REGIONAL WATER QUALITY CONTROL BOARD
SAN FRANCISCO BAY REGION

INTERNAL MEMO

TO: Steve Morse, Chief
SBT Cleanup Division

Date: June 4, 1993

Greg Walker
Section Leader

FROM: Tony Mancini
Asso EG *A J Mancini*

SUBJECT: Responsiveness Summary: Staff Responses to Comments Received Pertaining to Tentative Order Amending Order No. 90-134 Which Amended Order No. 89-167, Site Cleanup Requirements For Applied Materials, Inc. 3050 Bowers Avenue Building 1 Facility, Santa Clara, CA

EXECUTIVE SUMMARY

Comments were received only from Applied Materials (Discharger) during the legally noticed 30-day comment period (April 14 - May 14, 1993). All comments have been addressed and described below.

The Discharger's main concern was that Applied Materials would be required to perform new field investigation work (borings, wells, etc.). The Order and amended RAP does not require additional field work. The revised Order and RAP do require Applied Materials to continue to confirm its conclusion that groundwater extraction will clean up the site's groundwater and soil pollution in a timely fashion by collecting and analyzing data from existing wells. The Discharger's other main concern was that neither the Board nor Board staff has predetermined whether any additional wells, boreholes or soil remediation will be required in the future. While neither staff nor the existing Board can speak for future Board actions, Board staff finds that if circumstances change at a future date (e.g. risk, etc.), requirements *may* also change, either by Board direction or Discharger/RP request and Board concurrence. There is no intent to require future changes at this time.

Technical comments were received concerning four broad technical issues (brief staff responses are provided below, detailed responses are provided later):

- Suspected (by staff) presence of dense non-aqueous phase liquids (DNAPLs).
  Response: *Staff still suspects the presence of DNAPLs, but agrees that finding them is impractical at this time.*

- Further characterization of the source area.
  Response: *The suspected source area lacks deep borings or wells beneath the former tank because of inaccessbility. Because of the relatively small size of this volume and area and the apparent impracticability of access, this lack of data is considered acceptable.*

- Discharger's cleanup time estimates.
  Response: *The estimated cleanup times still appear optimistic to staff compared to other similar sites in the South Bay and elsewhere. However, if the discharger is right, the site will be cleaned up earlier than staff expects.*

- Downgradient offsite VOC migration.
  Response: *Staff is concerned that some of the pollutants are still not under control and have been and may still be migrating downgradient across Bowers Avenue on the Avantek site. The Order requires further geologic evaluation of available information to document control.*

Comments on Findings and Provisions of the Tentative Order were also received during the comment period. Responses have been provided to Applied Materials on all specific comments. None were considered significant. Numerous other minor comments were received concerning the Staff Report. None were considered significant. Some were addressed by responses to earlier comments, others were addressed by reformatting the report organization, and some were not adopted. Most of the comments were minor wording changes. In staff's opinion, there are no outstanding, significant, unresolved issues remaining from the comments received during the comment period.

INTRODUCTION

Staff introduced the subject Tentative Order (TO) at the Regional Board Meeting of April 21, 1993, for the purpose of making the proposed Order available for comment, and publicizing the 30-day public comment period which began April 14 and ended May 14, 1993. The Board issued Fact Sheet No. 4 in April, which provided a description of the proposed minor revisions to the cleanup plan along with relevant background information. A local public meeting and open house was held in Santa Clara the evening of April 21, 1993. (A newspaper advertisement for the Board Meeting and the local public meeting ran in the Santa Clara zone of the San Jose Mercury News on April 14, 1993.)

On May 3, 1993 Board staff met with Applied Materials representatives in Santa Clara to discuss the TO, and toured the Building 1 facility. A meeting was held in Board offices in Oakland on May 6, 1993, to discuss issues of a technical nature. After this meeting and prior to the close of the public comment period, we received four written submittals from Applied Materials which require responses. No other comments were received. The submittals were:

1. Revised TO from Weiss Associates, Applied Materials' technical consultant.
2. Letter from Applied Materials' legal counsel.
3. Letter from Weiss Associates.
4. Revised Board Staff Report from Weiss Associates (the second of two revisions of the Board Staff Report submitted by the Discharger).

Staff responses are presented in the same sequence as the submittals identified above.

COMMENTS AND STAFF RESPONSES

Revised Tentative Order

1. Comment. In 5b, Discharger suggests the following word changes in the first line: strike "up to" and replace with less than.

   Response. Staff agrees with the suggested change.

2. Comment. In 8a, Discharger suggests the following changes:

   Add, following "will be costly to Applied Materials" (third line), the phrase, and have limited affect on site cleanup time.(period, end of sentence)

   Delete original "and" following "Applied Materials", and add beginning of new sentence, Consideration of, before "any requirement for----------".

   Response. Staff agrees to the suggested changes, with the addition of the word "may":and may have limited effect (affect) on site cleanup time.

3. Comment. In 8c, Discharger suggests adding one word, will, between "requirements" and "continue".

   Response. Staff agrees with the suggested change.

4. Comment. At the top of page 4, Discharger makes a spelling correction.

   Response. Staff agrees with the correction.

No other changes to the proposed Tentative Order have been suggested.

Legal Counsel Letter

1. Comment. The May 14, 1993 letter states an understanding by Applied Materials that:

   a. The Tentative Order is intended to require Applied Materials to confirm its conclusion that groundwater extraction and treatment will clean up the Site's groundwater and saturated soils in a timely fashion by collecting and analyzing data from existing wells.

   b. The Order is not intended to require Applied Materials to install any additional wells nor to drill any additional boreholes.

   c. Neither the Board nor the Board staff has predetermined whether any future wells, boreholes, or soil remediation (other than through continued pumping and treatment of groundwater) will be required in the future.

   With this understanding and in light of changes discussed and agreed upon, Applied Materials will accept the Tentative Order as revised.

   Response. Staff agrees with the Discharger's understanding pertaining to the Tentative Order. The intent of "c" above is unclear. If circumstances change at a future date (toxicity, risk, etc.), requirements *may also change*, either by Board direction or Discharger/RP request and Board concurrence.

Weiss Associates Letter

The May 14, 1993 letter identifies four technical issues discussed in the Board Staff Report (Internal Memo dated March 1, 1993) which the Discharger feels are not supported by site data:

1. Dense non-aqueous phase liquids are suspected at the site.

2. The source area is not adequately characterized and may need additional saturated soil remediation.

3. Applied Materials cleanup time estimates are optimistic because of several factors, including DNAPLs and "tailing effects".

4. Further investigation is needed to characterize downgradient VOC migration along Applied Materials and Avantek property boundary.

The letter then discusses three Findings and one Provision of the Revised Tentative Order: Findings 6, 7 (b, c, and d), 8 (a); and Provision 6 (2d). Attached to the letter were copies of the Discharger's latest graphs of Relative Concentration vs. Time, for 1,1,1-TCA, 1,1-DCA, and 1,1-DCE, in wells AM1-1 and AM1-5E. (Two assumptions are: well AM1-1 represents a well in the former source area, and well AM1-5E represents a well in the non-source area; and, the non-source area well should clean up [reach MCLs for all VOCs] before the former source-area well cleans up.)

Staff responses are made to the specific comments in the letter, as follows:

1. Comment. The RWQCB Internal Memo presented four interpretations or conclusions the Discharger feels are not supported by site data.

   Response. Staff will address specifics (below) as presented.

2. Comment. With reference to Finding 6 of the Revised Tentative Order (RTO), the letter infers that, the rationale for the Discharger's proposal that no additional soil remediation be done, should be presented in this Finding.

   Response. Finding 5 of the RTO presents the Discharger's determinations based upon the completion of a site soil investigation in 1992, after previous Board Order 90-134 was adopted. Finding 6 reiterates the Discharger's conclusions made in the report of that investigation. Staff does not agree that a more detailed explanation of the Discharger's rationale is necessary in Finding 6.

3. Comment. With reference to Finding 7b, the letter states that no site characterization data directly indicate the presence of DNAPLs; and if DNAPLs are present, the effectiveness of groundwater extraction depends on their quantity, concentration, and subsurface conditions.

   Response. The presence of VOC DNAPL has not been reported by the Discharger but staff suspects the possible presence of VOC DNAPL based on the reported results of the U.S. EPA's re-evaluation of a number of Superfund Sites nationally and locally, and the application of EPA-developed criteria to this site.

