THIRD FIVE-YEAR REVIEW REPORT

Lindsay Manufacturing Co. Site
Lindsay, Platte County, Nebraska

September 2008

by:

United States Environmental Protection Agency
Region 7
Kansas City, Kansas

with assistance from:

United States Army Corps of Engineers
Kansas City District
Kansas City, Missouri

Approved by:

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Date:

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List of Abbreviations

ALM	Adult Lead Methodology
AOIW	Add-on Inspector Well
ARAR	Applicable or Relevant and Appropriate Requirement
CD	Consent Decree
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COCs	Contaminants of concern
COPCs	Contaminants of potential concern
DCA	Dichloroethane
DCE	Dichloroethene
EPA	United States Environmental Protection Agency
GAC	Granular Activated Carbon
HRC®	Hydrogen Release Compound
IEUBK	Integrated Exposure Uptake Biokinetic Model
MCL	Maximum Contaminant Level
MSL	Mean Sea Level
MSSL	Medium Specific Screening Level
MTBE	Methyl Tert Butyl ether
MW	Monitoring Well
NCP	National Contingency Plan
NDEC	Nebraska Department of Environmental Control
NDEQ	Nebraska Department of Environmental Quality
NOAEL	No-Observed-Adverse-Effect Level
NPDES	National Pollution Discharge Elimination System
NPL	National Priorities List
OIW	Original Interceptor Well
O&M	Operation and Maintenance
OMP	Operation and Maintenance Plan
PCE	Tetrachloroethene
PRG	Preliminary Remediation Goal
PRP	Potentially Responsible Party
QAPP	Quality Assurance Project Plans
QA/QC	Quality Assurance/Quality Control
RA	Remedial Action
RAO	Remedial Action Objective
RD	Remedial Design
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RPM	Remedial Project Manager
SDWA	Safe Drinking Water Act
SVE	Soil Vapor Extraction
TCA	Trichloroethane
TCE	Trichloroethene
TIW	Third Interceptor Well
VOCs	Volatile Organic Compounds
WasteLan	EPA's database of Superfund Sites

EXECUTIVE SUMMARY

The remedy for the Lindsay Manufacturing Co. (LMC) Superfund site (Site) in Lindsay, Nebraska, included a soil vapor extraction pilot, a full-scale soil vapor extraction system, a groundwater extraction and treatment system, a groundwater irrigation pilot system, a remediation alternative pilot injection of hydrogen release compound (HRC®), and groundwater monitoring. The Site achieved construction completion with the signing of the Preliminary Closeout Report on August 2, 1995. The trigger for this Five-Year Review was the signature date of the second Five-Year Review report on July 3, 2003.

The assessment of this Five-Year Review found that the remedy was constructed to meet the performance standards and to implement the remedy outlined in the Record of Decision (ROD). The immediate threats to human health and the environment have been addressed and the remedy remains protective. However, additional steps will continue to be implemented to address the downgradient groundwater plume, to verify that no additional domestic water supplies are affected, and to evaluate potential options for enhancement of the groundwater remediation system both on and off of the facility property.

Consistent plume pumping, conducting timely activities concurrently to ensure that pumping remains consistent (meeting substantive permit requirements, securing landowner access, and installation and maintenance of equipment, etc.), and adequate capture zone evaluation are issues that have been raised in past Five-Year Reviews and site evaluations. These issues will be reviewed to determine an appropriate approach to minimize interruptions in plume remediation. In addition, a summary evaluation of laboratory and field Quality Assurance/Quality Control (QA/QC) will be conducted to ensure that decisions are based on the best quality data and meet the requirements of the Site Operation and Maintenance (O&M) plan and Quality Assurance Project Plans (QAPP).

LMC is performing voluntary Site activities to promote reuse of a portion of property. These activities included soil sampling in an area of proposed building construction. The soil sampling has shown some soil contamination exceeding U.S. Environmental Protection Agency (EPA) Region 6 screening criteria. The results are being evaluated with EPA Region 6 soil-screening criteria, EPA Soil Screening Level guidance, and current EPA Region 7 risk evaluation policy. Further assessment will be conducted by LMC to refine the lateral and vertical extent. Given that this area is in a location of ongoing remediation, protectiveness is not expected to be affected. LMC will also evaluate the potential for Site-related vapor intrusion beginning with the area proposed for reuse.

In areas south of the LMC, carbon tetrachloride and methyl tert butyl ether (MTBE) have been historically detected in groundwater. The carbon tetrachloride has been historically detected in the two wells located approximately 1,900 and 8,000 feet southeast, respectively, of the Village of Lindsay. Its presence was identified in the second Five-Year Review for the Site. MTBE has been historically detected in a domestic well located approximately 750 feet southeast of the Village of Lindsay. The detections of these chemicals have not exceeded federal safe drinking water standards in the locations presented above. Based on the contaminants measured at the

Site, the carbon tetrachloride and MTBE may be originating from another potential source or sources located upgradient to, cross-gradient to, or near the current groundwater plume detection locations. The Nebraska Department of Environmental Quality (NDEQ) and EPA site assessment programs will be notified of these detections.

An EPA ecological technical evaluation was performed that suggested some additional surface water sampling of Shell Creek. The current discharge is protective of acute aquatic criteria. Acute aquatic criteria were determined appropriate given that the groundwater is mainly discharged during winter months and during periods of high rainfall. As part of the evaluation, sampling of surface water was recommended to provide a greater confidence interval for chronic aquatic criteria for metals and associated water hardness.

The 1990 ROD is silent with respect to institutional controls and their implementation. However, it does indicate that options will be evaluated as part of implementation of the ROD to ensure that drinking water wells are not installed in areas of the contaminant plume on- and off-site. The site consent decree indicates that through additional response actions institutional controls can be implemented. Therefore, the availability of institutional control mechanisms and the opportunity to implement those at the site shall be reviewed.

In summary, the remedy at the Site is currently protective of human health and the environment. There are no known nearby residents currently being exposed to the LMC contamination. At present, LMC is conducting quarterly groundwater monitoring of all domestic supply wells identified in the path of the groundwater plume or potential pathway. In addition, if any domestic well is found to be contaminated as a result of the Site, LMC will provide alternate water supplies.

Additional irrigation extraction wells have been installed to contain the migration of the contaminant plume. Additional monitoring wells (MW) have been installed to define the extent of the downgradient region of the groundwater plume. All other immediate threats have been addressed by prior efforts.

Long-term protectiveness of the remedial action (RA) will be verified by continued inspections, maintenance, and sampling of the groundwater treatment system at the Site as specified in the O&M Plan. Current data indicate no exposure to groundwater contaminants above health-based levels in the domestic wells at the Site. Two private domestic wells are currently being treated to remove the contamination. Current monitoring indicates that the remedy is functioning based on measured downgradient declining trends in contamination. Further review of plume capture will be conducted.

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site name *(from WasteLAN)*: Lindsay Manufacturing Co.		
EPA ID *(from WasteLAN)*: NED068645696		
Region: 7	**State: NE**	**City/County: Lindsay/Platte**
SITE STATUS		
NPL status: √ Final Deleted ☐ Other (specify)		
Remediation status (choose all that apply): ☐ Under Construction √ Operating ☐ Complete		
Site Wide FYR √ YES ☐ NO	**Construction completion date:** 08 / 03 /1995	
Has site been put into reuse? √ YES NO		
REVIEW STATUS		
Lead agency: √ EPA ☐ State ☐ Tribe ☐ Other Federal Agency		
Author name: Robert J. Weber with support from U.S. Army Corps of Engineers, Kansas City District (M. Saqib Khan, Project Manager)		
Author title: Remedial Project Manager	**Author affiliation: U.S. EPA, Region 7**	
Review period: 07 / 03 / 2003 to 07 / 03 / 2008		
Date(s) of site inspection: 11 / 26 / 2007		
Type of review: √ Statutory Policy √ Post-SARA ☐ Pre-SARA ☐ NPL-Removal only ☐ Non-NPL Remedial Action Site ☐ NPL State/Tribe-lead ☐ Regional Discretion		
Review number: ☐ 1 (first) ☐ 2 (second) √ 3 (third) ☐ Other (specify)		
Triggering action: ☐ Actual RA Onsite Construction at OU #____ ☐ Actual RA Start ☐ Construction Completion √ Previous Five-Year Review Report ☐ Other (specify)		
Triggering action date *(from WasteLAN)*: 07 / 03 / 2003		
Due date *(five years after triggering action date)*: 07 / 03 / 2008		

Five-Year Review Summary Form - Additional Information

Issues

(1) LMC is performing voluntary site activities to promote reuse of a portion of their property. These activities included soil sampling in an area of proposed building construction on their facility. The soil sampling has detected chemicals in soil exceeding EPA Region 6 screening criteria. The results are being evaluated with EPA Region 6 soil screening criteria, EPA Soil Screening Level guidance, and current EPA Region 7 risk evaluation policy. LMC has also expressed interest in further enhancing their groundwater extraction and treatment system. LMC provided a streamlined evaluation of potential supplemental groundwater remediation alternatives.

(2) Groundwater contaminant migration has been delineated through a series of MWs and existing irrigation wells. The groundwater plume has migrated approximately 14,000 feet (2.65 miles) from the LMC facility.

(3) Surface water discharges were approved by NDEQ to promote year-round pumping in extraction well G127000 and EXT07-02. Both discharges are into Shell Creek.

(4) Vapor intrusion has not been assessed for occupied structures (offices, residences, etc.) above the contaminant plume. Volatile organic compounds (VOCs) including chlorinated solvents comprise the soil and groundwater contamination on the facility and in off-site groundwater.

(5) In areas south of the LMC facility, carbon tetrachloride and MTBE have been historically detected in groundwater. The carbon tetrachloride has been historically detected in two wells located approximately 1,900 and 8,000 feet southeast, respectively, of the Village of Lindsay. Its presence was identified in the second Five-Year Review for the Site. MTBE has been historically detected in a domestic well located approximately 750 feet southeast of the Village of Lindsay. The detection levels of these chemicals have not exceeded federal safe drinking water standards in the locations presented above. Based on the contaminants measured at the Site, the carbon tetrachloride and MTBE may be originating from another potential source or sources located upgradient to, cross-gradient to, or near the current groundwater plume detection locations.

(6) Consistent plume pumping, conducting timely activities concurrently to ensure that pumping remains consistent (meeting substantive permit requirements, securing landowner access, and installation and maintenance of equipment, etc.), and adequate capture zone evaluation are issues that have been raised in past Five-Year Reviews and evaluations. An evaluation of the sample shipments over the past five years has shown that approximately half of the shipments received by the laboratory have had some errors in consistency. These errors, while not severe enough to disqualify the data, do create concerns regarding consistency in collection and handling of the samples.

(7) The 1990 ROD is silent with respect to institutional controls and their implementation. However, it does indicate that options will be evaluated as part of implementation of the

ROD to ensure that drinking water wells are not installed in areas of the contaminant plume on- and off- site.

Recommendations and Follow-Up Actions

(1) Further assessment in the area of proposed construction activities will be conducted by LMC to determine the lateral and vertical extent, current and future risks, and whether any further action is warranted. Based on these facility data and LMC's interest in enhancing groundwater treatment, LMC may also consider supplemental remediation in other areas on the LMC facility property and other portions of the groundwater plume as part of their assessment for enhancing groundwater treatment.

(2) Extraction well and discharge authorizations for G127000 and EXT07-02 were completed by LMC to capture and treat the distal portion of the groundwater contaminant plume. Both extraction wells are currently pumping continuously. If needed, additional MWs may be required to assess plume capture and treatment. As identified above, LMC may consider additional groundwater remedial alternatives.

(3) An ecological technical assessment was performed to evaluate the discharge from the permitted location. Acute aquatic criteria are considered appropriate given that the groundwater is mainly discharged during the winter months or during periods of high rainfall. Groundwater in well G127000 does not exceed acute aquatic criteria for metals and is well below conservative screening criteria for VOCs. However, additional samples for metals and hardness data from surface water in Shell Creek shall be collected and compared to surface water quality criteria. The additional data will provide a greater confidence interval for chronic aquatic criteria.

(4) LMC shall identify occupied structures (office areas, residences, etc.) located above the chlorinated solvent plume. LMC shall determine if vapor intrusion is likely in these structures, based on EPA guidance, and, if so, shall conduct vapor intrusion sampling to determine risk. If an increased risk is identified that threatens human health, LMC shall take actions to reduce the risk which may also require a revision to the Site decision documents. The evaluation of the potential for Site-related vapor intrusion will be initiated in the area proposed for reuse.

(5) The locations of detections for carbon tetrachloride and MTBE will be referred to NDEQ and EPA site assessment programs for further evaluation and/or assessment if determined necessary.

(6) Consistent plume pumping, conducting timely activities concurrently to ensure that pumping remains consistent (obtaining substantive permit requirements, securing landowner access, and installation and maintenance of equipment, etc.), and adequate capture zone evaluation are issues that have been raised in past Five-Year Reviews and evaluations. These issues will be reviewed to determine an appropriate approach to minimize interruptions in plume remediation. In addition, a summary evaluation of laboratory and field QA/QC will be conducted to ensure that decisions are based on the best quality data and meet the requirements of the Site O&M plan and QAPP.

(7) The site consent decree indicates that through additional response actions institutional controls can be implemented. Therefore, the availability of institutional control mechanisms and the opportunity to implement those at the site shall be reviewed.

Protectiveness Statement(s)

The remedy at LMC in its present state is protective of human health and the environment. LMC has taken several steps toward plume containment and stopping downgradient plume migration. However, due to numerous technical and logistical difficulties, a downgradient extraction well (G127000) could not be pumped continuously as planned, thus allowing the plume to migrate further downgradient. Those difficulties have been addressed through a surface water discharge point and associated authorization to discharge to Shell Creek during periods where irrigation discharge is not possible. An additional extraction well, EXT07-02, was installed in October 2007 to prevent further plume migration. Also at that time, two additional MWs were installed to evaluate plume migration. Permission to discharge extracted groundwater to Shell Creek at the second location near the newly installed extraction well was obtained from NDEQ.

The contamination present at the Site (source area) has been addressed to date through the use of soil vapor extraction and groundwater extraction and treatment. The extent of groundwater contamination migrating from the facility has been generally determined and LMC has presented potential alternatives to enhance the remediation of the groundwater plume.

LMC is providing drinking water and whole-house treatment for the owners of two domestic supply wells that are contaminated. Monitoring of the groundwater and domestic water supplies continue. Concentrations in the groundwater plume have been reducing over time based on site monitoring.

Long-Term Protectiveness

Long-term protectiveness of the RA will be verified by continuing inspections, maintenance, and sampling of groundwater at the Site as specified in the O&M Plan. Whole-house treatment systems provided to the private homeowners with impacted wells have been monitored on a quarterly basis to ensure the remedy is working as implemented. Future work will include continued monitoring to evaluate the extent of the off-site contamination and possible supplemental RAs. The potential for site-related vapor intrusion will be evaluated. Consistent pumping of extraction wells, plume capture, and sample handling will be reviewed. The opportunity for implementation of institutional controls at the Site shall be reviewed.

Other Comments

LMC will identify any remaining areas affected by Site contamination and present further alternatives to address this contamination. EPA and NDEQ will work with LMC to ensure that the migration of the plume is halted.

LINDSAY MANUFACTURING CO. SUPERFUND SITE
LINDSAY, PLATTE COUNTY, NEBRASKA
THIRD FIVE-YEAR REVIEW REPORT

I. INTRODUCTION

The purpose of the Five-Year Review is to determine whether the remedy at a site is protective of human health and the environment. The methods, findings, and conclusions of reviews are documented in the Five-Year Review report. In addition, the Five-Year Review report identifies issues found during the review, if any, and identifies recommendations to address them.

The Agency is preparing this Five-Year Review report pursuant to section 121 of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 as amended by the Superfund Amendments Reauthorization Act of 1986 (CERCLA) and the National Contingency Plan (NCP). CERCLA section 121(c) states:

> If the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site, the President shall review such remedial action no less often than each 5 years after the initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented. In addition, if upon such review it is the judgment of the President that action is appropriate at such site in accordance with section 104 or 106, the President shall take or require such action. The President shall report to the Congress a list of facilities for which such review is required, the results of all such reviews, and any actions taken as a result of such reviews.

The Agency interpreted this requirement further in the NCP. Specifically, 40 CFR section 300.430(f)(4)(ii) states:

> If a remedial action is selected that results in hazardous substances, pollutants or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after the initiation of the selected remedial action.

The U.S. Environmental Protection Agency (EPA) Region 7 conducted the third Five-Year Review of the remedy implemented at the Lindsay Manufacturing Co. (LMC) Superfund site (Site) in Lindsay, Nebraska. This review was conducted by the Remedial Project Manager (RPM) for the entire site by reviewing data collected from July 2003 through June 2008. This report documents the results of the review.

This is the third Five-Year Review for the Site. The triggering action for this statutory review is the signature date of the second Five-Year Review which was July 3, 2003. The third Five-Year Review is required due to the fact that hazardous substances, pollutants, or contaminants remain at the site above levels that allow for unlimited use and unrestricted exposure.

II. SITE CHRONOLOGY

The following table presents the site chronology. More details on the remediation events shown on the table are presented in Section III.

