EXTRA INFORMATION

Christine Joyce

From: Steve Ledoux
Sent: Monday, December 07, 2009 3:48 PM
To: Manager Department
Subject: FW: WR Grace Capture Zone Evaluation

12/7/1
(12)

For extra info

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From: Mary Michelman [mailto:msmichelman@comcast.net]
Sent: Monday, December 07, 2009 12:47 AM
To: Matt@actonwater.com; Chris Allen; Doug Halley; 'James Okun'; 'Bruce Nickelsen'
Cc: Steve Ledoux; Stephen Anderson; Paulina Knibbe (comcast)
Subject: WR Grace Capture Zone Evaluation

Hi fellow Acton Stakeholders,

FYI, Amongst other issues, on tomorrow's conference call with EPA, I'd like to hear their input on the following:

1. What methodology did WR Grace use to generate estimated capture zones?

2. The need to understand the dynamics at the site---Could changes to pumping rates trigger the need for additional treatment for 1,4 dioxane or other contaminants? (Please sample the treatment plant effluent for 1,4-dioxane asap, given the current decline in the total extraction rate in the landfill area, and the pending decision on treatment plant design.)

3. What were the October 29, 2009 extraction well flow rates for SELF-1 and SWLF-1?

4. The 2008 benzene plume cross-section appears different in the Capture Zone Evaluation than in two previous WR Grace reports that are based on the same 2008 data set.

5. Would EPA modelers please review/critique the evaluation? Note: EPA has guidance on capture zone analysis. See: http://www.epa.gov/ada/download/reports/600R08003/600R08003-FM.pdf

Below are more detailed versions of these comments.

1. Methodology to estimate capture zones?
The Nov. 19, 2009 Landfill Area Capture Zone Evaluation does not make it clear what methodology WR Grace used to generate the estimated capture zones from the September 2009 water level measurements. Did they use the model? Some other tool or method?

FYI, I have attached three documents pertinent to this question.

a. Section 4 of the Pre-Design Results Report that we received from EPA on May 15, 2009. (I would be happy to send you Section 4 figures in a separate email. Just let me know if you'd like them. The file is large, and you may already have the figures…)

b. EPA & DEP's June 9, 2009 Conditional Approval of the Pre-Design Results Plan.
In this document EPA directs WR Grace to collect additional water level data and use it "to generate potentiometric surfaces and estimate capture zones for overburden and bedrock." "Use these data, rather than the model-predicted capture zones, to determine if additional extraction wells may be needed in order to obtain the ROD specified capture zone."

The EPA comments also include some of the concerns that we had about the model-generated capture zones.

c. WR Grace's August 27, 2009 response to the EPA Comments on the Pre-Design Results Report.

Questions:
Did WR Grace adjust their groundwater model based on the September 2009 water level measurements and then use the adjusted model to estimate capture zones? (There were some serious shortcomings noted with the use of the model last spring.) If the model was not used, then what method was used? The evaluation should provide some discussion of the process and any uncertainties associated with whatever method was used.

2. Effects of varying pumping rates? Sample asap for 1,4-dioxane in effluent
We need to understand the effects of changes in pumping rates of individual wells on the water quality of the treatment system effluent, as well as on the horizontal and vertical extent of the capture zones and water quality in the Landfill Area. For example, the concentration of 1,4-dioxane is substantially higher at SELF-1 than at the other three extraction wells, which essentially provide dilution for this contaminant in the effluent. According to Table 2-2 in the 2009 *Draft Landfill Area Groundwater Concept Design* the maximum concentration of 1,4-dioxane in both the treatment plant influent and effluent was 2.6 ug/L. This is very close to the Massachusetts drinking water standard of 3 ug/L. If the proportion of effluent that comes from SELF-1 is increased by either an increase in pumping at this well or a decrease in pumping (and therefore dilution), at the other three extraction wells, then there is the potential that the concentration of 1,4-dioxane in the effluent discharged to Sinking Pond would exceed 3 ug/L.

Note that extraction well MLF supplies approximately 35 times more flow than SELF-1 and a very tiny fraction of the 1,4-dioxane in SELF-1. The concentration of 1,4-dioxane at MLF ranged from 0.76 ug/L to 1.6 ug/L, during the 2008 annual sampling, while the concentration at SELF-1 ranged from 22 ug/L to 28 ug/L during the same sampling round (*Monitoring Program Report, 2008, WR Grace Superfund Site*, April 30, 2009, Table 3-7). As of October 2009 there has been a decline in the pumping rates at extraction wells MLF and WLF.

- Please **sample the treatment plant effluent for 1,4-dioxane asap**, given the current decline in the total extraction rate in the landfill area, and the pending decision on treatment plant design.

3. October 29, 2009 flow rates at extraction wells SELF-1 and SWLF-2?
According to the report, the Capture Zone Evaluation used water level data collected when the total average pumping rate in the extraction wells was 47.6 gpm. As of October 29, 2009 the total flow rate had decreased by at least 7.1 gpm. (a decrease of 3.9 at MLF and 3.2 at WLF). What were the extraction rates at SELF-1 and SWLF-1 on October 29, 2009? What have the extraction rates at all four wells been since then?

4. Discrepancy in extent of 2008 Benzene plume
The *Landfill Area Groundwater Pre-Design Results Report* (April 2009), *Landfill Area Groundwater Concept Design* (September 2009), and *Landfill Area Capture Zone Evaluation* (November 2009), all present figures with colored contours showing the extent of VDC and benzene contamination at the site. In all three reports the data being presented are the 2008 annual monitoring data.

The cross section of the benzene plume along transect B to B' appears different in the *Landfill Area Groundwater Capture Zone Evaluation* than in the two previous reports that are based on the same data set, and show the same transect. In both the Pre-Design Report (Figure 4-22) and the Concept Design Report (Figure 1-5) the 31-100 ug/L contour of the benzene plume extends into bedrock to a depth of approximately 80 NGVD. However the comparable figure in the Capture Zone Evaluation, (Figure 18), depicts the 31-100 ug/L contour of the benzene plume as smaller than in the previous two reports, and as NOT extending into bedrock, and only going as deep as approximately 95 NGVD.

But, 56 ug/L of benzene was detected in bedrock well LF-06N (85 to 90 NGVD) on October 28, 2008, (*Monitoring Program Report, 2008, WR Grace Superfund Site*, April 30, 2009, Table A-1).

5. Review by EPA modelers requested
Would modeling experts from the EPA and DEP please review and critique the November 19, 2009 Landfill Area Capture Zone Evaluation? It's essential that the capture zones be both sufficient and sustainable.

Note the following EPA guidance on Capture Zone Evaluations: "A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems", EPA/600/R-08/00, January 2008
http://www.epa.gov/ada/download/reports/600R08003/600R08003-FM.pdf

I look forward to joining you on Monday's conference call at 1pm.

Mary

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ATTACHMENTS

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4 LANDFILL AREA GROUNDWATER MODELING

The groundwater flow and contaminant transport model that was developed for the Site during the Remedial Investigation/Feasibility Study (RI/FS), and revised to incorporate additional information regarding the Northeast Area of the Site, has been updated to incorporate data collected during the Landfill Area Pre-Design investigation, including data collected during the constant rate pumping test. Model parameter adjustments were made during calibration to drawdown observed during the ten-day pumping test, and to provide a better comparison between model-calculated and observed VDC and benzene concentrations trends in specific monitoring wells. The original groundwater flow and contaminant transport model was described in detail in Appendix A of the Public Review Draft Remedial Investigation Report (GeoTrans, 2005a) and Appendix B of the Public Review Draft Feasibility Study Report (GeoTrans, 2005b). Modifications made to the groundwater flow and contaminant transport model since the RI/FS were described in the September 17, 2008 letter *RE: Additional Modeling Results for Northeast Area Groundwater Remedy* (GeoTrans, 2008a) and the October 30, 2008 letter *RE: Sensitivity Analysis of Model Results for Northeast Area Groundwater Remedy* (GeoTrans, 2008b) that were submitted to USEPA and MassDEP.

This section of the report:

- Summarizes modifications made to the groundwater flow and contaminant transport model since October 2008;
- Compares model-calculated drawdown to the drawdown observed at the end of the 10-day constant rate pumping test described in Section 3.2;
- Compares model-calculated to observed VDC and benzene concentration trends at certain wells;
- Compares the February 2001 water level target calibration statistics calculated by the current version of the model to the calibration statistics calculated by the October 2008 version of the model;
- Evaluates the model-calculated capture zone for the proposed Landfill Area groundwater extraction well system; and
- Compares the model-calculated Landfill Area capture zone to the Landfill Area capture zone shown in the ROD and to the current understanding of the horizontal and vertical extent of groundwater contamination in the Landfill Area.

4.1 POST-OCTOBER 2008 MODIFICATIONS TO THE GROUNDWATER FLOW AND CONTAMINANT TRANSPORT MODEL

The Site groundwater flow and contaminant transport model was modified to incorporate data collected during the Landfill Area Groundwater Pre-Design Phase investigations and to improve the comparison between model-calculated and observed VDC and benzene concentration trends in specific Landfill Area monitoring and extraction wells. The version of the model with a hydraulic conductivity of 25 ft/day in the area of BOC Gases in Layers 1 and 2, described in the letter *RE: Sensitivity Analysis of Model Results for Northeast Area Groundwater Remedy* (GeoTrans, 2008b), was used as the base model for the Landfill Area groundwater modeling. Hydraulic properties of the landfill area portion of the model were modified to reflect the lithologic information and other hydraulic data collected during the Landfill Area pre-design investigation as well as to better match observed VDC and benzene groundwater concentration data over time. The following sections describe model calibration to the drawdown observed during the ten-day constant rate pumping test; compare model-calculated and observed VDC and benzene concentration trends at specific Landfill Area wells; and compare the February 2001 water level target summary calibration statistics calculated by the revised model with the summary calibration statistics calculated by the October 2008 version of the model. The revised model was then used to calculate the capture zone likely to be created by long-term operation of the existing Landfill Area extraction system.

4.1.1 TEN-DAY CONSTANT RATE PUMPING TEST

The Site groundwater model was modified to reflect the lithologic information collected during the pre-design investigation and the model was recalibrated to the drawdown observed during the ten-day constant rate pumping test. A ten-day transient simulation was made using model-specified pumping rates that were equal to the average pumping rates of the Landfill Area extraction wells during the ten-day test. The specified rates were: MLF at 37.1 gpm, SELF-1 at 1.3 gpm, SWLF-1 at 4.2 gpm and WLF at 9.6 gpm. The hydraulic properties that were modified during the calibration to the ten-day pumping test data included hydraulic conductivity and specific storage. Figures 4-1 through 4-4 show the hydraulic conductivity zonation and values specified for each of the model layers for the recalibrated model. These four figures can be compared to Figures 2-6 through 2-9 of Appendix A of the Public Review Draft Remedial Investigation Report (GeoTrans, 2005a) to see the modifications that were made to hydraulic conductivity. Specific storage values of the unconsolidated deposits and bedrock were reduced as part of the recalibration to the ten-day pumping test data. The specific storage of the unconsolidated deposits was reduced from 0.05 to 0.01, and the specific storage of the bedrock was reduced from 0.005 to 0.001.

Table 4-1 lists the observed and model-calculated drawdown after ten-days of pumping. Wells in which water levels were monitored continuously using pressure transducers and data loggers are highlighted in yellow on the table. Drawdown estimates in wells that had continuous water level monitoring were deemed to be more reliable than drawdown estimates from wells in which water levels were measured periodically by hand. Figures 4-5 and 4-6 show the model-calculated drawdown in unconsolidated deposits and bedrock groundwater, respectively. Figure 4-5 shows model-calculated drawdown from monitoring wells completed in model layers 1, 2 and 3 (sand and gravel and till), while Figure 4-6 shows model-calculated drawdown from monitoring wells completed in model layers 4 through 7 (bedrock). These maps of model-calculated drawdown can be compared to Figures 3-9 and 3-10 of this report, which show the observed ten-day drawdown in the unconsolidated deposits and bedrock groundwater, respectively.

A review of Table 4-1 and Figure 3-9, 3-10, 4-5 and 4-6, show that there is reasonably good agreement between the model-calculated and observed ten-day drawdown values. For example, there is reasonably good agreement between the contours showing 0.5 feet of observed and model-calculated drawdown in the unconsolidated deposits (Figure 3-9 and 4-5) and bedrock (Figure 3-10 and 4-6). Consequently, the modified hydraulic conductivity distribution that is reflected in Figures 4-1 through 4-4 was accepted as a calibration improvement.

4.1.2 HISTORIC VDC AND BENZENE CONCENTRATIONS

The groundwater flow and contaminant transport model was also recalibrated to observed VDC and benzene concentrations in groundwater over time in the Landfill Area. The hydraulic properties that were modified during the calibration to observed VDC and benzene concentration trends. Two separate simulations were made: one for VDC and one for benzene. All model conditions, except for the initial contaminant distribution, were identical for both simulations. The pumping rates for the Christofferson, Lawsbrook, and Scribner public water supply (PWS) wells were held constant at 156, 99, and 55 gpm, respectively. The pumping rates for the

Assabet 1 and Assabet 2 PWS wells were held constant at 208 and 199 gpm, respectively. These model-specified pumping rates are based on long-term average pumping rates at each well. Annual stress periods were used to represent annual variation in the pumping rates for the ARS extraction wells. Long-term average stage elevations were used for the Assabet River, Fort Pond Brook, Sinking Pond, Muskrat Pond, and Turtle Pond. The stage elevations were held constant for each simulation.

