DEQ Water Quality Division

Second Trend Analysis of Food Processor Land Application Sites in the Lower Umatilla Basin Groundwater Management Area

State of Oregon
Department of Environmental Quality

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LIST OF ACRONYMS

DEQ	Oregon Department of Environmental Quality
EPA	United States Environmental Protection Agency
GWMA	Groundwater Management Area
LOWESS	LOcally WEighted Scatterplot Smoothing
LUB GWMA	Lower Umatilla Basin Groundwater Management Area
mg/l	milligram per liter
ODA	Oregon Department of Agriculture
ppm	part per million
ppm/yr	part per million per year
USGS	United States Geological Survey

EXECUTIVE SUMMARY

This document describes the second trend analysis of nitrate concentrations in groundwater monitoring wells at twelve sites operated by six facilities located in the Lower Umatilla Basin Groundwater Management Area (LUB GWMA) where food processor wastewater is treated through land application.

Purpose of this Report

The purpose of this report is to evaluate one specific measure of progress detailed in the LUB GWMA Action Plan (the Action Plan). That measure of progress (Section VIII, Item G.3.c) relates to the land application of food processing wastewater and states, in part, that by December 2005 "monitoring data shows improving groundwater quality trends for nitrate". Average nitrate concentrations and each site's hydrogeologic setting were also considered in order to better evaluate the factors affecting nitrate concentrations.

Methods

Nitrate concentrations at groundwater monitoring wells were evaluated for monotonic trends using the Seasonal Kendall technique (when no data were censored) or the Censored Kendall technique (when data were censored). A data smoothing algorithm was used to produce a LOWESS line which is useful for identifying non-linear water quality changes. Maps depicting the nitrate trends and average nitrate concentrations at each well were produced. Trends and average nitrate concentrations were compared between this and the previous trend analysis. At the two sites not previously evaluated, groundwater elevation maps were prepared and used to select upgradient and downgradient wells. Conclusions regarding nitrate trends, as well as potential effects from each facility, were drawn using groundwater quality data and water level information, often including the selected upgradient and downgradient wells.

Conclusions

Nitrate concentrations are increasing at most wells, and at most sites. Therefore, the measure of Action Plan progress that states "monitoring data shows improving groundwater quality trends for nitrate" was not met. On the whole, the rate of increase is slower than it was during the previous analysis. In addition, the average nitrate concentration at most sites exceeds the GWMA trigger level. However, the trend analysis does not by itself provide an indication of whether or not the nitrate contamination is the result of current facility operations. Other factors that can affect nitrate trends include historical facility activities, offsite activities (both current and historical), and the site's hydrogeology. Potential methods exist to assess current facility operations, and include "age dating" groundwater samples and/or performing a detailed evaluation of the site's hydrogeology, land use, and contaminant transport regime.

Recommendations

Both site-specific and general recommendations are made in this report. The site-specific recommendations include additional assessment activities at several facilities in order to better define the site's groundwater flow regime and/or to determine the source of nitrate in groundwater. The general recommendations include pursuing funding to gauge the effects of BMP implementation, continued and expanded BMP implementation, and completion of the 2010 trend analysis required by the Action Plan.

Although nitrate concentrations are increasing at most wells and at most sites, there are some wells and sites where nitrate concentrations are decreasing. It is also recommended that DEQ and the food processors work together to identify what combination of factors produces the improving water quality trends, then apply those factors elsewhere, with the hope of improving water quality trends across the GWMA.

REGISTERED PROFESSIONAL GEOLOGIST SEAL

In accordance with Oregon Revised Statutes Chapter 672.505 to 672.705, specifically ORS 672.605 which states:

"All drawings, reports, or other geologic papers or documents, involving geologic work as defined in ORS 672.505 to 672.705 which shall have been prepared or approved by a registered geologist or a subordinate employee under the direction of a registered geologist for the use of or for delivery to any person or for public record within this state shall be signed by the registered geologist and impressed with the seal or the seal of a nonresident practicing under the provisions of ORS 672.505 to 672.705, either of which shall indicate responsibility for them.",

I hereby acknowledge that the document cited below was prepared by me.

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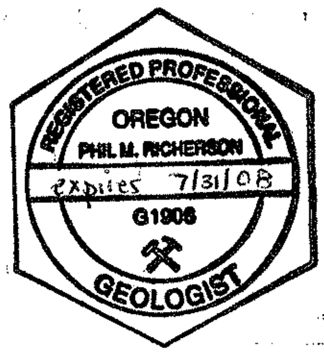

1.0 INTRODUCTION

1.1 Establishment of the Lower Umatilla Basin Groundwater Management Area

Oregon's Groundwater Protection Act of 1989 requires the DEQ to declare a Groundwater Management Area (GWMA) if area-wide groundwater contamination, caused primarily by nonpoint source pollution, exceeds certain trigger levels. In the case of nitrate, the trigger level is 7 milligrams per liter (mg/l) nitrate-nitrogen. Nonpoint source pollution of groundwater results from contaminants coming from diffuse land use practices, rather than from discrete sources such as a pipe or ditch. The contaminants of nonpoint source pollution can be the same as from point source pollution, and can include sediment, nutrients, pesticides, metals, and petroleum products. The sources of nonpoint source pollution can include construction sites, agricultural areas, forests, stream banks, roads, and residential areas.

When a GWMA is declared, the Groundwater Protection Act requires the establishment of a local Groundwater Management Area Committee comprised of affected and interested parties. The committee works with and advises the state agencies that are required to develop an action plan to reduce groundwater contamination in the area.

The Lower Umatilla Basin Groundwater Management Area (LUB GWMA) was declared in 1990 after nitrate contamination was identified in a 352,000-acre area in the northern portions of Umatilla and Morrow counties. The location of the LUB GWMA is shown in Figure 1-1. Groundwater samples from private wells had nitrate contaminations above the federal safe drinking water standard in many samples collected from the area. A four-year comprehensive study of the area was conducted in the early 1990s by the DEQ, the Oregon Water Resources Department, and the Oregon Health Division (now known as the Oregon Department of Human Services). The 1995 report titled "Hydrogeology, Groundwater Chemistry, & Land Use in the Lower Umatilla Basin Groundwater Management Area" identified five potential sources of nitrate loading to groundwater:

1. Confined Animal Feeding Operations,
2. Irrigated Agriculture
3. Land Application of Food Processing Wastewater
4. Septic Systems (rural residential areas), and
5. The Umatilla Chemical Depot Washout Lagoons

The LUB GWMA Action Plan was finalized in December 1997. The Action Plan details the activities to be conducted by the various agencies and organizations involved. The Umatilla and Morrow County Soil and Water Conservation Districts are the local agencies leading implementation of the Action Plan. The DEQ and the Oregon Department of Agriculture (ODA) have oversight responsibility. Local governments, private industry, and the US Army are also involved in implementation of the Action Plan.

DEQ and the Committee decided to implement the Action Plan on a voluntary basis recognizing that individuals, businesses, organizations, and governments will, if given adequate information and encouragement, take positive actions to adopt or modify practices and activities to reduce contaminant loading to groundwater.

The Action Plan recommends general activities and specific tasks to be conducted by involved agencies and groups representing the five sources of nitrate loading. The Action Plan also identifies methods and a schedule for evaluating progress in implementing the Action Plan.

1.2 Purpose of This Report

The purpose of this report is to evaluate one specific measure of progress detailed in the Action Plan. That measure of progress (Section VIII, Item G.3.c) relates to the land application of food processing wastewater and states, in part, that by December 2005, "monitoring data shows improving groundwater quality trends for nitrate". As of December 2005, there were six facilities within the LUB GWMA that land applied food processing wastewater at twelve sites. Figure 1-2 indicates the location of these twelve sites.

The nitrate trend analysis at these wells does not by itself provide an indication of whether or not the nitrate contamination is the result of current facility operations. Other factors that can affect nitrate trends include historical facility activities, offsite activities (both current and historical), and the site's hydrogeology. In an attempt to account for some of these other factors, average nitrate concentrations and the site's hydrogeologic setting were considered in order to better evaluate the factors affecting nitrate concentrations.

1.3 Methodology

The evaluation described in this report involved three aspects:

1) an evaluation of nitrate trends at wells located near where food processing wastewater is land applied,
2) an evaluation of average nitrate concentrations at these wells, and
3) a comparison to previous trends and average concentrations.

As part of a United States Geological Survey (USGS) study funded by the United States Environmental Protection Agency (EPA), the apparent recharge age of groundwater was calculated in the vicinity of two of the food processor land application sites. Results from this study were also considered when evaluating factors affecting nitrate concentrations at those sites.

Analysis of Censored Data

Some wells exhibited some data censoring (i.e., when values are reported as below a detection limit). For those wells with some data censoring, two values were entered into the electronic files for each result. The first value was the measured concentration for detected concentrations or the detection limit for censored values. The second value was a code indicating if the first value represents a detected concentration or the detection limit for a censored observation.

The censored data were recorded in this manner to allow more statistically robust evaluations of data set characteristics and trends. The procedures recommended in Helsel (2005) for computing summary statistics, estimating seasonality, and calculating trends were followed using macros written by Dr. Helsel for use within the Minitab statistical software program. These include the following:

- For wells with a small amount of censoring (<50%), the mean and median were calculated by the Kaplan-Meier method using the KMBMean and KMBoot macros.
- For wells with a significant amount of censoring (50% to 80%), the mean and median were calculated by the Maximum Likelihood Estimation method using the MLEBoot macro.
- Seasonality at wells with censoring was evaluated using the nonparametric Kruskal-Wallis test for comparing medians. The CensKW macro was used for these calculations.

Trend Analysis Technique Used

Nitrate results from wells with no censoring were analyzed for a monotonic trend using the Seasonal Kendall test. The Seasonal Kendall test was developed by the USGS in the 1980s and has become the most frequently used test for trend in the environmental sciences (Helsel, et.al. 2006). The Seasonal Kendall test performs separate tests for trends in each season, and then combines the results into one overall result.

The Seasonal Kendall test accounts for seasonality by computing the Mann-Kendall test on each season separately, and then combining the results. For example, February data are compared only to February data. No comparisons are made across seasonal boundaries. The overall Seasonal Kendall trend slope is computed as the median of all slopes between data points within the same season. No cross-season slopes contribute to the overall estimate of the Seasonal Kendall trend slope. This slope is the median rate of change over time. This overall result reflects whether there is a trend with time for that location, blocking out all seasonal differences in the pattern of change (Helsel and Frans, 2006).

Trends at wells with censoring were calculated by the Helsel-Turnbull adaptation of the Theil-Sen slope estimate herein called the Censored Kendall technique. This is a nonparametric regression line based on Kendall's tau correlation coefficient. The Ckend macro was used for these calculations.
In order to be consistent with previous trend analyses conducted by DEQ in Eastern Oregon GWMAs, a confidence level of 80% was used to distinguish between statistically significant trends (i.e., those with an 80% or higher confidence level) versus statistically insignificant trends (i.e., those with less than 80% confidence level). Appendix 1 of DEQ (2004) includes a discussion of the principles of trend analysis, including the Seasonal Kendall technique.

In addition to calculation the Seasonal Kendall trend, a locally weighted scatterplot smoothing (LOWESS) line was also calculated for each well. The LOWESS line is similar to a moving average and provides a good depiction of the underlying structure of the data. The LOWESS technique is discussed in more detail in Appendix 1 of DEQ (2004).

Average Nitrate Concentrations

The monitoring wells at the twelve land application sites were installed at various times. The average values indicated in summary tables of this report include the entire data set used for the trend analysis. However, in order to better facilitate comparisons across a particular site, the average values indicated in the figures of this report use the timeframe in which all wells were installed and sampled.

Comparison to Previous Analysis

At the ten sites previously analyzed, a comparison was made between the previous (through 2001) and current (through 2005) trend analyses. Changes in data set statistics as well as changes in the nitrate trends are summarized. These changes are then summarized as indications of improving and worsening water quality at each site.

Changes in Data Set Statistics

For each sample location evaluated during both analyses, five changes in data set statistics are evaluated:

1. The difference between the current and previous minimum value detected is indicated. If the current minimum equals the previous minimum, a value of zero is indicated. If the current minimum is less than the previous minimum, the difference between the two values is indicated.
2. The difference between the current and previous maximum value detected is indicated. If the current maximum equals the previous maximum, a value of zero is indicated. If the current maximum is higher than the previous maximum, the difference between the two values is indicated.
3. The difference between the current and previous mean value is indicated. If the current mean is higher than the previous mean, a positive value is indicated. Conversely, if the current mean is lower than the previous mean, a negative value is indicated.
4. The difference between the current and previous median value is indicated. If the current median equals the previous median, a value of zero is indicated. If the current median is higher than the previous median, a positive value is indicated. If the current median is lower than the previous median, a negative value is indicated.
5. The number of additional samples analyzed since the previous trend analysis is indicated. Most locations have about 16 additional samples.

Trend Analysis Steps

The specific steps used to conduct the trend analyses and prepare the tables and figures in this report include the following 15 steps:

1. *Compile the data submitted to DEQ by the permittee for each site*. Most of the data were in electronic format. Some recent data were provided verbally or from documents recently submitted to DEQ. It was assumed that the data sets were correct and complete. No attempts were made by DEQ to verify the data submitted. Furthermore, it was assumed that sampling and analytical procedures were consistent at each well.
2. *Thin the data to one sample per quarter*. Some wells at some facilities were sampled monthly for a while and then were sampled quarterly. In order to avoid biasing summary statistics, these data sets were thinned. The data point closest to the middle of the quarter was retained while the remainder of the data points was deleted.
3. *Condition the data*. Data conditioning was performed on censored data and sample dates. Data conditioning of censored data consisted of entering two values into the electronic file for each result. The first value was the measured concentration for detected concentrations or the detection limit for censored values. The second value was a code indicating if the first value represents a detected concentration or a censored observation. Data conditioning of sample dates consisted of (1) replacing “month/year” sample dates with the 15th day of the month (e.g., February 1995 was replaced with 2/15/95), (2) replacing “quarter/year” sample dates with the date of the middle of the quarter (e.g., 1st Quarter 1995 was replaced with 2/15/95), and (3) converting sample dates to a decimal date format (e.g., 2/15/95 = 1995.123) for plotting purposes.
4. *Look for outliers.* The data were visually examined for obvious outliers and potential transcription errors. If a data point was suspected of being an error, efforts were made to trace the data back to the original laboratory report to confirm the result. Statistical outliers were not deleted from the data set.
5. *Create input files for the statistical and graphing software programs used*. Input files for the software programs used to calculate summary statistics, evaluate data set characteristics, perform the trend analyses, and prepare graphs were prepared. Software programs used in this study include Minitab version 14 (from Minitab, Inc.), and Grapher version 6 (from Golden Software, Inc). The use of product names is for information purposes only. DEQ does not advocate the use of any particular software.
6. *Evaluate data set characteristics* including minimum, maximum, mean, median, sample size, and percentage of censored data.
7. *Calculate a monotonic trend line using the Seasonal Kendall or Censored Kendall technique.*
8. *Calculate a LOWESS line through nitrate data for each well.*
9. *Create time series plots* for each well including the trend line and LOWESS line at a scale appropriate for the nitrate range at each well.
10. *Create a one-page summary of LOWESS and trend lines at a scale appropriate for the nitrate range at each site.*
11. *Create a plot of all nitrate data from the site with a LOWESS line fit through the data.*
12. *Create a map illustrating the magnitude and direction of nitrate trends at each well.*
13. *Create a map illustrating the average nitrate concentration at each well.*
14. If not previously done in (DEQ, 2004), create a water table contour map and *identify upgradient and downgradient wells.*
15. *Create a time series plot and box plot of upgradient and downgradient nitrate concentrations.*

2.0 PORT OF MORROW SITES

2.1 Introduction

The Port of Morrow currently land applies approximately 1.3 billion gallons of wastewater and 4.4 billion gallons of supplemental irrigation water annually to approximately 8,500 acres near Boardman, Oregon. The wastewater consists largely of potato and onion processing wastewater. Other food processing wastewater streams include cheese and mint processing wastewater. In addition to the food processing wastewater, the Port of Morrow also land applies cooling tower wastewater, boiler lowdown, the City of Boardman's treated sewage (applied to Circle 52 at Farm 1), and floor/equipment wash water from the Portland General Electric Coyote Springs Co-Generation Plant. Future plans include the land application of wastewater from another co-generation plant, and a wine bottle manufacturing plant.

On average, the wastewater in 2005 contained approximately:

- 98 mg/l Total Kjeldahl Nitrogen (TKN),
- 29 mg/l ammonia (NH_4-N),
- 1,967 mg/l Total Dissolved Solids (TDS),
- 932 mg/l Total Suspended Solids (TSS), and
- 2,936 mg/l Chemical Oxygen Demand (COD).

