PART I

INSTALLATION RESTORATION PROGRAM
TWIN CITIES ARMY AMMUNITION PLANT

1989 ANNUAL MONITORING REPORT
TEXT - VOLUME 1 OF 3

Distribution is limited to U.S. Government Agencies only for protection of privileged information. Other requests for the documents must be referred to:

Commander
Twin Cities Army Ammunition Plant
New Brighton, Minnesota
55112-5000

Prepared for:

Commander
Twin Cities Army Ammunition Plant
ATTN: SMCTC-CO
New Brighton, Minnesota 55112-5000

Commander
U.S. Army Toxic & Hazardous Materials Agency
ATTN: CETHA-CO
Aberdeen Proving Ground, Maryland 21010-5401

MAY 1990
(Final Report)

Wenck Associates, Inc

Consulting Engineers
(612) 479-4200

May 28, 1991

Mr. Martin McCleery
Remedial Project Manager
Twin Cities Army Ammunition Plant
New Brighton, Minnesota 55112-5700

Re: TCAAP 1989 Annual Monitoring Report, Part I,
Volumes 1 through 3, May 1990, Wenck Associates, Inc.

Dear Mr. McCleery:

On behalf of Federal Cartridge Company (FCC), we are hereby submitting the final version of the above referenced document. Following is a brief summary of the report submittal and review.

The draft report was submitted to the Minnesota Pollution Control Agency (MPCA) and U.S. Environmental Protection Agency (EPA) in May 1990. EPA comments were provided to the Army in a letter dated August 24, 1990, while MPCA comments were dated October 26, 1990. A meeting was held at TCAAP on January 8, 1991 between representatives of FCC, Army, MPCA, EPA and Wenck Associates, Inc. (WAI) to discuss the comments. At that meeting, it was agreed that WAI would prepare a letter responding to all of the MPCA and EPA comments. It was also agreed that the report submitted in May 1990, along with the response letter, would comprise the final report. The WAI response letter was dated February 11, 1991. MPCA and EPA approval of the report was documented in a letter to the Army dated March 28, 1991.

The WAI response letter is attached as Exhibit #1, which also includes copies of the MPCA and EPA comment letters. The MPCA/EPA approval letter is attached as Exhibit #2. Note that the comments provided in the MPCA/EPA approval letter do not pertain to Part I, but rather to Part II of the 1989 Annual Monitoring Report prepared by Conestoga-Rovers & Associates (CRA) on behalf of Alliant Techsystems.

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In summary, the following report, along with Exhibits #1 and #2 to this letter, comprise the final version of the 1989 Annual Monitoring Report, Part I. Copies of this final report have been distributed as indicated below.

Respectfully submitted,

WENCK ASSOCIATES, INC.

Keith W. Benker, P.E.

KWB/rlb

copies furnished:
TCAAP, SMCTC-EV (2 copies)
USATHAMA, Attn:CETHA-IR-A (1 copy)
AEHA, Attn: HSHB-ME-SR, Jack Heller (1 copy)
HQDA, Attn: DAJA-ELL, CPT Diner (2 copies)
AMCCOM, Attn: AMSMC-IE (1 copy)
OASA (IL&E), Attn: Lewis Walker (1 copy)
AMC, Attn: AMCEN-A, Andy Talts (1 copy)
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Alliant Techsystems, Inc., Attn: Doug Fullen (2 copies)
U.S. EPA, Region V, Attn: Tom Barounis (2 copies)
MPCA, Attn: Mark Schmitt (1 copy)

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EXHIBIT #1

Wenck Associates, Inc.

February 11, 1991

Consulting Engineers
(612) 479-4200

Mr. Darryl Terho, P.E.
Federal Cartridge Company
Twin Cities Army Ammunition Plant
New Brighton, Minnesota 55112-5795

Re: 1989 Annual Monitoring Report, Part I, Volumes 1 through 3, May 1990, Wenck Associates, Inc.

Dear Mr. Terho:

This letter is intended to respond to Minnesota Pollution Control Agency (MPCA) and U.S. Environmental Protection Agency (USEPA) comments regarding the above referenced document. It is my understanding that by submitting a copy of this letter to the MPCA and USEPA, the 1989 Annual Monitoring Report (Part I) will pass the consistency test. Upon receipt of this letter, both regulatory agencies should send an approval letter to the U.S. Army signifying that the document is Final.

The 1989 Annual Monitoring Report consisted of Parts I and II which were submitted together to the MPCA ad USEPA in May 1990. Part I was prepared by Wenck Associates, Inc. (WAI) on behalf of Federal Cartridge Company (FCC), while Part II was prepared by Conestoga-Rovers & Associates (CRA) on behalf of Honeywell, Inc. (now Alliant Techsystems, Inc.). This letter addresses only Part I of the 1989 Annual Monitoring Report: CRA is working separately to finalize Part II.

A meeting was held at TCAAP on January 8, 1991 to discuss MPCA and USEPA comments to Part I of the 1989 Annual Monitoring Report. The meeting was attended by representatives of MPCA, PRC, U.S. Army, FCC, and WAI. At that meeting it was agreed that WAI would prepare a letter responding to MPCA and USEPA comments, and that resubmittal of the document would not be required.

Copies of the MPCA and USEPA comments are included as Attachments 1 and 2. The following responses refer to the comment numbers indicated in the Attachments. For the MPCA comments, responses are only presented for the comments specific to the 1989 Annual Monitoring Report. The general comments regarding reports have been considered and where appropriate, incorporated into the Fiscal Year 1990 Annual Monitoring Report.

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Responses to MPCA Comments

1. WAI recognizes that descriptions of hydrogeologic units presented in the 1989 Annual Monitoring Report were not necessarily consistent with those used by others. The descriptions have been revised for the Fiscal Year 1990 Annual Monitoring Report.

2. The draft 1990 Annual Monitoring Plan was submitted in February 1990 and the final plan was submitted in May 1990.

3. All "0.00" values shown on the isoconcentration maps represent data reported from the laboratory as less than the method detection limit. For example, a trichloroethene concentration of <0.50 is shown as 0.00 on the trichloroethene isoconcentration maps. It should be noted that the method detection limits vary for the different analytical parameters. Hence, 0.00 does not represent a single value, rather it denotes less than the parameter specific method detection limit. Note that for the Fiscal Year 1990 Annual Monitoring Report, less than values are shown as such on the contour maps; they are not shown as 0.00 values.

4. The 1989 Annual Monitoring Report was not intended to reiterate all findings and recommendations of the project Remedial Investigation (RI) Report, especially since the RI Report was not a final document when the 1989 Annual Monitoring Report was submitted. Statements in the annual report regarding the primary contaminants at various sites were included merely to establish the principal focus of groundwater monitoring at each site for 1989. Omission of recommendations from the RI Report was not intended to imply that other work is not necessary. The RI Report represents the comprehensive document with respect to what contaminants have and have not been detected at each site, and what additional work should be considered.

5. It is true that barium, cadmium, chromium, nickel, and lead were all detected in the sample from 03L137 on October 17, 1989; however, all concentrations were less than the groundwater action criteria specified in Table 3.7A of the Federal Facilities Agreement (FFA).

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6. The reference to Site E should read Site G.

7. It was incorrectly stated that no halogenated VOCs were detected in well 03U005. Trichloroethene and cis-1,2-dichloroethene were detected, but at concentrations below the respective criteria set forth in Table 3.7A of the FFA.

8. Analytical data for wells 03L006 and 04U006 was erroneously presented in Table 6: these wells do not even exist. The data is actually for wells 03L806 and 04U806. The elevated concentrations are consistent with previously reported values at these locations.

9. The intent of the 1989 Annual Report was to discuss the findings for monitoring performed in 1989. Since monitoring for manganese was not conducted during the year at the 005 and 007 well nests, discussion of manganese trends was not presented.

10. Same response as number 4 above.

11. The discussion does not take a position either way with regard to merging of the two TCAAP plumes off-post in Unit 4. It is true that additional monitoring locations in 1989 would have aided in preparation of the isoconcentration contour maps to address this issue. Note that additional monitoring locations were included for 1990 to provide better resolution off-post.

12. The water level contours for data obtained at Site A in 1989 indicate that groundwater flows generally to the west-northwest. The contours do bend suggesting that flow is divergent, but there does not appear to be a distinct "split" into northwest and west flow directions.

13. With the discovery of contamination at wells 01U901 and 01U902 during 1989, it is true that the extent of the outer limits of contamination may not have decreased during the year. Conversely, the apparent increase in the extent of contamination is not necessarily due to changing conditions; rather, it is a function of having additional monitoring locations.

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The true intent of statements regarding the decreasing extent of contamination was to indicate that the areas of highest concentrations, as defined by 100 and 1,000 µg/l contours, are diminishing in size. The 1,000 µg/l contour shown on Figure L-2 in the 1988 Annual Monitoring Report is no longer evident on Figure 8.5.1.4.4 in the 1989 report. Furthermore, the area encompassed by the 100 µg/l contour decreased from 1988 to 1989. This is a function of decreasing concentrations near the source area.

14. The groundwater recovery system does appear to be effectively capturing contamination in the vicinity of the source area. What is not clear from the 1989 data is whether the recovery system is capable of capturing contamination from areas off-post. Further assessment of this matter is presented in the Fiscal Year 1990 Annual Monitoring Report.

15. Prior MPCA staff had indicated approval for the use of water level data at recovery wells for preparation of contour maps. Future reports with respect to Site A will not include water levels at the recovery well for interpretation or discussion of the hydraulic capture zone.

16. Operation of the groundwater recovery system at Site K is the responsibility of Honeywell, Inc. (now known as Alliant Techsystems, Inc.). A more in-depth discussion regarding performance of the recovery system is presented in their portion of the 1990 Annual Monitoring Report.

17. The data for 03L822 was inadvertently omitted from the quarterly report, but was included in the annual report.

18. TOS represents Top of Surface which is the ground surface elevation at each well. The TOS is the reference elevation for each well stored in the USATHAMA database: top of casing elevations are not stored. Water level measurements for FCC were measured from top of casing at each well. The distance from the top of casing to TOS was subtracted from each measurement to yield depth to water from TOS. This depth was subtracted from the TOS elevation to arrive at the groundwater elevation. Groundwater elevations from Honeywell, Inc. were determined from top of casing elevations stored by CRA.

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19. Same response as number 15 above. It was agreed with the present MPCA staff at the January 8, 1991 meeting that these figures would not have to be re-submitted.

20. Same response as number 3 above.

Responses to USEPA Comments

1. Future annual reports, including the Fiscal Year 1990 Annual Monitoring Report, will summarize the volumes of groundwater recovered and the mass of volatile organic compounds removed.

2. The monitoring plan section of future annual reports will note and discuss any changes in analytical parameter lists relative to the previous year.

As stated at the beginning of this letter, it is my understanding that Part I of the 1989 Annual Monitoring Report will be considered a final document once the MPCA and USEPA have reviewed this letter. Therefore, it will be necessary to forward copies of this letter to the U.S. Army for submittal to the MPCA and USEPA.

If you have any questions concerning this matter, please contact me at (612) 479-4206.

Sincerely,

WENCK ASSOCIATES, INC.

Keith W. Benker

Keith W. Benker, P.E.

KWB/rlb
Attachments

cc: Bridgette Manderfeld, FCC

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ATTACHMENT 1

MPCA Comments to 1989 Annual Monitoring Report

Minnesota Pollution Control Agency
520 Lafayette Road, Saint Paul, Minnesota 55155-3898
Telephone (612) 296-6300

Celebrate MINNESOTA 1990

October 26, 1990

Mr. Martin McCleery
Remedial Project Manager
Twin Cities Army Ammunition Plant
New Brighton, Minnesota 55112-5700

Dear Mr. McCleery:

RE: Wenck Associates, Inc. and Federal Cartridge Company 1989 Annual Monitoring Report for TCAAP

Staff at the Minnesota Pollution Control Agency (MPCA) has reviewed the Wenck Associates, Inc. and Federal Cartridge Company 1989 Annual Monitoring Report for the Twin Cities Army Ammunition Plant (TCAAP). Our enclosed comments are divided into two sections.

The first section contains errata and other specific comments that must be addressed before the document will pass the Consistency Test in accordance with Article XIV of the Federal Facility Agreement (FFA). The second section contains comments which are generally conceptual in nature, and should be kept in mind for consideration and inclusion in the TCAAP 1990 Annual Monitoring Report.

