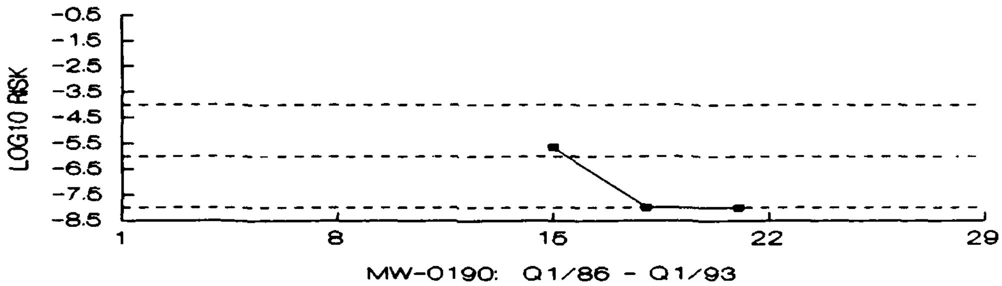
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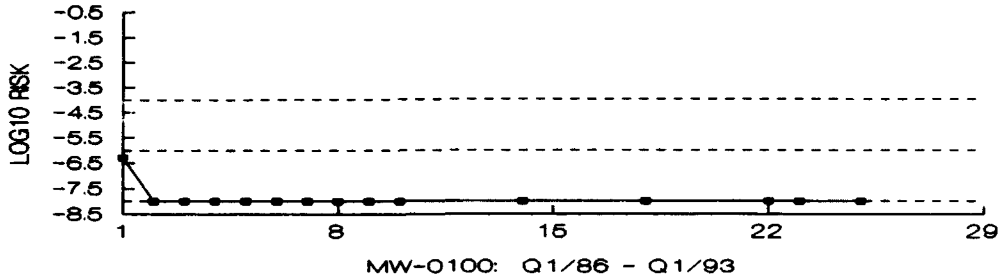
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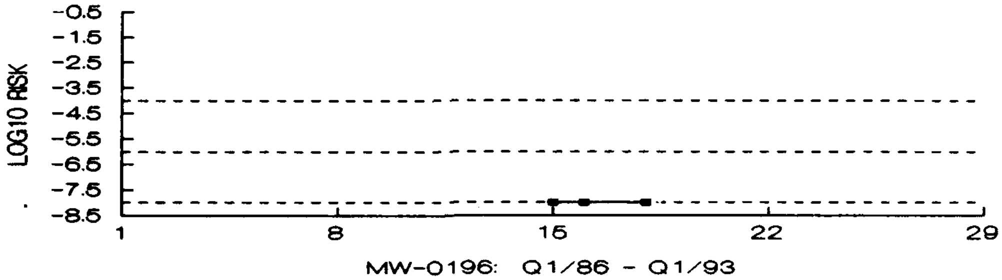
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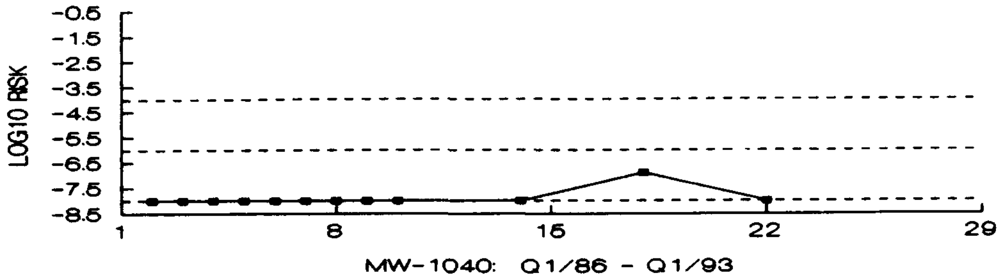
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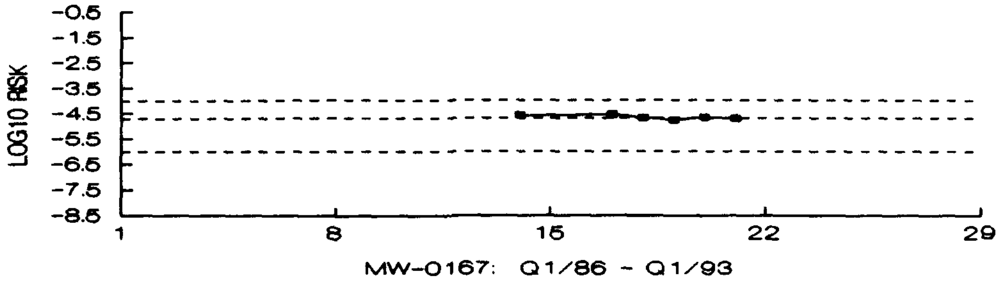
MW-1040: Q1/86 - Q1/93

Increased Lifetime Cancer Risk
Time Series
OUs B, C
D-zone Wells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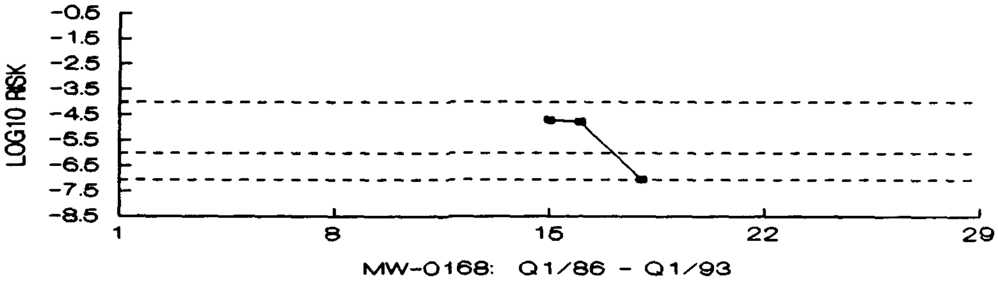
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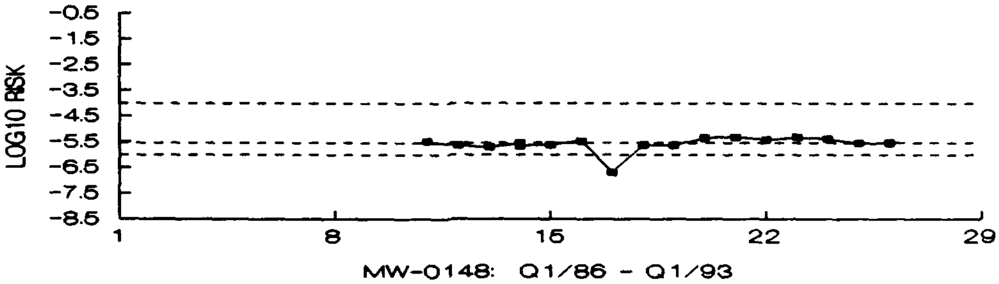
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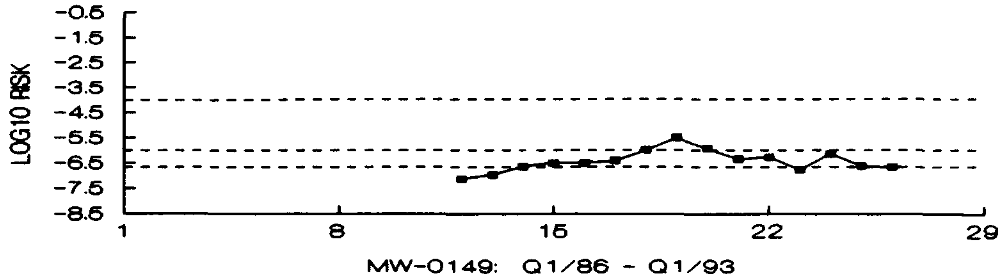

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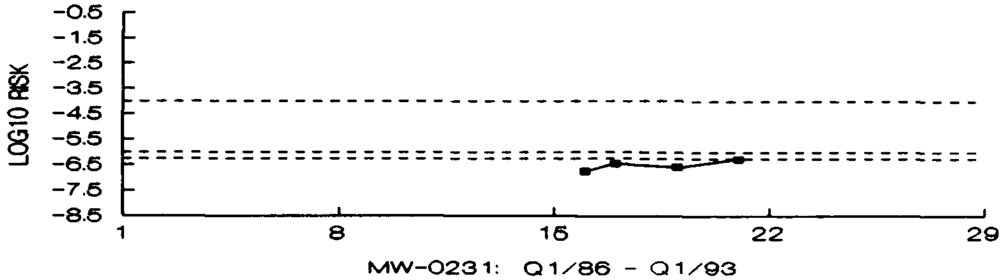

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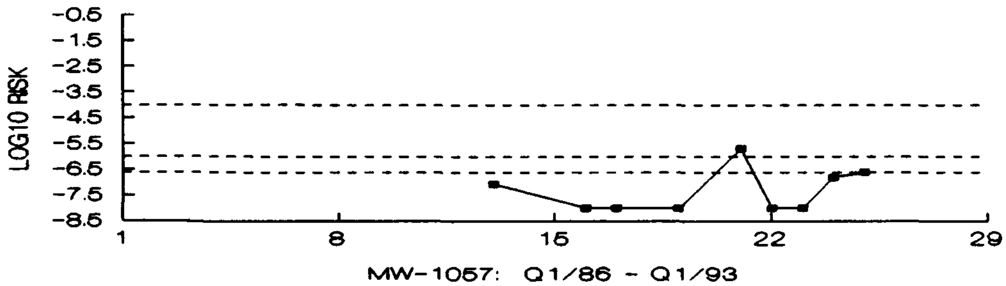

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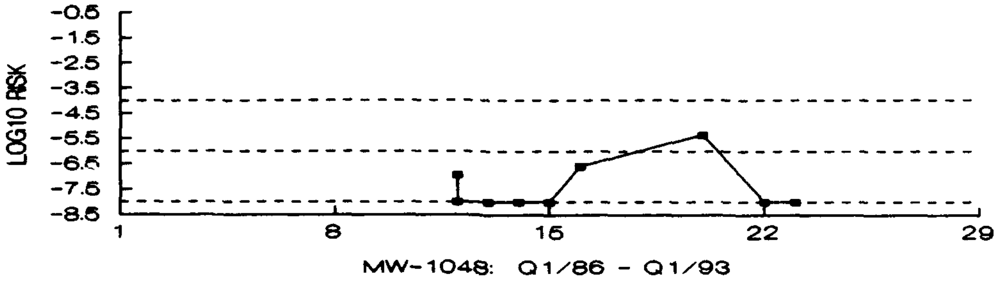
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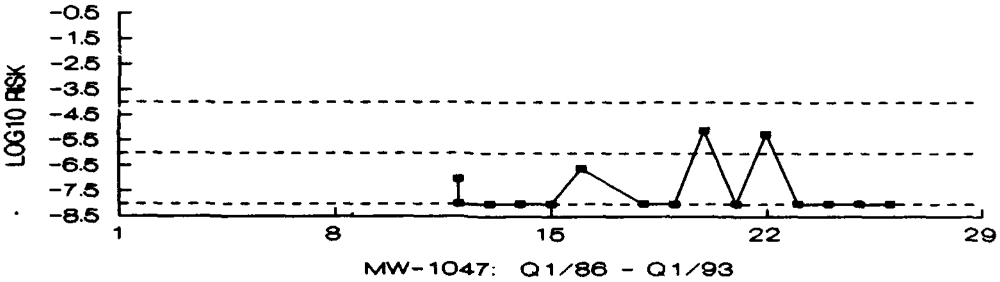
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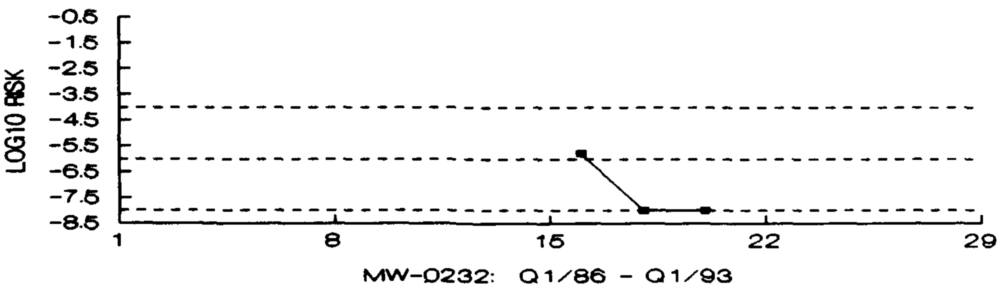
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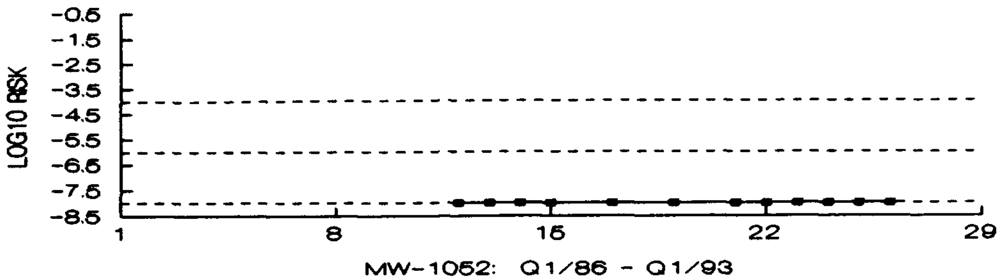

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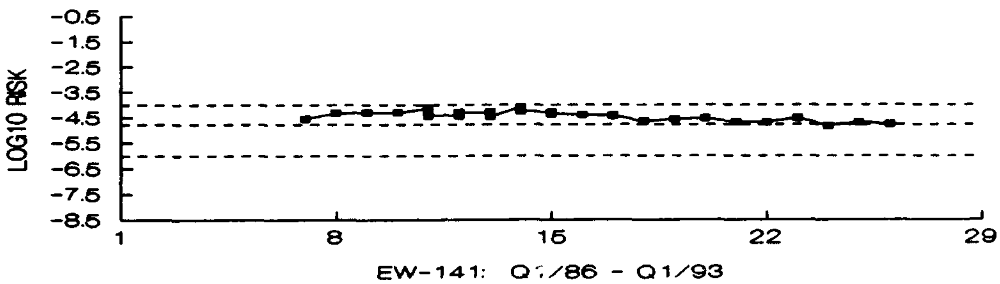

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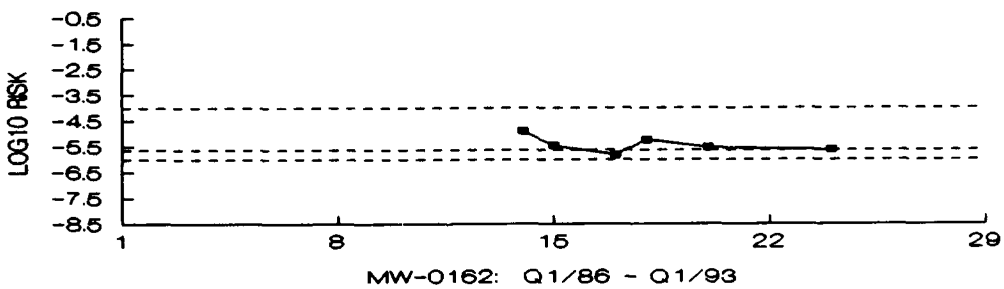

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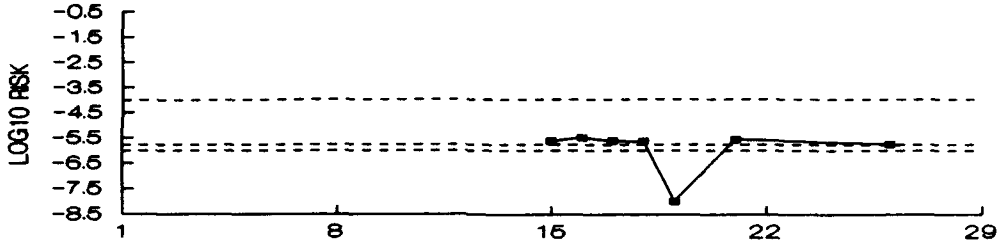

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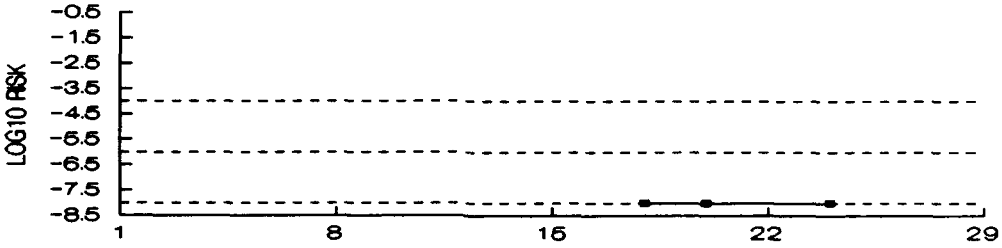

MW-0230: Q1/86 - Q1/93

PREPARED FOR: McClellan Air Force Base

DATE: November 5, 1993

SUBJECT: Risk Evaluation of Remedial Action Alternatives
Groundwater OU RI/FS Report
Delivery Order No. 5066

PROJECT: SAC28722.66.FS

Introduction

This technical memorandum presents an evaluation of human health risks associated with the different remedial action alternatives proposed for the GW OU RI/FS. This evaluation supports a detailed evaluation of alternatives in which each alternative is evaluated against the nine evaluation criteria specified within the National Contingency Plan (NCP), then compared against each other. Both long-term effectiveness (i.e., residual risk) and short-term effectiveness (i.e., risk to the community and workers during implementation of the remedy) are evaluated in the detailed analysis.

Guidance in preparation of the risk evaluation has been obtained from the EPA's *Risk Assessment Guidance for Superfund, Vol. I, Part C (Risk Evaluation of Remedial Alternatives)* (U.S. EPA, 1991). As recommended by EPA, the risk evaluation of remedial action alternatives is largely a qualitative study, based on the level of data available concerning alternatives at this time, and the nature of questions that must be answered to select and implement a remedy.

Approach to the Risk Evaluation

Questions about human health risks of remedial action alternatives to be addressed during the risk evaluation were:

- Which alternatives would achieve the cleanup levels in groundwater? What uncertainties are involved with this determination?

- Which alternatives will clearly not address the significant human exposure pathways identified in the baseline risk assessment?

- Are the expected residual risks or short-term risks from one alternative significantly different over another?

- Will implementation of specific technologies create new chemicals of concern or significant exposures and risks for the surrounding community?

- Is there a need for engineering controls or other measures to mitigate risks during implementation of a remedy?

The approach to the risk evaluation involves identification of the remedial action alternatives, evaluation of long-term human health risks associated with each alternative, and evaluation of short-term human health risks associated with each alternative. Evaluation of long-term risks involves consideration of residual risks and protectiveness over time (i.e., reduction of toxicity, mobility, and volume of contaminants). Evaluation of short-term risks includes any new risks to nearby communities and workers that could occur during implementation of a remedy.

Identification of Remedial Action Alternatives

On the basis of the results of alternatives development and screening, five alternatives were identified for detailed evaluation, including evaluation of health risks. Table C-1 summarizes the remedial action alternatives considered in the risk evaluation.

Many similarities exist between these alternatives. They all use air stripping for removal of contaminants from extracted water. All but one alternative use catalytic oxidation (CatOx) for offgas treatment of VOCs. All but one involve carbon polishing of treated water before purveying to nearby water districts. The principal differences between these alternatives are in the target volumes of groundwater that require treatment. Three different target volumes were used in the development and screening of remedial action alternatives, as described in Table C-2.

Evaluation of Long-Term Human Health Risks

Evaluation of Residual Risk

Since the target volumes are developed on risk-based levels (i.e., MCLs or acceptable health risk levels), they provide a means to evaluate long-term health risks associated with the different remedial action alternatives. Essentially, the target volumes reflect different levels of residual risk.

Figure C-1 presents the increased lifetime cancer risks achieved if TCE concentrations are reduced to the concentration within each target volume. There is a relatively small range of residual risks (3×10^{-6} to 3×10^{-7} for TCE) associated with each target volume, and each cleanup level (MCL, cancer risk-based and background) achieves or surpasses the lower end of EPA's acceptable risk range of 10^{-4} to 10^{-6}.

Table C-1 Remedial Action Alternatives		
Target Volume	**Treatment Technology**	**End Use**
MCL	AS/CatOx with carbon polishing - East side GWTP - West side	Water districts
10^{-6}	AS/CatOx with carbon polishing - East side GWTP - West side	Water districts
Background	AS/CatOx with carbon polishing - East side GWTP - West side	Water districts
MCL	AS/VGAC with carbon polishing - East side GWTP - West side	Water districts
MCL	AS/CatOx - East side GWTP - West side	Groundwater reinjection
MCL	LGAC - East side GWTP - West side	Water districts
	No Action	

Notes:

MCL - Target volume mapped using Maximum Contaminant Limits.
AS/CatOx - Air stripping with catalytic oxidation offgas treatment.
GWTP - Existing groundwater treatment plant.
Water districts - water to be purveyed to local water districts.
10^{-6} - Target volume mapped to a 10^{-6} increased lifetime cancer risk.
AS/VGAC - Air stripping with vapor-phase granular activated carbon offgas treatment.
Background - Target volume mapped to limit of detection (0.5 $\mu g/l$).
LGAC - Liquid-phase granular activated carbon treatment.

Table C-2 Target Volumes for Groundwater Remediation	
Target Volume	**Description**
MCL	Volume of groundwater mapped by the MCL of the contaminants with the largest extent (i.e., trichloroethene). Concentrations within the MCL target volume are $\geq$ MCL (generally 5 $\mu g/l$ for contaminants with the lowest MCLs). Remedial action would be expected to achieve concentrations in groundwater $\leq$ MCLs within this volume.
10^{-6} cancer risk	Volume of groundwater mapped by a 10^{-6} increased lifetime cancer risk calculated as the sum of risks across all contaminants detected within a monitoring well. Concentrations equivalent to a 10^{-6} risk vary from contaminant to contaminant. Remedial action would be expected to achieve concentrations in groundwater $\leq 10^{-6}$ within this volume. This target volume is slightly greater than, and substantially overlaps, the MCL target volume.
Background	Volume of groundwater mapped by the analytical detection limit (0.5 $\mu g/l$); this target volume defines the area of groundwater outside of which contaminants have not been detected in groundwater. Remedial action would be expected to achieve concentrations in groundwater below limits of detection within this volume. This target volume encompasses the other two target volumes and is significantly larger.

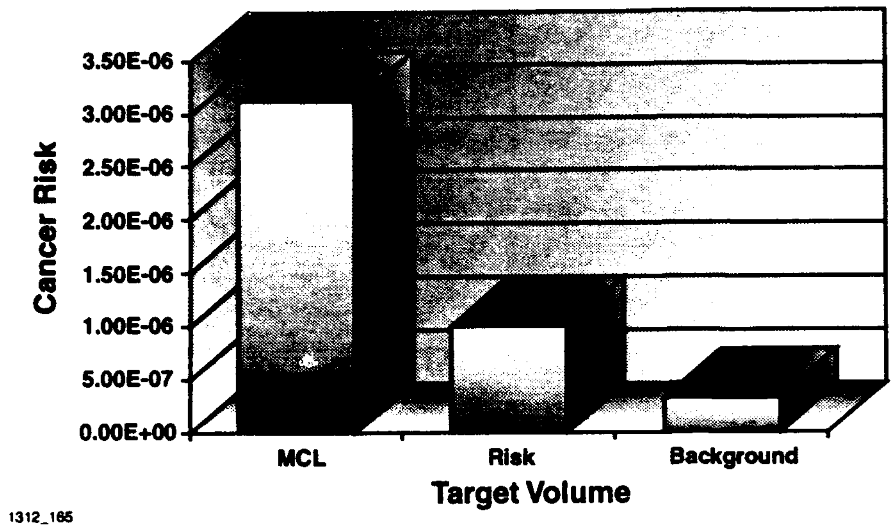

FIGURE C-1
RESIDUAL RISK LEVELS
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

Therefore, there is little discernable difference in residual risks (given the uncertainties in risk assessment methods) between alternatives that achieve cleanup to MCLs, 10^{-6} risk, or background. The assumption inherent in this calculation is that achieving remedial action objectives for TCE in groundwater implies achieving remedial action objectives for other contaminants in groundwater. With the exception of selected hot spot areas, this is reasonable, because the target volumes are determined largely from the distribution of TCE in groundwater.

All of the remedial action alternatives would achieve the same level of residual risk in treated water. All of the treatment technologies were sized and costed to attain a concentration of 0.5 μg/l in treated water, based on a set of conservative assumptions concerning flows, concentrations, and expected contaminants. Alternatives that involve purveying water to water districts include a carbon polishing step to enhance the suitability of treated water for municipal use. There would be no discernable difference in risks between purveying water to water districts and groundwater reinjection, since in either case, concentrations in water would be 0.5 μg/l or less.

Alternatives involving CatOx as an offgas treatment may provide somewhat greater residual risks compared with vapor-phase granular activated carbon (VGAC) treatment. The potential risks associated with VGAC are that trace emissions of volatile organic compounds would become emitted into the air. The health risks associated with this exposure would be similar (though of lesser magnitude) compared with the risks associated with exposure to contaminated groundwater. However, CatOx, which involves a combustion process, would involve emissions of oxidant and acid gases, such as oxides of nitrogen (NO_x), oxides of sulfur (SO_x) and hydrogen chloride (HCl). Two concerns with oxidant and acid gas emissions are: (1) health risks (effects to pulmonary function) associated with inhalation exposure and (2) air permitting concerns and emissions limits for NO_x and SO_x. CatOx would appear to provide somewhat greater residual risks compared with VGAC treatment by creating new contaminants; however, it is uncertain how significant these residual risks would be. Depending on location of a treatment plant using CatOx, emission rates, and prevailing meteorological conditions, use of CatOx could pose an inhalation risk to nearby workers.

Mitigation of the effects from increased emissions of oxidant gases from CatOx could take the form of siting a treatment facility such that maximum ambient air impacts fall on uninhabited areas, installing emissions controls, or obtaining offsets to accommodate the additional emissions.

Evaluation of Protectiveness Over Time

The ability of each remedial action alternative to reduce toxicity of contaminants diminishes past the MCL target volume. As shown in the baseline risk assessment, risks in most monitoring wells across McClellan AFB fall within the 10^{-4} to 10^{-6} risk range, with selected outliers exceeding this range. Removal of contaminant mass past the MCL target volume does not significantly reduce toxicity or the magnitude of health risks.

Whether an alternative is likely to provide a specific level of protection over time involves:

- Consideration of reliability, or the ability of the alternative to perform as expected
- The uncertainty that site conditions differed from those used in designing the alternative

There is reasonable similarity between the different alternatives, in terms of extraction network designs and treatment technologies. Each of the extraction networks is designed to capture a specific target volume, and each treatment technology is designed to achieve a level of 0.5 μg/l. Each alternative consists of similar components, with a known history of reliability. Therefore, it is anticipated that there would be little differences between alternatives in their abilities to perform as expected.

Uncertainties that site conditions could differ from those used in developing the alternatives include:

- Higher influent concentrations than expected
- Larger groundwater contaminant extent than expected
- Longer time to cleanup than expected.

Higher influent concentrations than expected, if not addressed, could result in effluent water with concentrations exceeding 0.5 μg/l. If the relationship between influent and effluent concentrations is linear, such that a control factor can be applied to influent concentrations, then effluent concentrations would increase proportionally with influent concentrations. These still would represent relatively low level concentrations in water, that would be treated with liquid-phase granular activated carbon (LGAC) treatment (carbon polishing) for alternatives involving purveying water to water districts. The treatment technology has some flexibility to address this uncertainty, since higher than expected influent concentrations can be treated with air stripping by increasing the air to water ratio.

Extent of groundwater contamination that is larger than expected (i.e., larger than an extraction network is designed for) would be unlikely to result in significant increases in health risks over time, though this situation probably would not achieve ARARs. The portions of the groundwater contaminant plume not captured by extraction wells is likely to consist of relatively low level contamination, which would undergo further attenuation from advection, retardation, and degradation before reaching receptor wells.

Longer times to cleanup would influence overall cost of a selected alternative, but would not influence the protectiveness of a remedy. The ability of each alternative to prevent future exposures to groundwater contaminants rests on the extraction network; as long as the extraction wells capture the target volume, the time to cleanup is not an issue for protection of public health. Figure C-2 provides estimates of time to cleanup for a range of concentrations in groundwater on the basis of the model presented in Section 6.6.3 of the RI/FS report.

Evaluation of Short-Term Human Health Risks

Workers involved with construction of facilities required to implement any of the remedial action alternatives would not be exposed to risks greater than normally encountered during construction activities. Portions of these facilities could be constructed over sites with soil contamination. Surface soil contaminants have been characterized at several of these sites; however, some sites would require some soil sampling and analysis prior to initiating construction activities. Sites with contaminant levels in soils representing health hazards to workers could be addressed by remediation of the soil contamination, relocating facility locations to uncontaminated areas (i.e., constructing a pipeline around rather than through a contaminated site), or performing work activities in accordance with the OSHA Hazardous Waste Operations and Emergency Response (HAZWOPER) Rule, 29 CFR 1910.120. Construction activities would not be expected to expose the public to increased health risks.

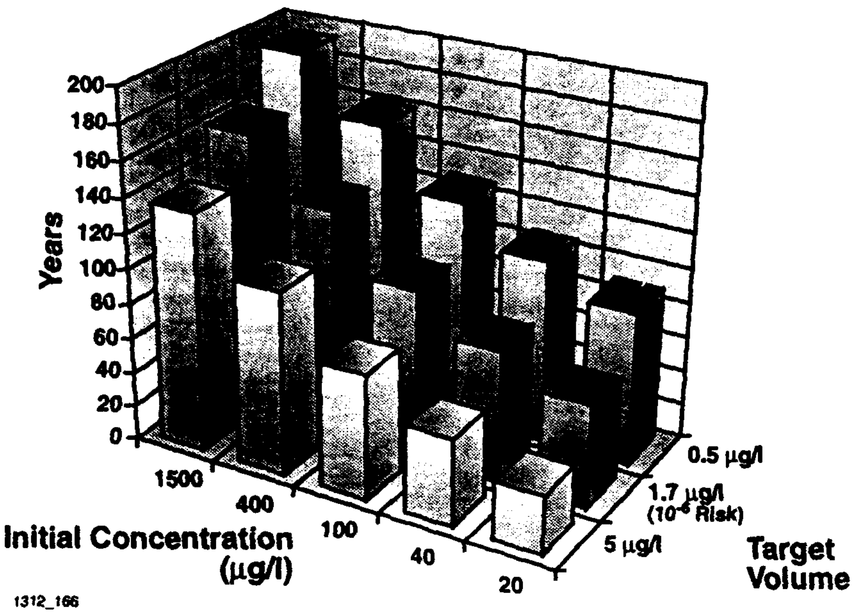

FIGURE C-2
ESTIMATED TIMES TO CLEANUP
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

Short-term health risks during implementation could be associated with emissions of oxidant and acid gases (NO_x, SO_x, and HCl) from CatOx offgas treatment. Depending on location of the treatment facilities, emission rates of oxidant and acid gases, and location of surrounding work areas, there could be adverse pulmonary responses in some workers associated with inhalation exposures to NO_x, SO_x, and HCl. As discussed previously, mitigation of these impacts could involve selection of an offgas treatment other than CatOx, installing scrubbers for control of NO_x, SO_x, and HCl, or siting the treatment facility so that air quality impacts fall at uninhabited locations.

PREPARED FOR: McClellan Air Force Base

DATE: March 25, 1994

SUBJECT: ARARs Analysis
Groundwater OU RI/FS Report
Delivery Order No. 5066

PROJECT: SAC28722.66.FS

Purpose

This technical memorandum defines the concept of applicable or relevant and appropriate requirements (ARARs) and summarizes the potential ARARs for the groundwater remedial options presented in this Remedial Investigation/Feasibility Study (RI/FS) for the McClellan Air Force Base (McClellan AFB) Groundwater Operable Unit (GW OU). These ARARs must be identified so that the regulatory requirements can be considered when evaluating the feasibility of each remedial alternative. Also included is a discussion of how ARARs fit into CERCLA process. *Chemical-*, *location-*, and action-specific ARARs have been selected to determine whether the conditions at the Base present a problem, what the extent of the problem is, and to what extent the problem will need to be remediated. In addition, probable ARARs for the selected remedial alternative have been identified which, after regulatory agency review, could potentially be included in the Interim Record of Decision (ROD). The ROD identifies the ARARs which serve as remedial goals for the groundwater remedial action.

Figure D-1 is a summary of how the preliminary alternatives for extraction, treatment, and end use of contaminated groundwater at the McClellan AFB Superfund site can be affected and/or governed by regulatory statutes considered to be ARARs or other to-be-considered criteria (TBCs).

ARARs and the CERCLA Process

The Superfund process is often represented as being serial, with site discovery leading to the remedial investigation and feasibility study (RI/FS) and on to the Record of Decision (ROD) and remedial actions. This serial representation is, in general, an oversimplification and has led to slow, inefficient progress at sites. Recent efforts to streamline the Superfund process have recognized that it is more complex, with many interrelated processes occurring in parallel and being dependent upon each other. Whether the process for any given site is simply serial or a complex interrelation of parallel activities, EPA's mandate through the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) is to protect human health and the environment; or in other words, "to ensure protectiveness."

One of the first steps in the Superfund process is to define the problem at a site and then determine that the action (or no action) taken in response to the problem is protective of human health and the environment. Along with risk assessment, one of the tools used in definition and solution of a site problem is evaluation of environmental laws and regulations. These are called "ARARs" (defined below).

Defining the problem at a site and evaluating the remedial alternatives for solving it require the evaluation of the facts at the site to determine:

- Is remedial action necessary, i.e., does a problem exist now or is there a threat of a problem?
- What is the areal extent of the action, i.e., how big is the problem?
- What are the performance requirements of the action, i.e., what does the remedial action have to do while it is operating?
- What is the end point, or duration, of the action, i.e., when is remediation completed?

Specific to the McClellan AFB GW OU RI/FS, the treatment parameters must be defined for the subsurface groundwater as well as for the groundwater that is discharged after treatment. For example:

- What are the maximum contaminant levels acceptable before groundwater treatment is required and to what level does the aquifer need to be restored?
- What are the maximum contaminant levels acceptable for the treated groundwater effluent?
- Once treated, how will the effluent be handled, i.e. what is the end use of the treated groundwater?
- What are air emission restrictions for treatment processes?

The ARARs analysis is an important part of answering these questions. The need to meet ARARs can be one factor that determines at what point remedial action is necessary and how it must be implemented.

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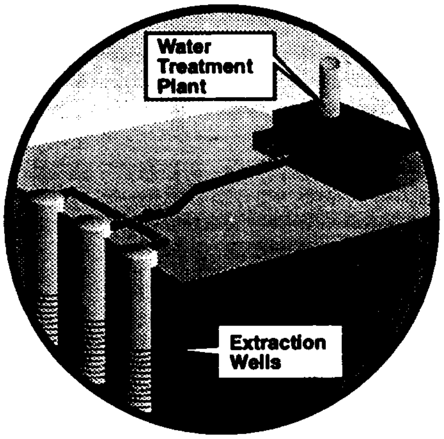

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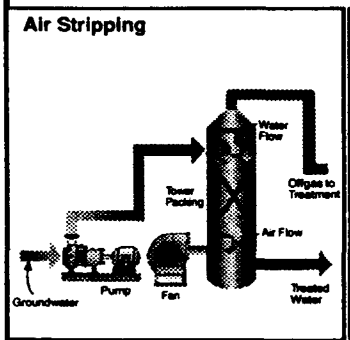
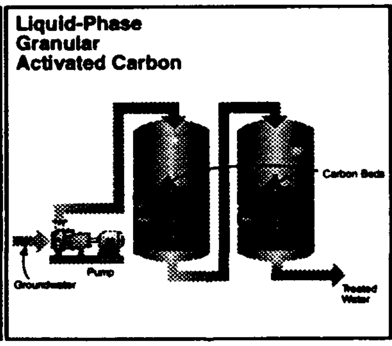
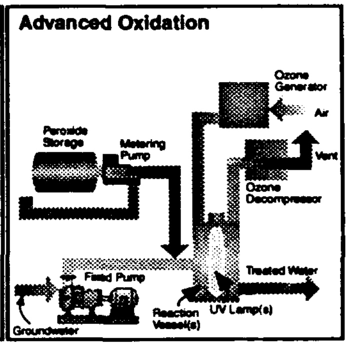
GROUNDWATER TREATMENT ALTERNATIVES







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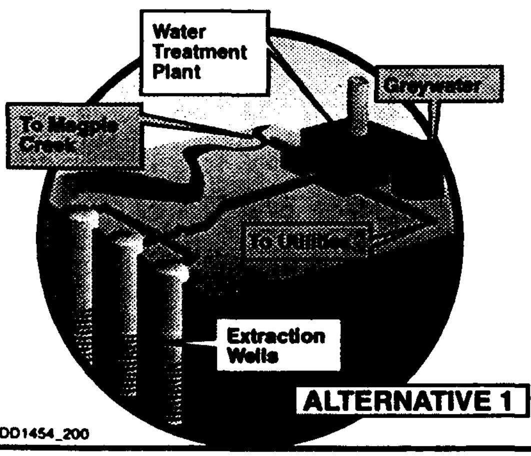

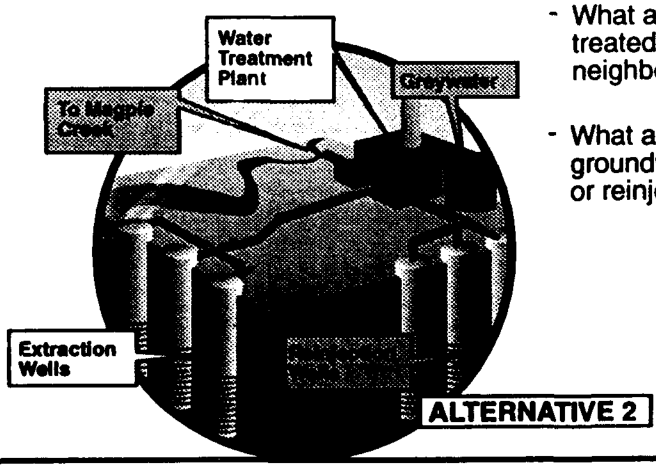

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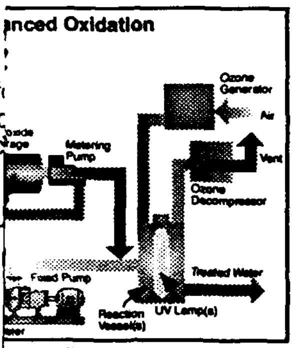
"How do the regulations apply to the design criteria for the McClellan Air Force Base Groundwater Remedial Action?"

Questions answered by potential chemical-specific ARARs and TBCs	Questions answered by potential location-specific ARARs and TBCs	Que… actic…
- What concentration of contamination can be left in the groundwater when remediation is complete? - What are the limits on fugitive dust generation during construction of extraction wells? - What are limits of contaminants in groundwater before the beneficial uses of the aquifer have been degraded?	- Is McClellan Air Force Base located within a flood plain or within an area containing significant artifacts? In a hazardous waste site? How will that affect construction of extraction wells? - What are the identified beneficial uses of groundwater in the area?	- Waste… gener… extrac… faciliti… treate… - Will c… constr… minim… - Will a… distur… will al… dispo…
- What are groundwater MCLs before treatment must occur? - What are MCL standards for human consumption for drinking, cooking, bathing, and other water contact activities? - What are the concentration limits for the treated groundwater effluent?	- Is McClellan Air Force Base located in a wetland or wilderness area which could be influenced by remedial action? Will it affect endangered species, fish, or wildlife? - Will the treatment unit be located on any historic sites? Will it have an impact on property eligible for the National Register? - How will treatment processes impact flood surface profiles? Will potential breakdowns caused by floods cause additional contamination?	- How … be sto… dispo… - Will a… it be t… atmos… - Does… misc…
- What are the contaminant limits on treated groundwater that is sent to neighboring water utilities? - What are the contaminant limits on treated groundwater discharged to local streams or reinjected?	- Will release of treated groundwater to surface water affect local streams, rivers, or wildlife?	- Will t… recei… prote… - Is rei… occu…



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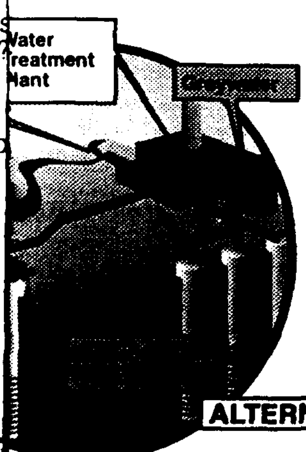

FIGURE D-1
EXAMPLE APPLICA…
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SACRAMENTO, CALIFORNIA

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Questions answered by potential location-specific ARARs and TBCs	Questions answered by potential action-specific ARARs and TBCs
- Is McClellan Air Force Base located within a flood plain or within an area containing significant artifacts? In a hazardous waste site? How will that affect construction of extraction wells? - What are the identified beneficial uses of groundwater in the area?	- Waste soils and water will be generated during construction of extraction, treatment, and end-use facilities. How will they be handled, treated, or disposed of? - Will contaminants be released during construction? How will they be minimized and monitored? - Will any wastes generated or disturbed onsite be moved offsite or will all wastes be treated and disposed of onsite?
- Is McClellan Air Force Base located in a wetland or wilderness area which could be influenced by remedial action? Will it affect endangered species, fish, or wildlife? - Will the treatment unit be located on any historic sites? Will it have an impact on property eligible for the National Register? - How will treatment processes impact flood surface profiles? Will potential breakdowns caused by floods cause additional contamination?	- How will contaminated groundwater be stored, transported, treated, or disposed of? - Will an offgas be generated? How will it be treated before released into the atmosphere? - Does treatment involve a miscellaneous RCRA unit?
- Will release of treated groundwater to surface water affect local streams, rivers, or wildlife?	- Will the beneficial uses of the creeks receiving treated groundwater be protected? - Is reinjection of treated groundwater occuring in a drinking water aquifer?

FIGURE D-1
EXAMPLE APPLICATIONS OF ARARs AND TBCs IN EVALUATING PERFORMANCE/ DESIGN CRITERIA FOR REMEDIAL ACTION
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

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Definition of ARARs and the CERCLA Process

Congress mandated in Section 121(d) of the 1986 Superfund Amendments and Reauthorization Act (SARA) that site cleanups conducted under the CERCLA comply with the requirements of federal and promulgated state environmental and facility siting laws that are applicable or relevant and appropriate to the remedial actions. These laws are known in the Superfund program as ARARs.

Once a requirement has been determined to be an ARAR, then the remedial action chosen by EPA must comply with that requirement (unless a waiver as defined by SARA can be invoked, and EPA decides to invoke that waiver—See Section Waivers). Potential ARARs are usually identified in the RI/FS, and then the final list of ARARs which the remedy must meet is established in EPA's ROD.

Identification of ARARs must be made on a site-specific basis and involves a two-part analysis: first, a determination of whether a given requirement is applicable; then, if it is not applicable, a determination of whether it is both relevant **and** appropriate.

Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that directly apply and specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site. A promulgated requirement is one that is legally *enforceable and of general applicability.* "*Legally enforceable*" means that the law or standard must be issued in accordance with state or federal procedural requirements and contain specific enforcement provisions.

Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not specifically "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well-suited to the particular site.

The determination that a requirement is relevant and appropriate generally involves a comparison of a number of site-specific factors, including the characteristics of the remedial action, the hazardous substances present at the site, or the physical characteristics of the site with those addressed in the statutory or regulatory requirement. If the requirement is not both relevant and appropriate, it is not considered an ARAR for the site. It is possible for portions of a requirement to be considered both relevant and appropriate, while the rest may be dismissed as irrelevant or inappropriate. If a requirement is determined to be both relevant and appropriate, the requirement must be complied with to the same degree as if it were applicable.

Five criteria must be met for a regulation to be considered as a State ARAR:

1. Promulgated standard, requirement, criterion, or limitation
2. More stringent than federal standards, requirements, criteria, or limitations
3. Identified to EPA by the State in a timely manner
4. Structured so it does not result in a statewide prohibition on land disposal
5. The State must apply the regulation consistently.

If a state standard is determined to be "applicable" while a more stringent federal standard is "relevant and appropriate," the more stringent federal standard will govern.

State and Federal ARARs can be divided into three categories. The three classifications are: (1) ambient or chemical-specific requirements, (2) location-specific requirements, and (3) performance, design, or other action-specific requirements. They are defined as follows:

- **Chemical-Specific ARARs** include those laws and requirements which regulate the release to the environment of materials possessing certain chemical or physical characteristics or containing specified chemical compounds. These requirements generally set health- or risk-based concentration limits or discharge limitations for specific hazardous substances. If, in a specific situation, a chemical is subject to more than one discharge or exposure limit, the more stringent of the requirements should generally be applied.

- **Location-Specific ARARs** are those requirements that relate to the geographical or physical position of the site, rather than the nature of the contaminants or the proposed site remedial actions. These requirements may limit the type of remedial actions that can be implemented, and may impose additional constraints on the cleanup action.

- **Action-Specific ARARs** are requirements that define acceptable treatment and disposal procedures for hazardous substances. These ARARs generally set performance, design, or other similar action-specific controls or restrictions on particular kinds of activities related to management of hazardous substances or pollutants. These requirements are triggered by the particular remedial activities that are selected to accomplish a remedy. Since there are usually several alternative actions for any remedial site, very different requirements can come into play. The action-specific requirements do not in themselves determine the remedial alternative; rather, they indicate the performance requirements a selected alternative must achieve.

According to CERCLA 121(e), a remedial response action that takes place entirely onsite may proceed without obtaining permits. This exemption allows the remedial action to progress in a timely manner without the lengthy delays of approval from administrative bodies. Although the administrative requirements do not need to be met, the remedial action must still comply with the substantive requirements of the ARAR. Therefore, for instance, if an environmental law imposes a certain limit that is an ARAR while also requiring that one obtain a permit, only the regulatory limit (substantive) would need to be met, and a permit (administrative) would not need to be acquired before taking the remedial action.

A requirement may not meet the definition of ARAR as defined above, but still be useful in determining whether to take action at a site or to what degree action is necessary. This can be particularly true when there are no ARARs for a site at all. Such requirements are called TBCs. TBC materials are nonpromulgated advisories or guidance issued by federal or state government that are not legally binding, but may provide useful information or recommended procedures for remedial action. Although TBCs do not have the status of ARARs, they are considered along with ARARs as part of the site risk assessment to establish the required level of cleanup for protection of health or the environment.

The critical difference between a TBC and an ARAR is that one is not required to comply with or meet a TBC when deciding on a remedial action. However, should EPA establish a TBC as a cleanup standard in the ROD, then the TBC effectively produces the same results as an ARAR.

ARARs and TBCs are identified at various points throughout the Superfund process. These criteria are identified on a site-specific basis, and therefore as additional information is developed about the site, including special features of the site location, the specific chemicals at the site, and the actions that are being considered as remedies, more ARARs will progressively be identified, and the list of potential ARARs further refined. Figure D-2 is a summary of which ARARs or actions are identified and communicated at each stage of the Superfund process.

ARARs play an important role when selecting a remedy. Each option that has been developed has a variety of factors that can be influenced by ARARs. For instance, a groundwater treatment plant must meet certain performance and treatment standards as outlined in state and federal hazardous waste regulations; an extraction option must be able to meet ARARs governing groundwater quality; an air emission control device option must be able to meet local air quality standards. Whether or not a particular option can meet the standards established in the ARARs may influence whether a particular option is chosen or if a waiver is necessary for an option that is chosen which cannot comply with ARARs.

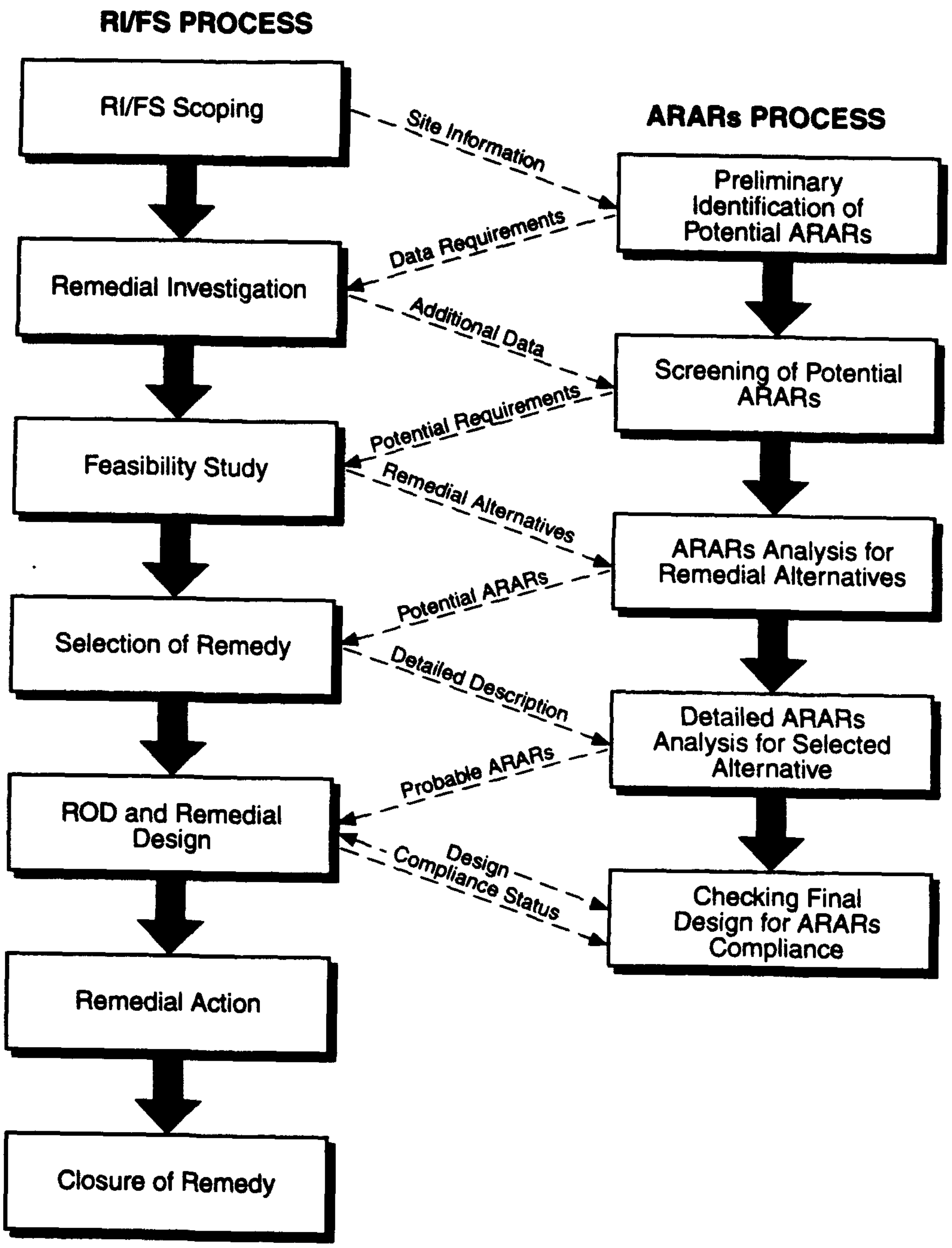

FIGURE D-2
INTERACTION OF THE ARARs PROCESS AND THE RI/FS PROCESS
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

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Waivers

CERCLA Section 121 provides that, under certain circumstances, an otherwise applicable or relevant and appropriate requirement may be waived. These waivers apply only to the attainment of the ARAR; other statutory requirements, such as that remedies be protective of human health and the environment, cannot be waived. The waivers provided by CERCLA Section 121(d)(4) are listed below.

1. Interim Remedy—The remedial action selected is only part of a total remedial action that will attain such a level or standard of control when completed.

2. Greater Risk to Human Health or the Environment—Compliance with the requirement at the site will result in greater risk to human health and the environment than alternative options.

3. Technical Impracticability—Compliance with the requirement is technically impracticable from an engineering perspective.

4. Equivalent Standard of Performance—The remedial action selected will attain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirement, criteria, or limitation through use of another method or approach.

5. Inconsistent Application of State Requirements—With respect to a state standard, requirement, criterion, or limitation, the state has not consistently applied (or demonstrated the intention to apply consistently) the standard, requirement, criterion, or limitation in similar circumstances at other remedial actions.

6. Fund Balancing—In the case of a remedial action to be undertaken solely under Section 104 using the Fund; selection of a remedial action that attains the level or standard of control in the requirement will not provide a balance between the need for protection of public health and welfare and the environment at the site under consideration, and the availability of amounts from the Fund to respond to other sites that present or may present a threat to public health or welfare or the environment, taking into consideration the relative immediacy of such threats.

The fund balancing waiver is not available to McClellan AFB because remedial actions taken at the Base are not fund actions. It is not anticipated that any waivers will be required for the proposed alternative. The selected extraction, treatment, and end-use alternatives will be able to meet all of the chemical-, location-, and action-specific ARARs.

ARAR Process for the Groundwater OU at McClellan AFB

To adequately manage the contamination at McClellan AFB, the Base has been divided into 10 OUs. These OUs correspond to specific source areas where historical industrial operations and waste management practices have led to soil, soil gas, and groundwater contamination. The Davis Site, which is located outside of McClellan AFB boundaries, has been designated as an offbase investigation and remediation management site. The GW OU encompasses the groundwater underlying the entire Base that has been contaminated by the source areas identified in the other OUs.

The OUs at McClellan AFB have been prioritized based on severity of contamination and whether it is a source of groundwater contamination. Potential ARARs have been or will be identified in the RI/FS reports for each OU. Between 1993 and 2001 an Interim ROD will be developed for each OU, and the ARARs identified in each Interim ROD will serve as remedial goals as implementation of the selected alternative proceeds. As each Interim ROD is completed, remedial design will be completed and the alternative implementation will proceed. The OU remedial actions that result in hazardous substances being left onsite above health-based levels will be reviewed 5 years after each of their respective Interim RODs to determine whether the remedial action has been effective.

Once all of the RODs have been completed, a final basewide ROD will incorporate and update all of the Interim RODs. The ARARs identified in the Interim ROD will be met during the remedial design/remedial action (RD/RA) phase and will be closely aligned to the ARARs presented in the final Basewide ROD. The Basewide ROD will allow for new information acquired at the site or new or updated regulations to be applied to the remedial actions as it becomes available. The ARARs presented in the Interim ROD will serve as goals for the RA, where the Basewide ROD ARARs will be fixed standards for all of OU the remedial actions. This ARAR process and how the Groundwater and other OU Interim RODs fit into this process are displayed on Figure D-3.

The potential and probable ARARs identified and analyzed in this appendix are those which could potentially impact the remedial goals and alternatives discussed in this RI/FS. This analysis is McClellan AFB's position on which ARARs define the problem at the Base and those performance requirements that must be met by the remedial alternatives. These ARARs will be submitted to U.S. EPA and various state agencies for review. The final ARARs will be identified in the Interim ROD for the GW OU.

Overview of the Groundwater OU

Groundwater OU Background

McClellan AFB was established in 1936 to function as an air repair depot and supply base. During World War II, the Base became a major industrial facility with capabilities ranging from bomber and cargo aircraft maintenance to wastewater treatment capabilities. In the early 1950s, the Base became a jet fighter maintenance depot. From its beginning, McClellan AFB has used a variety of toxic substances including solvents, caustic cleaners, metal plating solutions, fuel, oils, and lubricants. In 1979,

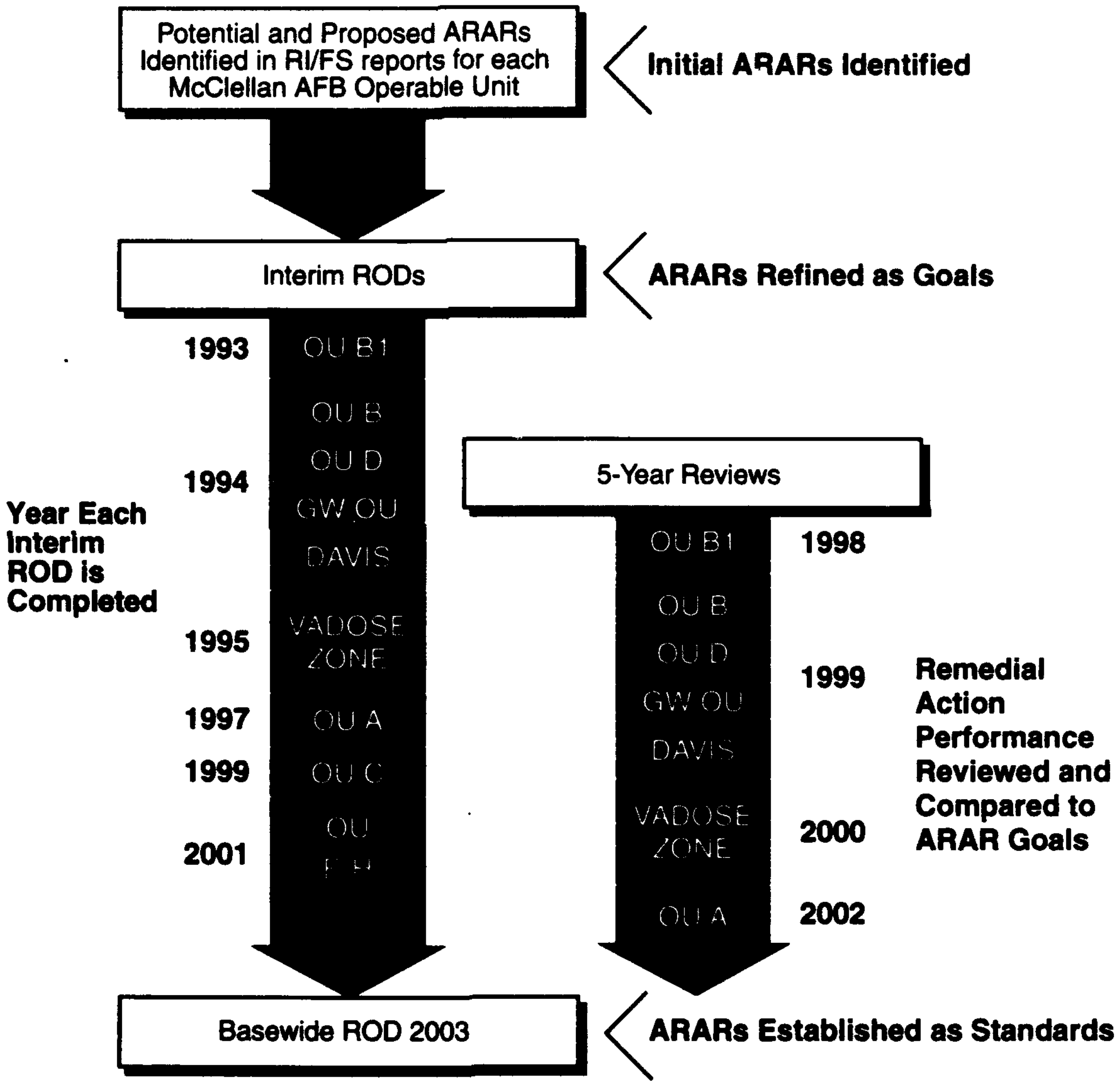

FIGURE D-3
ARARs PROCESS
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

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concern arose over the disposal practices of these materials so a groundwater sampling effort began. In 1980, trichloroethene was detected in some Base wells.

The historical hazardous material management practices that once occurred at the Base have contributed to the groundwater contamination that now exists at the site. Examples of sources that have contributed to the groundwater contamination include: hazardous waste leaching from unlined disposal pits; leaking underground storage tanks, surface spills, and improper hazardous material handling practices in aircraft maintenance areas; and an industrial wastewater pipeline that runs throughout McClellan AFB which has leaked over many years.

Groundwater levels have historically been higher than today. As the groundwater levels dropped because of increased agricultural, domestic, and McClellan AFB pumping, the direction of the groundwater flow changed. This change in the movement of the groundwater caused the contaminants to disperse, resulting in a Basewide groundwater problem.

The drop in the groundwater levels has also resulted in deposition of contaminant residual in the vadose zone. The thickness of the contaminated vadose zone will continue to increase if the groundwater levels continue to drop. The residual contamination in the vadose zone is a potential ongoing source of contamination to groundwater.

Generally, the aerial extent of the contaminated groundwater is within, and to a small extent, beyond the property boundaries of the Base. The four contaminants of concern include trichloroethene, cis-1,2-dichloroethene, tetrachloroethene, and 1,2-dichloroethane. The contaminants of concern were selected based on the frequency of detection, whether the concentrations were above maximum contaminant levels (MCLs) (see Section Potential Chemical-Specific ARARs), and whether the compounds were risk drivers.

Currently, the water table exists at a depth of approximately 95 feet to 105 feet beneath the surface with seasonal fluctuations of up to 5 feet. However, the water level is expected to continue to drop as the pumping of groundwater in the area continues. Additional information on the groundwater conditions at McClellan AFB is included in Chapter 4 of the RI/FS.

The beneficial uses of the groundwater in the vicinity of the Base include municipal, agricultural, industrial, and domestic water supply. Although the shallower zones of the groundwater underlying the Base contain most of the contamination, the Base still has active supply wells that pump from the deeper, less contaminated aquifer zones. A wellhead water treatment unit has been installed to treat the water prior to use on the Base. Outside of the zone of influence, groundwater is pumped for domestic and agricultural water supplies. The groundwater contamination at the Base threatens the beneficial uses of these offsite groundwater supplies.

Overview of Remedial Alternatives

In defining potential ARARs for the McClellan AFB Groundwater OU, the California Department of Toxic Substances Control (DTSC), the Department of Health Services (DHS) Office of Drinking Water, the Sacramento Metropolitan Air Quality Management District (SMAQMD), and the Regional Water Quality Control Board (RWQCB) were solicited to identify potential ARARs. The agencies were given a brief description of remedial alternatives that were under consideration so that they could provide a list of applicable regulations. From the lists of potential ARARs submitted by these agencies, the regulations have been organized into categories of potential chemical-, location-, and action-specific ARARs and TBCs, and are presented in this appendix.

In general, the sequence in identifying ARARs for a particular site is to identify the ARARs that impact remedial goals, independent of possible remedial alternatives. These are usually the chemical-specific and location-specific regulations. Chemical-specific laws and requirements regulate the release of specified chemical compounds or materials possessing certain chemical or physical characteristics into the environment. Location-specific ARARs relate to the geographical or physical position of the site rather than the contaminants or the remedial action. Next, the action-specific ARARs are identified for each remedial alternative. These are basically the performance requirements of the system and may impact the cost or implementability of the alternative. Based on this approach, the ARARs are fixed for a given alternative.

Table D-1 briefly describes the extraction, treatment, and end-use options presented in this McClellan AFB Groundwater OU RI/FS. There are three extraction options, each of which will include extraction of groundwater found to have TCE concentrations greater than 500 μg/l. This TCE extraction criterion is referred to as "hot spots" in this RI/FS. Each extraction option will pump to contain groundwater movement, i.e., minimize migration of contamination.

There are 12 groundwater treatment options considered in this RI/FS. Each of the options is made up of single technologies, or combinations of treatment technologies. The treatment options also include offgas control technologies, where applicable. The general treatment technology categories include advanced oxidation processes (AOP), air stripping, and liquid-phase granular activated carbon (LGAC). The AOPs chemically oxidize all VOCs present to nonhazardous reaction products that exit with the groundwater stream. UV/ozone AOP, UV/hydrogen peroxide AOP, and ozone/hydrogen peroxide AOP are the three technologies considered in this RI/FS. UV/ozone and ozone/hydrogen peroxide AOPs require offgas treatment. These AOP technologies are also being considered as pretreatment to other technologies such as air stripping.

Air stripping is performed using a tower to contact groundwater flowing downward with air flowing upward. VOCs are transferred from the groundwater to the gas and exit the tower in an offgas stream. The offgas requires treatment before being released to the environment.

Table D-1
McClellan AFB Groundwater OU
Summary of Extraction, Treatment, and End-Use Options

Option Name	Option Description
Extraction Options	
10^{-6} Increased Cancer Risk Target Volume	Extract volume of groundwater within plume contaminated with concentration levels equivalent to 10^{-6} increased cancer risk or greater.
MCL Target Volume	Extract volume of groundwater within plume contamin with concentration levels greater than or equal to maxi contaminant levels (MCL) set by the Safe Drinking Water Act.
Background Target Volume	Extract volume of groundwater within plume contaminated with detectable concentrations of organics.
Hot Spots	Extract groundwater in areas with TCE contamination greater than 500 $\mu g/l$.
Treatment Options	
Ozone Peroxide Advance Oxidation	Using hydrogen peroxide and ozone air stream, chemically oxidize VOCs in the extracted groundwater to nontoxic reaction products which pass system in treated water. Decompose to oxygen in a catalytic vent control device ozone not oxidized in reactor. Equipment: reaction vessel, ozone generator, pumps, hydrogen peroxide tanks and containment
UV Peroxide Advanced Oxidation	Chemically oxidize the VOCs with hydrogen peroxide, enhanced with UV light. Non-toxic reaction products pass system in treated water. Equipment: reaction vessel with integral UV lamps, pumps, hydrogen peroxide tanks, and containment

Table D-1
McClellan AFB Groundwater OU
Summary of Extraction, Treatment, and End-Use Options

Option Name	Option Description
Air Stripping with Vapor-Phase Activated Carbon (VGAC)	Air stripping uses a tower to contact groundwater with air where VOCs transfer from the water to gas and exit the tower in an offgas stream. The gas is heated, then passed through activated carbon beds where VOCs are removed through gas phase adsorption onto the carbon. Treated gas is released to the atmosphere. Treatment residuals include VOC-saturated carbon, which is typically regenerated offsite. Equipment: Air stripping tower, air blower, pumps, duct heaters, fiberglass vessels to house the carbon beds, and a stack.
Air Stripping with Catalytic Oxidation (CatOx)	Remove VOCs from the groundwater with air stripping as described above. Remove VOCs in the air stripper offgas by heating the offgas, and passing it through a catalyst bed, which oxidizes the VOCs to nontoxic by-products and hydrochloric acid. A separate scrubber treats offgas if residual hydrochloric acid is significant to warrant treatment. Equipment: Air stripping tower, air blower, pumps, packaged oxidizer system, stack, and, if scrubbing is required, sodium hydroxide storage system.
Liquid-Phase Activated Carbon (LGAC)	Groundwater is passed through activated carbon beds where the VOCs are adsorbed onto the carbon. The VOC-saturated carbon is typically regenerated at a vendor facility offsite. Equipment: Above-ground skid-mounted carbon-filled tanks and pumps.

Table D-1
McClellan AFB Groundwater OU
Summary of Extraction, Treatment, and End-Use Options

Option Name	Option Description
Ozone Peroxide Pretreatment Before Air Stripping with VGAC	Using an ozone air stream and hydrogen peroxide, VOCs in the extracted groundwater are reacted into nontoxic products. Pretreated groundwater is then passed through an air stripping tower, and the offgas is then treated through adsorption as described above for VGAC. VOC-saturated carbon is typically regenerated offsite. Equipment: ozone reaction vessel, ozone generator, pumps, hydrogen peroxide tanks and containment, air stripping tower, air blower, duct heaters, fiberglass carbon-bed vessels, and a stack.
Ozone Peroxide Pretreatment Before Air Stripping with CatOx	Using an ozone air stream and hydrogen peroxide, VOCs in the extracted groundwater are reacted into nontoxic products. Pretreated groundwater is then passed through an air stripping tower, then the offgas is treated through adsorption as described above for CatOx. Spent carbon is typically regenerated offsite. A separate scrubber treats offgas if residual hydrochloric acid warrants treatment. Equipment: ozone reaction vessel, ozone generator, pumps, hydrogen peroxide tanks and containment, air stripping tower, air blower, packaged oxidizer system, stack, and, if required, sodium hydroxide storage system.
UV Peroxide Pretreatment Before Air Stripping With VGAC	The extracted groundwater is pretreated by chemically oxidizing the VOCs with hydrogen peroxide, enhanced with UV light. The pretreated groundwater is transported through an air stripping tower. The offgas is then treated through adsorption as described above for VGAC. VOC-saturated carbon is typically regenerated offsite. Equipment: reaction vessel with integral UV lamps, pumps, hydrogen peroxide tanks and containment, air stripping tower, air blower, duct heaters, fiberglass carbon-bed vessels, and a stack.

Table D-1
McClellan AFB Groundwater OU
Summary of Extraction, Treatment, and End-Use Options

Option Name	Option Description
UV Peroxide Pretreatment Before Air Stripping with CatOx	Pretreat the extracted groundwater by chemically oxidizing the VOCs with hydrogen peroxide, enhanced with UV light. The pretreated groundwater is transported through an air stripping tower. The offgas is heated, then passed through a catalyst bed, oxidizing the VOCs to nontoxic products and hydrochloric acid. A separate scrubber treats offgas if residual hydrochloric acid warrants treatment. Equipment: reaction vessel with integral UV lamps, pumps, hydrogen peroxide tanks and containment, air stripping tower, air blower, packaged oxidizer system, stack, and if required, sodium hydroxide storage.
Air Stripping with VGAC Followed by LGAC Post-Treatment	Air stripping results in VOCs transferring from a water to a gas phase. Offgas is heated and treated as described above for VGAC. The air stripper water effluent is passed through carbon beds as described above for LGAC. Treatment residuals include VOC-saturated carbon, which is typically regenerated offsite. Equipment: Air stripping tower, air blower, pumps, duct heaters, fiberglass vessels to house the VGAC carbon beds, stack, and above-ground, skid-mounted, carbon-filled tanks for the LGAC treatment.
Air Stripping with CatOx Followed by LGAC Post-Treatment	Air stripping results in VOCs transferring from a water to a gas phase. Offgas is heated and treated as described above for CatOx. The air stripper water effluent is passed through carbon beds as described above for LGAC. Treatment residuals include VOC-saturated carbon, which is typically regenerated offsite. A separate scrubber treats offgas if residual hydrochloric acid is significant to warrant treatment. Equipment: Air stripping tower, air blower, pumps, packaged oxidizer system, stack, duct heaters, above-ground, skid-mounted, carbon-filled tanks for the LGAC treatment, and, if scrubbing is required, sodium hydroxide storage system.

Table D-1
McClellan AFB Groundwater OU
Summary of Extraction, Treatment, and End-Use Options

Option Name	Option Description
Use Existing Groundwater Treatment Plant	The existing treatment plant uses a combination of elevated temperature air stripping, secondary water treatment with LGAC, thermal incineration, and acid scrubbing of the incinerator offgas. Aqueous acid is stored onsite to control scale in the air stripper and heat exchangers. VOC-saturated carbon is regenerated offsite and carbon backwash water is discharged to McClellan AFB treatment systems.
End-Use Options	
Base Greywater/Neighboring Utilities/Magpie Creek	Use 200 gpm for McClellan AFB greywater system, sell the rest to neighboring water utilities with discharge to Magpie Creek as backup. Structures/equipment: conveyance pipeline, pump station and pumps, discharge structure
Base Greywater/Groundwater Reinjection/Magpie Creek	Use 200 gpm for McClellan AFB greywater system, inject remainder to groundwater onsite, with discharge to Magpie Creek as backup. Structures/equipment: conveyance pipeline, pump station and pumps, discharge structure, and injection wells.

The third groundwater technology is accomplished using LGAC. This technology works through the adsorption of contaminants onto carbon beds. Once the carbon beds are saturated, they are taken offsite for regeneration at a vendor facility. There is no offgas generated from this process.

The three offgas treatment technologies included as part of some of the options discussed in Table D-1 include catalytic oxidation (CatOx) thermal incineration, and vapor-phase granular activated carbon (VGAC). The CatOx process oxidizes VOCs to by-products including water vapor, carbon dioxide, and hydrochloric acid (which can be removed by a caustic scrubber if present in significant amounts).

Thermal incineration employs the heating of the airstream to the point where airborne contaminants will oxidize through combustion with atmospheric oxygen. The resulting stream consists of carbon dioxide, carbon monoxide, hydrochloric acid, and sulfur and nitrogen oxides. Hydrochloric acid may require scrubbing.

VGAC adsorption mechanism is similar to that used to treat groundwater. VOCs adsorb onto the carbon bed, which is then regenerated at an offsite facility.

Two end-use options considered in this RI/FS use treated groundwater in the McClellan AFB greywater system with discharge to Magpie Creek as backup. However, groundwater in excess of that used in the greywater system is sold to a neighboring utility in one option, and injected into the groundwater system in the second option. Additional information on the extraction, treatment, and end-use options is included in Chapters 8, 9, and 10, respectfully.

Potential Chemical-Specific ARARs and TBCs

The potential chemical-specific ARARs and TBCs presented on Tables D-2 and D-3 have been divided into two categories: groundwater remedial goals and surface water discharge requirements. The criteria listed on Table D-2 are ARARs and TBCs that represent promulgated regulatory limits and other water quality objectives for the groundwater underlying McClellan AFB. These numerical values are potential levels to which the groundwater may need to be remediated. Table D-3 is a list of effluent limitations for treated groundwater which may be discharged to Magpie Creek from a proposed groundwater treatment plant.

ARARs and TBCs Affecting Groundwater Remedial Goals

The major regulations and objectives that contribute to the list of potential chemical-specific ARARs and TBCs for the groundwater remedial goals include the Safe Drinking Water Act (SDWA), State Water Resources Control Board (SWRCB) Resolution 92-49, Region IX Preliminary Remediation Goals (PRGs), U.S. EPA Integrated Risk Information System (IRIS) Reference Doses, California Proposition 65 Regulatory Levels as water quality criteria, California EPA Cancer Potency Factors, and risk-based remedial action objectives developed through risk assessment.

Table D-2
Potential Chemical-Specific ARARs and TBCs
Groundwater Remedial Goals
µg/l

Compound	ARARS					TBCs		
	Drinking Water Standards					U.S. EPA IRIS Reference Dose [1]	California Proposition 65 [2]	Cal/EPA Cancer Potency Factors [3]
	CA DHS		EPA					
	Primary MCL	Secondary MCL	Primary MCL	Secondary MCL	MCLG			
METALS								
ALUMINUM	1000	--	--	50 to 200	--	--	--	--
ANTIMONY	--	--	6[A]	--	6[A]	2.8	--	--
ARSENIC	50	--	50	--	--	--	5	--
BARIUM	1000	--	2000	--	2000	490	--	--
BERYLLIUM	--	--	4[A]	--	--	--	15	--
BORON	--	--	--	--	--	630	--	--
CADMIUM	10	--	5	--	5	3.5	(F)	(F)
CALCIUM	--	--	--	--	--	--	--	--
CHROMIUM, TOTAL	50	--	100	--	100	35	--	--
CHROMIUM, HEXAVALENT	--	--	--	--	--	--	15	--
COBALT	--	--	--	--	--	--	--	--
COPPER	--	1000	1300[D]	--	1300	--	--	--
IRON	--	--	--	--	--	--	--	--
LEAD	50	--	15[D]	--	0	--	0.25[E]	--
MAGNESIUM	--	--	--	--	--	--	--	--
MANGANESE	--	50	--	--	--	900	--	--
MERCURY	2	--	2	--	2	2.1	--	--
MOLYBDENUM	--	--	--	--	--	35	--	--
NICKEL	--	--	100[A]	--	100[A]	--	--	--
POTASSIUM	--	--	--	--	--	140	(F)	(F)
SELENIUM	10	--	50	--	50	35	--	--
SILICON	--	--	--	--	--	--	--	--
SILVER	50	--	100	--	--	35	--	--
SODIUM	--	--	--	--	--	--	--	--
THALLIUM	--	--	2[A]	--	0.5[A]	0.5	--	--
TOTAL CYANIDE	--	--	200[A]	--	--	150	--	--
VANADIUM	--	--	--	--	--	21	--	--
ZINC	--	5000	--	5000	--	2100	--	--

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Table D-2
Potential Chemical-Specific ARARs and TBCs
Groundwater Remedial Goals
µg/l

Compound	ARARS					TBCs		
	Drinking Water Standards					U.S. EPA IRIS Reference Dose [1]	California Proposition 65 [2]	Cal/EPA Cancer Potency Factors [3]
	CA DHS		EPA					
	Primary MCL	Secondary MCL	Primary MCL	Secondary MCL	MCLG			
VOCs								
1,1,1-TRICHLOROETHANE	200	--	200	--	200	250	--	--
1,1,2,2-TETRACHLOROETHANE	1	--	--	--	--	--	--	--
1,1,2-TRICHLOROETHANE	32	--	5 [A]	--	3 [A]	--	--	--
1,1-DICHLOROETHANE	5	--	--	--	--	--	--	50
1,1-DICHLOROETHENE	6	--	7	--	7	6.3	--	--
1,2-DICHLOROBENZENE	--	--	600	10 [B]	600	620	--	--
1,2-DICHLOROETHANE	0.5	--	5	--	0	--	5	0.5
1,2-DICHLOROPROPANE	5	--	5	--	0	--	--	0.56
1,3-DICHLOROBENZENE	--	--	600	--	600	620	--	--
1,4-DICHLOROBENZENE	5	--	75	5 [B]	75	70	10	0.88
2-BUTANONE (MEK)	--	--	--	--	--	--	--	--
2-HEXANONE	--	--	--	--	--	--	--	--
4-METHYL-2-PENTANONE	--	--	--	--	--	--	--	--
ACETONE	--	--	--	--	--	700	--	--
BENZENE	1	--	5	--	0	--	3.5	0.35
BROMODICHLOROMETHANE	100 [C]	--	100 [C]	--	--	--	2.5	0.27
CARBON TETRACHLORIDE	0.5	--	5	--	0	--	2.5	0.23
CHLOROBENZENE	30	--	100	--	100	14	--	--
CHLOROETHANE	--	--	--	--	--	--	100 [B]	--
CHLOROFORM	100 [C]	--	100 [C]	--	--	--	10	1.1/0.43
CHLOROMETHANE	--	--	--	--	--	2.8	--	--
CIS-1,2-DICHLOROETHENE	6	--	70	--	70	--	5	0.5
DIBROMOCHLOROMETHANE	100 [C]	--	100 [C]	--	--	14	3.5	--
DICHLORODIFLUOROMETHANE	--	--	--	--	--	1400	--	--
ETHYLBENZENE	680	--	700	3 [B]	700	700	--	--
METHYLENE CHLORIDE	--	--	5 [A]	--	0 [A]	--	--	--
TETRACHLOROETHENE	5	--	5	--	0	--	--	--
TOLUENE	--	--	1000	40 [B]	1000	1400	3500 [E]	
TOTAL 1,3-DICHLOROPROPENE	0.5	--	--	--	--	--	--	0.19
TOTAL XYLENES	1750	--	10000	20 [B]	10000	14000	50 [B]	--

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Table D-2
Potential Chemical-Specific ARARs and TBCs
Groundwater Remedial Goals
µg/l

Compound	ARARS					TBCs		
	Drinking Water Standards					U.S. EPA IRIS Reference Dose [1]	California Proposition 65 [2]	Cal/EPA Cancer Potency Factors [3]
	CA DHS		EPA					
	Primary MCL	Secondary MCL	Primary MCL	Secondary MCL	MCLG			
TRANS-1,2-DICHLOROETHENE	10	--	100	--	100	--	5	0.5
TRICHLOROETHENE	5	--	5	--	0	--	--	--
TRICHLOROFLUOROMETHANE	150	--	--	--	--	2100	--	--
VINYL CHLORIDE	0.5	--	2	--	0	--	1.5	0.13

Notes:

(1) Assume 70 kg body weight, 2 liters/day water consumption, and 20% relative source contribution. an additional uncertainty factor of 10 is used for class C carcinogens.

(2) Regulatory dose level divided by 2 liters per day average consumption; represents a 1-in-100,000 incremental cancer risk estimate unless otherwise noted.

(3) Assumes 70 kg body weight and 2 liters/day water consumption.

(A) Effective 17 Jan 94

(B) Proposed

(C) For total trihalomethanes based largely on technology and economics.

(D) MCL includes this "Action level", to be exceeded in no more than 10% of samples

(E) Based on Reproductive Toxicity

(F) Determined not pose a risk of cancer through ingestion (Title 22, CCR, Division 2).

-- = not listed

Abbreviations:

DHS — Department of Health Services.
IRIS — Integrated Risk Information System
MCL — Maximum Contaminant Level.
MCLG — Maximum Contaminant Level Goal.

Source Documents: (A) Drinking Water Regulations and Health Advisories by Office of Water/EPA, December 1992
(B) Region 9/U.S. EPA, Drinking Water Standards and Health Advisories Table, December 1992
(C) Marshack, Jon B. A compilation of Water Quality Goals. May 199

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Table D-3
Potential Chemical-Specific ARARs and TBCs
Surface Discharge Quality Goals

Compound	ARARs		TBCs	
	Clean Water Act Ambient Water Quality Criteria		Inland Surface Waters Plan	
	Protection of Aquatic Life		Freshwater Aquatic Life Protection	
	Freshwater Acute (μg/l)	Freshwater Chronic (μg/l)	1-Hour Average (μg/l)	4-Day Average (μg/l)
Inorganics				
Aluminum	--	--	--	--
Antimony	(9,000)	(1,600)	--	--
Arsenic	360	190	360	190
Barium	--	--	--	--
Beryllium	(130)	(5.3)	--	--
Boron	--	--	--	--
Cadmium	(3.9)	(1.1)	1.4[a,c]	0.55[a,b]
Chromium, Hexavalent	(16)	(11)	16[d]	11[d]
Chromium, Trivalent	1,700	210	16[d]	11[d]
Cobalt	--	--	--	--
Copper	(18)	(12)	7.5[f,g]	5.4[a,e]
Cyanide, Total	22	5.2	22[k]	5.2[k]
Iron	--	--	--	--
Lead	(82)	(3.2)	25[a,h]	0.99[a,g]
Manganese	--	--	--	--
Mercury	(2.4)	(0.012)	2.4	--
Molybdenum	--	--	--	--
Nickel	(1,400)	(160)	653[a,j]	73[a,i]
Potassium	--	--	--	--
Selenium	(20)	(5)	20	5.0
Silver	(4.1)	(0.12)	--	--
Thallium	(1,400)	(40)	--	--
Vanadium	--	--	--	--
Zinc	(120)	(110)	54[a,m]	49[l]
Volatile Organic Compounds				
1,1,1-Trichloroethane	--	--	--	--
1,1,2,2-Tetrachloroethane	--	--	--	--
1,1,2-Trichloroethane	--	--	--	--

Table D-3
Potential Chemical-Specific ARARs and TBCs
Surface Discharge Quality Goals

Compound	ARARs: Clean Water Act Ambient Water Quality Criteria — Protection of Aquatic Life		TBCs: Inland Surface Waters Plan — Freshwater Aquatic Life Protection	
	Freshwater Acute (μg/l)	Freshwater Chronic (μg/l)	1-Hour Average (μg/l)	4-Day Average (μg/l)
1,1-Dichloroethane	--	--	--	--
1,1-Dichloroethene	(11,600)[n]	--	--	--
1,2-Dichlorobenzene	(1,120)[o]	(743)[o]	--	--
1,2-Dichloroethane	(118,000)	--	--	--
1,2-Dichloropropane	--	--	--	--
1,3-Dichlorobenzene	(1,120)[o]	(763)[o]	--	--
1,4-Dichlorobenzene	(1,120)[o]	(763)[o]	--	--
2-Butanone (MEK)	--	--	--	--
2-Hexanone	--	--	--	--
4-Methyl-2-Pentanone	--	--	--	--
Acetone	--	--	--	--
Benzene	(5,300)	--	--	--
Bromodichloromethane	(11,000)[p]	--	--	--
Carbon Tetrachloride	(35,200)	--	--	--
Chlorobenzene	(250)[q]	(50)	--	--
Chloroethane	--	--	--	--
Chloroform	(28,900)	(1,240)	--	--
Chloromethane	(11,000)[p]	--	--	--
cis-1,2-Dichloroethene	(11,600)[n]	--	--	--
trans-1,2-Dichloroethene	(11,600)[n]	--	--	--
Dibromochloromethane	(11,000)[p]	--	--	--
Dichlorodifluoromethane	(11,000)[p]	--	--	--
1,3-Dichloropropene, Total	(6,060)[r]	(244)[r]	--	--
Ethylbenzene	(32,000)	--	--	--
Methylene Chloride	(12,000)[p]	(6,400)[p]	--	--
Tetrachloroethene	(5,280)	(840)	--	--
Toluene	(17,000)	--	--	--
Trichloroethene	(45,000)	--	--	--
Trichlorofluoromethane	(11,000)[p]	--	--	--

Table D-3
Potential Chemical-Specific ARARs and TBCs
Surface Discharge Quality Goals

	ARARs		TBCs	
	Clean Water Act Ambient Water Quality Criteria		Inland Surface Waters Plan	
	Protection of Aquatic Life		Freshwater Aquatic Life Protection	
Compound	Freshwater Acute (μg/l)	Freshwater Chronic (μg/l)	1-Hour Average (μg/l)	4-Day Average (μg/l)
Vinyl Chloride	--	--	--	--
Xylenes, Total	--	--	--	--

[a]Value based on hardness of 40 mg/l; value increases with increasing hardness.

[b]For hardness in mg/l as $CaCO_3$, criterion = e(0.7852[In(hardness)] - 3.490) μg/l.

[c]For hardness in mg/l as $CaCO_3$, criterion = e(1.128[In(hardness)] - 3.828) μg/l.

[d]Value developed for chromium VI; may be applied to total chromium if valence unknown.

[e]For hardness in mg/l as $CaCO_3$, criterion = e(0.8545[In(hardness)] - 1.465) μg/l.

[f]For hardness in mg/l as $CaCO_3$, criterion = e(0.9422[In(hardness)] - 1.464) μg/l.

[g]For hardness in mg/l as $CaCO_3$, criterion = e(1.273[In(hardness)] - 4.705) μg/l.

[h]For hardness in mg/l as $CaCO_3$, criterion = e(1.273[In(hardness)] - 1.460) μg/l.

[i]For hardness in mg/l as $CaCO_3$, criterion = e(0.8460[In(hardness)] + 1.1645) μg/l.

[j]For hardness in mg/l as $CaCO_3$, criterion = e(0.8460[In(hardness)] + 3.3612) μg/l.

[k]Proposed.

[l]For hardness in mg/l as $CaCO_3$, criterion = e(0.8473[In(hardness)] + 0.7614) μg/l.

[m]For hardness in mg/l as $CaCO_3$, criterion = e(0.8473[In(hardness)] + 0.8604) μg/l.

[n]For sum of dichloroethenes.

[o]For sum of dichlorobenzenes.

[p]For sum of halomethanes.

[q]For sum of chlorinated benzenes.

Note:
Values in parentheses are TBC criteria, including federal AWQC that in 57 Federal Register 60847 were stated not to be applicable to the State of California, and other proposed criteria that have not been promulgated.

In determining whether the SDWA applies to the groundwater underlying McClellan AFB, the groundwater classification and beneficial uses must first be identified. EPA's policy for groundwater classification is set forth in the preamble to the NCP (55 Federal Register 8752-8756). This policy uses the groundwater classification system provided in the EPA *Guidelines for Groundwater Classification under the EPA Groundwater Protection Strategy* (U.S. EPA, 1986). Under this policy, groundwater is classified in one of three categories (Class I, II, and III) based on ecological importance, replaceability, and vulnerability considerations. Irreplaceable groundwater that is currently used by a substantial population or groundwater that supports a vital habitat is considered Class I. Class II groundwater consists of groundwater that is currently being used or water that might be used as a source of drinking water in the future. Groundwater that cannot be used for drinking water due to insufficient quality (e.g., high salinity or widespread naturally occurring contamination) or quantity is considered to be Class III. The beneficial uses for the groundwater in the McClellan AFB area, as designated by the Regional Water Quality Control Board, include municipal, agricultural, industrial, and domestic water supply. Based on these beneficial uses, the groundwater could be classified as a Class II aquifer because it is being used as a source of drinking water.

The Safe Drinking Water Act, 42 USC §300(f), et seq., provides limits on the concentrations of certain hazardous materials in drinking water "at the tap." The Act establishes both MCLs, which are enforceable limits, and maximum contaminant level goals (MCLGs), which are not enforceable against drinking water providers. The SDWA MCL standards are based on human consumption of water for drinking, cooking, bathing, etc. Economic considerations and technical feasibility of treatment processes are included in the justification for these levels. MCLs are applicable to the quality of drinking water at the tap pursuant to the SDWA and are ARARs for treated groundwater when the end use is drinking water.

If the treated groundwater that meets the promulgated MCLs is sold to neighboring utilities as an end-use option, the use of the water as a new source of supply for the utilities would have to be approved by Department of Health Services, Office of Drinking Water (DHS-ODW). The California Health and Safety Code, Chapter 7, Section 4016, states that if the utilities modify or add to their current permitted water supply, they would have to submit an application to DHS-ODW to have their permit amended.

MCLGs are established by U.S. EPA under the National Primary Drinking Water Regulations and are the first step in establishing MCLs. These MCLGs are set at levels which represent no adverse health risks, and are set at zero for known and probable human carcinogen.

CERCLA §121(d)(2)(B) provides that CERCLA response actions "shall require a level or standard of control which at least attains Maximum Contaminant Level Goals established under the Safe Drinking Water Act." When cleaning up an aquifer, EPA selects levels that are at least as protective as MCLs, and to the greatest extent possible, that are at least as protective as non-zero MCLGs. Pursuant to 40 CFR Section

300.430(e)(2)(i)(B), MCLs and nonzero Maximum Contaminant Level Goals are relevant and appropriate as in situ aquifer standards for groundwater that is or may be used for drinking water. Therefore, MCLs are potential "relevant and appropriate" ARARs for aquifers with Class I and Class II characteristics, which would include the groundwater at McClellan AFB. The California Department of Health Services MCLs are enforced if the levels are stricter than the SDWA MCLs.

As discussed above, MCLs are enforceable standards designed to apply to the water within a drinking water distribution system. These standards apply to drinking water as it comes from the tap. For this reason these values may not represent the protection of sources of drinking water such as groundwater. The TBC values presented below may, in some cases, be more stringent than MCLs. For instance, the health-based criteria may be a more accurate measure of potential impairment of the beneficial uses of groundwater used for domestic water supply. These values, although they are not promulgated criteria, may be applied to the contaminated aquifer.

SWRCB Resolution 92-49 establishes policies and procedures for the oversight of investigations and cleanup and abatement activities resulting from discharges which affect or threaten water quality. The Regional Board is authorized to "require complete cleanup of all waste discharged and restoration of affected water to background conditions (i.e., the water quality that existed before the discharge)" or the highest water quality which is reasonable if background conditions cannot be restored. Technical and economical feasibility are considered.

According to the RWQCB, "background" can be defined as the level at which contamination can be detected using a reliable EPA analytical method such as Method 601 or 602 which have detection limits of 0.5 μg/l for most VOCs. Under Resolution 92-49, the VOC contaminated groundwater at McClellan AFB would need to be remediated to 0.5 μg/l. Resolution 92-49 is currently considered a TBC because it is not a promulgated regulation. For this reason, the 0.5 μg/l cleanup criterion would be considered a remedial goal, not an enforceable remedial requirement. This level, as well as MCLs, was considered in the development of extraction options.

The Safe Drinking Water and Toxic Enforcement Act (also known as Proposition 65) establishes a discharge prohibition and warning requirement for carcinogens and reproductive toxins. Under Health and Safety Code §25249.5, "No person in the course of doing business shall knowingly discharge or release a chemical known to the State to cause cancer or reproductive toxicity into waters or onto or into land where such chemical passes or probably will pass into any source of drinking water...." Health and Safety Code §25249.6 prohibits any person in the course of business from exposing an individual to such a carcinogen or reproductive toxin without first providing a clear and reasonable warning. Regulations in 22 CCR §12000, et seq., establish "no significant risk" levels or "safe use numbers" for chemicals subject to the Act.

EPA has previously considered whether Proposition 65 is an ARAR for federal Superfund sites and has concluded it is not an ARAR because it does not impose a more stringent level of control than federal ARARs. However, these values are TBCs for compounds without MCL values.

The Integrated Risk Information System (IRIS) is an EPA computer-housed catalogue of agency risk assessment information for chemical substances. The IRIS database contains U.S. EPA's most up-to-date chemical risk information. (Marshack, 1993). These values have been reviewed and agreed upon by intra-agency work groups and represents Agency consensus and are TBC criteria for the groundwater remedial goals.

The cancer potency factors, which are equal to the risk of getting cancer per unit dose, are TBC criteria which are distributed by the Cal/EPA Office of Environmental Health Hazard Assessment. These values have been developed based on information developed by certain health-related programs. They are expressed in units of $(mg/kg/day)^{-1}$.

EPA Region IX has drafted Preliminary Remedial Goals (PRGs) for soil, air, and tap water which were issued in April 1993, and updated on August 6, 1993. PRGs are health-based concentrations that can be used as triggers for further investigation or as initial cleanup goals if applicable. These draft remedial goals are currently under revision and are not considered ARARs. They are, however, TBC criteria.

To determine compliance with the water quality protection standards discussed above, the regional board will specify the point of compliance which can be any point in the aquifer. As stated in 23 CCR 2550.5, the point of compliance is specified to determine if a release from a waste management unit has occurred and to ensure compliance with water quality protection standards. These requirements are relevant and appropriate to groundwater remediation because monitoring, as approved or established by the regional board, will need to be conducted to determine compliance with remedial goals.

ARARs and TBCs Regulating Groundwater Discharge

The regulations and objectives that are ARARs for the discharge of groundwater treatment plant effluent to Magpie Creek include the Clean Water Act and the RWQCB's Inland Surface Waters Plan. In addition to these regulations, the RWQCB considers the National Pollutant Discharge Elimination System (NPDES) permit limitations that have been issued for the existing groundwater treatment plant to be an ARAR. The criteria included in these materials establishes standards for pollutants that are discharged to waters of the State.

The main objective of the Clean Water Act (CWA) is to maintain the chemical, biological, and physical integrity of the navigable waters of the United States. This objective is achieved through the control of discharges of pollutants to navigable waters. For the McClellan Groundwater OU site, the surface water of sufficient size to be considered a navigable water is the Sacramento River. This is fed, in part, by

Magpie Creek which runs through McClellan AFB and is considered the first water body of concern for potential discharges.

Under Section 304, EPA is required to publish water quality criteria for specific pollutants which are non-enforceable guidelines used by the States to set water quality standards. The CWA recognizes this primary responsibility of the states in preventing and controlling water pollution, and for that reason, provides authority to the EPA to approve State-administered regulatory programs.

On December 22, 1992, EPA promulgated federal water quality standards for toxic pollutants under the authority of Section 303(c)(2)(B) of the CWA in order to establish water quality standards required by CWA where the State of California had failed to do so. These numerical standards are restricted to specific toxic pollutants in California and amend portions of the State standards contained in the Basin Plan. These criteria are applied to surface waters based on their use classification specified in 57 Federal Register 60847, 22 December 1992. Magpie Creek could be classified as an inland water that is not designated as a domestic or municipal water supply. The human health criteria for the consumption of aquatic life cannot be applied until it is determined through an ecological assessment whether aquatic life suitable for human consumption exists in the creek. An ecological assessment will be performed at the Base within the next 18 months to determine whether such aquatic life is present in the creek. These federal water quality standards for the protection of aquatic life are potentially applicable federal ARARs for surface water discharges to Magpie Creek.

The Inland Surface Waters Plan is a water quality control plan adopted by the State Water Resources Control Board. This plan establishes water quality standards for particular bodies of water, their beneficial uses, and water quality objectives designed to protect those beneficial uses. The water quality objectives included in the Plan are currently considered TBC requirements because the Plan was overturned on October 15, 1993. The tentative agreement prevents the standards contained in the Plan from being enforced while the State Board seeks to revise the Plan. These TBC requirements could be used as water quality guidelines for discharges to Magpie Creek. The Inland Surface Waters Plan and the CWA criteria are listed on Table D-3.

Some of the compounds listed on Table D-3 do not have regulatory criteria. Therefore, other TBC criteria have been listed, including federal AWQC that in 57 Federal Register 60847 were stated not to be applicable to the Sate of California, and other proposed criteria that have not been promulgated.

The NPDES permit that was issued by the RWQCB for the existing groundwater treatment plant is a potential ARAR because it sets limitations for VOCs in the treated effluent. These limitations are currently set at the detection limits for the EPA 500 methods. There are also specific limitations for inorganic in the permit. The NPDES permit is a potential ARAR because a new groundwater treatment plant may have to meet similar limitations.

Potential Location-Specific ARARs

Potential location-specific ARARs and other criteria for the McClellan AFB Groundwater OU are listed in Table D-4. Location-specific ARARs differ from chemical-specific or action-specific ARARs in that they are not closely related to the site's waste characteristics or to the specific remedial alternative under consideration. Location-specific ARARs are concerned with the area in which the site is located. Actions may be required to preserve or protect aspects of the area's environment or cultural resources that may be threatened by the site's existence or by the proposed remedial actions.

The major statutes from which the regulations are derived which contribute to the list of potential location-specific ARARs include:

- Resource, Conservation, and Recovery Act
- National Archaeological and Historic Preservation Act
- National Historic Preservation Act
- Endangered Species Act
- Clean Water Act
- Wilderness Act
- Fish and Wildlife Coordination Act
- Scenic Rivers Act
- Coastal Zone Management Act
- Marine Protection Resources and Sanctuary Act
- Migratory Bird Treaty Act

Two executive orders are also included: the Executive Order on the Protection of Wetlands, and the Executive Order on Protection of Flood Plains. R18-8-264.18 (40 CFR 264.18(b)) applies to the citing of new hazardous waste treatment facilities within the 100-year flood plain.

To the extent that the remedial action will affect historical resources, streams, flood plains, or wetlands, EPA requires that the potential remedial alternatives comply with the location-specific requirements. The major statutes and regulations included in the list of potential location-specific ARARs are described below.

Floodplain Management

The Executive Order on Flood Plain Management requires federal agencies to evaluate the potential effects of actions that may take place in a flood plain to avoid, to the extent possible, adverse effects associated with direct and indirect flood plain development. EPA's regulations to implement this Executive Order are set forth in 40 CFR 6 §6.302(b). In addition, EPA has developed guidance entitled "Policy on Flood Plains and Wetlands Assessments for CERCLA Actions," dated August 6, 1985. This policy would potentially apply to any new construction in the flood plains located at the Base.

Table D-4
Potential Location-Specific ARARs
for the MCAFB Groundwater OU Site

Location	Requirement/Prerequisite	Citation	Comment	Applicability
1. Within 61 meters (200 feet) of a fault displaced in Holocene time	All treatment, storage, and disposal of hazardous wastes is prohibited within 200 feet of a Holocene fault.	40 CFR 264.18(a) 22 CCR 66264.18(a) 23 CCR 2531(d)	There is no evidence of an active fault within 61 meters of the site. The nearest Holocene fault is approximately 23 miles from McClellan AFB.	Not an ARAR
2. Within 100-year flood plain	Treatment, storage, and disposal for hazardous wastes must be constructed to avoid washouts if located in a 100-year flood plain. Land treatment and disposal units for hazardous wastes may not be located in a 100-year flood plain.	40 CFR 264.18(b) 23 CCR 2531(c) 22 CCR 66264.18(b) 22 CCR 66270.14(b)(11)	Portions of McClellan AFB are located in the 100-year flood plain. No new permanent building is proposed in the 100-year flood plain zone. However, if a RCRA facility is located in a 100-year flood plain, it must be designed, constructed, operated, and maintained to prevent washout of any hazardous waste by a 100-year flood.	Potential ARAR
3. Within flood plain	Relates to actions that will occur in a flood plain, i.e., lowlands and relatively flat areas adjoining inland and coastal waters and other flood-prone areas. Actions must be taken to avoid adverse effects, minimize potential harm, restore and preserve natural and beneficial values.	Executive Order 11988, Protection of Flood Plains 40 CFR 6, §6.302(b)	Federal agencies are directed to ensure that planning programs and budget requests reflect consideration of flood-plain management, including the restoration and preservation of such land as natural undeveloped flood plains. If newly constructed facilities are to be located in a flood plain, accepted flood-proofing and other flood control measures shall be undertaken to achieve flood protection. Whenever practical, structures shall be elevated above the base flood level rather than fill land. As part of any federal plan or action, the potential for restoring and preserving flood plains so their natural beneficial values can be realized must be considered. Crossing the McClellan AFB site with piping or location of wells in the 100-year flood plain will be designed to result in no impact to flood surface profiles.	Potential ARAR
4. Within salt dome formation, underground mine, or cave	If a RCRA hazardous waste, placement of non-containerized, or bulk liquid hazardous waste is prohibited.	40 CFR 264.18(c) 22 CCR 66264.18(c)	The McClellan AFB site does not contain any salt dome formation, underground mine, or caves used for waste disposal. No such disposal is planned.	Not an ARAR

Table D-4
Potential Location-Specific ARARs
for the MCAFB Groundwater OU Site

Location	Requirement/Prerequisite	Citation	Comment	Applicability
5. Within area where action may cause irreparable harm, loss, or destruction of significant artifacts	Alteration of terrain that threatens significant scientific, prehistorical, historical, or archaeological data. Construction on previously undisturbed land would require an archaeological survey of the area. Provides for the preservation of historical and archaeological data.	National Archaeological and Historical Preservation Act (16 U.S.C. Section 469); 36 CFR Part 65	The proposed remedial alternatives will not alter or destroy any known prehistoric or historic archaeological features of the McClellan AFB site. The McClellan AFB site is essentially completely developed. However, since there is always a possibility that buried historic or prehistoric remains could be discovered during development, mitigation measures to protect the area would be required if such a discovery were uncovered.	Potential ARAR
6. Historic project owned or controlled by federal agency	If property is included in or eligible for the National Register of Historic Places, actions must be taken to preserve historic properties; planning of action to minimize harm to National Historic Landmarks.	National Historic Preservation Act Section 106 (16 USC 470 *et seq.*); 36 CFR Part 800	Property on McClellan AFB is not proposed for listing as a National Historic Landmark. The proposed remedial alternatives will not have any impacts on the existing buildings.	Not an ARAR
7. Critical habitat upon which endangered species or threatened species depend	Requires action to conserve endangered species or threatened species, including consultation with the Department of the Interior, Fish and Wildlife Service. Lists species of birds protected by four treaties between the U.S. and Canada, Mexico, Japan, and Russia Same as federal requirement but includes required consultation with California Department of Fish and Game.	Endangered Species Act of 1973 (16 USC 1531 *et seq.*); 50 CFR Part 200, 50 CFR Part 402 Migratory Bird Treaty Act (16 U.S.C. 703-712) with list of protected birds in 50 CFR 10.13 California Endangered Species Act California Fish and Game Code Sections 2070, 2080, 2090-2096 14 CCR Section 670.5	Two endangered floral species are known to occur within Sacramento County: the Sacramento Orcutt grass (*orcuttia Viscida*) and the Boggs Lake hedge hyssop (*Gratiola Heterosepala*). Four endangered wildlife species are expected to occur within 25 miles of McClellan AFB: Bald Eagle, Peregrine Falcon, Giant Garter Snake, and the Valley Elderberry Longhorn Beetle. McClellan AFB may be a habitat for the Burrowing Owl, a species of concern in California. A complete ecological assessment will have to be conducted at McClellan AFB to confirm the presence of these species. Threatened or endangered species and critical habitat which may be affected by the proposed remedial alternatives need to be identified.	Potential ARAR

Table D-4
Potential Location-Specific ARARs
for the MCAFB Groundwater OU Site

Location	Requirement/Prerequisite	Citation	Comment	Applicability
8. Wetlands	Wetlands are defined by Executive Order 11990, Section 7. Requires action to minimize the destruction, loss, or degradation of wetlands. Action to prohibit discharge of dredged or fill material into wetlands without permit.	Executive Order 11990, Protection of Wetlands (40 CFR 6, §6.302(a)	If wetlands are located within the area of proposed federal activities, the agency must conduct a wetlands assessment to identify wetlands and potential means of minimizing impacts. If there is no practical alternative to locating in or affecting the wetland, the Agency shall act to minimize potential harm to the wetland.	Potential ARAR
		Clean Water Act Section 404; 40 CFR Parts 230, 231 California Fish & Game Code Section 1603	The Clean Water Act prohibits discharge of dredged or fill material into wetlands without a permit. Vernal pools exist in the west area of McClellan AFB. Vernal pools are considered intermittent wetlands by the U.S. Fish and Wildlife Service and the Clean Water Act.	
9. Wilderness area	Areas federally owned and designated as wilderness areas must be administered in such a manner as will leave them unimpaired as wilderness and to preserve their wilderness character.	Wilderness Act (16 USC 1131 *et seq.*); 50 CFR 35.1 *et seq.*	The McClellan AFB site is not within or adjacent to any federally designated wilderness area.	Not an ARAR
10. Wildlife refuge	Only actions allowed under the provisions of 16 USC Section 668 dd(c) may be undertaken in areas that are part of the National Wildlife Refuge System.	16 USC 668 dd *et seq.*; 50 CFR Part 27	The McClellan AFB site is not designated as part of the National Wildlife Refuge System.	Not an ARAR
11. Area affecting stream or other water body	Proposed discharges of dredged or fill material into waters of the U.S. are evalauted with respect to impacts on the aquatic ecosystem.	CWA Section 404 40 CFR 230	Installation of pipelines to transport groundwater from the extraction wells to the treatment plant and pipelines from the treatment plant to the end use must not cause alterations to the banks of existing creeks.	Potential ARAR
	Diversion, channeling, or other activity that modifies a stream or river and affects fish or wildlife will require actions to protect fish or wildlife.	Fish and Wildlife Coordination Act (16 U.S.CC. 661 *et seq.*); 40 CFR 6.302	Proposed end-use options include discharge of treated water into Magpie Creek, which discharges into the American River.	Potential ARAR
	Diversions, channeling, or any other activity that affects a stream or watercourse is controlled. The Department of Fish and Game has primary responsibility for the protection of California's fish and wildlife resources.	California Fish & Game Code		Potential ARAR

Table D-4
Potential Location-Specific ARARs
for the MCAFB Groundwater OU Site

Location	Requirement/Prerequisite	Citation	Comment	Applicability
12. Within coastal zone	Applies to activities affecting the coastal zone including lands thereunder and adjacent shore-lands.	Coastal Zone Management Act (16 U.S.C. Section 1451 *et seq.*)	The site is an inland area with no direct access to coastal areas.	Not an ARAR
	Applies to activities affecting the coastal zone including lands thereunder and adjacent shorelands.	California Coastal Act of 1976 (PRC Div 20 Sections 30,000 *et seq.*)	The site is an inland area with no direct access to coastal areas.	Not an ARAR
13. Within area affecting national wild, scenic, or recreational river	Activities that affect or may affect any of the rivers specified in Section 1276(a). Avoid taking or assisting in action that will have direct adverse effect on scenic river.	Scenic Rivers Act (16 U.S.C. 1271 *et seq.* Section 7(a)); 40 CFR 6.302(e) California Wild and Scenic Rivers	No national wild or scenic rivers are located on the McClellan AFB site or will be impacted by proposed remediation.	Not an ARAR
14. Oceans or waters of the United States	Applies to oceans and waters of the United States, and action to dispose of dredge and fill material into ocean waters is prohibited without a permit.	Clean Water Act (Section 404 40 CFR 125) Subpart M; Marine Protection Resources and Sanctuary Act Section 103 Porter Cologne Water Quality Control Act	Proposed activities do not include dredging or sediment removal.	Not an ARAR
15. Sole-source aquifer	Protection of aquifer through federal assistance funding. Applies to aquifers that are sole or principal drinking water sources and if contamination would present a significant hazard to public health. Prohibits injection of waste.	SDWA 42 USC Section 300n; 40 CFR Section 146.4	Injection of treated groundwater may affect principal drinking water sources. Treatment criteria will be based on chemical-specific ARARs *defined in the ROD.*	Potential ARAR
16. Hazardous waste site	Actions to limit worker exposure to hazardous wastes or hazardous substances, including training or monitoring.	20 CRF 1910.120	Precautions will be made to ensure employee safety.	Potential ARAR

Table D-4
Potential Location-Specific ARARs
for the MCAFB Groundwater OU Site

Location	Requirement/Prerequisite	Citation	Comment	Applicability
17. Security	Unknowing and unauthorized entry to active portion of the facility shall be prevented.	22 CCR 66264.14	The McClellan AFB Groundwater OU site has a 24-hour surveillance system, fully fenced, and is restricted to nonmilitary personnel. Proper identificaiton is required for entry. Activities related to the proposed remedial alternatives would occur within the fenced compound. If physical contact with any waste, structure, or equipment could potentially injure unknowing or unauthorized persons or livestock, the area will be fenced and locked.	Potential ARAR

Note: This table identifies potential location-specific ARARs and TBCs for the remedial action alternatives presented in this Groundwater OU FS. Actual ARARs for the selected remedial actions for the McClellan AFB site will be identified in the Record of Decision.

Both federal and state solid and hazardous waste statutes have requirements pertaining to location of facilities in flood plain areas. Treatment unit locations and the injection well location proposed as part of the remedial alternatives presented in this RI/FS are not located within the 100-year flood zone hazard areas within McClellan AFB. The proposed remedial alternatives would not expose people or property to water-related hazards such as flooding and would be located away from the flood-plain areas within McClellan AFB. No new permanent buildings are planned in the 100-year flood plain. To the extent that the remedy involves storage or disposal of solid wastes, the federal and state requirements governing siting and operation of facilities in the flood plain would be potentially relevant and appropriate.

Historical and Archaeological Resources

The Archeological and Historic Preservation Act establishes procedures to provide for historical and archeological data preservation which might be destroyed through terrain alteration as a result of a federal construction project or a federally licensed activity or program. If proposed remedial action activities would cause irreparable loss or destruction of significant scientific, prehistorical, historical, or archeological data, EPA would require adherence to the procedures in the statute to provide for data recovery and preservation activities.

The National Historic Preservation Act requires federal agencies to take into account the effect of any federally assisted undertaking or licensing on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register of Historic Places. No structures are to be impacted by the proposed remedial alternatives. If an eligible structure would have been adversely affected, the procedures for protection of historic properties are set forth in Executive Order 11593 entitled "Protection and Enhancement of the Cultural Environment" and in 36 CFR Part 800, 36 CFR Part 63, and 40 CFR §6.301(c). These procedures are potentially relevant and appropriate for any action that might impact historic properties.

Wetlands Protection

Executive Order on Protection of Wetlands. The Executive Order on Protection of Wetlands requires federal agencies to avoid, to the extent possible, the adverse impacts associated with the destruction or loss of wetlands and to avoid support of new construction in wetlands if a practicable alternative exists. EPA's regulations to implement this Executive Order are set forth in 40 CFR 6, §6.302(a). In addition, EPA has developed guidance entitled "Policy on Flood Plains and Wetlands Assessments for CERCLA Actions," dated August 6, 1985. Vernal pools exist in the west area of McClellan AFB. Vernal pools are considered intermittent wetlands by the U.S. Fish and Wildlife Service and the Clean Water Act. No new construction is anticipated in the vernal pool area.

Potential Action-Specific ARARs

Remedial actions may trigger action-specific ARARs, and TBCs. These regulations define the performance, design, or other similar action-specific controls or restrictions on activities related to the management of hazardous substances or pollutants. Table D-5 lists components of the various remedial action options developed for the GW OU which may trigger action-specific ARARs.

The potential action-specific ARARs that relate to the extraction options, remedial alternatives, and end-use options are presented in Table D-6. Table D-6 also lists the options that will be impacted by the ARARs. The action-specific ARARs include technology- and activity-based requirements or limitations on actions taken with respect to hazardous substances at the site. Only the substantive requirements of these requirements would apply to onsite actions. However, for offsite treatment or disposal, all hazardous waste laws and regulations must be complied with.

A description of the requirements associated with each potential ARAR and a discussion of the conditions under which the ARAR would be applicable or relevant and appropriate are included in Table D-6. A more detailed discussion of some of these ARARs is presented below.

National Contingency Plan (40 CFR 300)

The National Contingency Plan (NCP) is the primary regulation governing CERCLA actions and establishes procedures for implementing the Superfund program. Under CERCLA, remedial actions must protect human health and the environment, be cost effective, comply with ARARs, and use permanent solutions and alternative treatment technologies to the maximum extent possible.

The NCP specifies nine evaluation criteria used during the detailed analysis of remedial alternatives. The first two criteria, which must be met by a selected alternative, are protection of human health and the environment and compliance with ARARs. The next five criteria are considered balancing criteria and are used to weigh trade-offs between alternatives. These criteria include: long-term effectiveness; reduction of toxicity, mobility, or volume of contaminants through treatment; short-term effectiveness; implementability; and cost. The final two criteria are state and community acceptance of the selected alternative.

Another provision under the NCP applies to wastes that are left onsite. If a selected alternative involves leaving waste onsite, then the alternative must be reviewed every five years to ensure

Clean Water Act

As stated earlier, the objective of the Clean Water Act (CWA) is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. In

Table D-5
Remedial Activities Which May Trigger
Action-Specific ARARs

Activity	Extraction Options	Treatment Options												End-Use Options	
		Ozone Peroxide Advanced Oxidation	UV Peroxide Advanced Oxidation	Air Stripping with VGAC	Air Stripping with CatOx	LGAC	Ozone Peroxide/ Air Stripping VGAC	Ozone Peroxide/ Air Stripping/ CatOx	UV Peroxide/ Air Stripping/ VGAC	UV Peroxide/ Air Stripping/ CatOx	Air Stripping/ VGAC/ LGAC	Air Stripping/ CatOx/LGAC	Existing Groundwater Treatment Plant	Sell to Utilities	Injection
Groundwater Extraction	Yes	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Onsite Chemical Storage (Hydrogen Peroxide, Sodium Hydroxide)	N/A	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	N/A	N/A
Onsite Tanks (Hydrogen Peroxide, Sodium Hydroxide, LGAC Beds)	N/A	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N/A	N/A
Miscellaneous Units (RCRA) (Air Strippers)	N/A	No	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N/A	N/A
Onsite Treatment	N/A	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N/A	N/A
Waste Products (HCl, Spent Carbon)	N/A	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N/A	N/A
Air Emissions (Ozone, VOCs)	N/A	No	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N/A	N/A
Process Vents and Equipment Leaks	N/A	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N/A	N/A
Incineration	N/A	No	No	No	Yes	No	No	Yes	No	Yes	No	Yes	Yes	N/A	N/A
Surface Discharge	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Yes	Yes
Injection	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No	Yes

Table D-6
Potential Action-Specific ARARs
for the McClellan AFB Groundwater OU Site

Action	Requirement/Prerequisite	Citation	Applicability	Comments
Waste Identification	Under RCRA, Title 22 CCR Section 66261.3 defines those solid wastes that are subject to regulation as hazardous wastes under subsequent sections.	22 CCR 66261.3	ARAR for all extraction, treatment, and end-use options	All regulations are applicable to any hazardous waste generated, treated, stored, or disposed of at the McClellan AFB site.
Container Storage (Onsite)	Containers holding RCRA hazardous waste (listed or characteristic) for a temporary period before treatment, disposal, or storage elsewhere (40 CFR 264.10) must be:			These requirements are applicable or relevant and appropriate for any contaminated groundwater or treatment system waste that might be containerized and stored onsite prior to treatment or final disposal. Groundwater containing a listed waste must be managed as if it were a hazardous waste so long as it contains the listed waste.
	• Maintained in good condition	40 CFR 264-171 (R18-18-264.170, et seq.)	ARAR for all extraction, treatment, and end-use options	
	• Compatible with hazardous waste to be stored	40 CFR 264.172		
	• Closed during storage (except to add or remove waste)	40 CFR 264.173		
	A container is any portable device in which a material is stored, transported, disposed of, or handled.			
	Inspect container storage areas weekly for deterioration.	40 CFR 264.174		
	Place containers on a sloped, crack-free base, and protect from contact with accumulated liquid. Provide containment system with a capacity of 10 percent of the volume of containers of free liquids.	40 CFR 264.175		
	Remove spilled or leaked waste in a timely manner to prevent overflow of the containment system.			
	Keep containers of ignitable or reactive waste at least 50 feet from the facility's property line.	40 CFR 264.176		
	Keep incompatible materials separate. Separate incompatible materials stored near each other by a dike or other barrier.	40 CFR 264.177		
	At closure, remove all hazardous waste and residues from the containment system, and decontaminate or remove all containers, liners.	40 CFR 264.178		

Table D-6
Potential Action-Specific ARARs
for the McClellan AFB Groundwater OU Site

Action	Requirement/Prerequisite	Citation	Applicability	Comments
Storage	A generator may accumulate hazardous waste onsite for 90 days without a permit provided:	22 CCR 66262.34	ARAR for all extraction and treatment options	Applicable to any hazardous waste stored onsite (i.e., spent solvents, spent activated carbon)
	• The waste is placed in containers in accordance with Title 22 CCR, Division 4.5, Chapter 15, Article 9.			
	• Each container is labeled with the contents and physical state of the waste and the date of accumulation.			
	• The generator complies with Title 22 CCR, Division 4.5, Chapter 15, Article 3 (Preparedness and Prevention) and Article 4 (Contingency Plan and Emergency Procedures).			
	A generator who accumulates waste for more than 90 days is an operator of a storage facility and is subjected to associated requirements.			
Tank Systems (onsite)	Facilities that use tank systems for transferring, storing or treating hazardous waste shall:	40 CFR 262 (Subpart J) Title 23 CCR Div 3 Chapter 16	ARAR for Treatment Options 1, 2, and 5 through 12, inclusive	These requirements are applicable or relevant and appropriate for any facility that uses tank systems for storing or treating hazardous waste, i.e., reaction vessels, hydrogen peroxide tanks, carbon-filled tanks
	• Be designed with sufficient shell strength, compatible with hazardous material in contact, and be acceptable for the storing and treating of hazardous waste	40 CFR 264.192		
	• Be provided with secondary containment with provision for leak detection, including ancillary equipment	40 CFR 264.193		
	• Be inspected daily	40 CFR 264.195		
	• Maintain an emergency response plan to contain leaks or spills and dispose of leaking or unfit tank systems	40 CFR 264.196		
	• Operated with approved closure and post-closure plan	40 CFR 264.197		
	• Permitted for the Hazardous Waste Permit Program under RCRA	40 CFR 270.16		

Table D-6
Potential Action-Specific ARARs
for the McClellan AFB Groundwater OU Site

Action	Requirement/Prerequisite	Citation	Applicability	Comments
Treatment (miscellaneous)	Treatment of hazardous wastes in units not regulated elsewhere under RCRA (e.g., air strippers).			
	Standards for miscellaneous units (long-term retrievable storage, thermal treatment other than incinerators, open burning, open detonation, chemical, physical, and biological treatment units using other than tanks, surface impounds, or land treatment units) require new miscellaneous units to satisfy environmental performance standards by protection of groundwater, surface water, and air quality, and by limiting surface and subsurface migration.	40 CFR 264 (Subpart X)	ARAR for Treatment Options 3, 4, and 6 through 12, inclusive	The substantive portions of these requirements will be applicable or relevant and appropriate to the construction, operation, maintenance, and closure of any miscellaneous treatment unit (a treatment unit that is not elsewhere regulated) constructed on the McClellan AFB site for treatment and/or disposal of hazardous wastes.
	Treatment of wastes subject to ban on land disposal must attain achievable concentrations by best demonstrated available treatment technologies (BDAT) for each hazardous constituent in each listed waste.	40 CFR 268 (Subpart D)		The substantive portions of these requirements are applicable to the disposal of any McClellan AFB site wastes that can be defined as restricted hazardous wastes.
	BDAT standards are based on one of four technologies or combinations: for wastewaters (1) steam stripping; (2) biological treatment; or (3) carbon adsorption (alone or in combination with (1) or (2); and for all other wastes, (4) incineration. Any technology may be used, however, if it will achieve the concentrations levels specified.			The substantive portions of these requirements are relevant and appropriate to the treatment prior to and disposal of any wastes that contain components of restricted wastes in concentrations that make the site wastes sufficiently similar to the regulated wastes. The requirements specify levels of treatment that must be attained prior to land disposal.
	A miscellaneous unit shall be located, designed, constructed, operated, maintained, and closed in a manner that will ensure protection of human health and the environment. Permits for miscellaneous units shall contain terms and provisions necessary to protect human health and the environment.	22 CCR 66264.601		The substantive portions of these requirements are applicable to construction, operation, maintenance, and closure of any miscellaneous treatment unit.
	Hazardous waste or reagents shall not cause treatment equipment to leak, corrode, or fail. Equipment shall have a means to stop continuously fed inflow. Hazardous waste must be sampled before being treated.	22 CCR Article 17, Chapter 15		The substantive portions of this requirement are applicable to the treatment of hazardous waste by chemical, physical, or biological methods.

