

Summary of 1996 RI Sampling Program

4.1 Quarterly Sampling Activities

4.1.1 Description of Activities

EPA's RI monitoring wells in the San Fernando Valley Basin (SFVB) were sampled during three quarterly events conducted by CH2M HILL during 1996 (Table 1-1). The inability to confirm adequate laboratory space at the beginning of the year resulting from budgetary driven shutdowns during the fall of 1995 resulted in the cancellation of the sampling event scheduled for January 1996. Two of the three events (March 19 through March 28 and July 23 through July 31) were quarterly sample events and consisted of collecting groundwater samples from 52 RI monitoring wells for VOCs and nitrate/nitrite analyses. The annual sampling event, December 5 through 18, involved collecting groundwater samples from 61 RI monitoring wells for VOCs, metals, nitrate/nitrite, and general water chemistry analyses. During this event, selected RI monitoring wells (primarily shallow cluster wells and VPBs) were also sampled for 1,4-dioxane as requested by EPA.

Water levels were measured at each of the RI monitoring wells before sampling. These data were incorporated into the GIS database and converted to elevations above MSL. A comparison of depth to water (dtw) (bgs) and water-level elevation (MSL) for the RI monitoring wells at the time of each sampling event during 1996 is provided in Table 2-1.

During each sampling event, each well was purged three to five well volumes before sampling. During purging, pH, temperature, electric conductivity, and turbidity of the groundwater were measured over time to ensure that these parameters stabilized before sampling. Table 2-2 presents a comparison of these parameters at each RI monitoring well during each sampling event conducted during 1996.

During the fourth quarter 1996 sampling event, circumstances led to four of the scheduled RI monitoring wells not to be sampled. Monitoring wells NH-VPB-13 and PO-VPB-10 were not sampled due to inoperable pumps. One monitoring well, NH-VPB-10, was unable to be located due to repaving operations conducted by the City of LA; and, one monitoring well, PO-C02-53, was destroyed by construction of a new sidewalk.

Purge water, or investigative derived waste (IDW), was collected from each RI monitoring well in a vacuum truck and transported to purge water storage tanks located at LADWP's Headworks Spreading Grounds staging area. Approximately 40,512 gallons of IDW collected during the three sampling events completed in 1996 were transported to the LADWP's Headworks Spreading Grounds staging area. VOC concentrations in the IDW stored at the LADWP's Headworks Spreading Grounds staging area were monitored, and when observed to be below MCLs, the purge water was discharged into the storm drains.

4.1.2 TCE Concentrations

Reported TCE concentrations at RI monitoring wells sampled during 1996 remained generally consistent (Table 4-1). The number of RI monitoring wells exhibiting concentrations of TCE greater than the MCL of 5 µg/L remained fairly consistent, ranging from 35 monitoring wells in the first quarter to 37 wells in the third quarter to 35 wells in the fourth quarter. This is also consistent with the fourth quarter of 1995 (34 monitoring wells). Of the monitoring wells unable to be sampled during the fourth quarter, only PO-C02-053 was scheduled as a quarterly well; the others were in the annual program and historically were below the MCL. (See sampling rationale in Appendix B.)

Comparison of TCE concentrations at the RI monitoring wells shows two wells (NH-C01-325 and NH-VPB-08) exhibiting an increase to above the MCL during 1996 (1 to 10 µg/L and 1 to 66 µg/L, respectively). Two wells exhibited a decrease, however, not to below the MCL: NH-CO6-160 (54 to 6 µg/L) and CS-VPB-08 (130 to 64 µg/L). One well (CS-VPB-05) exhibited a significant increase from 7 to 110 µg/L in the first quarter. Monitoring well NH-VPB-14 also exhibited a significant variation during 1996 (620 µg/L decreasing to 130 µg/L then increasing to 530 µg/L). These significant variations in TCE concentrations during 1996 appear to be artifacts of sampling or laboratory errors, creating an anomalous concentration.

4.1.3 PCE Concentrations

PCE concentrations at RI monitoring wells sampled during 1996 also exhibited little change throughout the year (Table 4-2). The number of RI monitoring wells exhibiting concentrations of PCE greater than the MCL of 5 µg/L ranged from 26 wells in the first quarter to 25 wells in the third and fourth quarters. All of the RI monitoring wells exceeding the MCL for PCE also exceeded the MCL for TCE during each event with the exception of three wells. Each of these wells (CS-VPB-10, CS-VPB-11, and CS-C01-325) were above the MCL for PCE but below the MCL for TCE during the first quarter sample event; however, during the third and fourth quarter sampling events, wells CS-VPB-10 and CS-VPB-11 exceeded PCE only.

