INSTALLATION RESTORATION PROGRAM
TWIN CITIES ARMY AMMUNITION PLANT
BOUNDARY GROUNDWATER RECOVERY SYSTEM (BGRS)

1988

IRA-BGRS ANNUAL MONITORING REPORT AND MONITORING PLAN

Volume 1 - Text

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Final Report
October 1989
Contract #DAA09-76-E-0030

HONEYWELL INC.
CONESTOGA-ROVERS & ASSOCIATES LIMITED

Minnesota Pollution Control Agency
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Celebrate MINNESOTA 1990

August 9, 1989

Mr. Clarence Oster
Remedial Project Manager
Twin Cities Army Ammunition Plant
New Brighton, Minnesota 55112

Dear Mr. Oster:

RE: Boundary Ground Water Recovery System Annual Monitoring Report

Staff at the Minnesota Pollution Control Agency (MPCA) and the U.S. Environmental Protection Agency (EPA) have reviewed the Boundary Ground Water Recovery System (BGRS) Annual Monitoring Report for the Twin Cities Army Ammunition Plant (TCAAP). The report passes the consistency test in accordance with Article XIV of the Federal Facility Agreement. Although it has passed the consistency test, the MPCA has noted several deficiencies in the report which merit comment. These comments, together with recommendations on the preparation of future reports of this type, are provided in an enclosure to this letter.

The MPCA and EPA expect that the comments and recommendations provided will be given serious consideration by the Army. The MPCA and EPA view many of the deficiencies in the report as characteristic of a first submittal on a newly designed system. However, since the BGRS constitutes a major barrier restricting the movement of contaminated ground water off TCAAP, future reports summarizing its performance should and will be held to a higher standard.

During our numerous discussions over various drafts of the report, it became clear that preparation and review of this document was a learning experience. We are confident the lessons learned will serve all of us well in the preparation and review of future documents addressing the BGRS, as well as other remedial actions at TCAAP.

If you have any questions, please contact Mark Schmitt of my staff at (612)296-7776, or Art Kleinrath at (312)886-7254.

Sincerely,

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

Arthur Kleinrath
U.S. Environmental Protection Agency
Region V

REM:AK/tks

Enclosure

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1.0 INTRODUCTION

In June 1986, the Groundwater Remediation Program Plan(1) (GRPP) was developed for the Twin Cities Army Ammunition Plant (TCAAP). Figure 1.1 is a Site location map for TCAAP. The GRPP involves the development of a groundwater remediation system for Volatile Organic Compound (VOC) plumes at TCAAP and represents the first phase of the Honeywell/Army remediation efforts at TCAAP. The second phase of the Honeywell/Army remediation was the construction of the Boundary Groundwater Recovery System (BGRS) completed in April 1987, which began operation on October 19, 1987. Subsequent phases involve expansion of the remediation system to complete groundwater remediation on and off TCAAP. The scope of the Phase III efforts was based on the operational performance of the BGRS during Phase II and is designated the TCAAP Groundwater Remediation System (TGRS).

On August 12, 1987, a Federal Facility Agreement(2) (FFA) between the U.S. Army, USEPA and MPCA was signed which formalized the TCAAP remedial program (the FFA became effective on December 31, 1987).

In September 1987 a Record of Decision(3) (ROD) was prepared by the USEPA in order to implement the IRAP for TCAAP. The ROD provides specific criteria for the BGRS with modifications. Following extensive interagency negotiations on the FFA and the ROD, the BGRS system was started on October 19, 1987.

SOURCE: USGS TOPOGRAPHIC MAP
NEW BRIGHTON, MINN. QUAD

SCALE: 1" = 3000'

figure 1.1
SITE LOCATION
Twin Cities Army Ammunition Plant

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In accordance with Section 3.7.2 of attachment 2 of the FFA, this report serves as the Annual Monitoring Report and presents the monitoring results from the first year of operation of the BGRS (October 1987 to October 1988).

The BGRS consists of 6 Unit 3 extraction wells which are connected by forcemain to an air stripping treatment facility.

Following the initial 90 day operation of the BGRS, the IRA-BGRS Performance Assessment Report[4] (PAR) was prepared. The PAR assessed the hydraulic and treatment performance of the BGRS in light of the requirements put forth in the ROD. The PAR presented an extensive database collected during the initial 90 day period of BGRS operation and prior pertinent data. The PAR also includes a summary of the geology, hydrogeology and remediation history for TCAAP. The conclusions of the PAR include:

1. The BGRS captures groundwater in the Unit 3 (Hillside Sand) aquifer across a continuous width of 3,400 feet at the southwest TCAAP boundary and this capture widens to 4,900 feet at Sites D and G. There is no Phase I capture criteria in Phase I of the ROD. There is complete capture between extraction wells at the TCAAP boundary.

2. The BGRS captures a portion of the Unit 4 (Prairie du Chien/Jordan) Aquifer groundwater based on drawdowns observed in the Unit 4 in response to pumping.

3. The Unit 3 VOC (Volatile Organic Compound) plumes are substantially captured by the operation of the BGRS. However, to the north of the system, a portion of the Unit 3 plume lies outside of the BGRS capture zone.

4. The BGRS captures a portion of the Unit 4 VOC plume.

5. During the 90 day assessment period, the BGRS treatment system extracted between 17.0 lbs./day and 28.6 lbs./day of VOCs with an average of 23.2 lbs/day.

6. Treated effluent exhibited VOC concentrations consistently below 5 ug/L and below the contaminant specific requirements of the ROD.

7. Effluent concentrations for metals, cyanide, PCB, radon, radionuclides, base/neutral compounds and pesticides were all below contaminant specific requirements of the ROD.

8. Phosphorus and orthophosphate analytical data indicated that discharge to Rice Creek would not significantly change the phosphorus concentrations in Rice Creek. Phosphorus loading in Rice Creek would increase from 0.22 percent to 1.3 percent over ambient levels.

9. The source control well (SC-1) at Building 502 (Site I) provides substantial capture of VOCs from Site I and meets the objectives of the FFA.

10. Recharge at the Arsenal Sand and Gravel Pit performs as designed and is acceptable as a water management option for treated water discharge.

11. Air emissions from the BGRS treatment system meet the contaminant specific requirements of the ROD. VOCs were not detected upwind or downwind of the BGRS.

The PAR made recommendations for expansion of the BGRS into the TCAAP Groundwater Remediation System (TGRS) in order to meet the Phase II remediation criteria established in the ROD. These modifications are currently being completed and the expanded system began operation on January 31, 1989. The expansions to the system consist of:

1. four Unit 4 and two additional Unit 3 extraction wells located along the southwest boundary of TCAAP,

2. two pairs of Unit 3 source control wells located immediately downgradient of Sites D and G,

3. an expanded treatment facility designed to accommodate additional flow from the BGRS/TGRS. This includes a fourth stripping tower and associated appurtenances, and

4. 4400 feet of forcemain to connect the additional extraction wells.

The performance of the expanded system will be evaluated on a quarterly basis in reports to the regulatory agencies in accordance with the FFA.

BGRS monitoring data was collected in general accordance with the BGRS Monitoring Plan[5] which calls for measurement of groundwater levels, groundwater quality, extracted groundwater quality, treated water quality, flow rates and recharge rates. Some monitoring tasks were omitted due to operational problems with the system. Table 1.1 summarizes the monitoring tasks conducted during the first year of BGRS operation as compared to the monitoring plan. The BGRS data base was generated and validated in accordance with the BGRS Quality Assurance Project Plan[6] (QAPP).

Based on the results of these monitoring efforts, the second part of this report presents an updated monitoring plan for the BGRS/TGRS.

TABLE 1.1

SUMMARY OF BGRS WATER MONITORING PLAN

Task	Location	Planned Frequency	Parameters	Frequency Achieved	Comments
Groundwater Level Monitoring	See Table 1 of Monitoring Plan	Monthly for 1 year (12 events)	Water Levels	12 events	
Groundwater Quality Monitoring	See Table 2 of Monitoring plan	Quarterly for 1 year (4 events)	VOCs	4 events	
Groundwater Quality Monitoring	B1, B2, B3, B4, B5, B6	Monthly for 6 months, quarterly thereafter for 6 months (8 events)	VOCs	6 events	System down 2-88, 3-88
Treatment Monitoring	Treatment Plant Influent	Weekly for 90 days, monthly thereafter for 9 months (21 events)	VOCs	19 events	System down 2-88, 3-88
Treatment Monitoring	Treatment Plant Effluent	Weekly for 90 days, monthly thereafter for 9 months (21 events)	VOCs and pH	19 events	System down 2-88, 3-88
		Four times in first 90 days, monthly thereafter for 9 months (13 events)	Metals, PCBS, Radionuclides and Radon	11 events 10 events 11 events	System down 2-88, 3-88 System down 2-88, 3-88, 1 sample broken System down 2-88, 3-88
		Monthly for 12 months (12 events)	Ortho and Total Phosphorus	10 events	System down 2-88, 3-88
		3 months after start-up (1 event)	Priority Pollutants	1 event	

2.0 BGRS ANNUAL MONITORING ASSESSMENT

This section presents the hydraulic and chemical data gathered during the first year of operation of the BGRS and provides interpretation of these data pursuant to the requirements of the ROD and FFA. This interpretation also serves as rationale for the updated monitoring plan presented in Section 4.

2.1 BGRS DATA BASE

The data base for the BGRS monitoring program has been compiled and included in the Appendices.

Appendix A contains water levels for groundwater and recharge at the gravel pit.

Appendix B contains the analytical data base for the BGRS, categorized as follows:

Appendix B.1	Monitoring Well Target VOC Data
Appendix B.2	Influent/Effluent VOC Data
Appendix B.3	Effluent PCB Data
Appendix B.4	Effluent Metals and Cyanide Data

Appendix B.5	Effluent Radon, Radionuclide and pH Data

Appendix B.6	Effluent Phosphorus Data

Appendix B.7	Effluent Priority Pollutant Scan

Appendix B also contains a key to the chemical abbreviations utilized in this report.

Appendix C contains the BGRS well attributes and cross referencing information.

Appendix D presents quarterly contoured VOC data, for each aquifer unit, for Trichloroethylene (TRCLE), 1,1-Dichloroethylene (11DCE) and 1,1,1-Trichloroethane (111TCE).

Appendix E contains a summary of the cumulative flow and discharge measurements and precipitation records for the operational year.

2.2 GROUNDWATER CAPTURE

2.2.1 BGRS Operation

During its first year of operation the BGRS extracted and treated approximately 363 million gallons of water at TCAAP. As discussed in the PAR, the total volume of Unit 3 and Unit 4 groundwater between the BGRS and the source areas is approximately 8.07 x 10^9 gallons. The BGRS, therefore, has extracted 4.5 percent of this volume.

Assuming that the water was extracted from the Unit 3 alone, the volume extracted represents that contained in a 270 foot length of Unit 3 (using a Unit 3 thickness of 150 feet, a porosity of 0.30 and an average capture width of 4,000 feet).

Appendix E presents the operational record for each of the six extraction wells. The wells each operate at approximately 200 gallons per minute (gpm) for a total design rate for the BGRS of 1200 gpm. The actual operating rate for the system is expected to be slightly less than 1200 gpm due to the normal cycling of pumps necessary for the system to operate smoothly.

The cumulative flow totals do not reflect full time operation of the BGRS for the entire year due to periods of inoperation by individual wells or the combined system. The flow totals also are misleading due to mechanical problems and freeze damage of the flow meters themselves. The BGRS encountered three areas of operational difficulty during its first year of operation:

- electrical/mechanical difficulties of individual components due to lack of operators and preventive maintenance,
- freeze damage to valves and/or piping,

- electrical damage resulting from lighting and transient static electrical charges.

Electrical and mechanical difficulties of individual components were primarily the result of a lack of necessary periodic adjustments and maintenance. Federal Cartridge Company (FCC) was providing operation and maintenance support from BGRS start-up through the end of 1987. Personnel reductions at TCAAP at the end of 1987 included lay-offs of the water plant operators, leaving the BGRS without full time operation and maintenance personnel. A local commercial plumbing contractor was retained to conduct emergency repairs on an interim basis. These electrical and mechanical problems normally only affected individual wells or treatment components for short periods of time (1 to 2 days) and did not have a significant impact on the overall system performance. The only incident of extended down time was for well B-3 which was down for approximately 2 months. A contractor was retained in April 1988 to provide daily inspections of the system in order to identify problems with the system so corrective action could be taken. The inspection program did not address the normal periodic maintenance requirements. As a result, an operation and maintenance contractor was retained in December 1988 to provide inspections, preventive maintenance and emergency response. It is anticipated that the formalized O & M program will significantly improve the operational record of the BGRS.

Freeze damage occurred on two occasions in February and March 1988 in pipe elbows, valves and the water distributor in Tower #1. This was caused by a malfunction in the electric check valve which resulted in a shutdown of the BGRS. These incidents impacted the entire system and resulted in down times of approximately 5 to 10 days each based on repair part lead times. It later became apparent that these incidents also caused damage to the water meters at Towers #1 and #2. Several modifications were made during construction of the expanded BGRS/TGRS system in an effort to eliminate weather related problems. An enclosure has been added around the treatment plant on the south side of Building 116 to protect the electric check valves, meters and appurtenances from cold weather problems. Insulation and heat tracing has also been added to exposed water transmission pipes to prevent freezing during shutdowns or extended cycling of the system. Drop pipes have been added to the treatment towers to reduce turbulence in the wet wells and timing delays have been added to level switches to eliminate potential problems with the electric check valves resulting from rapid cycling of level controls.