   The VOCs at this site, if in the free phase, are denser (heavier)-than-water colorless liquids not easily identified by visual observation in saturated soil or water samples recovered from borings and wells. Board staff began to suspect the presence of VOC DNAPL when high amounts of VOCs were found in groundwater from new well AM1-10, near the former source area, in 1990. The top of the extraction interval at 28-37 feet in AM1-10 is about 4 feet deeper than the base of the extraction interval in downgradient well AM1-1, and about 12 feet deeper than the bottom of AM1-EP (extraction pit) in the former source area. Total VOCs in several soil samples taken from the extraction interval in Well AM1-10 were ND (2

samples, one at 31 feet and the other at 35 feet), 0.01 ppm (1 sample at 33 feet), and 0.68 ppm (1 sample at 28 feet); total VOCs in one soil sample of silty clay at 26 feet, above the top of the extraction interval, was about 5 ppm. One of the goals of the most recent soil survey was to attempt to determine the locality of the source of the high VOC concentrations found in groundwater by well AM1-10; however, a local source was not identified. It has been postulated by the Discharger that well AM1-10 pulled VOCs into the well bore from elsewhere (in the former source area), an unidentified "hot spot". (It has been reported by the Consultant that all soil samples from borings made in the A2 zone in the near-source area as part of the most recent soil investigation were carefully inspected for DNAPLs but none were noted.)

Following an EPA-sponsored DNAPL workshop in 1991, the EPA published the report, "Dense Nonaqueous Phase Liquids--A Workshop Summary" (EPA/600/R-92/030, February 1992) in which it is concluded that: (1) failure to directly observe DNAPL at a site does not mean it does not exist; (2) often, only very low aqueous concentrations of DNAPL constituents are detected in monitoring wells at known DNAPL sites; (3) if dense, free-phase chemicals were widely used, handled, and disposed of according to standard industry practices common more than several years ago, chances are high that DNAPL is present; and more.

The EPA issued several other documents, including (January 1992) Publication 9355.4-07FS, "Estimating Potential for Occurrence of DNAPL at Superfund Sites", which provides several decision charts useful for indicating the potential presence of DNAPL. Decision Chart 1, "Does Historical Site Use Information Indicate Presence of DNAPL?", uses a flowchart to arrive at a logical answer. It identifies industries with high probability of historical DNAPL release, industrial processes or waste disposal practices with high probability of historical DNAPL release, and DNAPL-Related Chemicals including Halogenated Volatiles (1,1-DCA, 1,1-DCE, 1,1,1-TCA, and others). Site use information: electronics manufacturing; solvent use, storage and disposal (underground acid-neutralization system tanks); and DNAPL-related chemicals, indicate the presence of DNAPL at the Building 1 facility, by use of Decision Chart 1.

Decision Chart 2 is, "Do Site Characterization Data Indicate the Presence of DNAPL?" This chart uses physical data, such as: methods to confirm DNAPL in wells and soil samples; conditions that indicate potential for DNAPL based on laboratory data; and characteristics of extensive field programs to help indicate the presence or absence of DNAPL. Based on reported information, DNAPL has not been visually identified in water or soil samples, and field programs are not known to have been designed to help indicate the presence or absence of VOC DNAPL at this site. Based on laboratory data, at least two of four conditions cited on Chart 2 that indicate a potential for the presence of DNAPL may exist at this site: concentrations of DNAPL-related chemicals in groundwater are >1% of pure

phase solubility, and concentrations of DNAPL-related chemicals in groundwater increase with depth or appear in anomalous upgradient/across gradient locations.

Pure phase solubility for 1,1,1-TCA is given in the literature as 720, 950, or 1,500 mg/l. Relatively recent concentrations of 1,1,1-TCA in groundwater in new A2 zone extraction well AM1-10 near the former source area were as high as 60 mg/l(and 7.5 mg/l most recently). Concentrations of 1,1,1-TCA were as high as 370 mg/l in shallow A-zone well AM1-EP in February of 1985. As part of a previous soil investigation (1989-1990) several soil borings were completed peripheral to and upgradient from the former source area: boring B-23 just outside the excavation boundary, slightly upgradient of well AM1-EP and in proximity to the outside wall of Building 1, Boring B-25 approximately 20 feet upgradient from well AM1-EP in the other direction (towards the southwest), and boring B-30 about 20 feet upgradient of boring B-25.

Soil samples from depths of 15 and 20 feet in B-23 each found a total VOC concentration of about 0.31 or 0.32 ppm; a water sample from 20 feet had 720 ppb 1,1,1-TCA, 78 ppb 1,1-DCA, 34 ppb 1,1-DCE and 8 ppb TCE. Boring B-25 found1.14 ppm total VOCs in a soil sample from sandy silt at 16 feet. This was considered anomalous at the time, but not indicative of another source. (A water sample was not collected from this boring.) Boring B-30 found minor concentrations of TCE and Freon-113 in silt/clay from depths of 12, 15 and 19 feet. A water sample from 20 feet had 2.5 ppb 1,1,1-TCA, 1.2 ppb 1,1-DCA, 1.2 ppb Freon-113, and 12 ppb TCE.

In January of 1990 it was not surmised that VOCs detected in these borings could be due to a downgradient former source. In light of recently published information relative to DNAPL, it appears that the VOC concentration found in upgradient Borings B-23, B-25 and B-30 may be related to the former source and the former source at one time may have contained VOC DNAPL, and may still host DNAPL locally. Staff is aware that the Discharger, in the submitted report, states that the VOCs in the upgradient Boring B-23 resulted from the effects of "groundwater mounding at the tanks and a concrete slab underlying the tanks". The report does not provide data and calculations to support this contention, and does not mention VOCs in Borings B-25 and B-30 as resulting from this mounding.

The combined indications of the EPA Decision Charts 1 and 2 suggest at least a moderate potential (on a scale of from low, to moderate, to confirmed or high potential) for DNAPL at this site.

Staff agrees that the extent and concentration of DNAPL and subsurface conditions are some of the factors which can influence the effectiveness of groundwater extraction.

4. Comment. With reference to Finding 7c and 7d, the letter states that Applied Materials' improved and revised cleanup time estimates include the effects of any DNAPLs and sorption in fine-grained sediments ("tailing effect") at this site.

Response. This comment implies that the time estimates now can and do predict the future effects of any VOC DNAPL which may contribute dissolved VOCs to the pollutant plume, and future effects of VOC desorption from fine-grained sediments such as clays and silts.

Staff does not agree with the implications of this comment. The Discharger first presented site cleanup time estimates based on this new approach in a report dated January 15, 1991 ("Soil Cleanup Evaluation and Proposal for Applied Materials Building 1, 3050 Bowers Avenue, Santa Clara, California"), wherein estimates were 8 to 9 years without further source removal and about 8 years with additional soil (source) removal. These estimates were based on site data (through 1990) interpretations, using well AM1-1 to represent cleanup without further source removal (8 to 9 years), and well AM1-5E to represent cleanup with source removal (8 years). By this interpretation the source area would clean up by year 1999 or 2000, and the remainder of the site one year earlier, 1998 or 1999. The Discharger continued to update the interpretation; in a report dated August 14, 1992, cleanup times were estimated at about 7 years with source removal and about 9 years of groundwater extraction without source removal to reach ARARs sitewide.

The most recent interpretation by the Discharger, submitted with the May 14, 1993 letter from Weiss Associates, uses site data collected through the end of 1992 and into 1993, and updates the cleanup time estimates: the former source area (well AM1-1) is expected to clean up, by only groundwater extraction, by the end of year 1999, and the remainder of the site (well AM1-5E) will clean up by year 2007 or 2008. This seems to indicate that the estimated cleanup time has lengthened from about 9 years, as derived from projections based on site data through 1990, to 17 or 18 years based on site data through 1992 and into 1993. Staff notes that the earlier cleanup time estimate of 8 years for well AM1-5E does appear to have been optimistic. Also noting that the cleanup time estimate for well AM1-5E to reach MCLs for all VOCs has recently doubled, it seems logical to consider that cleanup time may have been extended because of the influence of desorption and perhaps DNAPL ("tailing effect") and to ponder whether the time for cleanup by groundwater extraction alone may be further extended as more annual data become available. It is also noted that the "source-remaining-well" now is projected to be remediated before the "source-removed-well", but no explanation for this has been provided.

5. Comment. With reference to Finding 8A, the letter states that the Discharger sees no justification for even considering excavation.

Response. Staff has agreed to modify this Finding as suggested by both the RTO and the letter submitted by the Discharger's outside legal counsel.

6. Comment. With reference to Provision 6, the letter states an understanding that while an evaluation of existing data is requested, no additional field work is required, and additional investigation is not presently necessary

Response. Provision 6 does not require field work or a field investigation. The Provision specifies certain elements to be included in an evaluation of groundwater extraction and monitoring.