Table 1: Chronology of Site Events

Event	Date
Paul Zimmerer starts a sprinkler irrigation business that would later become LMC.	1958
Plant constructed and LMC begins.	1961 - 1969
Incorporated and expanded.	1971 - 1972
DeKalb Agrasearch Inc., acquires LMC.	1974
LMC drills 4 test holes and a deep test hole. Proposed water treatment facility, acidic groundwater and elevated temperatures. New public water supply installed.	1983
Original Interceptor Well (OIW) installed. LMC proposed for National Priorities List (NPL)	1984
Add-on Inspector Well (AOIW) installed.	1988
LMC begins Remedial Investigation/Feasibility Study (RI/FS).	1988
NPL Final.	1989
Proposed Plan to Public.	1990
Record of Decision (ROD).	1990
Consent Decree Signed, Remedial Design approved for Third Interceptor Well (TIW).	1992
TIW installed date that triggered the first Five-Year Review.	1992
Design for soil vapor extraction (SVE) system approved. Remedial Action (RA) Work Plan Approved.	1994
Inspection of SVE System.	1995
Established SVE clean up criteria. Incorporated irrigation as part of the groundwater treatment system. New risk assessment by state.	1996
Determined that both Area 1 and Area 2 for SVE were approaching cleanup	1997
Decommissioned SVE in Area 2. Abandoned selected groundwater monitoring wells (MW). Changed groundwater pumping schedule.	1998
Completed first Five-Year Review.	1998
Turned over TIW to land owner. Investigated additional areas where plume could migrate. Identified additional domestic water supply wells where plume migrated.	1999
Hydrogen Release Compound (HRC®) study approved and conducted on plant site near treatment lagoon.	2001
Extraction system hit by ice storm. LMC requested that EPA and the Nebraska Department of Environmental Quality (NDEQ) consider using water for crop irrigation. Approval given.	2003
Initiated second Five-Year Review process.	2003
Conducted Five-Year Review Inspection. Held public availability session.	2003

Event	Date
Sampled 3 domestic water supply wells. Provided results to owners.	
Quarterly groundwater sampling initiated. Samples collected during February, May, August, and November of each year.	2003
Subsurface Investigation and Groundwater Monitoring Report Prepared.	2003
Whole-house treatment systems installed at two private residences and a new domestic well also installed.	2004
Installation of one irrigation well (G127000) between two residences to remove Volatile Organic Compounds (VOCs) in this portion of the lower Sand and Gravel Aquifer. Pumping initiated in May 2004.	2004
Additional 9 MWs installed to delineate southern extent of plume	2006
LMC received discharge authorization from NDEQ for Extraction well G127000.	2006
LMC began periodic discharging of water to Shell Creek.	2007
The 75th quarterly groundwater sampling event occurred in August 2007.	2007
Initiated third Five-Year Review process.	2007
A second extraction well EXT07-02 installed in the south terminus of the plume along with two MWs.	2007
LMC conducted sampling in support of an area of reuse on the facility property and presented plans for the intended reuse activity.	2007
LMC provided a voluntary evaluation of potential supplemental remedial alternatives for enhanced groundwater remediation.	2007
LMC received approval from NDEQ for periodic surface water discharge to Shell Creek from EXT07-02.	2008
LMC conducted additional sampling in support of reuse on the facility property.	2008
EPA Certification of Completion of the Remedy.	Not Yet Certified

III. BACKGROUND

A. Physical Characteristics

LMC operates a manufacturing facility on 42 acres and manufactures galvanized irrigation systems. LMC is located in the Village of Lindsay, Platte County, Nebraska. The Village of Lindsay lies on the east boundary of the Nebraska Sandhills and the local region is characterized by rolling and dissected loess plains. The Site is surrounded on the north and east by farmland and on the south and west by the Village of Lindsay. The Site is surrounded by farmland with an approximate population of 3,000 within a 3-mile radius of the Site including the Village of Lindsay. Wastes from the galvanizing process were discharged into an unlined earthen lagoon for 11 years between 1971 and 1982. Prior to the RAs, contaminants of concern (COCs) at the Site included zinc, iron, cadmium, sulfate, chromium, lead and VOCs including dichloroethene (DCE), dichloroethane (DCA), tetrachloroethene (PCE), trichloroethane (TCA), and trichloroethene (TCE). People could have been exposed to contaminants by drinking water from contaminated domestic wells, by direct contact with contaminated water, by inhaling contaminants released during water use, or by eating food in which contaminants had bioaccumulated.

B. Land and Resource Use

The site is bounded on the north by farmland, on the east by Lindsay Village limits and farmland, on the south by state highway 91, and a residential area of Lindsay, and on the west by a tributary to Shell Creek, its greenbelt, and a residential area of Lindsay. In 1980, the total population of Lindsay was 383 people. In 2000, the population of Lindsay was 276. Three schools serve the Lindsay area. Land use within the city limits is primarily residential with the exception of the Site and a community business and general commerce area located southwest of the site. A public recreational and utility area is located approximately 0.2 miles southwest of the Site. The utility area consists of the town public sewage treatment plant and ponds. The area within a 2 mile radius of the Lindsay Village limits is primarily agricultural with an average of three farmsteads per square mile. Groundwater elevation ranges from approximately 1,649 feet Mean Sea Level (MSL) at MW 89-14 on-site near the northern portion of the LMC to approximately 1,621 feet MSL at MW06-04, the furthest measured elevation point downgradient based on 2007 data. The site is in the upland drainage area of Shell Creek. The western boundary of the site is a tributary (Dry Creek) draining to Shell Creek which historically received nearly continuous discharge from an interim groundwater remediation operation which started in 1987. The treated waters were discharged under the facility's National Pollution Discharge Elimination System (NPDES) permit. Groundwater under the current remedy is extracted from wells MW89-12 and AOIW and the water is discharged through center pivot irrigation systems rather than to Dry Creek. The interim groundwater remediation is no longer in operation. Groundwater flow in the vicinity of Lindsay is generally to the south-southeast. The aquifer saturated thickness ranges from approximately 35 to 60 feet. The groundwater flow velocity is approximately 520 feet per year. Groundwater flow direction at the site is complex because of the influence of several high-capacity wells.

C. History of Contamination

The site was originally a gasoline station until the late 1950's. In 1958, Paul Zimmerer began manufacturing irrigation systems. In 1961, the plant was constructed and in 1965, LMC began. Disposal of materials from plant operations historically included discharge of spent acid from the galvanizing process. From the early 1970s to 1982, a spent acid stream was piped to an earthen disposal pit located north of LMC's galvanizing building. In 1982, Lindsay replaced the pit with a new wastewater treatment facility designed to neutralize the spent acid. During the installation of the wastewater treatment facility, four wells and a deep test hole were drilled and sampled in January 1983. The samples revealed the groundwater had abnormal acidity and temperatures. Lindsay reported these findings to NDEQ and began an investigation of the soils and groundwater.

D. Initial Response

In 1984, Lindsay began operating a groundwater extraction and treatment system, whereby the groundwater is treated by neutralizing and removing contaminants OIW. A second extraction well AOIW was installed in 1989 to control off-site migration of contaminants and increase the radius of influence. Lindsay began a study of the nature and extent of contamination remaining at the Site and completed its study in 1990. The Site was proposed to the NPL on October 15, 1984. On October 4, 1989, the Site was placed on the final NPL listing. In response to a release or a substantial threat of a release of hazardous substance(s) at or from the Site, Lindsay initiated an RI/FS on January 5, 1988. The RI report was completed on June 20, 1990, and an FS Report was completed on August 27, 1990. On July 10, 1990, the Proposed Plan identifying the preferred remedy was presented to the public for their review and comment along with the final RI and draft FS reports.

E. Basis for Taking Action: Contaminants

Hazardous substances that have been released at the site include sulfate, zinc, iron, cadmium, chromium, lead, and volatile organics from former process waste. Off-site groundwater contains heavy metals including cadmium and zinc, and VOCs including 1,1-DCA; 1,2-DCA; 1,1-DCE; 1,2-DCE; PCE; 1,1,1-TCA and TCE. These VOCs have been identified in the perched sand channel in the northern half of the site, in clay soils in the area around the northern quarter of the main plant, and between the main plant and the southern end of the galvanizing building. People could be exposed to contaminants by drinking water from contaminated domestic wells, by direct contact with contaminated water, by inhaling contaminants released during water use, or by eating food in which contaminants have bioaccumulated.

IV. REMEDIAL ACTIONS

A. Remedy Selection

EPA selected a remedy that included a pilot study to evaluate the feasibility of vacuum extraction of on-site soils; installation of such a system, if it is deemed practical; enhancement and utilization of the existing groundwater extraction and treatment systems; installation of additional groundwater MWs; installation of an additional extraction well; and continued monitoring of the groundwater collection/treatment system during cleanup activities. The ROD for the Site was signed on September 28, 1990. The following Remedial Action Objectives (RAOs) were developed from data collected during the remedial investigation to aid in the development and screening of remedial alternatives to be considered for the ROD.

The purpose of the selected remedy in this ROD is to prevent current or future exposure to the contaminated groundwater, to determine the practicability of reducing contaminant migration from the soil into the groundwater, to implement soil vapor extraction if practicable, and to restore the groundwater aquifer to MCL quality.

The major components of the selected remedy for the affected groundwater and soil include the following:

- A pilot study to evaluate the practicability of vacuum extraction of organic compounds from contaminated soil;

- If determined to be practicable by EPA and/or NDEC, design and implementation of full scale soil vapor extraction system based on pilot study data;

- Enhancement of the existing groundwater extraction and treatment system by either increasing the volume of on-site pumping from the existing extraction wells or by the installation of an additional interceptor (extraction) well;

- Utilization of the existing groundwater treatment facility to remove contaminants from the collected ground water;

- Installation of additional groundwater monitoring wells near irrigation well #54278 to further delineate the groundwater contaminant plume;

- The monitoring of the groundwater collection/treatment system and the groundwater contaminant plume during groundwater remediation activities; and

- If appropriate to protect human health, EPA and NDEC will evaluate options, as part of implementation of the ROD, to ensure that drinking water wells are not installed in areas of the contaminant plume on- and off- site.

B. Remedy Implementation

In a Consent Decree (CD) signed with EPA on April 9, 1992, the responsible party agreed to perform the remedial design/remedial action (RD/RA) and pay past costs for cleaning up the site. The RD was completed in conformance with the ROD. The RD was approved by EPA in 1992. In early 1993, a third extraction well became operational to assist in pumping and treating the groundwater. The SVE pilot study was concluded in 1993. Design of the full-scale SVE system was completed in mid 1994, construction began shortly thereafter, and the SVE system became operational in early 1995. In 1996, EPA evaluated the SVE system and determined site-specific remediation levels had been attained and verified. Once verified, the SVE system equipment was decommissioned and the site restored. EPA also evaluated the use of irrigation as a means for disposal of the removed groundwater. The Nebraska Department of Health performed a risk assessment and the results of this assessment determined that no unacceptable risks were associated with using irrigation as a disposal option. EPA modified the groundwater pumping and is allowing the pumped water to be beneficially reused for irrigation. This reduced the operating costs by approximately $100,000 annually. EPA completed the first Five-Year Review of the site activities in 1998, which served to document the modifications to the extraction and treatment system and also determined that the remedy remained protective of human health and the environment.

LMC and EPA have sampled downgradient domestic water wells since 1990. The wells that have been sampled are shown in Attachment 2, the Site Plan. In 1994, chlorinated solvents were detected in a domestic well. In 1995, this well was reported as nondetect for chlorinated solvents. In 1998, the Preister domestic well showed the presence of tetrachloroethene above the MCL. The other domestic wells remained free of site-related contamination.

In May 1998, LMC proposed conducting a three-month treatability study utilizing MW89-12 as the extraction well. Lindsay determined that water could be extracted from this well at a rate of 60 gallons per minute. The extracted groundwater would be piped into the settling pond for air stripping through a modified irrigation system. As the residual contamination is in the top of the aquifer, pumping only the upper zone would be more efficient than pumping the entire aquifer. In October 1998, EPA notified LMC that EPA and NDEQ supported the modification to use MW89-12 as the extraction well provided all remediation wells (OIW, AOIW, and TIW) remain in place until remediation levels are attained. In addition, EPA and NDEQ support the use of the low level contaminated groundwater as irrigation water during the summer months. In the fall of 1998, MW89-12 removed 6.2 million gallons of contaminated groundwater from the aquifer. In March 1999, OIW removed 30.5 million gallons of water from the aquifer. In the next six months, MW89-12 removed 12.8 million gallons of contaminated groundwater. In August 1999, several nearby domestic residents' water supplies were tested to determine if they contained contamination from the Site. No new domestic supplies were found to contain contamination from Lindsay above the MCLs.

In November 2000, EPA held discussions with LMC in order to explain the levels of contamination present in selected MWs. MW89-14 is located in the sandy channel area of LMC and the water in this well is from infiltration. MW89-15 is a deeper well and is screened in the upper portion of the sand and gravel aquifer. Water levels in the sand and gravel aquifer

fluctuate each summer based on seasonal irrigation demand. As the water levels drop, groundwater in the perched sand channel and in the silty clays between the sand channel and the aquifer drain in part to the aquifer. The silty clays between the sand channel and the aquifer contain chlorinated solvent residuum that continues to release to the aquifer. In 2000, drought conditions resulted in wider seasonal fluctuations in water levels in the aquifer. MW89-12 is in an area with mixed permeability. The upper portion has very low permeability. The lower portion of the screened interval is in the upper portion of the groundwater, therefore the levels of the VOCs removed from the pumping of this well reflect the contamination as it drains into the aquifer. See the letter report to EPA dated January 30, 2003, for further details. Remediation efforts are focused on the capture of the VOCs present to protect the aquifer and to enhance the degradation of the contamination present. In 2000, approximately 23,000,000 gallons of contaminated groundwater were removed from MW89-12. Irrigation wells removed contaminated groundwater, but the amount used for irrigation was not recorded. In 2001, approximately 19,000,000 gallons of contaminated groundwater were removed from MW MW89-12. Irrigation wells were used to remove the contamination migrating from the plant site.

In 2001, Lindsay proposed additional work using an innovative technology, hydrogen release compound or HRC® to address the residual aquifer contamination. The HRC® was injected into the aquifer at 22 locations. One hundred and fifty pounds of HRC® was injected at each location. This work was completed in September 2001. Quarterly groundwater monitoring was modified to include the inorganic parameters used to assess the effectiveness of the HRC®. The groundwater monitoring program was modified to test for the inorganic parameters (dissolved oxygen, oxygen release, potential sulfate, sulfide, dissolved iron, total iron) at MWs close to the injection locations. Based on data collected through February 2003, the field parameters monitored did not clearly indicate a change in the subsurface chemistry. This was thought to be due to the soils at the site or the drought conditions which would have accelerated the movement of the HRC® from the treatment zones into the aerobic aquifer. EPA completed the second Five-Year Review of the site activities in 2003, which served to document the modifications to the extraction and treatment system and also determined that the remedy remained protective of human health and the environment.

The analytical results from the 58th to the 75th quarters are presented in Attachment 3 of this document. The results indicated that contaminants of concern (COCs) are being removed via pump and treat system from the source area and downgradient irrigation/pumping wells. During the past five years, the plume has migrated farther downgradient. LMC installed two extraction wells to contain the plume. The first well, G127000, was not initially pumped as planned and thus was not able to contain the plume. However, the performance of the first well has shown improvement since 2007. LMC installed one additional extraction well, EXT07-02, in October 2007 and the results are pending.

This Five-Year Review, the third Five-Year Review, of the Site activities completed from 2003 to the signing of this document in 2008, serves to document the modifications to the extraction and treatment system and other activities at the Site. This document also determines that the remedy remains protective of human health and the environment.

C. System Operation, Operation and Maintenance

LMC is conducting groundwater monitoring and maintenance activities pursuant to the Operation and Maintenance Plan (OMP) that was approved by EPA in the 1992 CD. The primary activities associated with the OMP include the following:

- Inspect and maintain the condition of the MW network, the extraction system, and the irrigation system used for disposal of the extracted water;
- Conduct quarterly groundwater monitoring until the MCLs are reached;
- Prepare reports of the groundwater monitoring information and send to EPA on a biannual basis.

Table 2 below provides a yearly summary of the Operation and Maintenance (O&M) costs. These include monitoring and sampling efforts, installation of extraction wells, MWs, maintenance of monitoring and extraction wells, and costs of preparing reports.

Table 2: Operating Costs

Year	2003	2004	2005	2006	2007
Consultants Fees & Expenses	$114,885	$91,622	$91,580	$121,583	$152,037
Lab Fees	25,178	17,616	39,766	35,945	128,497
Construction & Operational Fees	36,590	202,004	122,067	196,927	95,497
Grand Totals	**$176,653**	**$311,241**	**$253,413**	**$353,455**	**$375,711**

Table 2 reflects costs associated with specific tasks. The O&M costs in the ROD were estimated at $636,600 per year. The time frame for this estimate was greater than five years of O&M. Although the costs have not exceeded this estimate, they have gradually increased during the past five years. This is primarily due to increase in extraction and monitoring network, additional consulting charges, engineering time, and laboratory costs.

V. PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

During the last five years, LMC continued to perform all the tasks including pumping of selected wells, installation of additional extraction wells, MWs, installation of Granular Activated Carbon (GAC) units on private drinking water wells, and other tasks requested and mutually agreed-upon by EPA and LMC. The following is a summary of all additional work completed at this Site:

- February 2004: Installation of one irrigation well (G127000) between two residences to remove VOCs in this portion of the lower Sand and Gravel Aquifer. Pumping initiated in May 2004;

- August 2004: 1,4-Dioxane sampling was initiated in selected wells. 1,4-Dioxane was detected in several of the extraction and MWs;

- November 2004: An additional three MWs were installed. The purpose was to delineate the eastern edge and southern extent of VOCs in groundwater;

- March 2006: Nine additional wells (MW06-01 through MW06-09) were installed;

- March 2006: LMC received discharge authorization from NDEQ to discharge extracted water from G127000 into Shell Creek;

- March 2006: MWs MW89-14 and MW89-15 were plugged and abandoned and replaced with MWs MW06-10 and MW06-11;

- 2007: LMC began discharging groundwater from G127000 to Shell Creek per Discharge Authorization. Since August 2007, this well has been pumping continuously at 400gpm; Lindsay is in the process of increasing the extraction rate in this well;

- October 2007: A second extraction well EXT07-02 and two additional MWs were installed in the south terminus of the plume.

Significant progress has been made towards delineating the downgradient end of the plume. During this review period, additional attempts were made to understand the nature and extent of the groundwater plume. Steps were taken to control further downgradient migration of the groundwater plume. Impacted private wells were connected to treatment systems and where applicable, new wells were installed. Other domestic water supply wells were tested in the areas. No contamination was detected in those wells.