The Port of Morrow land application areas are located approximately 3 miles east of the City of Boardman, in the vicinity of US Interstate 84 and US Highway 730 (Figure 1-2). The wastewater, along with supplemental fresh water, is land applied on three parcels of land known as Farm 1, Farm 2, and Farm 3.

Principal components of the Port of Morrow's wastewater treatment and disposal system include a clarifier and vacuum filter for potato processing wastewater, a pump station with lined overflow pond, land application areas, and a 196 million gallon lined storage lagoon. Farm 1 is located north of Interstate 84 on 1,512.3 acres. Farm 2 is located south of Interstate 84 on 1,466.6 acres. Farm 3 is located immediately east of Farm 1 and consists of 3810.1 acres; of which 2520.3 acres north of Highway 730 began receiving wastewater in October 2002. To this date, the remaining third of Farm 3 (i.e., south of Highway 730) continues to be farmed using conventional irrigated agricultural practices. The Port of Morrow contracts for management of the farming activity on the farms where wastewater is land applied.

Figure 2-1 shows the locations of Farm 1, Farm 2, and Farm 3 in relation to nearby surface water features. Several wetlands have developed over the past few decades in the vicinity of the Port of Morrow farms. Some of the largest occur along Bombing Range Road south of Interstate 84 (Figure 2-1).

2.2 Farm 1

As indicated in Section 2.1, the Port of Morrow Farm 1 consists of 1,512.3 acres located north of Interstate 84. Crops grown using the wastewater most recently include a rotation of alfalfa, triticale, corn, mint, sorghum, garlic, orchard grass, timothy grass, potatoes, onions, peas, lima beans and wheat.

The land application system at Farm 1 began in 1971 in the area where circles 53, 54, and 55 are located today (i.e., between the sewage lagoons and Coyote Springs Wildlife Area). Prior to the land application system, the land occupied by Farm 1 was operated as a commercial farm.

Farm 1 is located within the Columbia Basin physiographic province. The area is underlain by Columbia River Flood basalts overlain by sand, gravel, and silt. The overlying sediments were deposited during past flooding and damming of the Columbia River, and further reworked by wind. The soils at land surface are well drained to excessively drained loamy fine sands and sands (SCS, 1983). Topographic slopes are typically small (0 to 5%; some up to 12%) but pockets of dune lands slope 5 to 60% (SCS, 1983). Land surface topography at Farm 1 ranges from approximately 265 to 370 feet above mean sea level.

Nearby surface water features include the John Day Pool of the Columbia River and the West Extension Irrigation Canal (Figure 2-1). The John Day Pool forms a portion of the northwestern boundary of Farm 1 and extends approximately 76 miles from the upstream side (i.e., the fore bay) of the John Day Dam to the downstream side (i.e., the tail water) of the McNary Dam. The West Extension Irrigation Canal crosses the southeastern portion of Farm 1 and delivers water from the Umatilla River to irrigated lands in the area. The Coyote Springs Wildlife Area is located on the southern portion of Farm 1 in an area that periodically receives canal water. Water is released through a spillway gate on occasions such as at irrigation startup, when irrigation tail water volume is high, during canal repairs, and during gate malfunctions.

The depth to water beneath Farm 1 ranges from less than 6 (typically about 2½) feet below land surface (at well MW-6 located just south of Farm 1) to more than 80 feet below land surface (at wells MW-2, MW-4, MW-SP1, and MW-SP2 (located in the northeastern portion of the site). With all other variables being equal, wells with a greater depth to water would be slower to respond to changes in practices at land surface.

2.2.1 Upgradient and Downgradient Wells

The groundwater flow direction at the Port of Morrow farms is described in DEQ (2004). In general, groundwater flow is to the north-northwest with discharge to the John Day Pool of the Columbia River. Based on the regional water table map presented in Figure 2-1 of DEQ (2004) which shows a general north-northwesterly groundwater flow direction, upgradient wells at Farm 1 would be located south and southeast of the land application activities, and downgradient wells at Farm 1 would be located north and northwest of land application activities. The following discussion of upgradient and downgradient wells is based on the water levels in Figure 2-1 of DEQ (2004).

Upgradient wells for the western portion of Farm 1 include MW-6 and MW-3a. Well MW-3 is not considered an upgradient well because it is located primarily downgradient of Circle 52, and it is likely that water in this well is perched above the regional water table. Water recharging well MW-3 is expected to come from a relatively nearby source (e.g., the irrigation water discharged to the wetland located directly west of the well or Circle 52 located directly east of the well). Well MW-7 is not considered an upgradient well due to being located approximately downgradient from Circles 56 and 57. Downgradient wells for the western portion of Farm 1 include MW-10 and MW-11 (Figure 2-1).

Prior to expansion to Farm 3 in October 2002, well MW-2 was an upgradient well for Farm 1. Because Farm 3 wraps around Farm 1, wells MW-19 and MW-20 are upgradient wells for the eastern portion of Farm 1 and also the upgradient wells for the western portion of Farm 3. Well MW-2 is now in the middle of the Farm 1 / Farm 3 area. MW-19 will remain an upgradient well until wastewater is applied to the south at fields 3-33a, 3-33c, and/or 3-33d. Downgradient wells for the eastern portion of Farm 1 include MW-5 and MW-8 (Figure 2-1).

2.2.2 Nitrate Trends

A trend analysis of nitrate concentrations at each of the 14 Port of Morrow Farm 1 wells was conducted as described in Section 1.3. Table 2-1 summarizes the data used in this analysis and includes some data set statistics (e.g., mean and maximum values), a summary of the trend analysis (e.g., the slope and confidence level of the line) and a description of the LOWESS[1] pattern (e.g., increasing then decreasing). Time series graphs of nitrate concentrations and trends at each Port of Morrow well are included in Appendix 1.

Table 2-1 lists the individual results of the trend analyses for each well. The results can be summarized as follows:

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[1] The distinction between a trend line and a LOWESS line is that a trend line is the best straight line fit through the data that describes the overall change in water quality across the entire timeframe, while a LOWESS line is a type of data smoothing that describes the general pattern of the data throughout the timeframe. Changes in nitrate concentration are usually not a straight line. So, although it is useful to characterize changes as a "straight" trend line, additional useful information can be gained by evaluating "smoothed" LOWESS lines.

- 9 wells have increasing trends
- 3 wells have decreasing trends
- 2 wells have statistically insignificant trends

In summary, most wells (64%) have statistically significant increasing trends. The trends range from increasing at 1.90 ppm/yr at MW-7 to decreasing at 1.51 ppm/yr at MW-SP2. The site-wide average nitrate trend (i.e., the average of all 14 slopes) is increasing at approximately 0.52 ppm/yr. The average trend of the 12 statistically significant results is increasing at approximately 0.61 ppm/yr.

It is important to note that one of the statistically insignificant trends has an average concentration of 21.5 ppm while the other has an average of 4 ppm. The fact that a statistically significant linear trend cannot be drawn through the data does not mean that the concentrations are insignificant or unworthy of attention. Instead, it means that the statistical test could not identify a linear trend with a high degree of assurance.

Table 2-1 also lists a description of the LOWESS pattern for individual wells. The LOWESS patterns observed can be summarized as follows:

- 1 well is steadily increasing,
- 7 wells are recently increasing,
- 1 well is steadily decreasing, and
- 5 wells are recently decreasing

In other words, more than half of the wells exhibit either consistently increasing or recently increasing LOWESS patterns.

Figure 2-2 is a graph of all nitrate data from the 14 Farm 1 wells, with a LOWESS line drawn through the data. Figure 2-2 consists of many stacks of data points at approximately 3 month intervals. Each of these stacks of data represents one quarterly sampling event and contains one data point for each well sampled that event. It is evident from Figure 2-2 that the highest concentrations detected have occurred in the middle portion of the dataset. The LOWESS line suggests nitrate concentrations at Farm 1 increased from 1987 through about 1999, and then leveled off.

Figure 2-3 includes the nitrate trends and LOWESS lines at each of the 14 Port of Morrow Farm 1 wells. The 14 graphs are plotted at the same scale to allow a comparison of trends between wells. Useful information can be gained by comparing trend lines with LOWESS lines. Examination of LOWESS lines through the nitrate data illustrates non-linear changes in nitrate concentrations. For example, Figure 2-3 illustrates the following:

- The increasing trend line at MW-3 simplifies the pattern illustrated by the LOWESS line which indicates concentrations slowly increased from 1987 through 1993, then rapidly increased through about 1999, then rapidly decreased through 2005,
- Nitrate concentrations at MW-7 decreased from 1992 through about 1997, then increased through 2005 at a rate steeper than the overall 1.90 ppm/yr trend, and
- Nitrate concentrations at MW-2 increased from 1987 through about 1998, and then decreased through 2005.

Figure 2-4 is a map view of all three Port of Morrow farms illustrating nitrate trends at each well. Also included on this map are the March 2002 water levels from DEQ (2004). At Farm 1, most wells exhibit increasing trends. The decreasing trends are at the upgradient well MW-6 and at the two wells downgradient of the wastewater storage lagoon (MW-SP1 and MW-SP2). The two statistically insignificant trends are at the upgradient well MW-3a and the downgradient well MW-5.

The steepest increasing trends are at the interior well MW-7 (1.90 ppm/yr) and the downgradient wells MW-10 (1.46 ppm/yr) and MW-11 (1.51 ppm/yr). The steepest decreasing trends are at wells MW-SP1 (-0.8 ppm/yr) and MW-SP2 (-1.51 ppm/yr) located downgradient of the wastewater storage lagoon. The high percentage of increasing trends illustrates that nitrate concentrations are generally increasing at Farm 1. The steep increasing trends at some of the downgradient wells suggest facility operations have affected groundwater quality.

2.2.3 Average Nitrate Concentrations

Figure 2-5 illustrates the average nitrate concentrations at all Port of Morrow wells from 2002 through 2005, the timeframe in which most Port of Morrow were installed and being sampled (MW-6 has not been sampled since June 2000). The averages in Table 2-1 use all data since each well was installed. One well (MW-3a) exhibits an average concentration less than the 7 ppm GWMA target level (4.0 ppm). Three wells exhibit average concentrations less than the 10 ppm drinking water standard (4.0 ppm at MW-3a; 8.9 ppm at MW-3; and 9.0 ppm at MW-4). Well MW-3a is an upgradient well, well MW-3 monitors a perched zone which may not be representative of the regional aquifer, and well MW-4 is an interior well. The remaining 10 wells exhibit higher average nitrate concentrations. The highest average concentrations are along the downgradient boundary (37.6 ppm at MW-11; 36.4 ppm at MW-8; and 34.6 ppm at MW-10). The next highest average concentrations are in the vicinity of the wastewater storage lagoon area (34.5 ppm at MW-SP2 and 30.9 ppm at MW-SP1) and at two interior wells (33.2 ppm at MW-7 and 30.8 ppm at MW-1).

The high average nitrate concentrations along the downgradient boundary and near the wastewater storage lagoon suggest facility operations have adversely affected groundwater quality.

2.2.4 Upgradient to Downgradient Comparisons

As discussed in Section 2.2.1, wells MW-3a and MW-6 are upgradient wells while wells MW-10 and MW-11 are downgradient wells for the western portion of Farm 1. Similarly, wells MW-19 and MW-20 are upgradient wells while wells MW-5, MW-8, and MW-24 are downgradient wells for the eastern portion of Farm 1 and the western portion of Farm 3. Using these designations, the following comparisons of upgradient to downgradient nitrate concentrations were made.

Western Portion of Farm 1

Figure 2-6(a) is a time series graph showing nitrate concentrations at the upgradient and downgradient wells for the western portion of Farm 1. In addition to the individual data points connected by a thin line, a thick LOWESS line is drawn through the data. Figure 2-6(a) shows the upgradient nitrate concentration at MW-6 remained fairly constant at approximately 1 ppm from 1987 through 1999 when it began to increase shortly before well sampling ended. Similarly, the upgradient nitrate concentration at MW-3a remains fairly constant at about 4 ppm during the time it has been sampled (2002 through 2005). The LOWESS line drawn through these data therefore increases from about 1 ppm to about 4 ppm when these two data sets are combined.

Figure 2-6(a) shows concentrations at the downgradient wells MW-10 and MW-11 started higher than the upgradient concentrations and have increased over time.

Figure 2-6(b) is a box and whisker plot summarizing the nitrate concentrations from the upgradient wells (MW-3a and MW-6) and the downgradient wells (MW-10 and MW-11)[2]. Figure 2-6(b) shows the average upgradient nitrate concentration is approximately 1.6 ppm, and the IQR (representing the middle half of the data) is from approximately 0.4 to 3.5 ppm. Figure 2-6(b) also shows the average downgradient nitrate concentration is approximately 30 ppm, and the IQR is approximately 23 to 36 ppm.

Downgradient nitrate concentrations are higher than upgradient nitrate concentration indicating facility operations have affected groundwater quality.

[2] The "box" portion of the plot identifies the interquartile range (IQR). The IQR is the middle half of the data (i.e., those data between the 25th and 75th percentiles). The "whisker" portion of the plot extends outwards from the box to any point within 1.5 times the IQR. Any point beyond the whiskers is plotted individually. The horizontal line through the box represents the median value. The star represents the average value.

Eastern Portion of Farm 1 & Western Portion of Farm 3
Figure 2-7(a) is a time series graph showing nitrate concentrations at the upgradient and downgradient wells for the eastern portion of Farm 1 and western portion of Farm 3. In addition to the individual data points connected by a thin line, a thick LOWESS line is drawn through the data. Figure 2-7(a) shows the LOWESS line through the upgradient nitrate concentrations decreased from approximately 20 ppm to 13 ppm from 2002 through 2005. Conversely, the LOWESS line through the downgradient nitrate concentrations increased from about 15 ppm to 38 ppm from 1987 through 2005. From 2002 through 2005, the LOWESS line increases from about 35 to 38 ppm.

Figure 2-7(b) is a box and whisker plot summarizing the nitrate concentrations from the upgradient wells (MW-19 & MW-20) and the downgradient wells (MW-5, MW-8, and MW-24). Figure 2-7(b) shows the average upgradient nitrate concentration is approximately 19 ppm, and the IQR (representing the middle half of the data) is from approximately 14 to 21 ppm. Figure 2-6(b) also shows the average downgradient nitrate concentration is approximately 31 ppm, and the IQR is approximately 21 to 42 ppm.

Downgradient nitrate concentrations are higher than upgradient nitrate concentration indicating facility operations and/or previous farming activities have affected groundwater quality.

2.2.5 Comparison to Previous Analysis
A comparison was made between the previous (through 2001) and current (through 2005) trend analyses. Changes in data set statistics as well as changes in the nitrate trends at Farm 1 are summarized in Table 2-2. These changes are interpreted as indications of improving or worsening water quality between 2001 and 2005.

Indications of improving water quality since the previous analysis include:
- More wells exhibited lower mean concentrations than higher mean concentrations,
- More wells exhibited improving trends than worsening trends[3], and
- The site-wide average trend slope improved.

Indications of worsening water quality since the previous analysis include:
- More wells exhibited new maximum concentrations than new minimum concentrations,
- Slightly more wells exhibited higher median concentrations than lower median concentrations

In summary, although the majority of wells and the site as a whole exhibit increasing trends, the trends are increasing less steeply through 2005 than they did through 2001. The lower concentrations in recent years cause this change in long term trend.

2.2.6 Conclusions
Based on the discussion of the data for the Port of Morrow Farm 1 site discussed above, the following conclusions have been made, and are grouped by topic:

Upgradient and Downgradient Wells
- Upgradient wells for the western portion of Farm 1 include MW-3a and MW-6.
- Downgradient wells for the western portion of Farm 1 include MW-10 and MW-11.
- Upgradient wells for the eastern portion of Farm 1 and the western portion of Farm 3 include MW-19 & MW-20.
- Downgradient wells for the eastern portion of Farm 1 and the western portion of Farm 3 include MW-5, MW-8, and MW-24.

[3] An "improving" trend is defined as either a steeper decreasing trend or a less steeply increasing trend. A "worsening" trend is defined as either a steeper increasing trend or a less steeply decreasing trend.

Nitrate Trends

- Nitrate concentrations at Farm 1 are generally increasing, as evidenced by:
    - 64% of wells exhibit statistically significant increasing trends.
    - Trends range from decreasing at 1.51 ppm/yr to increasing at 1.90 ppm/yr with the site-wide average nitrate trend increasing at least 0.52 ppm/yr.
    - More than half of the wells exhibit either consistently increasing or recently increasing LOWESS patterns.

Average Nitrate Concentrations

- The highest average concentrations are along the downgradient boundary (37.6 ppm at MW-11; 36.4 ppm at MW-8; and 34.6 ppm at MW-10).
- The next highest average concentrations are in the vicinity of the wastewater storage lagoon area (34.5 ppm at MW-SP2 and 30.9 ppm at MW-SP1) and at two interior wells (33.2 ppm at MW-7 and 30.8 ppm at MW-1).