The most significant problems resulted from lightning and associated transient static electrical charges damaging the controlling computer program and communication components in the pumphouses and the main treatment plant controller. Standard lightning protection existed for the electrical services to all system components. A major electrical storm at the end of May 1988 damaged several major communication components in the BGRS. The system was restarted in less than five days and was run in a manual mode for roughly two months during the summer of 1988 while new electrical components were being obtained and installed. The lightning storm indicated that the cause of many of the minor transient electrical problems originated through the communication cables which transmit signals between the system controller and the pumphouses. Discovery of the real cause of the problem enabled corrective actions to be taken. Lightning arrestors and surge protectors have been added to the extraction wells and to the power transmission and communication lines in addition to the standard lightning protection already present.

In order to further improve system reliability; additional safety components, control changes and mechanical adjustments have been made during the BGRS modification/TGRS construction to better match the system to the existing circumstances at TCAAP.

2.2.2 Unit 3 Groundwater Capture

Figure 2.1 presents the background Unit 3 groundwater contours from September 1987 (prior to BGRS start up). Figure 2.2 presents the Unit 3 groundwater contours from January 1988 as presented in the PAR. Figure 2.3 and Plan 1 present the Unit 3 groundwater contours from October 1988. Due to the presence of a high density of monitoring wells along the boundary, the zone of capture can be determined by inspection of the groundwater contours. Capture between monitoring wells was determined from the observation of significant drawdowns at the mid-points between extraction wells during pumping tests (see BGRS pumping test report[8]) and during the 90 day performance assessment period. Comparison of Figure 2.1, Figure 2.2 and Figure 2.3 indicates that the BGRS developed a continuous zone of capture, approximately 3400 feet in width, within the initial 90 day operational period.

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figure 2.1
BACKGROUND UNIT 3 GROUNDWATER CONTOURS
BGRS-PAR
Twin Cities Army Ammunition Plant

figure 2.2
UNIT 3 GROUNDWATER CONTOURS
BGRS-PAR
Twin Cities Army Ammunition Plant

1687-25-27/1/88-M

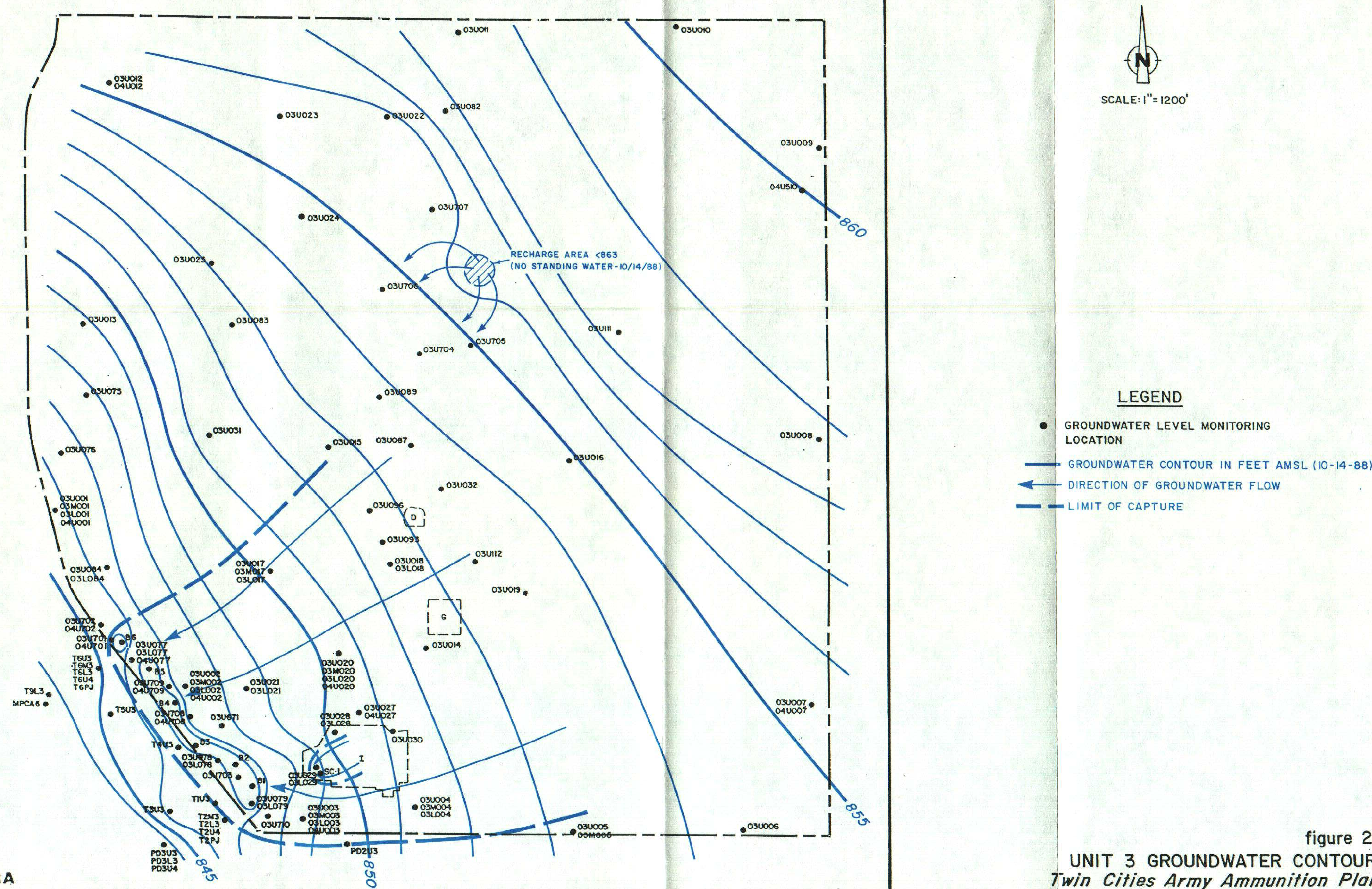

figure 2.3
UNIT 3 GROUNDWATER CONTOURS
Twin Cities Army Ammunition Plant

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During the remainder of the year the capture zone remained relatively constant in width and configuration with the exception of times when the system was shut down.

The capture zone to the north of B6 is somewhat narrower than to the south of B1. This is due, in part, to steeper ambient hydraulic gradients in this vicinity. It may also reflect the impact of recharge from the Arsenal Sand and Gravel Pit. The degree of this effect has not changed significantly between January 1988 (the end of the 90 day assessment period) and October 1988.

Background water levels have declined approximately three feet during the past year. This is believed to be a regional change as a result of the below average precipitation during 1987 and 1988.

Figure 2.4 shows the change in water levels between September 1987 (non-pumping, pre-BGRS start-up) and October 1988. Wells located at the greatest distances from pumping or recharge have exhibited water level declines on the order of three feet and wells along the BGRS have declined between 4.5 feet and 7 feet. Correcting for a background decline of 3 feet, wells near the BGRS have declined from 1.5 to 3 feet since pumping started.

Despite these changes in water levels the configuration of the zone of capture induced by the operating BGRS exhibits little variation. There is little significant difference in the pattern of groundwater contours between January 1988 (Figure 2.2) and October 1988 (Figure 2.3). The magnitude of the background water level change observed represents a small percentage of

figure 2.4
UNIT 3 WATER LEVEL CHANGE
Twin Cities Army Ammunition Plant

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the total Unit 3 thickness and therefore a small change in transmissivity. Therefore, a small background rise or decline does not significantly affect the hydraulic characteristics of the aquifer. It can be concluded that changes in the zone of capture do not occur over short time periods and are not significantly impacted by seasonal changes in regional water levels.

Originally, the zone of capture for the BGRS was estimated using the velocity capture formulae of Javandel and Tsang[10].

In these calculations a transmissivity of 30,000 ft^2/day, developed from the BGRS pumping tests, was utilized. Ongoing study has indicated that partial-penetration well effects have resulted in over-estimation of the Unit 3 transmissivity in the pumping test analyses. The BGRS extraction wells are screened across the Unit 3 only. Since Unit 3 and Unit 4 are hydraulically connected, the extraction wells behave as partially penetrating wells within the combined Unit 3/Unit 4 regime.

The zone of capture observed by interpretation of the groundwater contours is significantly larger than was indicated from the estimate based on the aquifer transmissivity. This difference is believed to reflect the effects of partial penetration on the transmissivity calculations. It appears that the actual transmissivities are lower than originally believed. The lower transmissivity accounts for observation of drawdowns between the extraction wells that generally exceeded the predicted drawdowns. These differences also confirm that BGRS capture estimates were conservative and allowed for a reasonable safety factor.

2.2.3 Unit 4 Groundwater Capture

Figure 2.5 presents the Unit 4 groundwater contours from October 1988. The degree of capture in the Unit 4 is not evident on Figure 2.5. It has been concluded previously, however, that there is a small degree of capture occurring within the Unit 4. This conclusion is based on observed drawdowns, in the Unit 4, in response to BGRS pumping.

2.2.4 Arsenal Sand and Gravel Pit Recharge

Following the initial 90 day operation period, as reported in the PAR, the water levels in the Arsenal Sand and Gravel Pit had risen in response to discharge approximately three feet. Prior to BGRS start-up the water level in the Pit was roughly coincident with the pit floor. The 3 foot rise was less than the 5.6 foot rise estimated for the pit in the IRA-BGRS Water Balance Report(7). It was concluded in the PAR that the Arsenal Sand and Gravel Pit is suitable as a treated water discharge option.

In the time period since the initial 90 day operational period for the BGRS, the water levels in the Arsenal Sand and Gravel Pit have declined to below the floor of the pit, thus, there is no accumulated water in the pit. As discussed in Section 2.2, ambient Unit 3 water levels have declined on the order of three feet. That is, the background water level decline roughly equals the magnitude of rise observed in the pit after 90 days of BGRS discharge. The fact that the decline in the water levels in the pit over the year equals or perhaps

figure 2.5

UNIT 4 GROUNDWATER CONTOURS

Twin Cities Army Ammunition Plant

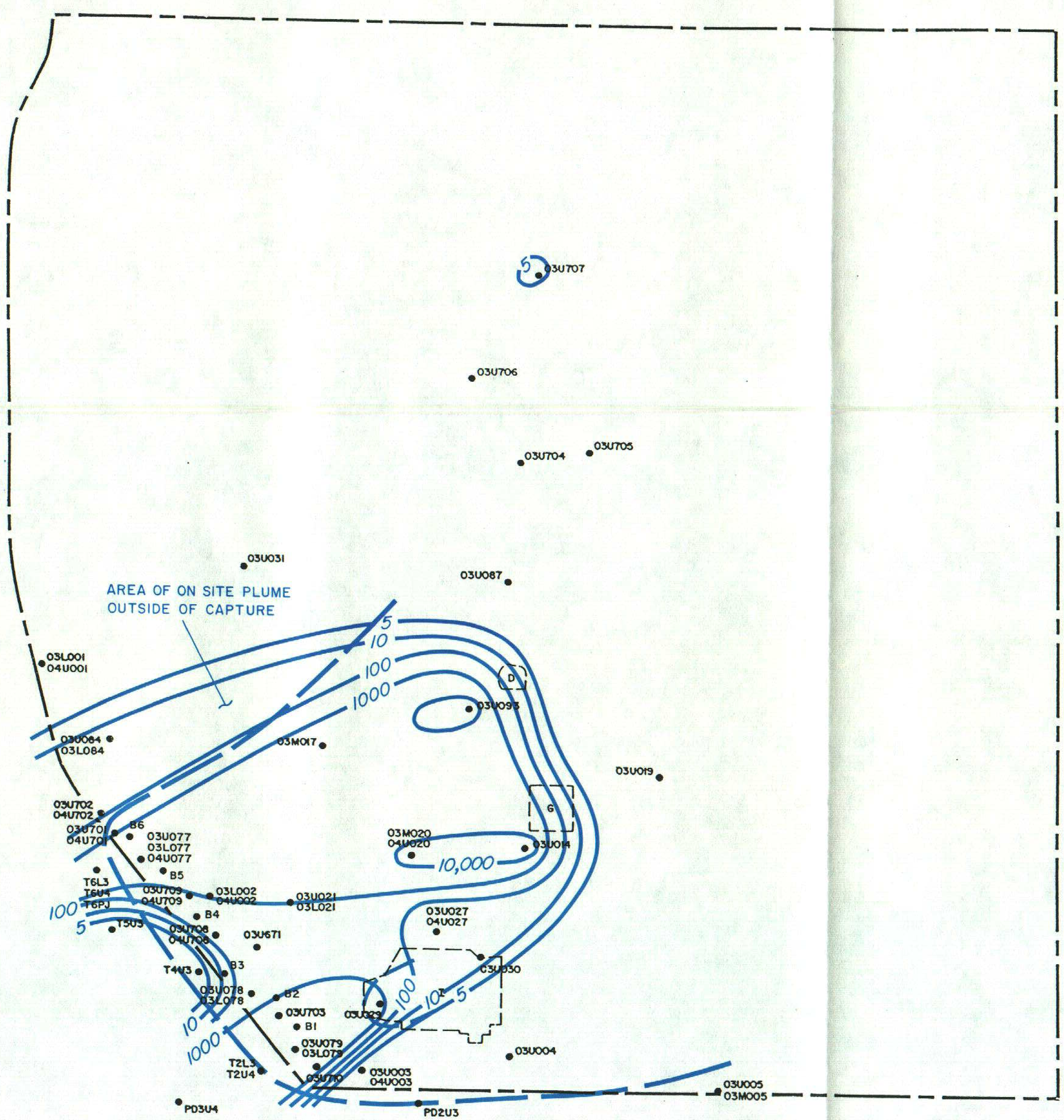
exceeds the observed ambient decline in water levels indicates that there has not been an increase in the groundwater mound beneath the pit in the time period since the end of the 90 day assessment period.