LMC is performing voluntary site activities to promote reuse of a portion of property. These activities included soil sampling in an area of proposed building construction. The soil sampling has shown some soil contamination exceeding EPA Region 6 screening criteria. The results are being evaluated with EPA Region 6 soil screening criteria, EPA Soil Screening Level guidance, and current EPA Region 7 risk evaluation policy.

Further assessment will be conducted by LMC to determine the lateral and vertical extent, any current and future risks, and if any further action is warranted. LMC will also evaluate the potential for vapor intrusion at the Site, beginning with the area proposed for reuse.

LMC has also expressed interest in further enhancing their groundwater extraction and treatment system. LMC provided a streamlined evaluation of potential supplemental groundwater remediation alternatives for future evaluation.

VI. FIVE-YEAR REVIEW PROCESS

A. Administrative Components

The third Five-Year Review Team was led by Robert Weber, the EPA remedial project manager (RPM) for this site. The review was conducted between September 11, 2007, and the signature date of this report. The review included document review, data review, site inspection, community involvement, local interviews, and report development and review.

B. Community Involvement

A newspaper advertisement was placed in the *Columbus Telegram* on November 27, 2007, notifying the public of the start of the Five-Year Review process. Upon completion of this report, a notice will be placed in the local newspapers announcing the completion of the Five-Year Review and its availability at the local library (or other appropriate location) and EPA Region 7 Records Center. The EPA will hold a public availability session to discuss the Five-Year Review Report and findings.

C. Document Review

The Five-Year Review included a review of all relevant documents including decision documents, site investigation documents, O&M records, and monitoring data.

D. Data Review

Groundwater monitoring was originally initiated at this site in 1982 and continues to date. This section discusses the groundwater monitoring results from April 1, 2003, to September 30, 2007. Quarterly sampling events are conducted in February, May, August, and November of each year. The data review includes the biannual report received by EPA on October 19, 2007. Any biannual reports received after this date will be included in the next Five-Year Review. Table 3 shows amount of contaminated water (gallons) that was pumped during the last five years.

Table 3: Summary of Pumping Volume (gallons):

Well No./Year	2003	2004	2005	2006	2007
Pumping Months	April – December	April – December	April – December	April - December	April – August
MW89-12	7,748,652	7,737048	16,714,685	20,959,476	10,426,999
AOIW	-	45,245,400	99,634,396	101,254,700	52,475,400
G127000	-	68,896171	63,683,765	49,063,341	35,191,774
TOTAL	**7,748,652**	**121,878,619**	**180,032,846**	**171,277,517**	**98,094,173**

Table 4 provides the total VOCs/1,4-dioxane removed from April 2005 through August 2007 from the three extraction wells: MW89-12, AOIW, and G127000. Mass removal data from April 2003 to March 2005 is not available.

Table 4: Total Contaminant Mass Removal (lbs):

Well No./Year	Contaminant	2005	2006	2007
MW89-12	Total VOCs (lbs)	57.800	63.600	22.700
	1,4-dioxane (lbs)	4.900	6.300	2.200
AOIW	Total VOCs (lbs)	83.200	53.500	39.300
	1,4-dioxane (lbs)	7.500	5.300	3.600
G127000	Total VOCs (lbs)	55.500	37.800	14.600
	1,4-dioxane (lbs)	0.393	0.735	0.313

Table 4 shows total VOCs, as well as 1,4-dioxane, removed from the groundwater during the past three years. During this time over 320 lbs of total VOCs have been removed from the source area groundwater. Approximately 107.9 lbs of VOCs were also removed from the downgradient extraction well.

Volatile Organic Compounds Results

Total VOCs concentration over time in extraction and MWs was plotted for each monitoring and extraction well and is illustrated graphically in Attachment 3. Figure 3.1 presents total VOC concentration detected in the MWs in the upper shallow perched sand channel. Figures 3.2 through 3.5 illustrate VOC concentrations in on-site extraction and MWs. Although contamination still exists in the groundwater, it appears to be decreasing in these wells. Figures 3.6, 3.7 and 3.8 show VOCs concentrations in off-site extraction and MWs. The overall VOCs levels exhibit a declining trend for most wells. Figures 3.9 and 3.10 show levels of 1, 4-dioxane detected in the source area wells; however, contamination is declining. Figure 3.11 illustrates low levels of 1,4-dioxane observed in the downgradient MWs.

In areas south of LMC, carbon tetrachloride and methyl tert butyl ether (MTBE) have been historically detected in groundwater. The carbon tetrachloride has been historically detected in two wells located approximately 1,900 and 8,000 feet southeast, respectively, of the Village of Lindsay. Its presence was identified in the second Five-Year Review for the site. MTBE has been historically detected in a domestic well located approximately 750 feet southeast of the Village of Lindsay. The detections of these chemicals have not exceeded federal safe drinking water standards in the locations presented above. Based on the contaminants measured at the Site, the carbon tetrachloride and MTBE may be originating from another potential source or sources located upgradient to, cross-gradient to, or near the current groundwater plume detection locations.

Metals Results:

Metal results are illustrated graphically in Figures 4.1 through 4.9 (Attachment 4)
The data analysis reveals that cadmium, chromium, lead, iron, and zinc are among the major contaminants present at the site. Data evaluation indicates that with the exception of iron and zinc (Graph 15), the concentration of metals in the north area wells remains significantly low. The iron and zinc levels are higher in MW06-11 and MW89-15. Chromium, in wells installed along highway 91 (including MW06-05, MW06-06, MW06-07, MW06-08, and MW06-09), although present in low levels, shows increasing trends.

E. Site Inspection

An inspection was conducted at the Site by EPA and NDEQ on November 27, 2007. The purpose of the inspection was to assess the protectiveness of the remedy, evaluate current site property conditions and areas within and near the downgradient groundwater plume, locate extraction wells and MWs, locate discharge areas including pivot irrigation locations and Shell Creek, and view the whole-house treatment systems installed in residences on-site.

The Site includes the LMC where public access is limited, the downgradient off-facility-property areas of the groundwater contamination plume, and any areas used to implement the remedy. There are no institutional controls for the Site including the facility property.

The inspection of the Site revealed no major O&M problems. The facility is a manufacturing site with limited access. Groundwater information is being presented to EPA and NDEQ on a biannual basis, so no documents were reviewed by EPA or NDEQ during the Site inspection. Extraction wells, including center-pivot irrigation systems and MWs, were found to be in good condition. A whole-house treatment system on a residential property was inspected and found to be operating as designed. A surface water discharge point was inspected and found to be operating as designed. A new extraction well, EXT07-02, being constructed and at the time of the inspection was not operational. Evidence of water transmission piping trenching and power poles for electric utility service was observed for this well.

In addition to the Site inspection and on the day of the inspection, EPA collected a groundwater sample from an existing irrigation well within the groundwater plume at the request of the private property owner to verify past results. The results from this sampling event were submitted to the private property owner and provided to LMC to incorporate into the site data set. The results show a decrease in contamination at this location since the last sampling event.

F. Interviews

During the Site inspection, EPA conducted in-person interviews with three LMC personnel. The responses were positive and indicated that progress was being made at the Site with the installation of an additional extraction well. It was mentioned that overall, contaminant concentrations were shown to be decreasing. It was noted that the scope of sampling had increased including more households to the south. System optimization was mentioned in the form of groundwater flow rate adjustment and that the groundwater plume has been delineated. No major issues were cited other than the usual weather-related concerns (e.g. temperature and precipitation, etc.).

VII. TECHNICAL ASSESSMENT

A. Question A: Is the remedy functioning as intended by the decision documents?

The review of biannual reports, applicable or relevant and appropriate requirements (ARARs), risk assumptions, and the results of the Site inspection indicate that the remedy is functioning as intended by the ROD. This report consists of the third Five-Year Review. The first and second Five-Year Reviews present information that documents the remediation of source area soils with SVE technology. However, the groundwater remained contaminated at the LMC. The VOC plume migrated further downgradient. Lindsay has taken additional steps toward preventing the further migration of the groundwater contaminant plume. Since these additional steps for the distal portion of the plume were taken at the end of this Five-Year Review period, the full impact of these efforts were not apparent at the time of this report. Quarterly monitoring of existing MWs and domestic supply wells will continue until remediation levels are attained. Optimization of the existing pump and treat system was observed in the form of pumping rate adjustment during this review. Direct discharge of the extracted groundwater from the downgradient well provides longer pumping duration which in turn will assist with plume capture. Although the downgradient extraction well G127000 did not operate for the period intended, it was able to remove a significant quantity of VOCs from the groundwater (see Table 4). With the installation of additional downgradient MWs, the existing MW network provides sufficient data to evaluate the effectiveness of the remedy on plant property and the downgradient end of the plume. Additional characterization may be required as data are collected.

B. Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the remedy selection still valid?

EPA Region 7 Risk Assessors conducted a technical assessment in support of the five-year review of the Site. The following responses were prepared based on data submitted.

Have there been changes to risk-based cleanup levels or standards identified as Applicable or Relevant and Appropriate Requirements (ARARs) in the Record of Decision (ROD) that call into question the protectiveness of the remedy?

Table 5: Groundwater Cleanup Levels for Lindsay Manufacturing Site:

COPC identified in ROD	Cleanup Level in ROD (µg/L)	Current MCL or Secondary Standard (µg/L)	Maximum Concentration (µg/L)
1,2-dichloroethane (DCA)	5	5	0.6
1, 1-dichloroethene (DCE)	7	7	930
cis-1, 2-dichloroethene	70	70	72 (total 1,2-DCE)
trans-1,2-dichloroethene	100	100	72 (total 1,2-DCE)
1,1,1-trichloroethane (TCA)	200	200	300
pH	6.5-8.5	6.5-8.5	4.96 (minimum)
Zinc	5000	5000	95,200
Sulfate	250,000	250,000	1,100,000
Cadmium	10	5	13
Chromium (total)	50	100	279
Lead	50	15	82

Only groundwater cleanup levels were established for the Site. All of the risk-based cleanup levels for groundwater are based on human health exposures. The groundwater ARARS are based on maximum contaminant levels (MCLs) and Secondary Drinking Water Regulations established under the Safe Drinking Water Act (SDWA). For three of the contaminants of potential concern (COPCs) – cadmium, chromium, and lead – the health based standards have changed since the completion of the ROD. The groundwater cleanup levels established in the ROD (Table 5) are the current regulatory standards (EPA, 2006a) and the highest contaminant concentrations identified in the biannual report (URS, 2007c). Note that Secondary MCLs are not health based, but instead reflect nuisance levels based upon taste, odor, color, etc. Secondary MCLs constitute nonenforced standards or guidelines. It should be noted that cleanup levels do not appear to have been established in the 1990 ROD for several contaminants for which regulatory values exist (Table 6).

Table 6: TCE/PCE Concentration in Groundwater:

Contaminant	Maximum Concentration (µg/L)	Regulatory Standard or Screening Value (µg/L)
TCE	35	5
PCE	1,100	5
Iron	101,000	300
1,4-dioxane	140	6.1

Are there newly promulgated standards that call into question the protectiveness of the remedy?

Please see Table 5 for groundwater standards that have changed since the development of the ROD.

Have TBCs used in selecting cleanup levels at the site changed in way that could affect the protectiveness of the remedy?

TBCs were not considered in selecting cleanup levels for this site. Whole-house treatment systems were installed at two residences whose drinking water wells were impacted by the groundwater contamination plume. Therefore, even though Tables 5 and 6 show elevated levels of contamination, the health of nearby residents is protected by the current remedy.

Changes in Exposure Pathways

Has land use or expected land use on or near the site changed (e.g., industrial to residential, commercial to residential)?

Land use has not changed at the site nor is any future land use change apparent.

Have any human health or ecological routes of exposure or receptors changed or been newly identified (e.g., dermal contact where none previously existed, new populations or species identified on site or near the site) that could affect the protectiveness of the remedy?

Groundwater in the area is relatively shallow. Table 4 of the biannual report (URS, 2007c) shows that elevated concentrations of VOCs continue to be present in the groundwater. EPA's subsurface vapor intrusion guidance (EPA, 2002) contains generic screening values against which site contaminant concentrations can be compared to see if a potential exists for the intrusion of VOCs into above ground structures at levels of possible concern. A comparison of the VOC concentrations (identified in Table 4 of the biannual report) with the screening values in EPA's vapor intrusion guidance indicates that the potential for subsurface vapor intrusion may exist. The vapor intrusion pathway was not evaluated in the original baseline risk assessment for the site.

LMC received a discharge authorization from NDEQ in March 2006 to pump groundwater from G127000 to Shell Creek. Therefore, aquatic receptors in Shell Creek may now come in contact with the treated groundwater. To address this new route of exposure, analytical results from discharges to Shell Creek were compared to risk-based ecological benchmarks (see Question C).

Are there newly identified contaminants or contaminant sources?

Table 4 of the biannual report (URS 2007c) shows elevated concentrations of both TCE and PCE. These two contaminants were identified as COPCs in the original risk assessment. However, it appears that cleanup levels were not established for either of these contaminants in the 1990 ROD. Similarly, a secondary drinking water regulation for iron exists, yet iron does not

appear to be included in the ROD. Finally, page 10 of the biannual report states that 1,4-dioxane has been identified in groundwater at concentrations which exceed the preliminary remediation goal (PRG) established in the EPA Region 6 screening levels (EPA, 2006b). Table 6 shows the maximum concentration of each of these contaminants presented in Table 4 of the biannual report, as well as the current MCLs for the TCE and PCE, the current secondary drinking water standard for iron, and the current EPA Region 6 screening level for 1,4-dioxane (EPA, 2008).

Are there unanticipated toxic byproducts of the remedy not previously addressed by the decision documents (e.g., byproducts not evaluated at the time of remedy selection)?

No unanticipated toxic by-products have been identified.

Have physical site conditions or the understanding of these conditions changed in a way that could affect the protectiveness of the remedy?

A comparison of Figure V-5 in the ROD with Figure 11 in the biannual report (URS, 2007c) indicates that the groundwater contamination plume has migrated approximately 9000 feet downgradient since the ROD was finalized. Several additional MWs have been installed in and near the plume since the ROD, and the installation of another extraction well at the south terminus of the groundwater plume is planned (URS, 2007b). This effort will further delineate the extent of the groundwater contamination, halt the downgradient migration of the plume, and prevent additional water supply wells from being impacted.

Other than discharges of groundwater to Shell Creek, no other changes in the physical site conditions exist.

Changes in Toxicity and Other Contaminant Characteristics

Have toxicity factors for contaminants of concern at the site changed in a way that could affect the protectiveness of the remedy?

Many of the noncarcinogic and carcinogenic toxicity factors identified in the ROD have been updated in the past 17 years. However, these changed toxicity values for VOCs do not impact the protectiveness of the remedy. The toxicity value for lead has also changed, and an action level for lead in drinking water supplies has been developed. As shown in Table 5 above, the current action level for lead in drinking water is 15 µg/L.

Have other contaminant characteristics changed in a way that could affect protectiveness of the remedy?

Other changes to contaminant characteristics have not been identified that could impact the protectiveness of the remedy.

Changes in Risk Assessment Methods

Have standardized risk assessment methodologies changed in a way that could effect the protectiveness of the remedy?

EPA has significantly revised its dermal risk assessment guidance since the completion of the original risk assessment. Region 7 also uses a different approach when estimating the health risks from inhalation of VOCs during household use of contaminated groundwater (i.e., bathing, showering, cooking, etc.). Several exposure assessment input parameters in the original risk assessment are slightly different than values currently used. EPA also now uses the Integrated Exposure Uptake Biokinetic Model (IEUBK) and the Adult Lead Methodology (ALM) to evaluate potential health risks from lead and to help establish cleanup levels. Finally, EPA has developed and implemented risk assessment guidance which evaluates the vapor intrusion pathway. These changes in methodology do not adversely affect the protectiveness of the remedy.

C. Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

Have newly found ecological risks been found?

Additional ecological pathways of concern that were not addressed in the original ecological risk assessment include direct exposure to aquatic life via groundwater discharge to Shell Creek, exposure to wildlife consuming water from Shell Creek, and exposure to livestock via ingestion of groundwater in stock wells. Tables 7 and 8 document that these potential ecological exposure pathways have been addressed. First, the maximum concentrations of contaminants in stock wells were compared to No-Observed-Adverse-Effect Level (NOAEL) benchmarks for cattle. Three scenarios are presented. First, NOAEL water concentrations were calculated for a calf weighing an average of 50 kg that drinks a portion of its water from stock wells per day. The next scenario is a pregnant cow weighing an average of 600 kg drinking a portion of her water from the stock well a day. Finally, the highest exposure scenario is for a dairy cow weighing 600 kg and drinking 100 liters per day from the stock well. All three scenarios assume the food was not contaminated and the only source of exposure is through drinking water. A NOAEL water concentration was not calculated for iron, but the maximum level of iron from the site is far above levels that may cause taste or appearance issues. Also, a NOAEL was not available for 1,1-DCA, so a NOAEL water concentration was not calculated. However, based on the NOAELs for other PCE/TCE break-down products, it is unlikely that 1,1-DCA would present a potential risk to cattle.

Next, the average groundwater concentrations of contaminants discharged to Shell Creek were compared to screening benchmarks for aquatic life as well as to NOAELs for wildlife that may be drinking from the creek. This comparison shows that concentrations of VOCs are well below conservative aquatic screening benchmarks and wildlife NOAELs. To determine if metal concentrations are meeting water quality criteria, the concentrations from G127000 were evaluated. Cadmium concentrations were all nondetect. The detection limit used for cadmium is above chronic criteria but below acute criteria.

Average lead and zinc concentrations detected at G127000 were above chronic criteria but well below acute criteria. At the highest hardness values of 400 ppm $CaCO_3$, lead and zinc concentrations fall below chronic criteria.

It may be appropriate to use acute criteria given that the groundwater is mainly discharged during the winter months or during periods of high rainfall. Groundwater in well G127000 does not exceed acute criteria for metals and is well below conservative screening criteria for VOCs. Metals and hardness data from surface water in Shell Creek compared to the water quality data and data from a suitable reference location upstream is recommended. This comparison would allow a more confident determination of the level of ecological risk posed by discharging groundwater into the creek.