Please recall that the MPCA staff will perform a November audit of 1987, 1988, 1989 and 1990 TCAAP data. Any revisions to the data may affect interpretation of the environmental conditions on or near TCAAP.

The MPCA staff has also reviewed the monitoring data available to date, and has decided that collecting large numbers of samples for chemical analysis in December of each year will no longer be necessary. However, December static water levels measurements will still need to be performed. The MPCA staff also recommends that wells 01U901 and 01U902 be sampled for volatile organic hydrocarbons each December to evaluate the nature of the contamination at these wells over time.

If you have any questions, please contact Mark Schmitt of my staff at 296-7776.

Sincerely,

Rodney E. Massey, P.E.
Director
Ground Water and Solid Waste Division

REM:pk

Enclosure

1989 ANNUAL REPORT PREPARED BY
FEDERAL CARTRIDGE COMPANY AND WENCK ASSOCIATES, INC.
FOR THE U.S. ARMY

Minnesota Pollution Control Agency (MPCA) staff comments to the 1989 Twin Cities Army Ammunition Plant (TCAAP) Annual Report prepared by Federal Cartridge Company and Wenck Associates, Inc. for the U.S. Army are listed below in two categories. The first category consists of errata and other specific comments that must be addressed before the document will past the Consistency Test. Revised pages need to be submitted for these items. The second category includes changes that need to be incorporated in future monitoring reports. Both categories are organized by volume, page number, section and paragraph of the 1989 Annual Report from Federal Cartridge Company and Wenck Associates, Inc.

Finally, an audit of the 1989 data will be conducted by the MPCA staff in November 1990. Some data may need to be changed based on the results of this audit and the significance of any changes will need to be evaluated.

Errata And Other Specific Comments
That Must Be Addressed Before The Document Will Pass The
Consistency Test

Volume 1 of 3

Page 2
Section I.A.
Second Paragraph

The text includes Unit 2 as one of "several aquifer units beneath the site." However, Unit 2 is comprised mostly of till and is not considered an aquifer. Refer to it as a geologic or hydrostratigraphic unit.

The definitions for Units 1 through 4 do not correspond well with those used by other parties involved in the TCAAP investigations. Define the units to be consistent with those used by others by making the following changes and/or additions:

Unit 1: Note that the unit is comprised of all the material above the Twin Cities Formation, and generally consists of lacustrine deposits. Briefly discuss where Unit 1 is discontinuous at TCAAP. Stating that "water table conditions generally exist" might lead the reader to assume that the true water table is found everywhere in Unit 1.

Unit 2: Note that this unit is comprised of the Twin Cities Formation till and that, within the TCAAP area, the Twin Cities Formation till is considered an aquitard. The till may contain sand and gravel lenses that allow horizontal movement of water.

Unit 3: Do not use the term "partially" to describe the hydraulic connection. The connection either does or does not exist, although poor hydraulic connection may be described as weak. This unit is defined as being comprised of the unconsolidated Hillside and Arsenal sands, not the St. Peter Sandstone.

Unit 4: Typo: "This unit is COMPRISED of the . . ."

Page 4
Section I.B.
Second Paragraph

Clarify that the draft 1990 Monitoring Plan was submitted in February 1990. The final 1990 monitoring plan was submitted in May 1990.

Page 17
Section F
Second Paragraph

Add an explanation that the 0.00 values on the isoconcentration maps represent contaminants that were not detected above the quantification limits and that the quantification limits for these compounds vary.

Pages 20 through 36
Sections V.A and B

Add statements to the appropriate source area sections that additional work Remedial Investigation work is needed. The Army should refer to RI and MPCA RI comments for possible work to be performed.

Also, present all parameters that were detected in the on-TCAAP RI for each source area and not just the principal ones.

Page 20
Section V.A.1 - - Site B
Paragraph 2

Modify the statement that the "Remedial investigations at Site B indicated that no significant impacts have occurred to groundwater in either Units 1 or 3." This statement is only a part of what was concluded in the on-TCAAP RI Report. Argonne National Laboratory (Argonne) also concluded that additional work is needed. Also, well 01U101 is not fully downgradient.

Page 22
Section V.A.4 - - Site E
Paragraph 4

Modify the sentence "Previous studies have suggested that groundwater contamination is moving beneath Site E from an upgradient source since the upgradient wells exhibited the highest concentrations." This statement is only partially true. Argonne also wrote on pages 7-40 and 7-43 in Volume 1 of the on-TCAAP RI Report that some contamination is attributable to Source Area E.

Page 24
Section V.A.5 - - Site F
Paragraph 1

Modify the statement that "No contaminants were detected at well 03L137." A few metals were detected.

Page 24
Section V.A.6 - - Site G
Third Paragraph

In the second sentence of the second paragraph on Source Area G, should not Site "E" be Source Area G?

Page 25
Section 7 - - Site H
Paragraph 5

The text states that "No halogenated VOCs were detected in" well 03U005. However, Table 6 (Page T3-2) indicates that cis-1,2-dichloroethene was present at 3.4 ug/L and trichloroethene was present at 0.30 ug/L in the sample collected in October 1989 from that well. The text needs to be modified so that it reflects these data.

Table 6 (Page T3-3) presents data for Honeywell's monitoring data for wells 03L006 and 04U006, which are associated with Site H. The text needs to be modified so that it discusses the sampling results for these wells, especially as VOCs were detected at levels significantly exceeding RALs.

Discussions of water quality trends over time need to be modified to recognize that manganese was detected in water samples collected from wells 03M005, 03L005, 03U007, 03L007, and 04U007 at concentrations exceeding secondary criteria in 1987, and that no analyses for manganese were conducted since.

Page 27
Section V.A.10 - - Site 129-3
Paragraph 4

Qualify the statement that "In general, significant groundwater contamination has not occurred at Site 129-3;" The MPCA staff have commented to the on-TCAAP RI Report that the investigation was not adequate.

Page 30
Section V.A.13 - - Southwest Boundary Area and Off-Post
Paragraph 3

There is inadequate information to know if the two TCAAP plumes join off-TCAAP in Unit 4.

Page 31
Section B.1
First Paragraph

According to the on-TCAAP RI Report, the ground water flow direction in the Unit 1 Aquifer at Source Area A split into northwest and west flow directions. Please modify the discussion of the ground water flow direction(s) in the first paragraph on this page.

Page 32
Section B.1. - - Site A

For Source Area A, discuss how the extent of contamination can be smaller in comparison to the past conditions shown in Figures L-2 and L-5 of the TCAAP 1988 Annual Monitoring Report if there is contamination that may or may not be attributable to TCAAP at off-TCAAP wells 01U901 and 01U902. It may be that the extent is not smaller; instead, the concentrations may be lower in the vicinity of well 01U350.

At present, it is not appropriate to claim that the Source Area A ground water recovery system is performing well. At best, it can be said that the effectiveness of the Source Area A ground water recovery system is unknown. If the contamination at off-TCAAP wells 01U901 and 01U902 is found to be attributable to TCAAP, then the Source Area A ground water recovery system is not performing well as claimed.

Page 31
Section B.1.a
Paragraph 3

Any discussion regarding the capture zone created by pumping well 01U350 is unfounded, as the analysis is based on contour maps constructed with water levels from the pumping well. Delete this discussion or modify it to reflect what can actually be inferred from the field data.

Page 32
Section B.2 - - Site K
Paragraph 2

Again, any discussion of capture zone effectiveness must be based on appropriate data. Modify the text to reflect actual conditions.

Page 34
Section B.2 - - Site K
Paragraphs 2 and 3

To evaluate the effectiveness of the ground water extraction system, it is necessary to discuss the source of water level data for the trench. Are the water levels measured in a sump that is being pumped? Or are they measured in an area away from the pump(s)? This may change the interpretation regarding the pump-out system effectiveness.

How do you know that the drain at Source Area K is working well if the wells are not properly surveyed and, according to the on-TCAAP RI Report, the Source Area has not been completely investigated?

Volume 2 of 3

According to the information from the quarterly reports, no static water level was measured for well 03L822 during Quarter 22. Yet, a measurement is shown in the ground water elevation summary in volume 2 of 3 of the 1989 Annual Report. Please explain.

Table 1. Pages 2, 7, 12, and 17. Clarify what the "Date Qtr By TOS" is. Is this the well's measuring point (generally top of internal casing in most cases)? Use a footnote at the page bottoms or at the beginning of this table and Table 13 to clarify. Were only Army measuring points (generally top of internal casings) elevations used to calculate ground water elevations or were CRA measuring point elevations also used?

Volume 3 of 3

Figures 5.1.2.1, 5.1.2.2, 5.1.3.1, 5.1.3.2, and 5.1.3.3.

It appears that water levels from pumping wells were used in contouring the Unit 1 piezometric surface. It is inappropriate to plot these values as few pumping wells operate at 100 percent efficiency, which means that the water level within the well is representative of that in the formation immediately outside the screen. Unless water levels in pumped wells can be adjusted based on quantified pumping efficiencies for individual wells, water levels from pumping wells shall not be used in contouring the ground water elevation maps for this and all subsequent reports. Therefore, correct these figures as discussed above.

Section 8. Refer to MPCA staff comment for page 17, Section F, Second Paragraph of the first volume above and provide a similar statement at the beginning of this section. Also, record the quantification limits if they do not vary for sampling events for 1989 data and, if necessary, the well numbers on this sheet or on each map.

Comments That Need To Be Included In Future Annual Monitoring Reports

General Comments

Values and units on all maps must be readable.

A summary table is needed of wells that were proposed to be sampled and the parameters proposed to be analyzed as part of that year's sampling event. Those wells not sampled for a particular sampling event or analyzed for a particular parameter need to be footnoted. The footnote needs to list the reason(s) why a sample was not collected and a water level was not measured.

One requirement of the Annual Report that is listed on page 28 of Attachment 3 to the FFA is that a summary of all changes to the monitoring system be included. This includes not only a status of the system's present condition, but also includes a list of any wells abandoned, installed, or modified within the past year, documentation of any work performed on the

monitoring system, and a proposal for any work that needs to be performed on the monitoring system. Include this information in future annual monitoring report submittals.

Distinguish pumping wells from monitoring wells by using a separate symbol for each.

Label units, such as feet MSL or ug/L, on all data plots.

Do not report water levels on figures to 0.01 feet when the values are only accurate to 0.1 feet.

Label each well in all figures that illustrate wells. This includes figures illustrating ground water level elevations and ground water quality.

Remove the "Groundwater Level Contours" label from figures in which water levels have not been contoured. Additionally, contouring could have been done for a number of figures, such as Figures 5.2.1.1, 5.2.2.1, and 5.2.2.2.

Label all water level and water quality values on the figures so that they are not obscured by other features, such as site boundaries.

The MPCA staff concurs with the two comments made by PRC in an August 24, 1990, letter to Art Kleinrath of U.S. Environmental Protection Agency from Majid Chaudhry of PRC regarding the 1989 Annual Monitoring Report. These comments were that:

(1) A summary should be provided of the progress of the interim remedial actions for the various sites by reporting every year the amounts of treated ground water and the mass of contaminants removed; and

(2) The Army should note and justify the reduction in analytical parameters from the approved analytical categories list.

Discuss in the text and provide maps showing vinyl chloride concentrations if vinyl chloride is detected in any wells. This information is requested in order to keep track of areas in which risks are posed by vinyl chloride, which has a low Recommended Allowable Drinking Water Limit (RAL) of 0.15 ug/L.

For the 1990 Annual Monitoring Report, show only ground water flow directions and sampling locations on the QB series Unit 1 maps.

Special analyses such as metals at Site F during Quarter 27 need to be mapped and included as part of the 1990 annual monitoring report if concentrations exceed the action levels.

Maps do not need to be provided in the 1990 Annual Monitoring Report for the dichloroethenes and the dichloroethanes.

Include Middle Unit 3 ground water elevations and concentrations in parentheses on either the Upper or Lower Unit 3 maps. The Upper Unit 3 maps are preferred.

Include source area outlines on maps.

Trends for select off-TCAAP wells need to be presented, provided the wells are sampled during a given year. Some of these wells shall include the New Brighton and St. Anthony municipal wells and the Gross Golf Course well. Others will be chosen based upon interest and importance.