The discontinuous nature of BGRS operation during 1988 makes it difficult to assess the impacts of long term continuous discharge to the Arsenal Sand and Gravel Pit. The performance of the Gravel Pit was further obscured by the regional water level decline over the year. However, there were no drastic rises in water levels observed in the pit at times when the BGRS was operating. Based on this observation it is concluded that the amount of water discharged to the pit during 1988 is a small fraction of the total recharge capacity of the Gravel Pit. Continued monitoring of the Gravel Pit will provide additional data on long term performance of the system.

Since water was not ponding in the Arsenal Sand and Gravel Pit, the amount of discharged water that evaporated was small.

2.3 VOC Plume Capture

Figure 2.6 presents the Unit 3 TRCLE contours from October 1988, the last monitoring round of the operational year. Superimposed on Figure 2.6 is the zone of capture created by the BGRS. In addition Appendix D contains the contoured analytical data from each of the four quarterly sampling rounds for Trichloroethylene (TRCLE), 1,1-Dichloroethylene (11DCE) and 1,1,1-Trichloroethane (111TCA).



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SCALE: 1" = 1200'

LEGEND

- ● GROUNDWATER QUALITY MONITORING LOCATION
- CHEMICAL CONTOUR IN ug/l
- LIMIT OF CAPTURE

CONTOURS BASED ON HIGHEST VALUE AT NESTED WELLS.

NOTE: SEE CHEMICAL DATA BASE FOR CONCENTRATIONS AT INDIVIDUAL WELLS

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figure 2.6

TRICHLOROETHYLENE (TRCLE) CONTOURS-UNIT 3 (OCT. 1988)

Twin Cities Army Ammunition Plant

As these figures illustrate, the BGRS substantially contains the Unit 3 VOC plumes at TCAAP. To the southeast the capture extends to beyond the 5 ug/L contour for all constituents. To the northwest there exists a portion of the Unit 3 plume, above 5 ug/L, outside of BGRS capture.

The plume configuration and its relationship to capture has not changed significantly from one quarter to the next. The similarity between the figures contained in Appendix D illustrates that significant changes in plume configuration occur at larger intervals than one year.

The April 1988 sampling round yielded a TRCLE concentration of 92 ug/L at well PD2U3. Historically, PD2U3 has exhibited TRCLE concentrations of non-detect to 0.3 ug/L. Honeywell resampled PD2U3, in duplicate, to verify the concentrations. The results of the resampling yielded 17 ug/L and 16 ug/L TRCLE. Subsequent sampling rounds in July 1988 and October 1988 yielded TRCLE concentrations of 5.7 and 0.91 ug/L, respectively.

Well 03M005 exhibited anomalous TRCLE concentrations in January 1988 and April 1988 of 33 ug/L and 7.1 ug/L, respectively. Subsequent rounds in July and October yielded non-detectable and 2 ug/L TRCLE.

In July 1988 Honeywell sampled well 03U099, as a reconnaissance effort, which is located upgradient of 03M005 and PD2U3. This well exhibited non-detectable levels of VOCs. The concentrations observed at

PD2U3 and 03M005 on these occasions are considered spurious. PD2U3 and 03M005 will continue to be monitored, as discussed in Section 4, to identify any VOC trends at these wells.

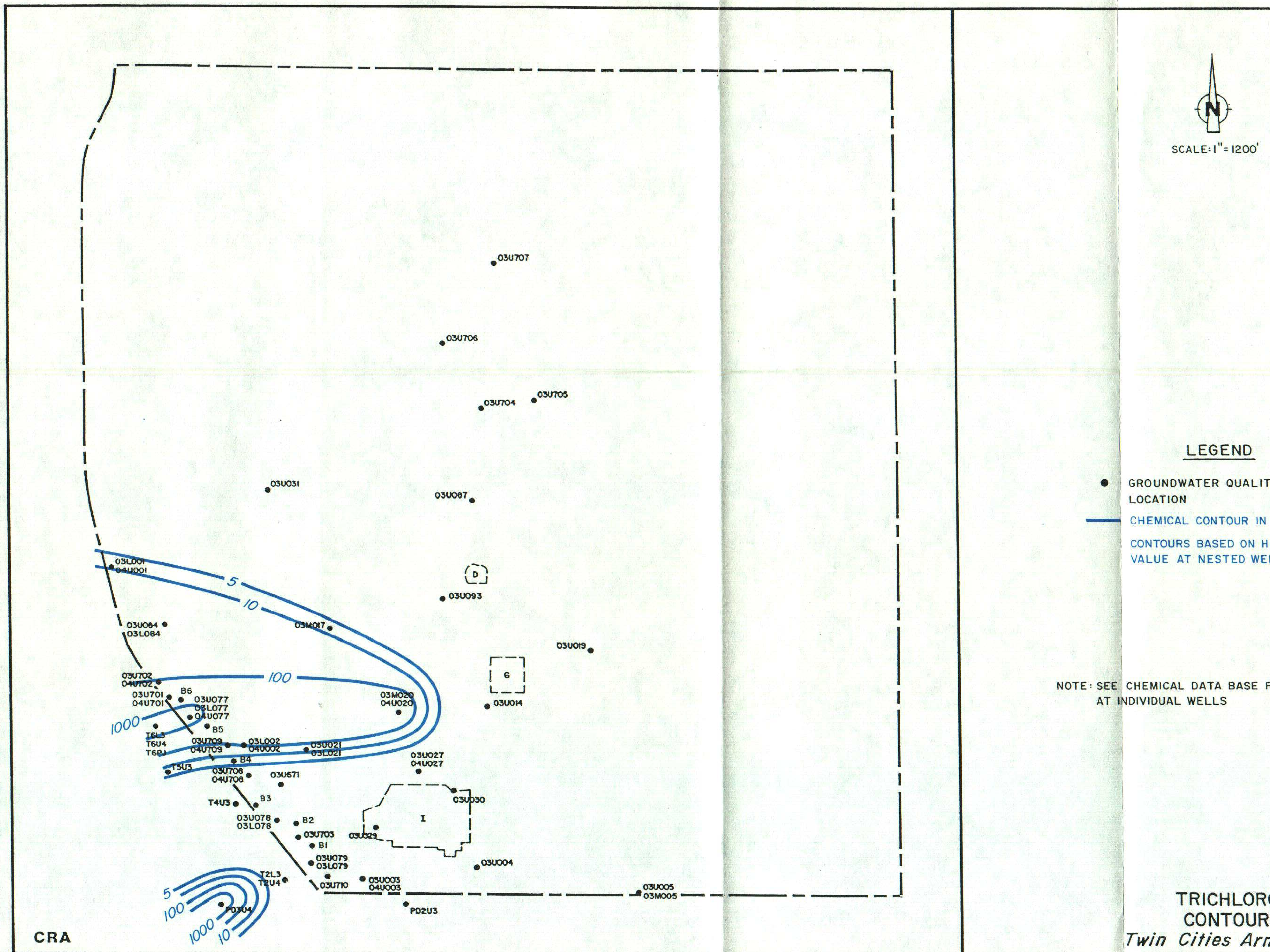
Figure 2.7 presents the October 1988 TRCLE contours for the Unit 4 groundwater. It has been concluded that the BGRS captures some portion of the Unit 4 aquifer. Therefore, the BGRS also captures a portion of the Unit 4 VOC plume. The expanded BGRS/TGRS is designed to complete the capture of the Unit 4 VOC plume.

Comparison of the Unit 4 VOC plumes from the four quarterly monitoring events (Appendix D) indicates little significant change in the Unit 4 plume configuration from quarter to quarter. During the 1988 operational year significant changes in the Unit 4 VOC plumes were not observed.

2.4 VOC EXTRACTION

2.4.1 Extracted Groundwater Quality

As discussed in Section 2.2, the BGRS has extracted groundwater from the immediate area of the BGRS wells (an approximate width of 270 feet perpendicular to the line of BGRS wells). Based upon VOC



LEGEND

● GROUNDWATER QUALITY MONITORING LOCATION

CHEMICAL CONTOUR IN ug/l

CONTOURS BASED ON HIGHEST VALUE AT NESTED WELLS.

NOTE: SEE CHEMICAL DATA BASE FOR CONCENTRATIONS AT INDIVIDUAL WELLS

figure 2.7

TRICHLOROETHYLENE (TRCLE) CONTOURS-UNIT 4 (OCT. 1988)

Twin Cities Army Ammunition Plant

2687-33-20/01/89-M

concentrations and flow rates measured in the extraction wells and discussed below, the BGRS has in one year extracted and treated approximately 4800 lbs. of VOCs.

Six rounds of samples were collected for VOC analysis from the six Unit 3 BGRS extraction wells. The results of these data are presented on Table 2.1. The predominant VOCs detected in wells B4, B5 and B6 are TRCLE followed by 111TCE. This matches the expected VOC profile for wells located in the North Plume. Wells B1 and B2 exhibit predominantly TRCLE followed in concentration by C12DCE. This is as expected in wells located within the South Plume. The VOC concentrations in well B3 are too low to characterize, but it is believed they reflect a mixture of North and South Plume constituents.

Figures 2.8a through 2.8f show TRCLE concentrations over time for wells B1 through B6. Wells B1 and B2 demonstrate increasing TRCLE levels. No clear trend can be determined at wells B3, B4, B5 or B6. It is noted that samples were not collected during February and March 1989 due to system shutdowns (see Table 1.1).

VOC mass removal is summarized on Table 2.2 for each well based on an operating rate of 200 gpm. As shown on Table 2.1 and 2.2, the highest VOC concentrations and mass are removed by wells B1, B2, B5 and B6 which are located in more contaminated plume areas. Approximately 99 percent of the total VOC mass is extracted by these four wells.

TABLE 2.1

EXTRACTION WELL SAMPLING RESULTS (ug/l)

WELLNAME	DATE	TRCLE	112TCE	11DCE	11DCLE	T12DCE	C12DCE	C2H3CL	CHCL3	111TCE	12DCLE	TCLEE
03F302	871117	1040.00	0.30	3.80	5.00	ND	51.40	ND	11.30	9.70	ND	0.60
(B1)	871215	2120.00	0.26	12.30	12.80	1.10	177.00	ND	20.80	23.20	ND	1.50
	871215	2110.00	0.28	9.10	10.80	0.70	69.00	ND	26.00	22.80	ND	1.20
	880112	2580.00	ND	12.00	20.00	ND	182.00	ND	18.00	23.00	ND	ND
	880428	2895.00	ND	12.00	14.00	ND	124.00	ND	22.00	41.00	ND	ND
	880719	4300.00	0.49	7.50	18.00	1.20	234.00	ND	ND	24.00	ND	2.70
	881021	4800.00	ND	10.00	14.00	0.66	135.00	ND	0.50	24.00	ND	2.20
03F303	871117	190.00	ND	9.90	9.00	ND	31.50	ND	9.20	18.10	ND	6.70
(B2)	871215	282.00	ND	8.10	10.20	0.30	28.90	ND	8.90	19.10	ND	8.90
	880112	375.00	ND	11.00	17.00	ND	60.00	ND	11.00	27.00	ND	15.00
	880112	390.00	ND	11.00	11.00	ND	49.00	ND	7.00	26.00	ND	16.00
	880428	274.00	ND	8.20	10.30	ND	41.90	ND	ND	18.50	ND	10.70
	880719	700.00	ND	5.00	13.00	ND	48.00	ND	ND	28.00	ND	18.00
	881021	1000.00	ND	5.20	7.60	ND	32.00	ND	ND	22.00	ND	14.00
03F304	871117	5.10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
(B3)	871215	8.33	ND	ND	ND	ND	1.11	ND	0.39	ND	ND	ND
	880112	8.20	ND	ND	ND	ND	1.10	ND	ND	ND	ND	ND
	880428	8.02	ND	ND	ND	ND	1.14	ND	ND	0.20	ND	ND
	880428	6.62	ND	ND	ND	ND	1.16	ND	ND	0.86	ND	ND
	880719	9.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
03F305	871117	22.90	2.40	2.20	2.00	ND	0.80	ND	0.40	17.60	ND	0.80
(B4)	871215	54.00	3.10	4.10	6.14	ND	1.55	ND	0.47	31.00	ND	1.10
	880112	61.00	2.30	3.60	5.50	ND	1.60	ND	0.75	39.00	ND	0.86
	880428	26.30	1.86	4.19	2.49	ND	1.38	ND	ND	34.90	ND	0.82
	880719	38.00	8.60	2.40	1.48	ND	0.73	ND	ND	85.00	ND	6.50
03F306	871117	1500.00	1.30	130.00	90.00	ND	17.00	0.20	15.80	845.00	2.50	0.40
(B5)	871215	2130.00	1.46	48.80	143.00	0.60	27.40	ND	15.30	1150.00	4.40	0.36
	880112	2420.00	ND	171.00	185.00	ND	5.70	ND	9.20	1224.00	ND	ND
	880428	530.00	ND	160.00	120.00	ND	38.00	ND	ND	100.00	ND	ND
	880719	2920.00	3.80	135.00	236.00	ND	34.00	ND	ND	1500.00	8.00	ND
	881021	1400.00	2.00	90.00	55.00	ND	25.00	ND	2.00	475.00	ND	1.10
03F307	871117	2370.00	3.00	60.00	48.00	ND	18.00	ND	ND	480.00	ND	3.00
(B6)	871215	3275.00	1.80	110.00	45.00	0.40	16.30	ND	13.10	90.80	4.10	1.70
	880112	3300.00	ND	61.40	103.00	ND	27.00	ND	131.00	786.00	ND	ND
	880428	3400.00	ND	100.00	75.00	ND	31.00	ND	ND	550.00	ND	ND
	880719	2860.00	2.00	76.00	66.00	ND	22.00	ND	ND	887.00	5.00	2.30
	880719	3020.00	1.90	69.00	82.00	ND	22.00	ND	ND	893.00	5.00	2.30
	881021	3200.00	1.20	55.00	70.00	ND	18.00	ND	2.00	400.00	3.20	1.50
	881021	2900.00	1.00	70.00	55.00	ND	17.00	ND	1.80	605.00	2.80	1.40