Table D-6
Potential Action-Specific ARARs
for the McClellan AFB Groundwater OU Site

Action	Requirement/Prerequisite	Citation	Applicability	Comments
Air Emissions from Groundwater Treatment	Control of air emissions of volatile organics and gaseous contaminants.	40 CFR 61	ARAR for Treatment Options 1, 3, 4, and 6 through 12, inclusive	Emissions from treatment unit(s) will be controlled according to the substantive portions of these requirements.
	RCRA Standards for air emissions from treatment process vents. Control devices shall be monitored and inspected to ensure proper maintenance and operation.	40 CFR 264, Subpart AA, and 22 CCR, Article 27, Chapter 15		
	Standards for air emissions from equipment leaks. Equipment shall be designed so as to prevent leakage of organic emissions to the atmosphere.	40 CFR 264, Subpart BB, and 22 CCR Article 28, Chapter 15		
	NSR rules require emissions units to provide offsets for the affected pollutant.	SMAQMD Rule 202		BACT will be applied to comply with Rules 202 and 401. All reasonable precautions will be taken to comply with the fugitive dust standards (Rule 403). Risk Assessment will be conducted to ensure compliance with nuisance standards (Rule 402).
	BACT requirements and new source emission standards must be met. Opacity, nuisance, and fugitive dust control standards must be met. A nonacceptable health risk shall not be imposed by applying TBACT.	SMAQMD Rules 401, 402, and 403		
Direct Discharge of Treatment System Effluent	Surface discharge of treated effluent.	CWA Section 304 CERCLA Section 121 (a)(2)(B)(i)	ARAR for End-Use Options 1 and 2	Treated wastewater effluent may be discharged to local streams. Effluent quality will comply with all discharge standards.
	Applicable federally approved state water quality standards must be complied with. These standards may be in addition to more stringent federal standards under CWA.	40 CFR 122, 125, and 136		
	Regulations established by the state and regional water boards to protect water quality by regulating waste disposal must be complied with.	California Water Code, Division 7, Section 13000, et seq		See Chemical-Specific ARARs.
	Applicable federal water quality criteria for the protection of aquatic life must be complied with when environmental factors are being considered.	50 FR 30784 (July 29, 1985)	ARAR for all extraction, treatment, and end-use options	Plan objectives must be complied with during the installation of extraction wells; standards must be met concerning the volume of groundwater removed for treatment; and objectives must be met in reinjected groundwater, irrigation water, and discharged water. See chemical-specific table and text for Inland Surface Waters Plan water quality objectives.
	SWRCB and RWQCB water quality objectives and standards must be complied with. Beneficial uses of particular bodies of water must be protected. Standards to protect aquatic life must be met.	Inland Surface Waters Plan and the Central Valley Basin Plan		
Land Disposal Restrictions (LDRs)	Identifies hazardous wastes that are restricted from land disposal and defines those limited circumstances under which an otherwise prohibited waste may be land disposed.	22 CCR Section 66268	ARAR for End-Use Option 2	If a waste is picked up from within a site, treated in an incinerator (CatOx) or tank (GAC) and then redeposited (reinjection), LDRs may be triggered, and they become potential ARARs.

Tabie D-6
Potential Action-Specific ARARs
for the McClellan AFB Groundwater OU Site

Action	Requirement/Prerequisite	Citation	Applicability	Comments
Underground Injection of Wastes and Treated Groundwater	Underground Injection Control (UIC) program prohibits:	40 CFR 144.12	ARAR for End-use Option 2	If any wastes excavated or extracted from the site or any treatment residues generated at the site can be classified as hazardous wastes, the substantive portions of construction, operation, and maintenance requirements would be applicable or relevant and appropriate to the disposal of these wastes by underground injection.
	• Injection activities that allow the movement of contaminants into underground sources of drinking water (USDW) and result in violation of MCLs or adversely affect health.			
	• Construction of new Class IV wells and operation and maintenance of existing wells.	40 CFR 144.13		
	Wells used to inject contaminated groundwater that has been treated and is being injected into the same formation from which it was drawn are not prohibited if activity is part of CERCLA or RCRA actions.	40 CFR 144.14		
	All hazardous waste injection wells must also comply with the RCRA requirements.	40 CFR 144.16		
	The director of a state UIC program may lessen the stringency of 40 CFR 144.23 construction, operation, and manifesting requirements for a well if injection does not occur into, through, or above a USDW or if the radius of endangering influence [see 40CFR 146.06(c)] is less than or equal to the radius of the well.	40 CFR 144.21		
	Injection of wastes into the subsurface will require the submittal of a report of waste discharge. Once a report of waste discharge has been submitted, limitations for the quality of water to be injected will be developed.	California Water Code, Division 7 Section 1300 et seq. Basin Plan for the Central Valley Region		Water will need to meet non-detection levels for VOCs for injection into a clean aquifer and meet background concentrations for inorganic species of pollutants.

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for the McClellan AFB Groundwater OU Site

Action	Requirement/Prerequisite	Citation	Applicability	Comments
Underground Injection of Wastes	Criteria for determining whether an aquifer may be determined to be an exempted aquifer include current and future use, yield, and water quality characteristics.	40 CFR 146.4	ARAR for End-Use Option 2	Water is proposed to be treated to MCLs before end use.
	Case and cement all Class I wells to prevent movement of fluids into USDW, taking into consideration well depth, injection pressure, hole size, composition of injected waste, and other factors.			
	Conduct appropriate logs and other tests during construction, prepare a descriptive report, and submit it to the UIC program director.			
	Injection pressure may not exceed a maximum level designed to ensure that injection does not initiate new fractures or propagate existing ones and cause the movement of fluids into a USDW.	40 CFR 146.13		
	Continued monitoring of injection pressure, flow rate and volume, and annual pressure is required.			
	Reinjection with Class V wells shall not cause a violation of primary MCLs in the receiving aquifer.			
	Injection of wastes into the subsurface will require the submittal of a report of waste discharge. Once a report of waste discharge has been submitted, limitations for the quality of water to be injected will be developed.	California Water Code, Division 7 Section 1300 et seq. Basin Plan for the Central Valley Region		Water will need to meet non-detection levels for VOCs for injection into a clean aquifer and meet background concentrations for inorganic species of pollutants.

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for the McClellan AFB Groundwater OU Site

Action	Requirement/Prerequisite	Citation	Applicability	Comments
Incineration	Performance Standards An incinerator burning wastes shall be designed, constructed, and maintained so that it will meet the following performance standards: 1. Except for EPA Hazardous Waste Nos. F020, F021, F022, F023, F026, and F027, an incinerator burning waste shall achieve a destruction and removal efficiency (DRE) of 99.99 percent for each principle organic hazardous constituent (POHC). 2. An incinerator burning hazardous wastes F020, F021, F022, F023, F026, and F027 shall achieve a destruction and removal efficiency (DRE) of 99.9999 percent for each principle organic constituent (POHC). In addition, the owner or operator shall notify the Department of the intent to incinerate these wastes.	22 CCR 66264.343	ARAR for Treatment Options 4, 7, 9, 11, and 12 ARAR for Treatment Options 4, 7, 9, 11, and 12	All federal, state, and local incineration requirements are applicable if incineration is used for offgas treatment. F020-Wastes of tri- or tetrachlorophenol or of intermediates F021-Wastes of pentachlorophenol F022-Wastes of tetra-, benta-, or hexa-chlorobenzenes under alkaline conditions F023-Wastes from the production of materials on equipment previously used for the production of tri- and tetrachlorophenols
	Operating Requirements a. An incinerator shall be operated in accordance with operating requirements specified in the permit. b. Each set of operating requirements will specify the composition of the waste feed.	22 CCR 66264.345		F026-Wastes from the production of materials on equipment previously used for the manufacturing use of tetra-, penta- or hexachlorobenzene under alkaline conditions F027-Discarded, unused formulations containing tri-, tetra- or pentachlorophenol The substantive portions of this requirement are applicable.

Notes:
Treatment Option 1 = Ozone Peroxide Advanced Oxidation
Treatment Option 2 = UV Peroxide Advanced Oxidation
Treatment Option 3 = Air Stripping with VGAC
Treatment Option 4 = Air Stripping with CatOx
Treatment Option 5 = LGAC
Treatment Option 6 = Ozone Peroxide Pretreatment/Air Stripping with VGAC
Treatment Option 7 = Ozone Peroxide Pretreatment/Air Stripping with CatOx
Treatment Option 8 = UV Peroxide Pretreatment/Air Stripping with VGAC
Treatment Option 9 = UV Peroxide Pretreatment/Air Stripping with CatOx
Treatment Option 10 = Air Stripping with VGAC/LGAC
Treatment Option 11 = Air Stripping with CatOx/LGAC
Treatment Option 12 = Use Existing Groundwater Treatment Plant
End-Use Option 1 = Base Greywater/Sell to Utilities/Magpie Creek
End-Use Option 2 = Base Greywater/Reinjection/Magpie Creek

addition to the water quality criteria, CWA regulates activities which may result in the deposition of fill or dredge material into waters of the United States. This regulation is applicable to actions such as well and treatment plant construction, and other activities which could potentially disturb or alter streams on the Base. The discharging of dredged or fill material, or the locating of a structure within a stream, will need to meet the substantive portions of the CWA Section 404. Bank material that may fall into the creek could be considered dredged or fill material. If the remedial alternative selected for this site includes installation of pipelines along or beneath the creek, this regulation may be an ARAR for the site.

In addition to the CWA Section 404 requirements, work performed within or below a streambed may require a 401 Water Quality Certification from the RWQCB and/or a 1603 Streambed Alteration Agreement from the Department of Fish and Game.

The Clean Water Act also regulates direct discharges to surface waters. Both onsite and offsite direct discharges from CERCLA sites to surface waters are required to meet the substantive requirements of the National Pollutant Discharge Elimination System (NPDES) program. These substantive requirements include discharge limitations, certain monitoring requirements, and best management practices. These requirements will be contained in an NPDES permit for offsite CERCLA discharges. For onsite discharges, as in the potential end-use remedial action of discharging to Magpie Creek, these substantive requirements must be identified and met even though onsite discharges are not required to have an NPDES permit.

Resource Conservation and Recovery Act

Many RCRA requirements are applicable or relevant and appropriate to the alternatives presented herein. The RCRA program is a delegable program; the states may manage the program in lieu of the EPA if the state statutes and regulations are equivalent to or more stringent than the federal statutes and regulations. California is authorized to manage the RCRA "base" program, i.e., the requirements in existence before the passage of the Hazardous and Solid Waste Amendments (HSWA) of 1984. The EPA enforces the requirements promulgated pursuant to HSWA. Therefore, in some cases the applicable or relevant and appropriate RCRA requirement will be cited as state law and in other cases as federal law.

Waste Identification

The key determination that must be made in addressing whether or not RCRA requirements are an ARAR at a CERCLA site is whether the wastes or contaminated material at the site are RCRA or non-RCRA (California) hazardous waste, in which RCRA or California hazardous waste regulations may be applicable or relevant and appropriate. A material is a hazardous waste if it is a solid waste, if it is not excluded from regulation, and if it meets one of the following conditions:

- Exhibits, on analysis, any of the characteristics of a hazardous waste, i.e., ignitability, corrosivity, reactivity, and toxicity as determined by a toxicity characteristic leaching procedure (TCLP) or California waste extraction test (WET). The California toxicity characteristic can also be determined using acute dermal, inhalation, oral, or aquatic toxicity criteria.

- Has been listed as a hazardous waste in the state or federal regulation. These listings specifically include wastes from non-specific sources (F-list), wastes from specific sources (K-list), and discarded chemical products (P- and U-list)

- Is a mixture containing a listed hazardous waste and a nonhazardous solid waste

- Is derived from a listed hazardous waste

If a waste is not a listed waste or it does not contain a listed waste, the determination as to whether the waste is ignitable, reactive, corrosive, or toxic must then be made. At McClellan AFB, contaminated media such as groundwater and soil, may contain contaminants at concentrations exceeding the characteristic waste tests. The environmental medium must then be handled as if it were a hazardous waste.

"Contained in" Interpretation

The EPA's "contained in" interpretation provides that an environmental medium (e.g., soil, groundwater, debris, surface water) that has been contaminated by a listed hazardous waste above a risk-based level or a level of concern must be managed as if it were a hazardous waste. Therefore, the RCRA regulations may be applicable or relevant and appropriate to the management of a contaminated environmental medium.

Storage

The RCRA storage requirements, 40 CFR 264.170 to 264.178 and the California hazardous waste storage requirements, 22 CCFR 66264.170 to 66264.178, will be applicable or relevant and appropriate to the storage of contaminated groundwater or treatment by-products onsite. These regulations include requirements governing the use, management, and containment of containers holding hazardous waste.

If the extracted groundwater is determined to be identified as a hazardous waste (e.g., a "listed" or "characteristic" hazardous waste), the RCRA secondary containment requirements will be applicable or relevant and appropriate to the extraction, treatment, and end-use remedial actions selected in the Interim ROD for the McClellan AFB Groundwater OU site. These criteria include secondary containment or above-ground piping requirements for the treatment plant influent lines as well as any tanks, storage containers, and ancillary equipment associated with the groundwater treatment plant.

Treatment

Soil vapor extraction units, air strippers, and the other treatment alternatives discussed in this RI/FS are miscellaneous RCRA units. Therefore, the substantive requirements of 40 CFR Subpart X, including any closure and postclosure care, will be applicable or relevant and appropriate.

Injection

RCRA Section 3020 is applicable or relevant and appropriate to injection of treated contaminated groundwater into or above a formation that contains an underground source of drinking water.

Land Disposal Restrictions (LDRs)

The land disposal restrictions, 40 CFR Part 268, and the general land disposal prohibition in absence of a permit will be applicable or relevant and appropriate to discharges of contaminated materials to land. The remedial alternatives presented do not include land disposal of untreated material, except as may occur through well installation, and this would be done entirely onsite. Treated water may be injected into the groundwater through a injection well located onsite.

It should be noted that disposal and displacement are synonymous for purposes of defining the applicability of LDRs under RCRA. When RCRA hazardous waste is moved from one part of the "unit" to another part of the same "unit," disposal/placement has not occurred, and LDRs are not triggered. If waste is picked up from within the unit and treated within the area of contamination in an incinerator, surface impoundment, or tank and then redeposited into the unit, placement has occurred, and LDRs are triggered. However, when waste is treated in situ, placement/disposal does not occur, and LDRs are not triggered. If incineration, LGAC, or advanced oxidation is selected as part of the remedial action for the treatment of the contaminated groundwater at McClellan AFB, and the end use is injection, LDRs become potential ARARs.

Air Monitoring for Process Vents and Equipment Leaks

The requirements of 40 CFR 264, Subparts AA and BB, and 22 CCR Chapter 15, Articles 27 and 28, may be applicable to onsite treatment units that treat RCRA wastes that contain organic concentrations equal to or greater than 10 ppm by weight. Control devices will need to be monitored and inspected to ensure proper maintenance and operation. Equipment shall be designed as to prevent leakage of organic emissions to the atmosphere.

A more stringent RCRA regulation for tanks and containers limiting air emissions from process vents and equipment leaks is expected to be promulgated in October 1993. This regulation may become a potential ARAR once it goes into effect.

Closure and Postclosure

To the extent present or former RCRA units are identified in the source areas, RCRA closure and postclosure requirements may be applicable or relevant and appropriate.

A waste management unit is required by CCR 23 2580 to be closed in accordance with an approved closure and postclosure maintenance plan. This will be necessary if wastes are to be left in place that could adversely impact groundwater quality.

Groundwater Monitoring and Groundwater Protection Standards

Groundwater monitoring requirements under 40 CFR 264 Subpart F are applicable if the CERCLA remedial action involves creation of a new disposal unit when remedial actions are undertaken at existing RCRA units, or where disposal of RCRA hazardous wastes occurs as part of the remedial action.

The requirements of 40 CFR Section 264.94 establish three categories of groundwater protection standards that are potentially relevant and appropriate: background concentrations, RCRA MCLs, and Alternative Concentration Limits (ACLs). The MCLs under the Safe Drinking Water Act are relevant and appropriate for the site (see Chemical-Specific ARARs, discussed previously). In complying with SDWA MCLs, cleanup will also be consistent with RCRA MCLs. When no MCL has been established, a remediation level that is the equivalent of a health-based ACL under RCRA may be relevant and appropriate.

Groundwater protection standards are also provided in Title 23 CCR, Division 3, Chapter 15 and are relevant and appropriate to the cleanup of the contaminated aquifer. Background concentrations are established as a starting point in determining cleanup levels. A cleanup level greater than background may be proposed only if the regional board finds that is technically and economically infeasible to achieve background levels. If cleanup levels greater than background are proposed, it must be demonstrated that the contaminants will not result in excessive exposure to sensitive biological receptors.

Corrective Action

The proposed 40 CFR Subpart S corrective action regulations are TBC to land-based remedial actions undertaken at the McClellan AFB Groundwater OU Site.

In addition to the federal requirements, 23 CCR 2550.10 requires the discharger to implement a corrective action program to remediate releases of wastes. A monitoring program should be established to demonstrate the effectiveness of the corrective action. This applies to any source contamination areas at the Base.

Ambient Air Quality Standards and New Source Review

Both the national (federal) and California governments have established ambient air quality standards (NAAQS and CAAQS, respectively) for a number of air pollutants, referred to as criteria pollutants. The criteria pollutants include:

- Carbon monoxide (CO)
- Lead
- Oxides of nitrogen (NO_x) as nitrogen dioxide (NO_2)
- Ozone (reactive organic gases [ROG] and NO_x are precursors to ozone formation)
- Particulate matter less than 10 microns in aerodynamic diameter (PM1O)
- Sulfur dioxide (SO_2)

A project cannot cause or contribute to an exceedance of the applicable NAAQS or CAAQS. To ensure this, new or modified sources of air pollutants are required to comply with new source review (NSR) regulations. Sources other than remedial actions are required to obtain an authority to construct (ATC) permit and a permit to operate (PTO). NSR regulations are promulgated and permits are issued by the local air pollution control districts in California. In the case of McClellan AFB, the local regulatory agency is the Sacramento Metropolitan Air Quality Management District (SMAQMD).

The SMAQMD proposed new NSR rules (Rule 202) in March 1992. These rules require that proposed emissions units with a potential to emit ROG, NO_x, or CO must provide offsets for the affected pollutant. Offsets for PM10 and SO_2 must be provided only if cumulative emission changes exceed 80 pounds per day (lb/day) for PM10 or 150 lb/day for SO_x. Applicants are also required to apply Best Available Control Technology (BACT) to any new emissions unit or modification of an existing unit that has the potential to emit ROG, NO_x, SO_2, PM10, or CO. BACT requirements may be considered performance-, design-, or other-action-specific ARARs.

Under NSR rules, BACT would need to be applied to any new treatment alternative that emits ROG, NO_x, SO_2, PM10, or CO. In addition, to be compliant with this rule, offsets would need to be provided by McClellan AFB to meet the NO_x requirement.

Other ARARs identified by SMAQMD in a March 11, 1993, letter from Jorge DeGuzman to Mark Malinowski, Department of Toxic Substances Control, include the following:

- SMAQMD Rule 401—Ringelmann Chart. No person shall discharge into the atmosphere from any single source of emissions whatsoever any air contaminant, other than uncombined water vapor, for a period or periods aggregating more than three minutes in any one hour which exceeds 20 percent in opacity or a No. 1 on the Ringelmann Chart, as published by the United States Bureau of Mines.

- SMAQMD Rule 402—Nuisance: The project should not create a public nuisance. This includes a non-acceptable health risk. Risk assessment must be conducted using SMAQMD's "Permit Procedure Regarding Criteria for Calculating an Excess Cancer Risk to the Public Whom May be Exposed to Carcinogenic Air Contaminants from a New/Modified Toxic Air Emission Source," September 9, 1991.

- SMAQMD Rule 403—Fugitive Dust: All reasonable precautions should be taken not to cause or allow the emissions of fugitive dust from being airborne beyond the property line from which the emission originates.

New Source Performance Standards

The EPA establishes standards of performance for new sources (NSPS). These standards reflect the degree of emission limitation and the percentage reduction achievable through the application of the best technological system of continuous emission reduction that EPA determines is adequately demonstrated for each particular source category. EPA must consider the cost of achieving emission reductions and energy requirements when drafting NSPS.

The only NSPS source category that might be considered applicable to the proposed offgas treatment alternatives would be those that apply to the thermal oxidizers under the incinerator requirements, found in Subpart E of 40 CFR, Part 60. These standards are only applicable to incinerators with charging rates greater than 50 tons per day. The proposed thermal oxidizer will have a charging rate of approximately 2.0 ton/day, far less than that regulated by the incinerator NSPS.

Requirements for Noncriteria Pollutants—Toxic Air Contaminants

In addition to the criteria pollutants discussed above, there has been increasing concern about toxic air contaminants in recent years. Toxic air contaminants (TACs) include airborne inorganic and organic compounds that can have both short-term (acute) and long-term (carcinogenic, chronic, and mutagenic) effects on human health.

Prior to the 1990 amendments to the Clean Air Act, the EPA conducted a program to establish National Emission Standards for Hazardous Air Pollutants (NESHAPs). NESHAPs were established for benzene, vinyl chloride, radionuclides, mercury, asbestos, beryllium, inorganic arsenic, radon 222, and coke oven emissions. The 1990 Clean Air Act amendments require EPA to set standards for categories and subcategories of sources that emit hazardous air pollutants, rather than for the pollutants themselves. The deadline for the first set of EPA standards is November 1994. NESHAPs set before 1991 will remain applicable.

Under Assembly Bill (AB) 1807, California has a program for identifying and developing emissions control and reduction methods for TACs. The California Air Resources Board (ARB) has identified 15 compounds as TACs; these are dioxins/furans, ethylene dibromide, ethylene dichloride, benzene, hexavalent chromium, cadmium, asbestos, vinyl chloride, chloroform, trichloroethene, methylene chloride, inorganic arsenic, ethylene oxide, carbon tetrachloride, and formaldehyde. Other compounds are being studied for possible identification as TACs. Control measures for TACs are being developed by the ARB. None of the control measures developed to date for the identified TACs are applicable to the proposed thermal oxidizer or its emissions.

In addition to AB 1807, California has implemented AB 2588, the Air Toxics "Hot Spots" Information and Assessment Act of 1987. Under AB 2588, industrial and municipal facilities must inventory and report emissions of listed toxic substances. High priority facilities must conduct risk assessments. McClellan AFB has prepared and submitted a health risk assessment based on 1989 facility-wide emissions. Follow-on legislation may require pollution control, but no such legislation has been enacted at this time.

SMAQMD has released a "Permit Procedure Regarding Criteria for Calculating an Excess Cancer Risk to the Public Whom May be Exposed to Carcinogenic Air Contaminants from a New/Modified Toxic Air Emission Source," September 9, 1991. This permit procedure requires screening and potentially refined risk assessment of human health effects associated with exposure to toxic air contaminants. Both residential and workplace exposures must be evaluated. Cancer risks are considered acceptable if risks do not exceed one theoretical excess lifetime cancer case per million individuals. If the applicant applies Toxic Best Available Control Technology (TBACT), risks are acceptable if they do not exceed 10 theoretical lifetime cancer cases per million individuals. The proposed groundwater treatment project will be required to conduct a risk assessment and demonstrate acceptable risks, as mentioned previously in the discussion of SMAQMD Rule 402—Nuisance.

Potential Nonspecific ARARs

In addition to the action-specific requirements discussed in Table D-6, there are a number of regulations or requirements that may not be related to a particular remedial action and do not fit the description of a chemical-specific or location-specific ARARs; however, these regulations or requirements may be considered relevant or applicable to several potential remedial actions. These potential ARARs are addressed in this section and should be evaluated during the selection and design of remedial actions at the McClellan AFB Groundwater OU Site.

SWRCB Resolution 68-16

This resolution requires the continued maintenance of high quality water of the state. Unlike the federal antidegradation policy, this state policy includes groundwater as well as surface water. Water quality may not be allowed to be degraded below what is necessary to protect the "beneficial uses" of the water source. Beneficial uses of waters in the vicinity of McClellan AFB are identified in the Inland Surface Waters Plan.

Resolution 68-18 applies most often to CERCLA cleanups that involve extracting, treating, and discharging treated groundwater. Activities that discharge to high quality waters (unaffected surface or groundwater) require the use of "best practicable treatment or control" of the discharge to avoid pollution or nuisance and maintain high quality. Best practicable treatment would take into account technical and economic feasibility. Any remedial actions at McClellan AFB must take into account the protection of beneficial uses and the maintenance of high quality waters in the area.

Porter-Cologne Water Quality Control Act

The State Water Resources Control Board and the Regional Water Quality Control Boards derive their statutes from Porter-Cologne and, as such, are responsible for the protection of existing and probable future beneficial uses of State waters. Under *Porter-Cologne*, the Regional Boards' objectives are achieved primarily though an ongoing basin planning program and the establishment of requirements for the discharge of waste to waters or to the land of the state where such discharge has the potential for water quality impacts. Additionally, waste discharge requirements (WDRs) are written to implement regulations promulgated by the State Board in Title 23 of the CCR. The establishment of the WDRs by the State Boards may be necessary to regulate any proposed offsite discharge where CERCLA waste has been mixed with non-CERCLA waste. The substantive requirements of Porter-Cologne would also be ARARs for nonsite remedial activities. Requirements under Porter-Cologne could be chemical-specific, action-specific, and/or location-specific.

Probable ARARs for Selected Alternatives

In selecting probable ARARs from the list of potential ARARs for any given site, a number of uncertainties must be accounted for and assumed. Unknown parameters include the actual extent of contamination, and the actual effectiveness of the innovative technology selected in the ROD. These uncertainties are discussed in detail in Chapter 6. These unknowns cannot be clarified until after remediation has begun and results of remedial action (RA) monitoring are examined. For example, results of RA monitoring may report more extensive contamination or other contaminants in addition to those assumed in the ROD. These revelations may trigger different ARARs, prompting modification of the ROD to ensure protectiveness and effective remediation. Figure D-4 graphically links the uncertainties assumed in this RI/FS and how they ultimately affect the ARARs.

Earlier in this appendix, chemical-, location-, action-, and non-specific ARARs were assembled as **potential** ARARs based on the extent of contamination known to exist in the McClellan AFB Groundwater OU and potential remedial actions presented in this RI/FS. At this point in the analysis, **probable** ARARs are defined for the extraction, treatment, and end-use remedial actions for the preferred alternative as presented in the RI/FS.

Once a proposed remedial action has been selected as part of the RI/FS process, an ARARs analysis must be performed for that remedial alternative. An ARARs analysis assembles probable location- and chemical-specific ARARs independent of the RA as well as those action-specific ARARs triggered by the proposed RA. If, during final selection of ARARs it is determined that the RA does not meet all criteria set in the ARARs, either a waiver would be included in the Interim ROD, or the RA would have to be reevaluated. Selection of the probable ARARs from the listing of potential ARARs is analogous to a sieve screening where all the potential ARARs become probable ARARs for the proposed RA and only a few "pass through the screen" when they do not specifically apply to the proposed RA (e.g., certain action-specific regulations). Figure D-5 presents the process of selecting probable ARARs, including provisions for inclusion of waivers in the ROD.

Two remedial actions were initially proposed to remediate the contaminated groundwater in the McClellan AFB Groundwater OU. On the east side, the proposed RA was to extract to MCL target volume, treat by air stripping followed by LGAC with VGAC offgas treatment, and greywater end use with excess sold to neighboring utilities. On the west side, the proposed remedial actions were to extract to MCL target volume, use the existing or modified groundwater treatment plant for treatment, and onsite greywater end use with excess sold to neighboring utilities. The target volume and end-use options have been revised based on agency response to these proposed alternatives. The agencies will not accept the MCL target volume because it would not be protective of the aquifer as a drinking water source. Therefore, the 10^{-6} additional cancer risk target volume has been selected as the preferred containment option.

In addition, the proposed end-use option that involves the selling of treated groundwater to local utilities has been reviewed by the DHS-ODW who responded to the alternative with a letter to Doris J. Varnadore dated 6 December 1993. This agency has determined that the use of treated groundwater for domestic consumption will not be approved because of the potential to introduce toxic contaminants into the water supply. The letter from DHS-ODW which details the agencies response to the proposed end-use option is included as Attachment D-1. Because the treated groundwater cannot be sold to the utilities, the injection end-use alternative has now been selected as the preferred end-use option.

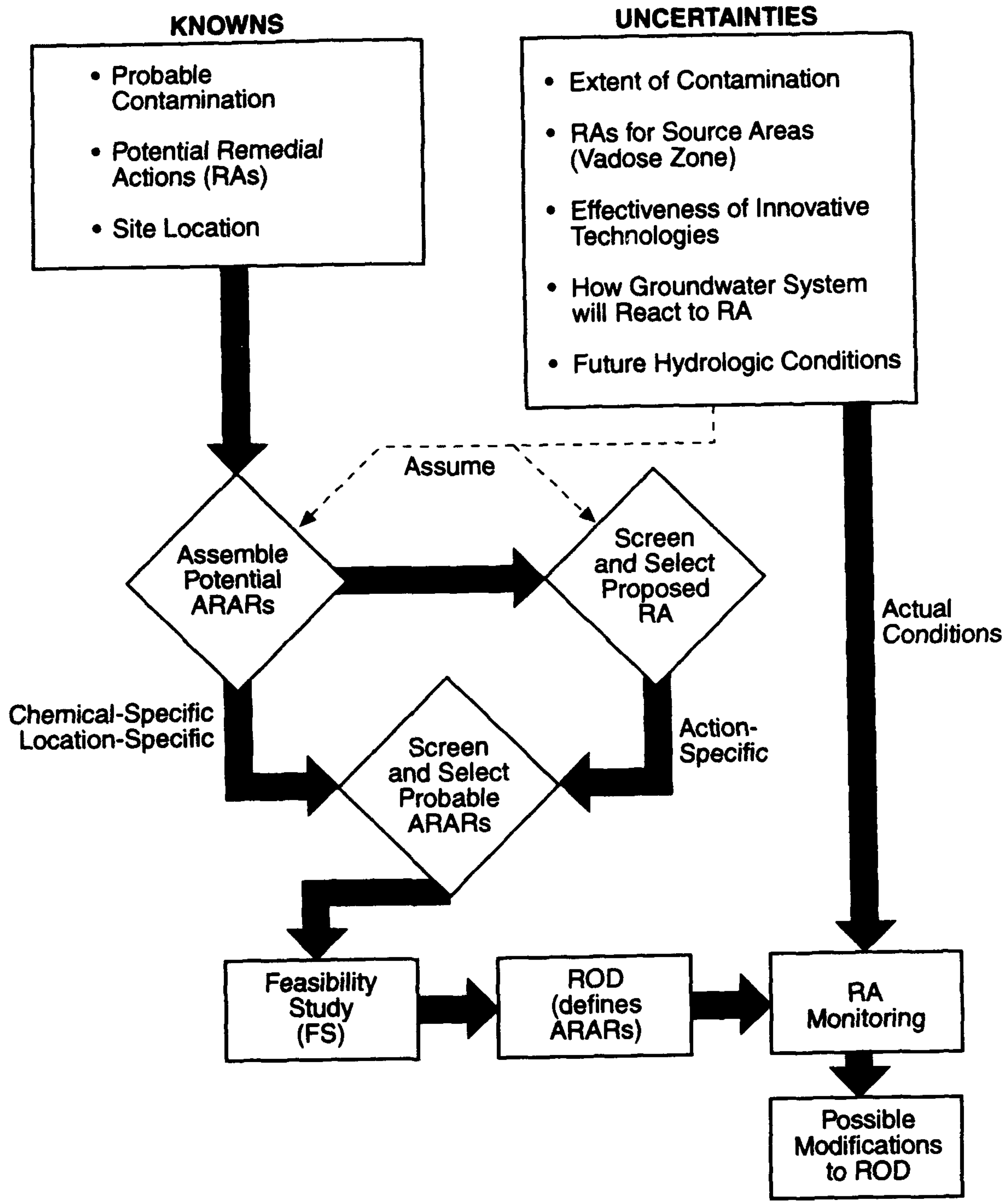

FIGURE D-4
EFFECT OF UNCERTAINTIES ON ARARs
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

RDD1454_205

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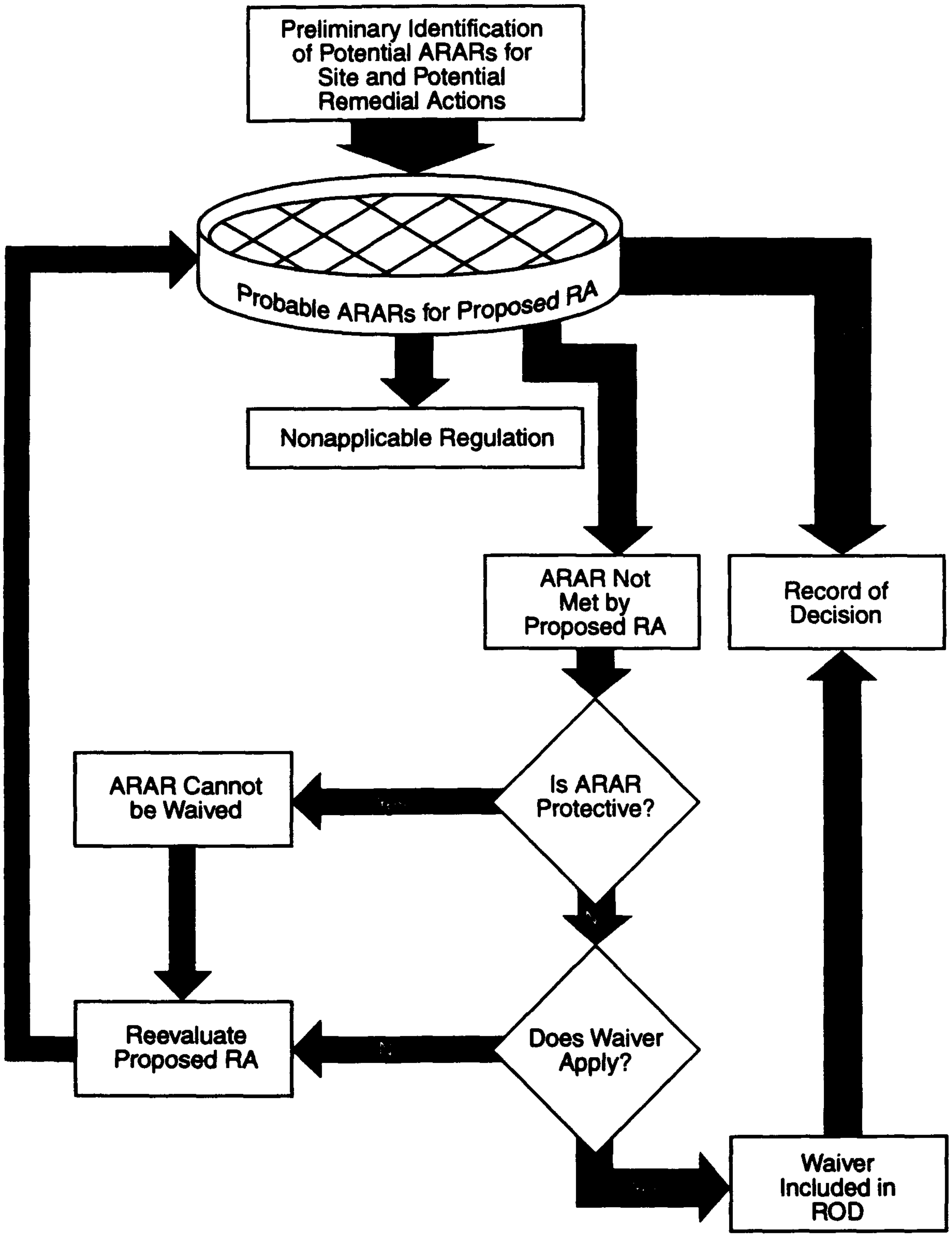

FIGURE D-5
PROBABLE ARAR SELECTION PROCESS
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

RDD1454_204

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Table D-7 is a summary of the ARARs that apply to these proposed alternatives. They represent the chemical-specific water quality criteria that the subsurface and treated groundwater must meet, the performance criteria that the treatment systems must comply with, and the requirements that will govern how and where the treatment facility will be located and operated.

Table D-7
Probable ARARs
East Side: 10^{-6} Additional Cancer Risk Target Volume/
Air Stripping followed by LGAC with VGAC Offgas Treatment/Injection
West Side: 10^{-6} Additional Cancer Risk Target Volume/
Existing Water Treatment Plant/Injection

ARAR	Citation
Location-Specific ARARs	
1. 100-year flood plain	40 CFR 264.18(b) 23 CCR 2531(c) 22 CCR 66264.18(b) 22 CCR 66270.14(b)(11)
2. Within flood plain	Executive Order 11988, Protection of Flood Plains 40 CFR 6, § 6.302(b)
3. Within historic or archaeological area	National Archaeological and Historical Preservation Act (16 USC Section 469); 36 CFR Part 65
4. Critical habitat for endangered or threatened species	Endangered Species Act of 1973 (16 USC 1531 *et seq.*); 50 CFR Part 200, 50 CFR, Part 402 Migratory Bird Treaty Act (16 U.S.C. 703-712) with list of protected birds in 50 CFR 10.13 California Endangered Species Act California Fish and Game Code Sections 2070, 2080, 2090-2096 14 CCR Section 670.5
5. Wetlands	Executive Order 11990 Protection of Wetlands (40 CFR 6, § 6.302(a) Clean Water Act Section 404; 40 CFR Parts 230, 231 California Fish & Game Code Section 1603
6. Area affecting stream or other body of water	Fish and Wildlife Coordination Act (16 USCC 661 *et seq.*); 40 CFR 6.302 California Fish and Game Code CWA Section 404 40 CFR 230

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East Side: 10^{-6} Additional Cancer Risk Target Volume/
Air Stripping followed by LGAC with VGAC Offgas Treatment/Injection
West Side: 10^{-6} Additional Cancer Risk Target Volume/
Existing Water Treatment Plant/Injection

ARAR	Citation
Location-Specific ARARs (continued)	
7. Sole-source aquifer	SDWA 42 USC Section 300n; 40 CFR Section 146.4
8. Hazardous waste site	20 CFR 1910.120
9. Security	22 CCR 66264.14
Action-Specific ARARs	
1. Waste identification	22 CCR 66261
2. Container storage	40 CFR 264.171 (R18-18-264.170, *et. seq.)* 40 CFR 264.172 - .178, inclusive
3. Storage	22 CCR 66262.34
4. Tank systems	40 CFR 262 (Subpart J) Title 23 CCR Div. 3, Chapter 16 40 CFR 264.192-197, inclusive 40 CFR 270.16
6. Miscellaneous treatment	40 CFR 264 (Subpart X) 40 CFR 268 (Subpart D) 22 CCR 66264.601 22 CCR Article 17, Chapter 15
7. Air emissions from groundwater treatment	40 CFR 61 40 CFR 264, Subpart AA, and 22 CCR, Article 27, Chapter 15 40 CFR 264, Subpart BB, and 22 CCR Article 28, Chapter 15 SMAQMD Rule 202 SMAQMD Rules 401, 402, and 403
8. Direct discharge of treatment system effluent	40 CFR 122, 125, and 136 50 FR 30784 (July 29, 1985) Inland Surface Waters Plan and the Central Valley Basin Plan
9. Incineration	40 CFR, Part 60, Subpart E 22 CCR 66264.343 22 CCR 66264.345
10. Land disposal restrictions	22 CCR Section 66268

Table D-7
Probable ARARs
East Side: 10^{-6} Additional Cancer Risk Target Volume/
Air Stripping followed by LGAC with VGAC Offgas Treatment/Injection
West Side: 10^{-6} Additional Cancer Risk Target Volume/
Existing Water Treatment Plant/Injection

ARAR	Citation
Action-Specific ARARs (continued)	
11. Injection	40 CFR 144.12-144.21, inclusive 40 CFR 146.4, 146.13 California Water Code, Division 7 Section 1300 et seq. Basin Plan for the Central Valley Region SWRCB Resolution 68-16
Chemical-Specific ARARs	
1. Groundwater remedial goals	40 CFR 300.430(e)(2)(i)(A)(2) California Domestic Water Quality and Monitoring Regulations CCR 22, Chapter 15
2. Groundwater discharge requirements	Clean Water Act, USC Section 1251 *et seq.* Inland Surface Waters Plan

Works Cited

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PREPARED FOR: McClellan Air Force Base

DATE: June 9, 1994

SUBJECT: Proposed Groundwater Monitoring Program
Groundwater OU RI/FS Report
Delivery Order No 5066

PROJECT: SAC28722.66.DA

Introduction

The objective of this technical memorandum is to determine the approximate number of additional monitoring wells that would be required to adequately monitor each of the proposed extraction networks. This information was used to develop budget level cost estimates for each of the extraction networks and to provide a basis for the costs presented.

The Groundwater OU remedy will be implemented using a phased approach, with each phase being preceded by a work plan and detailed sampling and analysis plan. Each phase will terminate with a report presenting the data collected during that phase and the results of the analyses performed on the data to revise the conceptual model of the site. The sampling and analysis plan developed for each phase will contain a detailed description of where each monitoring well is placed, its designation, and the rationale for its location. That detailed information is beyond the scope of this document and is not necessary to meet the objectives presented above.

Description of Current Monitoring Program

The current interpretation of the remedial action target volumes is a function of the groundwater monitoring network and the frequency of sampling of the individual wells. At McClellan AFB, the sampling of monitoring wells is variable, with some wells sampled quarterly while others have not been sampled for several years. The Groundwater Sampling and Analysis Program (GSAP) sampling schedule is periodically revised based on observed groundwater flow directions, plume boundaries, histories of analyses from each well, and redundancy of data. This sampling frequency has a significant influence on the understanding of the distribution of contamination because groundwater contaminant concentrations in critical areas may not be available to aid in the interpretation. To demonstrate the variability in the sampling program, figures have been developed to show the date of latest sampling by color code. The date of the most recent sampling of groundwater monitoring wells at the Base screened in Monitoring Zones A, B, C, and D/E are indicated on Figures E-1 through E-4, respectively.

It is apparent from Figure E-1 that almost half of Monitoring Zone A wells have not been sampled since January 1992, and as many as 20 percent of the wells have not been sampled since January 1986. This is partly because of the fact that numerous A-zone wells have gone dry over the last several years. Figures E-2 and E-3 suggest that far fewer Monitoring Zones B and C wells have been dropped from the monitoring program. Most of the wells in these units have been sampled since January 1992, and of those that have not, most have been sampled since April 1989. The wells in Monitoring Zones B and C that have been dropped from the monitoring program are located in the hot spot areas and have consistently shown high levels of contamination. Because of the small number of wells in Monitoring Zones D and E, most have been retained in the monitoring program.

Methodology for Selection of Well Locations

The groundwater monitoring networks developed for the recommended remedial alternatives are designed to achieve two major objectives:

1. To better define the spatial distribution of contamination at the Base to allow refinement of the remedial action target volumes.

2. To provide an adequate number of monitoring points so that the effectiveness of the extraction network at containing contaminated groundwater can be assessed.

New recommended well locations are classified by their primary function. The two primary functions of the proposed wells are water quality monitoring and monitoring of the extent of hydraulic containment of the remedial action target volumes. It should be noted that even the hydraulic containment wells will be constructed with a minimum 4-inch-diameter and will be sampled at some frequency to improve the definition of water quality across the site. On the basis of the interpretation of the groundwater quality data, some of the wells originally proposed for hydraulic monitoring may become critical to the understanding of the distribution of contamination. These wells will then be added to the routine groundwater quality monitoring network. Other wells originally proposed for water quality monitoring may fail to provide critical monitoring data, and these will be dropped from the water quality monitoring network.

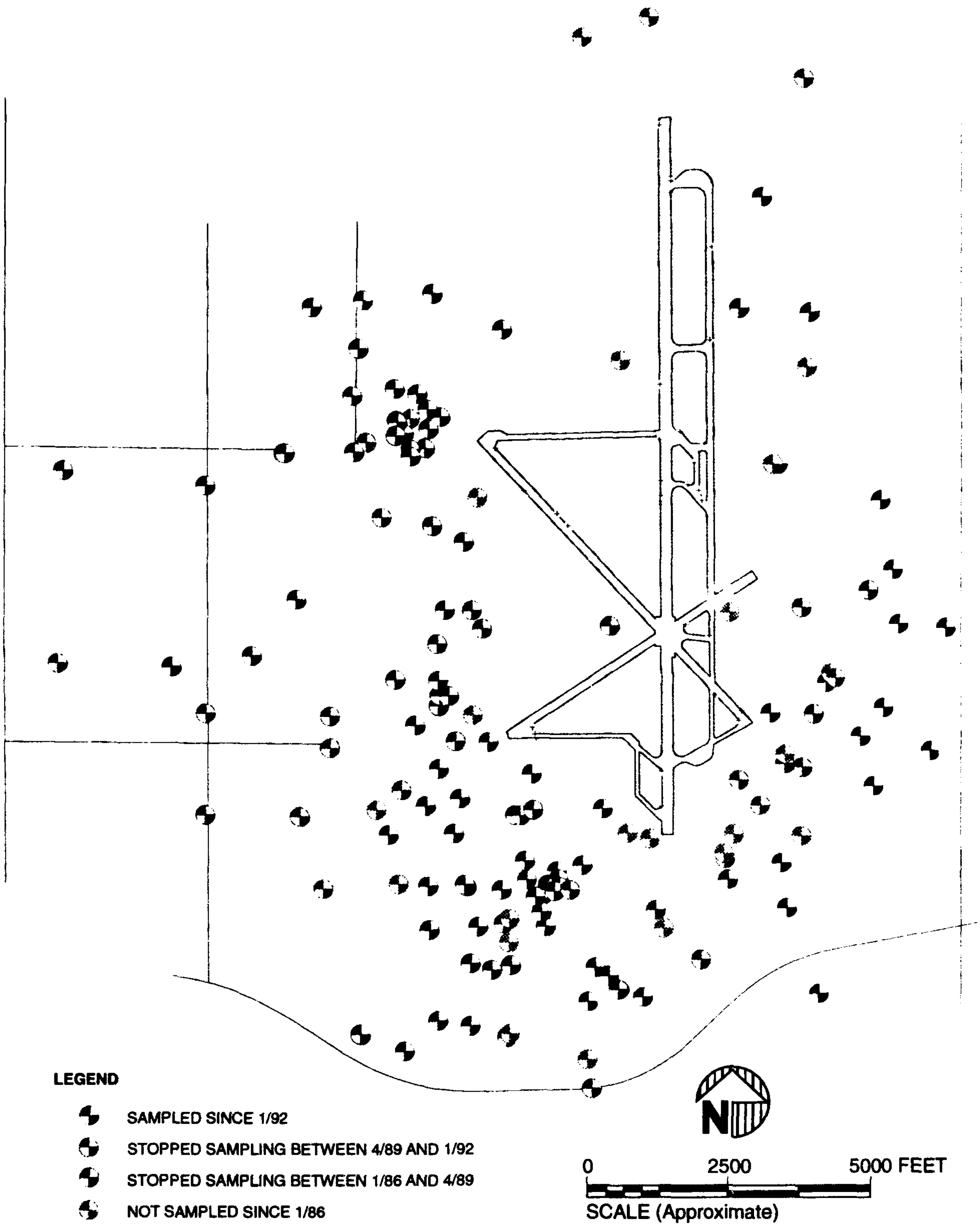

FIGURE E-1
MOST RECENT SAMPLING DATES FOR ZONE A MONITORING WELLS
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

RDD1312_297

CH2M HILL

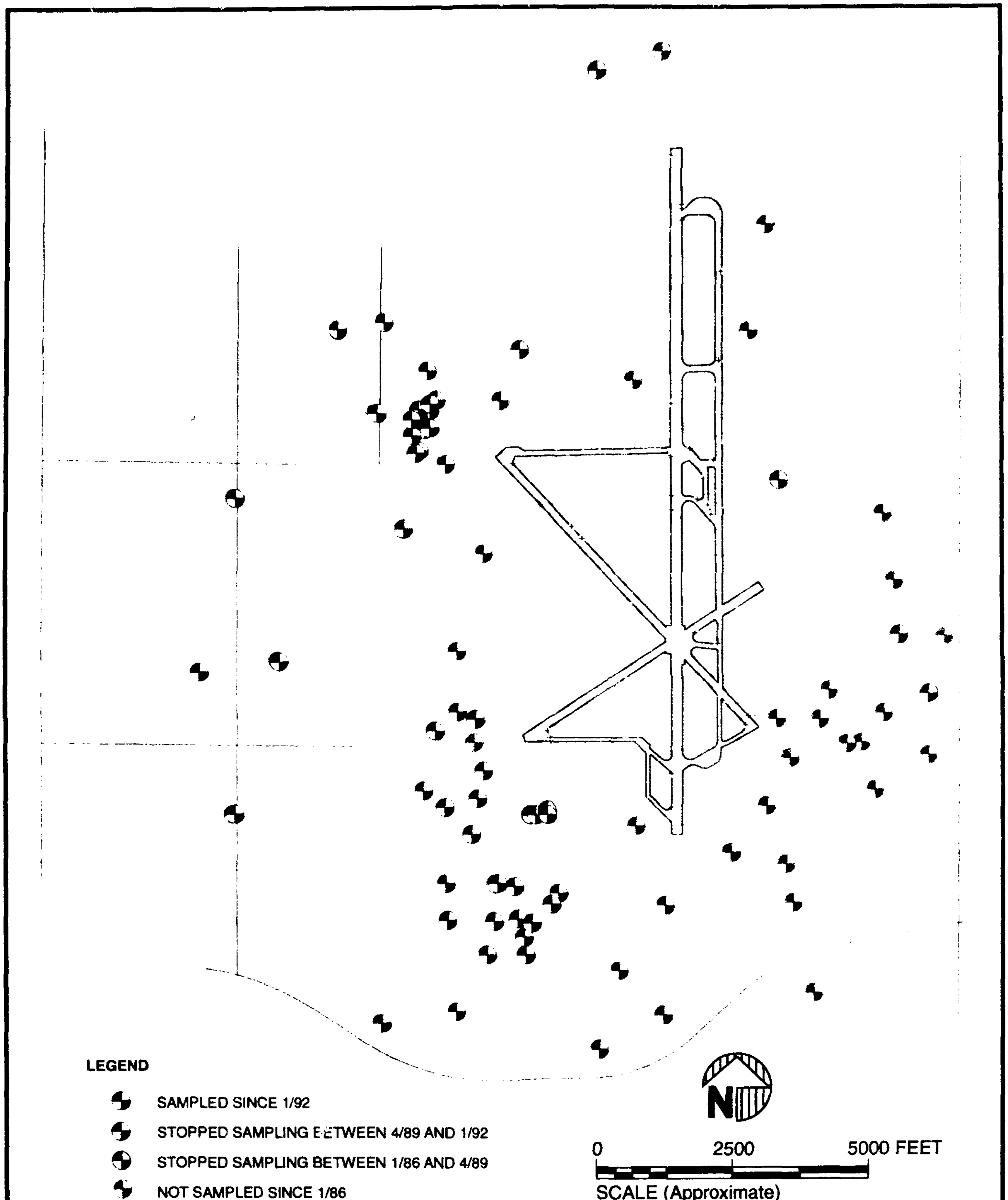

FIGURE E-2
MOST RECENT SAMPLING DATES FOR ZONE B MONITORING WELLS
GROUNDWATER OPERABLE UNIT RI/FS
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SACRAMENTO, CALIFORNIA

RDD1312 298

CH2M HILL

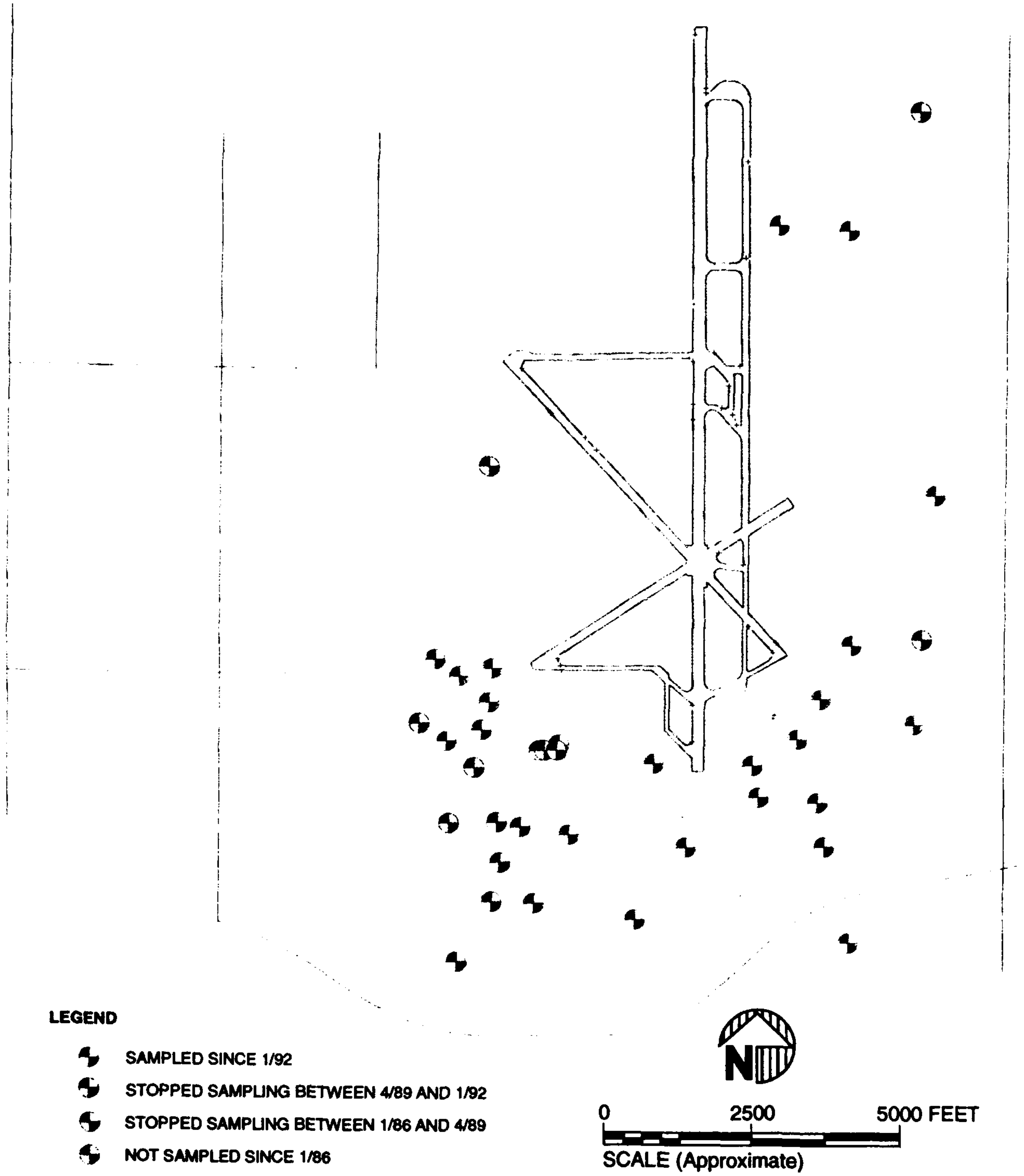

FIGURE E-3
MOST RECENT SAMPLING DATES FOR ZONE C MONITORING WELLS
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McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

RDD1312_299

CH2M HILL

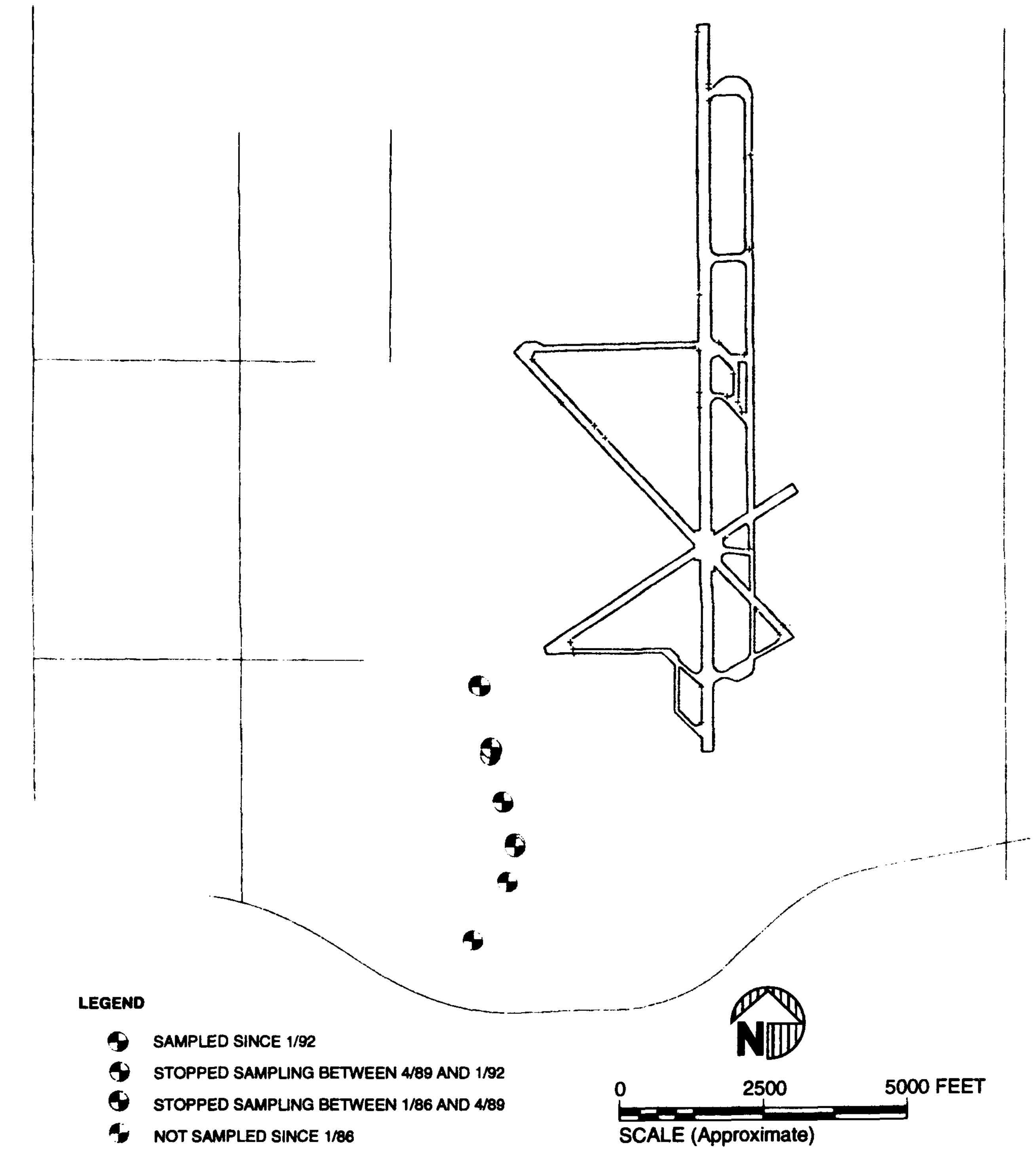


FIGURE E-4
MOST RECENT SAMPLING DATES
FOR ZONE D/E MONITORING WELLS
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

RDD1312_300

CH2M HILL

Groundwater Quality Wells

This set of monitoring wells is designed to improve the understanding of the spatial distribution of contamination at the Base. The current understanding of the extent of the remedial action target volumes is heavily influenced by the location of the existing monitoring wells. The current distribution of monitoring wells in each monitoring zone was evaluated, along with the monitoring data used to develop the target volumes, in an attempt to identify strategic well locations to reduce the uncertainty in target volume extent. In many areas, the currently identified target volumes are defined by widely spaced monitoring wells, and additional groundwater monitoring points are required to reduce the uncertainty in the location of the target volume boundaries.

Hydraulic Containment Monitoring Wells

This set of monitoring wells was developed to provide monitoring of the hydraulic containment of contaminated groundwater created by the extraction network. To adequately monitor the degree of containment of the target volume, a sufficient number of wells must be located around the perimeter of the target volume to demonstrate that a hydraulic gradient exists driving flow inward toward the extraction wells. This type of network will confirm horizontal capture of the contaminated groundwater. The other component of the hydraulic monitoring system is a network of wells that will demonstrate that vertical containment is achieved. In areas where contamination exists in a shallow monitoring zone overlying an uncontaminated deeper zone, monitoring wells should be installed to confirm that an upward gradient has been created by the extraction system to prevent the downward movement of contaminants.

Although it would be desirable to monitor the hydraulic gradients present along the entire perimeter of each target volume, the number of wells required to achieve this level of monitoring would be impractical. As an alternative, the hydraulic monitoring wells were situated in areas where a failure of containment is most likely. These are mainly on the southern edge of the target volumes where regional groundwater flow patterns are working against the containment system. Conversely, only a few hydraulic containment wells are required on the north boundary of the target volumes since the natural southerly groundwater flow direction will carry contamination to the extraction wells.

The hydraulic containment monitoring system presented below is based on the current interpretation of the target volume extent. Obviously, as additional groundwater quality information is collected and analyzed, target volume definitions may change. It should be understood that if the boundary of a given target volume changes significantly in the future, the associated hydraulic monitoring system will be adjusted as well.

Proposed Groundwater Monitoring Networks

This section presents the groundwater monitoring networks developed according to the strategy described above. The network developed for the MCL target volume will be presented first followed by those developed for the risk and background target volumes. Finally, additional Monitoring Zone D wells are proposed to gather additional information to improve our understanding of the spatial extent of contamination in that zone. This well layout is independent of any assumption of target volume extent.

MCL Monitoring Network

The groundwater monitoring network developed for the MCL target volume is presented in Figures E-5 through E-7 (located in a pocket at the end of this appendix) for Monitoring Zones A, B, and C, respectively. These figures show the approximate locations of the proposed new groundwater quality monitoring wells and the new hydraulic containment monitoring wells. Also shown on these figures is the extent of the MCL target volume in each monitoring zone and the location of the existing monitoring wells. Table E-1 summarizes the number of each type of monitoring wells required for each monitoring zone.

Risk Monitoring Network

The groundwater monitoring network developed for the risk target volume is presented in Figures E-8 through E-10 (located in a pocket at the end of this appendix). These figures present approximate well locations for Monitoring Zones A, B, and C, respectively, along with the Risk target volume extent in each monitoring zone. The total number of groundwater quality monitoring wells and hydraulic containment wells required to monitor this target volume are summarized in Table E-1.

Background Monitoring Network

The groundwater monitoring networks developed for the background target volume are presented in Figures E-11 through E-13 (located in a pocket at the end of this appendix). These figures present approximate well locations for Monitoring Zones A, B, and C, respectively. The total number of groundwater quality monitoring wells and hydraulic containment wells required to monitor this target volume are summarized in Table E-1.

Table E-1 Groundwater Monitoring Network Well Summary		
Monitoring Zone	**Hydraulic Containment Monitoring Wells**	**Water Quality Monitoring Wells**
MCL Target Volume		
A	21	28
B	9	10
C	0	9
Totals	30	47
Risk Target Volume		
A	28	38
B	9	15
C	0	17
Totals	37	70
Background Target Volume		
A	36	39
B	10	18
C	4	14
Totals	50	71

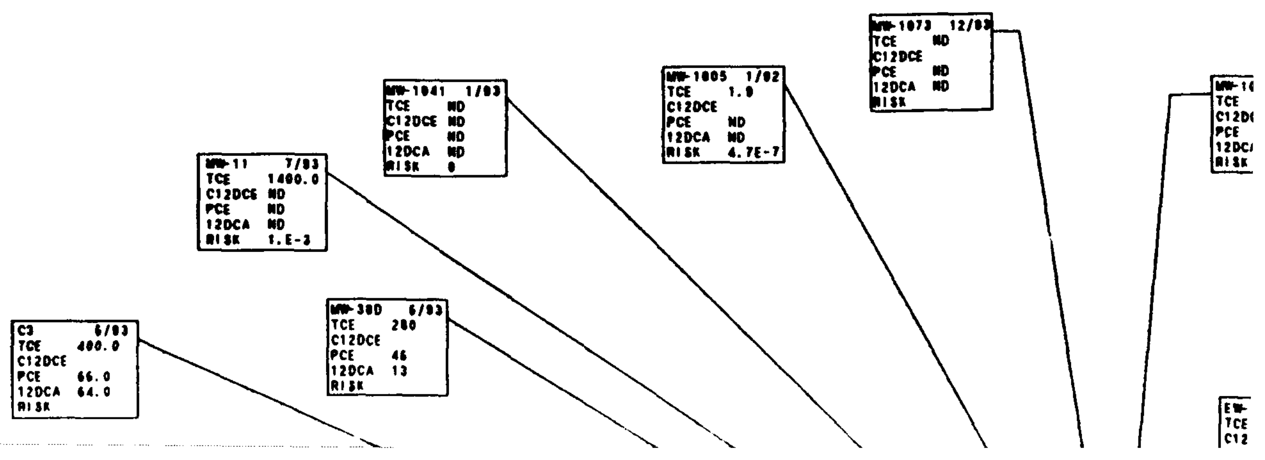
Monitoring Zone D Wells

The proposed new Monitoring Zone D wells are presented in Figure E-14. Because of the limited amount of water quality information available for this unit, these wells are located to improve our understanding of the spatial extent of contamination in this zone. Additional monitoring wells will likely be required to fully define the extent of contamination in Monitoring Zone D, but their locations cannot be determined until sampling results are obtained from the new wells proposed.

(1)

WELL SUMMARY

- X — EXISTING EXTRACTION WELLS
- • — NEW EXTRACTION WELLS
- ⯁ — NEW MONITORING WELLS FOR WATER QUALITY
- ⊕ — NEW MONITORING WELLS FOR HYDRAULIC CONTROL
- • — EXISTING MONITORING WELLS
- - - - - - — TARGET VOLUME BOUNDRY
- ——— — HOT SPOT BOUNDRY



LLS

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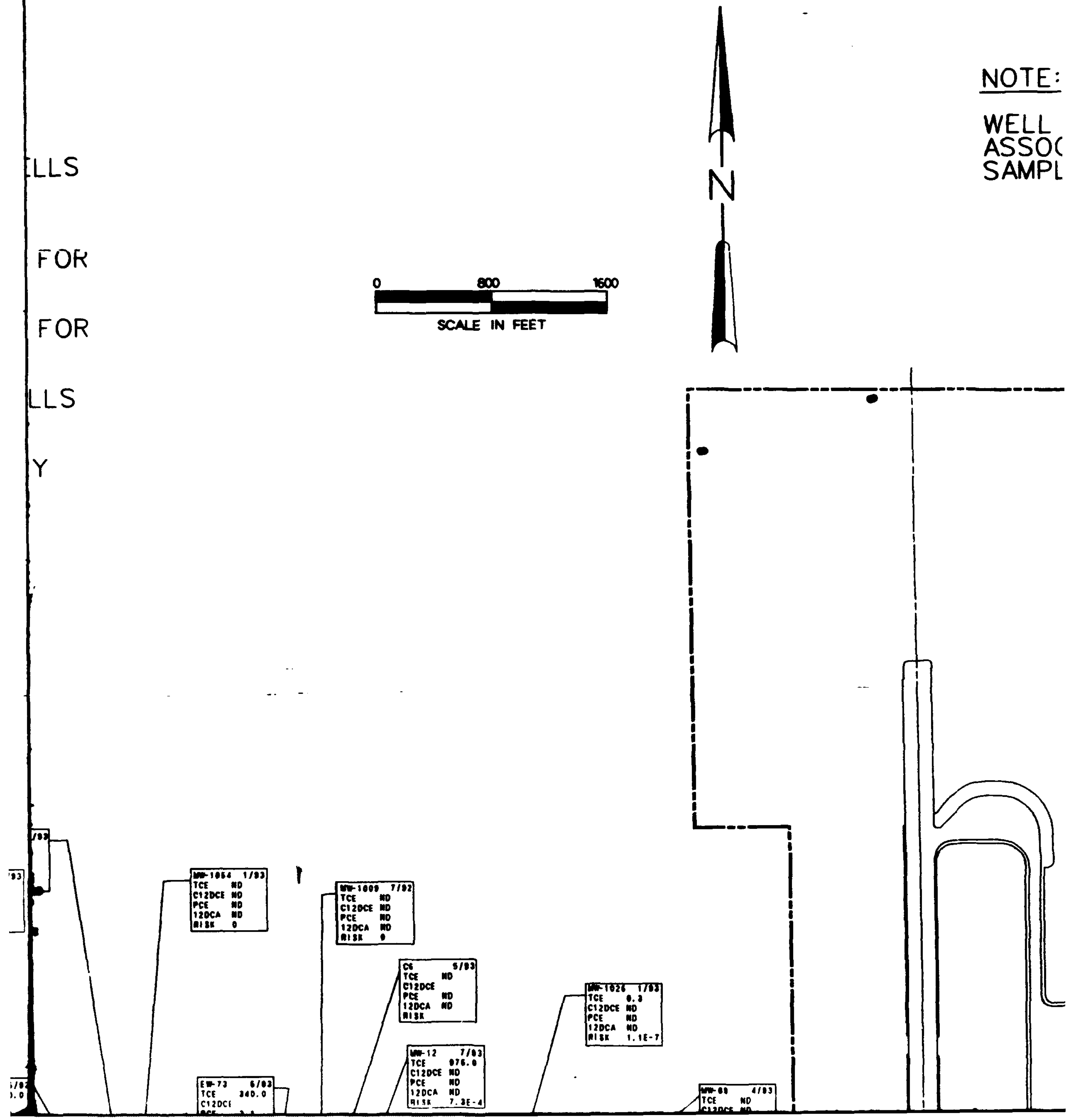
LLS

Y

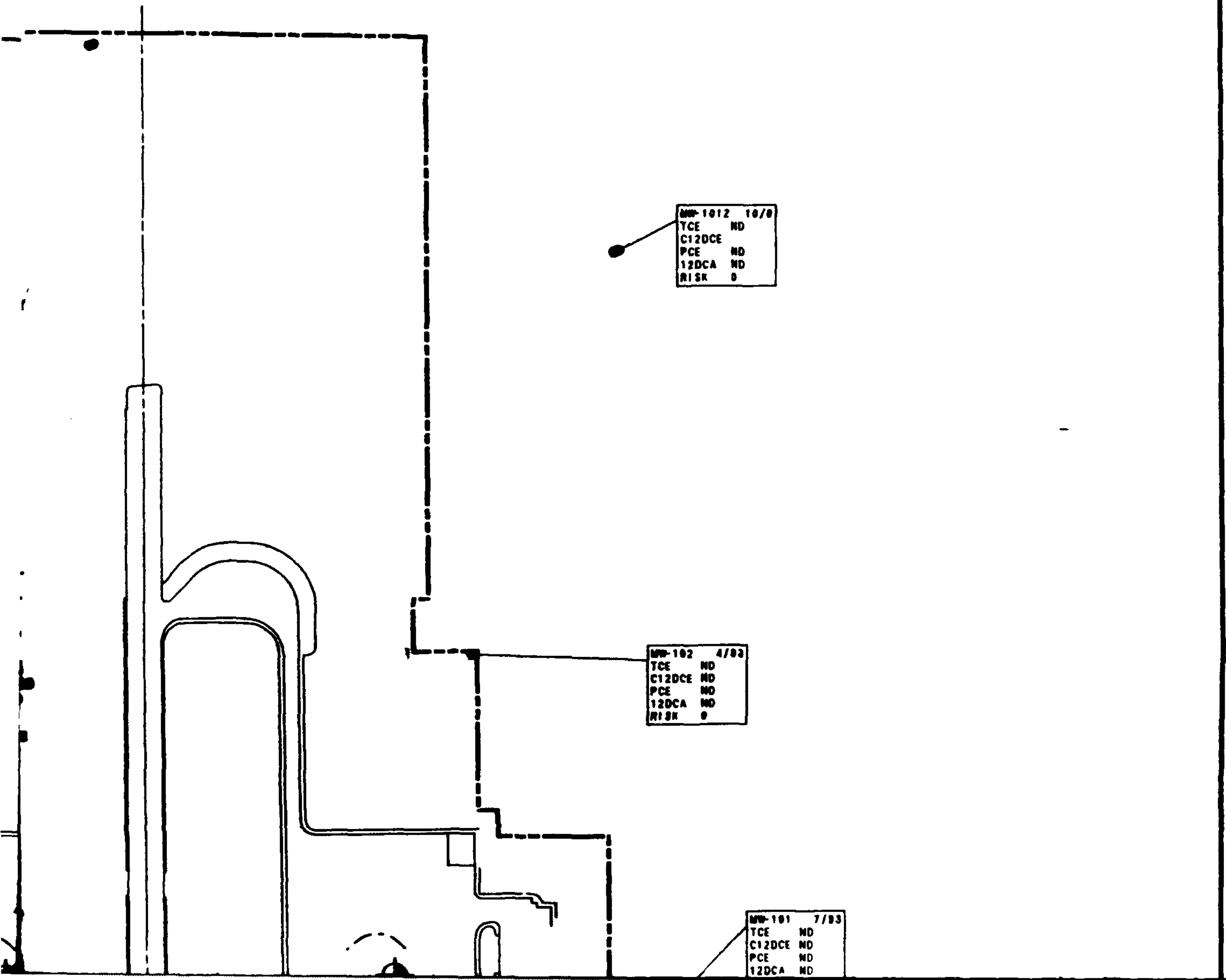
NOTE:

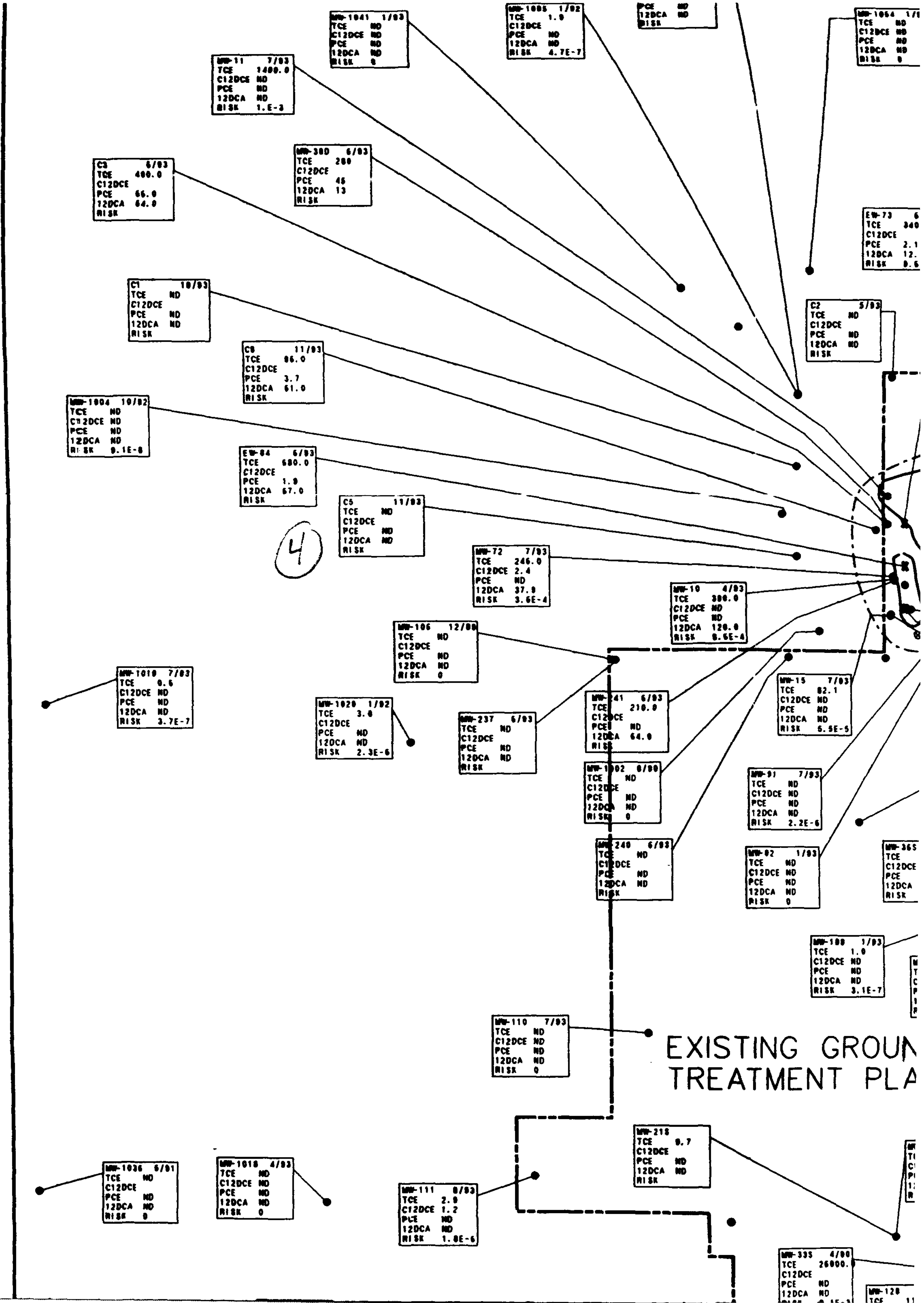
WELL
ASSOC
SAMPL



NOTE:

WELL LOCATIONS SHOWN WITHOUT ASSOCIATED DATA WERE NOT SAMPLED DURING OR AFTER 1988.





MW-1041 1/93
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C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1005 1/92
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C12DCE
PCE ND
12DCA ND
RISK 4.7E-7
PCE ND
12DCA ND
RISK
MW-1054
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C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-11 7/93
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C12DCE ND
PCE ND
12DCA ND
RISK 1.E-3
MW-38D 6/93
TCE 280
C12DCE
PCE 45
12DCA 13
RISK
C3 6/93
TCE 400.0
C12DCE
PCE 66.0
12DCA 64.0
RISK
EW-73
TCE 340
C12DCE
PCE 2.1
12DCA 12.
RISK
C1 10/93
TCE ND
C12DCE
PCE ND
12DCA ND
RISK
C2 5/93
TCE ND
C12DCE
PCE ND
12DCA ND
RISK
C8 11/93
TCE 86.0
C12DCE
PCE 3.7
12DCA 61.0
RISK
MW-1004 10/92
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C12DCE ND
PCE ND
12DCA ND
RISK 9.1E-8
EW-84 6/93
TCE 680.0
C12DCE
PCE 1.9
12DCA 67.0
RISK
C5 11/93
TCE ND
C12DCE
PCE ND
12DCA ND
RISK
4
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C12DCE 2.4
PCE ND
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RISK 3.6E-4
MW-10 4/93
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C12DCE ND
PCE ND
12DCA 120.0
RISK 8.6E-4
MW-106 12/88
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-1010 7/93
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C12DCE ND
PCE ND
12DCA ND
RISK 3.7E-7
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PCE ND
12DCA ND
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C12DCE
PCE ND
12DCA ND
RISK
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C12DCE
PCE ND
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RISK
MW-15 7/93
TCE 82.1
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C12DCE
PCE ND
12DCA ND
RISK 0
MW-91 7/93
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C12DCE ND
PCE ND
12DCA ND
RISK 2.2E-6
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C12DCE
PCE ND
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RISK
MW-82 1/93
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TCE
C12DCE
PCE
12DCA
RISK
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12DCA ND
RISK 3.1E-7
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C12DCE ND
PCE ND
12DCA ND
RISK 0
EXISTING GROUN
TREATMENT PLA
MW-218
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C12DCE
PCE ND
12DCA ND
RISK
MW-1036 6/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-1018 4/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-111 8/93
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C12DCE 1.2
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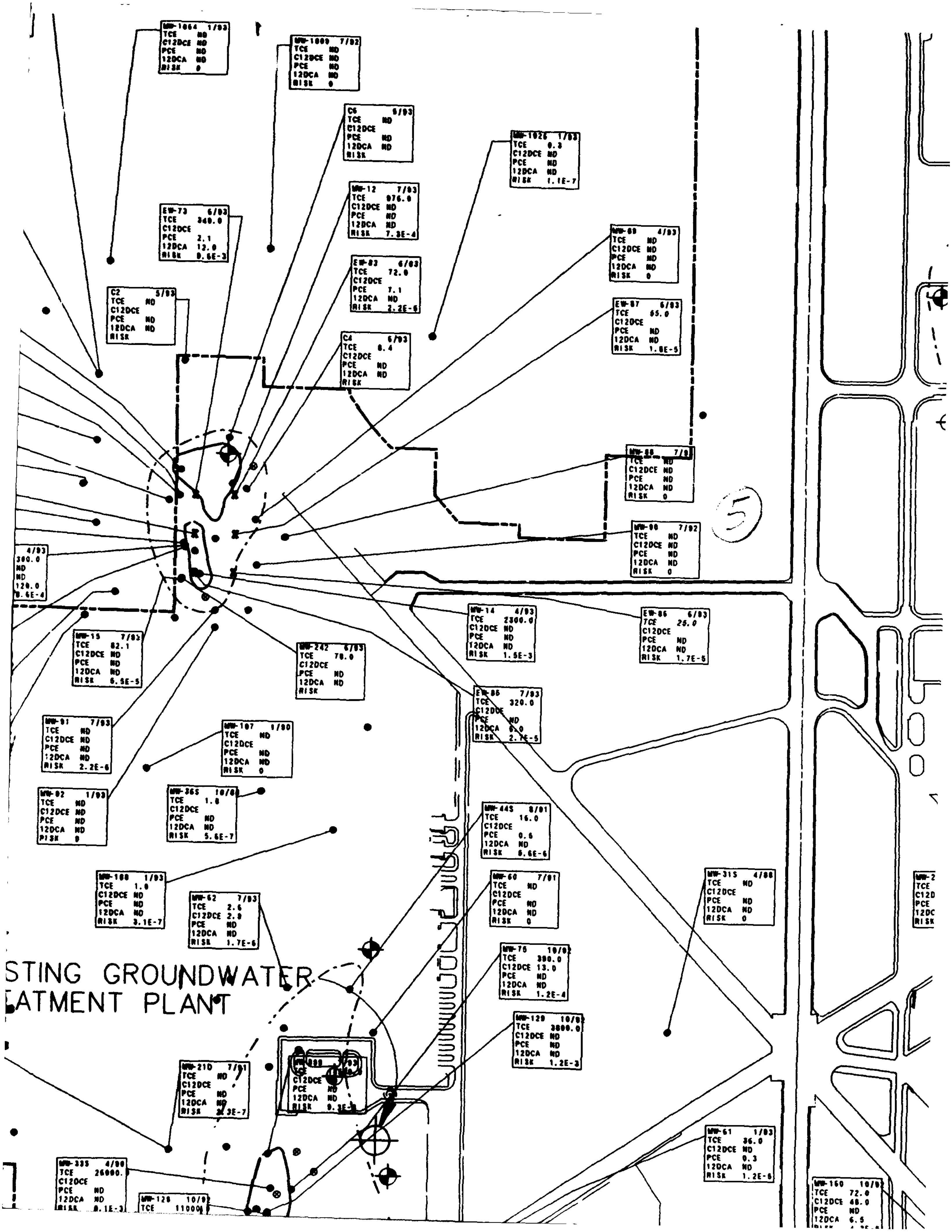
MW-128



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EW-73 6/93 TCE 340.0 C12DCE PCE 2.1 12DCA 12.0 RISK 9.6E-3
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STING GROUNDWATER
ATMENT PLANT
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C12DCE PCE ND 12DCA ND RISK 9.3E-8
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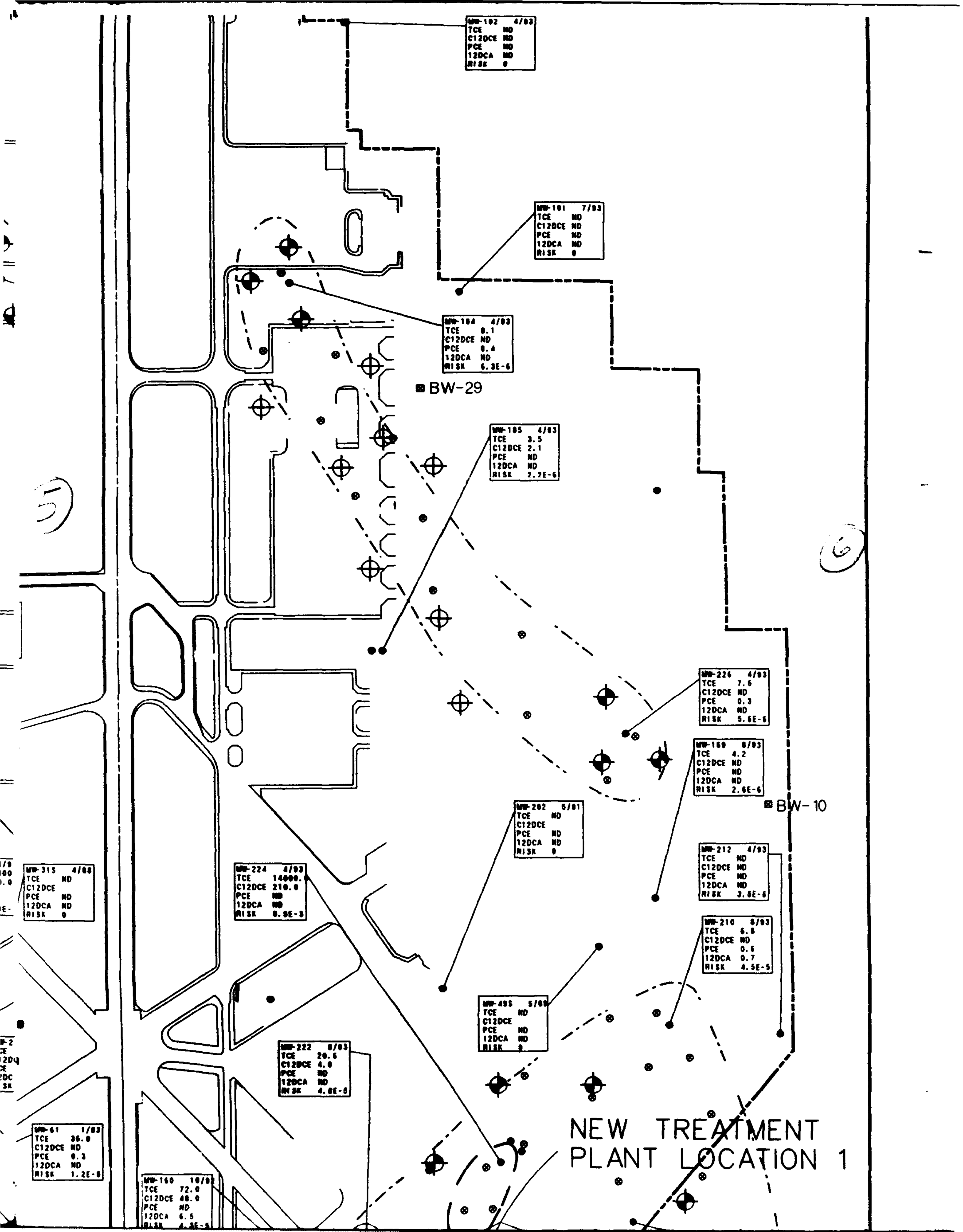
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12DCA 0.7
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C12DCE
PCE ND
12DCA ND
RISK 0
MW-222 8/93
TCE 20.6
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PCE ND
12DCA ND
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PCE 0.3
12DCA ND
RISK 1.2E-5
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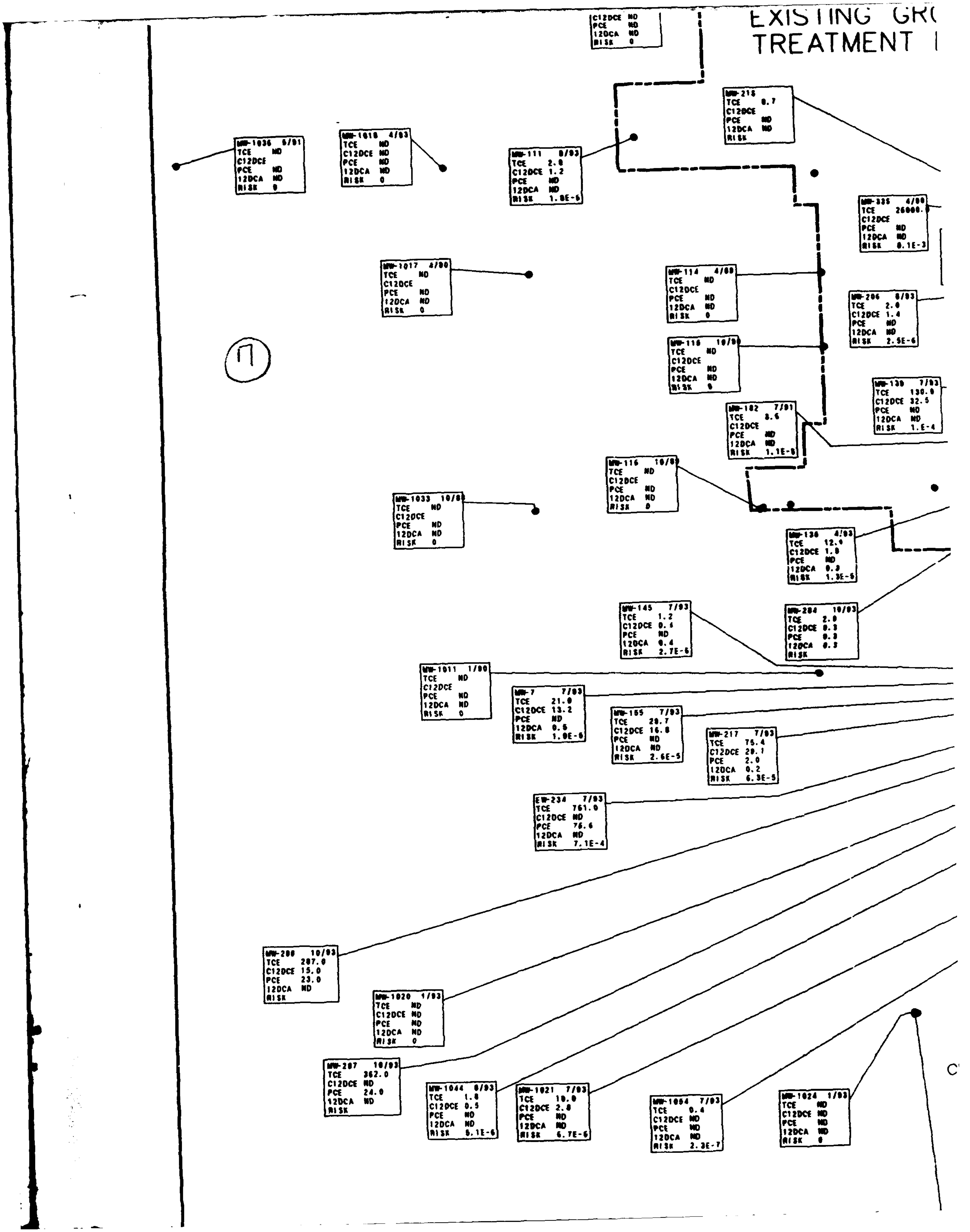
PLANT LOCATION 1
5
6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12DCA ND
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12DCA ND
RISK
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TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-1018 4/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-111 8/93
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12DCA ND
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12DCA ND
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12DCA ND
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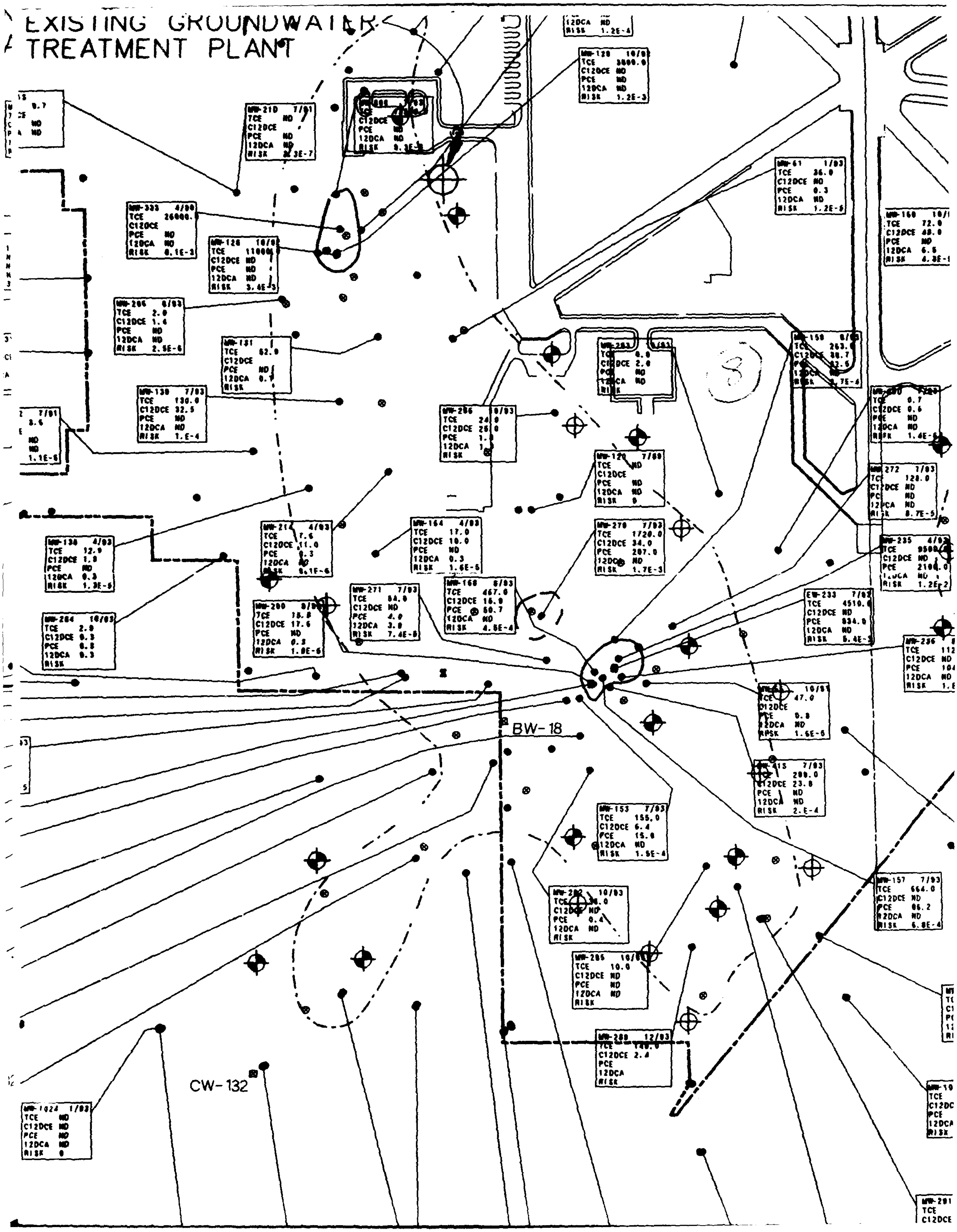
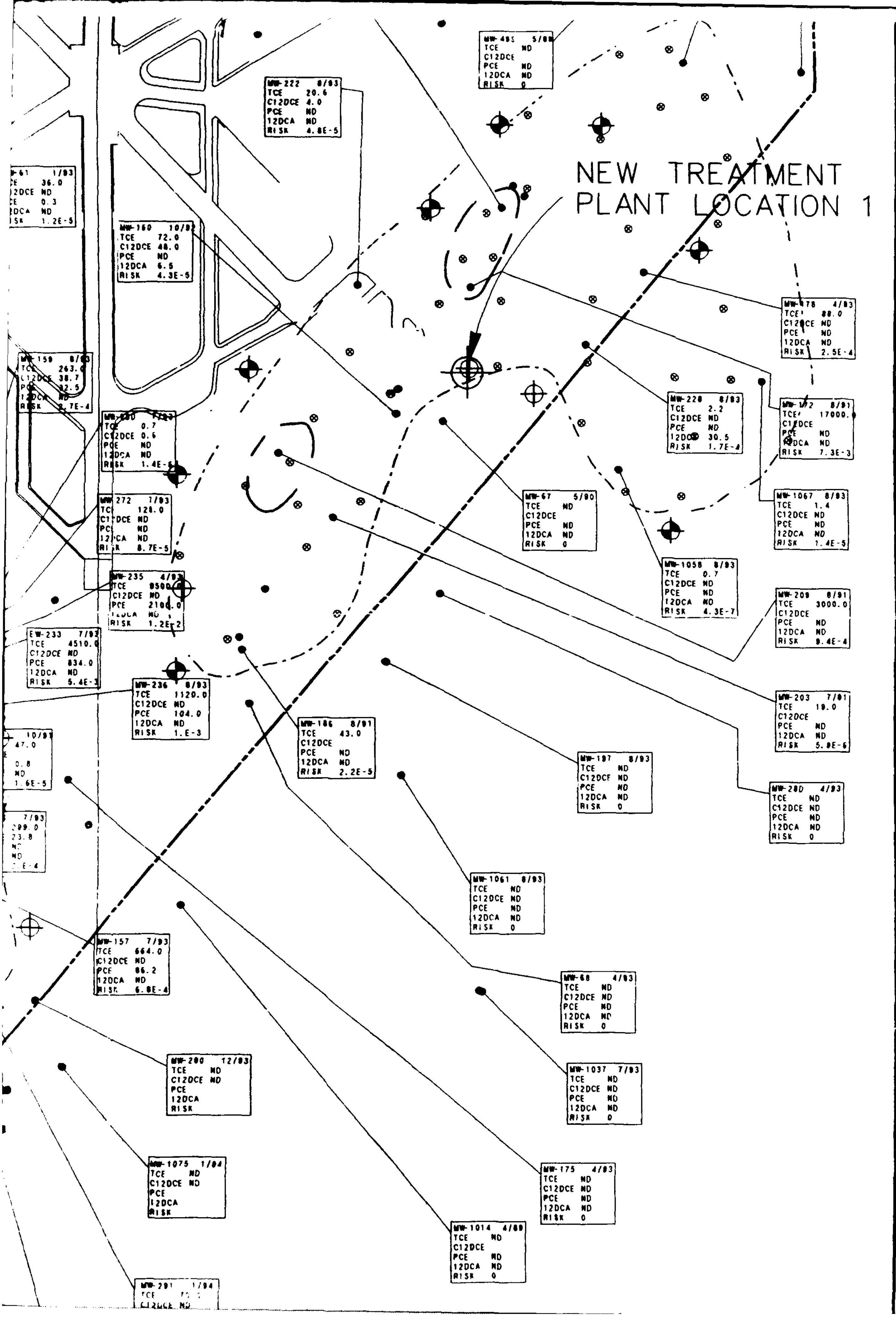
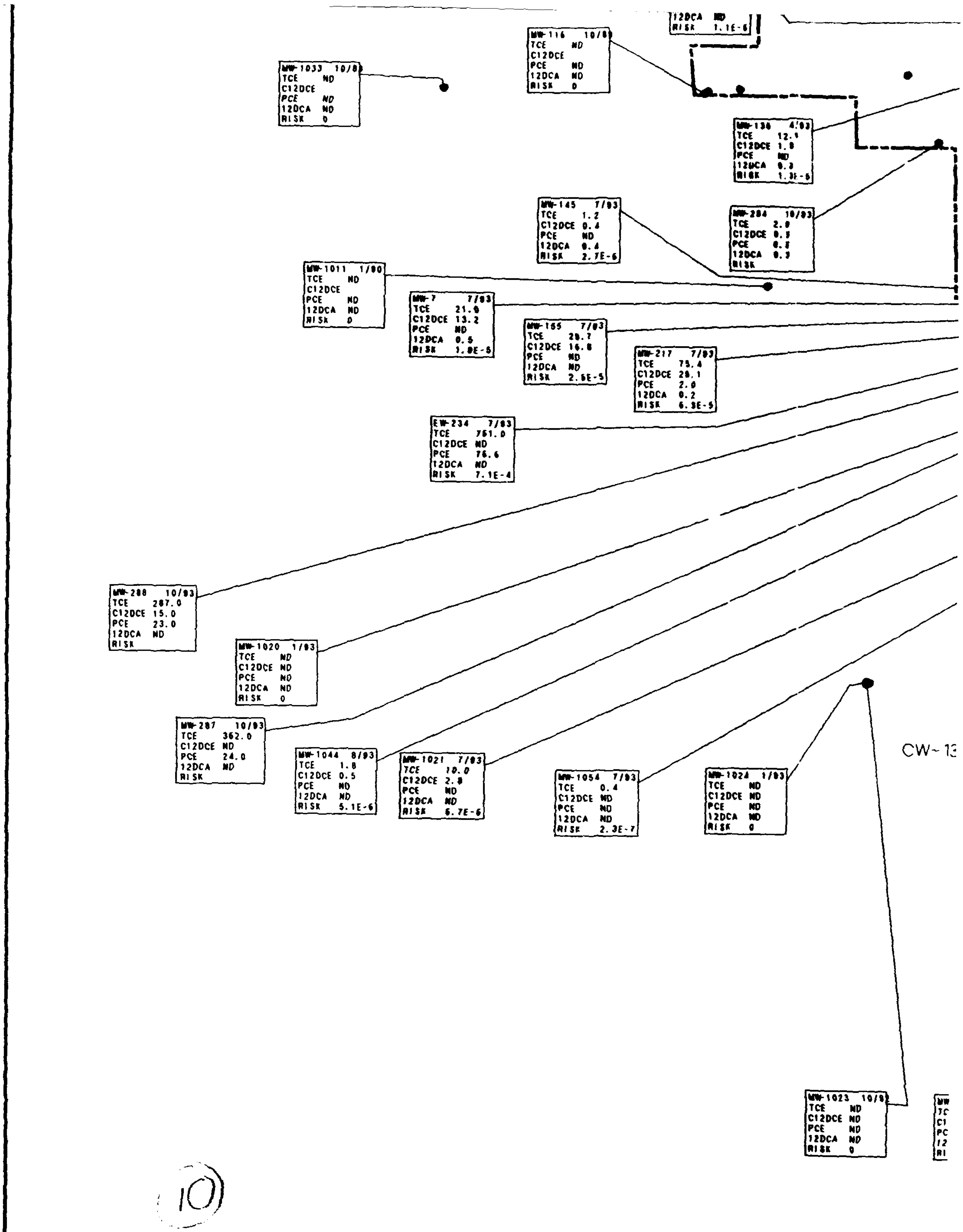
TCE 761.0
C12DCE ND
PCE 76.6
12DCA ND
RISK 7.1E-4
MW-208 10/93
TCE 287.0
C12DCE 15.0
PCE 23.0
12DCA ND
RISK
MW-1020 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-287 10/93
TCE 362.0
C12DCE ND
PCE 24.0
12DCA ND
RISK
MW-1044 8/93
TCE 1.8
C12DCE 0.5
PCE ND
12DCA ND
RISK 5.1E-6
MW-1021 7/93
TCE 10.0
C12DCE 2.8
PCE ND
12DCA ND
RISK 6.7E-6
MW-1054 7/93
TCE 0.4
C12DCE ND
PCE ND
12DCA ND
RISK 2.3E-7
MW-1024 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0



EXISTING GROUNDWATER
TREATMENT PLANT
BW-18
CW-132
MW-120 10/93
TCE 3800.0
C12DCE ND
PCE ND
12DCA ND
RISK 1.2E-3
MW-61 1/93
TCE 36.0
C12DCE ND
PCE 0.3
12DCA ND
RISK 1.2E-5
MW-130 7/93
TCE 130.0
C12DCE 32.5
PCE ND
12DCA ND
RISK 1.E-4
MW-164 4/93
TCE 17.0
C12DCE 10.0
PCE ND
12DCA 0.3
RISK 1.6E-5
MW-279 7/93
TCE 1720.0
C12DCE 34.0
PCE 207.0
RISK 1.7E-3
MW-271 7/93
TCE 84.0
C12DCE ND
PCE 4.0
12DCA 3.0
RISK 7.4E-5
MW-153 7/93
TCE 155.0
C12DCE 6.4
PCE 15.0
12DCA ND
RISK 1.5E-4
MW-285 10/93
TCE 10.0
C12DCE ND
PCE ND
12DCA ND
MW-157 7/93
TCE 664.0
C12DCE ND
PCE 86.2
RISK 6.8E-4
MW-1024 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0

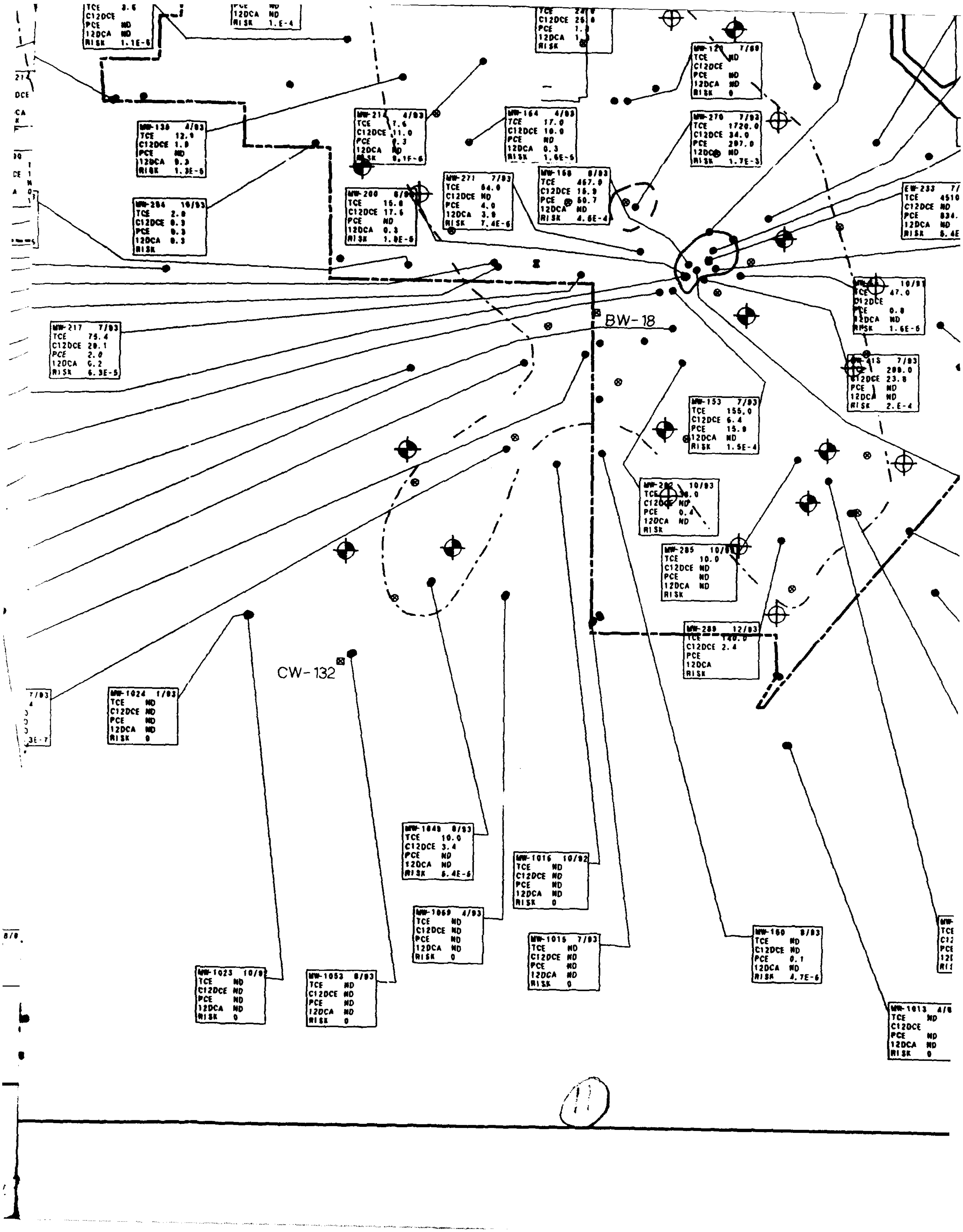


NEW TREATMENT PLANT LOCATION 1
MW-49S 5/80 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-222 8/93 TCE 20.6 C12DCE 4.0 PCE ND 12DCA ND RISK 4.8E-5
MW-160 10/93 TCE 72.0 C12DCE 48.0 PCE ND 12DCA 6.5 RISK 4.3E-5
MW-178 4/93 TCE 88.0 C12DCE ND PCE ND 12DCA ND RISK 2.5E-4
MW-220 8/93 TCE 2.2 C12DCE ND PCE ND 12DCA 30.5 RISK 1.7E-4
MW-172 8/91 TCE 17000.0 C12DCE PCE ND 12DCA ND RISK 7.3E-3
MW-159 8/93 TCE 263.0 C12DCE 38.7 PCE 32.5 12DCA ND RISK 8.7E-4
MW-272 7/93 TCE 128.0 C12DCE ND PCE ND 12DCA ND RISK 8.7E-5
MW-67 5/90 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-1067 8/93 TCE 1.4 C12DCE ND PCE ND 12DCA ND RISK 7.4E-5
MW-1058 8/93 TCE 0.7 C12DCE ND PCE ND 12DCA ND RISK 4.3E-7
MW-235 4/93 TCE 9500.0 C12DCE ND PCE 2100.0 12DCA ND RISK 1.2E-2
MW-209 8/91 TCE 3000.0 C12DCE PCE ND 12DCA ND RISK 9.4E-4
EW-233 7/93 TCE 4510.0 C12DCE ND PCE 834.0 12DCA ND RISK 5.4E-3
MW-236 8/93 TCE 1120.0 C12DCE ND PCE 104.0 12DCA ND RISK 1.E-3
MW-203 7/91 TCE 19.0 C12DCE PCE ND 12DCA ND RISK 5.8E-6
MW-186 8/91 TCE 43.0 C12DCE PCE ND 12DCA ND RISK 2.2E-5
MW-197 8/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-280 4/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-1061 8/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-157 7/93 TCE 664.0 C12DCE ND PCE 86.2 12DCA ND RISK 6.8E-4
MW-68 4/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-200 12/93 TCE ND C12DCE ND PCE 12DCA RISK
MW-1037 7/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-1075 1/94 TCE ND C12DCE ND PCE 12DCA RISK
MW-175 4/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-1014 4/89 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-291 1/94



RDD1454

MEY94/MEY-E-5.dgn



MW-138 4/93
TCE 12.9
C12DCE 1.9
PCE ND
12DCA 0.3
RISK 1.3E-5
MW-284 10/93
TCE 2.0
C12DCE 0.3
PCE 0.3
12DCA 0.3
RISK
MW-164 4/93
TCE 17.0
C12DCE 10.9
PCE ND
12DCA 0.3
RISK 1.6E-5
MW-276 7/93
TCE 1720.0
C12DCE 34.0
PCE 207.0
12DCA ND
RISK 1.7E-3
MW-271 7/93
TCE 64.0
C12DCE ND
PCE 4.0
12DCA 3.9
RISK 7.4E-6
MW-168 8/93
TCE 467.0
C12DCE 15.9
PCE 50.7
12DCA ND
RISK 4.6E-4
MW-200
TCE 15.8
C12DCE 17.5
PCE ND
12DCA 0.3
RISK 1.9E-5
MW-217 7/93
TCE 75.4
C12DCE 20.1
PCE 2.0
12DCA 0.2
RISK 6.3E-5
BW-18
MW-153 7/93
TCE 155.0
C12DCE 6.4
PCE 15.0
12DCA ND
RISK 1.5E-4
MW-285
TCE 10.0
C12DCE ND
PCE ND
12DCA ND
RISK
MW-289 12/93
C12DCE 2.4
PCE
12DCA
RISK
CW-132
MW-1024 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1049 8/93
TCE 10.0
C12DCE 3.4
PCE ND
12DCA ND
RISK 5.4E-6
MW-1016 10/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1059 4/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1015 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-160 8/93
TCE ND
C12DCE ND
PCE 0.1
12DCA ND
RISK 4.7E-6
MW-1023 10/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1053 8/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1013
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0

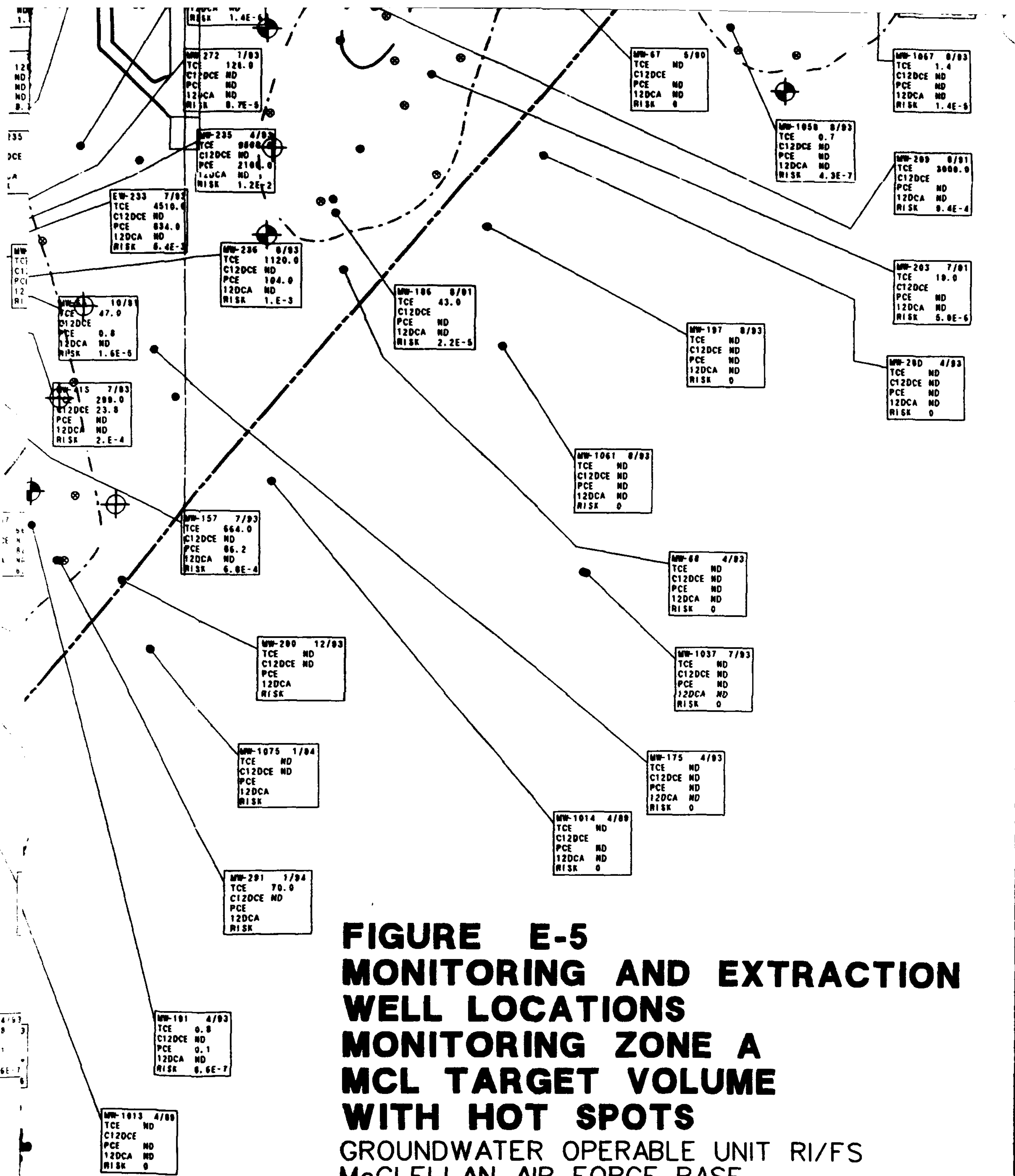


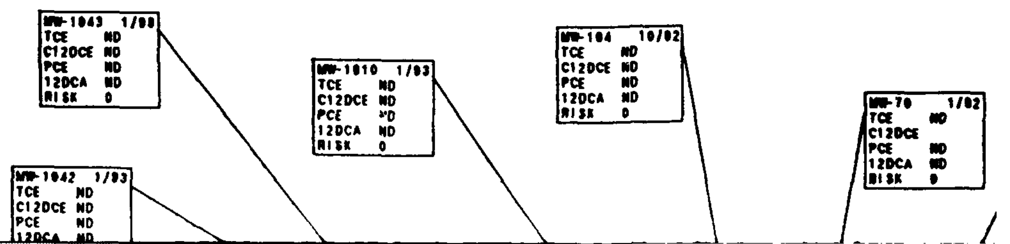
FIGURE E-5
MONITORING AND EXTRACTION WELL LOCATIONS
MONITORING ZONE A
MCL TARGET VOLUME
WITH HOT SPOTS