A review of PCE data obtained from RI monitoring wells during 1996 shows one well (NH-VPB-06) exhibiting a decrease to below the MCL (6 to 5 µg/L). However, two monitoring wells exhibited significant increases: NH-C01-325, 14 increasing to 71 µg/L then decreasing to 40 µg/L; and, NH-VPB-07, 5 increasing to 36 µg/L then decreasing to 19 µg/L. Both of these wells also showed significant increases in TCE.

4.1.4 Other VOCs

During 1996, VOCs other than TCE and PCE were observed above MCLs in 8 RI monitoring wells during the first quarter and seven monitoring wells in each the third and fourth quarters (Table 4-3). Compounds reported include 1,1-dichloroethane at CS-CO3-100 and CS-VPB-07; 1,1-dichloroethene at CS-CO3-100, CS-VPB-04, CS-VPB-05, CS-VPB-06, CS-VPB-07, PO-VPB-02, and PO-VPB-08; 1,2-dichloroethane at NH-VPB-05 (first quarter only); and carbon tetrachloride at CS-CO3-100, CS-VPB-04, and CS-VPB-07.

4.1.5 Nitrate

The number of RI monitoring wells exceeding the NO₃ MCL of 45 mg/L (as NO₃) ranged from 15 to 19 during 1996 (Table 4-4). During the first quarter, there were 15 monitoring wells exceeding the MCL, with 18 in the third quarter and 19 during the fourth quarter. Four wells (CS-VPB-09, NH-VPB-02, NH-VPB-08, and PO-VPB-01) included in the 1996 annual sampling program exceeded the MCL during the fourth quarter and are comparable to values observed during previous annual events. Due to a change of procedures at Region IX Laboratory, the results for NO₃ during the fourth quarter were reported as unvalidated.

4.1.6 Other Analytical Parameters

During the fourth quarter sampling event, groundwater was analyzed for general water chemistry parameters including chloride, sulfate, total alkalinity, hardness, TDS and TOC (Table 2-8). TDS values ranged from 266 (NH-VPB-11) to 1,340 mg/L (CS-VPB-09). The secondary MCL (500 mg/L) for TDS was exceeded in 38 of the 61 RI monitoring wells during the fourth quarter (Table 2-8). Total alkalinity ranged from 126 mg/L (VD-VPB-06) to a high of 572 mg/L (CS-VPB-09). All RI monitoring wells were below the secondary MCL for sulfate (250 mg/L), ranging from 32.1 mg/L (CS-VPB-03) to 234 mg/L (CS-VPB-02).

Analysis of dissolved metals was conducted during the fourth quarter 1996 sampling event. Metals that were reported above primary and secondary MCLs included dissolved iron, dissolved manganese, dissolved thallium, and dissolved chromium (Table 2-9). Iron was the most common dissolved metal reported in RI monitoring wells during this event. The presence of dissolved chromium in monitoring wells CS-VPB-04 and PO-VPB-02 remained comparable to the concentrations observed in these wells in the previous sampling events.

4.2 Additional Special Sampling Activities

Additional sampling activities included sampling of facility wells for hexavalent chromium sampling and statistical evaluation of VOC data.

4.2.1 Facility Wells–Hexavalent Chromium Sampling

4.2.1.1 Background

EPA's database currently contains metals data from various groundwater sources located in the SFVB. These sources include RI monitoring wells; production wells operated by LADWP and the cities of Burbank and Glendale; and monitoring wells located at facilities as directed by the RWQCB. Historically, groundwater samples from selected RI monitoring wells and selected monitoring wells at certain facilities were collected and submitted for hexavalent chromium analysis in addition to routine target analyte list (TAL) metals.

An evaluation was conducted by EPA with the goal of determining the approximate nature and extent of chromium (Cr) contamination in the SFVB. The following three tiers of data collection, review, and sampling and analysis were conducted in support of performing this assessment:

Activity 1. Review of historic data. EPA's GIS database contains trace metals data from various groundwater wells located in the SFVB. These sources include RI monitoring wells, production wells operated by the LADWP, the cities of Burbank and Glendale, and the La Crescenta Water District, and selected monitoring wells located at individual facilities, as directed by the RWQCB.