ND = Not Detected

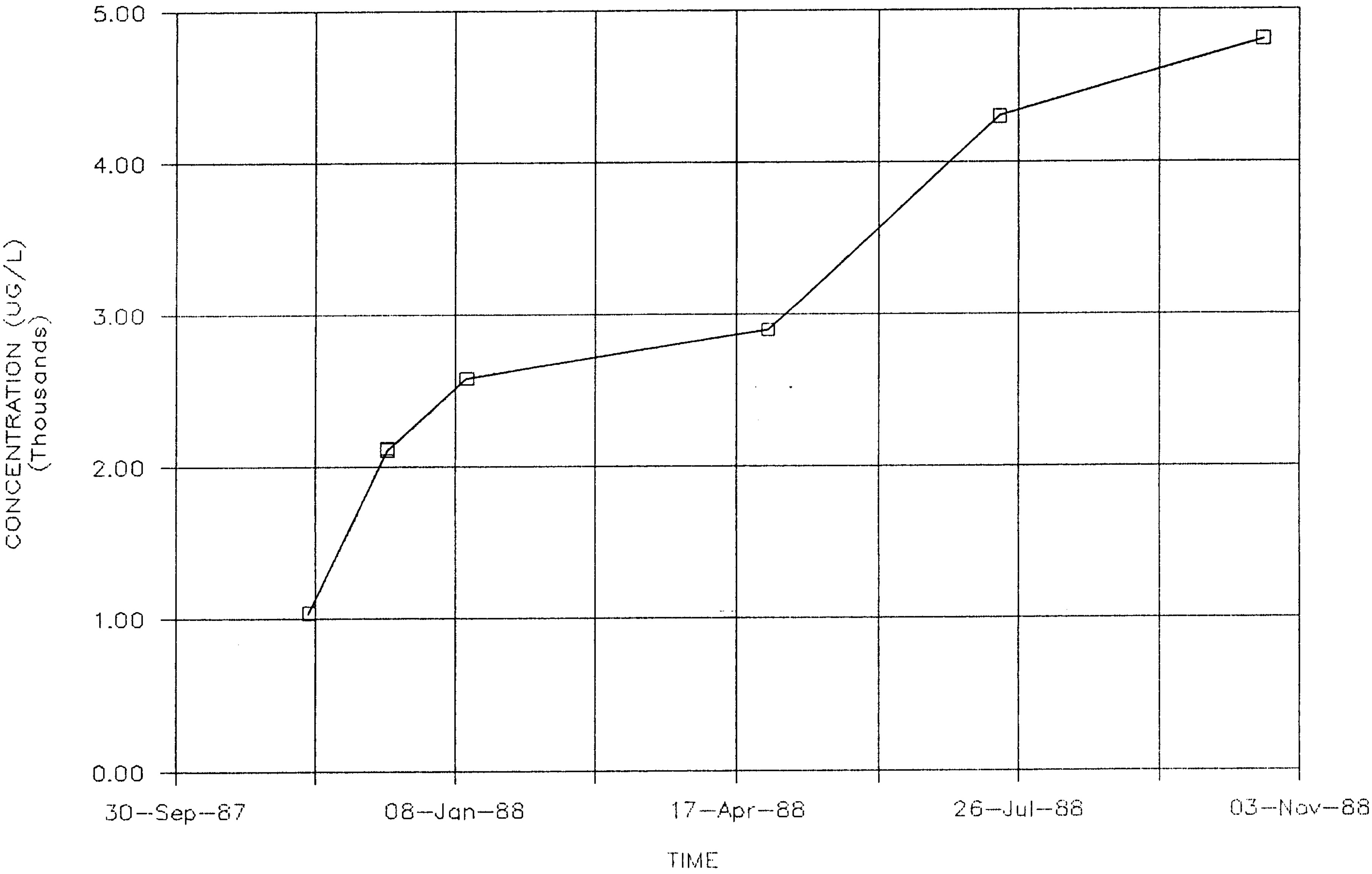


figure 2.8a
EXTRACTION WELL B1 - TRCLE vs TIME
Twin Cities Army Ammunition Plant

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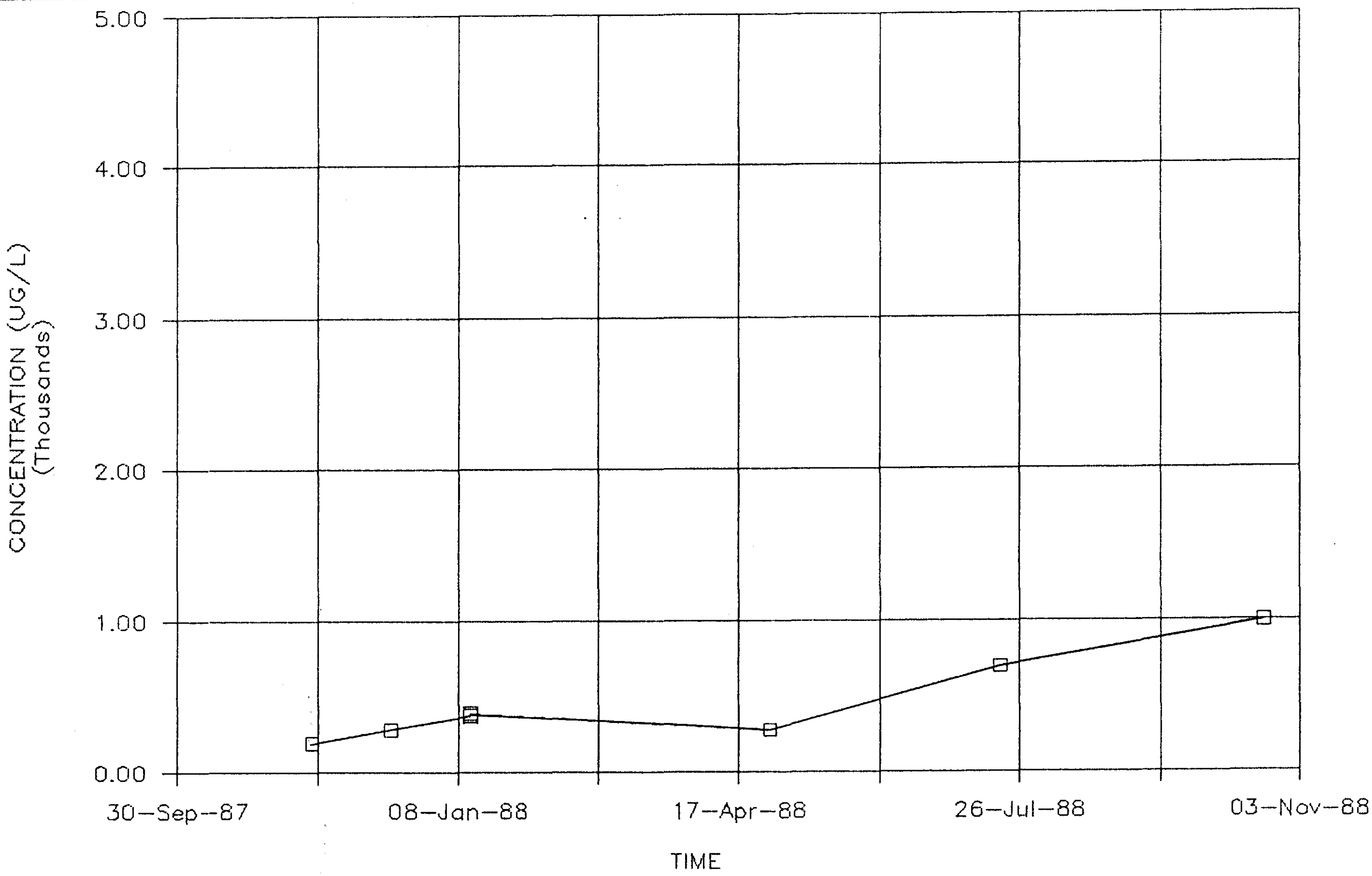

figure 2.8b
EXTRACTION WELL B2-TRCLE vs TIME
Twin Cities Army Ammunition Plant

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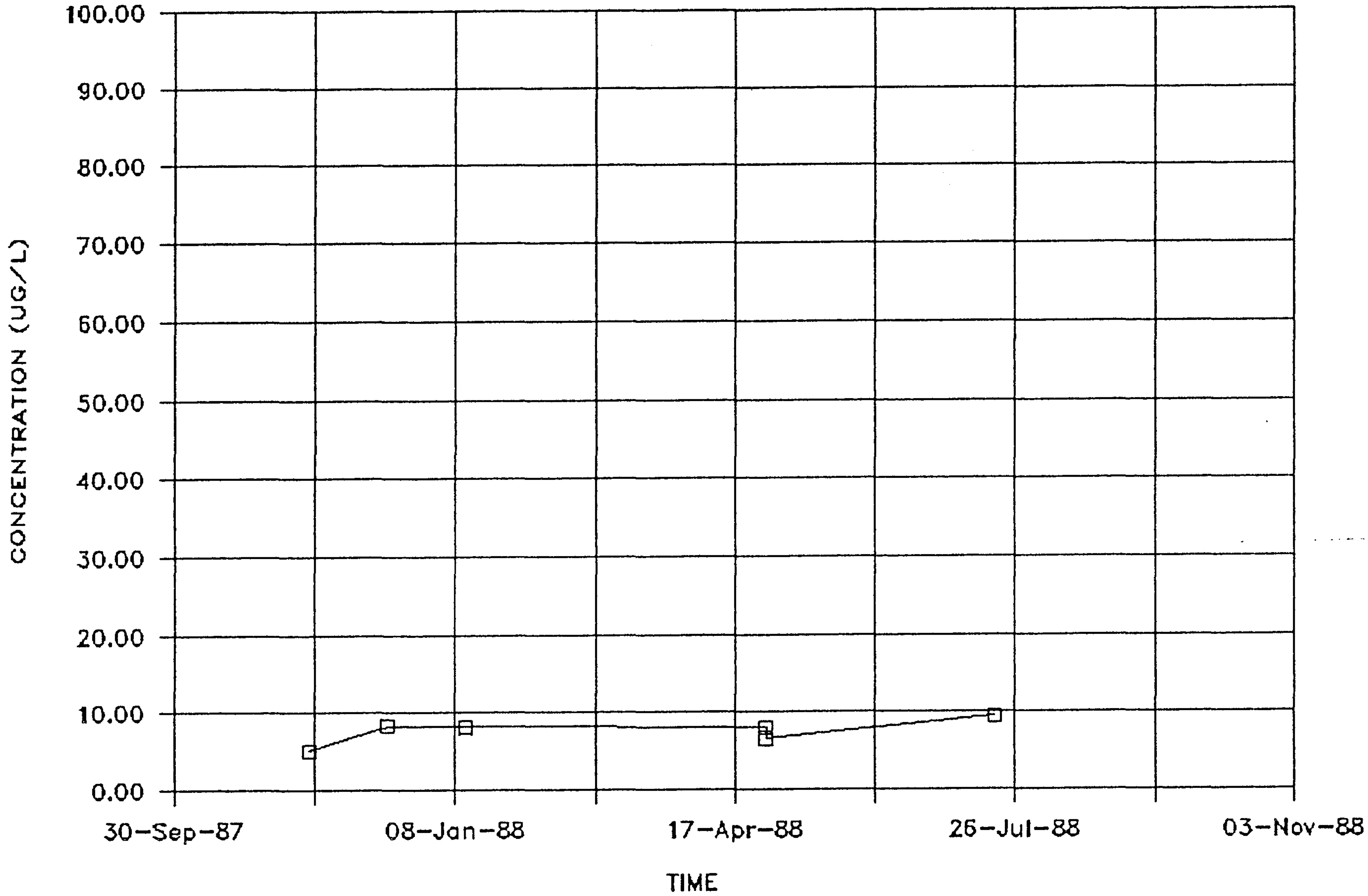