Tables and aerial maps depicting vertical gradients between and within aquifers of concern need to be presented.

Specific Comments

Page 6

Show figures that illustrate all surface water discharge and sampling locations. Discuss and cite figures in the text.

Does the LE Series Scale Map show sufficient area to the south and southeast to be useful?

Page 9
Paragraph 2
Last Sentence

Does this mean that not all wells are reported in Tables 1 and 2 or that not all water level data are reported? If the latter was the case, what criteria were used to decide which data set was used? This does not always appear to be the case though, as seen in Tables 1 and 2 for December 14, 1987.

Page 9
Section C

Water level data considered anomalous need to remain in Tables 1 and 2 but may be footnoted to indicate that there is doubt or uncertainty associated with the value. Merely presenting the anomalous data in Table 3 makes it difficult for the reader to reconstruct the patterns. The data needs to be presented so that readers of the report are allowed to make a comparison and evaluate the values. What criteria were used to determine "extremely high or low ground water level elevations"? How is the normal range defined? When ground water levels were checked against the specified "conditions", what criteria determined whether or not a value was incorrect? For example, was a value removed if the well was pumped or was under the influence of a nearby pumped well? Hydrogeologic conditions can sometimes cause water levels that appear anomalous and that are difficult to explain. Where this is the case, the inclusion of all water levels in the tables might offer clues that are critical in the interpretation of the hydrogeologic conceptual model.

Pages 10 and 11
Section D

The hydrographs are most useful in examining long-term vertical gradient trends by illustrating water levels from well nests on the same graph. Future reporting of hydrographs need only be constructed to illustrate vertical differences in head for particular well nests of interest.

Page 12
Section 3
Paragraph 3

It is not appropriate to average ground water elevation data that is measured over a period of a quarter. Yet, that is exactly what was done for the ground water elevations presented in Volume 2 of 3 of the U.S. Army's 1989 Annual Report. All ground water and surface water elevation data must be collected in as short a time period as possible so that the data represents a time instantaneous picture of ground water elevations in each aquifer. Therefore in the future, do not average ground water elevations. In addition, measure static water levels in wells within a maximum of three days instead of spreading water level measurements over a two week period.

It needs to be pointed out that Honeywell, Inc. and the U.S. Army do not use the same top of casing elevations. Each has surveyed the same wells with their own surveyors.

Page 16

Discuss the laboratories used in the discussion of methods.

Page 17
Section E
Paragraph 1

This section needs to be expanded to discuss and include illustrations of trends and seasonal variations of interest. For example, provide an explanation for differences between Maps 8.5.1.4.3 and 8.5.1.4.4 (Summer and Fall Quarters for Unit 1 at Source Area A. The contaminant is trichloroethene.), or 8.5.2.2.1, 8.5.2.2.2 and 8.5.2.2.3 (Winter, spring and summer Quarters for Upper Unit 3. The contaminant again is trichloroethene.)

Pages 20 through 36
Section V

Delete the words "significant" and "low-level". Compare concentrations with respect to the relevant action criteria. Indicate the number of times a particular well exceeds these values for a particular contaminant and how many wells exceed these values for a particular aquifer.

Pages 22 and 23

The U.S. Army needs to describe what they will do to investigate the source of the ground water contamination upgradient of Source Area E.

Page 26
Section 8 - - Source Area I
Paragraph 4

Be more specific: discuss types of contaminants, concentrations, and ranges.

Page 27
Section 9 - - Source Area J
Paragraph 1

What was detected in samples collected from well 01U526?

Page 27
Section 11 - - Source Area 129-5
Paragraph 5

Given that trichloroethene was detected in samples collected from wells associated with Source Area 129-5 (wells 03U111, 03U097, and 03U129 (up-gradient)) in 1987 but was not detected in late 1988, it would be appropriate to sample more than one Unit 3 well for that site in upcoming sampling events.

VOLUME 2 OF 3

According to Attachment 3, Page 27 to the FFA, all ground water elevations must to be measured to the nearest 0.01 feet. The ground water elevations summarized in this volume are only recorded to the nearest 0.1 feet. In the future all ground water elevations must be recorded to the nearest 0.01 feet.

As stated above, do not average ground water elevations. Also, measure all static water levels within three days.

None of the 5-23-89 data was included. It probably was averaged with static water level data collected at the end of the previous month.

VOLUME 3 OF 3

Zero concentrations are never correct. Use the method detection limits and "less than" symbols. Contour with the lowest value for a contour being greater than the method detection limit. Contour by hand, if necessary.

ATTACHMENT 2

USEPA Comments to 1989 Annual Monitoring Report

prc

PRC Environmental Management, Inc.

Planning Research Corporation

[illegible]

[illegible] 60601
[illegible] 8700
[illegible] 938 [illegible]

August 24, 1990

Mr. Art Kleinrath
Remedial Project Manager
Waste Management Division
U.S. EPA Region 5
230 South Dearborn Street
Chicago, IL 60604

Re: **Review of 1989 Annual Monitoring Report and**
1989 TGRS Annual Monitoring Report and
Monitoring Plan for TCAAP
Work Assignment No. 04-5P40, Contract No. 68-W8-0084

Dear Art:

We are enclosing three copies of our review comments on the above mentioned reports. Except for two points suggested in these comments for improving report quality, PRC found that previous comments on the 1988 version of these reports were properly addressed and incorporated in the 1989 version of the reports.

If you have any questions, please call me or Kostas Dovantzis at 312/856-8700.

Sincerely,

Majid A. Chaudhry, Ph.D., P.E.
Site Manager

MAC/klb

cc: Kostas Dovantzis, PRC

REVIEW OF 1989 ANNUAL MONITORING REPORT AND 1989 TGRS ANNUAL MONITORING REPORT AND MONITORING PLAN FOR TCAAP

1.0 INTRODUCTION

Under U.S. Environmental Protection Agency (U.S. EPA) Work Assignment No. 04-5P40, Contract No. 68-W8-0084, PRC Environmental Management, Inc. (PRC) reviewed the 1989 Annual Monitoring Report (AMR) for the Twin Cities Army Ammunition Plant (TCAAP) site, located in New Brighton, Minnesota. This report consists of three volumes that present tabular and graphical form of the monitoring data for the period January to December 1989 (Quarters 21 to 24). This report, dated May 1990, was prepared by Wenck Associates, Inc. (WAI), a consultant to the U.S. Army and Federal Cartridge Company (FCC). PRC also reviewed the 1989 TCAAP Ground-Water Recovery System (TGRS) annual monitoring report and monitoring plan (AMRP). This report, also dated May 1990, was prepared by Conestoga-Rovers & Associates (CRA), a consultant to the U.S. Army and Honeywell, Inc.

The 1989 TGRS AMRP describes the performance and operation of the Boundary Ground-Water Recovery System (BGRS) after it was expanded on January 31, 1989, by installing six additional ground-water extraction wells (making the number of southwest boundary wells 12) and connecting these wells with the source control wells (SC1 to SC5) of Sites D, G, and I. The expanded TGRS consists of 17 extraction wells as described in the 1989 TGRS AMRP.

PRC previously commented on both the 1988 AMR and 1988 BGRS AMRP. Many of PRC's comments and suggestions on the 1988 version of the reports were addressed and incorporated versions of the two reports. This review outlines the remaining issues that would improve the quality of presentation of the reports. PRC's review comments are presented below.

2.0 COMMENTS ON 1989 ANNUAL MONITORING REPORT

WAI addressed PRC's comments on the 1988 AMR and incorporated these changes in the 1989 version of the report. PRC has two suggestions to improve the quality of future reports: (1) provide a summary of the progress of the interim remedial actions for the various sites by reporting every year the amounts of treated ground water and the mass of contaminants removed and (2) note and justify the reduction in analytical parameters, both organic and inorganic, from the approved analytical categories list; this will facilitate future reviews of the AMR.

3.0 COMMENTS ON 1989 TGRS ANNUAL MONITORING REPORT AND MONITORING PLAN

PRC's review found that the 1989 TGRS AMRP satisfactorily addressed previous comments on the 1988 version of the report. PRC has no further comments on this report.

EXHIBIT #2

Minnesota Pollution Control Agency
520 Lafayette Road. Saint Paul. Minnesota 55155-3898
Telephone (612) 296-6300

March 28, 1991

Mr. Martin McCleery
Remedial Project Manager
Twin Cities Army Ammunition Plant
New Brighton, Minnesota 55112-5700

Dear Mr. McCleery:

Re: 1989 Annual Monitoring Report

Staff at the Minnesota Pollution Control Agency (MPCA) and the U.S. Environmental Protection Agency (EPA) have reviewed the Army's 1989 Annual Monitoring Plan for the Twin Cities Army Ammunition Plant (TCAAP). This document passes the Consistency Test in accordance with Article XIV of the Federal Facility Agreement.

The MPCA and the EPA acknowledge the Army's position and technical arguments regarding effectiveness of the TCAAP Ground Water Recovery System (TGRS), and recognize these as among many possible legitimate interpretations of the effectiveness of this interim remedial action. Be advised that the MPCA and EPA also recognize other interpretations on TGRS effectiveness as equally valid.

Approval of the 1989 Annual Monitoring Report is not conditional. However, we have attached a series of comments on the Report for your consideration and use. We also remind you that the audit of the 1989 data has not yet been completed, and interpretations may change if the data upon which the Report are based need to be qualified.

If you have any questions, please contact Mark Schmitt of the MPCA at (612) 296-7776 or Thomas Barounis of the EPA at (312) 353-5577.

Sincerely,

Rodney E. Massey

Rodney E. Massey, P.E.
Director
Ground Water and Solid Waste Division

Thomas Barounis

Thomas Barounis
U.S. Environmental Protection Agency

REM:pk

1989 ANNUAL MONITORING REPORT COMMENTS

Comments on the 1989 Annual Monitoring Report are divided into the following sections:

(1) General Comments concerning the Report
(2) Issues and Concerns
(3) Graphical Enhancement
(4) Errata

These categories reflect overall report comments, issues, and concerns that need to be addressed in the future, a request for additional documentation to be included in the graphical enhancement section, and errata found in the report.

Although the Report passes the Consistency Test, the Army should meet with the Minnesota Pollution Control Agency (MPCA) and U.S. Environmental Protection Agency (EPA) to discuss issues and concerns to be addressed in the future, and see that the Army supply a revised version with additional documentation for procedures used in graphical enhancement. Errata corrections do not need to be resubmitted. However, if the information is used again at a later date, the corrections must be made prior to resubmittal.

General Comments

MPCA staff has reviewed the data and the various hydrogeologic interpretations and has concluded that the professional opinions expressed by both Conestoga-Rovers and Associates Limited (CRA) and Camp Dresser and McKee, Inc. (CDM) are reasonable. Based on existing information and methods for analysis, an unqualified endorsement cannot be given at this time to the professional opinions of the hydrogeology at the Twin Cites Army Ammunition Plant (TCAAP) presented by CDM and CRA. MPCA staff is continuing to evaluate new data as they become available.

This uncertainty emphasizes the importance of long-term monitoring, modeling, and further evaluation of hydrogeology and contaminant transport. Model users must be able to test new hypotheses with rapid turnaround for both regulatory and responsible party concerns. The uncertainty also emphasizes the need for installation and monitoring the Plume Ground Water Recovery System (PGRS), and for long-term monitoring of the Boundary Ground Water Recovery System (BGRS).

MPCA staff evaluated the geologic information in the vicinity of the BGRS and believes it is not sufficient to determine the degree and continuity of low permeable zones within Units 3 or 4. Well logs indicate that the less permeable sands of the Hillside Sand may be interconnected or connected with lenses of low hydraulic conductivity clay, silty or sandy clay, or silt. However, no conclusive evidence was found that indicates that a low permeability zone within the Hillside Sand is continuous throughout the site. Similarly, insufficient data exist to confirm the relative degree of weathering and fracturing throughout the Prairie du Chien Group that would indicate the existence of a less permeable zone at its base.

Issues and Concerns

1. Based on the information presented in the report, there is a need for long-term monitoring downgradient of the BGRS capture zone. The present monitoring well network may not be adequate for long-term monitoring north of the T6 well nest. Please submit a proposal for monitoring and the installation of additional monitoring wells downgradient of the BGRS.

