GM CPC
OFF-SITE
GROUND WATER PURGE
EVALUATION
GRAND RAPIDS METALS FABRICATION
GRAND RAPIDS, MICHIGAN

Prepared for

GM CPC
300 36TH STREET
GRAND RAPIDS, MICHIGAN

Prepared by

WW ENGINEERING & SCIENCE
5555 GLENWOOD HILLS PARKWAY
GRAND RAPIDS, MICHIGAN 49588-0874

APRIL 1993

PROJECT 22579

WW Engineering & Science
A Summit Company

GM CPC

OFF-SITE

GROUND WATER PURGE

EVALUATION

GRAND RAPIDS METALS FABRICATION

GRAND RAPIDS, MICHIGAN

Prepared for

GM CPC
300 36TH STREET
GRAND RAPIDS, MICHIGAN

Prepared by

WW ENGINEERING & SCIENCE
5555 GLENWOOD HILLS PARKWAY
GRAND RAPIDS, MICHIGAN 49588-0874

APRIL 1993

PROJECT 22579

Reviewed by:

Theodore A. Lietzke
Project Manager

Julie A. Beaton
Director, Project Management

TABLE OF CONTENTS

PAGE

TABLES

FIGURES

APPENDICES

MEETING AGENDA

GM CPC Grand Rapids Metal Fabrication Plant
May 10,1993
MDNR Offices Grand Rapids

INTRODUCTIONS

BACKGROUND

MDNR REQUEST FOR EVALUATION OF OFF-SITE PURGE WELLS(S)

MODEL ASSUMPTIONS/CONSTRAINTS

- EXISTING SYSTEM
- OFF-SITE WELLS

MODEL PROCESS

- 1ST STEP WATER FLOW
- 2ND STEP CONTAMINANT CONCENTRATIONS

SCENARIOS

COST ANALYSIS/ENGINEERING CONSIDERATIONS

RESULTS

PROPOSAL

- RISK EVALUATION AND/OR RESTRICTIVE AGREEMENT
- MDNR APPROVAL

DISCUSSION

1.0 INTRODUCTION

GM CPC has previously investigated and begun remediation of a TCE plume emanating from beneath the facility. The remedial system consists of a purge well (installed in 1989) and soil vapor recovery system in the plant and an additional purge well in the north parking lot (PW-DISCH installed in 1989). The ground water from the purge wells is sent to the City of Wyoming for treatment.

The plume beyond PW-DISCH has been discharging by natural means to Cole Drain in the vicinity of MW-11. Cole Drain has been monitored since 1988 as documented in the ongoing monitor program. No adverse impact to the drain water quality from the ground water discharge is evident from the monitoring program.

At the request of MDNR, in a letter of February 17, 1993 to GM CPC, an assessment has been prepared for off-site purging to supplement the existing plume capture system. This report presents the ground water modeling and engineering evaluation of that assessment.

In order to evaluate the capture and effectiveness of off-site purging, a ground water flow and contaminant transport model was developed. The ground water flow and contaminant transport modeling section summarizes the methods and results of the evaluation of the current on-site ground water capture and effectiveness for off-site purging relative to the current system. The model was calibrated to match the existing conditions and then used to predict future changes in the plume. Predictions were completed for scenarios using the current ground water capture system and for scenarios with additional purging off-site.

The model was used to assess the effectiveness of:

- The current purging scenario;
- Purging off-site near Cole drain and MW-11 in the City of Wyoming Hillcraft Park at 10 gallons per minute (gpm); and
- Purging off-site near Cole drain and MW-11 at 40 gpm.

An additional purge well located midway between PW-DISCH and MW-11 was also considered for evaluation.

On the basis of the ground water modeling a cost analysis has been prepared for the 10 gpm scenario. In addition, engineering, site access, and treatment options are discussed.

GM CPC's objective with the remedial system has been to reach a Type B closure for the entire site. The effectiveness of the existing and requested systems to attain that objective are evaluated.

2.0 GROUND WATER FLOW AND CONTAMINANT TRANSPORT MODELING

A contaminant transport model was developed to simulate the contaminant migration. The contaminant transport model was developed using modeling software entitled " A Modular Three-Dimensional Transport Model for Simulation of Advection, Dispersion, and Chemical Reactions of Contaminants in Ground Water System "(MT3D) developed by S.S. Papadopulos & Associate, Inc.

As the basis of MT3D simulations, a ground water flow model was developed using modeling software developed by M. G. McDonald and A. W. Harbough of the U.S. Geological Survey entitled "A Modular Three-Dimensional Finite Difference Ground Water Flow Model" (MODFLOW). The ground water flow model results are used as input into the contaminant transport model.

2.1 GROUND WATER FLOW MODEL SIMULATIONS

The ground water flow system was modeled as a single layer, water table aquifer.

The modular design of MODFLOW allows the assignment of modules of computer code call packages to simulate the different aspects of the hydrogeologic system. Of these packages, the Basic Input, Block Center Flow, Well, Drain, General Head Boundary, and Recharge packages were used to simulate the ground water flow patterns.

Basic Package

The Basic Input package is used to define the model grid and boundary conditions. A 4000 ft by 7000 ft finite difference grid was constructed using a uniform cell discretization. The grid boundaries were set a sufficient distance away from the area of investigation to eliminate model boundary effects. The upgradient boundary (South-Southeast) and the downgradient boundary (North-Northwest) of the flow model were simulated as constant head boundaries. Both side boundaries were simulated as no-flow boundaries.

Block Center Flow Package

The Block Center Flow package is used to define the aquifer parameters for each cell of the model. The sand and gravel aquifer is under unconfined conditions. The aquifer thickness varies between 10 ft and 60 ft based on the well logs and cross sections in the hydrogeologic investigation reports(phase III and IV). Hydraulic conductivity values used in the model were based on the site permeability tests(slug tests) with a range of 17 to 192 ft/day.

Other Packages

Cole Drain was simulated using the General Head Boundary package. This package was chosen to simulate communication between water in the drain and the aquifer when water elevation in the drain fluctuates. A foundation drain under the GM CPC building was simulated using Drain package. Purge wells were simulated using Well package. The recharge package was used to simulate surface infiltration. A recharge rate of 10 inches per year was input to the modeled areas not covered with buildings, roads, or other paved areas.

Calibration

The ground water flow model was calibrated to the December 10, 1992 water table elevations using the steady-state flow option. A calibration of approximately ±0.3 ft was obtained over all the modeled area(see Table 1). The simulated ground water flow patterns are presented in Figure 1. These results indicate the current system is effectively capturing the ground water beneath the facility property.

Purge Scenarios

Two additional ground water flow purge scenarios were performed under steady-state conditions. Keeping the current pumping situation, an additional purge well (MPW) was modeled near well 87-11 with pumping rates at 10 gpm and 40 gpm.

The simulated ground water flow pattern for the two additional purge rates with off-site purging are illustrated in Figures 2 and 3.

The results of the calibration scenario (i.e., current purging conditions) and off-site purging scenarios were used as input into the contaminant transport model.

2.2 CONTAMINANT TRANSPORT SIMULATIONS

The input structure for MT3D is similar to the ground water flow model(MODFLOW). The input data is divided into packages which contain input parameters needed to simulate the different aspects of contaminant transport. Of the available packages the Basic Transport, Advection, Dispersion, Chemical Reaction, and Source/Sink Mixing packages were used to simulate the contaminant migration. The application of each of these packages is described below.

Basic Transport Package

Due to the similarity of the input formats between MODFLOW and MT3D, most of the information for the definition of the model domain was obtained directly from the existing MODFLOW Basic and Block Center Flow input files.

In this model, trichloroethene(TCE) was simulated. The initial concentrations were input based on the analytical results for samples collected on September 1989. Two grid cells were set as constant concentration sources(200 ug/L and 75 ug/L) to simulate the continuous TCE input from the vadose zone or capillary fringe.

Advection Packages

The advection package simulates the change in concentration due to advection. MT3D provide three types of Eulerian-Langrangian algorithms to solve for the advection portion of contaminant transport. The Method of Characteristics(MOC) was used in this model. It uses a conventional particle tracking technique for solving the advection term. One important feature of the MOC technique is that it is virtually free of numerical dispersion, which creates serious difficulty in many standard numerical schemes.

Dispersion Package

The dispersion package simulates the change in contaminant concentrations due to hydrodynamic dispersion. Hydrodynamic dispersion occurs because of mechanical mixing during advection through porous medium and because of molecular diffusion due to the thermal-kinetic energy of the contaminant particles.

The dispersivity term is broken down into three orthogonal components of spreading: longitudinal dispersivity (spreading in the direction of ground water flow), horizontal transverse dispersivity, and vertical transverse dispersivity. The values of longitudinal, horizontal, and vertical dispersivity were set 10 ft, 0.2 ft, and 0.2 ft, respectively. These values are considered appropriate considering the homogeneous nature of the aquifer. Spreading due to molecular diffusion was not considered during the transport simulations because the average linear ground water flow velocities observed at the site fell within an advection dominated flow regime(i.e., diffusion is negligible for the simulations).

Sink Source Mixing Package

The sink source mixing package simulates dissolved contaminants entering the simulated domain through sources (i.e. recharge), or leaving the simulated domain through sinks (i.e. well drain).

This package was used to simulate the removal of TCE due to pumping of purge wells PW-DISCH, 86-2, and the modeled off-site purge well, as well as Cole Drain and the foundation drain under GM CPC building. The locations and flow rates of point sources/sinks are obtained directly from the output of the ground water flow model.

Chemical Reaction Package

The chemical reaction package was used to simulate the retardation of contaminant migration due to sorption of the contaminants on the aquifer. A linear isotherm was selected to simulate the adsorption and desorption processes.

A bulk densitity of 120.6 lb/ft^3 and a distribution coefficient (kd) 0.00202 ft^3/lb were input into the contaminant transport model so that a retardation factor of 1.97 was calculated by the model. The first order irreversible rate reaction (radioactive decay or biodegradation) was not considered for any of the simulations. Because TCE is observed to breakdown to DCE at the site TCE concentrations may decrease slightly more rapidly than predicted due to degradation.

Calibration

A calibration of TCE migration was performed. The model was calibrated to the December 1992 TCE concentrations, with TCE concentrations from September 1989 used as the starting concentrations. Figures 4 and 5 illustrate the initial TCE concentrations and the simulated TCE concentrations for December 1992. The simulated results closely matched the observed conditions for December 1992 indicating the model is able to simulate the observed conditions.

Scenarios

Starting with the current conditions (i.e., December 1992) predictions were made for each scenario for three future time intervals: five years, December 1997; 10 years, December 2002; and 15 years, December 2007.

For the off-site purging scenarios a purge well (MPW) was modeled near monitoring well 87-11. Two scenarios were modeled. The first with purging at 10 gpm and the second with purging at 40 gpm. In each of the scenarios the purge well begins pumping in December 1993.

3.0 MODEL RESULTS

The results of the modeling are presented in Figures 6 through 15, Tables 1 and 2, and Appendix A. Figures 6 through 8 illustrate the predicted TCE concentrations under current pumping conditions. Evaluation of the data presented in Figures 6 through 8 indicate that the purge well in the parking lot (PW-DISCH) is preventing further migration of TCE from the plant area to the off-site area. By the end of 2002 the off-site plume is predicted to be at or near 3 ug/l beneath the southern half of the off-site property. By the end of 2007 the off-site plume is predicted to have decreased to 3 ug/l or less throughout most of the off-site area.

Figures 9 through 11 illustrate the predicted TCE concentrations with off-site purging at a rate of 10 gpm. Evaluation of the data presented in these figures illustrate that an off-site purge rate of 10 gpm has little effect on plume changes relative to no off-site purging. Figures 12 through 14 illustrate the predicted TCE concentrations with off-site purging at a rate of 40 gpm. The data presented in these figures indicate that off-site purging at a rate of 40 gpm should cause the concentrations within the central portion of the off-site plume to decrease below 50 ug/l by the end of 1997. The data presented in Figure 13 for the year 2002, however, indicates purging off-site at 40 gpm could cause migration of TCE past the existing purge well PW-DISCH (see Figure 7, 10, and 13).

Table 1 summarizes the ground water flow model calibration results. Table 2 summarizes the amount of TCE remaining off-site for each model scenario as a percentage of the initial amount present when the remedial system was started in 1989. A 25% reduction has already occurred in the off-site plume with the operation of the current system. Figure 15 presents the predicted reduction of total TCE present in the off-site plume area through time for each scenario. Appendix A presents tables of the modeling output summarizing the ground water volumetric and contaminant mass budgets for each of the modeled scenarios.

All three model scenarios, including continued operation of the existing system, show less than 1% of the mass remaining in the off-site plume at the end of 15 years. The total mass presented in Appendix A is over estimated from actual due to the model assumption that the entire thickness of the aquifer is at the modeled concentration. We estimate approximately one fourth of the aquifer thickness is contaminated to the level measured in the monitoring wells. The monitoring wells are placed in the most contaminated zone of the aquifer on the basis of analysis from temporary wells used to vertically profile the aquifer.