Factors Affecting Nitrate Concentrations

- Facility operations have affected groundwater quality, as evidenced by:
    - Downgradient concentrations are greater than upgradient concentrations.
    - The steepest increasing trends are at the interior well MW-7 and the downgradient wells MW-10 and MW-11, and
    - The highest average concentrations are near the wastewater storage lagoon and the downgradient boundary.
- The fact that most wells exhibit increasing trends, either consistently increasing or recently increasing LOWESS patterns, and the highest average nitrate concentrations are near the wastewater storage lagoon and downgradient boundary suggests facility operations continue to affect groundwater quality. Potential methods to assess the effectiveness of current facility operations are discussed in Section 8.4.

Comparison to Previous Analysis

Although the majority of wells and the site as a whole continue to exhibit increasing trends, the trends are increasing less steeply through 2005 than they did through 2001.

2.3 Farm 2

As indicated in Section 2.1, the Port of Morrow Farm 2 consists of 1,466.6 acres located south of Interstate 84. Crops grown using the wastewater most recently include a rotation of alfalfa, triticale, corn, mint, sorghum, garlic, orchard grass, timothy grass, potatoes, onions, peas, lima beans and wheat.

The land application system at Farm 2 began in 1992. Prior to the land application system, the land occupied by Farm 2 was farmed by a local farmer.

As is the case with Farm 1, Farm 2 is located within the Columbia Basin physiographic province. The area is underlain by Columbia River Flood basalts overlain by sand, gravel, and silt. The overlying sediments were deposited during past flooding and damming of the Columbia River, and further reworked by wind. The soils at land surface are somewhat excessively drained to excessively drained loamy fine sands and sands. Topographic slopes are typically small to moderate (0 to 12%) but pockets of dune lands slope 5 to 60%. Land surface topography at Farm 2 ranges from approximately 370 to 470 feet above mean sea level.

Nearby surface water features include the West Extension Irrigation Canal and two wetlands. The West Extension Irrigation Canal is primarily located north of Farm 2 but also forms a portion the farm's northwestern boundary. Two wetlands straddle the eastern boundary of Farm 2 (Figure 2-1).

The depth to water beneath Farm 2 ranges from approximately 22 feet below land surface (at well MW-18 located in the northeastern corner of the site) to approximately 58 feet below land surface (at well MW-15 (located in the southeastern corner of the site). With all other variables being equal, wells with a greater depth to water would be slower to respond to changes in practices at land surface.

2.3.1 Upgradient and Downgradient Wells

The groundwater flow direction at the Port of Morrow farms is described in DEQ (2004). In general, groundwater flow is to the north-northwest with discharge to the John Day Pool of the Columbia River. Based on the regional water table map presented in Figure 2-1 of DEQ (2004) which shows a general north-northwesterly groundwater flow direction, upgradient wells at Farm 2 would be located south and southeast of the land application activities, and downgradient wells at Farm 2 would be located north and northwest of land application activities. The following discussion of upgradient and downgradient wells is based on the water levels in Figure 2-1 of DEQ (2004).

Upgradient wells for Farm 2 include MW-15, MW-15s, MW-16, MW-16s and MW-17 while downgradient wells include MW-12, MW-12s, MW-13, MW-13s, MW-14 and MW-14s. Wells MW-12, MW-13, MW-14, MW-15, MW-16 and MW-17 are completed in the underlying basalt. Wells MW-13s, MW-14s and MW-16s are completed in the alluvial sediments overlying the basalt. Wells MW-12s and MW-15s are completed in the alluvial sediments and perhaps in the Alkali Canyon Formation (located between the alluvial sediments and the basalt). The Alkali Canyon Formation consists of tuffaceous silts and sands and moderately indurated gravels which were shed from the rising Blue Mountains in late Miocene and Pliocene times (DEQ, 1995).

The remaining well (MW-18) is harder to classify. Due to the land surface topography and presence of wetlands in the vicinity of Circle 15 and well MW-18, it is believed that groundwater flow directions range from west to southwest to northwest in that area. The Port of Morrow's historic use of a subsurface drain located between Circle 15 and Bombing Range Road likely lowered groundwater elevations directly east of Circle 15 and caused local variations in groundwater flow directions. The Port of Morrow reports that the tile drain became overwhelmed by the volume of water, so in Spring 2004, Morrow County used a large track hoe to make an open ditch along the road side.

2.3.2 Nitrate Trends

A trend analysis of nitrate concentrations at each of the 9 Port of Morrow Farm 2 wells that consistently have water in them[4] was completed using the methodology described in Section 1.3. Table 2-3 summarizes the data used in this analysis and includes some data set statistics (e.g., mean and maximum values), a summary of the trend analysis (i.e., the slope and confidence level of the line) and a description of the LOWESS pattern (e.g., increasing then decreasing). Time series graphs of nitrate concentrations and trends at each Port of Morrow well are included in Appendix 1.

The results of the trend analysis shown in Table 2-3 indicate 7 wells (both upgradient and downgradient) have increasing trends and 2 wells have statistically insignificant trends. The trends range from increasing at 0.84 ppm/yr at MW-18 to 3.02 ppm/yr at MW-15s. The site-wide average nitrate trend (i.e., the average of all 9 slopes) is increasing at approximately 1.1 ppm/yr.

Table 2-3 also lists a description of the LOWESS pattern for individual wells. The LOWESS patterns observed can be summarized as follows:

- 1 well shows a steadily increasing pattern
- 4 wells shows an increasing then increasing less steeply pattern
- 4 wells show an increasing then decreasing pattern

In other words, over half of the wells exhibit increasing LOWESS patterns.

[4] Wells MW-12s, MW-13s and MW-16s rarely have enough water to collect a sample.

Figure 2-8 is a graph of all nitrate data from the 9 Farm 2 wells, with a LOWESS line drawn through the data. Figure 2-8 consists of many stacks of data points at approximately 3 month intervals. Each of these stacks of data represents one quarterly sampling event and contains one data point for each well sampled that event. It is evident from Figure 2-8 that the highest concentrations detected have occurred in the middle and latter portions of the dataset. The LOWESS line increases steeply from 1992 through about 1999, then decreases through 2005.

It is also evident that there are many fewer data points between approximately 5 ppm and 30 ppm beginning in late 1995. A closer examination of the data shows minimum concentrations at 7 of the 9 wells were observed at two sampling events (4 on June 1993 and 3 on September 1995). These lower than usual data points within an overall increasing data set spread the early 1990s data towards lower concentrations and cause the appearance of a significant increase in late 1995. It is likely that there was no significant increase in concentrations in late 1995; rather laboratory problems likely caused the June 1993 and September 1995 data to be anomalously low.

Figure 2-9 includes the nitrate trends and LOWESS lines at each of the 9 Port of Morrow Farm 2 wells. The 9 graphs are plotted at the same scale to allow a comparison of trends between wells. As mentioned previously, useful information can be gained by comparing trend lines with LOWESS lines. For example, Figure 2-9 illustrates that nitrate trends at 4 wells (MW-13, MW-14, MW-14s and MW-16) increased until about 1999 or 2000 then began to decrease.

Figure 2-4 is a map view of all three Port of Morrow sites illustrating the nitrate trends at each well. 7 of 9 Farm 2 wells (both upgradient and downgradient) have increasing trends. The remaining two wells are statistically insignificant trends. The steepest increasing trend (3.02 ppm/yr) is at well MW-15s located near the southeastern (upgradient) corner of Farm 2. The least steep increasing trend (0.84 ppm/yr) is at well MW-18 located near the northeastern corner of Farm 2.

2.3.3 Average Nitrate Concentrations

Figure 2-5 illustrates the average nitrate concentrations at all Port of Morrow wells from 2002 through 2005, the timeframe in which most Port of Morrow wells were installed and being sampled. The averages in Table 2-3 use all data since each well was installed. With the exception of well MW-18 (which averages 11.5 ppm), the average nitrate concentration at each Farm 2 well is greater than 25 ppm. The highest average concentrations are at the southeastern (upgradient) boundary (47.6 ppm at MW-15 and 45.8 ppm at MW-15s). The next highest averages are near the northwestern (downgradient) and southwestern (upgradient) corners of Farm 2 at well MW-13 (45.6 ppm) and well MW-17 (44.2 ppm).

The high average nitrate concentrations along the southern (upgradient) boundary illustrate the significant amount of nitrate entering Farm 2. During 2005, the US Navy installed and sampled 7 monitoring wells at the Boardman Bombing Range (US Navy, 2006). Border well 2 is located approximately 1.75 miles south of well MW-15 and is screened in the uppermost basalt flow (interpreted as the Elephant Mountain member of the Saddle Mountain Formation of the Columbia River Basalt Group). Border well 2 exhibited a water level approximately 50 feet higher than MW-15 and a nitrate concentration of 34.6 ppm.

The 3004 DEQ Report (Figure 2-14) illustrated the similar pattern of water level and nitrate concentration over time at the MW-14/MW-14s and MW-15/MW-15s well pairs at Farm 2. This similarity suggests the wells are in hydraulic communication and are potentially monitoring portions of the same aquifer. In other words, Farm 2 wells installed in the uppermost basalt flow are in direct connection with wells installed in the overlying alluvium and are in effect alluvial aquifer wells.

This single data point provides some evidence of a significant source of nitrate upgradient of Farm 2. However, complicating factors indicate additional information is required to fully evaluate the upgradient source of nitrate. These include:

- the unknown extent of the alluvial aquifer on the Bombing Range,

- the unknown groundwater flow direction(s) on the Bombing Range,
- the unknown nitrate trend at Border well 2,
- the lack of nitrate and water applied at the Bombing Range,
- the unknown connection to and travel time between Border well 2 and Farm 2, and
- the fact that concentrations at the Farm 2 upgradient boundary are both higher (at MW-15 and MW-17) and lower (at MW-16) than at Border well 2.

2.3.4 Upgradient to Downgradient Comparisons

As discussed in Section 2.3.1, upgradient wells for Farm 2 include MW-15, MW-15s, MW-16, MW-16s and MW-17 while downgradient wells include MW-12, MW-12s, MW-13, MW-13s, MW-14 and MW-14s. Wells MW-12, MW-13, MW-14, MW-15, MW-16 and MW-17 are completed in the underlying basalt. Wells MW-13s, MW-14s and MW-16s are completed in the uppermost alluvial sediments. Wells MW-12s and MW-15s are completed in the alluvial sediments and perhaps the Alkali Canyon Formation (located between the alluvial sediments and the basalt). However, wells MW-12s, MW-13s, and MW-16s rarely have enough water to collect a sample, making the use of these wells in upgradient to downgradient comparisons difficult. Due to the similarity of data from the two well pairs discussed in Section 2.3.3 and the lack of data from the other shallow wells, the upgradient to downgradient comparison conducted for this report use only the wells completed in the basalt.

Based on the selection of wells MW-15, MW-16 and MW-17 as the upgradient wells and wells MW-12, MW-13, and MW-14 as downgradient wells, the following comparison of upgradient to downgradient nitrate concentrations was made.

Figure 2-10(a) is a time series graph showing the nitrate concentrations at the upgradient wells and the downgradient wells at Farm 2. In addition to the individual data points connected by a thin line, a thick LOWESS line is drawn through the data. Figure 2-10(a) shows both the upgradient and downgradient nitrate concentrations rose from late 1991 until about 1999, started to decrease. Throughout this time frame, upgradient concentrations were generally greater than downgradient concentrations.

Figure 2-10(b) is a box and whisker plot summarizing the nitrate concentrations from the upgradient wells (MW-15, MW-16, and MW-17) and the downgradient wells (MW-12, MW-13, and MW-14). Individual box and whisker plots are also included for wells MW-14s and MW-15s. Figure 2-10(b) shows the average upgradient nitrate concentration is approximately 41 ppm, and the middle half of the data is from approximately 35 to 49 ppm. Figure 2-10(b) also shows the average downgradient nitrate concentration is approximately 35 ppm, and the middle half of the data is from approximately 30 to 43 ppm.

2.3.5 Comparison to Previous Analysis

A comparison was made between the previous (through 2001) and current (through 2005) trend analyses. Changes in data set statistics as well as changes in the nitrate trends at Farm 2 are summarized in Table 2-4. These changes are interpreted as indications of improving or worsening water quality between 2001 and 2005.

Indications of improving water quality since the previous analysis include:

- all wells exhibited improving trends (i.e., a less steeply increasing trend), and
- the site-wide average trend slope improved.

Indications of worsening water quality since the previous analysis include:

- 3 wells exhibited new maximum concentrations while none exhibited new minimum concentrations,
- More wells exhibited higher median concentrations than lower median concentrations, and
- More wells exhibited higher mean concentrations than lower mean concentrations.

In summary, almost all of wells and the site as a whole exhibit increasing trends, the trends are increasing less steeply through 2005 than they did through 2001. The lower concentrations in recent years cause this change in long term trend.

2.3.6 Conclusions

Based on the discussion of the data for the Port of Morrow Farm 2 site discussed above, the following conclusions have been made, and are grouped by topic:

Upgradient and Downgradient Wells

- Upgradient wells for Farm 2 include MW-15, MW-15s, MW-16, MW-16s, and MW-17.
- Downgradient wells for Farm 2 include MW-12, MW-12s, MW-13, MW-13s, MW-14, and MW-14s.

Nitrate Trends

- Nitrate concentrations at the Port of Morrow Farm 2 are increasing, as evidenced by:
  - 78% of wells exhibit statistically significant increasing trends.
  - Trends range from increasing at 0.84 ppm/yr to 3.02 ppm/yr with the site-wide average nitrate trend increasing at least 1.1 ppm/yr.
  - Over half of the wells exhibit increasing LOWESS patterns.

Average Nitrate Concentrations

- With the exception of well MW-18 (which averages 11.5 ppm), the average nitrate concentration at each well is greater than 25 ppm.
- The highest average concentrations are at the southeastern (upgradient) boundary (47.6 ppm at MW-15 and 45.8 ppm at MW-15s).
- The next highest averages are near the northwestern (downgradient) and southwestern (upgradient) corners of Farm 2 at well MW-13 (45.6 ppm) and well MW-17 (44.2 ppm).
- The high average nitrate concentrations along the southern (upgradient) boundary illustrate the significant amount of nitrate entering Farm 2.

Factors Affecting Nitrate Concentrations

- There is evidence suggesting that facility operations have affected, and continue to affect, groundwater quality. There is, however, also evidence suggesting the possibility of a significant upgradient source of nitrate. Therefore, additional information is needed to determine the cause of increasing concentrations (including nitrate) at the site, and whether the land application activities at Farm 2 are adding significant nitrate to the groundwater.
  - Although not described in this report, chloride, sulfate, and total dissolved solids concentrations generally increase from upgradient to downgradient wells. This suggests facility operations are affecting groundwater.
  - Nitrate concentrations are elevated in all wells except MW-18, and nitrate trends are increasing in most wells suggesting facility operations may be affecting groundwater.
  - The higher nitrate concentrations in the upgradient wells and at Border well 2 on the Boardman Bombing Range suggest the possibility of a significant upgradient source of nitrate. However, additional information is required to fully evaluate the upgradient source of nitrate.
  - The fact that most wells exhibit increasing trends, and over half exhibit consistently increasing LOWESS patterns suggests that facility operations may be affecting groundwater quality. Potential methods to assess the effectiveness of current facility operations are discussed in Section 8.4.
- The substantially different nitrate concentrations at well MW-18 versus all other Farm 2 wells suggest different hydrogeologic and/or geochemical controls exist near well MW-18.
  - It is possible that the wetlands located south and southeast of MW-18 act as flow through wetlands in which groundwater discharges into the upgradient side of the wetland, flows

through it, and recharges the groundwater on the downgradient side of the wetland. The physical and chemical processes associated with such a flow through wetland could account for the lower nitrate and sulfate concentrations observed at well MW-18. An investigation could be performed to evaluate this theory.

Comparison to Previous Analysis

- Although almost all of the wells and the site as a whole exhibit increasing trends, the trends are increasing less steeply through 2005 than they did through 2001.

2.4 Farm 3

As indicated in Section 2.1, the Port of Morrow Farm 3 consists of 3,810.1 acres located north of Interstate 84. Approximately two-thirds of Farm 3 (2,520.3 acres) is currently receiving wastewater. Crops grown using the wastewater most recently include a rotation of alfalfa, triticale, corn, mint, sorghum, garlic, orchard grass, timothy grass, potatoes, onions, peas, lima beans and wheat. The land application system at Farm 3 was approved in August 2002, with wastewater first applied to fields north of Highway 730 in October 2002. As of the date of this report, wastewater has not been applied to fields south of Highway 730. Prior to the land application system, the land occupied by Farm 3 was operated as a commercial farm.