VDC concentration trends observed between 1984, when groundwater extraction first began, and 2008 were evaluated. An initial (1984) VDC concentration distribution in groundwater was estimated from available VDC concentration data and modified, as necessary, to improve the comparison between the model-calculated and observed VDC concentrations at several locations in the Landfill Area. Using an initial specified VDC concentration distribution, the transport model simulation was run for 24 years, from January 1, 1984 through December 31, 2007.

Model-calculated changes in VDC concentrations were compared to observed VDC concentrations at several monitoring locations in the Landfill Area. Figures showing observed and model-calculated VDC concentrations at monitoring wells AR-20A, B-03B, LF-02A, LF-10, and LF-19SBR and extraction wells MLF and WLF, respectively, are included in Attachment F. The figures show that model-calculated VDC concentrations and model-calculated VDC concentration trends compare well to observed VDC concentration data and trends at monitoring well AR-20A and extraction well WLF. The model-calculated VDC concentration trends at B-03B and MLF compare favorably to the observed VDC concentration trend, but the model over-predicts VDC concentrations at monitoring well B-03B and extraction well MLF with model-calculated VDC concentrations of 216 and 88 μg/L, respectively in 2007, compared to the observed concentrations of 16 and 4.6 μg/L. The model-calculated VDC concentrations trends at LF-10 and LF-19SBR are reasonably well replicated, but the model under-predicts VDC concentrations at these wells. Model-calculated VDC concentrations at monitoring wells LF-10 and LF-19SBR were 196 and 192 μg/L, respectively in 2007, compared to the observed concentrations of 480 and 520 μg/L. The model-calculated and observed 2004 to 2007 VDC concentrations at LF-02A are similar, but the VDC concentration trend is not well-replicated.

Benzene concentration trends observed between 1998, when the Landfill cap was completed, and 2008 were also evaluated. An initial (1998) benzene concentration distribution in groundwater was estimated from available benzene concentration data and modified, as necessary, to improve the match between the model-calculated and observed benzene concentrations at several locations in the Landfill Area. Using an initial specified benzene concentration distribution, the transport model simulation was run for 10 years, from January 1, 1998 through December 31, 2007.

Model-calculated benzene concentration trends were compared to observed benzene concentration trends at several monitoring locations in the Landfill Area. Figures showing observed and model-calculated benzene concentrations at monitoring wells AR-11B1, AR-21, B-08B, B-08B3, LF-05E, LF-06C, and LF-06N and extraction wells ELF and MLF are also included in Attachment F. The figures show that model-calculated benzene concentrations and model-calculated benzene concentration trends compare reasonably well to observed benzene concentration data at monitoring wells AR-11B1, B-08B, B-08B3 and LF-05E. Model-calculated benzene concentrations compare reasonably well to observed benzene concentration data from extraction well ELF. However, benzene concentration trends at extraction well ELF do not match as well. The model over-predicts benzene concentrations at monitoring wells AR-21 and LF-06N, and extraction well MLF with model-calculated benzene concentrations of 44, 260, and 9 µg/L, respectively in 2007 compared to the observed concentrations of not detected, 56 and 1 µg/L. The model under-predicts benzene concentrations at monitoring well LF-06C with a model-calculated benzene concentration of 600 µg/L, respectively in 2007 compared to an observed concentration of 1800 µg/L.

The comparison of model-calculated and observed VDC and benzene concentrations and concentration trends supports acceptance of the revised groundwater flow and chemical transport model.

4.1.3 February 2001 Calibration Simulation

When the groundwater flow model for the Site was originally constructed, it was calibrated to water level data collected in February 2001 (GeoTrans, 2005a). To provide an additional evaluation of the modifications made to the groundwater flow and chemical transport model since October 2008, the original February 2001 calibration targets were simulated using the revised model. Table 4-2 lists the residuals and summary statistics for the application of the revised model to the February 2001 calibration targets. The summary statistics for the revised model were compared to those presented in the letter *RE: Sensitivity Analysis of Model Results for Northeast Area Groundwater Remedy* (GeoTrans, 2008b). As shown in Table 4-3a, the summary calibration statistics in the revised simulation are similar to the October 2008 model version, but absolute values of the minimum and maximum residuals for the revised model are greater than for the October 2008 version of the model. In addition, the model-calculated groundwater fluxes to several surface water bodies were compared to the fluxes presented in the letter *RE: Sensitivity Analysis of Model Results for Northeast Area Groundwater Remedy* (GeoTrans, 2008b). As shown in Table 4-3b, the calculated fluxes of the revised model are similar to the model-calculated fluxes of the October 2008 version of the model.

4.2 LANDFILL AREA CAPTURE ZONE EVALUATION

Overall, the evaluation of the results of the modified groundwater flow and contaminant transport model, described above, indicates that the revised model provides a reasonably good representation of observed Site conditions. Therefore, the revised groundwater flow and contaminant transport model was used to calculate the expected capture zone of the Landfill Area groundwater extraction system. The model-calculated capture zone is a reasonable representation of the existing capture zone created by the Landfill Area extraction system.

The pumping rates used in the model evaluations described below are listed in Table 4-4. The pumping rates for the five public water supply wells represent the average 2005 to 2008 pumping rates and the pumping rates for the Landfill Area extraction wells represent the average rates from the ten-day constant rate pumping test. In order to better illustrate the capture zone created by the four Landfill Area extraction wells, model results are presented on several series of figures by model layer, with the model layers representing the following lithology:

- Layer 2 – lower sand and gravel;
- Layer 3 – till;
- Layer 4 - upper 20 feet of bedrock (weathered bedrock); and
- Layer 5 - 20 to 50 feet below the bedrock surface.

Figures 4-7 through 4-10 show the model-calculated capture zone in model layers 2, 3, 4, and 5, respectively. The model-calculated capture zone was determined by starting a particle of water in every grid cell of the model and determining which particles in each layer would be captured by the extraction wells. The area within the model-calculated capture zone shown on each of the four figures represents the area in which all the particles started in a given layer are captured by one of the Landfill Area extraction wells.

Model-generated particle tracks are also shown on Figures 4-7 through 4-10. The particle tracks shown on Figure 4-7 start in the center of model layer 2 (lower sands and gravels), the particle tracks shown on Figure 4-8 start in the center of model layer 3 (till) and the particle tracks shown on Figures 4-9 and 4-10, start in the middle of the model layers they represent. On all the figures, colors indicate which model layer each particle is traveling through. Particles were started along two lines through the Landfill Area to help illustrate the capture zone created by the Landfill Area extraction wells.

Figures 4-11 through 4-14 show the simulated potentiometric surface and model-calculated capture zones for model layers 2 through 5 overlain on the 2008 VDC plume. An evaluation of the model-calculated capture zone relative to the location of groundwater contamination is discussed further in Section 4.3.2.

4.3 Comparison of Existing Capture Zone to ROD Capture Zone

The following sections first describe the basis for the capture zone described in the ROD, then compares the model-calculated capture zone to the ROD capture zone and to the current distribution of groundwater contamination in the Landfill Area.

4.3.1 ROD Capture Zone

The ROD (USEPA, 2005) specified that the Remedial Action for the Landfill Area would consist of groundwater extraction wells installed to capture groundwater generally in the area described as the "ROD Capture Zone" on Figure 4-15 combined with Monitored Natural Attenuation (MNA) to remediate groundwater contamination not captured by the extraction system. Based on groundwater flow model analyses done for the Feasibility Study (GeoTrans, 2005b), it was estimated that four extraction wells (MLF, SELF-1, SWLF-1 and WLF) pumping at a combined rate of approximately 90 gallons per minute (gpm) would be needed to achieve this capture zone. Achieving the ROD capture zone specified in the ROD represents a goal of the groundwater extraction component of the selected remedy. It was understood that the actual pumping rate from the four wells necessary to create the ROD capture zone could be more or less than 90 gpm, and that if the actual capture zone established by the four extraction wells was significantly different from the ROD Capture Zone, then USEPA and MassDEP may require additional evaluations and/or investigations and/or additional extraction wells (design, installation, operation, maintenance and monitoring).

Also shown on Figure 4-15 is the 2001/2002 VDC plume, which was the basis for many of the evaluations done for the Feasibility Study (GeoTrans, 2005b) and ROD (USEPA, 2005). The ROD capture zone can be separated into two "lobes", the "western lobe" and the "eastern lobe". As can be seen on Figure 4-15, the "western lobe" of the capture zone was intended to capture groundwater with elevated VDC concentrations. A comparison of the locations of the 2001/2002 VDC contamination and the ROD capture zone shows that groundwater extraction downgradient of the Industrial Landfill was not designed to capture all contaminated groundwater but only groundwater with the highest concentrations.

As can also be seen on Figure 4-15, the "eastern lobe" of the ROD capture zone was not designed to capture VDC contaminated groundwater. As described in the Feasibility Study (GeoTrans, 2005b, pg 6-18), the "eastern lobe" of the ROD capture zone was designed to maintain hydraulic control of the area of wells LF-06, B-08, LF-15, MLF and ELF. This group of wells is approximately coincident with the region of elevated benzene and arsenic concentrations in groundwater. Figure 4-16 shows the correlation between the 2001/2002 benzene plume and the ROD capture zone. As with the "western lobe", the "eastern lobe" of the capture zone was not designed to capture all contaminated groundwater but only groundwater with the highest concentrations.

4.3.2 Comparison of Capture Zones

One reason for conducting the ten-day constant rate pumping test described in Section 3.2 was to determine if the capture zone created by Landfill Area extraction wells MLF, SELF-1, SWLF-1 and WLF fulfills the requirement of the ROD. Figures 4-17 through 4-20 show the model-calculated capture zones for model layers 2, 3, 4 and 5, respectively, as well as the ROD capture zone. As described above, the model-calculated capture zones encompass the area within which all particles started in model layers 2, 3, 4, and 5, respectively, are captured by the

Landfill Area extraction wells. A comparison of the model-calculated and ROD capture zones shows the following:

- Model Layer 2 – The model-calculated capture zone is more extensive than the ROD capture zone (Figure 4-17);
- Model Layer 3 – The model-calculated capture zone is more extensive than the ROD capture zone everywhere except immediately downgradient of monitoring well cluster LF-06, located in the "eastern lobe". In this area the ROD capture zone extends approximately 50 to 75 feet further downgradient than the model-calculated capture zone (Figure 4-18). However, as discussed below, groundwater contamination is not present at this depth in this area;
- Model Layer 4 – At the "western lobe", the model-calculated capture zone is more extensive than the ROD capture zone. At the "eastern lobe", the model-calculated capture zone is less extensive than the ROD capture zone (Figure 4-19). However, as discussed below, groundwater contamination is not present at this depth in this area; and
- Model Layer 5 – At the "western lobe", the model-calculated capture zone is more extensive than the ROD capture zone. At the "eastern lobe", the model-calculated capture zone is less extensive than the ROD capture zone (Figure 4-20). However, as discussed below, groundwater contamination is not present at this depth in this area.

The above comparison suggests that the existing capture zone may fulfill the capture zone objectives of the ROD. However, to fully evaluate the capture zone, the horizontal and vertical extent of groundwater contamination must be taken into consideration. In addition to the model-calculated and ROD capture zones, Figures 4-17 through 4-20, show the most recent water quality data from monitoring wells that are located in the vicinity of the capture zone in model layers 2, 3, 4 and 5, respectively. For example, Figure 4-17 shows the extent of the model-calculated capture zone for model layer 2 as well as the most recent water quality data from monitoring wells that are located in the vicinity of the capture boundary and are completed at the depth represented by model layer 2. Figure 4-18 shows the model-calculated capture zone for model layer 3 along with the most recent water quality data from monitoring wells that are located in the vicinity of the capture boundary and are completed at the depth represented by model layer 3. Figures 4-19 and 4-20 show similar information for model layers 4 and 5, respectively.

As described above, the "western lobe" of the capture zone was designed to capture groundwater with elevated VDC concentrations. As can be seen by looking at the water quality data on Figures 4-17 through 4-20, the highest VDC concentrations are present in monitoring wells completed in model layers 3 (till), 4 (upper 20 feet of bedrock) and 5 (20-50 feet below bedrock surface). Figure 4-21 is a cross-section showing the current vertical distribution of VDC in this area as well as the approximate location of the model-calculated capture zone. The location of Section A-A' is shown on Figures 4-17 through 4-20. Figures 4-17 through 4-21 show that groundwater with the highest VDC concentrations, both horizontally and vertically, is within the model-calculated Landfill Area capture zone and fulfills the requirements of the ROD.