The placement of a second off-site well in the axis of the plume midway between PW-DISCH in the north parking lot and MW-11 was considered for evaluation. The model results for the existing system indicate that the concentration of TCE is dropping already in that area.

4.0 COST ANALYSIS

The cost estimate, Table 3, lists the major assumptions for the construction of one 10 gpm purge well in Hillcraft Park near monitoring well MW 87-11. The well, to be effective, has to be located in the immediate vicinity of the baseball diamond. The estimate includes a capital cost of $70,000 for construction of the well, piping, and control vault and an annual operating cost of $20,000 based on current cost rates. The discharge is proposed to be directed to the City of Wyoming sanitary sewer, as is the existing operating system. The City of Wyoming has recently considered a substantial increase in the discharge fee rate for ground water discharges which could significantly increase the cost. The life cost, assuming 15 years of operation at 10 GPM, is $375,000. For a conservatively estimated 10 to 15 lbs of TCE that is dissolved and/or sorbed in the plume beyond PW-DISCH in the parking lot, the expected off-site purge well capture is 50% or 7.5 lbs based on the model. The minimum cost per pound captured would be approximately $50,000.

5.0 SITE ACCESS

Permission to place the well and vault in the park will have to be obtained from the City of Wyoming. The City will also have to allow the discharge of the ground water to the sanitary sewer. The purge well and equipment would be placed below grade to create the least hazard to the use of the park and present the least liability and vandalism issues to GM CPC. Power will have to be brought across adjacent property to operate the system.

GM CPC has no assurance that access can be obtained from either property owner for installation of any system. GM CPC would also need to be able to obtain easements or agreements for long term monitoring and maintenance of the system. For model purposes we have assumed that access and installation could be obtained by December 1993.

6.0 ENGINEERING CONSIDERATIONS

The off-site system would likely be constructed with all structures placed below grade in a vault. Access would be through a locked hatch. If a treatment system has to be installed along with the purge well system, a substantial increase in the vault size and access capabilities would be required.

7.0 TREATMENT OPTIONS

The existing operating system discharges directly to the City of Wyoming for treatment. The city is currently conducting a study of its waste water treatment facility which may affect its ability or willingness to accept ground water for treatment. GM CPC would incur additional cost if a treatment system has to be added to the requested off-site purge well.

8.0 COMPLIANCE CONSIDERATIONS

GM CPC has the objective to meet the Type B closure criteria for this site. The Type B criteria for ground water is 3 ug/l which is the health based drinking water criteria.

The Type B surface water criteria measured at the ground water/surface water interface (GSI) is 94 ug/l.

The MDNR contends that GM CPC must "undertake an aggressive and accelerated program to remediate and secure closure for all off-site contamination" in accordance with the Michigan Environmental Response Act (MERA; 1982 Public Act 307, as amended) and the Water Resources Commission Act (1929 Public Act 245). The purpose of this report is to present an evaluation of remedial alternatives for achieving compliance with these regulations. The remedial alternatives evaluated were: 1) continued operation of the existing purge well system; 2) installation of an additional purge well in the city park near monitoring well MW-11 to be operated in conjunction with the existing purge well system as proposed by the MDNR; and 3) installation of two purge wells off-site to be operated in conjunction with the existing purge well system. For alternatives, one well would be located as in alternative two and a second well would be located midway along the plume axis between PW-DISCH and MW-11.

Unlike Act 307, Act 245 does not contain guidelines for the evaluation of remedial alternatives. Act 245 stipulates only that the "best available technology" be used for discharges to the waters of the State. Because each remedial alternative uses the best available technology for remediation of ground water at the GM CPC facility, both remedial alternatives meet this requirement of Act 245.

Rule 603 of the Act 307 Administrative Rules requires the MDNR to evaluate remedial alternatives according to specific criteria. These criteria include effectiveness, long-term uncertainties, compliance with other regulations, threats to human health and the environment, reliability, failure costs, ease of performance monitoring, public's perspective, and permanent reduction/destruction of contaminants. Based on the ground water modelling results presented in this report and these evaluation criteria, each of the remedial alternatives "adequately protect the public health, safety, welfare and the environment and natural resources, consistent with part 7 of the Act 307 administrative rules" (Rule 601(3)).

9.0 SUMMARY AND RECOMMENDATIONS

The following conclusions can be drawn from the evaluation process.

1) The ground water capture analysis indicates that the purge well in the parking lot (PW-DISCH) is preventing further migration of TCE from the facility property to the off-site area. The progress of the plume reduction beyond the parking lot purge well is not apparent from the historic monitoring data because of the configuration of the monitoring wells off-site. The current reduction of the plume will be apparent in the monitor wells in the park only in the later stages of the clean up.

2) Off-site purging would reduce the concentration of TCE in the vicinity of MW-11. However, the off-site purging does not significantly reduce the duration of the clean up.

3) Off-site purging at 40 gpm in the park may increase the potential for contaminants to bypass the purge well PW-DISCH in the parking lot as evidenced in the model predictions for December 2002.

4) Approximately 7.5 or 11 lbs of the contaminant mass in the off-site plume area would be collected by the off-site purge well (MPW) pumping at 10 and 40 gpm, respectively.

5) The model predictions clearly indicate that installation of a purge well midway between MW-11 and PW-DISCH does not significantly increase the clean up rate over using the current system. The predictions also indicate that the concentrations in that area are currently decreasing. A mass reduction on the order of 25% is predicted to have already occurred in the off-site plume with the operation of the existing purge well system.

6) The model predictions indicate that the TCE plume in the off-site area will be remediated within a reasonable time frame with continued operation of the existing system. The concentration of TCE will be at or below current Type B values within approximately 10 to 15 years.

7) The additional purge well in the city park near MW-11 does not significantly increase the rate of mass reduction or reduce the time frame for reaching Type B cleanup numbers for the off-site plume as compared to the existing system (Figure 15). Less than 1% of the original off-site mass should remain after 15 years with either system.

8) The cost analysis indicates a $50,000 cost per pound of TCE captured for the additional well.

9) GM CPC's ability to purge water in the city park will depend upon the willingness of property owners to grant access.

According to Rule 603, when choosing among alternatives which are adequately protective such as the alternatives evaluated in this report, the MDNR must also evaluate the cost (including long-term maintenance costs) of each remedial alternative. Each alternative will achieve the same level of cleanup (i.e., Type B criteria) in the same time period (10-15 years) and the costs associated with the additional purge well in the park are significantly more than the costs associated with continued operation of the existing purge well system. Therefore, we recommend continued operation of the existing system as the best remedial alternative for addressing the off-site contaminant plume.

To alleviate the MDNR's concerns that remediation of the off-site plume will require 10-15 years, GM CPC may want to conduct a risk evaluation of current and future exposures to the off-site contamination and/or strive to reach an agreement with the adjacent property owners which would restrict use of the aquifer and prevent placement of a water supply well within the plume.

Table 1

GROUND WATER FLOW MODEL CALIBRATION FORM

GM CPC Group
Grand Rapids, Michigan

Well Location #	Elevation of Water Level(ft) (12/10/92)	Modeling Calibration Results (ft)	Difference (ft)
85 - 1	659.51	659.57	0.06
85 - 2	658.22	658.10	-0.12
85 - 3	659.92	659.72	-0.20
85 - 5B	660.10	659.86	-0.24
85 - 6	660.62	660.63	0.01
85 - 7	658.48	658.20	-0.28
86 - 1	659.17	659.19	0.02
86 - 2	658.81	659.18	0.37
86 - 3	657.60	657.31	-0.29
87 - 1	659.16	659.38	0.22
87 - 2	660.09	660.25	0.16
87 - 4	659.14	659.12	-0.02
87 - 5	659.07	659.14	0.07
87 - 8	657.82	657.67	-0.15
87 - 9	657.63	657.30	-0.33
87 - 10	656.21	655.93	-0.28
87 - 11	655.99	655.77	-0.22
87 - 13	653.83	653.90	0.07
88 - 2	655.08	654.78	-0.30
88 - 3	654.11	653.97	-0.14
88 - 4	653.11	653.13	0.02
C - 1	657.84	657.95	0.11
C - 2	651.94	651.99	0.05
C - 4	657.85	657.84	-0.01
X - 10	658.69	658.61	-0.08
PWDISCH	644.75	657.12	

Table 2
Percentage of TCE Remaining in Off-Site Area For Each Scenario Though Time

GM CPC Group

Grand Rapids Metal Fabrication Plant
Grand Rapids, Michigan

Purge Condition	Percent TCE Remaining By Date				
	Sept. 1989	Dec. 1993	Dec. 1997	Dec. 2002	Dec. 2007
Scenario 1 (Current Conditions)	100.00	77.52	51.53	16.26	0.83
Scenario 2 (MPW @ 10 gpm)	100.00	77.52	45.81	11.05	0.34
Scenario 3 (MPW @ 40 gpm)	100.00	77.52	32.95	2.56	0.16

Notes:
(1): The modeled purge well MPW start pumping at 12/1993.

TABLE 3 - COST ESTIMATE FOR
OFF-SITE GROUND WATER REMEDIATION SYSTEM
GENERAL MOTORS - CPC GROUP
GRAND RAPIDS METAL FABRICATION PLANT
WYOMING, MICHIGAN

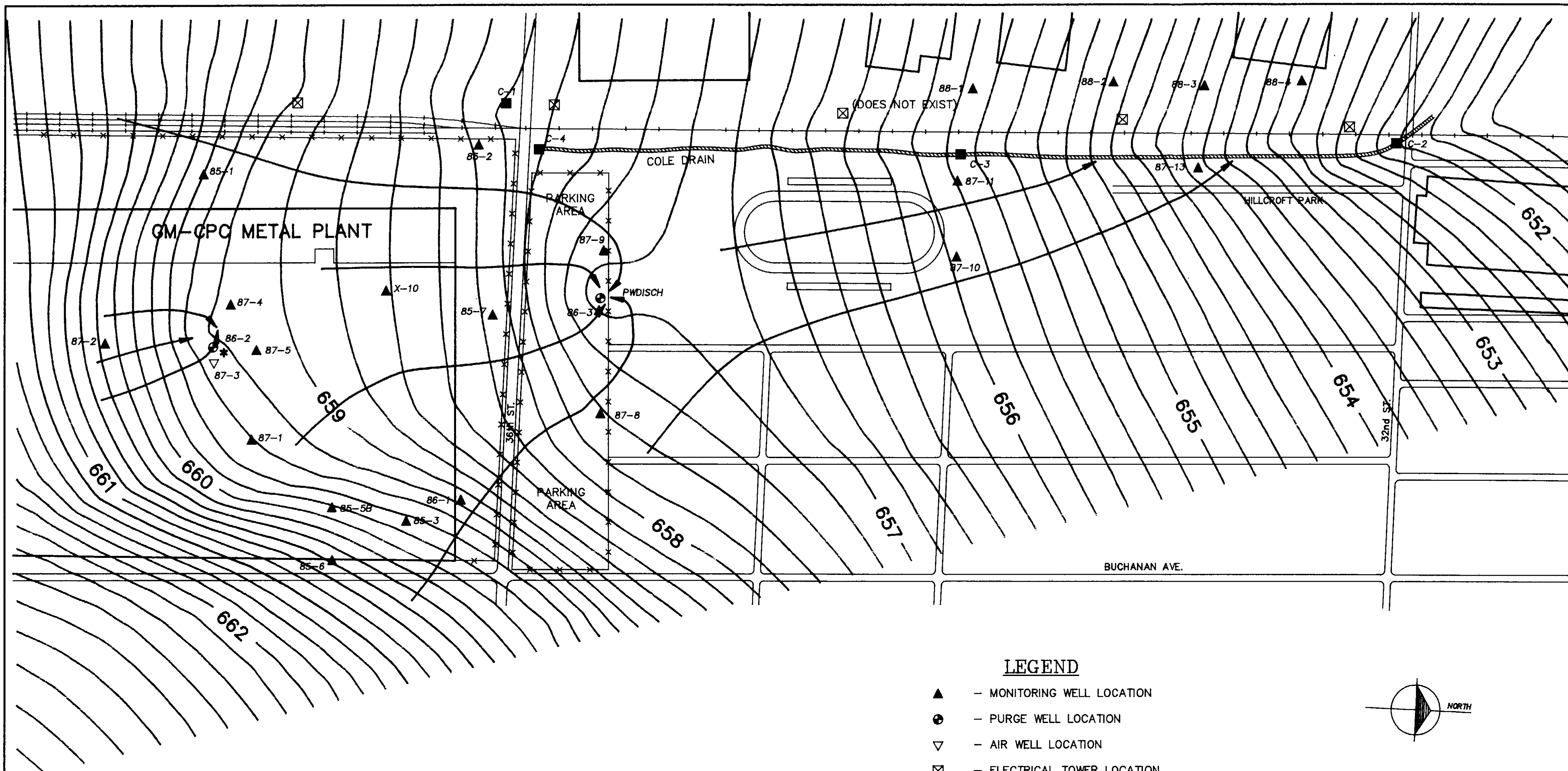
	Unit	Qty	Rate	Cost
Research City of Wyoming engineering requirements	HR	8	$58	$464
Drawings	EA	3	$4,000	$12,000
Specifications	HR	48	$68	$3,264
Permission from adjacent properties for access and system installation	HR	8	$78	$624
Encroachment permit for municipal sewer manhole modification	HR	8	$78	$624
Bid out contract services	HR	24	$68	$1,632
Evaluate bids	HR	24	$68	$1,632
Issue contracts	HR	12	$68	$816
Health and safety plan	HR	16	$78	$1,248
Site survey	LS	1	$1,400	$1,400
Utility survey	LS	1	$1,500	$1,500
Install monitoring well(s)	EA	1	$2,500	$2,500
Install wellhead vault(s)	EA	1	$920	$920
Develop well(s)	HR	4	$48	$192
Containerize soil cuttings	HR	2	$48	$96
Permission for disposal of development water to municipal sewer	HR	4	$68	$272
Dispose soil cuttings	LS	1	$50	$50
Remove and replace chain link fence	LF	10	$23.25	$233
Trench adjacent property	LF	1250	$2.26	$2,829
Trench GM property	LF	550	$2.26	$1,245
Install pull boxes	EA	5	$1,000	$5,000
Lay in conduit	LF	1250	$3.00	$3,750
Install piping	LF	1800	$3.70	$6,658
Connect with municipal sewer manhole	LS	1	$500	$500
Install flow meter	EA	1	$2,000	$2,000
Backfill and compact	LF	1800	$2.20	$3,960
Set pumps	EA	1	$3,500	$3,500
Install pump controls	LS	1	$4,000	$4,000
Pull power and control cable	LF	2500	$2.09	$5,225
Connect electric service	LS	1	$1,000	$1,000
Test system	HR	16	$63	$1,008
TOTAL CAPITAL COSTS				$70,000