Table 7: Ecological Assessment for Domestic Cattle

Contaminant	Maximum Concentrations in Stock Wells (µg/L)	Calf NOAEL (µg/L)	Cow NOAEL (µg/L)	Dairy Cow NOAEL (µg/L) 100 L/day
1,2-DCA	1.0	1.2e+5	6.5e+4	2.5e+4
1,1-DCE	38	1.3e+5	7.2e+4	2.8e+4
1,1, DCA	16	NA	NA	NA
1,2-DCE	2.5	1.1e+5	5.9e+4	2.3e+4
1,1,1-TCA	47	2.5e+6	2.3e+6	5.0e+6
Zinc	0.032	7.1e+5	3.8e+5	1.5e+5
Cadmium	0.002	4.5e+3	2.4e+3	932
Chromium	0.005	1.5e+4	7.8e+3	3.1e+4
Lead	0.002	3.6e+4	1.9e+4	7.5e+3
TCE	1.5	1.7e+3	905.6	353
PCE	130	3.5e+3	1.8e+3	710
Iron	0.05	NA	NA	NA
1,4-dioxane	23	2.2e+3	1.2e+3	466.1

Table 8: Ecological Assessment for Wildlife

Contaminant	*Maximum Concentrations in stock wells (µg/L)	Aquatic Screening Benchmark (µg/L)	Whitetail Deer NOAEL (µg/L)	Wild Turkey NOAEL (µg/L)
1,2-DCA	0.2 J	910	1.2e+5	5.3e+5
1,1-DCE	7.5 J	65	1.3e+5	NA
1,1, DCA	0.6 J	47	NA	NA
1,2-DCE	2.9	970	1.0e+5	NA
1,1,1-TCA	9.8 J	76	2.4e+6	NA
Zinc	120	80.0h	6.9e+5	4.4e+5
Cadmium	2.0 U	0.27h	4e+3	4.4e+4
Chromium	5.0 U	11	1.4e+4	3.1e+4
Lead	23.0	3.0h	3.4e+4	1.2e+5
TCE	0.2 UJ	350	1.6e+3	NA
PCE	7.5 J	120	3.3e+3	NA
Iron	48400	1000	NA	NA
1,4-dioxane	5.0 U	2.2e+4	2.1e+3	NA

h – Criteria calculated based on hardness

U – Nondetect

* Metal data taken from G127000 samples, VOC Data taken from Shell Creek.

Are there impacts from natural disasters (e.g., a 100-year flood)?

No natural disasters have been recorded on this site.

Has any other information come to light which could affect the protectiveness of the remedy?

LMC has submitted documents (URS, 2007d) indicating their intention to reclaim the land near the northern boundary of the facility for future expansion of facility operations. This area formerly contained an earthen disposal pit which received waste from the galvanizing process and portions of a burn pit which was also used to dispose of facility waste materials. The extent of soil contamination resulting from the previous waste disposal operations is being evaluated. At this time, the surface soil and shallow subsurface sampling results are not available to evaluate the residential and commercial/industrial pathways. The evaluation of residential and some industrial scenarios require near-surface soil samples; the evaluation of exposure to utility or construction workers requires samples from the top ten feet of soil. Figures 4.2-1, 4.2-2 and 4.2-3 of the RI report present isopleths maps of VOC contamination in soil borings but Table B shows that those results are from deep, rather than shallow, soil borings. Similarly, the results of limited sampling in the areas of Cell 1 and Cell 2 show the presence of contamination, particularly TCE and PCE (URS, 2007d), but no samples were taken at the surface or from depths greater than six feet. Lindsay will submit plans for additional sampling in the area of proposed reuse/reclamation which includes the former burn and disposal pits. The results of the additional sampling will be screened against EPA Region 6 MSSLs to determine if further on-site activities are warranted.

Lindsay's submitted a voluntary evaluation of potential supplemental groundwater remediation alternatives. Lindsay may wish to evaluate additional areas of the groundwater plume and source area as part of these supplemental alternatives to determine whether any residual materials exist and whether treatment of those materials would enhance the groundwater extraction system effectiveness. Areas where residual materials may be present include a former TCA tank site maintenance area and an area near the back door of the main plant where solvents and other degreasing compounds may have been discarded.

Consistent plume pumping, conducting timely activities concurrently to ensure that pumping remains consistent (meeting substantive permit requirements, securing landowner access, and installation and maintenance of equipment, etc.), and adequate capture zone evaluation are issues that have been raised in past Five-Year Reviews and site evaluations. These issues will be reviewed to determine an appropriate approach to minimize interruptions in plume capture. In addition, a summary evaluation of laboratory and field Quality Assistance/Quality Control (QA/QC) will be conducted to ensure that decisions continue to be made based on the best quality data and meet the requirements of the site O&M plan and QAPP. An evaluation of sample shipments over the past five years has shown that approximately half of the shipments received by the labs had some errors in consistency when received by the laboratory. These errors, while not severe enough to disqualify the data, do create concerns regarding consistency in collection and handling of the samples.

The 1990 ROD is silent with respect to institutional controls and their implementation. However, it does indicate that options will be evaluated as part of implementation of the ROD to ensure that drinking water wells are not installed in areas of the contaminant plume on- and off-site. The Site consent decree indicates that through additional response actions institutional controls can be implemented. Therefore, the availability of institutional control mechanisms and the opportunity to implement those at the Site shall be reviewed.

D. Technical Assessment Summary

VIII. ISSUES

Issue	Currently Affects Protectiveness (Y/N)	Affects Future Protectiveness (Y/N)
LMC is performing voluntary site activities. These activities included soil sampling in an area on their facility to promote reuse. The proposed reuse activity includes construction of a new building. The soil sampling has detected chemicals in the soil exceeding EPA Region 6 Medium Specific Screening Level (MSSL) screening criteria. The results are being evaluated with EPA Region 6 soil screening criteria, EPA Soil Screening Level guidance, and current EPA Region 7 risk evaluation policy. LMC has also expressed interest in further enhancing their groundwater extraction and treatment system. LMC provided a streamlined evaluation of potential supplemental groundwater remediation alternatives.	N	N
Groundwater contaminant migration has been delineated through a series of MWs and existing irrigation wells. The groundwater plume has migrated approximately 14,000 feet (2.65 miles) from LMC.	N	N
Surface water discharges were approved by NDEQ to promote year-round pumping in extraction wells G127000 and EXT07-02. Both discharges are into Shell Creek.	N	N
Vapor intrusion has not been assessed for occupied structures above the contaminant plume. VOCs including chlorinated solvents comprise the soil and groundwater contamination on the facility and in the groundwater off the facility.	N	N
In areas south of LMC, carbon tetrachloride and MTBE have been historically detected in groundwater. The carbon tetrachloride has been historically detected in two private wells located approximately 1,900 and 8,000 feet southeast, respectively, of the Village of Lindsay. Its presence was identified in the second Five-Year Review for the site. MTBE has been historically detected in a domestic well located approximately 750 feet southeast of the Village of Lindsay. The detections of these chemicals have not exceeded federal safe drinking water standards in the locations presented above. Based on the contaminants measured at the Site, the carbon tetrachloride and MTBE may be originating from another potential source or sources located upgradient to, cross-gradient to, or near the current groundwater plume detection locations.	N	N
Consistent plume pumping, conducting timely activities concurrently to ensure that pumping remains consistent (obtaining substantive permit requirements, securing landowner access, and installation and maintenance of equipment, etc.), and adequate capture zone evaluation are issues that have been raised in past Five-Year Reviews and evaluations. An evaluation of the sample shipments over the past five years has shown that approximately half have had some errors in consistency when received by the laboratory. The errors have not been severe enough to disqualify portions of the data sets, but have been identified as concerns regarding consistency in collection and handling of the samples.	N	N
The 1990 ROD is silent with respect to institutional control s and their implementation. However, it does indicate that options will be evaluated as part of implementation of the ROD to ensure that drinking water wells are not installed in areas of the contaminant plume on and off site. Institutional controls have not been implemented at the Site due to a historical absence of possible implementing mechanisms.	N	N

IX. RECOMMENDATION OF FOLLOW-UP ACTIONS

Issue	Recommendations/ Follow up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness? (Y/N)	
					Current	Future
LMC voluntary site source area reuse activities and voluntary potential supplemental groundwater activities	Further assessment of the area of proposed construction activities will be conducted by Lindsay to determine the lateral and vertical extent, any current and future risks, and if any further action is warranted. Based on these facility data and Lindsay's interest in enhancing groundwater treatment, Lindsay may also consider supplemental remediation in other areas on the Lindsay facility property and other portions of the groundwater plume as part of their assessment for enhancing groundwater treatment.	LMC	EPA/NDEQ	December 31, 2009	N	N
Groundwater contaminant plume migration and delineation	Extraction well and discharge authorizations for G127000 and EXT07-02 were completed by LMC to capture and treat the distal portion of the groundwater contaminant plume. Both extraction wells are currently pumping continuously. If needed, additional MWs may be required to assess plume capture and treatment. As identified above, LMC may consider additional groundwater remedial alternatives.	LMC	EPA/NDEQ	December 31, 2008	N	N
Surface water discharge and ecological surface water quality criteria	A ecological technical assessment was performed to evaluate the discharge from the permitted location. Acute surface water ecological criteria is considered appropriate given that the groundwater is mainly discharged during the winter months or during periods of high rainfall. Groundwater in well G127000 does not exceed acute criteria for metals and is well below conservative screening criteria for VOCs. However, additional samples for metals and hardness data from surface water in Shell Creek shall be collected and compared to surface water quality criteria. The additional data will provide a greater confidence interval for chronic surface water ecological criteria.	LMC	EPA/NDEQ	December 31, 2008	N	N

					Affects Protectiveness? (Y/N)	
Vapor intrusion evaluation	Lindsay shall identify occupied structures located above the chlorinated solvent plume. Lindsay shall determine if vapor intrusion is likely in these structures based on EPA guidance and if so, shall conduct vapor intrusion sampling to determine risk. If an increased risk is identified that threatens human health, Lindsay shall install vapor mitigation systems to reduce the risk. Lindsay shall begin its evaluation in the source area near the area proposed for reuse activities.	LMC	EPA/NDEQ	December 31, 2008	N	N
Carbon tetrachloride and MTBE detections in groundwater below safe drinking water act levels that are not thought to be related to LMC	The locations of detections for carbon tetrachloride and MTBE will be referred to the NDEQ and EPA site assessment programs for further evaluation and/or assessment, if determined to be necessary.	EPA/NDEQ	EPA/NDEQ	September 30, 2008	N	N
Plume pumping, capture zone analysis, and sample handling	Lindsay shall ensure the extraction wells pump continuously at designed rates, evaluate the capture zone in detail, and recommend any further assessment which may include soil and or groundwater samples, and evaluate the current sample collection and handling procedures in accordance with the O&M plan and QAPP and take corrective actions as needed.	LMC	EPA/NDEQ	December 31, 2008	N	N
Institutional controls	The site consent decree indicates that through additional response actions institutional controls can be implemented. Therefore, the availability of institutional control mechanisms and the opportunity to implement those at the site shall be reviewed.	LMC/ EPA/NDEQ	EPA/NDEQ	July 3, 2013	N	N

X. PROTECTIVENESS STATEMENT

The remedy at the site is currently protective of human health and the environment. There are no known nearby residents currently being exposed to the Lindsay contamination. At present, Lindsay is conducting quarterly groundwater monitoring of all domestic supply wells identified in the path of the groundwater plume or potential pathway. In addition, if any domestic or stock well is found to be contaminated, Lindsay will provide alternate water supplies.

Additional irrigation extraction wells have been installed to contain the migration of the contaminant plume. Additional MWs were installed to define the extent of the downgradient region of the groundwater plume. All other threats have been addressed by prior efforts.

Long-term protectiveness of the RA will be verified by continued inspections, maintenance, and groundwater sampling at the Site as specified in the O&M Plan. Current data indicate no exposure to groundwater contaminants in the wells in the surrounding area other than identified during the second Five-Year Review. Two domestic wells are currently being treated to remove the contamination. Current monitoring indicates that the remedy is functioning based on declining trends measured downgradient in contamination. Further review of plume capture and sample handling will be conducted. The potential for site-related vapor intrusion will be evaluated. The opportunity for implementation of institutional controls at the Site shall be reviewed.

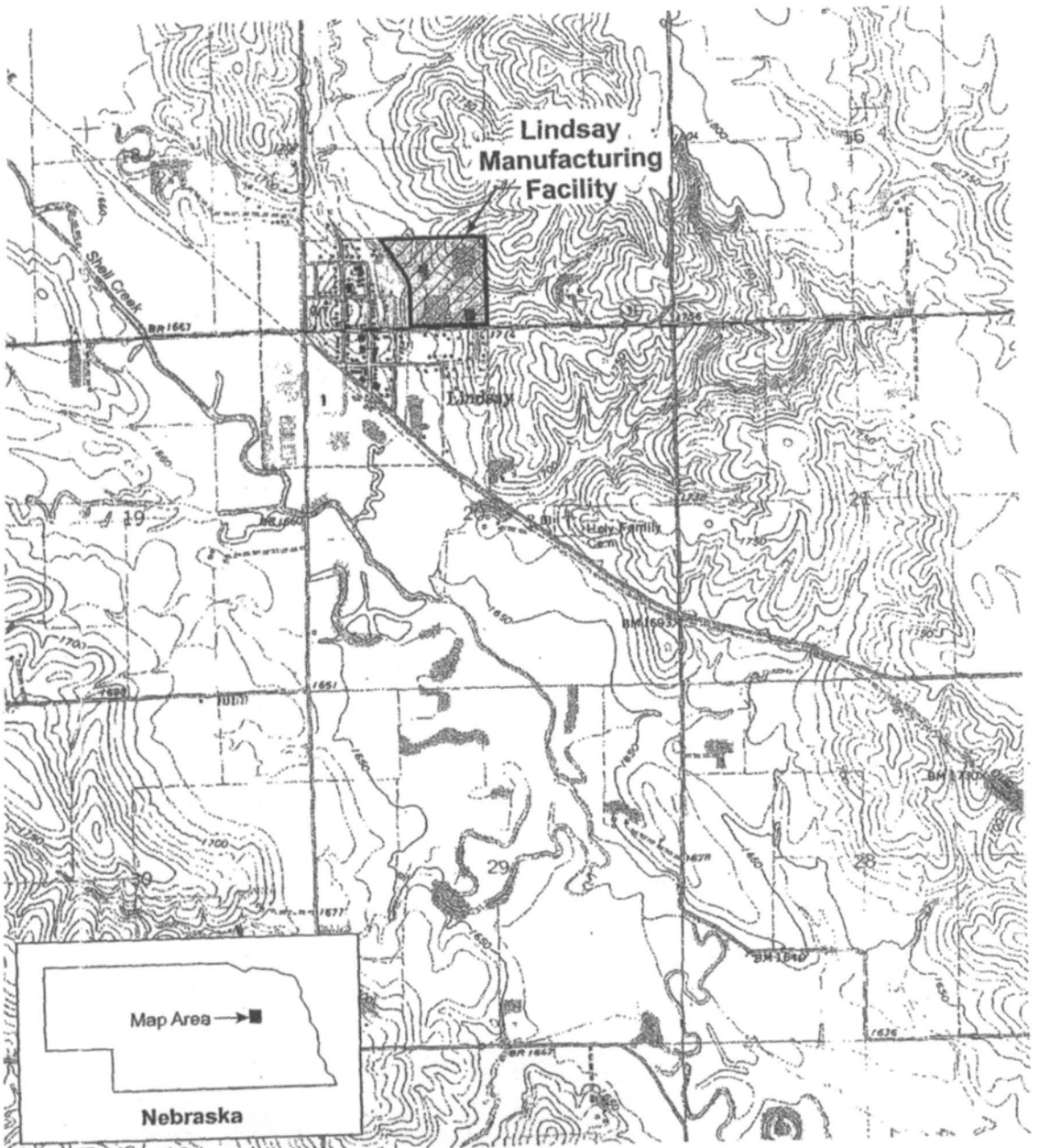
XI. NEXT REVIEW

The next Five-Year Review for the Site is required five years from the date this review is signed. EPA and NDEQ may consider conducting another review of the effectiveness of the systems at Lindsay earlier if conditions change or otherwise warrant such evaluation.