figure 2.8c
EXTRACTION WELL B3-TRCLE vs TIME
Twin Cities Army Ammunition Plant

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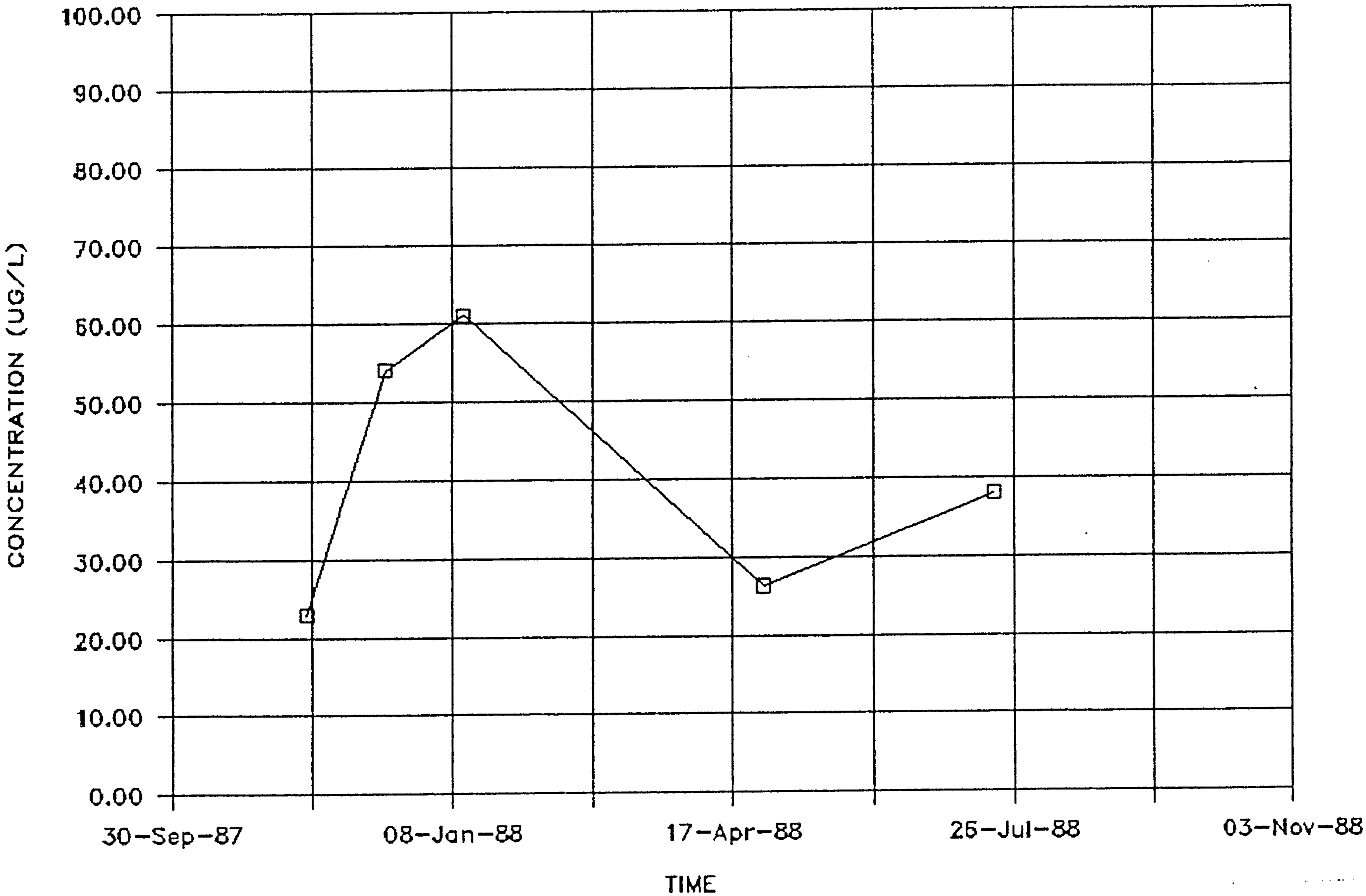

figure 2.8d
EXTRACTION WELL B4-TRCLE vs TIME
Twin Cities Army Ammunition Plant

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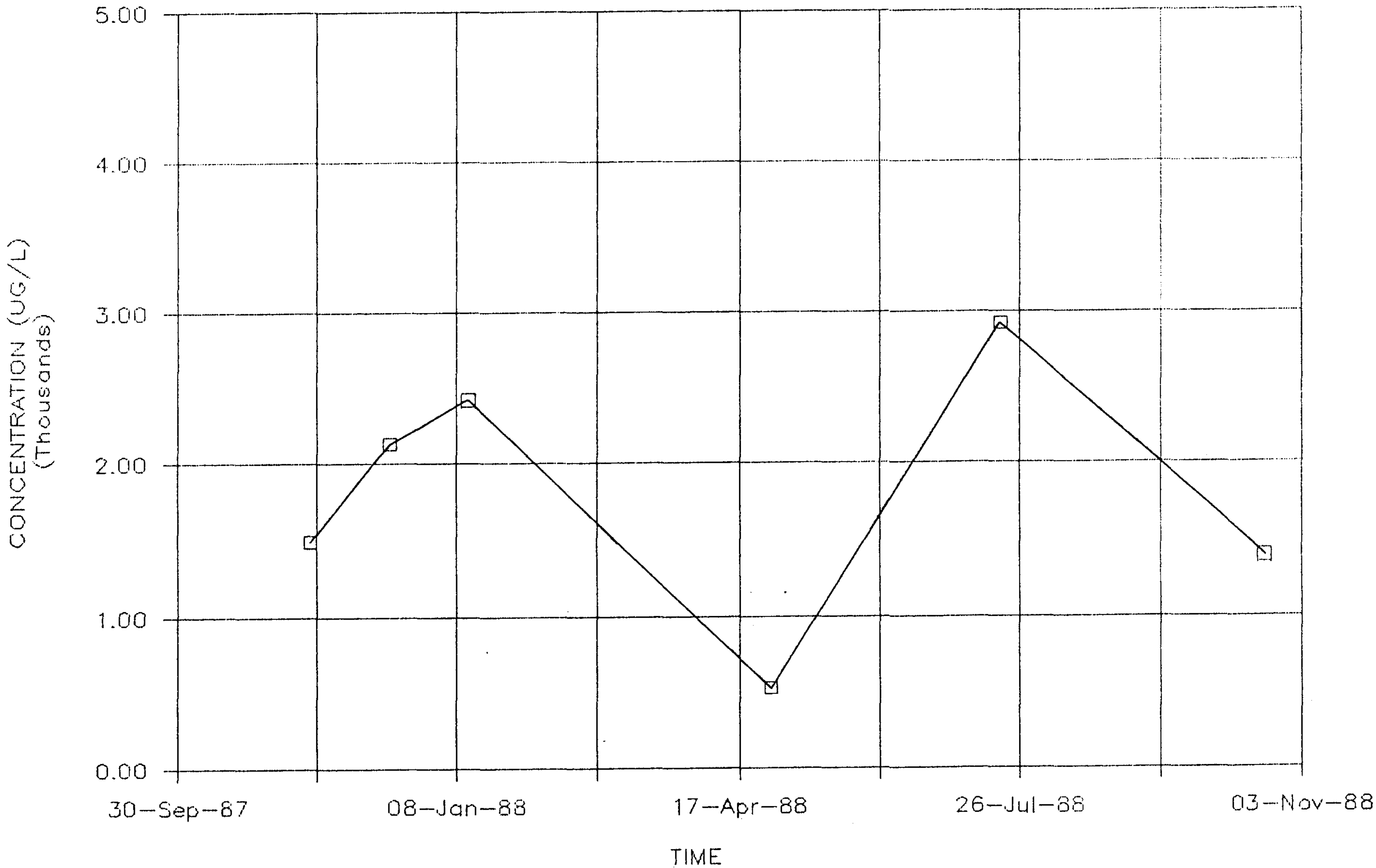

figure 2.8e
EXTRACTION WELL B5-TRCLE vs TIME
Twin Cities Army Ammunition Plant

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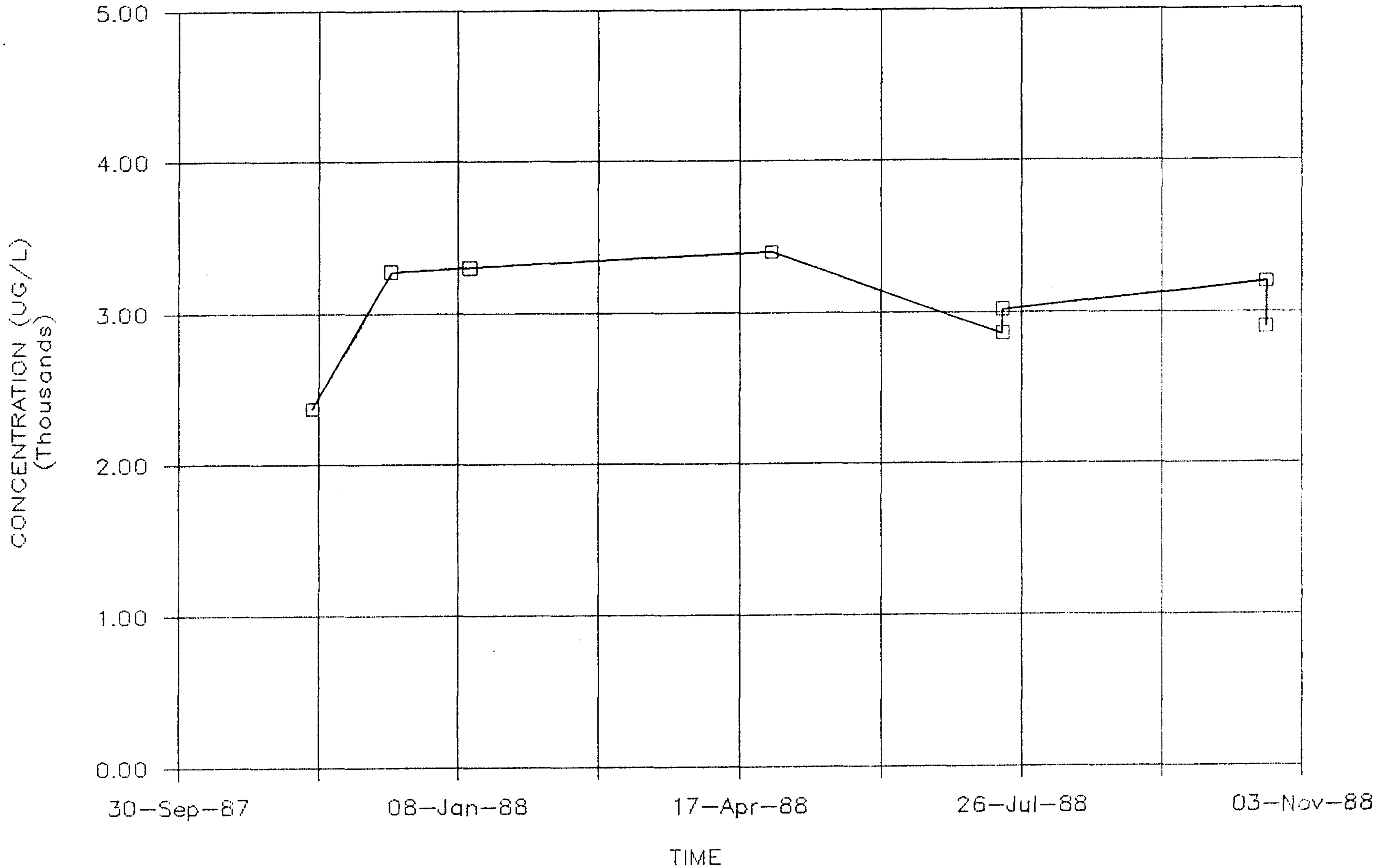

figure 2.8f
EXTRACTION WELL B6-TRCLE vs TIME
Twin Cities Army Ammunition Plant

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TABLE 2.2
VOC MASS REMOVAL RATES
BGRS EXTRACTION WELLS (LBS/DAY)(1)

Well	11/17/87	12/15/87	1/12/88
B1	2.7	5.7	6.8
B2	0.66	0.88	1.2
B3	0.01	0.02	0.02
B4	0.12	0.24	0.28
B5	6.3	8.5	9.7
B6	7.2	8.5	10.6
Total	17.0	23.8	28.6

Well	4/28/88	7/19/88	10/21/88	Average
B1	7.5	11.0	12.0	7.3
B2	.83	2.0	2.6	1.4
B3	0.02	0.02	NS	0.02
B4	0.2	0.3	NS	0.2
B5	2.3	11.6	4.9	7.2
B6	10.0	9.6	8.9	9.2
Total	20.8	34.5	28.4	25.3

Note:

(1) - Extraction based on wells operating at 200 gpm and 1987 - 1988 average VOC concentrations.

NS - Not sampled, wells were not operating.

Under operating conditions wells B3 and B4 contribute 33 percent of BGRS flow. However, they contribute only approximately 1 percent of the total VOC mass. These wells are operated since the concentrations exceed the Contaminant Specific Requirements of the ROD at this point on the boundary.