As described above, the "eastern lobe" of the capture zone was designed to maintain hydraulic control in the area of wells LF-06, B-08, LF-15, MLF and ELF, a region of elevated benzene and arsenic groundwater concentrations. As can be seen by looking at the water quality data on Figures 4-17 through 4-20, the highest benzene concentrations are present in monitoring wells completed in model layer 2 (deep sand and gravel). Figure 4-22 is a cross-section showing the current vertical distribution of benzene in this area as well as the approximate location of the model-calculated capture zone. The location of Section B-B' is shown on Figures 4-17 through 4-20. Figures 4-17 through 4-20 and Figure 4-22 show that groundwater with the highest benzene concentrations, both horizontally and vertically, is within the model-calculated Landfill Area capture zone. The water quality data from monitoring well LF-06C shows that benzene concentrations are approximately 1,800 µg/L in the sand and gravel, while water quality data from deeper monitoring well LF-06N shows that benzene concentrations are approximately 56 µg/L in the deep till and upper bedrock, indicating that depth of the "eastern lobe" capture zone does not have to extend to the till and bedrock. In fact, extraction well SELF-1 was specifically designed to extract groundwater from the lower sand and gravel, since that is where the highest contaminant concentrations are found in that area. The above analysis indicates that the model-calculated capture zone would maintain hydraulic control in the area of wells LF-06, B-08, LF-15, MLF and ELF at depths at which elevated groundwater contamination is present; it therefore fulfills the requirement of the ROD.

4.4 CONCLUSIONS

The groundwater flow and contaminant transport model for the Site was recalibrated in the Landfill Area based on the ten-day constant rate pumping test and observed VDC and benzene concentrations over time. The hydraulic testing and groundwater flow modeling results demonstrate that current pumping from extraction wells MLF, WLF, SELF-1, and SWLF-1, has created a capture zone similar to the one required by the ROD. The existing Landfill Area extraction system is meeting the capture zone objectives of the ROD by capturing groundwater with elevated VDC concentrations in the "western lobe" of the capture zone and is maintaining hydraulic control within the area of wells LF-06, B-08, LF-15, MLF and ELF at depths at which elevated groundwater contamination is present. Groundwater contamination that is beyond the limits of the capture zone will be remediated through natural attenuation processes as anticipated by the ROD.

Table 4-1. Observed versus Model-Calculated Drawdown After 10-Days of Pumping

Name	Layer	Observed	Model-Calculated	Residual
B-03P	1	0.27	0.98	-0.71
LF-02P	1	1.06	1.73	-0.67
LF-11CR	1	0	0.56	-0.56
LF-14	1	0.07	1.73	-1.66
LF-19S	1	0.19	1.69	-1.50
OSA-16A	1	0	0.27	-0.27
AR-12	2	1	0.48	0.52
AR-21A	2	0.68	0.34	0.34
AR-22	2	0.68	0.76	-0.08
LF-03P	2	0	0.80	-0.80
LF-05E	2	0.03	1.44	-1.41
LF-06S	2	0	4.17	-4.17
LF-09A	2	1.24	2.15	-0.91
OSA-16B	2	0.46	0.25	0.21
AR-12D	3	0	0.40	-0.40
B-08B	3	1.22	2.45	-1.23
ELF-OBS	3	0.17	1.92	-1.75
LF-04P	3	1.07	2.85	-1.78
LF-05D	3	0.99	2.18	-1.19
LF-06C	3	1.17	1.87	-0.70
LF-09	3	1.24	2.37	-1.13
LF-10	3	1.23	1.33	-0.10
LF-11AR	3	0.6	0.45	0.15
LF-12/A	3	0.67	0.53	0.14
LF-13A	3	0.97	0.30	0.67
LF-17D	3	0.72	0.44	0.28
LF-19D	3	1.54	1.99	-0.45
LF-21D	3	0.4	0.24	0.16
AR-11SBR	4	0.84	0.25	0.59
AR-12SBR	4	0.51	0.39	0.12
AR-21	4	0.65	0.47	0.18
LF-02A	4	0.89	2.01	-1.12
LF-03A	4	0.56	0.86	-0.30
LF-06N	4	1.5	1.34	0.16
LF-13SBR	4	0.62	0.24	0.38
LF-17SBR	4	0.67	0.55	0.12
LF-21SBR	4	0.66	0.38	0.28
OSA-16BR	4	0.41	0.13	0.28
B-08A	5	0.72	1.54	-0.82
LF-11R	5	0.69	0.59	0.10
LF-19SBR	5	7.19	8.19	-1.00
AR-12DBR	6	0.71	0.37	0.34
LF-06	6	0.5	1.04	-0.54
LF-13	6	0.42	0.23	0.19
LF-19DBR	6	1.15	3.08	-1.93
LF-21DBR	6	0	0.55	-0.55
(shaded)	Water level monitored continuously with pressure transducer/data logger.			

Table 4-2. Targets and Revised Residuals for the February 2001 Calibration

Name	Layer	Observed	Model-Calculated	Residual
AR-04P	1	135.63	136.28	-0.65
AR-06P	1	137.40	138.81	-1.41
AR-08P	1	131.57	133.66	-2.09
AR-09P	1	136.81	136.25	0.56
AR-10P	1	136.38	136.57	-0.19
AR-11P	1	133.92	130.61	3.31
AR-13P	1	129.46	132.59	-3.13
AR-14P	1	127.39	129.12	-1.73
AR-15P	1	134.38	133.51	0.87
AR-16BSH	1	129.84	129.20	0.64
AR-19ASH	1	134.16	132.17	1.99
AR-21B	1	134.51	128.20	6.31
AR-25S	1	136.84	137.01	-0.18
AR-26S	1	136.84	136.12	0.72
AR-28S	1	126.13	129.49	-3.36
AR-29S	1	128.64	130.18	-1.54
AR-30S	1	119.00	119.37	-0.37
AR-31S	1	124.33	126.55	-2.22
B-01P	1	135.73	133.72	2.01
B-03P	1	134.10	134.44	-0.34
B-04P	1	137.18	136.16	1.02
B-06P	1	126.33	125.49	0.84
B-08D	1	135.23	132.28	2.95
B-10P	1	136.73	135.34	1.39
BD-2	1	136.05	134.55	1.50
CLF-1P	1	125.52	126.87	-1.35
CLF-2A	1	124.09	125.71	-1.62
CLF-3A	1	124.79	125.15	-0.36
EL-3	1	135.41	133.96	1.45
G-1	1	138.11	138.02	0.09
G-2	1	135.67	133.74	1.93
G-3	1	136.29	136.25	0.04
LAWSBROOK	1	128.00	129.10	-1.11
LF-05A	1	135.37	132.50	2.87
LF-05B	1	135.47	132.68	2.79
LF-05C	1	135.39	133.21	2.18
LF-05P	1	135.39	132.40	2.99
LF-10C	1	136.00	134.49	1.51
LF-11CR	1	136.35	135.16	1.19
LF-14	1	135.39	133.19	2.20
LF-16	1	135.21	132.92	2.29
LF-17S	1	134.27	133.26	1.01
LF-19S	1	133.90	133.66	0.24
MW-01S	1	137.12	136.20	0.92
MW-04S	1	134.21	134.26	-0.05
MW-06S	1	134.61	134.27	0.33
MW-07S	1	138.08	135.10	2.98
MW-08S	1	137.07	136.73	0.34
MW-10S	1	138.08	135.36	2.72
MW-15S	1	137.52	134.76	2.76
OSA-01A	1	135.73	134.36	1.37
OSA-02A	1	135.85	134.85	1.00

Table 4-2 Targets and Revised Residuals for the February 2001 Calibration

Name	Layer	Observed	Model-Calculated	Residual
OSA-03A	1	136.16	135.39	0.76
OSA-04	1	135.94	134.66	1.28
OSA-05A	1	135.35	134.86	0.49
OSA-06A	1	133.54	133.67	-0.13
OSA-07A	1	134.25	134.22	0.03
OSA-08R	1	134.84	134.88	-0.04
OSA-10A	1	135.98	134.58	1.40
OSA-11A	1	134.89	134.54	0.35
OSA-12A	1	136.28	136.18	0.10
OSA-13A	1	134.76	133.10	1.66
OSA-14A	1	135.80	135.34	0.46
OSA-15A	1	133.62	132.38	1.24
OSA-16A	1	136.26	135.75	0.51
OSA-21	1	138.39	137.03	1.36
OSA-23A	1	135.39	135.75	-0.36
OW-8	1	122.35	122.21	0.14
OW-E	1	122.96	124.55	-1.59
PS-22A	1	126.50	129.29	-2.79
PT-03P	1	123.04	123.03	0.01
PT-10	1	124.58	124.68	-0.10
PT-12	1	136.84	138.09	-1.25
SL-9	1	136.20	136.03	0.17
UNA-3	1	129.69	132.16	-2.47
WRG2-OBS	1	131.28	134.05	-2.77
73-4	2	131.61	133.70	-2.09
9-78	2	125.70	125.39	0.31
A-2E	2	120.55	122.51	-1.96
AR-07P	2	145.21	146.76	-1.55
AR-12	2	123.83	123.32	0.51
AR-18P	2	134.91	134.53	0.38
AR-20A	2	130.88	123.25	7.63
AR-22	2	121.18	122.60	-1.42
AR-23B	2	133.84	135.26	-1.42
AR-26D	2	132.98	135.85	-2.87
AR-27S	2	135.38	134.96	0.42
AR-28D	2	126.55	129.49	-2.94
AR-29D	2	128.62	130.18	-1.56
AR-30D	2	119.76	118.42	1.34
AR-31D	2	125.01	126.54	-1.53
B-08C	2	135.10	132.23	2.87
LF-01P	2	135.89	135.11	0.78
LF-03P	2	136.13	134.86	1.27
LF-05E	2	134.57	133.25	1.32
LF-06S	2	135.18	133.28	1.90
LF-09A	2	132.14	132.54	-0.40
LF-11BR	2	135.03	135.04	-0.01
LF-13B	2	123.12	122.04	1.08
LF-15	2	135.25	132.17	3.08
MW-01D	2	136.96	136.00	0.96
MW-03S	2	132.53	133.74	-1.21
MW-04D	2	135.28	134.25	1.03
MW-07D	2	137.43	135.10	2.33

Table 4-2. Targets and Revised Residuals for the February 2001 Calibration

Name	Layer	Observed	Model-Calculated	Residual
OSA-01B	2	134.96	134.31	0.65
OSA-05B	2	135.25	134.80	0.45
OSA-07B	2	133.35	134.19	-0.84
OSA-10B	2	134.86	134.29	0.57
OSA-12B	2	135.87	136.17	-0.30
OSA-16B	2	134.09	135.65	-1.56
OSA-17	2	144.08	143.46	0.62
OSA-18	2	137.60	136.70	0.90
OSA-20	2	148.49	144.37	4.12
OSA-22	2	135.98	136.04	-0.06
OSA-23B	2	134.73	135.63	-0.90
OW-B	2	122.83	123.65	-0.82
PS-22B	2	127.55	129.29	-1.74
PT-09	2	124.65	124.35	0.30
R-2A	2	127.16	127.73	-0.57
UNA-5	2	133.39	135.39	-2.00
WLF-OBS	2	132.13	133.73	-1.60
77-3	3	128.28	132.22	-3.94
A4-78	3	125.24	126.09	-0.85
A6-78	3	126.85	128.52	-1.67
AR-05	3	133.84	137.23	-3.39
AR-09A	3	133.88	135.46	-1.58
AR-12D	3	124.65	123.11	1.54
AR-17BDP	3	129.65	132.63	-2.98
AR-27D	3	130.37	134.30	-3.93
B-08B	3	132.48	132.07	0.41
ELF-OBS	3	134.16	132.36	1.80
G-3A	3	134.93	135.68	-0.75
LF-02A	3	132.55	132.87	-0.32
LF-04P	3	132.77	131.70	1.07
LF-05D	3	132.92	132.32	0.60
LF-06C	3	132.48	132.46	0.02
LF-09	3	132.29	132.30	-0.01
LF-10	3	133.12	133.90	-0.78
LF-11AR	3	133.73	134.75	-1.02
LF-12	3	130.30	135.41	-5.11
LF-13A	3	123.10	122.17	0.93
LF-17D	3	130.08	132.63	-2.55
LF-19D	3	131.54	131.82	-0.28
MW-03D	3	132.44	133.54	-1.10
R-1	3	127.54	128.97	-1.43
R-2	3	126.28	128.18	-1.90
R-3P	3	127.56	128.26	-0.70
AR-09BR	4	133.88	135.12	-1.24
AR-11SBR	4	127.69	129.87	-2.18
AR-12SBR	4	126.99	124.43	2.56
AR-16ADP	4	130.00	133.10	-3.10
AR-20	4	127.97	124.87	3.10
AR-21	4	127.89	128.82	-0.93
AR-23	4	133.75	135.01	-1.26
AR-27SBR	4	132.26	133.74	-1.48
AR-28SBR	4	126.70	129.76	-3.06