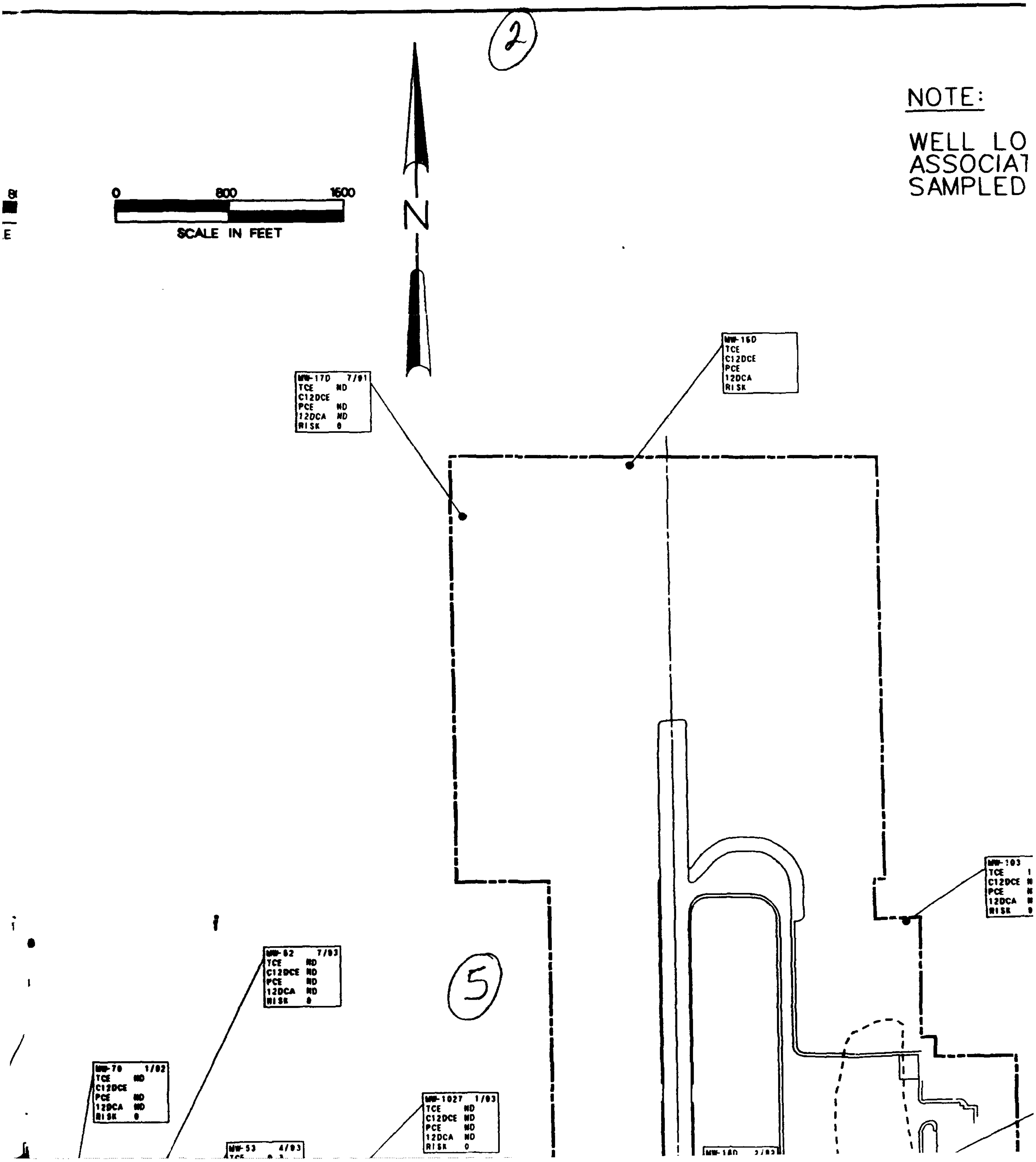
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

CH2M HILL

WELL SUMMARY

- X EXISTING EXTRACTION WELLS
- ◆ NEW EXTRACTION WELLS
- ⌖ NEW MONITORING WELLS FOR WATER QUALITY
- ⊕ NEW MONITORING WELLS FOR HYDRAULIC CONTROL
- • EXISTING MONITORING WELLS
- -- TARGET VOLUME BOUNDARY

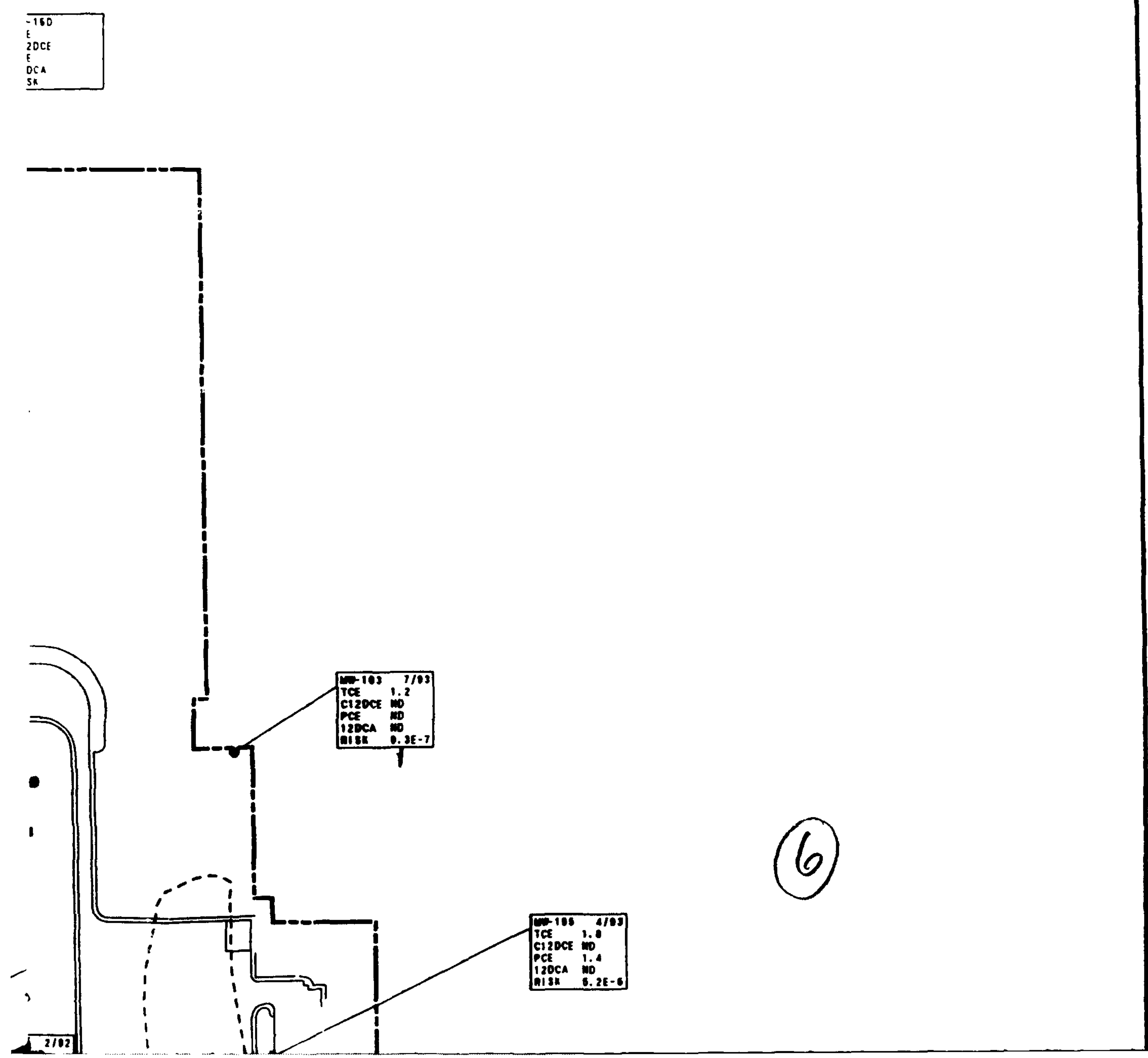


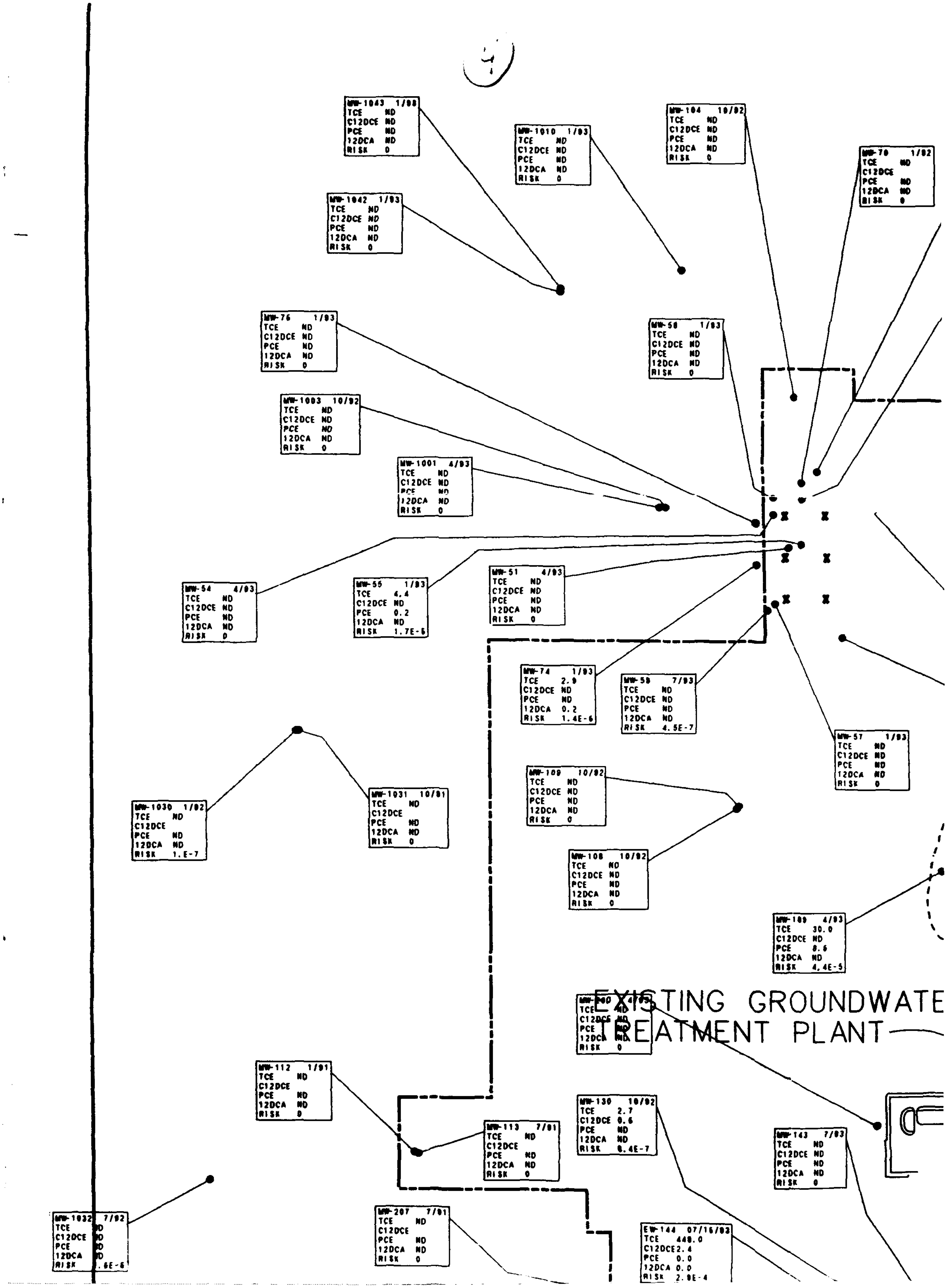


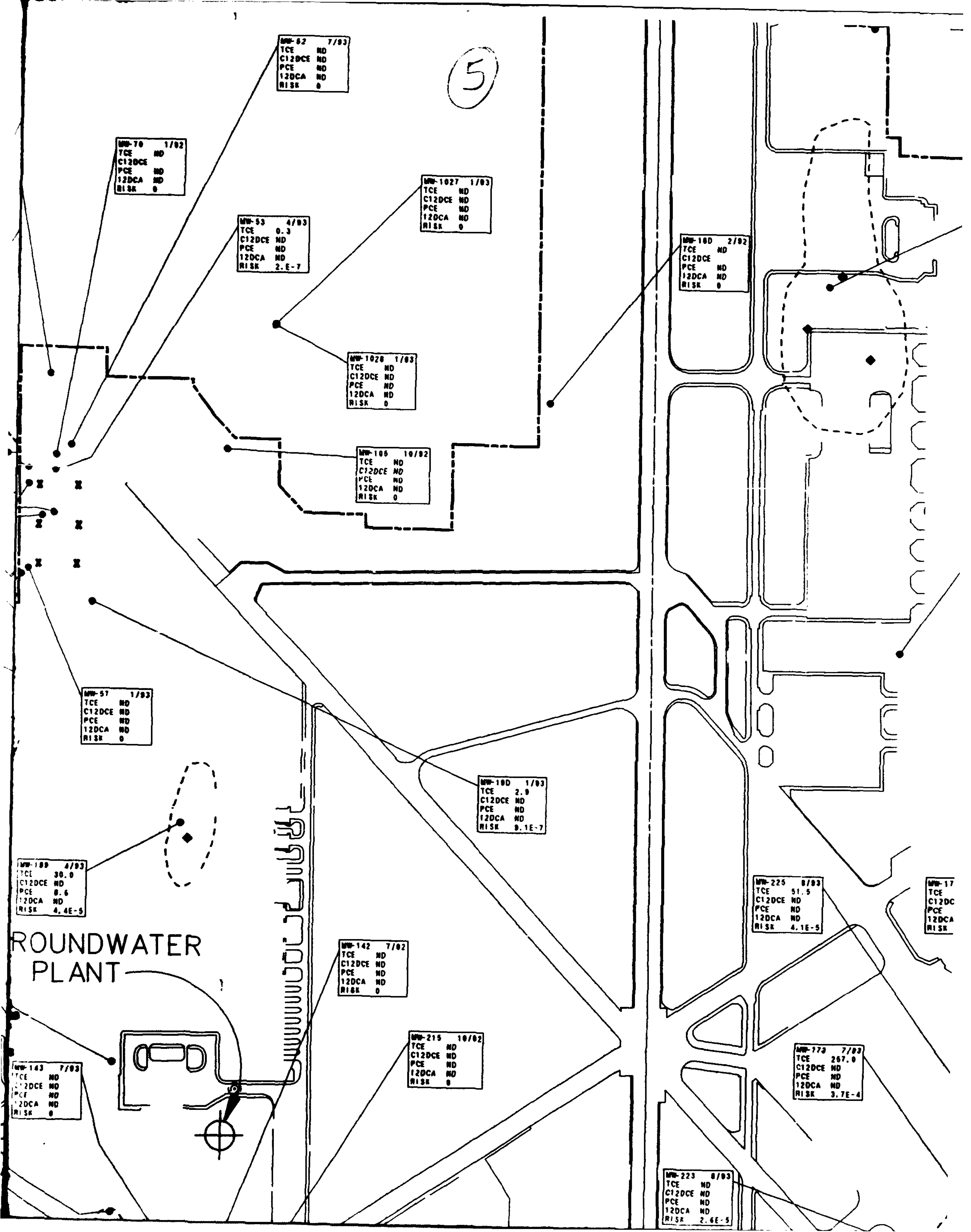
NOTE:
WELL LO
ASSOCIAT
SAMPLED
0
800
1600
SCALE IN FEET
N
MW-17D 7/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-15D
TCE
C12DCE
PCE
12DCA
RISK
MW-103
TCE
C12DCE
PCE
12DCA
RISK
MW-62 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-70 1/92
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-1027 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0

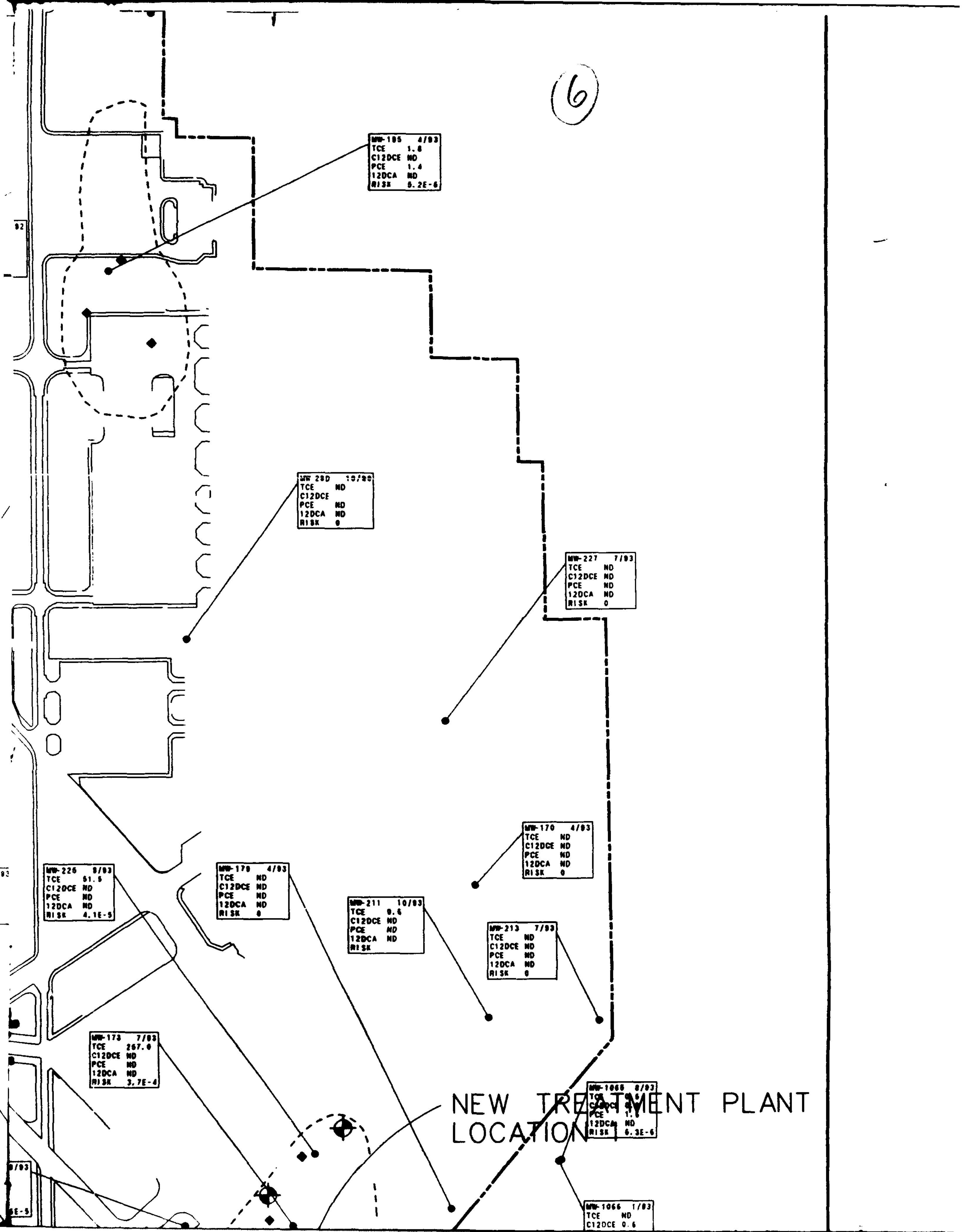
NOTE:

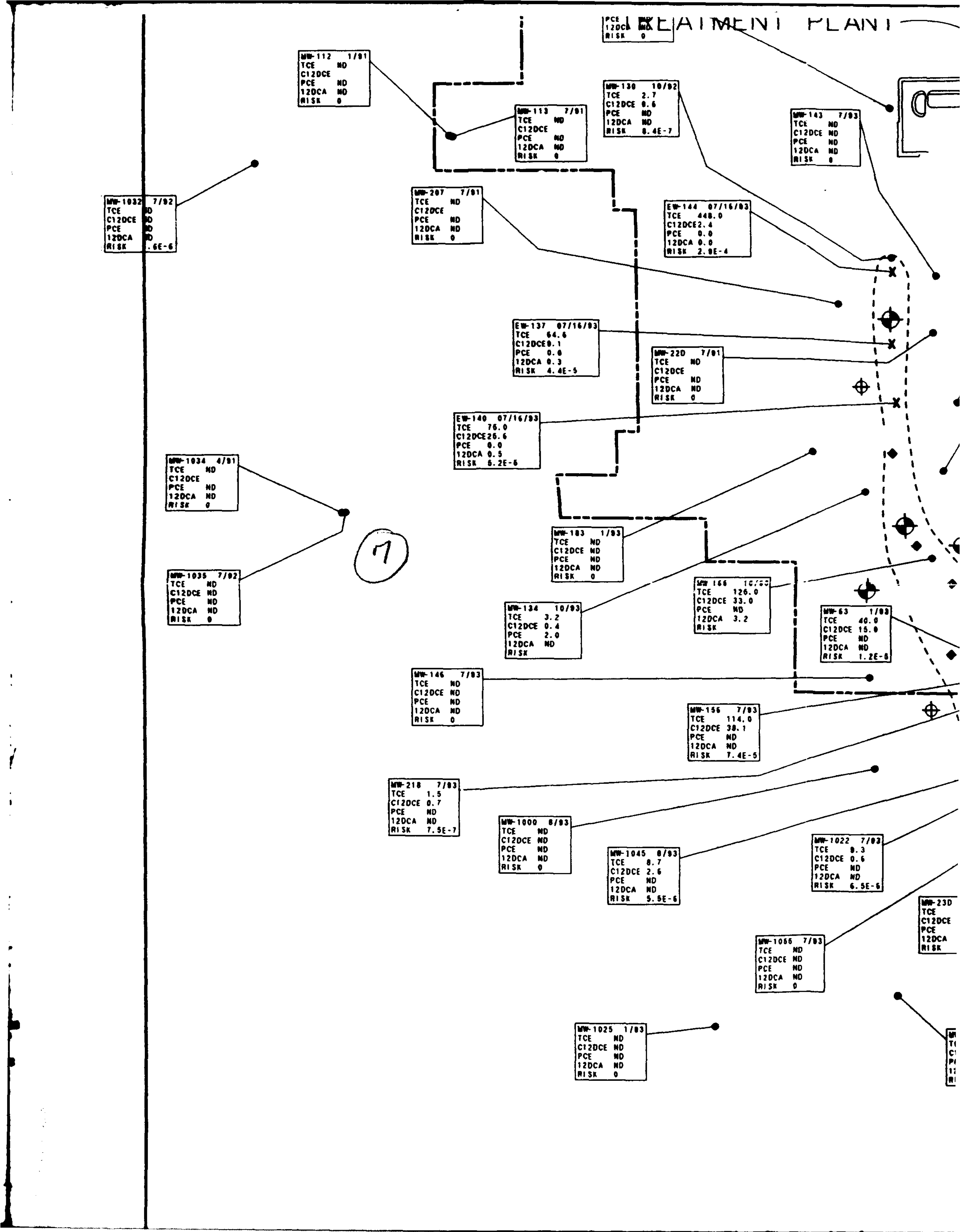
WELL LOCATIONS SHOWN WITHOUT ASSOCIATED DATA WERE NOT SAMPLED DURING OR AFTER 1988.

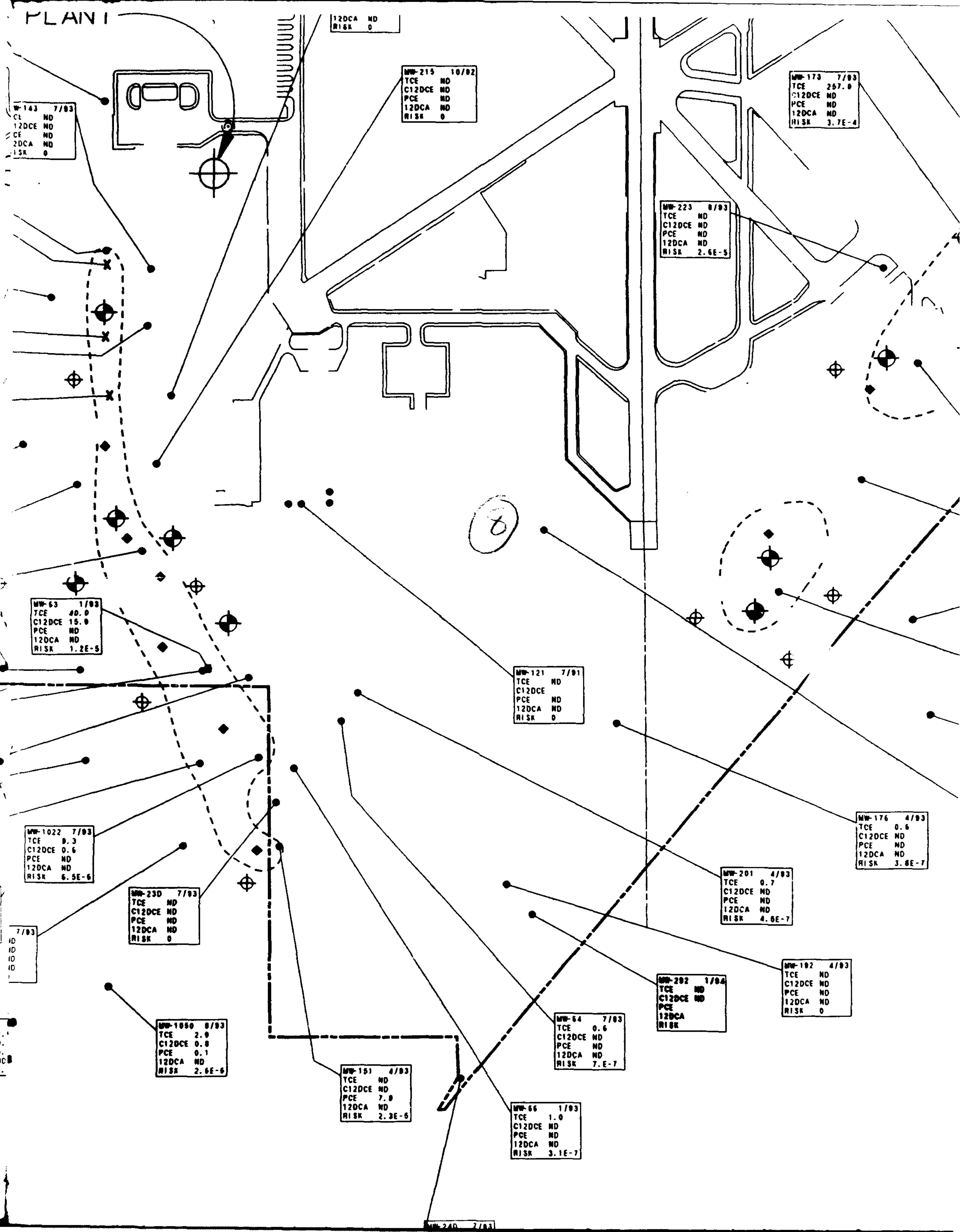



MW-1043 1/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-1010 1/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-104 10/92 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-70 1/92 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-1042 1/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-76 1/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-58 1/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-1003 10/92 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-1001 4/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-54 4/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-55 1/93 TCE 4.4 C12DCE ND PCE 0.2 12DCA ND RISK 1.7E-6
MW-51 4/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-74 1/93 TCE 2.9 C12DCE ND PCE ND 12DCA 0.2 RISK 1.4E-6
MW-59 7/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 4.5E-7
MW-57 1/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-109 10/92 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-1030 1/92 TCE ND C12DCE PCE ND 12DCA ND RISK 1.E-7
MW-1031 10/91 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-108 10/92 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-189 4/93 TCE 30.0 C12DCE ND PCE 8.6 12DCA ND RISK 4.4E-5
EXISTING GROUNDWATE
TREATMENT PLANT
MW-112 1/91 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-130 10/92 TCE 2.7 C12DCE 0.6 PCE ND 12DCA ND RISK 8.4E-7
MW-113 7/91 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-143 7/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-207 7/91 TCE ND C12DCE PCE ND 12DCA ND RISK 0
EW-144 07/16/93 TCE 448.0 C12DCE 2.4 PCE 0.0 12DCA 0.0 RISK 2.9E-4

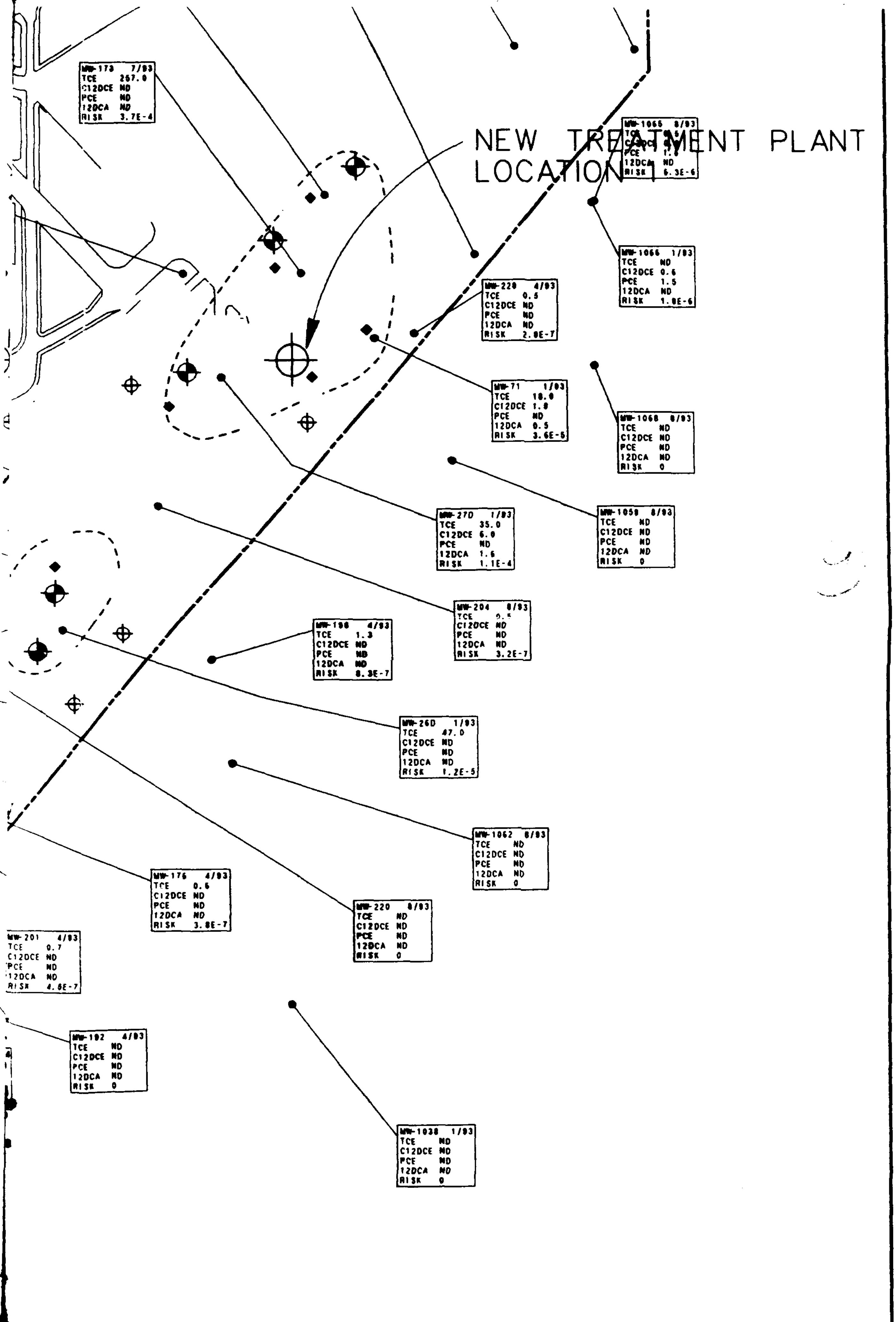

5
MW-52 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-70 1/92
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-1027 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-53 4/93
TCE 0.3
C12DCE ND
PCE ND
12DCA ND
RISK 2.E-7
MW-18D 2/92
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-1028 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-105 10/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-57 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-19D 1/93
TCE 2.9
C12DCE ND
PCE ND
12DCA ND
RISK 9.1E-7
MW-189 4/93
TCE 30.0
C12DCE ND
PCE 8.6
12DCA ND
RISK 4.4E-5
MW-225 8/93
TCE 51.5
C12DCE ND
PCE ND
12DCA ND
RISK 4.1E-5
MW-17
TCE
C12DC
PCE
12DCA
RISK
ROUNDWATER
PLANT
MW-142 7/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-215 10/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-143 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-773 7/93
TCE 267.0
C12DCE ND
PCE ND
12DCA ND
RISK 3.7E-4
MW-223 8/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 2.6E-5

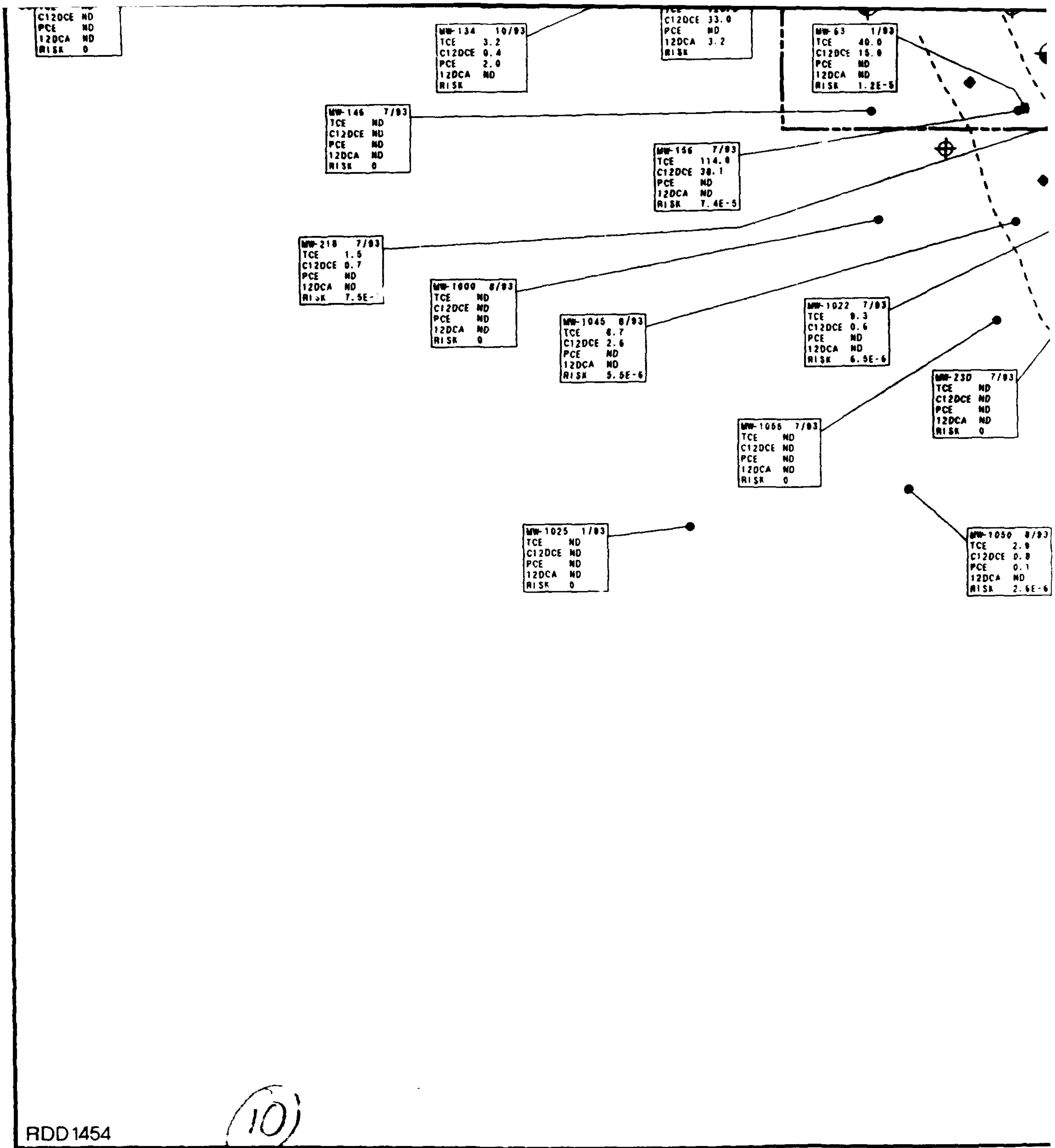

(6)
MW-195 4/93
TCE 1.6
C12DCE ND
PCE 1.4
12DCA ND
RISK 5.2E-6
MW 28D
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-227 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-170 4/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-225 9/93
TCE 51.5
C12DCE ND
PCE ND
12DCA ND
RISK 4.1E-5
MW-179 4/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-211 10/93
TCE 0.6
C12DCE ND
PCE ND
12DCA ND
RISK
MW-213 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-173 7/93
TCE 267.0
C12DCE ND
PCE ND
12DCA ND
RISK 3.7E-4
NEW TREATMENT PLANT
LOCATION 1
MW-1065 8/93
12DCA ND
RISK 6.3E-6
MW-1066 1/93
TCE ND
C12DCE 0.6


REATMENT PLANT
PCE
12DCA
RISK 0
MW-112 1/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-113 7/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-130 10/92
TCE 2.7
C12DCE 0.6
PCE ND
12DCA ND
RISK 8.4E-7
MW-143 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1032 7/92
TCE
C12DCE
PCE
12DCA
RISK .6E-6
MW-207 7/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
EW-144 07/16/93
TCE 448.0
C12DCE2.4
PCE 0.0
12DCA 0.0
RISK 2.9E-4
EW-137 07/16/93
TCE 64.6
C12DCE0.1
PCE 0.0
12DCA 0.3
RISK 4.4E-5
MW-220 7/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
EW-140 07/16/93
TCE 76.0
C12DCE25.6
PCE 0.0
12DCA 0.5
RISK 6.2E-5
MW-1034 4/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-1035 7/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
7
MW-183 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-166
TCE 126.0
C12DCE 33.0
PCE ND
12DCA 3.2
RISK
MW-134 10/93
TCE 3.2
C12DCE 0.4
PCE 2.0
12DCA ND
RISK
MW-63 1/93
TCE 40.0
C12DCE 15.0
PCE ND
12DCA ND
RISK 1.2E-5
MW-146 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-156 7/93
TCE 114.0
C12DCE 38.1
PCE ND
12DCA ND
RISK 7.4E-5
MW-218 7/93
TCE 1.5
C12DCE 0.7
PCE ND
12DCA ND
RISK 7.5E-7
MW-1000 8/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1045 8/93
TCE 8.7
C12DCE 2.6
PCE ND
12DCA ND
RISK 5.5E-6
MW-1022 7/93
TCE 9.3
C12DCE 0.6
PCE ND
12DCA ND
RISK 6.5E-6
MW-230
TCE
C12DCE
PCE
12DCA
RISK
MW-1055 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1025 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0

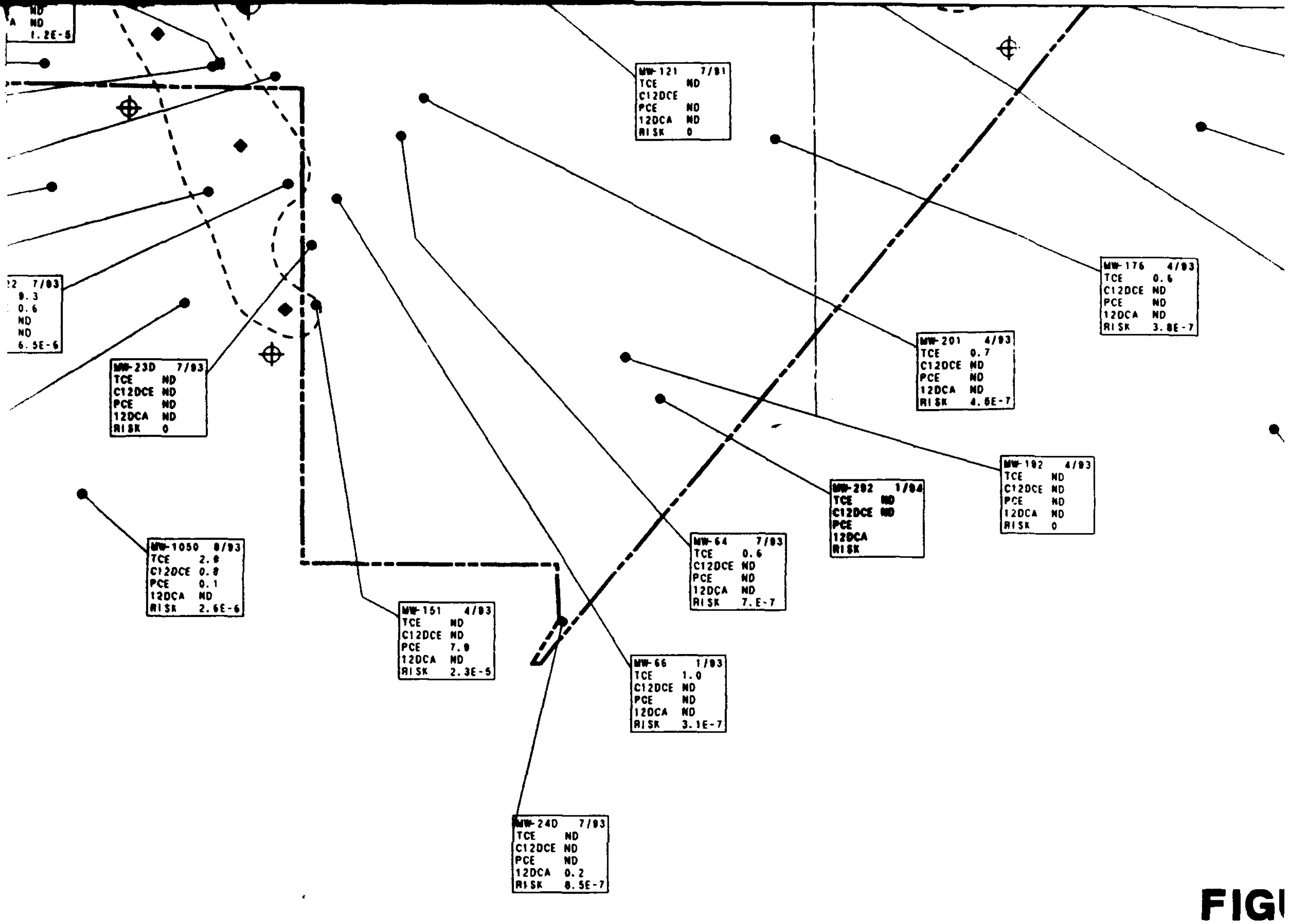


PLANT
12DCA ND
RISK 0
MW-215 10/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-173 7/93
TCE 257.0
C12DCE ND
PCE ND
12DCA ND
RISK 3.7E-4
W-143 7/93
MW-223 8/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 2.6E-5
6
MW-63 1/93
TCE 40.0
C12DCE 15.0
PCE ND
12DCA ND
RISK 1.2E-5
MW-121 7/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-176 4/93
TCE 0.6
C12DCE ND
PCE ND
12DCA ND
RISK 3.8E-7
MW-201 4/93
TCE 0.7
C12DCE ND
PCE ND
12DCA ND
RISK 4.6E-7
MW-1022 7/93
TCE 0.3
C12DCE 0.6
PCE ND
12DCA ND
RISK 6.5E-6
MW-230 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
7/93
MW-202 1/94
TCE ND
C12DCE ND
PCE
12DCA
RISK
MW-192 4/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-64 7/93
TCE 0.6
C12DCE ND
PCE ND
12DCA ND
RISK 7.E-7
MW-1050 8/93
TCE 2.0
C12DCE 0.8
PCE 0.1
12DCA ND
RISK 2.6E-6
MW-151 4/93
TCE ND
C12DCE ND
PCE 7.0
12DCA ND
RISK 2.3E-5
MW-66 1/93
TCE 1.0
C12DCE ND
PCE ND
12DCA ND
RISK 3.1E-7
MW-240 7/93


NEW TREATMENT PLANT LOCATION
MW-173 7/93 TCE 257.0 C12DCE ND PCE ND 12DCA ND RISK 3.7E-4
MW-1065 8/93 12DCA ND RISK 6.3E-6
MW-1066 1/93 TCE ND C12DCE 0.6 PCE 1.5 12DCA ND RISK 1.8E-6
MW-228 4/93 TCE 0.5 C12DCE ND PCE ND 12DCA ND RISK 2.8E-7
MW-71 1/93 TCE 18.0 C12DCE 1.8 PCE ND 12DCA 0.5 RISK 3.6E-5
MW-1068 8/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-27D 1/93 TCE 35.0 C12DCE 6.0 PCE ND 12DCA 1.6 RISK 1.1E-4
MW-1059 8/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-204 8/93 TCE 0.5 C12DCE ND PCE ND 12DCA ND RISK 3.2E-7
MW-198 4/93 TCE 1.3 C12DCE ND PCE ND 12DCA ND RISK 8.3E-7
MW-26D 1/93 TCE 47.0 C12DCE ND PCE ND 12DCA ND RISK 1.2E-5
MW-1062 8/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-176 4/93 TCE 0.6 C12DCE ND PCE ND 12DCA ND RISK 3.8E-7
MW-220 8/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-201 4/93 TCE 0.7 C12DCE ND PCE ND 12DCA ND RISK 4.8E-7
MW-192 4/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-1038 1/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0



MEY94/MEY-E-6.dgn



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MO
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SACR

11

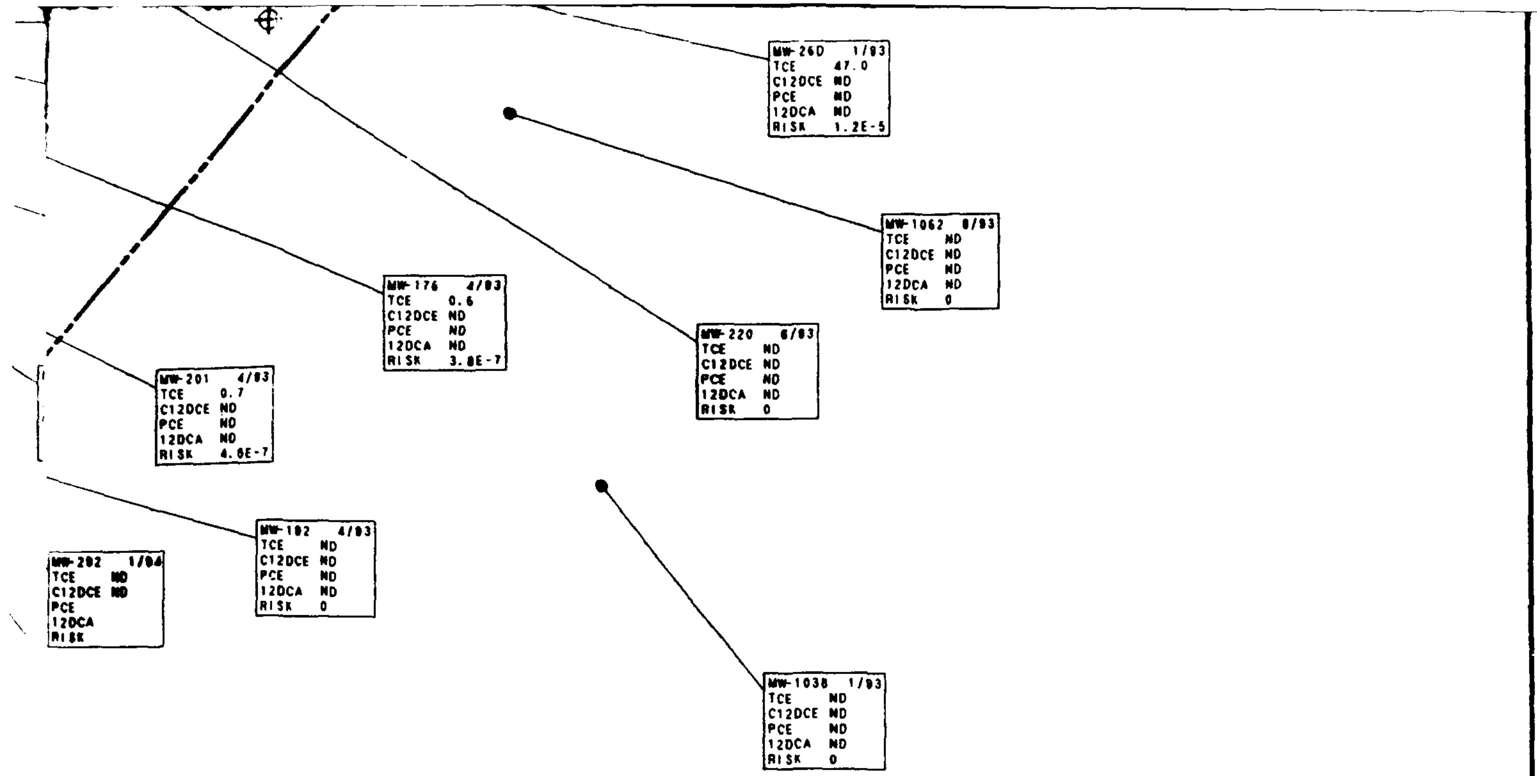


FIGURE E-6
MONITORING AND EXTRACTION WELL LOCATIONS MONITORING ZONE B MCL TARGET VOLUME

GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

CH2M HILL

1

WELL SUMMARY

X EXISTING EXTRACTION WELLS

▸ NEW EXTRACTION WELLS

⊕ NEW MONITORING WELLS FOR WATER QUALITY

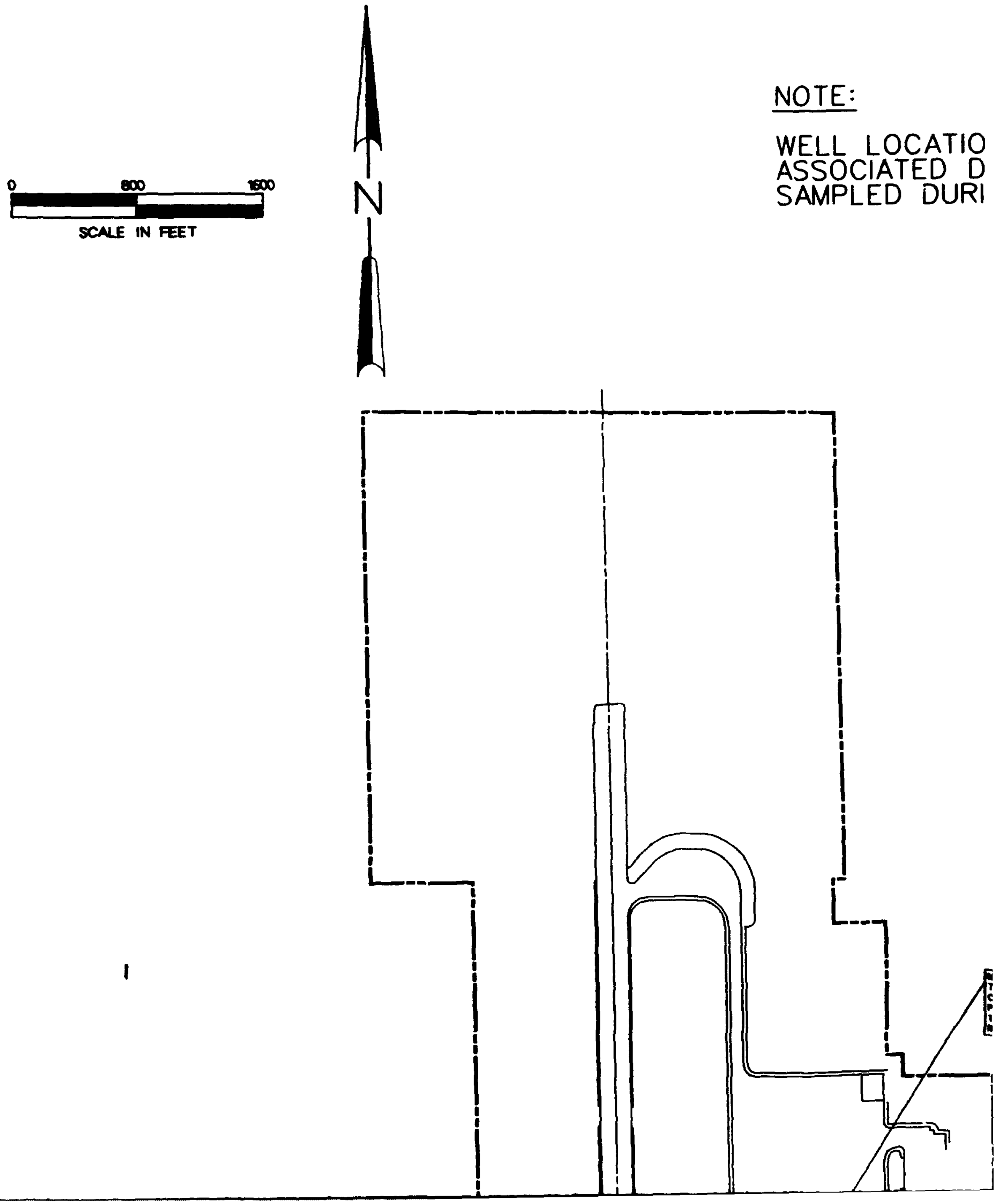
⊕ NEW MONITORING WELLS FOR HYDRAULIC CONTROL

• EXISTING MONITORING WELLS

--- TARGET VOLUME BOUNDARY

0

(2)



NOTE:

WELL LOCATIO
ASSOCIATED D
SAMPLED DURI

3

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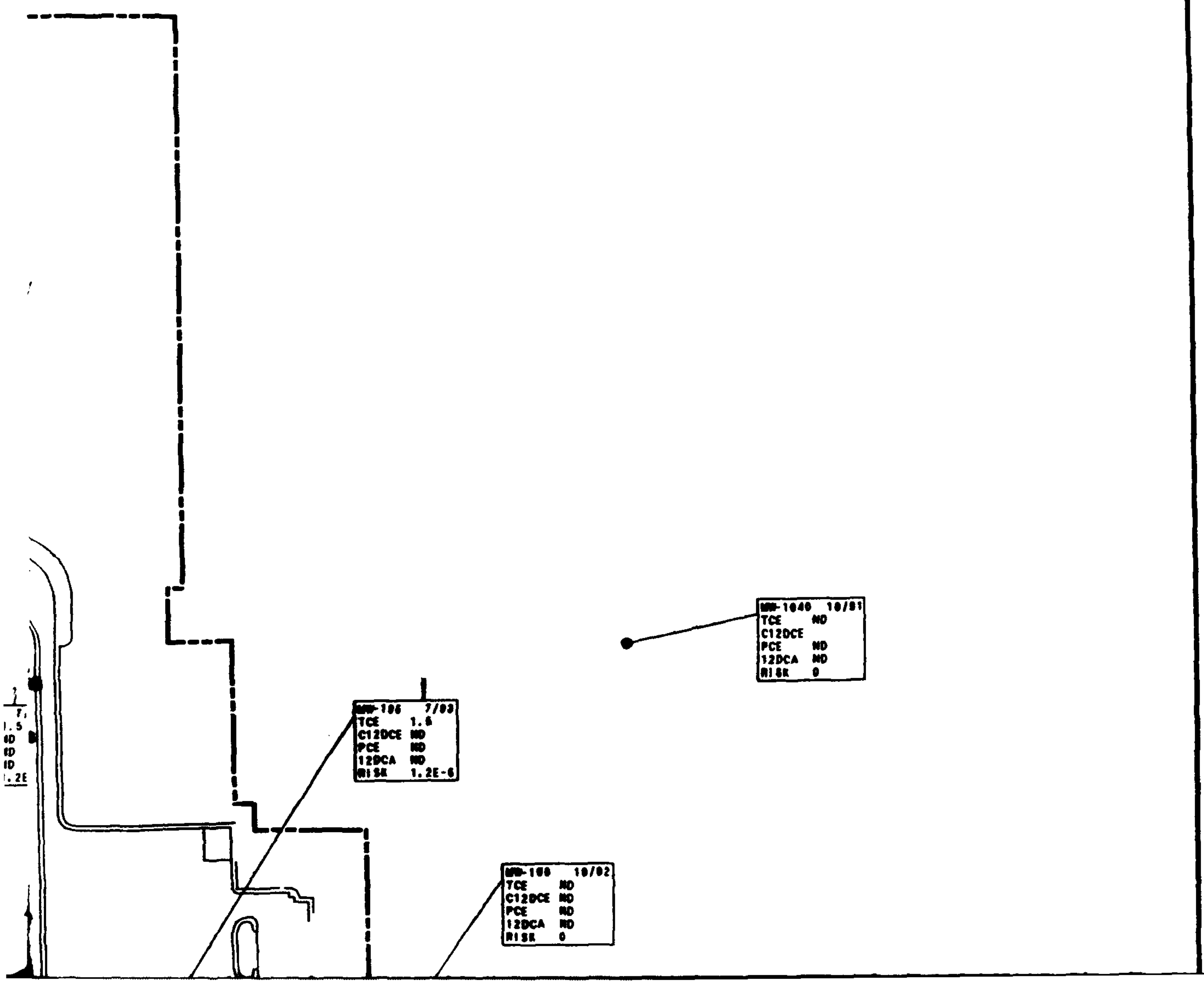
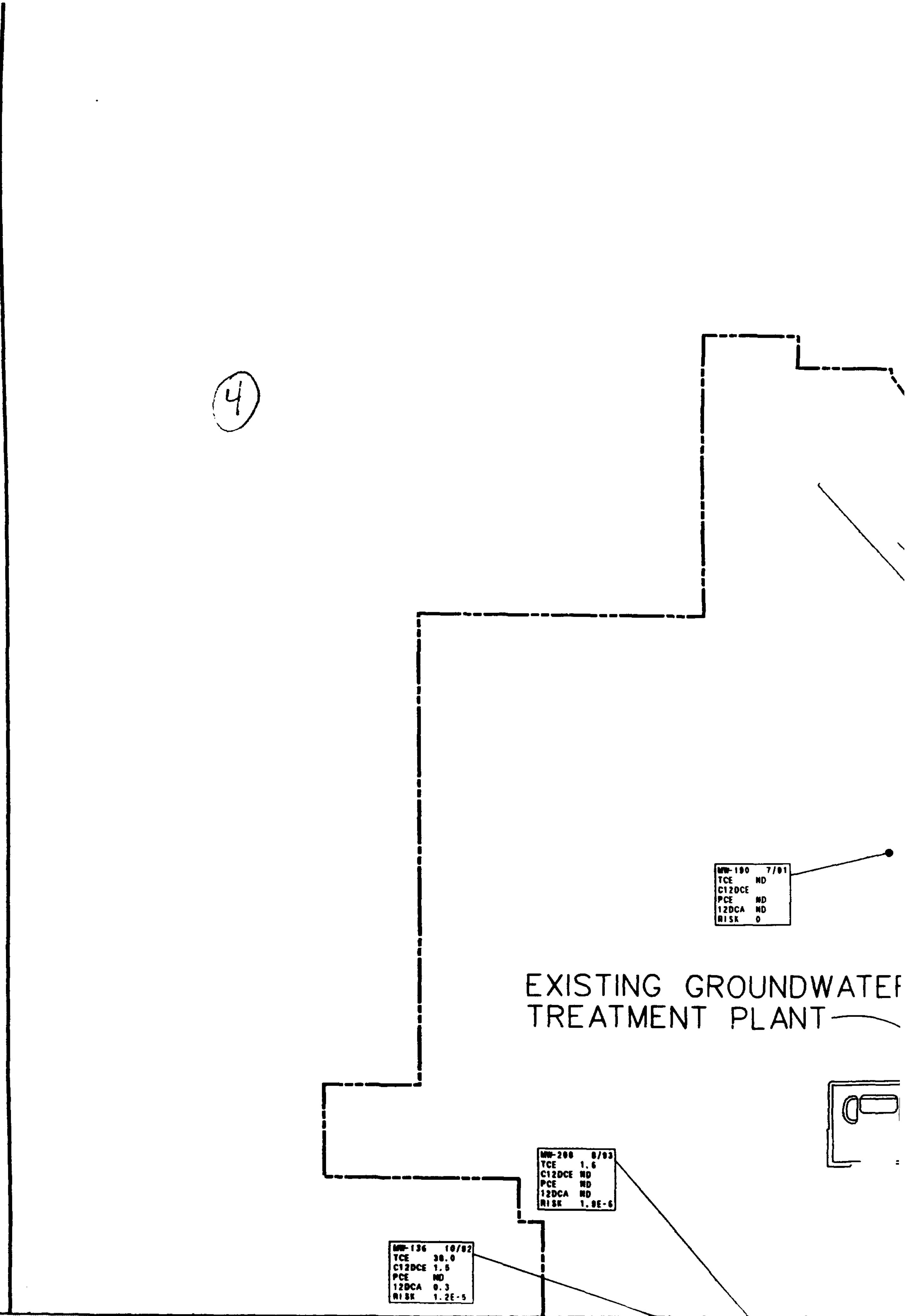
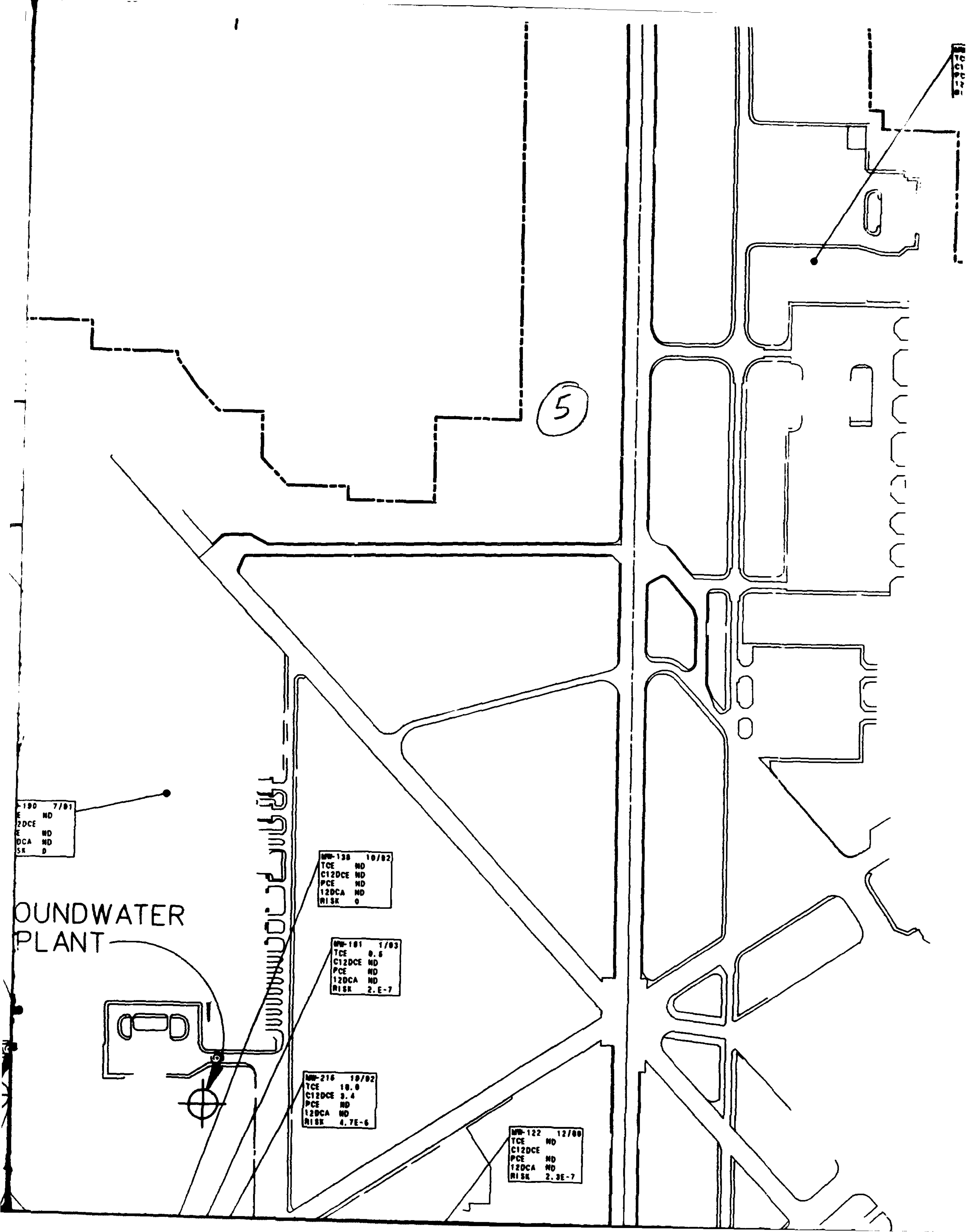
NOTE:

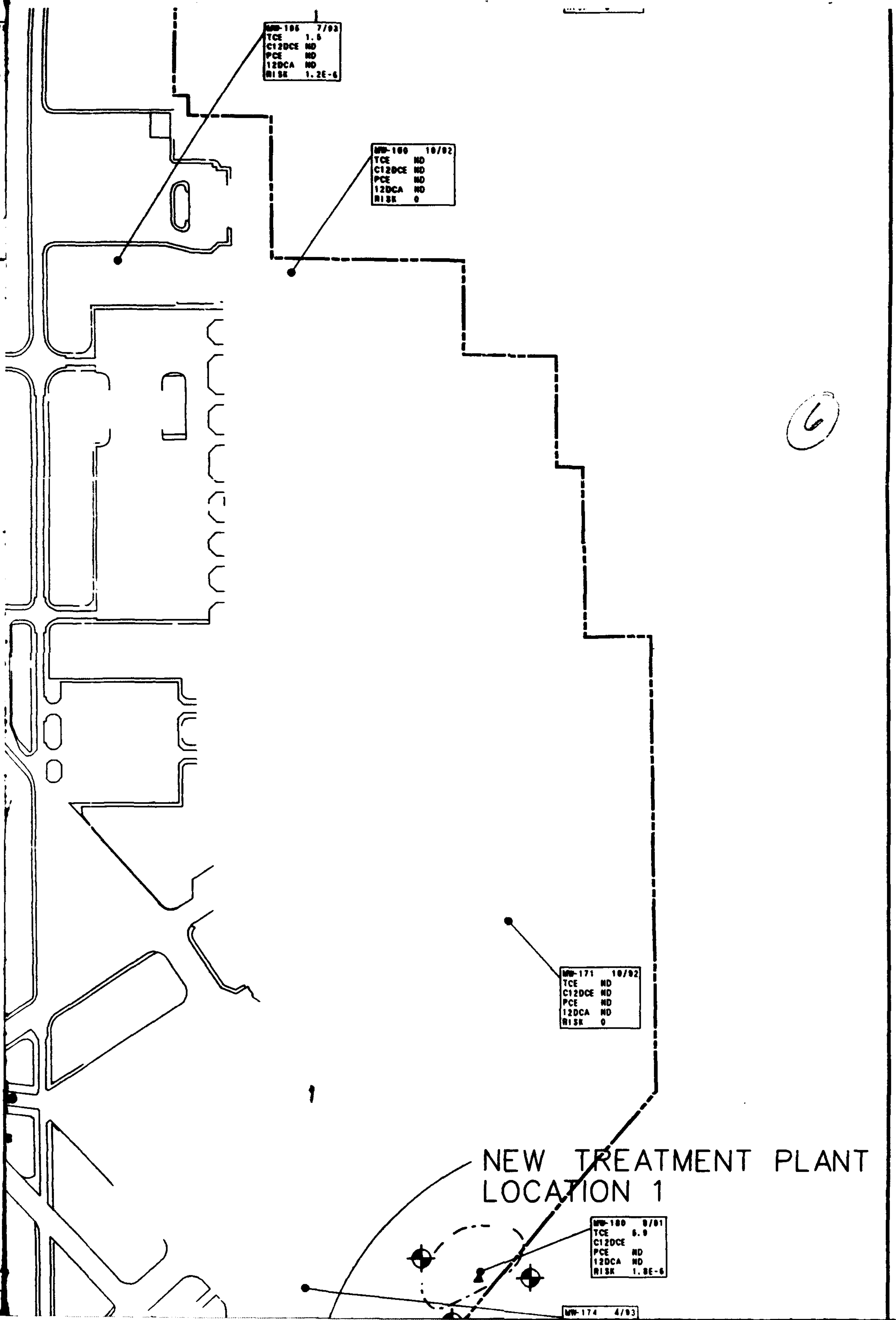
WELL LOCATIONS SHOWN WITHOUT ASSOCIATED DATA WERE NOT SAMPLED DURING OR AFTER 1988.




4
EXISTING GROUNDWATER
TREATMENT PLANT
MW-190 7/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-200 8/93
TCE 1.6
C12DCE ND
PCE ND
12DCA ND
RISK 1.9E-6
MW-136 10/92
TCE 38.0
C12DCE 1.5
PCE ND
12DCA 0.3
RISK 1.2E-5

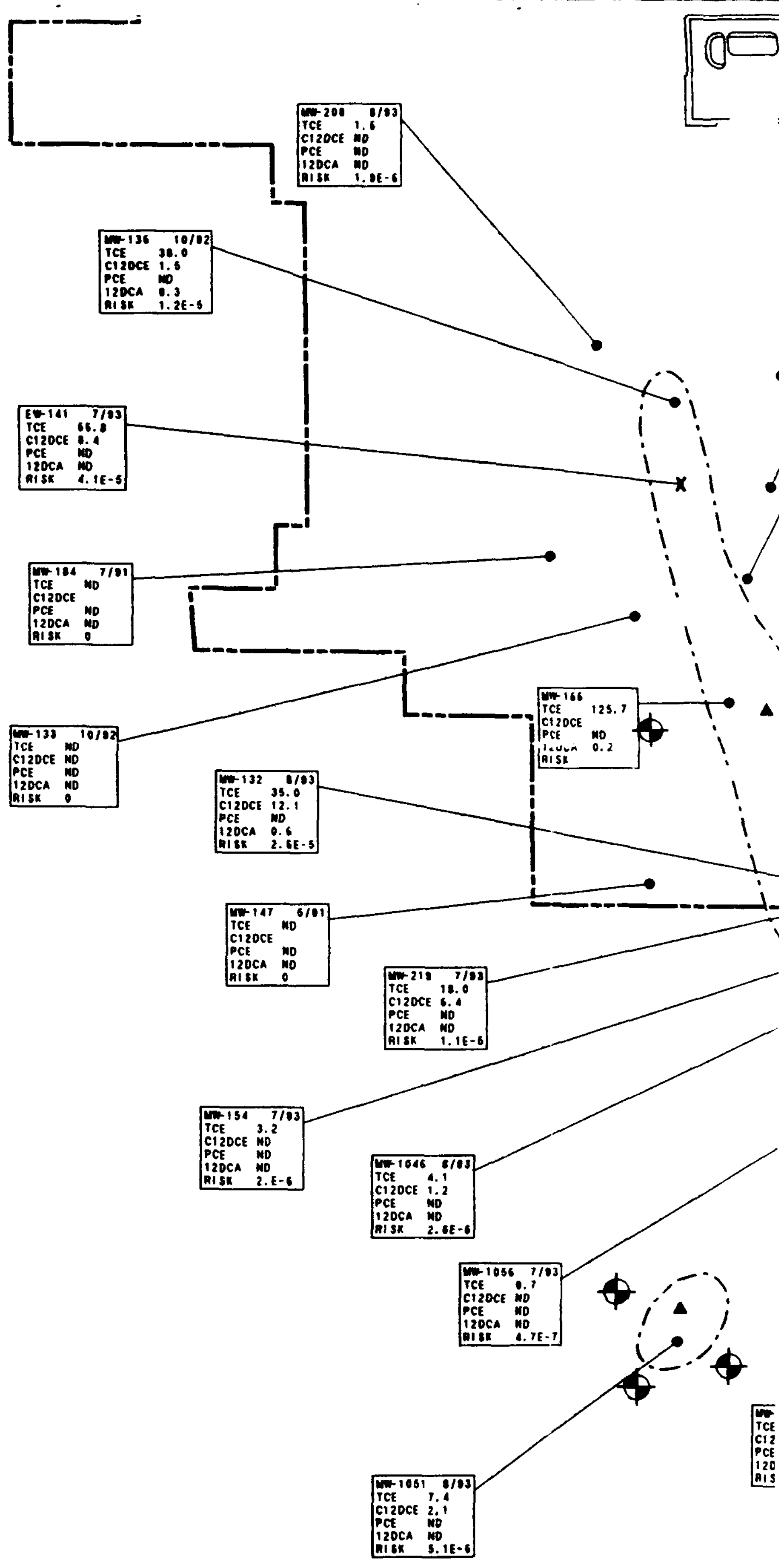


5
-190 7/81
E ND
2DCE
E ND
DCA ND
SK 0
OUNDWATER
PLANT
MW-138 10/82
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-181 1/83
TCE 0.6
C12DCE ND
PCE ND
12DCA ND
RISK 2.E-7
MW-216 10/82
TCE 10.0
C12DCE 3.4
PCE ND
12DCA ND
RISK 4.7E-6
MW-122 12/88
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 2.3E-7

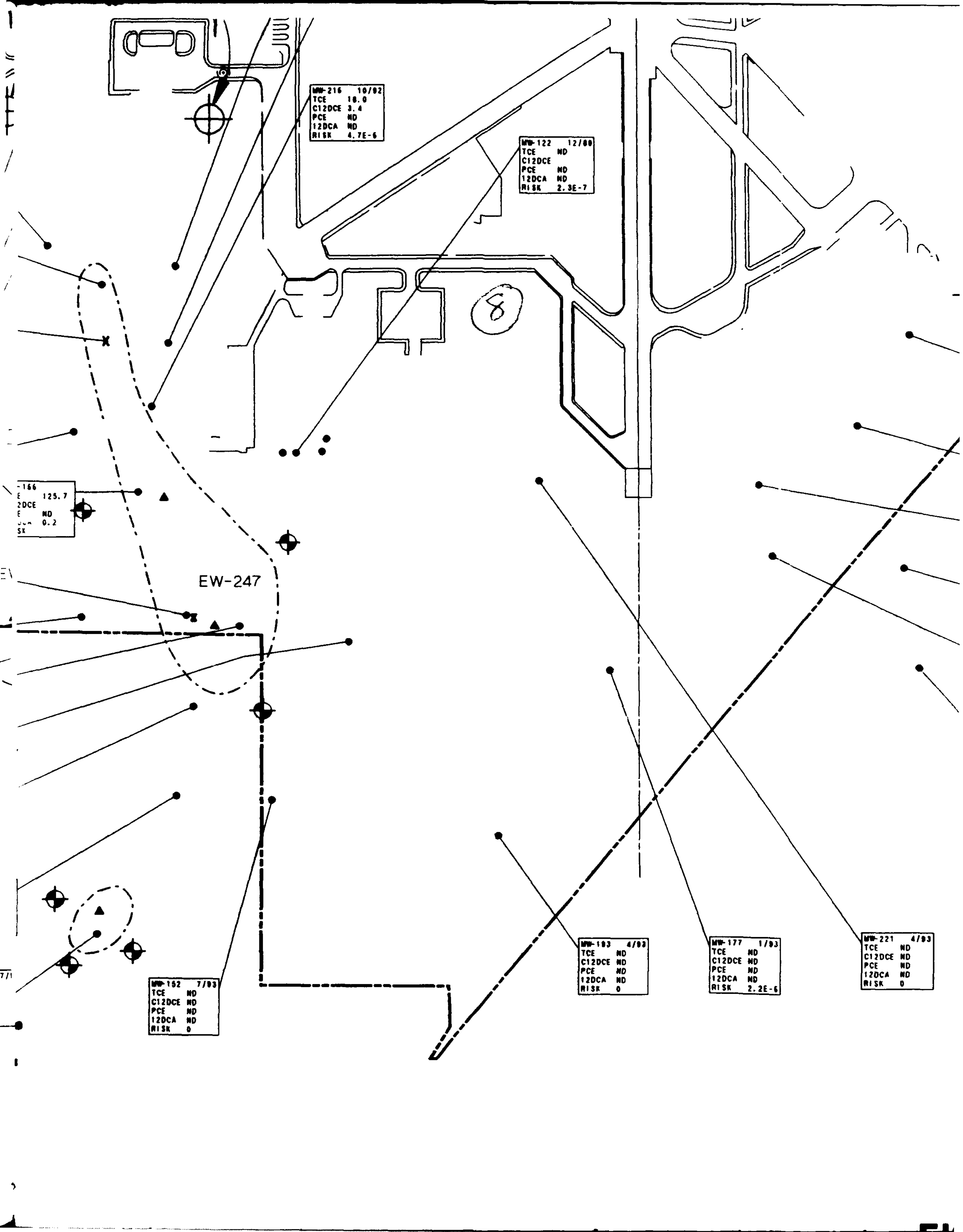


MW-186 7/93
TCE 1.5
C12DCE ND
PCE ND
12DCA ND
RISK 1.2E-6
MW-160 10/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-171 10/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
NEW TREATMENT PLANT
LOCATION 1
MW-180 9/91
TCE 6.9
C12DCE
PCE ND
12DCA ND
RISK 1.8E-6
MW-174 4/93

(7)



MW-208 8/93
TCE 1.6
C12DCE ND
PCE ND
12DCA ND
RISK 1.9E-6
MW-136 10/92
TCE 38.0
C12DCE 1.6
PCE ND
12DCA 0.3
RISK 1.2E-5
EW-141 7/93
TCE 66.8
C12DCE 8.4
PCE ND
12DCA ND
RISK 4.1E-5
MW-184 7/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-133 10/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-166
TCE 125.7
C12DCE
PCE ND
0.2
RISK
MW-132 8/93
TCE 35.0
C12DCE 12.1
PCE ND
12DCA 0.6
RISK 2.6E-5
MW-147 6/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-219 7/93
TCE 18.0
C12DCE 6.4
PCE ND
12DCA ND
RISK 1.1E-6
MW-154 7/93
TCE 3.2
C12DCE ND
PCE ND
12DCA ND
RISK 2.E-6
MW-1046 8/93
TCE 4.1
C12DCE 1.2
PCE ND
12DCA ND
RISK 2.6E-6
MW-1056 7/93
TCE 0.7
C12DCE ND
PCE ND
12DCA ND
RISK 4.7E-7
MW-1051 8/93
TCE 7.4
C12DCE 2.1
PCE ND
12DCA ND
RISK 5.1E-6



MW-216 10/92
TCE 18.0
C12DCE 3.4
PCE ND
12DCA ND
RISK 4.7E-6
MW-122 12/88
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 2.3E-7
8
EW-247
MW-193 4/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-177 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 2.2E-6
MW-221 4/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-152 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0

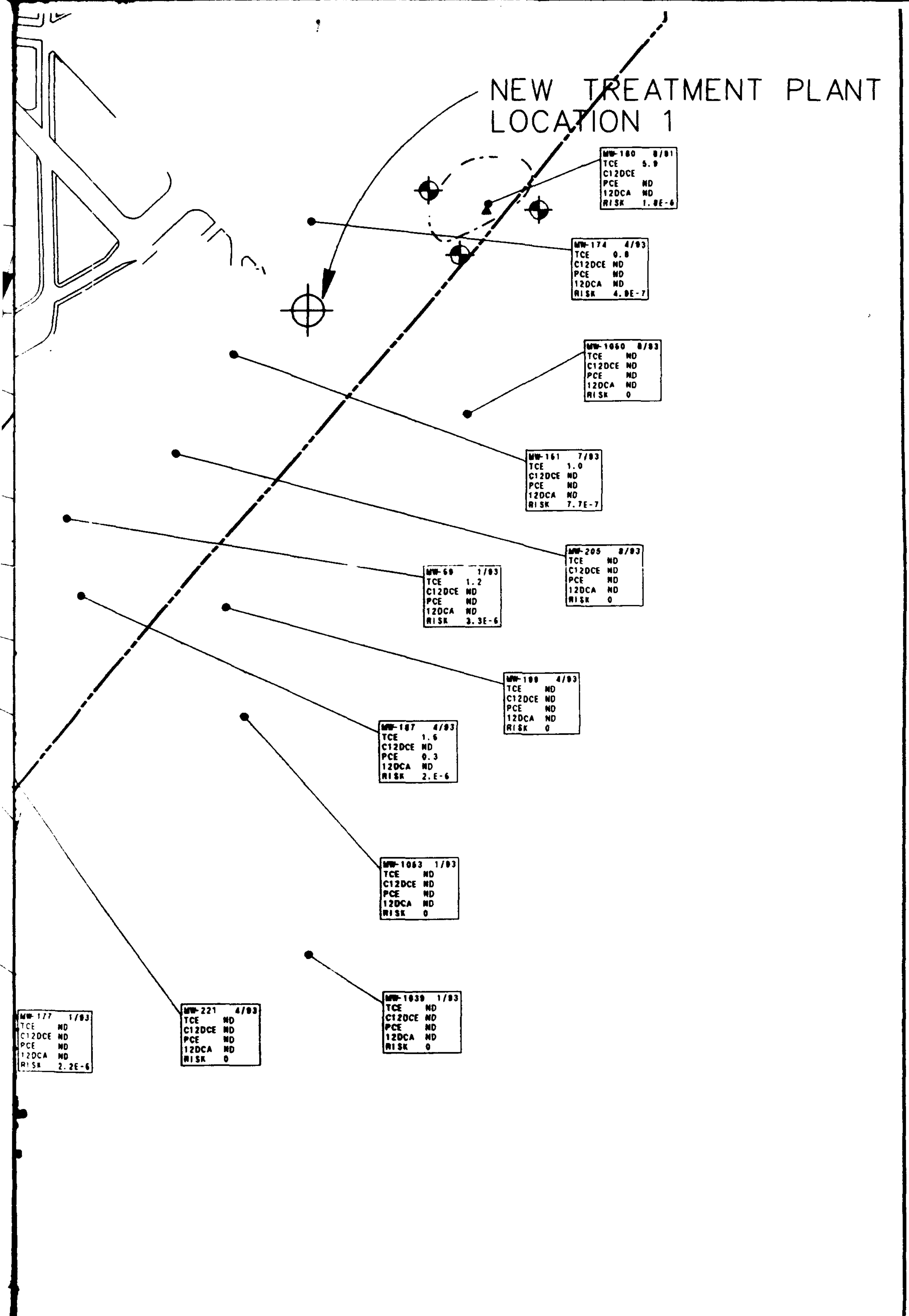
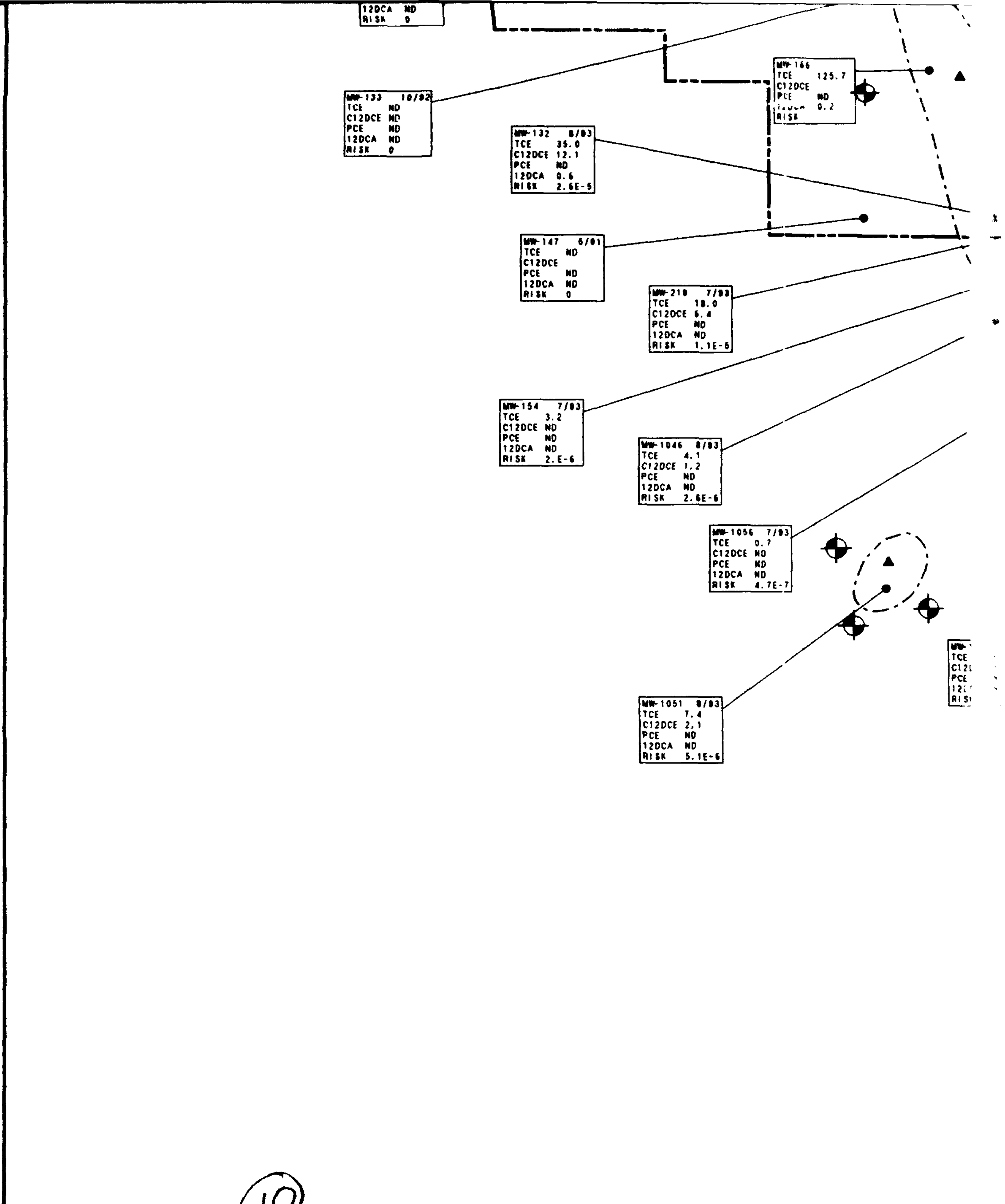

NEW TREATMENT PLANT
LOCATION 1
MW-180 8/91
TCE 5.9
C12DCE
PCE ND
12DCA ND
RISK 1.8E-6
MW-174 4/93
TCE 0.8
C12DCE ND
PCE ND
12DCA ND
RISK 4.8E-7
MW-1060 8/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-161 7/93
TCE 1.0
C12DCE ND
PCE ND
12DCA ND
RISK 7.7E-7
MW-205 8/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-69 1/93
TCE 1.2
C12DCE ND
PCE ND
12DCA ND
RISK 3.3E-6
MW-188 4/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-187 4/93
TCE 1.6
C12DCE ND
PCE 0.3
12DCA ND
RISK 2.E-6
MW-1063 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-177 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 2.2E-6
MW-221 4/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1039 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0

FIGURE E-7



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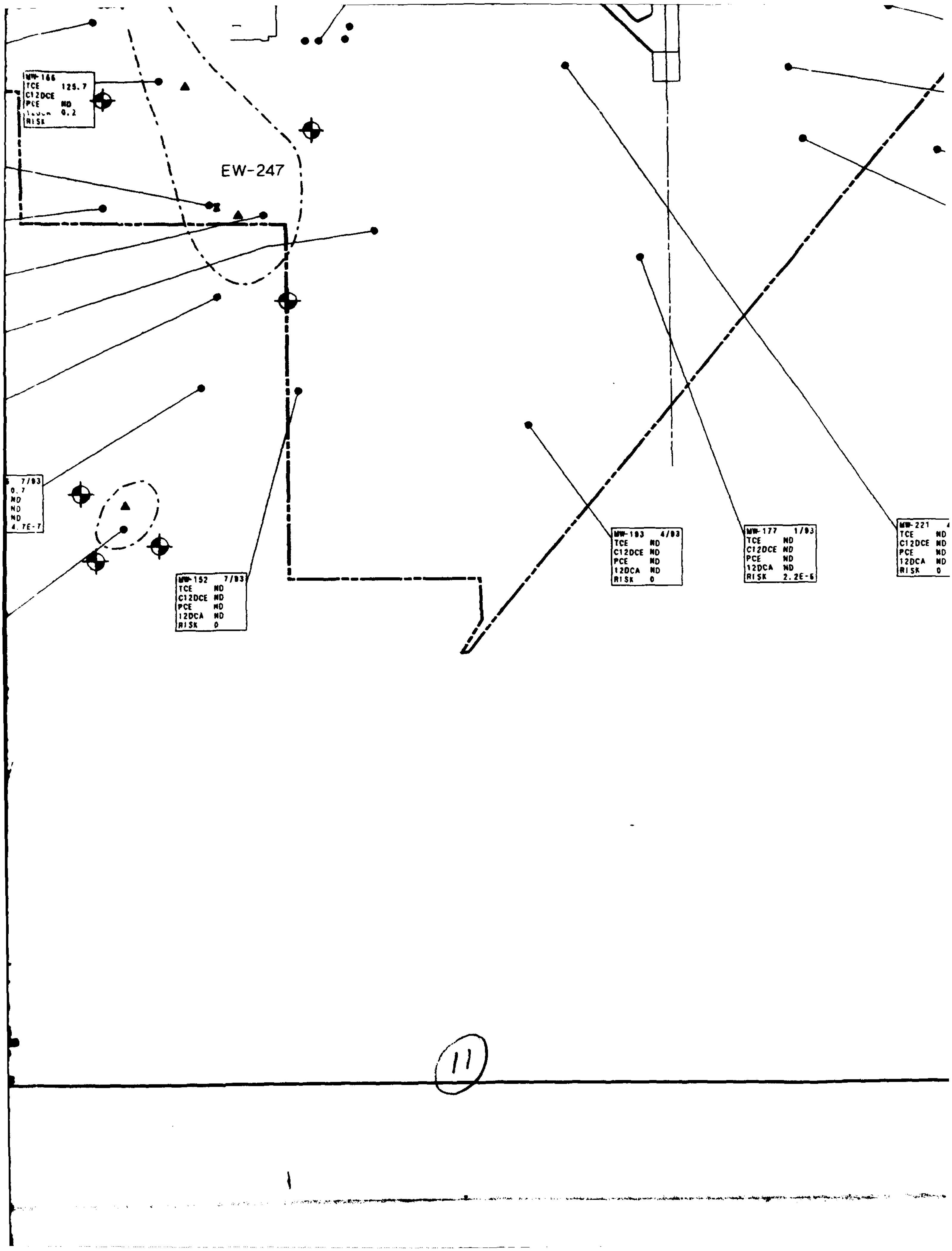


MW-166
TCE 125.7
C12DCE
PCE ND
0.2
RISK
EW-247
7/93
0.7
ND
ND
ND
4.7E-7
MW-152 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-193 4/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-177 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 2.2E-6
MW-221
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
11

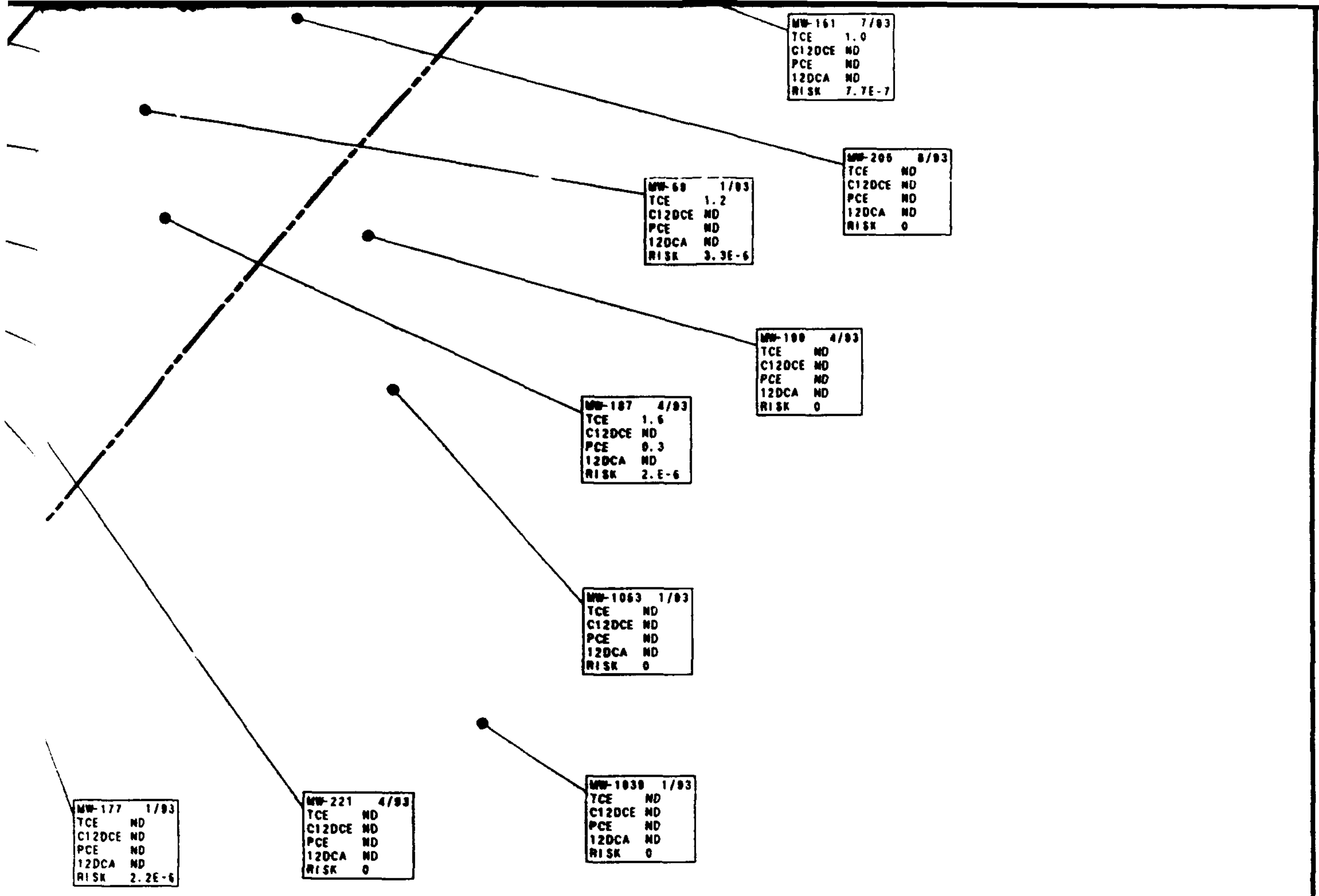


FIGURE E-7
MONITORING AND EXTRACTION WELL LOCATIONS MONITORING ZONE C MCL TARGET VOLUME

GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

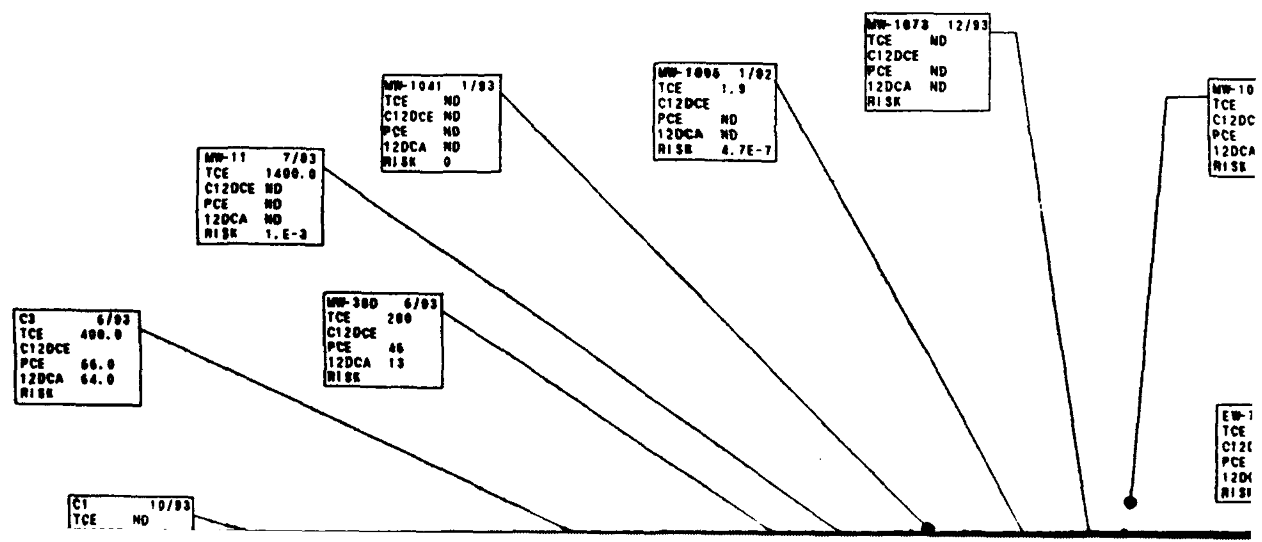
CH2M HILL

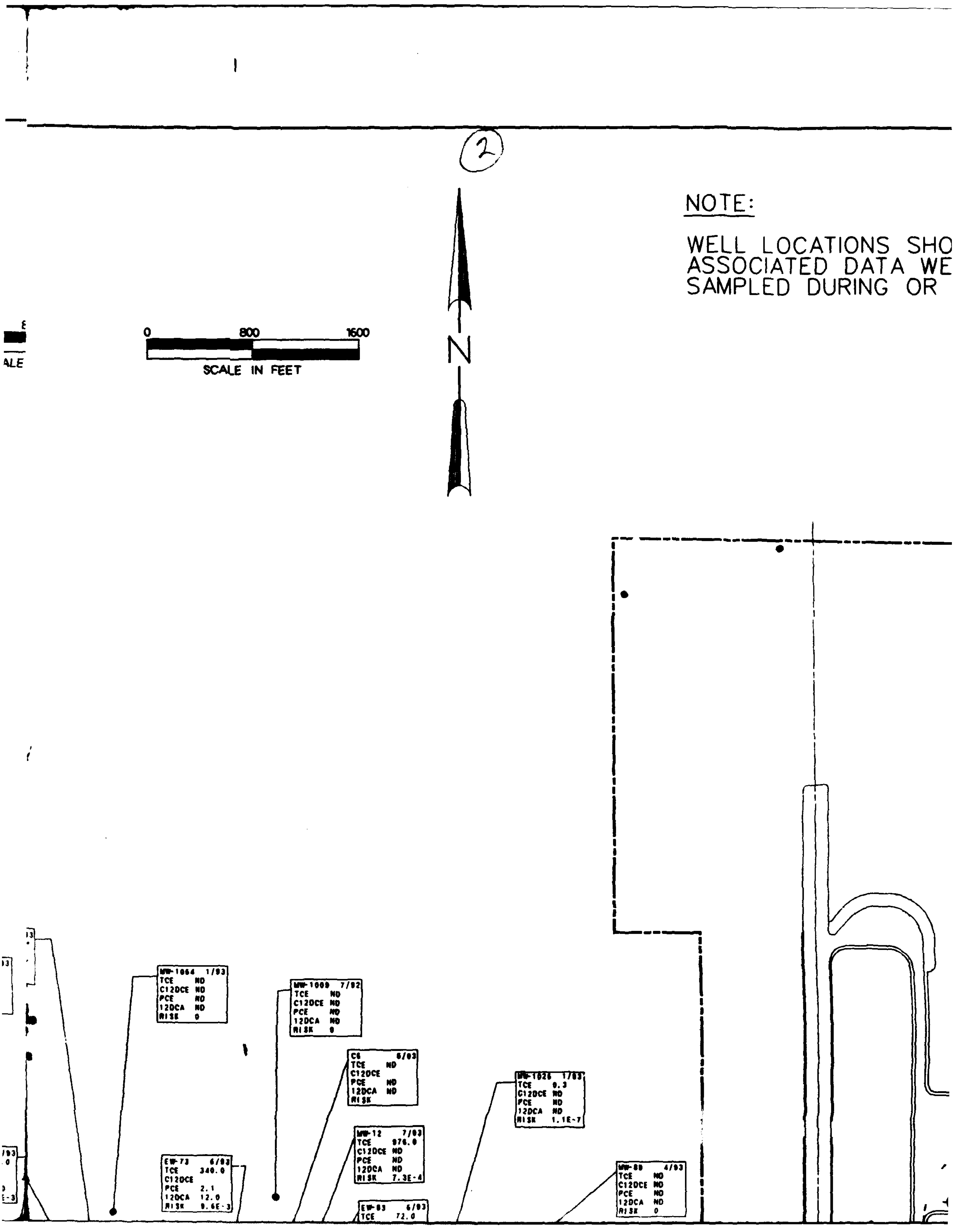
(12)

(1)

WELL SUMMARY

- X EXISTING EXTRACTION WELLS
- • NEW EXTRACTION WELLS
- ⯐ NEW MONITORING WELLS FOR WATER QUALITY
- ⊕ NEW MONITORING WELLS FOR HYDRAULIC CONTROL
- • EXISTING MONITORING WELLS
- —··— TARGET VOLUME BOUNDARY
- —— HOTSPOT BOUNDARY



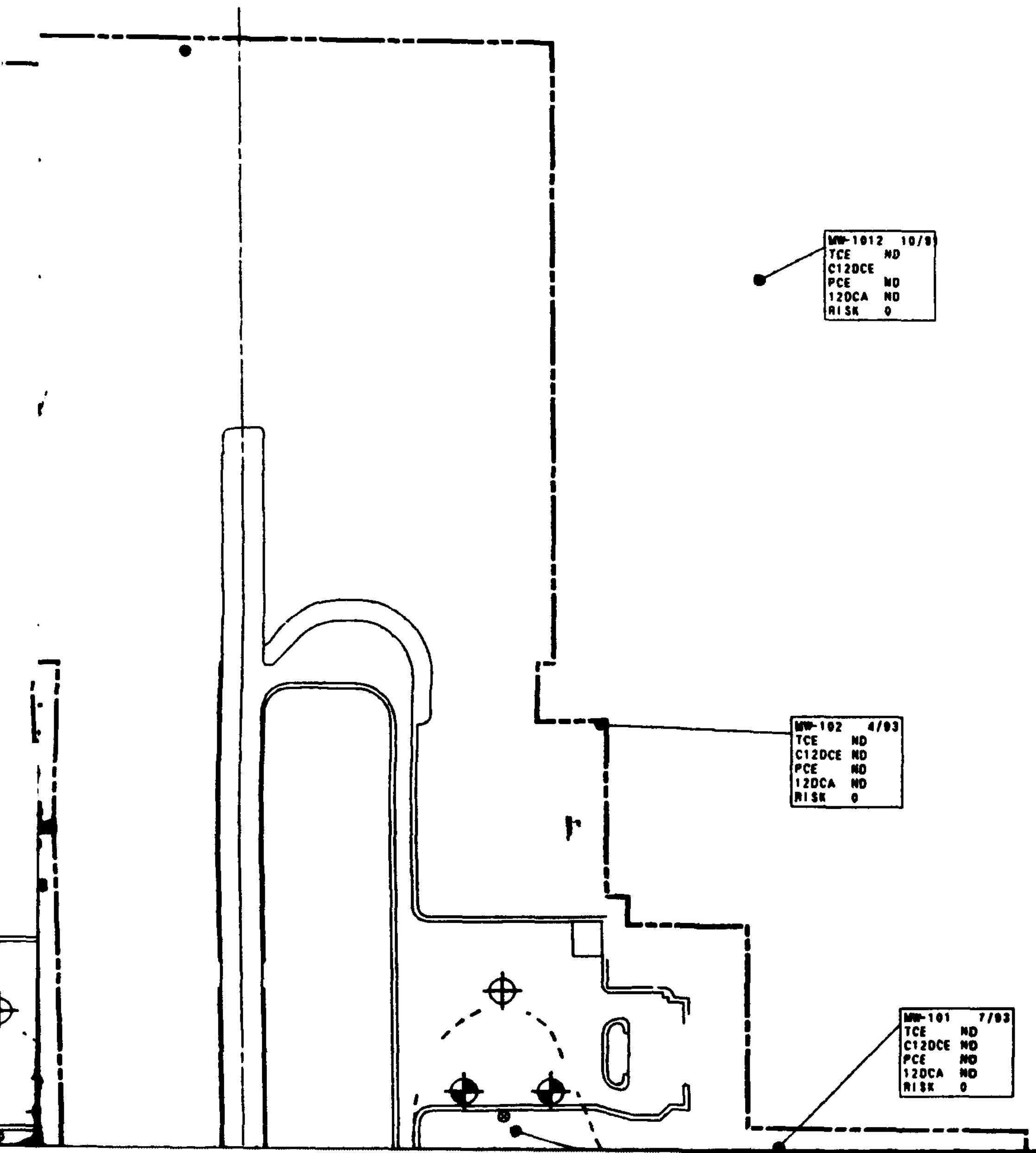


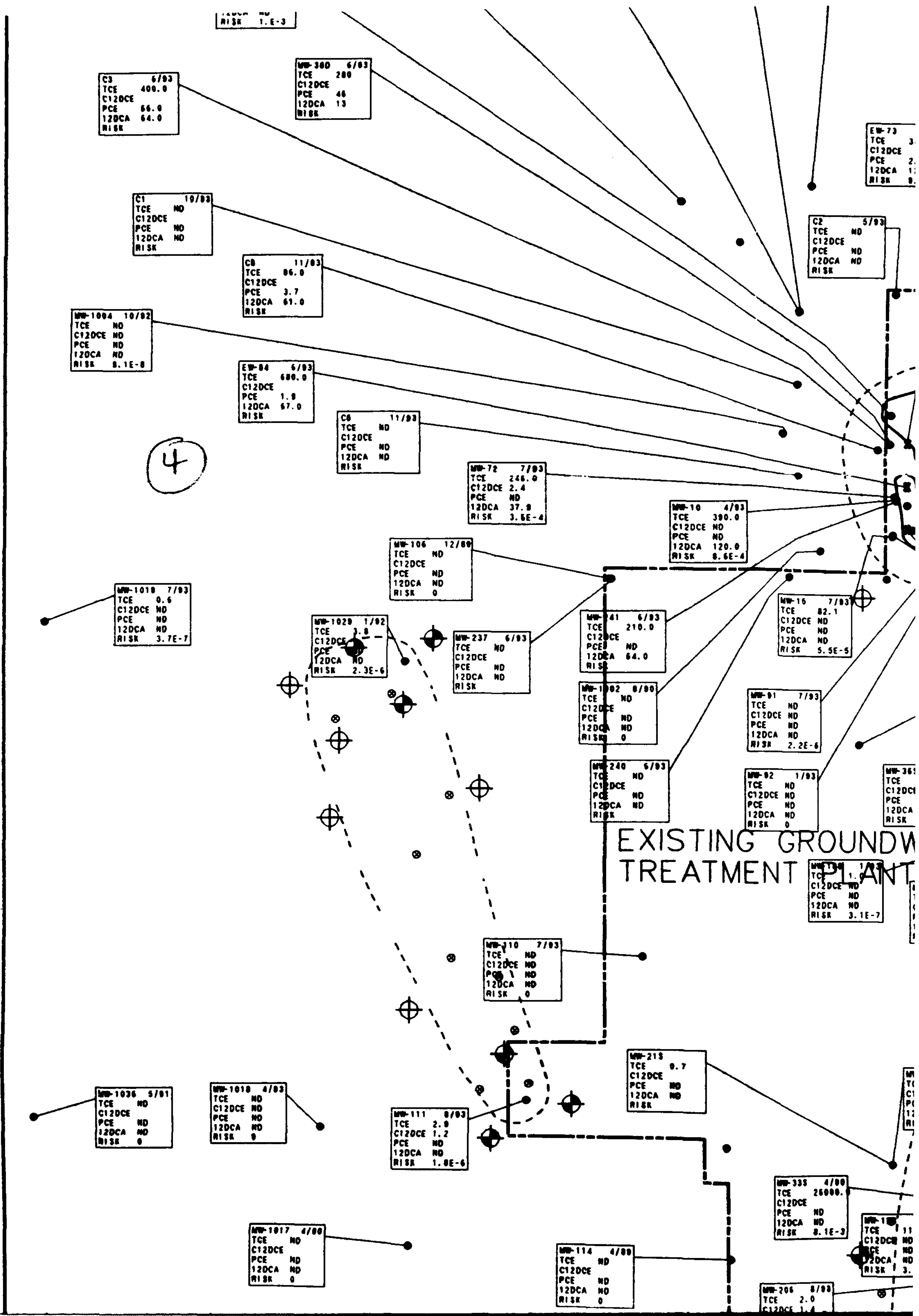
NOTE:
WELL LOCATIONS SHO
ASSOCIATED DATA WE
SAMPLED DURING OR
0 800 1600
SCALE IN FEET
N
MW-1064 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1009 7/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
C6 6/93
TCE ND
C12DCE
PCE ND
12DCA ND
RISK
MW-1026 1/93
TCE 0.3
C12DCE ND
PCE ND
12DCA ND
RISK 1.1E-7
MW-12 7/93
TCE 976.0
C12DCE ND
PCE ND
12DCA ND
RISK 7.3E-4
EW-73 6/93
TCE 340.0
C12DCE
PCE 2.1
12DCA 12.0
RISK 9.6E-3
EW-83 6/93
TCE 72.0
MW-80 4/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0

3

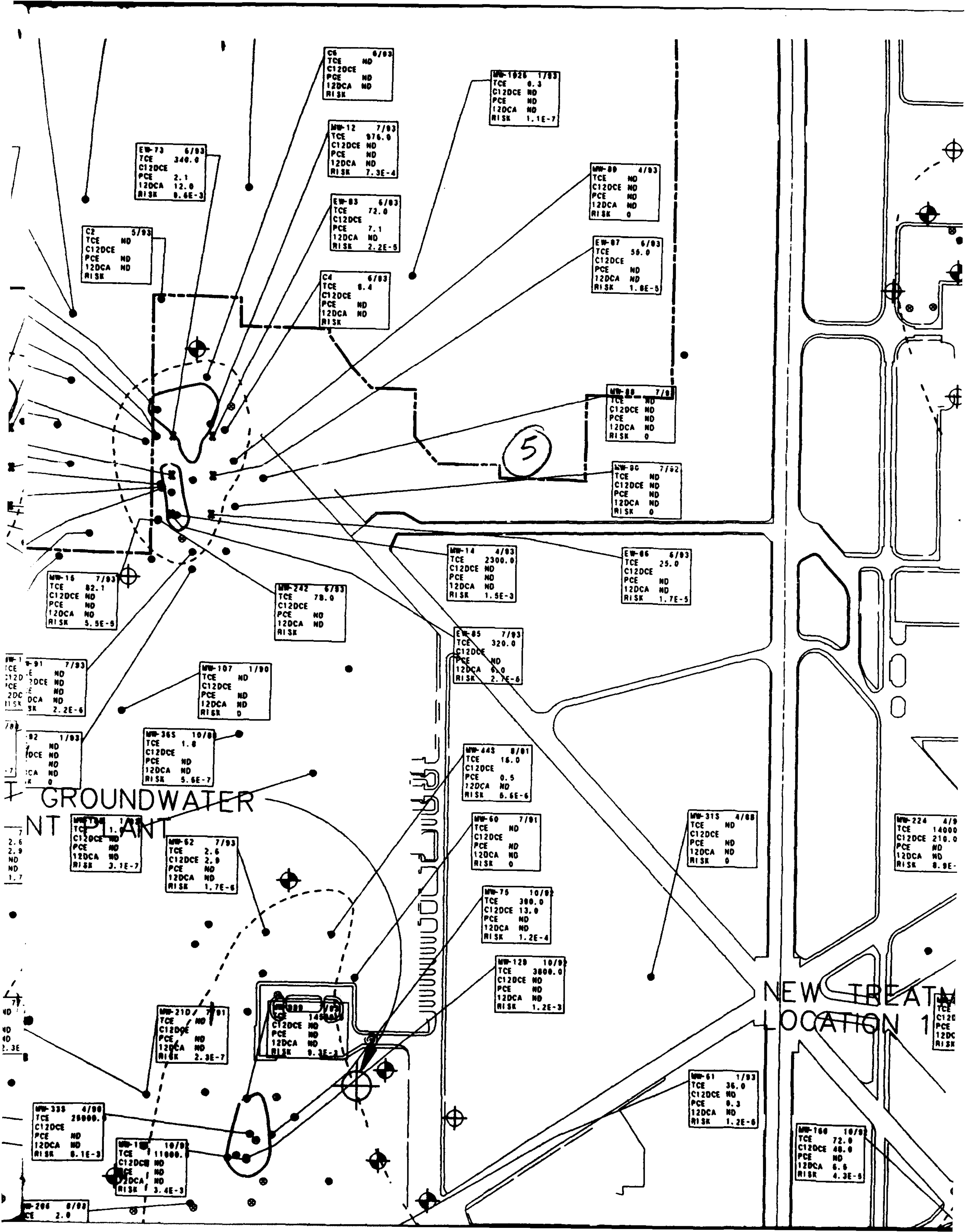
NOTE:

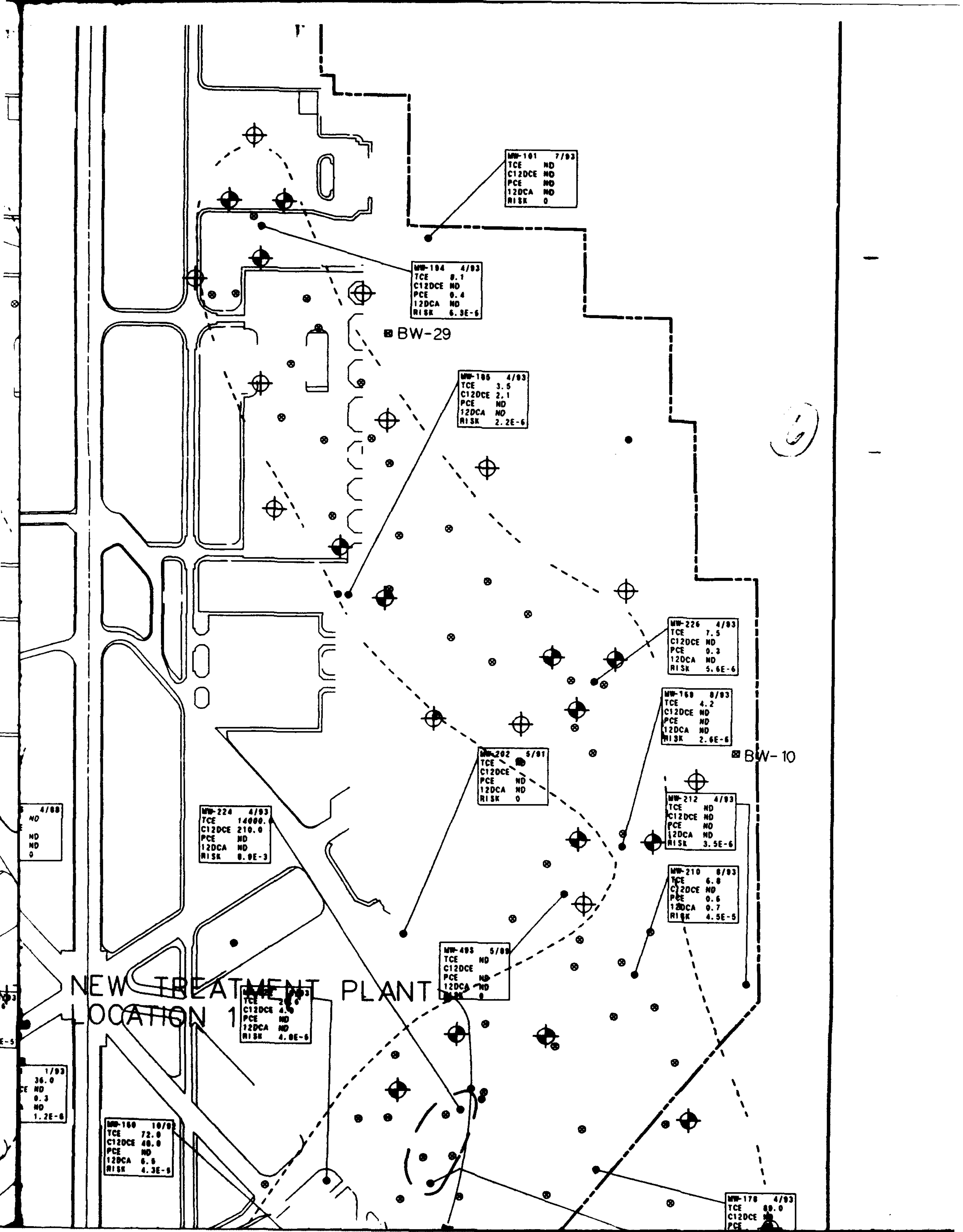
WELL LOCATIONS SHOWN WITHOUT ASSOCIATED DATA WERE NOT SAMPLED DURING OR AFTER 1988.