2. Water quality data indicate that pump out well SC-4 is not effectively capturing ground water contamination from Source Area D (Tables 5.1, 5.2, and 5.5, and Plan Sheet 1 of this report; the 1989 Annual Report from Federal Cartridge Company and Wenck Associates, Inc.; and the on-TCAAP Remedial Investigation Report from Argonne National Laboratory). Please submit a proposal for placing a pump out well in the Hillside Sand at the center of the plume near well 03U093 that will replace pumping of Well SC-4.

   Based on the same information provided above, also propose the installation of an additional source control well at and immediately downgradient of source area G.

3. The vertical hydraulic gradients between the Prairie du Chien Group and the Jordan Sandstone have reversed from upward to downward at well nests 077, 702, 708, 713, and 714. The changes in vertical gradients cause concern that contamination may be driven downward into zones not within the capture zone of the BGRS. Address this concern in future monitoring reports using all available data.

4. MPCA staff is concerned about identifying the source of the metals contamination to the influent at the BGRS pump out wells. We have commented on this issue and are in the process of seeing that the issue is addressed. The remedial action(s) ultimately chosen will be influenced by the degree to which metals contamination of ground water is found to emanate from a particular source area.

Graphical Enhancement

The MPCA staff would like additional documentation supporting Section 4.1, Graphical Enhancement of Equipotential Maps. We believe the approach taken is good since it relies on direct aquifer response rather than precise determination of intrinsic aquifer characteristics. However, we are requesting explicit information that was used to determine the equipotentials presented as part of the graphical enhancement. Although these issues have been largely resolved through discussions with CRA, we would like a written record on file that can be used for future reference to eliminate potential confusion on how the technique was applied. The additional information could be presented in a format similar to Section 4.1 of the annual monitoring report, but augmented with the information --that we request.

The source of our confusion has been how water levels were determined for Units 3 and 4 in the vicinity of the 077 well nest. We request that the Army explain how drawdown contours around the 077 well nest were determined in the absence of reliable head data for March 1989. A frozen lock on Well 04U077 and an apparent water level error for Well 03L077 posed problems that ultimately influenced the outcome of Figures 4.14 and 4.15. From our conversations with CRA, we understand

that heads for Units 3 and 4 were determined for the graphical enhancement by overlaying the grid over drawdown and water level maps and subtracting the drawdown from the water levels. We request that all information be submitted for each of the steps that were used for constructing the final water level maps (see below).

The water level changes (drawdowns) on Plans 16, 17, and 18 plot values for both Units 3 and 4. Indicate explicitly which water levels (include dates) were used to draw the contours in the figures that were used in the graphical enhancement process. These water levels should be plotted on the appropriate plans. If contours were placed on the figures using information other than the values plotted, discuss this information in the text.

In addition to the information needs cited above, we specifically request the following documentation:

*Table(s) of all water levels used in the analysis.

*Figures for each unit illustrating pre-pumping water levels, water levels while the system was pumping, drawdowns, and the graphically enhanced water levels (as shown in the report). Each figure should show the measured value at each well, the contours, and the value assigned to each node used in the analysis. The format should be similar to that of Figures 4.14 and 4.15. Also, some values in Table 4.2 were found to be incorrect. Please correct in the updated copy.

Augmenting the report with this information should provide the necessary data to those who wish to review it in the future and want to understand the rationale behind the analysis.

Closed water level contours around pump out wells should not be drawn without supporting data. We realize that the graphical enhancement procedure was used to infer closed contours in many instances. This is acceptable, but we prefer dashed contours, since actual water level measurements are not available. At a minimum, if solid contours are used in these instances, they should be explicitly qualified in the text by citing the graphical enhancement report in future monitoring reports. Dashed contours shall be used where data or analyses cannot ascertain the existence of closed contours. Additionally, all closed contours illustrating drawdown should be hachured.

Errata

The following comments list errata in the text, appendices or on plan sheets. Responses to these comments are unnecessary. If this information is reused in future reports or letters, the information must contain the revisions documented below.

Table 1.2

For ground water quality monitoring, this table needs a footnote stating that annual and quarterly sampling equals four events a year. For extraction well ground water quality monitoring, there are three quarterly events and one annual event.

Figure 2.2

The red sandy till is missing on this cross-section.

Pages 15 and 18
Paragraphs 3 and 2

The 70 foot saturated thickness of the Hillside Sand at well B2 does not appear to be correct.

Page 15 and Figure 2.3

The 04U and 03L plots may be mislabeled. Additionally, the two plots appear to cross at 200 minutes. No explanation was provided that accounts for this seemingly erroneous phenomenon.

No discussion of spatial variations in transmissivities between the source control wells and the BGRS wells was provided.

Page 19

The equations at the top of the page are inconsistent.

Page 24
Paragraph 3

Although Well Pump 4 is mentioned, no mention is made of the fate of water entering wet well 4. It appears that it is treated in a fashion similar to that of the water from wet well 3.

Page 43
Paragraph 3

The text refers to a "northeasterly gradient from T2L3 to 03L077". Well 03L077 should be well 03L079 instead.

Page 44
Paragraph 1

Well T6U3 should be well T6L3.

Page 46
Paragraph 2

Further justification is needed to attribute mounding from the gravel pit as the sole cause of the higher pumping rate observed for the northern portion of the BGRS, relative to that of the southern portion. The higher discharge from the northern portion of the BGRS may be attributable in large part to the contaminant distribution and to the locations of pump out well screens.

Pages 53 and 55
Paragraphs 2 and 3

No attempt is made to relate the transmissivities of the source control wells (Table 2.5), CRA's transmissivity of "21,424 ft 2/day" derived on page 17 for the entire Unit 3, and the soils stratigraphy from Unit 3 in the vicinity of the BGRS.

Appendix A.1 (Water Level Database)

Water levels in the first column for January 11, 1990, do not make sense.

Appendix B.1

In future reports, organize data presented by well nest.

Plan Sheets 2 and 3

Sampling dates are not provided on plan sheets.

Plan Sheet 4

Cross-section B-B' does not show well 03L091 penetrating three feet into the St. Lawrence Formation, as is noted on its log.

The log for well T6L3 shows the contact between the Hillside Sand and the Prairie du Chien Group at approximately 655 feet MSL. On the B-B' cross-section, the top of the Prairie du Chien Group for well T6L3 is shown incorrectly at approximately 668 feet MSL .

The MGS log for well 03L018 shows a depth that extends five feet into the Prairie du Chien Group and an approximate elevation of 762 feet MSL. The contact at well 03L018 is shown incorrectly on the B-B' cross-section as approximately 700 feet MSL.

The screened interval for well 03U090 on cross-section B-B' is not shown. Also, the bottom elevation of the boring for well 03U090 is 826 feet MSL, which does not penetrate the St. Lawrence Formation.

The St. Lawrence Formation is not shown at the bottom of the boring for well 03L113; nor is the line representing the contact extended.

Plan Sheet 5

According to the log, the top of the open interval for well T2PJ is 198 feet from ground surface (704 feet MSL). However, the top of the open interval for the well is shown on Cross-section C-C' at 694 feet MSL.

A bottom elevation of 782 feet MSL is depicted for well 03U647 on cross-section C-C'. However, we estimate an elevation of approximately 822 feet MSL from the well log. List the source of the information from 822 to 782 feet MSL on future reports that illustrates this well in cross-section.

The log for well 03L029 shows the top of the Prairie du Chien Group at approximately 752 feet MSL elevation, not 715 to 710 feet MSL. The source of the information for the stratigraphy from 752 to 715 or 710 feet MSL at that location was not provided.

Plan Sheet 6a

The red sandy till in the Hillside Sand that extends through well 89 and the 077 well nest on this cross-section was not illustrated.

Plan Sheet 6b

The log for Well 03L078 indicates that the Prairie du Chien Group contact is at approximate elevation 751 feet MSL instead of approximate elevation 710 feet MSL.

Plan Sheets 7 through 18

Water level measurement dates are not provided on the plan sheets.

PART I

INSTALLATION RESTORATION PROGRAM
TWIN CITIES ARMY AMMUNITION PLANT

1989 ANNUAL MONITORING REPORT
TEXT - VOLUME 1 OF 3

Distribution is limited to U.S. Government Agencies only for protection of privileged information. Other requests for the documents must be referred to:

Commander
Twin Cities Army Ammunition Plant
New Brighton, Minnesota
55112-5000

Prepared for:

Commander
Twin Cities Army Ammunition Plant
ATTN: SMCTC-CO
New Brighton, Minnesota 55112-5000

Commander
U.S. Army Toxic & Hazardous Materials Agency
ATTN: CETHA-CO
Aberdeen Proving Ground, Maryland 21010-5401

MAY 1990
(Final Report)

FEDERAL CARTRIDGE COMPANY
WENCK ASSOCIATES, INC.

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PART I

INSTALLATION RESTORATION PROGRAM
TWIN CITIES ARMY AMMUNITION PLANT
1989 ANNUAL MONITORING REPORT

VOLUME 1 - TEXT

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GLOSSARY

3M	Minnesota Mining and Manufacturing Company
CRA	Conestoga-Rovers & Associates Limited
FCC	Federal Cartridge Company
FFA	Federal Facility Agreement
IRA	Interim Remedial Action
IRDMS	Installation Restoration Data Management System
ISV	In-Situ Volatilization System
MCL	Maximum Contaminant Level
MPCA	Minnesota Pollution Control Agency
MSL	Mean Sea Level
NA	Not Applicable or Not Available
NPDES	National Pollution Discharge Elimination System
QA/QC	Quality Assurance/Quality Control
RAL	Recommended Allowable Limit
SEC	Secondary Drinking Water Standard
SLAEM	Single Layer Analytic Element Model
TCAAP	Twin Cities Army Ammunition Plant
TGRS	TCAAP Groundwater Recovery System
TOS	Top of Ground Surface Elevation
USATHAMA	United States Army Toxic and Hazardous Materials Agency
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound
WAI	Wenck Associates, Inc.

I. INTRODUCTION

A. Site Description and Background

The Twin Cities Army Ammunition Plant (TCAAP), a government-owned, contractor-operated facility, is located near New Brighton, Minnesota, in the northern portion of the Minneapolis - St. Paul metropolitan area (Figure 1.1). The facility occupies about 2,300 acres lying immediately east of U.S. Interstate Highway 35W and north of Minnesota Highway 96. Federal Cartridge Company (FCC) is the contracted operator, and several other private companies including Honeywell Inc. and Minnesota Mining and Manufacturing Company (3M) conduct operations on the facility as tenants.

TCAAP consists of seven major production buildings and numerous support buildings concentrated in the south and west portions of the facility.

TCAAP was constructed in 1941 to provide small caliber ammunition for the military needs of the United States. Production began in 1941 and since then there have been periods of activity and shutdown. Production was most recently suspended in August of 1974 and the facility has been on standby since then.

During periods of activity, solvents were utilized as part of the manufacturing process. Disposal of solvents at the TCAAP site has resulted in groundwater contamination which has migrated beyond the site boundary.

Groundwater contamination was first discovered in July of 1981 at four of the six TCAAP production wells. Since then, groundwater contamination has been detected in the municipal water supply wells in New Brighton and St. Anthony, communities southwest of TCAAP. The United States Army, FCC, Honeywell Inc. and the Minnesota Pollution Control Agency (MPCA) have since installed numerous on- and off-site wells to

monitor and assess the movement and remediation of TCAAP groundwater contamination.

On- and off-site monitoring wells have been installed in several aquifer units beneath the site. These aquifer units, as referred to in this report, are described below:

Unit 1-the uppermost aquifer beneath TCAAP where water table conditions generally exist.

Unit 2-underlies Unit 1 and is considered an aquitard. This unit is not discussed further in this report.

Unit 3-underlies Unit 2 and is considered to be partially hydraulically connected to Unit 4. This unit is considered to be at least in part the St. Peter sandstone.

Unit 4-underlies Unit 3 and is hydraulically connected to Unit 3. This unit is of the Prairie du Chien-Jordan aquifer.

The report includes information on wells screened in the Units 1, 3, and 4.

A number of contaminant source sites have been identified on the TCAAP property (Sites A, B, C, D, E, F, G, H, I, J, K, 129-3, 129-5, 129-15). These sites are shown on the map in Figure 1.2.