As with Farms 1 and 2, Farm 3 is located within the Columbia Basin physiographic province. The area is underlain by Columbia River Flood basalts overlain by sand, gravel, and silt. The overlying sediments were deposited during past flooding and damming of the Columbia River, and further reworked by wind. The soils at land surface are excessively drained loamy fine sands and sands (SCS, 1983). Topographic slopes are typically small (0 to 12%) but pockets of dune lands slope 5 to 60% (SCS, 1983). Land surface topography at Farm 3 ranges from approximately 290 to 470 feet above mean sea level.

Nearby surface water features include the John Day Pool of the Columbia River and the West Extension Irrigation Canal (Figure 2-1). The West Extension Irrigation Canal crosses Farm 3 and delivers water from the Umatilla River to irrigated lands in the area.

The depth to water beneath Farm 3 ranges from less than 10 feet below land surface (at well MW-20 located along the southern boundary) to more than 80 feet below land surface (at well MW-23 (located in the northeastern corner of the site). With all other variables being equal, wells with a greater depth to water would be slower to respond to changes in practices at land surface.

2.4.1 Upgradient and Downgradient Wells

The groundwater flow direction at the Port of Morrow farms is described in DEQ (2004). In general, groundwater flow is to the north-northwest with discharge to the John Day Pool of the Columbia River. Based on the regional water table map presented in Figure 2-1 of DEQ (2004) which shows a general north-northwesterly groundwater flow direction, upgradient wells at Farm 3 would be located south and southeast of land application activities, and downgradient wells would be located north and northwest of land application activities. The following discussion of upgradient and downgradient wells is based on the water levels in Figure 2-1 of DEQ (2004).

Upgradient wells for the western portion of Farm 3 include MW-19, MW-20, and MW-21. MW-19 will remain an upgradient well until wastewater is applied to fields 3-33a, 3-33c, and/or 3-33d located south of MW-19.

Well MW-24 is a downgradient well for the western portion of Farm 3. There are no downgradient wells for the eastern portion of Farm 3.

2.4.2 Nitrate Trends

A trend analysis of nitrate concentrations at each of the six Port of Morrow Farm 3 wells was conducted as described in Section 1.3. Table 2-5 summarizes the data used in this analysis and includes some data set statistics (e.g., mean and maximum values), a summary of the trend analysis (e.g., the slope and confidence level of the line) and a description of the LOWESS pattern (e.g., increasing then decreasing). Time series graphs of nitrate concentrations and trends at each Port of Morrow well are included in Appendix 1.

Table 2-5 lists the individual results of the trend analyses for each well. The results can be summarized as follows:

- 3 wells have increasing trends
- 2 wells have decreasing trends
- 1 well has a statistically significant trend

The trends range from increasing at 7.51 ppm/yr to decreasing at 3.17 ppm/yr. The site-wide average nitrate trend (i.e., the average of all 6 slopes) is increasing at approximately 2.3 ppm/yr. The average of the 5 statistically significant results is increasing at approximately 2.9 ppm/yr.

It is important to note that the statistically insignificant trend has an average concentration of 46 ppm. The fact that a statistically significant linear trend cannot be drawn through the data does not mean the concentrations are insignificant or unworthy of attention. Instead, it means that the statistical test could not identify a linear trend with a high degree of assurance.

Table 2-5 also lists a description of the LOWESS pattern for individual wells. The LOWESS patterns observed can be summarized as follows:

- 2 wells are steadily increasing
- 1 well increased then leveled off
- 1 well increased then decreased
- 2 wells decreased then increased

In other words, most wells exhibit either steadily or recently increasing LOWESS patterns.

Figure 2-11 is a graph of all[5] nitrate data from the six Farm 3 wells, with a LOWESS line drawn through the data. Figure 2-11 consists of many stacks of data points at approximately three-month intervals. Each of these stacks of data represents one quarterly sampling event and contains one data point for each well sampled that event.

The LOWESS line in Figure 2-11 suggests an overall increasing trend. However, it is evident that nitrate concentrations are diverging: concentrations at MW-19 and MW-20 are decreasing while concentrations at MW-21, MW-22, and MW-23 are increasing (concentrations at MW-24 are remaining fairly constant). This divergence causes a gap in concentrations in 2005 (i.e., no concentrations are between approximately 20 and 35 ppm). Because MW-19 and MW-20 are behaving similarly (i.e., starting at about 20 ppm then decreasing) while MW-21 is behaving differently (i.e., starting at about 20 ppm then increasing), it is likely that these wells are being affected by different upgradient activities. If so, they will require different downgradient wells to adequately gauge potential impacts from activities at Farm 3.

Figure 2-12 includes the nitrate trends and LOWESS lines at each of the 6 Port of Morrow Farm 3 wells. The 6 graphs are plotted at the same scale to allow a comparison of trends between wells. Useful information can often be gained by comparing trend lines with LOWESS lines. For example, Figure 2-12 illustrates the following:

[5] Port of Morrow Farm 3 wells were sampled monthly for a year, then quarterly thereafter. For this analysis, the first year of data was trimmed to quarterly results so as to not overemphasize early time data.

- nitrate concentrations at MW-19 initially decreased steeper than the monotonic trend then began to increase, and
- nitrate concentrations at MW-20 initially increased then decreased.

Figure 2-4 is a map view of all three Port of Morrow farms illustrating nitrate trends at each well. Also included on this map are the March 2002 water levels described in Section 2.2.1. At Farm 3, the wells along the western boundary are increasing while the wells along the southern boundary are decreasing. The well along the northwestern boundary exhibits a statistically insignificant trend. The steepest increasing trend (7.51 ppm/yr) is at well MW-22 along the eastern boundary which suggests offsite activities are contributing significant amounts of nitrate to the alluvial aquifer. The steepest decreasing trend (-3.17 ppm/yr) is at well MW-20 located along the southern boundary which suggests a change in offsite activities resulting in less nitrate being added to the alluvial aquifer.

2.4.3 Average Nitrate Concentrations

Figure 2-5 illustrates the average nitrate concentrations at all Port of Morrow wells from 2002 through 2005, the timeframe in which all 6 Farm 3 wells were installed and being sampled. All 6 Farm 3 wells exhibit an average greater than 20 ppm. The highest average nitrate concentration (54.9 ppm) is at well MW-23 located in the northeastern corner of Farm 3. The lowest average nitrate concentration (20.2 ppm) is at the upgradient well MW-20 located along the southern boundary of Farm 3. The high averages along the eastern boundary suggest offsite activities are contributing significant amounts of nitrate to the alluvial aquifer. The high average at the downgradient boundary (46.7 ppm at well MW-24) suggests operations at Farm 1 and/or the western portion of Farm 3 have adversely affected groundwater quality.

2.4.4 Upgradient to Downgradient Comparisons

As discussed in Section 2.2.1, because the western portion of Farm 3 wraps around the eastern portion of Farm 1, wells MW-19 and MW-20 serve as upgradient wells for the western portion of Farm 3 and the eastern portion of Farm 1. MW-21 serves as an upgradient well for the eastern portion of Farm 3, but there are no corresponding downgradient wells for the eastern portion of Farm 3.

Figure 2-7(a) is a time series graph showing nitrate concentrations at the upgradient and downgradient wells for the eastern portion of Farm 1 and western portion of Farm 3. Figure 2-7(a) shows the LOWESS line through the upgradient nitrate concentrations decreased from approximately 20 ppm to 13 ppm from 2002 through 2005. Conversely, the LOWESS line through the downgradient nitrate concentrations increased from about 15 ppm to 38 ppm from 1987 through 2005. From 2002 through 2005, the LOWESS line increases from about 35 to 38 ppm.

Figure 2-7(b) is a box and whisker plot summarizing the nitrate concentrations from the upgradient wells (MW-19 & MW-20) and the downgradient wells (MW-5, MW-8, and MW-24). Figure 2-7(b) shows the average upgradient nitrate concentration is approximately 19 ppm, and the IQR is approximately 14 to 21 ppm. Figure 2-6(b) also shows the average downgradient nitrate concentration is approximately 31 ppm, and the IQR is approximately 21 to 42 ppm.

Downgradient nitrate concentrations are higher than upgradient nitrate concentrations indicating land use has affected groundwater quality.

2.4.5 Comparison to Previous Analysis

Farm 3 wells were not sampled during the timeframe of the previous analysis so no comparison is made.

2.4.6 Conclusions

Based on the discussion of the data for the Port of Morrow Farm 3 site discussed above, the following conclusions have been made, and are grouped by topic:

Upgradient and Downgradient Wells

- Upgradient wells for the eastern portion of Farm 3 include MW-19 and MW-20.
- The downgradient well for the western portion of Farm 3 is MW-24.
- MW-21 is an upgradient well for the eastern portion of Farm 3.
- There are currently no downgradient wells for the eastern portion of Farm 3.
- Additional downgradient wells are needed for both the eastern and western portions of Farm 3.

Nitrate Trends

- Nitrate concentrations at the Port of Morrow Farm 3 are generally increasing, as evidenced by:
  - Nitrate concentrations are increasing at about half of the Farm 3 wells while decreasing at the other half.
  - The site-wide average nitrate trend (i.e., the average of all 6 slopes) is increasing at approximately 2.3 ppm/yr.
  - Most wells exhibit either steadily or recently increasing LOWESS patterns.

Average Nitrate Concentrations

- All 6 Farm 3 wells exhibit averages greater than 20 ppm.
- The highest average nitrate concentration is at the downgradient boundary (46.7 ppm at well MW-24).

Factors Affecting Nitrate Concentrations

- Evidence suggesting facility operations have affected groundwater quality on the western portion of Farm 3 include:
  - Downgradient concentrations are greater than upgradient concentrations. Potential methods to assess the effectiveness of current facility operations are discussed in Section 8.4.
- Evidence suggesting offsite activities have adversely affected groundwater quality on the eastern portion of Farm 3 include:
  - The steepest increasing trends and highest averages are at wells along the eastern (largely upgradient) boundary.

Comparison to Previous Analysis

Farm 3 wells were not sampled during the timeframe of the previous analysis so no comparison is made.

2.5 Recommendations

Based on the conclusions and discussion above, the following recommendations are made:

- The source of the elevated and increasing nitrate concentrations along the southern boundary of Farm 2 should be determined. This recommendation was made in the previous report and still stands.
- The source of the elevated and increasing nitrate concentrations along the eastern boundary of Farm 3 should be determined.
- In order to gauge when the effects of BMP implementation will be observed as improving groundwater quality, it is recommended that funding be pursued to allow additional research into factors including: (1) quantifying the amount of nitrate that exists between the root zone and the water table, (2) the rate of nitrate transport through the unsaturated zone, and (3) more precisely quantifying groundwater flow velocity at the site.
- Due to the high percentage of increasing trends and affects to groundwater from land application activities, it is recommended that BMP implementation to reduce the area-wide extent of elevated nitrate concentrations be continued and, when possible, improved. BMPs should include detailed procedures to:
  - establish appropriate crop specific nitrogen loading rates,

- accurately quantify hydraulic loading from all sources,
- document nutrient additions from all sources,
- insure uniform sample acquisition and analysis,
- characterize and monitor nitrogen concentration and movement in the soil column,
- monitor moisture content and movement in the soil column, and
- perform annual site specific analysis to identify farming activities and/or soil conditions that increase the potential for impact to groundwater.

- In accordance with the Action Plan, it is recommended that a trend analysis of data from the same wells be conducted in 2010 to evaluate progress towards improving groundwater quality at the food processing wastewater land application sites.

3.0 CONAGRA SITES

3.1 Introduction

ConAgra (known as Lamb-Weston in the previous trend analysis) currently land applies approximately 700 to 800 million gallons of wastewater annually consisting of potato processing wastewater, defrost wastewater and wash water from Americold, and the Hermiston Co-Generation facility wastewater. During 2005, average values for ConAgra's wastewater include:

- 2,546 mg/l Chemical Oxygen Demand (COD)
- 123 mg/l Total Kjeldahl Nitrogen (TKN)
- 38 mg/l ammonia
- 1,853 mg/l total dissolved solids (TDS)
- 223 mg/l total suspended solids (TSS)
- 4.9 pH

Principal components of ConAgra's wastewater treatment system include screens, a primary clarifier, an oil/grease separator, a lined surge pond, and an unlined five million gallon storage lagoon. The wastewater is applied on two parcels of land: the North Farm and Madison Ranch. The locations of the North Farm and Madison Ranch are indicated in Figure 1-2. The North Farm is owned by ConAgra and consists of 693 acres, while the Madison Ranch site is owned by Madison Farms and consists of approximately 4,200 acres. Both sites are managed by Madison Farms and are irrigated with center pivot and wheel line systems. Crops grown using the wastewater include a rotation of alfalfa, wheat, corn, peas, pasture grass, and canola.

It should be noted that nitrate data from both ConAgra sites collected prior to October 1995 are not included in this analysis because sampling procedures (and hence analytical results) changed at that time.

3.2 North Farm

The ConAgra North Farm is located approximately 4 miles west of the City of Hermiston, northwest of Interstate 82 and east of the Umatilla Ordnance Depot (Figure 1-2). The land application system at the North Farm began in 1972 or 1973. Prior to the land application system, the land occupied by the North Farm was dry land. Approximately 75 to 100 million gallons of wastewater are applied on the North Farm per year.

The North Farm is located on the southeast flank of a relatively broad topographic ridge trending northeast/southwest. The ridge slopes down to the Umatilla River to the east and down to the Columbia River to the north and west. Coyote Coulee (a dry ravine) bisects the ridge and is located approximately ½ mile northwest of the North Farm.

Soils at the North Farm are excessively drained loamy fine sands and sands. Topographic slopes of up to 25% are present. Land surface elevation at the North Farm drops fairly evenly approximately 90 feet from the northwest corner (approximately 650 feet above mean sea level) to the southeastern boundary (approximately 560 feet above mean sea level). Based solely on land surface topography, groundwater flow across the North Farm would be expected to be towards the southeast. However, as will be discussed in Section 3.2.1, that is not the case.

Nearby surface water features include the unlined pond located in the south-central portion of the site, and the Westland A canal which parallels the southeastern boundary of the property. The gravel pits located immediately south of the Farm occasionally receive overflow from the Westland A Canal.

The average depth to water beneath the North Farm ranges from approximately 13 feet (at the "shallow" well MW-7 located southeast of the storage lagoon) to approximately 76 feet (at the "deep" well MW-3 located on the western property boundary). With all other variables being equal, wells with a greater depth to water would be slower to respond to changes in practices at land surface.

In August 2004, the United States Environmental Protection Agency (EPA) and the United States Geological Survey (USGS) collected groundwater samples from three North Farm Site wells and from five wells located at the Umatilla Chemical Depot landfill. The purpose of the sampling was to determine if nitrate from food processing wastewater could be distinguished from other sources of nitrate like animal and human waste, soil nitrate, and commercial fertilizer. The study determined that it was not possible to differentiate between food processing wastewater and other nitrate sources (Frans, 2006 written communication). Four of the samples (one from the North Farm and three from the Depot) were analyzed for tritium (^3H) and its radioactive decay product helium-3 (^3He). The $^3H/^3He$ ratio was used to calculate the apparent age of the water. The $^3H/^3He$ age is defined as the time elapsed since the parcel of water was isolated from the atmosphere following recharge (USGS, 2006).

Groundwater age is similar to solute concentration in that its distribution is controlled by how molecules move along with flowing groundwater, spread out while flowing, and are diluted with solute-free water as it moves. Mixing water of different solute concentration or age will mix the concentration or age. For example, mixing a kilogram of 10 year old water with a kilogram of 30 year old water yields 2 kilograms of 20 year old water (Bethke and Johnson, 2002). The apparent recharge age results are discussed in Section 3.2.4.

3.2.1 Upgradient and Downgradient Wells

The groundwater flow direction at the North Farm and Madison Ranch is described in DEQ (2004). In summary, a groundwater mound exists beneath the North Farm. It is assumed that the groundwater mound is shaped somewhat like the northeast/southwest trending topographic ridge on which the North Farm sits with groundwater flowing radially away from the center of the mound.

Because no water level data are available from north of the North Farm, it is not possible to determine either the exact shape of the mound or the location of the center of the mound. Additional wells were installed at the North Farm in the summer of 2006 but information from these new wells is still being incorporated into an understanding of the site hydrogeology. Based on existing information, the center of the mound is believed to be located near, or somewhere northeast of well MW-4. The following discussion of upgradient and downgradient wells is based on the hydrogeology discussion in Section 3.2.1 of DEQ (2004).

Upgradient wells for the North Farm would be located near the center of the groundwater mound along the northern property boundary. Downgradient wells would be located near the southern, eastern, and western property boundaries. Because the source of nitrate loading is at land surface, shallow wells that bracket the water table provide the most useful water quality and water level information to gauge the effects of facility operations. Because the lithology at the site is variable, the most meaningful evaluation of potential effects from the North Farm would be made using comparisons between wells completed in similar materials at similar elevations.