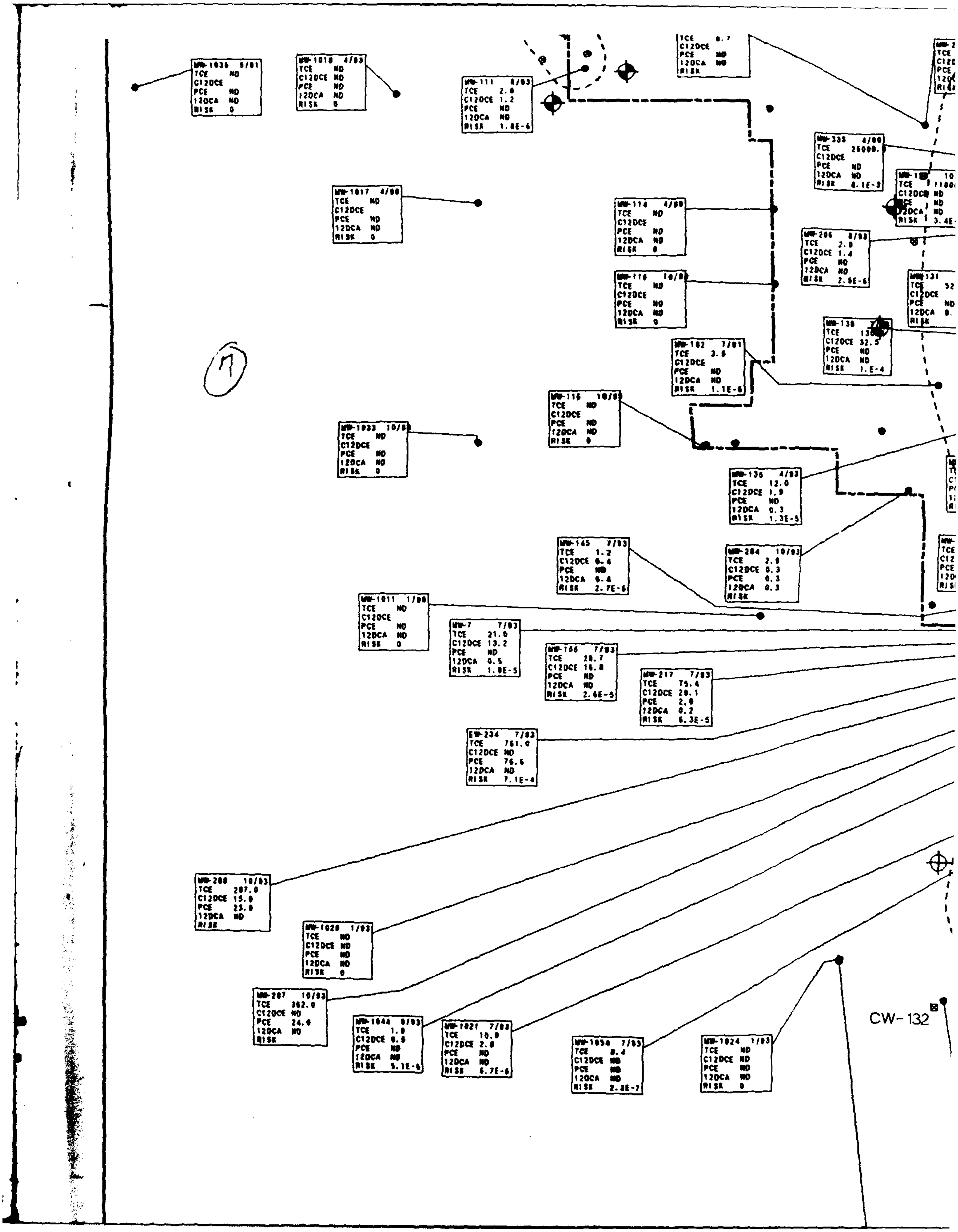


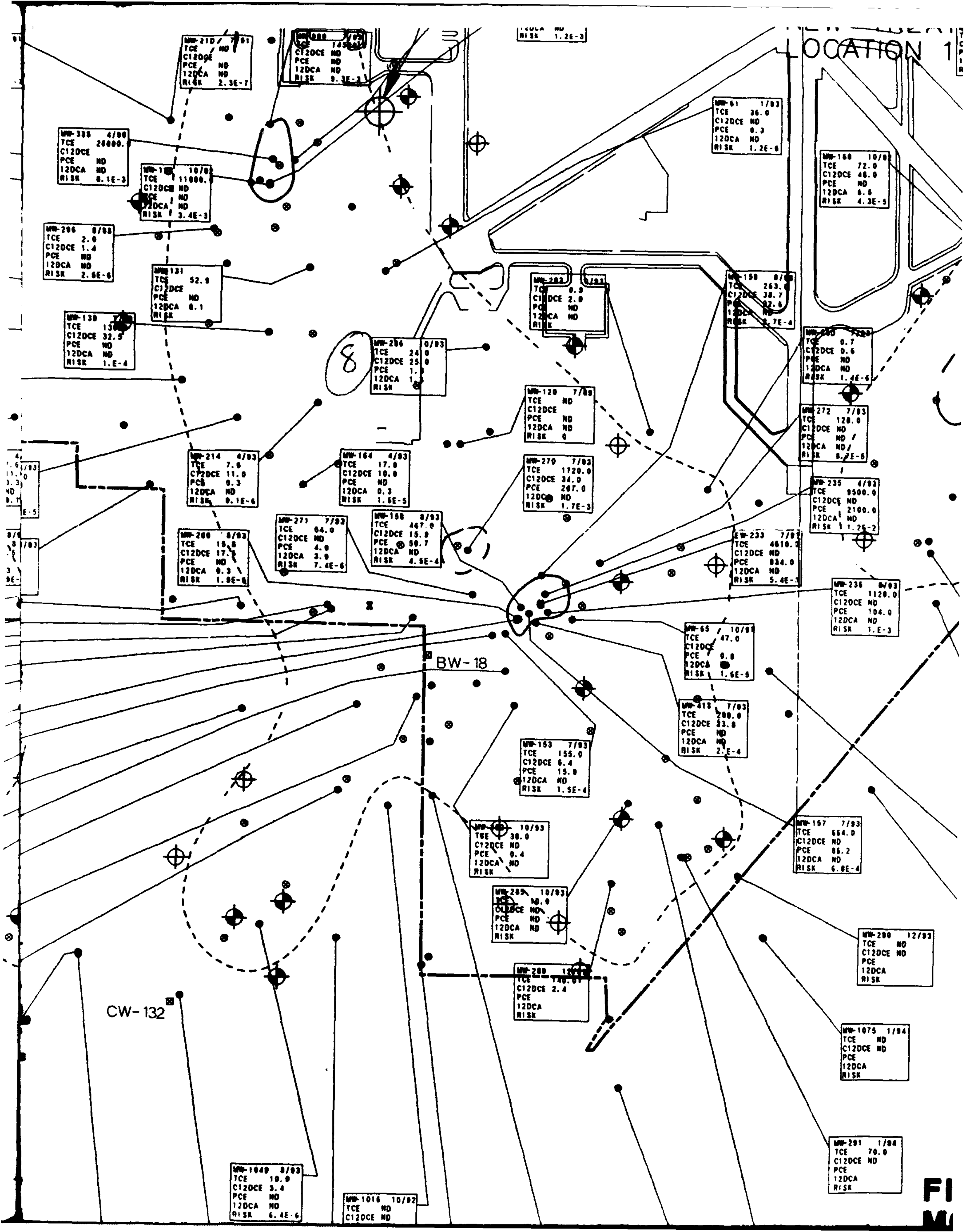


C3 6/93 TCE 400.0 C12DCE PCE 66.0 12DCA 64.0 RISK
MW-38D 6/93 TCE 280 C12DCE PCE 46 12DCA 13 RISK
EW-73 TCE C12DCE PCE 12DCA RISK
C1 10/93 TCE ND C12DCE PCE ND 12DCA ND RISK
C2 5/93 TCE ND C12DCE PCE ND 12DCA ND RISK
C8 11/93 TCE 86.0 C12DCE PCE 3.7 12DCA 61.0 RISK
MW-1004 10/92 TCE ND C12DCE ND PCE ND 12DCA ND RISK 8.1E-8
EW-84 6/93 TCE 680.0 C12DCE PCE 1.9 12DCA 67.0 RISK
C6 11/93 TCE ND C12DCE PCE ND 12DCA ND RISK
4
MW-72 7/93 TCE 246.0 C12DCE 2.4 PCE ND 12DCA 37.9 RISK 3.6E-4
MW-10 4/93 TCE 390.0 C12DCE ND PCE ND 12DCA 120.0 RISK 8.6E-4
MW-106 12/89 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-1019 7/93 TCE 0.6 C12DCE ND PCE ND 12DCA ND RISK 3.7E-7
MW-1029 1/92 TCE 3.8 C12DCE PCE 12DCA ND RISK 2.3E-6
MW-237 6/93 TCE ND C12DCE PCE ND 12DCA ND RISK
MW-241 6/93 TCE 210.0 C12DCE PCE ND 12DCA 64.0 RISK
MW-16 7/93 TCE 82.1 C12DCE ND PCE ND 12DCA ND RISK 5.5E-5
MW-1002 8/90 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-91 7/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 2.2E-6
MW-240 6/93 TCE ND C12DCE PCE ND 12DCA ND RISK
MW-92 1/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
EXISTING GROUNDW
TREATMENT PLANT
12DCA ND RISK 3.1E-7
MW-110 7/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-215 TCE 9.7 C12DCE PCE ND 12DCA ND RISK
MW-1036 5/91 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-1018 4/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-111 8/93 TCE 2.9 C12DCE 1.2 PCE ND 12DCA ND RISK 1.8E-6
MW-335 4/90 TCE 26000.0 C12DCE PCE ND 12DCA ND RISK 8.1E-3
MW-1017 4/90 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-114 4/90 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-206 8/93 TCE 2.0 C12DCE 1.4


C6 6/93 TCE ND C12DCE PCE ND 12DCA ND RISK
TCE 0.3 C12DCE ND PCE ND 12DCA ND RISK 1.1E-7
MW-12 7/93 TCE 976.0 C12DCE ND PCE ND 12DCA ND RISK 7.3E-4
EW-73 6/93 TCE 340.0 C12DCE PCE 2.1 12DCA 12.0 RISK 8.6E-3
MW-89 4/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
EW-83 6/93 TCE 72.0 C12DCE PCE 7.1 12DCA ND RISK 2.2E-5
C2 5/93 TCE ND C12DCE PCE ND 12DCA ND RISK
EW-87 6/93 TCE 56.0 C12DCE PCE ND 12DCA ND RISK 1.8E-5
C4 6/93 TCE 6.4 C12DCE PCE ND 12DCA ND RISK
MW-88 7/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
5
MW-90 7/92 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-14 4/93 TCE 2300.0 C12DCE ND PCE ND 12DCA ND RISK 1.5E-3
EW-86 6/93 TCE 25.0 C12DCE PCE ND 12DCA ND RISK 1.7E-5
MW-15 7/93 TCE 82.1 C12DCE ND PCE ND 12DCA ND RISK 5.5E-5
MW-242 6/93 TCE 78.0 C12DCE PCE ND 12DCA ND RISK
EW-85 7/93 TCE 320.0 C12DCE PCE ND 12DCA 6.0 RISK 2.7E-6
MW-91 7/93 ND ND ND RISK 2.2E-6
MW-107 1/90 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-36S TCE 1.8 C12DCE PCE ND 12DCA ND RISK 5.6E-7
1/93 ND ND ND ND 0
MW-44S 8/91 TCE 16.0 C12DCE PCE 0.5 12DCA ND RISK 6.6E-6
GROUNDWATER
NT PLANT
RISK 3.1E-7
MW-60 7/91 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-31S 4/88 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-224 TCE 14000 C12DCE 210.0 PCE ND 12DCA ND RISK 8.9E-
MW-62 7/93 TCE 2.6 C12DCE 2.9 PCE ND 12DCA ND RISK 1.7E-6
MW-75 10/92 TCE 380.0 C12DCE 13.0 PCE ND 12DCA ND RISK 1.2E-4
MW-120 10/92 TCE 3800.0 C12DCE ND PCE ND 12DCA ND RISK 1.2E-3
NEW TREATM
LOCATION 1
MW-21D 7/91 TCE ND C12DCE PCE ND 12DCA ND RISK 2.3E-7
C12DCE ND PCE ND 12DCA ND RISK 9.3E-3
MW-61 1/93 TCE 36.0 C12DCE ND PCE 0.3 12DCA ND RISK 1.2E-5
MW-33S 4/90 TCE 25000. C12DCE PCE ND 12DCA ND RISK 8.1E-3
10/92 TCE 11000.0 C12DCE ND PCE ND 12DCA ND RISK 3.4E-3
MW-160 10/92 TCE 72.0 C12DCE 48.0 PCE ND 12DCA 6.6 RISK 4.3E-5
MW-206 8/93 TCE 2.0


MW-101 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-194 4/93
TCE 8.1
C12DCE ND
PCE 0.4
12DCA ND
RISK 6.3E-6
BW-29
MW-185 4/93
TCE 3.5
C12DCE 2.1
PCE ND
12DCA ND
RISK 2.2E-6
MW-226 4/93
TCE 7.5
C12DCE ND
PCE 0.3
12DCA ND
RISK 5.6E-6
MW-169 8/93
TCE 4.2
C12DCE ND
PCE ND
12DCA ND
RISK 2.6E-6
BW-10
MW-202 5/91
TCE
C12DCE
PCE ND
12DCA ND
RISK 0
MW-212 4/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 3.5E-6
MW-210 8/93
TCE 6.8
C12DCE ND
PCE 0.6
12DCA 0.7
RISK 4.5E-5
MW-224 4/93
TCE 14000.
C12DCE 210.0
PCE ND
12DCA ND
RISK 8.9E-3
MW-495 5/89
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
NEW TREATMENT PLANT
LOCATION 1
TCE
C12DCE
PCE ND
12DCA ND
RISK 4.8E-6
MW-160 10/92
TCE 72.0
C12DCE 48.0
PCE ND
12DCA 6.5
RISK 4.3E-5
MW-178 4/93
TCE 89.0
C12DCE
PCE


MW-1036 5/91 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-1018 4/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-111 8/93 TCE 2.0 C12DCE 1.2 PCE ND 12DCA ND RISK 1.8E-6
TCE 0.7 C12DCE PCE ND 12DCA ND RISK
MW-335 4/90 TCE 26000.0 C12DCE PCE ND 12DCA ND RISK 8.1E-3
MW-1017 4/90 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-114 4/89 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-116 10/89 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-296 8/93 TCE 2.0 C12DCE 1.4 PCE ND 12DCA ND RISK 2.5E-6
MW-130 TCE C12DCE 32.5 PCE ND 12DCA ND RISK 1.E-4
MW-102 7/91 TCE 3.6 C12DCE PCE ND 12DCA ND RISK 1.1E-6
MW-115 10/89 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-1033 10/89 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-135 4/93 TCE 12.0 C12DCE 1.9 PCE ND 12DCA 0.3 RISK 1.3E-5
MW-145 7/93 TCE 1.2 C12DCE 0.4 PCE ND 12DCA 0.4 RISK 2.7E-6
MW-284 10/93 TCE 2.9 C12DCE 0.3 PCE 0.3 12DCA 0.3 RISK
MW-1011 1/90 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-7 7/93 TCE 21.0 C12DCE 13.2 PCE ND 12DCA 0.5 RISK 1.9E-5
MW-156 7/93 TCE 28.7 C12DCE 16.8 PCE ND 12DCA ND RISK 2.6E-5
MW-217 7/93 TCE 75.4 C12DCE 28.1 PCE 2.0 12DCA 0.2 RISK 6.3E-5
EW-234 7/93 TCE 761.0 C12DCE ND PCE 76.6 12DCA ND RISK 7.1E-4
MW-288 10/93 TCE 287.0 C12DCE 15.0 PCE 23.0 12DCA ND RISK
MW-1029 1/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-287 10/93 TCE 362.0 C12DCE ND PCE 24.0 12DCA ND RISK
MW-1044 9/93 TCE 1.8 C12DCE 0.5 PCE ND 12DCA ND RISK 5.1E-6
MW-1021 7/93 TCE 10.0 C12DCE 2.0 PCE ND 12DCA ND RISK 6.7E-6
MW-1054 7/93 TCE 0.4 C12DCE ND PCE ND 12DCA ND RISK 2.3E-7
MW-1024 1/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
CW-132


LOCATION 1
MW-210 7/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 2.3E-7
MW-338 4/90
TCE 26000.
C12DCE
PCE ND
12DCA ND
RISK 8.1E-3
MW-61 1/93
TCE 36.0
C12DCE ND
PCE 0.3
12DCA ND
RISK 1.2E-6
MW-160 10/92
TCE 72.0
C12DCE 48.0
PCE ND
12DCA 6.5
RISK 4.3E-5
MW-206 8/93
TCE 2.0
C12DCE 1.4
PCE ND
12DCA ND
RISK 2.6E-6
TCE 52.9
PCE ND
12DCA 0.1
MW-139
TCE
C12DCE 32.5
PCE ND
12DCA ND
RISK 1.E-4
8
MW-120 7/90
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-272 7/93
TCE 128.0
MW-214 4/93
TCE 7.6
C12DCE 11.0
PCE 0.3
12DCA ND
RISK 8.1E-6
MW-164 4/93
TCE 17.0
C12DCE 10.0
PCE ND
12DCA 0.3
RISK 1.6E-5
MW-270 7/93
TCE 1720.0
C12DCE 34.0
PCE 207.0
RISK 1.7E-3
MW-235 4/93
TCE 9500.0
C12DCE ND
PCE 2100.0
12DCA ND
MW-271 7/93
TCE 64.0
C12DCE ND
PCE 4.0
12DCA 3.9
RISK 7.4E-6
MW-158 8/93
TCE 467.0
C12DCE 15.9
PCE 50.7
12DCA ND
RISK 4.5E-4
TCE 4610.0
C12DCE ND
PCE 834.0
12DCA ND
RISK 5.4E-3
MW-236
TCE 1120.0
C12DCE ND
PCE 104.0
12DCA ND
RISK 1.E-3
BW-18
MW-153 7/93
TCE 155.0
C12DCE 6.4
PCE 15.9
12DCA ND
RISK 1.5E-4
MW-157 7/93
TCE 664.0
C12DCE ND
PCE 86.2
12DCA ND
RISK 6.8E-4
MW-280 12/93
TCE ND
C12DCE ND
PCE
12DCA
RISK
MW-1075 1/94
TCE ND
C12DCE ND
PCE
12DCA
RISK
CW-132
MW-1049 8/93
TCE 10.0
C12DCE 3.4
PCE ND
12DCA ND
RISK 6.4E-6
MW-1016 10/92
TCE ND
C12DCE ND
MW-291 1/94
TCE 70.0
C12DCE ND
PCE
12DCA
RISK

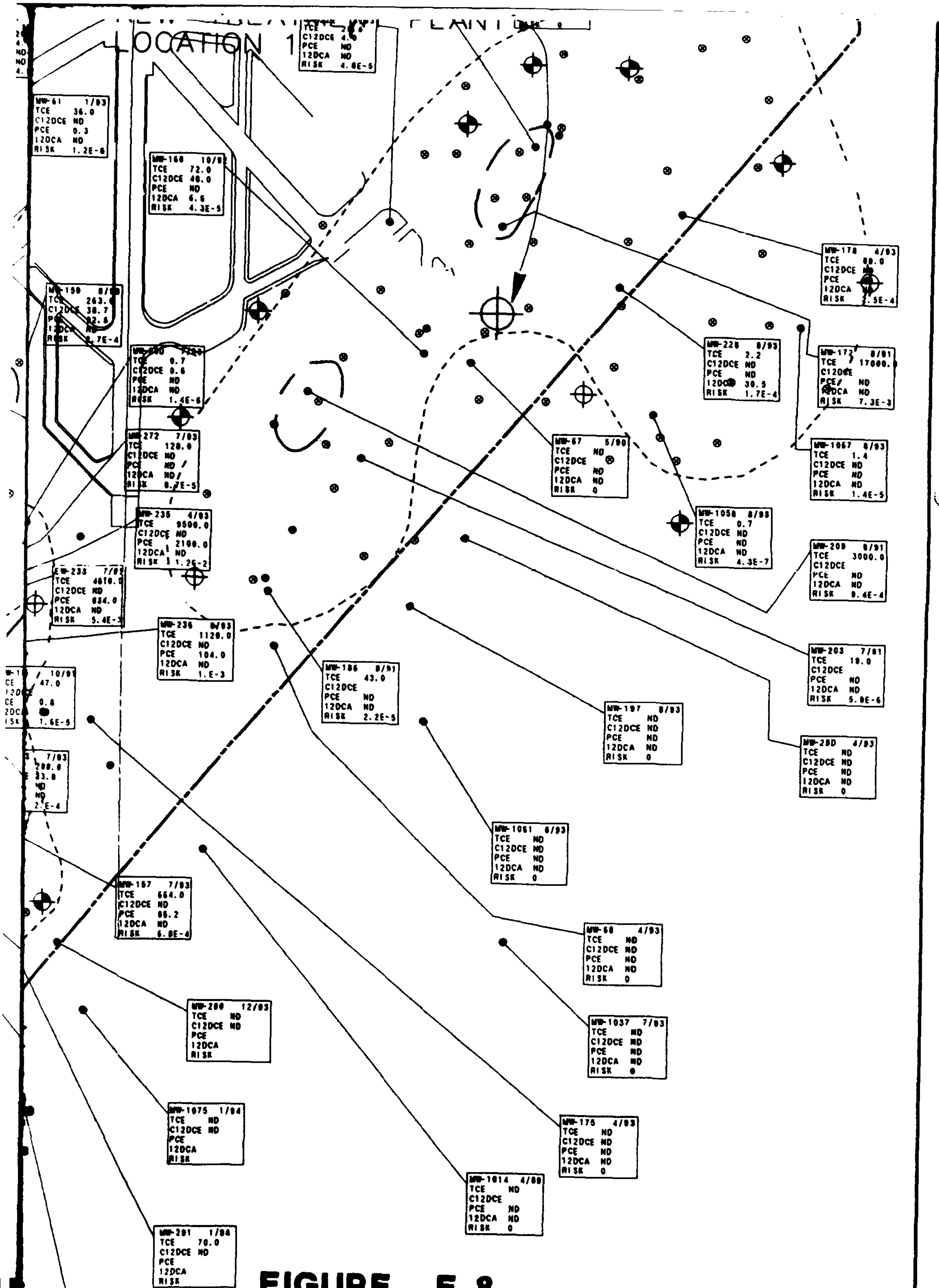
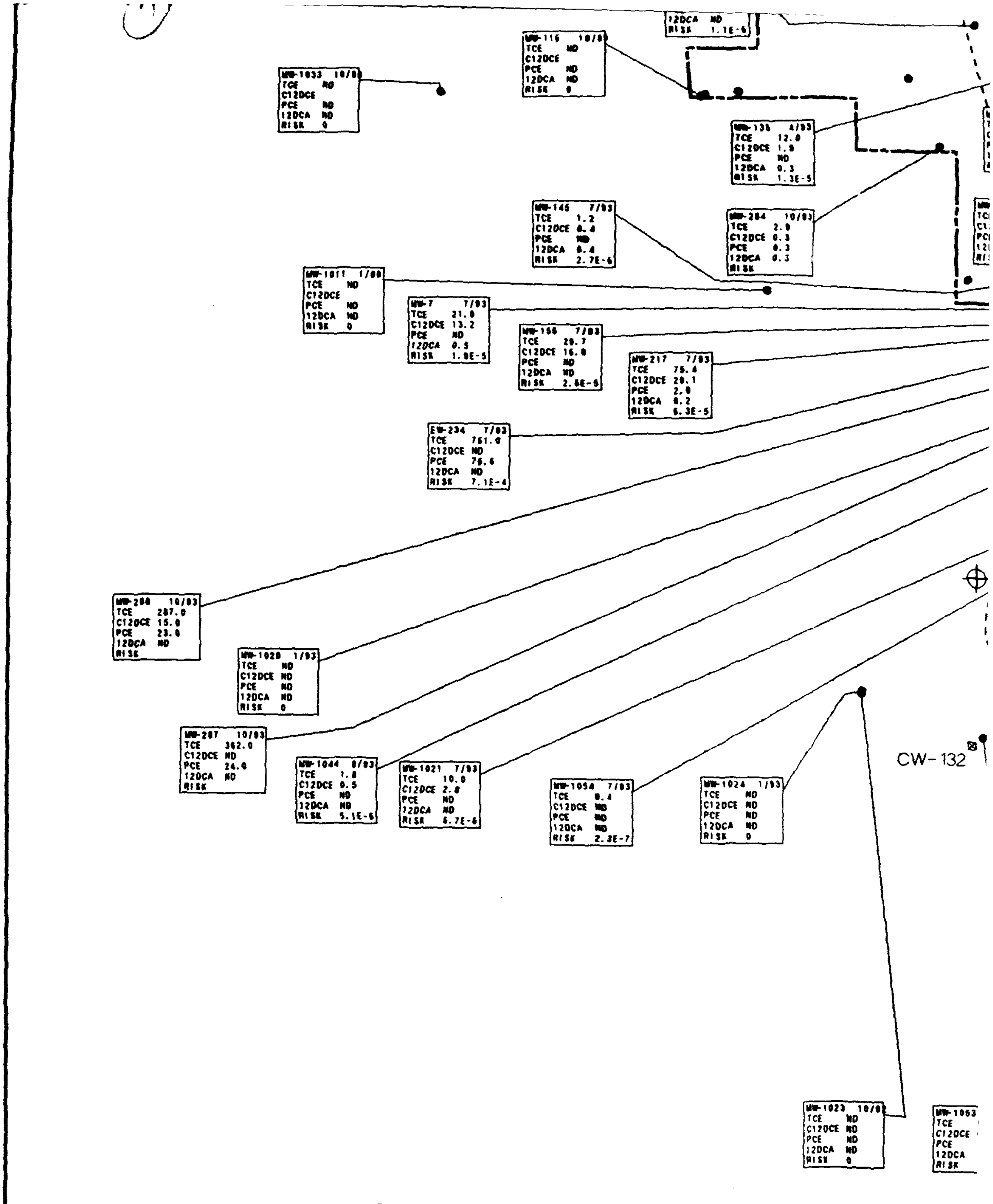


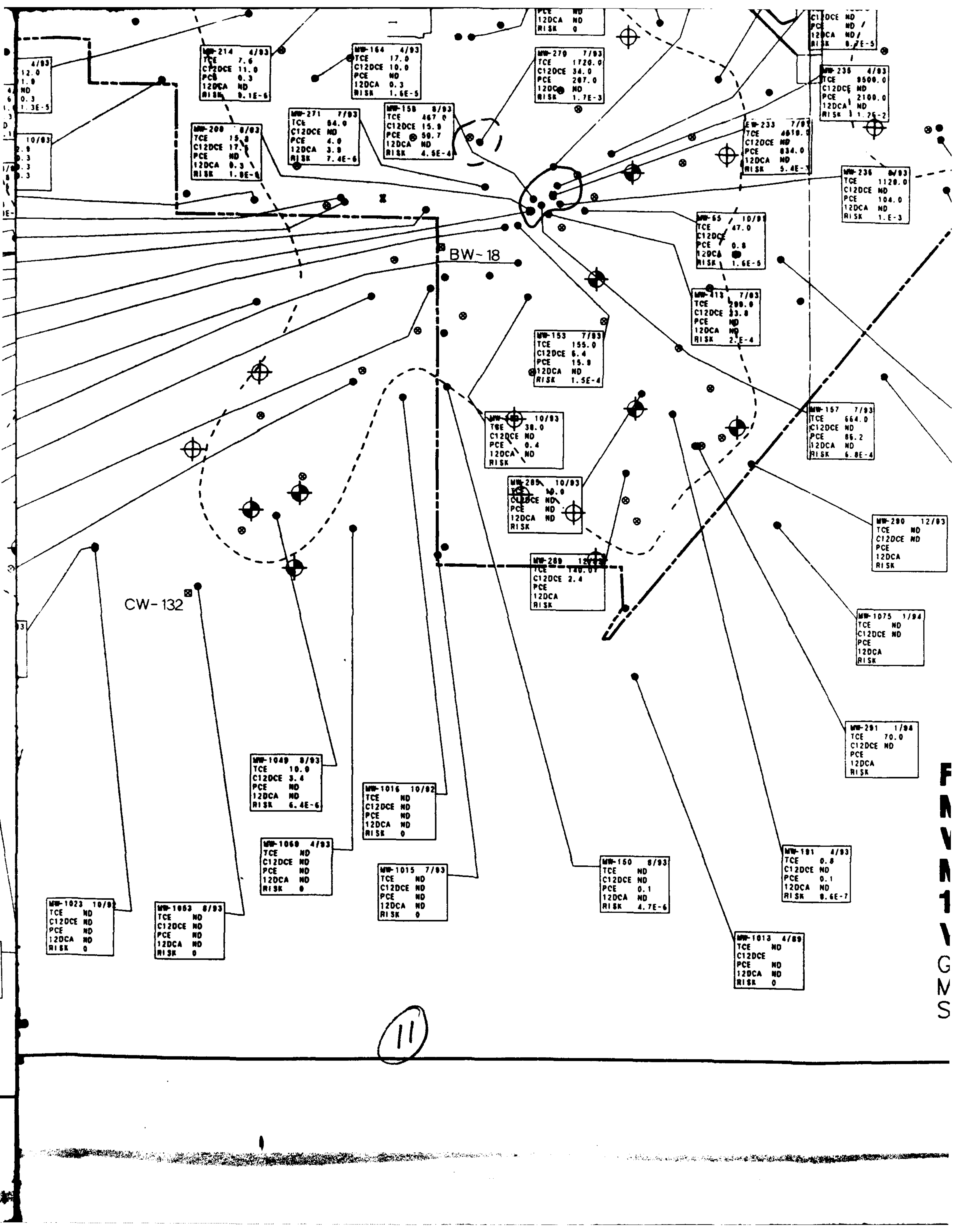
FIGURE E-8
MONITORING AND EXTRACTION



(10)

RDD 1454

MEY94/MEY-E-8.dgn



BW-18
CW-132
MW-214 4/93 TCE 7.6 C12DCE 11.0 PCE 0.3 12DCA ND RISK 9.1E-6
MW-164 4/93 TCE 17.0 C12DCE 10.0 PCE ND 12DCA 0.3 RISK 1.6E-5
MW-270 7/93 TCE 1720.0 C12DCE 34.0 PCE 287.0 12DCA ND RISK 1.7E-3
MW-235 4/93 TCE 9500.0 C12DCE ND PCE 2100.0 12DCA ND
MW-271 7/93 TCE 64.0 C12DCE ND PCE 4.0 12DCA 3.9 RISK 7.4E-6
MW-158 8/93 TCE 467.0 C12DCE 15.9 PCE 50.7 12DCA ND RISK 4.5E-4
MW-200 8/93 TCE 15.8 PCE ND 12DCA 0.3
MW-236 8/93 TCE 1120.0 C12DCE ND PCE 104.0 12DCA ND RISK 1.E-3
MW-65 10/93 TCE 47.0 PCE 0.8 RISK 1.6E-5
MW-153 7/93 TCE 155.0 C12DCE 6.4 PCE 15.9 12DCA ND RISK 1.5E-4
MW-157 7/93 TCE 664.0 C12DCE ND PCE 86.2 12DCA ND RISK 6.8E-4
10/93 TCE 38.0 C12DCE ND PCE 0.4 12DCA ND RISK
MW-285 10/93 PCE ND 12DCA ND RISK
MW-289 TCE C12DCE 2.4 PCE 12DCA RISK
MW-280 12/93 TCE ND C12DCE ND PCE 12DCA RISK
MW-1075 1/94 TCE ND C12DCE ND PCE 12DCA RISK
MW-291 1/94 TCE 70.0 C12DCE ND PCE 12DCA RISK
MW-1049 8/93 TCE 10.0 C12DCE 3.4 PCE ND 12DCA ND RISK 6.4E-6
MW-1016 10/92 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-1060 4/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-1015 7/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-150 8/93 TCE ND C12DCE ND PCE 0.1 12DCA ND RISK 4.7E-6
MW-181 4/93 TCE 0.8 C12DCE ND PCE 0.1 12DCA ND
MW-1023 10/92 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-1053 8/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-1013 4/89 TCE ND C12DCE PCE ND 12DCA ND RISK 0
11

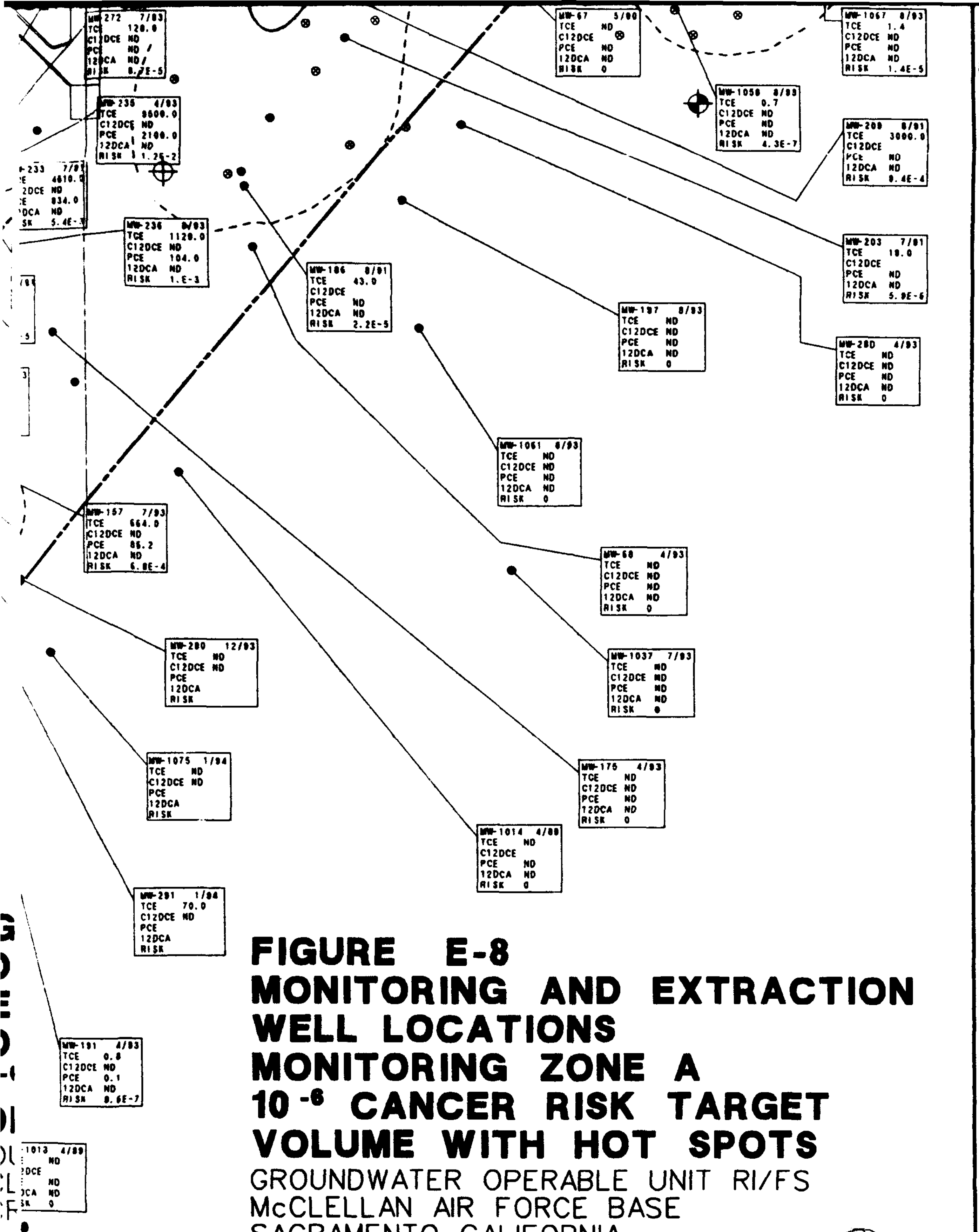
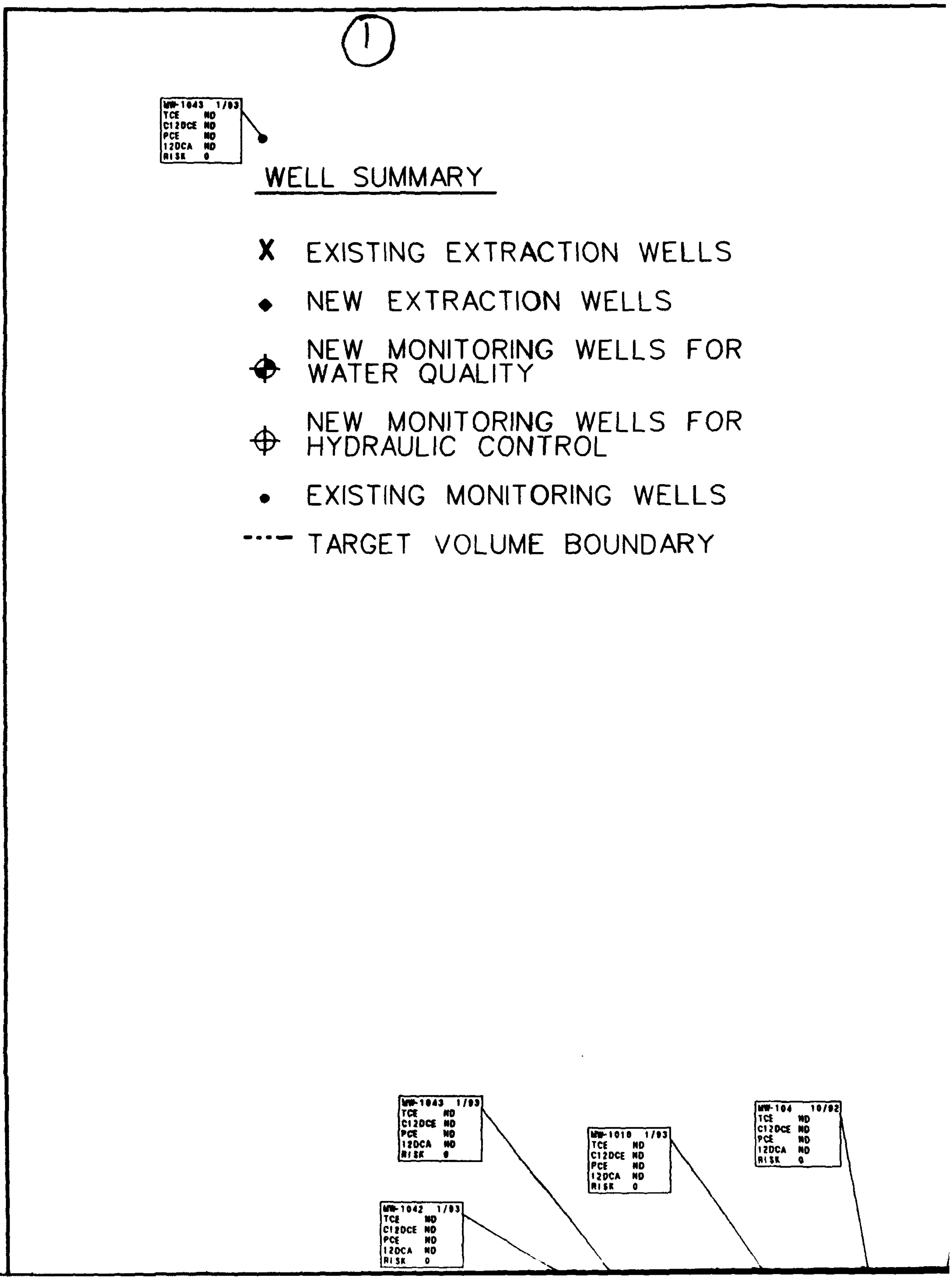


FIGURE E-8
MONITORING AND EXTRACTION WELL LOCATIONS MONITORING ZONE A 10^{-6} CANCER RISK TARGET VOLUME WITH HOT SPOTS

GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

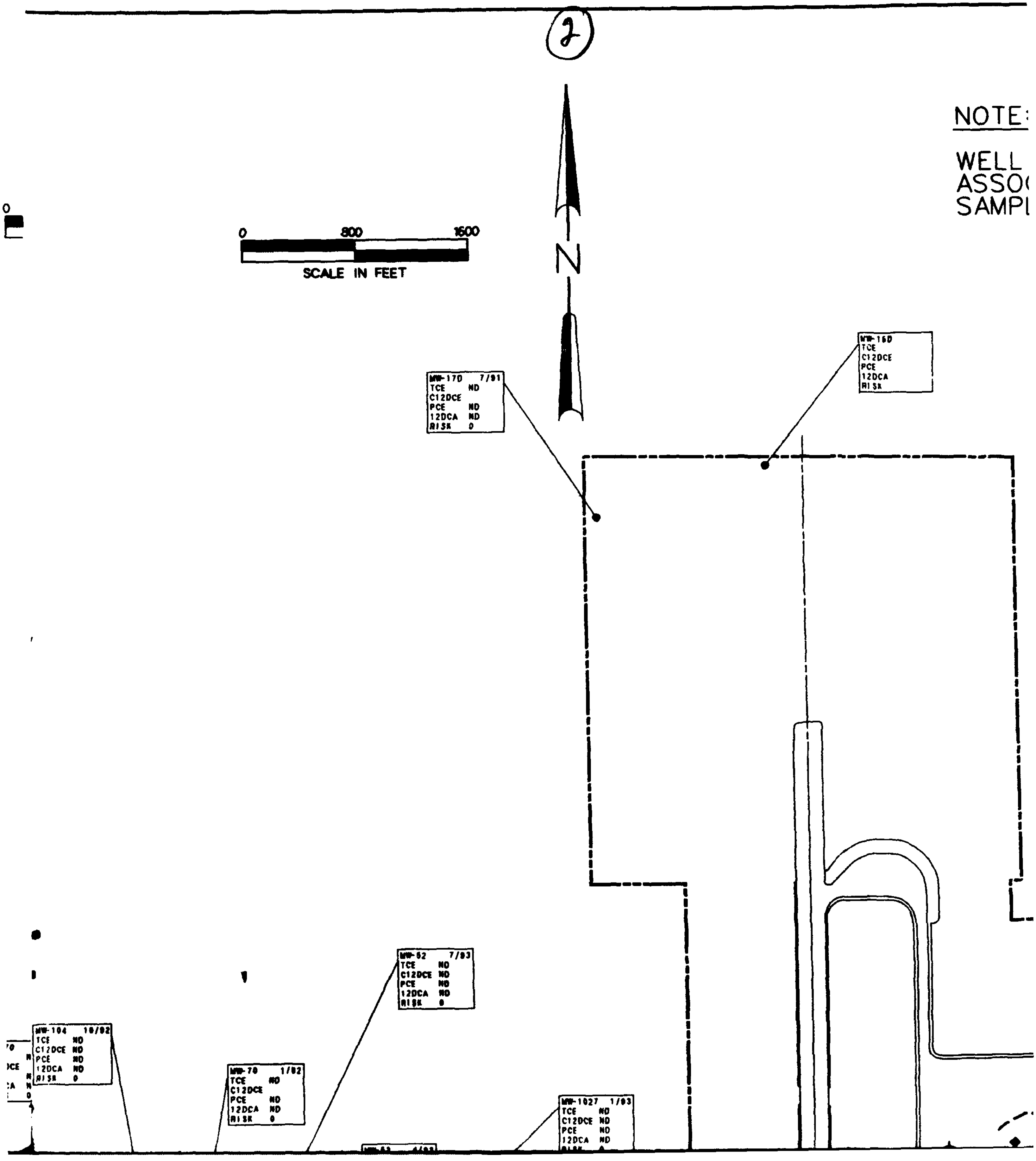
CH2M HILL

12



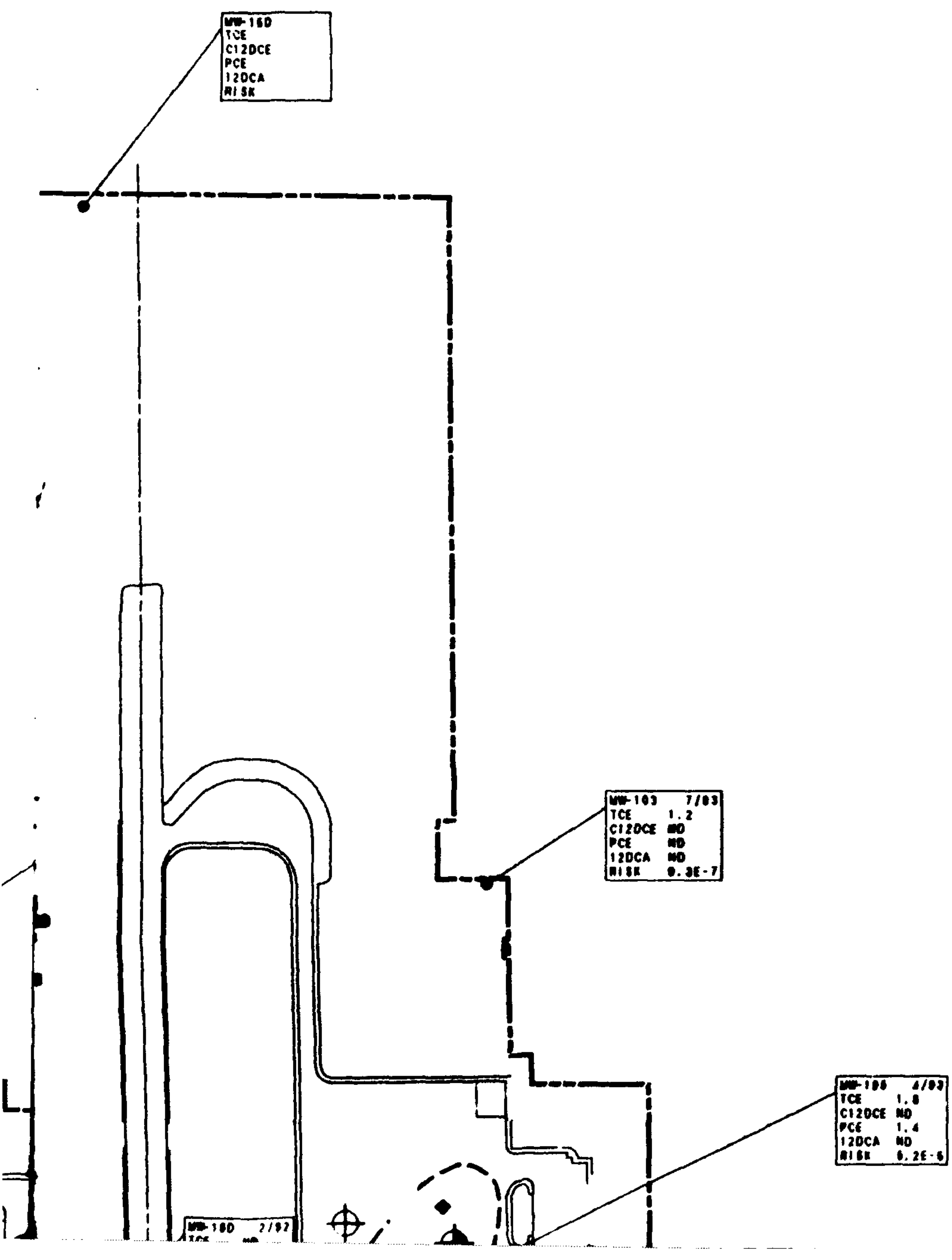
1
MW-1043 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
WELL SUMMARY
X EXISTING EXTRACTION WELLS
NEW EXTRACTION WELLS
NEW MONITORING WELLS FOR WATER QUALITY
NEW MONITORING WELLS FOR HYDRAULIC CONTROL
EXISTING MONITORING WELLS
TARGET VOLUME BOUNDARY
MW-1043 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1010 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-104 10/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1042 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0

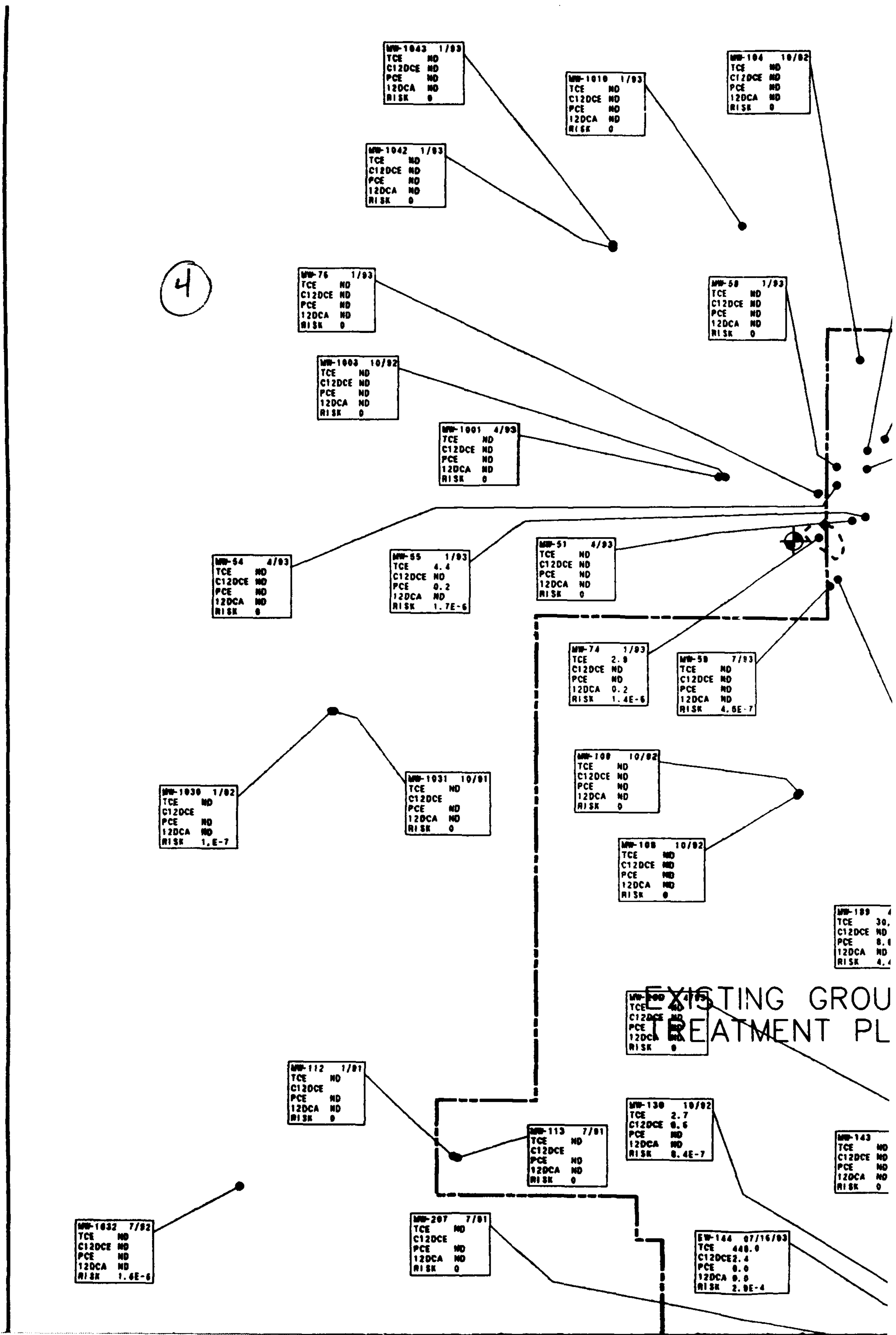
2

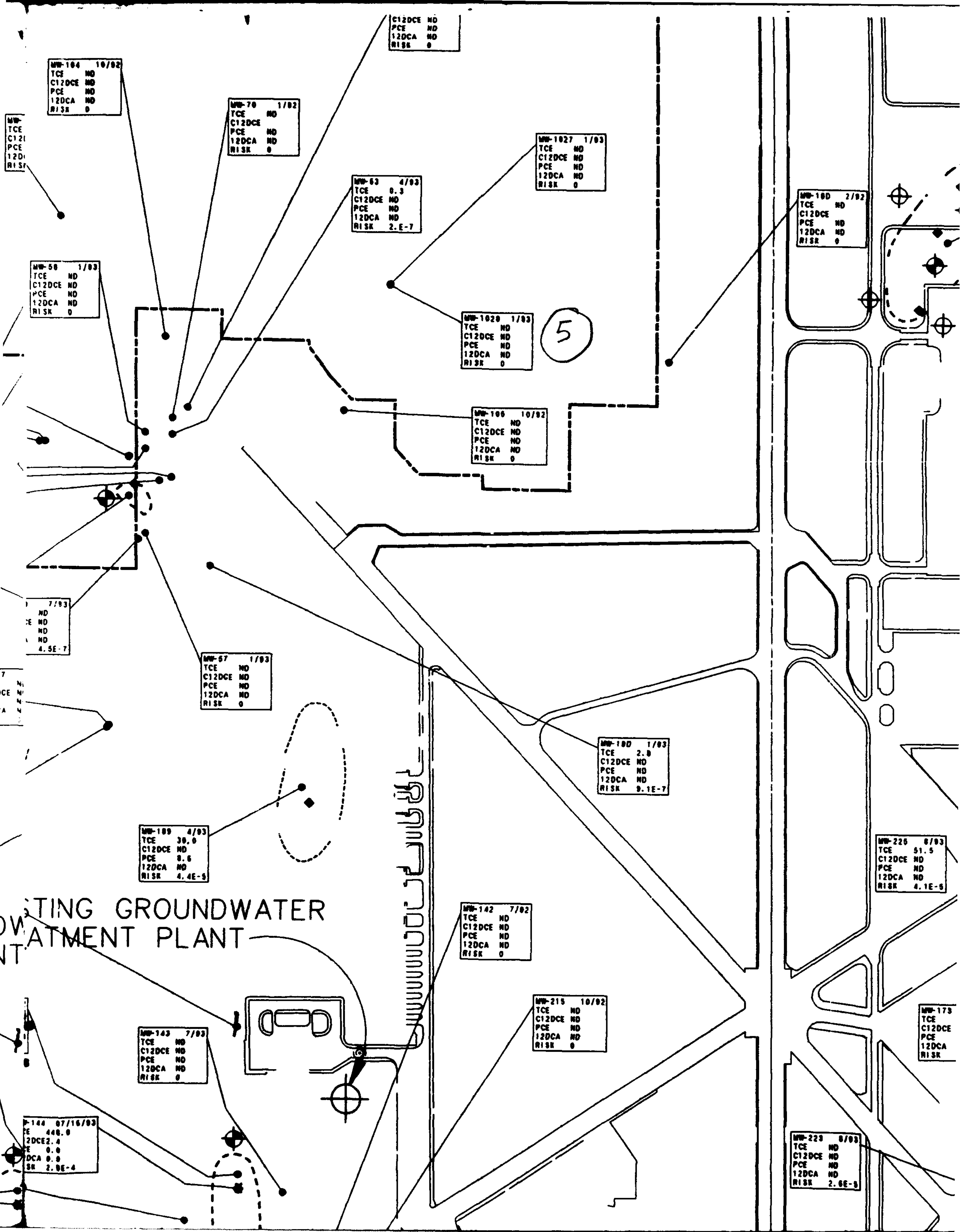

NOTE:
WELL
0 800 1600
SCALE IN FEET
N
MW-17D 7/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-16D
TCE
C12DCE
PCE
12DCA
RISK
MW-62 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-104 10/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-70 1/92
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-1027 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND

NOTE:

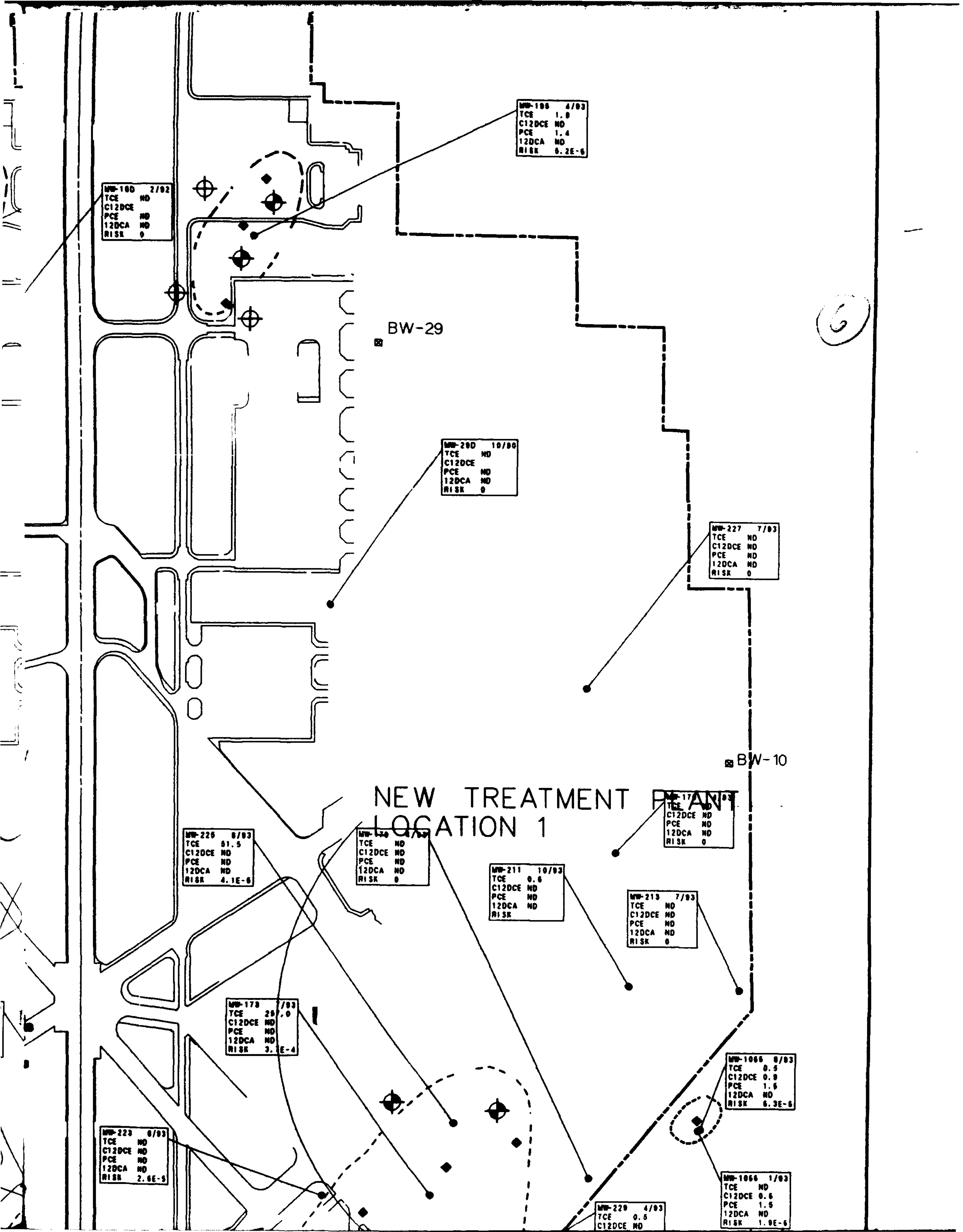
WELL LOCATIONS SHOWN WITHOUT ASSOCIATED DATA WERE NOT SAMPLED DURING OR AFTER 1988.




4
MW-1043 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1010 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-104 10/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1042 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-76 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-58 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1003 10/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1001 4/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-54 4/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-55 1/93
TCE 4.4
C12DCE ND
PCE 0.2
12DCA ND
RISK 1.7E-6
MW-51 4/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-74 1/93
TCE 2.9
C12DCE ND
PCE ND
12DCA 0.2
RISK 1.4E-6
MW-59 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 4.6E-7
MW-100 10/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1030 1/92
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 1.E-7
MW-1031 10/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-108 10/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-189
TCE 30.
C12DCE ND
PCE 8.
12DCA ND
RISK 4.
EXISTING GROU
TREATMENT PL
RISK 0
MW-112 1/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-113 7/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-130 10/92
TCE 2.7
C12DCE 6.6
PCE ND
12DCA ND
RISK 8.4E-7
MW-143
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1032 7/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 1.6E-6
MW-207 7/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
EW-144 07/16/93
TCE 448.0
C12DCE2.4
PCE 0.0
12DCA 0.0
RISK 2.9E-4



C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-104 10/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-70 1/92
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-1027 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-63 4/93
TCE 0.3
C12DCE ND
PCE ND
12DCA ND
RISK 2.E-7
MW-18D 2/92
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-58 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1020 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
5
MW-106 10/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
7/93
ND
ND
ND
ND
4.5E-7
MW-57 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-19D 1/93
TCE 2.0
C12DCE ND
PCE ND
12DCA ND
RISK 9.1E-7
MW-189 4/93
TCE 30.0
C12DCE ND
PCE 8.6
12DCA ND
RISK 4.4E-5
MW-225 8/93
TCE 51.5
C12DCE ND
PCE ND
12DCA ND
RISK 4.1E-6
STING GROUNDWATER
ATMENT PLANT
MW-142 7/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-215 10/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-173
TCE
C12DCE
PCE
12DCA
RISK
MW-143 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
-144 07/16/93
440.0
2DCE2.4
0.0
DCA 0.0
2.9E-4
MW-223 8/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 2.6E-5



MW-19S 4/93
TCE 1.0
C12DCE ND
PCE 1.4
12DCA ND
RISK 6.2E-6
MW-19D 2/92
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
BW-29
MW-20D 10/90
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-227 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
BW-10
NEW TREATMENT PLANT
LOCATION 1
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-226 8/93
TCE 51.5
C12DCE ND
PCE ND
12DCA ND
RISK 4.1E-6
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-211 10/93
TCE 0.6
C12DCE ND
PCE ND
12DCA ND
RISK
MW-213 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-178
C12DCE ND
PCE ND
12DCA ND
MW-1066 8/93
TCE 0.5
C12DCE 0.9
PCE 1.6
12DCA ND
RISK 6.3E-6
MW-223 8/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 2.6E-5
MW-1066 1/93
TCE ND
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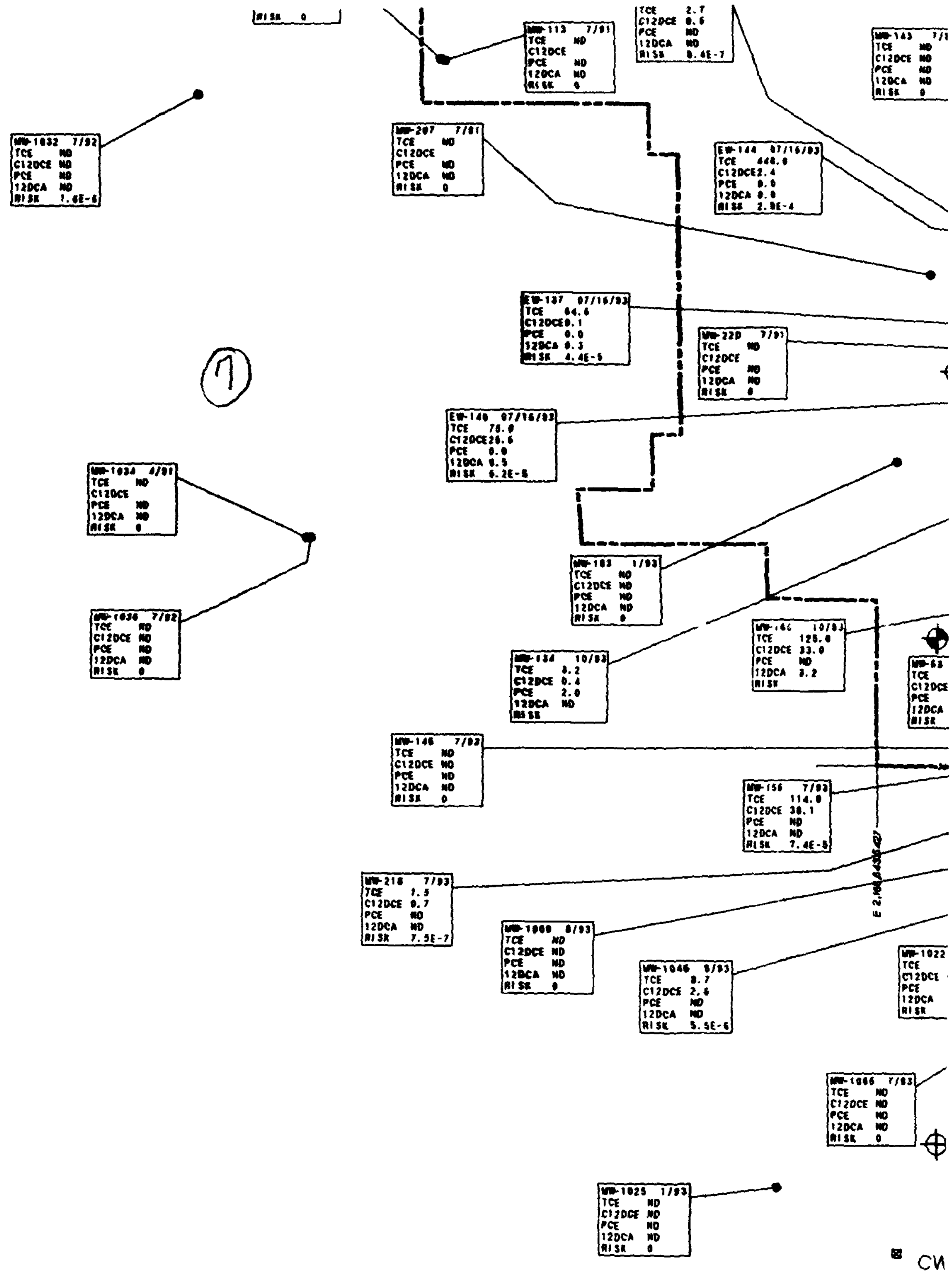
PCE 1.5
12DCA ND
RISK 1.9E-6
MW-229 4/93
TCE 0.5
C12DCE ND


RISK 0
MW-113 7/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
TCE 2.7
C12DCE 0.6
PCE ND
12DCA ND
RISK 8.4E-7
MW-143 7/9
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1032 7/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 1.6E-6
MW-207 7/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
EW-144 07/16/93
TCE 446.0
C12DCE 2.4
PCE 0.9
12DCA 0.0
RISK 2.9E-4
EW-137 07/16/93
TCE 64.6
C12DCE 0.1
PCE 0.0
12DCA 0.3
RISK 4.4E-5
MW-22D 7/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
7
EW-140 07/16/93
TCE 76.0
C12DCE 26.6
PCE 0.0
12DCA 0.5
RISK 6.2E-5
MW-1034 4/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-183 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1036 7/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-134 10/93
TCE 3.2
C12DCE 0.4
PCE 2.0
12DCA ND
RISK
MW-166 10/93
TCE 125.0
C12DCE 33.0
PCE ND
12DCA 3.2
RISK
MW-63
TCE
C12DCE
PCE
12DCA
RISK
MW-146 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-156 7/93
TCE 114.0
C12DCE 38.1
PCE ND
12DCA ND
RISK 7.4E-5
MW-218 7/93
TCE 1.5
C12DCE 0.7
PCE ND
12DCA ND
RISK 7.5E-7
MW-1060 8/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1046 8/93
TCE 8.7
C12DCE 2.6
PCE ND
12DCA ND
RISK 5.5E-6
MW-1022
TCE
C12DCE
PCE
12DCA
RISK
MW-1066 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
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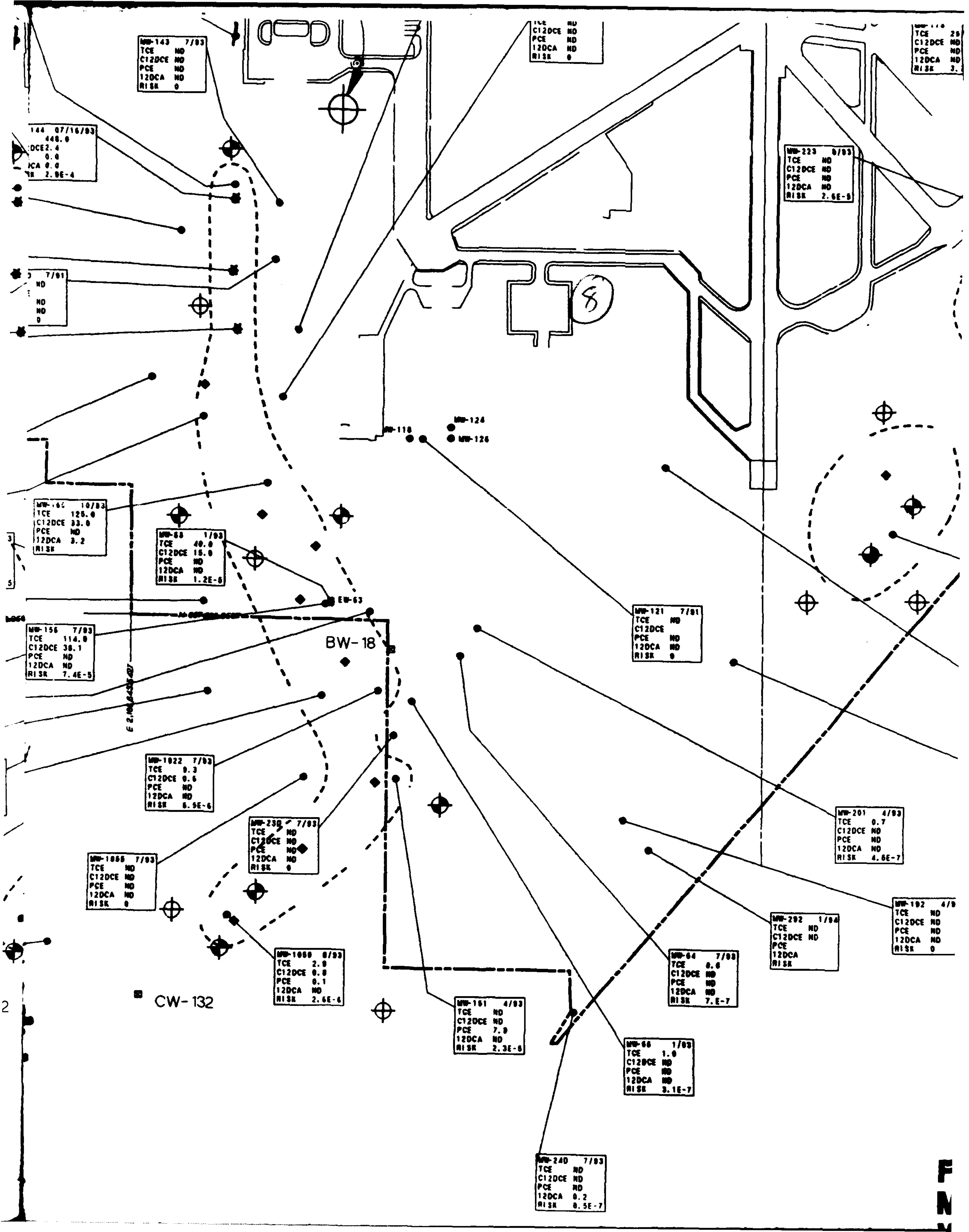
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
CW



MW-143 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-223 8/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 2.6E-5
MW-124
MW-126
MW-118
MW-63 1/93
TCE 40.0
C12DCE 15.0
PCE ND
12DCA ND
RISK 1.2E-6
EW-63
MW-156 7/93
TCE 114.0
C12DCE 38.1
PCE ND
12DCA ND
RISK 7.4E-5
BW-18
MW-121 7/93
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-1022 7/93
TCE 9.3
C12DCE 0.6
PCE ND
12DCA ND
RISK 6.5E-6
MW-230 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-201 4/93
TCE 0.7
C12DCE ND
PCE ND
12DCA ND
RISK 4.6E-7
MW-292 1/94
TCE ND
C12DCE ND
PCE
12DCA
RISK
MW-64 7/93
TCE 8.6
C12DCE ND
PCE ND
12DCA ND
RISK 7.E-7
MW-151 4/93
TCE ND
C12DCE ND
PCE 7.9
12DCA ND
RISK 2.3E-6
CW-132
MW-66 1/93
TCE 1.0
C12DCE ND
PCE ND
12DCA ND
RISK 3.1E-7
MW-240 7/93
TCE ND
C12DCE ND
PCE ND
12DCA 0.2
RISK 8.5E-7

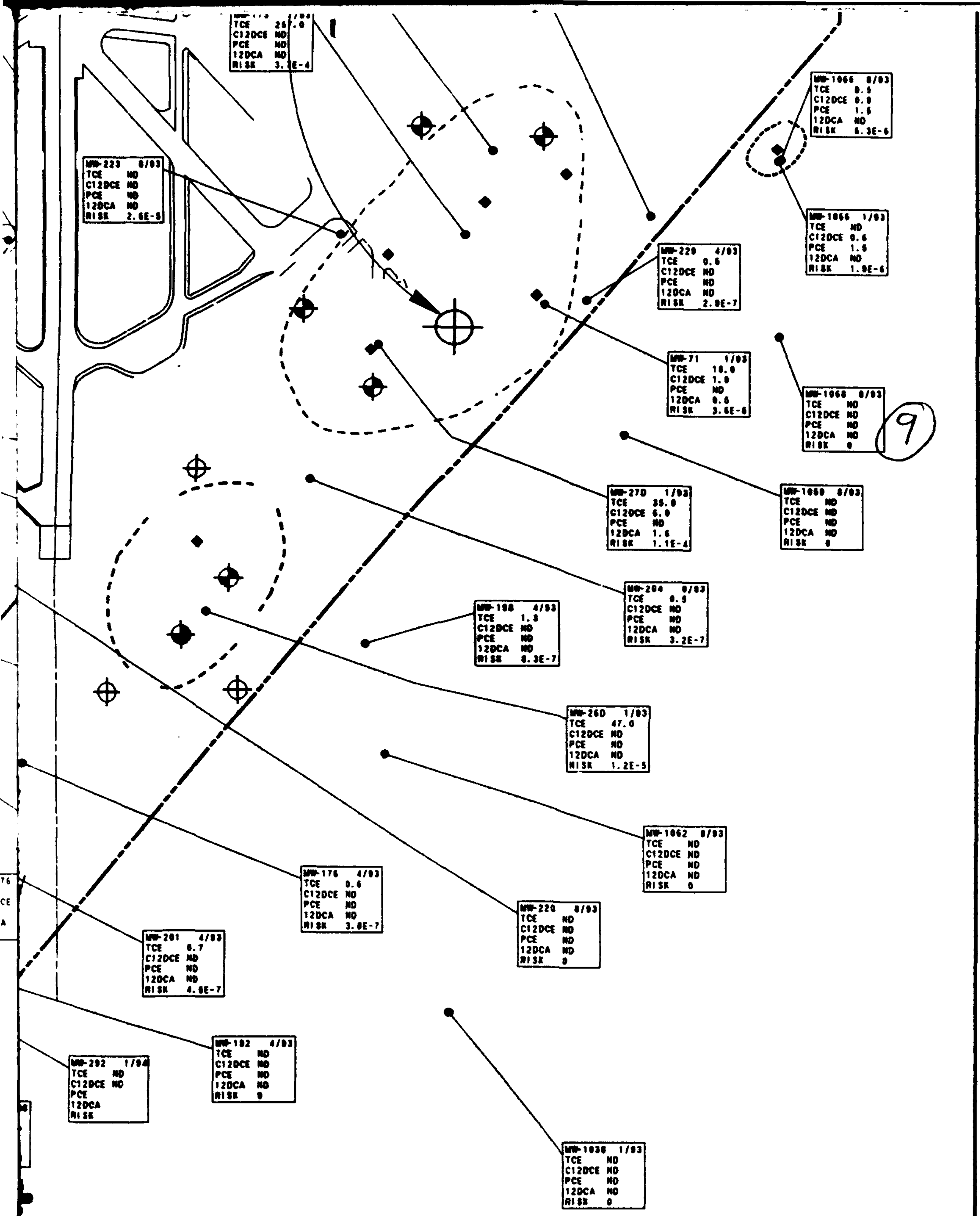
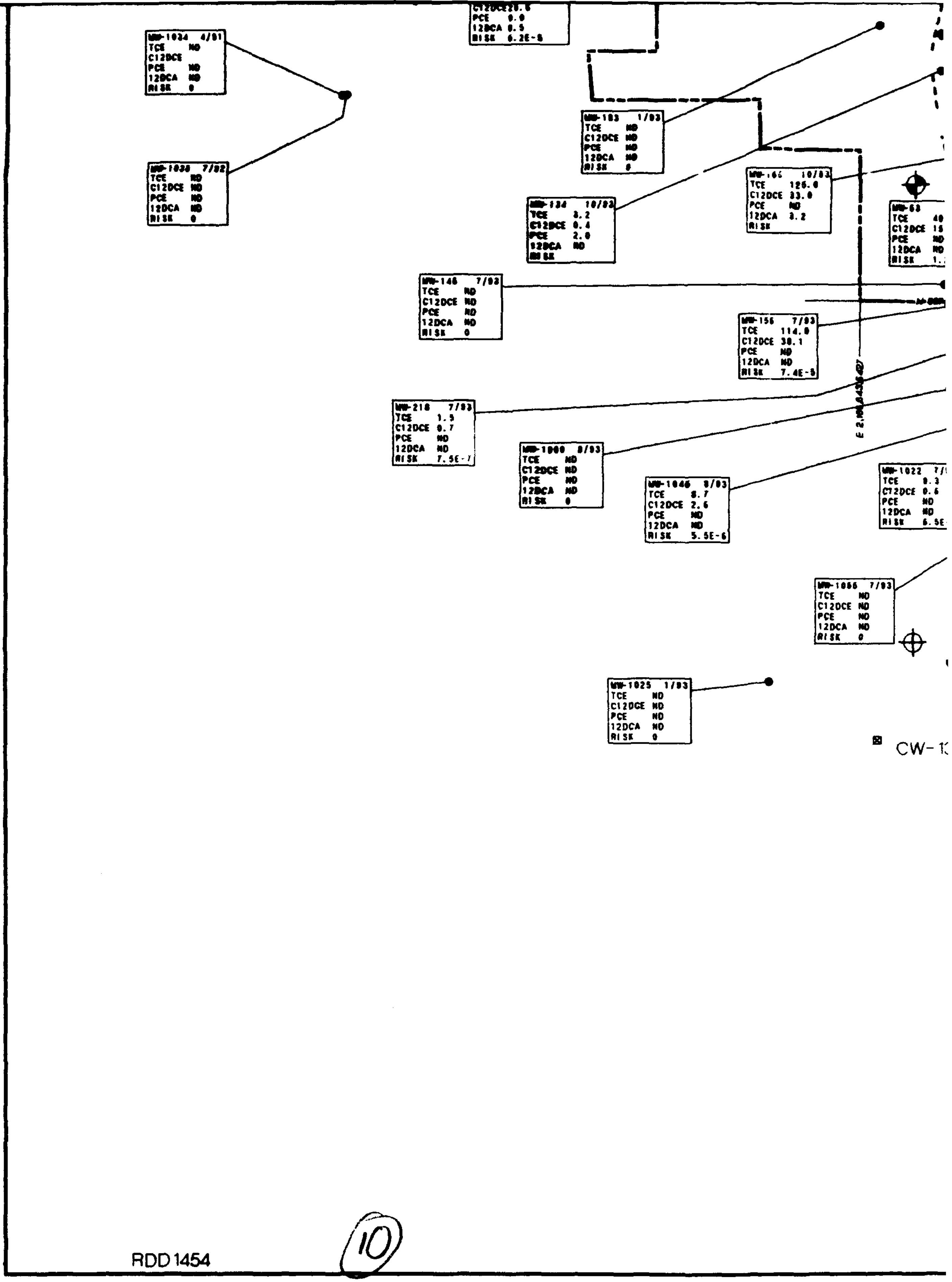
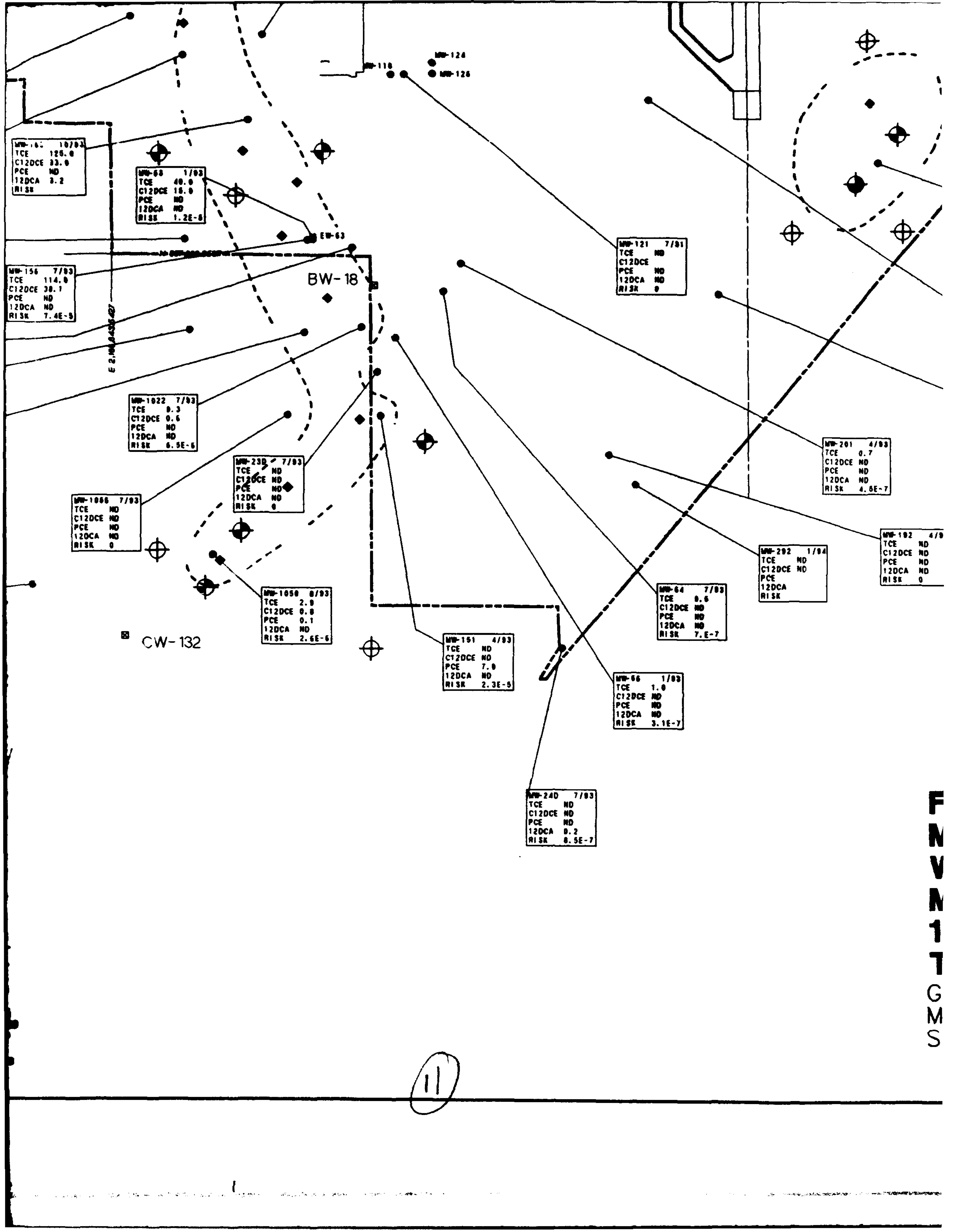


FIGURE E-9
MONITORING AND EXTRACTION WELL LOCATIONS



MEY94/MEY-E-9.dgn



MW-124
MW-126
MW-118
10/93 TCE 125.0 C12DCE 33.0 PCE ND 12DCA 3.2 RISK
MW-68 1/93 TCE 40.0 C12DCE 16.0 PCE ND 12DCA ND RISK 1.2E-6
EW-63
MW-156 7/93 TCE 114.0 C12DCE 38.1 PCE ND 12DCA ND RISK 7.4E-5
BW-18
MW-121 7/93 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-1022 7/93 TCE 0.3 C12DCE 0.6 PCE ND 12DCA ND RISK 6.5E-6
MW-23D 7/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-1066 7/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-201 4/93 TCE 0.7 C12DCE ND PCE ND 12DCA ND RISK 4.6E-7
MW-192 4/9 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-292 1/94 TCE ND C12DCE ND PCE 12DCA RISK
MW-64 7/93 TCE 0.6 C12DCE ND PCE ND 12DCA ND RISK 7.E-7
MW-1050 8/93 TCE 2.9 C12DCE 0.8 PCE 0.1 12DCA ND RISK 2.6E-6
CW-132
MW-151 4/93 TCE ND C12DCE ND PCE 7.0 12DCA ND RISK 2.3E-5
MW-66 1/93 TCE 1.0 C12DCE ND PCE ND 12DCA ND RISK 3.1E-7
MW-24D 7/93 TCE ND C12DCE ND PCE ND 12DCA 0.2 RISK 8.5E-7
G
M
S

11

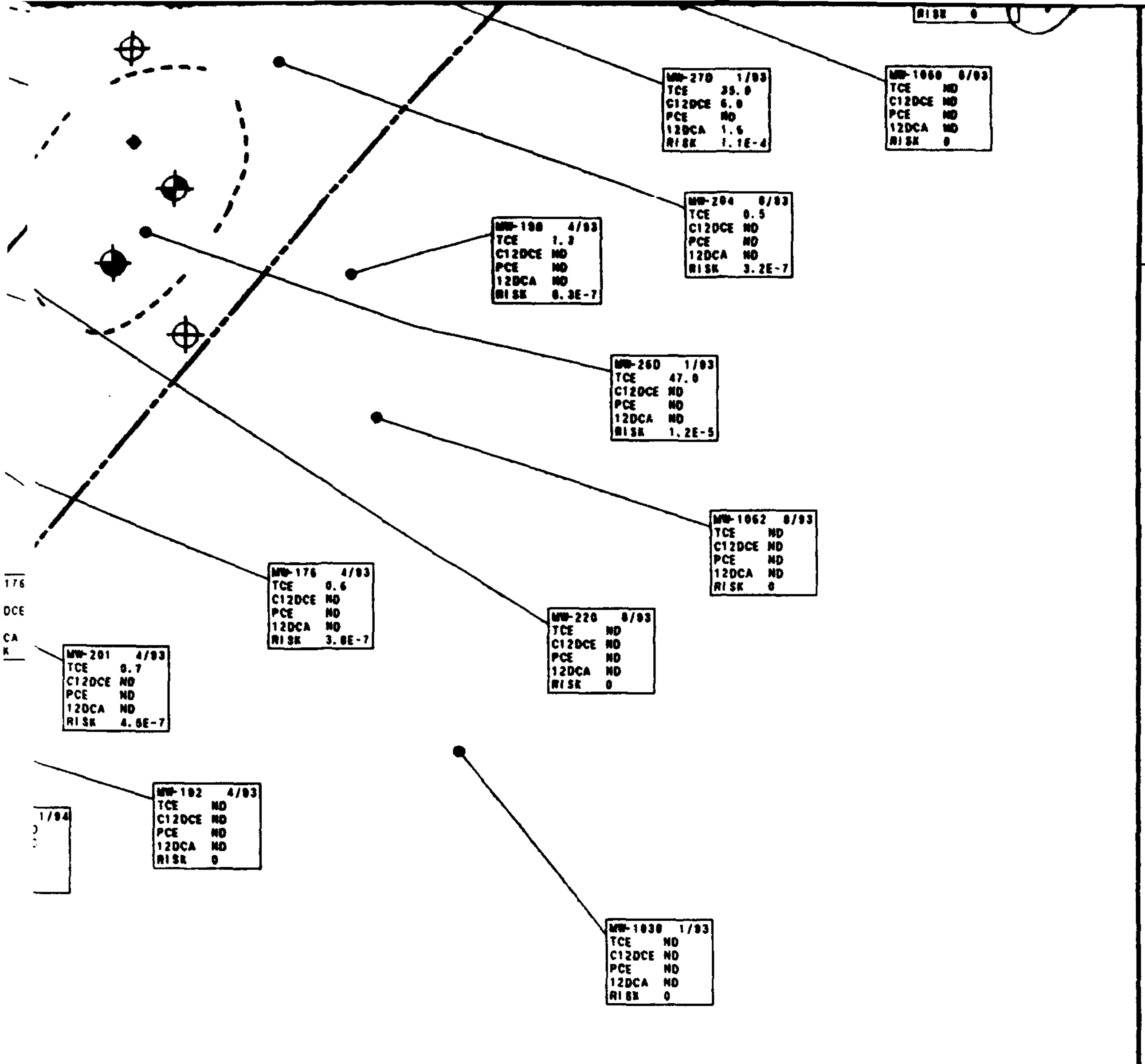


FIGURE E-9
MONITORING AND EXTRACTION WELL LOCATIONS MONITORING ZONE B 10^{-6} CANCER RISK TARGET VOLUME

GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

(12)

CH2M HILL

(1)

WELL SUMMARY

X EXISTING EXTRACTION WELLS

► NEW EXTRACTION WELLS

⌖ NEW MONITORING WELLS FOR WATER QUALITY

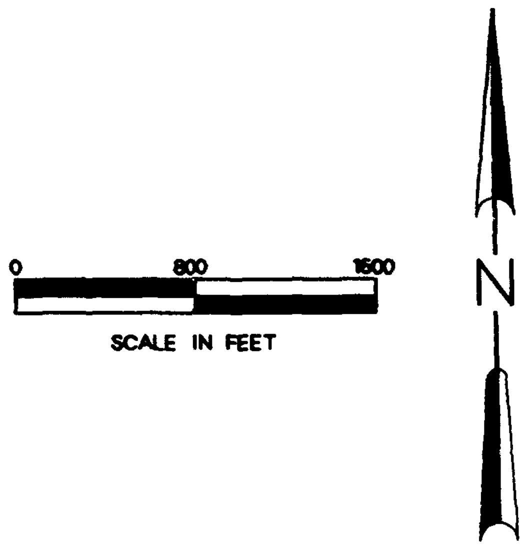
• EXISTING MONITORING WELLS

---- TARGET VOLUME BOUNDARY

0

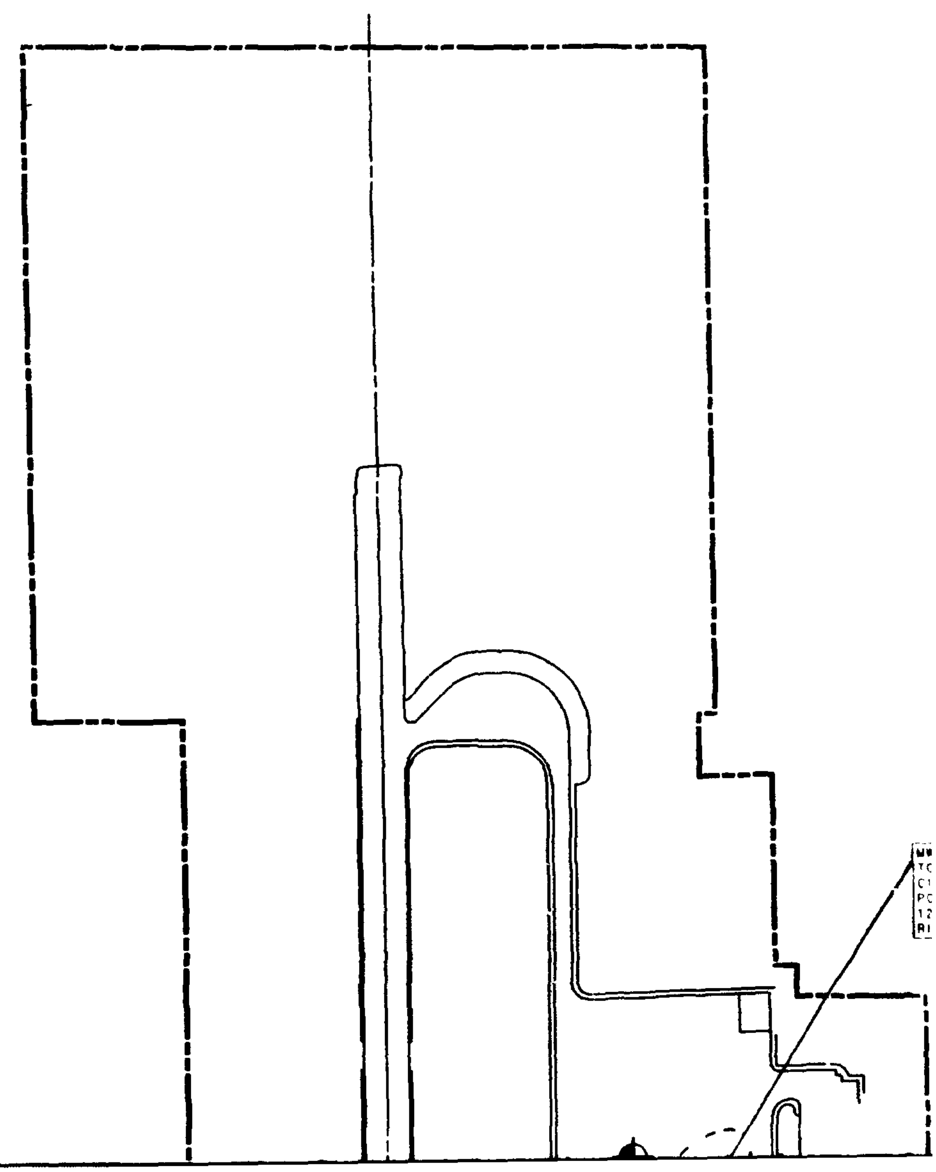
SCAL

2



NOTE:

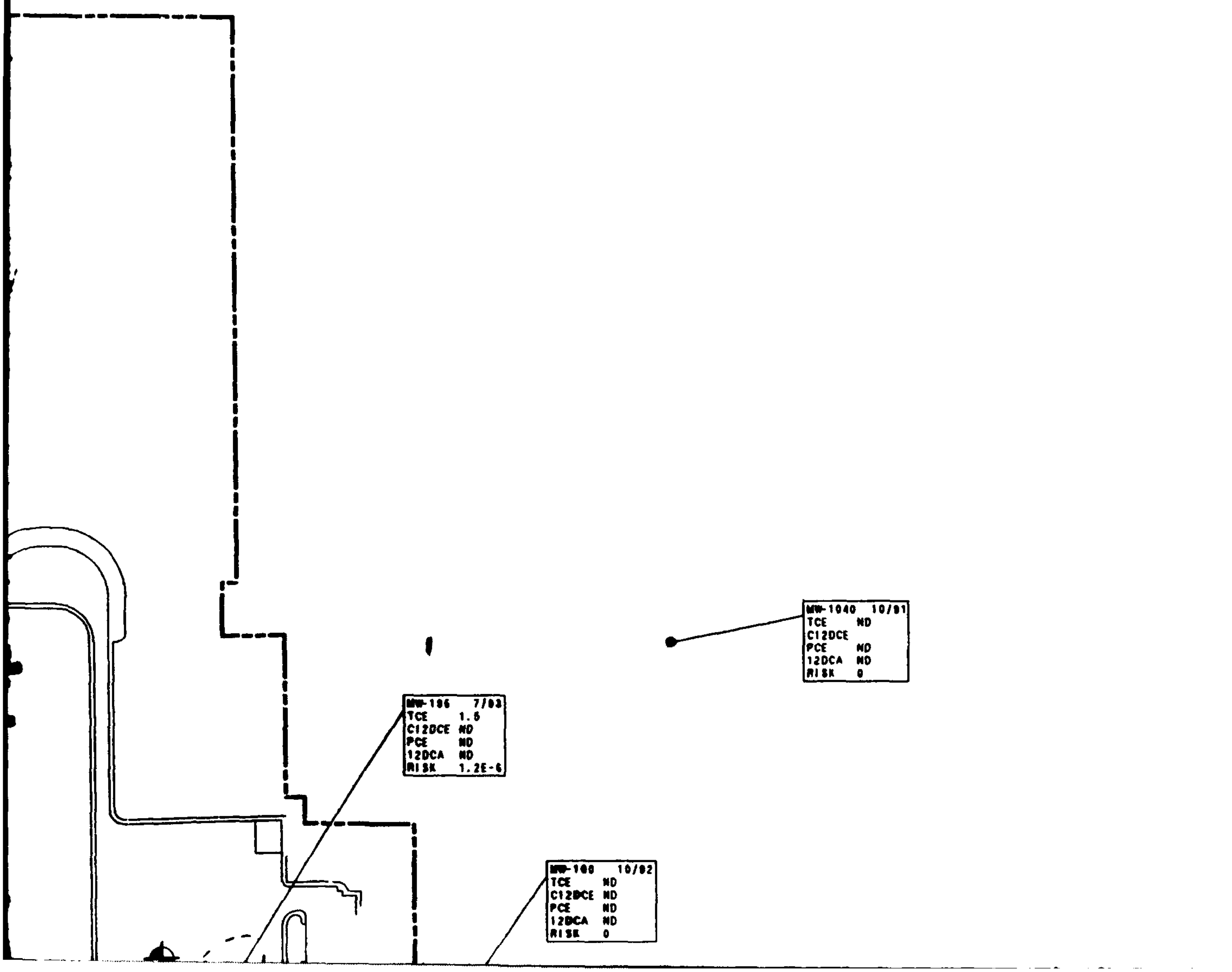
WELL LOCATIONS SH
ASSOCIATED DATA W
SAMPLED DURING OR

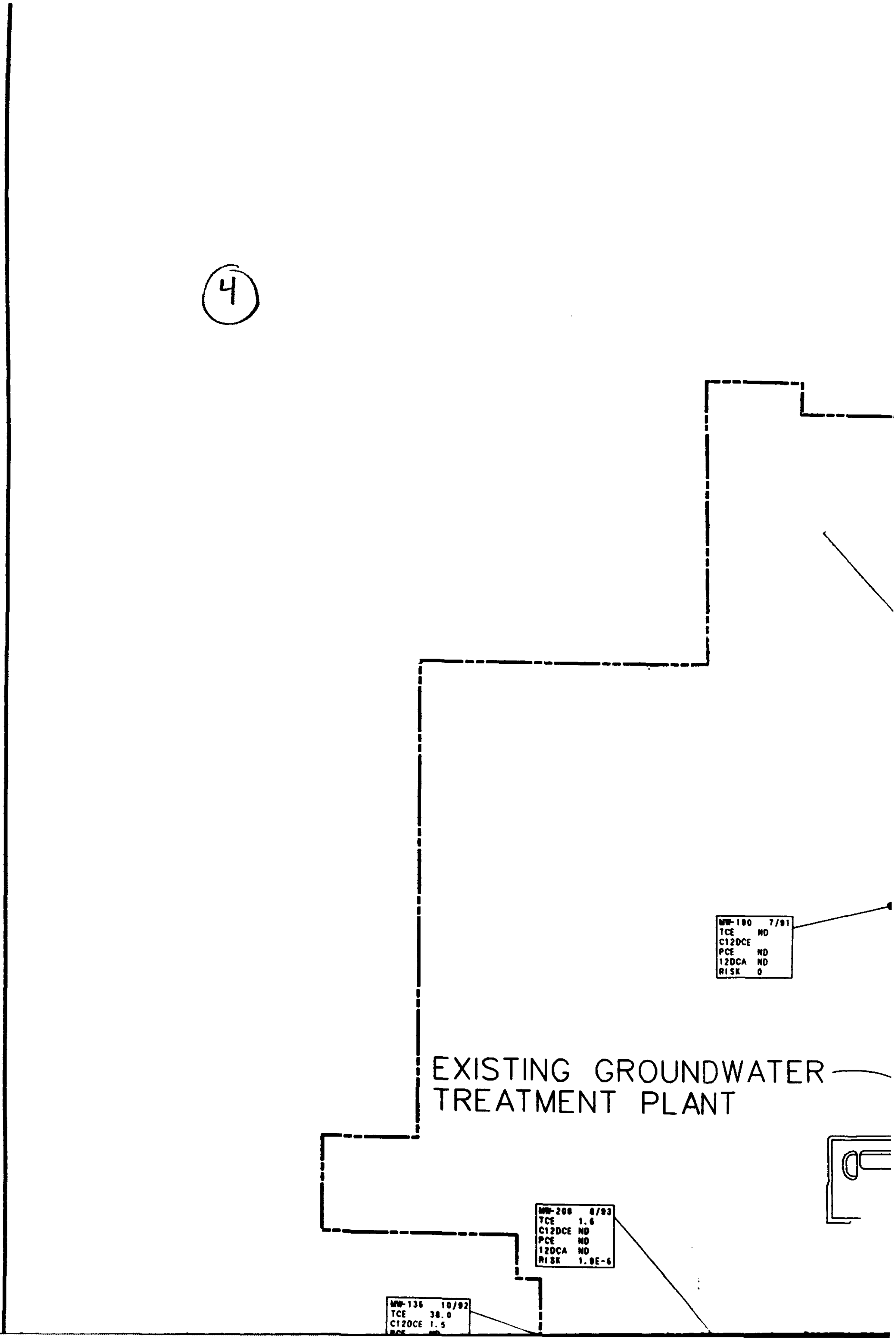


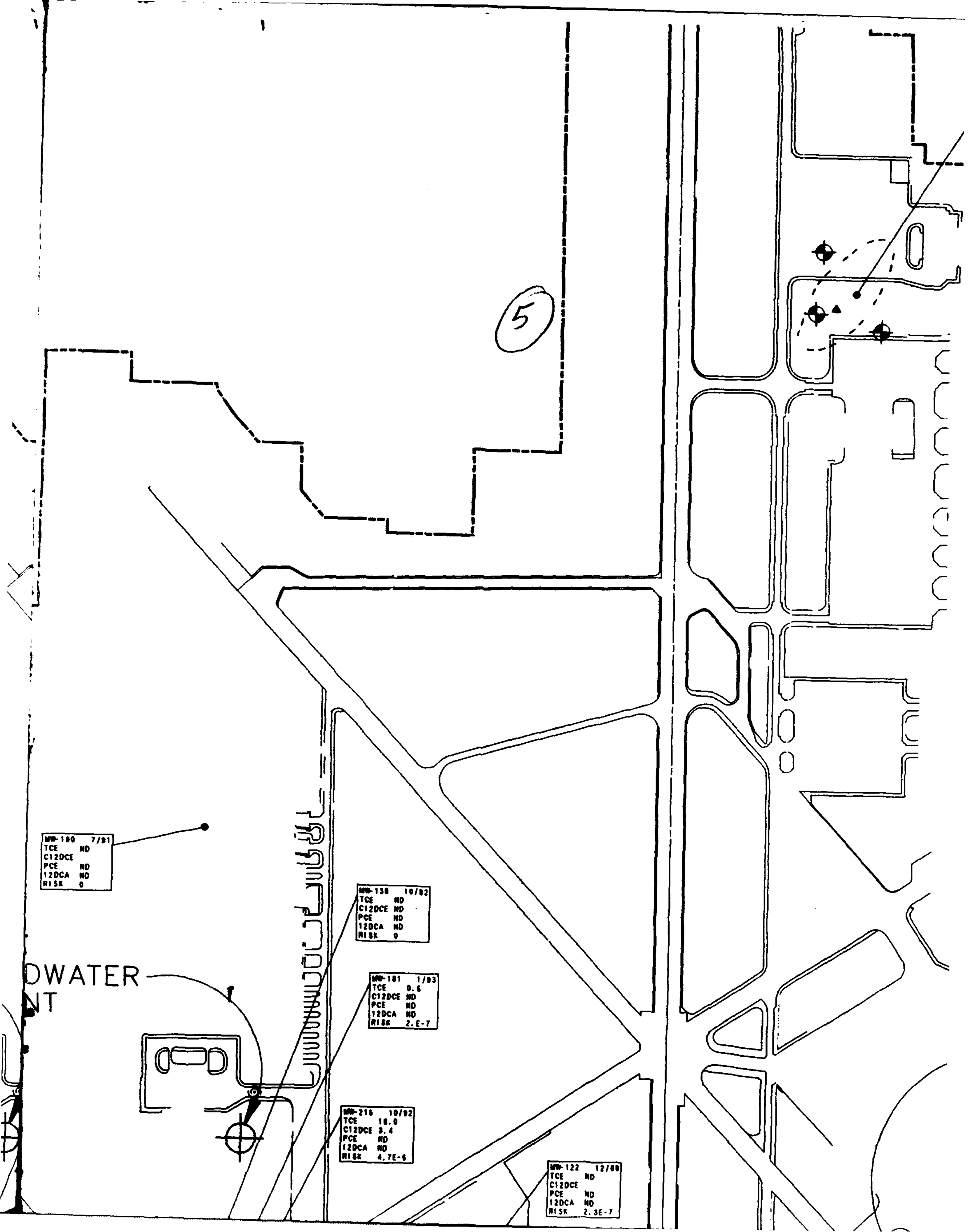
(3)

NOTE:

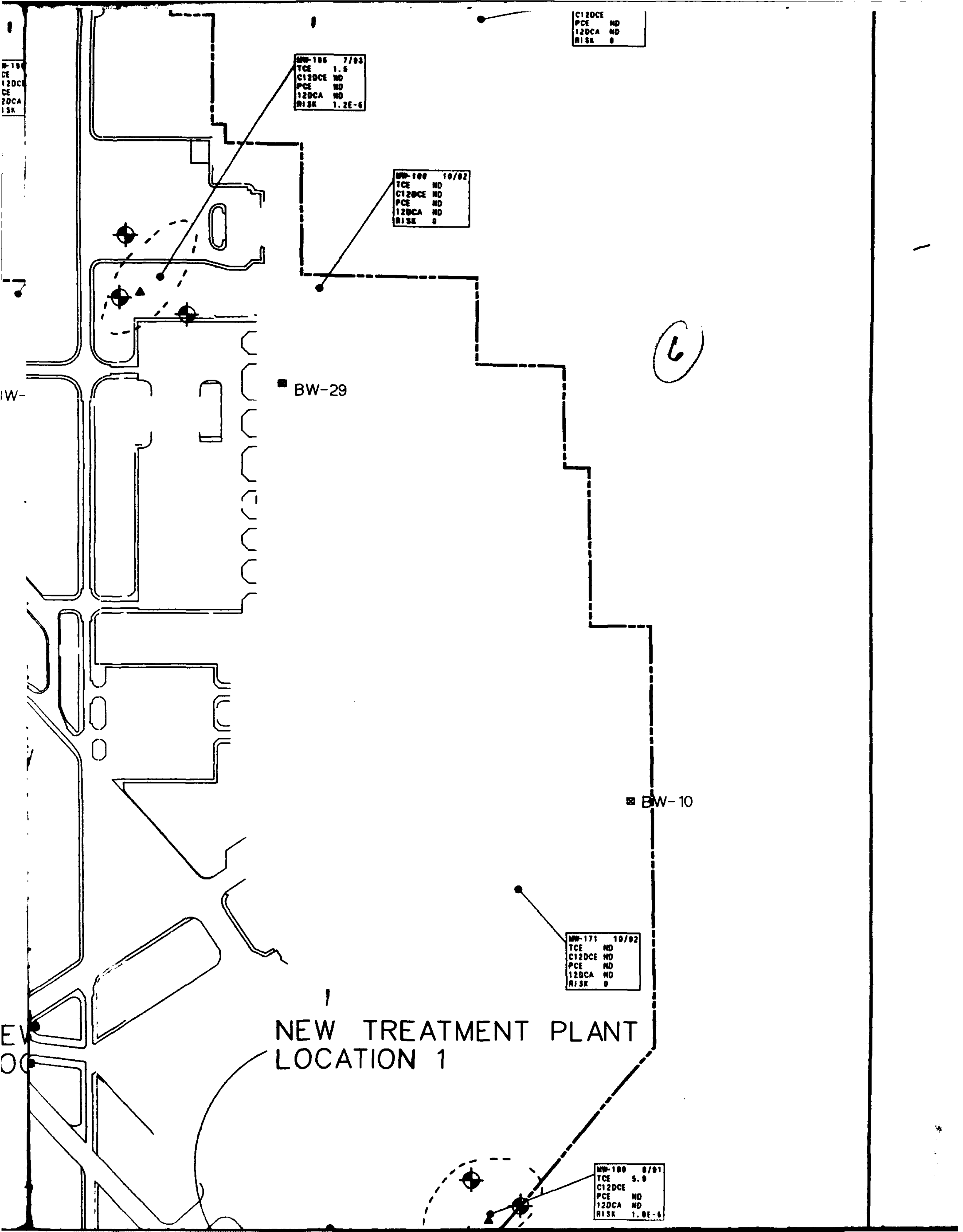
WELL LOCATIONS SHOWN WITHOUT ASSOCIATED DATA WERE NOT SAMPLED DURING OR AFTER 1988.