Following a review of Cr data contained in the SFVB GIS database, it was observed that several areas of potential chromium contamination exist along the "Golden State Freeway" corridor between the Burbank Airport and Los Feliz Street in Glendale, hereinafter termed the study area (Figure 4-1). Authorization from EPA was received by CH2M HILL to further evaluate these areas to assist EPA in determining the nature and extent of potential chromium contamination.

Activity 2. Groundwater sampling of RI monitoring wells. Data obtained during "special sampling event No. 1," conducted in conjunction with the third quarter 1995 sampling event.

Activity 3. Groundwater sampling of selected facility monitoring wells. Supplemental Cr and Cr⁶⁺ data from selected facility monitoring wells located immediately upgradient and downgradient from areas where detectable concentrations of Cr⁶⁺ have been observed. These data were obtained during "special sampling event No. 4." This sampling event, conducted during the spring and summer of 1996, required assistance from RWQCB on obtaining access to the selected facilities.

Following the completion of the above activities, a technical memorandum (TM) was submitted to EPA (EPA, 1997). The purpose of this TM was to present the results of these activities with the goal of determining the approximate nature and extent of Cr contamination in the SFVB. A background section was included that provided a brief introduction into the transformations of Cr in the subsurface. Presented below are excerpts from this memorandum.

4.2.1.2 Description of Activities/Results

Data from various sources are incorporated into the SFVB GIS. Of the 68 RI monitoring wells for which dissolved metals data are obtained during the annual sampling program, 23 are in the vicinity of the study area (Figure 4-1). In addition to EPA's RI monitoring well network, additional data on groundwater quality are routinely obtained from over 100 facilities in the vicinity of the study area (Figure 4-1). Numerous monitoring wells at these facilities are sampled on a regular basis, and the data are submitted to the RWQCB. Each facility collects and submits groundwater for analysis independently, and based on the potential contaminants at each site, analysis for trace metals contamination may or may not be included (Table 4-5).

Activities 1 and 2 were completed during the 1995 sampling year and are described in a TM previously submitted to EPA (EPA, 1995d). Following the completion of these activities, it was apparent that the areas of Cr and Cr⁶⁺ exceeding the MCL were somewhat localized and that Activity 3 should proceed as Special Sampling Event No. 4.

A total of 41 groundwater monitoring wells were targeted at facilities immediately upgradient and downgradient from area where detectable concentrations of Cr⁶⁺ were observed in the previous two activities (Table 4-6). Prior to mobilization for special sampling event No. 4, coordination for access to each facility and arrangements for split samples and/or oversight personnel were completed. Samples were collected from the targeted facility monitoring wells and submitted for dissolved metals and Cr⁶⁺ analyses between May 29 and June 10, 1996. Sample collection, preservation and shipping followed the procedures as outlined in the SAP and QAPP (EPA, 1995a and 1995b).

Supplemental Cr and Cr⁶⁺ data from facility monitoring wells located immediately upgradient and downgradient from the areas of potential Cr⁶⁺ contamination indicated by the previous activities were collected during Activity 3. Results of this sampling indicated that elevated concentrations of Cr⁶⁺ are locally present. Summarized results for each of the Subareas within the Study area are presented below:

For Subarea 1.

- In the vicinity of the Lockheed facility, dissolved Cr data provided delineation of three small, isolated areas where a maximum concentration of 314 µg/L was observed at well lb1-CW12 (Figure 4-2 for contours, Figure 4-1 for well location). A separate isolated area appears in the vicinity of well NH-VPB-14. Cr detections in this area ranged from 36 to 83 µg/L at the International Electric Research Corporation (IER) monitoring wells (Table 4-5). The apparent downgradient extent of potential Cr contamination in this area was delineated by results obtained from monitoring wells at the Burbank Steel Treating (BST) and Mersola Properties (MPI) facilities.
- Areas of observable Cr⁶⁺ concentrations were comparable to those observed for Cr in the small isolated areas of Cr contamination around the BST, IER, and MPI facilities (Figure 10 for contours, Figure 1 for well locations). In the vicinity of the Lockheed facility, a maximum Cr⁶⁺ concentrations of 430 µg/L occurred at well lb1-MW12. At a fourth area, well NH-VPB-14 was observed to have a maximum concentration of 80 µg/L (Activity 2), whereas concentrations of Cr⁶⁺ at the IER monitoring wells ranged from 4 to 11 µg/L.