No shallow well is currently located in an upgradient location. Therefore, no upgradient to downgradient comparison can be made in the shallow aquifer zone. However, the deep well MW-4 is presumed to be located in an upgradient location. This well is screened in silt and clay at an elevation of approximately 500 to 510 feet above sea level. Wells MW-2 and MW-3 are constructed in somewhat similar material (sand at MW-2; clay at MW-3) and at similar elevations. Therefore, the best upgradient to downgradient comparison using the existing well network is using MW-4 as an upgradient well and MW-3 and MW-2 as downgradient wells.

3.2.2 Nitrate Trends

A trend analysis of nitrate concentrations at the ten ConAgra North Farm wells was conducted as described in Section 1.3. Table 3-1 summarizes the data used in this analysis and includes some data set statistics (e.g., mean and maximum values), a summary of the trend analysis (e.g., the slope and confidence level of the line) and a description of the LOWESS pattern (e.g., increasing then decreasing). Time series graphs of nitrate concentrations and trends at each ConAgra well are included in Appendix 2.

Table 3-1 lists the individual results of the trend analyses for each well. The results can be summarized as follows:

- 5 wells exhibit increasing trends,
- 2 wells exhibit decreasing trends, and
- 3 wells exhibit statistically insignificant trends.

The trends range from increasing at 3.67 ppm/yr at MW-7 to decreasing at 0.17 ppm/yr at MW-3. The site-wide average nitrate trend (i.e., the average of all 10 slopes) is increasing at approximately 0.5 ppm/yr. The average of the 7 statistically significant trends is approximately 0.7 ppm/yr.

Table 3-1 also lists the description of the LOWESS pattern for individual wells. The LOWESS patterns observed can be summarized as follows:

- 3 wells show a steadily increasing pattern
- 2 well shows an increasing then decreasing pattern
- 1 well shows a flat then decreasing pattern
- 1 well shows a decreasing pattern
- 3 wells shows an basically flat pattern

In other words, about one-third of the wells exhibit increasing patterns, one-third exhibit decreasing or recently decreasing patterns, and one-third exhibit flat patterns.

Figure 3-1 is a graph of all nitrate data from the ten North Farm wells, with a LOWESS line drawn through the data. Figure 3-1 consists of many stacks of data points at approximately 3 month intervals. Each of these stacks of data represents one quarterly sampling event and contains one data point for each well sampled that event. It is evident from Figure 3-1 that most the highest concentrations detected have occurred in the latter portions of the data set and that the minimum concentration detected has increased. The LOWESS line increases from 1996 through about 1999 then levels off through 2005.

Figure 3-2 includes the nitrate trends and LOWESS lines at each of the ten North Farm wells. The ten graphs are plotted at the same scale to allow a comparison of trends between wells. Useful information can be gained by comparing trend lines with LOWESS lines. For example, Figure 3-2 illustrates the following:

- Nitrate concentrations at the well with the overall steepest trend (3.67 ppm/yr at MW-7) increased, then began to level off,
- Nitrate concentrations at MW-8 increased until about 2000, then decreased through about 2003, then leveled off.

Figure 3-3 is a map view of the site illustrating the nitrate trends at each of the wells. The three shallow wells (MW-7, MW-8, and MW-10) exhibit one increasing and two statistically insignificant trends. The seven deep wells are a mix of increasing, decreasing, and statistically insignificant trends. The steepest increasing trend (3.67 ppm/yr) is at the shallow well MW-7 located near the wastewater storage lagoon. The next steepest increasing trend (0.63 ppm/yr) is at the deep downgradient well MW-6 located along the southeastern property boundary. The steepest decreasing trend is at deep well MW-3 located near the eastern boundary of the North Farm. The fact that the steepest increasing trend is located downgradient of the storage lagoon suggests wastewater may be leaking from the lagoon. The fact that the presumed upgradient well has an increasing trend suggests some of the increasing nitrate may be the result of off site activities.

3.2.3 Average Nitrate Concentrations

Figure 3-4 is a map view of the site illustrating the average nitrate concentrations at each of the North Farm wells from October 1995 or January 1996 through November 2005. The highest average nitrate concentrations are at the 3 shallow wells (51.3 ppm at MW-8, 47.4 ppm at MW-10, and 41.1 ppm at MW-7). The lowest average nitrate concentrations are at the 2 wells completed in basalt (6.0 ppm at MW-6 and 6.9 ppm at MW-9).

The remaining wells have average nitrate concentrations ranging from 9.8 to 27.3 ppm. The decreasing nitrate concentration with depth suggests facility operations have affected groundwater.

3.2.4 Apparent Recharge Age of Water

The apparent age of groundwater samples collected from one North Farm Site well and three Depot landfill wells was calculated using tritium and helium-3 concentrations. The four wells tested include the North Farm well MW-10 and the Depot landfill wells 11-3, MW-33, and 11-7. The Depot landfill wells are located downgradient of MW-10 (approximately ⅜ to ⅞ mile west of MW-2). Apparent recharge age results were 5 years at the North Farm Site well and greater than 50 years at the 3 Depot landfill wells.

The young age of groundwater at MW-10 suggests groundwater impacts at the North Farm are, in large part, due to recent facility operations. The old age of groundwater at the Depot landfill wells suggests relatively minor effects from recent wastewater application at the North Farm Site are evident at the landfill.

3.2.5 Upgradient to Downgradient Comparisons

Based on the selection of well MW-4 as the upgradient well and well MW-2 and MW-3 as downgradient wells, the following comparison of upgradient to downgradient nitrate concentrations was made. It should be noted that these wells are deep wells; no upgradient shallow well data exist to allow comparisons. Furthermore, the location of the center of the mound is not known, so MW-4 may not be upgradient of MW-2 and MW-3. Finally, due to the radial nature of groundwater flow, one upgradient/downgradient comparison may not be representative of the entire site.

Figure 3-5(a) is a time series graph showing the nitrate concentrations at the presumed upgradient well and the downgradient wells. In addition to the individual data points connected by a thin line, a thick LOWESS line is drawn through the data. Figure 3-5(a) shows while the upgradient nitrate concentrations rose from about 1996 through 1999, the downgradient concentrations remained fairly constant. With two exceptions, upgradient concentrations were greater than downgradient concentrations throughout this time frame.

Figure 3-5(b) is a box and whisker plot summarizing the nitrate concentrations from the upgradient deep well (MW-4) and the downgradient deep wells (MW-2, and MW-3)[6]. Figure 3-5(b) shows the average upgradient deep nitrate concentration is approximately 25 ppm, and half of the values are from approximately 24 to 26 ppm. Figure 3-5(b) also shows the average downgradient deep nitrate concentration is approximately 15 ppm, and half of the values are from approximately 9 to 19 ppm.

Based on a comparison of the deep upgradient well MW-4 to deep downgradient wells MW-2 and MW-3, land application activities have not caused an increase above background nitrate concentrations in the deeper sediments at the western portion of the North Farm.

3.2.6 Comparison to Previous Analysis

A comparison was made between the previous (through 2001) and current (through 2005) trend analyses. Changes in data set statistics as well as changes in the nitrate trends at the North Farm are summarized in Table 3-2. These changes are interpreted as indications of improving or worsening water quality between 2001 and 2005[7].

Indications of improving water quality since the previous analysis include:

- more wells exhibited improving trends (i.e., a less steeply increasing trend) than worsening trends, and

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[6] The "box" portion of the plot identifies the interquartile range (IQR). The IQR is the middle half of the data (i.e., those data between the 25th and 75th percentiles). The "whisker" portion of the plot extends outwards from the box to any point within 1.5 times the IQR. Any point beyond the whiskers is plotted individually. The horizontal line through the box represents the median value. The star represents the average value.

[7] An "improving" trend is defined as either a steeper decreasing trend or a less steeply increasing trend. A "worsening" trend is defined as either a steeper increasing trend or a less steeply decreasing trend.

- the site-wide average trend slope improved (i.e., less steeply increasing trend).

Indications of worsening water quality since the previous analysis include:

- more wells exhibited a new maximum concentration than a new minimum concentration,
- more wells exhibited higher mean concentrations than lower mean concentrations, and

In summary, although the majority of wells and the site as a whole exhibit increasing trends, the trends are increasing less steeply through 2005 than they did through 2001. The lower concentrations in recent years cause this change in long term trend.

3.2.7 Conclusions

Based on the discussion of the data for the ConAgra North Farm site presented above, the following conclusions have been made, and are grouped by topic:

Upgradient and Downgradient Wells

- The 10-well network is insufficient to gauge upgradient to downgradient water quality changes. Once information from the summer 2006 well installations is incorporated into an understanding of the sites hydrogeology, a decision can be made as to the adequacy of the well network.

Nitrate Trends

- Nitrate concentrations at the North Farm are generally increasing, as evidenced by:
    - 50% of the wells have statistically significant increasing trends.
    - Another 20% of the wells have statistically insignificant increasing trends.
    - Trends range from decreasing at 0.17 ppm/yr to increasing at 3.67 ppm/yr with the site-wide average nitrate trend increasing at least 0.5 ppm/yr.
    - Two-thirds of the wells exhibit either flat or increasing LOWESS patterns.
    - Most of the highest concentrations occur in the latter portion of the data set.
    - Minimum concentrations detected are increasing.

Average Nitrate Concentrations

- The highest average nitrate concentrations are in the shallow wells (41 to 51 ppm).
- The lowest average nitrate concentrations are in the deep wells completed in basalt (6 to 7 ppm).

Apparent Recharge Age of Groundwater

- The apparent recharge age of water at MW-10 is 5 years.
- The apparent recharge age of water at the Umatilla Chemical Depot landfill is greater than 50 years.

Factors Affecting Nitrate Concentrations

- There is evidence suggesting facility operations have affected, and continue to affect, groundwater quality, such as:
    - Shallow groundwater has higher nitrate concentrations than deeper groundwater. The highest average concentrations are in the 3 shallow wells while the lowest average concentrations are in the 2 deep wells completed in basalt.
    - The steepest increasing trend is located in a shallow well downgradient of the storage lagoon suggesting wastewater may be leaking from the storage lagoon.
    - The apparent recharge of groundwater at MW-10 is 5 years.
- There is also evidence suggesting an upgradient source of nitrate.
    - The fact that the deep presumed upgradient well has elevated nitrate and an increasing trend suggests some of the increasing nitrate may be the result of off site activities.

- Based on a comparison of the deep presumed upgradient well MW-4 to deep downgradient wells MW-2 and MW-3, land application activities have not caused an increase above background nitrate concentrations in the deeper sediments of the western portion of the North Farm.
- Potential methods to assess the effectiveness of current facility operations are discussed in Section 8.4.

Comparison to Previous Analysis

- Although the majority of wells and the site as a whole exhibit increasing trends, the trends are increasing less steeply through 2005 than they did through 2001.

3.3 Madison Ranch

The ConAgra Madison Ranch site is located approximately 5 miles south of the City of Hermiston, south of Interstate 84 and west of State Road 207 (Figure 1-2). The land application system at Madison Ranch began in 1991. The Butter Creek flood plain portion of Madison Ranch has been farmland since the 1800's. Prior to the land application system, the land occupied by the upland portion of Madison Ranch was unfarmed dry land. Approximately 700 million gallons of wastewater are applied on Madison Ranch per year.

The Madison Ranch site includes portions of both the Butter Creek flood plain and the uplands to the west of the flood plain. Soils within the flood plain include silt loams, loamy sands, and sandy loams that are predominantly well drained. Soils that are somewhat poorly drained, moderately well drained, and excessively drained also occur in the flood plain. Topographic slopes are generally 0 to 5%, but slopes of 5% to 25% also occur. The dominant soils within the uplands also include silt loams, loamy sands, and sandy loams, but are well drained to excessively drained. Topographic slopes within the uplands are generally less than 7%, but slopes of up to 25% are common. Small portions of the site have steeper slopes.

Land surface elevation within the Butter Creek flood plain slopes fairly evenly from approximately 800 feet above mean sea level at the southern property boundary to 640 feet above mean sea level at the northern property boundary. The uplands are cut by several ephemeral drainages with land surface elevation ranging from approximately 1,040 feet above mean sea level at the southern property boundary to approximately 640 feet above mean sea level at the northern property boundary.

Nearby surface water features include Butter Creek which flows northward through the eastern portion of the site, several unnamed irrigation canals and ditches within the Butter Creek flood plain, and the High Line canal which forms a portion of the northern property boundary before emptying into Lost Lake located approximately ½ mile north/northwest of the property.

The average depth to water beneath the Butter Creek flood plain portion of the Madison Ranch site ranges from approximately 12 feet below land surface (at well MW-10) to 15 feet below land surface (at wells MW-11 and MW-12). The average depth to water beneath the upland portion of the Madison Ranch site ranges from approximately 33 feet below land surface (at well MW-3) to more than 150 feet below land surface (at well MW-2). With all other variables being equal, wells with a greater depth to water would be slower to respond to changes in practices at land surface.

3.3.1 Upgradient and Downgradient Wells

The groundwater flow direction at the ConAgra Madison Ranch site is described in DEQ (2004). In general, groundwater within the Butter Creek floodplain is expected to flow straight down the floodplain. Groundwater on the flanks of the floodplain is expected to flow into the floodplain. Groundwater flow beyond the flanks of the floodplain is expected to be controlled by land surface topography, location of surface water features, location of recharge (i.e., where irrigation water is applied), and the elevation of the underlying basalt surface.

Well MW-12 is an upgradient well for the Butter Creek drainage. Wells MW-5 and MW-11 are located on land that received wastewater from 1992 through 1998 but are no longer part of the ConAgra permit. Therefore, MW-5 and MW-11 are not suitable downgradient wells. There are currently no downgradient wells for the floodplain portion of Madison Ranch.

Groundwater flow directions in the uplands are not well understood. Based on the discussion in DEQ (2004), upgradient wells would be located either at the upper ends of drainages (e.g., where Fourmile Canyon enters the property) or near the center of topographic and hydraulic “islands” (e.g., Ward Butte). Currently there are no upgradient wells for the uplands.

Additional wells were installed at Madison Ranch in the summer of 2006 but information from these new wells is still being incorporated into an understanding of the site hydrogeology.

3.3.2 Nitrate Trends

A trend analysis of nitrate concentrations at the twelve ConAgra Madison Ranch wells was conducted as described in Section 1.3. Table 3-3 summarizes the data used in this analysis and includes some data set statistics (e.g., mean and maximum values), a summary of the trend analysis (e.g., the slope and confidence level of the line) and a description of the LOWESS pattern (e.g., increasing then decreasing). Time series graphs of nitrate concentrations and trends at each ConAgra well are included in Appendix 2.

Table 3-3 lists the individual results of the trend analysis for each well. The results can be summarized as follows:

- 7 onsite wells exhibit increasing trends,
- 1 onsite well and 2 offsite wells exhibit decreasing trends, and
- 2 onsite wells exhibit statistically insignificant trends.

Statistically significant trends range from increasing at 2.03 ppm/yr (at MW-6) to decreasing at 0.47 ppm/yr (at MW-10). The site-wide average nitrate trend (i.e., the average of all 10 slopes) is increasing at approximately 0.21 ppm/yr. The average of the 8 statistically significant trends is approximately 0.28 ppm/yr.

Table 3-3 also lists the description of the LOWESS pattern for each individual well. The LOWESS patterns observed can be summarized as follows:

- 6 wells show a steadily or recently increasing pattern
- 4 wells shows an increasing then decreasing pattern

In summary, most wells exhibit consistently or recently increasing LOWESS patterns. The remaining wells exhibit an early increasing pattern followed by decreasing concentrations.

Figure 3-6 is a graph of all nitrate data from the 10 Madison Ranch wells, with a LOWESS line drawn through the data. It is evident from Figure 3-6 that the highest concentrations detected have occurred at well MW-6, and that concentrations at MW-6 continue to increase. The LOWESS line is basically flat (it has a gentle upward curve through 1998 then gently decreases through 2001, then gently increases through 2005). The relatively flat LOWESS line reflects the generally consistent nitrate concentrations between wells and relatively flat trends at individual wells.

Figure 3-7 includes the nitrate trends and LOWESS lines at each of the Madison Ranch wells (including the two offsite wells). The 12 graphs are plotted at the same scale to allow a comparison of trends between wells. As mentioned previously, useful information can be gained by comparing trend lines with LOWESS lines. For example, Figure 3-7 illustrates that nitrate concentrations at 4 wells (MW-1, MW-10, MW-11, & MW-12) increased then decreased.

Figure 3-8 is a map view of the site illustrating the nitrate trends at each of the wells. Increasing trends occur in both the uplands and the floodplain. Decreasing trends occur in the floodplain. Statistically insignificant trends occur in the uplands and floodplain.