Revised Board Staff Report

In November 1992 Staff prepared Draft Review Comments on the Discharger's most recent soil-investigation report, and asked the Discharger to comment before the Staff Report was finalized. After receiving the Discharger's comments, a revised Draft dated March 1, 1993 was prepared and again released, along with the proposed Tentative Order, for comment. The Discharger's technical consultant's submittal included a "Revised Board Staff Report". The following comments and responses pertain to this item.

The Staff Report is divided into 5 major parts: Summary, Background, Recent Work, Discussion, and Conclusions and Recommendations. The Discharger's submittal (again) included numerous suggested changes, in all 5 parts. As a means of reducing staff's task to a more manageable level, all suggestions which relate to work done by the Discharger are adopted; suggestions relating to Staff Conclusions and Recommendations are reviewed, and may be adopted or otherwise made if deemed appropriate or necessary to make a conclusion or recommendation conform to the Revised Tentative Order. The Discussion is the result of Board staff evaluation of significant information in the Discharger's reports and data, in light of developments described in EPA and other literature. The Discharger's suggested changes have been considered but not necessarily adopted. The Summary consists of two parts: "Applied Materials' Report" and "Board Staff Review". The first part is substituted for the first paragraph under Recent Work and incorporates all suggested changes. The removed paragraph is now included under Discussion. The second part becomes a Summary for the Discussion, and Summary and Discussion now are parts of Board Staff Review.

In adopting certain comments, parenthetical expressions or additions are used to clarify the source of the comment.

1. Comments on the Summary have been made by the Discharger.

Response. All the Discharger's comments (with one correction) on the first part of the Summary are adopted, and this is substituted for the first paragraph under Recent Work in the Staff Report.

The second part of the Summary, noted as Board Staff Review, is moved to become the Summary preceding the Discussion, and both now are under a new major topic called Board Staff Review. The Discharger's comments will be addressed as appropriate in the new sequence of topics.

2. Comments have been made on statements in the Background section by the Discharger.

   Response. All the Discharger's comments on statements in the Background section which relate to the Discharger's activities are adopted and changes are made in the Staff Report. Any comment which relates specifically to Board actions or activities is not adopted.

3. Comments have been made on the Recent Work section by the Discharger.

   Response. The first two paragraphs of the Summary, as revised by the Discharger, are substituted for the original first paragraph under Recent Work. The original first paragraph, which was not revised by the Discharger's comments, is deleted from this section and moved to the beginning of the Discussion.

   Beginning with "New Soil Borings", all the Discharger's comments on the Recent Work section are adopted and changes are made in the Staff Report.

4. Comments have been made on the Discussion section by the Discharger.

   Response. The title of this section is changed to Board Staff Review, and there are two subsections, Summary and Discussion. The new Summary is the second part of the original Summary, which had a subheading of Board Staff Review and consisted of two paragraphs.

Board Staff Review: Summary

5. Comment. Several word deletions and additions are proposed by the Discharger in the first paragraph, beginning with the third sentence.

   Response. Wording is changed to read: "An explanation provided in the report assumes that a pumping well AM1-10 pulls in polluted groundwater from elsewhere. Another explanation may be the presence of one or more as yet unidentified VOC hot spots contributing to the concentrations found in the A2 zone, and these may be dense non-aqueous phase liquids (DNAPLs). Although

DNAPL has not been identified at the site, Board staff suspects its presence and if present it could significantly increase cleanup time by groundwater extraction alone. If extensive DNAPL is present, the only techniques currently known for completely remediating this pollution are excavation and isolation."

6. Comment. In the second sentence of the second paragraph, Discharger proposes to change "are being achieved" to "will be achieved".

   Response. Wording is changed to conform to the Tentative Order: "----cleanup standards are being achieved--------in a timely manner."

Board Staff Review: Discussion

7. No comments were made on the new first paragraph.

8. Comment. The Discharger has proposed several word deletions and new word and phrase additions in the next (new second) paragraph.

   Response. Staff does not agree with the proposed changes.

Extent of Pollution: Groundwater pollution

9. Comment. In the first paragraph, the Discharger has deleted and added several new words.

   Response. Staff does not agree with the proposed changes.

10. Comment. The Discharger has suggested several changes in the second paragraph.

    Response. Staff agrees with the proposed changes, with slight modification: well AM1-EP initially extracted groundwater having a total VOC concentration in excess of 400 ppm (not 370 ppm, which was the concentration of only 1,1,1-TCA).

Extent of Pollution: Soil pollution

11. Comment. The Discharger has made a number of suggested changes in this paragraph.

    Response. Staff is not in full agreement with the suggested changes, but agrees to rewrite this paragraph in the following manner: The first sentence is unchanged; the remainder of the paragraph now reads: "At the Building 1 site the soil pollution is, for all practical purposes, in the zone of saturation and the 1 ppm guidance may not be appropriate for the purpose of determining cleanup objectives. The most recent groundwater amendment to the Basin Plan adopted by

the Regional Board implies that 1 ppm is appropriate for the unsaturated zone but is silent on a soil cleanup standard for the saturated zone. The cleanup standard for polluted soil adopted in the existing Board Order is 1 ppm total VOCs or some other level justified by the Discharger. Groundwater extraction has been satisfactory for remediating this site thus far, but the A/A2 aquitard is a low permeability interval which may not be amenable to groundwater extraction by pumping. The VOCs in the aquitard may desorb into the overlying A aquifer and could eventually be removed by extraction from the aquifer but this process (desorption) is very slow. The results of this most recent investigation confirm the presence of VOC soil pollution which could continue to impact A-zone groundwater quality, perhaps for many years to come.

Well AM1-10

12. There were no comments for the first paragraph.

13. Comment. The Discharger has proposed extensive changes to this short second paragraph.

Response. This paragraph is entirely rewritten as: "Prior to the implementation of the most recent soil investigation by Applied Materials, Board staff expressed a concern and desire; the concern was based on the staff belief that the extent of high VOC concentrations found in well AM1-10 had not been fully determined, and there were no deep borings below the excavation in the former source area. The desire was for the focus of the new soil investigation to be below the depth of the excavation, and for the Discharger to complete 3 or 4 deep soil borings in the former source area, possibly below the A2 zone. One of the main questions to be answered by this investigation was: What and where is the source of VOC pollution found in well AM1-10? The investigation report attempted to answer this question with: "--the VOCs migrated to well AM1-10's screened interval from a nearby area"; and, "--pumping at well AM1-10 probably induced VOC migration into its screened interval." Board staff believes another possible explanation is a yet unidentified pocket (hot spot) of VOC pollution in the former source area, below the main A-zone aquifer, and that this may be VOC DNAPL."

Dense Non-Aqueous Phase Liquid (DNAPL)

14. Comment. The Discharger has suggested several changes in the first paragraph.

Response. The first sentence is deleted. The second sentence is rewritten as, "As mentioned above, the subject report states that VOCs migrated to well AM1-10's screened interval from a nearby area." The remainder of the paragraph is unchanged.

15. Comment. The Discharger has suggested a number of changes in the second paragraph.

Response. This paragraph is rewritten to conform to the staff response given earlier to comment #3 of the Weiss Associates Letter, and now reads: "The presence of DNAPL at the Building 1 site is inferred from application of EPA guidelines, stated in EPA-issued documents, such as:(1) type of industry - Electronics manufacturing; (2) solvent use, storage and disposal - VOC liquids were used and stored onsite, and wasted into underground acid-neutralization tanks (inadvertent discharges to these tanks, according to Discharger's comment); (3) DNAPL-related chemicals - Halogenated volatiles. DNAPL has not been visually identified in water and soil samples (this is a difficult accomplishment by direct observation, and it would have been extremely unusual but fortuitous if DNAPL had been visually observed), and field programs are not known to have been designed to help indicate the presence or absence of VOC DNAPL at this site. Based on laboratory data, at least two of four conditions cited by the EPA which indicate a potential for the presence of DNAPL may exist at this site: concentrations of DNAPL-related 1,1,1-TCA were >1% of pure phase solubility in groundwater, and concentrations of DNAPL-related chemicals appear in an anomalous upgradient/across gradient locations at borings B-23, B-25 and B-30. At least a moderate potential for DNAPL exists at this site."

16. Comment. The Discharger has made suggested changes in the third and final paragraph of this sub-section.

Response. The suggested individual word changes are adopted; the two suggested new sentences are adopted as modified by staff and now read: "The U.S. EPA and some academic entities, with industry support, have been conducting research and field studies of DNAPL and are becoming more active in disseminating information on their findings. There is now a greater awareness of the potential impact of DNAPL on site remediation where DNAPL-related chemicals were used in the past."