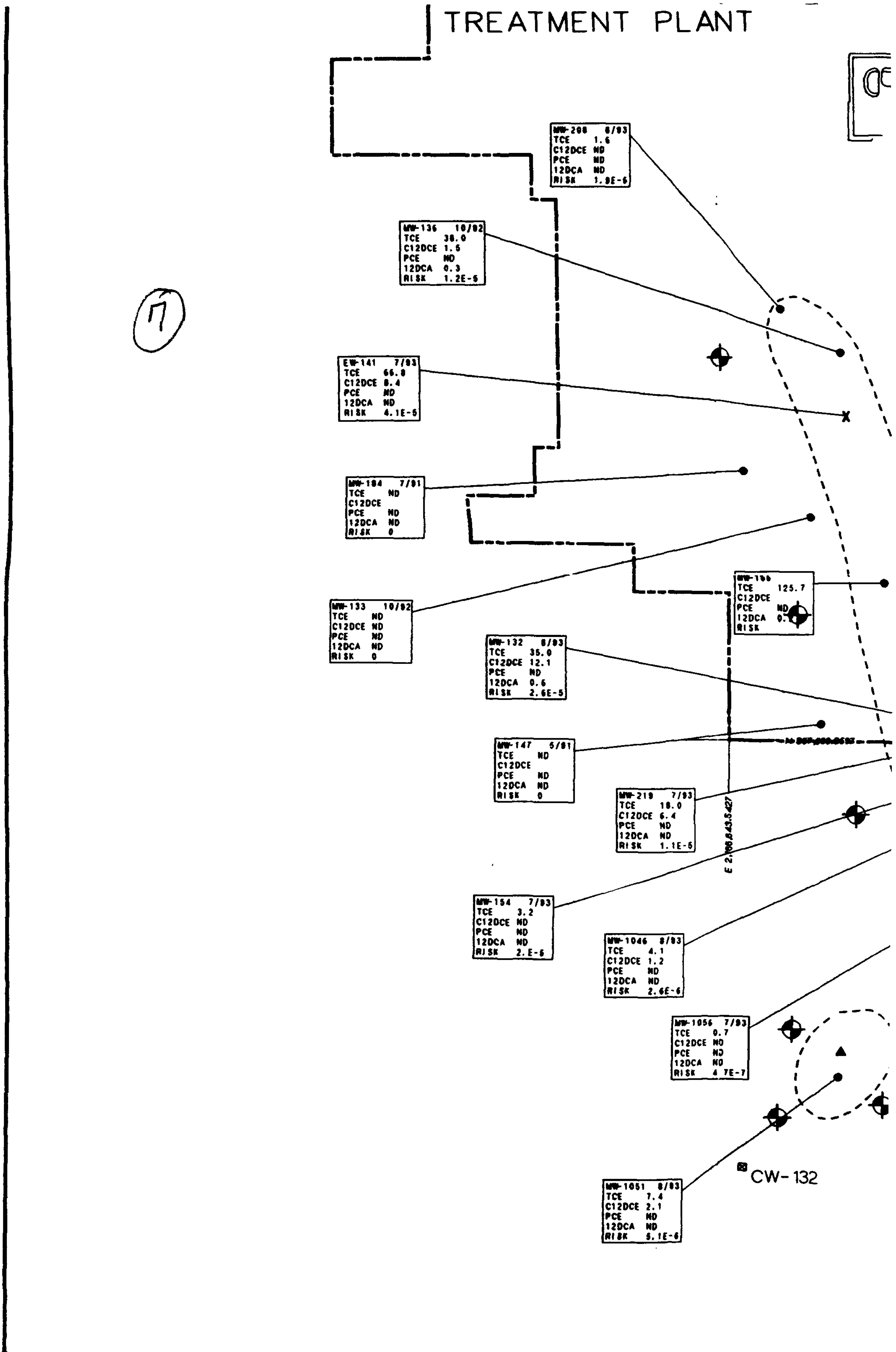

MW-190 7/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
EXISTING GROUNDWATER
TREATMENT PLANT
MW-208 8/93
TCE 1.6
C12DCE ND
PCE ND
12DCA ND
RISK 1.9E-6
MW-136 10/92
TCE 38.0
C12DCE 1.5



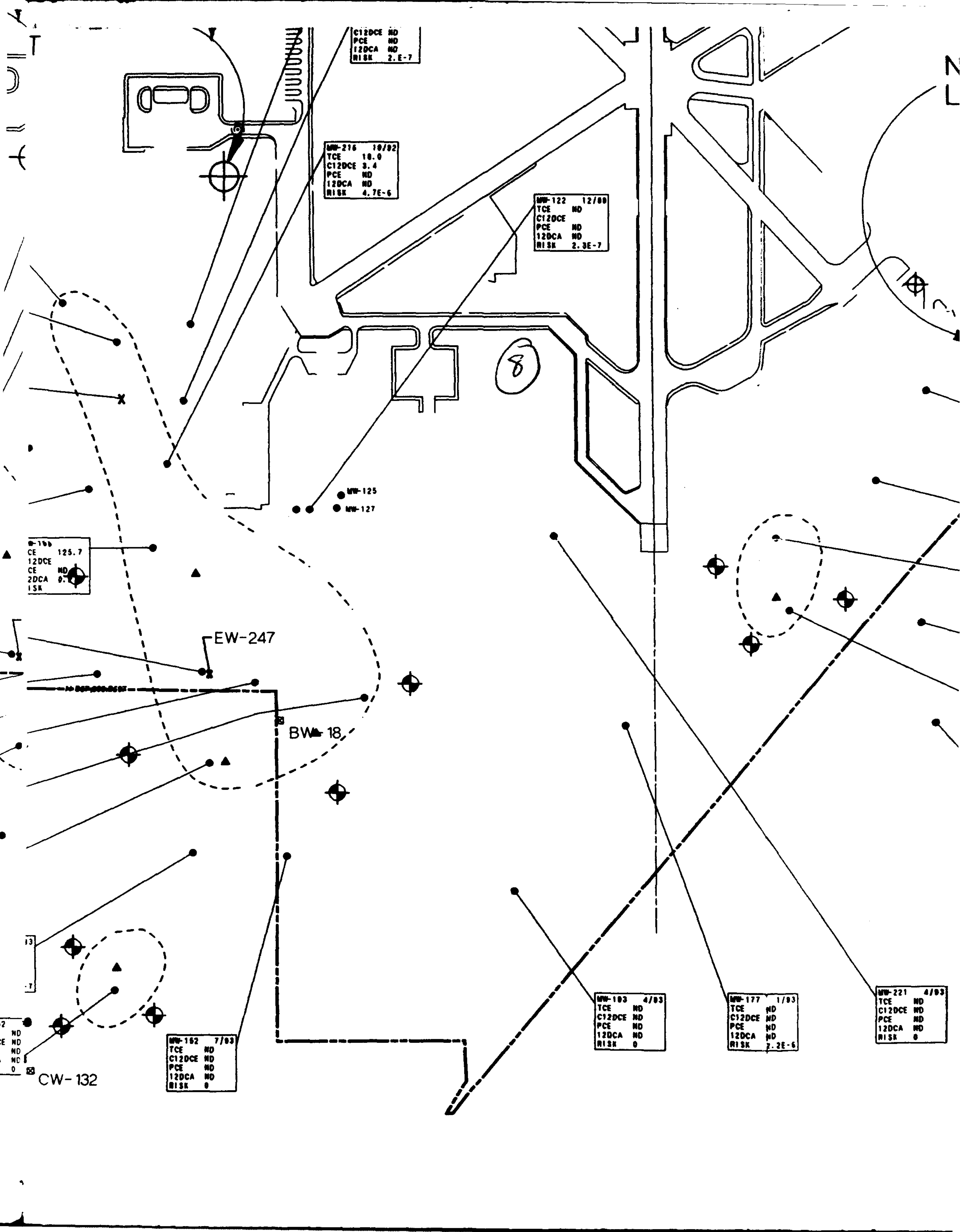
5
MW-190 7/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-130 10/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-181 1/93
TCE 0.6
C12DCE ND
PCE ND
12DCA ND
RISK 2.E-7
DWATER
NT
MW-216 10/92
TCE 10.0
C12DCE 3.4
PCE ND
12DCA ND
RISK 4.7E-6
MW-122 12/80
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 2.3E-7

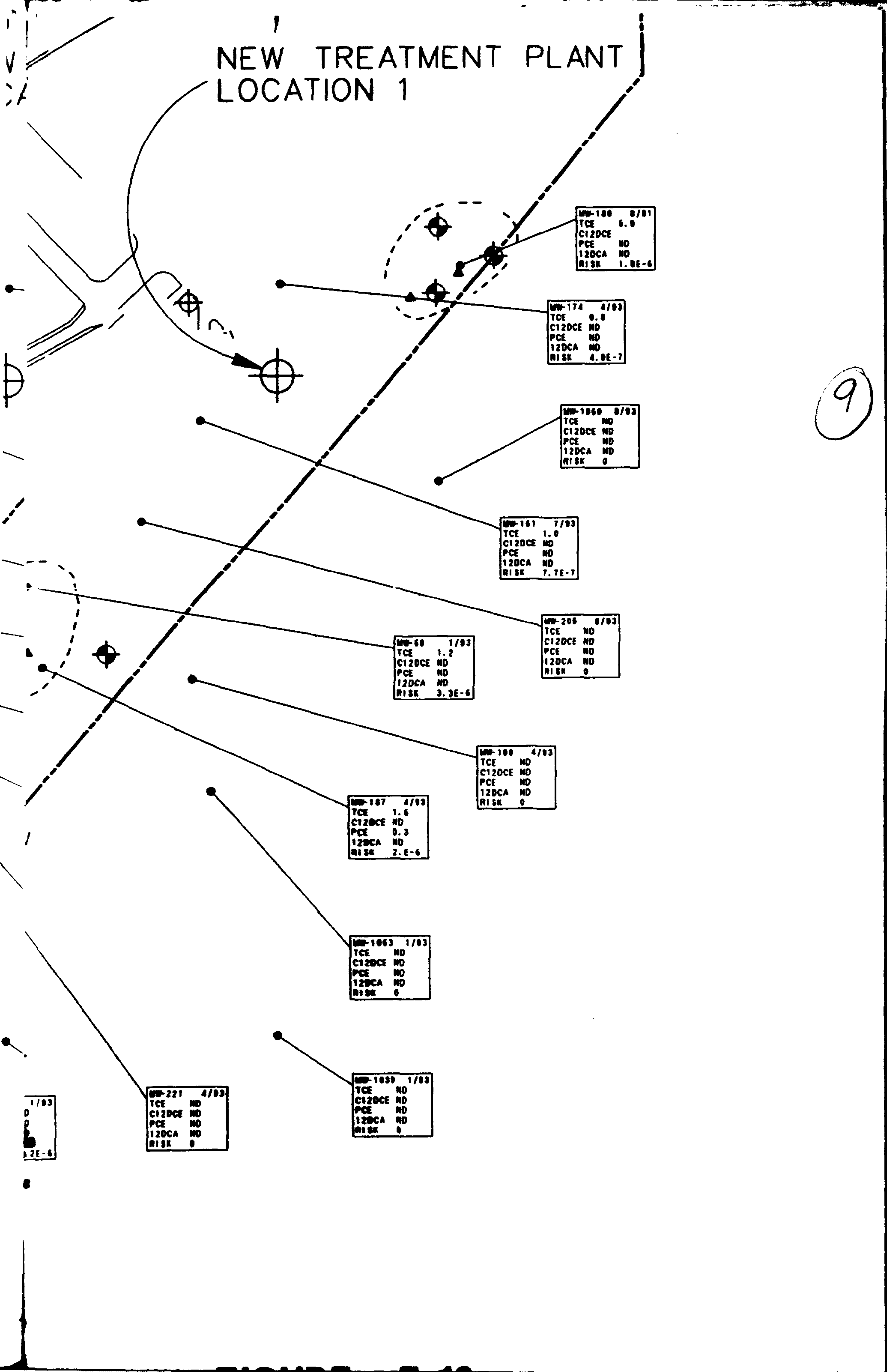


MW-106 7/93
TCE 1.6
C12DCE ND
PCE ND
12DCA ND
RISK 1.2E-6
MW-166 10/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
BW-29
BW-10
MW-171 10/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
NEW TREATMENT PLANT
LOCATION 1
MW-180 8/91
TCE 5.9
C12DCE
PCE ND
12DCA ND
RISK 1.8E-6

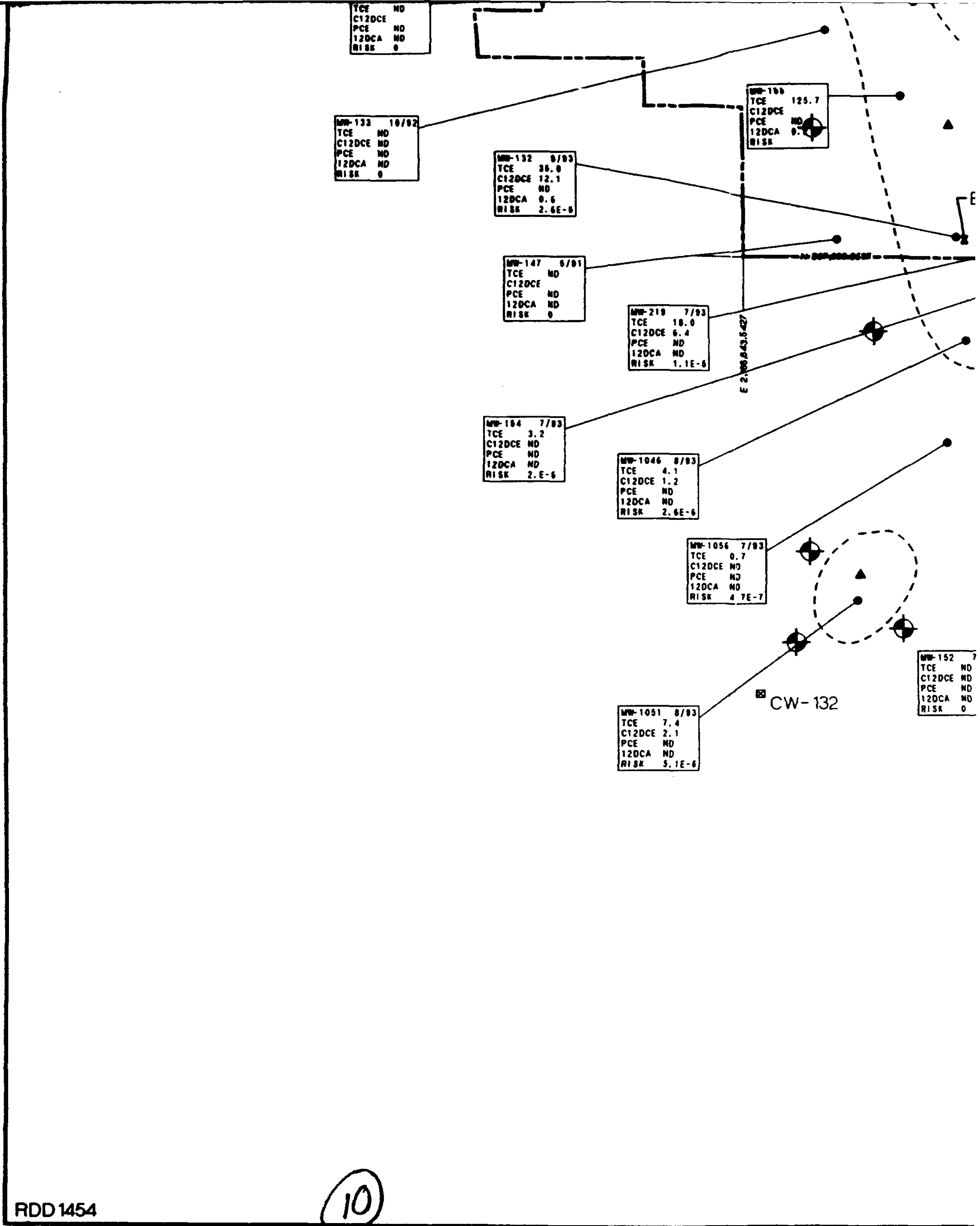


TREATMENT PLANT
17
MW-208 8/93
TCE 1.6
C12DCE ND
PCE ND
12DCA ND
RISK 1.9E-6
MW-136 10/92
TCE 38.0
C12DCE 1.5
PCE ND
12DCA 0.3
RISK 1.2E-5
EW-141 7/93
TCE 66.8
C12DCE 8.4
PCE ND
12DCA ND
RISK 4.1E-5
MW-184 7/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-133 10/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
TCE 125.7
C12DCE
PCE ND
12DCA
RISK
MW-132 8/93
TCE 35.0
C12DCE 12.1
PCE ND
12DCA 0.6
RISK 2.6E-5
MW-147 5/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-219 7/93
TCE 18.0
C12DCE 6.4
PCE ND
12DCA ND
RISK 1.1E-5
MW-154 7/93
TCE 3.2
C12DCE ND
PCE ND
12DCA ND
RISK 2.E-6
MW-1046 8/93
TCE 4.1
C12DCE 1.2
PCE ND
12DCA ND
RISK 2.6E-6
MW-1056 7/93
TCE 0.7
C12DCE ND
PCE ND
12DCA ND
RISK 4.7E-7
MW-1051 8/93
TCE 7.4
C12DCE 2.1
PCE ND
12DCA ND
RISK 5.1E-6
CW-132


C12DCE ND
PCE ND
12DCA ND
RISK 2.E-7
MW-216 10/92
TCE 10.0
C12DCE 3.4
PCE ND
12DCA ND
RISK 4.7E-6
MW-122 12/88
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 2.3E-7
8
MW-125
MW-127
EW-247
BW-18
MW-103 4/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-177 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 2.2E-6
MW-221 4/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-152 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
CW-132


NEW TREATMENT PLANT
LOCATION 1
MW-180 8/91
TCE 5.9
C12DCE
PCE ND
12DCA ND
RISK 1.0E-6
MW-174 4/93
TCE 0.8
C12DCE ND
PCE ND
12DCA ND
RISK 4.0E-7
MW-1060 8/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-161 7/93
TCE 1.0
C12DCE ND
PCE ND
12DCA ND
RISK 7.7E-7
MW-205 8/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-60 1/93
TCE 1.2
C12DCE ND
PCE ND
12DCA ND
RISK 3.3E-6
MW-199 4/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-187 4/93
TCE 1.6
C12DCE ND
PCE 0.3
12DCA ND
RISK 2.E-6
MW-1063 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-221 4/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1039 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
1/93
2E-6

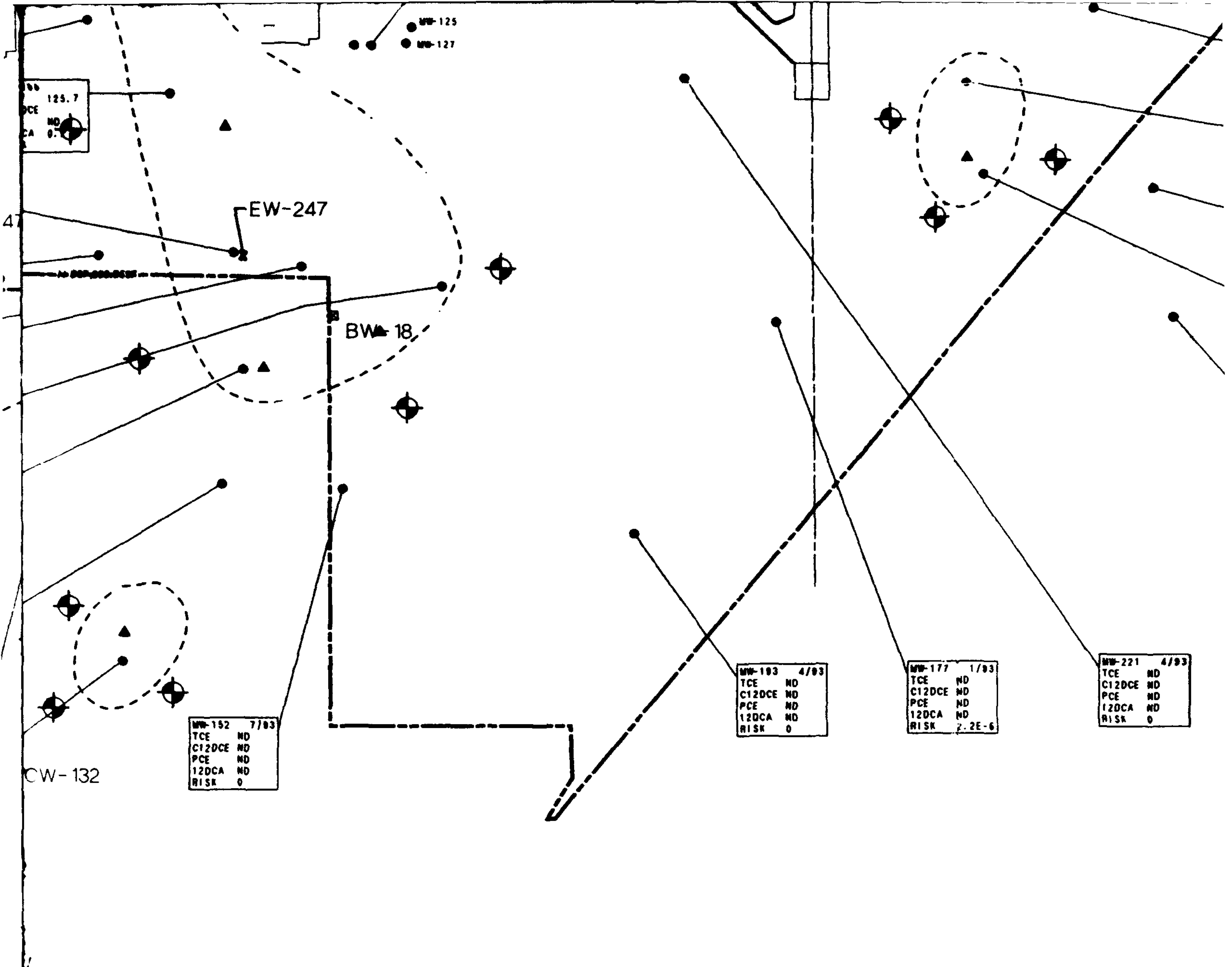
9



RDD 1454

10

MEY94/MEY-E-10.DGN



FI
MC
WE
MC
10
TA
GRC
McC
SAC

11

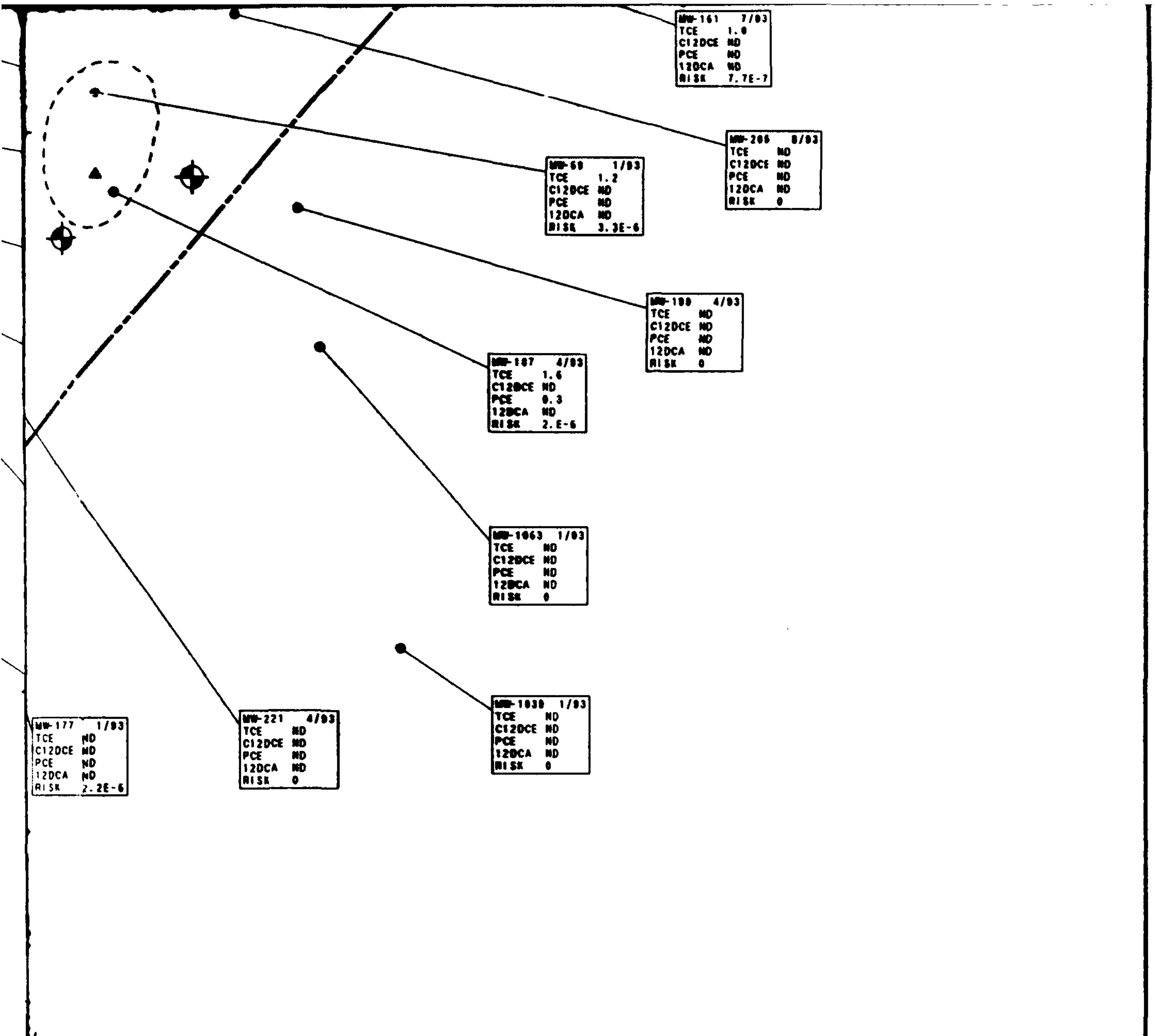


FIGURE E-10
MONITORING AND EXTRACTION WELL LOCATIONS MONITORING ZONE C 10^{-6} CANCER RISK TARGET VOLUME

GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

12

CH2M HILL

1

WELL SUMMARY

X EXISTING EXTRACTION WELLS

• NEW EXTRACTION WELLS

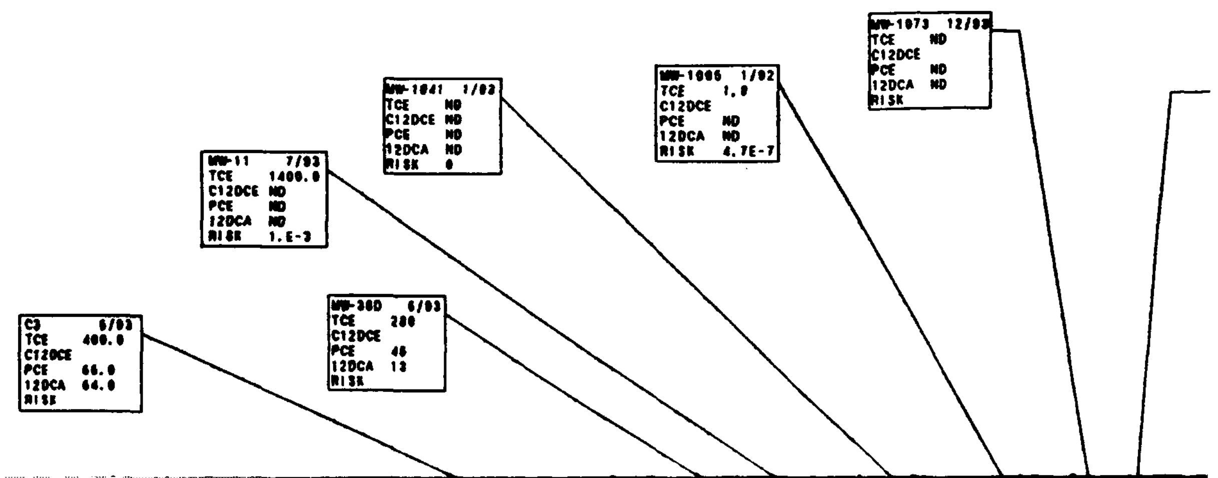
⊕ NEW MONITORING WELLS FOR WATER QUALITY

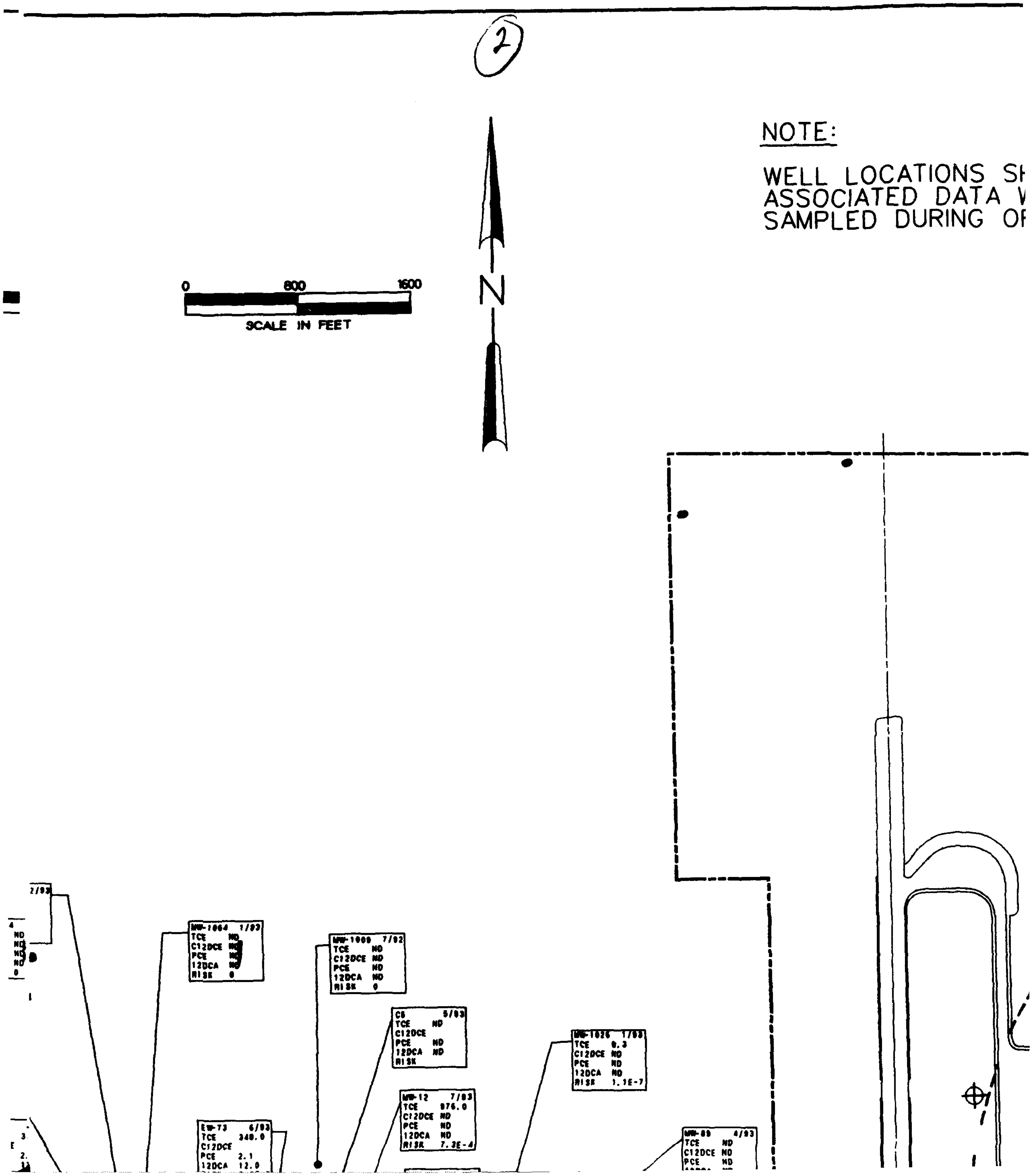
⊕ NEW MONITORING WELLS FOR HYDRAULIC CONTROL

• EXISTING MONITORING WELLS

---- TARGET VOLUME BOUNDRY

—— HOT SPOT BOUNDRY



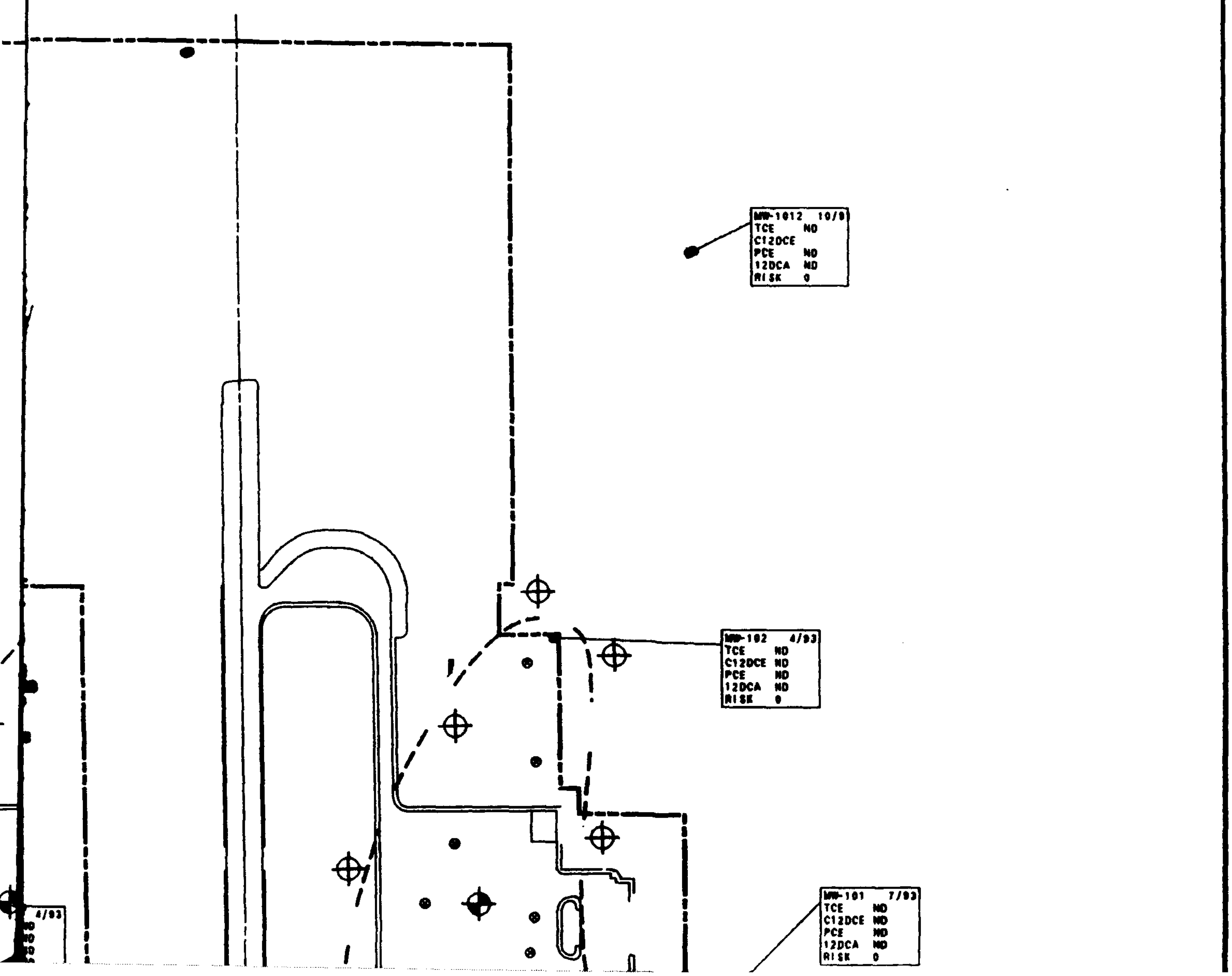


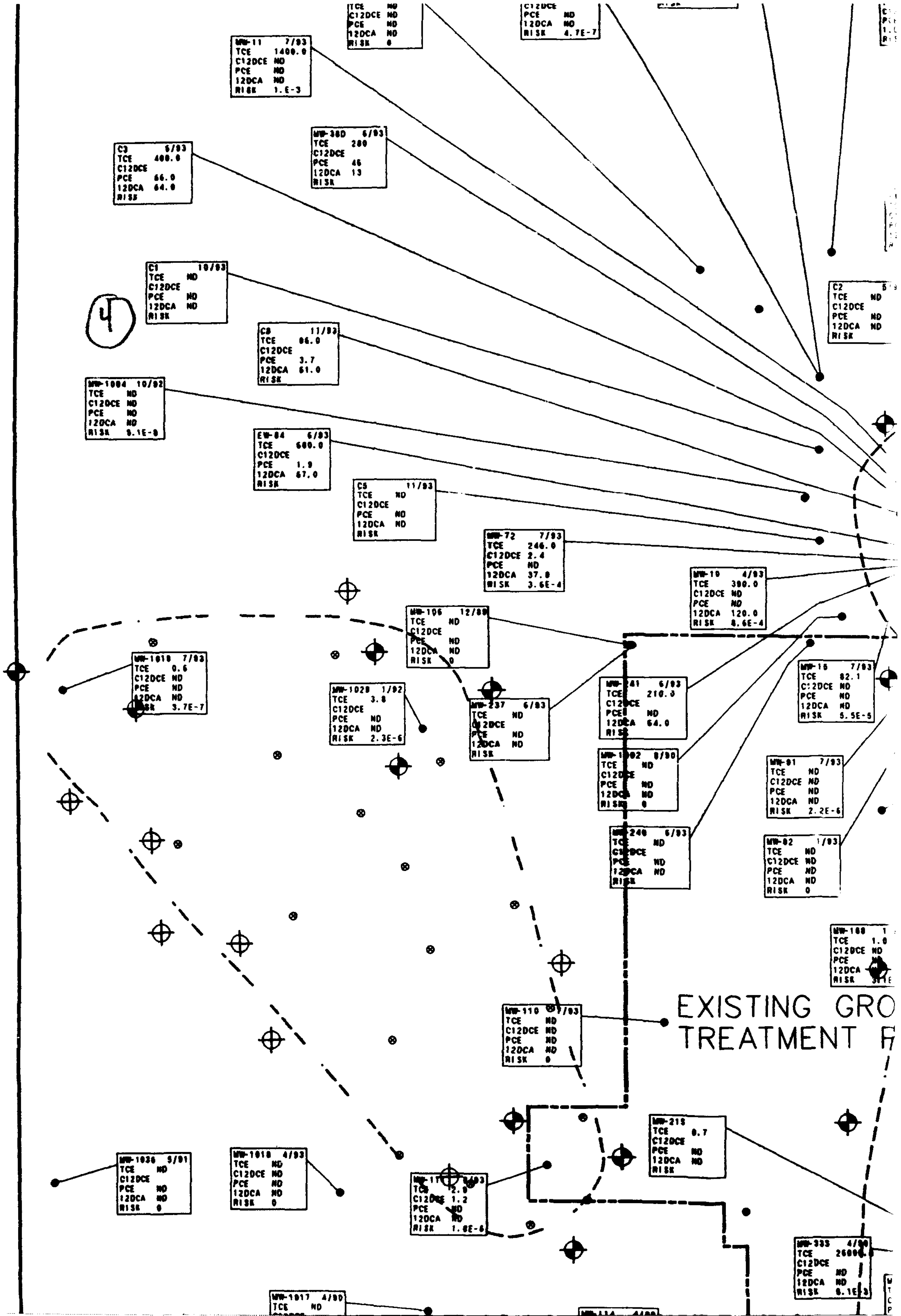
NOTE:
WELL LOCATIONS SI
ASSOCIATED DATA V
SAMPLED DURING OI
0
800
1600
SCALE IN FEET
N
MW-1064 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1009 7/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
C6 5/93
TCE ND
C12DCE
PCE ND
12DCA ND
RISK
MW-1026 1/93
TCE 0.3
C12DCE ND
PCE ND
12DCA ND
RISK 1.1E-7
MW-12 7/93
TCE 976.0
C12DCE ND
PCE ND
12DCA ND
RISK 7.3E-4
EW-73 6/93
TCE 340.0
C12DCE
PCE 2.1
12DCA 12.0
MW-89 4/93
TCE ND
C12DCE ND
PCE ND

(3)

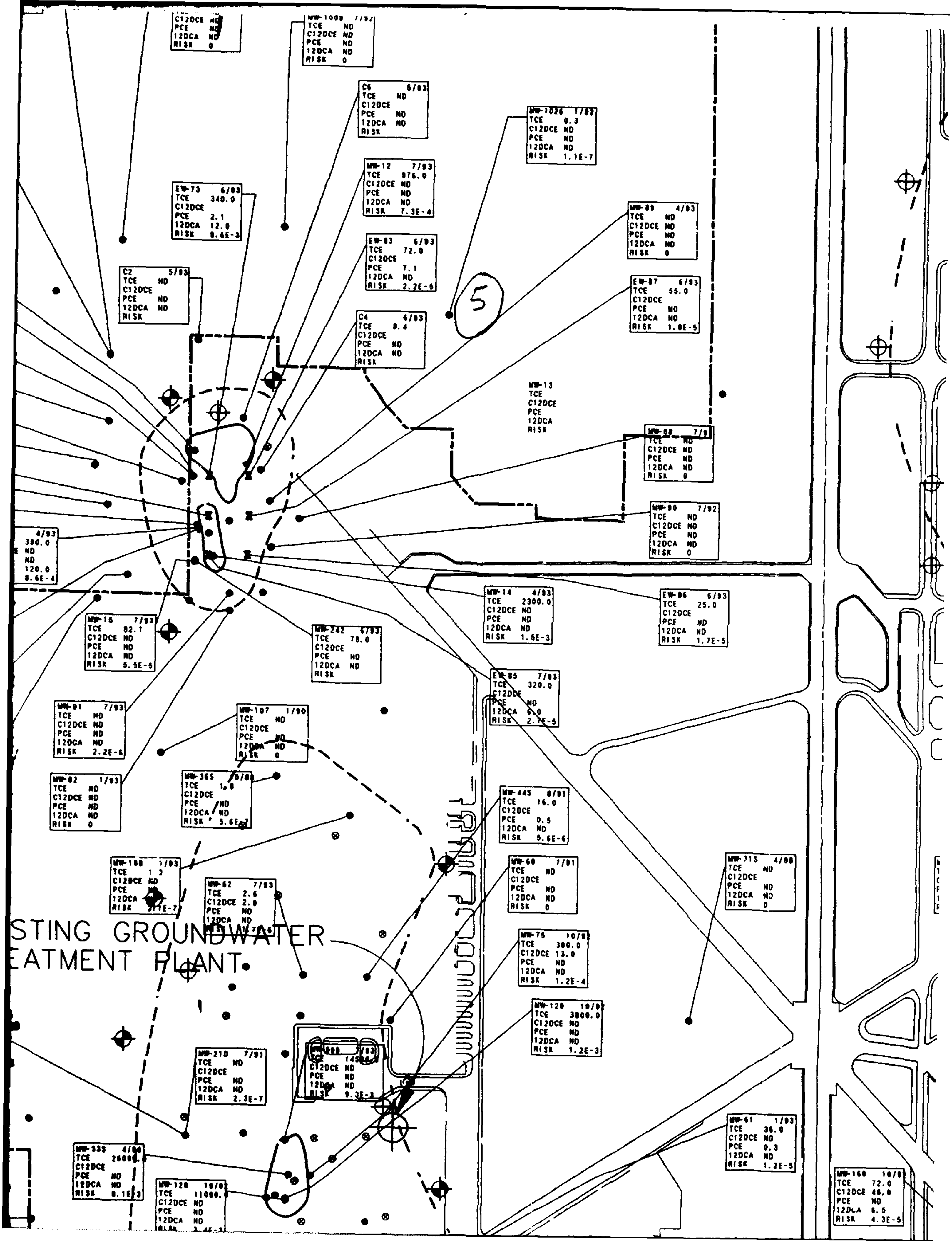
NOTE:

WELL LOCATIONS SHOWN WITHOUT ASSOCIATED DATA WERE NOT SAMPLED DURING OR AFTER 1988.

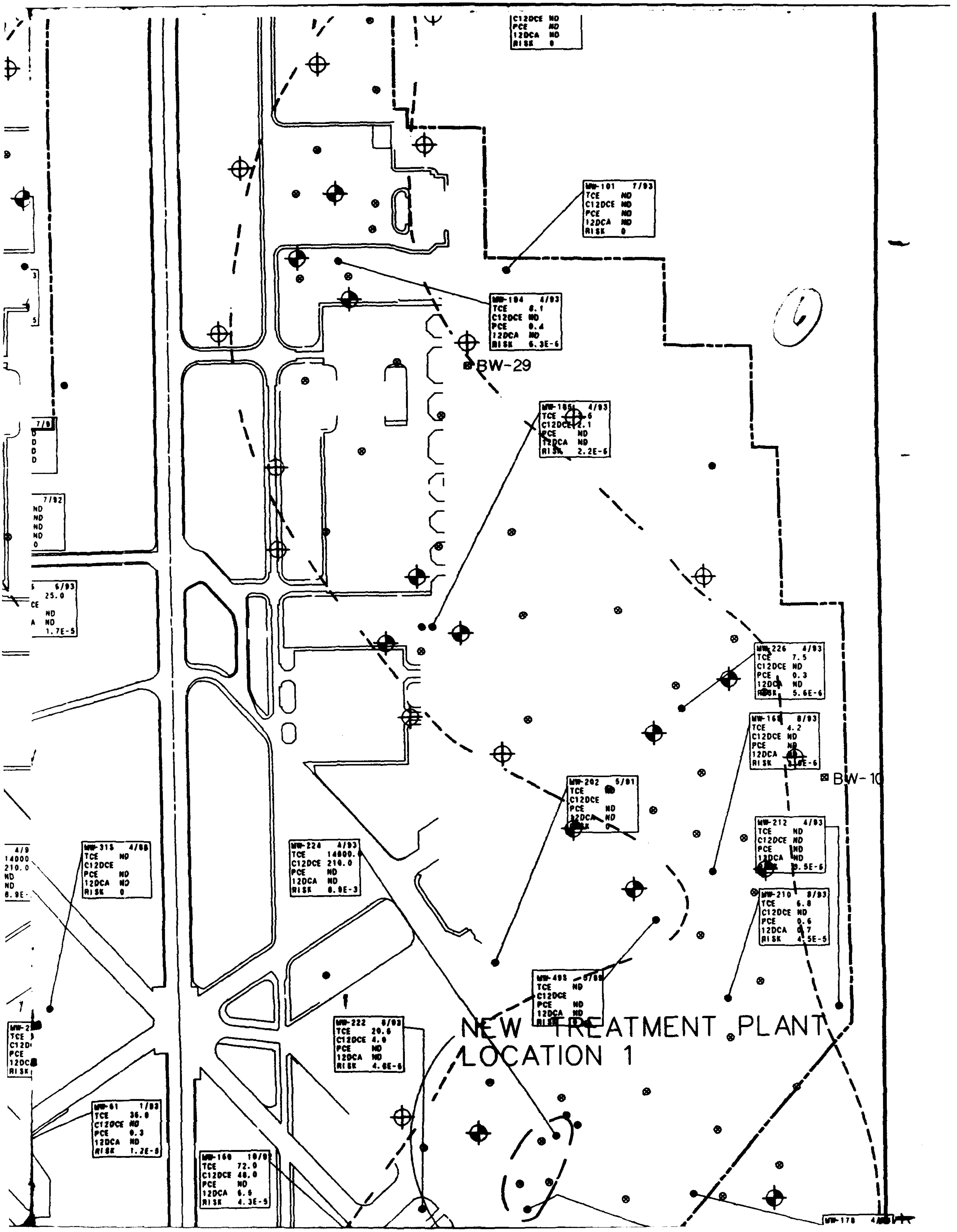




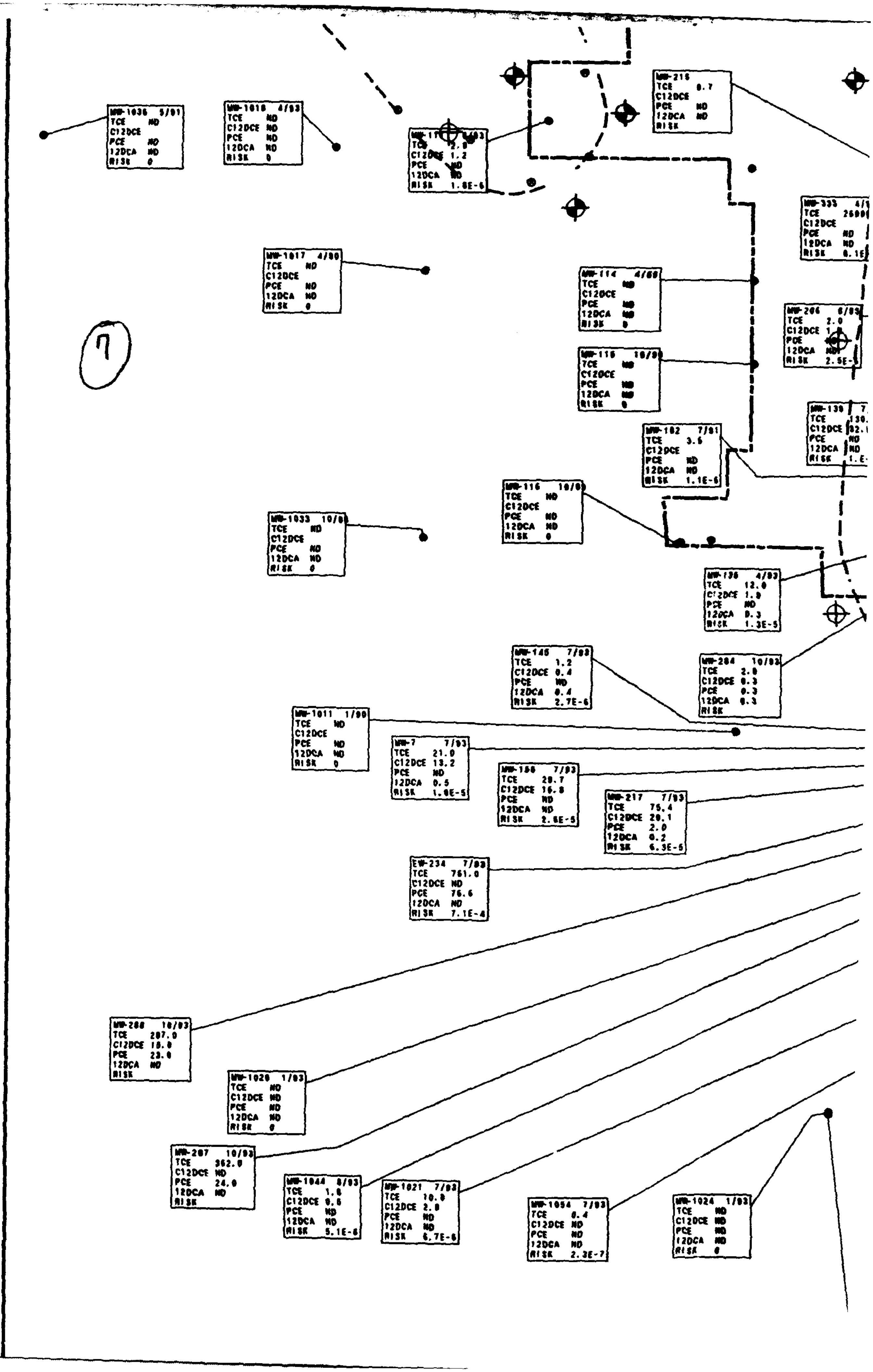
MW-11 7/93 TCE 1400.0 C12DCE ND PCE ND 12DCA ND RISK 1.E-3
MW-38D 6/93 TCE 280 C12DCE PCE 45 12DCA 13 RISK
C3 6/93 TCE 400.0 C12DCE PCE 66.0 12DCA 64.0 RISK
C1 10/93 TCE ND C12DCE PCE ND 12DCA ND RISK
C8 11/93 TCE 86.0 C12DCE PCE 3.7 12DCA 61.0 RISK
MW-1004 10/92 TCE ND C12DCE ND PCE ND 12DCA ND RISK 9.1E-9
EW-84 6/93 TCE 680.0 C12DCE PCE 1.9 12DCA 67.0 RISK
C5 11/93 TCE ND C12DCE PCE ND 12DCA ND RISK
MW-72 7/93 TCE 246.0 C12DCE 2.4 PCE ND 12DCA 37.8 RISK 3.6E-4
MW-10 4/93 TCE 390.0 C12DCE ND PCE ND 12DCA 120.0 RISK 8.6E-4
MW-106 12/89 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-1010 7/93 TCE 0.6 C12DCE ND PCE ND 12DCA ND RISK 3.7E-7
MW-1028 1/92 TCE 3.8 C12DCE PCE ND 12DCA ND RISK 2.3E-6
MW-237 6/93 TCE ND C12DCE PCE ND 12DCA ND RISK
MW-241 6/93 TCE 210.0 C12DCE PCE ND 12DCA 64.0 RISK
MW-15 7/93 TCE 82.1 C12DCE ND PCE ND 12DCA ND RISK 5.5E-5
MW-1002 8/90 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-91 7/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 2.2E-6
MW-240 6/93 TCE ND C12DCE PCE ND 12DCA ND RISK
MW-82 1/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-110 7/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
EXISTING GRO
TREATMENT F
MW-21S TCE 0.7 C12DCE PCE ND 12DCA ND RISK
MW-1036 5/91 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-1018 4/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
C12DCE 1.2 PCE ND 12DCA ND RISK 1.8E-6
MW-333 4/90 TCE C12DCE PCE ND 12DCA ND RISK
MW-1017 4/90 TCE ND
C2 TCE ND C12DCE PCE ND 12DCA ND RISK



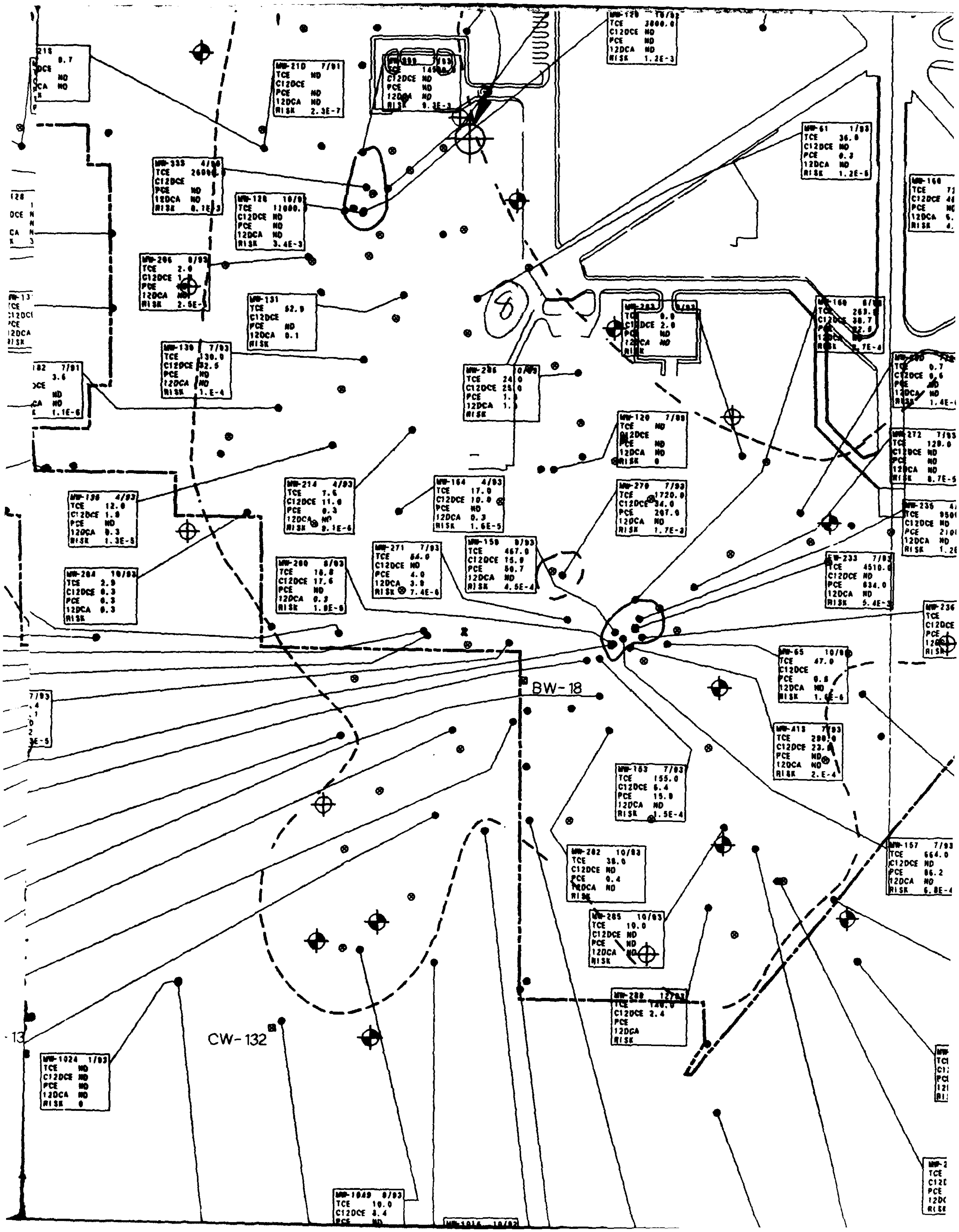
C12DCE ND PCE ND 12DCA ND RISK 0
MW-1009 7/92 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
C6 5/93 TCE ND C12DCE PCE ND 12DCA ND RISK
MW-1026 1/93 TCE 0.3 C12DCE ND PCE ND 12DCA ND RISK 1.1E-7
MW-12 7/93 TCE 976.0 C12DCE ND PCE ND 12DCA ND RISK 7.3E-4
EW-73 6/93 TCE 340.0 C12DCE PCE 2.1 12DCA 12.0 RISK 9.6E-3
MW-89 4/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
EW-83 6/93 TCE 72.0 C12DCE PCE 7.1 12DCA ND RISK 2.2E-5
C2 5/93 TCE ND C12DCE PCE ND 12DCA ND RISK
EW-87 6/93 TCE 55.0 C12DCE PCE ND 12DCA ND RISK 1.8E-5
5
C4 6/93 TCE 8.4 C12DCE PCE ND 12DCA ND RISK
MW-13 TCE C12DCE PCE 12DCA RISK
MW-88 7/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-90 7/92 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
4/93 390.0 ND ND 120.0 8.6E-4
MW-14 4/93 TCE 2300.0 C12DCE ND PCE ND 12DCA ND RISK 1.5E-3
EW-86 6/93 TCE 25.0 C12DCE PCE ND 12DCA ND RISK 1.7E-5
MW-16 7/93 TCE 82.1 C12DCE ND PCE ND 12DCA ND RISK 5.5E-5
MW-242 6/93 TCE 78.0 C12DCE PCE ND 12DCA ND RISK
EW-85 7/93 TCE 320.0 C12DCE PCE ND 12DCA 6.0 RISK 2.7E-5
MW-91 7/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 2.2E-6
MW-107 1/90 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-92 1/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-36S TCE 1.8 C12DCE PCE ND 12DCA ND RISK 5.6E-7
MW-44S 8/91 TCE 16.0 C12DCE PCE 0.5 12DCA ND RISK 5.6E-6
MW-168 TCE C12DCE ND PCE 12DCA RISK
MW-62 7/93 TCE 2.6 C12DCE 2.0 PCE ND 12DCA ND RISK
MW-60 7/91 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-31S 4/88 TCE ND C12DCE PCE ND 12DCA ND RISK 0
STING GROUNDWATER
EATMENT PLANT
MW-75 10/92 TCE 380.0 C12DCE 13.0 PCE ND 12DCA ND RISK 1.2E-4
MW-129 10/92 TCE 3800.0 C12DCE ND PCE ND 12DCA ND RISK 1.2E-3
MW-21D 7/91 TCE ND C12DCE PCE ND 12DCA ND RISK 2.3E-7
7/93 TCE C12DCE ND PCE ND 12DCA ND RISK 9.3E-3
MW-61 1/93 TCE 36.0 C12DCE ND PCE 0.3 12DCA ND RISK 1.2E-5
MW-33S TCE 26000 C12DCE PCE ND 12DCA ND RISK 8.1E-3
MW-128 10/92 TCE 11000. C12DCE ND PCE ND 12DCA ND
MW-160 10/92 TCE 72.0 C12DCE 48.0 PCE ND 12DCA 6.5 RISK 4.3E-5



C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-101 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-104 4/93
TCE 8.1
C12DCE ND
PCE 0.4
12DCA ND
RISK 6.3E-6
BW-29
MW-105 4/93
C12DCE 2.1
PCE ND
12DCA ND
RISK 2.2E-6
MW-226 4/93
TCE 7.5
C12DCE ND
PCE 0.3
12DCA ND
RISK 5.6E-6
TCE 4.2
C12DCE ND
BW-10
MW-202 5/91
C12DCE
PCE ND
12DCA ND
MW-212 4/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
MW-210 8/93
TCE 6.8
C12DCE ND
PCE 0.6
RISK 4.5E-5
MW-31S 4/88
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-224 4/93
TCE 14000.
C12DCE 210.0
PCE ND
12DCA ND
RISK 8.9E-3
MW-49S 5/89
TCE ND
C12DCE
PCE ND
12DCA ND
NEW TREATMENT PLANT
LOCATION 1
MW-222 8/93
TCE 20.6
C12DCE 4.0
PCE ND
12DCA ND
RISK 4.6E-6
MW-61 1/93
TCE 36.0
C12DCE ND
PCE 0.3
12DCA ND
RISK 1.2E-5
TCE 72.0
C12DCE 48.0
PCE ND
12DCA 6.6
RISK 4.3E-5
MW-178



MW-1036 5/91 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-1018 4/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
TCE 2.0 C12DCE 1.2 PCE ND 12DCA ND RISK 1.8E-6
MW-215 TCE 0.7 C12DCE PCE ND 12DCA ND RISK
MW-1017 4/90 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-114 4/89 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-115 10/90 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-206 TCE 2.0 RISK 2.5E-
MW-182 7/91 TCE 3.5 C12DCE PCE ND 12DCA ND RISK 1.1E-6
MW-116 10/89 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-1033 10/89 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-136 4/93 TCE 12.0 C12DCE 1.9 PCE ND 12DCA 0.3 RISK 1.3E-5
MW-145 7/93 TCE 1.2 C12DCE 0.4 PCE ND 12DCA 0.4 RISK 2.7E-6
MW-284 10/93 TCE 2.0 C12DCE 0.3 PCE 0.3 12DCA 0.3 RISK
MW-1011 1/90 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-7 7/93 TCE 21.0 C12DCE 13.2 PCE ND 12DCA 0.5 RISK 1.8E-5
MW-158 7/93 TCE 28.7 C12DCE 16.8 PCE ND 12DCA ND RISK 2.6E-5
MW-217 7/93 TCE 75.4 C12DCE 20.1 PCE 2.0 12DCA 0.2 RISK 6.3E-5
EW-234 7/93 TCE 761.0 C12DCE ND PCE 76.6 12DCA ND RISK 7.1E-4
MW-288 10/93 TCE 287.0 C12DCE 18.0 PCE 23.0 12DCA ND RISK
MW-1020 1/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-287 10/93 TCE 362.0 C12DCE ND PCE 24.0 12DCA ND RISK
MW-1044 8/93 TCE 1.8 C12DCE 0.6 PCE ND 12DCA ND RISK 5.1E-6
MW-1021 7/93 TCE 10.0 C12DCE 2.0 PCE ND 12DCA ND RISK 6.7E-6
MW-1054 7/93 TCE 0.4 C12DCE ND PCE ND 12DCA ND RISK 2.3E-7
MW-1024 1/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0



MW-120 10/93 TCE 3800.0 C12DCE ND PCE ND 12DCA ND RISK 1.2E-3
MW-210 7/91 TCE ND C12DCE PCE ND 12DCA ND RISK 2.3E-7
MW-333 4/93 TCE C12DCE PCE ND 12DCA ND
MW-128 10/93 TCE 11000. C12DCE ND PCE ND 12DCA ND RISK 3.4E-3
MW-61 1/93 TCE 36.0 C12DCE ND PCE 0.3 12DCA ND RISK 1.2E-5
MW-206 8/93 TCE 2.0 C12DCE PCE 12DCA RISK
MW-131 TCE 52.9 C12DCE PCE ND 12DCA 0.1 RISK
MW-130 7/93 TCE 130.0 C12DCE 32.5 PCE ND 12DCA ND RISK 1.E-4
MW-286 10/93 TCE C12DCE PCE 12DCA RISK
MW-120 7/93 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-272 7/93 TCE 120.0 C12DCE ND PCE ND 12DCA ND
MW-136 4/93 TCE 12.0 C12DCE 1.9 PCE ND 12DCA 0.3 RISK 1.3E-5
MW-214 4/93 TCE C12DCE 11.0 PCE 0.3 12DCA ND
MW-164 4/93 TCE 17.0 C12DCE 10.0 PCE ND 12DCA 0.3 RISK 1.6E-5
MW-279 7/93 TCE 1720.0 C12DCE 34.0 PCE 207.0 12DCA ND RISK 1.7E-3
MW-204 10/93 TCE 2.9 C12DCE 0.3 PCE 0.3 12DCA 0.3 RISK
MW-200 8/93 TCE 18.8 C12DCE 17.6 PCE ND 12DCA 0.2
MW-271 7/93 TCE 64.0 C12DCE ND PCE 4.0 12DCA 3.0 RISK 7.4E-6
MW-159 8/93 TCE 467.0 C12DCE 15.9 PCE 50.7 12DCA ND RISK 4.5E-4
EW-233 7/93 TCE 4510.0 C12DCE ND PCE 834.0 12DCA ND RISK 5.4E-3
MW-65 10/93 TCE 47.0 C12DCE PCE 0.8 12DCA ND
BW-18
MW-413 7/93 TCE 290.0 C12DCE PCE ND 12DCA ND RISK 2.E-4
MW-153 7/93 TCE 155.0 C12DCE 6.4 PCE 15.9 12DCA ND RISK 1.5E-4
MW-157 7/93 TCE 664.0 C12DCE ND PCE 86.2 12DCA ND
MW-282 10/93 TCE 38.0 C12DCE ND PCE 0.4 12DCA ND RISK
MW-285 10/93 TCE 10.0 C12DCE ND PCE ND 12DCA ND RISK
MW-289 12/93 C12DCE 2.4 PCE 12DCA RISK
CW-132
MW-1024 1/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-1049 8/93 TCE 10.0 C12DCE 3.4 PCE ND

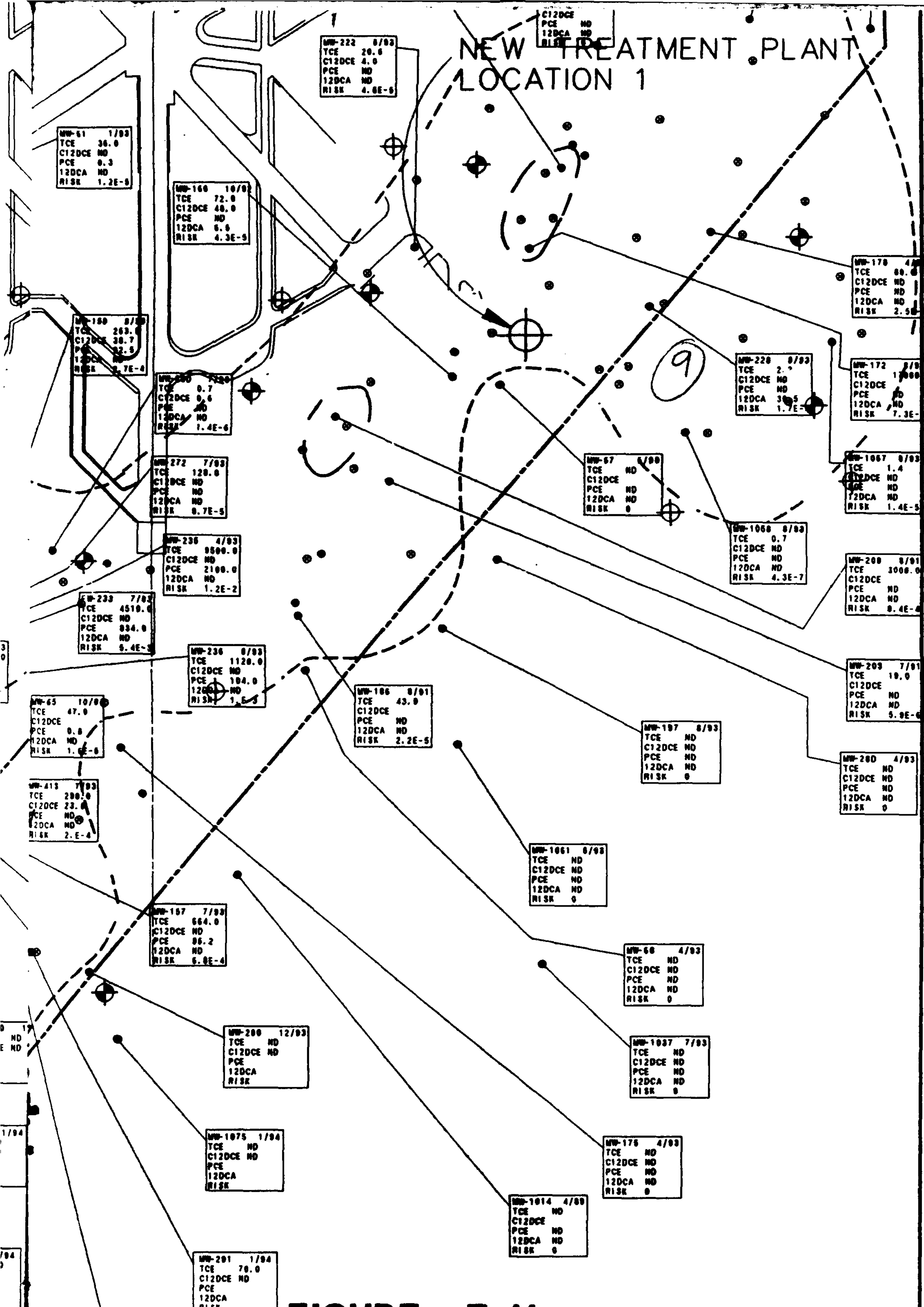
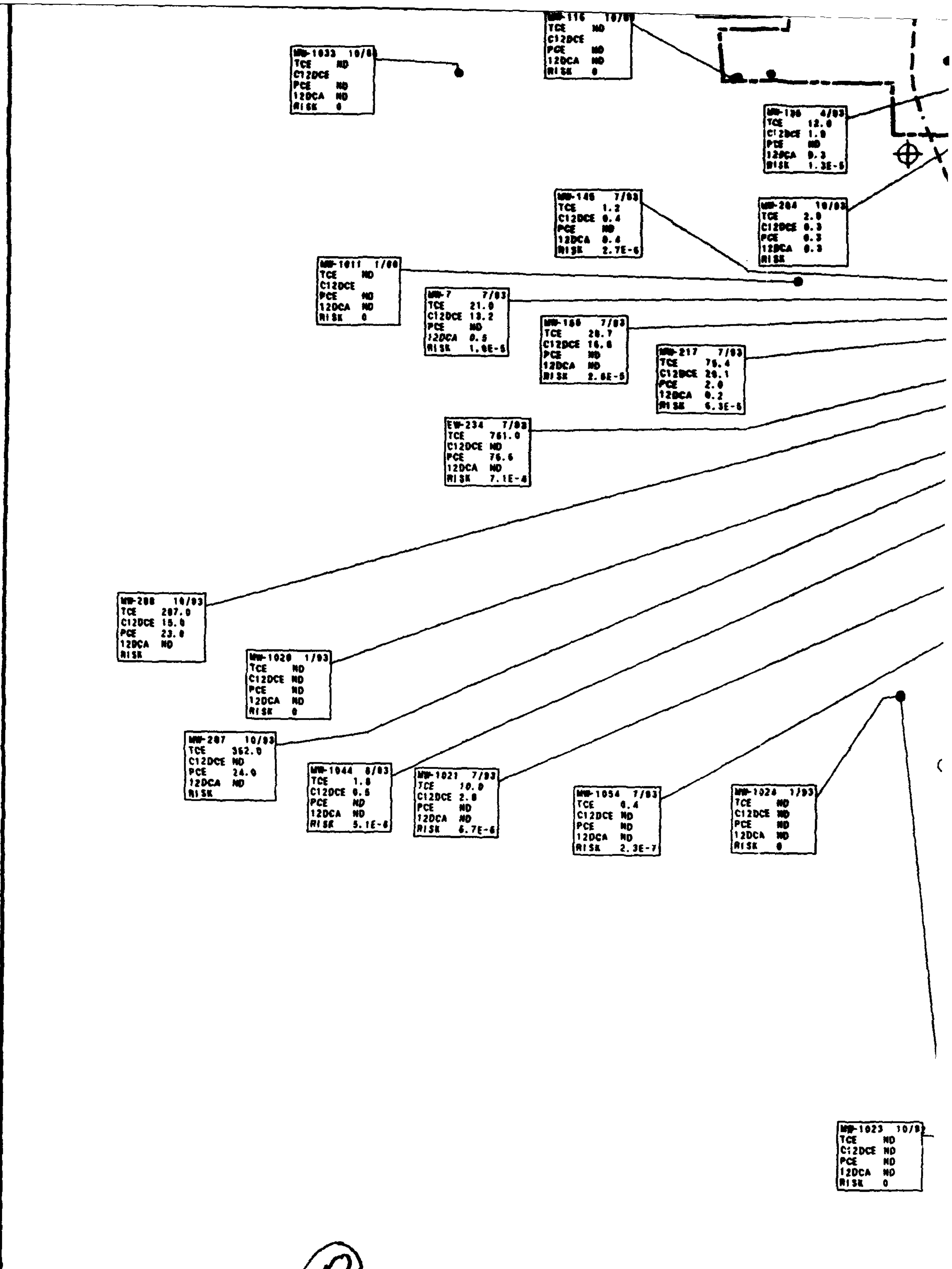

NEW TREATMENT PLANT
LOCATION 1
9
MW-222 8/93 TCE 20.0 C12DCE 4.0 PCE ND 12DCA ND RISK 4.0E-6
MW-61 1/93 TCE 36.0 C12DCE ND PCE 0.3 12DCA ND RISK 1.2E-5
MW-166 10/92 TCE 72.0 C12DCE 46.0 PCE ND 12DCA 6.6 RISK 4.3E-5
MW-178 TCE C12DCE ND PCE ND 12DCA ND RISK
MW-228 8/93 TCE C12DCE ND PCE ND 12DCA RISK
MW-172 TCE C12DCE PCE 12DCA RISK
MW-272 7/93 TCE 120.0 C12DCE ND PCE ND 12DCA ND RISK 8.7E-5
MW-67 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-1057 8/93 TCE 1.4 C12DCE ND PCE ND 12DCA ND RISK 1.4E-5
MW-235 4/93 TCE 9500.0 C12DCE ND PCE 2100.0 12DCA ND RISK 1.2E-2
MW-1060 8/93 TCE 0.7 C12DCE ND PCE ND 12DCA ND RISK 4.3E-7
MW-233 7/93 TCE 4510.0 C12DCE ND PCE 834.0 12DCA ND RISK
MW-236 8/93 TCE 1120.0 C12DCE ND PCE 194.0 RISK
MW-203 7/91 TCE 19.0 C12DCE PCE ND 12DCA ND RISK
MW-65 10/8 TCE 47.9 C12DCE PCE 0.8 12DCA ND RISK
MW-106 8/91 TCE 43.0 C12DCE PCE ND 12DCA ND RISK 2.2E-5
MW-197 8/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-280 4/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-1061 8/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-157 7/93 TCE 664.0 C12DCE ND PCE 86.2 12DCA ND RISK 6.8E-4
MW-66 4/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-286 12/93 TCE ND C12DCE ND PCE 12DCA RISK
MW-1037 7/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-1075 1/94 TCE ND C12DCE ND PCE 12DCA RISK
MW-175 4/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-1014 4/89 TCE ND C12DCE PCE ND 12DCA ND RISK 0
MW-291 1/94 TCE 79.0 C12DCE ND PCE 12DCA RISK

FIGURE E-11



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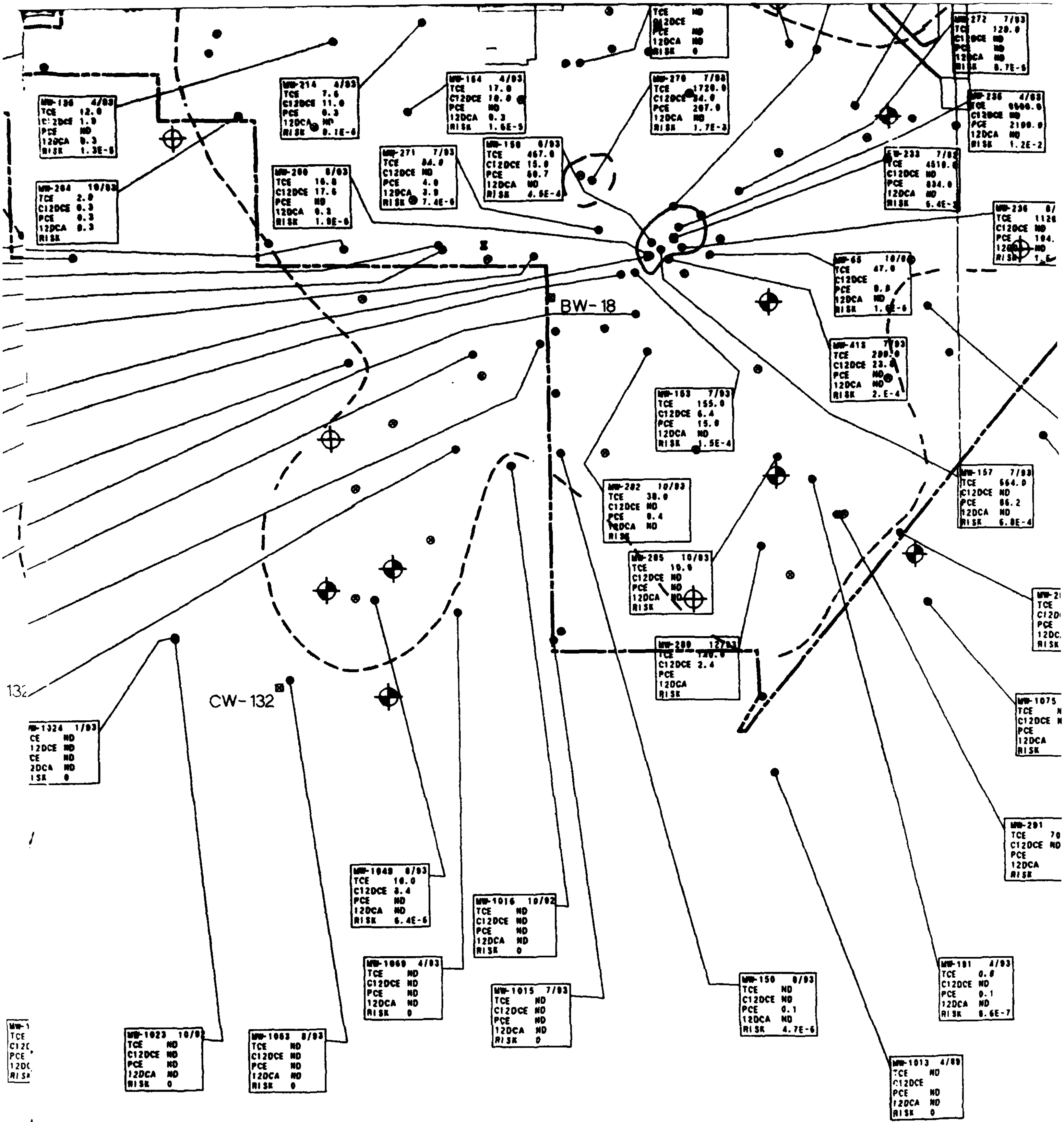
mey94/MEY-E-11dgn


BW-18
CW-132
MW-136 4/93 TCE 12.0 C12DCE 1.9 PCE ND 12DCA 0.3 RISK 1.3E-6
MW-204 10/93 TCE 2.0 C12DCE 0.3 PCE 0.3 12DCA 0.3 RISK
MW-214 4/93 TCE 7.6 C12DCE 11.0 PCE 0.3 12DCA ND RISK 9.1E-6
MW-164 4/93 TCE 17.0 C12DCE 10.0 PCE ND 12DCA 0.3 RISK 1.6E-5
MW-270 7/93 TCE 1720.0 C12DCE 34.0 PCE 207.0 12DCA ND RISK 1.7E-3
MW-272 7/93 TCE 120.0 C12DCE ND PCE ND 12DCA ND RISK 8.7E-5
MW-286 4/93 TCE 6600.0 C12DCE ND PCE 2100.0 12DCA ND RISK 1.2E-2
MW-271 7/93 TCE 84.0 C12DCE ND PCE 4.0 12DCA 3.0 RISK 7.4E-6
MW-158 6/93 TCE 467.0 C12DCE 15.0 PCE 60.7 12DCA ND RISK 4.5E-4
MW-280 8/93 TCE 16.0 C12DCE 17.6 PCE ND 12DCA 0.3 RISK 1.9E-6
EW-233 7/93 TCE 4510.0 C12DCE ND PCE 834.0 12DCA ND RISK 6.4E-3
MW-65 10/93 TCE 47.0 C12DCE PCE 0.8 12DCA ND RISK 1.0E-6
MW-413 7/93 TCE 290.0 C12DCE 23.0 PCE ND 12DCA ND RISK 2.E-4
MW-153 7/93 TCE 155.0 C12DCE 6.4 PCE 15.0 12DCA ND RISK 1.5E-4
MW-157 7/93 TCE 664.0 C12DCE ND PCE 86.2 12DCA ND RISK 6.8E-4
MW-282 10/93 TCE 38.0 C12DCE ND PCE 0.4 12DCA ND RISK
MW-285 10/93 TCE 10.0 C12DCE ND PCE ND 12DCA ND RISK
MW-289 12/93 TCE C12DCE 2.4 PCE 12DCA RISK
MW-1075 TCE C12DCE PCE 12DCA RISK
MW-1324 1/93 CE ND 12DCE ND CE ND 2DCA ND ISK 0
MW-291 TCE C12DCE ND PCE 12DCA RISK
MW-1049 8/93 TCE 10.0 C12DCE 3.4 PCE ND 12DCA ND RISK 6.4E-6
MW-1016 10/92 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-1069 4/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-1015 7/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-159 8/93 TCE ND C12DCE ND PCE 0.1 12DCA ND RISK 4.7E-6
MW-191 4/93 TCE 0.8 C12DCE ND PCE 0.1 12DCA ND RISK 6.6E-7
MW-1023 10/92 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-1063 8/93 TCE ND C12DCE ND PCE ND 12DCA ND RISK 0
MW-1013 4/89 TCE ND C12DCE PCE ND 12DCA ND RISK 0

15

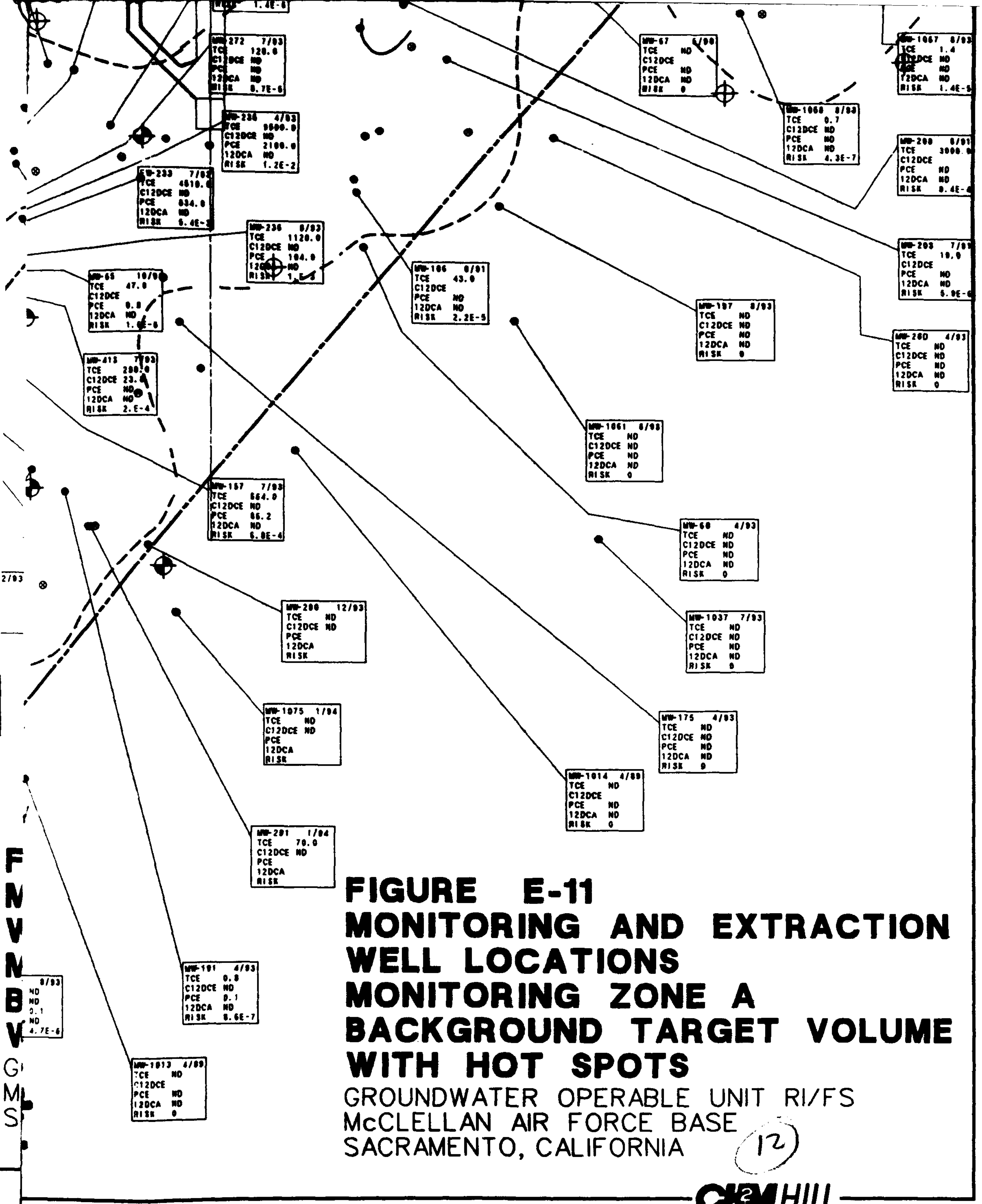


FIGURE E-11
MONITORING AND EXTRACTION WELL LOCATIONS MONITORING ZONE A BACKGROUND TARGET VOLUME WITH HOT SPOTS

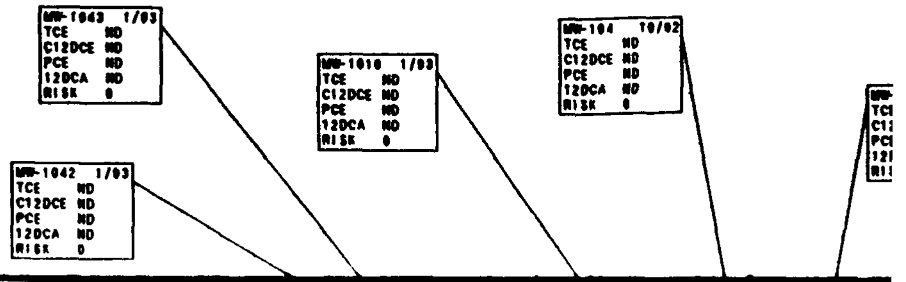
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

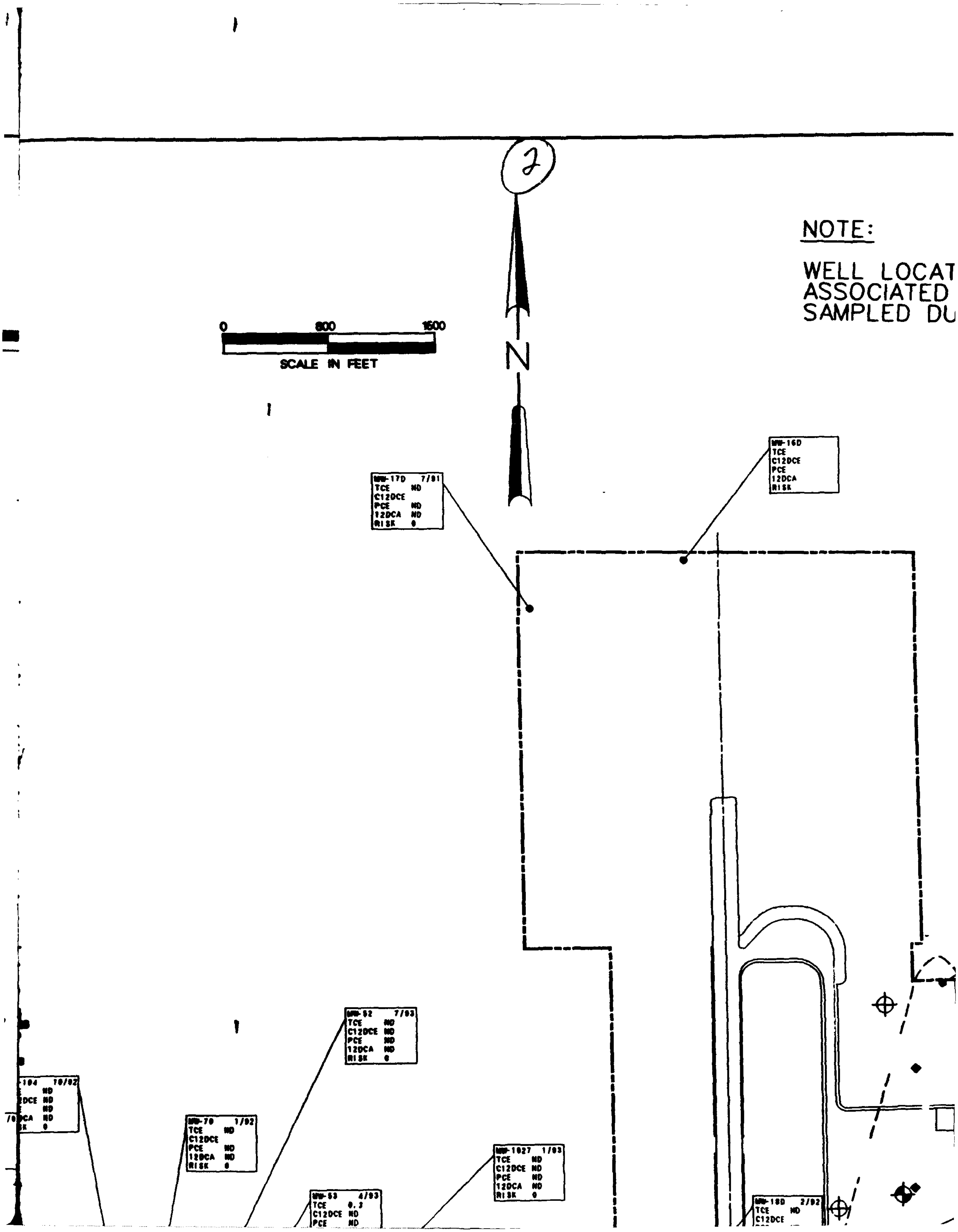
CH2M HILL

1

WELL SUMMARY

- X EXISTING EXTRACTION WELLS
- ◆ NEW EXTRACTION WELLS
- ⊕ NEW MONITORING WELLS FOR WATER QUALITY
- ⊕ NEW MONITORING WELLS FOR HYDRAULIC CONTROL
- • EXISTING MONITORING WELLS
- ---- TARGET VOLUME BOUNDARY



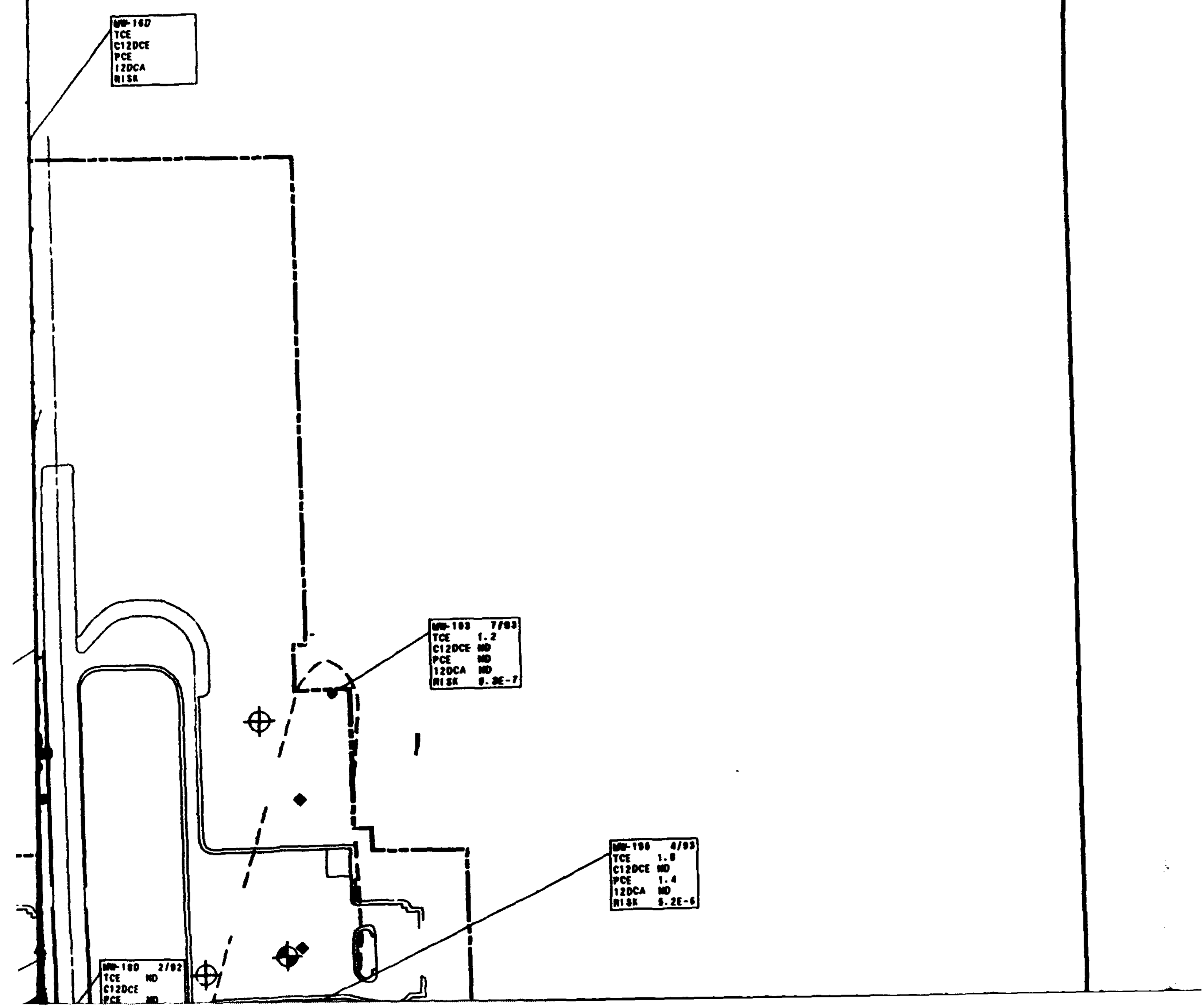


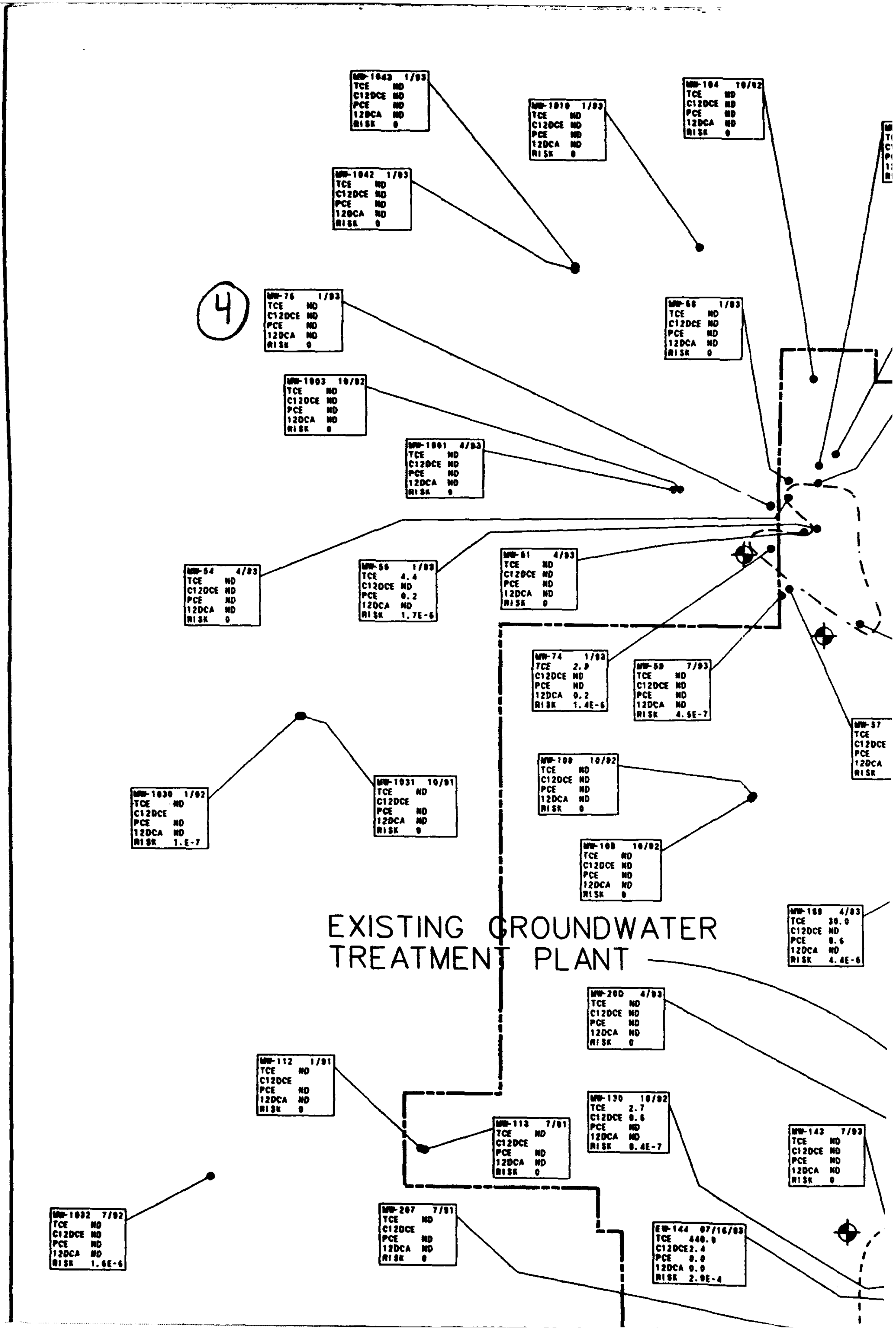
NOTE:
WELL LOCAT
ASSOCIATED
SAMPLED DU
0 800 1600
SCALE IN FEET
N
MW-17D 7/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-16D
TCE
C12DCE
PCE
12DCA
RISK
MW-52 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
-104 10/92
ND
DCE ND
ND
CA ND
K 0
MW-70 1/92
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-1027 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-53 4/93
TCE 0.3
C12DCE ND
PCE ND
MW-18D 2/92
TCE ND
C12DCE

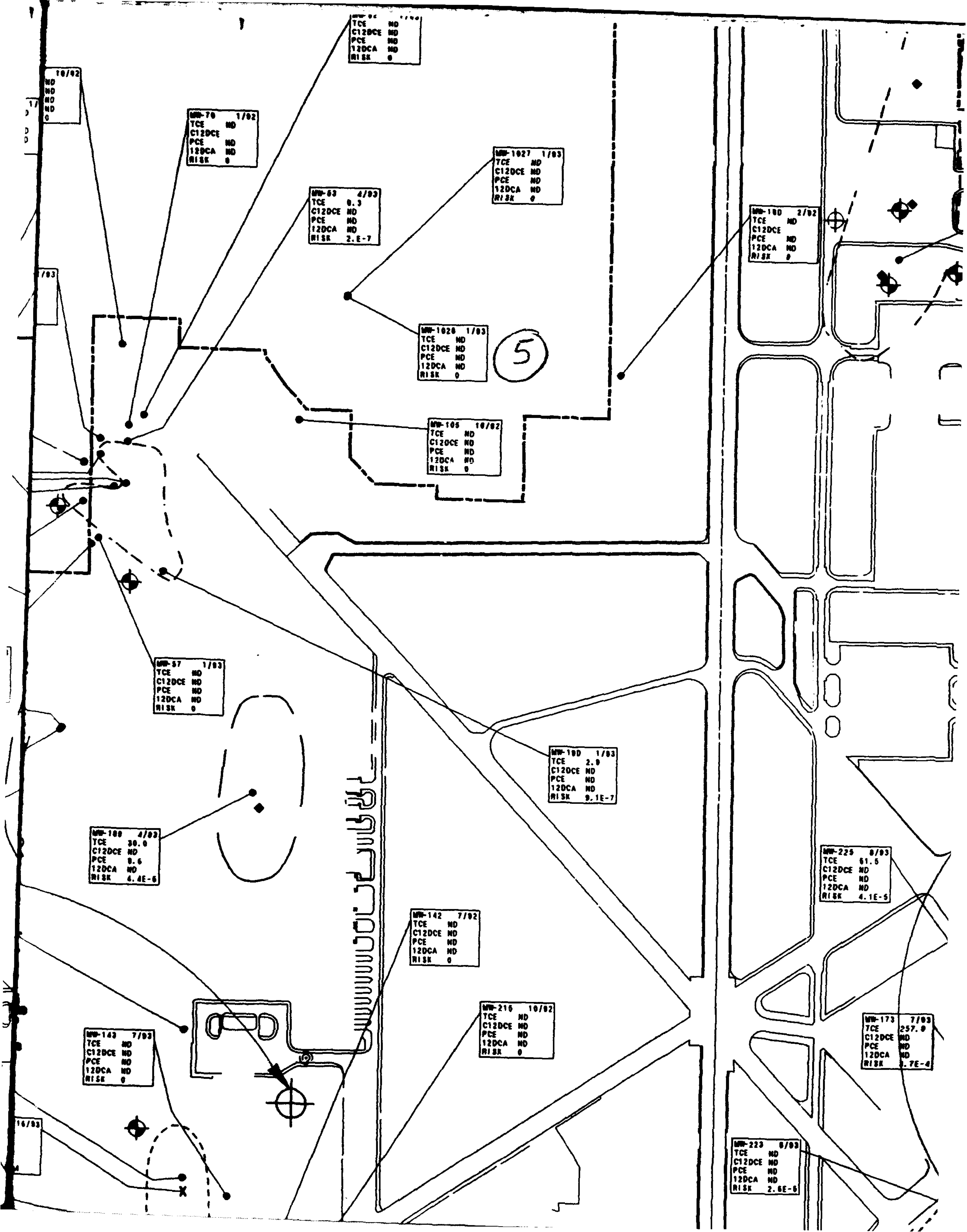
3

NOTE:

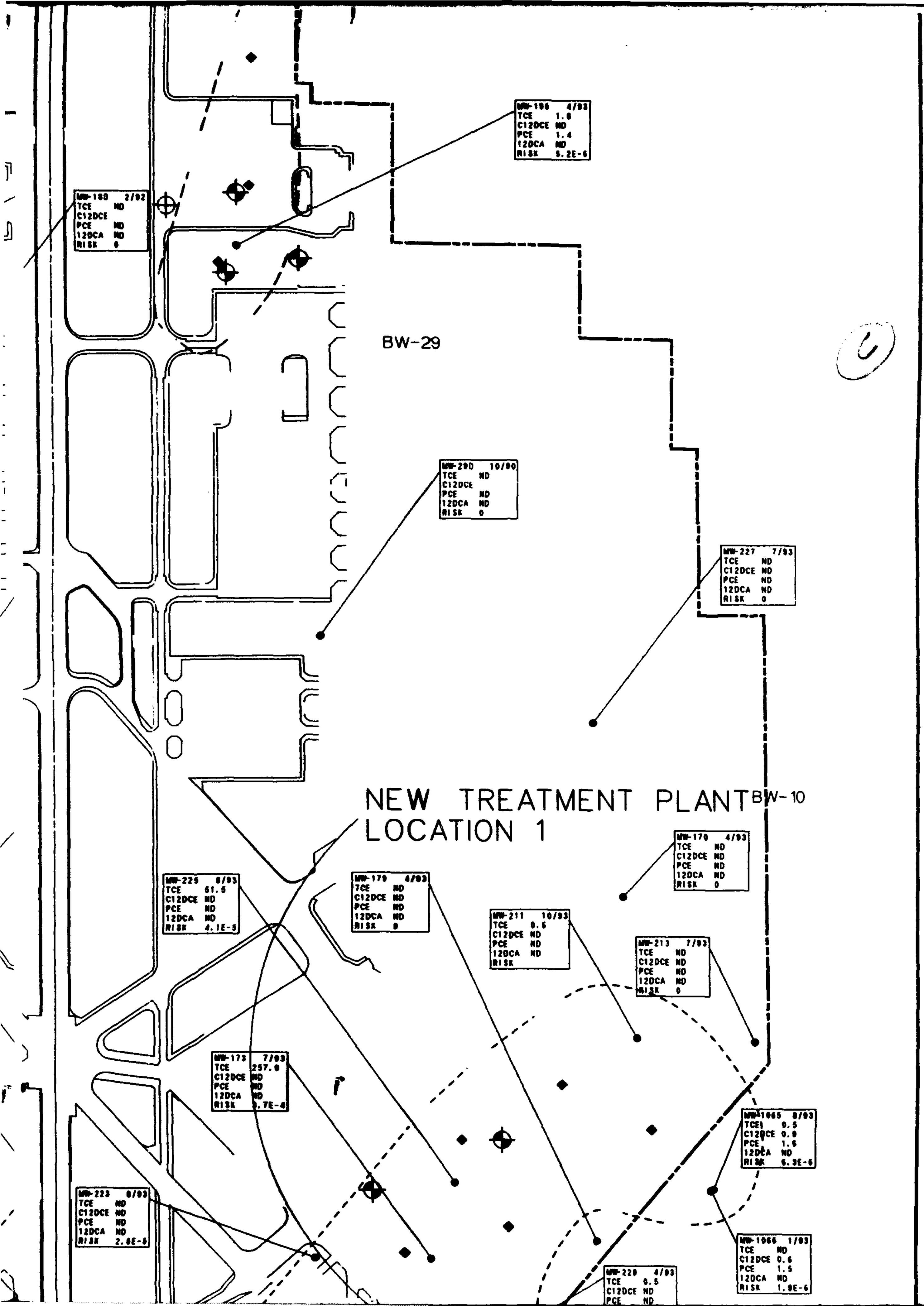
WELL LOCATIONS SHOWN WITHOUT ASSOCIATED DATA WERE NOT SAMPLED DURING OR AFTER 1988.

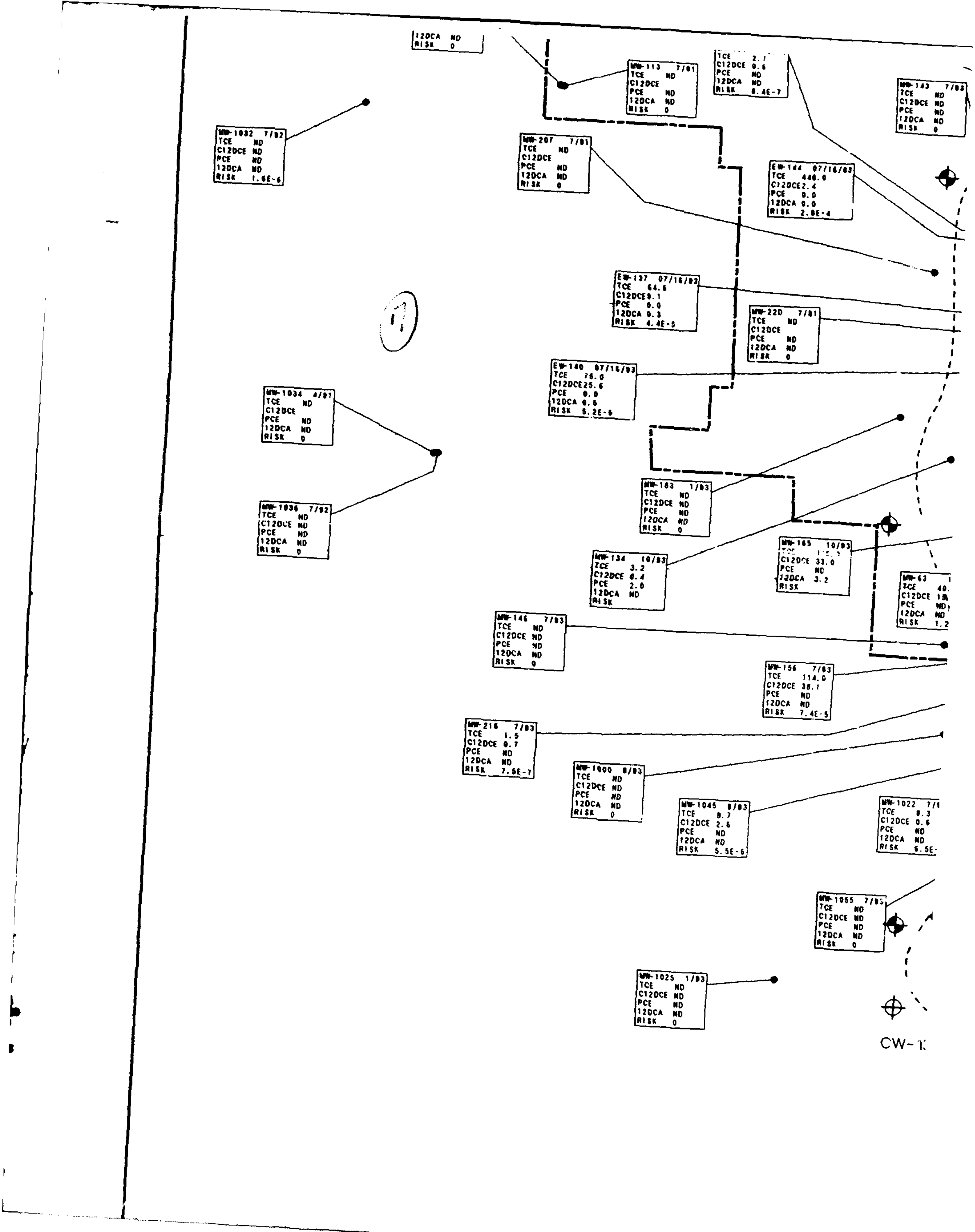


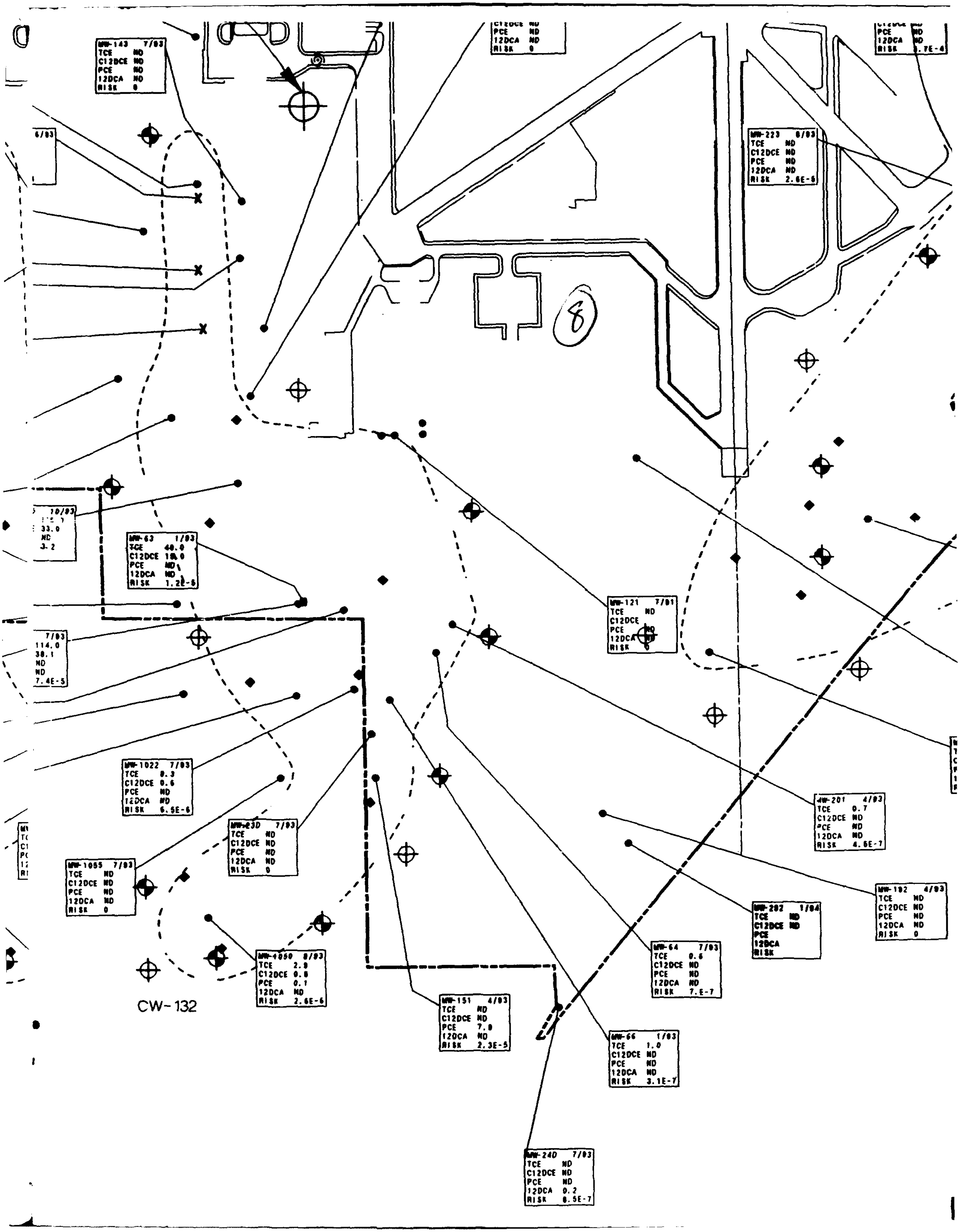

MW-1043 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1010 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-104 10/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1042 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-76 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-68 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1003 10/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1001 4/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-54 4/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-56 1/93
TCE 4.4
C12DCE ND
PCE 0.2
12DCA ND
RISK 1.7E-6
MW-61 4/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-74 1/93
TCE 2.9
C12DCE ND
PCE ND
12DCA 0.2
RISK 1.4E-6
MW-59 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 4.5E-7
MW-57
TCE
C12DCE
PCE
12DCA
RISK
MW-1030 1/92
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 1.E-7
MW-1031 10/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-109 10/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-108 10/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-188 4/93
TCE 30.0
C12DCE ND
PCE 8.6
12DCA ND
RISK 4.4E-5
EXISTING GROUNDWATER
TREATMENT PLANT
MW-200 4/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-112 1/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-113 7/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-130 10/92
TCE 2.7
C12DCE 0.6
PCE ND
12DCA ND
RISK 8.4E-7
MW-143 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1032 7/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 1.6E-6
MW-207 7/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
EW-144 07/16/93
TCE 440.0
C12DCE 2.4
PCE 0.0
12DCA 0.0
RISK 2.9E-4

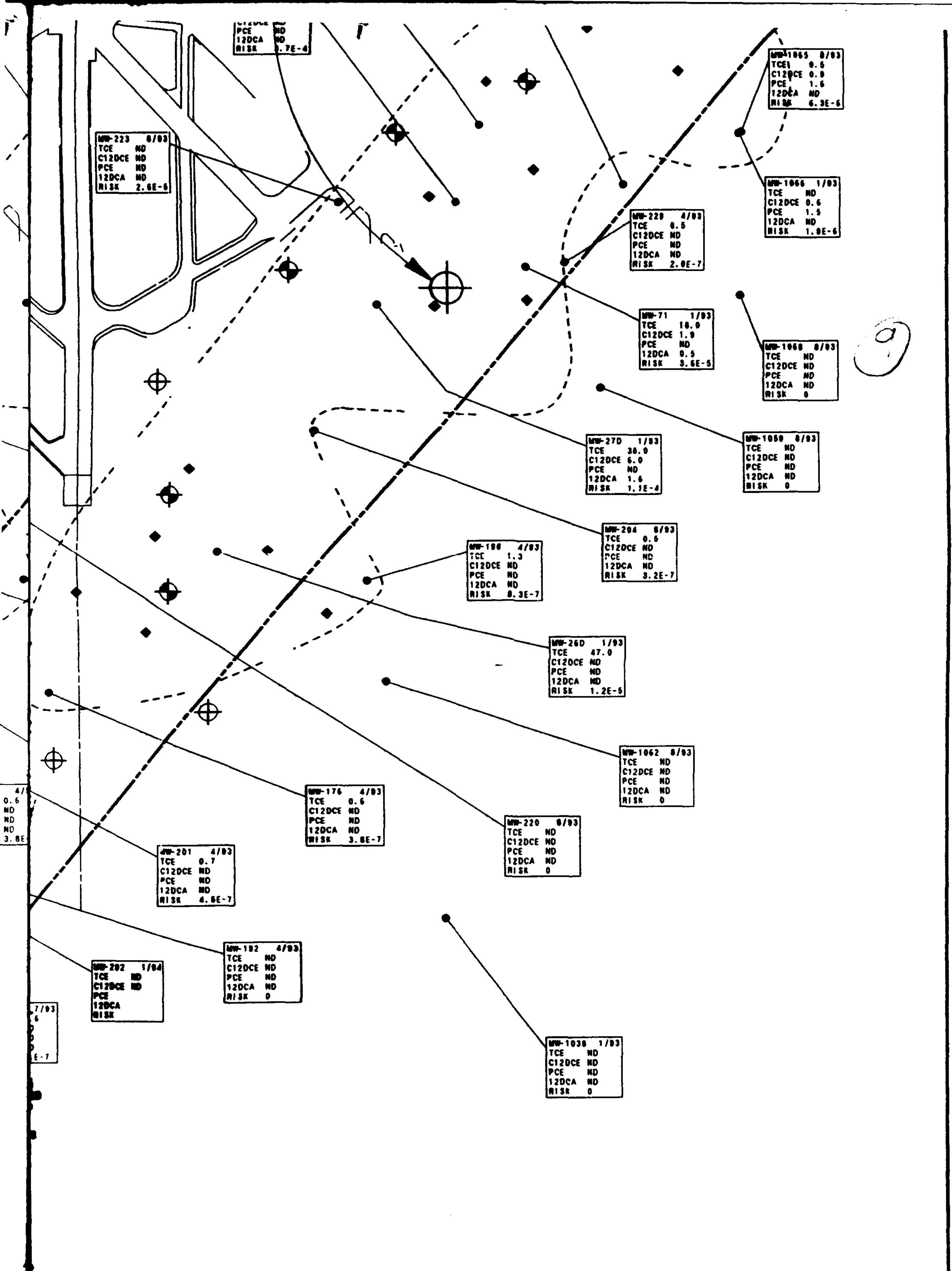


TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
10/92
ND
ND
ND
ND
0
MW-79 1/92
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-1027 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-53 4/93
TCE 0.3
C12DCE ND
PCE ND
12DCA ND
RISK 2.E-7
MW-18D 2/92
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-1028 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
5
MW-105 10/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-57 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-19D 1/93
TCE 2.9
C12DCE ND
PCE ND
12DCA ND
RISK 9.1E-7
MW-180 4/93
TCE 30.0
C12DCE ND
PCE 0.6
12DCA ND
RISK 4.4E-6
MW-225 8/93
TCE 61.5
C12DCE ND
PCE ND
12DCA ND
RISK 4.1E-5
MW-142 7/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-216 10/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-143 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-173 7/93
TCE 257.9
C12DCE ND
PCE ND
12DCA ND
RISK
MW-223 8/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 2.6E-6


MW-196 4/93
TCE 1.8
C12DCE ND
PCE 1.4
12DCA ND
RISK 5.2E-6
MW-18D 2/92
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
BW-29
MW-29D 10/90
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-227 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
NEW TREATMENT PLANT
LOCATION 1
BW-10
MW-170 4/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-225 8/93
TCE 61.5
C12DCE ND
PCE ND
12DCA ND
RISK 4.1E-5
MW-179 4/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-211 10/93
TCE 0.6
C12DCE ND
PCE ND
12DCA ND
RISK
MW-213 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-173 7/93
TCE 257.0
C12DCE ND
PCE ND
12DCA ND
RISK .7E-4
MW-1065 8/93
TCE 9.5
C12DCE 0.9
PCE 1.6
12DCA ND
RISK 6.3E-6
MW-223 8/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 2.6E-6
MW-1066 1/93
TCE ND
C12DCE 0.6
PCE 1.5
12DCA ND
RISK 1.9E-6
MW-220 4/93
TCE 0.5
C12DCE ND
PCE ND


12DCA ND
RISK 0
MW-113 7/81
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
TCE 2.7
C12DCE 0.6
PCE ND
12DCA ND
RISK 8.4E-7
MW-143 7/83
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1032 7/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 1.6E-6
MW-207 7/81
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
EW-144 07/16/93
TCE 446.0
C12DCE 2.4
PCE 0.0
12DCA 0.0
RISK 2.9E-4
EW-137 07/16/93
TCE 64.6
C12DCE 8.1
PCE 0.0
12DCA 0.3
RISK 4.4E-5
MW-220 7/81
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
EW-140 07/16/93
TCE 75.0
C12DCE 25.6
PCE 0.0
12DCA 0.6
RISK 5.2E-5
MW-1034 4/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-183 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1036 7/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-185 10/93
C12DCE 33.0
PCE ND
12DCA 3.2
RISK
MW-134 10/93
TCE 3.2
C12DCE 0.4
PCE 2.0
12DCA ND
RISK
MW-63
TCE 40.
C12DCE 15
PCE ND
12DCA ND
RISK 1.2
MW-146 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-156 7/93
TCE 114.0
C12DCE 38.1
PCE ND
12DCA ND
RISK 7.4E-5
MW-216 7/93
TCE 1.5
C12DCE 0.7
PCE ND
12DCA ND
RISK 7.5E-7
MW-1000 8/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1045 8/93
TCE 8.7
C12DCE 2.6
PCE ND
12DCA ND
RISK 5.5E-6
MW-1022
TCE 8.3
C12DCE 0.6
PCE ND
12DCA ND
RISK 6.5E-
MW-1055 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1025 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
CW-1

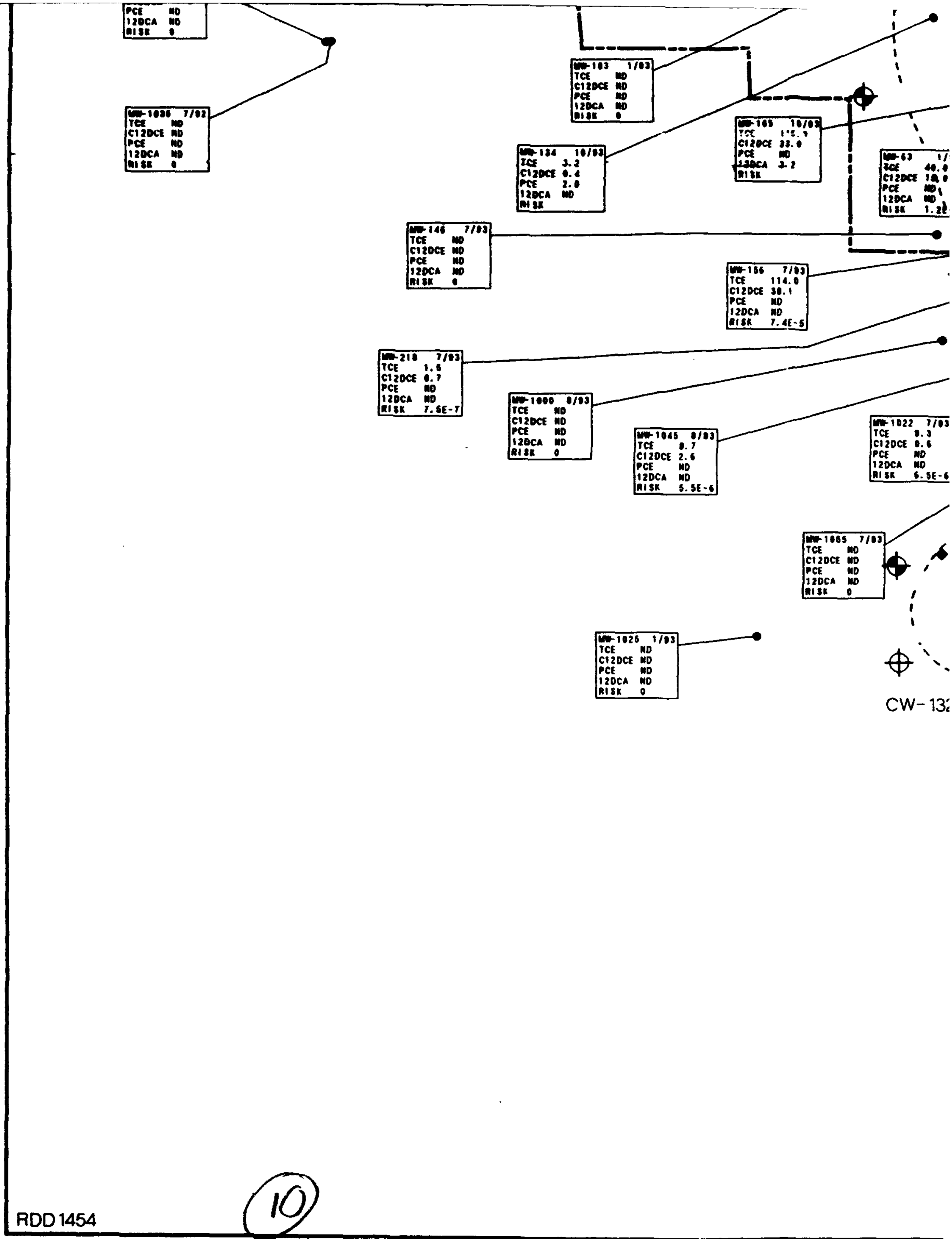

MW-143 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
C12DCE ND
PCE ND
12DCA ND
RISK 0
PCE ND
12DCA ND
MW-223 8/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 2.6E-6
8
10/93
33.0
ND
3.2
MW-63 1/93
TCE 40.0
PCE ND
12DCA ND
7/93
114.0
38.1
ND
ND
7.4E-5
MW-121 7/93
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-1022 7/93
TCE 0.3
C12DCE 0.6
PCE ND
12DCA ND
RISK 6.5E-6
MW-23D 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-201 4/93
TCE 0.7
C12DCE ND
PCE ND
12DCA ND
RISK 4.6E-7
MW-1055 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-192 4/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-202 1/94
TCE ND
C12DCE ND
PCE
12DCA
RISK
MW-4050 8/93
TCE 2.9
C12DCE 0.8
PCE 0.1
12DCA ND
RISK 2.6E-6
MW-64 7/93
TCE 0.6
C12DCE ND
PCE ND
12DCA ND
RISK 7.E-7
CW-132
MW-151 4/93
TCE ND
C12DCE ND
PCE 7.0
12DCA ND
RISK 2.3E-5
MW-66 1/93
TCE 1.0
C12DCE ND
PCE ND
12DCA ND
RISK 3.1E-7
MW-24D 7/93
TCE ND
C12DCE ND
PCE ND
12DCA 0.2
RISK 6.5E-7



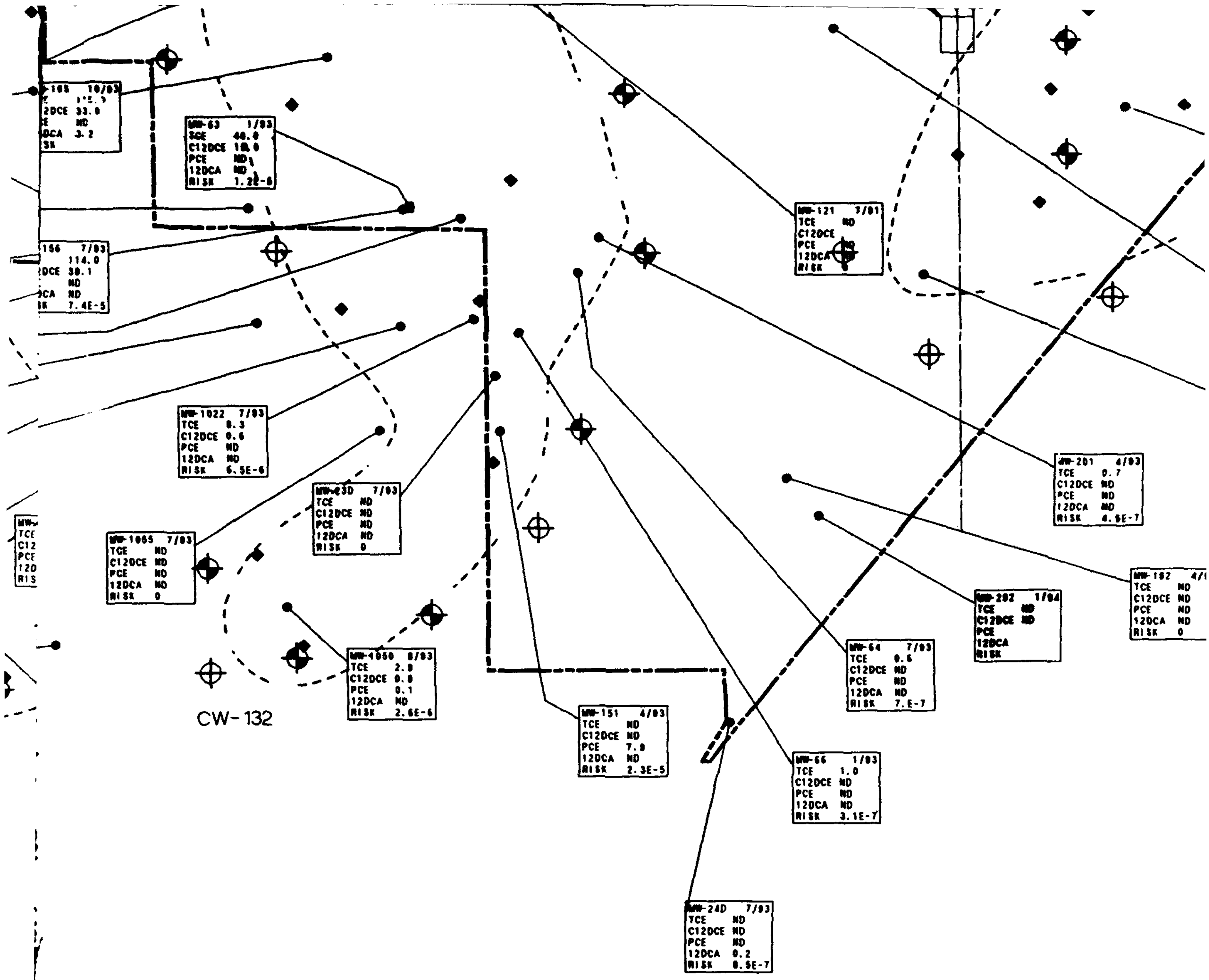
PCE ND
12DCA ND
RISK .7E-4
MW-1065 8/93
TCE 0.5
C12DCE 0.9
PCE 1.6
12DCA ND
RISK 6.3E-6
MW-223 8/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 2.6E-6
MW-1066 1/93
TCE ND
C12DCE 0.6
PCE 1.5
12DCA ND
RISK 1.8E-6
MW-229 4/93
TCE 0.5
C12DCE ND
PCE ND
12DCA ND
RISK 2.0E-7
MW-71 1/93
TCE 18.0
C12DCE 1.9
PCE ND
12DCA 0.5
RISK 3.6E-5
MW-1068 8/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-27D 1/93
TCE 36.0
C12DCE 6.0
PCE ND
12DCA 1.6
RISK 1.1E-4
MW-1059 8/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-204 8/93
TCE 0.6
C12DCE ND
PCE ND
12DCA ND
RISK 3.2E-7
MW-196 4/93
TCE 1.3
C12DCE ND
PCE ND
12DCA ND
RISK 8.3E-7
MW-26D 1/93
TCE 47.0
C12DCE ND
PCE ND
12DCA ND
RISK 1.2E-5
MW-1062 8/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-176 4/93
TCE 0.6
C12DCE ND
PCE ND
12DCA ND
RISK 3.8E-7
MW-220 8/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-201 4/93
TCE 0.7
C12DCE ND
PCE ND
12DCA ND
RISK 4.6E-7
MW-192 4/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-292 1/94
TCE ND
C12DCE ND
PCE
12DCA
RISK
MW-1038 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0