ATTACHMENTS

ATTACHMENT 1

SITE LOCATION MAP



SOURCE: USGS 7.5-minute topographic map, Lindsay, Nebraska, revised 1985

0 2,000 4,000

Scale in Feet

Figure 1

Vicinity Map

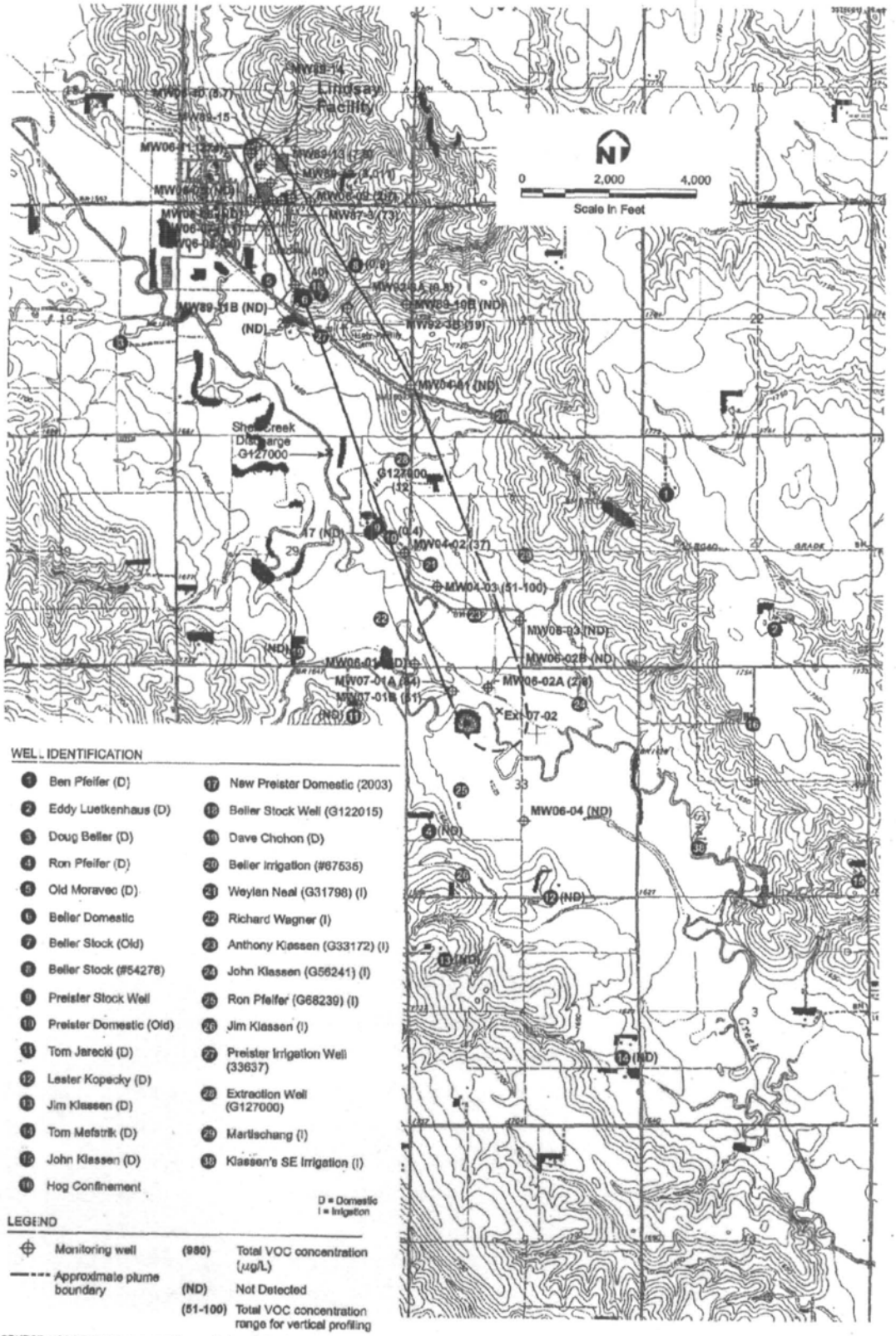
Job No. 38759811

URS

Lindsay Manufacturing LLC
Lindsay, Nebraska

ATTACHMENT 2

Site Plan Showing Monitoring Well Locations



SOURCE: USGS 7.5-minute topographic map, Lindsay, Nebraska, revised 1985

Job No. 33759811

Figure 11

Total VOC Concentrations (February 2008)

URS

Lindsay Manufacturing LLC
Lindsay, Nebraska

ATTACHMENT 3

Graphs showing total VOCs and 1,4-dioxane vs. time in extraction and monitoring wells