For Subarea 2.

Twenty-three monitoring wells at 5 separate facilities were sampled in this subarea. The monitoring wells sampled at the Lawrence Engineering (LAW) facility, included in subarea 1, were included in delineation of one of the areas identified within subarea 2. A total of 4 small, isolated areas of potential Cr contamination were observed in subarea 2. These areas are separated by wells with nondetect or low concentrations of Cr in between.

- At the northern boundary of subarea 2, the first isolated area of elevated Cr concentrations was observed in the vicinity of the LAW and Menasco Division (MAD) facilities. In this area, maximum Cr concentrations were observed at wells LAW-MW2 (93 µg/L) and MAD-MW3D (303 µg/L). Maximum Cr⁶⁺ concentrations observed at wells LAW-MW2 and MAD-MW3D were 12 µg/L and 36 µg/L, respectively (Figures 4-2 and 4-3 for contours, Figure 4-1 for well locations).
- Slightly downgradient, two small isolated areas are apparent in the vicinity of the Haskell International (HSK) and ITT facilities: well HSK-MW5 with 49 µg/L and two ITT wells (ITT-PW4 and ITT-PW5) with elevated Cr concentrations identified in activity 2. The maximum Cr⁶⁺ concentration observed at well HSK-MW5 was 6 µg/L; Cr⁶⁺ concentrations for monitoring wells at the ITT facility are reported in Activity 2.
- In the vicinity of the Pacific Bell (PAB) Corporation and Western Magnetics (WEM) facilities is the fourth isolated area of elevated Cr and Cr⁶⁺ concentrations. Wells PAB-MW1 and WEM-MW5 were observed to

have Cr concentrations of 130 and 78 $\mu\text{g/L}$ and Cr^{6+} concentrations of 15 and 9 $\mu\text{g/L}$, respectively. Monitoring wells PAB-MW2, PAB-MW4, and WEM-MW3 also were observed to have lower but reportable concentrations of Cr and Cr^{6+} .

- The fifth isolated area appears to be in the vicinity of well CS-VPB-04. Although this area is only slightly downgradient of the previously described area, observations from monitoring wells between the areas indicate low concentrations. Monitoring wells at the Librascope (LOR) facility indicate slightly elevated levels of Cr at well LOR-MW2 (33 $\mu\text{g/L}$).

For Subarea 3.

In Subarea 3, three isolated areas of elevated Cr and Cr^{6+} are apparent. Although values from October 1994 only are available for BBL-WW2, at this area in the center of this subarea, maximum concentrations of 72,100 $\mu\text{g/L}$ and 72,380 $\mu\text{g/L}$ for Cr and Cr^{6+} were the highest reported in the study area. At monitoring wells in the vicinity of the CAI facility, in the northern portion of this subarea, Cr concentrations as high as 2,400 $\mu\text{g/L}$ have been observed. The third isolated area of elevated concentrations is located in the vicinity of PO-VPB-02. Concentrations of Cr and Cr^{6+} at this RI monitoring well were 628 $\mu\text{g/L}$ and 559 $\mu\text{g/L}$, respectively (Figures 4-2 and 4-3).

During Activity 3, three monitoring wells were sampled in this subarea. Monitoring wells at the Grayson Power Plant (GPP-MW4, GPP-MW5, and GPP-MW6) were selected to assist in determining the northern extent of Cr contamination observed in Activity 2. Samples from these wells indicated nondetectable concentrations of Cr and Cr^{6+} .

4.2.1.3 Discussion

Dissolved Cr has been observed in groundwater samples collected from RI and facility monitoring wells in the “Golden State Freeway” corridor between the Burbank Airport and Los Feliz Boulevard (Figure 4-1). Concentrations of dissolved Cr from wells in the study area ranged from nondetectable to 72,100 $\mu\text{g/L}$ for BBL-W2. The most recently available data indicate three RI monitoring wells in this area (NH-VPB-14, CS-VPB-04, and PO-VPB-02) contain dissolved Cr concentrations above the MCL of 50 $\mu\text{g/L}$ (64.5, 178, and 713 $\mu\text{g/L}$, respectively). Cr concentrations exceeding the MCL at RI and facility monitoring wells in the study area appear to be small and somewhat isolated from one another.