MW-6 (located on the eastern edge of the flood plain) exhibits the steepest increasing trend (2.06 ppm/yr). The next steepest trend (0.22 ppm/yr) is at well MW-12 located at the upgradient edge of Butter Creek floodplain. The steepest increasing trend at an upland well (0.20 ppm/yr) is at well MW-9 near the northern property boundary.

The fact that the steepest increasing trends are located near the upgradient and eastern edge of Butter Creek floodplain suggests some impact is occurring to the site from off site activities. Although the increasing trends at the uplands are relatively small (i.e., less than or equal to 0.2 ppm/yr), the fact that upland wells and wells near the northern property boundary exhibit increasing trends suggests facility operations are affecting groundwater.

3.3.3 Average Nitrate Concentrations

Figure 3-9 illustrates the average nitrate concentrations at each of the Madison Ranch wells from late 1995/early 1996 through 2005. The highest average nitrate concentration is at well MW-6 (located on the eastern edge of the floodplain). The lowest average nitrate concentrations are at the 2 deepest upland wells (0.2 ppm at MW-2 and 0.5 ppm at MW-7). The remaining wells have average nitrate concentrations ranging from 0.9 to 6.9 ppm. The lower average nitrate concentration in upland wells may reflect better nitrogen management, the greater depth to groundwater, and/or shorter duration of farming activities.

3.3.4 Upgradient to Downgradient Comparisons

Based on the groundwater flow regime discussed in Section 3.3.1, there are currently no Butter Creek flood plain wells that are solely downgradient of ConAgra activities. Similarly, there are currently no upgradient wells located within the uplands. Therefore, no meaningful comparisons of upgradient to downgradient concentrations within the Butter Creek flood plain or within the uplands can be made.

3.3.5 Comparison to Previous Analysis

A comparison was made between the previous (through 2001) and current (through 2005) trend analyses. Changes in data set statistics as well as changes in the nitrate trends at Madison Ranch are summarized in Table 3-4. These changes are interpreted as indications of improving or worsening water quality between 2001 and 2005.

Indications of improving water quality since the previous analysis include:

- slightly more wells exhibited improving trends than worsening trends, and
- the site-wide average trend slope improved.

Indications of worsening water quality since the previous analysis include:

- 3 wells exhibited new maximum concentrations while none exhibited new minimum concentrations,
- More wells exhibited higher mean and median concentrations than lower mean and median concentrations.

In summary, although the majority of wells and the site as a whole exhibit increasing trends, the trends are increasing less steeply through 2005 than they did through 2001. The lower concentrations in recent years cause this change in long term trend.

3.3.6 Conclusions

Based on the discussion of the data for the ConAgra Madison Ranch site discussed above, the following have been made, and are grouped by topic:

Upgradient and Downgradient Wells

- Well MW-12 is located upgradient of the Madison Ranch portion of the Butter Creek flood plain.
- There are no Butter Creek flood plain wells that are solely downgradient of ConAgra activities.

- Currently there are no upgradient wells for the uplands.

Nitrate Trends

- Nitrate concentrations at Madison Ranch are generally increasing, as evidenced by
  - 70% of the wells have statistically significant increasing trends.
  - The site-wide average nitrate trend is increasing at least 0.2 ppm/yr.
  - Most wells exhibit consistently or recently increasing LOWESS patterns.
  - The highest concentrations occur in the latter portion of the dataset.

Average Nitrate Concentrations

- The highest average nitrate concentration (23.9 ppm) is at well MW-6 located on the eastern edge of the floodplain.
- The lowest average nitrate concentrations are at the 2 deepest upland wells (0.2 ppm at MW-2 and 0.5 ppm at MW-7).
- The remaining wells have average nitrate concentrations ranging from 0.9 to 6.9 ppm.

Factors Affecting Nitrate Concentrations

- The existing groundwater monitoring network is insufficient to adequately evaluate upgradient to downgradient nitrate concentrations in both the uplands and the Butter Creek flood plain. However,
  - The fact that upland wells near the downgradient property boundary exhibit increasing trends suggests facility operations may be affecting groundwater, and
  - The fact that the steepest increasing trends are located near the upgradient and eastern edge of Butter Creek floodplain suggests some nitrate is coming from off site activities.
- The lower average nitrate concentration in upland wells versus flood plain wells may reflect better nitrogen management, the greater depth to groundwater, and/or shorter duration of farming activities at the uplands.
- The large range of depth to water across the site could cause substantial variability in the timing of groundwater quality responses to activities at land surface.
- Potential methods to assess current facility operations are discussed in Section 8.4.

Comparison to Previous Analysis

Although the majority of wells and the site as a whole exhibit increasing trends, the trends are increasing less steeply through 2005 than they did through 2001.

3.4 Recommendations

Based on the conclusions above, the following recommendations are made:

- Expand the well network at the North Farm to allow upgradient to downgradient comparisons in the shallow sediments. This recommendation was made in the previous report and still stands.
- Expand the well network at Madison Ranch to allow upgradient to downgradient comparisons in the Butter Creek flood plain and in the uplands. This recommendation was made in the previous report and still stands.
- In order to gauge when the effects of BMP implementation will be observed as improving groundwater quality, it is recommended that funding be pursued to allow additional research into factors including: (1) quantifying the amount of nitrate that exists between the root zone and the water table, (2) the rate of nitrate transport through the unsaturated zone, and (3) more precisely quantifying groundwater flow velocity at the site.
- Due to the high percentage of increasing trends and impacts to groundwater from land application activities, it is recommended that BMP implementation to reduce the area-wide extent of elevated nitrate concentrations be continued and, when possible, improved. BMPs should include detailed procedures to:
  - establish appropriate crop specific nitrogen loading rates,
  - accurately quantify hydraulic loading from all sources,

  - document nutrient additions from all sources,
  - insure uniform sample acquisition and analysis,
  - characterize and monitor nitrogen concentration and movement in the soil column,
  - monitor moisture content and movement in the soil column, and
  - perform annual site specific analysis to identify farming activities and/or soil conditions that increase the potential for impact to groundwater.
- In accordance with the Action Plan, it is recommended that a trend analysis of data from the same wells be conducted in 2010 to evaluate progress towards improving groundwater quality at the food processing wastewater land application sites.

4.0 SIMPLOT SITES

4.1 Introduction

The Simplot potato processing facility began operations in 1977. Over the years, Simplot modified practices and procedures to reduce the amount of nitrate and hydraulic loading to the groundwater system. In the late 1990s, Simplot voluntarily entered into a Remedial Investigation / Feasibility Study to identify and document potential remedies for the increasing groundwater nitrate concentrations. Recommendations from the Feasibility Study included the following practices:

- *Expansion of land application areas* – Simplot increased the land area used to apply wastewater to include the Terrace Site in 1981, the Expansion Site in 1991, and the Levy Site in 2002.
- *Improved waste treatment process* – In 1987, Simplot built a digester and improved solids removal by installing a centrifuge. In 1995, Simplot built a larger clarifier and installed a second centrifuge for additional solids removal.
- *Limiting winter irrigation* – In 1991, Simplot built the Terrace Site Lagoon so that water could be stored during a portion of the winter months rather than land applied.
- *Eliminating winter irrigation* **–** In 2002, Simplot built a second lagoon so that water could be stored during the entire winter, which eliminated winter irrigation.
- *Reducing nitrogen loading* – In 2001, Simplot stopped taking credit for ammonia volatilization which equates to a 40% reduction in planned nitrogen loading. In 2002, Simplot reduced the loading on alfalfa at the Levy property to 250 lb/acre.

The Simplot potato processing facility shut down in November 2004. At that time, some potato processing wastewater remained in the Terrace Site Lagoon. The CalPine power plant continued to generate wastewater that was added to the lagoon throughout the winter of 2004/2005. Wastewater associated with potato processing was gradually pumped out during 2005. Wastewater from the power plant continues to be piped to the lagoon for use as irrigation water. After expansion to the Levy farm in 2002, Simplot did not have enough nitrogen to fulfill the needs of all crops grown so they began applying commercial fertilizer at that time. The amount of commercial fertilizer applied has increased since the plant shut down.

Simplot's wastewater system can handle approximately 2.35 million gallons per day (MGD). Prior to November 2004, the bulk of the water (2.0 MGD) was food processing wastewater from the preparation and packaging of potato products. Other sources of wastewater that are land applied include co-generation wastewater from the adjacent CalPine steam electric generation facility (0.35 MGD), and filter back wash wastewater from the Umatilla Regional Water Facility.

In 2000, Simplot land applied approximately 616 million gallons. From 1991 through 2000, average values for Simplot's wastewater include:

- 1,350 mg/l Chemical Oxygen Demand (COD)
- 145 mg/l Total Kjeldahl Nitrogen (TKN)
- 104 mg/l ammonia
- 1,672 mg/l total dissolved solids (TDS)
- 1 mg/l nitrate-nitrogen (NO_3)
- 107 mg/l chloride (Cl)
- 28 mg/l calcium (Ca)
- 103 mg/l sodium (Na)
- 46 mg/l magnesium (Mg)
- 363 mg/l potassium (K)
- 795 mg/l bicarbonate (HCO_3)
- 58 mg/l total phosphorus (P)

In 2005, Simplot land applied approximately 510.5 million gallons of water. Because there was no more potato processing water being generated, the CalPine waste stream (513,000 gallons) was the only significant wastewater stream going to the wastewater lagoon. To decrease the TDS concentration in the water prior to irrigation, 510 million gallons of groundwater was pumped into the lagoon. The water pumped from the lagoon used for irrigation contained an average 17 mg/l TKN and 399 mg/l TDS.

As of the end of 2005, the water was applied on four parcels of land: the Plant Site, the Terrace Site, the Expansion Site, and the Levy Site. The locations of the Plant Site, Terrace Site, and Expansion Site are indicated in Figure 1-2.

4.2 Plant Site

The Simplot Plant Site is located approximately 3 miles south of the City of Hermiston, northeast of the junction of US Interstate 84 and Oregon 207 (Figure 1-2). Until November 2004, wastewater was screened, treated (using a primary clarifier, diffused air flotation system, and an anaerobic digester) at the Plant Site, and then stored in a surge pond or a storage pond before being applied to agricultural land at one of Simplot's parcels of land. At the Plant Site, wastewater was historically applied to as many as 12 fields comprising as much as 220 acres. Crops grown using the wastewater include a rotation of grain (corn, wheat, and barley), forage grasses (tall fescue, reed canary grass, and other suitable forage grass species), and alfalfa. When alfalfa is used in a rotation, it is maintained for four or more years.

The land application system at the Plant Site began in 1977. Prior to the land application system, the land occupied by the Plant Site included houses and small farming operations using Umatilla River water for irrigation.

The geomorphology of the Plant Site includes an upland terrace and the Umatilla River flood plain. The terrace and flood plain generally exhibit gentle slopes (0 to 5%) except where they meet, when slopes reach 25%. Topography at the Plant Site ranges from approximately 530 to 610 feet above mean sea level.

Nearby surface water features include the Umatilla River (which flows east to west across the property), Manns Pond and several un-named irrigation canals located south of the River, and the Feed Canal (delivering water from the Umatilla River to Cold Springs Reservoir) approximately ½ mile northeast of the Plant Site. Because deep percolation of irrigation water is a major source of recharge to the alluvial aquifer, wells closer to leaky fresh water canals (and for that matter fresh water streams) are more likely to exhibit lower nitrate concentrations due to dilution from the surface water.

The depth to water beneath the Plant Site ranges from approximately 6 feet below land surface (at wells MW-17 and MW-19; located within the flood plain) to approximately 122 feet below land surface (at well MW-59 located on the terrace). Wells monitoring the deeper portion of the aquifer beneath the terrace (i.e., MW-13d) have water levels as deep as 149 feet below land surface. With all other variables being equal, wells with a greater depth to water would be slower to respond to changes in practices at land surface.

4.2.1 Upgradient and Downgradient Wells

The groundwater flow direction at the Simplot Plant site is described in DEQ (2004). In general, groundwater flows northwest across the site regardless of season. Groundwater flows toward the Umatilla River from the south but not from the north. The maps in DEQ (2004) suggest some shallow groundwater is "cutting the corner", so to speak[8], where the river changes from flowing west to flowing north. These maps suggest a shallow groundwater flow path extends under the terrace that underlies the Simplot Plant site towards Minnehaha Spring.

[8] As the Umatilla River passes the Plant Site flowing west, some surface water is believed to "cut the corner" to the north-flowing portion. In other words, some water exits the channel by moving northwest, enters the groundwater system, crosses the site, and re-enters the river channel, perhaps at Minnehaha Spring.

DEQ (2004) classifies the wells at the Simplot Plant site as either a flood plain well or an alluvial well. This distinction is based on location, typical water level, timing of water level fluctuations, typical lithology, and general water quality. Flood plain wells are located within the Umatilla River flood plain, are generally screened in coarser-grained sediments (sand and gravel), exhibit water levels near 540’, fluctuate annually with highest water levels typically in the winter or spring, and lowest water levels in the summer and fall. Total Dissolved Solids (TDS) concentrations of flood plain wells are less than alluvial wells but higher than river concentrations.

Flood plain wells are located within the Umatilla River flood plain, are generally screened in coarser-grained sediments (sand and gravel), exhibit water levels near 540’, fluctuate annually with highest water levels typically in the winter or spring, and lowest water levels in the summer and fall. In addition, the TDS concentrations of flood plain wells are less than alluvial wells but higher than river concentrations.

Alluvial wells are located on the terrace on either side of the flood plain, are generally screened in finer-grained sediments (silty sands), exhibit water levels near 500’, and fluctuate annually with highest water levels in summer and fall, and lowest water levels in winter and spring. TDS concentrations are higher in alluvial wells than in flood plain wells or the river.

Based on the discussion above, upgradient wells for the Simplot Plant site would be located south and east of facility operations, while downgradient wells would be located north and west of facility operations. Wells MW-50, MW-19, and MW-49 are located upgradient of current facility operations. Wells MW-50 and MW-19 are located north of the River while MW-49 is located south of the River. It should be noted that wastewater was historically applied at the four fields located upgradient of MW-49 and MW-19 (between Umatilla Meadows Road and I-84) from 1981 to not later than 1990. Therefore, the potential exists for these wells to be affected by those facility operations. However, time versus concentration graphs indicate low nitrate concentrations (always less than 2 mg/l) at all three of these wells, suggesting these wells have not been affected by facility operations. However, because MW-49 is on the south side of the River and all current facility operations are north of the river, it is not an ideal upgradient well. Therefore, for the purposes of this report, wells MW-50 and MW-19 are considered upgradient wells.

Wells MW-16, MW-17, MW-20, MW-21, and MW-45 are located within the flood plain and downgradient of facility operations, thus making them potentially usable in upgradient to downgradient comparisons of flood plain water quality. Because there are some differences in general water quality between alluvial wells and flood plain wells, it would be ideal to have both upgradient and downgradient comparison wells in both areas. Wells MW-10s, MW-11s, and MW-46 are located onsite and downgradient of facility operations. However, based on the elevated nitrate concentrations at wells MW-12, MW-48, MW-13s, and others, there are no upgradient alluvial wells unaffected by facility operations. Therefore, all upgradient to downgradient comparisons in this report are made with wells MW-50 and MW-19 as the only upgradient wells.

4.2.2 Nitrate Trends

A trend analysis of nitrate concentrations at the 19 wells located on Simplot property and 4 wells located offsite was conducted as described in Section 1.3. Table 4-1 summarizes the data used in this analysis and includes some data set statistics (e.g., mean and maximum values), a summary of the trend analysis (e.g., the slope and confidence level of the line) and a description of the LOWESS pattern (e.g., increasing then decreasing). Time series graphs of nitrate concentrations and trends at each Simplot well are included in Appendix 3.

Table 4-1 lists the individual results of the trend analysis for each well. The results can be summarized as follows:

- the onsite wells exhibit:
  - 4 increasing trends (although MW-18 has not been sampled since May 1996),
  - 8 decreasing trends, and
  - 6 statistically insignificant trends.

- the offsite wells exhibit:
    - 1 increasing trend
    - 1 decreasing trend, and
    - 2 statistically insignificant trends.

Statistically significant trends range from increasing at 0.59 ppm/yr (at MW-10S) to decreasing at 2.82 ppm/yr (at MW-48). The site-wide average nitrate trend (i.e., the average of all 19 slopes) is decreasing at approximately 0.4 ppm/yr. The average of the 9 statistically significant trends is decreasing at approximately 0.7 ppm/yr.

Table 4-1 also lists the description of the LOWESS patterns for individual wells. Approximately half of the wells showed basically flat patterns. The other wells fluctuated between increasing and decreasing through time, with approximately half ending with increasing patterns and half ending with decreasing patterns. Only one well (MW-20) showing a consistent trend (decreasing).