Table 4-2. Targets and Revised Residuals for the February 2001 Calibration

Name	Layer	Observed	Model-Calculated	Residual
AR-29SBR	4	128.55	131.10	-2.55
AR-30SBR	4	120.82	121.46	-0.64
AR-31SBR	4	127.70	127.95	-0.25
LF-03A	4	132.48	134.57	-2.09
LF-06N	4	129.90	131.60	-1.70
LF-13SBR	4	125.73	123.46	2.27
LF-17SBR	4	128.87	131.95	-3.08
MW-01B	4	137.11	135.11	2.00
MW-06B	4	133.67	133.09	0.58
MW-07B	4	133.67	134.22	-0.55
MW-13B	4	133.37	135.21	-1.84
MW-16B	4	133.67	133.45	0.22
OSA-01BR	4	134.08	134.05	0.03
OSA-03BR	4	133.79	134.63	-0.84
OSA-05BR	4	134.03	134.68	-0.65
OSA-06BR	4	133.38	134.06	-0.68
OSA-11BR	4	133.81	133.55	0.26
OSA-12BR	4	135.65	135.93	-0.28
OSA-14BR	4	134.20	135.03	-0.83
OSA-16BR	4	133.99	135.10	-1.11
OSA-24	4	132.90	133.82	-0.92
R-4	4	130.61	131.90	-1.29
R-5	4	127.55	129.28	-1.73
AR-10BR	5	133.37	134.82	-1.45
AR-26DBR	5	132.78	135.08	-2.31
AR-28DBR	5	126.96	129.78	-2.82
AR-29DBR	5	129.05	131.11	-2.06
AR-30DBR	5	120.84	122.48	-1.64
B-08A	5	132.65	132.37	0.28
G-3BR	5	136.36	135.12	1.24
LF-11R	5	132.82	134.37	-1.55
LF-19SBR	5	131.54	133.02	-1.48
MW-02B	5	133.80	134.32	-0.52
OSA-02BR	5	134.82	134.34	0.48
AR-12DBR	6	127.06	126.60	0.46
AR-31DBR	6	129.95	127.97	1.98
LF-06	6	128.91	130.93	-2.02
LF-13	6	126.22	125.64	0.58

Residual Mean	-0.11
Res. Std. Dev.	1.81
Sum of Squares	638.88
Abs. Res. Mean	1.41
Min. Residual	-5.11
Max. Residual	7.63
Range in Target Values	29.49
Std. Dev./Range	0.06

Table 4-3a. Calibration Statistics

	October 2008 Statistics*	May 2009 Statistics
Residual Mean	-0.05	-0.11
Res. Std. Dev.	1.70	1.81
Sum of Squares	558.08	638.88
Abs. Res. Mean	1.34	1.41
Min. Residual	-4.23	-5.11
Max. Residual	4.62	7.63
Range	29.49	29.49
Std/Range	0.06	0.06
*Statistics from GeoTrans, 2008b, with K of Layers 1-2 @BOC Gases = 25 ft/day		

Table 4-3b. Flux Estimates

	October 2008 Fluxes*	May 2009 Fluxes
Assabet River (cfs)	0.54	0.43
Fort Pond Brook (cfs)	1.59	1.61
Sinking Pond (gpm)	341	307
Muskrat/Turtle Pond (gpm)	7.2	8
*Fluxes from GeoTrans, 2008b, with K of Layers 1-2 @BOC Gases = 25 ft/day		

Table 4-4. Pumping Rates Used for Landfill Area Capture Zone Evaluation

	Pumping Rate (gpm)
Assabet 1A	242
Assabet 2A	207
Christofferson	58
Lawsbrook	115
Scribner	118
MLF	37.1
SELF-1	1.3
SWLF-1	4.2
WLF	9.6

6 REFERENCES

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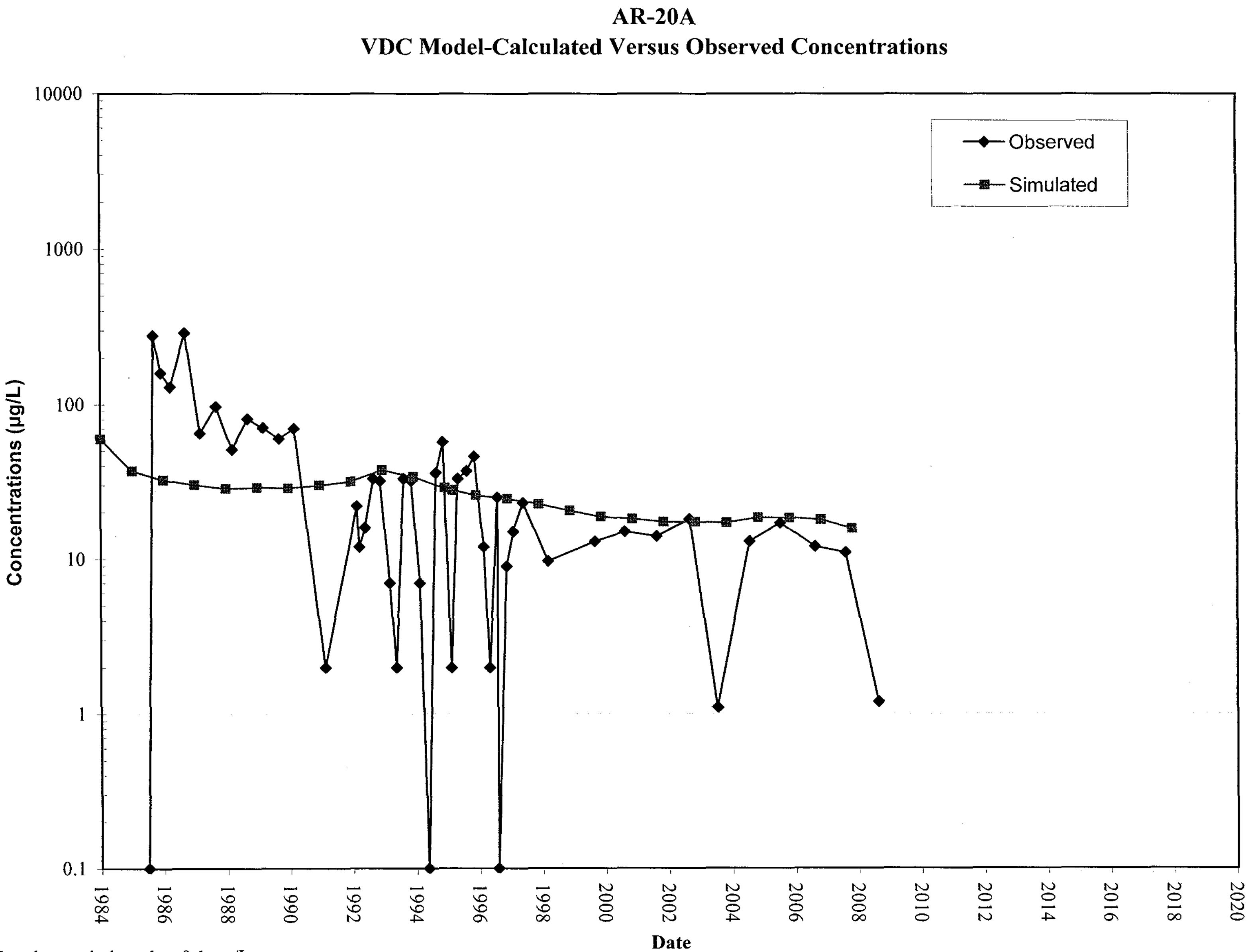
USEPA, 2005. Record of Decision, W. R. Grace & Co. (Acton Plant) Superfund Site, Operable Unit Three, September 2005.

ATTACHMENT F

GROUNDWATER QUALITY VERSUS TIME GRAPHS



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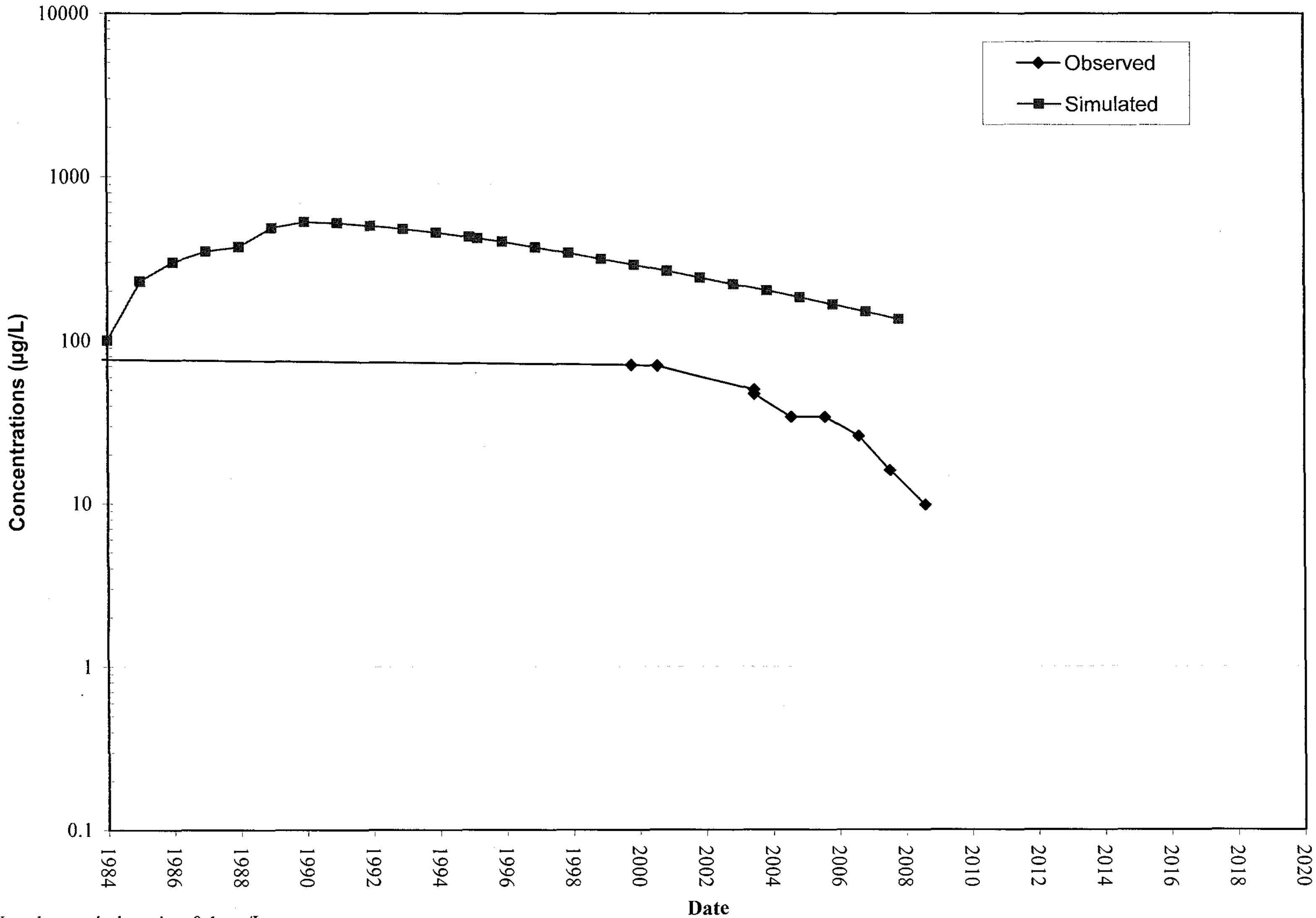
B-03B
VDC Model-Calculated Versus Observed Concentrations