TABLE 3 - COST ESTIMATE FOR
OFF-SITE GROUND WATER REMEDIATION SYSTEM
GENERAL MOTORS - CPC GROUP
GRAND RAPIDS METAL FABRICATION PLANT
WYOMING, MICHIGAN

	Unit	Qty	Rate	Cost
Quarterly monitoring	QTR	4	$609	$2,436
Monthly sampling and analysis	MO	12	$225	$2,700
System maintenance	MO	12	$384	$4,608
Energy consumption	YR	1	$518	$518
Sewer discharge fee	GAL	5184000	$0.0008	$4,228
Reporting	YR	1	$5,832	$5,832
TOTAL ANNUAL O&M COSTS				$20,322

Assumptions:

GM maintains appropriate general liability insurance for offsite equipment
Two monitoring wells on school district property
One flush mount utility vault per wellhead; I&C located in vaults
Replace exist 30 A main breaker with 60 A to power pumps
Pull boxes every 250 feet, maximum
Downhole pumps
No water treatment required
Soil cuttings are nonhazardous
Pump controls located in existing equipment building
Quarterly monitoring and S&A
Energy at $0.08/kwh
Discharge fee =$0.61/100 c.f.
No turf will be disrupted on school district property
Quarterly reports prepared by WWES; monthly reports by GM_CPC personnel



LEGEND

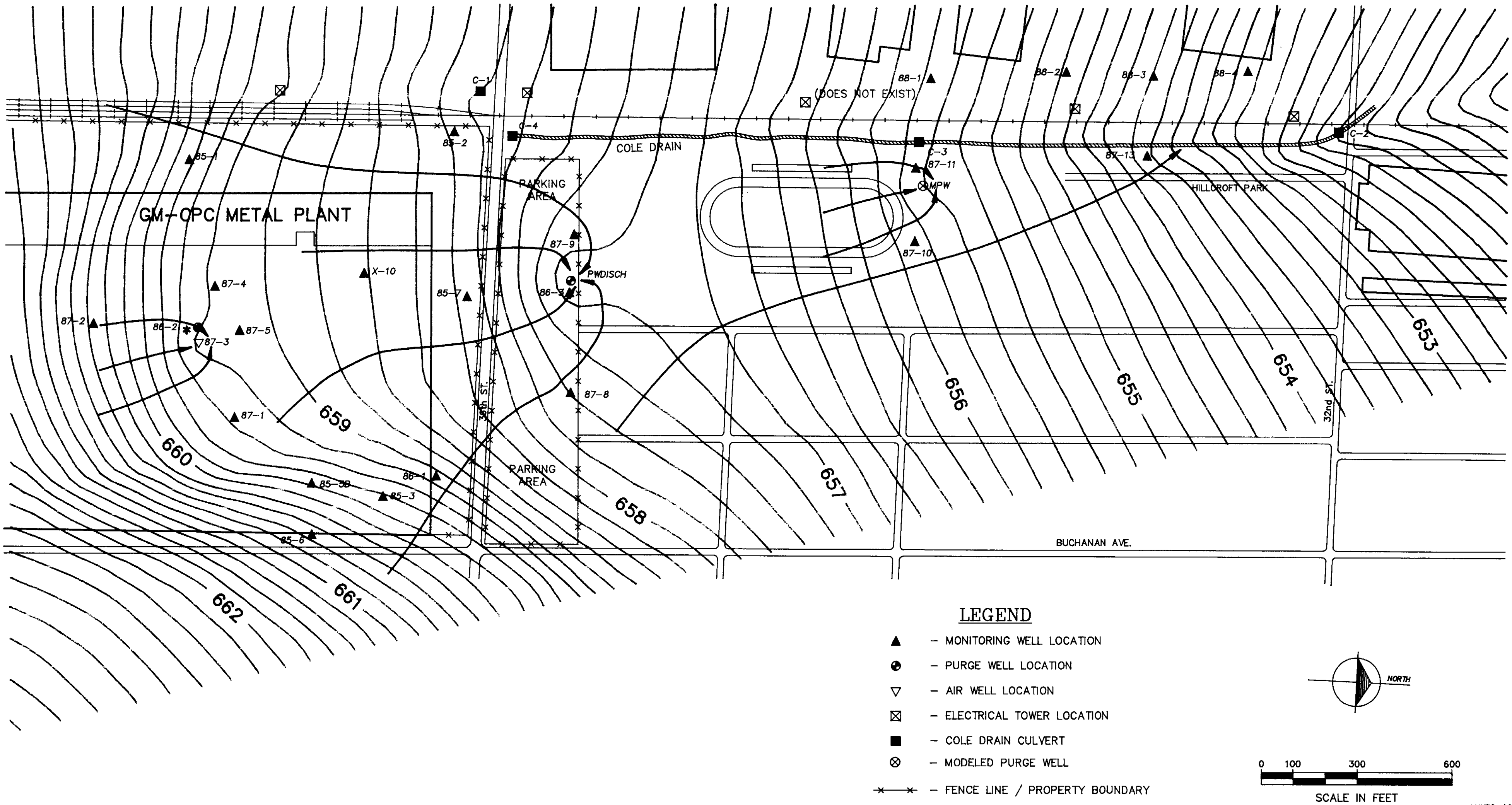
- ▲ – MONITORING WELL LOCATION
- – PURGE WELL LOCATION
- ▽ – AIR WELL LOCATION
- ⊠ – ELECTRICAL TOWER LOCATION
- ■ – COLE DRAIN CULVERT
- – FENCE LINE / PROPERTY BOUNDARY
- – RAILROAD TRACKS
- 657 —— – MODELED WATER TABLE ELEVATION CONTOUR
- – MODELED GROUND WATER FLOW LINE

* NOTE: MODELED LOCATION OF PURGE WELL IS SLIGHTLY DIFFERENT THAN THE ACTUAL PURGE WELL LOCATION DUE TO MODEL GRID SPACING.

MWTC-DEC
VR042193

FIGURE 1
MODELED WATER TABLE CONTOURS CALIBRATION TO DECEMBER 1992
GENERAL MOTORS – CPC GROUP
GRAND RAPIDS METAL FABRICATION PLANT
APRIL, 1993 22579

WW Engineering & Science



LEGEND

- ▲ – MONITORING WELL LOCATION
- ⊕ – PURGE WELL LOCATION
- ▽ – AIR WELL LOCATION
- ⊠ – ELECTRICAL TOWER LOCATION
- ■ – COLE DRAIN CULVERT
- ⊗ – MODELED PURGE WELL
- –×–×– – FENCE LINE / PROPERTY BOUNDARY
- –+–+– – RAILROAD TRACKS
- 657 ------- – MODELED WATER TABLE ELEVATION CONTOUR
- ◄—— – MODELED GROUND WATER FLOW LINE

* NOTE: MODELED LOCATION OF PURGE WELL IS SLIGHTLY DIFFERENT THAN THE ACTUAL PURGE WELL LOCATION DUE TO MODEL GRID SPACING.