Figure 4-1 is a graph of all nitrate data from the 19 onsite Simplot Plant Site wells, with a LOWESS line drawn through the data. Figure 4-1 consists of many stacks of data points at approximately 3 month intervals. Each of these stacks of data represents one quarterly sampling event and contains one data point for each well sampled that event. It is evident from Figure 4-1 that the highest concentrations detected have occurred in the early to middle portion of the dataset. The LOWESS line has a gentle downward slope through about 2000, then it is fairly level which reflects the overall decrease in nitrate concentrations at the site.

Figure 4-2 includes the nitrate trends and LOWESS lines at each of the 23 Simplot Plant Site wells. The 23 graphs are plotted at the same scale to allow a comparison of trends between wells. Useful information can be gained by comparing trend lines with LOWESS lines. For example, Figure 4-2 illustrates that nitrate concentrations at several wells (most notably MW-18, MW-47, & MW-48) increased then decreased.

Figure 4-3 is a map view of the site illustrating the nitrate trends at each of the wells. Most wells exhibit decreasing trends or statistically insignificant trends. Statistically significant trends range from increasing at 0.59 ppm/yr to decreasing at 2.82 ppm/yr. Four of the five increasing trends occur on the western portion of the alluvial terrace (i.e., the downgradient side of the site and offsite). The other increasing trend is at MW-18. However, this well has not been sampled since May 1996 so it is possible that nitrate concentrations are decreasing in this vicinity as they are in nearby wells.

The fact that the majority of wells exhibit decreasing or statistically insignificant trends with generally decreasing LOWESS lines, and that increasing trends are on the downgradient portion of the site suggests groundwater quality may be responding to the reductions in nitrate loading at the site. However, diesel biodegradation may also be reducing nitrate concentrations beneath a portion of the site. This idea is discussed in more detail in Section 4.2.4 of DEQ (2004).

4.2.3 Average Nitrate Concentrations

Figure 4-4 is a map view of the site illustrating the average nitrate concentrations at each of the Simplot Plant Site wells from 1996 through 2005, the timeframe in which all wells except MW-18 were installed and sampled. The averages in Table 4-1 use all data since each well was installed. MW-18 was sampled from November 1988 through June 1996, and abandoned shortly thereafter. In summary, average nitrate concentrations were highest in the onsite alluvial wells, lower in the offsite alluvial wells, and lowest in the flood plain wells.
The highest average nitrate concentration (33.2 ppm) is at the alluvial well MW-48. The lowest average nitrate concentrations are generally at flood plain wells (MW-50, MW-17, MW-19, and MW-49 all average less than 1 ppm). The remaining wells have average nitrate concentrations ranging from less than 1 to 21.9 ppm. The lower average nitrate concentrations in flood plain wells may reflect improvements in wastewater management, dilution of groundwater by surface water (i.e., the Umatilla River), and/or the effects of diesel biodegradation.

4.2.4 Upgradient to Downgradient Comparisons
As discussed in Section 4.2.1, wells MW-19 and MW-50 are upgradient flood plain wells while wells MW-16, MW-20, MW-21, and MW-45 are downgradient flood plain wells. While there are no upgradient alluvial wells, wells MW-10S, MW-11S, and MW-46 are downgradient alluvial wells. Using these designations, the following comparisons of upgradient to downgradient nitrate concentrations were made.

Figure 4-5(a) is a time series graph showing the nitrate concentrations at the upgradient flood plain wells MW-50 and MW-19 and the downgradient flood plain wells MW-16, MW-20, MW-21, and MW-45. In addition to the individual data points connected by a thin line, a thick LOWESS line is drawn through the data. Figure 4-5(a) shows upgradient nitrate concentrations are consistently low (less than 2 ppm) while the downgradient nitrate concentration are significantly higher (the LOWESS line begins at approximately 18 ppm). It is noteworthy that downgradient concentrations are decreasing.

Figure 4-5(b) is a box and whisker plot summarizing the nitrate concentrations from the upgradient wells (MW-19 & MW-50) and the downgradient wells (MW-16, MW-20, MW-21, and MW-45)[9]. Figure 4-5(b) shows the average upgradient nitrate concentration is approximately 0.3 ppm with all concentrations less than 2 ppm. Figure 4-5(b) also shows the average downgradient nitrate concentration is approximately 10 ppm with half of the concentrations between approximately 1 and 15 ppm.

Based on comparisons of nitrate concentrations at upgradient flood plain wells and downgradient flood plain wells, facility operations impacted groundwater quality in the past but are currently having little impact.

As indicated in Section 4.2.1, there are currently no upgradient flood plain wells that are unaffected by facility operations. Therefore, wells MW-50 and MW-19 are considered the best upgradient wells available for comparisons to both downgradient flood plain wells and alluvial wells. As discussed in Section 4.2.1, alluvial wells generally have higher nitrate concentrations than floodplain wells. Therefore, a hypothetical upgradient alluvial well would likely exhibit slightly higher nitrate concentrations than those at MW-19 and MW-50.

Figure 4-6(a) is a time series graph showing the nitrate concentrations at the upgradient *flood plain* wells MW-50 and MW-19 and the downgradient *alluvial* wells MW-10s, MW-11s, and MW-46. Figure 4-6(a) shows upgradient nitrate concentrations are consistently low (less than 2 ppm) while the downgradient nitrate concentration are significantly higher (the LOWESS line begins at approximately 12 ppm).

Figure 4-6(b) is a box and whisker plot summarizing the nitrate concentrations from the upgradient wells (MW-19 & MW-50) and the downgradient wells (MW-10s, MW-11s, and MW-46). Figure 4-6(b) shows the average upgradient nitrate concentration is approximately 0.3 ppm with all concentrations less than 2 ppm. Figure 4-6(b) also shows the average downgradient nitrate concentration is approximately 8 ppm with half of the concentrations between approximately 4 and 12 ppm.

Based on comparisons of nitrate concentrations at upgradient flood plain wells and downgradient alluvial wells, facility operations have impacted groundwater quality.

4.2.5 Comparison to Previous Analysis
A comparison was made between the previous (through 2001) and current (through 2005) trend analysis. Changes in data set statistics as well as changes in the nitrate trends at the Plant Site are summarized in Table 4-

[9] The "box" portion of the plot identifies the interquartile range (IQR). The IQR is the middle half of the data (i.e., those data between the 25th and 75th percentiles). The "whisker" portion of the plot extends outwards from the box to any point within 1.5 times the IQR. Any point beyond the whiskers is plotted individually. The horizontal line through the box represents the median value. The star represents the average value.

2. These changes are interpreted as indications of improving or worsening water quality between 2001 and 2005[10].

Indications of improving water quality since the previous analysis include:

- The site-wide average trend slope decreased from -0.30 to -0.44 ppm/yr, and
- More wells exhibited lower mean concentrations than higher mean values.

Indications of worsening water quality since the previous analysis include:

- Slightly more stations exhibited new maximum concentrations than new minimum concentrations,
- More stations exhibited an increase in median concentration than a decrease in median concentration, and
- More stations exhibited worsening trends than improving trends.

4.2.6 Conclusions

Based on the discussion of the data for the Simplot Plant site presented above, the following conclusions have been made, and are grouped by topic:

Upgradient and Downgradient Wells

- Upgradient wells for the Simplot Plant Site include MW-19 and MW-50.
- Because there are some differences in general water quality between alluvial wells and flood plain wells, it would be ideal to have both upgradient and downgradient comparison wells in both areas. However, no upgradient alluvial wells are unaffected by facility operations.
- Downgradient wells for the Simplot Plant Site include MW-16, MW-20, MW-21, and MW-45.
- Downgradient wells in the alluvium include MW-10s, MW-11s, and MW-46.

Nitrate Trends

- Nitrate concentrations are increasing at some wells and decreasing at other wells, as evidence by:
    - Nitrate trends are decreasing at 42% of the wells.
    - Nitrate trends are increasing at 21% of the wells.
    - The site-wide average nitrate trend is decreasing between 0.4 and 0.7 ppm/yr.
    - Approximately half of the wells showed basically flat LOWESS patterns. The other wells fluctuated between increasing and decreasing through time, with approximately half ending with increasing patterns and half ending with decreasing patterns.

Average Nitrate Concentrations

- Average nitrate concentrations are highest in the onsite alluvial wells, lower in the offsite alluvial wells, and lowest in the flood plain wells.
- The highest average nitrate concentration (33.2 ppm) is at the alluvial well MW-48.
- The lowest average nitrate concentrations are generally at flood plain wells (MW-50, MW-17, MW-19, and MW-49 all average less than 1 ppm).

Factors Affecting Nitrate Concentrations

- Facility operations have affected groundwater quality in the past, but water quality is improving, as evidenced by:
    - Downgradient wells have higher nitrate concentrations than upgradient wells indicating facility operations have impacted groundwater quality.
    - Average nitrate concentrations are highest in the onsite alluvial wells, lower in the offsite alluvial wells, and lowest in the flood plain wells. The lower average nitrate concentrations in

[10] An "improving" trend is defined as either a steeper decreasing trend or a less steeply increasing trend. A "worsening" trend is defined as either a steeper increasing trend or a less steeply decreasing trend.

flood plain wells may reflect improvements in wastewater management, dilution of groundwater by surface water (i.e., the Umatilla River), and/or the effects of diesel biodegradation.

- Wells closer to leaky fresh water canals and fresh water streams are more likely to exhibit lower nitrate concentrations due to dilution from the surface water.
- Biodegradation of diesel is occurring at a portion of the site which is reducing nitrate concentrations.
- The general site-wide decrease in nitrate concentrations is likely due to a combination of better wastewater management, dilution of groundwater by surface water, and biodegradation of diesel.
- The large range of depth to water across the site could cause substantial variability in the timing of groundwater quality responses to activities at land surface.

Comparison to Previous Analysis

Nitrate concentrations for the site as a whole and at many wells are improving. The number of statistically significant decreasing trends doubled from 4 to 8. The number of statistically significant increasing trends doubled from 2 to 4. The site-wide average trend continues to decrease, but steeper than previously. The lower concentrations in recent years cause this change in long term trend.

4.3 Terrace Site

The Simplot Terrace Site is located approximately 4 miles south of the City of Hermiston, southeast of the junction of US Interstate 84 and Oregon 207 (Figure 1-2). As indicated in Section 4.1, wastewater is screened, treated at the Plant Site, and then stored in a surge pond or a storage pond before being applied to agricultural land at one of Simplot's parcels of land. At the Terrace Site, wastewater is applied to as many as 6 fields comprising as much as 582 acres.

The land application system at the Terrace Site began in 1981. Prior to the land application system, the land occupied by the Terrace Site was a mixture of farmland and unfarmed dry land.

The Terrace Site is located on an upland terrace, situated between Emigrant Buttes (the surface expression of the Service Anticline) and the Butter Creek flood plain. The terrace exhibits a gentle northward slope (0 to 5%). Topography at the Terrace Site ranges from approximately 610 to 700 feet above mean sea level.

Nearby surface water features include Butter Creek (which is located just west of the site and flows south to north), and the Hunt Ditch (a component of the Westland Irrigation District delivering water from the Umatilla River to irrigated land in the vicinity) which wraps around the east, north, and west property boundaries. The Hunt Ditch is closest to the Terrace site at the northeast property boundary. The depth to water beneath the Terrace Site ranges from approximately 50 feet below land surface (at MW-51; a well located close to the Butter Creek flood plain) to approximately 90 feet below land surface (at MW-53; a well in the northern portion of the site).

In August 2004, the United States Environmental Protection Agency (EPA) and the United States Geological Survey (USGS) collected groundwater samples from nine Terrace Site wells and from four temporary wells located southeast of the intersection of State Road 207 and Interstate 84. The purpose of the sampling was to determine if nitrate from food processing wastewater could be distinguished from other sources of nitrate like animal and human waste, soil nitrate, and commercial fertilizer. The study determined that it was not possible to differentiate between food processing wastewater and other nitrate sources (Frans, 2006 written communication). Some of the samples were analyzed for tritium (^3H) and its radioactive decay product helium-3 (^3He). The $^3H/^3He$ ratio was used to calculate the apparent age of the water. The $^3H/^3He$ age is defined as the time elapsed since the parcel of water was isolated from the atmosphere following recharge (USGS, 2006).

Groundwater age is similar to solute concentration in that its distribution is controlled by how molecules move along with flowing groundwater, spread out while flowing, and are diluted with solute-free water as it moves. Mixing water of different solute concentration or age will mix the concentration or age. For example, mixing a kilogram of 10 year old water with a kilogram of 30 year old water yields 2 kilograms of 20 year old water (Bethke and Johnson, 2002). The apparent recharge age results are discussed in Section 4.3.4.

4.3.1 Upgradient and Downgradient Wells

The groundwater flow direction at the Terrace Site is described in DEQ (2004). In general, groundwater flows north to northwest across the site. Based on this groundwater flow direction, upgradient wells for the Simplot Terrace site would be located south and east of facility operations, while downgradient wells would be located north and west of facility operations. Wells MW-40 and MW-54 are located upgradient of current facility operations. Wells MW-22, MW-52, and MW-53 are located downgradient of current facility operations.

4.3.2 Nitrate Trends

A trend analysis of nitrate concentrations at the 10 wells located at the Simplot Terrace Site was conducted as described in Section 1.3. Table 4-3 summarizes the data used in this analysis and includes some data set statistics (e.g., mean and maximum values), a summary of the trend analysis (e.g., the slope and confidence level of the line) and a description of the LOWESS pattern (e.g., increasing then decreasing). Time series graphs of nitrate concentrations and trends at each Simplot well are included in Appendix 3.

Table 4-3 lists the individual results of the trend analysis for each well. The results can be summarized as follows:

- 7 wells exhibit increasing trends,
- 1 well exhibits a decreasing trend, and
- 2 wells exhibit statistically insignificant trends.

Statistically significant trends range from increasing at 1.80 ppm/yr (at MW-14) to decreasing at 2.07 ppm/yr (at MW-53). The site-wide average nitrate trend (i.e., the average of all 10 slopes) is increasing at 0.57 ppm/yr. The average of the 7 statistically significant trends is increasing at 0.68 ppm/yr.

Table 4-3 also lists the description of the LOWESS pattern for individual wells. The LOWESS patterns observed can be summarized as follows:

- 2 wells show increasing patterns with some fluctuations,
- 2 well shows an increasing then leveling off pattern,
- 3 wells show increasing trends, and
- 3 wells show increasing then decreasing patterns.

In summary, half of the wells exhibit consistently increasing or recently increasing LOWESS patterns. The other half exhibit increasing then decreasing trends or increasing then leveling off trends.

Figure 4-7 is a graph of all nitrate data from the 10 Simplot Terrace Site wells, with a LOWESS line drawn through the data. The solid data points represent those from well MW-53. It is evident from Figure 4-7 that (1) nitrate concentrations at well MW-53 are substantially higher than at all other wells, and (2) the highest concentrations detected have occurred in the middle and latter portions of the dataset, even if well MW-53 is not considered. The LOWESS line has an upward slope reflecting the overall increase in nitrate concentrations at the site.

Figure 4-8 includes the nitrate trends and LOWESS lines at each of the 10 Simplot Terrace Site wells. The 10 graphs are plotted at the same scale to allow a comparison of trends between wells. Figure 4-8 illustrates that nitrate concentrations at a few wells (most notably MW-39 & MW-53) increased then decreased.

Figure 4-9 is a map view of the site illustrating the nitrate trends at each of the wells. Seven out of ten wells exhibit increasing trends. MW-14 (located in the northwestern portion of the property) exhibits the steepest increasing trend (1.80 ppm/yr). Well MW-53 exhibits the only decreasing trend (2.07 ppm/yr). The LOWESS lines for the two wells with statistically insignificant trends (Figure 4-8) indicate a shift from increasing to decreasing trends at those locations.

The fact that most wells exhibit increasing trends and that half of the wells exhibit consistently increasing or recently increasing LOWESS patterns suggests the facility operations are impacting groundwater quality.

4.3.3 Average Nitrate Concentrations

Figure 4-10 illustrates the average nitrate concentrations at each of the Simplot Terrace Site wells from 1996 through 2005, the timeframe in which all wells except MW-15 were installed and sampled. The average at MW-15 is from 1996 through February 1998; it was abandoned shortly thereafter. Due to the increasing trend there, an average over the same timeframe as other wells would likely be higher than 14 ppm. In summary, average nitrate concentrations range from approximately 14 to 55 ppm, and were higher in the downgradient wells than in the upgradient wells.

The highest average nitrate concentration (54.6 ppm) is at well MW-53, located along the northern downgradient property boundary. Except for well MW-15, which has not been sampled since 1998, the lowest average nitrate concentration (14.2 ppm) is at wells MW-38 and MW-39, located near the northeast corner of the property. Well MW-38 is located in a cross gradient position (i.e., neither upgradient nor downgradient of facility operations). Well MW-39 is located downgradient of a portion of the land application area.