A monitoring program was initiated in January of 1984 by the United States Army Toxic and Hazardous Materials Agency (USATHAMA) to obtain water quality and water level information. Twenty-four quarterly monitoring events have occurred in the period since then. The data gathered during those events have been recorded in the USATHAMA Installation Restoration Data Management System (IRDMS).

B. Purpose

This 1989 Annual Monitoring Report summarizes and evaluates data from Monitoring Quarters 21 through 24 (Winter Quarter 1989 to Fall Quarter 1989). The Winter Quarter is the first quarter of the year, or January through March.

The purposes of this 1989 Annual Monitoring Report are to:

1. Provide a comprehensive source for data from TCAAP monitoring activities.

2. Evaluate the remediation systems (Interim Remedial Action systems [IRAs]) that are in operation at TCAAP.

3. Characterize groundwater conditions associated with TCAAP based on both on- and off-site monitoring wells.

4. Characterize TCAAP surface water conditions at on-site sampling locations.

The contents, preparation, and schedules for this report have been determined by a TCAAP agreement with federal and state environmental agencies. The Federal Facility Agreement (FFA) was signed December 31, 1987 between the United States Army, the United States Environmental Protection Agency (USEPA) and the MPCA. The agreement dictates the content requirements of the Annual Monitoring Report.

Volume 1 of this report includes the Text, while Volume 2 includes the Tables and Volume 3 includes the Figures. This report also includes in Appendix A (Volume 3) those figures for the 1988 Monitoring Report that have been revised in response to MPCA comments.

In response to the requirements of the FFA, two other reports have also been submitted as separate documents. Those reports, which address FFA requirements not addressed herein, include:

- 1990 Annual Monitoring Plan.
- The Honeywell, Inc. portion of the 1989 Annual Monitoring Report prepared by their consultant Conestoga-Rovers Associates (CRA).

The 1990 Annual Monitoring Plan was submitted in February 1990. The Honeywell, Inc. portion of the 1989 Annual Monitoring Report will be referred to herein as Part 2 of the 1989 Annual Monitoring Report. The present document will be referred to herein as Part 1 of the 1989 Annual Monitoring Report.

C. Report Format

The following four major sections report and discuss the 1989 monitoring data.

Chapter II-Groundwater Levels presents data collected during groundwater level measurements at on- and off-site monitoring wells. The chapter presents data from those measurements as complete tables of groundwater level data for Monitoring Quarters 16 through 24 (Fall Quarter 1987 to Fall Quarter 1989). Maps of locations where groundwater measurements were taken are also presented. Groundwater level hydrographs showing trends in groundwater levels and groundwater level contour maps showing areal variation of groundwater levels in the various aquifer units are also presented.

Chapter III-Groundwater Quality presents data obtained from groundwater sampling and analysis from on- and off-site TCAAP monitoring wells. The chapter presents the sampling data as tables of groundwater quality data for Monitoring Quarters 16 through 24 (Fall Quarter 1987 to Fall Quarter 1989). Groundwater quality trends showing

changes in groundwater quality over time are also discussed (the actual trend plots prepared from the data are included in the 1990 Annual Monitoring Plan - Wenck Associates, Inc., February 1990). A final section of the chapter discusses groundwater water quality data found to exceed the groundwater action criteria (threshold values of various chemical compounds) as defined by the Federal Facility Agreement (FFA) for TCAAP. Groundwater quality isoconcentration maps are also presented. These maps show the areal variation of chemical compounds found in the aquifer units beneath and downgradient from the TCAAP site.

Chapter IV-Surface Water presents data obtained from surface water sampling associated with TCAAP monitoring activities. The chapter presents data in tables showing chemical compounds found at various sampling locations. The number of data items from surface water sampling is significantly smaller than the groundwater data presented in Chapters II and III.

Chapter V-Discussion is an evaluation of contaminant source sites that have been delineated on the TCAAP facility. The first two sections of the chapter are divided between two groups of contaminant source sites associated with the TCAAP facility. The first section characterizes a group of sites that are presently under remedial investigation [not undergoing any remediation activities (non-IRA)]. The section also characterizes those sites undergoing interim remedial action (IRA) that are more fully discussed in Part 2 of the 1989 Annual Monitoring Report by Honeywell, Inc. (Sites D, G, and I). The second section of the chapter discusses those sites (Sites A and K) not discussed in Part 2 by Honeywell, Inc. that are presently undergoing remediation [undergoing Interim Remedial Action (IRA)]. The remedial activities (IRAs) at these sites are assessed for their effectiveness. The data from the above three chapters were integrated into the analysis of these two groups of sites. A final section of the chapter discusses groundwater quality data found to exceed the groundwater action criteria as defined by the FFA.

II. GROUNDWATER LEVELS

A. Groundwater Level Measurement Locations

Groundwater levels were measured at multiple well locations across the TCAAP facility and at numerous off-site wells. All locations at which groundwater level measurements were taken have been compiled onto several maps. Due to the density of monitoring wells within the TCAAP boundaries, location maps of the site were separated into varying areas of coverage. The maps (without well locations) and their coded series names are described in the following list. These L-Series base maps ("L" for Levels) are shown in Volume 3 of this report as Figures 2.1 through 2.5.

- LA Series-Scale=1 inch to 5000 feet: the map extends six miles south and four miles west of the TCAAP boundaries (Figure 2.1, New Brighton Area)

- LB Series-Scale=1 inch to 2500 feet: the map extends two miles south and one mile west of the TCAAP boundaries (Figure 2.2, TCAAP and Vicinity).

- LC Series-Scale=1 inch to 200 feet: the map shows the area around TCAAP Site K (Figure 2.3, Site K Area).

- LD Series-Scale=1 inch to 300 feet: the map shows the area around TCAAP Site A (Figure 2.4, Site A Area).

- LE Series-Scale=1 inch to 500 feet: the map shows the area around the TCAAP-TGRS Site (Figure 2.5, Southwest Boundary Area).

The L-Series base maps will be used in the presentation of mapped data associated with groundwater level measurements.

Using the L-Series format, maps of the locations where groundwater levels were measured are provided in Figures 3.1.1 through 3.5.3. The maps show the locations of the TCAAP facility and off-post monitoring wells that were measured during Monitoring Quarters 16 to 24 (Fall Quarter 1987 to Fall Quarter 1989). Well locations are indicated on the maps with a cross. The monitoring well number corresponding to the location is placed immediately to the right of the well symbol.

In most instances on the maps, each well name indicates the aquifer unit in which the well is screened. The first three letters of the well name indicate the aquifer unit:

1. Unit 1 Upper = 01U
2. Unit 1 Lower = 01L
3. Unit 3 Upper = 03U
4. Unit 3 Middle = 03M
5. Unit 3 Lower = 03L
6. Unit 3 (Pumping Wells) = 03F
7. Unit 4 Upper = 04U
8. Unit 4 (Prairie du Chien or Jordan Wells) = PJ#, 04J

The last three numbers of the well names indicate a specific well in the aquifer unit.

The maps of the groundwater measurement locations are arranged according to different aquifer units. The maps are arranged as shown in the following list:

3.1 Unit 1 Measurement Locations:
LB-Series Map, LC-Series Map, LD-Series Map, LE-Series Map (Figures 3.1.1 through 3.1.4.

3.2 Unit 3 Upper Measurement Locations:
LB-Series Map, LE-Series Map (Figures 3.2.1 and 3.2.2).

3.3 Unit 3 Middle Measurement Locations:
LA-Series Map, LB-Series Map (Figures 3.3.1 and 3.3.2).

3.4 . Unit 3 Lower-Measurement Locations:
LA-Series Map, LB-Series Map (Figures 3.4.1 through 3.4.3).

3.5 Unit 4-Measurement Locations:
LA-Series Map, LB-Series Map, LE-Series Map (Figures 3.5.1 through 3.5.3).

Data for the maps, tables, and figures in this chapter were taken from two databases provided by USATHAMA and Honeywell, Inc. The data included FCC and Honeywell, Inc. on-site monitoring wells and TCAAP off-site wells used by FCC for monitoring purposes. For cross-referencing monitoring well names and coordinate locations, this information is included in Volume 2 as Table 13. The table includes multiple well names corresponding to the same well and coordinates in two separate geographic coordinate systems. Creation of the maps of this section used the data in Table 13 to plot the monitoring well names to their proper locations.

B. Groundwater Level Data

The groundwater level data are compiled in Tables 1 and 2. Table 1 presents the groundwater level data arranged by well number. Table 2 presents the groundwater level data arranged according to well nest. In both tables, the well numbers are listed vertically along the left-hand side of each page. Tables 1 and 2 consist of five pages vertically by four pages horizontally. Also included along the left-hand side of each page is the ground surface elevation (TOS) at the well. The TOS is recorded in feet, Mean Sea Level (MSL).

Specific monitoring quarters and dates are listed as column headings across the top of each page of each table. The monitoring dates covered by Tables 1 and 2 are from

Monitoring Quarters 16 to 24 (Fall Quarter 1987 to Fall Quarter 1989). Units of all groundwater elevations are in feet, MSL. The data from Monitoring Quarters 16 through 20 (Fall Quarter 1987 to Fall Quarter 1988) were also included in the tables to cross reference to the groundwater level hydrographs discussed later in this chapter. The hydrographs were more complete in showing groundwater level trends by including the level data gathered previous to 1989.

Data on specific wells at each monitoring event were combined across the tables so that time variations in groundwater levels can be readily determined. From analysis of the FCC groundwater level data, a total of 367 wells with 2328 data values were found. From the Honeywell data, 167 wells with 2697 data values were found. Some of the same wells were sampled by both FCC and Honeywell. As a result, less than the sum total of wells from the two data sets is included in Tables 1 and 2.

C. Quality Assurance/Quality Control (QA/QC) Checks

To ensure that reasonable data values were used in compiling the groundwater level data, Quality Assurance/Quality Control(QA/QC) procedures were incorporated into the construction of the groundwater level tables. From the QA/QC procedures, Table 3 was created. This table represents all data points not included from the original FCC and Honeywell data sets of groundwater levels. A total of 128 data points were considered outliers and were removed from the original data sets. In the table, the removed data item and its corresponding monitoring date are indicated with each well number. The rationale and the data set from which the data [FCC or Honeywell/CRA] were removed are also listed for each item. The rationale are explained in the following paragraphs.

To begin the QA/QC procedures, the original groundwater level data were first compiled into tables similar to Tables 1 and 2. Trend plots of groundwater levels for groups of six wells were created. The trend plots were checked for extremely high or low groundwater elevations as the first iterative QA/QC test. Those data values found to be out of the

normal range for the cumulative data set were considered outliers and removed from the tables. These removed data points have "too high" or "too low" listed in Table 3 as the rationale. A second QA/QC iteration was performed on the revised tables. Trend plots were again created from the revised data. The revised trends were then checked on a finer scale for data points that did not fit into realistic behavior for groundwater levels. Conditions against which the groundwater levels were checked on the second iteration included:

- similarity to groundwater levels in wells in the same aquifer and in close proximity.
- whether a well was under the influence of direct or nearby pumping.
- whether groundwater levels increased dramatically on a single monitoring date.
- whether groundwater levels followed typical variation between seasons.

Those data points removed during the second iteration were listed with "inconsistent" as the rationale. All data points removed in the two iterative steps were then saved and compiled into Table 3.

D. Hydrographs

For review of time variation in groundwater levels, hydrographs or trend plots were created from the FCC data presented in Table 1. The resulting plots are provided as Figures 4.1 through 4.76. In each of the plots, groundwater level data for a group of up to six wells are shown for the time period between Monitoring Quarters 16 to 24 (Fall Quarter 1987 and Fall Quarter 1989).

To better indicate the trends in groundwater levels, well data from Table 1 were regrouped by aquifer unit and well location. The plots in Figures 4.1 through 4.76 are arranged as follows:

- Unit 1-Arranged by Wells in Similar Locations (Figures 4.1 through 4.29).

- Unit 3 or 4-Arranged by Wells in Similar Locations (Figures 4.30 through 4.76).

A more complete listing of the hydrographs can be found in the List of Tables.

Wells located in close proximity and whose screens are in the same aquifer should have similar groundwater level behavior. The above arrangement allows for the most wells to be shown in conjunction with other wells having similar groundwater level trends.

Each well with its corresponding symbol is shown at the bottom of each plot. Monitoring dates are placed along the horizontal axis and groundwater elevations along the vertical axis of each plot. Groundwater elevations were kept within a range of 20 feet on the vertical scale.