MWTC-10
VR042193

FIGURE 2

MODELED WATER TABLE CONTOURS MODELED MPW AT 10 GPM

GENERAL MOTORS – CPC GROUP
GRAND RAPIDS METAL FABRICATION PLANT
APRIL, 1993 22579

WW Engineering & Science

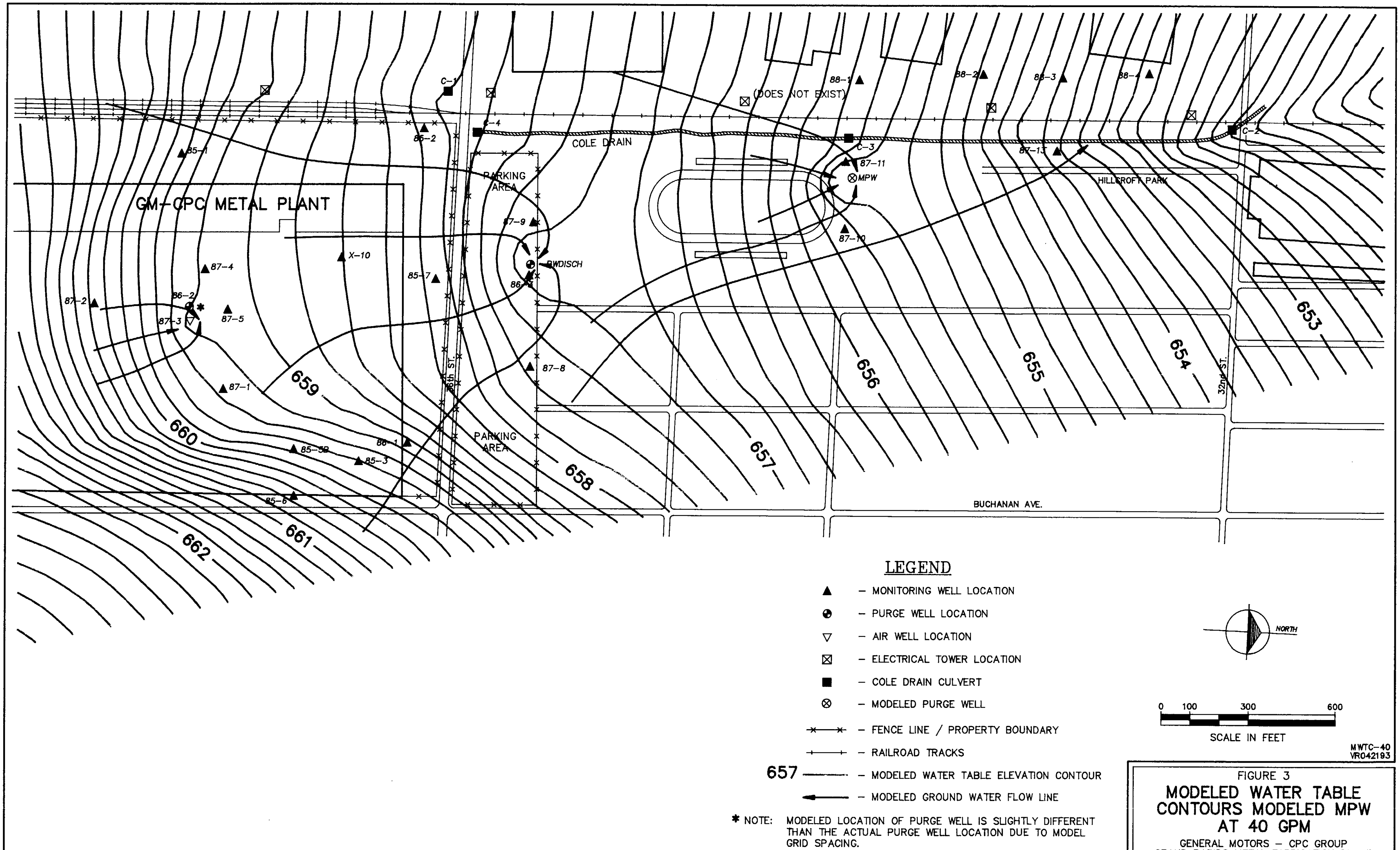


FIGURE 3

MODELED WATER TABLE CONTOURS MODELED MPW AT 40 GPM

GENERAL MOTORS – CPC GROUP
GRAND RAPIDS METAL FABRICATION PLANT

APRIL, 1993 22579

WW Engineering & Science

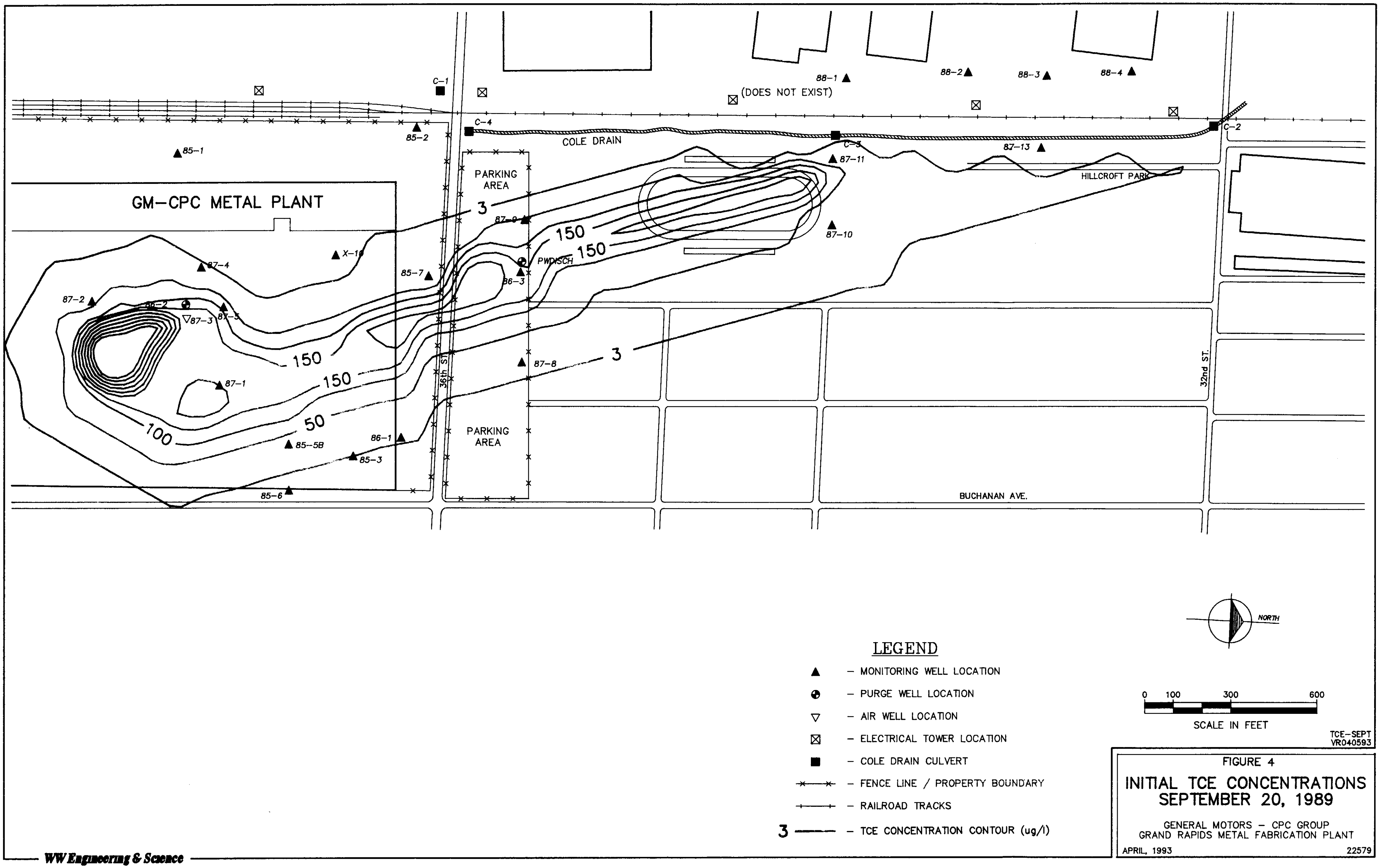
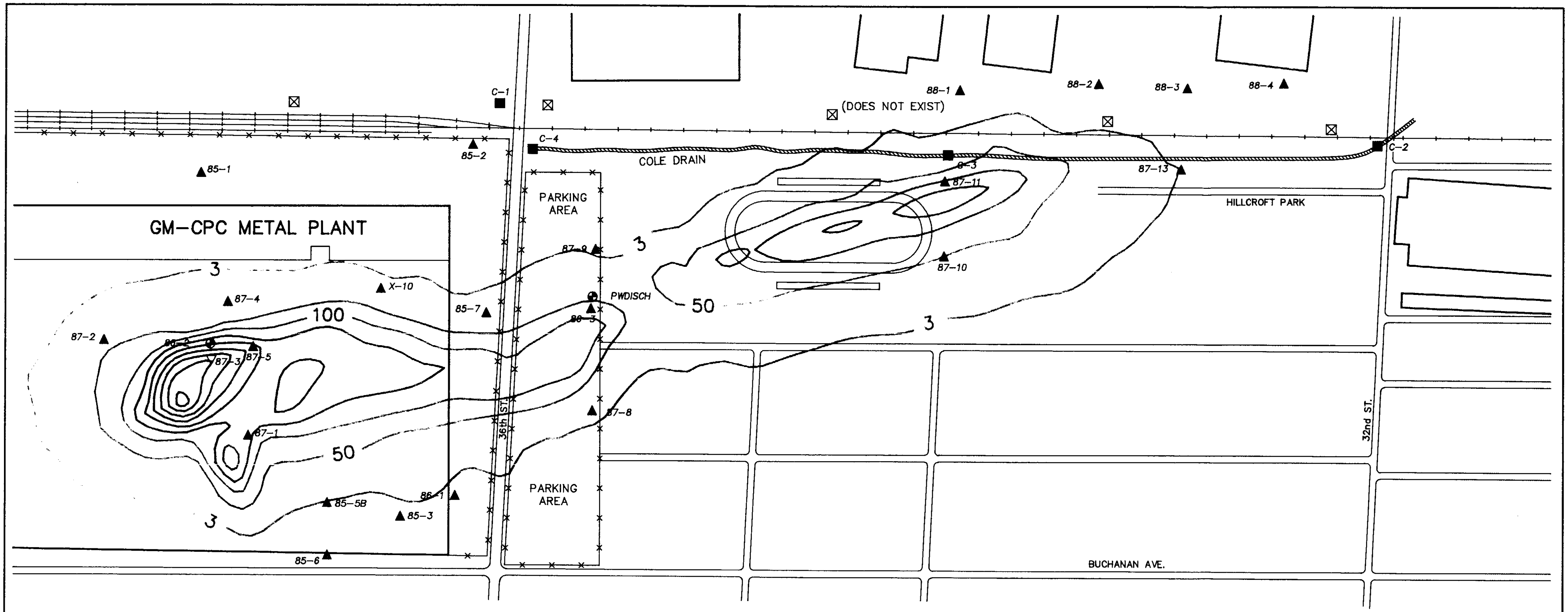


FIGURE 4
INITIAL TCE CONCENTRATIONS SEPTEMBER 20, 1989
GENERAL MOTORS – CPC GROUP
GRAND RAPIDS METAL FABRICATION PLANT
APRIL, 1993
22579



NORTH

LEGEND

- ▲ – MONITORING WELL LOCATION
- – PURGE WELL LOCATION
- ▽ – AIR WELL LOCATION
- ⊠ – ELECTRICAL TOWER LOCATION
- ■ – COLE DRAIN CULVERT
- –x–x– – FENCE LINE / PROPERTY BOUNDARY
- –+–+– – RAILROAD TRACKS
- 3 ——— – TCE CONCENTRATION CONTOUR (ug/l)

0 100 300 600
SCALE IN FEET

TCE-DEC
VR040693

FIGURE 5
MODELED TCE CONCENTRATIONS CALIBRATION TO DECEMBER 1992
GENERAL MOTORS – CPC GROUP
GRAND RAPIDS METAL FABRICATION PLANT