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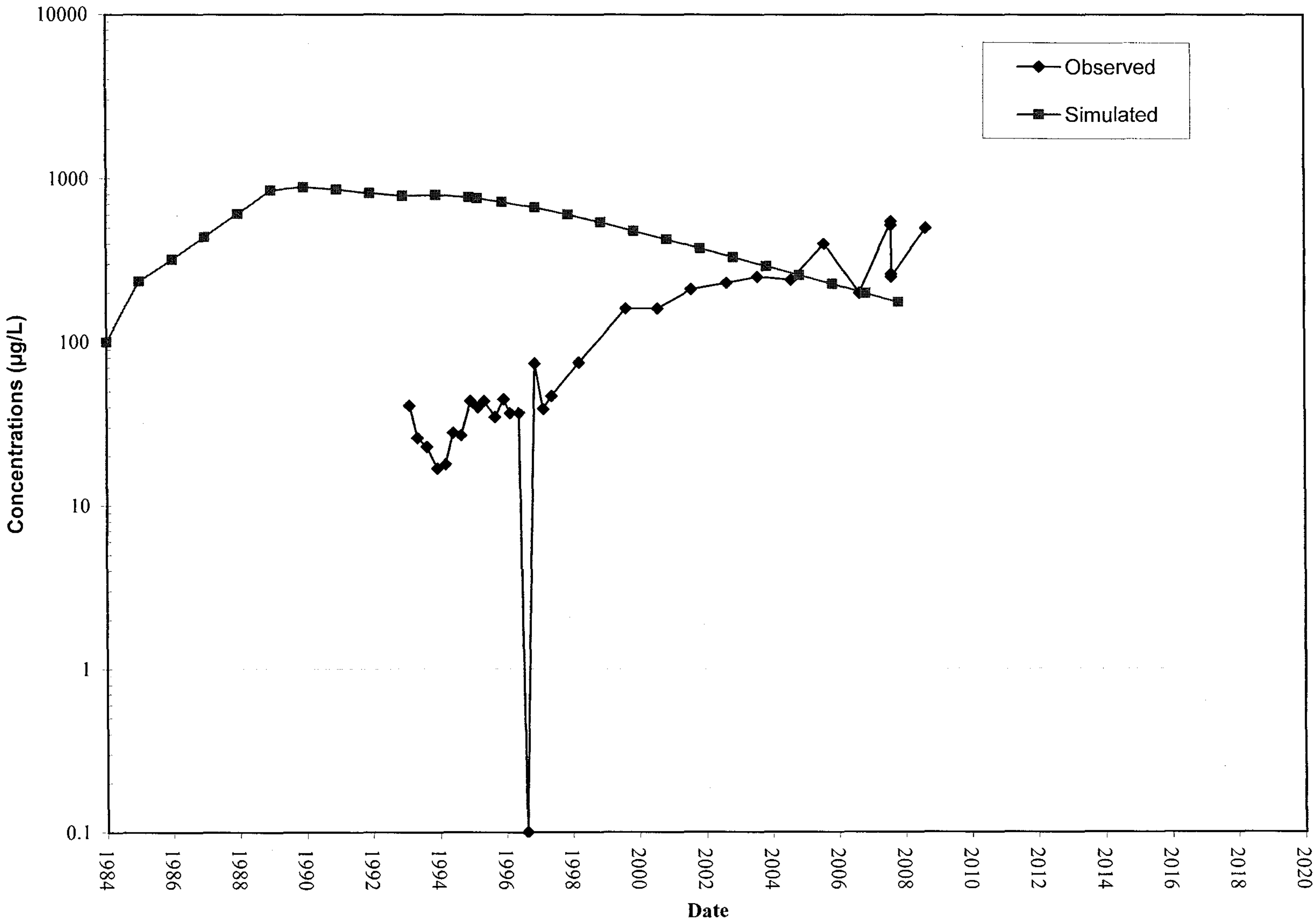
LF-02A
VDC Model-Calculated Versus Observed Concentrations



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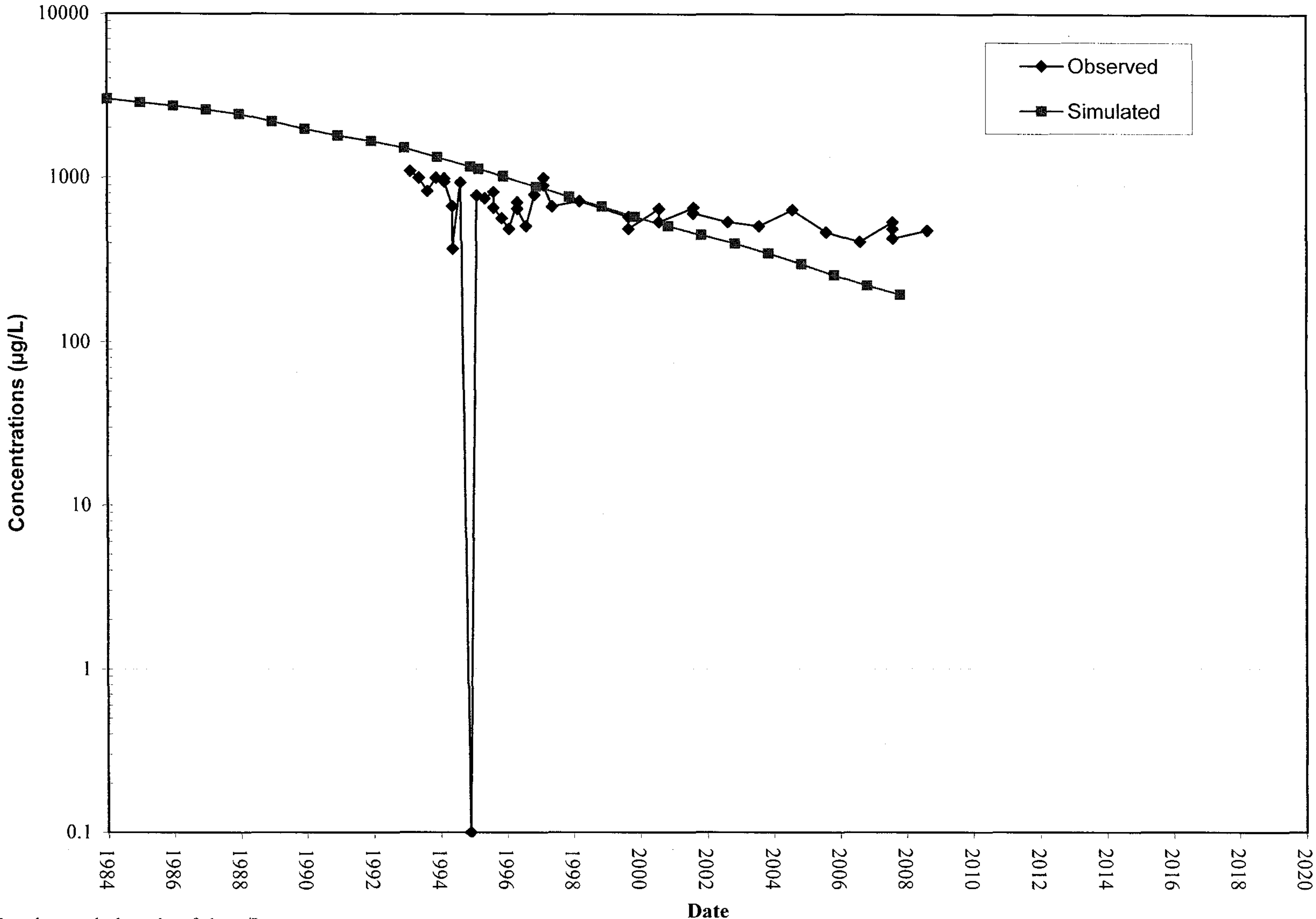
LF-10
VDC Model-Calculated Versus Observed Concentrations



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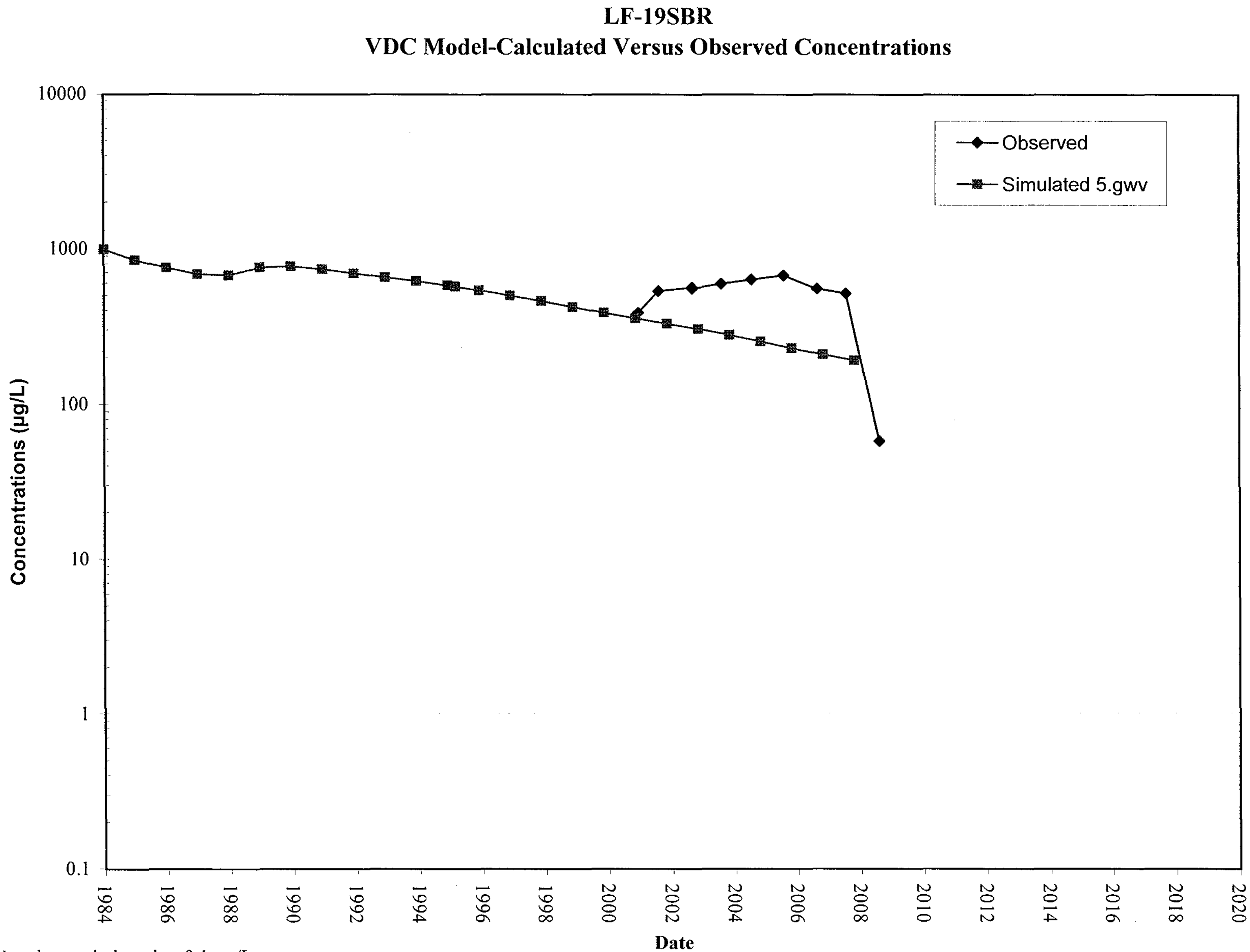

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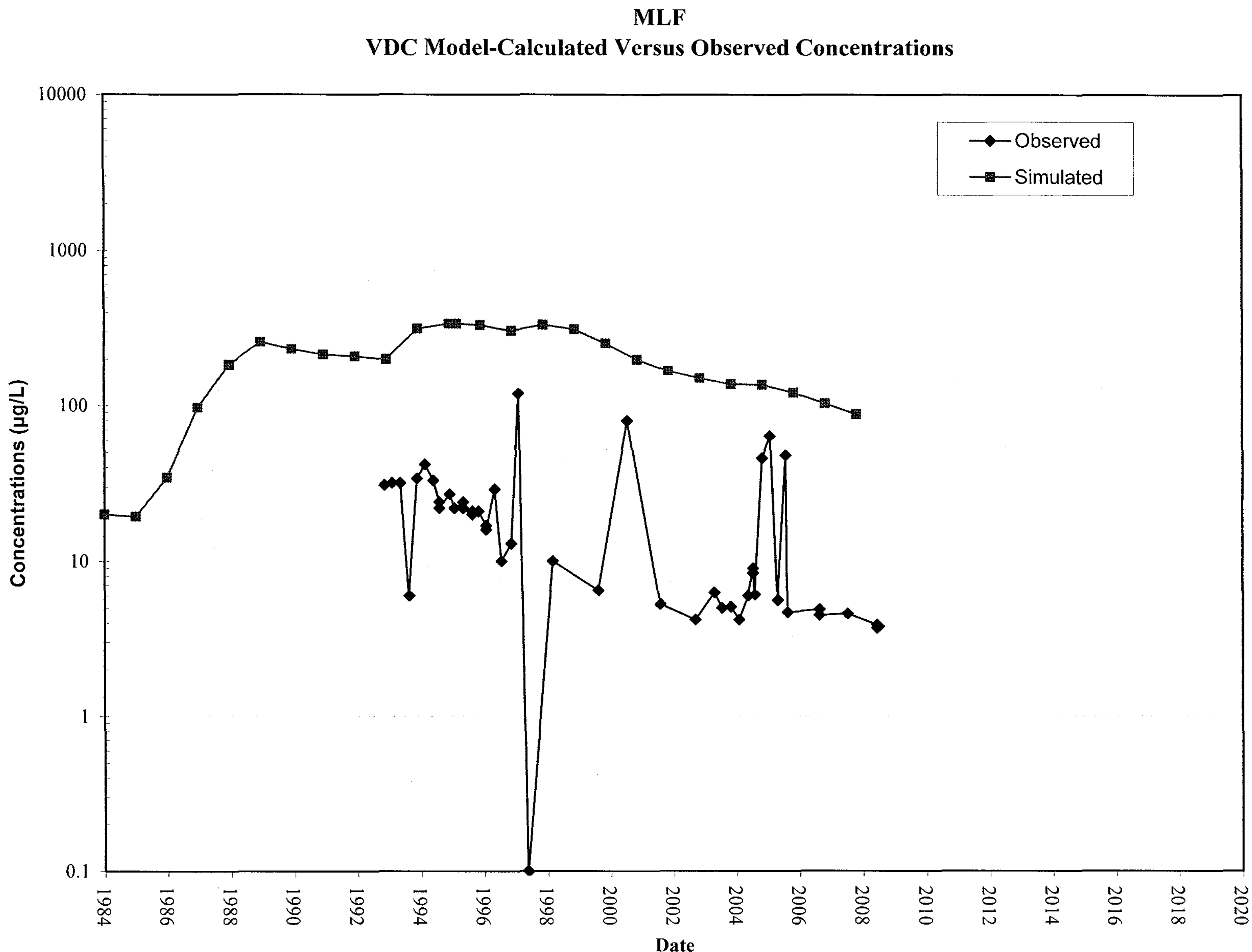