E. Contour Plots of Groundwater Levels

To present the spatial variation of groundwater levels at TCAAP, map plots of groundwater levels were created from the FCC data in Table 1. The plots are provided in Volume 3 of this report as Figures 5.1.1.1 through 5.5.3.2. The groundwater level data for 1989 covered by the contour plots includes Monitoring Quarter 22 to 24 (Spring Quarter 1989 to Fall Quarter 1989). Note that Quarter 22 (Spring Quarter 1989) is the first monitoring quarter shown. No groundwater level data were available for Quarter 21 (Winter Quarter 1989). The groundwater level data in the plots overlay various L-Series maps of the areas at or near the TCAAP facility. Groundwater level contours were also included in almost all of the plots. Where there were insufficient data points to create a contour plot, only the groundwater elevations were included on the maps.

All plots include groundwater level data for a specific aquifer unit measured during a specific monitoring quarter. The well locations corresponding to the groundwater levels shown on the plots are indicated by a cross symbol. The groundwater elevation is shown to the right and down from the well symbol. In the map title, the aquifer unit, L-Series

Map, and quarter in which the groundwater levels were measured are indicated. The groundwater elevation contours shown on the plots are in feet, MSL.

A full listing of the arrangement of the plots of groundwater elevations and contours is included in the List of Figures of this report.

Generally, groundwater levels were measured only once per well per quarter. However, if the groundwater levels were measured more than once during the quarter, then data for that monitoring point was averaged. The Honeywell, Inc. (CRA) database was not included in the plots because almost all its monitoring wells were also included in the FCC database. Including the Honeywell, Inc. database would have introduced elevation data measured on dates differing from the FCC quarterly measurement dates, sometimes by up to two to three months. The averaging of level data for such time-separated measurements of fluctuating groundwater levels would have introduced gross errors in areal groundwater levels.

The representation of realistic groundwater levels by the data was considered before contours were included on any of the plots. Contours were included on the plots only after determining that the groundwater levels were consistent with the known flow conditions and pumping configurations at the TCAAP site. Those wells deemed inconsistent with site groundwater levels were not included on the plots.

III. GROUNDWATER QUALITY

For monitoring activities associated with the TCAAP facility, groundwater quality data for the period from Monitoring Quarters 16 to 24 (Fall Quarter 1987 to Fall Quarter 1989) have been included in this report.

A. Groundwater Sampling Locations

Groundwater samples were gathered at numerous well locations across the TCAAP facility site and at numerous off-post wells. Like the groundwater measurement locations, all locations at which groundwater quality samples were taken have been compiled onto several maps.

Due to the density of monitoring wells within the TCAAP boundaries, location maps of the site were separated into varying areas of coverage. The location maps (without well locations) and their coded series names are described in the following list. These Q-Series maps ("Q" for Quality) are shown as Figures 6.1 through 6.5.

- QA Series-Scale=1 inch to 10000 feet: the map extends fifteen miles south and ten miles west of the TCAAP boundaries (Figure 6.1 Twin Cities Metropolitan Area).

- QB Series-Scale=1 inch to 2500 feet: the map extends two miles south and one mile west of the TCAAP boundaries (Figure 6.2, TCAAP and Vicinity).

- QC Series-Scale=1 inch to 200 feet: the map shows the area around TCAAP Site K (Figure 6.3, Site K Area).

- QD Series-Scale=1 inch to 300 feet: the map shows the area around TCAAP Site A (Figure 6.4, Site A Area).

- QE Series-Scale=1 inch to 500 feet: the map shows the area around the TCAAP-TGRS Site (Figure 6.5, Southwest Boundary Area).

The Q-Series base maps will be used in the presentation of all mapped data associated with groundwater quality sampling.

Maps of the locations where groundwater samples were taken are provided in Volume 3 of this report as Figures 7.1.1 through 7.5.3. The maps show the locations of all TCAAP facility and off-post monitoring wells that were sampled sometime during Monitoring Quarters 16 to 24 (Fall Quarter 1987 to Fall Quarter 1989). Well locations are indicated on the maps with a cross. The monitoring well number corresponding to the location is placed to the right of the well symbol.

Like the groundwater measurement data, data for the maps, tables, and figures in this chapter were taken from two databases provided by USATHAMA and Honeywell, Inc. The data included FCC and Honeywell, Inc. on-site monitoring wells and TCAAP off-site wells used by FCC for monitoring purposes. For cross-referencing monitoring well names and coordinate locations, this information is included as Table 13. The table includes multiple well names corresponding to the same well and coordinates in two separate geographic coordinate systems. Creation of the maps of this section used the data in Table 13 to plot the monitoring well names to their proper locations.

B. Groundwater Quality Data

Groundwater quality data are compiled in Tables 4 through 7. The tables are provided in two sets. The first set of two tables (Tables 4 and 5) is arranged by wells in numerical order. The second set of two tables (Tables 6 and 7) is arranged by well nest. The first table of each set (Table 4 or 6) is composed of groundwater quality analyses for organic compounds--the second (Table 5 or 7) for inorganics.

Each table consists of 29 pages vertically by 2 pages horizontally. The monitoring dates covered by Tables 4 through 7 are from Monitoring Quarters 16 to 24 (Fall Quarter 1987 to Fall Quarter 1989). Data from Monitoring Quarters 16 through 20 (Fall Quarter 1987 to Fall Quarter 1988) were also included in the tables to cross reference to the groundwater quality trends discussed later in this chapter. The trend plots were more complete in showing groundwater quality trends by including the quality data gathered previous to 1989. In all four tables, the well numbers are listed vertically along the left-hand side of each page. Compounds or monitoring parameters are listed as column headings across the top of the tables. The monitoring parameter headings also include the original TCAAP chemical code beneath the proper parameter name.

All units for the data are in micrograms per liter (ug/l), except for radionuclides, which are in picocuries per liter (pC/l). Whenever a parameter was analyzed to be below detection limits (BDL), the data item is shown in the tables as a < sign preceding the detection limit(e.g. <0.10). Under the heading QTR, the quarter of analysis is indicated. The quarter number is preceded by an F or an H, where F corresponds to FCC data and H corresponds to Honeywell data. Under each column heading, a value for Recommended Allowable Limit (RAL), Maximum Concentration Limit (MCL), or Secondary Drinking Water Standard (SEC) is listed. These values are provided in reference to the groundwater quality trend plots discussed in section E of this chapter. These limits were obtained from a Minnesota Department of Health Release No. 2 (November, 1988). For most compounds or parameters, the RAL value was used. If the RAL was unavailable, the MCL or SEC was listed. If no value for any of these limits could be found, NA is listed (Not Available). The value used for RAL, MCL, or SEC was also plotted as a straight horizontal line in the graphs of the groundwater quality trends (discussed in a next section).

C. Exceedance of Groundwater Action Criteria

Groundwater quality data found to exceed the groundwater action criteria defined in the FFA are compiled in Table 8. The monitoring dates covered by Table 8 are from Monitoring Quarters 21 to 24 (Winter Quarter 1988 to Fall Quarter 1989). Like the groundwater quality data tables, well numbers are listed vertically along the left-hand side of each page. Compounds or monitoring parameters are listed as column headings across the top of the tables. The monitoring parameter headings also include the original TCAAP chemical code beneath the proper parameter name.

All units for the data are in micrograms per liter (ug/l), except for radionuclides, which are in picocuries per liter (pC/l). Another column indicates the full sampling date. Under the heading QTR, the quarter of analysis and data source are indicated (F=FCC data, H=Honeywell data). Under each compound or monitoring parameter heading, a value for the groundwater action criteria is listed in addition to the RAL (the RAL is not related to the action criteria).

D. Groundwater Quality QA/QC Data

Groundwater sampling QA/QC data were also provided in the original groundwater quality data. These data values were not included in the tables of groundwater quality data (Tables 4 through 7). Instead, they were compiled into separate tables (Tables 9 and 10) described in this section. The two tables have been separated into groundwater quality analyses for gas chromatography/mass spectrometry (GC/MS) and GC/inorganics (Tables 9 and 10, respectively). Table 9 of GC/MS data consists of 19 pages; Table 10 of GC/inorganic data consists of 46 pages. The tables list those samples analyzed for quality control purposes as part of the TCAAP monitoring program. The data is first arranged by type of QA/QC sample and then by monitoring quarter along the left side of the table. Entries in the table include the type of QA/QC sample, spiked concentration, the sampling parameter analyzed for, the lab test method, and the concentration measured. The codes for sample type and spikes are included at the end of the tables.

E. Groundwater Quality Trends

Trend plots showing time variation in groundwater quality with time were not included in this report. Groundwater quality trends created from Tables 4 and 5 of this report were presented in the TCAAP 1990 Annual Monitoring Plan (Wenck Associates, Inc., February 1990). The trends represented data for 48 monitoring parameters covering Monitoring Quarters 16 through 24 (Fall Quarter 1987 to Fall Quarter 1989). Due to the large number of the trend plots, they are part of this report by reference.

F. Groundwater Quality Data Plots/Isoconcentration Contour Maps

Spatial variations in groundwater quality data are presented in this report as data plots or isoconcentration contour plots. The plots were created from the data of Tables 4 and 5. The plots are provided in Volume 3 of this report as Figures 8.1.2.2.2 through 8.10.5.5.4. The data covered by the plots includes Monitoring Quarters 21 through 24 (Winter 1989 through Fall 1989). The groundwater quality data in the plots for a specific monitoring parameter overlay various maps of areas at or near the TCAAP facility. Concentrations of monitoring parameters measured during a given monitoring quarter are indicated on the maps at the locations of the wells sampled. The plots are limited to groundwater concentrations for a specific aquifer unit sampled during a specific monitoring quarter. The well locations where samples collected are shown on the plots are indicated by a cross. The parameter concentrations are shown to the right of the well symbol. In the map title, the sampling parameter, the aquifer unit, Q-Series map and quarter from which the samples were taken are indicated.

A list of the groundwater quality isoconcentration maps for various monitoring parameters is included in the List of Figures of this report and can be found in Volume 3.

IV. SURFACE WATER

For monitoring activities associated with the TCAAP facility, available surface water quality data for Monitoring Quarters 16 to 24 (Fall Quarter 1987 to Fall Quarter 1989) were included in this report. The amount of data was much less relative to the groundwater quality and level data of the previous two chapters. The data were, however, compiled into tables much like the groundwater data.

A. Surface Water Quality Data

Surface water quality data are compiled in two tables (Tables 11 and 12). Table 11 is composed of surface water quality analyses for organic compounds--Table 12 is data from analyses for inorganics.

Table 11 (organics data) consists of two pages vertically by two pages horizontally. Table 12 (inorganics data) consists of two pages vertically by three pages horizontally. The monitoring dates covered by Tables 11 and 12 are from Monitoring Quarters 16 to 24 (Fall Quarter 1987 to Fall Quarter 1989). In both tables, the sampling site description and number are listed vertically along the left-hand side of each page. Compounds or monitoring parameters are listed as column headings across the top of the tables. The monitoring parameter headings also include the original TCAAP chemical code beneath the proper parameter name.

All units for the data are in micrograms per liter (ug/l), except for radionuclides, which are in picocuries per liter (pC/l). Whenever a parameter was analyzed to be below detection limits (BDL), the data item is shown in the tables as a < sign preceding the detection limit(e.g. <0.10). Under the heading QTR, the quarter of analysis is indicated. Under the heading DATE, the sampling date is also indicated.

B. Exceedance of Surface Water Action Criteria

No surface water quality data for Quarters 21 to 24 were found to exceed the surface water action criteria as defined in the FFA.

V. DISCUSSION

The first two sections, Sections A and B, of this chapter are divided between two groups of contaminant source sites associated with the TCAAP facility. The first section characterizes a group of sites (Sites B, C, E, F, H, J, 129-3, 129-5, 129-15) that are presently under remedial investigation [not undergoing any remediation activities (non-IRA)]. The section also characterizes those sites undergoing Interim Remedial Action (IRA) that are more fully discussed in Part 2 of the 1989 Annual Monitoring Report by Honeywell, Inc. (Sites D, G, and I). The second section of the chapter discusses those sites (Sites A and K) not discussed in Part 2 by Honeywell, Inc. that are presently undergoing remediation [undergoing Interim Remedial Action (IRA)]. The remedial activities (IRAs) at these sites are assessed for their effectiveness. A final section, Section C, of the chapter discusses water quality data found to exceed the groundwater action criteria defined by the FFA.