Offsite Pollution Migration

17. Comment. The Discharger has made several suggested changes to the first paragraph.

Response. Staff agrees only to add the date, in May 1992, as suggested.

18. Comment. The Discharger has made several suggested changes to the second paragraph.

Response. Staff does not agree with any of the suggested changes.

19. Comment. The Discharger has made several suggested changes to the third paragraph.

Response. Staff does not agree with any of the suggested changes.

A2-Zone Pollution

20. Comment. The Discharger has made several suggested changes to the first paragraph.

Response. Staff agrees with some of the suggested changes. Changes made are: About the middle of the paragraph, in the sentence beginning, "Boring DB-22 was drilled----", the word saturated is added between "VOC" and "soil". In the second-to-last sentence, the phrase, three-foot-thick is added between the words "the" and "aquitard", and the word -aquifer is added between "A" and "gravelly".

No other changes are made.

21. Comment. The Discharger has suggested several changes in the second paragraph.

Response. Staff agrees to some of the suggested changes. Changes made are: In the second sentence, add the word saturated between "VOC" and "soil". In the third sentence, add 25.25 feet, at between "10.93 ppm, at" and "the base of", and -aquifer between "A" and "sand"; and 1.38 ppm at 31 feet in the A2 zone. These VOCs between "sand, and", and "include mainly".

No other changes are made.

Time to Accomplish Site Remediation

22. No comments were made on the first paragraph.

23. Comment. The Discharger has made suggested changes at the end of the second paragraph.

Response. This comment refers to information not of the report, but recently submitted with the Weiss Associates Letter and addressed earlier. Staff does not agree with the suggested changes.

24. Comment. The Discharger has proposed several changes in the third paragraph.

Response. Staff does not agree with the suggested changes.

25. Comment. The Discharger has suggested a number of changes in the fourth paragraph.

Response. Staff agrees with some of the suggested changes. The following changes are made: In the second sentence, add the word actively between "being" and "remediated"; delete the words, "does not appear to be", and replace with, may or may not be. Near the end of the fourth sentence, add -aquifer between "A" and "sand". In the fifth sentence, add the phrase, and will be evaluated in the five-year status report, after "---is not known".

26. Comment. The Discharger has made several suggested changes to the fifth (final) paragraph.

Response. The basis for this comment appears to be the post-report information recently submitted with the Weiss Associates Letter addressed earlier in this Responsiveness Summary. Rather than repeat the earlier staff response, this paragraph is deleted in its entirety.

Staff Conclusions and Recommendations

27. Comment. The Discharger has suggested numerous changes in the conclusions.

Response. Staff has considered all suggested changes and has modified some of the conclusions and recommendations, as shown below:

Conclusions:

1. No change.

2. Deleted; rewritten to conform to the Revised Tentative Order, as : "The effect of on-going groundwater extraction on the source-area A sand cannot be directly verified because there is not a well into the A sand directly beneath the source area; and, the A sand in the source area may require a long time for remediation by groundwater extraction by a well outside the source area. Well AM1-EP which was constructed above the A sand has provided data on the effectiveness of groundwater extraction at the source area from 1985 through September 3rd, 1991. Although concentrations generally decreased during this period, showing declines from 370 to 0.180 ppm for 1,1,1-TCA, 13 to 0.043 ppm for 1,1-DCA, and 19 to 0.034 ppm for 1,1-DCE, concentrations of 1,1-DCA and 1,1-DCE were still above MCLs of 0.005 ppm and 0.006 ppm, respectively, when the period ended."

3. Suggested word changes are adopted.

4. No change.

5. No change.

6. No change.

7. No change.

8. No change.

9. Suggested word changes are adopted.

10. Suggested change is adopted, but the word "significantly" is added after may, so that the words may significantly now appear between "present," and "increase".

11. Deleted; this is now included in #2.

12. New #11; suggested word change is adopted.

13. New #12; the suggested change based on post-report information is not adopted, but the single word change ("recent" to "prior") is adopted.

14. New #13; no change.

Recommendations

1. Changed by adding after "remediated," as may be required to meet Board cleanup standards.

2. No change.

3. No change.

4. Changed to conform to word and intent of the Revised Tentative Order, and now reads: "Groundwater monitoring and remediation should be evaluated with the submittal of the Status Report, due October 1, 1994. The evaluation should attempt to show that extraction wells AM1-1 and AM1-10 can and do remediate the A-zone

and A2-zone groundwater pollution in the source area, and extraction well AM1-5E does hydraulically contain the pollutant plume onsite and prevents VOCs from migrating offsite."

5. Changed by adopting word changes suggested by the Discharger: delete "increasing and" between "by" and "coordinating", and replacing the word "investigating", between "and by" and "and interpreting", with the word evaluating.

REGIONAL WATER QUALITY CONTROL BOARD
SAN FRANCISCO BAY REGION

INTERNAL MEMO

TO: S. Morse, Division Chief
G. Walker, Section Leader

DATE: March 1, 1993

FROM: A. Mancini, Asso. EG A J Mancini

SUBJECT: Review and Comments on August 14, 1992 "A2-Zone Hydrogeology, VOC Mass and Distribution, and Feasibility Study Alternatives at Applied Materials Building 1, 3050 Bowers Avenue, Santa Clara, California"

BACKGROUND

Regulatory History

June 19, 1985 - NPDES permit adopted

September 17, 1986 - Waste Discharge Requirements Order adopted

July 22, 1987 - Site added to final National Priorities List (NPL)

December 21, 1988 - Revised NPDES permit adopted

September 20, 1989 - Site Cleanup Requirements Order adopted

June 20, 1990 - NPDES permit renewal adopted

September 19, 1990 - Order amending Site Cleanup Requirements adopted

September 28, 1990 - Record of Decision for Groundwater Operable Unit issued

Site Cleanup Requirements Order No. 90-134

A final cleanup plan for this site was adopted by Board Order on September 19, 1990. This plan includes remediation of groundwater pollution to reach cleanup standards which are the most stringent of MCLs, ALs, or non-zero MCLGs for drinking water; soil pollution to reach the cleanup standard of less than or equal to one ppm total VOCs.

Soil and Groundwater Pollution

Previous work by Applied Materials found soil and groundwater pollution in the A zone, an interval of sand/gravel/silt/clay from the surface to a depth of about 25 feet, with a predominantly sand/gravel aquifer interval at about 15-25 feet. (The gravelly sand thickness is not constant and varies, as reported, from 4 to 10 feet.) Soil pollution reportedly begins about 9-10 feet below the ground surface, at about the same depth as the present top of the piezometric surface, with all concentrations of total VOCs greater than one ppm occurring in saturated soil. There are presently two active groundwater extraction wells in the A zone: well AM1-1 (installed in 1983) is about 20-25 feet downgradient from the former source area; and well AM1-5E further downgradient, near the site boundary along Bowers Avenue, about 500 feet northeast from the former source area.

A third extraction well, AM1-EP (completed at a depth of 17 feet in 1985), was installed in a void created by excavation of the underground tanks in the source area. In 1989 a hand auger was used to go inside the well casing (after temporary removal of the pump) and recover two soil samples from about 19 feet. The maximum total VOC concentration was 1.69 ppm. Use of this well was discontinued in late 1991 because it was a poor water producer and Board staff wanted to increase the sampling frequency of another well without necessarily increasing Applied Materials' operating costs.

Supplemental Soil Survey

In 1989 and 1990 Applied Materials conducted a near-source area soil survey with major objectives of (1) evaluating concentrations of VOCs still present in saturated soils around the former tank excavation, (2) determining whether or not a separate as yet unidentified source could be contributing to the volume of VOCs being extracted in groundwater, and (3) determining whether or not VOCs were present below the A water-bearing zone which were not controlled by extraction of groundwater in the A zone. One boring (DB-22) was located on the concrete equipment pad near existing monitoring well AM1-2 and reached a depth of about 45 feet into a sand believed to be the top of the B zone. Eleven saturated soil samples indicated VOCs in tested intervals from 16 to 40 feet, with a total VOC concentration from 0.09 to 20.47 ppm, with the highest VOC concentrations in a thin zone at about 26 feet depth. Total VOC concentrations in saturated soil samples decreased to 0.11 ppm at 28.25 feet and 1.25 and 4.61 ppm at 28.5 feet and much less between 28.75 and 39.75 feet. The groundwater level was about 11 feet in January 1990; water samples were not collected for analyses.