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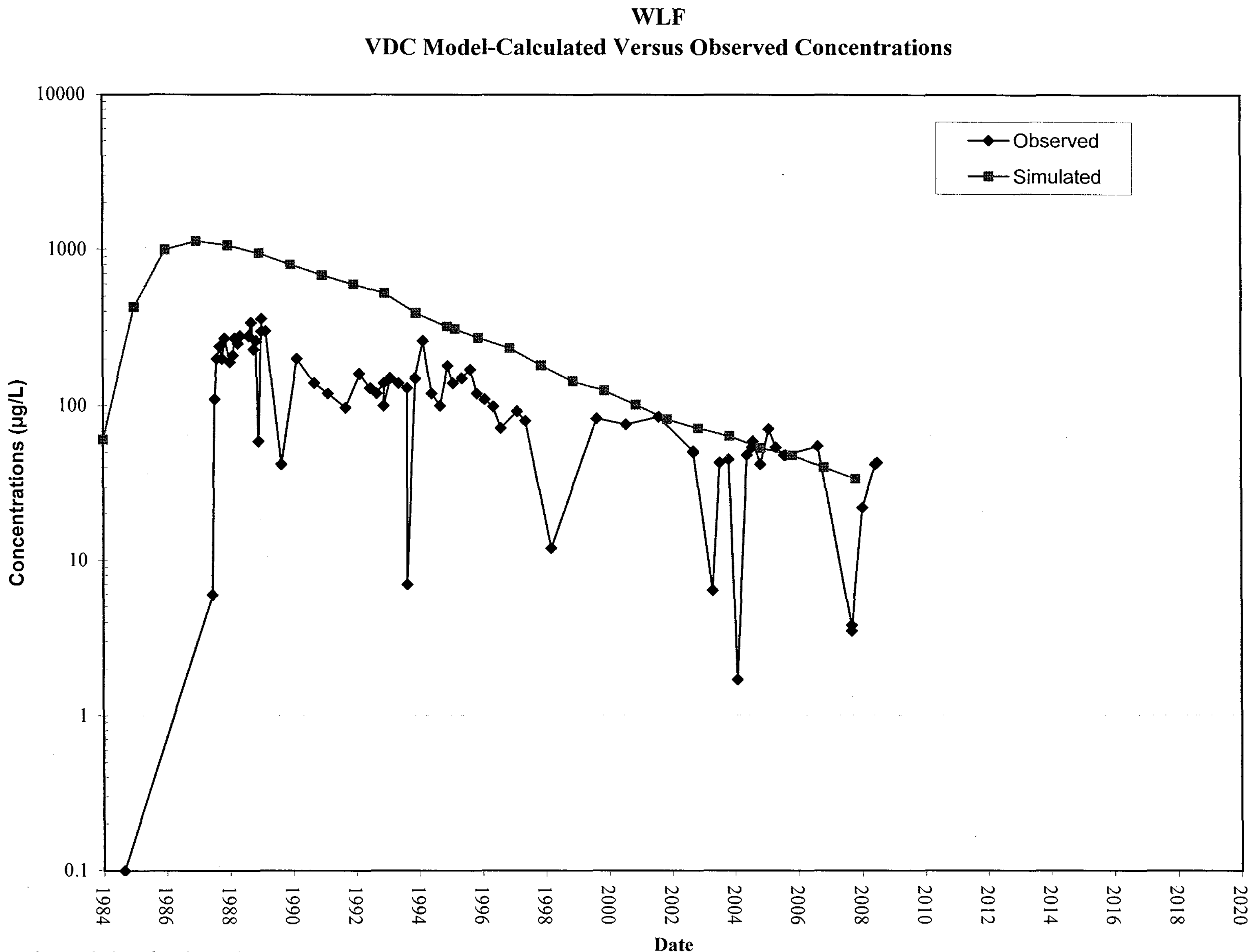

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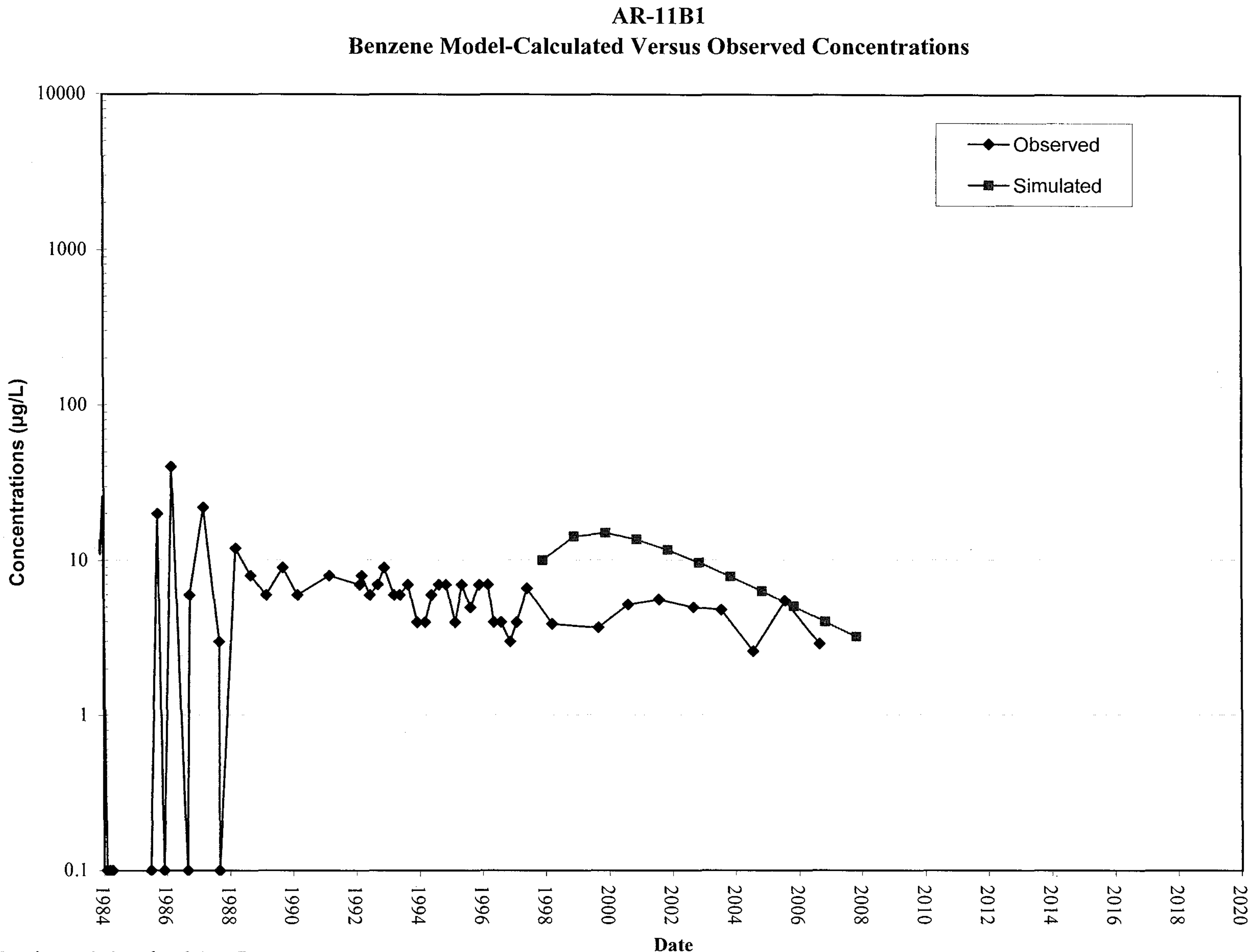

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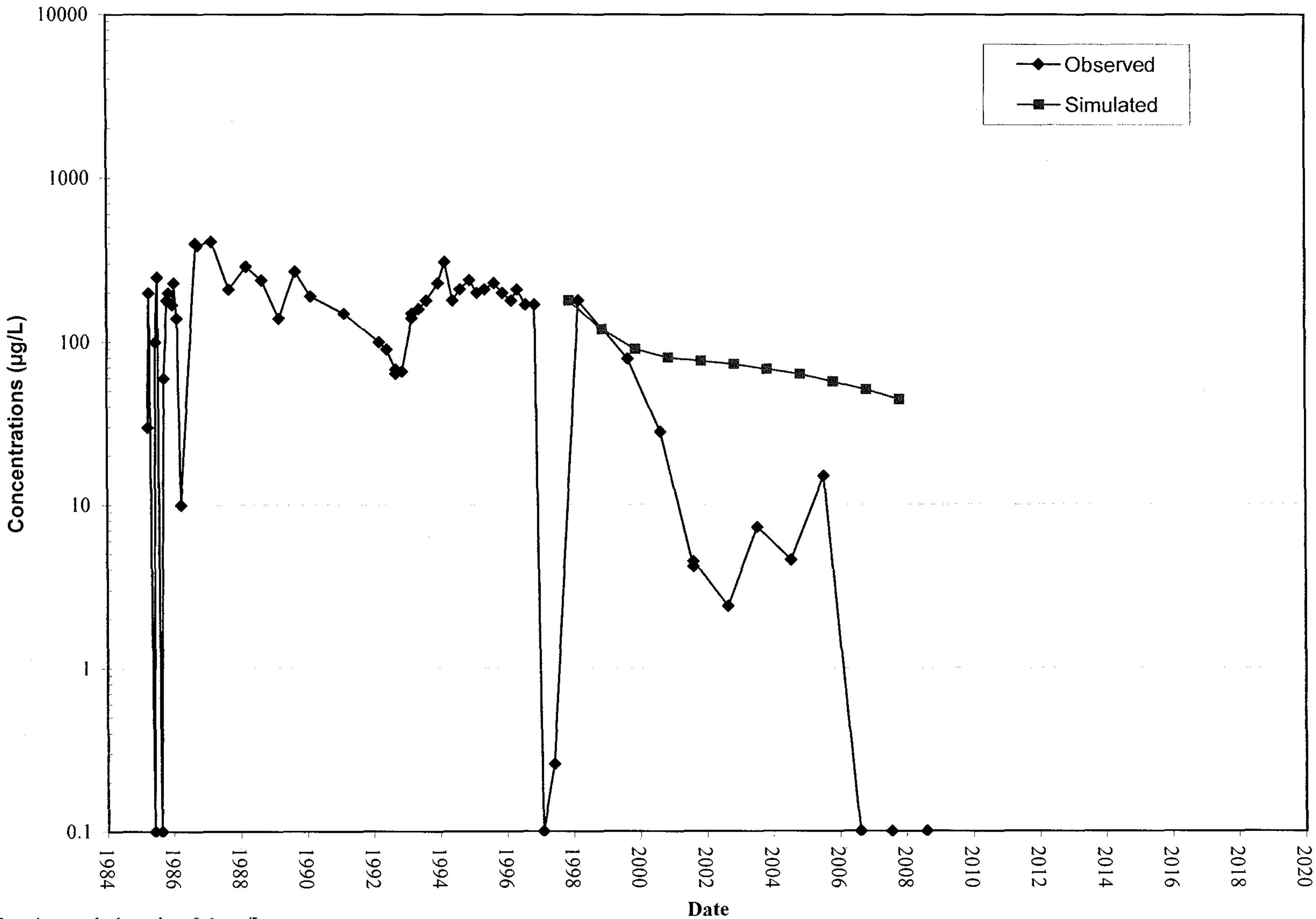
AR-21
Benzene Model-Calculated Versus Observed Concentrations