A. Site Characterization

1. Site B

Site B is located near the northern boundary of the TCAAP facility (see Figure 1.2). Remedial investigations at Site B indicated that no significant impacts have occurred to groundwater in either Units 1 or 3. Limited monitoring was performed at Site B during 1989 to verify that no impacts have occurred. The principal wells monitored were 01U036 and 01U101.

The groundwater flow pattern observed in 1989 at Site B is similar to previous years. Groundwater in Unit 1 flows northwest beneath most of the site; however, a groundwater flow divide exists such that beneath the eastern boundary groundwater flows to the northeast. Groundwater in Unit 3 flows to the southwest. Hydrographs for Site B wells

in Unit 1 are shown as Figures 4.3 and 4.12. Groundwater elevation contour maps are designated Figures 5.1.1.1 through 5.1.1.3 for Unit 1 and 5.2.1.1 through 5.2.1.3 for Unit 3.

Similar to previous years, sporadic detections of VOCs were observed in Site B wells during 1989. The cause of the inconsistent detections is unclear. Water quality trends for Site B wells were presented in the 1990 Monitoring Plan. Plots of selected parameters from the 1989 groundwater quality data are also presented as Groundwater Quality Isoconcentration Maps in Section 8 of the Figures.

2. Site C

Site C is located near the north-central area of the TCAAP facility as shown on Figure 1.2. Previous investigations of Site C revealed no significant impacts to groundwater in either Unit 1 or Unit 3. Water level measurements were conducted at Site C wells during 1989, but no water quality analysis was performed.

Hydrographs for wells in the vicinity of Site C are shown in Section 4 of the Figures. Groundwater elevation contour maps for wells near Site C are designated Figures 5.1.1.1 through 5.1.1.3 for Unit 1 and Figures 5.2.1.1 through 5.2.1.3 for Unit 3.

Groundwater flow in Unit 1 discharges to an east-west trending ditch in the southern portion of Site C. Groundwater in Unit 3 flows southwest.

3. Site D

Site D is located in the central portion of the TCAAP facility as illustrated in Figure 1.2. The primary focus of site investigations and remedial activities is on Unit 3, since Units 1 and 2 are absent at this site. Significant contamination of the Unit 3 aquifer has occurred as a result of activities at Site D. Corrective measures, including an in-situ

volatilization system (ISV) and a groundwater recovery system, have been installed at or near the site. Halogenated VOCs represent the parameters of principal interest. Historically, only sporadic, low-level detections of aromatic VOCs have been observed.

Hydrographs for wells near Site D are presented in Section 4 of the Figures and groundwater elevation contour maps are in Section 5 of the Figures. Similar to previous years, groundwater flow near Site D is generally to the southwest. Local flow is influenced by two recovery wells which are being pumped downgradient of Site D. Honeywell, Inc. assessed the performance of the recovery wells, including determination of the hydraulic capture zone, in Part 2 of the 1989 Annual Monitoring Report.

Wells 03U018, 03U093, 03M017 near Site D were sampled for analytical testing in 1989. Water quality trends for these wells are presented in the TCAAP 1990 Annual Monitoring Plan. Similar to previous years, significant concentrations of halogenated VOCs were detected in Site D wells. Overall, the concentrations appear to be remaining consistent. Plots of selected parameters from the 1989 groundwater quality data are presented as Groundwater Quality Isoconcentration Maps in Section 8 of the Figures. Groundwater quality in the vicinity of the recovery wells at this site is also addressed in Part 2 of the 1989 Annual Monitoring Report by Honeywell, Inc.

4. Site E

Site E is located near the center of the TCAAP facility as shown on Figure 1.2. The primary focus of site investigations at Site E is on Unit 3 since Units 1 and 2 are absent. Previous studies have suggested that groundwater contamination is moving beneath Site E from an upgradient source since the upgradient wells exhibited the highest concentrations. Halogenated VOCs are the contaminants of concern.

Hydrographs for wells in the vicinity of Site E are presented in Section 4 of the Figures and groundwater elevation contour maps are shown in Section 5 of the Figures. Groundwater near Site E flows to the west-southwest.

Wells 03U704 and 03U705 upgradient from the site were sampled in 1989. Similar to previous sampling events, 1,1,1-trichloroethane and trichloroethene were detected in the wells. In addition, 1,1-dichloroethene was detected in both wells. The concentrations were higher at 03U705, which is farther upgradient than well 03U704. The data continue to suggest an upgradient source. Groundwater quality trends for Site E wells are presented in the TCAAP 1990 Annual Monitoring Plan. These figures indicate that the concentrations are increasing at the wells near the Site E upgradient boundary. Plots of selected parameters from the 1989 groundwater quality data are presented as Groundwater Quality Isoconcentration Maps in Section 8 of the Figures.

5. Site F

Site F is located in the south-central region of the TCAAP facility, somewhat between Sites D and G (see Figure 1.2). Unit 3 represents the aquifer of primary concern. Previous groundwater monitoring studies indicated that halogenated VOCs are the primary concern at Site F, but sporadic detections of aromatic VOCs and cyanide have also been reported.

Hydrographs for wells near Site F are presented in Section 4 of the Figures and groundwater elevation contour maps are shown as Figures 5.2.1.1 through 5.2.1.3. Near Site F, groundwater in Unit 3 flows southwest. Further downgradient of Site F, groundwater flow in the same unit is influenced by recovery wells installed for Sites D and G. The effectiveness of the recovery system is addressed in Part 2 of the 1989 Annual Monitoring Report prepared by Honeywell, Inc.

Well 03U019 near the southeast corner of Site F and well 03L137 near Site F's northwest corner were sampled in 1989. Similar to previous sampling events, low concentrations of 1,1,1-trichloroethane and trichloroethene were reported for well 03U019. No contaminants were detected at well 03L137. The observed concentrations at Site F are relatively insignificant compared to contaminant concentrations at Sites D and G, which are northwest and south of Site F, respectively. Water quality trends for Site F wells are presented in the TCAAP 1990 Annual Monitoring Plan. Plots of selected parameters from the 1989 groundwater quality data are presented as Groundwater Quality Isoconcentration Maps in Section 8 of the Figures.

6. Site G

Site G is located in the south-central portion of the TCAAP facility as shown on Figure 1.2. The primary focus of site investigations and remedial activities is on Unit 3 and the underlying bedrock (Unit 4). Significant contamination to groundwater has resulted from activities at Site G. Corrective measures, including an in-situ volatilization system (ISV) and a groundwater recovery system, have been installed at or near the site. The contaminants of primary concern are halogenated VOCs.

Hydrographs for wells near Site G are shown in Section 4 of the Figures and groundwater elevation contour maps are presented as Figures 5.2.1.1 through 5.2.1.3 for upper Unit 3, Figures 5.4.1.1 through 5.4.1.3 for lower Unit 3, and Figures 5.5.2.1 through 5.5.2.3 for Unit 4. Similar to previous years, groundwater flow near Site E is to the southwest in both Units 3 and 4. Local flow is influenced by two recovery wells being pumped downgradient of Site G. Honeywell, Inc. assessed the performance of the recovery wells for Site G, including determination of the hydraulic capture zone, in Part 2 of the 1989 Annual Monitoring Report.

Wells 03U014, 03M020, 03L138, and 04U020 near Site G were sampled in 1989. Well 03L138 is located upgradient, well 03U014 is immediately downgradient, and wells

03M020 and 04U020 are farther downgradient. Water quality trends for these wells are shown in the TCAAP 1990 Annual Monitoring Plan. Similar to previous years, significant concentrations of halogenated VOCs were detected in Site G wells.

Plots of selected parameters from the 1989 groundwater quality data are presented as Groundwater Quality Isoconcentration Maps in Section 8 of the Figures. Groundwater quality in the vicinity of the recovery wells at this site is also addressed in Part 2 of the 1989 Annual Monitoring Report by Honeywell, Inc.

7. Site H

Site H is located near the southeast corner of TCAAP facility as illustrated on Figure 1.2. Both Units 1 and 3 have been investigated in the past. Previous studies have determined that minimal contamination has occurred to groundwater at Site H; however, sporadic detections of halogenated and aromatic VOCs have been reported.

Hydrographs for wells in the vicinity of Site H are presented in Section 4 of the Figures and groundwater elevation contour maps are presented in Section 5 of the Figures. The groundwater flow direction is unclear in Unit 1. Groundwater in Unit 3 flows southwest.

Wells 03U005 and 03M005 were sampled in 1989. Both wells are located downgradient of Site H. No halogenated VOCs were detected in either well. The samples were not analyzed for aromatic VOCs.

8. Site I

Site I is located at Building 502 near the south boundary of TCAAP (see Figure 1.2). Units 1 and 2 are present beneath all but the northeast portion of Site I. Contamination exists in Units 1, 3, and 4 near the site. Halogenated VOCs represent the contaminants of primary concern, but sporadic detections of aromatic VOCs have also been reported.

Hydrographs for Site I wells are presented in Section 4 of the Figures. Groundwater elevation contours are shown in Section 5 of the Figures. Groundwater flow in Unit 1 varies from south to southwest beneath the eastern portion of Site I to westward beneath the western area of the site. Groundwater in Units 3 and 4 generally flows southwest. Local flow in Unit 3 is influenced by recovery well 03U301 in operation at Site I. Honeywell, Inc. assessed the performance of the recovery well as part of the TGRS, including determination of the hydraulic capture zone, in Part 2 of the 1989 Annual Monitoring Report.

Groundwater quality trends for Unit 1, Upper Unit 3, Middle Unit 3, Lower Unit 3 and Unit 4 are presented in the TCAAP 1990 Annual Monitoring Plan. Plots of selected parameters from the 1989 groundwater quality data are presented as Groundwater Quality Isoconcentration Maps in Section 8 of the Figures. Eleven Unit 1 wells were sampled near Site I during 1989. Detections of halogenated VOCs were reported at six of the eleven wells. Insufficient data are available for these wells to clearly identify trends in water quality.

Fourteen upper Unit 3 wells were sampled during 1989 in the vicinity of Site I and contamination was detected in every well. Water quality trends remained consistent over 1989.

Two Unit 4 wells downgradient of Site I were also sampled during 1989. Contaminants were detected in well 04U003, but not in well 04U027. Water quality trends show consistency over the past two years.

In general, contamination migrating away from Site I is moving towards the TCAAP Groundwater Recovery System (TGRS) at the southwest TCAAP boundary. Honeywell, Inc. assessed the effectiveness of the TGRS, including capture and removal efficiencies, in Part 2 of the 1989 Annual Monitoring Report.

9. Site J

Site J is a sewer line which roughly parallels the southwest boundary of TCAAP as shown in Figure 1.2. The primary focus of investigations at Site J has been on the Unit 1 aquifer. With the exception of well 01U526, no contaminants have been detected in Site J wells in the past.

Hydrographs for Site J wells are shown in Section 4 of the Figures and groundwater elevation contour maps for Unit 1 are presented as Figures 5.1.1.1 through 5.1.1.3. Groundwater flow in Unit 1 varies from southward near the southern and eastern portion of Site J to westward along the western area of the site.

Wells 01U054, 01U062, 01U525, and 01U526 near Site J were sampled in 1989 for both halogenated and aromatic VOC analysis. Similar to previous sampling events, trichloroethene was detected in well 01U526 at a low concentration. No other contaminants were detected in well 01U526, nor any other Site J wells. The water quality trend plot for trichloroethene at well 01U526 is illustrated in the TCAAP 1990 Annual Monitoring Report. The trichloroethene concentration appears to be increasing slightly, but remains at low levels.

10. Site 129-3

Site 129-3 is located near the middle of the TCAAP facility as shown on Figure 1.2. Unit 3 represents the primary concern of site investigations since Units 1 and 2 are absent. In general, significant groundwater contamination has not occurred at Site 129-3; however, sporadic detections of halogenated VOCs have been reported. Cyanide is also a potential contaminant at the site.

Hydrographs for wells near Site 129-3 are presented in Section 4 of the Figures and groundwater elevation contour maps are designated as Figures 5.2.1.1 through 5.2.1.3. Groundwater near Site 129-3 flows to the southwest.