2.4.2 Groundwater Treatment

Influent and effluent water were sampled on a weekly basis during the 90 day start up period and monthly for the remainder of the first year of operation. These data are contained in Appendix B.2 and a summary of these analyses are presented on Table 2.3. Figure 2.9 presents a graph of influent TRCLE concentrations versus time during the first year operational period. This graph illustrates that the average TRCLE concentration of the recovered groundwater over the operating period was 1201 ug/L.

As was noted in the PAR, the measurement of December 29, 1987, is not considered representative since the system was undergoing adjustment and well B6 was contributing a greater portion of the flow than usual. Since well B6 is located within the center of the north plume, composite concentrations increased due to a disproportionate contribution from B6. The TRCLE concentration of 2400 ug/L, recorded on January 19, 1988, may also be due to disportionate flow. However, the operational records are not of sufficient detail to make this determination.

TABLE 2.3

INFLUENT/EFFLUENT SAMPLING RESULTS (ug/L)

Compound	Average Influent	Range Influent	Average Effluent	Range Effluent
Vinyl chloride	.03	ND - 0.61	ND	ND
1,1-Dichloroethene	52.58	ND - 189	ND	ND - 0.24
Trans-1,2-dichloroethene	.01	ND - 0.38	ND	ND
1,1-Dichloroethane	40.0	19.3 - 150.0	ND	ND
Cis-1,2-dichloroethene	32.2	9.25 - 150.0	ND	ND - 0.58
Chloroform	3.4	ND - 21.0	ND	ND - 0.55
1,1,1-Trichloroethane	305.7	92.0 - 830.0	ND	ND - 0.94
Carbon tetrachloride	ND	ND	ND	ND - 0.21
1,2-Dichloroethane	.75	ND - 2.2	ND	ND
Trichloroethene	1229.	1350. -2495	0.5	ND - 2.7
1,2-Dichloropropane	ND	ND	ND	ND
1,1,2-Trichloroethane	.79	ND - 1.67	ND	ND - 0.59
Tetrachloroethene	2.28	ND - 5.40	ND	ND
Benzene	ND	ND - 0.56	ND	ND - 0.55
Toluene	ND	ND - 0.91	ND	ND - 0.92
M and P-Xylene	ND	ND - 2.00	ND	ND - 1.10
O-Xylene	ND	ND - 0.98	ND	ND - 0.69
1,1,2-Trichlorotri-fluoroethane	ND	ND - 0.93	ND	ND

Note:

ND - Not Detected

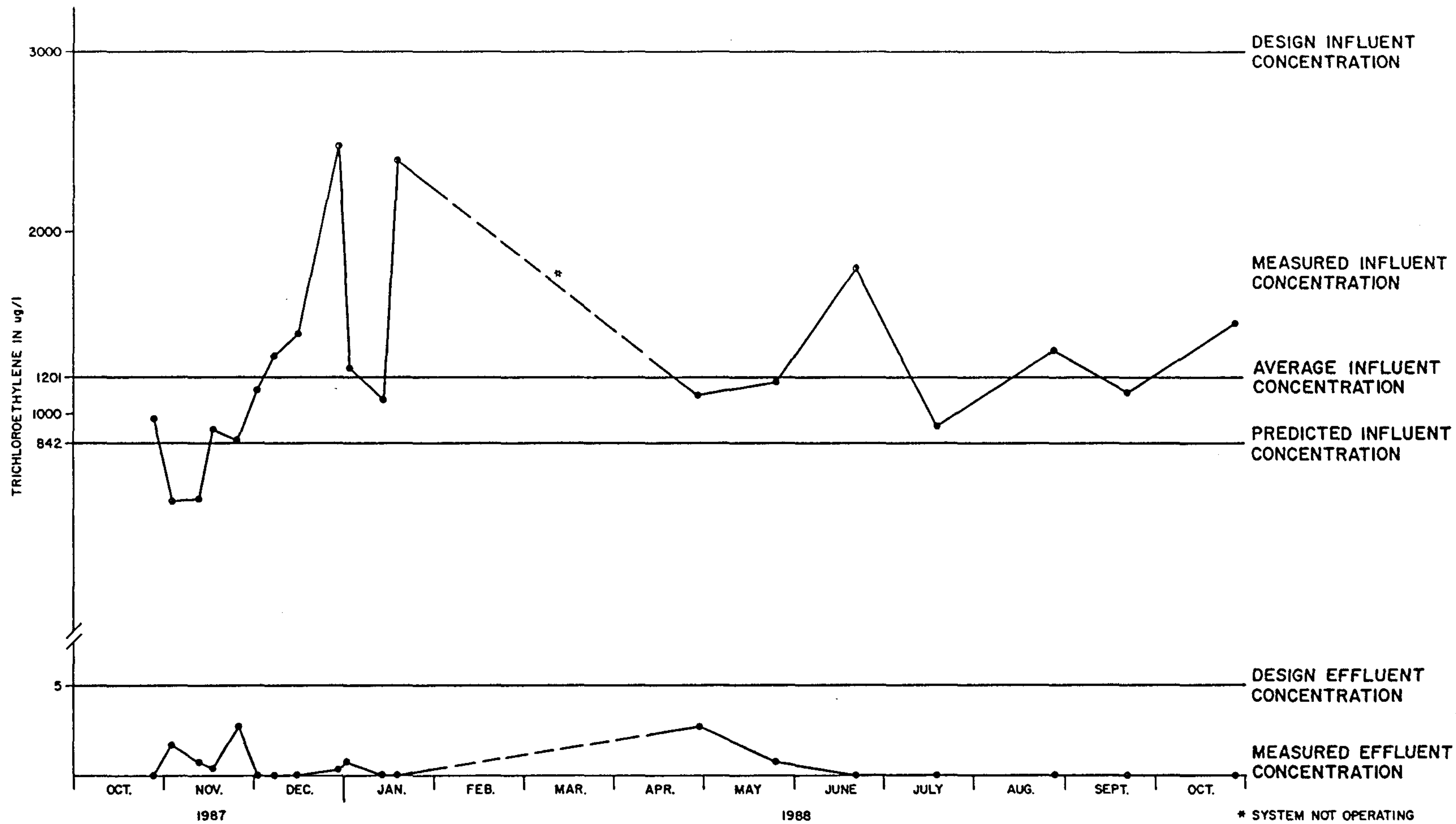

figure 2.9
BGRS TREATMENT SYSTEM PERFORMANCE
Twin Cities Army Ammunition Plant

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Figure 2.9 also demonstrates that the predicted initial TRCLE concentration of 842 ug/L, from the GRPP, is similar to the measured TRCLE concentrations. In addition, the extracted TRCLE concentrations are well below the concentration of 3,000 ug/L TRCLE used to design the treatment plant.

The BGRS treatment system was designed to treat VOCs to provide effluent TRCLE concentrations below 5 ug/L. Table 2.3 summarizes VOC data for BGRS effluent. Figure 2.9 illustrates that the effluent concentrations of TRCLE have been consistently below 5 ug/L. A review of the data base indicates that effluent has been below the Contaminant Specific Requirements for the other VOC compounds listed in the ROD.

As shown in Appendix B.4, cadmium was detected once in 11 sampling events at 12 ug/L. This exceeded the Contaminant Specific Requirements of 5 ug/L listed in the ROD. Lead also exceeded the Contaminant Specific Requirements once in the 11 sampling events (the same sampling event as for Cadmium). Lead was detected at 26 ug/L. The requirement from the ROD is 20 ug/L. The concentration of the remaining metals did exhibit concentrations above the average during this sampling round (with the exception of mercury which was not detected). This finding warrants detailed metals monitoring as discussed in the Section 4 Monitoring Plan. When the remaining metals were detected, they were found to be well below the Contaminant Specific Requirements of the ROD.

Appendix B.3 summarizes PCB data for the effluent. No PCBs were detected. The detection limits are below the Contaminant Specific Requirements of the ROD.

Appendix B.5 summarizes radon and radionuclide data in the effluent. Radionuclide concentrations were well below the Contaminant Specific Requirements of the ROD. Radon was detected once in the eleven sampling events. The ROD does not contain a Contaminant Specific Requirement for Radon.

Appendix B.6 summarizes phosphorus concentrations for the effluent. These data were collected to evaluate potential nutrient loading to Rice Creek. Table 2.4 shows the potential mass loading of phosphorus at various flow rates. The ROD precludes any phosphorus mass loading increase to Rice Creek as a result of treated water discharge. For this reason, the Rice Creek discharge option currently cannot be utilized. Due to the wide variability in the phosphorus results, continued monitoring is required to better define the average concentrations and potential mass loadings.

Appendix B.7 summarizes the results of the priority pollutant scan. These data were collected once to evaluate the possible presence of contaminants other than VOCs.

Effluent concentrations for metals, cyanide, PCB, radon, radionuclides, phosphorus, base/neutral compounds and pesticide compounds

TABLE 2.4

MASS LOADING OF PHOSPHORUS IN TREATED WATER

BGRS Discharge Rate (gpm	Resultant Mass Loading Increase (lbs./day)[1] Total P	Ortho P
200 (0.45 cfs)	1.15	0.08
600 (1.35 cfs)	3.46	0.25
1200 (2.70 cfs)	6.72	0.50

Notes:

(1) - Based on average effluent concentrations in Appendix B.6.

are all considered generally representative of water quality of the Unit 3 aquifer in the vicinity of the BGRS extraction wells since these parameters are essentially unaffected by the treatment process.

2.5 AIR EMISSIONS

VOC air emissions from the BGRS air strippers were calculated by a mass balance of the influent and effluent VOC concentrations and flow presented earlier in this section. This calculation found air emissions to range from 17 to 28 lbs/day based on the system operating at the design capacity of 1200 gpm. During 1988 the total mass of VOC released is approximately equal to that extracted, or 4800 lbs of VOCs (see Section 2.4.1).

3.0 CONCLUSIONS AND RECOMMENDATIONS

Based on a review of the BGRS Monitoring data from the past year of operation, the following conclusions are made:

1. The BGRS produces a continuous zone of capture that is approximately 3400 feet in width at the TCAAP boundary under operating conditions. The capture extends through the entire thickness of the Unit 3 aquifer and an undefined portion of the Unit 4 aquifer. This zone of capture did not fluctuate significantly over the 1 year assessment period.

2. The Unit 3 VOC plume is substantially captured by the BGRS. There exists a portion of the VOC plume outside of capture to the North. This portion of the plume is being addressed by the expanded BGRS/TGRS.

3. An undefined portion of the Unit 4 VOC plume is captured. Capture in the Unit 4 is being addressed under the BGRS/TGRS expansions to the system.

4. The VOC plumes at TCAAP showed little variation in configuration and relationship to capture from quarter to quarter during the 1988 operational year.

5. The VOC compounds Benzene, Toluene, 1,2 Dichloropropane, Xylenes, and 1,1,2 Trichlorotrifluoroethane were never detected in the influent above contaminant specific requirements. These compounds have typically not been considered Target compounds at TCAAP.

6. The Arsenal Sand and Gravel Pit was found suitable to accommodate the treated water discharge under the conditions of the operational year.

7. The operational problems that resulted in a number of system shut downs during the year have been addressed through physical improvements to the system and through the reinstatement of an operation and maintenance contractor.

8. In general, the hydraulic and treatment performance conclusions presented in the PAR continue to be supported by the BGRS data base.

The following recommendations are made regarding the BGRS Monitoring Plan:

1. Reduce the frequency of the groundwater level monitoring to one comprehensive round per year and monitor key locations during the remaining three quarters.

2. Reduce the frequency of groundwater sampling to one comprehensive round per year and monitor key locations (including PD2U3 and 03M005) during the remaining three quarters.

3. Increase the scope of the monitoring activities to address the expanded BGRS/TGRS system.

4. Eliminate the non-target VOCs, listed in conclusion No. 5 above, from the influent/effluent sampling program and monitor for the same VOC compounds as for the monitoring wells. Appendix F.1 contains a list of the Target VOC compounds.

5. Conduct analysis for metals from all extraction wells and the treatment system effluent on a quarterly basis in an effort to determine the source of the metals discussed in Section 2.4.2.

6. Monitor the system effluent for Priority Pollutant Compounds on an annual basis to address the potential for the presence of non-target compounds at TCAAP.

7. Continue to monitor water levels and discharge rates with respect to the Arsenal Sand and Gravel pit to assess its long term suitability to accommodate BGRS/TGRS discharge.

These recommendations are detailed in the following section of this report.

4.0 BGRS/TGRS MONITORING PLAN

Based on the conclusions of this BGRS Annual Assessment Report (AAR), a modified monitoring plan has been developed for the 1989 operation of the BGRS/TGRS. Figure 4.1 illustrates the general layout of the BGRS/TGRS. The expansions made to the system include four Unit 4 extraction wells (B8, B9, B10 and B11), two additional Unit 3 extraction wells along the boundary (B7 and B11) and two pairs of Unit 3 source control wells downgradient of Sites D and G (SC2, SC3, SC4 and SC5). In addition, the source control well located at Site I (SC1) has also been included as a part of the BGRS/TGRS.

Nine additional monitoring wells were also installed under the BGRS/TGRS construction program to establish a suitable monitoring network for the expanded system.

The BGRS/TGRS is designed to meet the VOC capture criteria contained in the ROD for both the Unit 3 and Unit 4 aquifers.