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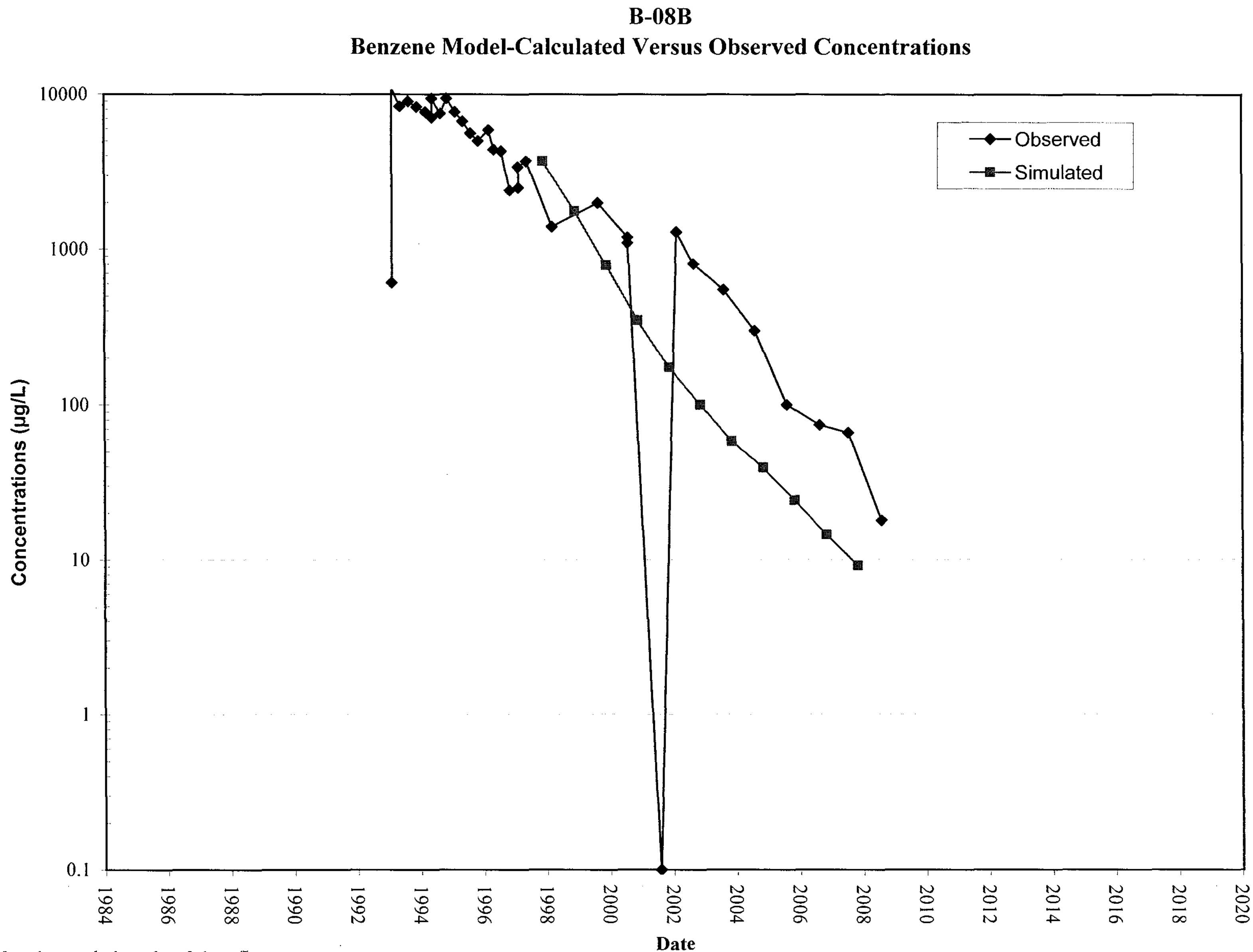

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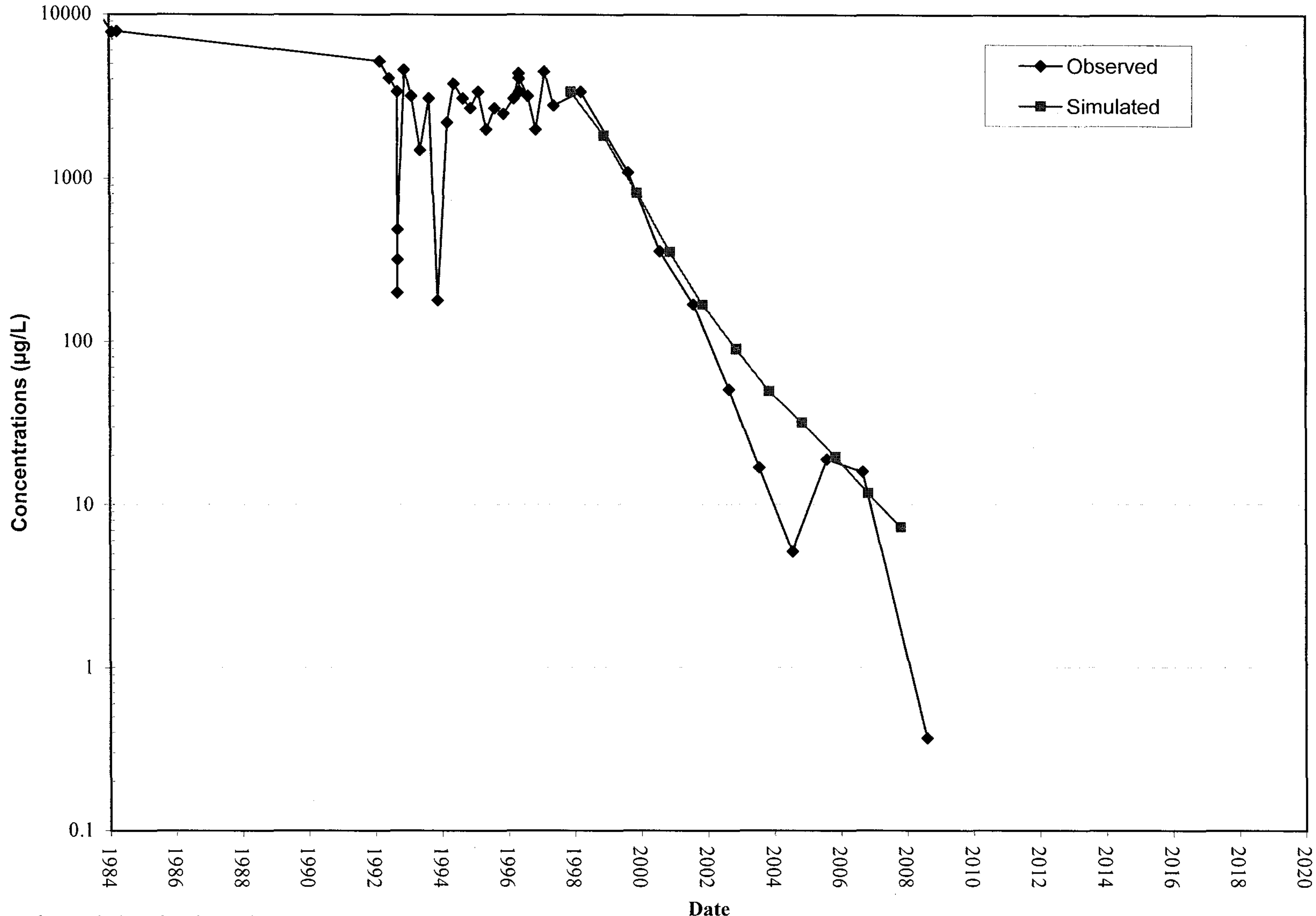
B-08B3
Benzene Model-Calculated Versus Observed Concentrations



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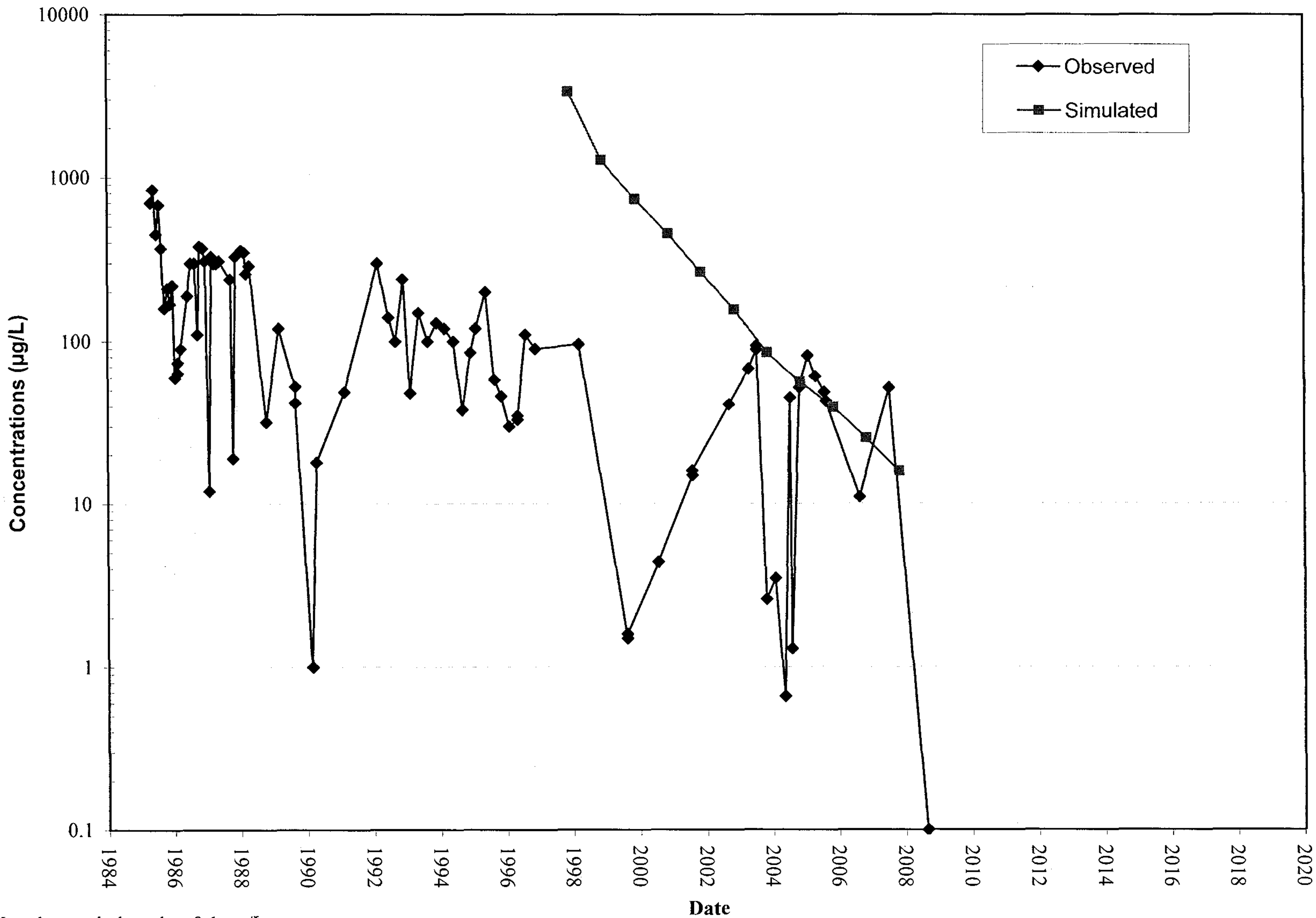
ELF
Benzene Model-Calculated Versus Observed Concentrations



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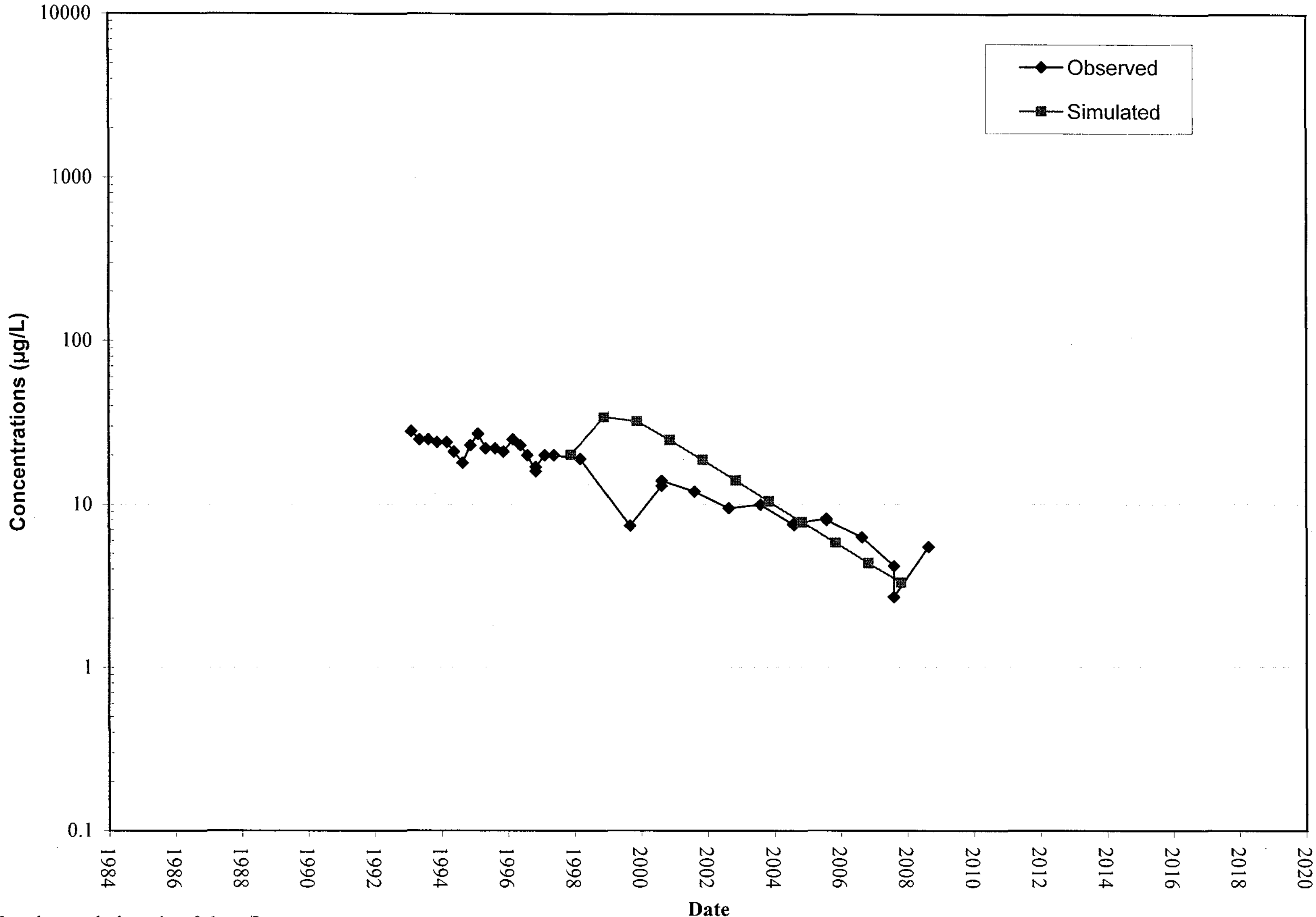
LF-05E
Benzene Model-Calculated Versus Observed Concentrations