G

FIGURE E-12



MEY94/MEY-E-12.DGN



MW-63 1/93
TCE 40.0
C12DCE 10.0
PCE ND
12DCA ND
RISK 1.2E-6
MW-1022 7/93
TCE 8.3
C12DCE 0.6
PCE ND
12DCA ND
RISK 6.5E-6
MW-1065 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1050 8/93
TCE 2.9
C12DCE 0.8
PCE 0.1
12DCA ND
RISK 2.6E-6
CW-132
MW-151 4/93
TCE ND
C12DCE ND
PCE 7.9
12DCA ND
RISK 2.3E-5
MW-121 7/91
TCE ND
C12DCE
RISK
MW-201 4/93
TCE 0.7
C12DCE ND
PCE ND
12DCA ND
RISK 4.5E-7
MW-192
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-292 1/94
TCE ND
C12DCE ND
PCE
12DCA
RISK
MW-64 7/93
TCE 0.6
C12DCE ND
PCE ND
12DCA ND
RISK 7.E-7
MW-66 1/93
TCE 1.0
C12DCE ND
PCE ND
12DCA ND
RISK 3.1E-7
MW-24D 7/93
TCE ND
C12DCE ND
PCE ND
12DCA 0.2
RISK 8.5E-7

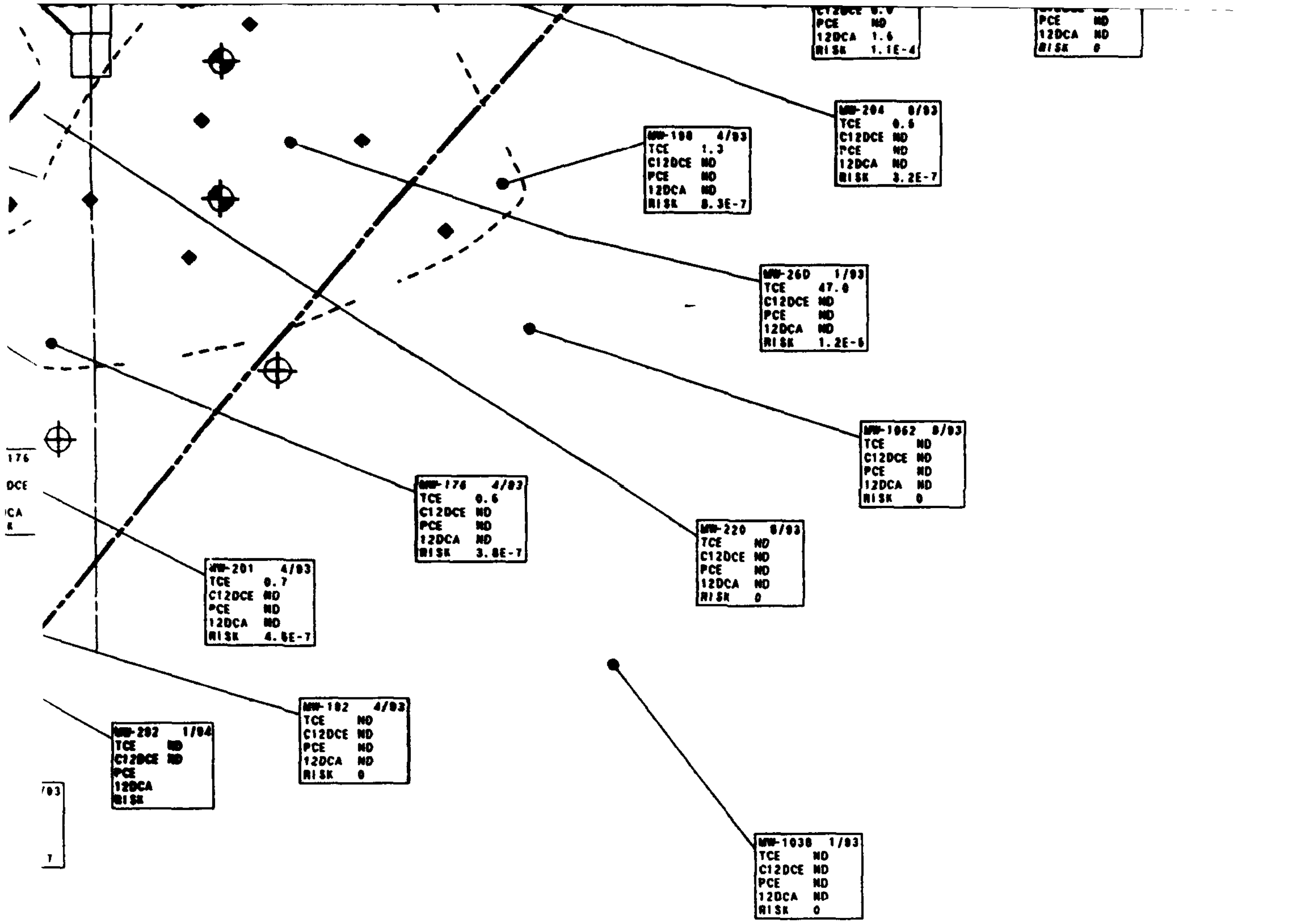


FIGURE E-12
MONITORING AND EXTRACTION WELL LOCATIONS MONITORING ZONE B BACKGROUND TARGET VOLUME
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

CH2M HILL

(1)

WELL SUMMARY

X EXISTING EXTRACTION WELL

▶ NEW EXTRACTION WELLS

⊕ NEW MONITORING WELLS FOR WATER QUALITY

⊕ NEW MONITORING WELLS FOR HYDRAULIC CONTROL

• EXISTING MONITORING WELLS

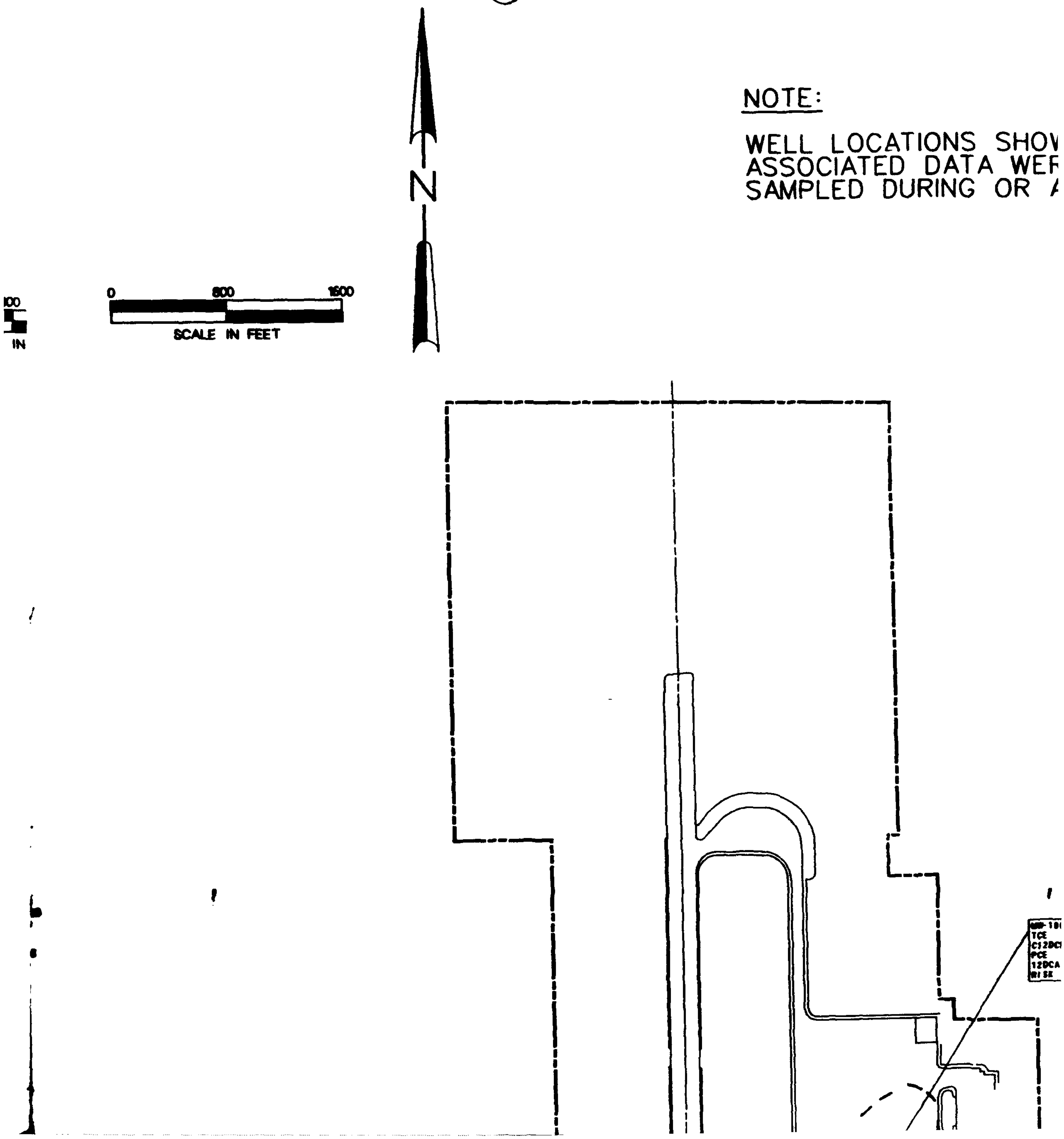
---- TARGET VOLUME BOUNDARY

0

2

NOTE:

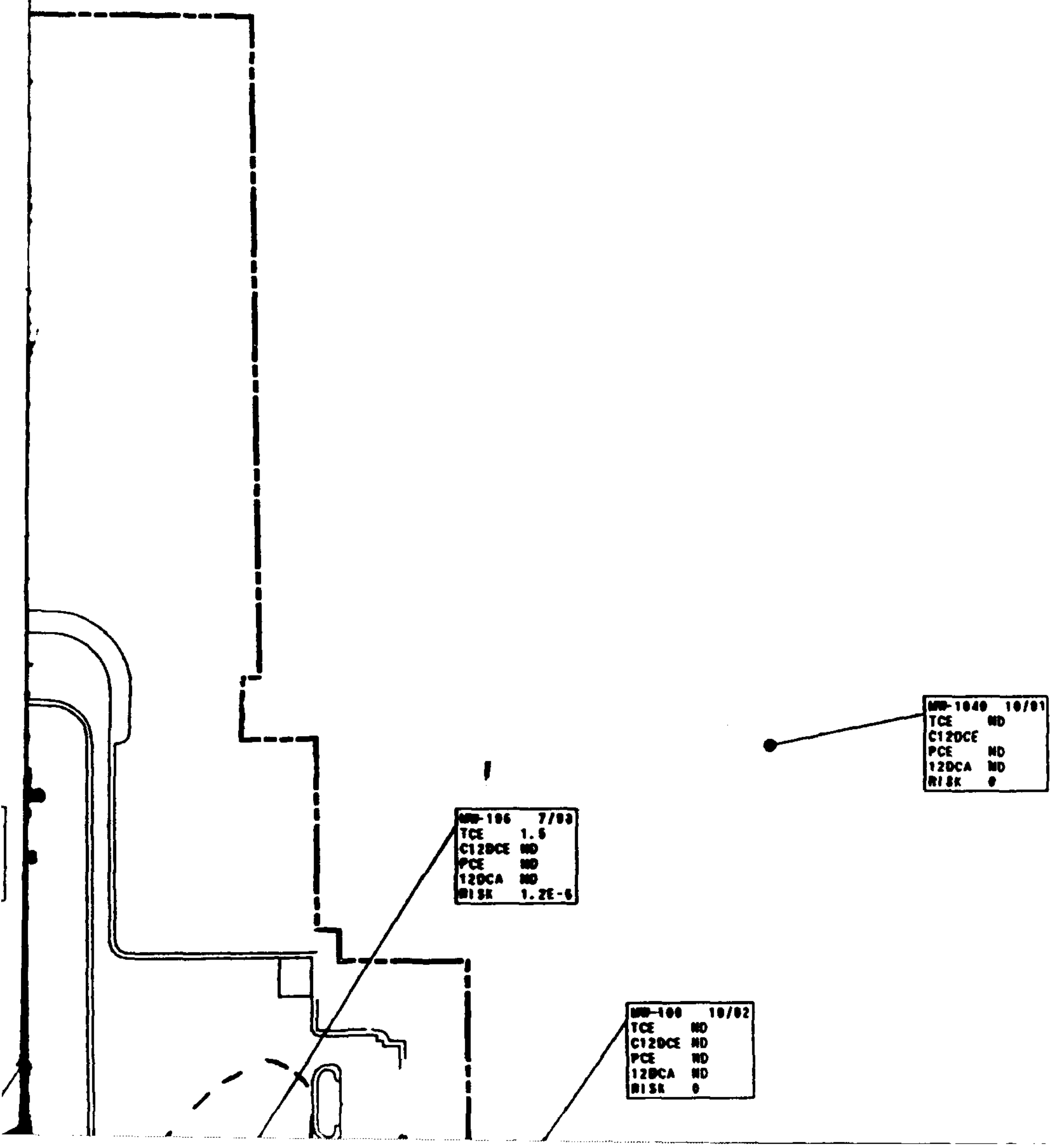
WELL LOCATIONS SHOW
ASSOCIATED DATA WER
SAMPLED DURING OR A

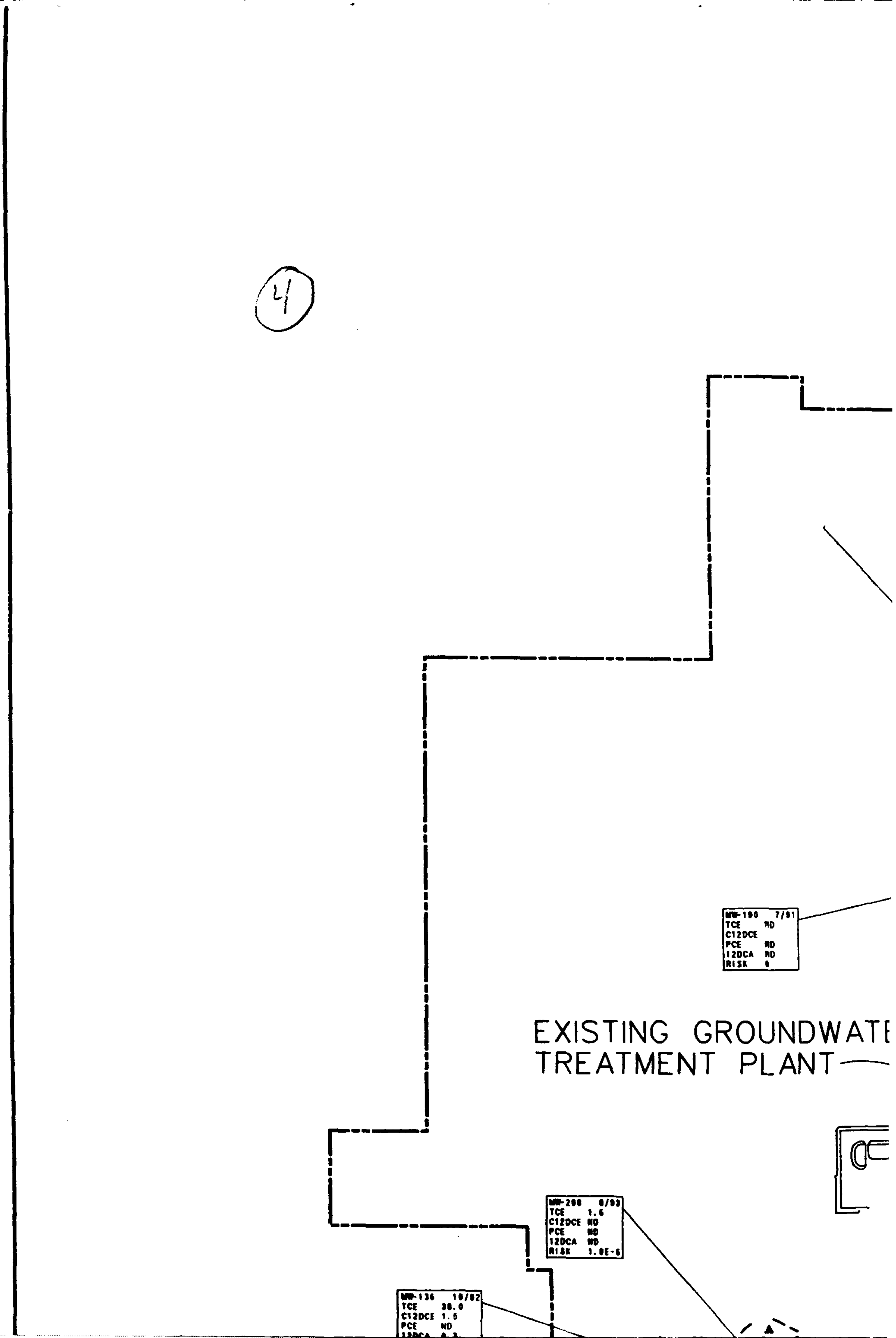


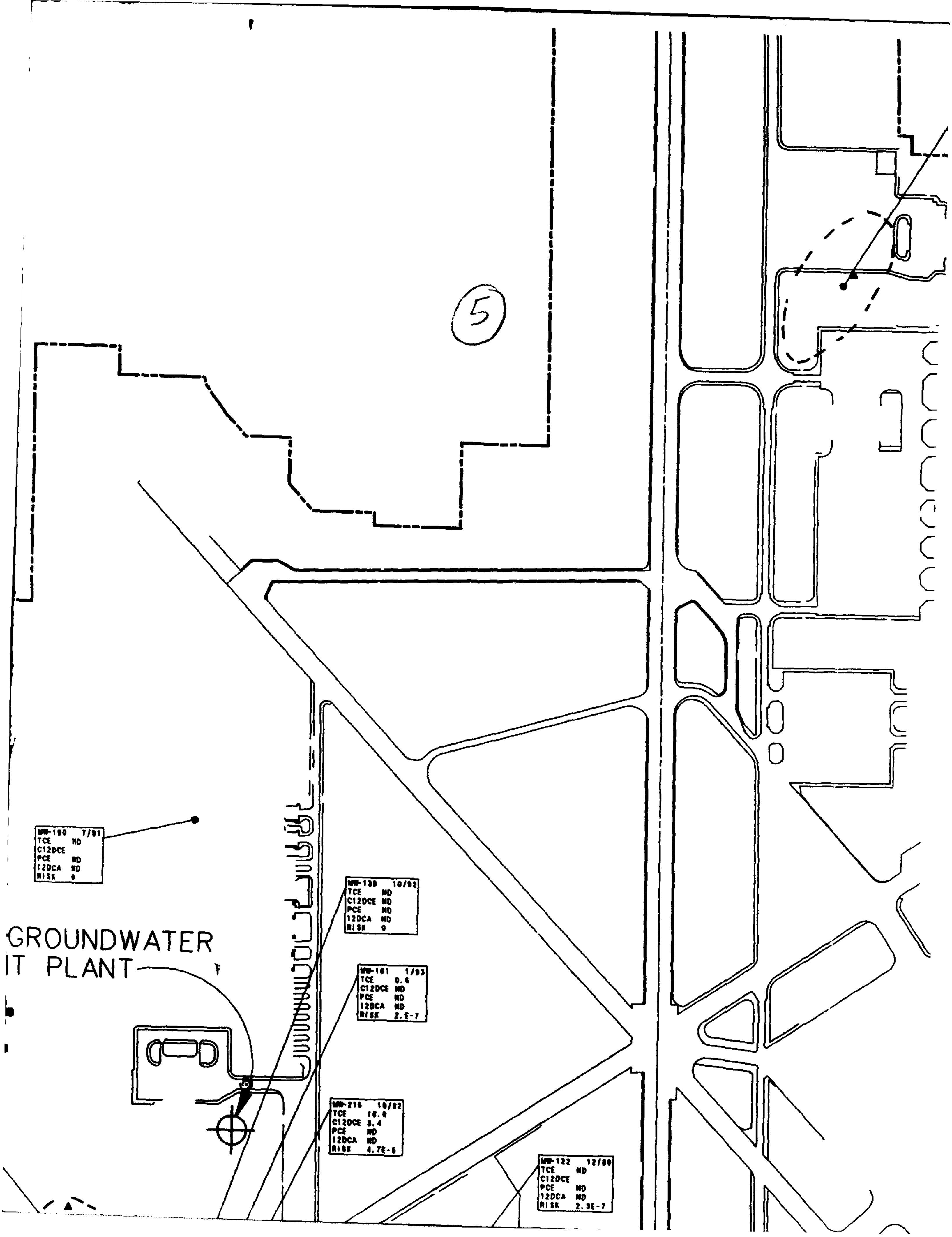
(3)

NOTE:

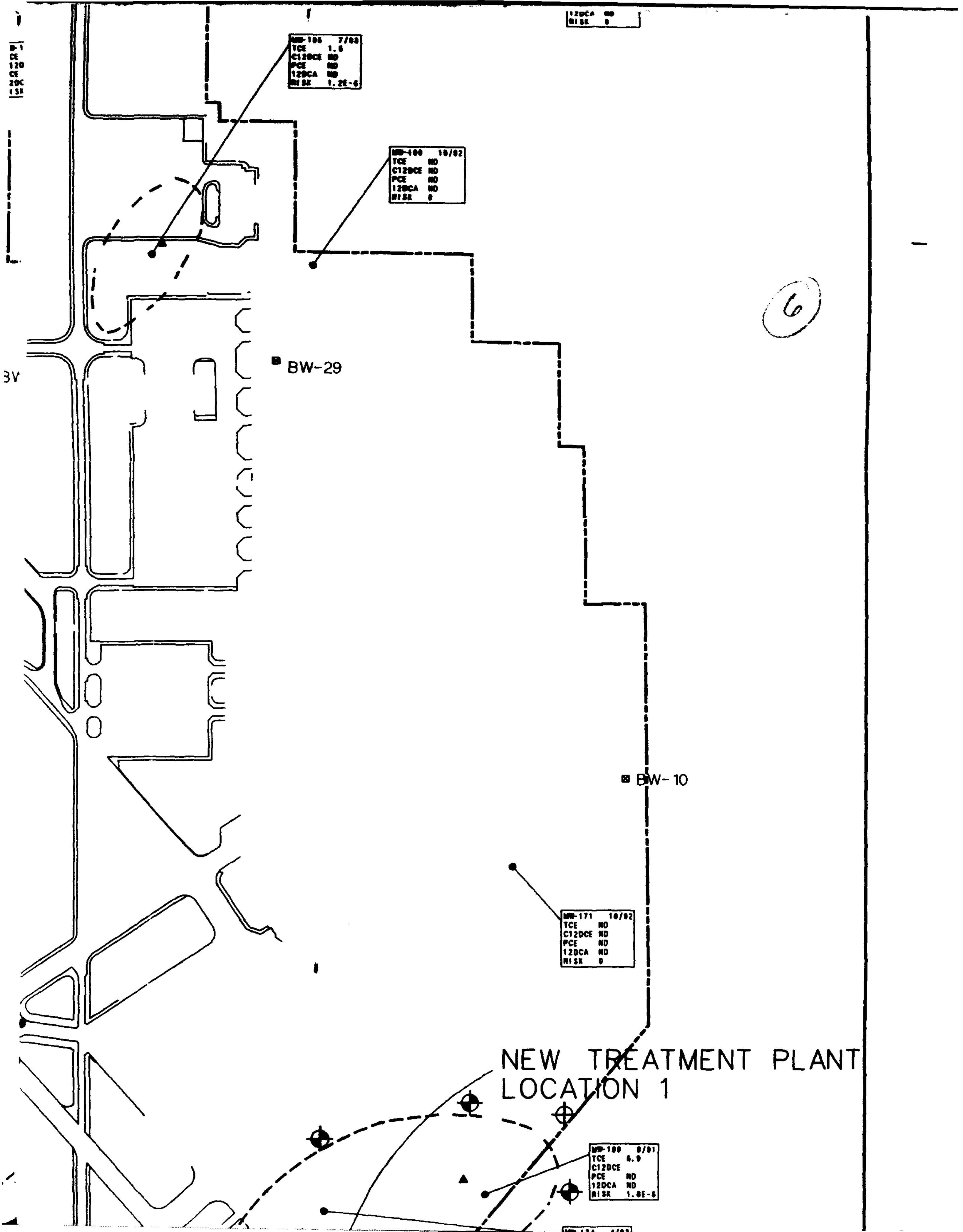
V WELL LOCATIONS SHOWN WITHOUT
N ASSOCIATED DATA WERE NOT
E SAMPLED DURING OR AFTER 1988.




4
MW-190 7/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
EXISTING GROUNDWATE
TREATMENT PLANT
MW-208 8/93
TCE 1.6
C12DCE ND
PCE ND
12DCA ND
RISK 1.0E-6
MW-136 10/92
TCE 38.0
C12DCE 1.6
PCE ND

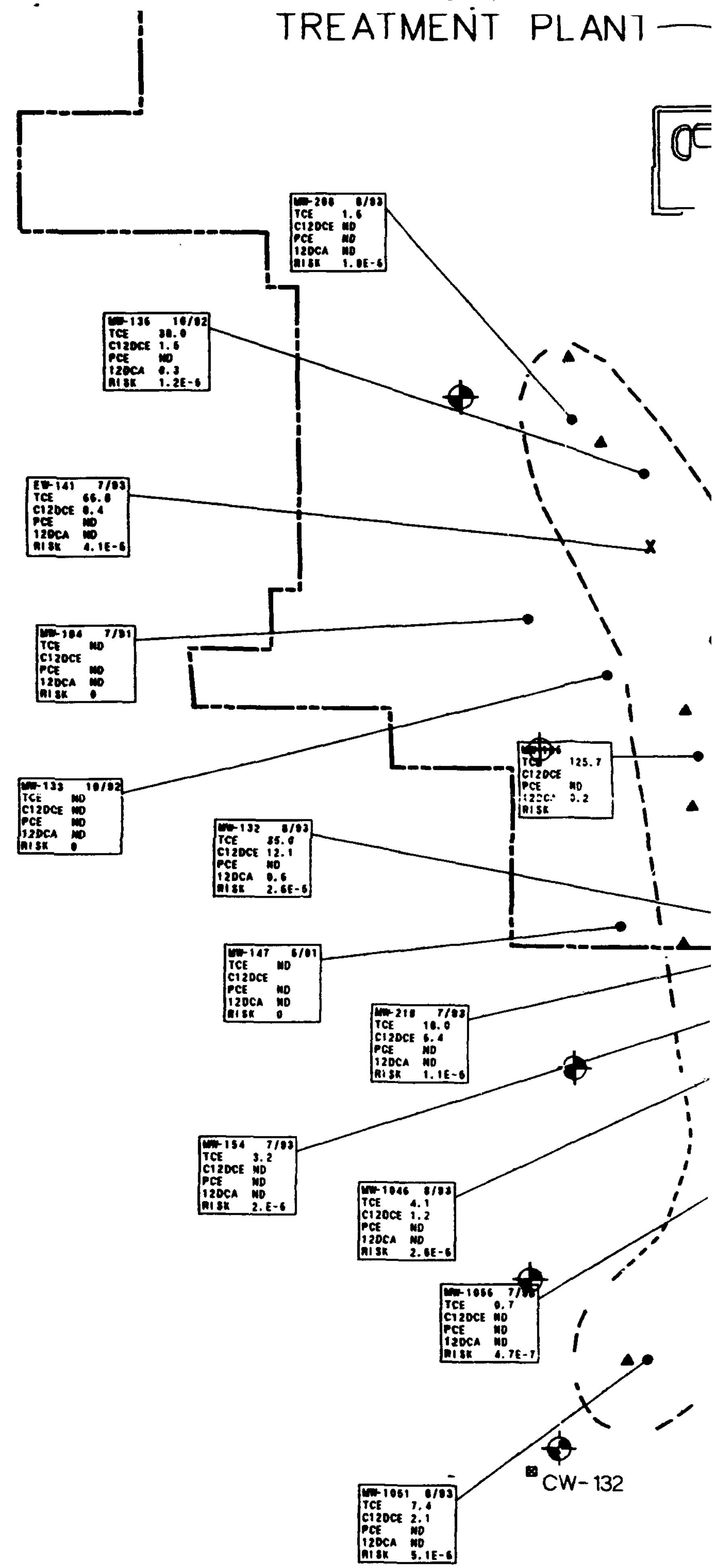


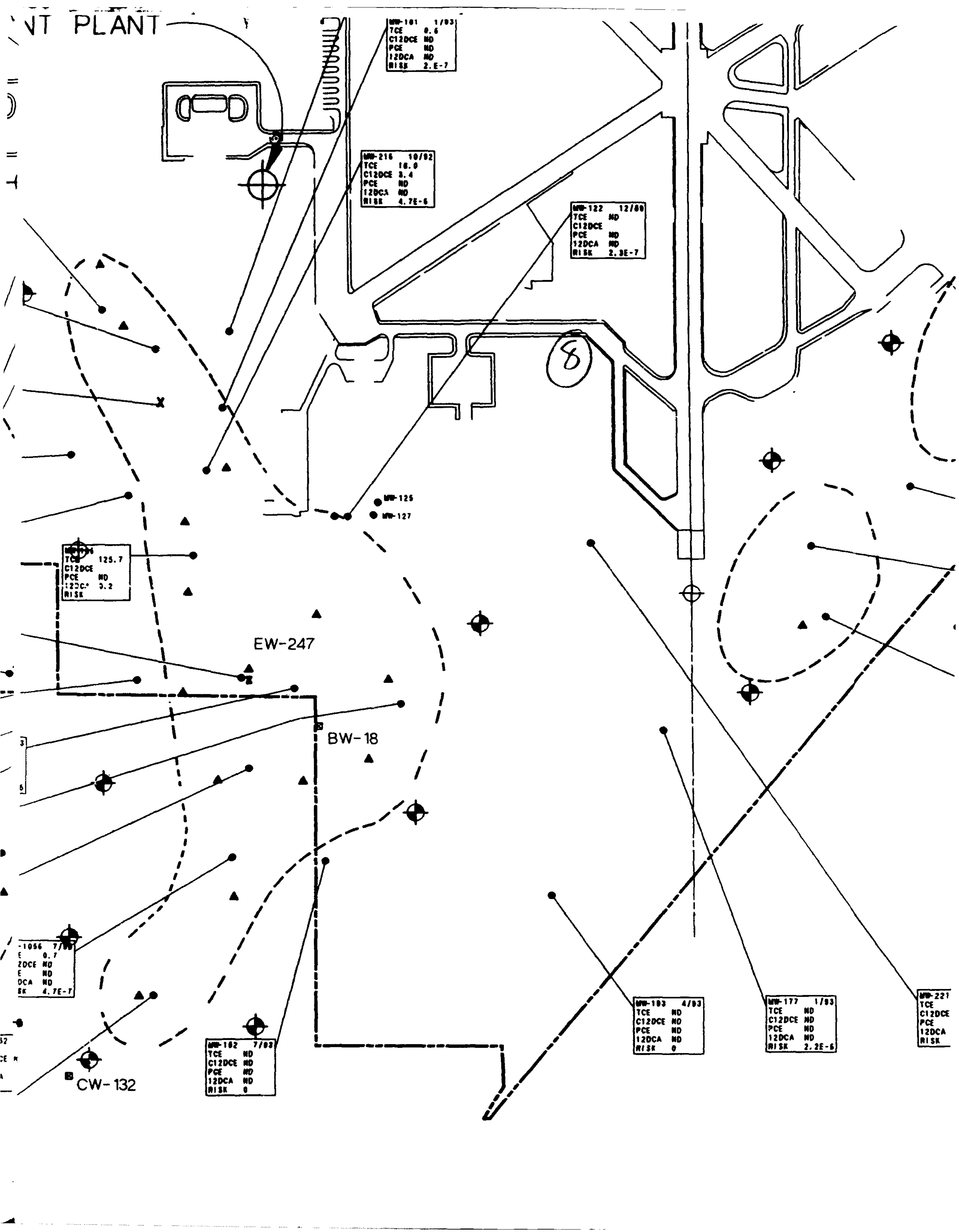
5
MW-190 7/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-138 10/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
GROUNDWATER
IT PLANT
MW-181 1/93
TCE 0.6
C12DCE ND
PCE ND
12DCA ND
RISK 2.E-7
MW-216 10/92
TCE 16.0
C12DCE 3.4
PCE ND
12DCA ND
RISK 4.7E-6
MW-122 12/90
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 2.3E-7



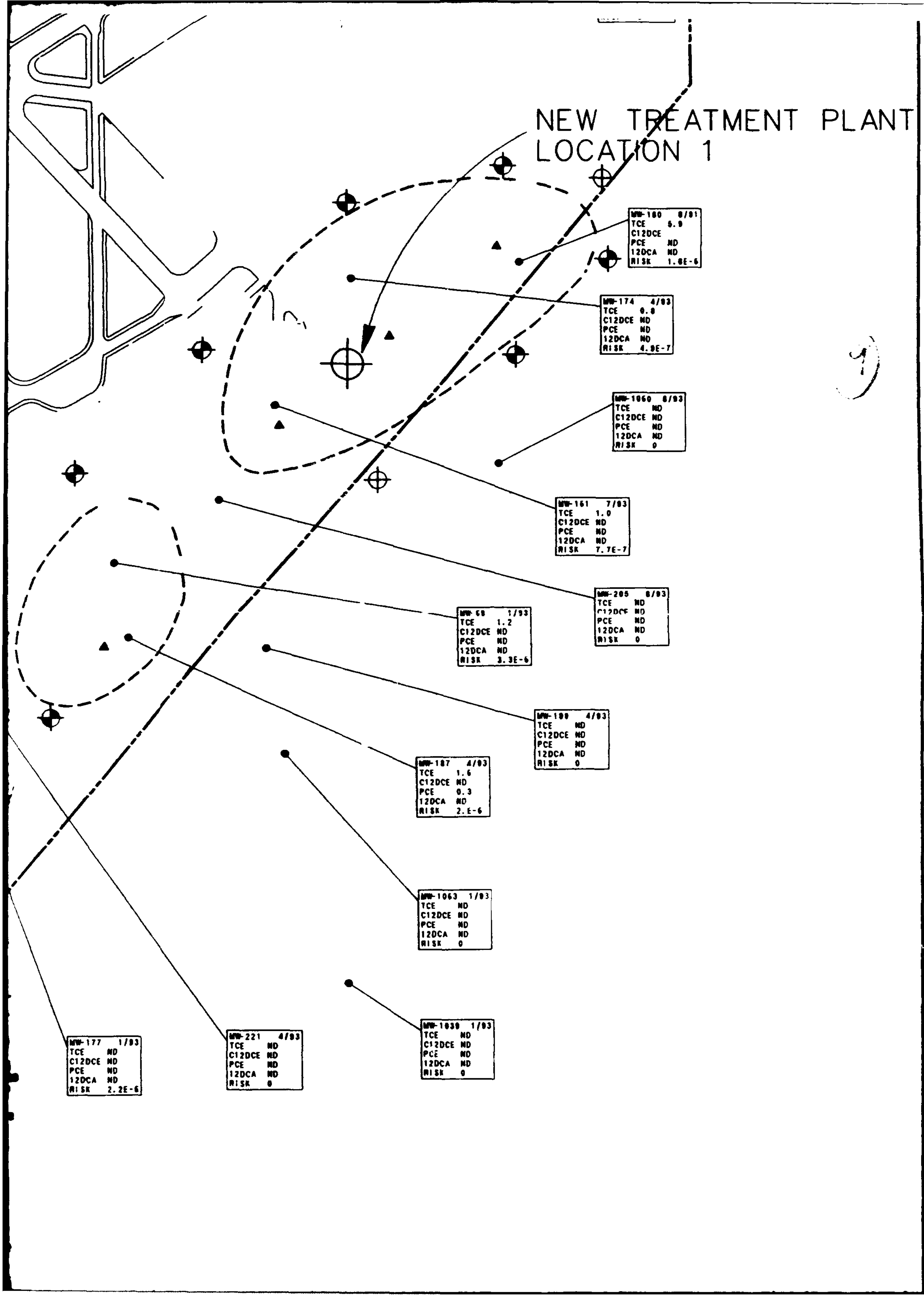
BW-29
BW-10
MW-171 10/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
NEW TREATMENT PLANT
LOCATION 1
6

7

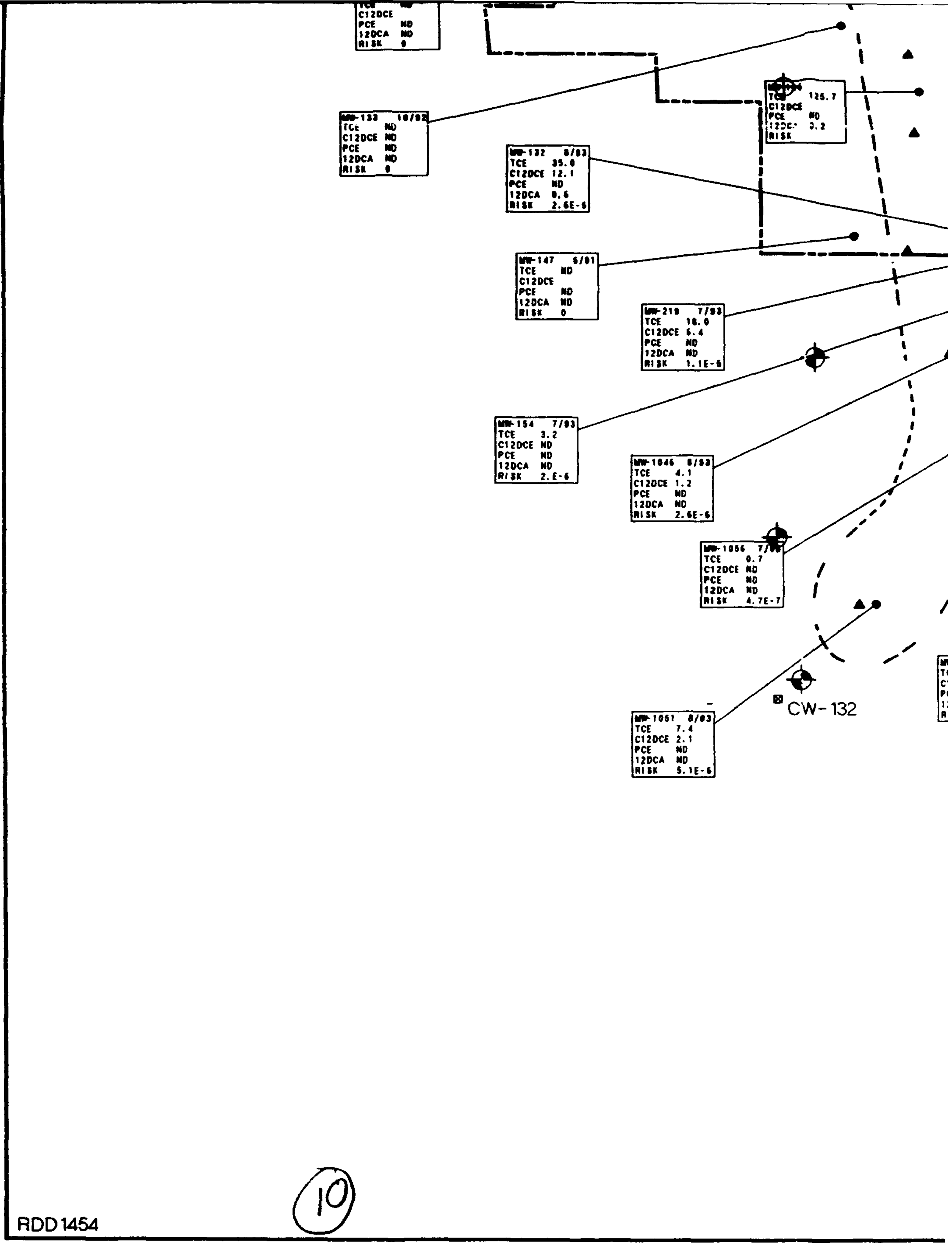

TREATMENT PLANT
MW-208 8/93
TCE 1.6
C12DCE ND
PCE ND
12DCA ND
RISK 1.0E-6
MW-136 10/92
TCE 30.0
C12DCE 1.6
PCE ND
12DCA 0.3
RISK 1.2E-6
EW-141 7/93
TCE 66.0
C12DCE 0.4
PCE ND
12DCA ND
RISK 4.1E-6
MW-104 7/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
TCE 125.7
C12DCE
PCE ND
12DCA 0.2
RISK
MW-133 10/92
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-132 8/93
TCE 35.0
C12DCE 12.1
PCE ND
12DCA 0.6
RISK 2.6E-6
MW-147 6/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-218 7/93
TCE 10.0
C12DCE 6.4
PCE ND
12DCA ND
RISK 1.1E-6
MW-154 7/93
TCE 3.2
C12DCE ND
PCE ND
12DCA ND
RISK 2.E-6
MW-1046 8/93
TCE 4.1
C12DCE 1.2
PCE ND
12DCA ND
RISK 2.6E-6
MW-1066
TCE 0.7
C12DCE ND
PCE ND
12DCA ND
RISK 4.7E-7
CW-132
MW-1061 6/93
TCE 7.4
C12DCE 2.1
PCE ND
12DCA ND
RISK 5.1E-6



NT PLANT
MW-101 1/93
TCE 0.6
C12DCE ND
PCE ND
12DCA ND
RISK 2.E-7
MW-216 10/92
TCE 16.0
C12DCE 3.4
PCE ND
12DCA ND
RISK 4.7E-6
MW-122 12/89
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 2.3E-7
8
MW-125
MW-127
TCE 125.7
C12DCE
PCE ND
RISK
EW-247
BW-18
MW-193 4/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-177 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 2.2E-6
MW-221
TCE
C12DCE
PCE
12DCA
RISK
MW-182 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
CW-132

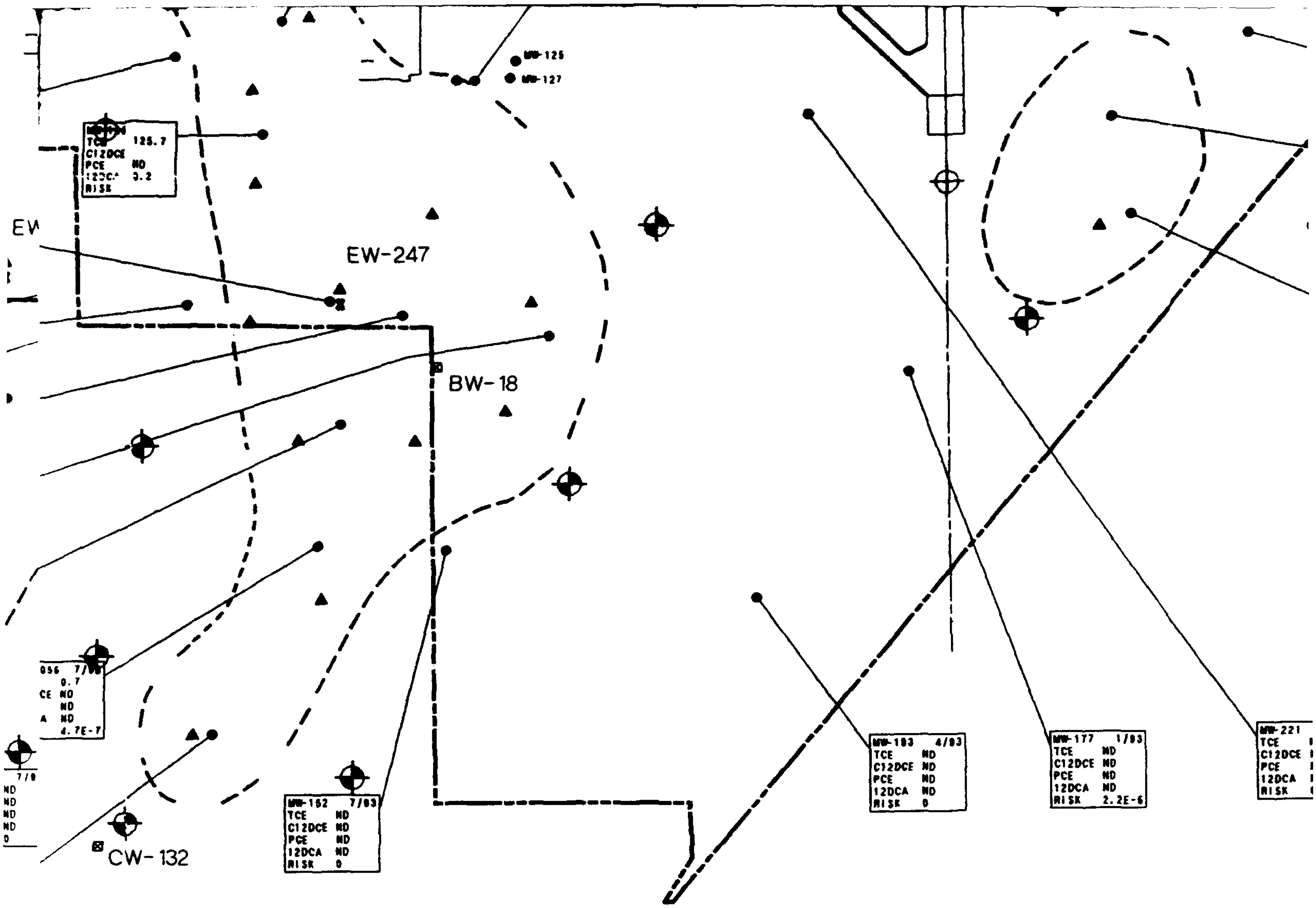


NEW TREATMENT PLANT
LOCATION 1
MW-180 8/91
TCE 5.9
C12DCE
PCE ND
12DCA ND
RISK 1.8E-6
MW-174 4/93
TCE 0.8
C12DCE ND
PCE ND
12DCA ND
RISK 4.9E-7
MW-1060 8/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-161 7/93
TCE 1.0
C12DCE ND
PCE ND
12DCA ND
RISK 7.7E-7
MW-205 8/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-68 1/93
TCE 1.2
C12DCE ND
PCE ND
12DCA ND
RISK 3.3E-6
MW-189 4/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-187 4/93
TCE 1.6
C12DCE ND
PCE 0.3
12DCA ND
RISK 2.E-6
MW-1063 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-1039 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-177 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 2.2E-6
MW-221 4/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0



10

MET94/MEY-E-13.dgn


MW-125
MW-127
TCE 125.7
C12DCE
PCE ND
RISK
EW
EW-247
BW-18
056 7/
0.7
CE ND
ND
A ND
4.7E-7
7/9
ND
ND
ND
ND
0
CW-132
MW-152 7/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-193 4/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-177 1/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 2.2E-6
MW-221
TCE
C12DCE
PCE
12DCA
RISK

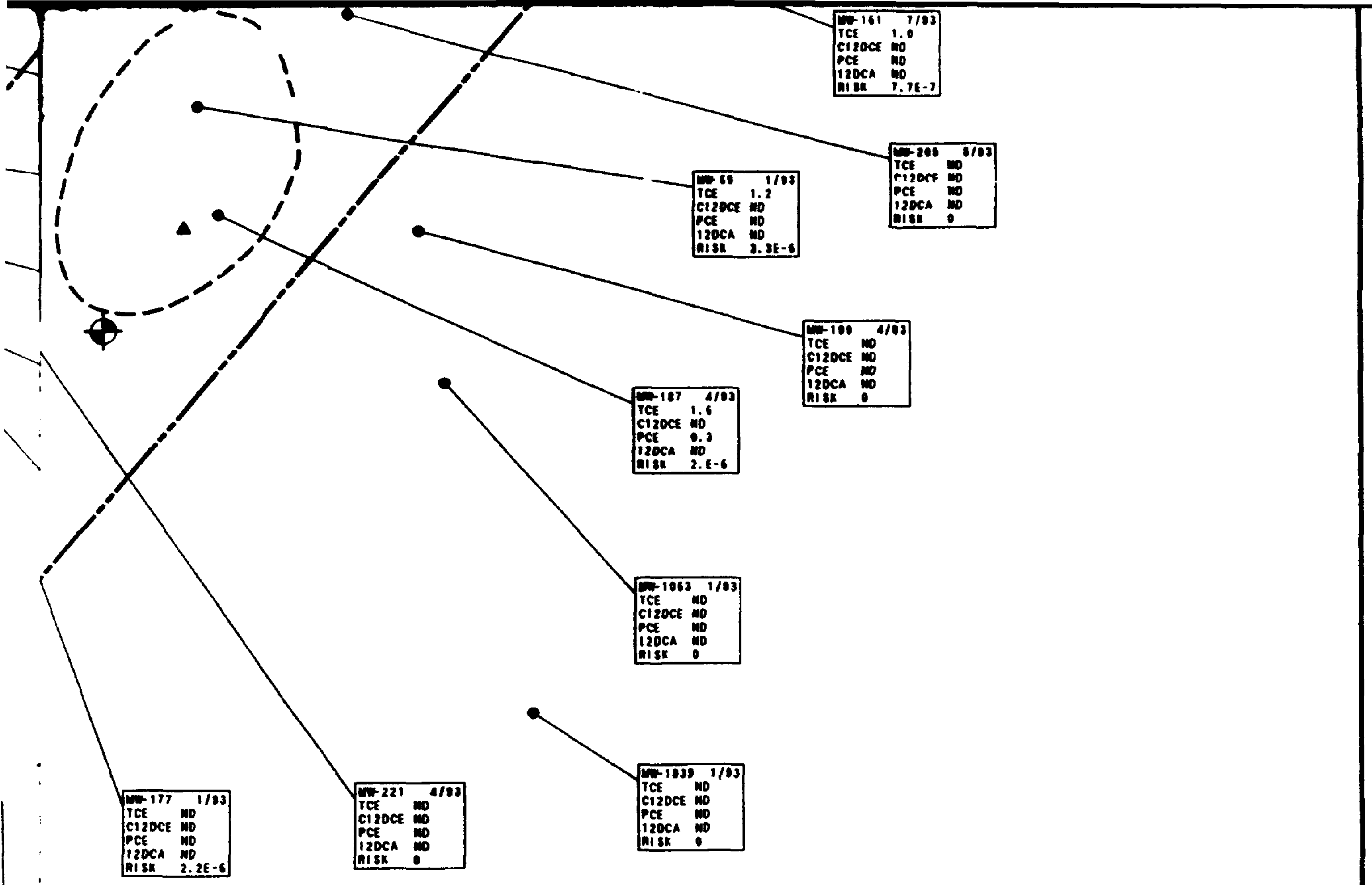
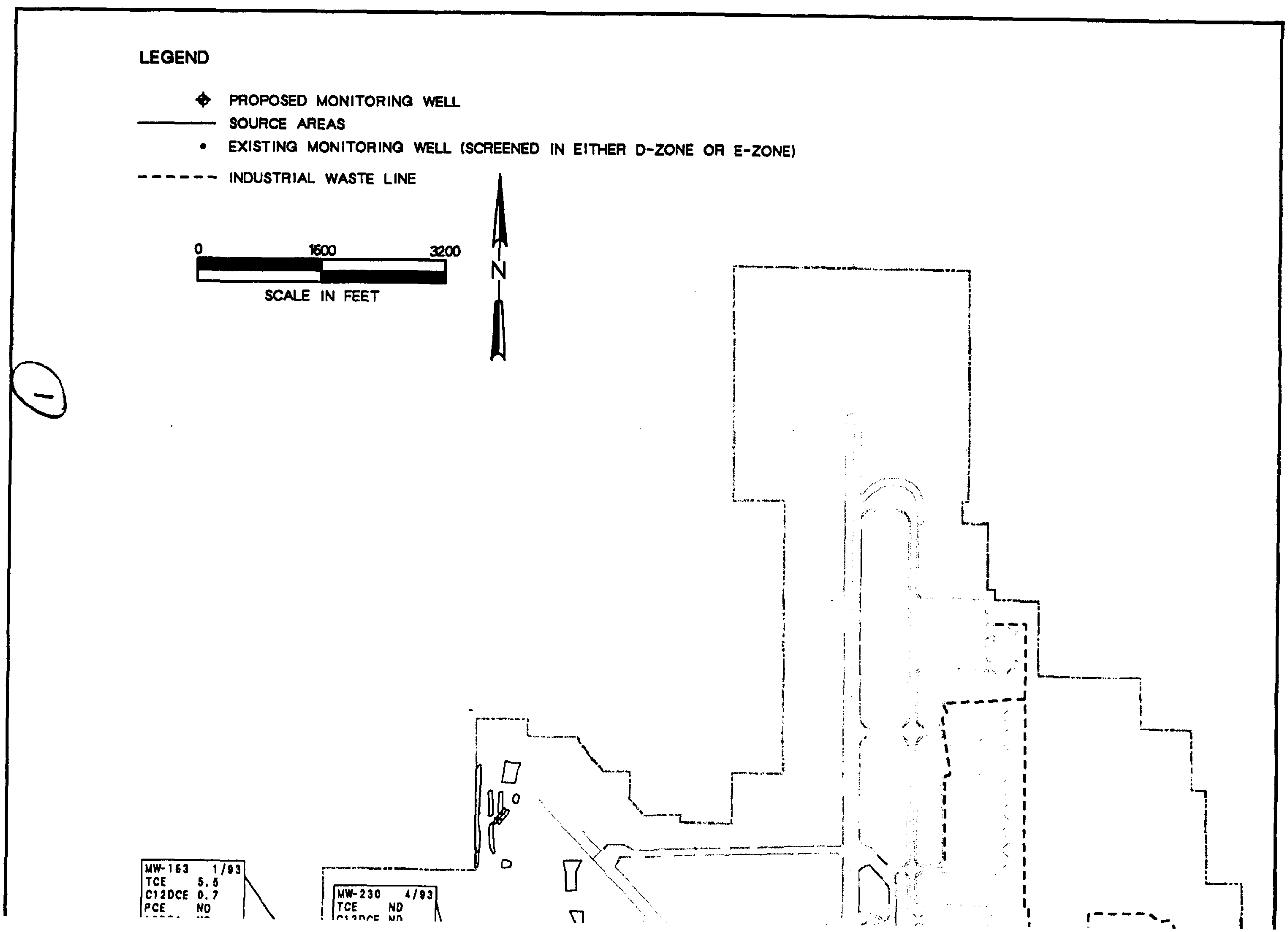
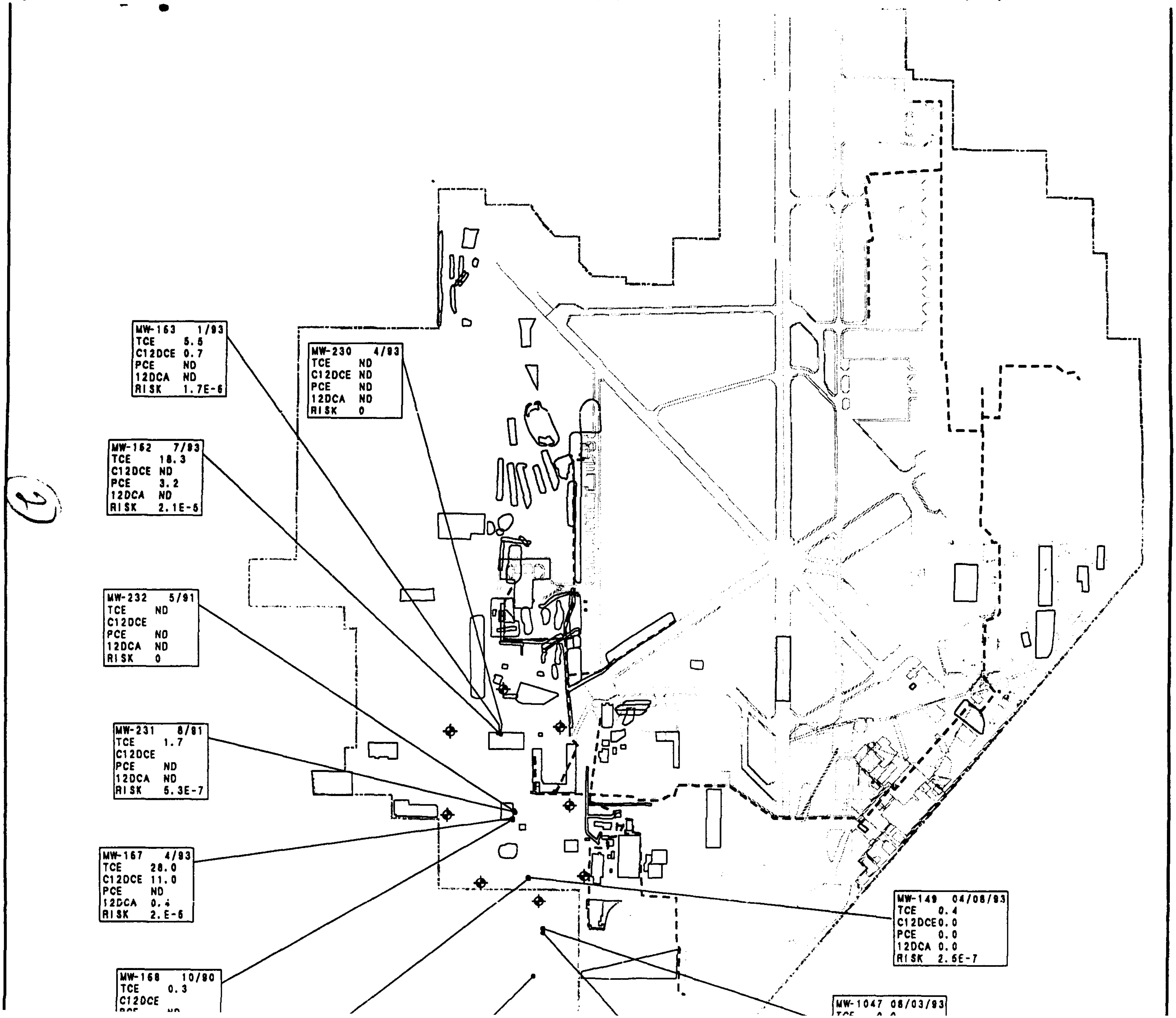


FIGURE E-13
MONITORING AND EXTRACTION WELL LOCATIONS
MONITORING ZONE C
BACKGROUND TARGET VOLUME
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

12

CH2M HILL


LEGEND
PROPOSED MONITORING WELL
SOURCE AREAS
EXISTING MONITORING WELL (SCREENED IN EITHER D-ZONE OR E-ZONE)
INDUSTRIAL WASTE LINE
0
1600
3200
SCALE IN FEET
N
MW-163 1/93
TCE 5.5
C12DCE 0.7
PCE ND
MW-230 4/93
TCE ND


MW-163 1/93
TCE 5.5
C12DCE 0.7
PCE ND
12DCA ND
RISK 1.7E-6
MW-230 4/93
TCE ND
C12DCE ND
PCE ND
12DCA ND
RISK 0
MW-162 7/93
TCE 18.3
C12DCE ND
PCE 3.2
12DCA ND
RISK 2.1E-5
MW-232 5/91
TCE ND
C12DCE
PCE ND
12DCA ND
RISK 0
MW-231 8/91
TCE 1.7
C12DCE
PCE ND
12DCA ND
RISK 5.3E-7
MW-167 4/93
TCE 28.0
C12DCE 11.0
PCE ND
12DCA 0.4
RISK 2.E-6
MW-168 10/90
TCE 0.3
C12DCE
MW-149 04/08/93
TCE 0.4
C12DCE 0.0
PCE 0.0
12DCA 0.0
RISK 2.6E-7
MW-1047 08/03/93

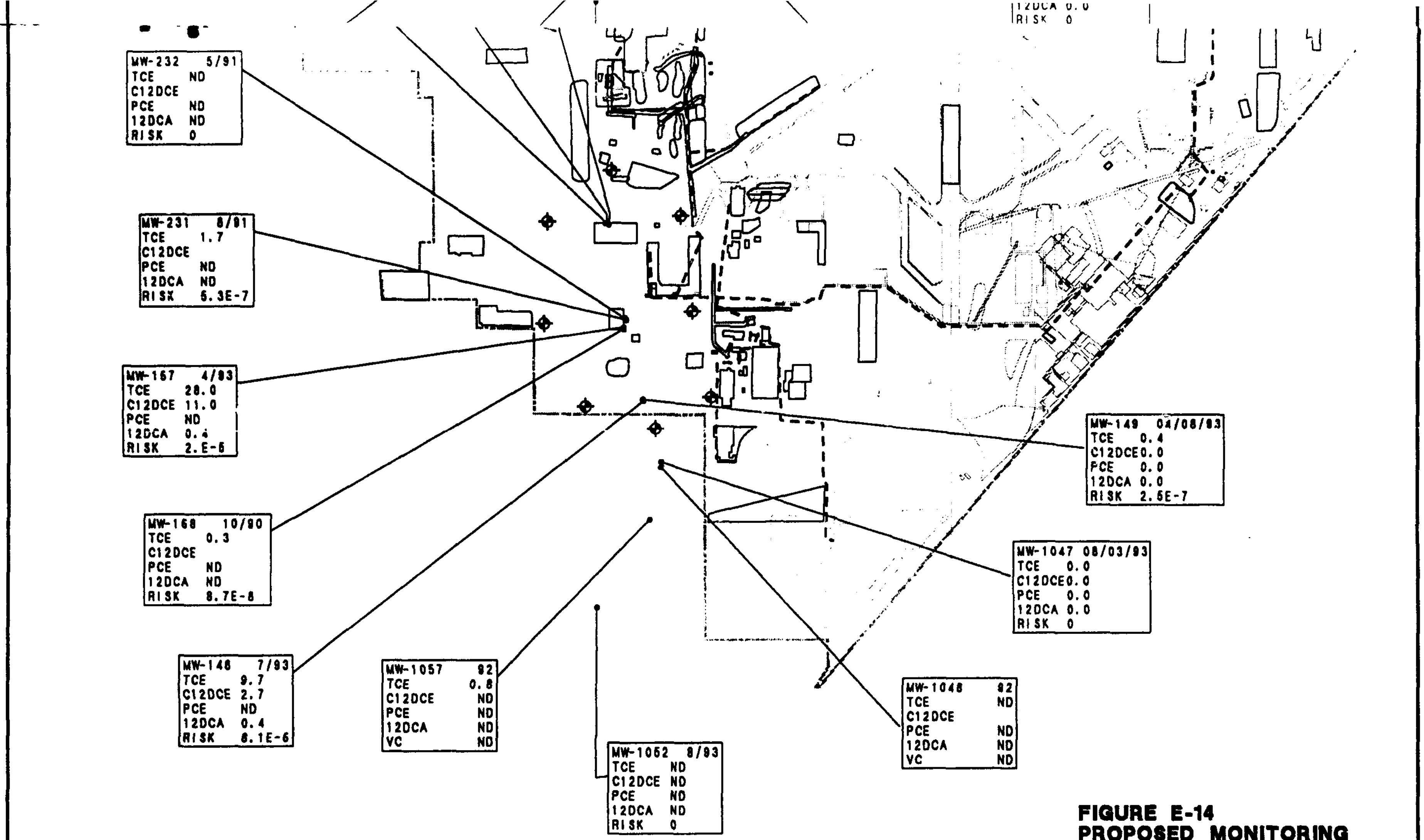


FIGURE E-14
PROPOSED MONITORING WELL LOCATIONS MONITORING ZONE D

GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

CH2M HILL

RDD148
MEY94/MEY-E-14.DGN

PREPARED FOR: McClellan Air Force Base

DATE: March 23, 1994

SUBJECT: Data Management
Groundwater OU RI/FS
Delivery Order No. 5066

PROJECT: SAC28722.66.FS

Data Management Overview

Data management can be defined as the functions of creating and accessing stored data, enforcing data storage conventions, and regulating data input and output. The stored data will include physical, chemical, or biological parameters measured in groundwater, surface water, soil, sediment, or other types of media at the McClellan AFB.

Data management for McClellan AFB will involve the use of a computerized environmental data management system. The system will provide a centralized, secure location for environmental data of known quality that can be shared and used for multiple purposes. The data management system will assist in the information flow for the project by providing a means of cataloging, organizing, archiving, and accessing information. The data management system alone will not analyze or graphically display the data; its function is to provide an "electronic filing cabinet" for the project's environmental data. These data may then be used with other software for data analysis, plotting, and presentation.

The data management process will include three main elements:

- Database – An organized and structured storehouse of data used for multiple purposes.
- Data Management Procedures – The steps involved in the data management process.
- Personnel – People who develop, implement, and administer the database and procedures.

McClellan AFB Database

This section describes the database that will be used to store historical and new data collected as part of the McClellan AFB groundwater remedy. Data for the groundwater remedy will initially be stored in CH2M HILL's environmental data management system written in Paradox®. Data will then be download directly into the existing Technical Information System, supplemented by Supervisory Control and Data Analysis (SCADA) software.

The McClellan database will consist of several tables, along with associated forms, reports, and validation files. Each of the database tables can be categorized into one of three data types:

- Primary Data, which includes *spatial data*, describing locations, *temporal data* describing events, and *measurement data* describing quantitative measurements that can be referenced to locations and events.
- Lookup data (also called referential data), which provide additional pieces of information that are cross-referenced to primary data.
- Dictionary data, which are a special set of referential data describing the database.

Data Management System Implementation

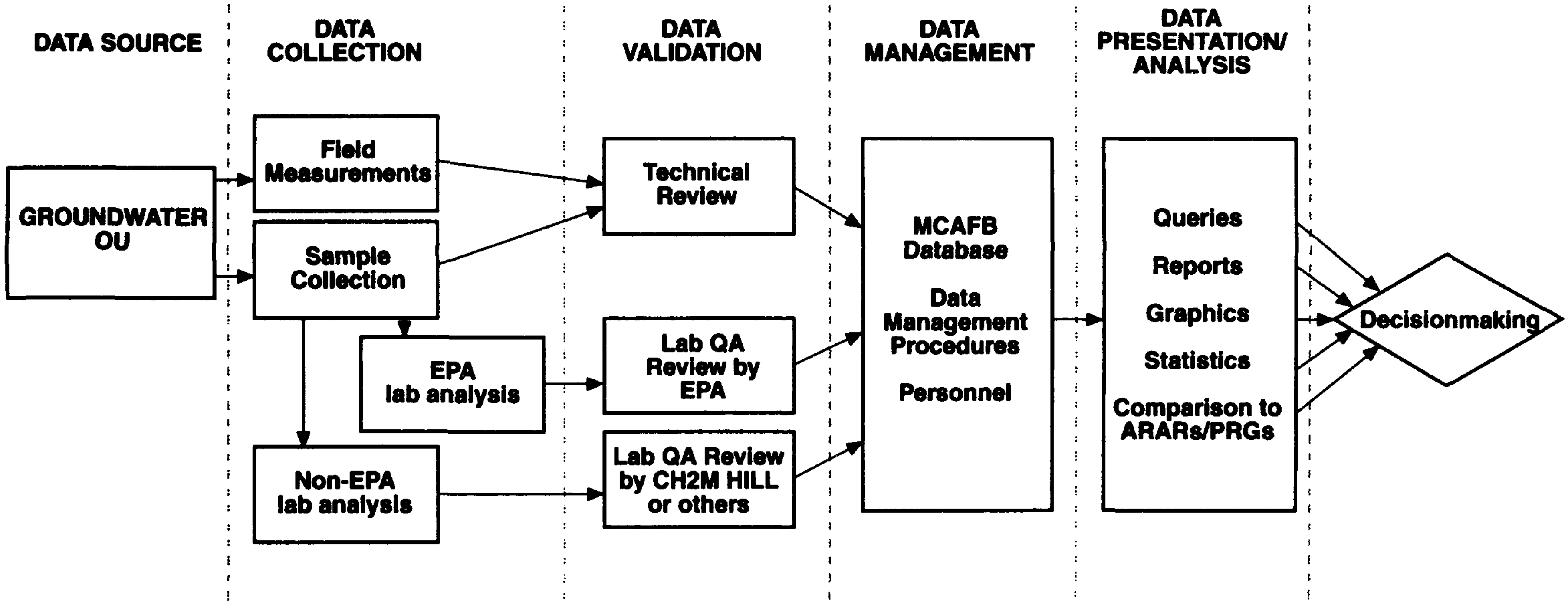
Implementation of the data management system requires established data management procedures and the personnel required to execute these procedures.

Successful data management is based on understanding the project information flow. The data collected in the field and the data generated from analytical work completed at the laboratory must go through an established route to those involved in project evaluation and decision-making. Figure F-1 illustrates the project information flow for McClellan AFB groundwater remedy data to be entered into the computerized database.

Data Management Procedures

Data management procedures are a crucial part of the data management system. Established procedures are necessary to ensure consistency among data sets, internal database integrity, and a verified, usable data set. The tasks and procedures that will be performed for all McClellan AFB data include:

- Data mapping
- Electronic data interchange
- Data entry and verification
- Data presentation and analysis



1312_260

FIGURE F-1
PROJECT INFORMATION FLOW
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

CH2M HILL

- Data administration

Data Mapping

Data mapping is a term that describes the process by which the collected environmental data are selected, marked, and correctly named for entry into the database. Data mapping often involves annotating laboratory data reports to show which pieces of information contained on the report go in the database and which pieces do not. In a sense, the annotated laboratory report provides a map for the data management team.

Field reports especially need to be annotated to show which pieces of information (data elements) are destined for the database. Often, comments in a field notebook need to be condensed to fit in a database field with a certain length; certain comments might be irrelevant while others could be extremely important. The project team (not data management personnel) will make these decisions and will provide an annotated copy of the field notebook (a map).

Similarly, for electronic data, a map will be developed that illustrates the way in which the data find their way into the database. This will involve printing the first page of the electronic data file and annotating it.

Data mapping is especially crucial when data are coming in from separate sources (e.g., multiple consultants or multiple laboratories). To effectively compare and analyze data, data must be represented in an internally consistent manner, whether taken from field notebooks, laboratory reports, or electronic data files.

An important part of the mapping process involves proper naming of the data elements. The following subsections describe special naming considerations needed for mapping data in the McClellan AFB database.

Station

Station ID. Station IDs will be standardized. Subtle differences such as distinguishing between MW1 and MW01 will affect the user's ability to group and compare data. These types of issues will be addressed in the SAP before station IDs are entered into a database.

The manner in which station IDs are assigned will affect how the data are presented in reports. It is common to sort by station ID; therefore, special attention will be given to these codes. In general, station and sample IDs will be assigned in view of the way they will sort alphanumerically. A common sorting problem occurs when sequential well numbers are assigned without consistent use of digits. For example, the well numbers below will alphanumerically sort as follows:

Well	Sort Order
MW1	MW1
MW2	MW10
MW3	MW101
MW10	MW11
MW11	MW2
MW21	MW21
MW35	MW3
MW101	MW35

Therefore, if well numbers extend into the hundreds, well numbers that all have three digits (e.g., MW001, MW002, MW010) will be assigned. The same convention holds for sample IDs or any other alphanumeric field for which sorting will be desired. Minimizing the number of digits for stations will also reduce the likelihood of incorrect data entry and use.

Coordinates. To facilitate plotting of coordinates and elevations, station location coordinates will be of the same units of measure and sitewide reference frame for all stations monitored.

Sample

Sample ID. Sample IDs will be standardized as sequential numbers. The same sorting considerations exist as for the station ID. It is **unnecessary** and **redundant** to build codes into the sample ID when that information can be stored in another field in the sample table. Simplifying sample IDs is beneficial for several reasons, including:

- Redundancy is minimized.
- Sample IDs are blind to analytical laboratories.
- Transcription errors are reduced.

Subsample Codes. Subsample codes identify duplicates, replicates, splits, and field blanks. A coding scheme will be used to identify the type of subsample (e.g., field duplicate, split sample), plus a unique sequential number (if required). Codes for the type of subsample will include the following:

Field Duplicate	FD
Replicate	RE
Split	SP
Rinsate Blank	RB
Bottle Blank	BB
Trip Blank	TB
Equipment Blank	EB

For related samples, a unique sequential number will distinguish samples having the same subsample code (e.g., FD01). These codes will never be part of the sample ID or be disclosed to the laboratory performing analyses of the sample.

Sample Matrix Codes. Sample matrix codes indicate the type of material being sampled (e.g., soil, water) and will be identified prior to sampling and used in a consistent manner. The codes will be defined in a matrix reference code table (lookup) and as part of the system documentation.

Field Measurements and Analytical Values

Parameter Codes. Field parameter names will be matched to parameter codes in the appropriate reference code table (lookup). Likewise, the chemical names or codes used by the analytical laboratory will be matched to the parameter lookup.

Qualifiers. Field and laboratory qualifiers will be defined either in a miscellaneous lookup or in the project documentation. Consideration will be given to standardizing qualifiers even if they differ among laboratories (e.g., some laboratories use B for estimated values while others use J; some laboratories report undetected constituents with < while others use U). If decisions are made to change reported qualifiers, the decision will be documented and hard copies of the original data changed.

Units of Measure. Units of measure must be reported for each field and analytical parameter. If concentrations are reported in different units for the same parameter, a decision will need to be made whether or not to standardize to one set of units or to retain the original units and remain consistent with the source of the data. Conversion to consistent units is crucial when calculating summary statistics on a data set.

Batch

Batch ID. The batch ID stored in the database is usually the laboratory sample ID associated with any given sample. If the laboratory sample ID is the same for different groups of chemicals, a letter code can be added to the existing laboratory sample ID that corresponds to the chemical group. For example, for a typical laboratory sample ID of 21234-001, the batch ID for the volatiles analysis associated with this laboratory ID could be 21234-001V; the batch ID for the semivolatiles analysis could be 21234-001S.

If laboratory IDs are not available, a convention will be used to distinguish different groups of analyses (e.g., the sample ID plus a letter code defining the chemical group).

Electronic Data Interchange

To facilitate data interchange between McClellan AFB, regulatory agencies, and CH2M HILL, and other subcontractors, detailed specifications will be developed for both receipt and delivery of electronic data.

Data Importing of Treatment System Data

Electronic data format specifications will be developed as part of the overall laboratory analysis or subcontractor contract. Laboratories providing electronic data must be able to deliver data on IBM PC-compatible 5-1/4-inch or 3-1/2-inch disks in comma-delimited, string-quoted ASCII format. The exact format will be negotiated as part of the contract. It will also be specified that electronic data must match laboratory reporting forms.

For producing electronic data, there are several degrees of automation depending on the instrumentation and analytical methods. Data may be manually entered by laboratory personnel to accommodate the client's electronic data requirements. This results in errors, extra quality control time at the laboratory, and longer delivery times. Serious consideration will be given to evaluating the time it would take data management personnel to manually enter and check the data versus having laboratory personnel perform the same task.

Data Importing of Water Level Data

Electronic data format specifications will be developed as part of the overall innovative technology strategy. A network of transducers capable of transmitting pressure readings continuously is possible. For the remedial action, it is recommended that water levels from transducers be electronically downloaded daily with weekly time trends submitted to the EMR and reported monthly to the agencies.

Data Exporting

Electronic data specifications will required for end-use software tools used to present and analyze the data. An identification scheme for disks and file information will be included with each transmittal of electronic data, and a hard copy of the raw data will be included. The exact format for data exporting will be determined on a case-by-case basis as required.

Data Entry and Verification

Data entry and verification is the process by which data are correctly entered into the database. It is usually desirable to download data electronically into a database; this minimizes transcription errors and reduces data entry and verification time dramatically. Most laboratories can provide electronic deliverables generated from their instruments in some format. As discussed in the previous section, specifications for electronic data transmittal will be developed when preparing the overall laboratory analysis contract prior to field sampling efforts. Some data, such as descriptive station and sample information, will probably need to be entered manually. Both electronic and manual data entry involve three steps:

- Data preparation
- Data import and entry
- Data verification

Electronic Data

Preparation. Incoming data will be checked for completeness by comparing the data received with Chain-of-Custody forms. Electronic data disks will be logged in, and, when it has been verified that files received match the transmittal paperwork, the disks will be copied and archived for the project files. If any errors or discrepancies are noticed, corrections to the diskettes will be initiated by the data management personnel, but must be made only after authorization by the responsible parties. Documentation of the discrepancies will be made and distributed to the project personnel.

Entry. Data will be downloaded into temporary database tables, at which point the tables can be restructured to fit the database structures if required. If not already in final format, the tables will be filtered and mapped with the appropriate station, sample ID, batch ID, parameter, and qualifier codes as designated in the import specification (discussed under *Data Importing*) structures will be documented.

Verification. The data file will be printed, and the following will be verified against hard copies of the data:

- The number and identity of all samples.

- To identify any initial problems, 100 percent of all analytical values and qualifiers on the first files received from laboratory, 10 percent thereafter.

If there are any discrepancies between the electronic submittal and the hard copies, the entire electronic submittal will be manually checked against the hard copy data. The laboratory will be notified about the errors, and corrective action will be taken. When the temporary tables have been verified as complete and accurate, they may be loaded into final database tables.

Manual (Hard Copy) Data

Preparation. Incoming data will be checked for completeness by comparing the data received with the Chain-of-Custody forms. Filing and coding will be performed as follows:

- Manual Filing:
  - Field Data—Make one copy of the field data and the file original. Provide a copy to a designated project team member for a technical quality check.
  - Analytical Data—Make one complete copy of the results for an in-house quality assurance (QA) check at the appropriate level for the project. A second copy of the data will be made (without QA information) to be used for data entry. Hard copies of data submitted for entry into a database must be complete and final to minimize the possibility of error. File the original in accordance with standard project filing protocol.
- Manual Coding:
  - Pertinent information not printed on the hard copy forms (e.g., station, if not already identified, and batch ID, if not clear) will be added.
  - Analytical batch information to be entered will be clearly identified (e.g., case number, laboratory number, sample number, dilution, units).
  - Values and qualifiers other than nondetects may be highlighted to help facilitate data entry.

Entry. Data will be entered using relational data structure and input constraints available through Paradox® to aid in the data entry process. The data will be entered into temporary tables, which will be loaded into final tables when verification is complete.

The McClellan AFB database will be built from the **top down**. This means that the data collected first will be entered first. For example, once sampling stations (locations) have been identified, they will be entered into the database station table. Then, following a field sampling event, the information from the field notes (e.g., field measurements) and chain-of-custody forms should be entered into the database sample table. When analytical data are received from the laboratory, data are entered or downloaded to the analytical batch and values tables. By entering data from the top down, reports can be generated that verify, for example, that all of the samples delivered to the laboratory were analyzed for the right group of parameters.

Also, as soon as analytical results are in, reports can be generated that include descriptive sample information or are grouped by site or other location classifications.

Verification. The following minimum procedures will be followed to verify manually entered data:

- Produce a list of all data entered. This list will serve as the check print.
- Compare each record entered into the database with the original coded sheets; highlight correct values, and mark and revise incorrect values in red. Each page of the data list will be signed and dated by the person completing the comparison.
- Edit database.
- Produce list of all data corrected; repeat comparison (only to corrected values); repeat procedure until all corrections are made.
- File coded data and checkprints; label documents.
- Convert temporary tables to final tables.
- Produce initial project verification reports; these reports will be provided to the project team upon completion of each data entry episode. They include the following:
  - A list of station IDs
  - A list of sample IDs
  - A list of parameters, units, and minimum and maximum values for both detects and nondetects, for each matrix type

  These initial reports will be used to further verify the integrity of the data set.

Data Presentation and Analysis

The data from the database will be presented in a clear and logical format to aid data analysis and decisionmaking, which includes the following reports:

- Compliance reports for the existing GWTP include a monthly report to the agencies on the influent and effluent water quality and the water levels with the wellfield. The report includes interpretation of the capture zone of the wellfield.

- Time series analysis of the last six monitoring events or 6 months, whichever is greater.

- Control chart style analysis of the chemical data (selected VOCs and metals), physical property data (pH, temperature), and well-specific risk data.

- Operational measurements, including pumping rate by well, total influent, and maintenance activities.

- Summaries and time series analysis of the measurements related to risk reduction.

- Summaries and time series analysis of the process improvement measurements.

- Appendix-style reports (tabular listings sorted by station and sample ID; these reports may be formatted with samples as row headers and parameters as column headers, or vice versa).

- Summary statistics (frequency of detection, mean, minimum, maximum values, standard deviation, and variance) sorted by station, parameter, or matrix

Data will also be exported directly to word processing, spreadsheet, or graphing programs to facilitate data presentation.

Data Administration

Effective administration of the data management system will reduce the likelihood of errors and ensure the integrity of the database. In this subsection, data administration is discussed under the topics of data redundancy control, operation and maintenance of the database, documentation of the data management process, and closing out the data management task in both interim and final stages of completion.

Data Redundancy Control

A primary purpose of managing data in the database environment is to ensure that each data record is unique and that the information contained within each field is consistent with conventions defined in other areas of the database. To ensure uniqueness, a key field or fields will be identified for each data record. Key fields define the record as unique. To maintain consistency with naming conventions used in a database, Paradox® allows the establishment of parent-child relationships between database files. These relationships have been facilitated by configuring database tables to "look up" to the proper parent table. Strategies for enforcing parent-child relationships are different for electronic versus manual data entry.

Electronic data entry into the database will require that all parent-child relationships be verified following the data input process. Queries will be performed on the parent and child tables to isolate the key fields common to both tables. A copy of each resulting file will be made so that the parent key file can be electronically compared to the child key file.

For manual data entry, Paradox® has a feature that allows only valid entries into a database, including fields that can look up to other fields in a parent table and fields that can be set up to default to a specific value or only accept certain alphanumeric characters. Therefore, if data entry is done manually, the followup integrity checks will not be necessary.

Operation and Maintenance

Tasks to be completed as part of the operation and maintenance activity include ongoing data entry and verification, query and report generation, and system consistency checks; these tasks are discussed above. Other tasks include internal audits by the project staff, maintenance of security, preparation of database backups, and documentation.

Audits. The McClellan AFB data management system, including the database and the procedures used, will be audited to ensure performance in accordance with both the specifications outlined in this DMP. The audit will include ad hoc data retrieval, inspection of manual files, and interviews with the data management team staff about their specific procedures.

Security. Database security will be enforced by requiring a valid user name and secret password to gain access.

Backups. During data entry or modification, the database will be backed up every 8 hours to ensure that a system failure would not stop operations for an unacceptable period of time. One copy of the database backup will be secured at a remote location. The backup media (disk, tape) will also be readable by another readily accessible machine in case of primary machine failure.

Documentation

As part of the data management process, the following documents will be compiled and organized as part of the documentation:

- A final copy of the DMP.
- Project memorandums and telephone notes that pertain to the data management task.
- Notes pertaining to data mapping.

- Original and data-entry hard copies of all data that are entered into the database; this includes laboratory reports, field notes, and disks with electronic data files.

- Interim and final database output; this is necessary to document database changes made as a result of data entry mistakes or corrections by the laboratory.

Project Closeout

On completion of a data management task, all documentation will be updated and completed. Disks and hard copies of the following data will be produced and distributed to the appropriate parties:

- Data management plan and associated addendums.

- Hard copies of all data, including lookups.

- Disk files in original database format and comma-delimited, string-quoted ASCII format.

An extra copy of data files will be stored offsite.

Personnel Roles and Responsibilities

Successful implementation of a data management system requires a clear definition of responsibilities. It is necessary for the project staff to become familiar with the structure and activities associated with data management; however, it is not necessary that each role be assigned to a different person. The following roles will be assigned.

- **Database Administrator**. Has an overall view of the database structures and uses. Responsibilities include database integrity, redundancy control, data sharing and version control, performance, security, and backup. Assists in preparing the DMP and schedules staff to implement a data management system for a project.

- **Project Data Coordinator**. Has an overall view of the sampling and analysis plan. Responsibilities include data logging and tracking, data preparation, coordination of data entry and verification, data archiving, data requests, and report formats.

- **Database Technician**. Has a comprehensive knowledge of the database structure, its software, and associated analysis tools. Responsibilities include data entry and verification, queries, and report generation. It is not necessary that each role be assigned to a different person.

Glossary

Child. The subordinate entity in a relationship between two entities in a hierarchical or relational database.

Database. A collection of data shared and used for multiple purposes. It is created by implementing a data model by use of computer-based data management software.

Database Administrator. A person with an overview and understanding of the makeup of environmental database(s) used in an office. The database administrator commonly helps prepare a proposal for a project, prepares data management plans, and schedules staff to implement the data management system for a given project.

Database Coordinator. Data management team member with an overall view of the data and data relationships for any given project. Responsibilities include data preparation, correspondence with analytical labs, data requests, and report format design.

Database Technician. Data management team member with comprehensive knowledge of the database structure, software, and associated analytical tools. Responsibilities include data entry and verification, queries, report generation, and system backups.

Data Dictionary. An entity describing the database and the data. It contains information on all data types, names, structures, and usage.

Data Element. The smallest unit of data that has meaning in describing information.

Data Management. The functions that provide for creation of and access to stored data, enforce data storage conventions, and regulate data input and output. The purpose of these functions is to provide a centralized, secure location for data of known quality that can be shared and used for multiple purposes.

Data Management System. A data management system is comprised of three components: (1) software that provides the mechanism for loading, storing, updating, and accessing data in a database, (2) data management procedures that include, among other things, assurance that accurate and consistent compilation and organization of data has occurred before it is entered into a database, and verification that entry of data into a database has taken place in an accurate manner, and (3) personnel trained in dealing with the complexities of environmental data.

Data Mapping. An imposed relationship that defines links between data elements in the database and actual data of interest. The data administrator usually maps project data into specific data elements at the beginning of a project.

Data Model. A conceptual framework that defines how data should be organized and viewed. It is a logical map of data that represents the inherent properties of the data independently of software or hardware. It defines the data elements to be managed and the relationships and structures of the data elements.

Data Redundancy. The repetition of the same data element or elements across different records or files. This may be needed in order to tie related records together or because compatible applications need the same data. Redundancy tends to be reduced with a systematic approach to data management.

Data Structures. The entities and data elements used and the relationships between them.

Entity. An entity is a conceptual organization of data elements in the data model.

Field. A data element structured in a database.

Index. A table used to determine the location of a record.

Information Flow. The movement of information from the project environment, analytical labs, and QC validators to the data management system, data analysis and presentation, or other external users.

Key. A data element or combination of data elements used to uniquely identify a record.

Link. An association or relationship between entities or records.

Lookup. An entity that contains the set of all possible values for a specific data element.

Parent. The superior, or higher level, entity in a relationship between two entities in a hierarchical or relational database.

Record. A group of related data elements treated as a unit by an application program. May be thought of as one row of a database table.

Reference Codes Table. See Lookup.

Relational Database. A database that is made up of two-dimensional arrays of data elements and uses a database management system. It has the capability to recombine the data items to form different two-dimensional arrays, thus giving great flexibility in the use of data.

PREPARED FOR: McClellan Air Force Base

DATE: March 23, 1994

SUBJECT: Interactions of the Vadose Zone and Groundwater Remedial Action Alternatives Groundwater OU RI/FS Report Delivery Order No. 5066

PROJECT: SAC28722.66.FS

Introduction and Approach

The cause of groundwater contamination at McClellan Air Force Base (McClellan AFB) can be traced to sites where hazardous materials and substances are known to have been routinely used, stored, treated, and/or disposed of since McClellan AFB began operation in the late 1930s. As contaminants migrated from source areas to the water table, portions remained trapped in the soil, rendering much of the vadose zone at McClellan AFB contaminated. Since 1912, the water table at McClellan AFB has continually declined from 45 feet below ground surface (bgs) to over 100 feet bgs. Any contamination in the saturated zone that was sorbed onto soil particles remained in the soil as the water table declined. This contaminated extension of the vadose zone formed by the fluctuating water table is called the smear zone, and is a source for long-term groundwater contamination.

A thorough plan aimed at cleaning up groundwater contamination at McClellan AFB must also consider appropriate remedial actions for cleaning up the vadose zone. The purpose of this technical memorandum is to identify interactions between vadose zone and groundwater remedial alternatives. To determine such interactions the following vadose zone and groundwater remediation issues are addressed: (1) what are applicable vadose zone remediation alternatives, (2) at what locations will vadose zone remediation be employed, (3) what are applicable groundwater remediation alternatives, (4) at what locations will groundwater remediation be employed, (5) what are the physical interactions between the vadose zone and groundwater remedial alternatives, and (6) what are the logistical interactions between the vadose zone and groundwater remedial alternatives? Each of these issues is addressed in the discussion that follows.

Applicable Vadose Zone Remediation Alternatives

In order to determine appropriate remedial alternatives for vadose zone contamination, McClellan AFB reviewed the records of decision (RODs) from eleven California

Superfund sites. Each of the ROD sites reviewed has features comparable to those at McClellan AFB; soil characteristics, depth of soil contamination, and soil contaminants all compare to McClellan AFB site conditions. Each ROD followed the remedial evaluation procedure outlined in the National Contingency Plan (NCP), and at each of the sites soil vapor extraction (SVE) was chosen as the presumptive remedy for volatile organic compound (VOC) contamination in the vadose zone. The term presumptive remedy refers to a remedial technology that has been consistently selected as the preferred remedial alternative through the remedy selection process (McClellan AFB, Basewide EE/CA for SVE, 1993).

VOCs are the most prevalent types of contaminants found in the vadose zone at McClellan AFB; therefore, SVE was chosen as the presumptive vadose zone remedial action. In all of the RODs reviewed, and based on conditions at McClellan AFB, four other stand-alone remedial alternatives were considered possible candidates, but were rejected at all sites. The four alternatives included: (1) institutional controls, (2) capping, (3) excavation, and (4) soil flushing (McClellan AFB, Basewide EE/CA for SVE, 1993). Because soil gas plumes have migrated offbase and contribute directly to groundwater contamination, no-action as an alternative is not considered a viable remedial option. Table G-1 summarizes the rejected alternatives, and gives the reasons why the eleven ROD sites and McClellan AFB rejected them (McClellan AFB Basewide EE/CA for SVE, 1993).

Table G-1
Basis for Rejection of Alternatives

Alternative	Basis for Rejection at 11 California Superfund Sites	Applicability to McClellan AFB
Institutional Controls	• Lack of permanence, long-term effectiveness	Same objection applies
Capping	• No reduction in soil contamination	Same objection applies
Excavation	• Short-term adverse health effects	Same objection applies
	• Difficult to implement (access, impact on other operations)	Same objection applies
	• Residual contamination in unexcavated soils	Same objection applies
	• Air emissions	Same objection applies
	• High cost	Same objection applies
Soil Flushing	• Limited effectiveness	Same objection applies
	• Incompatability with slurry walls	Not applicable
	• High cost	Same objection applies

SVE has proven to be very effective in removing large amounts of VOCs from the soil, and there is no known incompatibility of this technology with other remedial technologies. Results of an SVE pilot study done in Operable Unit (OU) D indicate that SVE can be effectively implemented at McClellan AFB. Site conditions, types of contaminants, and depth of contamination make SVE ideal for the removal of VOCs from the vadose zone at McClellan AFB.

Locations Requiring Vadose Zone Remediation

Various sites around McClellan AFB have been singled out as candidates for SVE implementation. Two sites in OU B, two in OU C, and one in OU D have all been specified as locations in need of vadose zone remediation. Generally speaking, however, sites with confirmed soil and groundwater contamination are located in all of the OUs basewide. In order to meet the goals of groundwater remediation, SVE may have to be implemented at all of these sites.

In OU B, IC 1 and IC 7 are singled out for SVE because various industrial activities causing soil contamination are known to have taken place there. Further concern stems from a section of the Industrial Wastewater Line (IWL) running through OU B where leakage is suspected (Basewide SVE EE/CA Site-Specific Document IC 1 and IC 7). Sites 68 and 42 in OU C are sources of VOC contamination. SVE is expected to be used to not only remediate high-concentration VOCs, but also semi-VOCs in the vadose zone (McClellan Air Force Base Management Action Plan, 1993). High levels of VOCs have been located in OU D west of Site 3 (SVE EE/CA Site Specific Document-OU D, 1993). Migration of the soil gas plume offbase is the reason for considering SVE remediation there. SVE at Site S, which has been an SVE pilot study in OU D, will continue for further study and as a removal action (McClellan AFB Management Action Plan, 1993). Figure G-1 (located in a pocket at the end of this appendix) shows the locations of the sites selected for SVE remediation.

Other VOC hot spots have been confirmed to exist in the vadose zone at locations in all of the OUs at McClellan AFB. Confirmed sites (CS) and potential release locations (PRLs) shown in Figure G-1 are known to be sources of VOC contamination. Without implementing SVE at these locations, VOC hot spots will continue to threaten groundwater quality even after the projected time to treat the groundwater has expired.

Applicable Groundwater Remediation Alternatives

One of six treatment alternatives will be selected to treat contaminated groundwater at McClellan AFB. Each alternative is made up of three systems: an extraction system, a treatment system, and an end-use system.

Groundwater Extraction System

One groundwater extraction system will be used for all six possible treatment alternatives. Fundamental components of the extraction system are extraction wells, monitoring wells, a telemetry system, a collection pipeline, and pump stations. Number of wells, size of pipe, and pumping rate will be determined by the level of cleanup required. If groundwater contaminant concentrations must be reduced to background levels, the extraction system will be more extensive than one designed to reduce groundwater contamination to maximum contaminant levels (MCLs). Regardless of size, the extraction system will be comprised of the above-mentioned components.

Groundwater Treatment System

Treatment systems are made up of several treatment technologies, including air stripping (AS), catalytic oxidation (CatOx), gas-phase granular activated carbon (VGAC), and liquid-phase granular activated carbon (LGAC). Different combinations of technologies are used to develop various treatment systems for the six treatment alternatives.

Groundwater End-Use System

All six treatment alternatives will use one of two end-use systems. After groundwater is sufficiently treated to predetermined contamination levels, the water will either be sold to a neighboring water utility, or be reinjected back into an aquifer beneath McClellan AFB. Of the six treatment alternatives, five plan to sell the treated water to a water utility nearby. One alternative calls for reinjecting the water back into the ground as the end use for the treated groundwater.

Locations Requiring Groundwater Remediation

In 1979, concern had arisen that waste disposal practices, surface spills at chemical storage yards and wastewater treatment plants, and leaks in the industrial waste conveyance line had allowed toxic chemicals to contaminate soil and groundwater at McClellan AFB. A groundwater sampling effort commenced that same year, and by 1980 it was confirmed that trichloroethene (TCE) was present in certain McClellan AFB wells.

In response to this finding, McClellan AFB developed an investigatory program aimed at evaluating past operation and waste disposal practices, identifying contamination sources, and determining the extent of contamination in soil and groundwater (Radian Corporation, 1990).

Throughout the 1980s and early 1990s, monitoring wells were installed at locations where contamination was expected to exist. Routine sampling of the monitoring wells has provided good indication of the lateral and vertical extent of groundwater contamination around McClellan AFB. Based on contaminant concentrations detected in the groundwater, plumes of contamination at hot spot, MCL, risk, and background concentration levels have been estimated. Figures G-2 through G-5 approximate the lateral extent of shallow (A zone) groundwater contamination for each concentration level. Depending on the level of treatment specified, these figures indicate where groundwater remediation would be necessary.

Physical Interactions Between Vadose Zone and Groundwater Remedial Alternatives

As shown in Figures G-1 through G-5, vadose zone and groundwater remediation will be implemented at about the same locations around McClellan AFB. Contamination at McClellan AFB assumes three phases: vaporized into soil gas, sorbed to organic matter on soil particles, or dissolved into groundwater or porewater. Because contaminants are free to assume different phases, both remedial alternatives should be implement at the same time. Two main physical interactions between vadose zone and groundwater remedial alternatives are fluctuations of the water table and emissions discharged to the air.

Fluctuations in the Water Table

Pumping groundwater for extended periods of time can eventually lower the water table. If an SVE system is not prepared to remediate a thicker vadose zone, portions of the soil will remain contaminated and continue to affect groundwater quality. In the current situation at McClellan AFB, there is a possibility that the A Zone of the aquifer in OU A may become dewatered as groundwater remediation proceeds. With this knowledge, the SVE system in OU A will need to be designed with vapor extraction wells screened over sufficient depths, and placed at locations where an increase in the thickness of the vadose zone is anticipated.

The same flexibility must be designed into an SVE system if the water table is anticipated to rise, thus submerging vapor extraction wells. In this case, SVE technology that can perform dual-phase extraction would need to be designed into the SVE system.

Emissions Discharged to the Air

Decisions on remediation technologies are largely based on cost and emission standards imposed by Applicable or Relevant and Appropriate Requirements (ARARs). Standards regulating air emissions will allow a certain air loading to be emitted from a treatment facility. Because groundwater and SVE treatment systems will be operated at the same time, total air loading will be composed of air emissions from both treatment systems. If remediation technologies allow air emissions from groundwater treatment to make up most of the total air loading allowed by law, when SVE is brought on line, air emission standards could possibly be exceeded.

Logistical Interactions Between Vadose Zone and Groundwater Remedial Alternatives

Because implementation of vadose zone and groundwater remedial alternatives must be coordinated to occur at the same time, logistical interactions between the two must be determined in order to avoid inefficiencies and redundancies in construction, scheduling, and treatment.

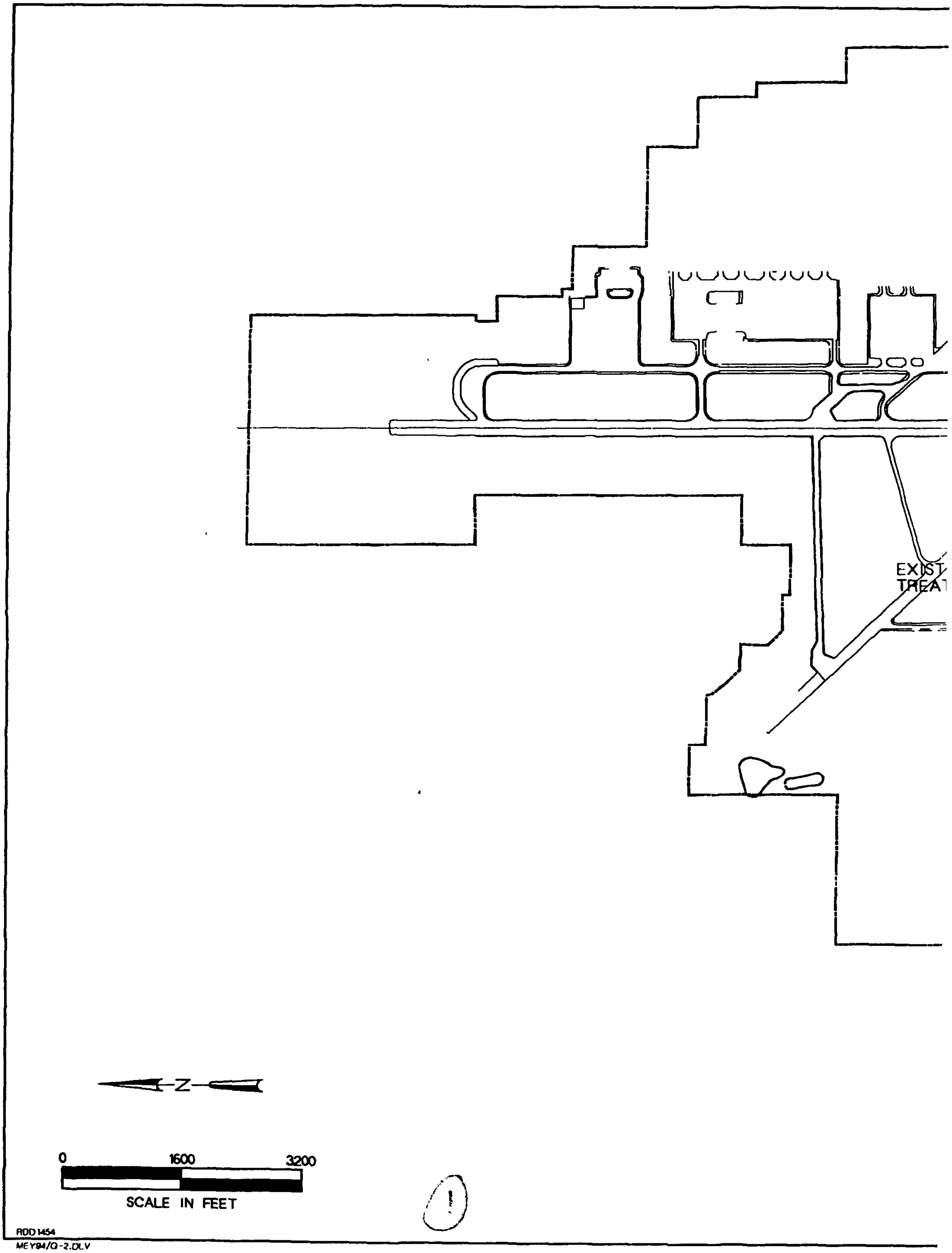
Some construction procedures are similar between the vadose zone and groundwater alternatives. For example, both require wells to be installed. At areas of McClellan AFB where both forms of remediation will be implemented, construction can be performed concurrently to avoid redundant fees for mobilization of equipment and crews. If innovative approaches to monitoring the complete remediation program are developed, concurrent construction could also promote strategic placement of wells for groundwater extraction, groundwater monitoring, and SVE.

Where implementation schedules are tight, understanding of the logistical interactions between the groundwater and vadose zone remediation alternatives will prevent schedule overlaps. For example, it would be less likely that the groundwater remediation schedule would be put on hold if logistical implications with the SVE schedule were already worked out.

Treatment processes will also be more efficient if logistical interactions are identified. In the example of a fluctuating water table, if the logistics of SVE and groundwater extraction technologies are synchronized, both systems will be able to adapt to the varying water table and perform as needed to fully remediate the site.

Conclusions

Subsurface contamination at McClellan AFB is spread throughout the vadose zone and groundwater. In order to attain groundwater remediation goals, vadose zone remediation cannot be ignored. Because vadose zone contamination is so deep at McClellan AFB, and VOCs are the major soil contaminants, soil vapor extraction has been chosen as the presumptive remedy for vadose zone contamination. Confirmed soil contamination locations indicate that where groundwater remediation is needed, vadose zoned remediation is required as well. Because most areas of McClellan AFB will implement both remediation alternatives concurrently, it becomes increasingly important to identify the physical and logistical interactions between the vadose zone and groundwater remedial alternatives for either to achieve its respective remediation goals.