Figure 3.1: Total VOCs, Lindsay facility wells - perched sand channel

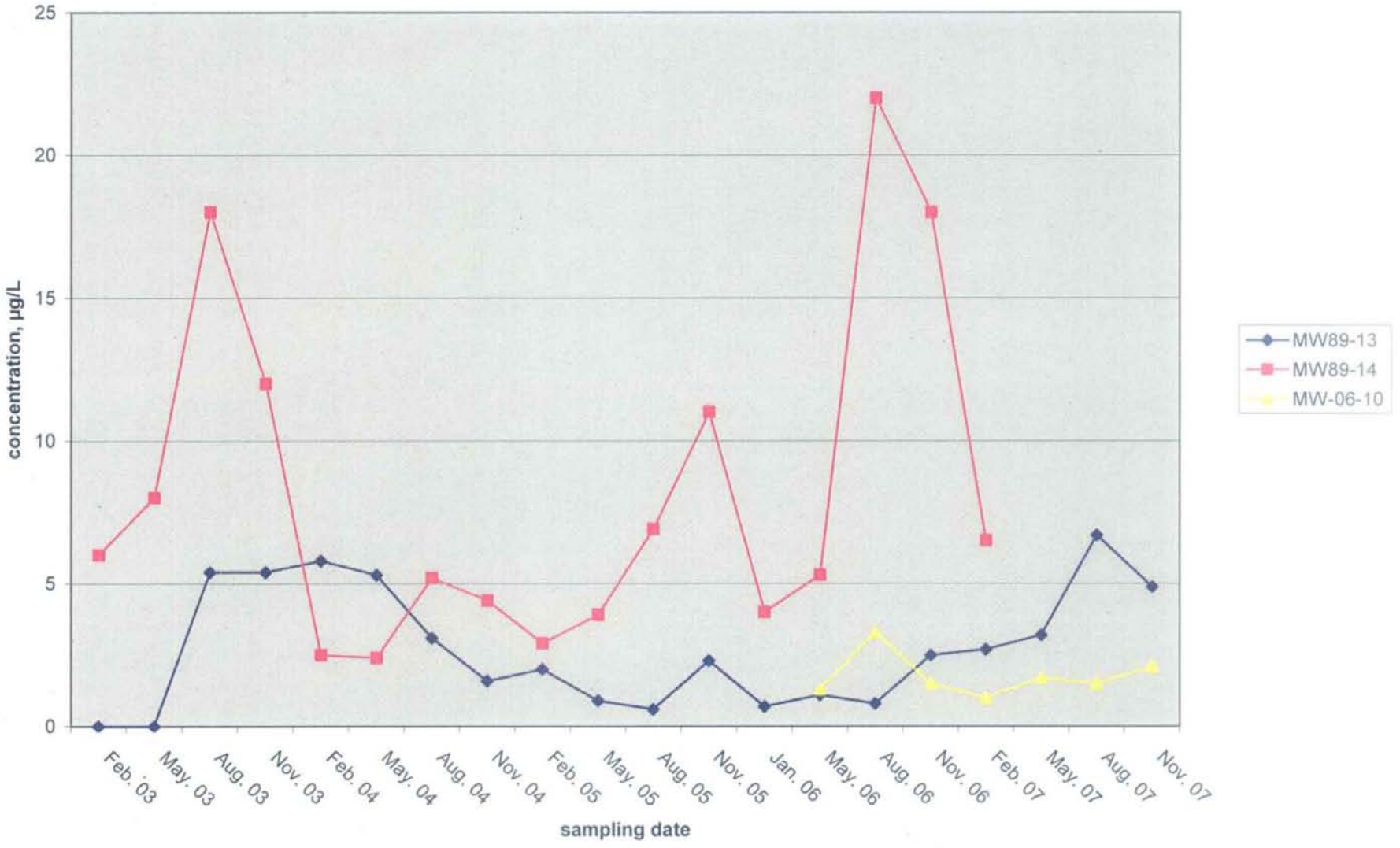


Figure 3.2: Total VOCs, Lindsay facility wells - sand & gravel aquifer

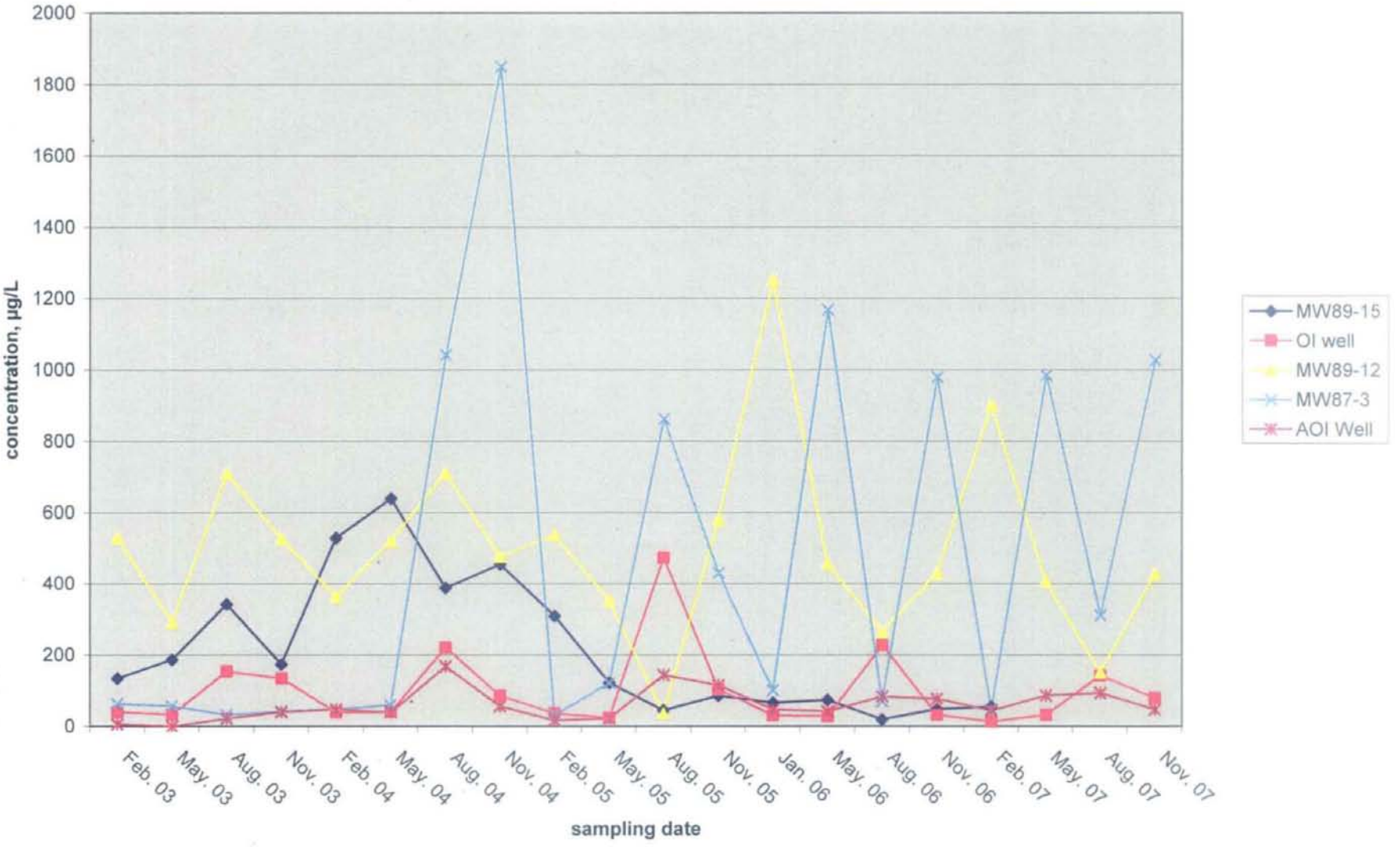


Figure 3.3: Total VOCs, Lindsay north area wells

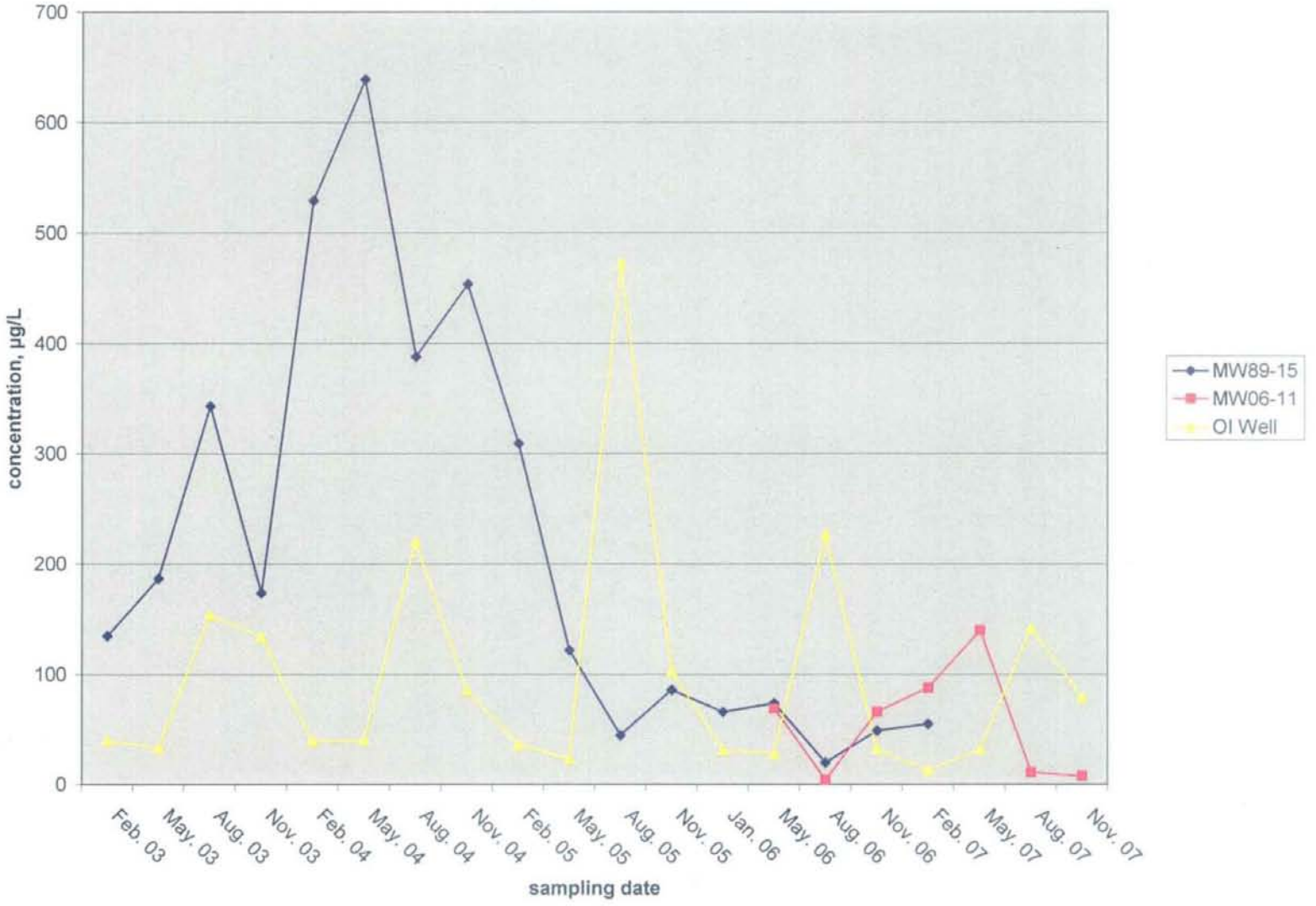


Figure 3.4: Total VOCs - Lindsay main area wells

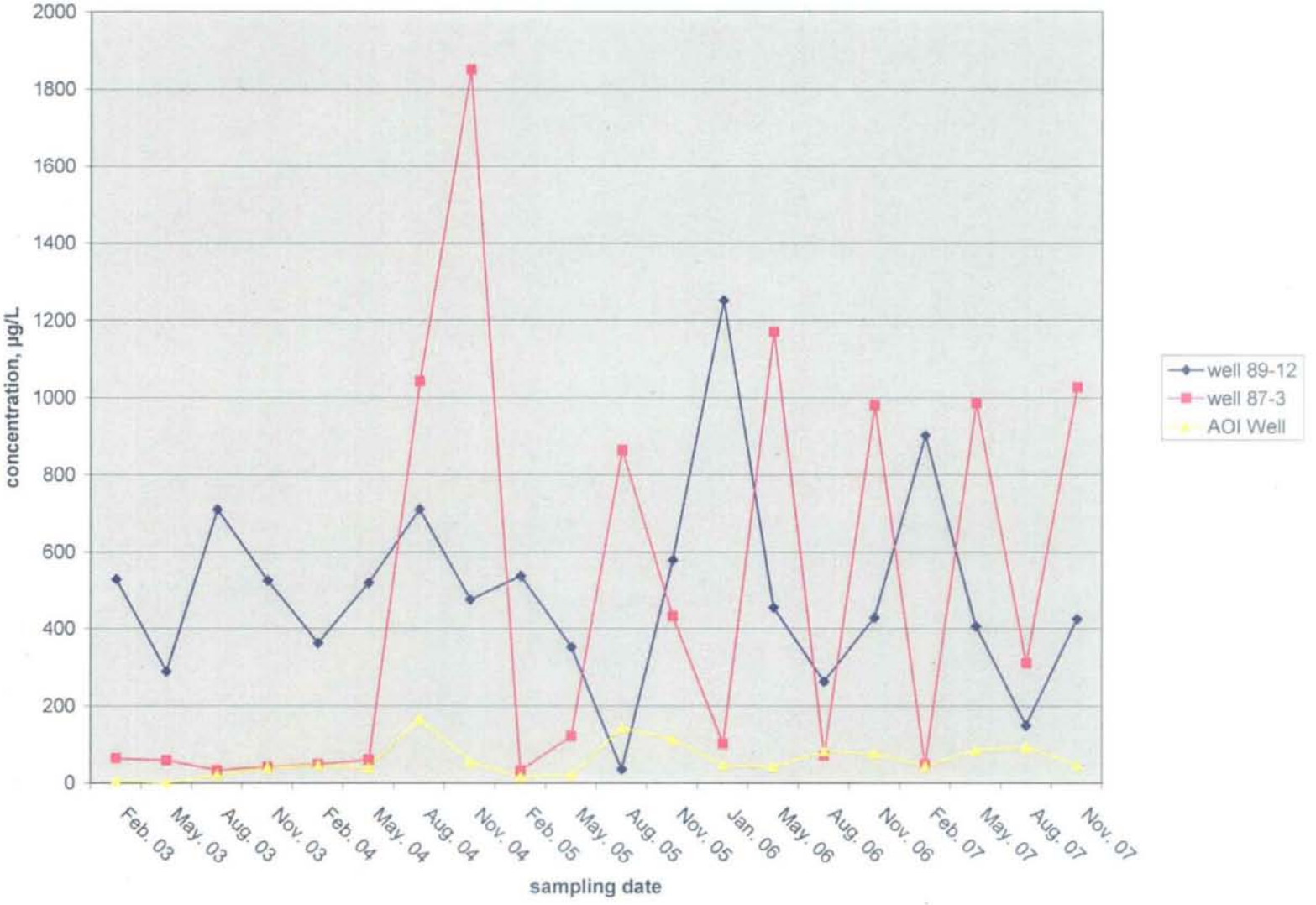


Figure 3.5: Total VOCs, hwy 91 monitoring wells

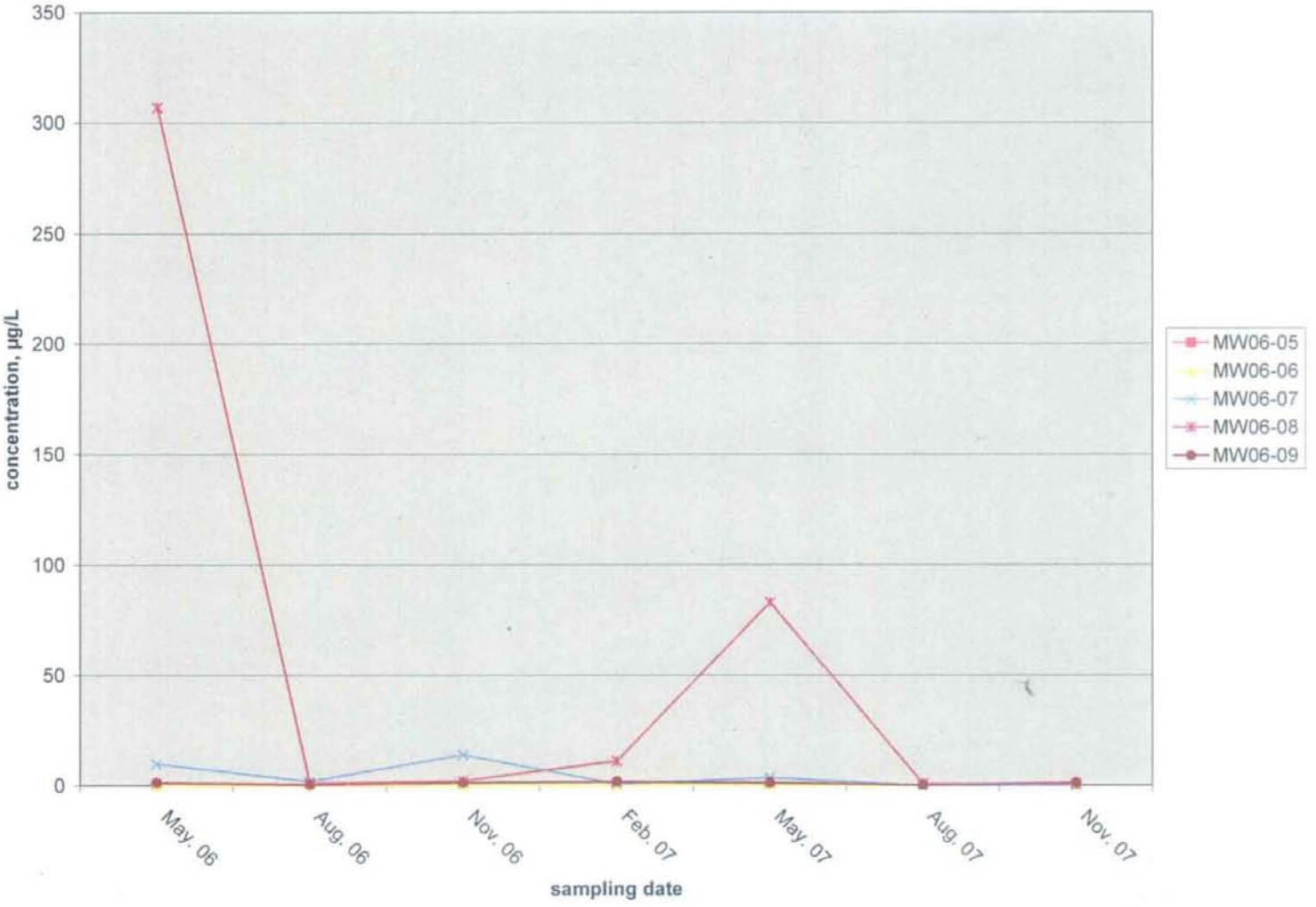