In summary, this modified monitoring plan reduces the frequency of monitoring activities based on the consistency in results discussed in Section 2. Correspondingly, the plan has also been expanded in total number and extent of wells monitored in order to address the expansions made under the BGRS/TGRS construction activities. It has also been expanded to

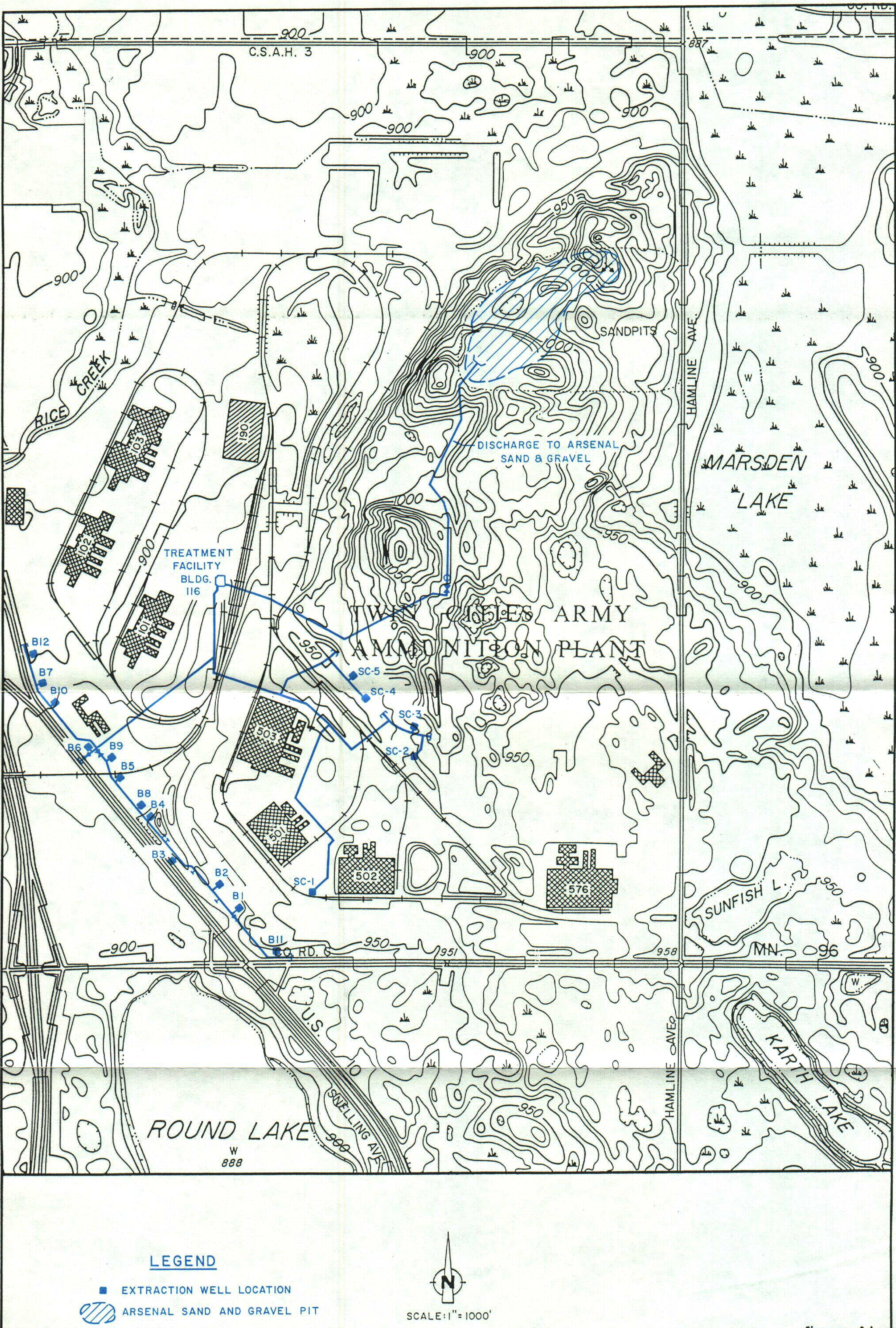

figure 4.1
BGRS MOD / TGRS SYSTEM
Twin Cities Army Ammunition Plant

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accommodate the required monitoring activities at the three source areas, Sites D, G and I. The source control activities at Site D, Site G and Site I comprise the TGRS.

This report presents a plan to continue monitoring of the operation and performance of the BGRS/TGRS by monitoring hydraulic and water quality performance of groundwater extraction, groundwater treatment and treated water recharge during the operation of the BGRS/TGRS.

The monitoring program described herein is one of several monitoring programs ongoing at TCAAP.

The seven objectives of the BGRS/TGRS Monitoring Plan are:

1. to monitor the horizontal and vertical hydraulic zone of capture within the Unit 3 and Unit 4 aquifers which results from pumping the seventeen extraction wells installed on TCAAP by collection and assessment of groundwater levels,

2. to monitor groundwater flow patterns resulting from the recharge of treated groundwater to the Arsenal Sand and Gravel Pit by the collection and assessment of groundwater levels,

3. to monitor flow patterns at TCAAP as modified by the operation of the BGRS/TGRS groundwater capture and recharge system by the collection and assessment of groundwater levels,

4. to monitor the long term improvement of groundwater quality at TCAAP by the collection and chemical analysis of groundwater samples from monitoring and extraction wells,

5. to monitor the treatment of extracted groundwater for VOC removal efficiencies by the collection and chemical analysis of influent and effluent water samples from the treatment system,

6. to monitor the quality of treated water prior to:
   a) use as a raw water supply for TCAAP, or
   b) recharge at the Arsenal Sand and Gravel Pit by monitoring treated effluent for parameters in addition to VOCs and

7. to monitor and quantify air emissions from the treatment towers by evaluation of influent and effluent water quality data.

The objectives of the BGRS/TGRS Monitoring Plan will be met by three monitoring tasks. These are:

TABLE 4.1
COMPREHENSIVE NETWORK
GROUNDWATER LEVEL MONITORING LOCATIONS

On-TCAAP

03U001
03M001
03L001
04U001
03U002
03M002
03L002
04U002
03U003
03M003
03L003
04U003
03U004
03M004
03L004
03U005
03M005
03L005
03U006
03U007
04U007
03U008
03U009
03U010
03U011
03U012
04U012
03U013
03U014
03U015
03U016
03U017
03M017
03L017
03U018
03L018
03U019
03U020
03M020
03L020
04U020
03U021
03L021

03U022
03U023
03U024
03U025
03U027
03L027
04U027
PJ#027
03U028
03L028
03U029
03L029
03U030
03U031
03U032
03U075
03U076
03U077
03L077
04U077
04J077
03U078
U3L078
03U079
03L079
03L080
03U082
03U083
03U084
0L3084
03U087
03U089
03U093
03U096
03U111
03U112
04U510
03U647
03U648
03U658
03U659
03U674
03U671

03U701
04U701
03U702
04U702
04J702
03U703
03U704
03U705
03U706
03U707
03U708
04U708
04J708
03U709
04U709
03U710
03U711
04U711
03M713
04U713
04J713
04U714
04J714
03U715 (SM-1)
03U716 (SM-2)
B1
B2
B3
B4
B5
B6
B7
B8
B9
B10
B11
B12
SC-1
SC-2
SC-3
SC-4
SC-5

Off TCAAP

PD2U3
PD3U3
PD3L3
PD3U4
T1U3
T2M3
T2L3
T2U4
T2PJ
T3U3

T4U3
T5U3
T6U3
T6M3
T6L3
T6U4
T6PJ
T9L3
MPCA 6

- groundwater level monitoring,
- groundwater quality monitoring and
- treatment monitoring.

4.1 GROUNDWATER LEVEL MONITORING

The groundwater level monitoring task will meet the first three objectives of the BGRS/TGRS Monitoring Program. Two networks of monitoring wells will be utilized to collect and assess groundwater elevation data for the BGRS/TGRS on a quarterly basis.

An extensive list of monitoring wells, designated the Comprehensive Water Level Network, will be monitored once per year. These wells are listed on Table 4.1 and illustrated on Figure 4.2. These data will be utilized to prepare detailed groundwater contour maps of the Site in order to assess the zone of capture for the BGRS/TGRS in the Unit 3 and Unit 4 aquifers.

During the remaining three quarterly water level events a smaller core network of wells will be monitored. Table 4.2 lists the Core Network Wells. These data will provide more continuous water level records to monitor seasonal fluctuations and other minor fluctuations in the piezometric surface. The wells were chosen to represent background wells, wells near extraction centers, wells intermediate to extraction centers and wells near the Arsenal Sand and Gravel Pit recharge area. As discussed earlier, the overall pattern of groundwater flow does not change significantly over the short term.

TABLE 4.2

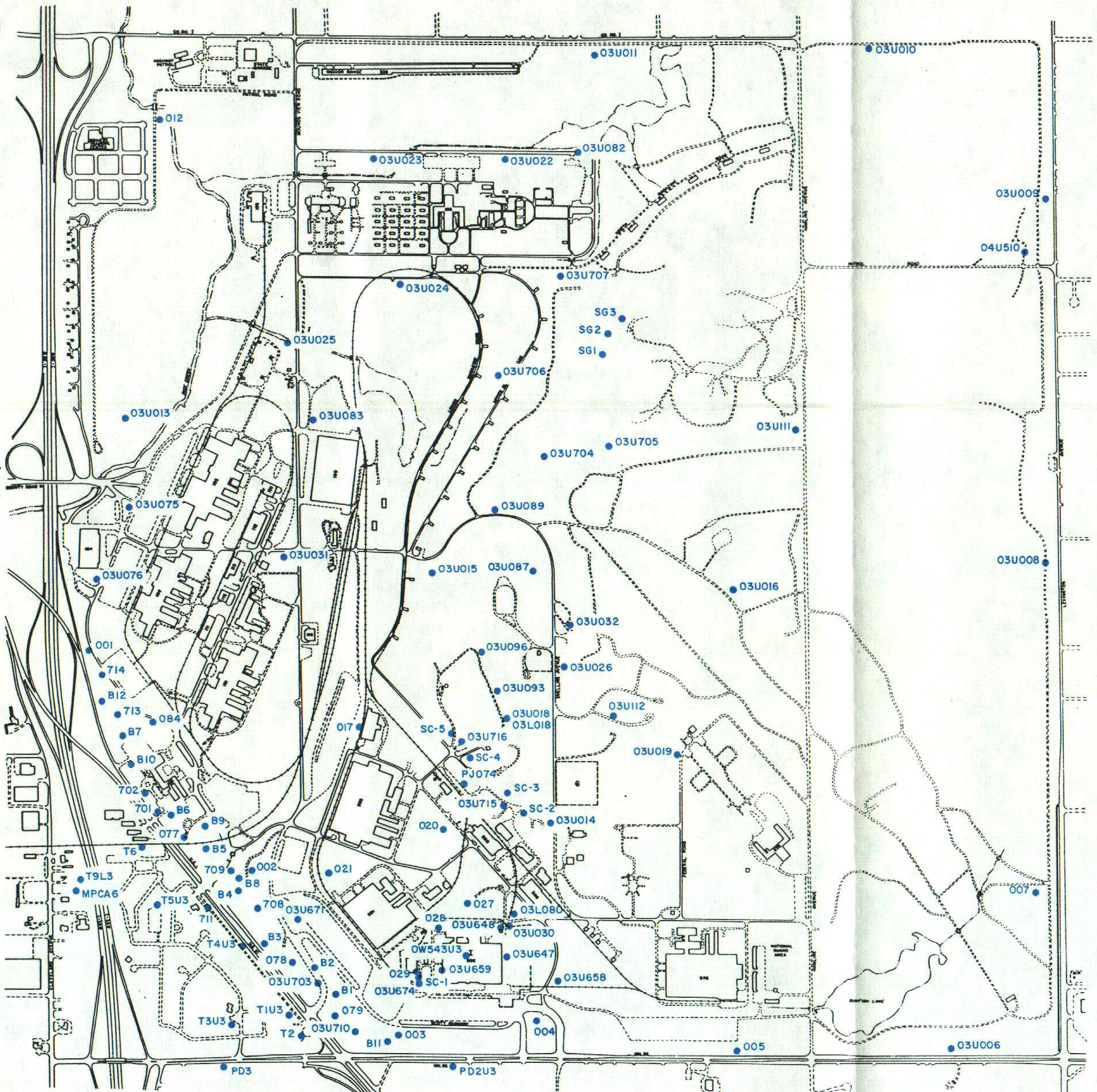
QUARTERLY CORE NETWORK
GROUNDWATER LEVEL MONITORING LOCATIONS

On TCAAP

03L001	03U711	B3
04U001	04U711	B4
03U012	03M713	B5
04U012	04U713	B6
03U007	04J713	B7
04U007	04U714	B8
03U706	04J714	B9
03U704	03U715	B10
03U002	03U716	B11
03M002	03U020	B12
03L002	03M020	SC1
04U002	03L020	SC2
03U003	04U020	SC3
03M003	B1	SC4
03L003	B2	SC5
04U003		

Off TCAAP

PD2U3
PD3U3
PD3L3
PD3U4
T2L3
T6L3
T6U4



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SCALE: 1" = 1200'

LEGEND

● GROUNDWATER LEVEL MONITORING LOCATION

NOTE: SEE TEXT FOR COMPLETE WELL LISTING AT NESTS.