Another soil boring located on the equipment pad about 4 or 5 feet away from AM1-EP, similar to DB-22, found 4.97 ppm VOC soil concentration at 25.5 feet, below the base of the A-aquifer sand. This boring was converted into a fourth extraction well, AM1-10, which did not examine groundwater in the main A-zone aquifer but did find VOC groundwater pollution in an interval about 10 to 15 feet deeper, in what came to be called the A2 zone. The soil survey of 1989-90 determined that VOCs were present below the A water-bearing zone which were not controlled by extraction of groundwater in the A zone.

A2-Zone Geohydrologic Investigation

A geohydrologic investigation of the A2 zone in 1991-1992 included the installation of one downgradient monitoring well in the A2 zone but did not provide information needed to interpret the significance of VOC pollution thus far found in soils and groundwater in the A2 zone. Following this investigation, staff reviewed the site history and concluded that regulatory concerns still remained. Staff had several major concerns: the unknown source and undefined extent of pollution which had resulted in the high VOC concentrations being detected in well AM1-10, and there were no borings extending below the former source-area excavation to delineate the extent of pollution. Staff did not believe that the existing information was adequate for making a determination about final soil cleanup. Staff was concerned about a potential pollution source area located under the air stripper foundation structure, and proposed that Applied Materials fully investigate the former source area with three or four deep soil borings and relocate equipment as necessary. Applied Materials objected to moving the air stripper, but was amenable to conducting one more soil survey.

December 1991 and January 1992 Meetings

In December 1991 and January 1992 staff and Applied Materials' consultant developed a work plan for an A2-zone investigation. The work plan included an item to determine the VOC mass already removed from the site by interim remediation, and the VOC mass remaining. Consistent with Board Staff recommendations, the investigation's focus was on the A2 zone, below the A zone and immediately above the B zone, in and near the former source (underground tank) area, presently covered with a concrete equipment pad adjacent to the west side of Building 1. Work was initiated and concluded, resulting in the submittal of the subject report.

RECENT WORK

Applied Materials has completed a new soil investigation of the low to moderate permeability A2 water-bearing zone (A2 zone) and found an interval of high volatile organic compound (VOC) concentrations, up to 20.47 ppm (this value should be 10.93 ppm, 20.47 ppm was detected previously) in saturated soil at the base of the "A" aquifer. (According to the Discharger) Applied Materials' report presents a plausible explanation for the source of VOCs in A2-zone groundwater based on site groundwater and soil data. VOC concentrations increased to about 64.5 ppm in A2-zone groundwater only after pumping started in A2-zone well AM1-10, indicating that pumping induced VOC migration into the well's screened interval.

About 620 pounds of VOCs have been removed by groundwater extraction; Applied Materials calculates that about 52 pounds of VOCs remain in soil and groundwater, and estimates about 9 additional years of groundwater extraction will be enough to achieve drinking water MCLs throughout the site in the A-zone groundwater and is proposing to complete site cleanup by groundwater extraction alone. The Discharger states that these cleanup time estimates include the potential effects of any dense nonaqueous phase liquids (DNAPLs) and sorption from fine-

grained sediments in the former source area, and that historical groundwater chemical data show that the groundwater extraction system is remediating groundwater according to the predicted calculations.

New Soil Borings

Three soil borings were made for the purpose of investigating the A2 zone and collecting soil samples for analyses. Due to the presence of electrical lines beneath the concrete equipment pad, considerable preliminary work was required to locate safe and accessible drilling sites. Restricted access necessitated the use of specialized equipment. The final selected boring location was not always the location selected as a first choice for obtaining information from the A2 zone. A strategic location was made in the former source area, to probe the subsurface underneath the locations of soil samples of 1985 which detected total VOC concentrations up to 65 ppm at 17 feet; however, field conditions prevented completing this boring. The three borings that were completed were B-38, B-39, and B-40. These borings are shown on Figure 1. No deep borings were completed below the former tank excavation.

Boring B-38. Boring B-38 was placed within the former excavation near the excavation limit next to Building 1, and completed at a depth of only 20 feet which was two feet into clayey sand (probably the top of the A-aquifer sand). A soil sample had 0.08 ppm 1,1,1-TCA.

Boring B-39. Boring B-39 was located between DB-22 and AM1-10, and completed at a depth of 40.5 feet; and had 10.93 ppm total VOCs in silty clay at 25.5 feet, at the A/A2 interface (1.38 ppm total VOCs were found at 31 feet, and VOCs at or below 0.34 ppm were detected in deeper intervals to 38.5 feet).

Boring B-40. Boring B-40 was about 8 feet downgradient of well AM1-10, just inside the equipment pad enclosure and completed at a depth of 40 feet. VOCs (0.59 ppm, total) were found at 19.5 feet at the top of the A sand, and at the A/A2 interface at 26 feet (0.19 ppm). A very low soil concentration (0.02 ppm) was found at 39 feet.

Soil Pollution at A/A2 Interface

Previous work found VOC concentrations in soil, up to 20.47 ppm, immediately underlying the base of the main A-aquifer gravelly sand, in fine-grained material sometimes referred to as the A/A2 aquitard. The recent investigation has confirmed that concentrations of VOCs, principally 1,1,1-TCA, 1,1-DCA, and 1,1-DCE, persist in fine-grained soils at the base of the A aquifer beneath a portion of the equipment pad on the west side of Building 1, and may extend under the building as well. The report describes this soil layer as having an average thickness of about 3.3 feet and containing VOCs greater than 1 ppm around the 25-foot depth beneath the equipment pad. The VOC mass in soil and groundwater is calculated using an average total VOC concentration of 12 ppm, but the cutoff for the area of concern in the report is the 1 ppm concentration.

Based on an evaluation of soil data Applied Materials interprets high concentrations of total VOCs in fine-grained soil at the base of the A aquifer (A/A2 interface) extending under the equipment pad from the vicinity of the air stripper in a northeasterly direction about 25-40 feet to the west side of Building 1 (Figure 1). For potential VOC mass calculations only, (according to the Discharger), the report assumes the extent of this pollution under the building equals its extent under the pad.

VOCs in Well AM1-10

The report includes an evaluation of the performance of extraction well AM1-10. Concerning the apparent disparity between VOC concentrations in soil and concentrations in groundwater in this well, the report states that data suggest that both soil and groundwater VOC concentrations were initially low in the vicinity of AM1-10's screened interval, but the pumping of well AM1-10 pulled polluted groundwater into this well from elsewhere; and that this apparent source has a limited size and mass and is being effectively remediated by well AM1-10.

Investigation of 1989-90. This investigation showed that VOCs were present below the zone then being remediated by groundwater extraction. A new extraction well was constructed to remediate the near-source area A2 zone: AM1-10 is located about 4 or 5 feet downgradient of the former source area (well AM1-EP), and completed to extract water from an interval about 30-37 feet deep, identified as the A2 zone. This interval underlies and is separated from the main A-zone water-bearing sand in the former source area by a leaky confining layer (according to the Discharger), and is deeper than the bottom of the vault created by tank excavation. The pumping yield from this well has not been sustainable, and is very low and intermittent. The analyses of groundwater samples from this well showed a significant change in water quality after the first month of pumping. Early results were as follows:

	Concentration in PPB		
	05-03-90	06-05-90	09-11-90
1,1,1-TCA	46-93	15,000	60,000
1,1-DCA	29-34	1,300	1,800
1,1-DCE	36-4.0	2,700	2,500
PCE	0.7-<1.0	160	120
1,2-DCA	0.5-<1.0	<0.5	27
1,1,2-TCA	<0.2-<1.0	9.7	34
TCE	<0.2-<1.0	12	24
vinyl chloride	2.2-<1.0	1.6	3.4
Freon 113	<0.2-<1.0	<0.5	7.1
chloroform	0.9-1.0	5.7	14
methylene chloride	3-<1.0	<2	17

The results of an increased sampling frequency for well AM1-10 (every two months) showed continued high but decreasing levels of pollutants; 1,1,1-TCA decreased from 28,000 ppb in January '91 to 11,000 ppb in March '92, 6,700 ppb in May, 1,900 ppb in July, and 3,300-

5,300 ppb in September '92. While these concentrations show a decreasing trend, they are much above concentrations in all other onsite wells for the corresponding time periods. (According to the Discharger) this is expected because extraction wells in the A zone have been removing and treating groundwater since 1985. In addition, AM1-10 is an extraction well and is pulling in VOCs from the former source area, and is expected to have higher concentrations than monitoring wells in the area for the same time. Previously high concentrations were reported from AM1-EP in February 1985 (370,000 ppb 1,1,1-TCA) and AM1-1 in December 1985 (44,000 ppb 1,1,1-TCA). The 60,000 ppb in AM1-10 is greater than anything ever reported from AM1-1, but is much less than the highest total VOC concentration in groundwater at AM1-EP).