APRIL, 1993 22579

WW Engineering & Science

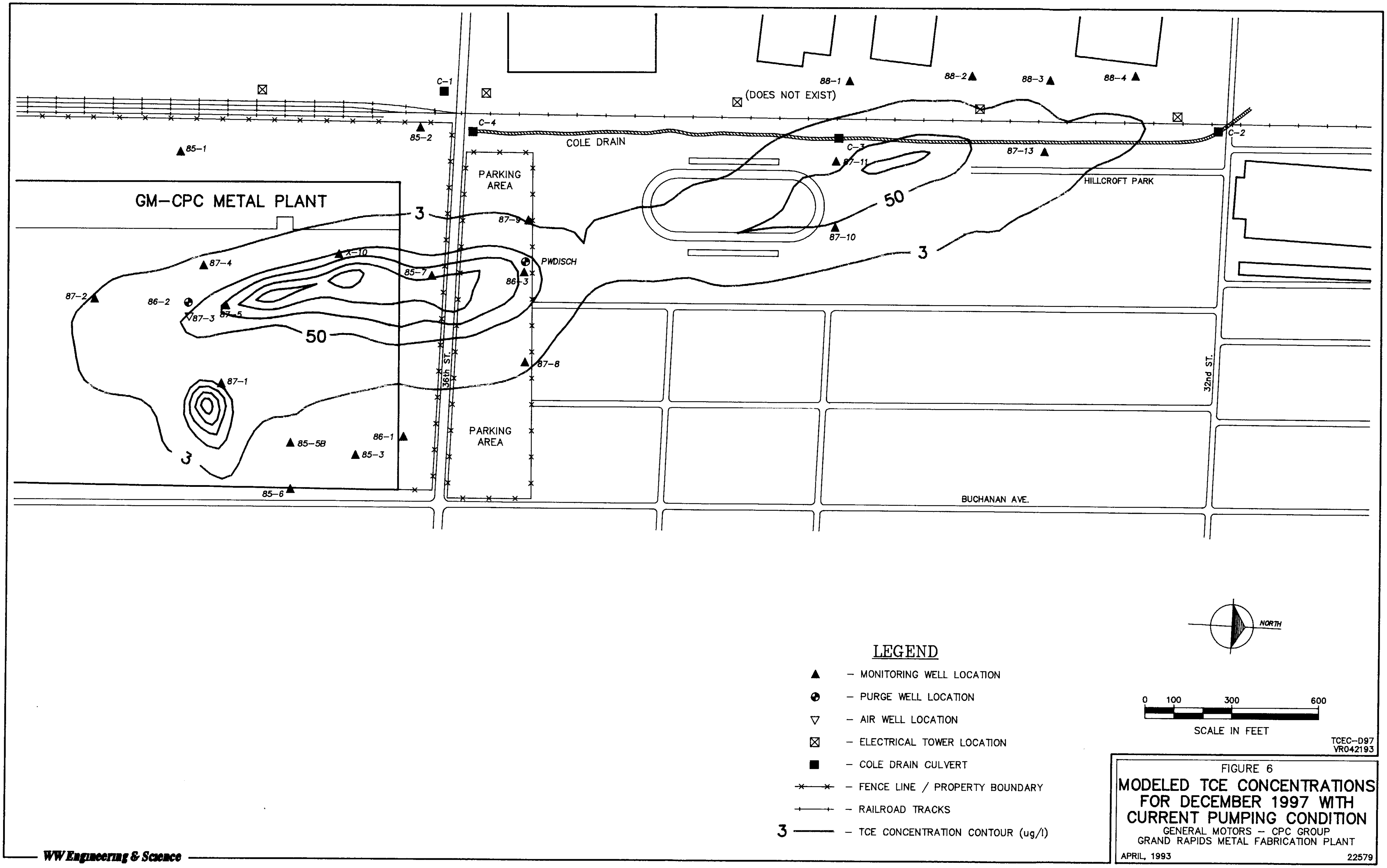


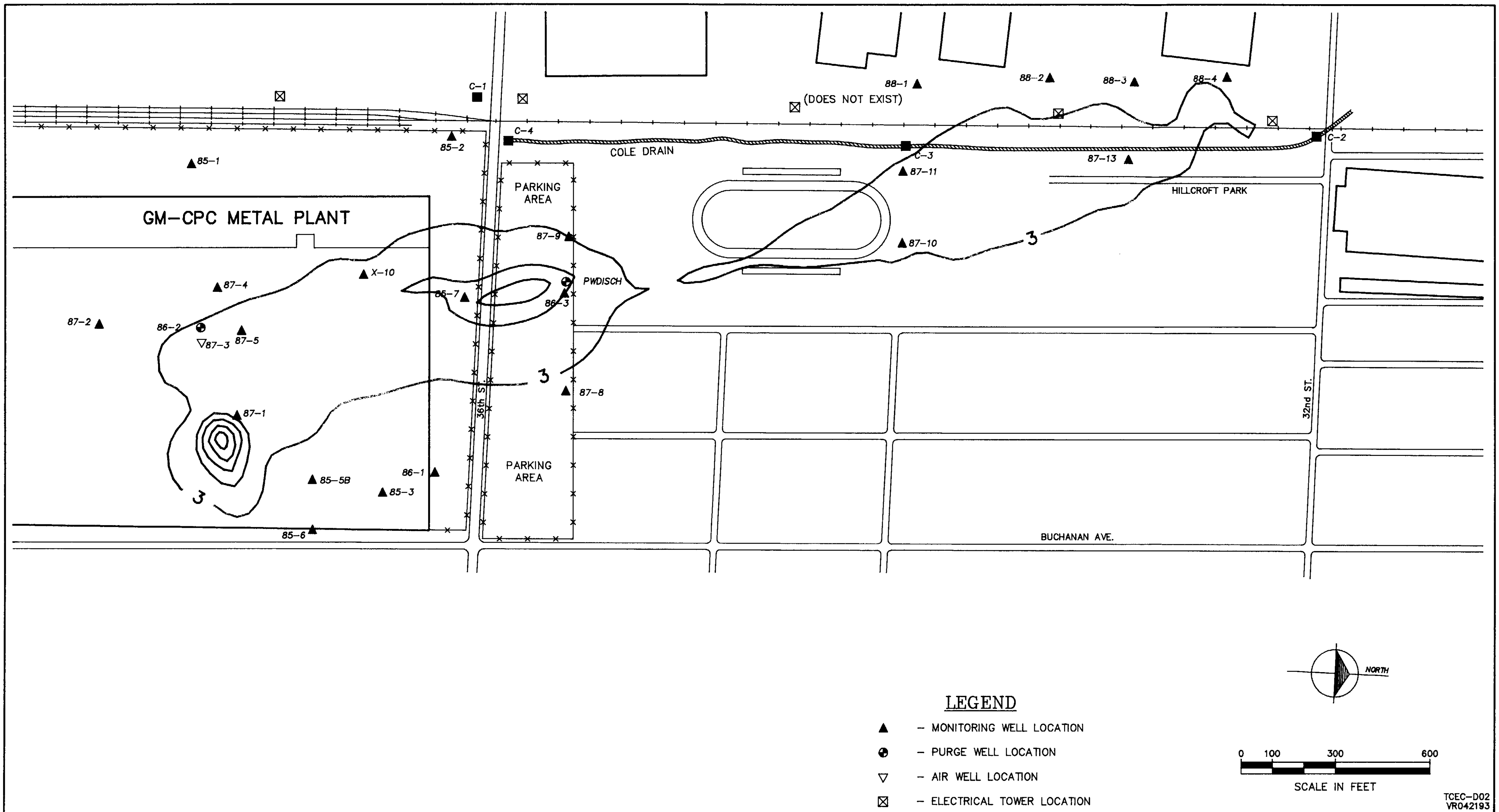
FIGURE 6

MODELED TCE CONCENTRATIONS FOR DECEMBER 1997 WITH CURRENT PUMPING CONDITION

GENERAL MOTORS – CPC GROUP
GRAND RAPIDS METAL FABRICATION PLANT

APRIL, 1993 22579

WW Engineering & Science



LEGEND

- ▲ – MONITORING WELL LOCATION
- – PURGE WELL LOCATION
- ▽ – AIR WELL LOCATION
- ⊠ – ELECTRICAL TOWER LOCATION
- ■ – COLE DRAIN CULVERT
- –×–×– – FENCE LINE / PROPERTY BOUNDARY
- –+–+– – RAILROAD TRACKS
- 3 —— – TCE CONCENTRATION CONTOUR (ug/l)

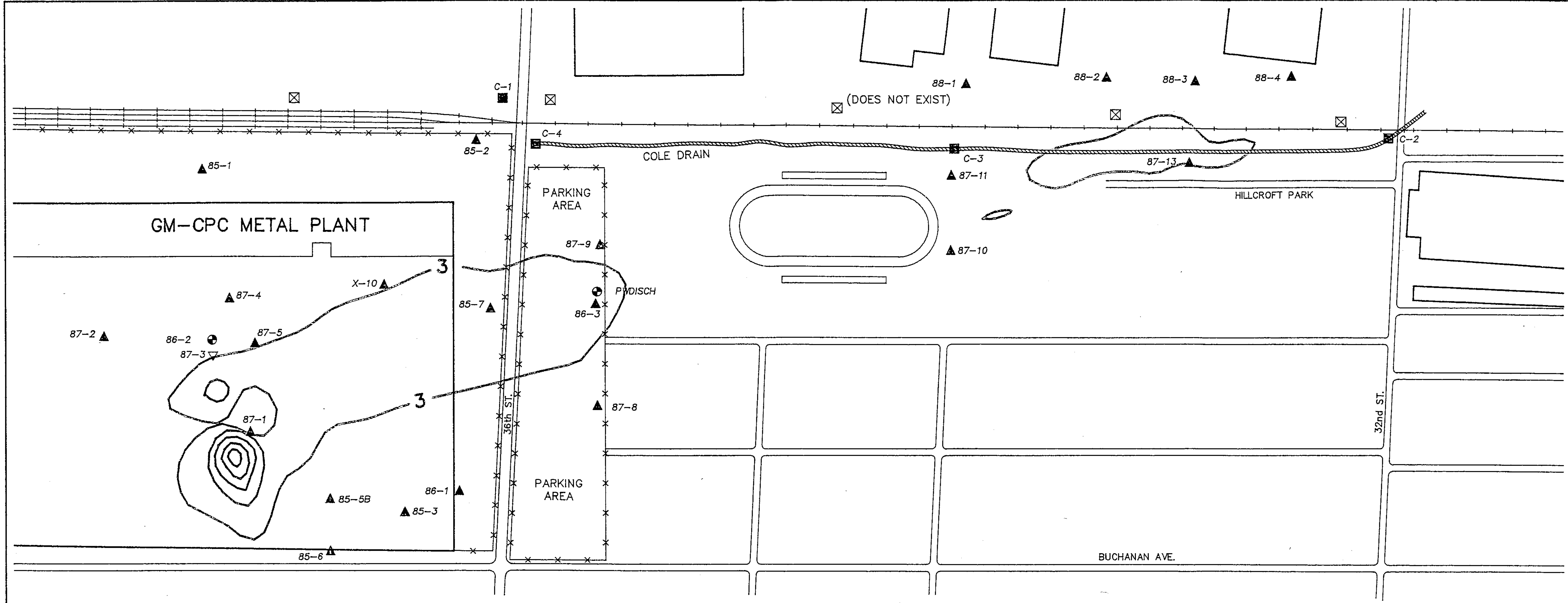
FIGURE 7

MODELED TCE CONCENTRATIONS FOR DECEMBER 2002 WITH CURRENT PUMPING CONDITION

GENERAL MOTORS – CPC GROUP
GRAND RAPIDS METAL FABRICATION PLANT

APRIL, 1993 22579

WW Engineering & Science



LEGEND

- ▲ – MONITORING WELL LOCATION
- – PURGE WELL LOCATION
- ▽ – AIR WELL LOCATION
- ☒ – ELECTRICAL TOWER LOCATION
- – COLE DRAIN CULVERT
- –×–×– – FENCE LINE / PROPERTY BOUNDARY
- – RAILROAD TRACKS
- 3 – TCE CONCENTRATION CONTOUR (ug/l)

TCEC-D07
VR042193

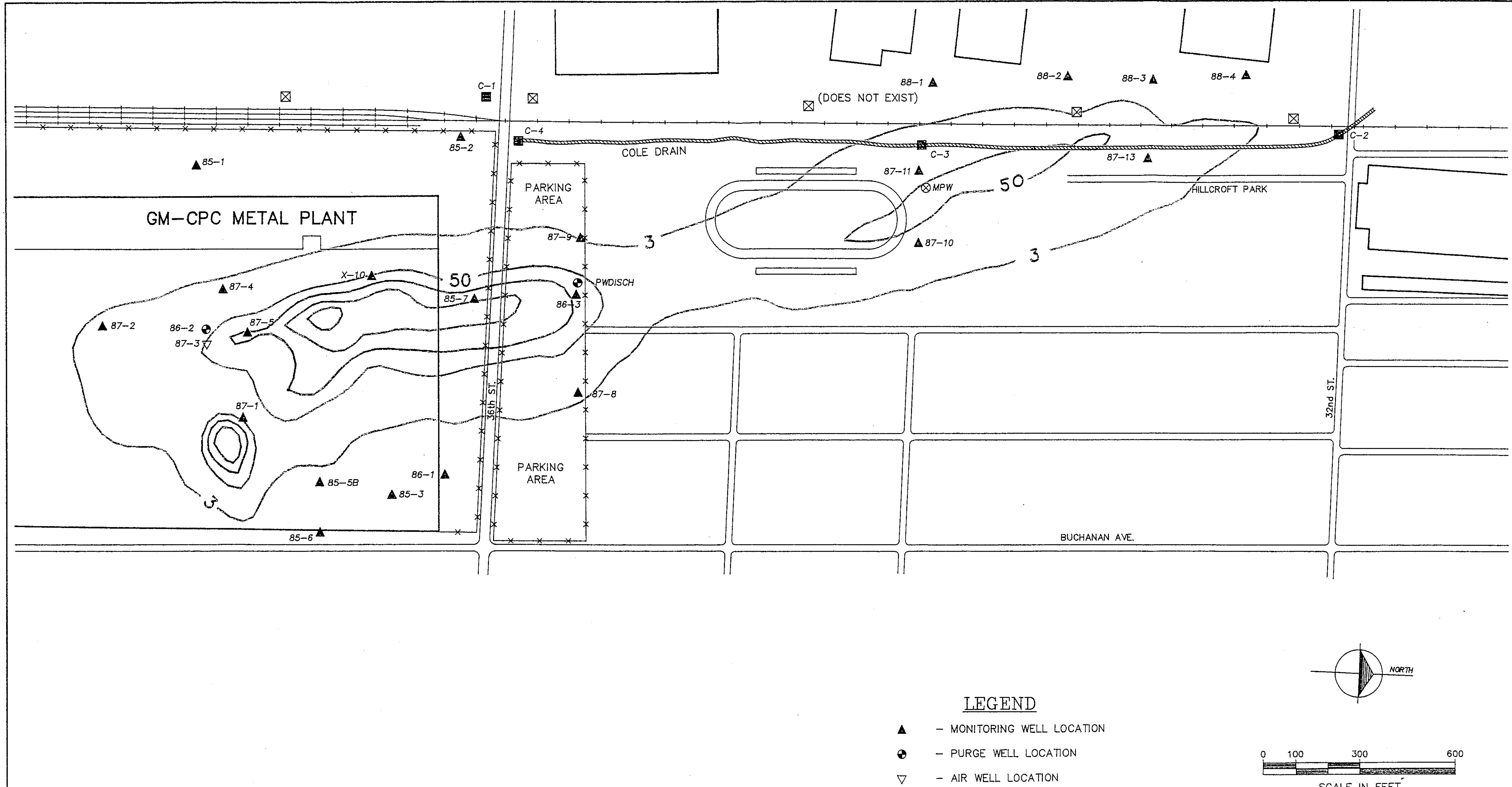
FIGURE 8

MODELED TCE CONCENTRATIONS FOR DECEMBER 2007 WITH CURRENT PUMPING CONDITION

GENERAL MOTORS – CPC GROUP
GRAND RAPIDS METAL FABRICATION PLANT

APRIL, 1993 22579

WW Engineering & Science



LEGEND

- ▲ – MONITORING WELL LOCATION
- PURGE WELL LOCATION
- ▽ – AIR WELL LOCATION
- ⊠ – ELECTRICAL TOWER LOCATION
- COLE DRAIN CULVERT
- FENCE LINE / PROPERTY BOUNDARY
- RAILROAD TRACKS
- ⊗ – MODELED PURGE WELL
- 3 – TCE CONCENTRATION CONTOUR (ug/l)