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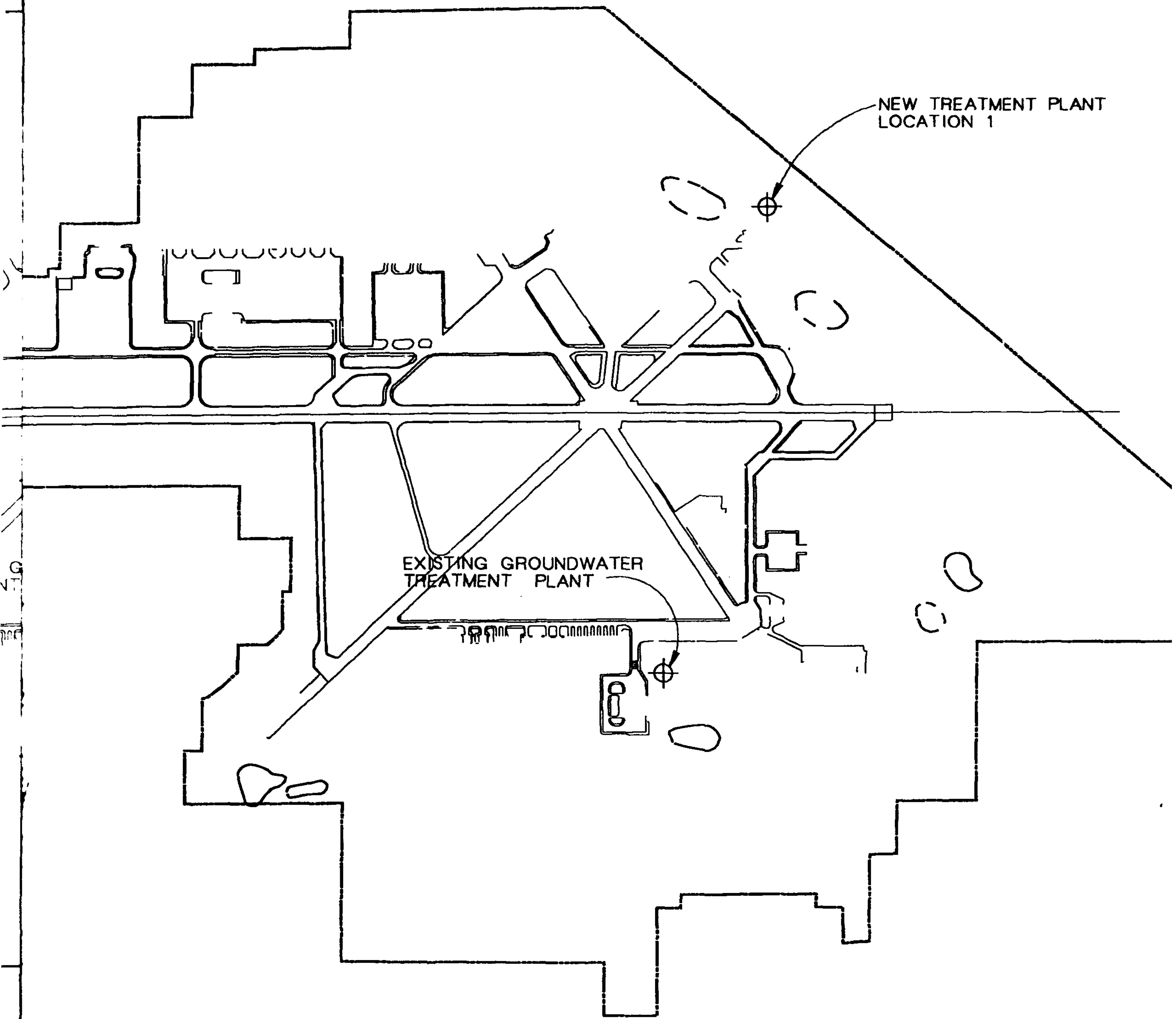

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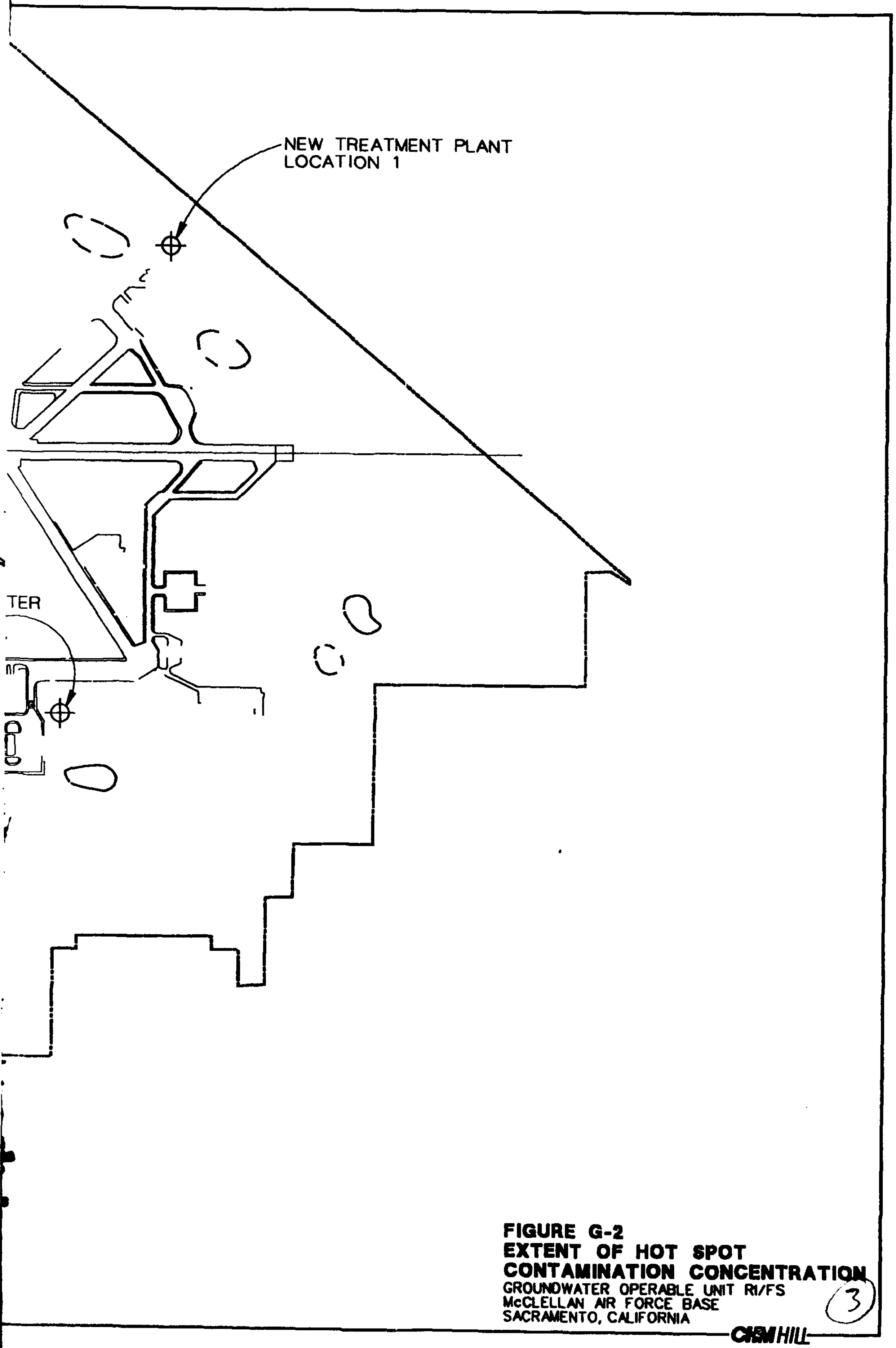
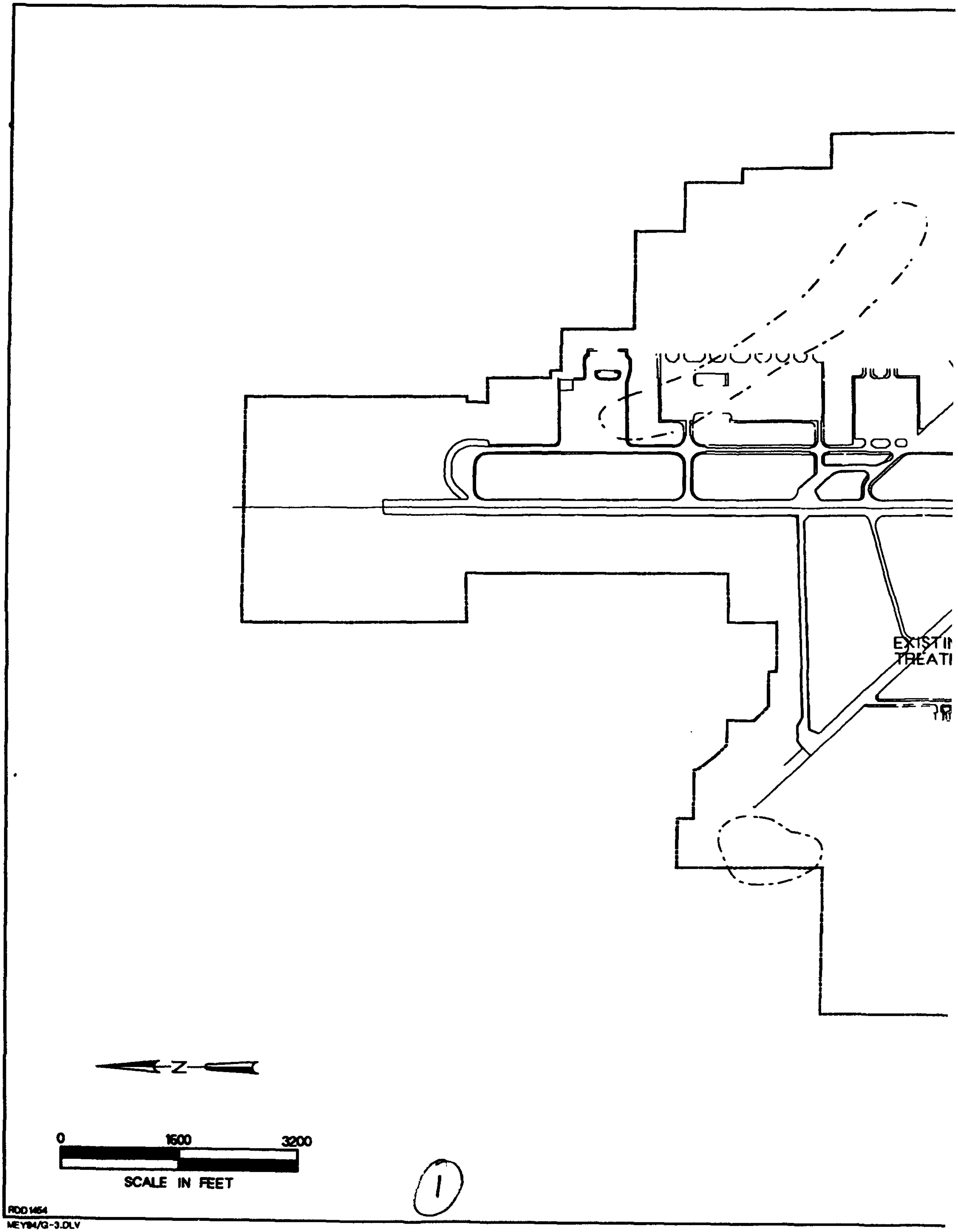


FIGURE G-2
EXTENT OF HOT SPOT
CONTAMINATION CONCENTRATION
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA
CH2M HILL



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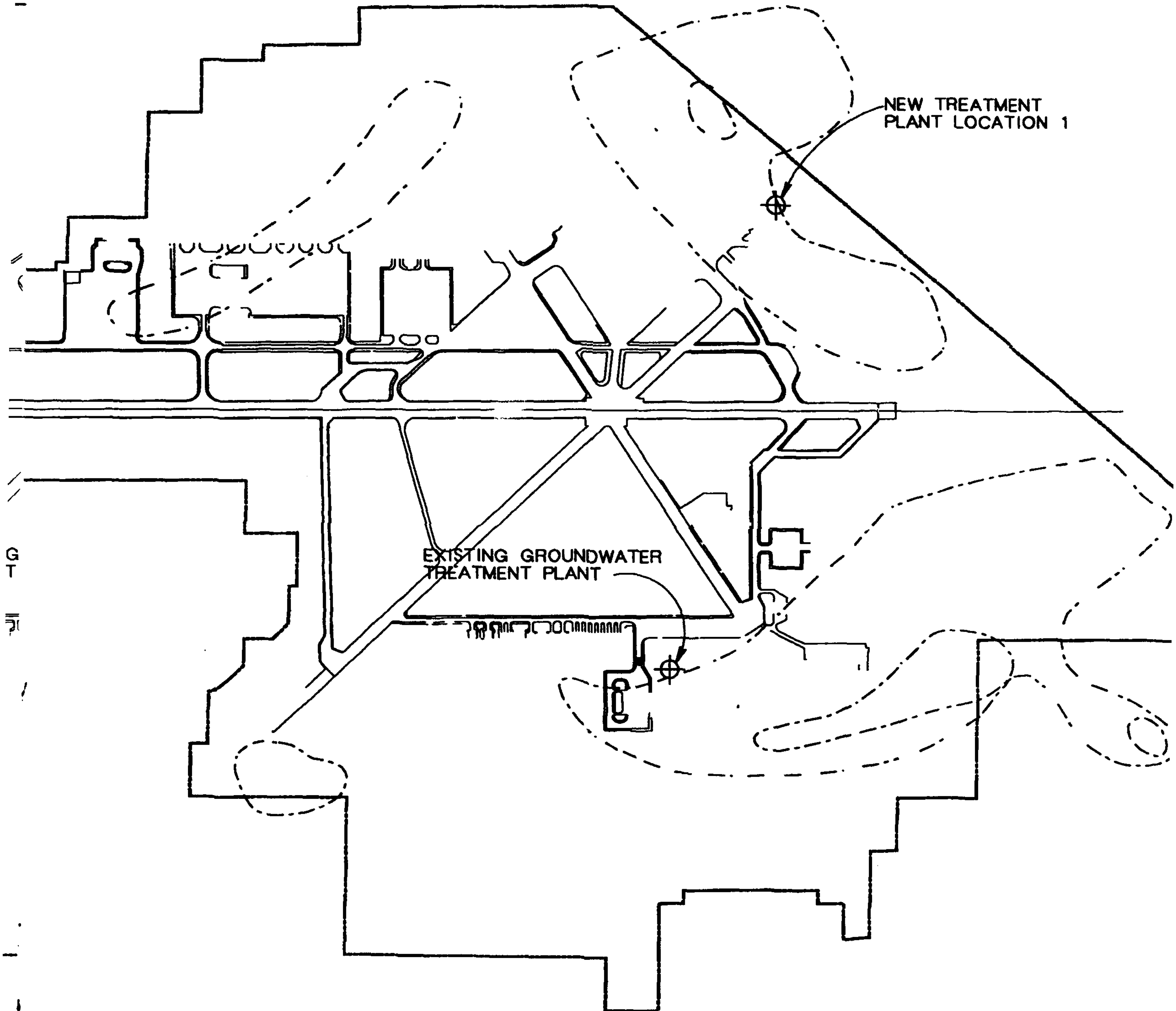

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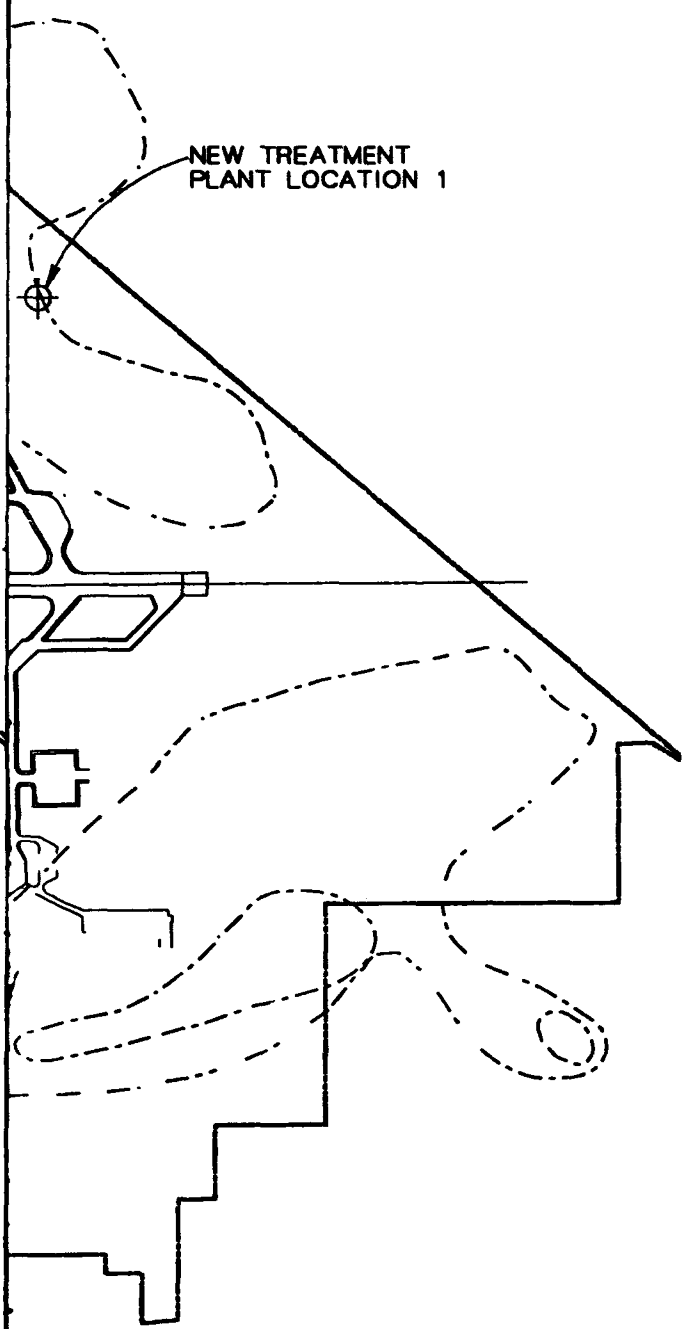

FIGURE G-3
EXTENT OF MCL
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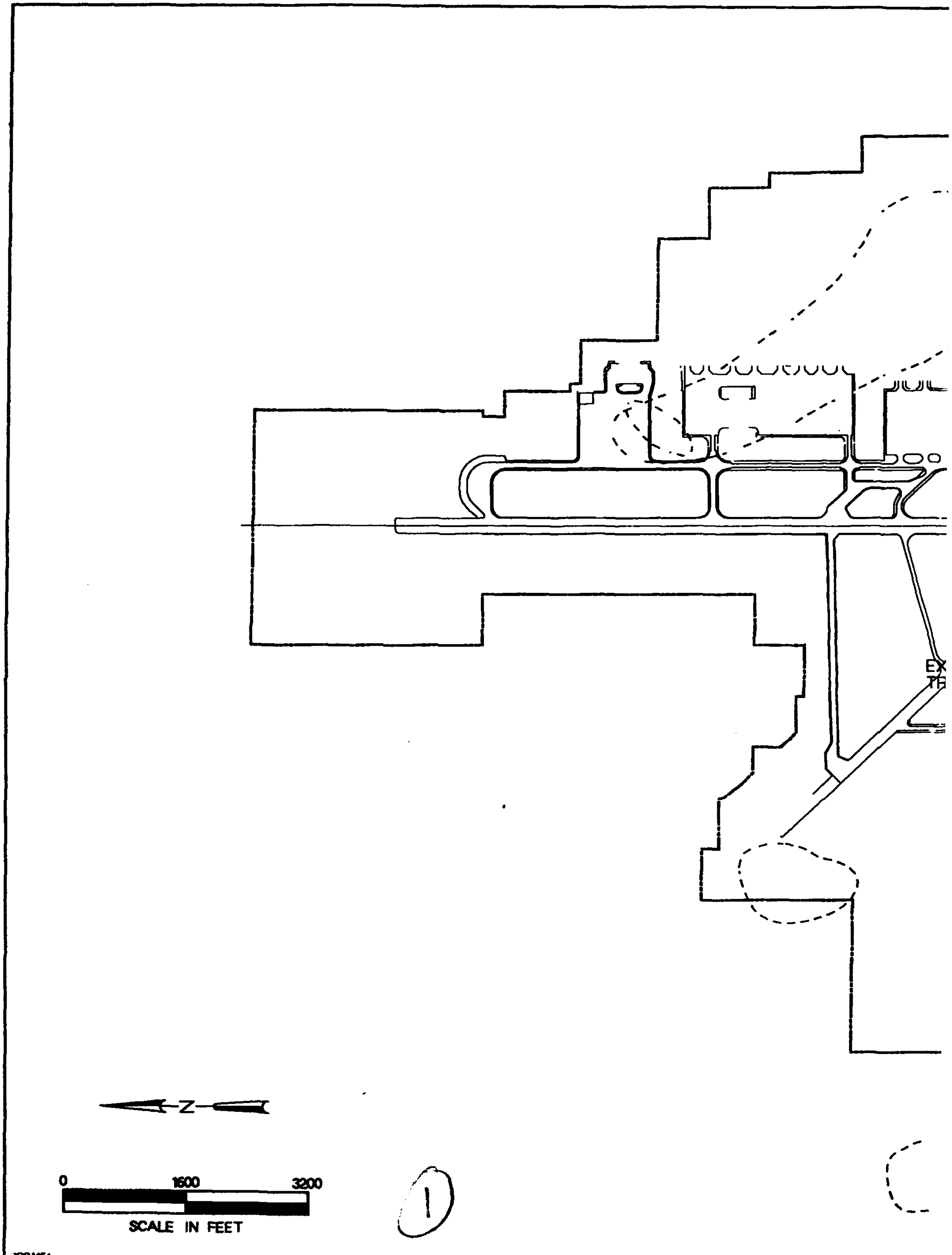

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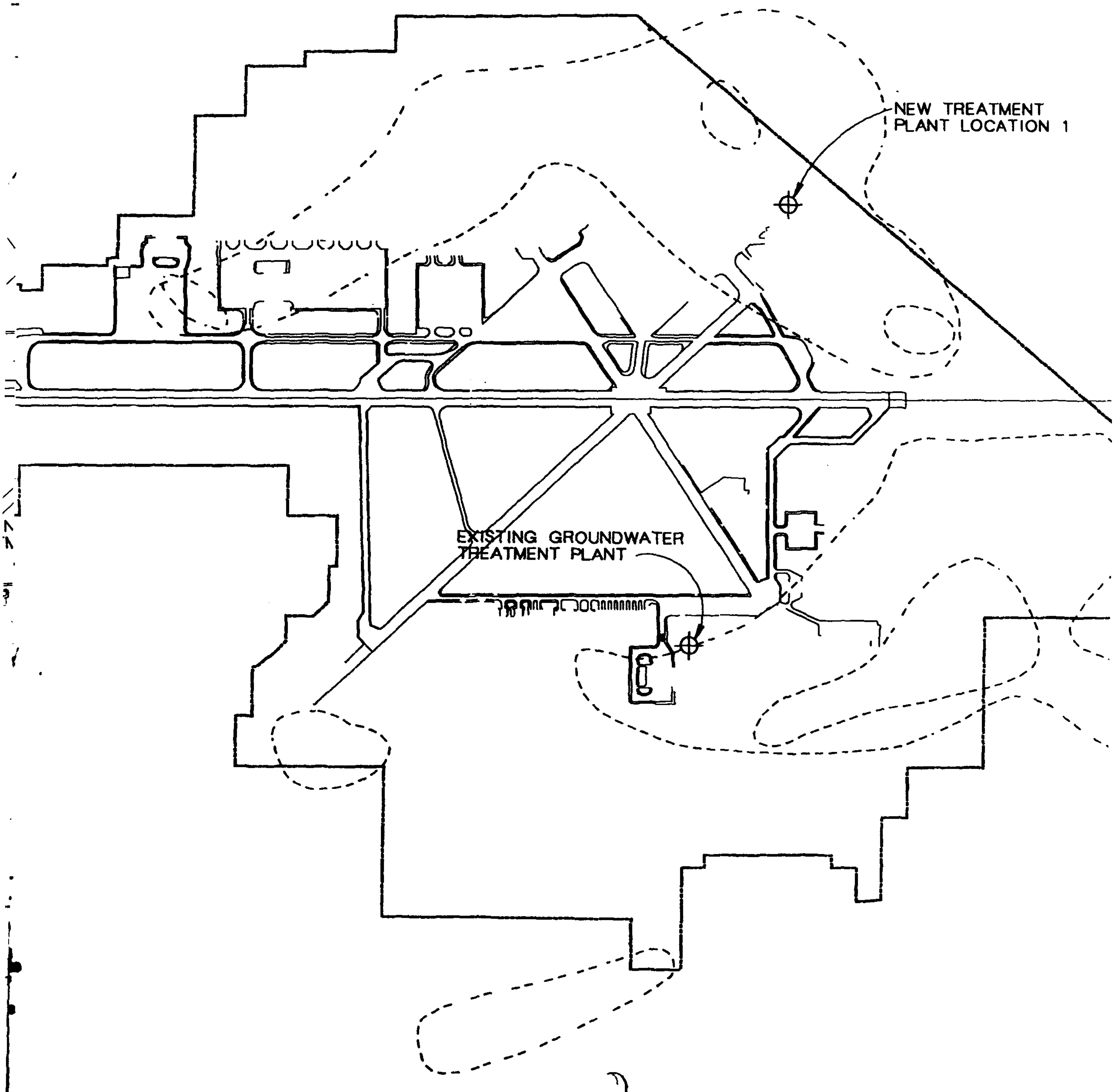

NEW TREATMENT
PLANT LOCATION 1
EXISTING GROUNDWATER
TREATMENT PLANT

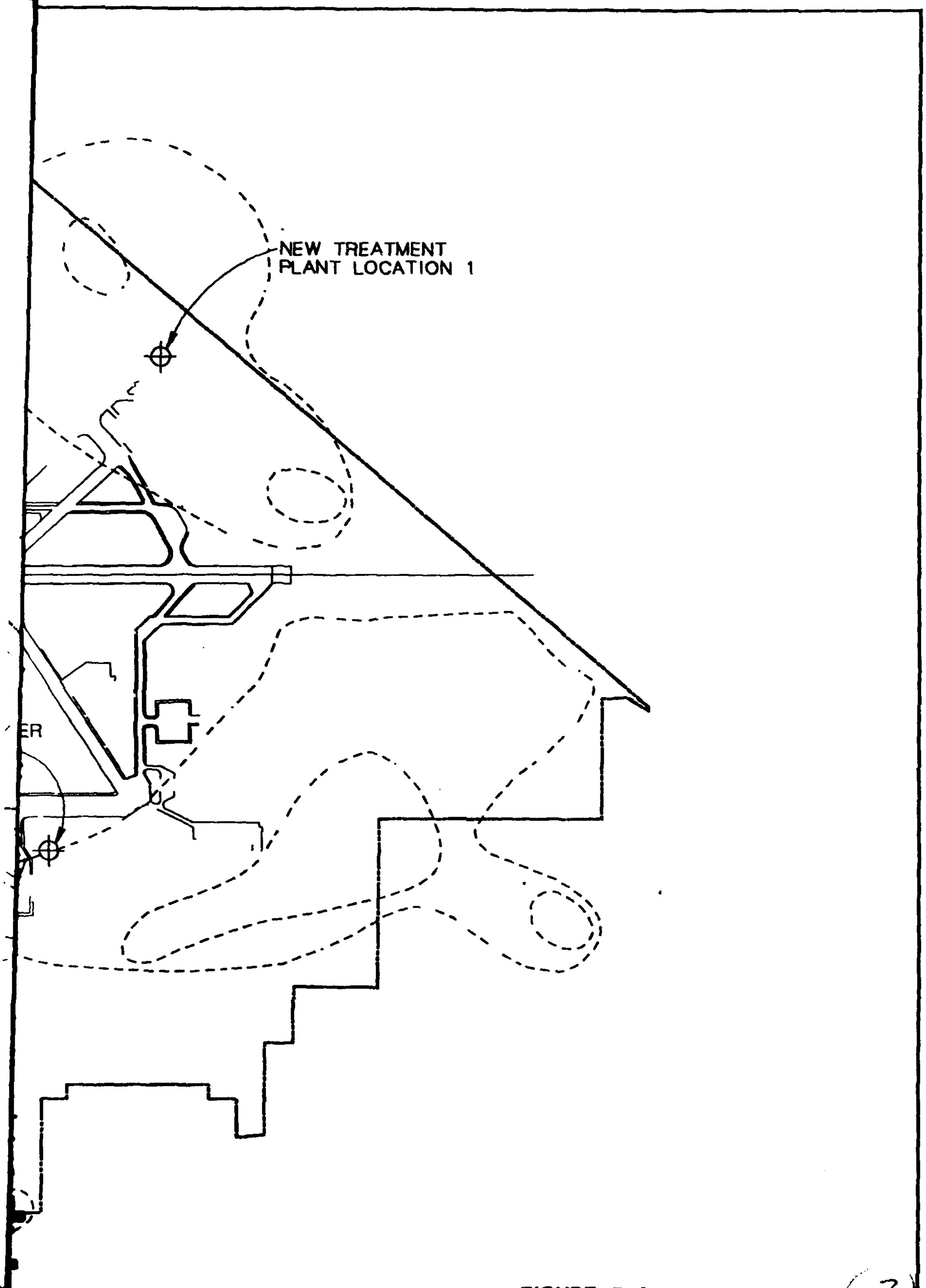

FIGURE G-4
EXTENT OF RISK
CONTAMINATION CONCENTRATION
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

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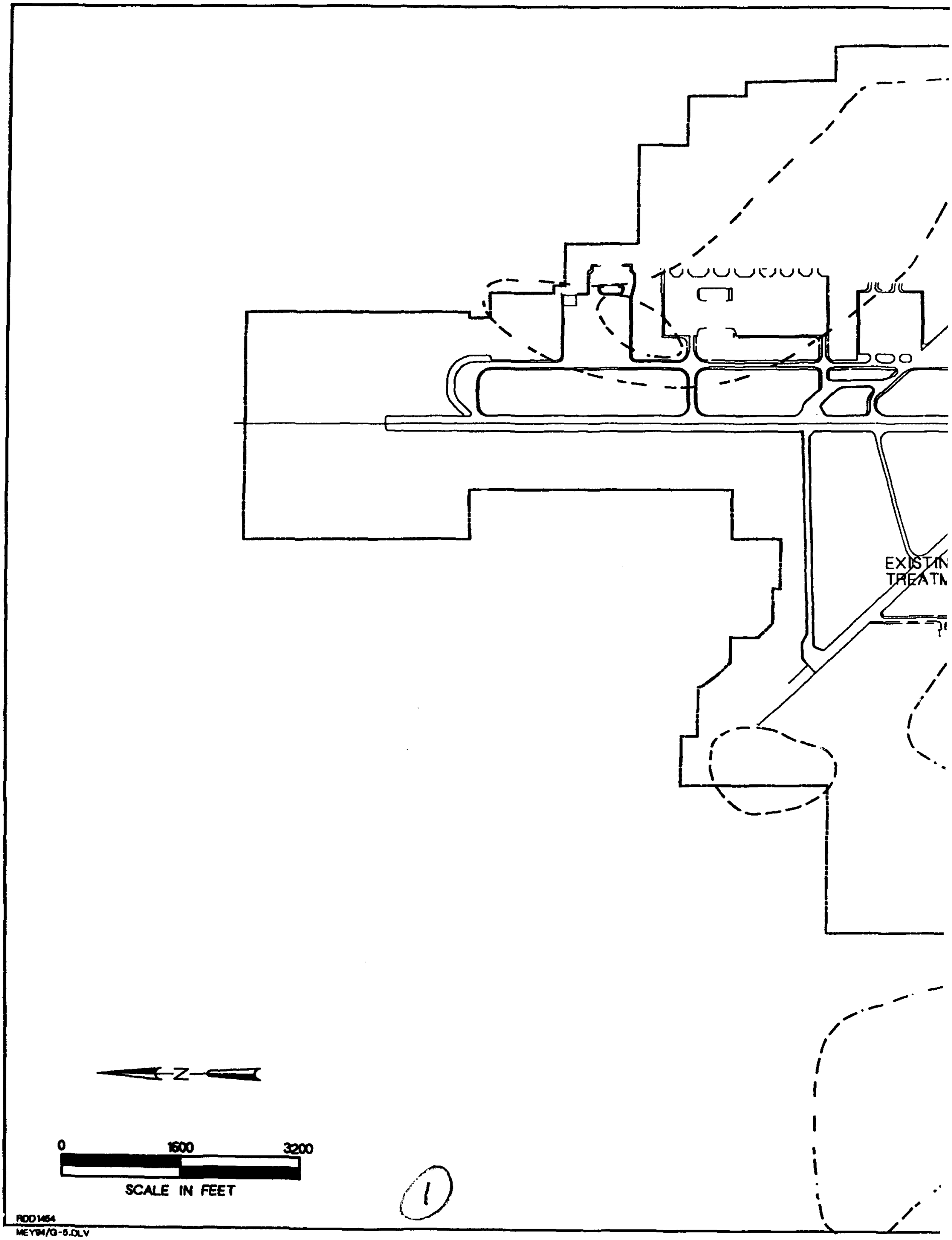

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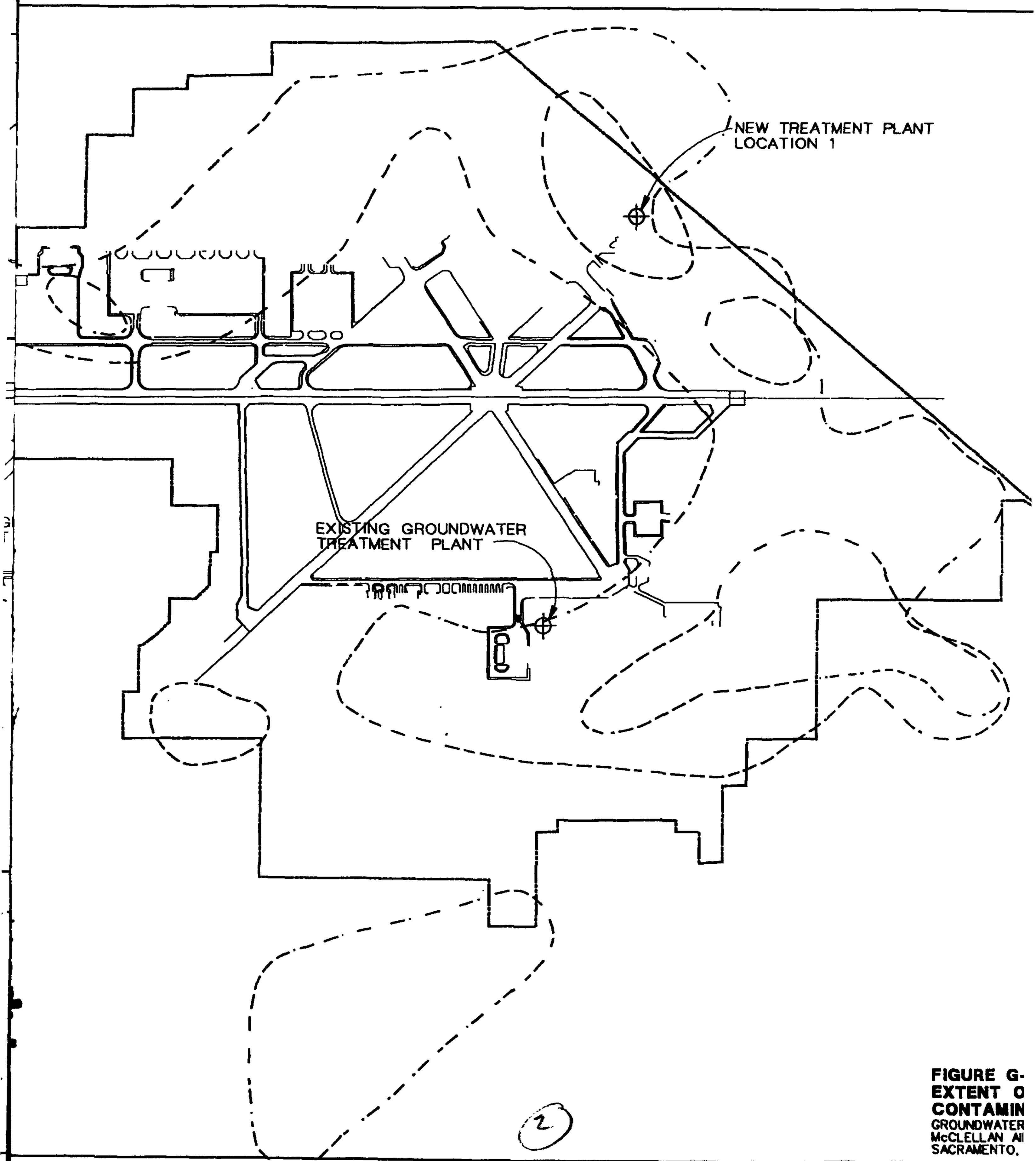

FIGURE G-
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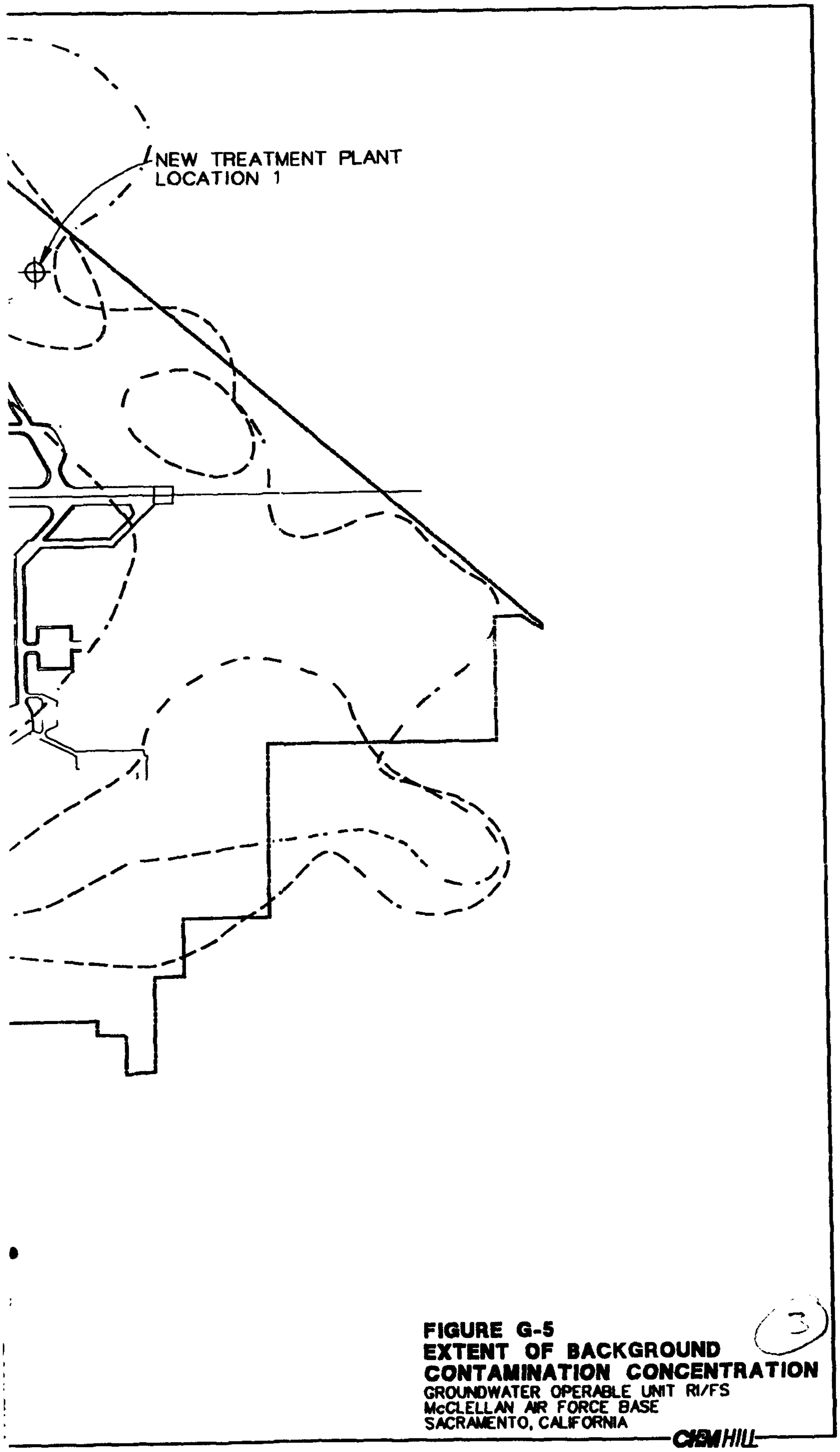

FIGURE G-5
EXTENT OF BACKGROUND
CONTAMINATION CONCENTRATION
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

CH2M HILL

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- APPROXIMATE LOCATIONS OF PRLS IN OUS E,F,G, AND H BASED ON SVE EE/CA

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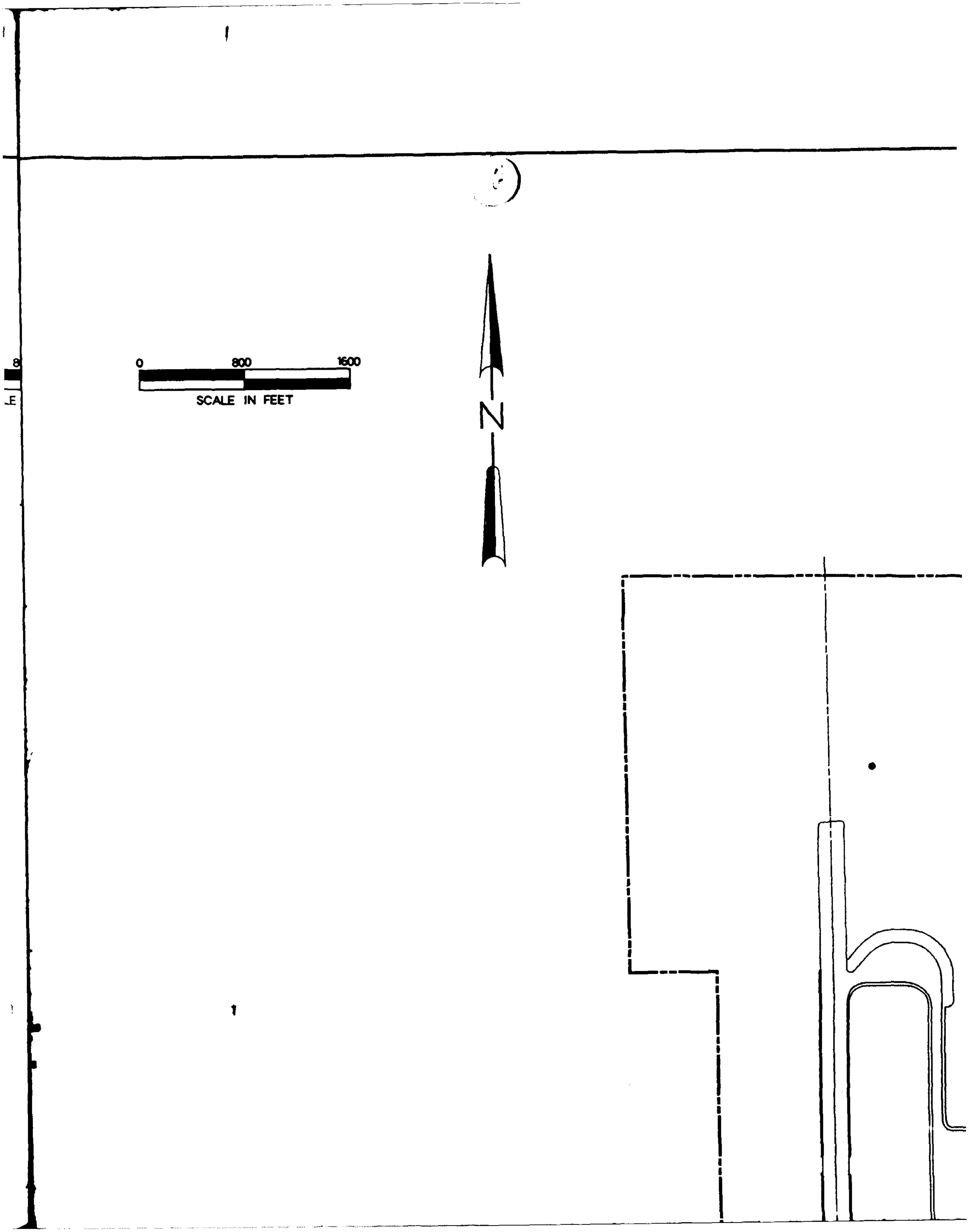
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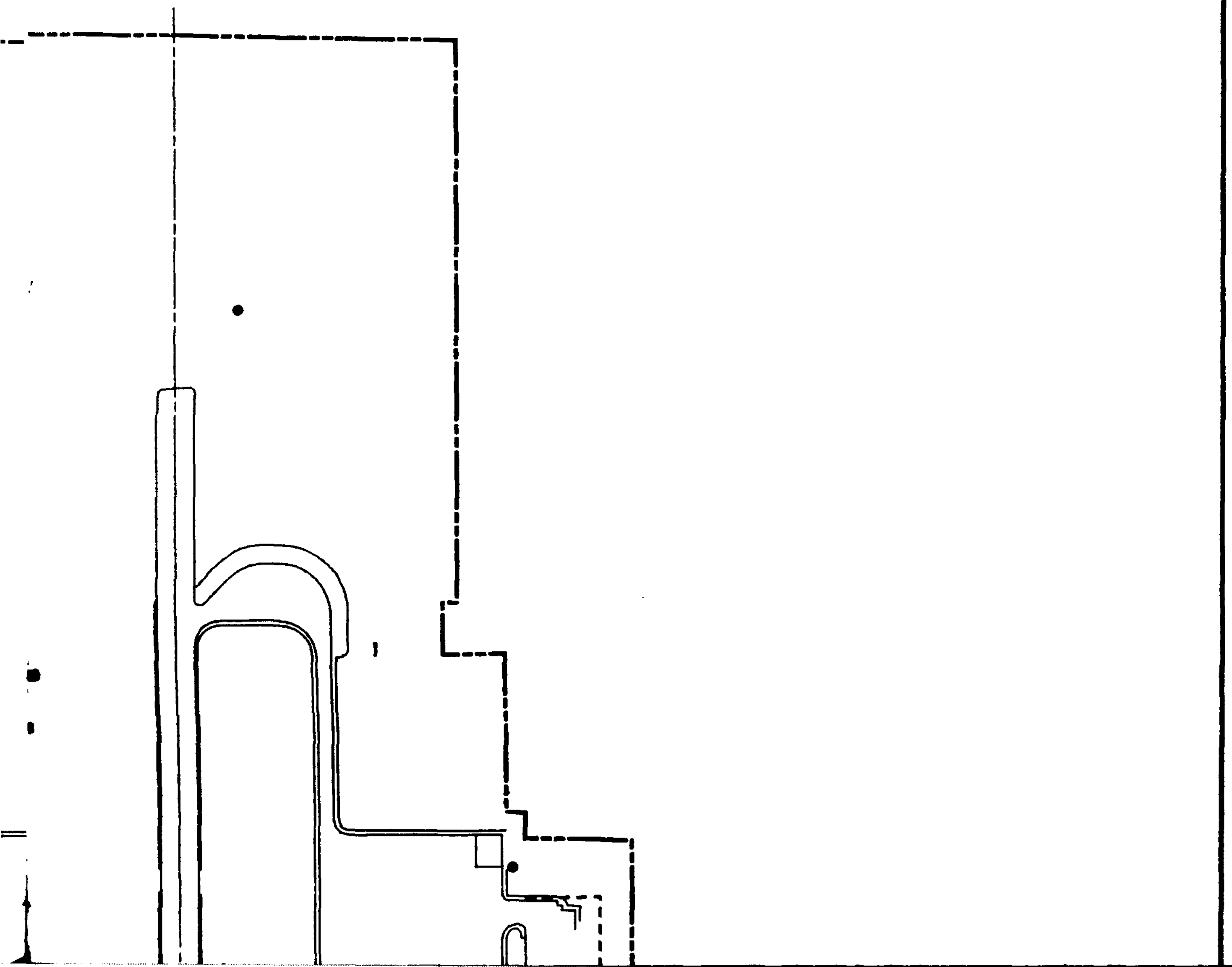

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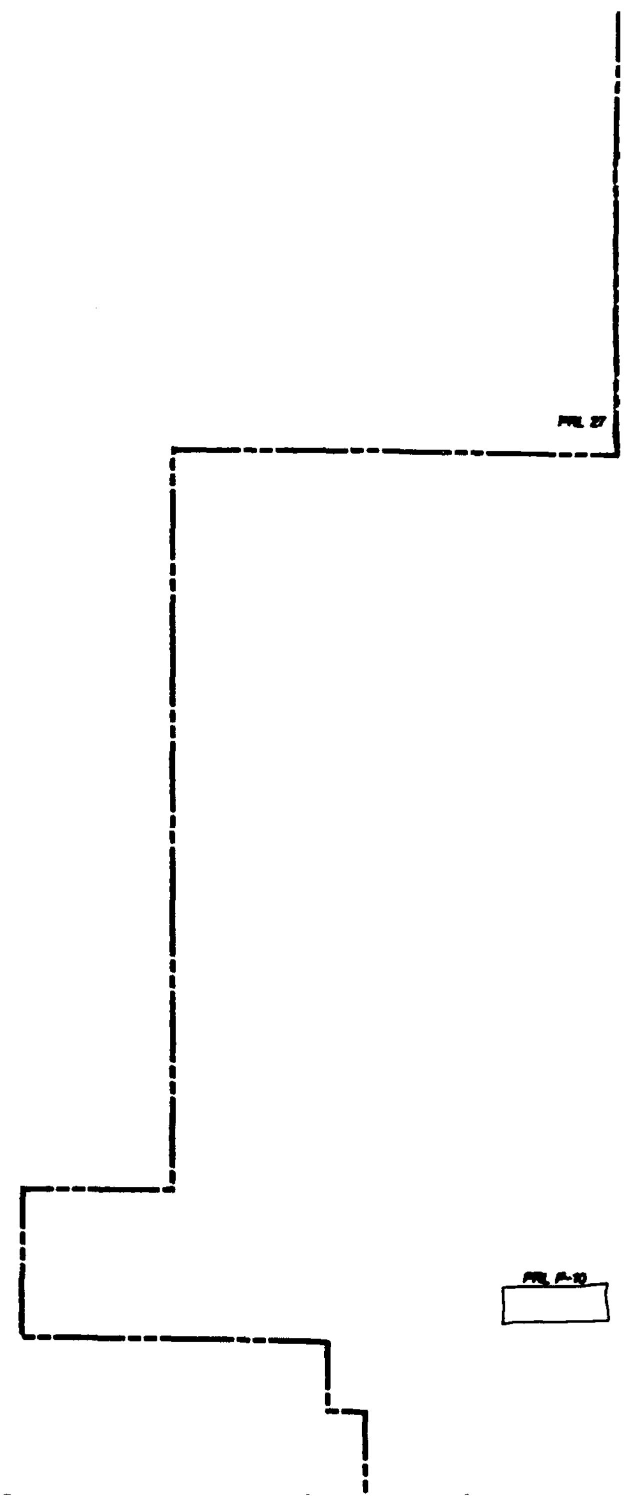

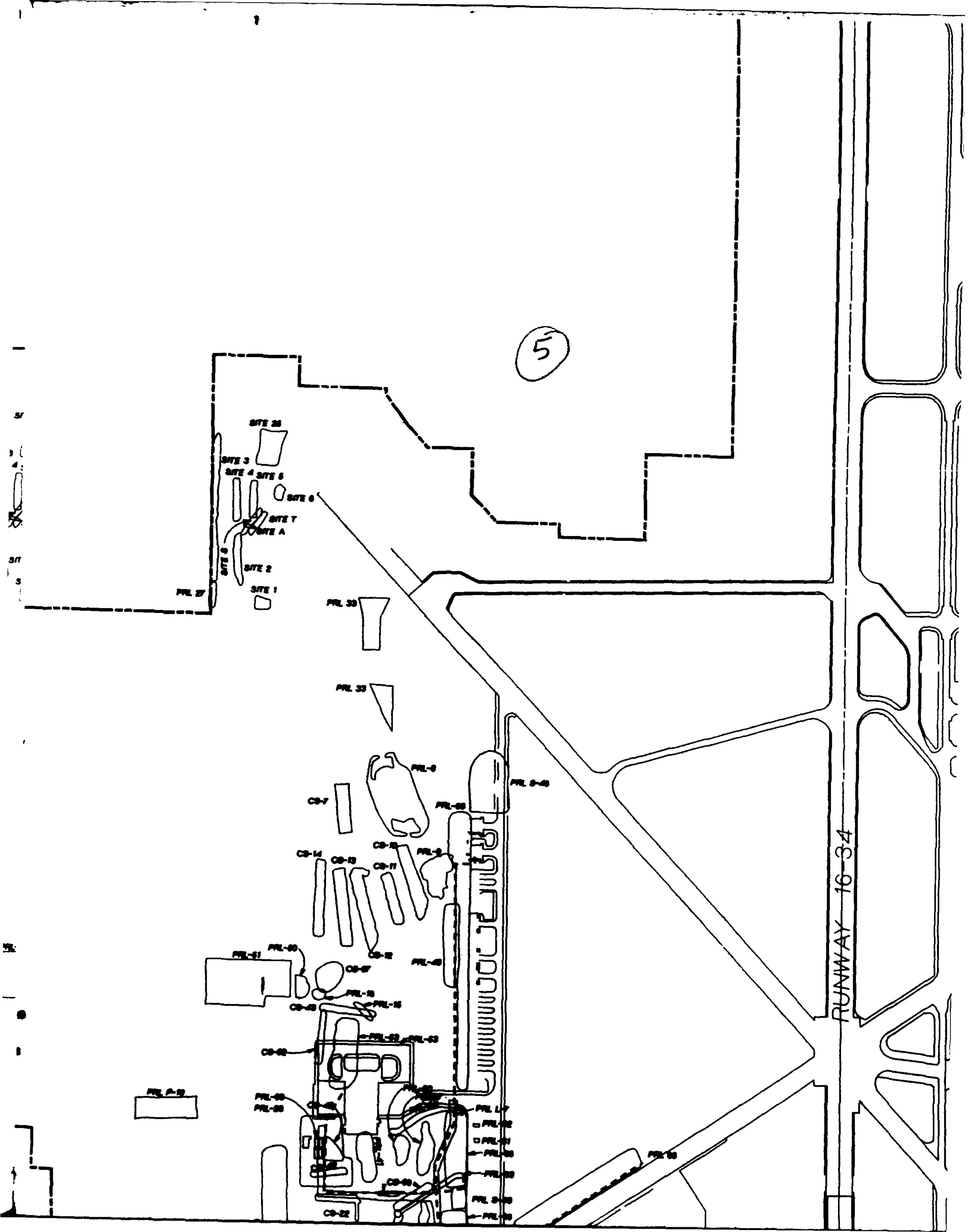
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PRL 33
PRL-8
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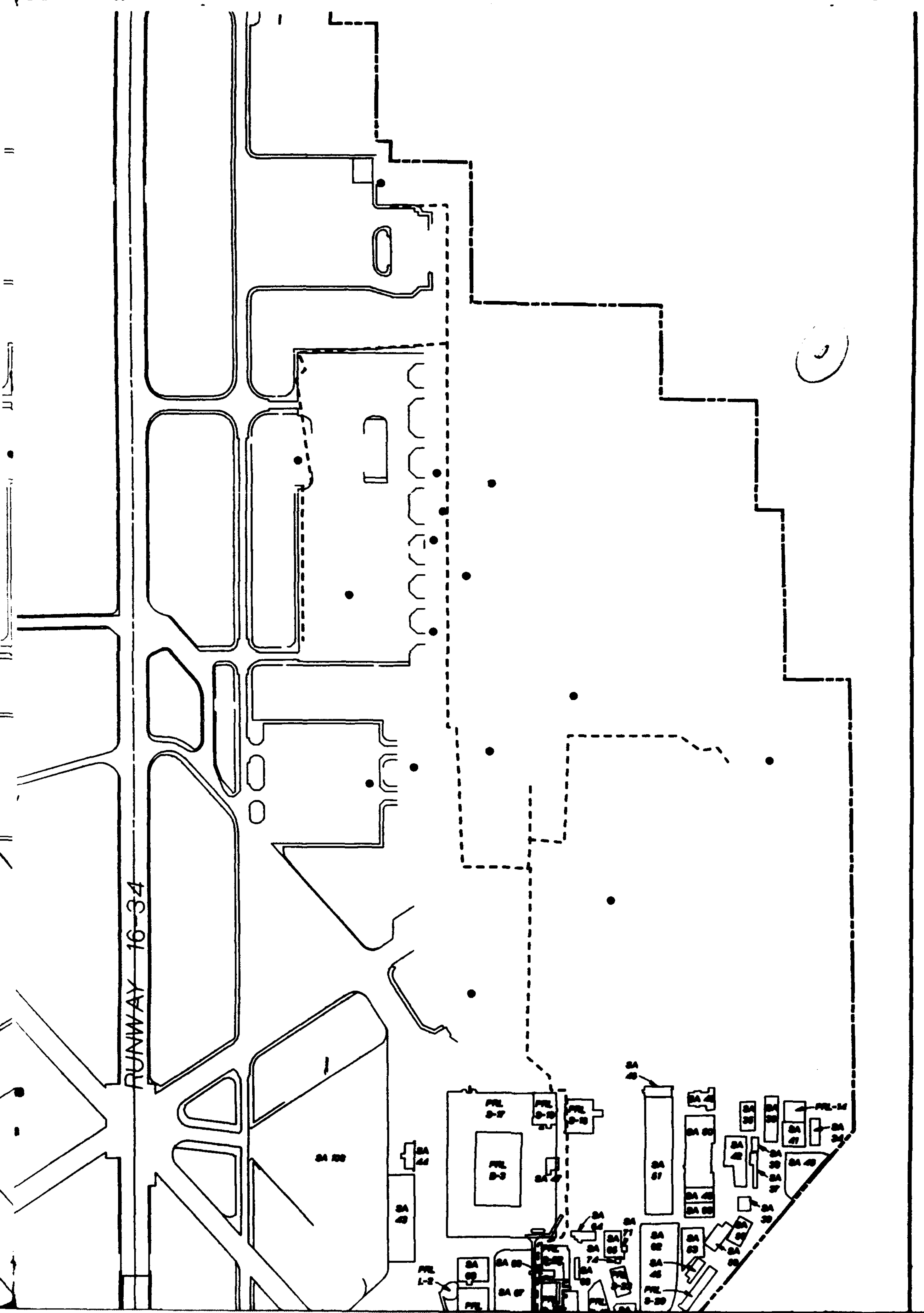
CS-22
RUNWAY 16-34



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SA 43
SA 51

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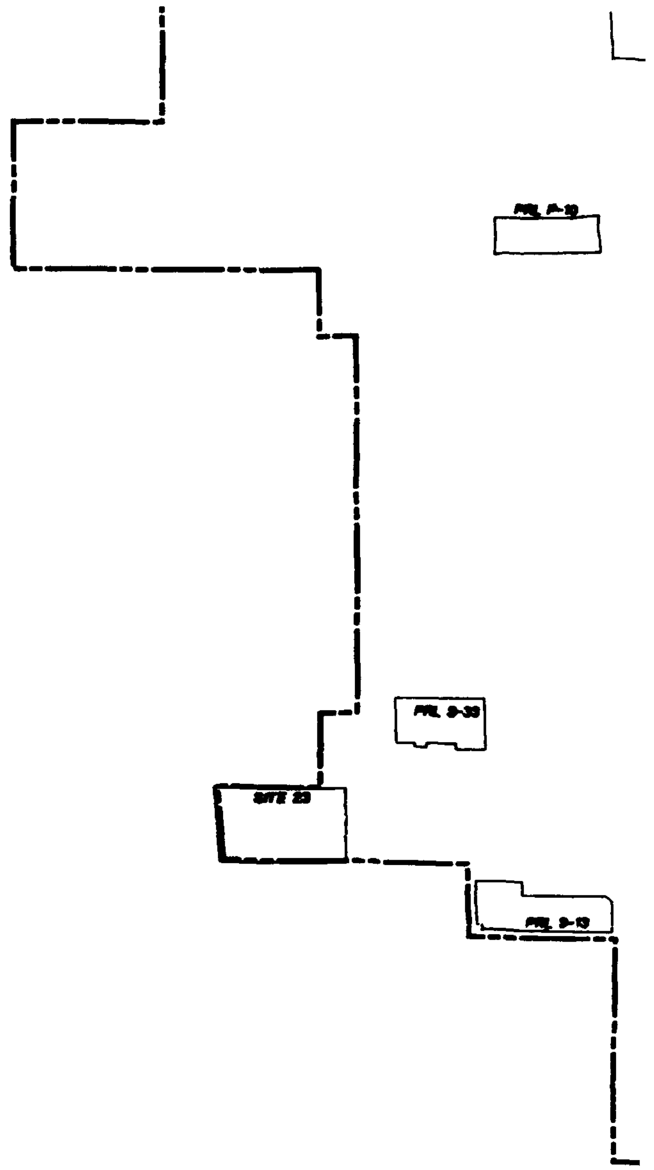

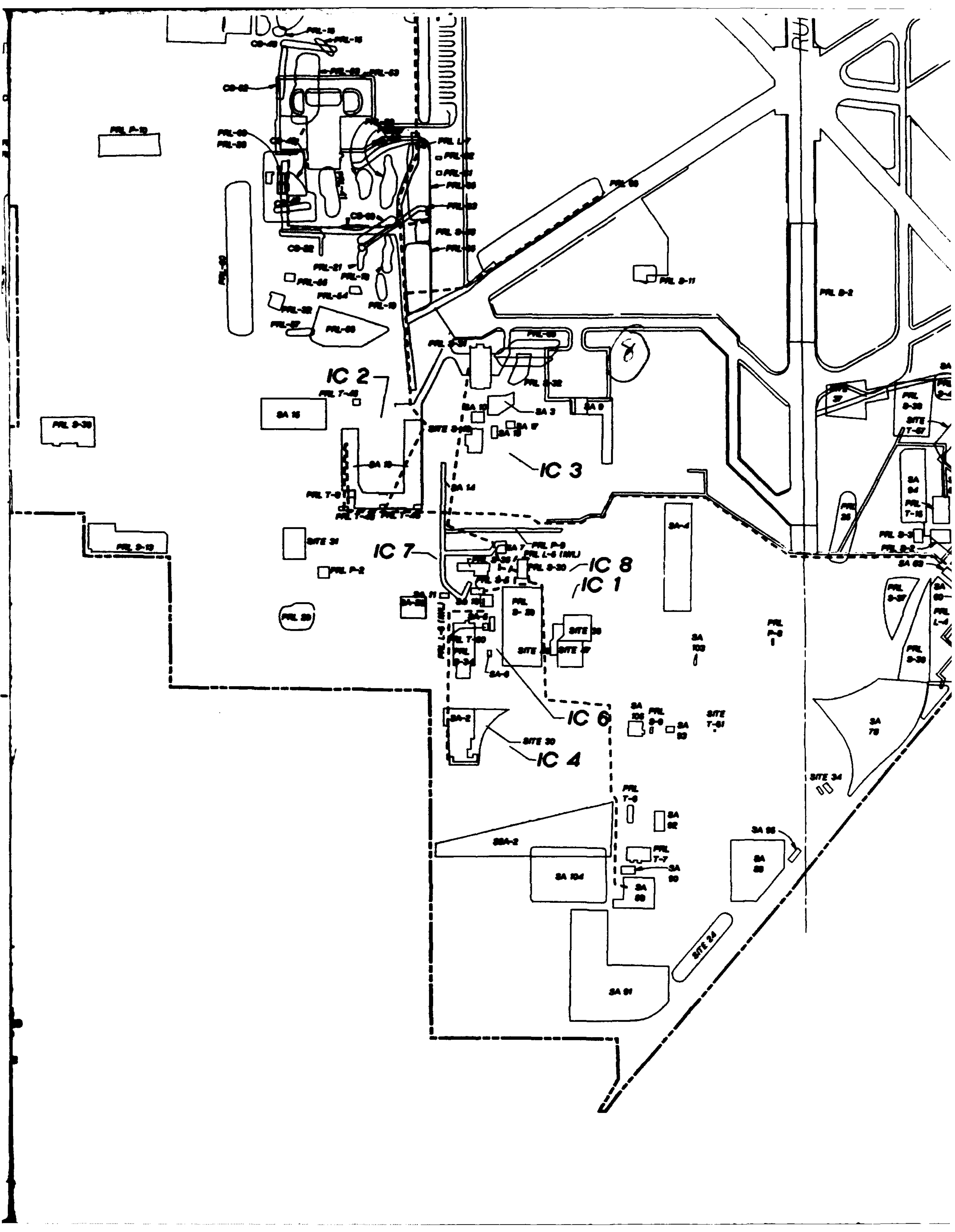

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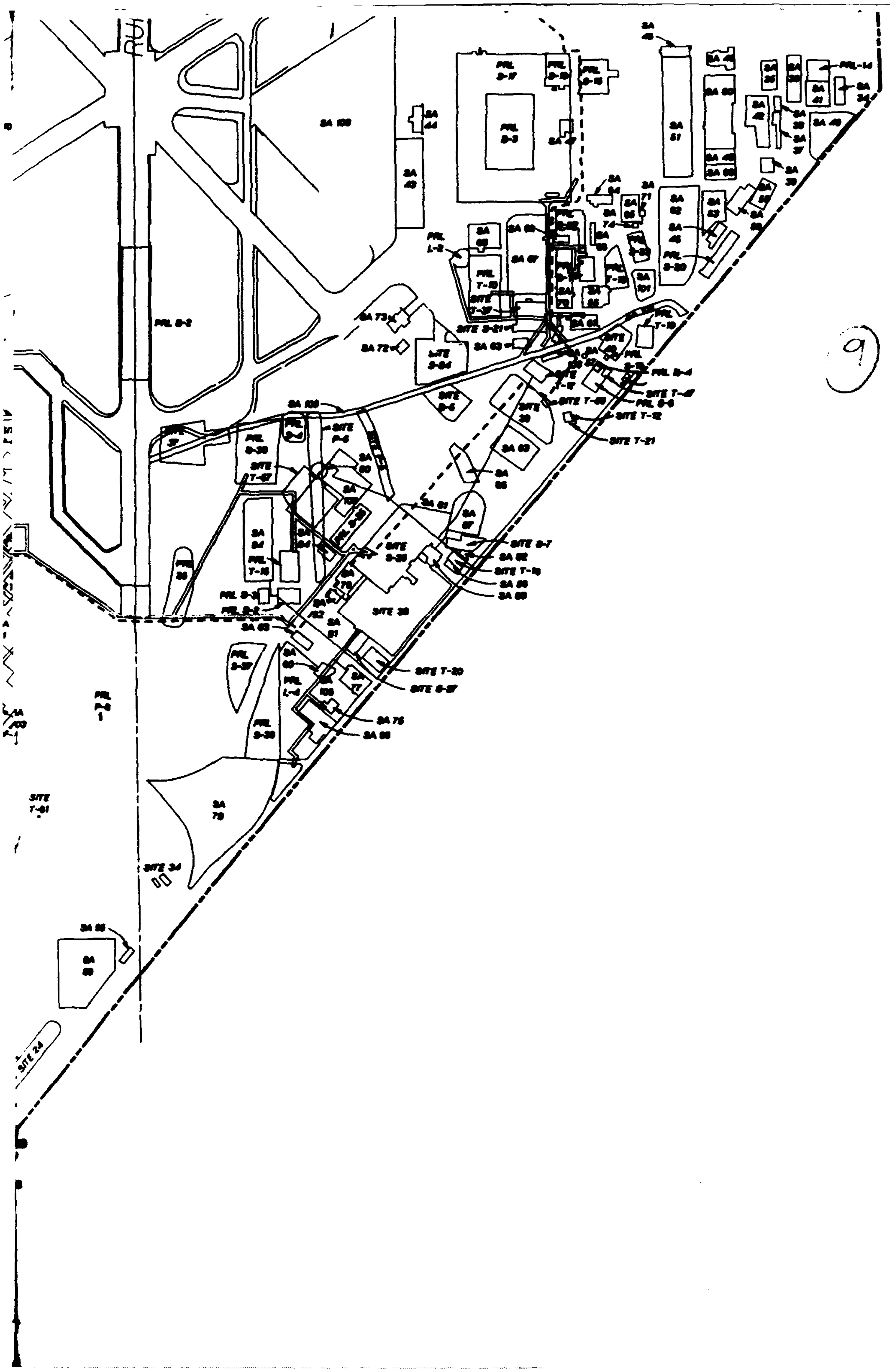
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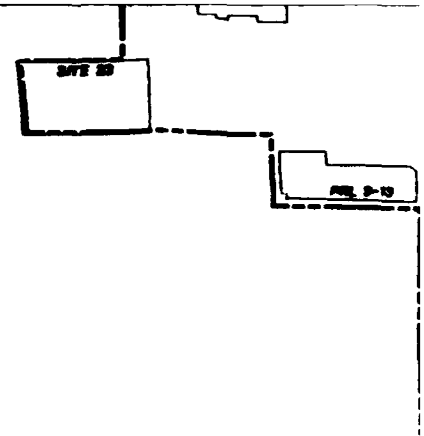

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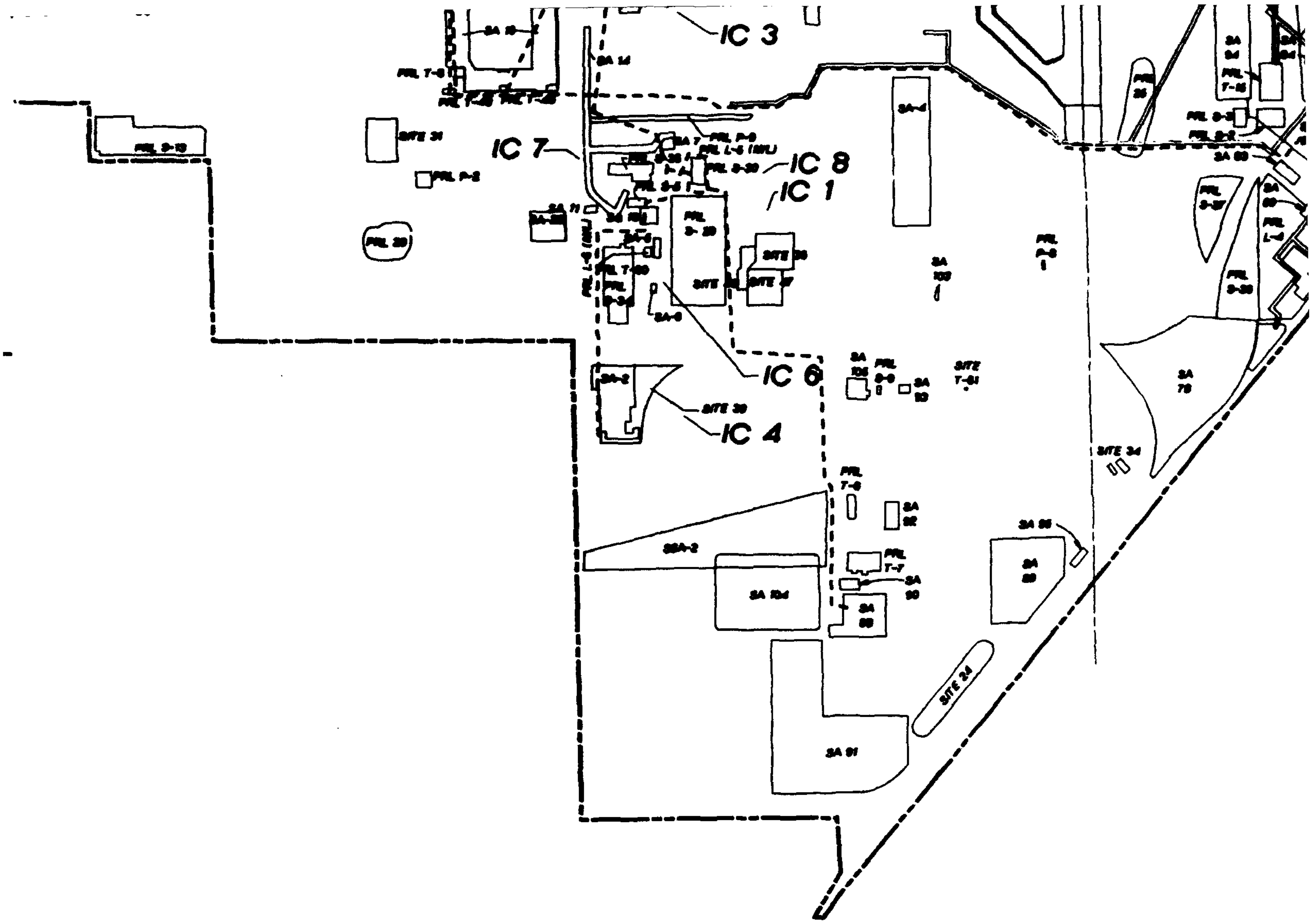
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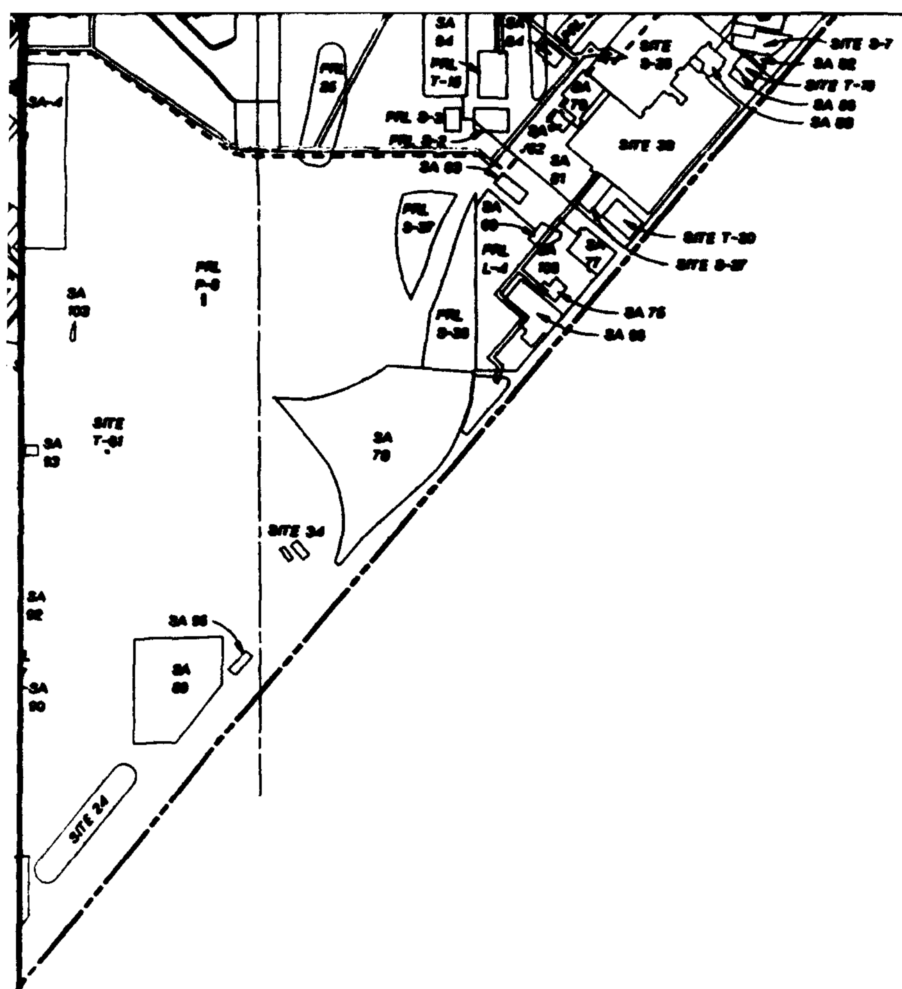

FIGURE G-1
LOCATION OF CONFIRMED SITES, PRLS, AND STUDY AREAS
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

12

CH2M HILL

PREPARED FOR: McClellan Air Force Base

DATE: November 8, 1993

SUBJECT: Decision Analysis
Groundwater Operable Unit RI/FS
Delivery Order No. 5066

PROJECT: SAC28722.66.DA

Introduction

A primary goal for the GW OU RI/FS is to develop a strategy that selects an extraction network design, treatment technology, and effluent discharge system to successfully remediate contaminated groundwater at McClellan AFB. The RI/FS should select the least-cost remedial action alternative that removes contaminant mass and reduces contaminant concentrations within the target volume of groundwater to a specified level. The RI/FS must analyze the impacts of several important uncertainties and risks, including variability in the flow and contaminant concentrations, potential impact from air emissions during groundwater treatment, suitability of treated water for end uses, and a possible mission change of McClellan AFB to dual use. The selected strategy should include flexibility so that it can respond to the changing future conditions of these uncertainties and risks.

There are four main types of information used to select remedial action alternatives:

- **Strategic Options**—The options, such as an extraction network design or treatment technology, from which the decisionmaker may choose.
- **Uncertainties**—The uncertain state of events, such as the actual flows from the different extraction network designs, which will be resolved in the future and will influence the consequences of selecting different strategic options.
- **Evaluation Criteria**—The criteria, such as selecting the least-cost solution, which the decisionmaker uses to evaluate the strategic options.
- **Assumptions**—The rules that guide the structure of the model, such as the requirement to select a treatment technology alternative before knowing what the future groundwater flow rates will be, and the values of certain variables, such as the probable range of flow rates for the extraction network design.

These four types of information are incorporated into a strategic planning process known as **decision analysis**. Within decision analysis, these four types of information are modeled using influence and decision tree diagrams, as described in this technical memorandum. The information used in this decision analysis was developed through discussions with the McClellan AFB decisionmakers and through preparation of the GW OU RI/FS report.

Approach To Decisionmaking

Overview of Decision Analysis

Decision analysis is a rigorous, mathematically valid approach used to improve the decisionmaking process. The process differentiates between options or decisions to determine an optimal strategy to resolve the targeted problem. If an activity impacts all strategies equally, then it is not included in the model because there is no differentiation. The impacts of these activities can be calculated independently of the model and then included in the implementation plans.

The process is especially useful when a decisionmaker faces at least one of the following four issues:

- A large number of combinations of different decisions or strategies must be evaluated.
- Multiple decisionmakers will be involved.
- Several different criteria will be used to judge the decisions, such as human health versus ecological impacts.
- Various uncertainties and risks impact the decisions in complex ways.

There are three primary benefits to using decision analysis for developing the GW OU remediation plan:

- Analyze important issues thoroughly
- Make assumptions explicit
- Improve communications

Decision analysis will thoroughly analyze all combinations of key decisions and uncertainties. This analysis can combine monetary and nonmonetary issues. It also allows the problem to be divided into smaller pieces. This facilitates data gathering because intuition and judgement are more effective on smaller, less complex problems.

Decision analysis explicitly depicts the content and impact of key assumptions. Making all assumptions explicit and consistent helps to ensure consistency in selecting strategies. This process focuses discussions on discrete assumptions and eliminates many confusing and conflicting issues. This facilitates incorporating McClellan AFB decisionmakers' key concerns and assumptions and attitudes towards risk. The process also explicitly depicts the structural relationships between different decisions, between different uncertainties, and between decisions and uncertainties. These assumptions are critical to understanding the logical structure of the model and strategy being developed.

Decision analysis clearly shows the impact of all important issues on the selected strategies. Each decision is identified and each uncertainty is evaluated. The process shows the structure of the problem and individual facts or data. Graphics are used for clear communication of the strategy and potential consequences. Sensitivity analyses of the key assumptions can also be presented graphically for the selected strategies. This facilitates explaining the rationale for selecting certain strategies when there are many complex alternatives. The combination of graphical and textual output is also a very effective communication tool when there are a large number of people involved, such as public involvement presentations.

Two tools commonly used in decision analysis are influence diagrams and decision trees. Influence diagrams depict the interrelationships between decisions, uncertain events, and consequences. On the basis of this information, a decision tree is drawn to depict the logical structure and chronology of the problem. This decision tree can be "solved" to yield an optimal strategy for accomplishing the objectives which takes into consideration the risks and uncertainties involved.

Decision Analysis Process

The decision analysis process used to select a preferred remedial action alternative for the GW OU RI/FS involved five principal steps:

- Problem formulation
- Deterministic analysis
- Probabilistic analysis
- Model Evaluation
- Communication

This section presents a conceptual approach to the decision analysis process used for the GW OU RI/FS. The specific decisions, uncertainties, evaluation criteria, and assumptions used in the analysis are described in the Model Description section.

Problem Formulation

Problem formulation involved identifying the primary decisions to be made in remediating contaminated groundwater at McClellan AFB, the criteria for evaluating the impacts of those decisions, the primary uncertainties or risks, how those uncertainties could impact the decisions, and the values and constraints of the decisionmakers. Information developed throughout the RI/FS was synthesized during the process of formulating the problem. The McClellan AFB decisionmakers (both

Base and agency personnel) and subject-matter experts (i.e., specialists such as engineers and hydrogeologists) were consulted during this process. Different cleanup strategies and decisions related to those strategies were identified in this step.

Deterministic Analysis

The logical structure of the problem was defined on the basis of the results from the problem formulation process. This involved developing a decision model that linked the decisions, uncertainties, and consequences so that alternatives can be compared in terms of the evaluation criteria specified during problem formulation. This model was formulated as an influence diagram and a decision tree using the Decision Programming Language (DPL) model developed by Applied Decision Analysis, of Menlo Park, California. Within this model, the decisions uncertainties, and evaluation criteria were expressed as parameters to which numerical values, distributions, or mathematical expressions could be assigned as appropriate. Data developed from the RI/FS, including flow rates from groundwater containment and extraction systems, contaminant concentrations in groundwater, and cost estimates, were assigned to these parameters. Sensitivity analyses were then performed to identify the key parameters that impact the strategy. A criterion for sensitivity in decision models is whether any decision changes when an uncertain parameter is set to its extreme points (i.e., 10th and 90th percentile values) while holding all other parameters at their nominal values. If no decisions are changed, the uncertainty of this parameter is relatively less important to decisionmaking compared with other uncertainties. The sensitivity analyses focused attention on those uncertainties with the greatest impact and helped prioritize data collection.

Probabilistic Analysis

Parameters in the model that reflect uncertain events could have variable values (i.e., there could be a range of flows from the groundwater containment and extraction system). This variability was reflected by estimating probability distributions for each uncertain event. This involved assigning probabilities and, where needed, values to each possible state of an uncertain event that will be modeled. Development of the probability distributions for uncertain parameters is discussed in the Model Description section. Probabilistic analysis provided the best representation of how uncertain events could influence decisions to be made in the remediation of groundwater contamination at McClellan AFB. The mode! evaluation step was based on a probabilistic analysis.

Model Evaluation

Several thousand different cleanup strategies were possible, given the range of decisions and uncertainties. The decision tree was solved to determine the optimal cleanup strategy and the risk profile of each strategy. Risk profiles demonstrate the range of possible outcomes (i.e., range of costs) under a given cleanup strategy. Different scenarios were performed to calculate the value of additional information, such as collection of additional groundwater contaminant data, in making better decisions.

Communication

The recommendations from the model were then expressed in terms of a robust cleanup strategy. This involves developing a strategy of actions that specifies future actions based on previous decisions. This strategy also considers the impacts of different outcomes of uncertain events as their outcomes become known in the future.

Factors Impacting Strategies

This section contains an overview of the decisions and uncertainties associated with the remediation of groundwater contamination at McClellan AFB. These decisions and uncertainties have been reflected in the model, which is described in further detail in the Model Description section.

Decisions

There are three major decisions that must be made to develop a remediation plan. Each of these decisions are evaluated against specific evaluation criteria. The three decisions are:

- Cleanup strategy (target volume)
- Groundwater treatment technologies
- End-use alternatives

The cleanup strategy decision is reflected by selection of the target volume. The target volumes (cleanup strategies) that were defined in the model include:

- Hot spots, 500 μg/l or greater TCE

- MCL 5 μg/L TCE (determined largely by the extent of TCE in groundwater)

- Health risk 10^{-6} increased lifetime cancer risk

- Background 0.5 μg/l determined largely by the extent of TCE in groundwater

A groundwater containment and extraction network design was developed based on the selected target volume. Development of the groundwater containment and extraction network designs is discussed in Chapter 6 and Appendix J of the RI/FS report. Each cleanup strategy decision was evaluated against the criterion of least cost.

The groundwater treatment technology decision is composed of 12 alternative remediation technologies, including the existing GWTP. These treatment technologies are discussed in Chapter 7 and Appendix I of the RI/FS report. The treatment technology decision is evaluated against the criteria of mass removal and least cost. The impact of a change in McClellan AFB's mission to dual use also influences the technology decision. Instead of an evaluation criterion, though, the change in mission is treated as an uncertainty.

The end-use decision consists of two systems for handling the effluent after treatment. These systems include different combinations of water districts, reinjection, and surface discharge. The end-use decision is evaluated against the criterion of least cost.

Uncertainties

There are six major uncertainties that influence these decisions. These uncertainties have various possible outcomes with probabilities associated with each outcome. These various outcomes influence the decisions by impacting the consequences of selecting different alternatives.

For instance, one uncertainty is whether water quality in terms of mineral concentrations would be suitable for reinjection. The two possible future outcomes of a change in water quality for end use could be either yes (there is a change in water quality, meaning that the quality of treated water is different from that in the reinjection aquifer) or no (there is no change). This uncertainty analyzes the strategic implications of a change in water quality between the treatment plant's effluent and the composition of the water at the point of reinjection. The outcome of this uncertainty will influence the consequences of selecting the different end-use alternatives. If there is a change in water quality, then the reinjection option will incur additional costs to implement another feasible alternative. The model penalizes strategies that attempt reinjection when there is a change in water quality by adding these costs.

The six uncertainties considered in this model include:

- Change in water quality
- Air permitting complexity
- Mission change
- Added permit complexity
- Extraction network flows
- Influent contaminant concentrations

The change in water quality uncertainty is described above. This uncertainty influences the treated water discharge cost of the end-use alternatives.

The air permitting complexity relates to the impact of technologies that produce emissions to the air (principally air stripping). This uncertainty influences the up-front cost of the treatment technologies. If air stripping is chosen, then additional costs will be incurred to offset these emissions, either through additional offgas treatment or by trading emissions credits.

The mission change uncertainty relates to the impact of civilian use of portions of McClellan AFB. This uncertainty influences the up-front cost of the treatment technologies. If the mission changes to dual use, then certain technologies become more expensive because of the increased permitting difficulty.

The added permit complexity uncertainty relates to the cost impact of civilian use of McClellan AFB. This uncertainty also influences the up-front cost of the treatment technologies.

The extraction network flows uncertainty relates to the quantity of groundwater pumped by the containment and extraction network. This uncertainty influences the cost of treatment technologies, water polishing (i.e., treatment of effluent with activated carbon prior to delivery to water districts), transport time of the contaminants through the aquifer, and end-use reinjection.

The contaminant concentration uncertainty relates to the concentration level of the principal contaminant in groundwater, TCE. Uncertainty in contaminant concentration in groundwater influences the time to clean up the particular target volume. The calculation of time to clean up is described further in Chapter 6 of the RI/FS report.

Model Description

The decision model is depicted in two primary graphics: the influence diagram (Figure H-1) and the decision tree diagram (Figure H-2). The influence diagram depicts the decision, uncertainty, and value nodes that represent the groundwater remediation problem at McClellan AFB. The influence diagram shows which nodes are influenced by other nodes. These influences determine how the outcome of one node will change the outcome of other nodes. The decision tree diagram shows the decision and uncertainty nodes. Specific value nodes needed to evaluate the strategies are included within these nodes. These nodes are arranged according to the logical structure and chronology of the problem.

These diagrams contain all four types of information: strategic options, uncertainties, evaluation criteria, and assumptions. The strategic options are shown in the rectangles called decision nodes. The uncertainties are shown in the ovals called uncertainty nodes. The evaluation criteria are calculated in the rounded-rectangles called value nodes. The assumptions are reflected in the structure of the diagrams and the beginning values for certain variables.

Influence Diagram

The influence diagram contains 26 nodes as follows:

- Decision nodes containing the strategic options
- Uncertainty nodes defining the uncertainties and risks
- Value nodes containing the evaluation criteria calculations

Table H-1 presents the information contained in the decision and uncertainty nodes. This includes the values for each alternative within each decision or uncertainty node, and the probability of a particular alternative occurring for each of the uncertainty nodes. For example, "Change in Water Quality" which reflects the suitability of treated water for reinjection has two alternatives (yes/no) and a 50 percent chance of water quality either being suitable for reinjection (yes), or unsuitable for reinjection (no). The probabilities for the two air permit complexity uncertainties reflect normal distribution. The values (costs) for air permitting were based on expert judgments obtained from senior planners within CH2M HILL. The probabilities associated with mission change are subjective and may reflect a slight bias towards McClellan AFB's remaining military use. The probabilities for alternative flows skewed to reflect the extraction network design, which is intended to not underestimate flows in order to obtain containment. Flows represent 10th, 50th, and 90th percentile values. Concentrations are discrete approximations of the distribution of TCE concentrations used in development of the target volumes. These flow and concentration values are presented in Table H-2.

Table H-3 presents the information contained in each of the value nodes. The value nodes provide calculations of costs as a function of flow and, for catalytic oxidation as an offgas treatment, a function of air permit complexity. Other value nodes hold data used in calculations. Capital and O&M costs were calculated from regression equations developed from order-of-magnitude cost estimates used in screening remedial action alternatives.

Decision Tree Diagram

The decision tree (Figure H-2) shows that the four decisions must be made before any of the uncertainties are resolved. The first decision in the tree is labeled "Mass Or Cost Decision." This node is used as a switch in the model to evaluate each strategy's effectiveness in achieving either least-cost or mass removal. When it is set to "Cost," then the model uses least-cost as the evaluation criterion. When it is set to "Mass," the model calculates the expected mass removal during the first year by multiplying the expected range of flows by the expected range of contaminant concentrations. Each of these numbers are weighted by their expected probabilities of occurrence, so the final mass number is the expected mass removed during the first year. All of the technologies remove contaminants at an exponential decay rate, so time to clean up and mass removed during subsequent years can be estimated from this point.

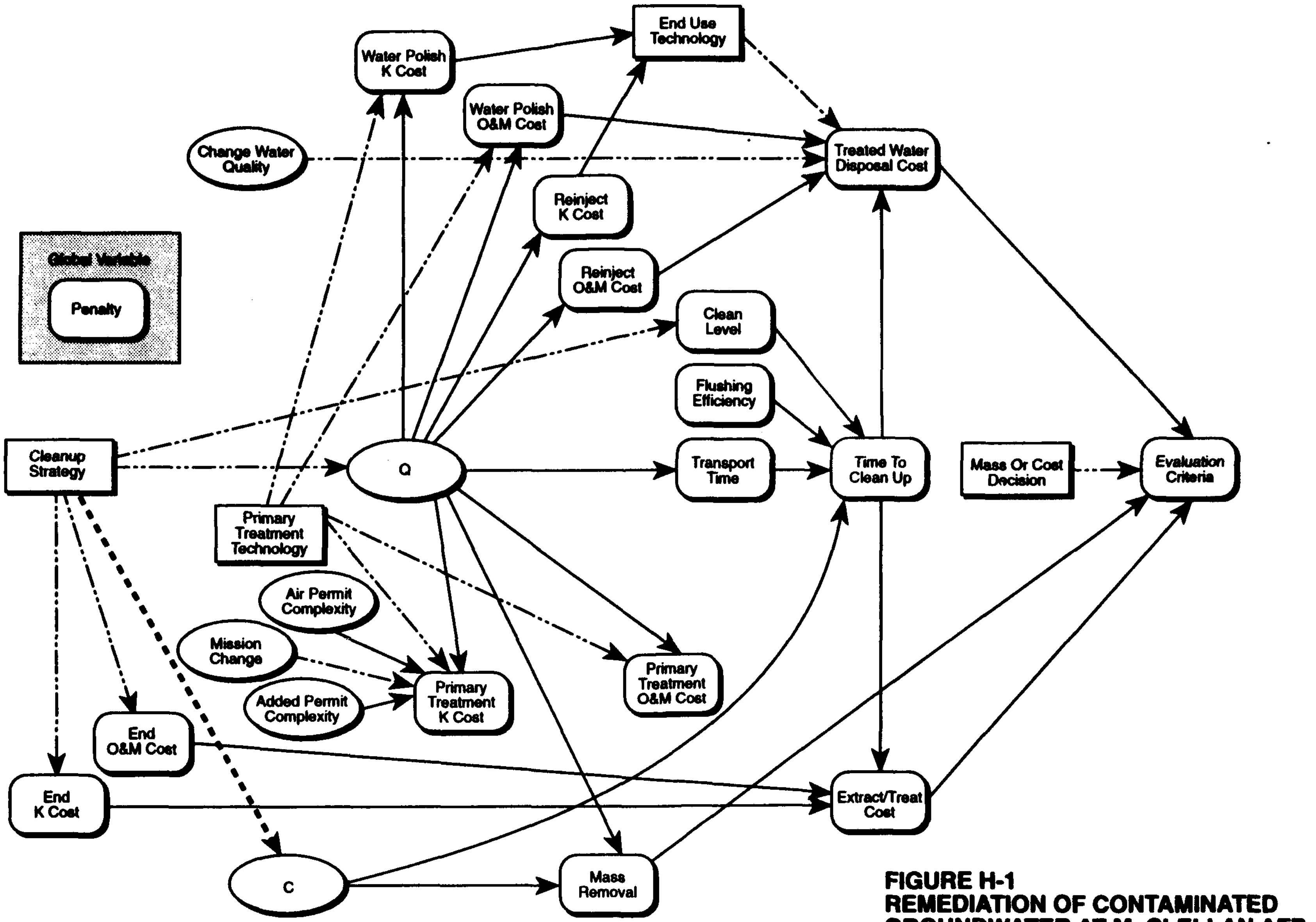

FIGURE H-1
REMEDIATION OF CONTAMINATED GROUNDWATER AT McCLELLAN AFB
INFLUENCE DIAGRAM
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

CH2M HILL

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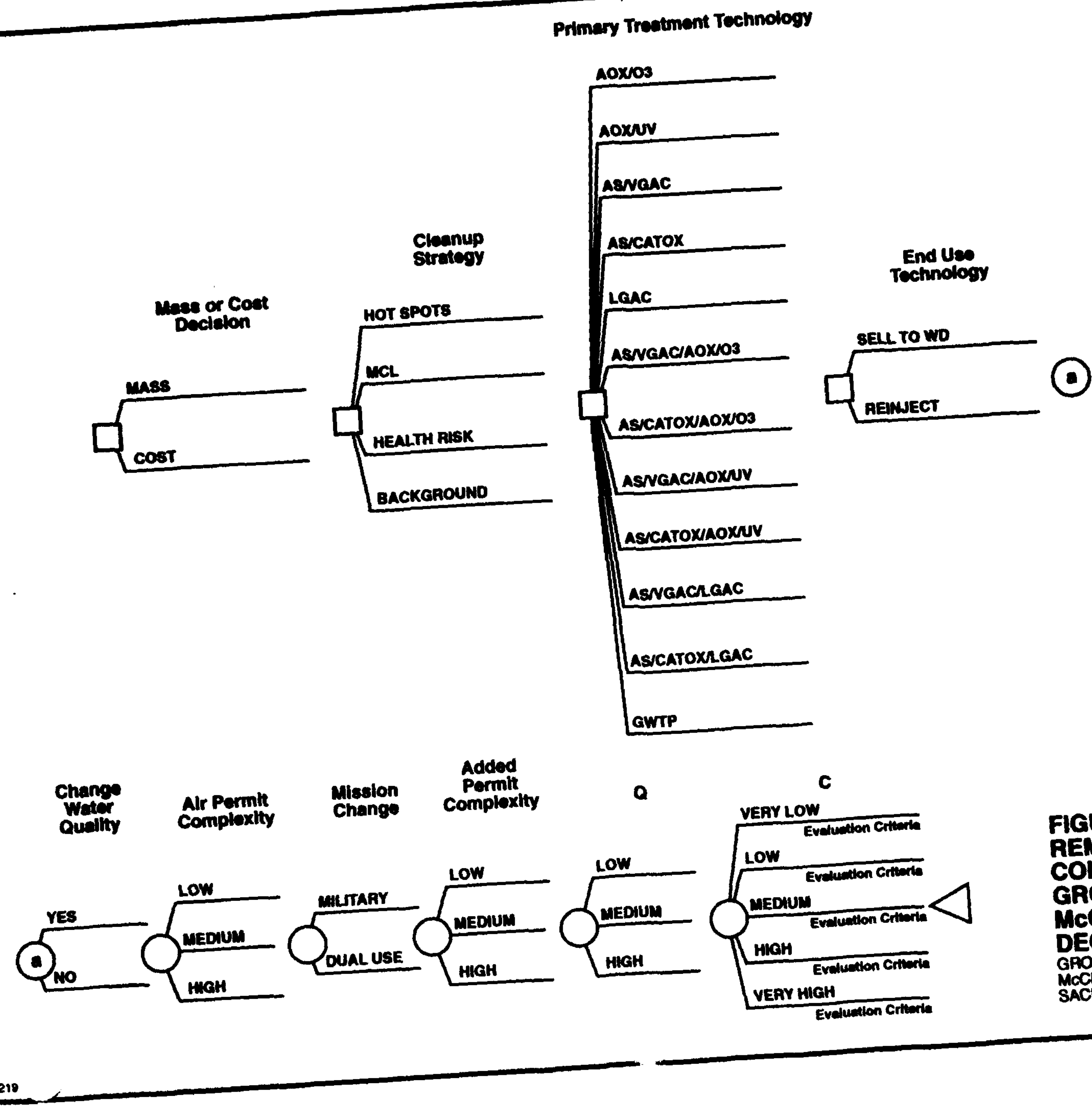

FIGURE H-2
REMEDIATION OF CONTAMINATED GROUNDWATER AT McCLELLAN AFB DECISION TREE
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFO

CH2M HILL

Table H-1
Decision and Uncertainty Nodes

Node Index	Node Name	Node Type	Alternatives Evaluated	Probability (C Nodes)	Value (x $000,000 or Node Which Calculates Value)	Associated Value Nodes (in Table H-3)
1	Mass or Cost	D	Mass Cost			26
2	Cleanup Strategy	D	Hot Spots MCL Health Risks Background		Node 11: END K Cost Node 12: END O&M Cost Node 13: Clean Level	9, 11, 12, 13
3	Primary Treatment Technology	D	AOP/O3 AOP/UV AS/VGAC AS/CatOx LGAC AS/VGAC/AOP/O3 AS/CATOX/AOP/O3 AS/VGAC/AOP/UV AS/CatOx/AOP/UV AS/VGAC/LGAC AS/CatOx/LGAC GWTP		Node 14: Primary Treatment K Cost Node 15: Primary Treatment O&M Cost Node 16: Water Polish K Cost	14, 15, 16
4	End-Use Technology	D	Sell To Water District Reinject		Node 16: Water Polish K Cost Node 18: Reinject K Cost	16, 18, 24
5	Change Water Quality	C	Yes No	0.5 0.5		24
6	Air Permit Complexity	C	Low Medium High	0.25 0.5 0.25	0.1 0.35 1.2	
7	Mission Change	C	Military Dual Use	0.8 0.2		14
8	Added Permit Complexity	C	Low Medium High	0.25 0.5 0.25	0.3 0.5 0.8	
9	Q	C	Low Medium High	0.1 0.6 0.3	Function 1 Function 2 Function 3	

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Table H-1
Decision and Uncertainty Nodes

Node Index	Node Name	Node Type	Alternatives Evaluated	Probability (C Nodes)	Value (x $000,000 or Node Which Calculates Value)	Associated Value Nodes (in Table H-3)
10	C	C	Very Low	Function 4	Function 5	
			Low	Function 6	Function 7	
			Medium	Function 8	Function 9	
			High	Function 10	Function 11	
			Very High	Function 12	Function 13	

Notes:
D = Decision node
C = Chance (uncertainty) node

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Table H-2
Functions for Concentration (C) and Flow (Q)

	East	West
F1: Q.Low (gpm)		
	40 Cleanup Strategy.HotSpots	134 Cleanup Strategy.HotSpots
	338 Cleanup Strategy.MCL	613 Cleanup Strategy.MCL
	387 Cleanup Strategy.HealthRisk	876 Cleanup Strategy.HealthRisk
	518 Cleanup Strategy.Background	1279 Cleanup Strategy.Background
F2: Q.Medium (gpm)		
	50 Cleanup Strategy.HotSpots	167 Cleanup Strategy.HotSpots
	422 Cleanup Strategy.MCL	766 Cleanup Strategy.MCL
	484 Cleanup Strategy.HealthRisk	1095 Cleanup Strategy.HealthRisk
	648 Cleanup Strategy.Background	1599 Cleanup Strategy.Background
F3: Q.High (gpm)		
	75 Cleanup Strategy.HotSpots	251 Cleanup Strategy.HotSpots
	633 Cleanup Strategy.MCL	1149 Cleanup Strategy.MCL
	726 Cleanup Strategy.HealthRisk	1643 Cleanup Strategy.HealthRisk
	972 Cleanup Strategy.Background	2399 Cleanup Strategy.Background
F4: C.Very Low (Probability)		
	0.4457 Cleanup Strategy.HotSpots	
	0.8028 Cleanup Strategy.MCL	
	0.8262 Cleanup Strategy.HealthRisk	
	0.8669 Cleanup Strategy.Background	
F5: C.Very Low (ppb)		
	792 Cleanup Strategy.HotSpots	
	63.36 Cleanup Strategy.MCL	
	53.24 Cleanup Strategy.HealthRisk	
	37.41 Cleanup Strategy.Background	
F6: C.Low (Probability)		
	0.2572 Cleanup Strategy.HotSpots	
	0.1207 Cleanup Strategy.MCL	
	0.1068 Cleanup Strategy.HealthRisk	
	0.0822 Cleanup Strategy.Background	
F7: C.Low (ppb)		
	2246 Cleanup Strategy.HotSpots	
	1477 Cleanup Strategy.MCL	
	1467 Cleanup Strategy.HealthRisk	
	1451 Cleanup Strategy.Background	
F8: C.Medium (Probability)		
	0.1717 Cleanup Strategy.HotSpots	
	0.04471 Cleanup Strategy.MCL	
	0.03919 Cleanup Strategy.HealthRisk	
	0.02976 Cleanup Strategy.Background	
F9: C.Medium (ppb)		
	5423 Cleanup Strategy.HotSpots	
	5003 Cleanup Strategy.MCL	
	4996 Cleanup Strategy.HealthRisk	
	4986 Cleanup Strategy.Background	
F10: C.High (Probability)		
	0.0555 Cleanup Strategy.HotSpots	
	0.01425 Cleanup Strategy.MCL	
	0.0125 Cleanup Strategy.HealthRisk	
	0.009498 Cleanup Strategy.Background	
F11: C.High (ppb)		
	8990 Cleanup Strategy.HotSpots	
	8554 Cleanup Strategy.MCL	
	8547 Cleanup Strategy.HealthRisk	
	8536 Cleanup Strategy.Background	
F12: C.Very High (Probability)		
	0.0699 Cleanup Strategy.HotSpots	
	0.0175 Cleanup Strategy.MCL	
	0.01532 Cleanup Strategy.HealthRisk	
	0.01162 Cleanup Strategy.Background	
F13: C.Very High (ppb)		
	10890 Cleanup Strategy.HotSpots	
	10849 Cleanup Strategy.MCL	
	10849 Cleanup Strategy.HealthRisk	
	10848 Cleanup Strategy.Background	

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Table H-3
Value Nodes and Evaluation Criteria

Node Index	Node Name	Influencing States	East	West
11	END K Cost	Cleanup Strategy	0.004*(Q^1.045)	Same
12	END O&M Cost	Cleanup Strategy	0.00022*(Q^1.045)	Same
13	Clean Level	Cleanup Strategy.HotSpots	500	Same
		Cleanup Strategy.MCL	5	
		Cleanup Strategy.Health Risk	2.5	
		Cleanup Strategy.Background	0.5	
14	Primary Treatment K Cost	AOP/Ozone	@max(0.0331*Q-2.413,5.86)	0.00942*Q+6.992
		AOP/UV	@max(0.0127*Q-0.14,3.03)	0.00131*Q+9.242
		Air Stripping/VGAC	0.0007*Q+0.058	0.00056*Q+0.1164
		Air Stripping/Catalytic Oxidation		
		Mission Change.Military	@max(0.0016*Q-0.1097+Air Permit Complexity,.28+Air Permit Complexity)	0.00077*Q+0.1159+Air Permit Complexity
		Mission Change.Dual Use	@max(0.0016*Q-0.1097+Added Permit Complexity+Air Permit Complexity,	0.00077*Q+0.1159+Air Permit Complexity+Added Permit Complexity
			3.42+Added Permit Complexity+Air Permit Complexity)	
		LGAC	@max(0.0007*Q-0.034,0.15)	0.00054*Q+0.0714
		Air Stripping/VGAC/AOP/Ozone	@max(0.0228*Q-8.024,3.36)	0.00092*Q+8.207
		Air Stripping/Catalytic Oxidation/AOP/Ozone		
		Mission Change.Military	@max(0.0229*Q-8.02+Air Permit Complexity,3.42+Air Permit Complexity)	0.00101*Q+8.199+Air Permit Complexity
		Mission Change.Dual Use	@max(0.0229*Q-8.02+Added Permit Complexity+Air Permit Complexity,	0.00101*Q+8.199+Air Permit Complexity+Added Permit Complexity
			3.42+Added Permit Complexity+Air Permit Complexity)	
		Air Stripping/VGAC/AOP/UV	@max(0.0116*Q-3.495,2.29)	@max(0.00196*Q-1.728,1.02)
		Air Stripping/Catalytic Oxidation/AOP/UV		
		Mission Change.Military	@max(0.0116*Q-3.454+Air Permit Complexity,2.35+Air Permit Complexity)	@max(0.00205-1.698,1.17)+Air Permit Complexity
		Mission Change.Dual Use	@max(0.0116*Q-3.454+Added Permit Complexity+Air Permit Complexity,	@max(0.00205-1.698,1.17)+Air Permit Complexity+
			2.35+Added Permit Complexity+Air Permit Complexity)	Added Permit Complexity
		Air Stripping/VGAC/LGAC	@max(0.0013*Q-0.002,0.31)	0.00076*Q+0.2356
		Air Stripping/Catalytic Oxidation/LGAC		
		Mission Change.Military	@max(0.0014*Q-0.0103+Air Permit Complexity,0.34+Air Permit Complexity)	0.00085*Q+0.2639+Air Permit Complexity
		Mission Change.Dual Use	@max(0.0014*Q-0.0103+Added Permit Complexity+Air Permit Complexity,	0.00085*Q+0.2639+Air Permit Complexity+Added Permit Complexity
			0.34+Added Permit Complexity+Air Permit Complexity)	
		Current Water Treatment Plant		@max(0.00141*Q-1.22,0)
15	Primary Treatment O & M Cost	AOP/Ozone	0.00075*Q+0.95	0.00075*Q+1.95
		AOP/UV	0.00094*Q+2.03	0.00094*Q+4.46
		Air Stripping/VGAC	0.00012*Q+0.41	0.00012*Q+0.78
		Air Stripping/Catalytic Oxidation	0.0002*Q+0.15	0.0002*Q+0.17
		LGAC	0.00047*Q+0.37	0.00047*Q+2.13
		Air Stripping/VGAC/AOP/Ozone	0.00039*Q+0.28	0.00039*Q+0.64
		Air Stripping/Catalytic Oxidation/AOP/Ozone	0.0004*Q+0.05	0.0004*Q+0.29
		Air Stripping/VGAC/AOP/UV	0.00087*Q+0.47	@max(0.00087*Q-0.33,0.71)
		Air Stripping/Catalytic Oxidation/AOP/UV	0.00088*Q+0.24	@max(0.00088*Q-0.67,0.38)
		Air Stripping/VGAC/LGAC	0.0016*Q+0.41	0.00163*Q+0.5
		Air Stripping/Catalytic Oxidation/LGAC	0.0016*Q+0.19	0.00161*Q+0.18
		Current Water Treatment Plant		0.00061*Q+0.2387

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Table H-3
Value Nodes and Evaluation Criteria

Node Index	Node Name	Influencing States	East	West
16	Water Polish K Cost	AOP/Ozone	0.0006*Q+0.00016*Q+0.0395	Same
		AOP/UV	0.0006*Q+0.00016*Q+0.0395	Same
		Air Stripping/VGAC	0.0006*Q+0.00016*Q+0.0395	Same
		Air Stripping/Catalytic Oxidation	0.0006*Q+0.00016*Q+0.0395	Same
		LGAC	0	Same
		Air Stripping/VGAC/AOP/Ozone	0.0006*Q+0.00016*Q+0.0395	Same
		Air Stripping/Catalytic Oxidation/AOP/Ozone	0.0006*Q+0.00016*Q+0.0395	Same
		Air Stripping/VGAC/AOP/UV	0.0006*Q+0.00016*Q+0.0395	Same
		Air Stripping/Catalytic Oxidation/AOP/UV	0.0006*Q+0.00016*Q+0.0395	Same
		Air Stripping/VGAC/LGAC	0	Same
		Air Stripping/Catalytic Oxidation/LGAC	0	Same
		Current Water Treatment Plant		Same
17	Water Polish O&M Cost		0.00067*Q+0.12	Same
18	Reinject K Cost		0.00205*Q+1.074	
19	Reinject O&M Cost		0.000091*Q+0.0258	
20	Transport Time		0.00305*Q+11.15254	
21	Mass Removal		Q*C	
22	Flushing Efficiency		0.45	
23	Time To Clean up		(-Transport Time/Flushing Efficiency)*@ln(Clean Level/C)	
24	Treated Water Disposal Cost	End-Use Technology.Sell To Water District	@pv(Water Polish O&M Cost, 0.05, @min(Time To Clean up,20))+End-Use Technology	
		End-Use Technology.Reinject		
		Change Water Quality.Yes	Water Polish K Cost+End-Use Technology+	
			@pv(Water Polish O&M Cost,0.05,MIN(Time To Clean up,20))	
		Change Water Quality.No	@pv(Reinject O&M Cost,0.05,@min(Time To Clean up,20))+End-Use Technology	
25	Extract/Treat Cost		END K Cost+Primary Treatement K Cost+	
			@pv(END O&M Cost+Primary Treatment O&M Cost,0.05,@min(Time To Clean up,20))	
26	Evaluation Criteria	Mass Or Cost Decision.Mass	Mass Removal	
		Mass Or Cost Decision.Cost	Extract Treat Cost+Treated Water Disposal Cost	

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The second decision in the tree is labeled "END" for extraction network design. This node also acts as a switch to compare strategies for different target volumes. The cost of the wells that comprises the extraction network is a function of the expected flow rate and is included in the model. By selecting different target volumes, the cost of the extraction network is calculated and the expected flow rate is derived. Larger target volumes, and consequently larger extraction networks, will require larger flow rates to achieve containment.

The third and fourth decisions contain the alternatives for the treatment technologies and the end-use options. The costs for these are divided into capital or up-front costs and O&M costs.

After all four decisions are made, the five uncertainties are resolved. Other than the current estimates included in the model, there is no additional information pertaining to the outcomes of these uncertainties. All four decisions must be made before any of the uncertainties are resolved.

Optimal Remedial Action Strategies

East

The optimal strategy for the hot spot target volume on the east side of McClellan AFB (OU A) is to use air stripping/catalytic oxidation/LGAC and to discharge the effluent to water districts. The expected net present cost of this strategy is $4.4 million. This is shown in Figure H-3. The next best alternative is air stripping/catalytic oxidation with carbon polishing and discharging to water districts, with an expected cost of $4.8 million. The range of costs for the optimal strategy varies from approximately $3 million to $6.9 million, depending on the outcome of various uncertainties.

The primary difference between the alternatives is whether to use carbon for treatment or polishing. When carbon is used for treatment, then the carbon is used to remove a larger portion of the contaminants. For polishing, the water is primarily treated by the air stripper/catalytic oxidation unit, then run through the carbon. In both cases, air stripping/catalytic oxidation treats the first portion of the contaminants. For the remaining contaminants, the combination of higher capital and operating costs for the air stripping/catalytic oxidation unit causes LGAC to be selected as the optimal strategy.

The optimal strategy for the larger target volumes shifts to using only LGAC and discharging to the water districts. The expected costs for the MCL, risk, and Background target volumes are $12.3, $13.4, and $16.5 million. This is shown in Figures H-4, H-5, and H-6. The next best alternative for all three target volumes is air stripping/catalytic oxidation. As shown in these figures, fewer uncertainties impact these strategies, and the costs vary approximately 20 percent around the expected value.

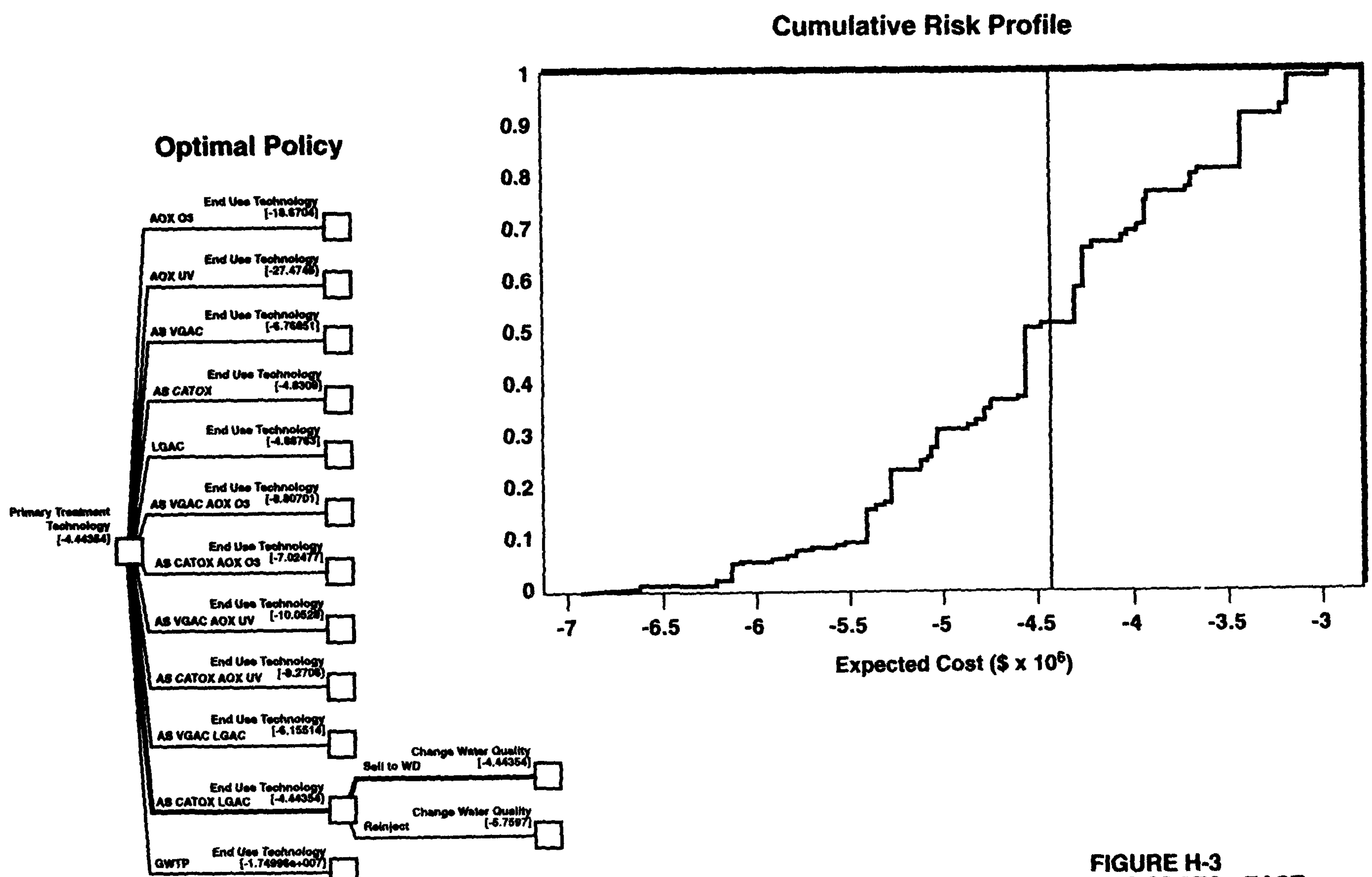

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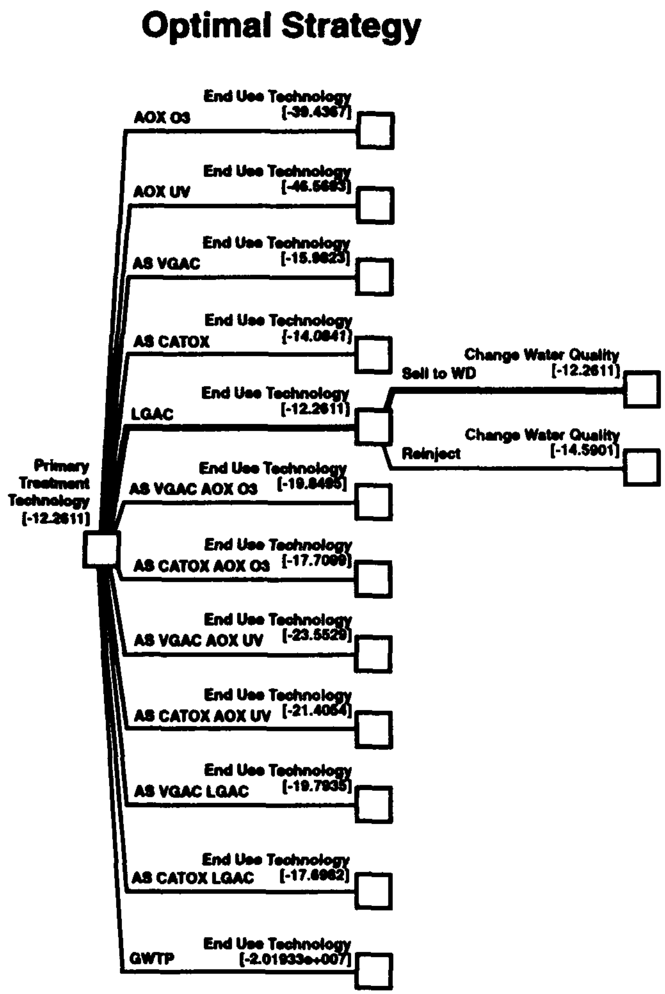
FIGURE H-3
HOT SPOTS - EAST
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

CH2M HILL



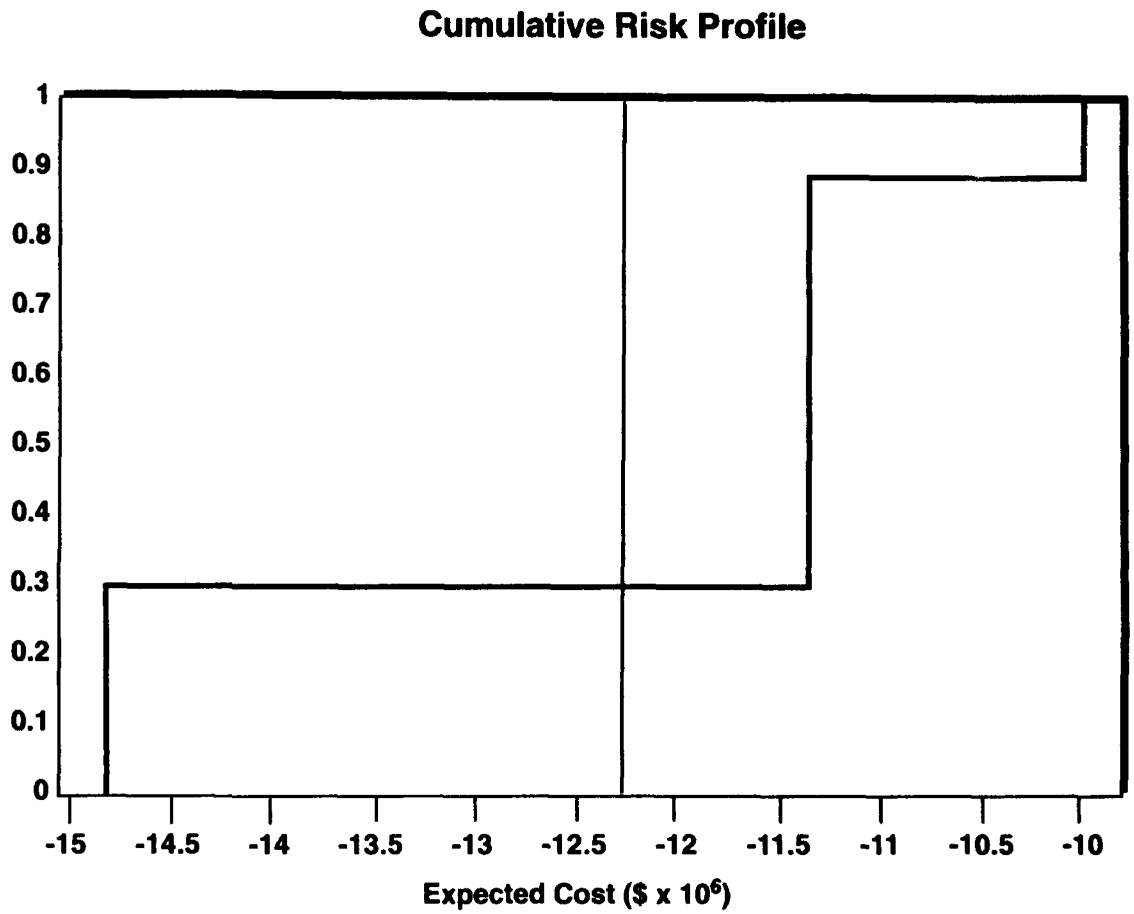


FIGURE H-4
MCL - EAST
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIF

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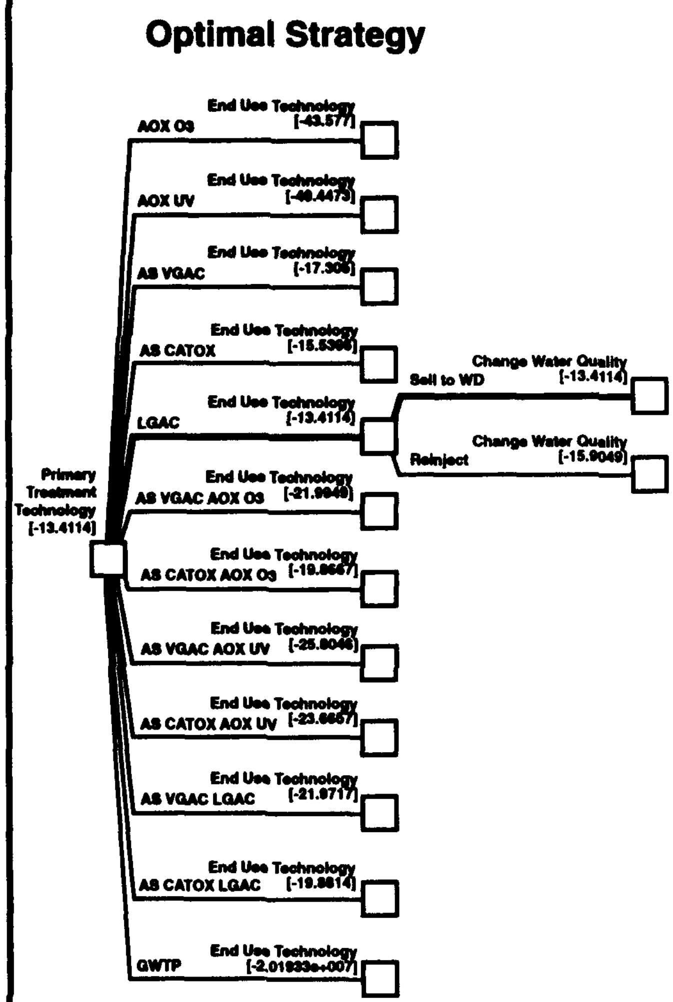
CH2M HILL



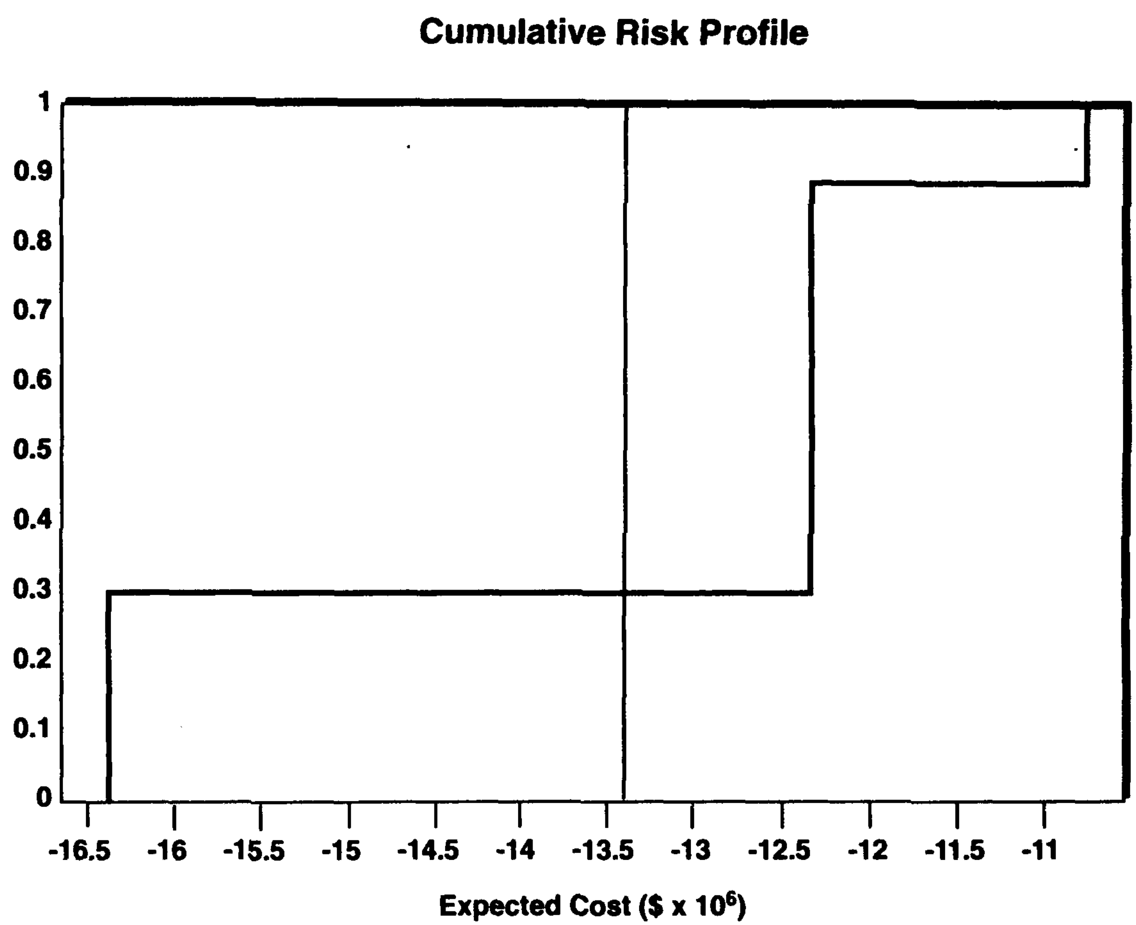
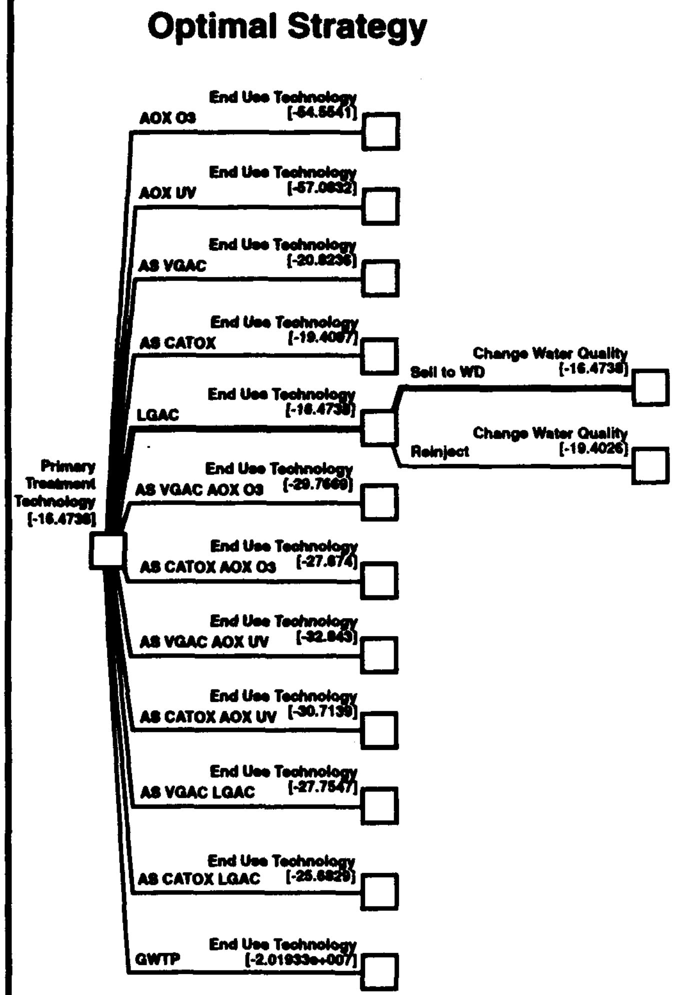


FIGURE H-5
HEALTH RISK - EAST
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA
CH2M HILL

RDD1454_223



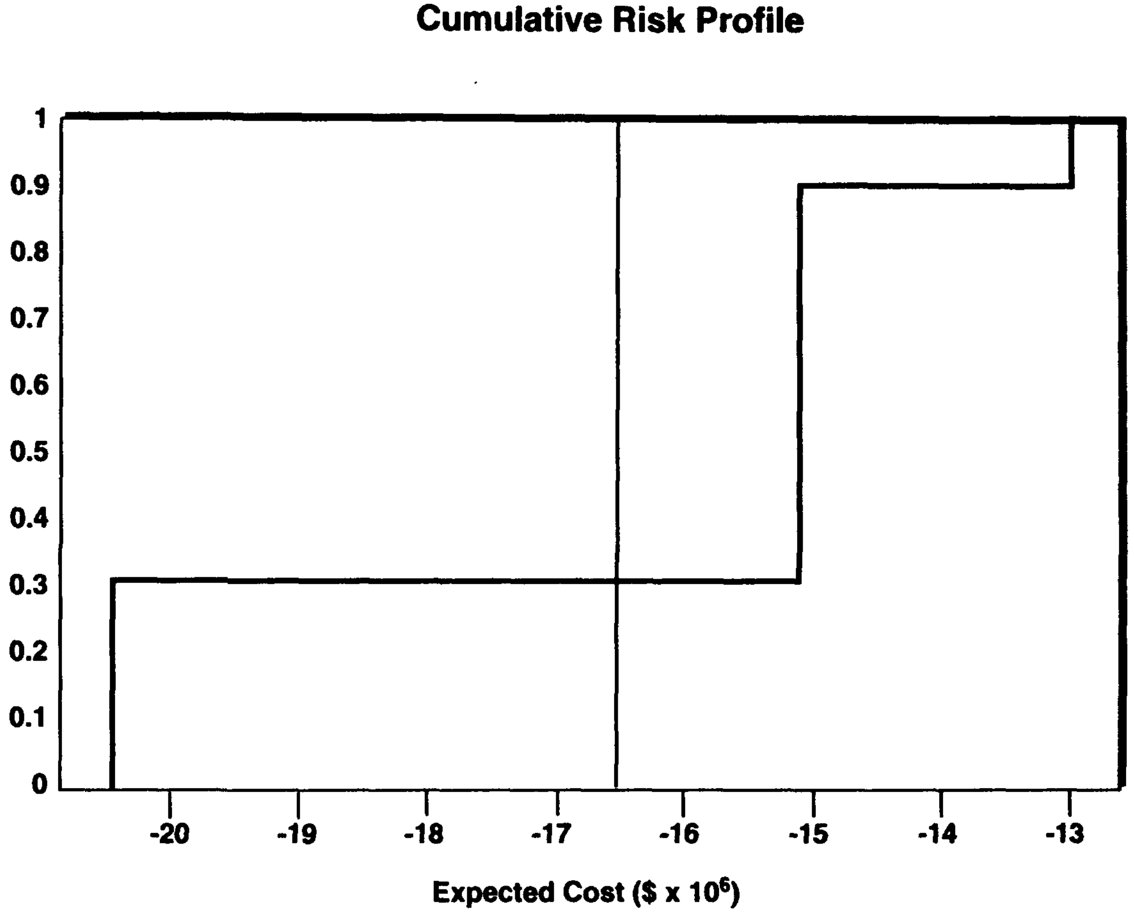


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FIGURE H-6
BACKGROUND - EAST
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORC⁻ ⁻ASE
SACRAMENTO, CALIF(

CH2M HILL

The uncertainties for flows and concentrations only influence the optimal strategy when there are low flows and low concentration target volumes. The range of flows and concentrations is a function of the extraction network design. If a design yields flows below 100 gpm, then the optimal strategy is to use air stripping/catalytic oxidation/LGAC treatment and water districts. If a design yields flows above 100 gpm, the policy shifts to only LGAC treatment and water districts. Alternatively, if a design yields low flows and a concentration below 700 ppb, air stripping/catalytic oxidation/LGAC and water districts are optimal again. Once flows exceed 100 gpm, the strategy is insensitive to changes in flows or concentration, and the optimal strategy remains LGAC and water districts. Therefore, there is no value to further sampling to develop a more precise estimate of flows and concentrations above this point, because the optimal strategy remains the same.

Additional calculations related to the value of additional sampling or testing also were conducted for the uncertainty of changes in water quality from treatment to reinjection. These tests would determine if a change in water quality would occur if reinjection was selected. The calculations estimate the value of this information to the decisionmaker in terms of making better treatment and end-use decisions before committing to alternatives. If the target volume is set to hot spots, then there is no change in optimal strategies, so this information has no value. For the other target volumes, however, there is a change in optimal strategies. Obtaining information concerning a change in water quality would be worth $0.39 million, $0.38 million, and $0.37 million for target volumes of MCL, health risk, and background. If sampling can be performed for less than these amounts, then it should be conducted. If the results of the sampling show that there is no change in water quality, then air stripping/catalytic oxidation should be used and the treated effluent should be reinjected.

To select reinjection, the cost of the system must be reduced relative to discharging to the water districts. The reductions could be in up-front capital or reduced O&M since these figures are net present values. The approximate costs by which reinjection would have to be reduced to become part of the optimal strategy for the different target volumes include:

- Hot spots - $800,000
- MCL - $1,800,000
- Health risks - $2,100,000
- Background - $2,900,000

A general assumption is that the treated groundwater's contaminant concentration will decline exponentially over time. If nonaqueous phase liquids (NAPLs) are encountered, then they impact the time to clean up by either increasing or holding steady the concentration over time. This has a major impact on cost because of the O&M factor used to calculate the net present values of costs. It does not, however, impact the optimal strategy. The selected strategy is robust in relation to changing concentrations over time.

The impacts of air permitting complexities must be considered for the hot spot strategy of air stripping/catalytic oxidation/LGAC. In this case, if the total cost of theair emissions is greater than $900,000, then the optimal strategy switches to LGAC. There is no change for any of the other target volumes. Also, if air emission limits are encountered, then this could impact the optimal strategy.

On the basis of the present assumptions, there is also value to determining the outcome of the air permitting complexity before selecting a treatment strategy, but only for the hot spot target volume. In this case, the information would be worth $60,000. If perfect information on air permitting complexity could be obtained for less than $60,000, then it would be a worthwhile expenditure. If air permitting complexity resolved to be high, then the optimal strategy would switch to LGAC and the water districts.