Extent of VOCs in Groundwater

The report includes a depiction of the lateral extent of VOCs in groundwater and shows, by inference, that the A zone plume has migrated offsite, across (under) Bowers Avenue and onto the Avantek site (Figure 2). To provide a conservative estimate of the VOC mass in the A2-zone groundwater only, the report's authors assume that polluted groundwater bodies in the A and A2 zones have both a similar shape and VOC distribution.

Previous work. The actual date of the "leak" which resulted in soil and groundwater pollution has not been reported and presumably is not known, but predates November 21, 1983. (The Building 1 facility has been in operation since the early 1970's.) The suspected source was a nest of three underground acid neutralization tanks and associated lines on the west side of Building 1. This was verified by a number of soil borings in the vicinity of the tanks; after the tanks were removed several saturated soil samples were taken from 1 to 3 feet below the bottom of one of the former tanks, at a depth of 14 to 17 feet, and showed a maximum total VOC concentration of about 65 ppm. At this time the static water level was about 7 to 8 feet below ground level. All of the soil samples were taken in the zone of saturation but above the main A-zone water-bearing unit at about 20-25 feet below ground level.

The main area of polluted soil was shown to underlie one of the tanks and inferred to extend from the base of the tank downward to the top of the main water-bearing gravelly sand (refer to Figures 3A, 3B, and 3C). In 1984-85 some but not all of the polluted soil was removed, and extraction well AM1-EP was installed in the void of a former tank and the area backfilled with clean gravel. A total of three A-zone extraction wells were installed and remediation by groundwater extraction, treatment and discharge was implemented.

Groundwater pollution detected. VOC pollution in groundwater was detected when Applied Materials installed the AM1-1 well downgradient of the underground tanks in 1983. This well was later converted to an extraction well. In 1984 monitoring well AM1-5 was installed further downgradient, near the property boundary along Bowers Avenue. Later, in 1985, well AM1-EP (extraction pit) was installed in the source area, in a vault (void) created by excavation and removal of the acid neutralization tanks. The initial groundwater sample analysis for each well showed the following:

Concentration in PPB

	AM1-1 (11-21-83)	AM1-5 (06-11-84)	AM1-EP (02-06-85)
1,1,1-TCA	14,000	4,000	370,000
1,1-DCA	790	54	13,000
1,1-DCE	380	80	19,000
1,2-DCA	37		560
TCE	6		70
PCE			65
Freon 113	45		110
1,1,2-TCA			190
vinyl chloride			18
chloroform	15		41
methylene chloride			7

Wells 1 and 5 were screened in the interval 14-24 feet, in the main water-bearing gravelly sand of the A zone. Well AM1-EP bottomed at about 17 feet, in the saturated A zone but several feet above the main water-bearing sand; at this location the main water-bearing sand may be only about 3-5 feet thick. Following a suggestion by Board staff, during the soil investigation of 1990 the investigators were able to collect two soil samples from below the bottom of AM1-EP, by inserting an auger through the six-inch well casing. Samples were taken from clay or silt at depths of 19.0 and 19.25 feet; analyses showed total VOC concentrations of 1.69 and 0.70 ppm, predominantly 1,1,1-TCA. It was not possible to auger deeper, and the main aquifer sand was not reached.

Groundwater extraction. A groundwater extraction and containment program was implemented by pumping AM1-EP in the source area, AM1-1 about 20 feet downgradient, and AM1-5E some 500 feet further downgradient in the direction of groundwater movement and near the site boundary along Bowers Avenue. The pumping yield from AM1-EP, which bottomed several feet above the main water-bearing sand, was low and intermittent. The yield of each of the other two wells was relatively constant. (Applied Materials reports that) historical groundwater monitoring data to date show the A zone is being remediated and the plume is being contained onsite.

VOC Mass Removed and Remaining

The report includes information to further characterize the A2 zone in the near-source area and calculations to show how much VOC mass has been removed from the A zone (and B zone) and how much remains. About 620 pounds of chemicals (VOCs) have been removed by groundwater extraction (an unrecorded quantity of VOCs was removed by the initial soil excavation); about 52 pounds of VOCs remain in the A-zone soil and groundwater by Applied Materials' estimate, and an addition quarter-pound (0.25 pound) is estimated to remain in the underlying B-zone groundwater.

Time to Accomplish Groundwater Remediation

Applied Materials continues to support a belief that linear regression models based on empirical data indicate about 9 additional years of groundwater extraction will achieve MCLs (ARARs sitewide), and if this pumping is augmented by source-area soil removal MCLs will be achieved in 7 years, only a two-year improvement in site cleanup time. Applied Materials is not proposing any changes to the remediation program currently being implemented.

Report Conclusions

Applied Materials has concluded that:

1. The calculated mass of VOCs remaining represents only about 8% of the estimated VOCs historically in the subsurface; hence, groundwater extraction has reduced the VOC mass by about 92% in seven years.

2. The VOC mass with concentrations over one ppm sorbed onto soil particles in the A/A2-zone confining layer beneath the equipment pad represents only about 3% of the total VOC mass remaining at the site, and only 0.25% of the original mass before cleanup began.

3. The only two technically feasible remedial alternatives are soil excavation and continued groundwater extraction. The cost to remove the mass of VOC-bearing saturated soil beneath the equipment pad is substantial; the additional cost would be without significant benefit because cleanup time may be enhanced by only a few years.

Report Recommendation

Applied Materials recommends not removing the remaining VOC mass in saturated soil, but to continue groundwater extraction and treatment until MCLs are achieved sitewide.

BOARD STAFF REVIEW

Summary

The VOCs at the base of the "A" aquifer are in fine-grained saturated soil which is poorly permeable and believed not to be amenable to timely remediation by groundwater extraction. VOCs may be released by the slow process of desorption, over a long or very long period of time. An explanation provided in the report assumes that a pumping well AM1-10 pulls in polluted groundwater from elsewhere. Another explanation may be the presence of one or more as yet unidentified VOC hot spots contributing to the concentrations found in the A2 zone, and these may be dense non-aqueous phase liquids (DNAPLs). Although DNAPL has not been identified at the site, Board staff suspects its presence and if present it could significantly

increase cleanup time by groundwater extraction alone. If extensive DNAPL is present, the only techniques currently known for completely remediating this pollution are excavation and isolation.

Board staff recommend conditional acceptance of the Applied Materials proposal to cleanup the site by groundwater extraction alone. This conditional acceptance requires the Discharger to document in the 5-year status report due October 1, 1994 that groundwater cleanup standards are being achieved throughout the site including the "A" and "A2" zones in the former source (underground tank) area in a timely manner. Because the equipment pad and Building 1 are expected to remain operational for an unspecified period of time, any requirement for direct cleanup of saturated soil under the pad and building will be deferred until the 5-year status report is reviewed, and the efficiency of the extraction system is evaluated. If the existing extraction program is not remediating VOC pollution in the "A" aquifer and deeper in the source and near-source areas, a plan to address these areas shall be developed and implemented.

Discussion

Applied Materials has submitted, for our review and comment, a report on the most recent soil investigation at the Building 1 site in Santa Clara. The goals of this investigation were discussed at a meeting in December of 1991: the overall goal was to determine if soil remediation would be required at this site. The investigation (soil survey) was to be conducted to provide information to fill in knowledge gaps, and set the stage for final site cleanup provisions.

Extraction by pump-and-treat, based on information and data presented in the report, has removed about 620 pounds of VOCs from site A-zone groundwater since 1985. The report's authors have calculated a percentage of VOCs remaining at the site, and have estimated a percentage of VOCs removed since 1985. The quantity of VOCs spilled has never been reported and presumably is unknown, so the estimate is not based on complete knowledge or information, and it may not be appropriate to relate the mass removed to the mass remaining, as a percentage removed.

Extent of Pollution

Groundwater pollution. VOC pollution in groundwater at the Building 1 site has been characterized by the results of an ongoing monitoring program which began in 1983 and the ensuing extraction program. However, the extent of VOC pollution in the former source area has not been fully characterized. Well AM1-1 was originally installed (1983) as a downgradient monitoring well to examine shallow groundwater for signs that the underground tanks on the west side of Building 1 may have been leaking. After tank leakage was detected by this well, AM1-1 was converted to an extraction well.