Figure 3.6: Total VOCs, Lindsay downgradient wells - sand & gravel aquifer

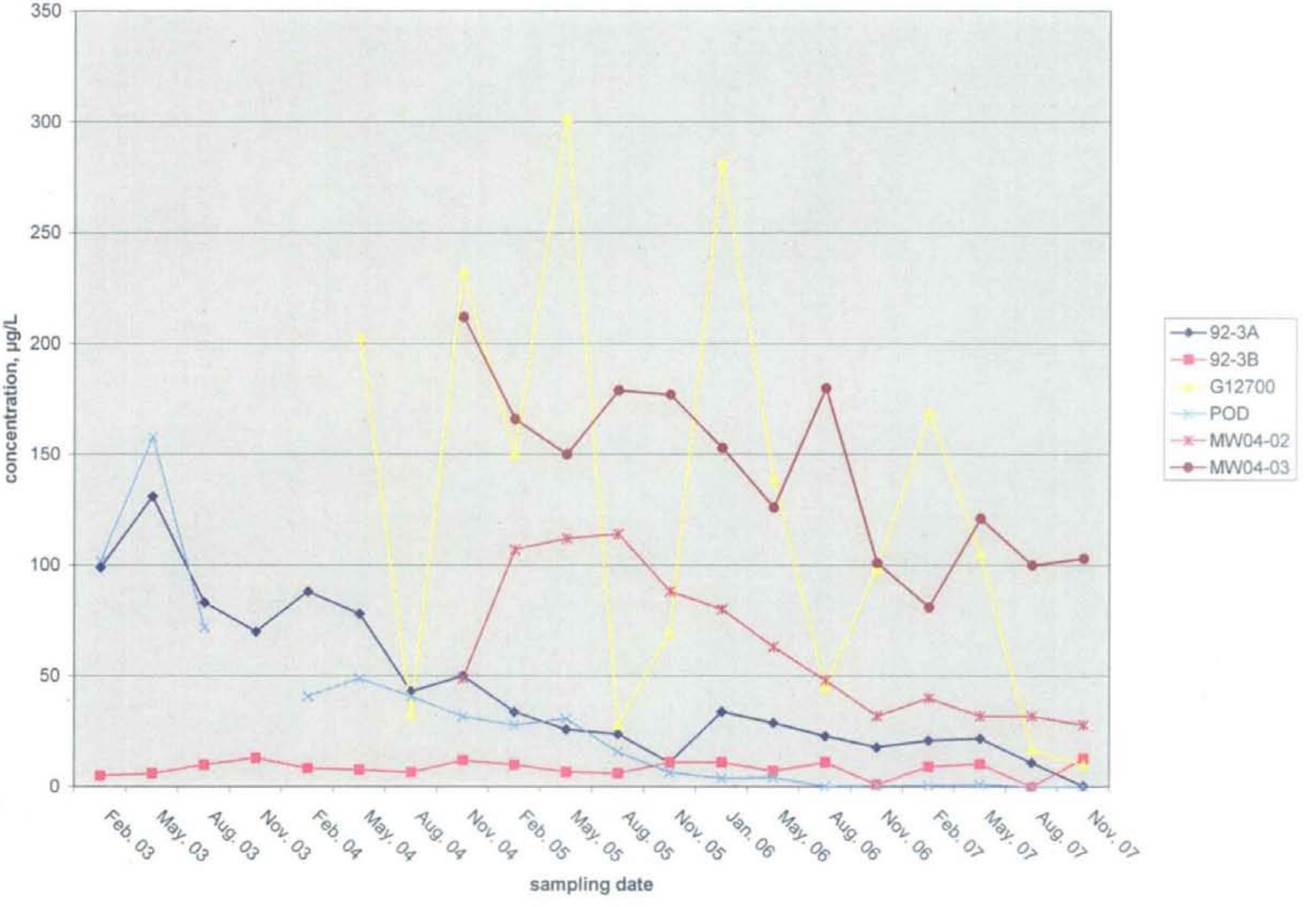


Figure 3.7: Total VOCs, Beller farm vicinity wells

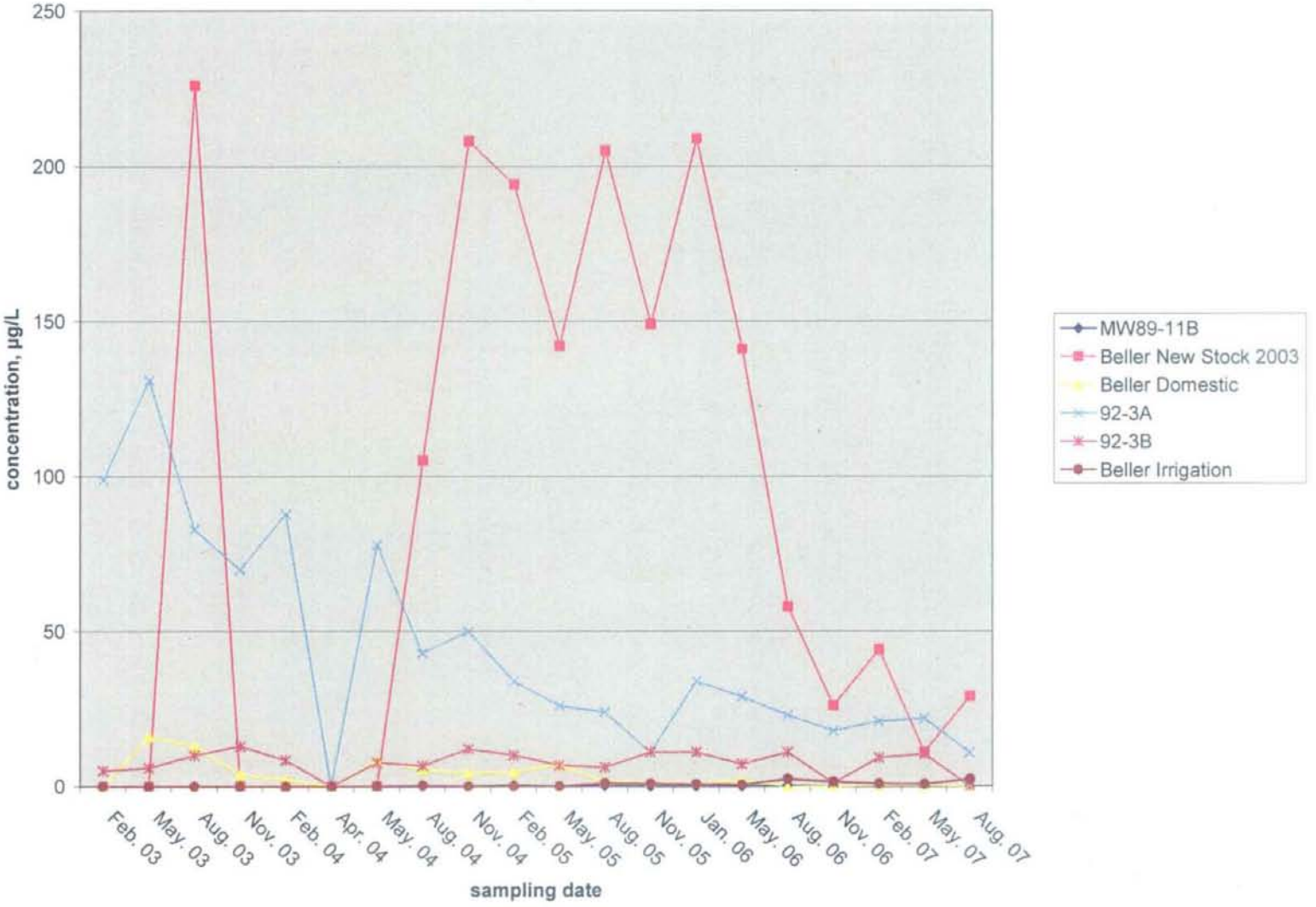


Figure 3.8: Total VOCs, Priester Farm vicinity wells

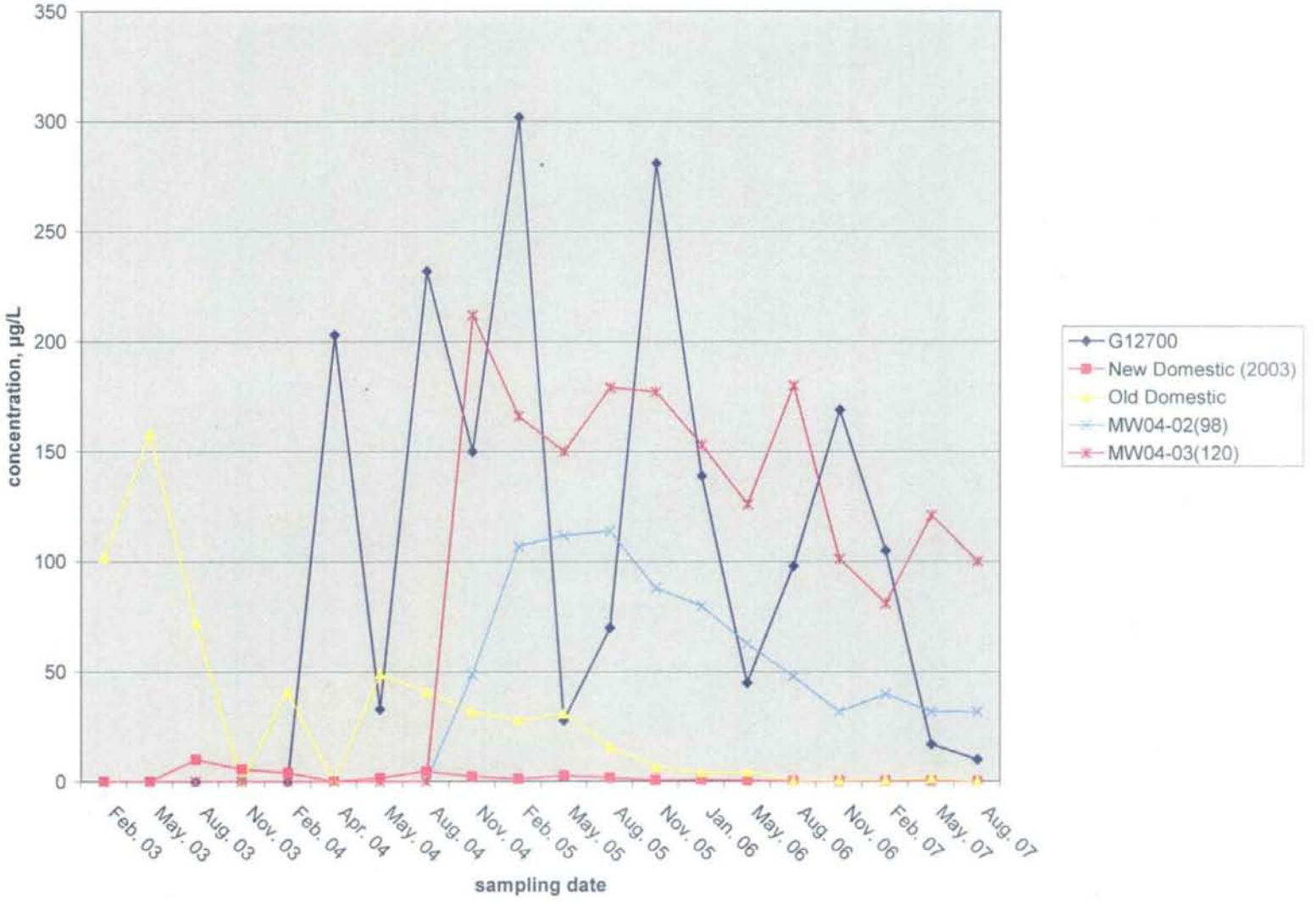


Figure 3.9: 1,4-dioxane - Lindsay north area wells

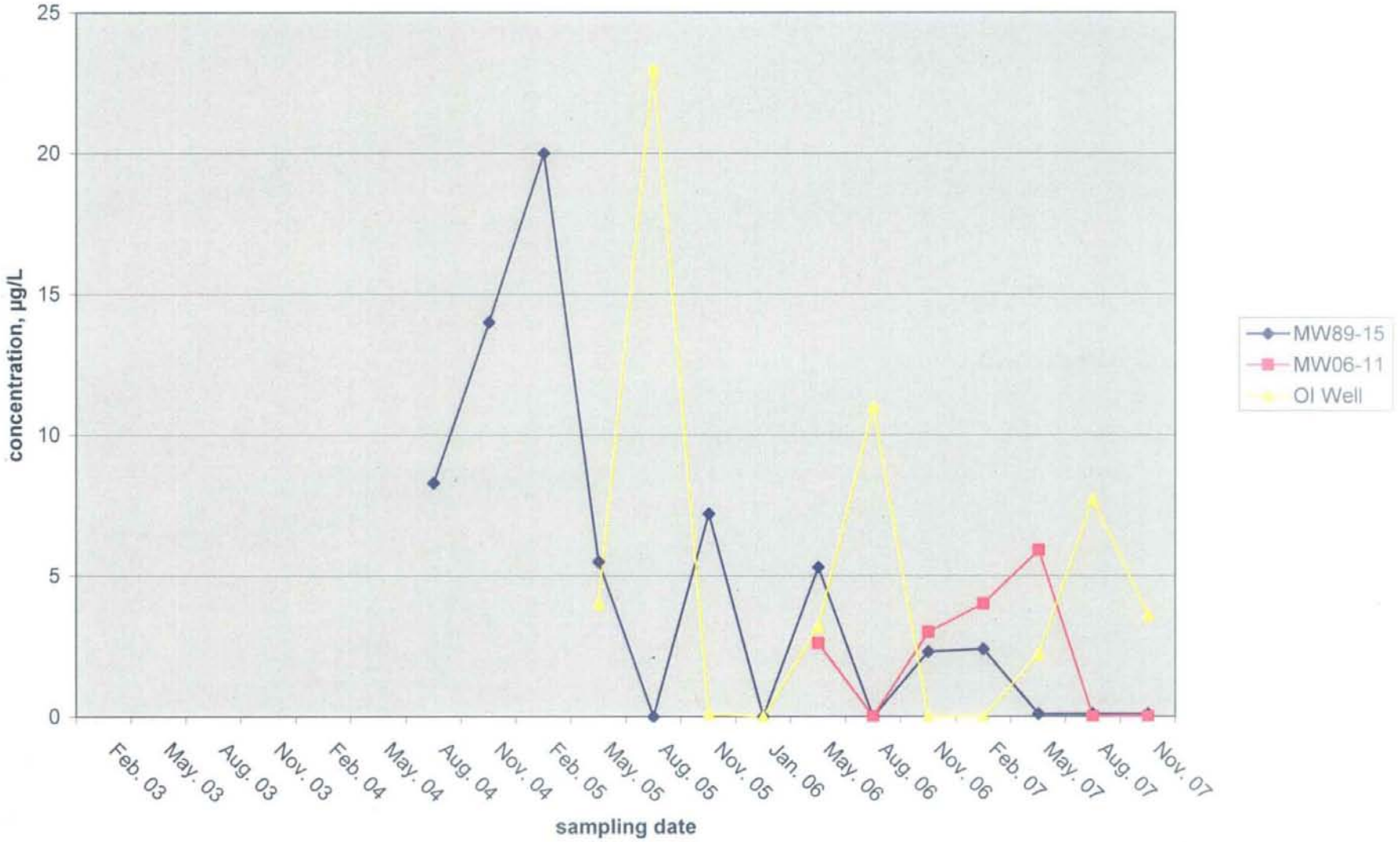


Figure 3.10: 1,4-dioxane - Lindsay main area wells

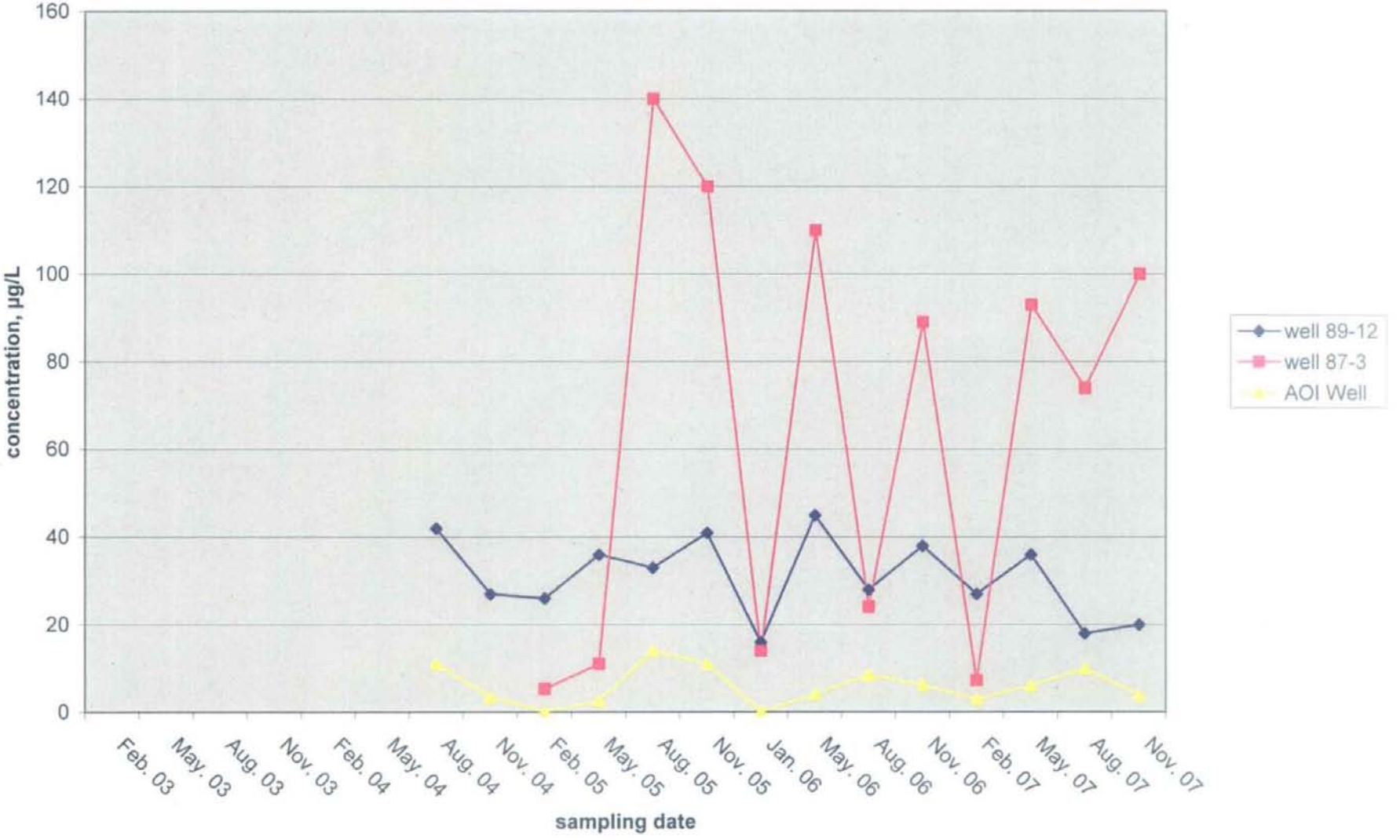
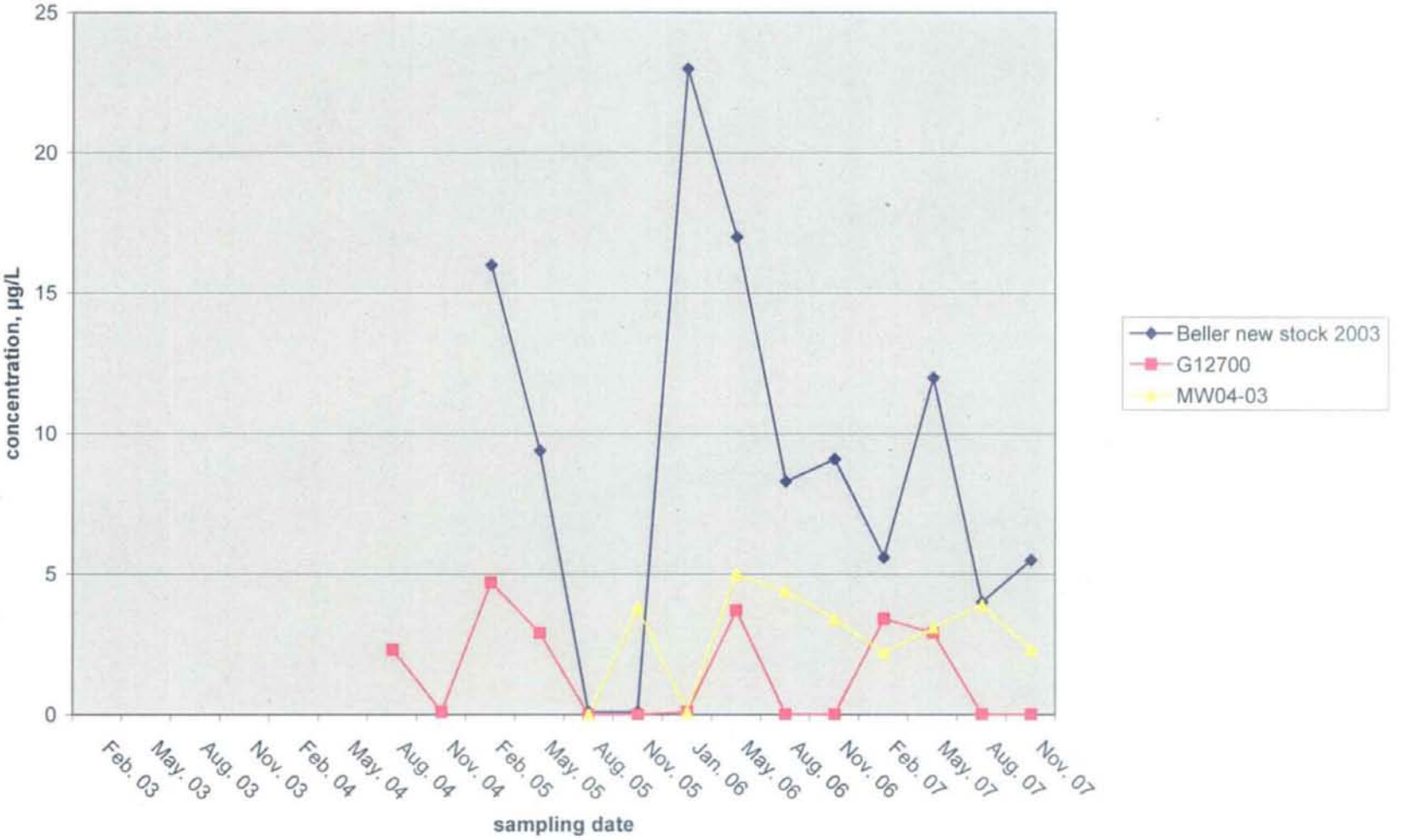