An analysis of the lower and upper 10 percent cost ranges from the risk profiles for the optimal strategies yields useful results for the hot spot target volume. The lower 10 percent costs range from $2.9 million to $3.5 million. When costs resolve to this region, mission change is military 98 percent of the time, and concentration is always very low. Therefore, either of these two outcomes will generally guarantee that the costs for the optimal strategy will be in the lowest 10 percent of the total possible range.

The upper 10 percent costs of the hot spot target volume ranges from $5.3 million to $6.9 million. If costs are in this range, concentration cannot be in a very low state. In addition, the probability that air permit complexity will be in its high state is 80 percent, up from the general 25 percent for the total distribution. Therefore, if the hot spot target volume is selected, the air permit complexity should be monitored closely to determine if costs are going to be in the high range.

West

Because of the low net present cost of the current GWTP, the optimal strategy on the west side is to use the GWTP regardless of the target volume and discharge to the water districts. This is shown in Figures H-7, H-8, H-9, and H-10. The expected costs for the hot spot, MCL, health risk, and background target volume optimal strategies are $5.55 million, $18.48 million, $25.61 million, and $36.8 million, respectively. The treated effluent should be discharged to the water districts. The next best alternative for all of the target volumes is using air stripping/catalytic oxidation and carbon polishing the effluent before sending it to the water districts. The variances in the expected cost range shown in these figures result from the impacts of varying flow rates.

Consistent with the east side, obtaining information related to changes in water quality from treatment to reinjection has no value for hot spots. For the MCL, health risk, and background target volumes, perfect information related to changes in water quality are worth $1.46 million, $2.45 million, and $4.05 million, respectively.

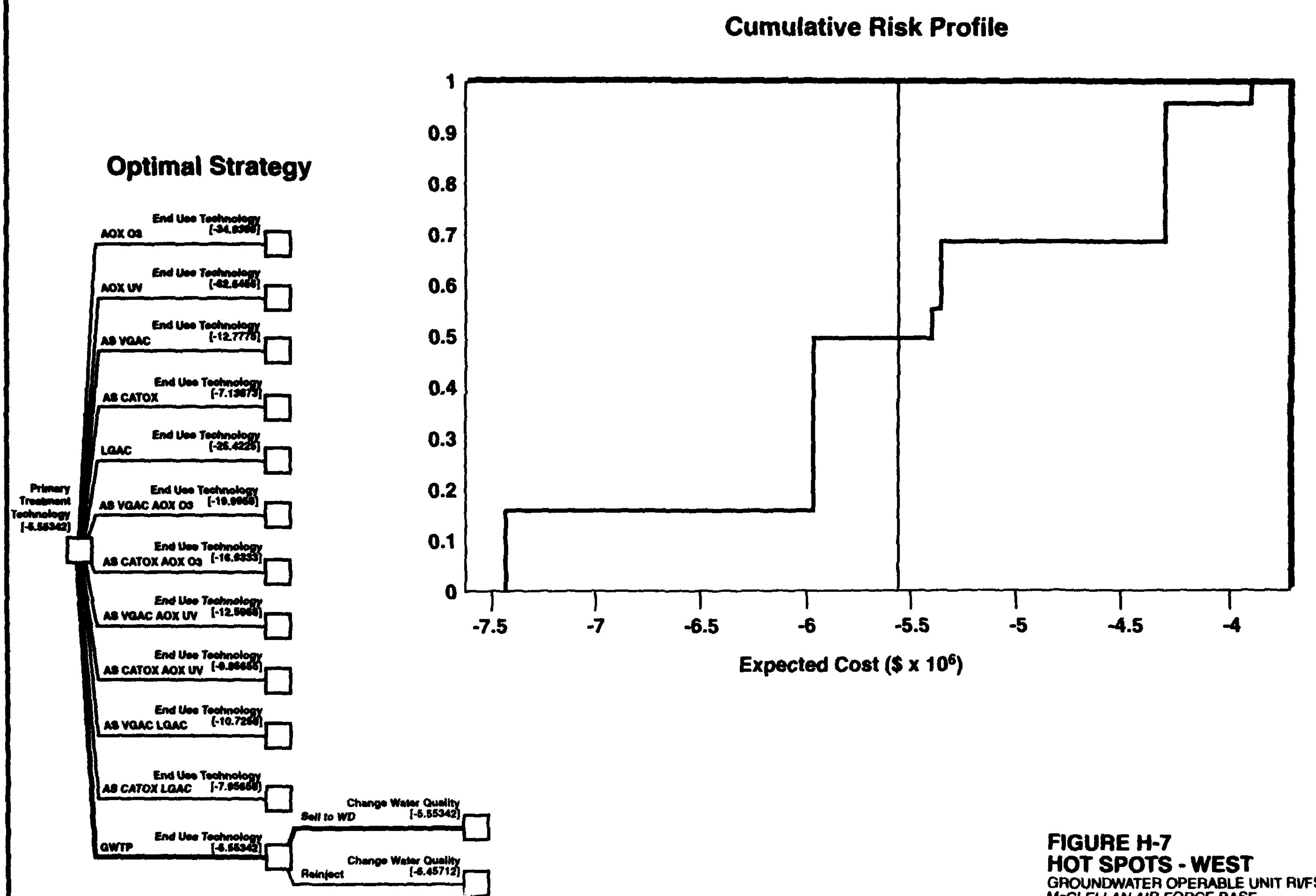

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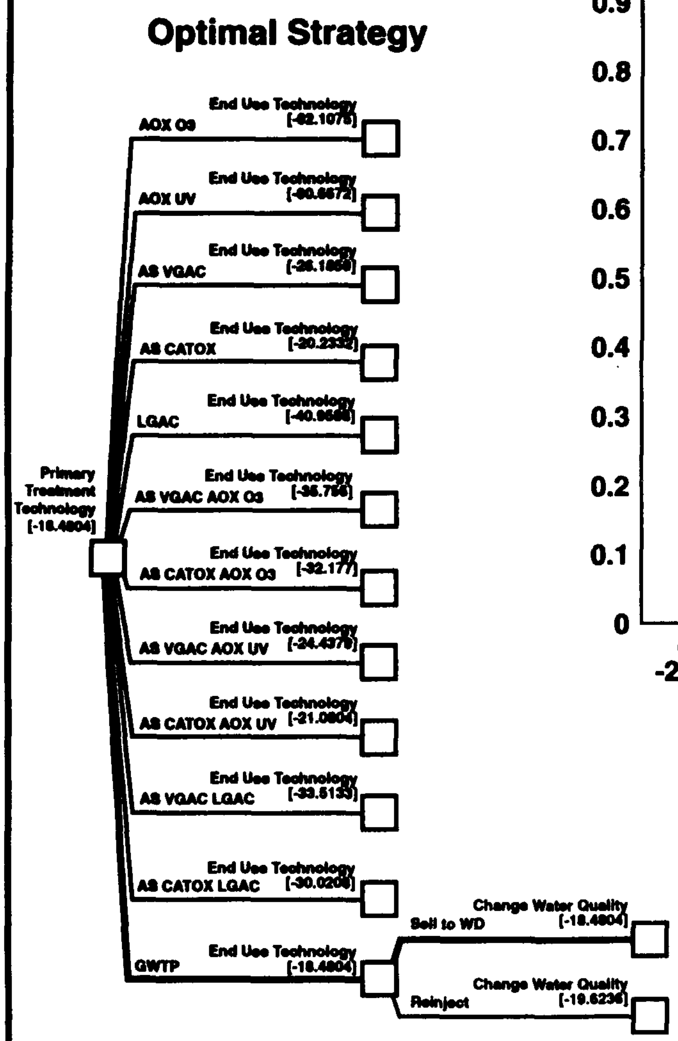
FIGURE H-7
HOT SPOTS - WEST
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

CH2M HILL



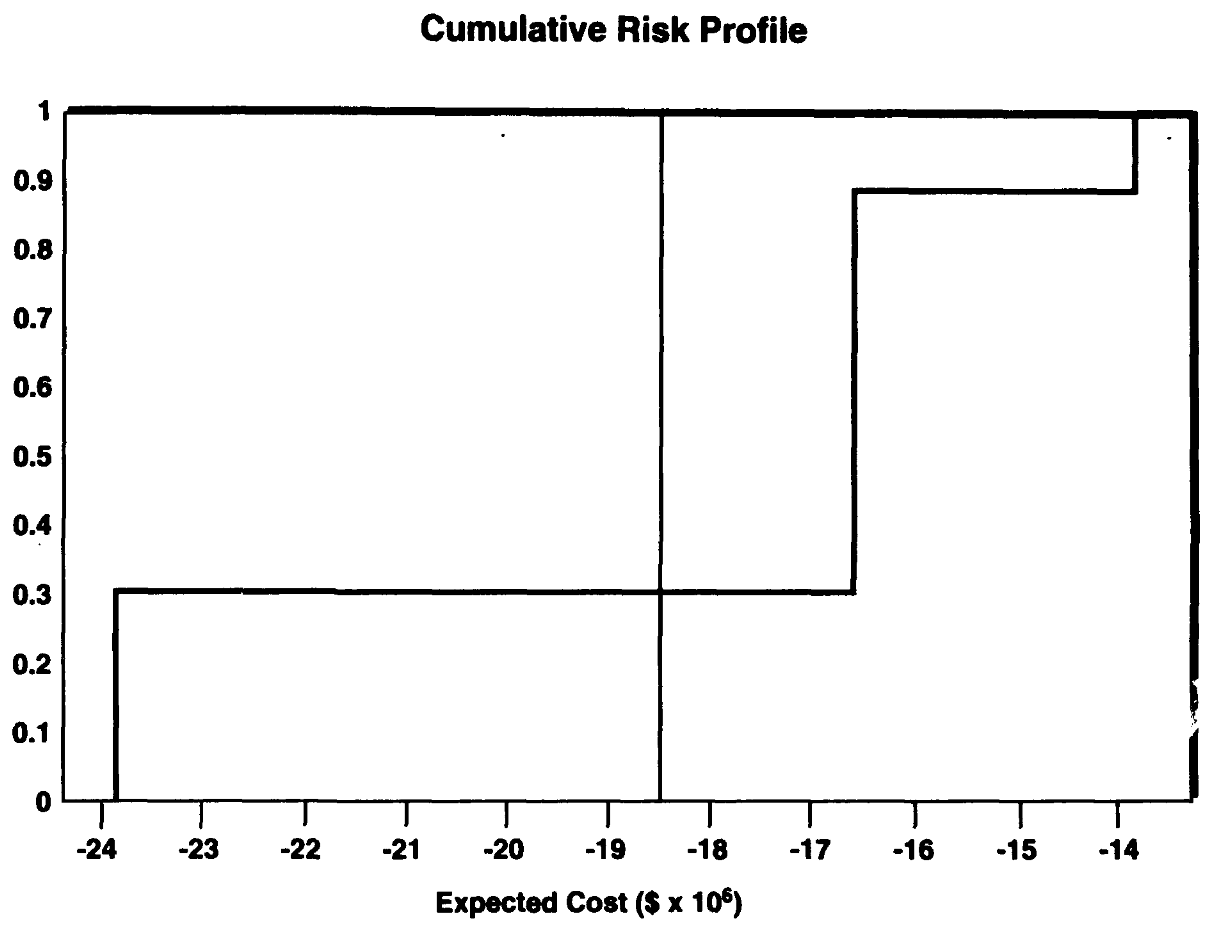


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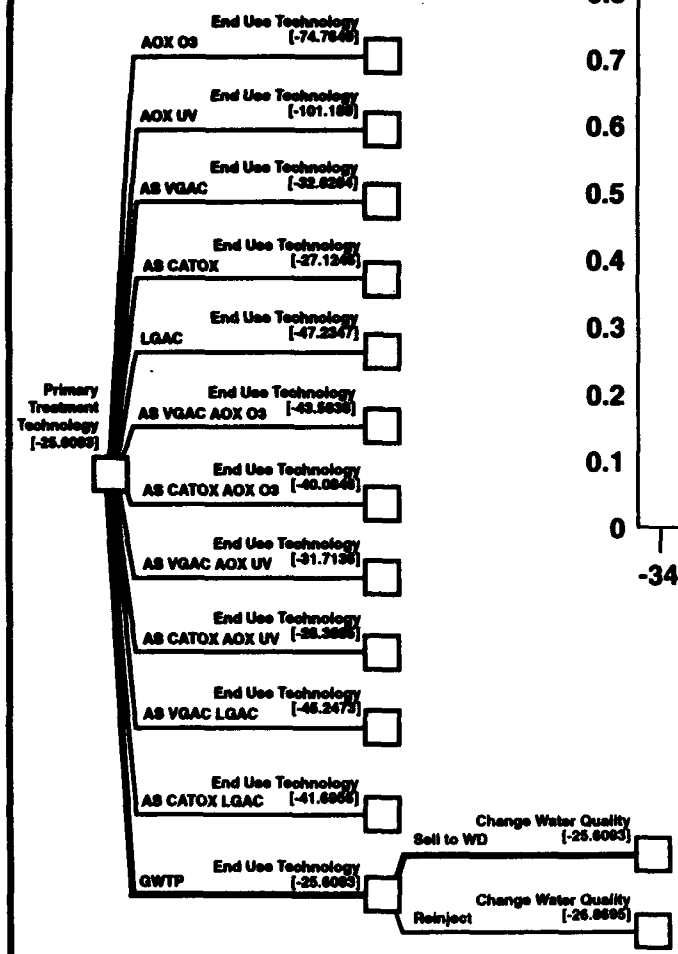
FIGURE H-8
MCL - WEST
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORC⁻ ^ASE
SACRAMENTO, CALIF

CH2M HILL

Optimal Strategy



Cumulative Risk Profile

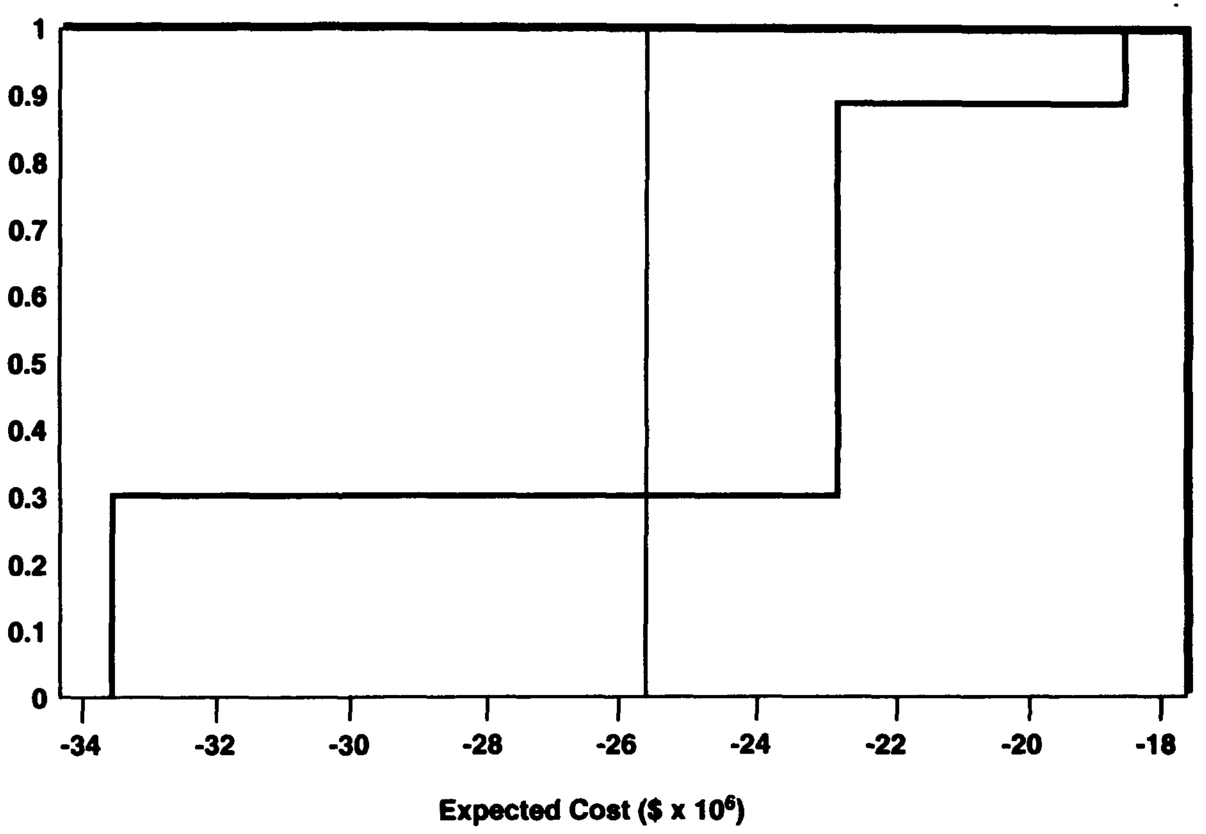


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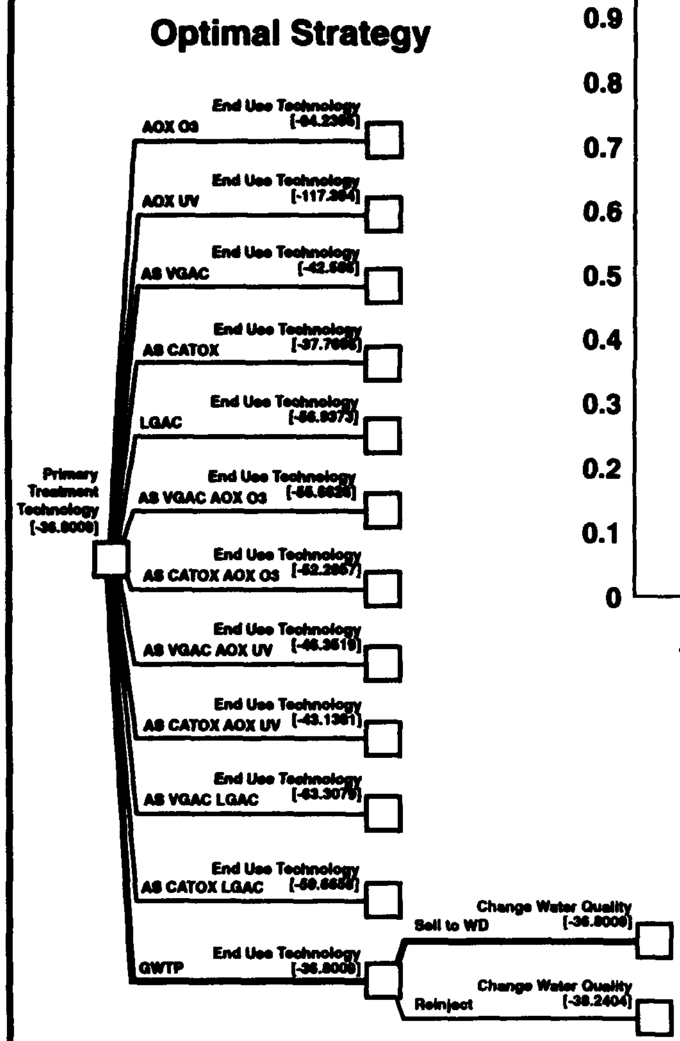
FIGURE H-9
HEALTH RISK - WEST
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

CH2M HILL



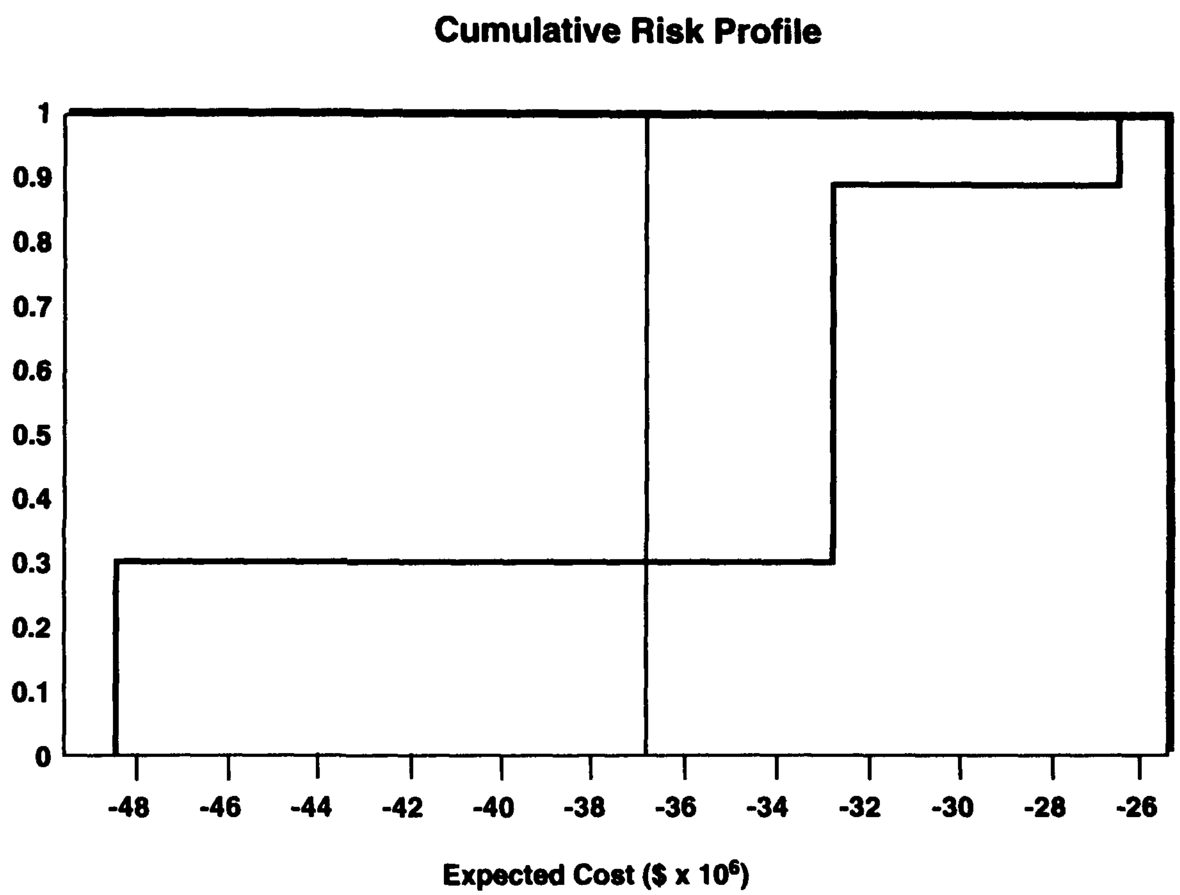


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FIGURE H-10
BACKGROUND - WEST
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORC⁻ ⁻ASE
SACRAMENTO, CALIF

CH2M HILL

In all three of these cases, if there is no change in water quality, the strategy switches to a air stripping/catalytic oxidation and reinjection.

The optimal strategies select discharging to the water district. The approximate costs by which reinjection would have to be reduced to become part of the optimal strategy for the different target volumes include:

- Hot spots - $900,000
- MCL - $1,100,000
- Health risks - $1,200,000
- Background - $1,000,000

These costs are lower than for the east side, indicating that reinjection is more of a possibility for the west's effluent. In addition, if the reinjection costs for containing the background target volume are reduced by the required $1,000,000, then the LGAC treatment can be removed.

The air emission limits and permitting costs have no impact on the west optimal strategies because of the use of the current GWTP.

Mass Removal Versus Cost

The cost effectiveness of mass removal for the east and the west sides is shown in Figures H-11 and H-12, respectively. As indicated on the figures, there are diminishing returns for additional mass removal. On the basis of marginal cost analysis of the mass removed during the first year, the cost for hot spot mass removed is $25.19/$\mu$g and $9.42/$\mu$g for the east and west sides, respectively. These costs increase with the MCL target volume to $41.49/$\mu$g and $178.41/$\mu$g for the east and west sides, respectively.

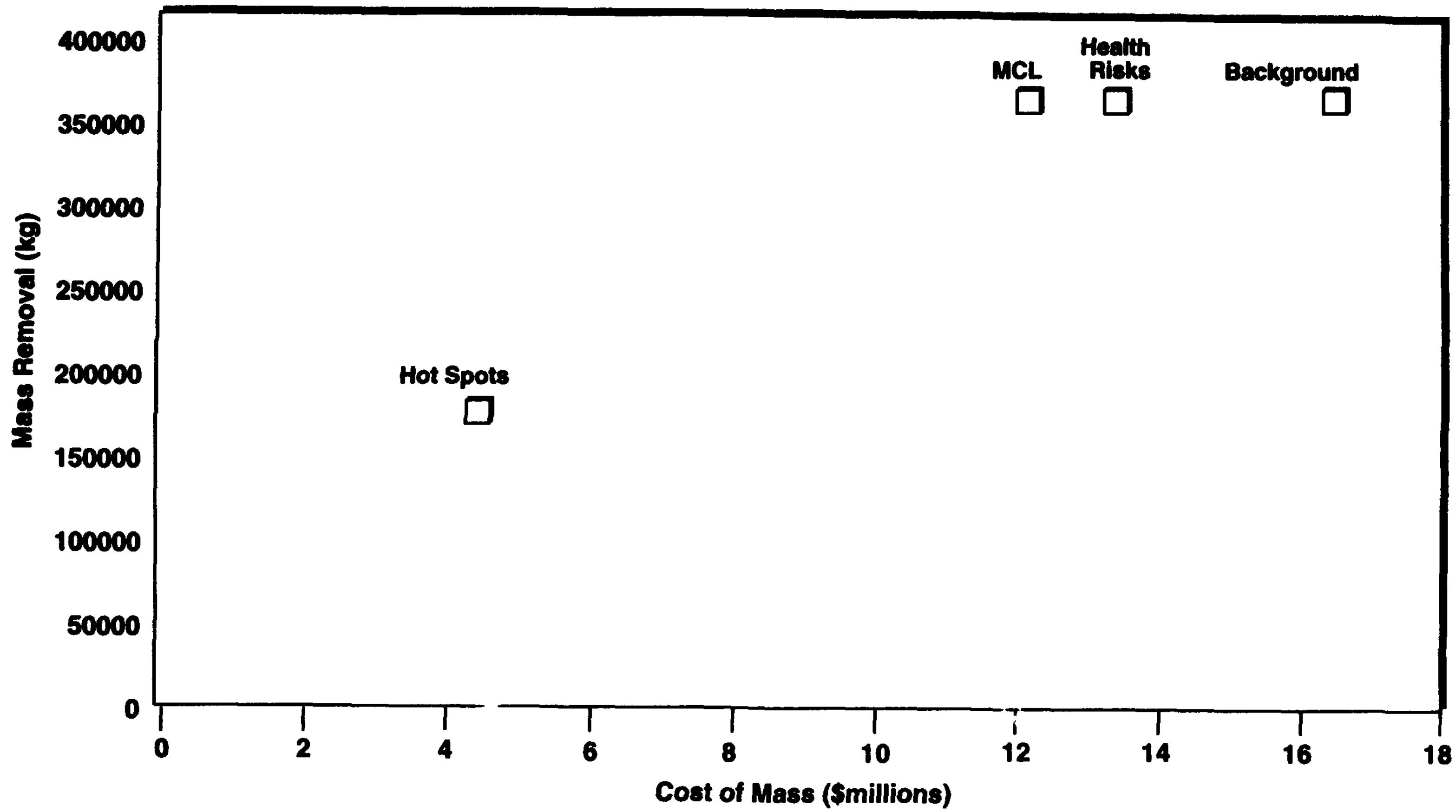

FIGURE H-11
MASS REMOVAL VERSUS COST - EAST
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

RDD1454_216

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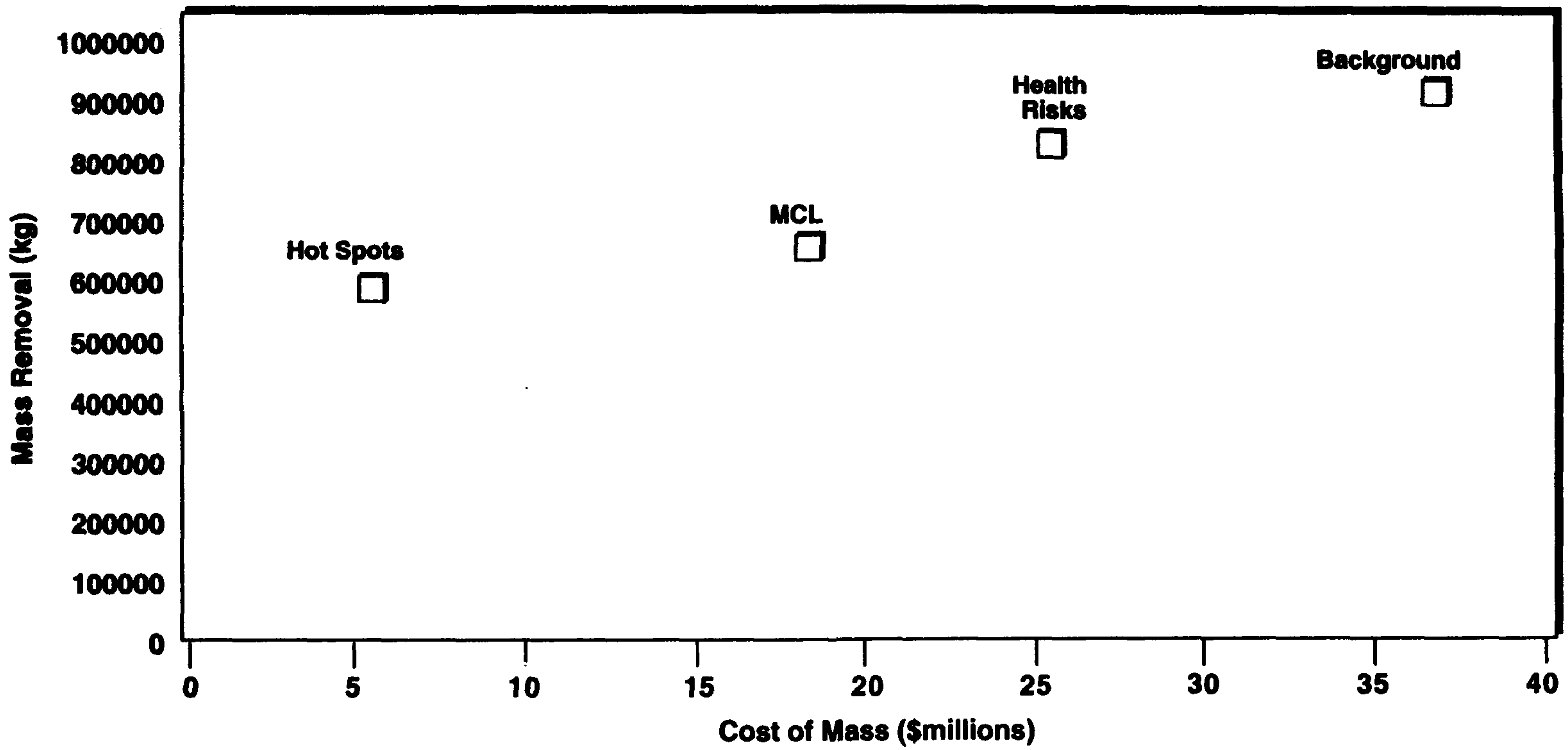


FIGURE H-12
MASS REMOVAL VERSUS COST - WEST
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

RDD1454_220

CH2M HILL

PREPARED FOR: McClellan Air Force Base

DATE: November 5, 1993

SUBJECT: Technology Screening and Groundwater Treatment Cost Estimates
Groundwater OU RI/FS Report
Delivery Order No. 5066

PROJECT: SAC28722.66.FS

Introduction

The GW OU FS uses a stepwise approach to screen technologies. The first step is the Murder Board, where a given set of standard technologies is screened to remove those which appear nonfeasible. Following the Murder Board screening, these technologies are assembled into treatment options. These options are composed of single water treatment technologies, water treatment technologies combined with offgas treatment technologies, or combinations of water treatment technologies. Costs for these options are then developed over a range of flow rates that are anticipated for the individual target volumes. These costs are presented as cost versus flow plots. There are five different target volumes. Each target volume has one plot that presents capital cost versus groundwater flow and another that presents O&M costs versus groundwater flow. These plots are located in Attachment I1.

As part of the Murder Board screening, the technologies were screened for various criteria. Standard technologies that passed the Murder Board screening were deemed satisfactory in the criteria of effectiveness, implementability, and robustness. It was assumed that combining technologies into options would also be effective, implementable, and robust. The main differentiating factor for assembled options is assumed to be cost.

Following the Murder Board screening, the next step in the FS is assembly of alternatives by combining extraction, treatment, and end-use options. To identify the preferred treatment options, cost was used as the differentiating factor. By developing and using cost plots of the various treatment options, preferred treatment options are identified for a range of potential target volumes. By using the cost plots, treatment options for alternatives were chosen. The selection process included evaluation of various scenarios, use of the decision analysis model, and engineering judgement.

This technical memorandum summarizes the approach used to screen individual technologies to the alternative selection phase and to develop capital and operation and maintenance (O&M) cost/flow plots.

The following five groundwater treatment technologies were considered as the initial set of standard treatment technologies for the Groundwater Operable Unit Feasibility Study (GW OU FS):

- Ultraviolet (UV) ozone advanced oxidation process (AOP)
- UV/hydrogen peroxide AOP
- Ozone/hydrogen peroxide AOP
- Air stripping
- Liquid-phase granular activated carbon (LGAC)

The air stripping technology releases a residual gas stream. To treat this residual gas stream, three offgas treatment technologies were considered in addition to the groundwater treatment technologies. The offgas treatment technologies are:

- Catalytic oxidation (CatOx)
- Thermal incineration
- Vapor-phase granular activated carbon (VGAC)

Murder Board Screening

The weighted sum method was used to screen the options. This method is a quantitative method for screening and ranking the remediation technologies. It provides a means of quantifying the important and relevant criteria to help evaluate cost-effective remediation technologies. This method involved the following four steps:

- Listing the important issues of each of the three screening criteria.

- Assigning weights to each of the criteria in relation to their importance. For instance, the effectiveness of technology was considered more important than its robustness. Therefore, the former was given a weight of 40, and the latter was given a weight of 30.

- Scoring each technology using a scale of 0 to 5 against each issue. The justification for the scoring was based on information compiled for each technology as summarized in Tables I-1 through I-8.

- Multiplying the percent score of each criterion by the weight of the criterion, the option's overall weighted score was determined.

Tables I-1 through I-8 rank each of the identified technologies against three criteria. The criteria are broken down into three to four important issues. Numerical ranking results are compiled for each technology.

Table I-1
UV/Ozone Advanced Oxidation Process
Groundwater Treatment Technology

Description	Effectiveness		Robustness		Implementability	
	Issue	Score	Issue	Score	Issue	Score
This oxidation process uses UV/ozone to destroy organic contaminants. The UV catalyzes the chemical oxidation of organics in water through the combined effect on the organic contaminant and its reaction with ozone. Ozone is fed as a gas and must be generated onsite immediately before use because of its molecular instability.	Level of Treatment for Individual Compounds: • O_3 is an effective oxidizer. • Level of treatment is 90% or more.	3	Number of Compounds Treated: • DCE, TCE, aromatics—treatable. • TCA, DCA, CCl_4, TCFM—treatable with longer retention time, higher O_3 dose. • Acetone and MEK—not treatable in comparison to other technologies.	3	Vendor Availability: • Solarchem. • Ultrox. • Vendors may be difficult to negotiate with. • Pilot testing typically required for performance guarantee.	3
	Degree of Treatment Consistency: • Consistently treats unsaturated organics. • Other compounds may not be consistently treated without an increased reaction time. • Turbidity affects UV effectiveness.	4	Turndown Capability: • System can operate at less than design flow rate. System can theoretically be turned down infinitely. • Turndown of >1:2 likely with O_3 dosage control is practical.	4	State of Development: • Over 25 commercial systems installed. • Flow rates up to 1,025 gpm.	4
	Residuals Generated: • Theoretically no hazardous residuals generated from treating hydrocarbons. • Acid is a byproduct of treating halogenated compounds. • Free ozone from reactor needs to pass through a deozonator.	4	Relative Response to Upsets: • Can handle variations in dissolved concentrations, but cannot handle extreme free organic concentrations. • Can vary from design flow rate. • Fouling on quartz tubes can decrease treatment capability.	3	Relative Cost: • Ozone generation is energy intensive. • Running the system as a batch allows it to run at off-peak times. • Ozone generation is more expensive than hydrogen peroxide feed. • High relative cost.	3
					Permitting Issues: • Construction. • No air emissions expected. • Process requires ozone decomposition. • Public and community acceptance likely.	5

Table I-1
UV/Ozone Advanced Oxidation Process
Groundwater Treatment Technology

Description	Effectiveness		Robustness		Implementability	
	Issue	Score	Issue	Score	Issue	Score
	SUMMARY: • UV/ozone is an effective treatment process for straight chain hydrocarbons. • No hazardous residuals generated.		SUMMARY: • This system is not effective for treating the ketones and alkanes. • Turndown possible. • Tubes can foul.		SUMMARY: • Technology is proven. • Typically high cost. • Limited permit issues.	
Subtotal		11		10		15
Maximum Possible Score		15		15		20
Percent Score		73		67		75
Weight		40		30		30
Total Weight						100
Weighted Score		29		20		24
Total Weighted Score						73

Table I-2
UV/Hydrogen Peroxide Advanced Oxidation Process
Groundwater Treatment Technology

Description	Effectiveness: Issue	Score	Robustness: Issue	Score	Implementability: Issue	Score
This oxidation process uses UV/hydrogen peroxide (H_2O_2) to destroy organic contaminants in the groundwater. The UV catalyzes the chemical oxidation of organics with H_2O_2. High power UV can increase the reaction rate by almost 40 times.	Level of Treatment for Individual Compounds: • Efficiency of treatment is 99.9% or more for aromatics, alkynes, ketones, and alkanes.	5	Number of Compounds Treated: • DCE, TCE, benzene, dichlorobenzene, toluene, xylenes – all treatable. • TCA, DCA, CCl_4, TCFM – treatable with increased reaction time. • Acetone and MEK treatable.	4	Vendor Availability: • Peroxidation Systems Inc. • Solarchem. • Vendors may be difficult to negotiate with. • Pilot testing typically required for performance guarantee.	3
	Degree of Treatment Consistency: • Consistently treat unsaturated organics. • Alkanes can be treated consistently only *with extended reaction time.* • UV tubes fouled by Fe, $CaCO_3$. • Turbidity affects UV affectiveness. • Temperature increase from prolonged UV treatment.	4	Turndown Capability: • Systems can operate at less than the design flow rate with no system problems. • Limitation at minimum chemical dosing rate (turndown > 1:2).	4	State of Development: • This technology has been applied since the 1970s. • There are approximately less than 100 applications at remediation sites. • Systems have been proven, but these are borderline innovative technologies.	3
	Residuals Generated: • Typical reaction products are CO_2 and water. • Theoretically, no hazardous residuals are generated when treating hydrocarbons. • Acid is a byproduct of treating halogenated compounds, which remains in the effluent.	4	Relative Response to Upsets: • Units can handle variations in dissolved concentrations, but cannot handle extreme concentration variations. • Scaling of quartz tubes in UV applications can reduce effectiveness from 90% down to 15 to 20%.	3	Relative Cost: • Typically moderate to high cost. • Possibly lower cost than AOP technologies that require ozone.	3
					Permitting Issues: • Construction. • Little air emissions. • Public and community acceptance likely.	5

Table I-2
UV/Hydrogen Peroxide Advanced Oxidation Process
Groundwater Treatment Technology

Description	Effectiveness		Robustness		Implementability	
	Issue	Score	Issue	Score	Issue	Score
	SUMMARY: • UV H_2O_2 is very effective in organics at over 99% with adequate residence time. • UV/H_2O_2 can treat VOCs pr sent. • No hazardous residuals generated.		SUMMARY: • All constituents of concern are treatable. The system is relatively flexible. • Greater than 1:2 turndown capable. • Tolerant of concentration swings. • Tubes can foul.		SUMMARY: • Limited number of vendors. • Typically moderate to high cost. • Minimal permit issues.	
Subtotal		13		11		14
Maximum Possible Score		15		15		20
Percent Score		87		73		70
Weight		40		30		30
Total Weight						100
Weighted Score		35		22		21
Total Weighted Score						78

Note:
- Fe = iron
- $CaCO_3$ = calcium carbonate
- CO_2 = carbon dioxide
- CCl_4 = carbon tetrachloride
- TCFM = trichlorofluoromethane

Table I-3
Ozone/Hydrogen Peroxide Advanced Oxidation Process
Groundwater Treatment Technology

Description	Effectiveness		Robustness		Implementability	
	Issue	Score	Issue	Score	Issue	Score
This oxidation process uses ozone (O_3) and hydrogen peroxide (H_2O_2) to destroy organic compounds in water. The H_2O_2/O_3 system is the most practical for potable water treatment when the organic oxidation is not catalyzed with UV. H_2O_2/O_3 is most practical AOP system for treatment of turbid water.	Level of treatment for individual compounds: • Efficiency of treatment: DCE > TCE > PCE > TCA. • Efficiency of treatment for short chain alkenes can exceed 99%. • Acetone may be difficult to remove.	4	Number of Compounds Treated: • All VOCs present can be treated. • Difficult to treat aliphatic compounds and ketones.	4	Vendor Availability: • Vendors may be difficult to negotiate with. • Pilot testing typically required for performance guarantee.	3
	Degree of treatment consistency: • Consistently treats unsaturated organics. • Alkanes can be treated consistently only with extended reaction time.	4	Turndown Capability: • Systems can operate at less than the design flow rate. • Case studies describe operations at 50% of design flow rate. • Modular systems can be added to increase capacity and/or performance.	4	State of Development: • This technology has been in use in various forms since the mid-1970s. • There are approximately 10 ozone/hydrogen peroxide systems in service. • This technology is a borderline innovative technology.	3
	Residuals Generated: • Typical reaction products are CO_2 and water. • Theoretically, no hazardous residuals are generated when treating hydrocarbons. • Acid is a byproduct of treating halogenated compounds.	4	Relative Response to Upsets: • Units cannot tolerate extreme variations in concentration levels or free product. • System operation can accommodate moderate dissolved concentration variations.	3	Relative Cost: • Units can be run in batch mode to operate at off-peak hours. • Relatively high power cost. • Capital cost is moderate. • Operating costs: ozone @ $1.40/lb, hydrogen peroxide @ $1.50/lb (potentially high).	4
					Permitting Issues: • Construction. • No air emissions. • Process requires ozone decomposition. • Public and community acceptance likely.	5

Table I-3
Ozone/Hydrogen Peroxide Advanced Oxidation Process
Groundwater Treatment Technology

Description	Effectiveness: Issue	Effectiveness: Score	Robustness: Issue	Robustness: Score	Implementability: Issue	Implementability: Score
	SUMMARY: • Ozone/hydrogen peroxide is effective for treating alkenes and aromatics at >99%. • Ozone/hydrogen peroxide can treat ketones and alkanes, given sufficient reaction time. • No hazardous residuals were generated.		SUMMARY: • Capable of treating the VOCs present. • Greater than 2:1 turndown. • Tolerant of concentration swings.		SUMMARY: • Limited number of vendors. • Technology is proven. • Typically moderate to high cost. • *Minimal permit issues.*	
Subtotal		12		11		15
Maximum Possible Score		15		15		20
Percent Score		80		73		75
Weight		40		30		30
Total Weight						100
Weighted Score		32		22		23
Total Weighted Score						77

Table I-4
Air Stripping
Groundwater Treatment Technology

Description	Effectiveness		Robustness		Implementability	
	Issue	Score	Issue	Score	Issue	Score
Using a packed tower, contaminated water is brought into contact with air. During this air/water contact, volatile contaminants existing in the aqueous phase subsequently enter the gas phase (air). The offgas often requires further treatment.	Level of Treatment for Individual Compounds: • 99% removal rate for most VOCs. • Not a viable technology for removal of acetone or MEK unless elevated temperatures used.	4	Number of Compounds Treated: • Chlorinated and nonchlorinated VOCs. • Limited removal of acetone and MEK.	4	Vendor Availability: • Readily available.	5
	Degree of Treatment Consistency: • Possible fouling caused by scaling (metals) or biological growth. • Acid wash systems common.	4	Turndown Capability: • Roughly 4:1 turndown capability.	5	State of Development: • Proven technology.	5
	Residuals Generated: • Offgas will contain contaminants to be treated with secondary system.	3	Relative Response to Upsets: • Simple startup and shutdown procedures. • Fluctuations in contaminant levels will not *cause operation trauma, but may affect* product. • Cannot handle free product.	4	Relative Cost: • Inexpensive; offgas treatment typically pushes option to moderate cost.	5
					Permitting Issues: • Offgas treatment requires risk assessment modeling. • Possible building permits needed. • Public and community acceptance likely.	4
	SUMMARY: • Effective technology except for acetone and MEK removal. • Offgas will contain contaminants and may require further treatment.		SUMMARY: • Large turndown range, simple to operate. • Limited acetone, MEK removal.		SUMMARY: • Many vendors exist; demonstrated effective and inexpensive technology. • Offgas treatment probably required • Risk assessment required.	
Subtotal		11		13		19
Maximum Possible Score		15		15		20
Percent Score		73		87		95
Weight		40		30		30
Total Weight						100
Weighted Score		29		26		29
Total Weighted Score						84

Table I-5
Liquid-Phase Granular Activated Carbon
Groundwater Treatment Technology

Description	Effectiveness Issue	Score	Robustness Issue	Score	Implementability Issue	Score
Contaminated water flows through a bed of granulated activated carbon. Contaminants adsorb to carbon.	Level of Treatment for Individual Compounds: • High removal rate of VOCs (99% or more). • Acetone and MEK removal may require further treatment.	4	Number of Compounds Treated: • Chlorinated and nonchlorinated VOCs. • Poor loading of acetone and MEK.	4	Vendor Availability: • Readily available. • No volume limitations for regeneration. • Regeneration is possible at least two West Coast sites.	5
	Degree of Treatment Consistency: • Prior to breakthrough, very consistent operation. • Presence of suspended and biological solids will require backwash.	4	Turndown Capability: • Approximate 4:1 turndown with gravity down flow. • Greater than 4:1 turndown with pressure vessel.	5	State of Development: • Proven technology.	5
	Residuals Generated: • Used carbon can be landfilled or regenerated. (Regeneration may be performed onsite or offsite.)	3	Relative Response to Upsets: • Simple startup and shutdown procedures. • Free organic phase can be handled, may upset system. • Series operation reduces risk of upset breakthrough. • Series or parallel operation possible.	4	Relative Cost: • Moderately expensive.	3
					Permitting Issues: • Construction. • Hauling permit (manifest) required for used carbon. • Potential negative public opinion to hauling carbon.	4
	SUMMARY: • High removal rate for most contaminants except MEK and acetone. • Consistent operation. • Residuals generated probably require transport, disposal, or regeneration.		SUMMARY: • Acetone and MEK impact O&M costs. • Good turndown capacity. • Flexible operation.		SUMMARY: • Many vendors. • Proven technology. • Disposal issues exist.	
Subtotal		12		11		17
Maximum Possible Score		15		15		20
Percent Score		80		73		85

Table I-5
Liquid-Phase Granular Activated Carbon
Groundwater Treatment Technology

Description	Effectiveness		Robustness		Implementability	
	Issue	Score	Issue	Score	Issue	Score
Weight		40	.	30		30
Total Weight						100
Weighted Score		32		29		26
Total Weighted Score						87

Table I-6
Catalytic Oxidation
Offgas Treatment Technology

Description	Effectiveness		Robustness		Implementability	
	Issue	Score	Issue	Score	Issue	Score
Air pollution control technique whereby VOC emissions are oxidized with the assistance of a catalyst. VOC oxidation is generally performed at temperatures below 1,000°F. Emissions scrubbed to neutralize acid gases.	Level of Treatment for Individual Compounds: • TCA, DCE, TCE, PCE−95% DRE • ≥ 99% DRE for TCE shown at Wurtsmith AFB. • 97 to 99% DRE in several pilot applications.	5	Number of Compounds Treated: • Chlorinated VOCs. • Hydrocarbons.	5	Vendor Availability: • Readily available with noble metal and metal oxide catalysts.	4
	Degree of Treatment Consistency: • Insensitive to space velocity over range 7,000 to 10,500 hr^{-1}, VOC feed gas concentration over range 50 to 3,000 ppmv, mixture composition effect on DRE of individual compounds sensitive to catalyst bed inlet temperature with optimal treatment between 650 to 1,150°F. • Chlorinated compounds cause flame inhibition and catalyst degradation. ARI chromia alumina catalyst minimally affected. • DRE is a function of humidity, gas concentration, gas composition, temperature, presence of poisons (e.g., H_2S), dust, and dirt.	4	Turndown Capability: • Insensitive to space velocity over range 7,000 to 10,500 hr^{-1}, VOC feed gas concentration over range 50 to 3,000 ppmv, mixture composition effect on DRE of individual compounds sensitive to catalyst bed inlet temperature with optimal treatment between 650 to 1,150°F. • Turndown may result in high fuel usage. • Cost effective typically for offgas concentrations from 600 to 2,500 ppm.	4	State of Development: • Demonstrated applications of air stripper in conjunction with catalytic oxidizer. • The technology has been demonstrated for 17 years.	4
	Residuals Generated: • Dioxin and phosgene formation possible although moderate temperatures will probably preclude this. • Liquid brine stream produced as a result of emissions scrubbing. • NO_x generated. • Potential for benzene formation caused by combustion of natural gas.		Relative Response to Upsets: • Insensitive to space velocity, feed gas concentration, mixture composition (see above). • Easily restarted.		Relative Cost (excluding scrubber): • Moderate to high cost. • Heat recovery options require economic comparison.	4

Table I-6
Catalytic Oxidation
Offgas Treatment Technology

Description	Effectiveness Issue	Effectiveness Score	Robustness Issue	Robustness Score	Implementability Issue	Implementability Score
		3		4	Permitting Issues: • Dioxin and phosgene generation. • Scrubber brine stream. • Air risk assessment required. • Public perception of "incineration" possibly negative.	3
	SUMMARY: • Demonstrated ≥ 95% DRE with chromia alumina and magnesium oxide catalysts. • Insensitive to process changes with exception of catalyst inlet temperature.		SUMMARY: • Demonstrated for chlorinated and non-chlorinated VOCs. • Turndown capable. • Relatively insensitive to upsets, readily restarted.		SUMMARY: • Readily available; HCl resistant catalyst is proprietary. • Fairly well demonstrated. • Cost is moderately high. • Air risk assessment required.	
Subtotal		12		13		15
Maximum Possible Score		15		15		20
Percent Score		80		87		75
Weight		40		30		30
Total Weight						100
Weighted Score		32		26		23
Total Weighted Score						81

Note: DRE = destruction removal efficiency

Table I-7
Thermal Incineration
Offgas Treatment Technology

Description	Effectiveness Issue	Score	Robustness Issue	Score	Implementability Issue	Score
Air pollution control technique whereby VOCs are oxidized at high temperatures, generally greater than 1,500°F. Emissions scrubbed to neutralize acid gases.	Level of Treatment for Individual Compounds: • Chlorinated VOCs – ≥ 98% DRE @ 2,000°F. • Nonchlorinated VOCs – ≥ 98% DRE @ 1,600°F.	5	Number of Compounds Treated: • Chlorinated VOCs. • Other hydrocarbons.	5	Vendor Availability: • Readily available.	5
	Degree of Treatment Consistency: • Chlorinated compounds require higher operating temperatures, but all hydrocarbons can be degraded at the higher temperature. • 99% DRE @ 2,200°F, 1 second residence time.	5	Turndown Capability: • Readily performed. Requires regulation of combustion chamber temperature. • Turndown may result in increased fuel usage.	4	State of Development: • Well demonstrated.	5
	Residuals Generated: • Dioxin and phosgene generation possible; probably transferred to scrubber blowdown. • Liquid brine stream produced as residual as a result of emissions scrubbing. • NO_x generation likely higher than catalytic.	2	Relative Response to Upsets: • Mixing within combustion chamber must be monitored and adjusted. • Easily restarted.	4	Relative Cost (excluding scrubber): • Moderate to high cost. • Heat recovery options require economic comparison.	3
					Permitting Issues: • Dioxin and phosgene generation. • Air risk assessment required. • Emission scrubber brine stream. • Public perception of "incinerator" possible negative.	2
	SUMMARY: • Demonstrated ≥ 98% DRE @ 2,200°F. • Residuals will primarily be brine stream from scrubber. Brine may contain dioxins, phosgene, and very low concentrations of VOCs; NO_x formation likely.		SUMMARY: • Demonstrated for destruction of chlorinated and nonchlorinated VOCs. • Turndown capable. • Relatively insensitive to upsets, easily restarted.		SUMMARY: • Readily available. • Well demonstrated. • Cost is high. • Risk assessment required.	

Table I-7
Thermal Incineration
Offgas Treatment Technology

Description	Effectiveness		Robustness		Implementability	
	Issue	Score	Issue	Score	Issue	Score
Subtotal		12		13		15
Maximum Possible Score		15		15		20
Percent Score		80		87		75
Weight		40		30		30
Total Weight						**100**
Weighted Score		32		26		23
Total Weighted Score						**81**

Table I-8
Vapor-Phase Granular Activated Carbon
Offgas Treatment Technology

Description	Effectiveness: Issue	Effectiveness: Score	Robustness: Issue	Robustness: Score	Implementability: Issue	Implementability: Score
Air pollution control technique whereby VOCs are adsorbed on the surface of materials. Adsorption materials include activated carbon, silica gel, or alumina. This evaluation focuses on activated carbon adsorption.	Level of Treatment for Individual Compounds: • Favors high molecular weight and cyclic compounds and unsaturated hydrocarbons. • Poor removal of vinyl chloride. • Presence of acetone and ketones will decrease efficiency. • 99.9 % removal possible.	4	Number of Compounds Treated: • Chlorinated hydrocarbons. • Hydrocarbons. • Trouble with vinyl chloride and ketones.	4	Vendor Availability: • Readily available.	5
	Degree of Treatment Consistency: • Requires consistent gas concentration. Fluctuations may desorb lesser adsorbable compounds. • Humidity impacts effectiveness (>50% relative humidity is negative).	3	Turndown Capability: • Turndown capable.	5	State of Development: • Well demonstrated.	5
	Residuals Generated: • Regenerative carbon system produces concentrated VOCs in steam condensate. Condensate requires treatment. • No NO_x or dioxin generation. • Otherwise carbon has to be sent offsite for regeneration or disposal. • No residuals discharged directly to atmosphere.	3	Relative Response to Upsets: • Sensitive to mass loading rate and volumetric flow rate changes. • Upsets can be controlled using multiple beds in series.	4	Relative Cost: • Dependent on offgas composition. • Offgas heating typically required to lower relative humidity. • Typical range of cost effectiveness from >0 to approximately 600 ppm.	5
					Permitting Issues: • Permit to discharge air pollutants possible. • Easier than thermal approaches. • Air risk assessment probably required.	4

Table I-8
Vapor-Phase Granular Activated Carbon
Offgas Treatment Technology

Description	Effectiveness: Issue	Effectiveness: Score	Robustness: Issue	Robustness: Score	Implementability: Issue	Implementability: Score
	SUMMARY: • Demonstrated ≥ 99% removal provided bed sized for poorly adsorbable compounds. • Relatively sensitive to gas mix and flow rate. • Residuals are treatable.		SUMMARY: • Demonstrated for removal of chlorinated and nonchlorinated hydrocarbons. Difficulty with vinyl chloride and ketones. • Turndown capable. • Relatively sensitive to upsets. Easily restarted.		SUMMARY: • Readily available. • Well demonstrated. • Cost is moderate. • Air risk assessment probably required.	
Subtotal		10		13		19
Maximum Possible Score		15		15		20
Percent Score		67		87		95
Weight		40		30		30
Total Weight						**100**
Weighted Score		27		26		29
Total Weighted Score						**82**

The information compiled in these tables formed the basis of the Murder Board workshop meeting held between CH2M HILL, McClellan AFB, Agencies, and other interested parties at McClellan AFB. On the basis of these compiled score evaluations, certain technologies were screened out once consensus within the group was obtained. The technologies screened were thermal incineration and ozone/UV AOP.

Thermal incineration was discussed and determined to have a high potential negative public opinion. In addition, thermal incineration was identified as requiring rigorous permitting efforts for installation of a new device. Because of these issues, thermal incineration was screened from further consideration as an offgas treatment technology.

UV/ozone AOP was assigned the lowest combined score of the treatment technologies because of its poor effectiveness compared to the other technologies. For this reason this technology was omitted from further consideration as a water treatment technology.

Option Assembly and Cost Plots

Using the technologies which passed the Murder Board, treatment options were assembled and order-of-magnitude costs were developed.

The following stand-alone standard treatment technologies were considered following the initial screening for assembled treatment options:

- LGAC
- UV/hydrogen peroxide AOP
- Ozone/hydrogen peroxide AOP
- Air stripping/CatOx
- Air stripping/VGAC

The following treatment technologies were considered as components in multitechnology treatment trains:

- Air stripping as a partial treatment system (with VGAC and CatOx)

- AOP as a partial treatment system (both types)

- LGAC as a polishing treatment device for partial treatment with air stripping

Basis for Evaluation

Estimates of flow and concentrations from the various operable units (OUs) at McClellan Air Force Base (McClellan AFB) was compiled by CH2M HILL staff in Redding, California, and Corvallis, Oregon, to form the basis for comparing these treatment technologies.

A treatment performance requirement of removing acetone, methylethylketone (MEK), and methyl isobutyl ketone (MIBK) to less than 1 mg/l and all other VOCs to less than 0.5 μg/l was used in developing the treatment options.

Table I-9 below shows the five flow and concentration sets used for evaluation.

Table I-9
Condensed Flow and Concentration Scenarios

Treatment Plant	Design Conditions						
		Concentrations (μg/l)					
	Flow Rate (gpm)	TCE	1,2-DCA	1,1-DCA	1,1,1-TCA	Acetone	MeCl
East Hot Spot	90	4,560	7	2	850	500	3
West Hot Spot	0 to 180 (Cost 50, 140)	3,700	0.0	7	180	150	230
Containment Target Volumes: 1. East Background 2. West Background 3. East MCLs 4. West MCLs	0 to 2,200 (Cost 600, 1,700)	32	12	1	7	5	0
Combined West Side Hot Spot and Containment	390	1,070	11	1	195	120	0.7
Combined West Side Hot Spot and Containment	1,190	296	11	2	20	16	19

The five sets above were chosen for the following reasons:

- Flows between hot spots and containment target volumes may be segregated. Developing cost of treatment for the individual and combined extracted flows will provide a basis for choosing if segregation or mixing is preferred.

- Flows will be split between the east and west sides of McClellan AFB into two treatment facilities, leading to the east versus west flow segregation in the scenarios.

- The concentrations of contaminants were not appreciably different between the four containment target zones; therefore, one lumped concentration set over a wide range of flows was evaluated.

Cost Estimation Method

For each option, the five treatment plant scenarios are applied from Table I-9. The cost analysis assumes a fixed concentration and a variable flow rate, as indicated in Table I-9. Plots are presented for capital and O&M costs as a function of flow. Estimates are based on vendor quotations and assumptions outlined in the following sections. Under each of the scenarios, estimates using vendor quotes for treatment systems at either one or two flow rates have been developed. Linear interpolation and some extrapolation is used to estimate treatment costs over the entire range of flows where two flow cases were evaluated. For scenarios with one flow case evaluation, similar slopes of cost versus flow from other curves are assigned.

Estimated costs are developed using a variety of methods and assumptions. The following sections briefly describe the methods and assumptions used.

Treated water discharge standards for all options was 0.5 ppb or less of any of the influent contaminants. This level was identified as the worst case, yet most probable requirement for treatment since end-use options included resale to water districts and reinjection. On the basis of this communication with regulators and ARARs analysis contained in the main body of the FS, this level was chosen as the basis for developing order-of-magnitude costs.

Order-of-magnitude costs presented on the plots are intended to be accurate from +50 percent to -30 percent of the values shown. This level of accuracy results mainly from the assignment of cost per flow slopes from one target volume to the next. Vendor quotes were obtained for at least one specific flow point in all target volumes. These vendor quote estimates are anticipated to be more accurate than order-of-magnitude, while interpolated and extrapolated costs over a range of flows are intended to be accurate from +50 percent to -31 percent.

For capital costs, battery limits of the treatment plants are set to include the major treatment equipment, such as stripping towers, pumps, blowers, carbon vessels, initial carbon charges, and piping. Allowances are made for direct cost such as instrumentation, electrical, and contractor installation fees. Indirect costs such as engineering, insurance, bonding, and scope or bid contingencies are not included in these order-of-magnitude capital cost estimates. Capital items not included for the order-of-magnitude costs, which are included in the budget level estimates, include equalization tanks and operations buildings. Capital items not included which are considered portions of other components of the alternative are extraction conveyance piping from the wellhead to the plant boundary, end-use piping from the plant boundary to the end-use location, and any instrumentation or other related costs associated with that piping.

For O&M costs, line items estimated for each treatment option include operating labor, power, natural gas, administrative labor, maintenance reimbursables (including carbon replacements), and analytical. Data from the existing GWTP was used directly for some of these items, such as analytical and administrative labor costs, since these are assumed to be similar for any new facility at McClellan AFB, regardless of the treatment technology used.

Existing Groundwater Treatment Plant

Costs are developed for the existing Groundwater Treatment Plant (GWTP) to treat up to 2400 gpm of combined west side flows. The methods used to estimate costs are given in the GWTP Evaluation Technical Memorandum (Appendix A). The table below shows the capital and O&M costs for comparison of the GWTP with new grass-roots facilities.

Table I-10
Existing GWTP Capital and O&M Costs for Future Flow Scenarios

Flow Rate (gpm)	Capital Required ($)	O&M Costs ($/yr)
330	15,000	720,000
700	0	750,000
1,000	200,000	1,140,000
2,400	2,190,000	1,970,000

Grass-Roots Facilities

Air Stripping

Preliminary air stripper sizing was performed using STRIPR, an in-house CH2M HILL program for the various flow and concentration scenarios. Two air stripper designs were chosen, one which used a low air flow to remove TCE, and one with a higher air flow to remove the 1,2-DCA to required discharge levels. Tower height was limited to 40 feet for aesthetic and air traffic reasons. A single tower was used for both the high and low air flow sizing within each scenario. For assembly into treatment options, the low air flow stripper size was combined with other technologies (AOP and LGAC) to achieve treatment to required levels, while the high air flow stripper size was designed to approximately meet the required treatment levels without additional water treatment. All air stripper cases were combined with either CatOx or VGAC for offgas control.

Capital costs for air strippers were developed using spreadsheet algorithms, which were calibrated based on vendor quotes. Installation costs were included as an allowance of 50 percent of the capital cost.

Operating and maintenance costs were estimated by assigning operator labor hours, power requirements, and allowances for other items. McClellan AFB labor and analytical costs were assigned based on data from the existing groundwater treatment plant, assuming that these costs would remain constant for a similar technology.

Vapor-Phase Granular Activated Carbon

Vapor-phase carbon systems were sized assuming a superficial air velocity of 50 fpm or less through the carbon beds. With this basis, small single-bed adsorbers were assumed up to 7 feet in diameter. For air flows requiring larger vessels, dual-bed vessels were assumed. The largest air flow was estimated to require three 12-foot-diameter dual-bed carbon vessels. The smallest was estimated to require one single-bed 3-foot-diameter vessel. Capital cost of the VGAC vessels was estimated using algorithms to calculate fabricated FRP vessel cost for the given diameter and height and vendor information on carbon costs.

Operating and maintenance costs includes estimates of operating labor required, and carbon usage based on the offgas flow and concentration for each case. Computer spreadsheets using Freundlich isotherms were used to estimate carbon bed life. Carbon replacement costs are based on offsite regeneration and are included in the O&M cost for VGAC.

Catalytic Oxidation

Catalytic incinerator capital costs are estimated based on vendor-provided capital cost estimates for specific flow cases, corrected to the case-specific air flow using a correction factor.

O&M costs for operator labor are estimated based on project experience. Utility requirements are calculated for the specific cases, based on general vendor-supplied information.

Liquid-Phase Granular Activated Carbon

Preliminary sizing for three LGAC applications is provided: LGAC as a stand-alone treatment system, LGAC as a post-treatment technology combined with air stripping, and LGAC as a polishing technology following air stripping where air stripping is sized to remove contaminants to below the existing NPDES permit levels for the GWTP.

Preliminary equipment sizing and cost for LGAC systems is based on vendor information for required empty bed contact times and skid mounted system costs. A 20 percent installation factor is used to calculate installed system costs, since these skid-mounted systems require less installation effort than other technologies.

Operation and maintenance costs are calculated based on Fruendlich isotherm data for carbon usage, and estimates of labor, analytical, and other O&M costs.

Ozone/Hydrogen Peroxide AOP

Preliminary ozone/hydrogen peroxide oxidation equipment sizing was performed using in-house CH2M HILL worksheets based on known reaction rates of the contaminants of concern for various oxidant feed ratios. Two ozone/hydrogen peroxide oxidation designs were chosen, one which was smaller, with less detention and reaction time to remove the pollutants to higher concentration levels than required for final discharge, and another design that treats the contaminants down to the 0.5 ppb concentration required for discharge. The smaller design was combined with air stripping to achieve treatment to the required levels.

Capital cost of the ozone/peroxide oxidation system were developed using spreadsheet algorithms to calculate installed cost of the system based on factors provided by the literature and in-house CH2M HILL resources.

Operating and maintenance costs were also estimated using spreadsheet algorithms based on factors for ozone/peroxide systems from the literature and in-house CH2M HILL resources.

UV/Hydrogen Peroxide AOP

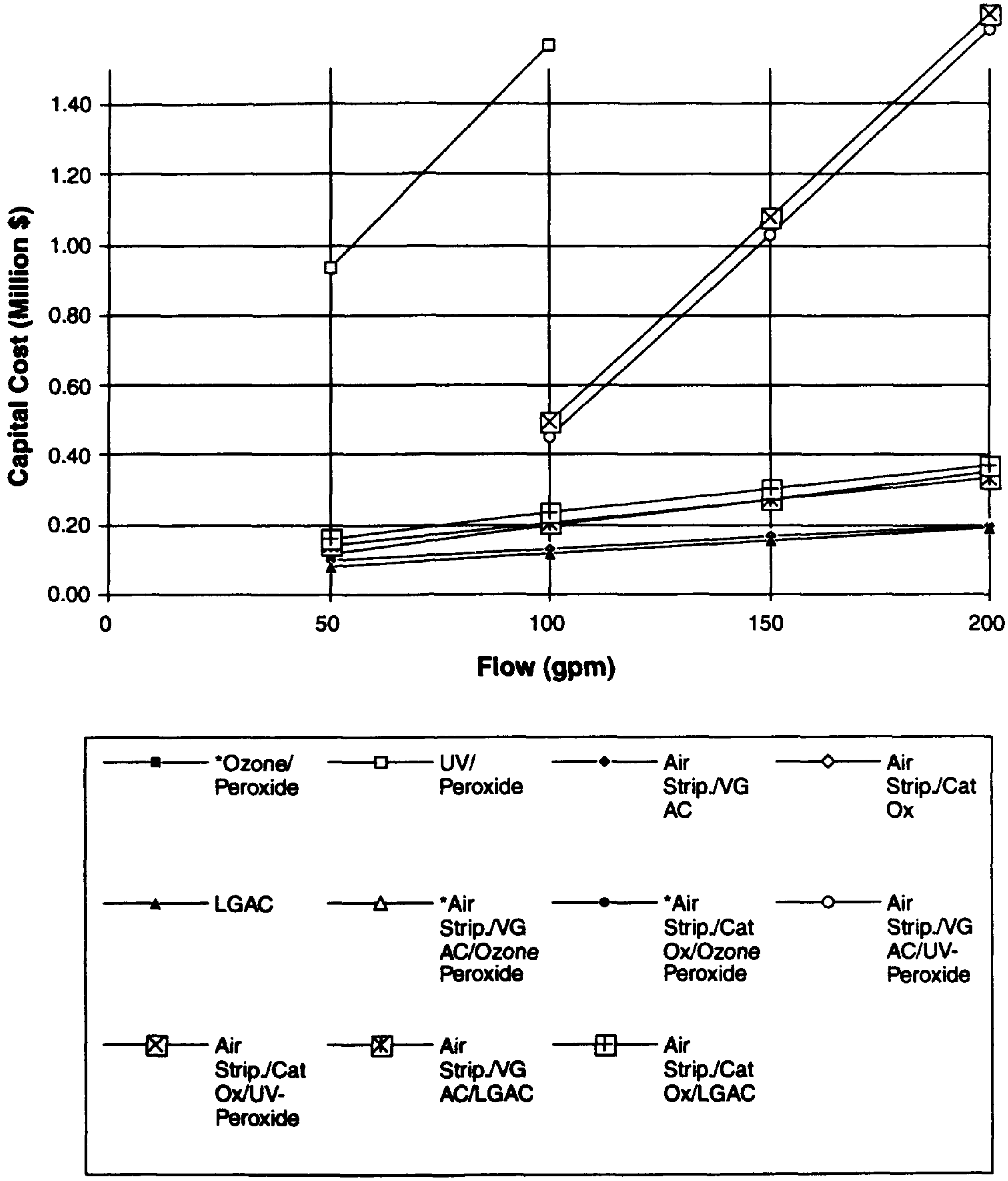
UV/hydrogen peroxide AOP capital costs were estimated based on vendor-provided capital cost estimates for the flow and concentration cases documented in Table I-9. Installation costs were included as an allowance of 50 percent of the capital cost.

Operating and maintenance costs were estimated based on vendor-provided estimates of power and peroxide dosage requirements. Operator hours, analytical costs, and other allowances are based on project experience.

Cost Plots

Figures I-1 through I-10 are the results of the cost estimation. Linear interpolation with two points was used in developing cost curves for both west hot spot and the containment scenarios, while the position of the cost curves for the remaining scenarios were estimated using a single point coupled with the slopes of the two scenarios listed above (west hot spot and containment). Because of similar flow rates, the west hot spot slopes were used for the east hot spot cost curves, and the containment slopes were used to develop the eastside combined and westside combined curves.

Potential inaccuracies may result as the curves are extrapolated to high and low flow rates, especially those curves developed based on a single point (east hot spot, eastside combined, and westside combined). Points were removed from the graphs where linear interpolation at low flow rates predicted negative costs. Data used to develop the cost plots are in Attachment I1.

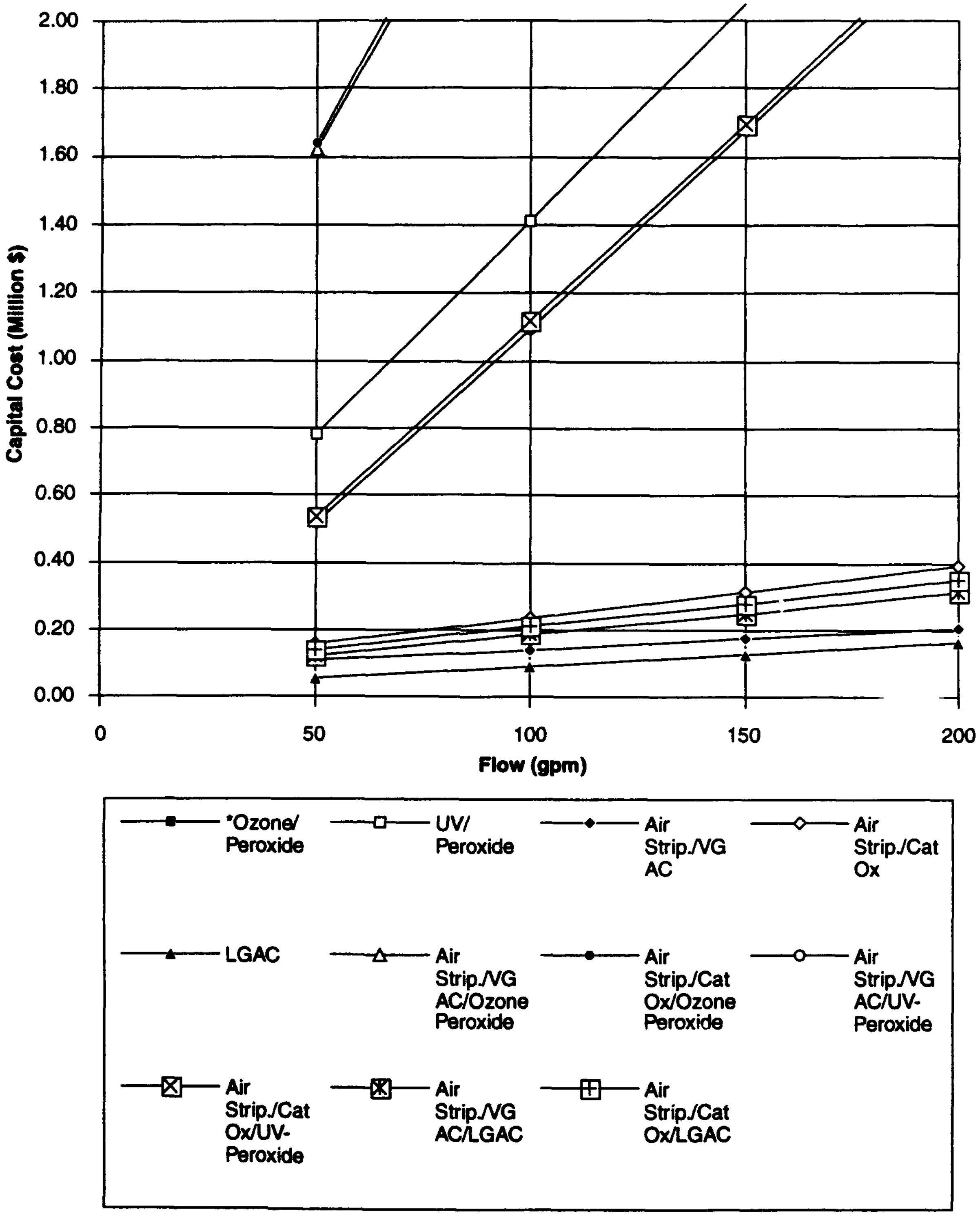


* Cost for this option(s) are greater than the scale of this plot.

FIGURE I-1
EAST HOT SPOT
CAPITAL COSTS
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

RDD1454_360

CH2MHILL

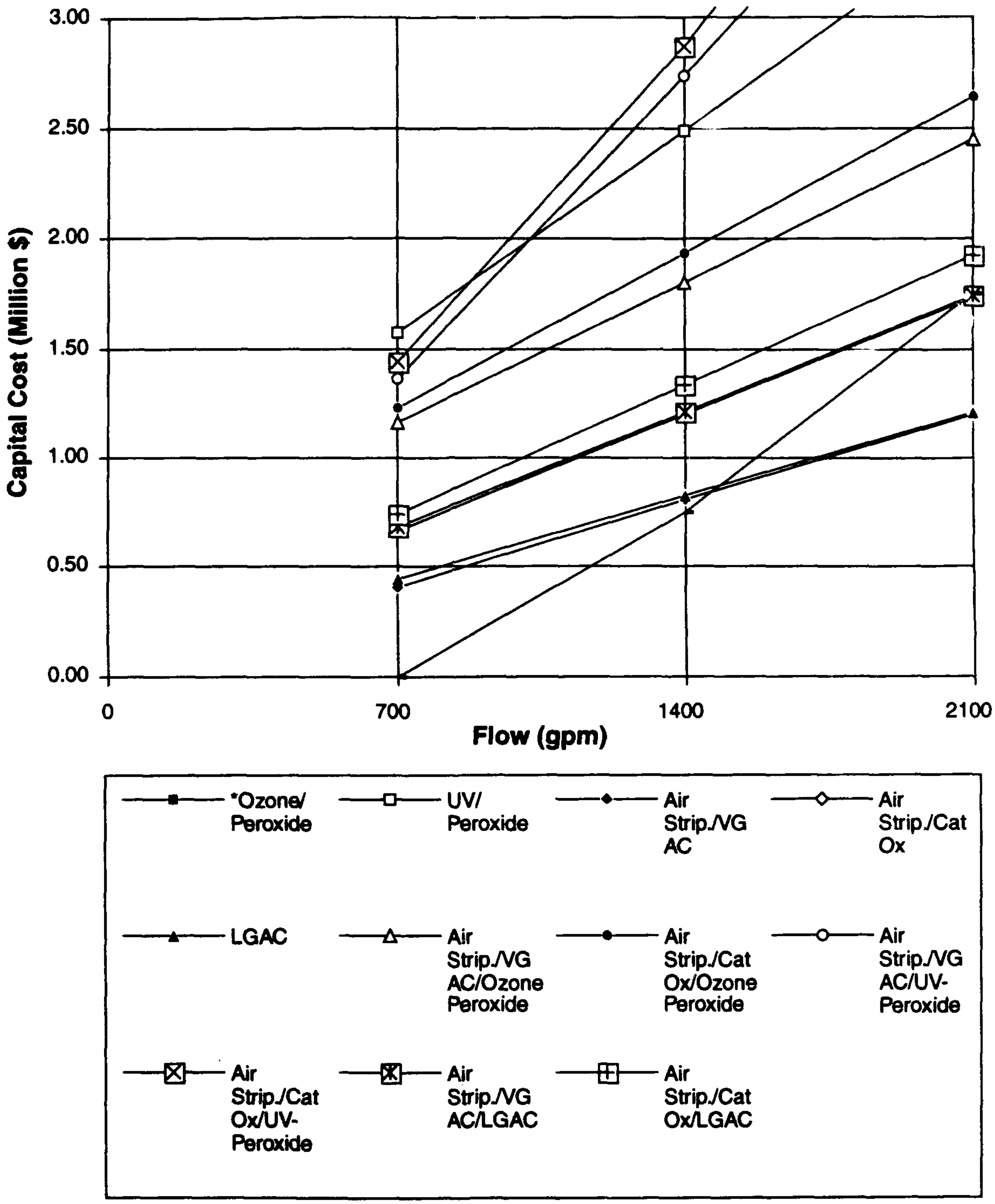


* Cost for this option(s) are greater than the scale of this plot

FIGURE I-2
WEST HOT SPOT
CAPITAL COSTS
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

RDD1454_351

CH2M HILL

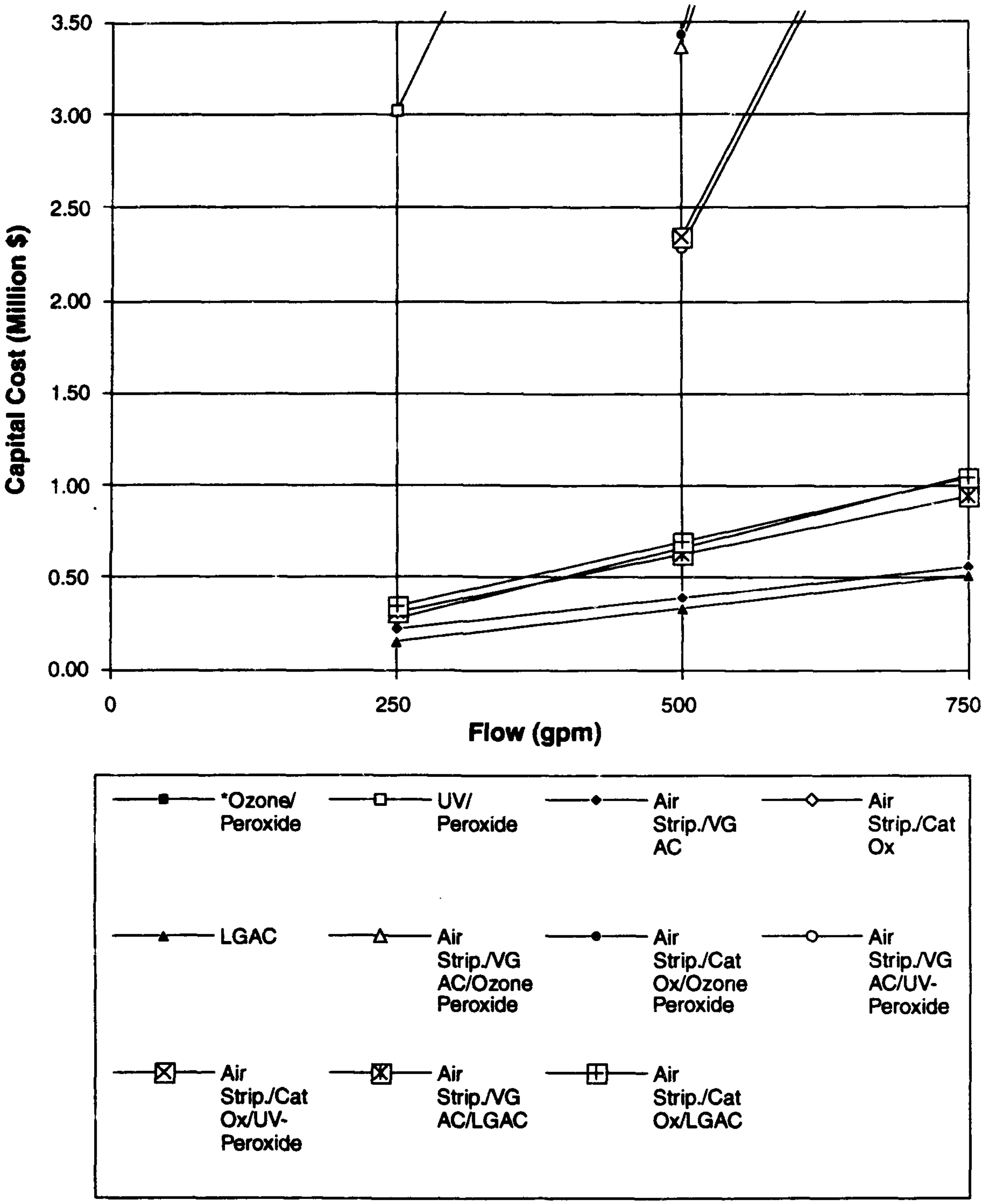


* Cost for this option(s) are greater than the scale of this plot

FIGURE I-3
CONTAINMENT CAPITAL COSTS
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

RDD1454_362

CH2M HILL

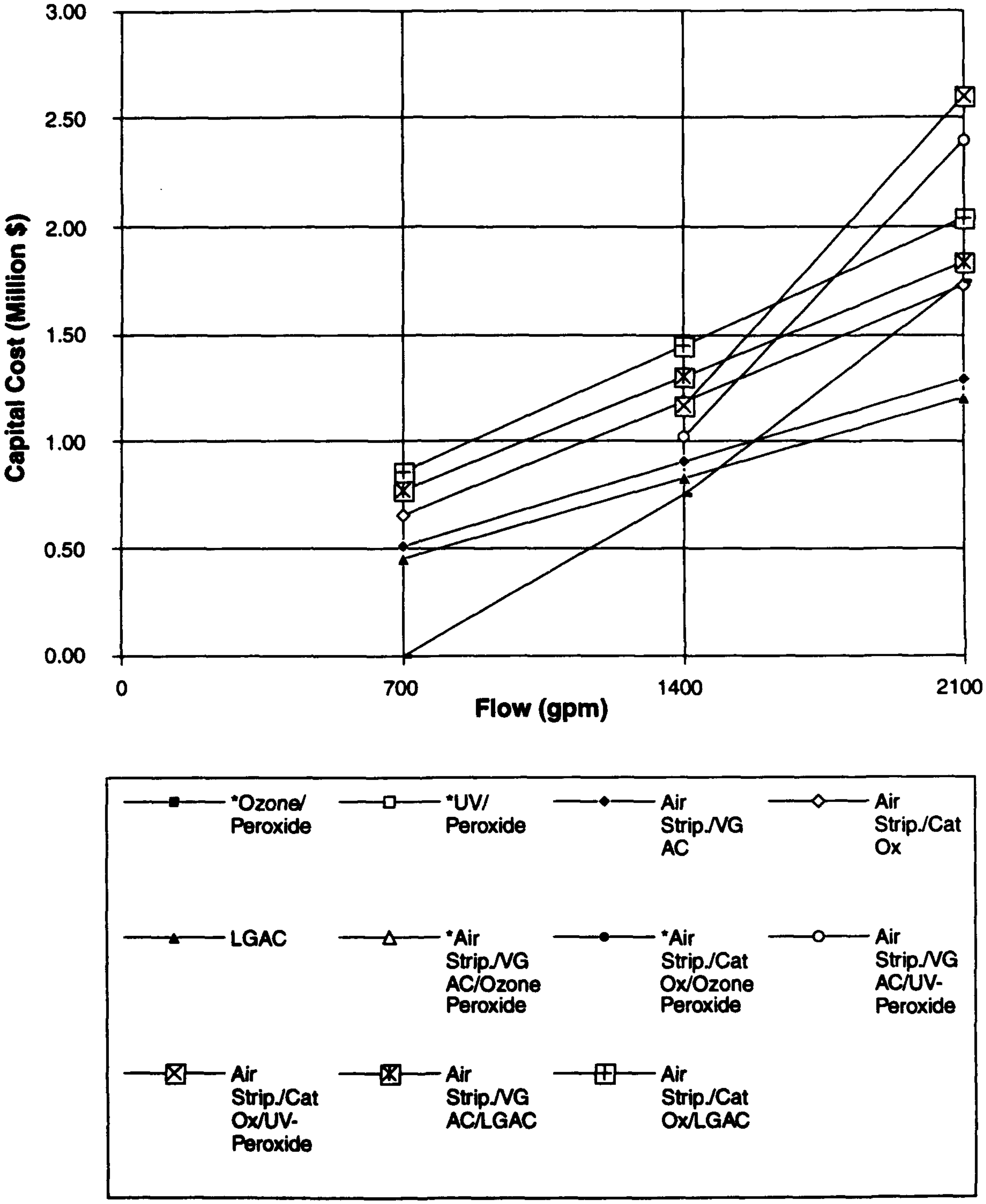


* Cost for this option(s) are greater than the scale of this plot

FIGURE I-4
EAST COMBINED CAPITAL COSTS
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

RDD1454_354

CH2M HILL



* Cost for this option(s) are greater than the scale of this plot

FIGURE I-5
WEST COMBINED CAPITAL COSTS
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

RDD1454_366

CH2MHILL

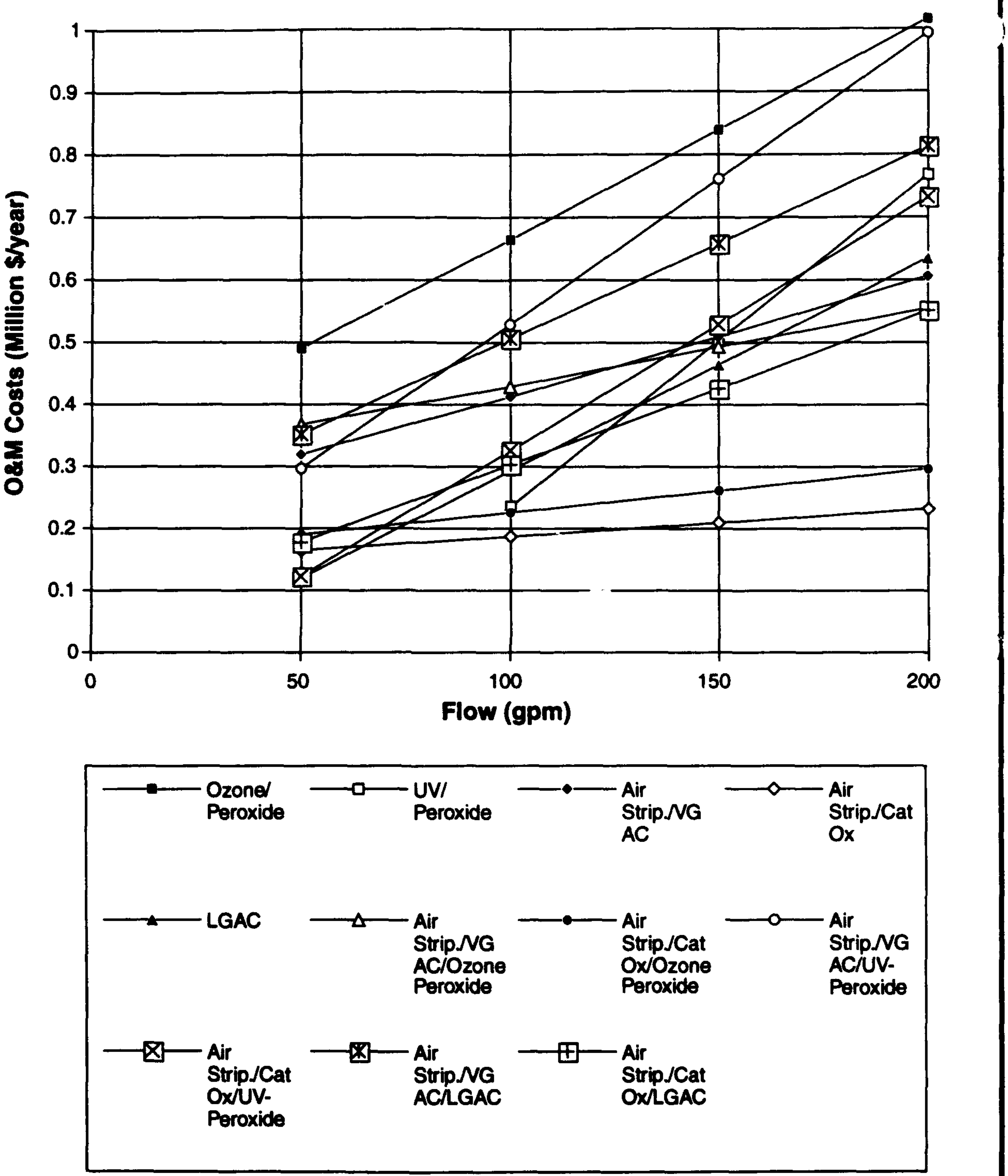


FIGURE I-6
EAST HOT SPOT
O&M COSTS
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

RDD1464_366

CH2M HILL

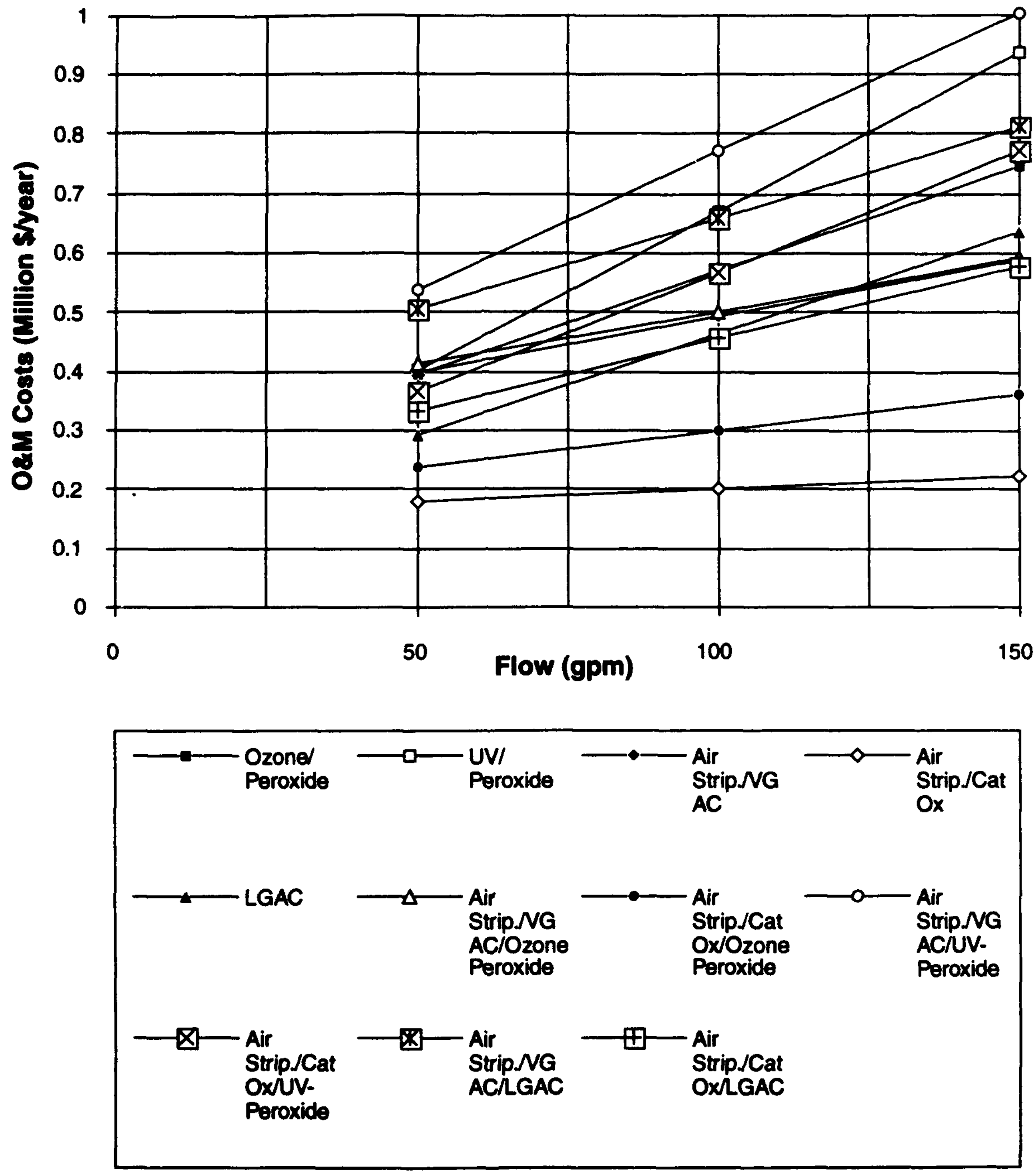


FIGURE I-7
WEST HOT SPOT
O&M COSTS
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

RDD1454_357

CH2M HILL

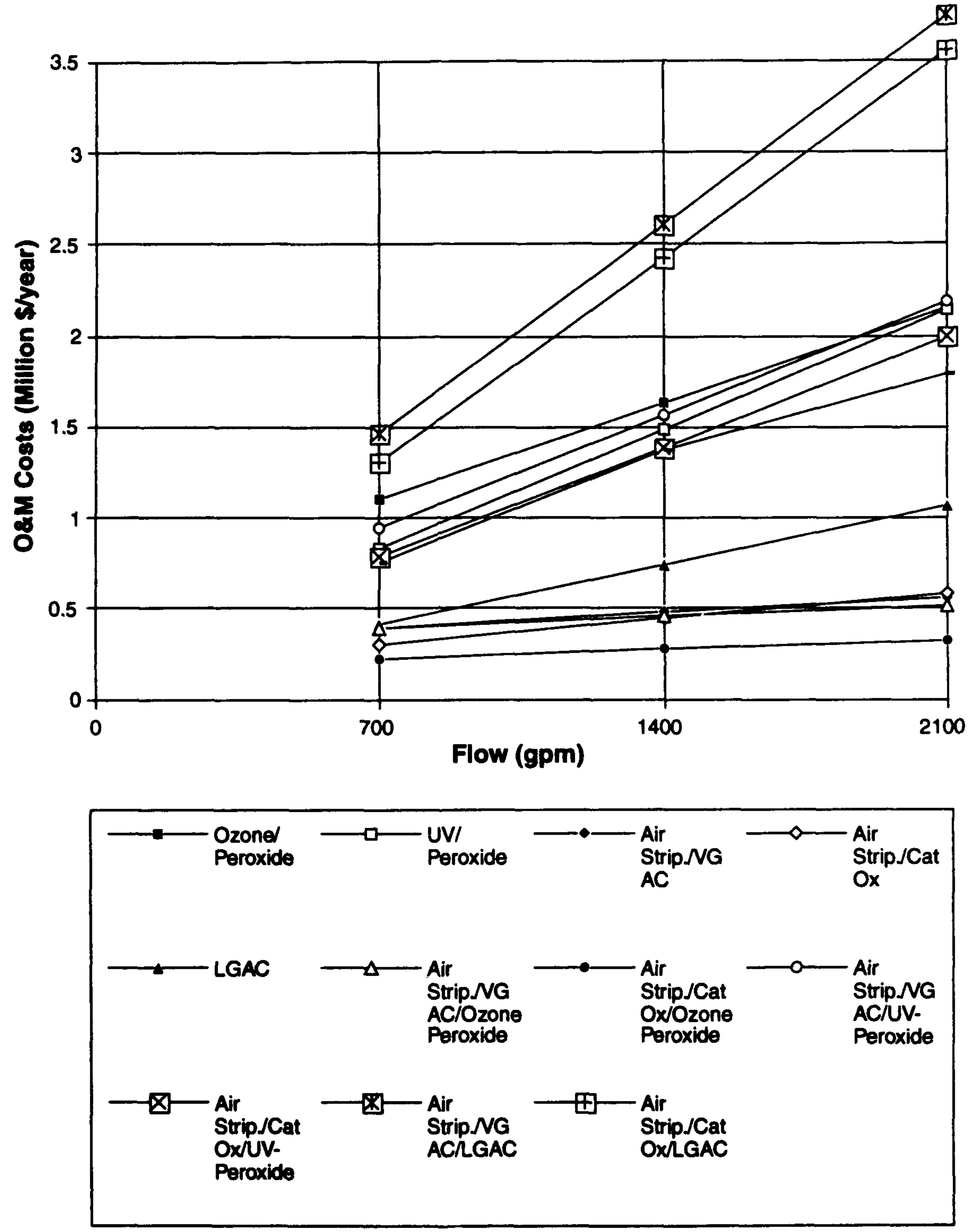


FIGURE I-8
CONTAINMENT
O&M COSTS
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

RDD1454_358

CH2M HILL

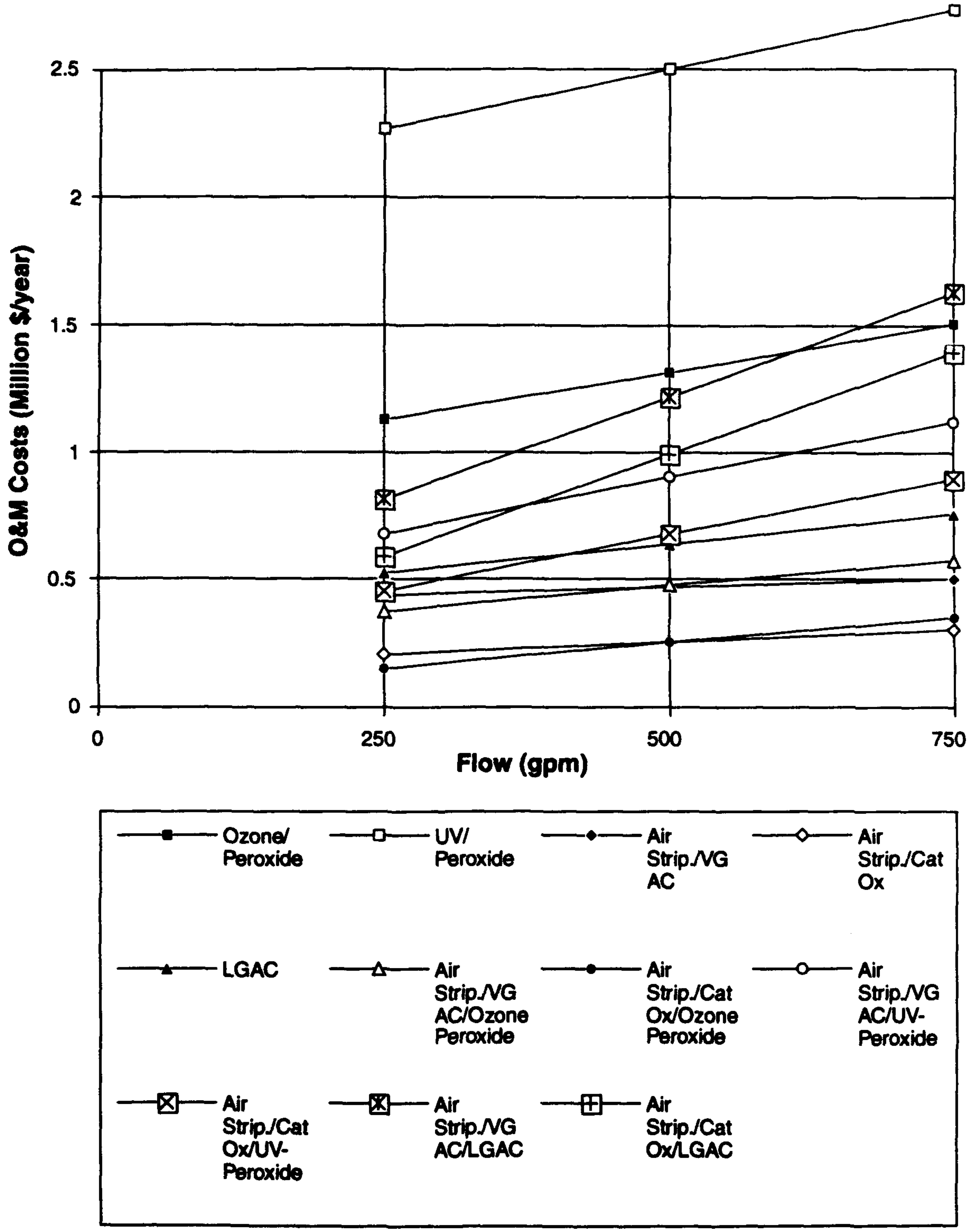
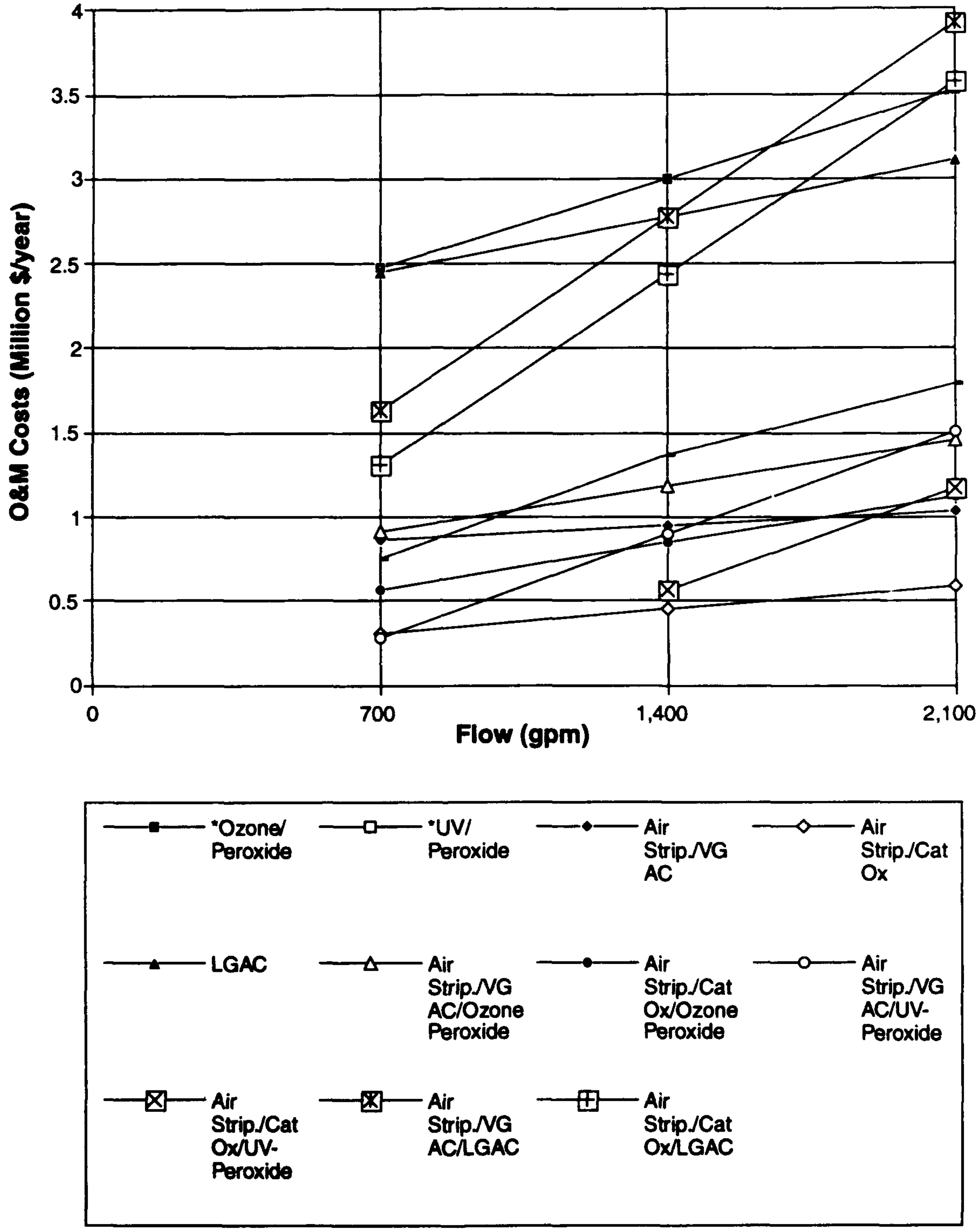


FIGURE I-9
EAST COMBINED FLOW
O&M COSTS
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

RDD1464_369

CH2MHILL



* Cost for this option(s) are greater than the scale of this plot

FIGURE I-10
WEST COMBINED FLOW
O&M COSTS
GROUNDWATER OPERABLE UNIT RI/FS
McCLELLAN AIR FORCE BASE
SACRAMENTO, CALIFORNIA

RDD1454_380

CH2M HILL

Attachment I1

Capital Cost Summary

By JSO,ATO,GZ
Date - 8-Oct-93 *Costs shown are for installed facilities, given in millions of dollars.*
Project SAC28722.00.WT *Slope values are Million dollars per gpm*

West Hot Spot

Flow	Oz/Perox Oxid.	UV/Perox Oxid	Air Strip/VGAC	Air Strip/Catox	LGAC	AS/VGAC/OZ-Perox	AS/Catox/OZ-Perox	AS/VGAC/UV-Perox	AS/Catox/UV-Perox	AS/VGAC/LGAC	AS/Catox/LGAC
Slope	0.0331	0.0127	0.0007	0.0016	0.0007	0.0228	0.0229	0.0116	0.0116	0.0013	0.0014
50	2.46	0.78	0.100	0.150	0.054	1.82	1.84	0.518	0.536	0.123	0.14
140	5.43	1.82	0.100	0.298	0.12	3.67	3.7	1.56	1.56	0.237	0.287
0	0.794	0.147	0.075	0.080	0.017	0.481	0.496	-0.061	-0.044	0.060	0.069

Flow	Oz/Perox Oxid.	UV/Perox Oxid	Air Strip/VGAC	Air Strip/Catox	LGAC	AS/VGAC/OZ-Perox	AS/Catox/OZ-Perox	AS/VGAC/UV-Perox	AS/Catox/UV-Perox	AS/VGAC/LGAC	AS/Catox/LGAC
0											
50	2.45	0.78	0.11	0.18	0.05	1.82	1.64	0.52	0.54	0.12	0.14
100	4.11	1.41	0.14	0.24	0.09	2.76	2.78	1.10	1.12	0.19	0.21
150		2.05	0.17	0.31	0.13	3.90	3.93	1.68	1.70	0.25	0.28
200		2.68	0.21	0.39	0.16			2.25	2.28	0.31	0.35

Containment

Flow	Oz/Perox Oxid.	UV/Perox Oxid	Air Strip/VGAC	Air Strip/Catox	LGAC	AS/VGAC/OZ-Perox	AS/Catox/OZ-Perox	AS/VGAC/UV-Perox	AS/Catox/UV-Perox	AS/VGAC/LGAC	AS/Catox/LGAC	GWTP
Slope	0.0094	0.0013	0.0006	0.0008	0.0005	0.0009	0.0010	0.0020	0.0020	0.0008	0.0008	
800	8.24	1.44	0.354	0.585	0.396	1.07	1.13	1.17	1.23	0.604	0.66	0
1700	10.6	2.88	0.873	1.43	0.90	2.08	2.24	3.33	3.48	1.44	1.59	1.2
0	2.589	0.655	0.016	0.124	0.072	0.519	0.525	-0.008	0.003	0.148	0.153	0

Flow	Oz/Perox Oxid.	UV/Perox Oxid	Air Strip/VGAC	Air Strip/Catox	LGAC	AS/VGAC/OZ-Perox	AS/Catox/OZ-Perox	AS/VGAC/UV-Perox	AS/Catox/UV-Perox	AS/VGAC/LGAC	AS/Catox/LGAC	GWTP
0.000												
700	8.16	1.57	0.41	0.86	0.45	1.18	1.23	1.37	1.43	0.68	0.74	0
1400		2.49	0.80	1.20	0.83	1.80	1.94	2.74	2.87	1.21	1.34	0.75
2100		3.40	1.20	1.74	1.21	2.45	2.64	4.12	4.30	1.74	1.93	1.75

Combined East Side

Flow	Oz/Perox Oxid.	UV/Perox Oxid	Air Strip/VGAC	Air Strip/Catox	LGAC	AS/VGAC/OZ-Perox	AS/Catox/OZ-Perox	AS/VGAC/UV-Perox	AS/Catox/UV-Perox	AS/VGAC/LGAC	AS/Catox/LGAC
Slope	0.0331	0.0127	0.0007	0.0016	0.0007	0.0228	0.0229	0.0118	0.0118	0.0013	0.0014
300	10.5	4.8	0.310	0.497	0.252	0.850	0.807	1.82	1.87	0.482	0.54
0	-2.413	-0.140	0.058	-0.110	-0.034	-8.024	-8.020	-3.495	3.454	-0.002	-0.010

Flow	Oz/Perox Oxid.	UV/Perox Oxid	Air Strip/VGAC	Air Strip/Catox	LGAC	AS/VGAC/OZ-Perox	AS/Catox/OZ-Perox	AS/VGAC/UV-Perox	AS/Catox/UV-Perox	AS/VGAC/LGAC	AS/Catox/LGAC
0											
250	5.86	3.03	0.22	0.28	0.15					0.31	0.34
500		6.19	0.39	0.67	0.33	3.38	3.42	2.29	2.35	0.63	0.70
750		9.36	0.56	1.06	0.52	9.08	9.15	5.19	5.25	0.95	1.05

Combined West Side

Flow	Oz/Perox Oxid.	UV/Perox Oxid	Air Strip/VGAC	Air Strip/Catox	LGAC	AS/VGAC/OZ-Perox	AS/Catox/OZ-Perox	AS/VGAC/UV-Perox	AS/Catox/UV-Perox	AS/VGAC/LGAC	AS/Catox/LGAC	GWTP
Slope	0.0094	0.0013	0.0006	0.0008	0.0005	0.0009	0.0010	0.0020	0.0020	0.0008	0.0008	
1100	18.2	10.6	0.786	1.03	0.714	9.3	9.4	0.888	0.738	1.14	1.27	0.47
0	8.092	9.242	0.116	0.116	0.071	8.207	8.199	1.728	1.898	0.238	0.264	0

Flow	Oz/Perox Oxid.	UV/Perox Oxid	Air Strip/VGAC	Air Strip/Catox	LGAC	AS/VGAC/OZ-Perox	AS/Catox/OZ-Perox	AS/VGAC/UV-Perox	AS/Catox/UV-Perox	AS/VGAC/LGAC	AS/Catox/LGAC	GWTP
0												
700	13.59	10.16	0.51	0.65	0.45	8.85	8.91			0.77	0.86	0
1400		11.07	0.90	1.19	0.83	9.49	9.61	1.02	1.17	1.30	1.45	0.75
2100		11.99	1.30	1.73	1.21	10.14	10.32	2.40	2.60	1.83	2.04	1.75

East Hot Spot

Flow	Oz/Perox Oxid.	UV/Perox Oxid	Air Strip/VGAC	Air Strip/Catox	LGAC	AS/VGAC/OZ-Perox	AS/Catox/OZ-Perox	AS/VGAC/UV-Perox	AS/Catox/UV-Perox	AS/VGAC/LGAC	AS/Catox/LGAC
Slope	0.0331	0.0127	0.0007	0.0016	0.0007	0.0228	0.0229	0.0116	0.0116	0.0013	0.0014
90	4.07	1.44	0.126	0.18	0.188	11	11	0.338	0.38	0.184	0.218
0	1.090	0.300	0.066	0.040	0.042	8.950	8.940	0.706	0.664	0.080	0.091

Flow	Oz/Perox Oxid.	UV/Perox Oxid	Air Strip/VGAC	Air Strip/Catox	LGAC	AS/VGAC/OZ-Perox	AS/Catox/OZ-Perox	AS/VGAC/UV-Perox	AS/Catox/UV-Perox	AS/VGAC/LGAC	AS/Catox/LGAC
0											
50	2.75	0.93	0.10	0.12	0.08					0.14	0.16
100		1.57	0.13	0.20	0.12			0.45	0.50	0.21	0.23
150		2.20	0.17	0.27	0.15			1.03	1.08	0.27	0.30
200		2.83	0.20	0.35	0.19			1.61	1.66	0.33	0.37

Containment O & M Cost Summary ($/yr)

Flow	Oz/Perox	UV/Perox	Air Strip/VGAC	Air Strip/Catox	LGAC	AS/VGAC/OZ-Perox	AS/Catox/OZ-Perox	AS/VGAC/UV-Perox	AS/Catox/UV-Perox	AS/VGAC/LGAC	AS/Catox/LGAC	GWTP
0												
700	1.1071	0.8288	0.3929	0.3017	0.4179	0.3892	0.2261	0.9462	0.7830	1.4648	1.3017	0.7500
1,400	1.6293	1.4876	0.4781	0.4438	0.7447	0.4552	0.2761	1.5686	1.3895	2.6067	2.4276	1.3771
2,100	2.1516	2.1464	0.5634	0.5860	1.0714	0.5212	0.3261	2.1911	1.9960	3.7485	3.5534	1.7921
600	**1,032,494**	**734,679**	**380,691**	**281,349**	**371,232**	**379,773**	**218,921**	**857,251**	**696,399**	**1,301,728**	**1,140,875**	
1,700	**1,853,160**	**1,769,936**	**514,678**	**504,787**	**884,722**	**483,517**	**297,554**	**1,835,379**	**1,649,416**	**3,096,027**	**2,910,064**	
Slope	746	941	122	203	467	94	71	889	866	1,631	1,608	
Intercept	584,858	169,993	307,607	159,474	91,147	323,185	176,030	323,727	176,572	323,019	175,863	

East Hot Spot O & M Cost Summary ($/yr)

Flow	Oz/Perox	UV/Perox	Air Strip/VGAC	Air Strip/Catox	LGAC	AS/VGAC/OZ-Perox	AS/Catox/OZ-Perox	AS/VGAC/UV-Perox	AS/Catox/UV-Perox	AS/VGAC/LGAC	AS/Catox/LGAC
0											
50	0.4889		0.3181	0.1652	0.1198	0.3664	0.1901	0.2971	0.1208	0.3522	0.1767
100	0.6641	0.2337	0.4134	0.1876	0.2911	0.4291	0.2250	0.5289	0.3247	0.5052	0.3009
150	0.8393	0.5008	0.5087	0.2100	0.4625	0.4919	0.2598	0.7607	0.5286	0.6582	0.4251
200	1.0145	0.7679	0.6040	0.2324	0.6339	0.5546	0.2947	0.9925	0.7326	0.8112	0.5493
90	**629096**	**180336**	**394344**	**183074**	**256854**	**416585**	**217992**	**482510**	**283917**	**474621**	**276028**
Slope	3504	5341.389	1905.82222	448	3427.467	1254.9778	697.6	4635.9556	4078.578	3060	2483.933
Intercept	313,736	-300,389	222,820	142,754	-51,618	303,637	155,208	65,274	-83,155	199,221	52,474

East Mix O & M Cost Summary ($/yr)

Flow	Oz/Perox	UV/Perox	Air Strip/VGAC	Air Strip/Catox	LGAC	AS/VGAC/OZ-Perox	AS/Catox/OZ-Perox	AS/VGAC/UV-Perox	AS/Catox/UV-Perox	AS/VGAC/LGAC	AS/Catox/LGAC
0											
250	1.1332	2.2624	0.4411	0.2033	0.5274	0.3785	0.1531	0.6843	0.4589	0.8149	0.5927
500	1.3197	2.4977	0.4716	0.2541	0.6441	0.4764	0.2519	0.9029	0.6784	1.2224	0.9952
750	1.5062	2.7330	0.5020	0.3049	0.7608	0.5742	0.3506	1.1215	0.8979	1.6299	1.3977
390	**1,237,624**	**2,394,168**	**458,163**	**231,741**	**592,760**	**433,331**	**208,407**	**806,719**	**581,795**	**1,043,072**	**818,148**
Slope	746	941	122	203	467	391	395	874	878	1,630	1,610
Intercept	946,661	2,027,122	410,659	152,522	410,704	280,699	54,350	465,725	239,376	407,372	190,248

West Hot Spot O & M Cost Summary ($/yr)											
Flow	Oz/Perox	UV/Perox	Air Strip/VGAC	Air Strip/Catox	LGAC	AS/VGAC/OZ-Perox	AS/Catox/OZ-Perox	AS/VGAC/UV-Perox	AS/Catox/UV-Perox	AS/VGAC/LGAC	AS/Catox/LGAC
0											
50	0.3939	0.4026	0.3977	0.1787	0.2935	0.4124	0.2385	0.5376	0.3638	0.5050	0.3311
100	0.5691	0.6697	0.4930	0.2011	0.4649	0.5024	0.2997	0.7703	0.5676	0.6579	0.4552
150	0.7443	0.9368	0.5883	0.2235	0.6362	0.5925	0.3609	1.0030	0.7715	0.8109	0.5793
200	0.9195	1.2039	0.6836	0.2459	0.8076	0.6825	0.4222	1.2357	0.9753	0.9638	0.7035
50	**393,890**	**402,646**	**397,730**	**178,674**	**293,498**	**412,386**	**238,512**	**537,649**	**363,775**	**504,990**	**331,116**
140	**709,250**	**883,371**	**569,254**	**218,994**	**601,970**	**574,478**	**348,705**	**956,468**	**730,695**	**780,291**	**554,518**
Slope	3,504	5,341	1,906	448	3,427	1,801	1,224	4,654	4,077	3,059	2,482
Intercept	218,690	135,577	302,439	156,274	122,125	322,335	177,294	304,972	159,931	352,045	207,004

West Mix O & M Cost Summary ($/yr)

Flow	Oz/Perox	UV/Perox	Air Strip/VGAC	Air Strip/Catox	LGAC	AS/VGAC/OZ-Perox	AS/Catox/OZ-Perox	AS/VGAC/UV-Perox	AS/Catox/UV-Perox	AS/VGAC/LGAC	AS/Catox/LGAC	GWTP
0												
700	2.4722	5.1143	0.8676	0.3075	2.4528	0.9092	0.5714	0.2857		1.6370	1.3108	0.7500
1,400	2.9945	5.7731	0.9529	0.4497	2.7796	1.1832	0.8479	0.8978	0.5625	2.7780	2.4378	1.3771
2,100	3.5167	6.4319	1.0382	0.5919	3.1064	1.4571	1.1244	1.5098	1.1771	3.9190	3.5648	1.7921
1,190	**2,837,784**	**5,575,496**	**927,324**	**407,027**	**2,681,572**	**1,100,970**	**764,954**	**714,165**	**378,149**	**2,435,673**	**2,099,657**	
Slope	746	941	122	203	467	391	395	874	878	1,630	1,610	
Intercept	1,949,973	4,455,536	782,374	165,308	2,126,069	635,246	294,882	-326,303	-666,667	495,973	183,757	