DEC97-10
VR040693

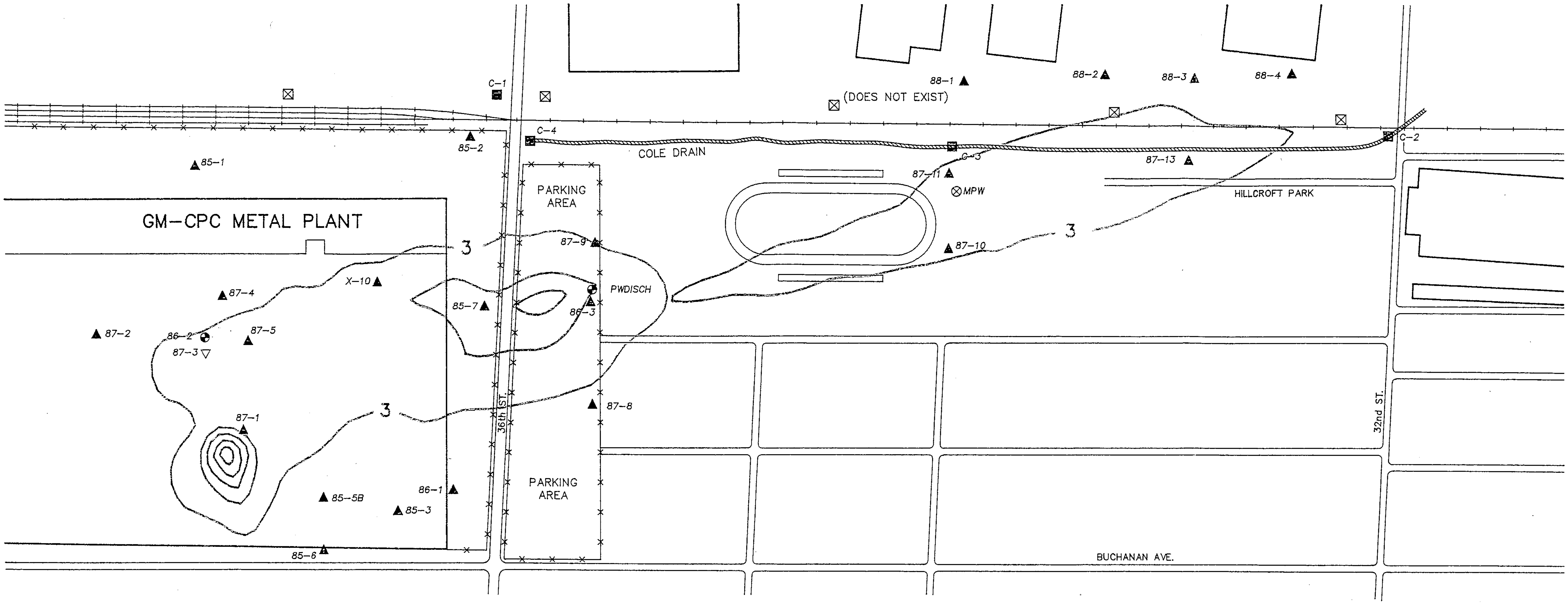
FIGURE 9

MODELED TCE CONCENTRATIONS FOR DEC. 1997 WITH MPW PUMPING AT 10 GPM STARTING DEC. 1993

GENERAL MOTORS – CPC GROUP
GRAND RAPIDS METAL FABRICATION PLANT

APRIL, 1993 22579

WW Engineering & Science



NORTH

0 100 300 600
SCALE IN FEET

DEC02-10
VR040693

LEGEND

▲ – MONITORING WELL LOCATION

– PURGE WELL LOCATION

▽ – AIR WELL LOCATION

⊠ – ELECTRICAL TOWER LOCATION

– COLE DRAIN CULVERT

–×–×– – FENCE LINE / PROPERTY BOUNDARY

–+–+– – RAILROAD TRACKS

⊗ – MODELED PURGE WELL

3 – TCE CONCENTRATION CONTOUR (ug/l)

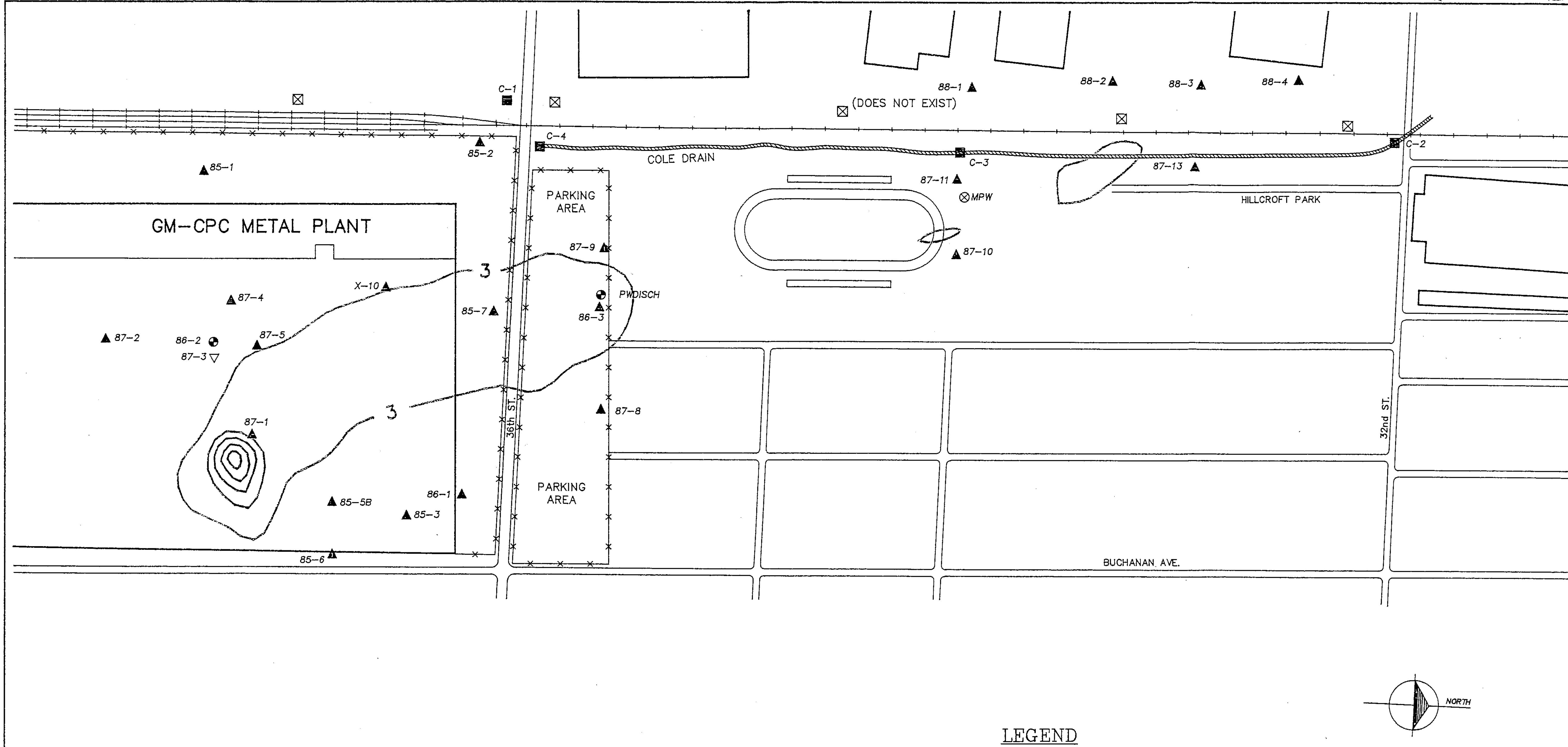
FIGURE 10

MODELED TCE CONCENTRATIONS FOR DEC. 2002 WITH MPW PUMPING AT 10 GPM STARTING DEC. 1993

GENERAL MOTORS – CPC GROUP
GRAND RAPIDS METAL FABRICATION PLANT

APRIL, 1993 22579

WW Engineering & Science



LEGEND

- ▲ – MONITORING WELL LOCATION
- ◕ – PURGE WELL LOCATION
- ▽ – AIR WELL LOCATION
- ☒ – ELECTRICAL TOWER LOCATION
- ▪ – COLE DRAIN CULVERT
- –x–x– – FENCE LINE / PROPERTY BOUNDARY
- –+–+– – RAILROAD TRACKS
- ⊗ – MODELED PURGE WELL
- TCE CONCENTRATION CONTOUR (ug/l)

0 100 300 600

SCALE IN FEET

DEC07-10
VR040693

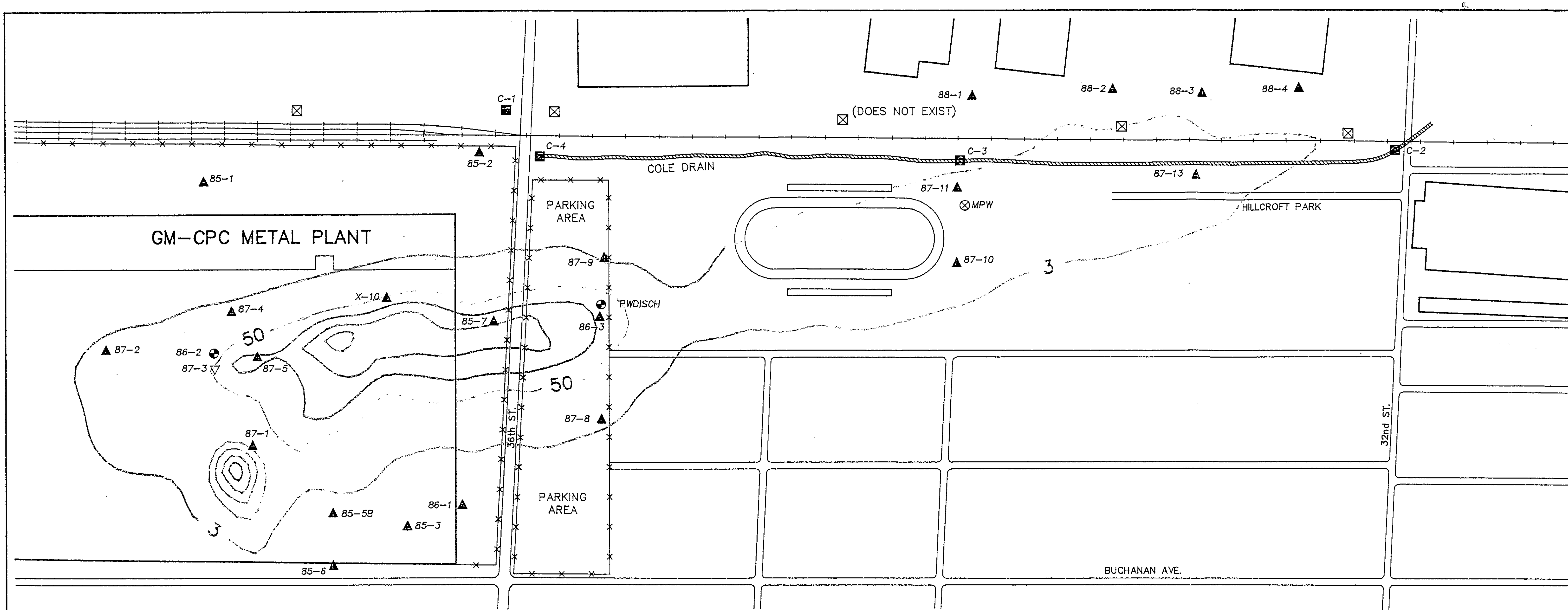
FIGURE 11

MODELED TCE CONCENTRATIONS FOR DEC. 2007 WITH MPW PUMPING AT 10 GPM STARTING DEC. 1993

GENERAL MOTORS – CPC GROUP
GRAND RAPIDS METAL FABRICATION PLANT

APRIL, 1993 22579

WW Engineering & Science



LEGEND

- ▲ – MONITORING WELL LOCATION
- ◒ – PURGE WELL LOCATION
- ▽ – AIR WELL LOCATION
- ⊠ – ELECTRICAL TOWER LOCATION
- ■ – COLE DRAIN CULVERT
- –x–x– – FENCE LINE / PROPERTY BOUNDARY
- –+–+– – RAILROAD TRACKS
- ⊗ – MODELED PURGE WELL
- 3 ------ – TCE CONCENTRATION CONTOUR (ug/l)