Analysis of the ratios of Cr^{6+}/Cr was also conducted to get a sense for the relative presence of the hexavalent and trivalent Cr species. The analysis yielded conflicting results for the data collected in Activities 1 and 2 and that collected in Activity 3. The mean ratio of Cr^{6+}/Cr for all samples taken at facility and RI wells between 1993 and 1995 (Activities 1 and 2) is 0.95, which suggests that 95 percent of the chromium in these samples exists in the hexavalent state and 5 percent in the trivalent state. However, data collected from facility wells in 1996 (Activity 3) has a Cr^{6+}/Cr mean ratio of 0.15, suggesting only 15 percent of the chromium is present in the hexavalent form while 85 percent exists in the trivalent state. The data from Activities 1 and 2 would indicate little or no transformation of Cr^{6+} to Cr^{3+} , while the data from Activity 3 appears to indicate substantial transformation of Cr^{6+} to Cr^{3+} , assuming all Cr entering the water table originates from releases of the hexavalent species. Further work to identify the reason for the conflicting data is warranted in order to gain a more thorough understanding of the transformation and fate of Cr contamination in the SFVB.

4.2.2 Statistical Evaluation of VOC Data

4.2.2.1 Background

In order to evaluate temporal changes in SFVB groundwater, EPA directed CH2M HILL to conduct a statistical evaluation to examine changes in contaminant levels (specifically TCE and PCE) over the period of available data. This statistical evaluation was to be used to achieve a two-fold purpose: (1) Determine whether statistically significant evidence of contaminant migration and concentration changes exist; and (2) Use these data to optimize the sampling frequency of the RI monitoring well network in terms of cost effectiveness and accuracy. In order to achieve these objectives, the current method for determining the frequency of sampling at RI monitoring wells and the limitations of the comparison between successive concentration contour maps were examined.

Sampling Frequency: EPA conducts a periodic review of the sampling program to focus data collection on the most critical wells. The primary criteria for modifying sampling frequency have been previous contaminant levels and the potential for contaminant migration toward a well. To date, these criteria have been used to decrease the sampling frequency of wells that consistently have nondetect or below MCL concentrations of PCE or TCE, especially if these wells define cross-gradient or upgradient plume boundaries. Quarterly sampling is maintained for wells interpreted to be near the leading edge of contaminant migration. Specifically, these criteria have been applied as follows:

- Triennial sampling if a nondetect is found for four consecutive quarters, and is not downgradient of the plume leading edge
- Annual sampling if below MCLs but above detection limits for at least two consecutive quarters
- Quarterly sampling if above MCLs

Map Preparation: Since 1992, CH2M HILL has prepared concentration contour maps depicting interpretations of TCE and PCE concentration intervals for the shallow and deep contaminated groundwater zones of SFVB. These maps are based on groundwater quality data for the 84 RI monitoring wells, as well as data submitted to the SFV GIS database from approximately 500 additional wells (facility monitoring wells reported to RWQCB and production wells routinely sampled by LADWP, the cities of Glendale and Burbank, and the Crescenta Valley County Water District).

Delineated concentration intervals (e.g., 5 to 50 µg/L) may change configuration from map to map for several potential reasons. During the 1992 to 1995 timeframe, changing contaminant sources and migration of contaminant mass are relatively insignificant because of relatively slow rates of groundwater flow, even slower rates of contaminant transport, and relatively persistent sources of contamination residualized in the vadose zone. However, other potential reasons (data availability, fluctuating water table conditions, variability among sampling and analytical conditions and procedures and subjective manual contouring of plume concentrations) may contribute to data and map "noise" that masks potential data trends. For this reason, it is difficult to interpret potential contaminant migration through a comparison of successive maps.

The following activities were proposed to achieve the objectives:

- Evaluate the PCE and TCE concentration histories of the monitoring wells for statistically significant trends using a nonparametric technique such as the Cox-Stuart test.
- Prepare maps reflecting the results of the trend tests; i.e., "+," "-", or "0" posted at each well location for each plume map to indicate whether there has been an increasing or decreasing trend, or no trend, of statistical significance. Inspection of these maps and the plotted concentration histories will be used to evaluate statistically significant evidence of contaminant migration and concentration changes.
- Prepare and use a proximity analysis on the basis of the trend analysis results to identify wells positioned near the apparent leading fronts of the plume. This factor influences the recommended sampling frequency.