Well 03U087 near Site 129-3 was sampled and analyzed for halogenated VOCs in 1989. Low concentrations of 1,1,1-trichloroethane and trichloroethene were the only contaminants detected. The water quality trends for well 03U087 are presented in the TCAAP 1990 Annual Monitoring Plan. The concentrations over time have been highly variable, but in general they remain low. It is unclear whether the contaminants detected are the result of activities at Site 129-3 or activities further upgradient beyond Site E.

11. Site 129-5

Site 129-5 is located near the east-central region of TCAAP (see Figure 1.2). Unit 1 is limited to the southeast portion of Site 129-5. Unit 2 is suspected to be discontinuous, but this has not been confirmed. The primary focus of investigations at this site has been on the Unit 3 aquifer. Previous investigations reported sporadic detections of halogenated VOCs, but no significant contamination has been observed.

Hydrographs for Site 129-5 wells are presented in Section 4 of the Figures and groundwater elevation contour maps are shown as Figures 5.2.1.1 through 5.2.1.3. Groundwater in Unit 3 flows to the southwest at Site 129-5.

No Site 129-5 wells were sampled in 1989 for water quality analysis, however, a Unit 3 well at Site 129-5 will be sampled in 1990.

12. Site 129-15

Site 129-15 is located near the center of the TCAAP facility as illustrated on Figure 1.2. Site 129-15 is immediately upgradient of Site D. Investigations at this site have focused

on Unit 3 since Units 1 and 2 are absent. Halogenated VOCs are the parameters of primary concern, but sporadic detections of aromatic VOCs have also been reported.

Hydrographs for Site 129-15 wells are presented in Section 4 of the Figures and groundwater elevation contour maps are shown as Figures 5.2.1.1 through 5.2.1.3. Groundwater in Unit 3 flows to the southwest at Site 129-15.

No Site 129-15 wells were sampled in 1989 for water quality analysis, however, two upper Unit 3 wells and one lower Unit 3 well will be sampled at the site during 1990.

13. Southwest Boundary Area and Off-Post

Since the principal direction of groundwater flow in Units 3 and 4 is to the southwest, numerous wells have been installed near the southwest boundary of TCAAP to delineate contaminant plumes. Additional off-post wells further downgradient have been sampled to aid in definition of the contaminant plumes.

Previous studies have shown that as contaminants migrate downgradient, they are also migrating downward within the aquifers. Hence, on-post, the primary focus of investigative activities is on upper Unit 3, with greater emphasis placed on middle Unit 3, lower Unit 3, and Unit 4 at greater distances from the TCAAP boundary.

To control contaminant migration at the TCAAP boundary, a series of recovery wells has been installed that is collectively referred to as the TCAAP Groundwater Recovery System (TGRS). The TGRS operation has a significant impact on groundwater flow patterns and contaminant concentrations in its vicinity. Honeywell, Inc. assessed the performance of the TGRS, including hydraulic capture zones and contaminant removal efficiencies, in Part 2 of the 1989 Annual Monitoring Report.

The scope of this section is to discuss the overall conditions observed during 1989 near the southwest boundary area and off-post areas.

Hydrographs and groundwater elevation contour maps for wells in the various aquifer units are presented in Section 4 of the Figures. Groundwater elevation contour maps for areas near and downgradient from the southwest boundary are shown in Section 5 of the Figures. Groundwater in upper, middle, and lower Unit 3 generally flows to the southwest, both near TCAAP and farther downgradient. Groundwater in Unit 4 flows southwest near TCAAP, but farther downgradient swings more southward. The transition in flow direction is most apparent approximately three miles downgradient from the TCAAP southwest boundary.

Water quality trends for wells near the southwest boundary and off-post are presented in the TCAAP 1990 Annual Monitoring Plan. Groundwater Quality Isoconcentration Maps, for selected parameters, are presented in Section 8 of the Figures. The isoconcentration contour maps indicate that there are two separate lobes to the contaminant plume migrating away from TCAAP (e.g. see Figure 8.5.2.2.4). The southern lobe appears to be the result of activities at Site I, while the northern lobe appears to be linked primarily to Site D. Contamination in upper Unit 3 appears to be limited to an area within one mile of TCAAP, while contamination in Unit 4 extends approximately four and one-third miles downgradient. Inspection of Figures 8.5.5.1.4 and 8.10.5.1.4 suggests that a separate plume of VOC contamination, apparently unrelated to TCAAP, is present in Unit 4 approximately five miles downgradient. The source of this plume is unknown.

B. Interim Remedial Action Evaluation

1. Site A

Site A is located near the northern boundary of the TCAAP facility (see Figure 1.2). The main contamination source found at this site is located near Well 01U108. The

major contaminant compounds found at this site are trichlorethene, tetrachloroethene, and 1,2-dichloroethene. Groundwater located directly beneath Site A in Unit 1 flows in a west-northwesterly direction. The contamination plume is also migrating in Unit 1 in a west-northwesterly direction.

Remediation has been in place at this site since September 1988. Contaminated groundwater is being removed via Well 01U350 and then treated. As required, Federal Cartridge Company submitted a Site A 90-day performance report dated April 28, 1989 to USEPA/MPCA. Additional data on the performance of this Site A recovery system were submitted in the 1988 Annual Monitoring Report in September 1989 by Wenck Associates, Inc. In the following section, the performance of the Site A groundwater recovery system during the period of Quarters 21 through 24 (Winter Quarter 1989 to Fall Quarter 1989) will be discussed.

a. Discussion

Groundwater level hydrographs in the vicinity of Site A are shown in Figures 4.16 through 4.18 in this report. In the hydrographs, minor seasonal fluctuations in groundwater levels are indicated, however, these changes were not as great as those found in the falling groundwater levels in underlying aquifers in the past few years. Groundwater level contours in aquifer Unit 1 for Quarters 22, 23, and 24 are Figure 5.1.3.1, Figure 5.1.3.2, and Figure 5.1.3.3, respectively. The contour maps indicate consistent flow patterns and pumping influence zones. Based on the contour maps, the capture zone for Well 01U350 extends approximately 200 feet downgradient.

Groundwater quality trends for Site A wells can be found in the 1990 Monitoring Plan in Figures C-1 through C-153. Figure C-78 shows the change in concentrations of trichloroethene at Well 01U108 over time. Over the past five quarters of remediation, concentrations of trichloroethene at Well 01U108 have dropped from 750 to 160 ug/l as expected under groundwater remediation.

Groundwater isoconcentration maps for trichloroethene and Total Volatile Organic Compounds (Total VOCs) are shown for Quarter 24 in Figure 8.5.1.4.4 and Figure 8.10.1.4.4, respectively. The extent of contamination shown in the two maps is smaller in comparison to the past conditions shown in Figures L-2 and L-5 of the TCAAP 1988 Annual Monitoring Report.

b. Conclusions

The Site A groundwater recovery system is performing well. The capture zone of the recovery system encloses the entire contamination area. At the current rate of contaminant removal, trichloroethene at Well 01U108 should fall below the groundwater action criteria in four to five years.

c. Recommendations

In order to define the captured zone of the pumping system and to evaluate the rate of site cleanup, a simulation of the recovery systems via a computer groundwater flow model is recommended. The recovery system could be easily simulated with a pumping well in a uniform flow field. Dr. Otto Strack's Single Layer Analytic Element Model (SLAEM) would adequately handle such a simulation.

2. Site K

Site K is located near the west central boundary of the TCAAP facility (see Figure 1.2). This site is currently under remediation via a groundwater collection and treatment system. The presence of VOCs, primarily trichlorethene, in the perched water table at Site K was the reason for the installation of the treatment system. With the installation of the collection system, it appears that gradients have been directed towards the groundwater drain, thereby intercepting the groundwater that would have originally flowed off-site to the west-northwest.

a. Discussion

Hydrographs of the groundwater levels in the vicinity of Site K are shown in Figures 4.19 through 4.26 in this report. In the hydrographs, minor seasonal fluctuations in groundwater levels are indicated. Groundwater level contours in aquifer Unit 1 near Site K for Quarters 22, 23, and 24 are shown in Figure 5.1.2.1, Figure 5.1.2.2, and Figure 5.1.2.3, respectively. Note that the contours have been produced for the Site K vicinity after analyzing the groundwater elevation data near the site.

A number of groundwater elevation data near Site K were found to show unrealistic flow conditions when contoured. Note that the hydrographs for the following well nests at this site have groundwater elevations that are consistently lower than 870 feet, Mean Sea Level (see Figures 4.22 through 4.26).

- 01U624 B,C,D
- 01U625 A,B,C,D
- 01U626 A,B,C,D
- 01U627 A,B,C,D
- 01U628 A,B,C,D

Due to these low groundwater elevations, the elevation data for these wells were not considered in the groundwater contour plots for Unit 1 near Site K. A resurvey is recommended below.

Groundwater elevation data from several other wells were not included in the computer contour plots near Site K. The omitted elevation data were from the following wells:

- 01U604
- 01U607
- 01U613
- 01U615

In omitting these data points from the contours, much more regular contour intervals are shown for the upgradient flow towards the drain from the east-southeast. This type of flow condition would be expected in Unit 1. These four omitted wells are suspected of being influenced by the building foundation or by perched groundwater. As such, they are not useful indicators of flow conditions in Unit 1.

The groundwater collection drain was shown in the contour plots as four points along the system. The specified groundwater elevations varied from 873 feet, MSL, at the southern end of the drain to 875 at the northern end. Contours for the Site K area indicate that the groundwater collection drain is working. Wells on both sides of the collection system have groundwater elevations that indicate the collection drain is operating effectively.

b. Conclusions

Flow interception by the groundwater collection system at Site K appears to be operating properly. Recent data were not available to assess actual water quality and levels found at the drain during its operation. Obtaining additional water level and quality data is recommended below as a first step in determining the performance of the site collection and treatment systems.

c. Recommendations

The remediation system in operation at Site K is likely working to intercept groundwater flowing away from building 103. It is recommended that groundwater elevations at this site be measured after a resurvey is completed of top-of-casing elevations and well

locations for all wells at this site. Water levels inside the groundwater collection drain would also need to be determined. A more thorough hydrogeological analysis of the flow conditions could be conducted with this new information.

After confirming flow conditions at Site K, it is recommended that the monitoring frequencies and sampling parameters specified for Site K in the 1990 Annual Monitoring Plan be followed. In addition, flow conditions determined in the hydrogeological analysis would be used to determine any additional wells or locations in the collection drain system to sample. Data gathered at these sampling locations would then be used to calculate the effectiveness of contaminant removal at Site K. Parameters to be sampled at this site that are suggested in the 1990 Annual Monitoring Plan should be sufficient for any monitoring conducted in the near future.

C. Exceedance of Groundwater Action Criteria

Table 8 compiles the groundwater quality data from Monitoring Quarter 21 through 24 (Winter Quarter 1989 to Fall Quarter 1989) found to exceed the groundwater action criteria (as defined in the FFA and described earlier in this report). The data in Table 8 form the body of information for this discussion.

Table 8 shows that the predominant monitoring parameters found to exceed the action criteria are VOCs. Specifically, the following three halogenated VOCs are the majority of the 1989 data points included in Table 8:

- 1,1,1-trichloroethane
- 1,1-dichloroethene
- trichloroethene

The large number of data points for these three chemical compounds would be expected based on past investigations of contaminated areas at TCAAP. They comprise 73

percent of all 1989 groundwater quality data above the action criteria. It is expected that remedial activities at TCAAP will result in less exceedances for the three VOCs in the future.

Wells 03U014, 03U018, and 03U093 located near Sites D, F, and G showed some of the highest levels of the three VOCs. Other Upper Unit 3 wells showing high concentrations of the three halogenated VOCs included 03U314 through 03U317. These wells are also in the vicinity of Sites D, F, and G, although they are closer to Sites F and G. Wells 03F302 through 03F308, as part of the TGRS recovery system, indicated levels of VOCs above the action criteria. These findings are expected and desired in the recovery system. Future remediation by the TGRS should reduce the number of groundwater action exceedances.

Unit 4 wells, such as 04U806, 04U077, and 04U673, near the southwest TCAAP boundary also showed relatively high levels of trichloroethene and other VOCs.

VI. REFERENCES

Federal Facility Agreement under CERCLA Section 120, July 1987, by and between TCAAP, U.S. EPA and MPCA.

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