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LF-06C
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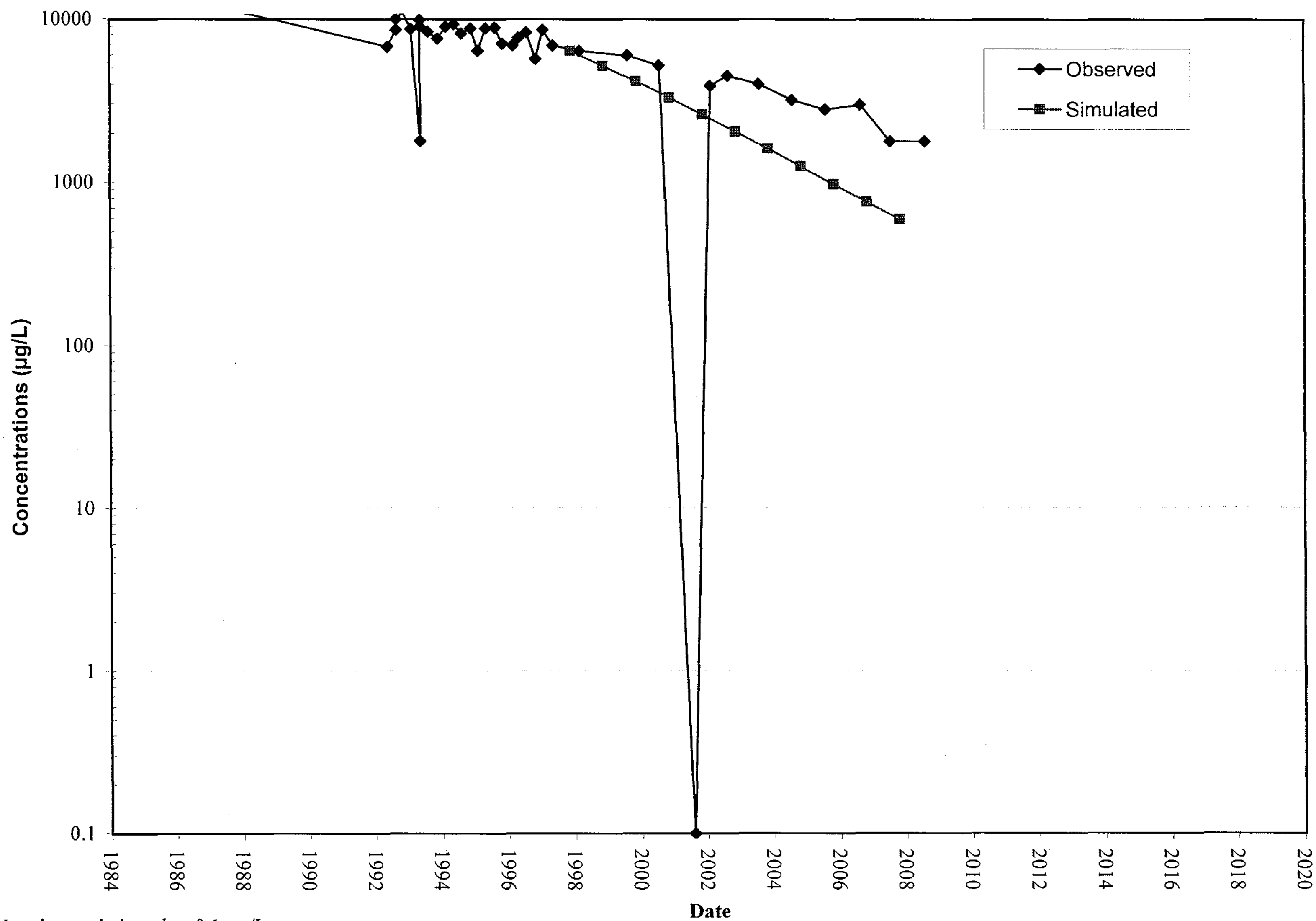

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LF-06N
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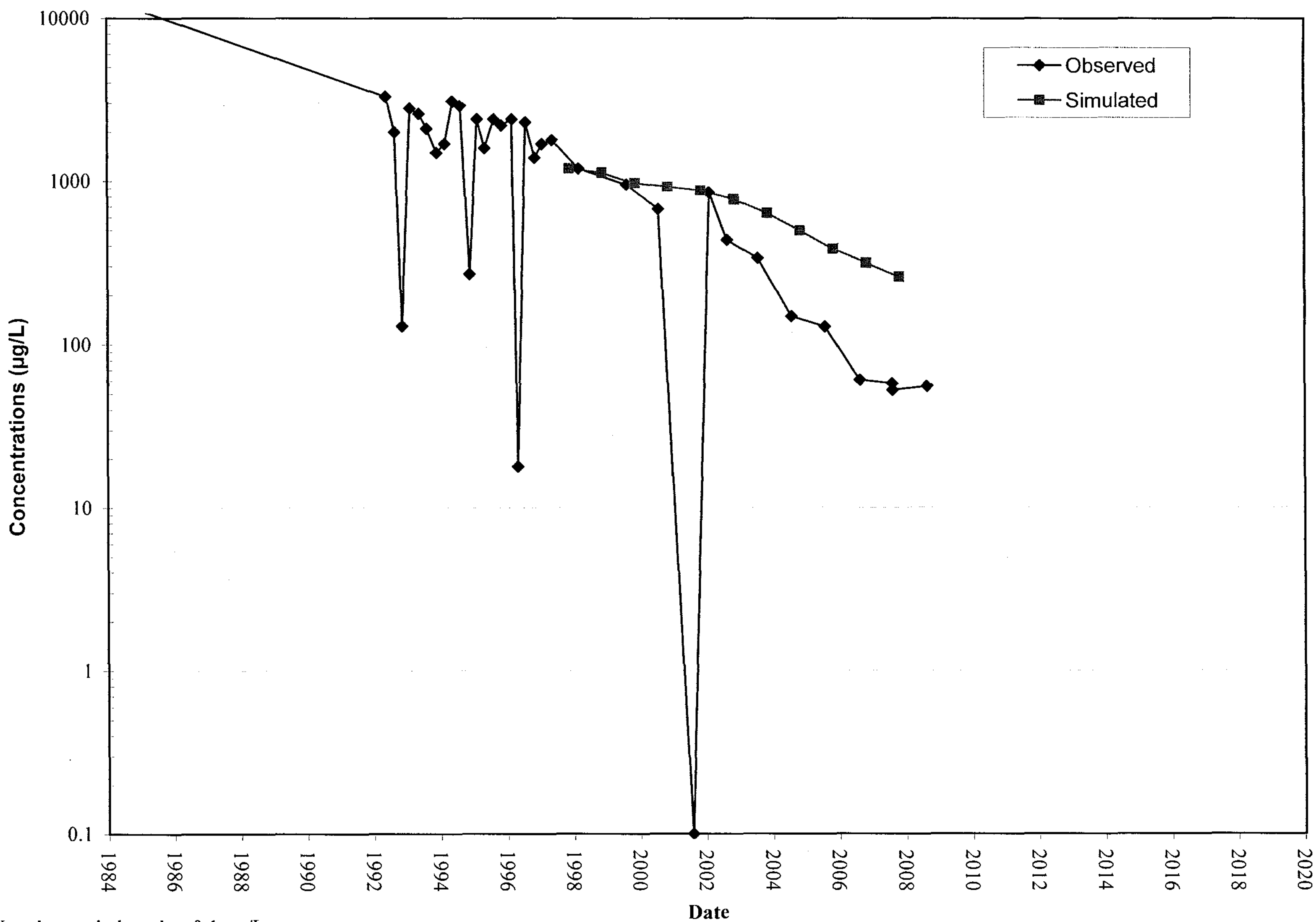

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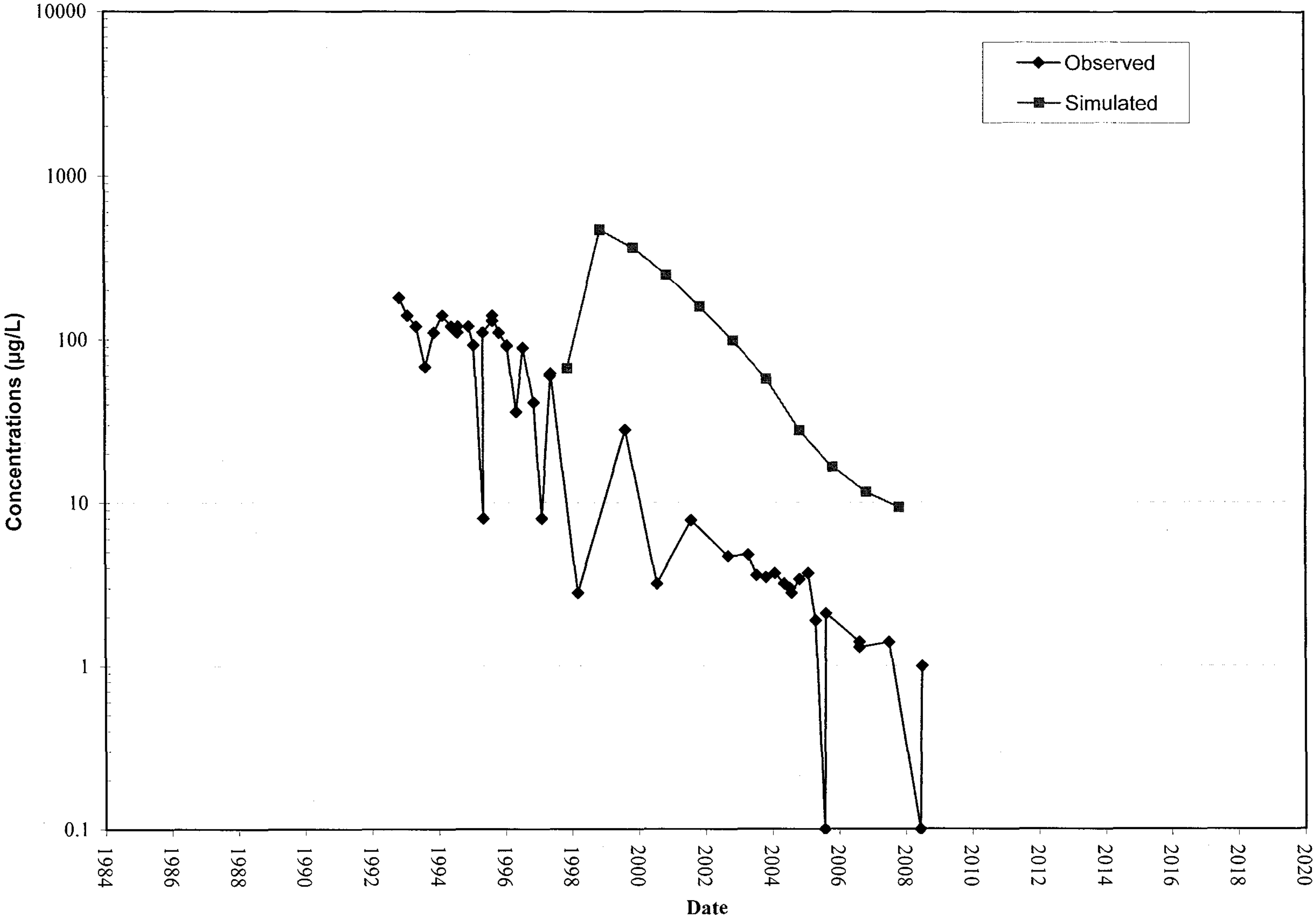
MLF
Benzene Model-Calculated Versus Observed Concentrations



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4/30/2009