In 1984 the tanks and soil around them were excavated and well AM1-EP (extraction pit) was installed in the source area excavation to a depth of about 17 feet, which was in the A zone above the depth of the main water-bearing sand. This well initially did extract groundwater

having total concentrations of VOCs in excess of 400 ppm from an interval in the A zone above the main aquifer gravelly sand, but did not examine (or remediate) the main A-zone aquifer from which VOC pollution is being removed by downgradient extraction wells AM1-1 and AM1-5E. Follow-up investigations of the source area were made extremely difficult by the presence of underground utilities, a concrete equipment pad, and an air stripper treatment unit over the source area.

Soil pollution. The soil remediation standard in the Board Order is 1 ppm total VOCs; however, this guidance was developed to address soil pollution in the vadose zone, with the objective of remediating a source above the water table before the source could impact or add to the pollution in the underlying groundwater. At the Building 1 site the soil pollution is, for all practical purposes, in the zone of saturation and the 1 ppm guidance may not be appropriate for the purpose of determining cleanup objectives. The most recent groundwater amendment to the Basin Plan adopted by the Regional Board implies that 1 ppm is appropriate for the unsaturated zone but is silent on a soil cleanup standard for the saturated zone. The existing Board Order implies that 1 ppm is the cleanup standard for saturated soil at this site. Groundwater extraction has been satisfactory for remediating this site thus far, but the A/A2 aquitard is a low permeability interval which may not be amenable to groundwater extraction by pumping. The VOCs in the aquitard may desorb into the overlying A aquifer and could eventually be removed by extraction from the aquifer but this process (desorption) is very slow. The results of this most recent investigation confirm the presence of VOC soil pollution which could continue to impact A-zone groundwater quality, perhaps for many years to come.

Well AM1-10. In 1989 staff developed some concerns about site characterization and remediation, and Applied Materials began a supplemental soil survey which revealed the presence of high concentrations of VOCs in soil in the A2 zone beneath the equipment pad and resulted in the installation of a fourth extraction well, AM1-10, near the source area, in 1990 (refer to Figure 4). In well AM1-10 polluted groundwater is extracted from an interval at a depth of about 30-37 feet below the surface, close to the estimated top of the B zone at about 42 feet. The results of analyses of periodic water samples from AM1-10 influenced the implementation of a geohydrologic investigation of the A2 zone, followed by the most recent soil investigation.

Prior to the implementation of the most recent soil investigation by Applied Materials, Board staff expressed a concern and desire; the concern was based on the staff belief that the extent of high VOC concentrations found in well AM1-10 had not been fully determined, and there were no deep borings below the excavation in the former source area. The desire was for the focus of the new investigation to be below the depth of the excavation, and for the Discharger to complete 3 or 4 deep soil borings in the former source area, possibly below the A2 zone. One of the main questions to be answered by this investigation was: What and where is the source of VOC pollution found in well AM1-10? the investigation report attempted to answer this question with: "---the VOCs migrated to well AM1-10's screened interval from a nearby area"; and, "---pumping at well AM1-10 probably induced VOC migration into its screened interval." Board staff believes another possible explanation is a yet unidentified pocket (hot spot) of VOC

pollution in the former source area, below the main A-zone aquifer, and this may be VOC DNAPL.

Dense Non-Aqueous Phase Liquid (DNAPL). As mentioned above, the subject report states that VOCs migrated to well AM1-10's screened interval from a nearby area. It is possible that a yet-undetected source exists at or near (beneath) the former tanks, in a place not yet penetrated by a well or boring. Such a source may include pockets of DNAPL. As stated in U.S. EPA Publication 9355.4-07FS, dated January 1992 ("Estimating Potential for Occurrence of DNAPL at Superfund Sites"), DNAPL is separate-phase hydrocarbon liquid that is denser than water, including chlorinated solvent either as a single component or as a mixture of solvents. Most DNAPLs undergo only limited degradation in the subsurface, and persist for long periods while slowly releasing soluble organic constituents to groundwater through dissolution. Even with moderate DNAPL release, dissolution may continue for hundreds of years or longer under natural conditions before all the DNAPL is dissipated and concentrations of soluble organics in groundwater return to background levels.

The presence of DNAPL at the Building 1 site is inferred from application of EPA guidelines, stated in EPA-issued documents, such as: (1) type of industry - Electronics manufacturing; (2) solvent use, storage and disposal - VOC liquids were used and stored onsite, and wasted into underground acid-neutralization tanks (inadvertent discharges to these tanks, according to Discharger's comments); (3) DNAPL-related chemicals - Halogenated volatiles. DNAPL has not been visually identified in water and soil samples (this is a difficult accomplishment by direct observation, and it would have been extremely unusual but fortuitous if DNAPL had been visually observed, or even detected by use of indirect methods); and field programs are not known to have been designed to help indicate the presence or absence of VOC DNAPL at this site. Based on laboratory data, at least two of four conditions cited by the EPA which indicate a potential for the presence of DNAPL may exist at this site: concentrations of DNAPL-related 1,1,1-TCA were $> 1\%$ of pure phase solubility in groundwater, and concentrations of DNAPL-related chemicals appear in an anomalous upgradient/across gradient locations at borings B-23, B-25 and B-30. At least a moderate potential for DNAPL exists at this site.

It is difficult if not impossible, as reported by the U.S. EPA, to identify and recover all residual DNAPL in the subsurface. Pump-and-treat may remove only a small fraction of residual DNAPL. To date there have been no field demonstrations where an aquifer impacted by DNAPL has been returned to drinking water quality. The U.S. EPA and some academic entities, with industry support, have been conducting research and field studies of DNAPL and are becoming more active in disseminating information on their findings. There is now a greater awareness of the potential impact of DNAPL on site remediation where DNAPL-related chemicals were used in the past.

Offsite Pollution Migration

The possible presence of DNAPL is a major concern, but not the only concern. According to the report, the extent and lateral distribution of groundwater pollution in the A2 zone

approximates that in the shallower main A-zone aquifer. Figure 2 shows the extent of total VOCs in the A-zone water-bearing sand, in May 1992, on the Building 1 site and extending under Bowers Avenue and onto the Avantek site. The position of the 1 ppb contour is controlled by Avantek well AV-1A. Wells AV-1A and AV-1B are Avantek monitoring wells located upgradient from the Avantek source area, but downgradient from Applied Materials. Both Avantek wells indicate the presence of VOC pollutants. Only well AV-1A was included in the VOC mass calculations in the subject report.

Avantek has identified two polluted groundwater intervals and calls them A and B; however, it is apparent that Avantek's B zone is between Applied Materials' A zone and B zone, and probably is equivalent to the A2 zone (refer to Figure 5). With this in mind, it appears that the A2 zone was penetrated by AM1-5B and found to contain a gravelly sand about 3 to 4 feet thick and having high estimated permeability; the presence of VOCs has not been reported. This A2 interval is interpreted to be in Avantek's well AV-1B and may be a conduit for the movement of polluted groundwater. It also appears that pollution in the A water-bearing sand, and perhaps also in the A2 zone, is migrating from the Building 1 site to the Avantek site, as measured in well AV-1B. The source of the pollutants previously identified in Avantek well AV-1A most likely is also the Building 1 site.

On the Applied Materials side of Bowers Avenue, extraction well AM1-5E pumps 5-15 gpm polluted groundwater from the A-zone aquifer at 14-24 feet. The water-producing interval is a medium-grained sand, increasing in grain size to 1/2-inch gravel, and with high estimated permeability at a depth interval of about 16 to 21 feet. The total depth of this well is 25 feet, and a lower A2 sand was not penetrated. Pumping this well influences the shallow A zone (including well AV-1B) on the Avantek site, but there is no information to indicate if the pumping influences the deeper sand interval found at 32-37 feet in the AV-1B well, which is equivalent to an A2 interval on the Applied Materials site. The B zone identified at the Building 1 site has not been explored on the other side of Bowers Avenue, on the Avantek site, and the downgradient extent of pollution detected in well AM1-5B has not been determined. However, the current concentrations of VOCs in well AM1-5B are below MCLs.

A2-Zone Pollution

The report does not recommend placing any additional extraction wells in the A2 zone, nor does the report acknowledge that A2 groundwater may be migrating offsite and may be transmitting pollution to the Avantek well AV-1B. (The offsite migration of A-zone groundwater is inferred on Figure 14 of the report.) No samples of groundwater have been obtained for analyses from either boring DB-22 or boring B-39 on the Applied Materials equipment pad. Boring DB-22 was drilled into the top of the B zone in the vicinity of B-zone monitoring well AM1-2, about 15-20 feet downgradient of the source area (refer to Figure 1) and found VOC saturated soil pollution throughout the interval from the base of the A aquifer (about 24 feet) to the top of the B zone (about 42 feet). The highest concentration was a reported 20.47 ppm total VOCs in the three-foot-thick aquitard immediately underlying the A gravelly sand. The pollutants were mainly 1,1,1-TCA and 1,1-DCA, with some PCE.