Figure 3. 11: 1,4-dioxane - Lindsay downgradient wells



ATTACHMENT 4

Graphs showing metals vs. time in extraction and monitoring wells

Figure 4.1: Cadmium, chromium, & lead in Lindsay north area wells

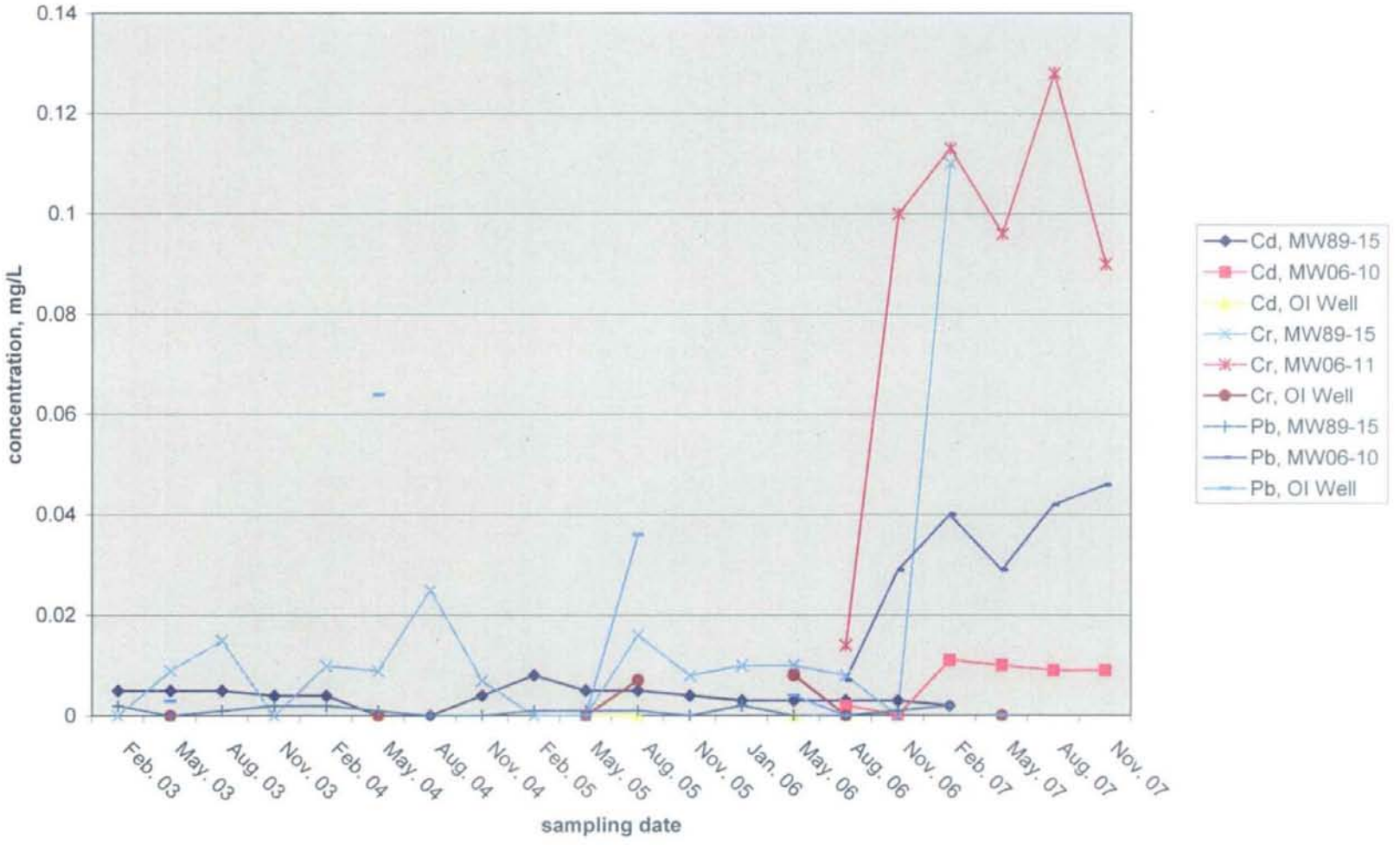


Figure 4.2: Iron & zinc in Lindsay north area wells

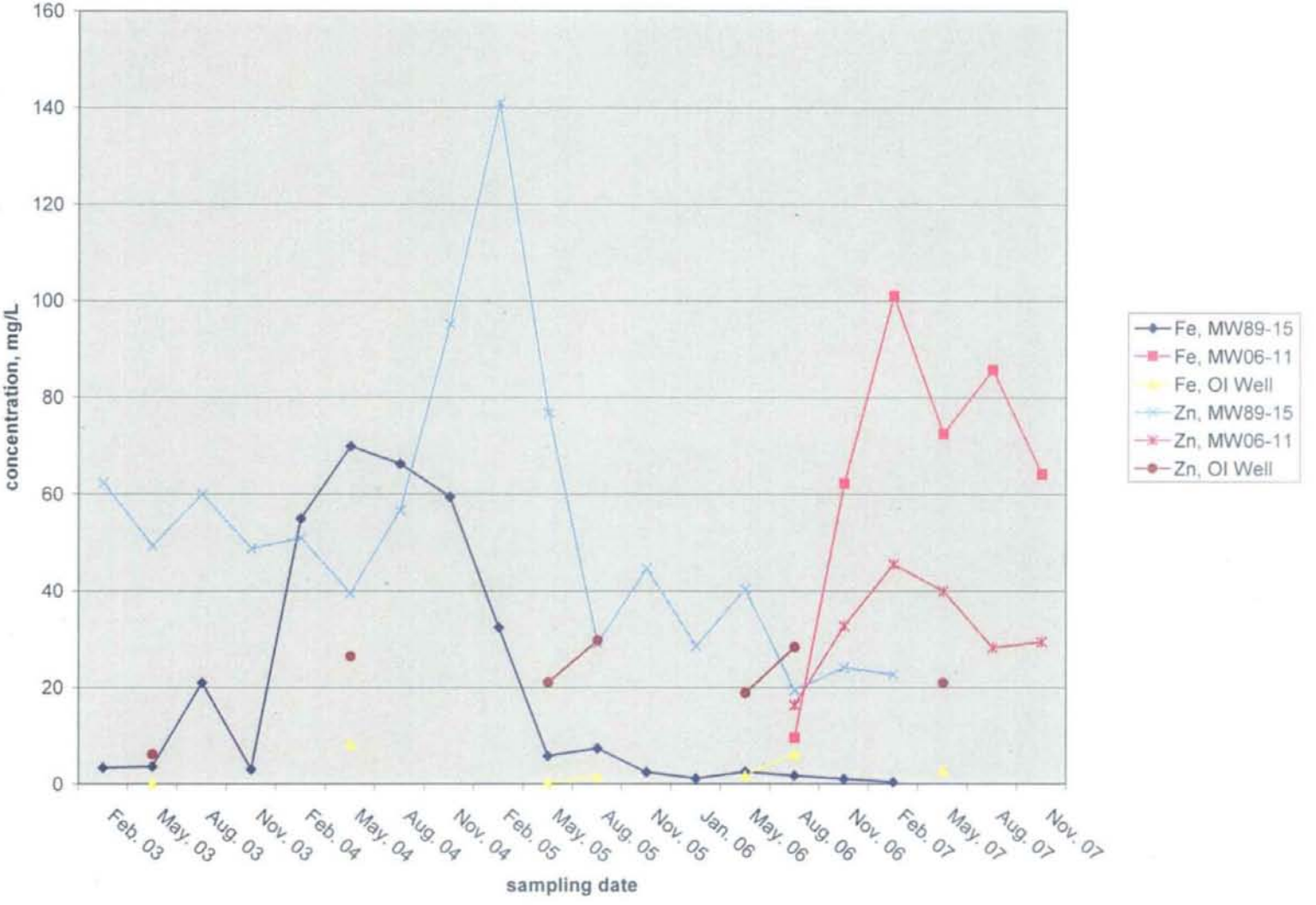


Figure 4.3: Cadmium, chromium, & lead in Lindsay main area wells

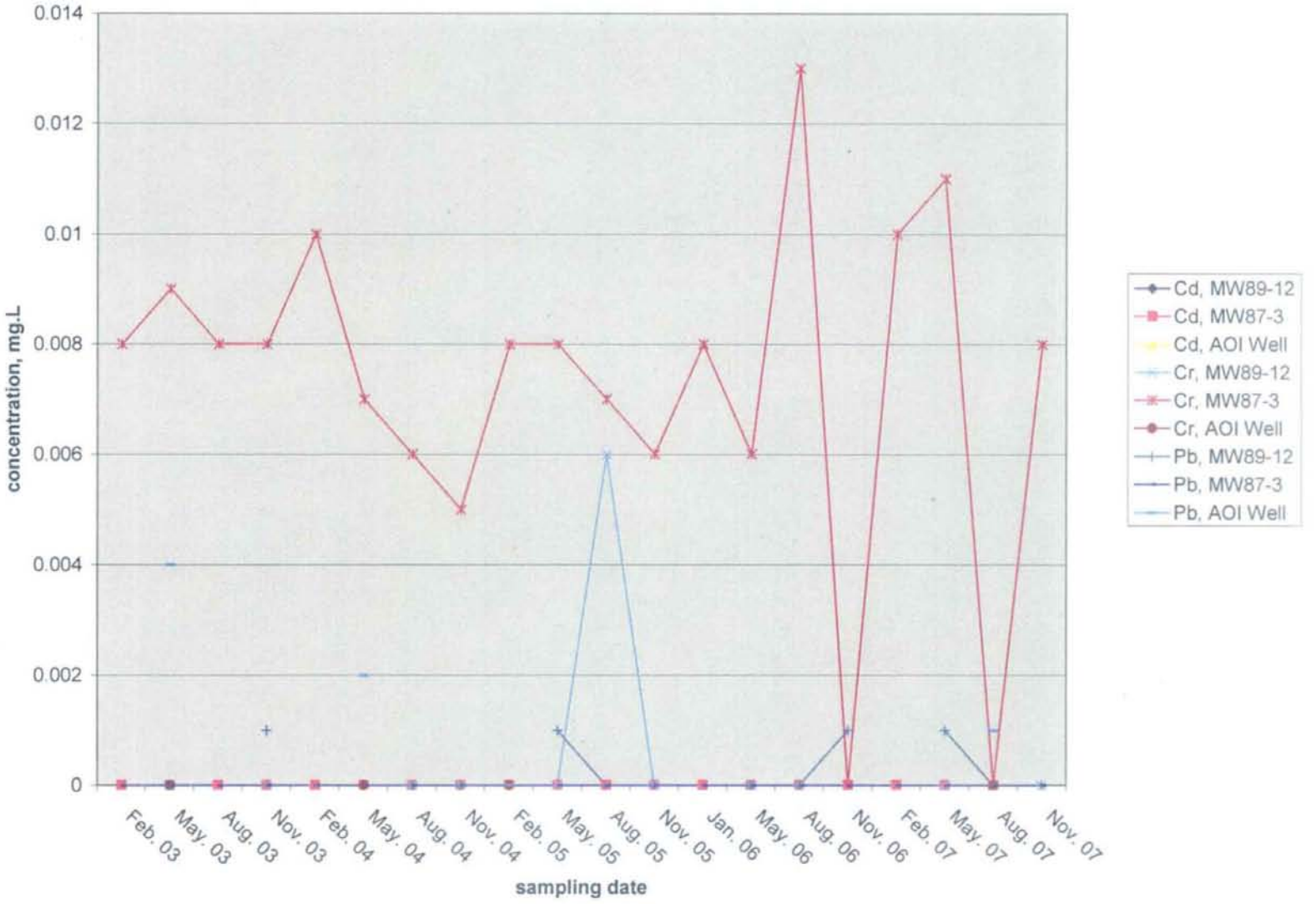


Figure 4.4: Iron & zinc in Lindsay main area wells

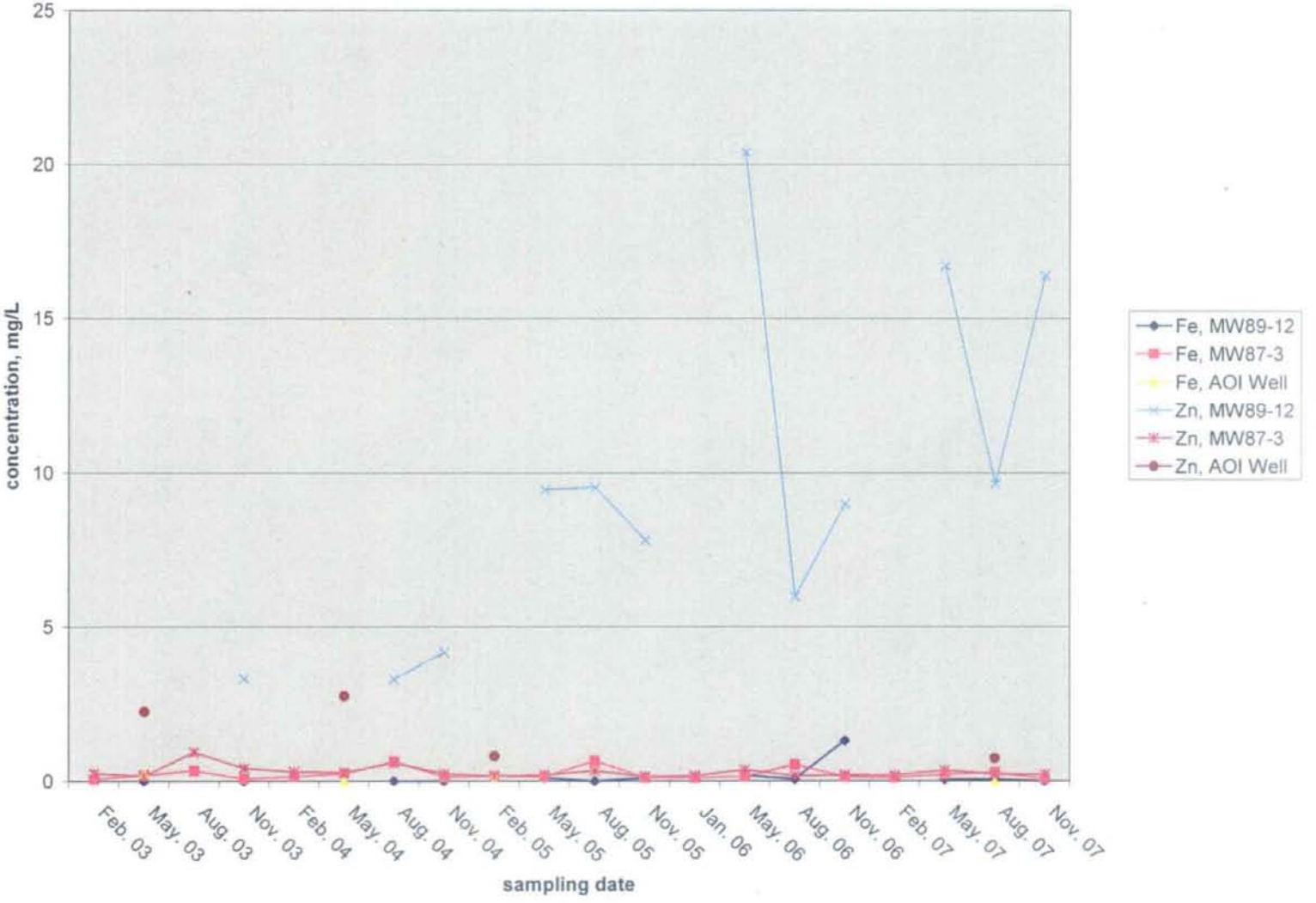


Figure 4.5: Cadmium in hwy 91 wells

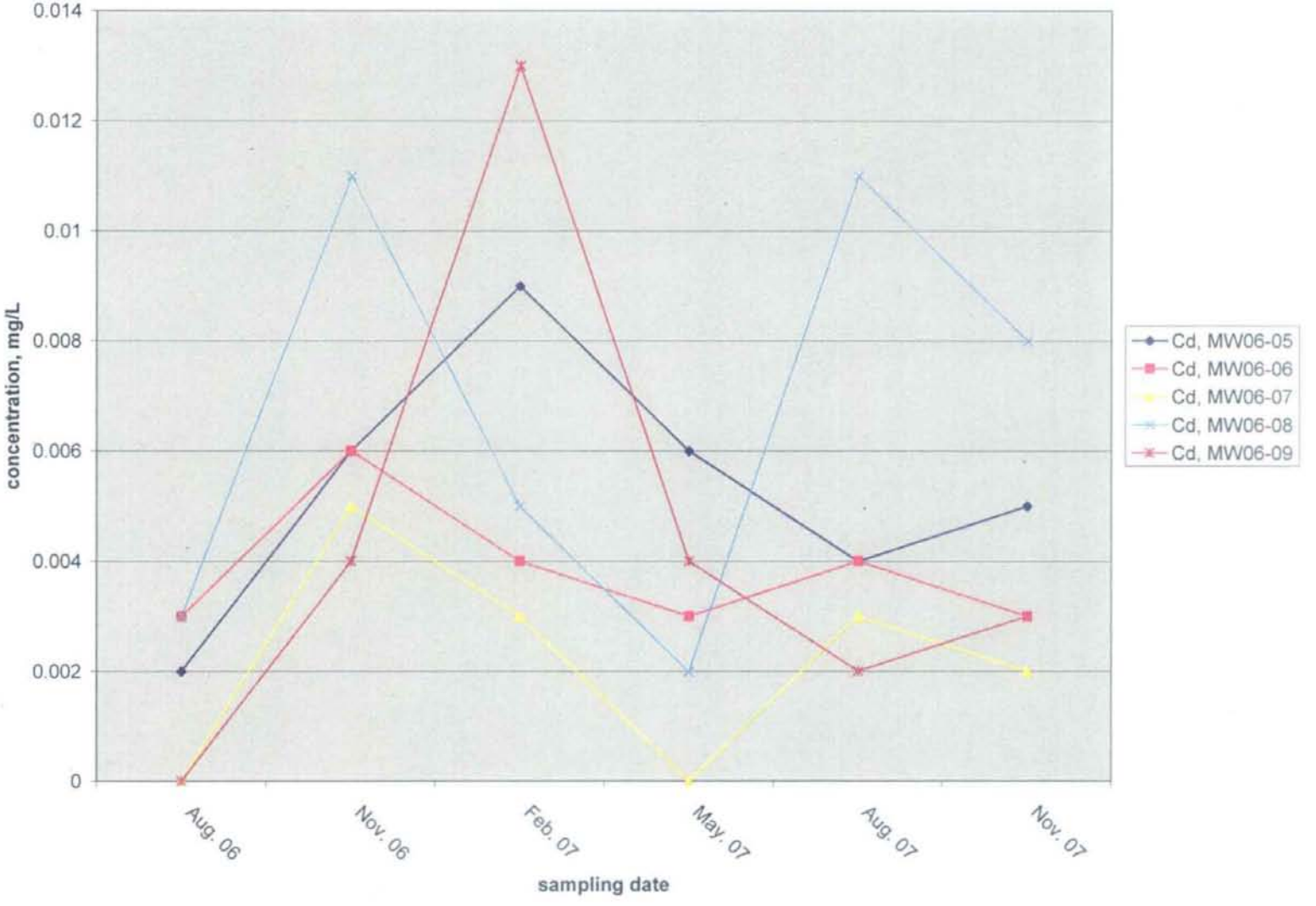


Figure 4.6: Chromium in hwy 91 wells

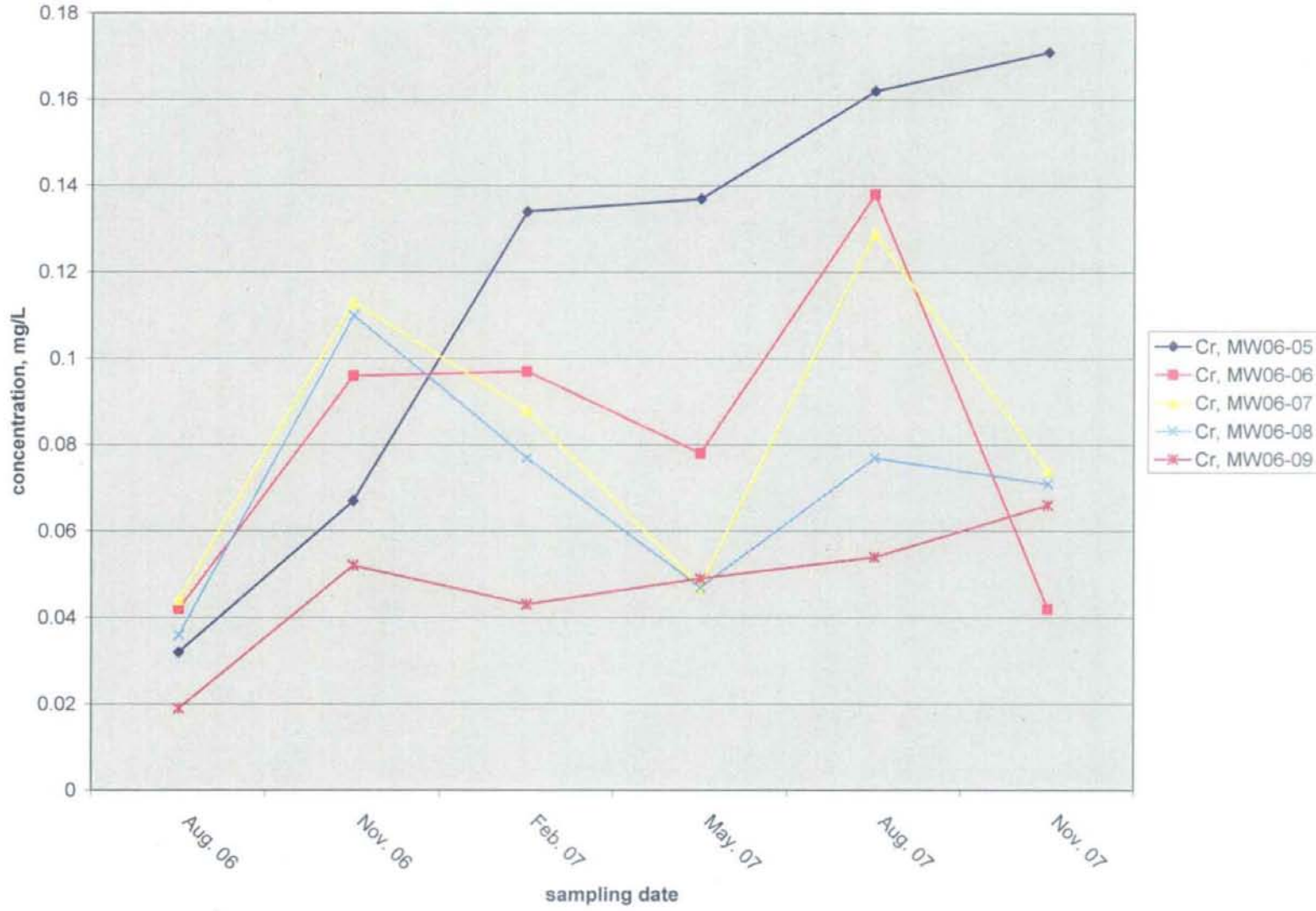


Figure 4.7: Lead in hwy 91 wells

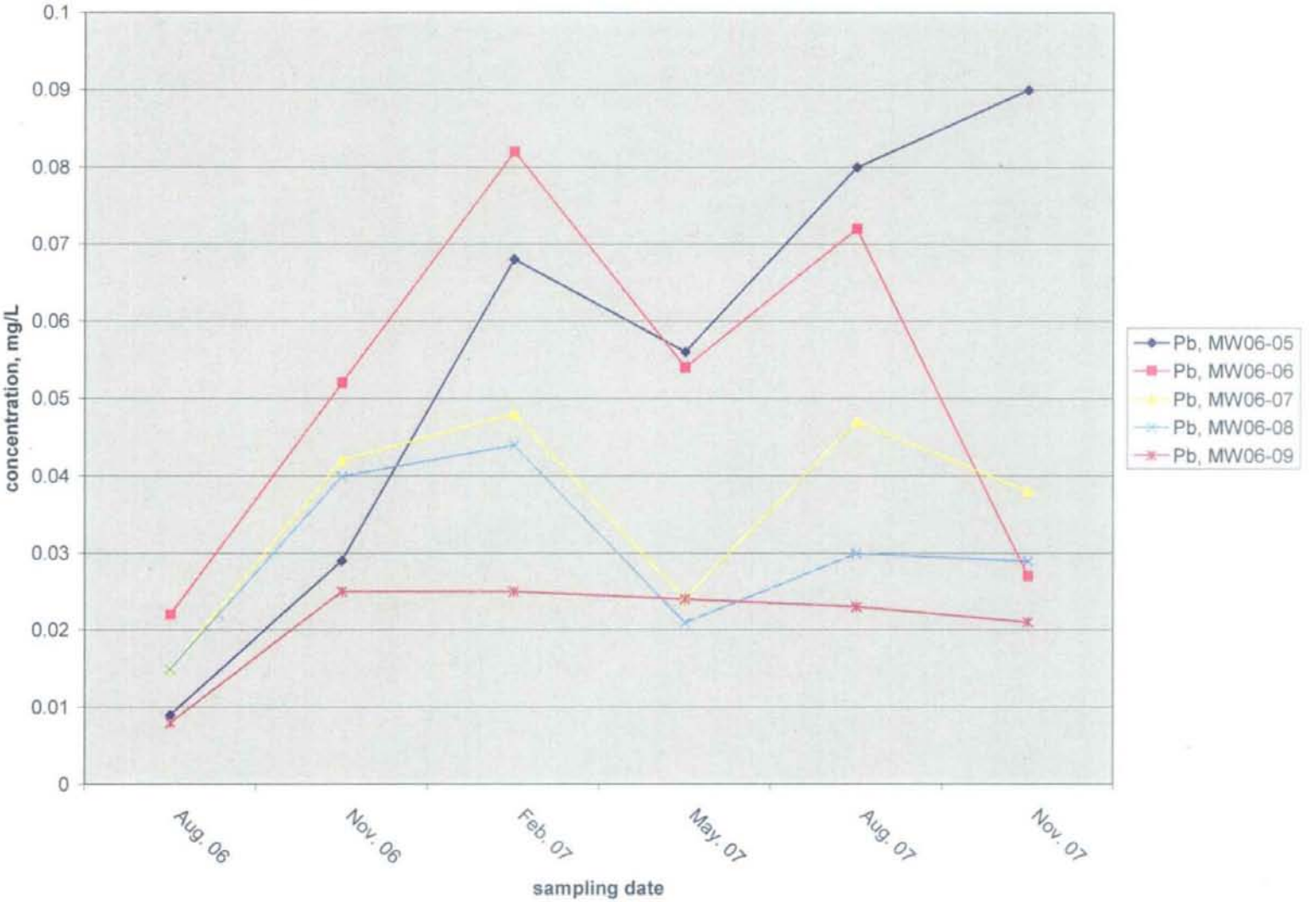


Figure 4.8: Iron in hwy 91 wells