DEC97-40
VR040693

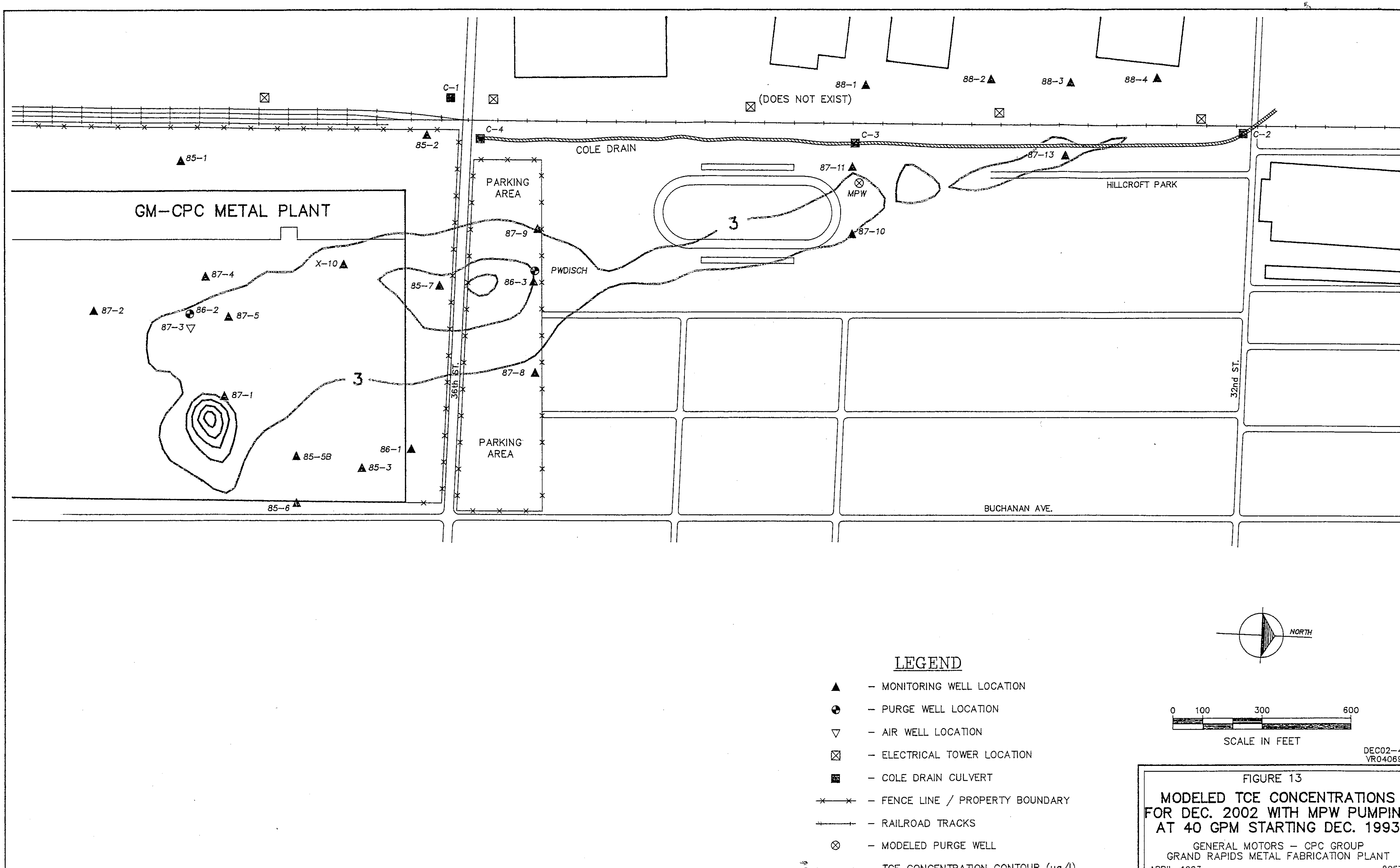
FIGURE 12

MODELED TCE CONCENTRATIONS FOR DEC. 1997 WITH MPW PUMPING AT 40 GPM STARTING DEC. 1993

GENERAL MOTORS – CPC GROUP
GRAND RAPIDS METAL FABRICATION PLANT

APRIL, 1993 22579

WW Engineering & Science



DEC02-40
VR040693

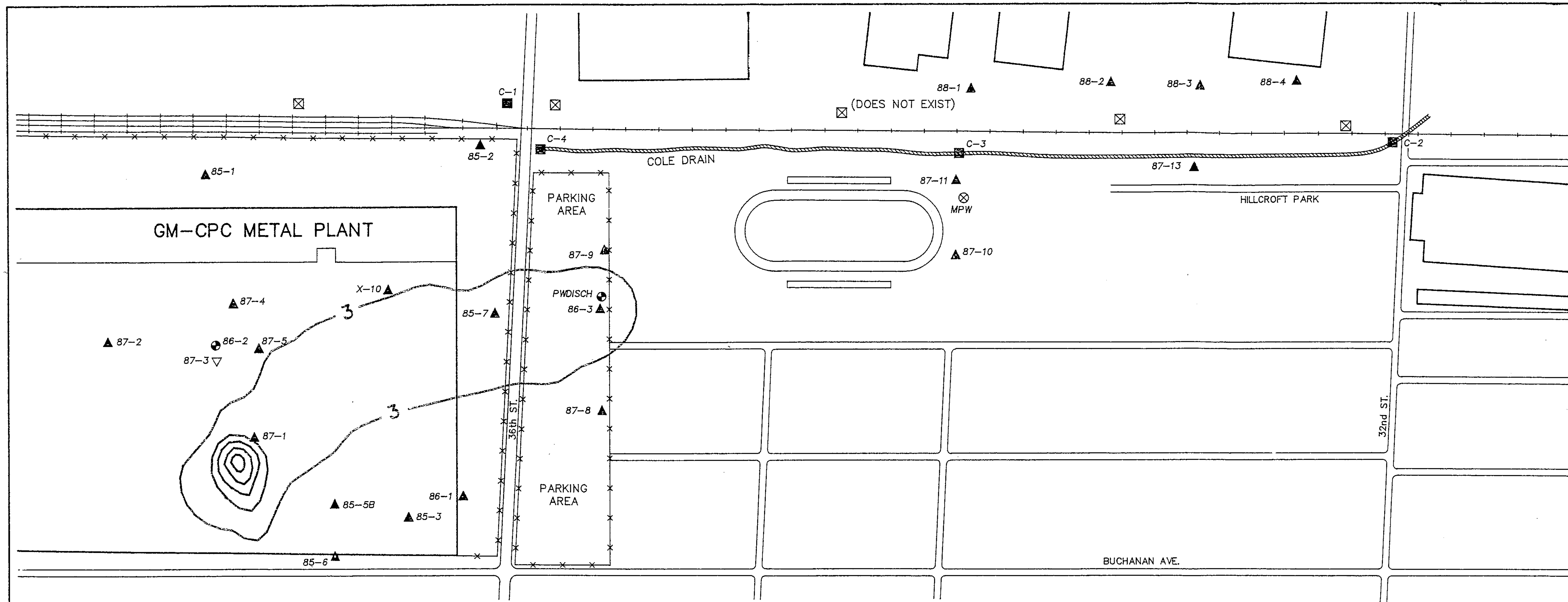
FIGURE 13

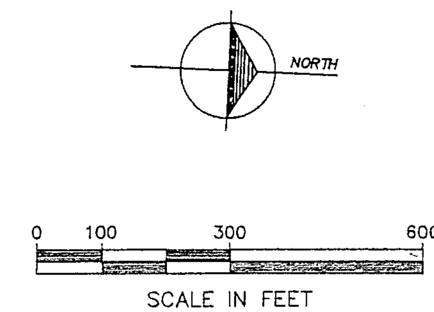
MODELED TCE CONCENTRATIONS FOR DEC. 2002 WITH MPW PUMPING AT 40 GPM STARTING DEC. 1993

GENERAL MOTORS – CPC GROUP
GRAND RAPIDS METAL FABRICATION PLANT

APRIL, 1993 22579

WW Engineering & Science





LEGEND

- ▲ – MONITORING WELL LOCATION
- – PURGE WELL LOCATION
- ▽ – AIR WELL LOCATION
- ⊠ – ELECTRICAL TOWER LOCATION
- – COLE DRAIN CULVERT
- –×–×– – FENCE LINE / PROPERTY BOUNDARY
- – RAILROAD TRACKS
- ⊗ – MODELED PURGE WELL
- 3 – TCE CONCENTRATION CONTOUR (ug/l)

DEC07-40
VR040693

FIGURE 14

MODELED TCE CONCENTRATIONS FOR DEC. 2007 WITH MPW PUMPING AT 40 GPM STARTING DEC. 1993

GENERAL MOTORS – CPC GROUP
GRAND RAPIDS METAL FABRICATION PLANT

APRIL, 1993 22579

WW Engineering & Science

Figure 15

Summary of Total TCE in Off-Site Area For Each Scenario Though Time

GM CPC Group

Grand Rapids Metal Fabrication Plant
Grand Rapids , Michigan

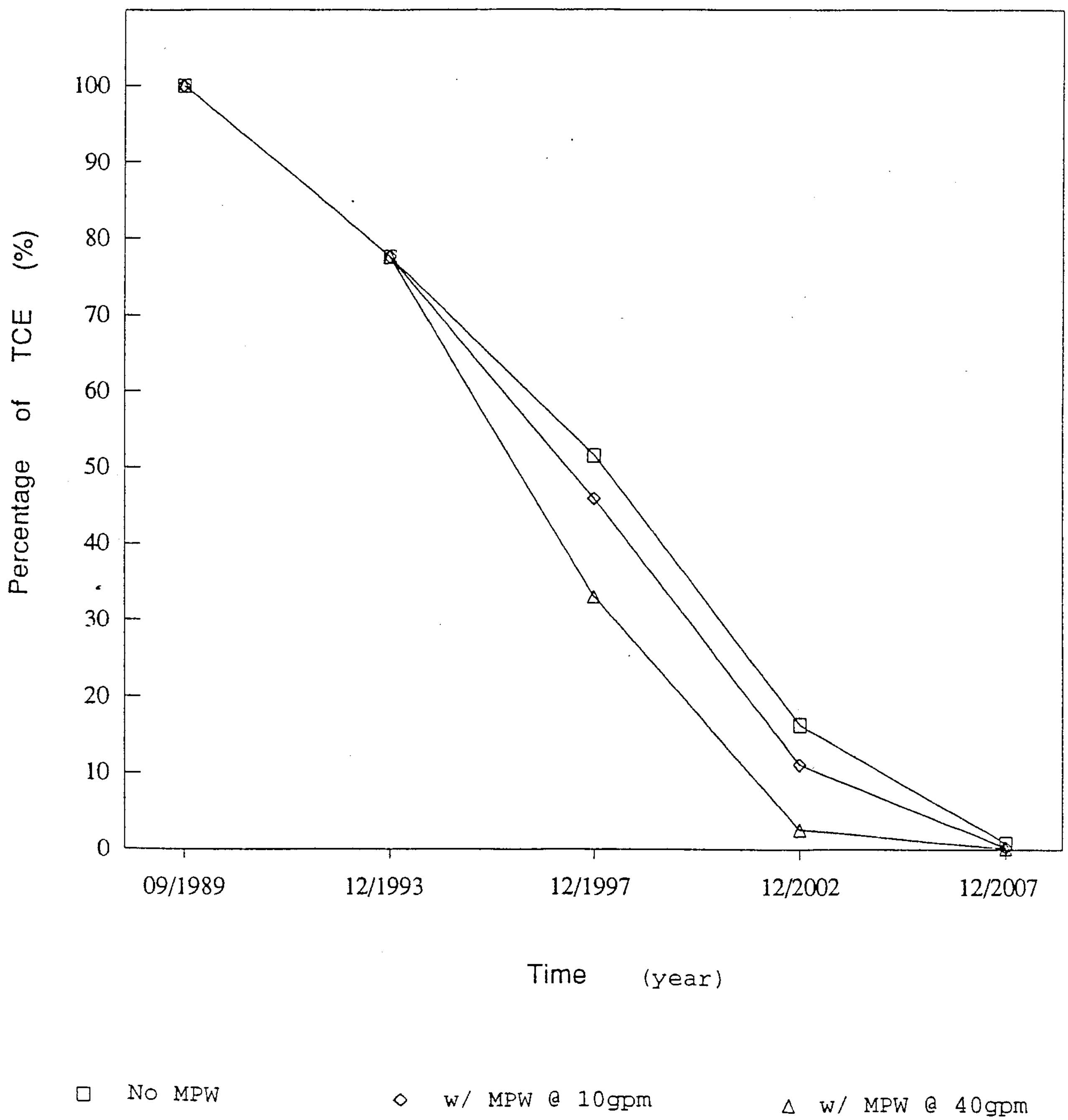


Table 1. Volumetric Budget For Entire Modeled Area

Unit: CFT/DAY

Pumping Rate:	86-2 = 6 gpm PWDISCH = 45 gpm
Flow Status:	Steady State

Cumulative Volumes (L**3)		Rates For This Time Step (L**3/T)	
IN:		IN:	
Storage =	0.00000	Storage =	0.00000
Constant Head =	17811.0	Constant Head =	17811.0
Wells =	0.00000	Wells =	0.00000
Drain =	0.00000	Drain =	0.00000
Recharge =	51141.0	Recharge =	51141.0
Head Dep. Bounds =	3204.2	Head Dep. Bounds =	3204.2
TOTAL IN:	72156.2	TOTAL IN:	72156.2
OUT:		OUT:	
Storage =	0.00000	Storage =	0.00000
Constant Head =	26725.0	Constant Head =	26725.0
Wells =	9818.0	Wells =	9818.0
Drain =	2518.1	Drain =	2518.1
Recharge =	0.00000	Recharge =	0.00000
Head Dep. Bounds =	33074.0	Head Dep. Bounds =	33074.0
TOTAL OUT:	72135.1	TOTAL OUT:	72135.1
IN - OUT:	21.100	IN - OUT:	21.100
Percent Discrepancy	0.03	Percent Discrepancy	0.03