Boring B-39 is also located near AM1-2 but closer to the former source area. This boring did not reach the top of the B-zone sand and found VOC saturated soil pollution within the interval from the base of the A aquifer (about 25 feet) to the bottom of the boring (about 40 feet). The highest concentration of total VOCs was 10.93 ppm, at 25.25 feet at the base of the A sand, and 1.38 ppm at 31 feet in the A2 zone. These VOCs included mainly 1,1,1-TCA, 1,1-DCA and 1,1-DCE, with PCE, TCE, and 1,2-DCA. The total VOC concentrations in soil in DB-22 and B-39 were much greater than that found in well AM1-10 (4.97 ppm); groundwater from AM1-10 contained very high concentrations of VOCs, but water samples were not available for analyses from either DB-22 or B-39.

Time to Accomplish Site Remediation

The existing site cleanup requirements (Order No. 90-134) summarizes the 5 cleanup plans originally evaluated in the RI/FS, and includes mention of a later re-evaluation with a conclusion by Applied Materials that remediation can be accomplished either by (1) groundwater extraction alone or by (2) extraction combined with partial soil removal, with an estimated cleanup time of 53 years for (1) and 35 years for (2). Applied Materials favored (1) possibly modified by some soil removal if future operational changes at Building 1 provide an opportunity to transfer manufacturing and R&D activities out of Building 1. Applied Materials has recently reported that operational changes within Building 1 will take place very soon, but accessibility to the area beneath the equipment pad will not improve and soil remediation does not appear to be any more feasible now than it was earlier.

The submitted report includes a review of feasibility study alternatives with some modifications. Remedial action alternatives have been updated to show a cleanup time of about 9 years from the present "to achieve ARARs sitewide" by groundwater extraction alone, and about 7 years of groundwater extraction if augmented by partial soil removal (augured caisson). With such a similarity in cleanup times, soil remediation is not considered worthwhile by Applied Materials. These cleanup times are based on linear regression analyses using data from two extraction wells, AM1-1 and AM1-5E. The 7-year estimate is for well AM1-5E in which 1,1,1-TCA has been below the MCL for some time, and the 9-year estimate is for well AM1-1 which is closer to the source area. When Applied Materials used a similar model in 1988, staff thought it was too optimistic based on the historical information and analysis of pump-and-treat by the U.S. EPA. Applied Materials later revised the estimate upward. Now, the estimate has been revised downward and is about the same as it was in 1988.

Applied Materials' model utilizes data from the permeable A-zone groundwater interval found in two downgradient wells: one well is about 25 feet from the tank source area, the other is about 400 feet from the source area. We would normally expect the more-distant well (AM1-5E) to clean up faster than the other well. The extent of pollution in the A zone in the source area is not known; to consider well AM1-1 a "source-area well" may or may not be appropriate: well AM1-1 may clean up several years after well AM1-5E cleans up, but that doesn't necessarily mean the source area is clean. There is not now (nor has been) a well in the source area to monitor cleanup of the A-sand aquifer.

Soil surveys have identified a silty clay interval (poorly permeable), below the A-sand aquifer, which has high concentrations of VOCs in three borings in the near-source area. This polluted interval is not now being actively remediated and may or may not be amenable to remediation by groundwater extraction. The full extent of this pollution is unknown but it is projected to extend from under the equipment pad on the west side of Building 1, to under Building 1. Well AM1-10 removes VOC pollution from an interval about 15 feet deeper than the A-aquifer sand. The source of the VOCs extracted by AM1-10 has not been identified. The effectiveness of AM1-10 in remediating this source is not known and will be evaluated in the five-year status report. It has been conjectured that this source could be DNAPL; if so, it most likely will not be remediated by groundwater extraction, or could take a very long time (decades and longer) to remediate.

STAFF CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. Applied Materials considers the "signature" VOCs of the Building 1 site to be 1,1,1-TCA, 1,1-DCA, and 1,1-DCE.

2. The effect of on-going groundwater extraction on the source-area A sand cannot be directly verified because there is not a well into the A sand directly beneath the source area; and, the A sand in the source area may require a long time for remediation by groundwater extraction by a well outside the source area. Well AM1-EP which was constructed above the A sand has provided data on the effectiveness of groundwater extraction at the source area from 1985 through September 3rd, 1991. Although concentrations generally decreased during this period, showing declines from 370 to 0.180 ppm for 1,1,1-TCA, 13 to 0.043 ppm for 1,1-DCA, and 19 to 0.034 ppm for 1,1-DCE, concentrations of 1,1-DCA and 1,1-DCE were still above MCLs of 0.005 ppm and 0.006 ppm, respectively, when the period ended.

3. Well AM1-10, the extraction well closest to the former tank location, found concentrations, up to 60 ppm, of a number of VOCs in groundwater from an interval, now called the A2 zone, about 10-15 feet deeper than the bottom of the main A aquifer. The concentrations of VOCs in saturated soil of the water-producing A2 interval are ND (one sample had 0.01 ppm 1,1,1-TCA) and do not correspond to the subsequent high concentrations of VOCs in the extracted groundwater after pumping of well AM1-10.

4. The source of high concentrations of VOCs in groundwater from well AM1-10 has not been revealed by the recent investigation; nor has the investigation revealed a definitive correlation between VOC soil pollution and VOC groundwater pollution in this well.

5. The VOCs detected in groundwater from well AM1-10 may be pulled into the well from elsewhere by the pumping of well AM1-10, or may indicate a yet-undetected source at or near (beneath) the former tanks.

6. No deep borings were completed below the former tanks.

7. The presence of electrical and other equipment above ground and underground utilities (electrical lines and conduits) interferes with the installation of borings and wells on the equipment pad which overlies the source and near-source areas.

8. VOC soil pollution at the Building 1 site appears to be in the zone of saturation; high concentrations of VOCs found in the A/A2 aquitard are in poorly permeable soil and are not believed to be amenable to remediation by groundwater extraction.

9. The subject report shows high-concentration VOC soil pollution to exist under the concrete equipment pad, and assumes that it may extend under Building 1. This pollution occurs in saturated soil, and desorption may take place over a long period of time. The concentrations of VOCs, including potential carcinogens, above MCLs may persist for the period that pollutants are desorbing from soil. VOCs which desorb into groundwater may eventually be captured by groundwater extraction.

10. The presence of DNAPL is suspected, and if present, may significantly increase cleanup time by groundwater extraction alone.

11. It is highly unlikely that changing circumstances will allow Applied Materials to attempt soil remediation beneath the concrete equipment pad and building in the foreseeable future.

12. Applied Materials now estimates that sitewide groundwater remediation will be accomplished by groundwater extraction alone in less than ten years, as compared to a prior estimate of 53 years by extraction alone and 35 years by groundwater extraction augmented by soil remediation.

13. Variable concentrations of the signature VOCs have been detected in groundwater in monitoring wells on the Avantek site, across Bowers Avenue and downgradient from the Applied Materials Building 1 site, but upgradient from the former source area at Avantek. Polluted groundwater apparently has migrated from the Applied Materials site to the Avantek site.

Recommendations

1. If and when feasible, polluted soil under the equipment pad and Building 1 should be remediated, as may be required to meet Board cleanup standards.

2. Polluted groundwater should be completely contained onsite and not allowed to migrate offsite.

3. Groundwater remediation should achieve cleanup standards, sitewide.

4. Groundwater monitoring and remediation should be evaluated with the submittal of the Status Report, due October 1, 1994. The evaluation should attempt to show that extraction wells AM1-1 and AM1-10 can and do remediate the A-zone and A2-zone groundwater pollution in the source area, and extraction well AM1-5E does hydraulically contain the pollutant plume onsite and prevents VOCs from migrating offsite.

5. Applied Materials should be required to evaluate the adequacy of downgradient plume containment, by coordinating groundwater sampling and water-level measurement events on both sides of Bowers Avenue, and by evaluating and interpreting the geology of the A zone from the surface to the top of the underlying B zone and describing potential pathways for transmitting groundwater pollution offsite. If required, a plan to address offsite migration should be developed and implemented.

/s/ G Walker

Concur
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Section Leader

Concur
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