4.2.2.2 Methodology

For the Draft of the Statistical Evaluation TM, one VOC parameter (TCE) was selected due to the volume of data. The approach taken in the evaluation of TCE consisted of five steps:

1. Performance of the nonparametric Cox-Stuart statistical test for trend data for all available wells over the period of record;
2. Preparation of TCE time-series maps for all wells with fixed axes to facilitate comparison among wells that have been sampled at different frequencies over different periods of time;
3. Adjustment of results from the statistical test (based upon visual interpretations of time series plots) to define symbols for maps to discriminate: wells that are exhibiting increasing and decreasing trends over the monitoring period, wells that are exhibiting no change over time and wells for which data are either inadequate or

inconclusive;

4. Mapping of adjusted TCE trend results for shallow wells, overlaid with the Fall 1995 TCE plume map; and
5. Determine a proximity analysis map to identify proposed sampling frequencies for RI wells based on the above outputs.

Available Data

Groundwater data collected from approximately 680 wells over the period 1980 to 1995 were evaluated to examine within wells the changes in levels of TCE, PCE, and NO₃; the well distribution for TCE data only; identify the number of wells per well type and aquifer zone (S=shallow, D=deep and U=unknown) and the range (minimum and maximum) and mean count of events per well. The following summarizes some major features of the available TCE data:

- Approximately 50 percent of wells (338 of 681) represent facility samples from the shallow aquifer.
- Individual wells have been sampled as rarely as once and as frequently as 176 times over the 192-month period of record.
- Mean numbers of sample per well ranged from three (EPA RI/FS wells in the unspecified aquifer) to 26 (production).

Limitations

Results from the Cox-Stuart test were used to group the 681 wells, based upon similar behavior of TCE levels through time. Review of the time series sampling and the results from the statistical test indicated that results were not always consistent. As could be expected, discrepancies commonly occurred where analytical results fall in the range between the limit of detection and the MCL, which approaches the lower limit of analytical resolution. In these instances, “changes” as determined by the statistical test represent differences in analytical results in the area of analytical “white noise.” In cases where sampling has been extensive, the resolution of the analytical method increased, resulting in a reduced analytical detection, suggesting an apparent decreasing trend. While the trend could be representative of TCE levels in the groundwater, it could also simply reflect changes in analytical capability or a change in analytical lab. Two other factors adversely affected the statistical test: inconsistencies in laboratory results and inconsistencies in the intervals between sampling events in the same well.

4.2.2.3 TCE Results

Twenty of the 681 wells were classified as exhibited decreasing trends in TCE; increasing trends were exhibited in 97 wells; and no significant changes in TCE levels were observed in 250 wells. Data from 250 wells were not adequate to support a conclusion as to the presence of change. Finally, results from 71 wells were inconclusive.

4.2.2.4 Outstanding Tasks

The adjusted categorization has been developed in order to more accurately map temporal changes in the SFVB. Aquifer-specific ARC maps are being developed that will plot well trend and well type by different colors (red=increasing, green=decreasing, blue=no change, orange=uncertain change, and grey=inadequate sampling). Additionally, a subset of wells where followup sampling could be particularly useful will be indicated.

Preliminary maps developed on the basis of the Cox-Stuart results (without interpretation of the time series plots) were not conclusive. Wells within a localized area of either the shallow or deep aquifers yielded conflicting trends. Even with the obvious caveat that trends in adjacent wells may reflect trends over different periods of time due to sampling, it is hoped that clarification of the trends within the wells will clarify changes spatially.

Results described above are limited to TCE levels. The Cox-Stuart test and time series plots have been developed for PCE and NO₃ but have not been integrated or interpreted. In addition to the behavior of these two parameters over time, it is of interest as to how the parameters cover through the aquifer. A preliminary evaluation, performed by comparing the counts of wells with Cox-Stuart results, suggests that PCE behavior has paralleled that of TCE. This could reflect true covariance or confoundment of analytical results, based upon analysis and quantification in the same sample. NO₃ behavior appears distinctly different not only in terms of wells analyzed but also in terms of dates.

Figure 4-1

Figure 4-2

Figure 4-3