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figure 4.2
GROUNDWATER LEVEL MONITORING LOCATIONS
Twin Cities Army Ammunition Plant

2687-33-2/02/89-M

These locations and frequencies will be reevaluated after each year of operation.

In conjunction with the start-up of the Modified BGRS/TGRS two additional rounds of water levels will be collected on the comprehensive well network. These water levels will serve to establish hydraulic performance data for the expanded system. These rounds will be conducted at suitable intervals following the initial system debugging period. It is likely that these comprehensive rounds will be conducted at the scheduled quarterly monitoring intervals.

4.2 GROUNDWATER QUALITY MONITORING

The groundwater quality monitoring task will meet the fourth objective of the BGRS/TGRS Monitoring Plan, namely, to monitor the long term improvement of groundwater quality at TCAAP.

In a similar fashion to the water level monitoring, two networks of monitoring wells have been identified for quarterly sampling.

The Comprehensive Network, listed on Table 4.3 and illustrated on Figure 4.3, will be sampled and analyzed for the VOC compounds listed in Appendix F.1 once per year. These data will be utilized to construct detailed VOC plume maps for TCAAP.

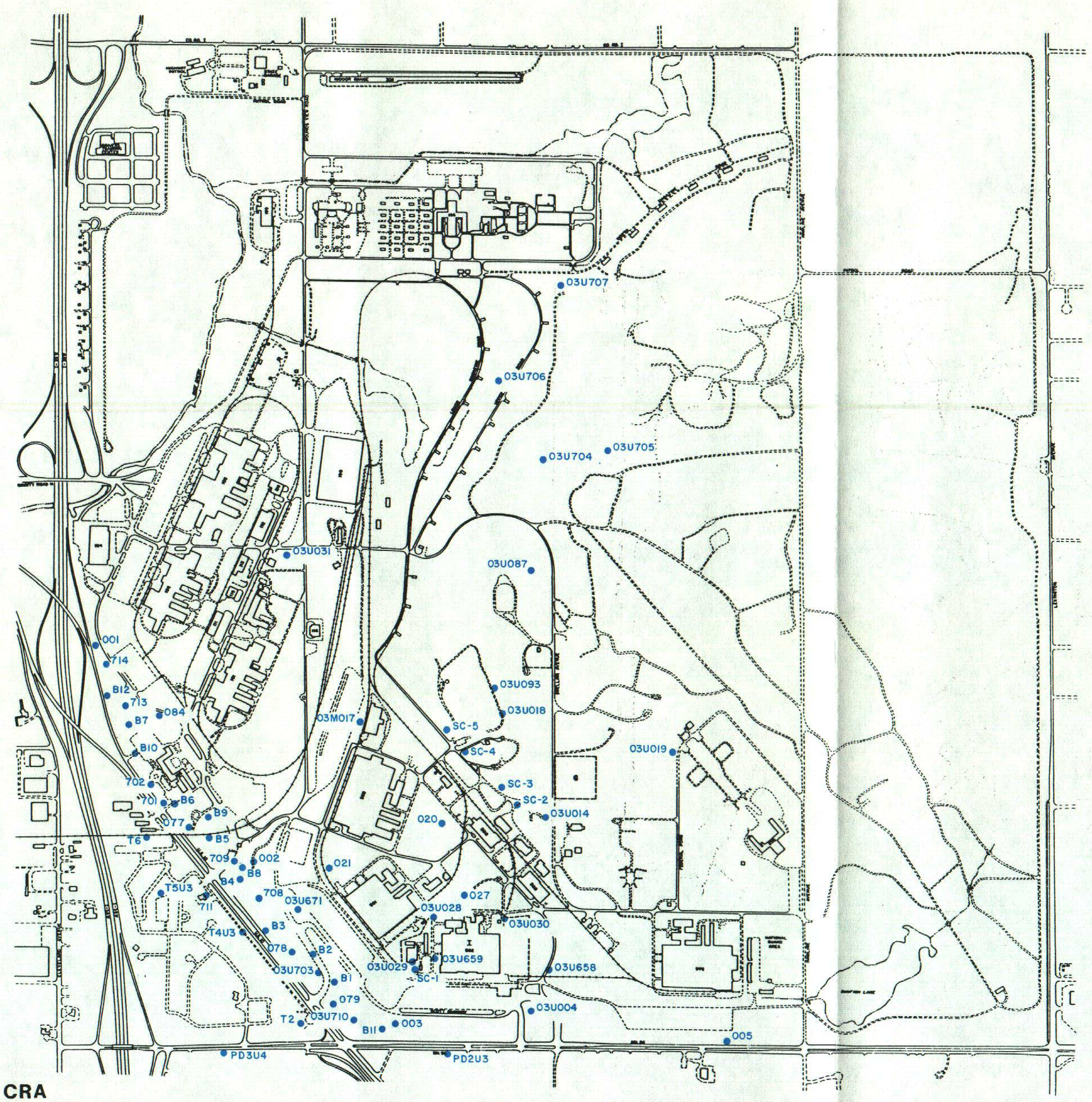
TABLE 4.3

COMPREHENSIVE GROUNDWATER QUALITY SAMPLING LOCATION

03L001
04U001
03L002
04U002
03U003
04U003
03U004
03U005
03M005
03U014
03M017
03U018
03U019
03M020
04U020
03U021
03L021
03U027
04U027
03U028
03U029
03U030
03U031
03U077
03L077
04J077
03M005
04U077
03U078
03L078
03U079
03L079
03U084
03L084
03U087
03U093
03U658
03U659
03U671
03U701
04U701
03U702
04U702
04J702
03U703
03U704
03U705
03U706
03U707
03U708
04U708
04J708
03U709
04U709
03U710
03U711
04U711
04U714
04J714
04U713
04J713
B1
B2
B3
B4
B5
B6
B7
B8
B9
B10
B11
B12
SC1
SC2
SC3
SC4
SC5

Off TCAAP

T2L3
T2U4
PD2U3
T4U3
T5U3
T6L3
T6U4
T6PJ
PD3U4



LEGEND

● GROUNDWATER QUALITY MONITORING LOCATION

NOTE: SEE TEXT FOR COMPLETE WELL LISTING AT NESTS.

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figure 4.3
GROUNDWATER QUALITY MONITORING LOCATIONS
Twin Cities Army Ammunition Plant

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The Core Network, listed on Table 4.4, consists of a smaller number of key wells to monitor the VOC plume during the remaining three quarterly monitoring events. These wells were chosen to monitor key background, plume center and plume fringe areas on TCAAP. In this manner, any unforeseen plume variations which may impact the effectiveness of the system would be identified on a quarterly basis. As discussed earlier, the VOC plumes at TCAAP do not exhibit significant variations over the short term.

The 17 extraction wells are included in the core network wells. These wells will be analyzed for the compounds listed in Appendix F.1. This monitoring task will allow for an essentially continuous record of water quality and VOC mass removal data for each well. In addition, the extraction wells will be monitored for the priority pollutant metals on a quarterly basis in order to address the presence of metals discussed in Section 2.4.2.

These locations and frequencies will be reevaluated after each year of operation.

Sampling and analysis procedures will follow those established in the IRA-BGRS Quality Assurance Project Plan[6].

4.3 TREATMENT EFFICIENCY MONITORING

The treatment monitoring task will meet the fifth and sixth objectives of the IRA-BGRS/TGRS Monitoring Plan.

TABLE 4.4

QUARTERLY CORE NETWORK GROUNDWATER QUALITY MONITORING LOCATIONS

03L001	03U704	B9
04U001	B1	B10
03U711	B2	B11
04U711	B3	B12
04U714	B4	SC1
04J714	B5	SC2
03U003	B6	SC3
04U003	B7	SC4
03U018	B8	SC5
03U014		

Off TCAAP

T2L3
PD2U3
T6L3
T6U4

Influent and effluent samples from the treatment plant will be collected for analysis of the VOCs listed on Appendix F.1 on a monthly basis. This effort is required to monitor the efficiency of the treatment system and to characterize effluent water quality for end use. In addition, effluent will be monitored for total phosphates, ortho phosphates and pH each time it is sampled. This effort will aid in developing a data base for nutrient loading evaluation. On quarterly basis the influent will be sampled for priority pollutant metals.

Once each year a sample of treated water will be collected and analyzed for priority pollutant compounds (listed in Appendix F.2). This effort is intended to assess the overall quality of the groundwater extracted and treated under the BGRS/TGRS. The results of these sample analyses will identify the presence of any compounds other than those routinely monitored for following treatment.

The water quality assessment for priority pollutants has been included as a result of the water quality data base review included in the GRPP. The data base review identified the presence of hazardous substances, other than VOCs, which are present in TCAAP source area soils which could potentially leach to groundwater. The detection of priority pollutants, other than VOCs, in treated water is not expected (with the exception of metals) due to the following factors:

- treated water is not being used under the BGRS to flush source areas, and

- TCAAP source areas D and G have been capped with clay to reduce potential leaching.

Nevertheless, samples will be analyzed for priority pollutants to monitor this potential.

The scope and frequency of treatment monitoring will be reevaluated after one year.

4.4 SUMMARY OF WATER MONITORING PLAN

Table 4.5 provides a summary of the monitoring tasks and the frequency of each task.

4.5 AIR MONITORING

Air emissions will be calculated by comparing influent VOC mass loading with effluent VOC mass. The difference between these accurately represents the VOC mass removed and discharged by the air stripping system.

TABLE 4.5

SUMMARY OF BGRS/TGRS MONITORING PLAN

Task	Locations	Frequency	Parameters
Groundwater Level Monitoring	See Table 4.1 and Table 4.2	Quarterly	- Water Levels
Groundwater Qaulity Monitoring	See Table 4.3 and Table 4.4	Quarterly	- VOCs (See Appendix F.1)
Extracted Groundwater Quality Monitoring	B1, B2, B3, B4, B5, B6, B7, B8, B9, B10, B11, B12, SC1, SC2, SC3, SC4, SC5	Quarterly	- VOCs and Metals (See Appendix F.1 and Appendix F.2)
Treatment Monitoring	Treatment Plant Influent	Monthly	- VOCs (See Appendix F.1)
Treatment Monitoring	Treatment Plant Effluent	Monthly	- VOCs, Ortho and Total Phosphorus (See Appendix F.1) and pH
		Quarterly	- Metals (See Appendix F.2)
		Annually	- Priority Pollutants (See Appendix F.2)

Note:

Scope and frequency to be reevaluated after one year.

4.6 MONITORING REPORTS

Quarterly and annual monitoring reports will be prepared for submittal to the MPCA through the Army.

4.6.1 Quarterly Monitoring Reports

The quarterly monitoring reports will be data reports documenting water levels recorded during the past quarter and results of groundwater quality monitoring.

4.6.2 Annual Monitoring Reports

Annual monitoring reports will be prepared and will present the results of all monitoring data collected for the previous year. These annual reports will contain the following information:

1. tabulated water levels and groundwater level contour maps for the Unit 3 and Unit 4 aquifers showing the zone of capture created by the system,

2. tabulated results of groundwater quality analyses,

3. isoconcentration maps for trichloroethylene, 1,1,1-trichloroethane and 1,1-dichloroethylene based on the most recent sampling results for wells in the Unit 3 and Unit 4 aquifer,

4. a proposed sampling program or recommendation to continue present monitoring for the following year, including an assessment of the monitoring parameters and frequencies and the feasibility for changes and/or deletions to the program,

5. an evaluation of the past year's data,

6. a discussion of program effectiveness,

7. proposals for future modifications.

4.7 SCHEDULE

The original Monitoring Plan was initiated on 10/19/87. This updated Monitoring Plan will continue to be in effect through the 1989 operations year and will be reevaluated in the subsequent annual report.

The frequency of monitoring is outlined on Table 4.5 of this report. Quarterly reports will be completed 45 days following the end of each quarter. Annual reports will be completed by February 15 of the year following each year of operation.

All of Which is Respectfully Submitted,

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REFERENCES

(1) Groundwater Remediation Program Plan (GRPP), by Honeywell/CRA, dated June 18, 1986.

(2) Federal Facility Agreement (FFA), between Army, USEPA and MPCA, dated August 12, 1987.

(3) Record of Decision (ROD) for Gradient Control System, for TCAAP, Issued by USEPA, dated September 25, 1987.

(4) IRA-BGRS Performance Assessment Report, by Honeywell/Army/CRA, dated August 4, 1988.

(5) IRA-BGRS Monitoring Plan, by Honeywell/CRA, dated February 19, 1988.

(6) Quality Assurance Project Plan (QAPP), IRA Monitoring Program, TCAAP by Honeywell/Army/CRA, dated February 18, 1988.

(7) IRA-BGRS: Water Balance, by Honeywell/Army/CRA, dated February 18, 1988.

(8) BGRS Extraction Well Pumping Test, by Honeywell/Army/CRA, dated April 1, 1987.

(9) Extraction Well Pumping Test Report (EW542U3), Building 502, TCAAP Groundwater Remediation System, by Honeywell/CRA, dated February 1986.

(10) Javandel, I. and Tsang, C.F. (1986), "Capture Zone Type Curves: A tool for Aquifer Clean Up". Groundwater, Vol. 24, No. 5, pp. 616-625