Table 2. Volumetric Budget For Entire Modeled Area

Unit: CFT/DAY

Pumping Rate:	86-2 = 6 gpm PWDISCH = 45 gpm MPW = 10 gpm
Flow Status:	Steady State

Cumulative Volumes (L**3)		Rates For This Time Step (L**3/T)	
IN:		IN:	
Storage =	0.00000	Storage =	0.00000
Constant Head =	17820.0	Constant Head =	17820.0
Wells =	0.00000	Wells =	0.00000
Drain =	0.00000	Drain =	0.00000
Recharge =	51141.0	Recharge =	51141.0
Head Dep. Bounds =	3504.3	Head Dep. Bounds =	3504.3
TOTAL IN:	72465.3	TOTAL IN:	72465.3
OUT:		OUT:	
Storage =	0.00000	Storage =	0.00000
Constant Head =	26681.0	Constant Head =	26681.0
Wells =	11743.0	Wells =	11743.0
Drain =	2485.6	Drain =	2485.6
Recharge =	0.00000	Recharge =	0.00000
Head Dep. Bounds =	31533.0	Head Dep. Bounds =	31533.0
TOTAL OUT:	72442.6	TOTAL OUT:	72442.6
IN - OUT:	22.700	IN - OUT:	22.700
Percent Discrepancy	0.03	Percent Discrepancy	0.03

Table 3. Volumetric Budget For Entire Modeled Area

Unit: CFT/DAY

Pumping Rate:	86-2 = 6 gpm PWDISCH = 45 gpm MPW = 40 gpm
Flow Status:	Steady State

Cumulative Volumes (L**3)		Rates For This Time Step (L**3/T)	
IN:		IN:	
Storage =	0.00000	Storage =	0.00000
Constant Head =	17847.0	Constant Head =	17847.0
Wells =	0.00000	Wells =	0.00000
Drain =	0.00000	Drain =	0.00000
Recharge =	51141.0	Recharge =	51141.0
Head Dep. Bounds =	6354.8	Head Dep. Bounds =	6354.8
TOTAL IN:	75342.8	TOTAL IN:	75342.8
OUT:		OUT:	
Storage =	0.00000	Storage =	0.00000
Constant Head =	26562.0	Constant Head =	26562.0
Wells =	17518.0	Wells =	17518.0
Drain =	2461.2	Drain =	2461.2
Recharge =	0.00000	Recharge =	0.00000
Head Dep. Bounds =	28779.0	Head Dep. Bounds =	28779.0
TOTAL OUT:	75320.0	TOTAL OUT:	75320.0
IN - OUT:	22.800	IN - OUT:	22.800
Percent Discrepancy	0.03	Percent Discrepancy	0.03

Table 4. Cummulative Mass Budget for Entire Modeled Area

Unit: LB.

Pumping Rate:	86-2 = 6 gpm PWDISCH = 45 gpm
Flow Status:	Transient State
Starting Time:	Sptember 1989
Ending Time:	December 1992

Mass Balance In Ground Water Flow System:

	IN:	OUT:
Constant Concentration:	12.32553	0.00000
Constant Head:	0.00000	0.00000
Well:	0.00000	-75.34651
Drain:	0.00000	-3.83695
Head-Dependent Boundary:	0.00000	-6.47700
Recharge:	0.00000	0.00000
Decay or Biodegradation:	0.00000	0.00000
Mass Storage(Solute):	112.74650	-71.00082
Mass Storage(Adsorbed):	109.86570	-69.18662
TOTAL :	234.93773	-225.84790
NET (IN - OUT) :	9.08983	
DISCREPANCY(percent) :	3.94536	

C:\GMCPC\table4.WK1

Table 5. Cummulative Mass Budget for Entire Modeled Area

Unit: LB.

Pumping Rate:	86-2 = 6 gpm PWDISCH = 45 gpm
Flow Status:	Transient State
Starting Time:	Sptember 1989
Ending Time:	December 1997

Mass Balance In Ground Water Flow System:

	IN:	OUT:
Constant Concentration:	38.78429	0.00000
Constant Head:	0.00000	0.00000
Well:	0.00000	-141.77120
Drain:	0.00000	-4.75996
Head-Dependent Boundary:	0.00000	-38.78831
Recharge:	0.00000	0.00000
Decay or Biodegradation:	0.00000	0.00000
Mass Storage(Solute):	241.79430	-156.83220
Mass Storage(Adsorbed):	235.61590	-152.82480
TOTAL :	516.19449	-494.97647
NET (IN - OUT) :	21.21802	
DISCREPANCY(percent) :	4.19672	

Table 6. Cummulative Mass Budget for Entire Modeled Area

Unit: LB.

Pumping Rate:	86-2 = 6 gpm PWDISCH = 45 gpm
Flow Status:	Transient State
Starting Time:	Sptember 1989
Ending Time:	December 2002

Mass Balance In Ground Water Flow System:

	IN:	OUT:
Constant Concentration:	65.82980	0.00000
Constant Head:	0.00000	0.00000
Well:	0.00000	-205.29100
Drain:	0.00000	-5.07956
Head-Dependent Boundary:	0.00000	-64.44821
Recharge:	0.00000	0.00000
Decay or Biodegradation:	0.00000	0.00000
Mass Storage(Solute):	323.40960	-202.26060
Mass Storage(Adsorbed):	315.14580	-197.09240
TOTAL :	704.38520	-674.17176
NET (IN - OUT) :	30.21344	
DISCREPANCY(percent) :	4.38334	

Table 7. Cummulative Mass Budget for Entire Modeled Area

Unit: LB.

Pumping Rate:	86-2 = 6 gpm PWDISCH = 45 gpm
Flow Status:	Transient State
Starting Time: Ending Time:	Sptember 1989 December 2007

Mass Balance In Ground Water Flow System:

	IN:	OUT:
Constant Concentration:	92.87055	0.00000
Constant Head:	0.00000	0.00000
Well:	0.00000	-231.38990
Drain:	0.00000	-5.35681
Head-Dependent Boundary:	0.00000	-73.92852
Recharge:	0.00000	0.00000
Decay or Biodegradation:	0.00000	0.00000
Mass Storage(Solute):	351.96570	-218.90720
Mass Storage(Adsorbed):	342.97230	-213.31370
TOTAL :	787.80855	-742.89613
NET (IN - OUT) :	44.91242	
DISCREPANCY(percent) :	5.86820	

Table 8. Cummulative Mass Budget for Entire Modeled Area

Unit: LB.

Pumping Rate:	86-2 = 6 gpm PWDISCH = 45 gpm
Flow Status:	Transient State
Starting Time:	Sptember 1989
Ending Time:	December 1993

Mass Balance In Ground Water Flow System:

	IN:	OUT:
Constant Concentration:	17.45945	0.00000
Constant Head:	0.00000	0.00000
Well:	0.00000	-91.85497
Drain:	0.00000	-4.18389
Head-Dependent Boundary:	0.00000	-11.16678
Recharge:	0.00000	0.00000
Decay or Biodegradation:	0.00000	0.00000
Mass Storage(Solute):	143.01370	-92.91093
Mass Storage(Adsorbed):	139.35940	-90.34198
TOTAL :	299.83255	-290.45855
NET (IN - OUT) :	9.37400	
DISCREPANCY(percent) :	3.17606	

C:\GMCPC\table8.WK1

Table 9. Cummulative Mass Budget for Entire Modeled Area

Unit: LB.

Pumping Rate:	86-2 = 6 gpm PWDISCH = 45 gpm MPW = 10 gpm
Flow Status:	Transient State
Starting Time:	December 1993
Ending Time:	December 1997

Mass Balance In Ground Water Flow System:

	IN:	OUT:
Constant Concentration:	20.90512	0.00000
Constant Head:	0.00000	0.00000
Well:	0.00000	-64.95621
Drain:	0.00000	-0.71343
Head-Dependent Boundary:	0.00000	-20.56678
Recharge:	0.00000	0.00000
Decay or Biodegradation:	0.00000	0.00000
Mass Storage(Solute):	96.17483	-61.38072
Mass Storage(Adsorbed):	93.71733	-59.81233
TOTAL :	210.79728	-207.42947
NET (IN - OUT) :	3.36781	
DISCREPANCY(percent) :	1.61052	

C:\GMCPC\table9.WK1

Table 10. Cummulative Mass Budget for Entire Modeled Area

Unit: LB.

Pumping Rate:	86-2 = 6 gpm PWDISCH = 45 gpm MPW = 10 gpm
Flow Status:	Transient State
Starting Time:	December 1993
Ending Time:	December 2002

Mass Balance In Ground Water Flow System:

	IN:	OUT:
Constant Concentration:	47.90842	0.00000
Constant Head:	0.00000	0.00000
Well:	0.00000	-128.95660
Drain:	0.00000	-1.05739
Head-Dependent Boundary:	0.00000	-36.52038
Recharge:	0.00000	0.00000
Decay or Biodegradation:	0.00000	0.00000
Mass Storage(Solute):	179.71650	-108.86280
Mass Storage(Adsorbed):	175.12440	-106.08110
TOTAL :	402.74932	-381.47827
NET (IN - OUT) :	21.27105	
DISCREPANCY(percent) :	5.42471	

C:\GMCPC\table10.WK1

Table 11. Cummulative Mass Budget for Entire Modeled Area

Unit: LB.

Pumping Rate:	86-2 = 6 gpm PWDISCH = 45 gpm MPW = 10 gpm
Flow Status:	Transient State
Starting Time:	December 1993
Ending Time:	December 2007

Mass Balance In Ground Water Flow System:

	IN:	OUT:
Constant Concentration:	74.93900	0.00000
Constant Head:	0.00000	0.00000
Well:	0.00000	-155.64330
Drain:	0.00000	-1.35052
Head-Dependent Boundary:	0.00000	-41.71561
Recharge:	0.00000	0.00000
Decay or Biodegradation:	0.00000	0.00000
Mass Storage(Solute):	204.70150	-122.06170
Mass Storage(Adsorbed):	199.47100	-118.94280
TOTAL :	479.11150	-439.71393
NET (IN - OUT) :	39.39757	
DISCREPANCY(percent) :	8.57564	

Table 12. Cummulative Mass Budget for Entire Modeled Area

Unit: LB.

Pumping Rate:	86-2 = 6 gpm PWDISCH = 45 gpm MPW = 40 gpm
Flow Status:	Transient State
Starting Time:	December 1993
Ending Time:	December 1997

Mass Balance In Ground Water Flow System:

	IN:	OUT:
Constant Concentration:	20.95008	0.00000
Constant Head:	0.00000	0.00000
Well:	0.00000	-87.72757
Drain:	0.00000	-0.69963
Head-Dependent Boundary:	0.00000	-11.25273
Recharge:	0.00000	0.00000
Decay or Biodegradation:	0.00000	0.00000
Mass Storage(Solute):	100.69140	-61.74780
Mass Storage(Adsorbed):	98.11854	-60.17003
TOTAL :	219.76002	-221.59776
NET (IN - OUT) :	-1.83774	
DISCREPANCY(percent) :	-0.83277	

Table 13. Cummulative Mass Budget for Entire Modeled Area

Unit: LB.

Pumping Rate:	86-2 = 6 gpm PWDISCH = 45 gpm MPW = 40 gpm
Flow Status:	Transient State
Starting Time:	December 1993
Ending Time:	December 2002

Mass Balance In Ground Water Flow System:

	IN:	OUT:
Constant Concentration:	48.00901	0.00000
Constant Head:	0.00000	0.00000
Well:	0.00000	-155.52460
Drain:	0.00000	-1.01681
Head-Dependent Boundary:	0.00000	-18.15664
Recharge:	0.00000	0.00000
Decay or Biodegradation:	0.00000	0.00000
Mass Storage(Solute):	176.34890	-103.30600
Mass Storage(Adsorbed):	171.84280	-100.66640
TOTAL :	396.20071	-378.67045
NET (IN - OUT) :	17.53026	
DISCREPANCY(percent) :	4.52469	

C:\GMCPC\table13.WK1

Table 14. Cummulative Mass Budget for Entire Modeled Area

Unit: LB.

Pumping Rate:	86-2 = 6 gpm PWDISCH = 45 gpm MPW = 40 gpm
Flow Status:	Transient State
Starting Time:	December 1993
Ending Time:	December 2007

Mass Balance In Ground Water Flow System:

	IN:	OUT:
Constant Concentration:	75.01453	0.00000
Constant Head:	0.00000	0.00000
Well:	0.00000	-182.72490
Drain:	0.00000	-1.30533
Head-Dependent Boundary:	0.00000	-19.09705
Recharge:	0.00000	0.00000
Decay or Biodegradation:	0.00000	0.00000
Mass Storage(Solute):	198.62150	-115.32710
Mass Storage(Adsorbed):	193.54620	-112.38030
TOTAL :	467.18223	-430.83468
NET (IN - OUT) :	36.34755	
DISCREPANCY(percent) :	8.09507	