4.3.4 Apparent Recharge Age of Water

The apparent age of groundwater samples collected from four Terrace Site wells and two temporary wells north of the site was calculated using tritium and helium-3 concentrations. Apparent recharge age results (indicated in Figure 4-10) ranged from 1.6 years (at MW-53) to 48.9 years (at MW-14). Other results included 1.9 years (at MW-39), 2.6 years (at MW-40), 7.8 years (at Terrace-1) and 8.2 years (at Terrace-2). The average of all six age dates is 11.8 years while the average of the four age dates from the Terrace Site is 13.8. The geometric mean (which is a useful way of characterizing the central tendency of a highly skewed data set) of all six age dates is 5.4 years while the geometric mean of the four age dates from the Terrace Site is 4.4 years.

The young age of groundwater at the Site suggests groundwater impacts at the Terrace Site are, in large part, due to recent activities at land surface. It is unclear why the water at well MW-14 appears to be so much older than the other wells sampled. The boring that contains MW-14 is 30 feet deeper, and the well screen is 5 feet lower in elevation than the next deepest well dated. If water entering well MW-14 is from deeper in the aquifer, the older age may be due to mixing groundwater of differing ages.

4.3.4 Upgradient to Downgradient Comparisons

Figure 4-11(a) is a time series graph showing the nitrate concentrations at the upgradient wells MW-40 and MW-54 and the downgradient wells MW-22, MW-52, and MW-53. In addition to the individual data points connected by a thin line, thick LOWESS lines are drawn through the data to illustrate general patterns. Figure 4-11(a) shows both upgradient and downgradient nitrate concentrations are increasing at similar rates through about 2001 when the downgradient concentrations start to level off. However, downgradient concentrations are approximately 10 ppm higher than upgradient concentrations. If downgradient well MW-53 is not considered, concentrations increase less steeply through 2001 and decrease more steeply through 2005 (Figure 4-11).

Figure 4-11(b) is a box and whisker plot summarizing the nitrate concentrations from the upgradient wells (MW-40 & MW-54) and the downgradient wells (MW-22, MW-52, and MW-53). Because the downgradient well MW-53 is substantially different than the other downgradient wells, box plots for both the individual wells and the combined data are presented. Figure 4-11(b) shows the average upgradient nitrate concentration is approximately 19 ppm with all concentrations less than 34 ppm. Figure 4-11(b) also shows the average downgradient nitrate concentration is approximately 33 ppm.

Based on comparisons of nitrate concentrations at upgradient wells and downgradient wells, facility operations have impacted groundwater quality.

4.3.5 Comparison to Previous Analysis

A comparison was made between the previous (through 2001) and current (through 2005) trend analyses. Changes in data set characteristics as well as changes in the nitrate trends at the Terrace Site are summarized in Table 4-4. These changes are interpreted as indications of improving or worsening water quality between 2001 and 2005.

Indications of improving water quality since the previous analysis include:

- more wells exhibited improving trends (i.e., a less steeply increasing trend), and
- the site-wide average trend slope improved.

Indications of worsening water quality since the previous analysis include:

- more wells exhibited new maximum concentrations than new minimum concentrations, and
- more wells exhibited higher mean and median concentrations than lower mean and median concentrations.

In summary, although the majority of wells and the site as a whole exhibit increasing trends, the trends are increasing less steeply through 2005 than they did through 2001. The lower concentrations in recent years cause this change in long term trend.

4.3.6 Conclusions

Based on the discussion of the data for the Simplot Terrace site presented above, the following conclusions have been made, and are grouped by topic:

Upgradient and Downgradient Wells

- Upgradient wells for the Simplot Terrace Site include MW-40 and MW-54.
- Downgradient wells for the Simplot Terrace Site include MW-22, MW-52, and MW-53.

Nitrate Trends

- Nitrate concentrations are increasing at most Simplot Terrace Site wells.
- The site-wide average nitrate trend is increasing at least 0.6 ppm/yr.
- Half of the wells exhibit consistently increasing or recently increasing LOWESS patterns. The other half exhibit increasing then decreasing trends or increasing then leveling off trends.

Average Nitrate Concentrations

- All 9 Simplot Terrace Site wells exhibit averages greater than 10 ppm.
- The highest average concentration (54.6 ppm) is at well MW-53 located along the northern downgradient property boundary.
- Except for well MW-15, which has not been sampled since 1998, the lowest average nitrate concentration (14.2 ppm) is at wells MW-38 and MW-39, located near the northeast corner of the property. Well MW-38 is located in a cross gradient position (i.e., neither upgradient nor downgradient of facility operation). Well MW-39 is located downgradient of a portion of the land application area.

Apparent Recharge Age of Water

- Apparent recharge age results ranged from 1.6 years (at MW-53) to 48.9 years (at MW-14).
- Other results included 1.9 years (at MW-39), 2.6 years (at MW-40), 7.8 years (at Terrace-1) and 8.2 years (at Terrace-2).
- The geometric mean of all six age dates is 5.4 years while the geometric mean of the four age dates from the Terrace Site is 4.4 years.

Factors Affecting Nitrate Concentrations

- There is evidence suggesting facility operations have affected, and continue to affect groundwater quality. Potential methods to assess the effectiveness of current facility operations are discussed in Section 8.4. Evidence suggesting impacts from facility operations include:
  - downgradient wells have higher nitrate concentrations than upgradient and cross-gradient wells
  - most wells exhibit increasing trends,
  - half of the wells exhibit consistently increasing or recently increasing LOWESS patterns, and
  - the young apparent recharge age of groundwater.
- Wells closer to leaky fresh water canals and fresh water streams are more likely to exhibit lower nitrate concentrations due to dilution from the surface water.

Comparison to Previous Analysis

Although the majority of wells and the site as a whole exhibit increasing trends, the trends are increasing less steeply through 2005 than they did through 2001.

4.4 Expansion Site

The Simplot Expansion Site is located approximately 4 miles south of the City of Hermiston, southwest of the junction of US Interstate 84 and Oregon 207 (Figure 1-2).

The land application system at the Expansion Site began in 1991. Prior to the land application system, the land occupied by the Expansion Site was used for farmland and cattle grazing.

The Expansion Site is located primarily within the Butter Creek flood plain but the western portion of the site also includes a portion of an upland terrace. The flood plain exhibits a gentle northward slope (0 to 5%). The terrace portion exhibits a steeper eastward slope (5 to 25%). Topography at the Expansion Site ranges from approximately 550 to 680 feet above mean sea level.

Nearby surface water features include Butter Creek (which flows south to north through the Site), as well as the Hunt Ditch, the High Line Canal, and various un-named irrigation canals (components of the Westland Irrigation District delivering water from the Umatilla River to irrigated land in the vicinity) which flow across the property at several locations. The depth to water beneath the Expansion Site ranges from as shallow as 2½ feet below land surface (at MW-25; a well close to an irrigation ditch) to 87 feet below land surface (at MW-42; an upland well located along the western property boundary).

4.4.1 Upgradient and Downgradient Wells

The groundwater flow direction at the Simplot Expansion site is described in DEQ (2004). In general, groundwater flows north-northeast across the site. Based on the regional water table map presented in Figure 3-8 of DEQ (2004), upgradient wells for the Simplot Expansion site would be located south and west of facility operations, while downgradient wells would be located north and east of facility operations. Wells MW-36, MW-41, MW-42, MW-43, and MW-44 are located upgradient of current facility operations. Wells MW-31, MW-32, MW-33, and MW-55 are located downgradient of current facility operations.

4.4.2 Nitrate Trends

A trend analysis of nitrate concentrations at the 20 wells located at the Simplot Expansion Site was conducted as described in Section 1.3. Table 4-5 summarizes the data used in this analysis and includes some data set statistics (e.g., mean and maximum values), a summary of the trend analysis (e.g., the slope and confidence level of the line) and a description of the LOWESS pattern (e.g., increasing then decreasing). Time series graphs of nitrate concentrations and trends at each Simplot well are included in Appendix 3.

Table 4-5 lists the individual results of the trend analysis for each well. The results can be summarized as follows:

- 18 wells exhibit increasing trends, and
- 2 wells exhibit a statistically insignificant trend.

Statistically significant trends range from increasing at 0.10 ppm/yr (at MW-31) to 1.04 ppm/yr (at MW-41). The site-wide average nitrate trend is increasing at approximately 0.4 ppm/yr.

Table 4-5 also lists the description of the LOWESS patterns for individual wells. The LOWESS patterns observed can be summarized as follows:

- 6 wells show increasing, then decreasing patterns
- 7 wells show increasing then slight decreasing patterns,
- 2 wells show increasing patterns then begin to level off,
- 2 wells shows an increasing pattern with fluctuations,
- 1 well shows an increasing, decreasing, then increasing pattern, and
- 1 well shows a level then increasing pattern.

In summary, fourteen of the wells (70%) exhibit a recently decreasing LOWESS pattern while six wells (30%) exhibit a recently increasing pattern. The large percentage of recently decreasing LOWESS patterns suggests nitrate concentrations at the site are beginning to decline.

Figure 4-12 is a graph of all nitrate data from the 20 Simplot Expansion wells, with a LOWESS line drawn through the data. It is evident from Figure 4-12 that the highest concentrations detected have occurred in the middle and latter portions of the dataset. The LOWESS line has an upward slope of approximately 1 ppm/yr from 1990 through 1996, when it becomes nearly flat through 2005. The LOWESS line and pattern of data indicate the general increase then leveling off of nitrate concentrations at the site.

Figure 4-13 shows the nitrate trends and LOWESS lines at each of the 20 Simplot Expansion Site wells. The 20 graphs are plotted at the same scale to allow a comparison of trends between wells. Figure 4-13 illustrates that nitrate concentrations at several wells (most notably MW-28, MW-31, MW-35, MW-37, and MW-41) increased then decreased.

Figure 4-14 is a map view of the site illustrating the nitrate trends at each of the wells. 18 out of 20 wells exhibit increasing trends. The remaining wells exhibit statistically insignificant increasing trends. The steepest increasing trend (1.04 ppm/y at MW-41) is located near the northwestern property boundary. The remaining increasing trends (ranging from 0.10 ppm/yr to 0.56 ppm/yr) occurred throughout the site. The statistically insignificant trends also increase at 0.05 ppm/yr.

The fact that all of the wells exhibit increasing trends suggests the facility operations have impacted groundwater quality. The large percentage of recently decreasing LOWESS lines suggests implementation of the feasibility study recommendations is beginning to improve groundwater quality.

4.4.3 Average Nitrate Concentrations

Figure 4-15 illustrates the average nitrate concentrations at each of the Simplot Expansion Site wells from 1996 through 2005, the time frame in which all wells were installed and sampled. In summary, average nitrate concentrations range from approximately 7 to 17 ppm, and were generally higher in the downgradient wells than in the upgradient wells.

The highest average nitrate concentration (16.9 ppm) is at downgradient well MW-55, located near the northwestern property boundary. The lowest average nitrate concentration (7.1 ppm) is at the upgradient well MW-44, located near the southwest corner of the property. The fact that average concentrations are lowest at an upgradient well and highest at a downgradient well indicates facility operations have impacted groundwater.

4.4.4 Upgradient to Downgradient Comparisons

Figure 4-16(a) is a time series graph showing the nitrate concentrations at the upgradient wells MW-36, MW-41, MW-42, MW-43, and MW-44 and the downgradient wells MW-31, MW-32, MW-33, and MW-55. In addition to the individual data points connected by a thin line, thick LOWESS lines are drawn through the data to illustrate general patterns. Figure 4-16(a) shows both upgradient and downgradient nitrate concentrations follow similar patterns from 1991 through about 1999 (i.e., increase at approximately 1 ppm/yr with downgradient concentrations approximately 3 ppm higher than upgradient concentrations). Starting in about 1999 and extending through 2005, the LOWESS lines indicate downgradient concentrations decline as upgradient concentrations continue to increase, although less steeply. The LOWESS lines intersect in early 2005 reflecting the fact that downgradient concentrations are approaching upgradient concentrations (2005 nitrate concentrations average 10.4 ppm in the five upgradient wells and 11.0 ppm in the four downgradient wells).

Figure 4-16(b) is a box and whisker plot summarizing the nitrate concentrations from the upgradient wells and the downgradient wells. Figure 4-16(b) shows the average upgradient nitrate concentration is approximately 7.7 ppm with half of the concentrations between 4.5 and 9 ppm. Figure 4-16(b) also shows the average downgradient nitrate concentration is approximately 10 ppm with half of the concentrations between 7.5 and 12 ppm.

Based on comparisons of nitrate concentrations at upgradient wells and downgradient wells, facility operations impacted groundwater quality in the early 1990s but implementation of the Feasibility Study recommendations reduced downgradient nitrate concentrations starting in the late 1990s.

4.4.5 Comparison to Previous Analyses

A comparison was made between the previous (through 2001) and current (through 2005) trend analyses. Changes in data set characteristics as well as changes in the nitrate trends at the Expansion Site are summarized in Table 4-6. These changes are interpreted as indications of improving or worsening water quality between 2001 and 2005.

Indications of improving water quality since the previous analysis include:

- all but one well exhibited an improving trend (i.e., a less steeply increasing trend), and
- the site-wide average trend slope improved.

Indications of worsening water quality since the previous analysis include:

- more wells exhibited new maximum concentrations than new minimum concentrations, and
- more wells exhibited higher mean and median concentrations than lower mean and median concentrations.

In summary, although individual wells and the site as a whole exhibit increasing trends, the trends are increasing less steeply through 2005 than they did through 2001. The lower concentrations in recent years cause this change in long term trend.

4.4.6 Conclusions

Based on the discussion of the data for the Simplot Expansion site presented above, the following conclusions have been made, and are grouped by topic:

Upgradient and Downgradient Wells

- Upgradient wells for the Simplot Expansion Site include MW-36, MW-41, MW-42, MW-43, and MW-44.
- Downgradient wells for the Simplot Expansion Site include MW-31, MW-32, MW-33, and MW-55.

Nitrate Trends

- Nitrate trends are increasing at all Simplot Expansion Site wells.
- The site-wide average nitrate trend is increasing at approximately 0.4 ppm/yr.
- 70% of wells exhibit a recently decreasing LOWESS pattern while 30% exhibit a recently increasing pattern. The large percentage of recently decreasing LOWESS patterns suggests nitrate concentrations at the site are beginning to decline.

Average Nitrate Concentrations

- The highest average nitrate concentration (17.2 ppm) is at downgradient well MW-55, located near the northwestern property boundary.
- The lowest average nitrate concentration (6.1 ppm) is at the upgradient well MW-44, located near the southwest corner of the property.

Factors Affecting Nitrate Concentrations

- There is evidence suggesting facility operations have affected groundwater quality, such as:
    - downgradient wells have higher nitrate concentrations than upgradient well, and
    - all wells exhibit increasing trends.
- There is also evidence suggesting implementation of the feasibility study recommendations is beginning to improve groundwater quality, such as:
    - the large percentage of recently decreasing LOWESS lines, and
    - the fact that downgradient concentrations are approaching upgradient concentrations.

Comparison to Previous Analysis

- Based on comparisons of nitrate concentrations at upgradient wells and downgradient wells, facility operations impacted groundwater quality in the early 1990s but implementation of the Feasibility Study recommendations reduced downgradient nitrate concentrations starting in the late 1990s.

4.5 Levy Site

The Simplot Levy Site is located approximately 8 miles south of the City of Hermiston, east of SR 207 (Butter Creek Highway) and north and south of SR 320 (Echo-Lexington Highway; Figure 1-2). The land application system at the Levy Site began in 2002. Prior to the land application system, the land occupied by the Levy Site was used for farmland.

The Levy Site is located south of Emigrant Buttes and north of Service Buttes (the surface expression of the Service Anticline). Two intermittent drainages (Spikes Gulch and Service Canyon) cross the site from southwest to northeast. Fine sandy loam is the dominant soil type with slopes predominantly less than 7%. Soils within Spikes Gulch and Service Canyon slope as much as 20%. The site exhibits a northward slope with topography ranging from approximately 640 to 800 feet above mean sea level.

Nearby surface water features include Butter Creek (which is located approximately one mile west of the site and flows south to north), and the Hunt Ditch (a component of the Westland Irrigation District delivering water from the Umatilla River to irrigated land in the vicinity) which is adjacent to the northeast end of the site. The depth to water beneath the Levy site ranges from approximately 23 feet below land surface (at HL-5; a well located in the north central portion of the site) to approximately 43 feet below land surface (at SP-1; a well in the southeastern portion of the site).

4.5.1 Upgradient and Downgradient Wells

Figure 4-17 is a water table map of the Simplot Levy Site using second quarter 2005 water levels. During the preparation of this map, it was assumed that topographic relief affects water table elevations. This assumption is reflected in the curvature of the groundwater contours in the northern portion of the site. Groundwater contours are not included in the southwest portion of the site between Spikes Gulch and Service Canyon to reflect the fact that no alluvial groundwater was found at soil borings L-7A and L-7C (Figure 4-17). The extreme curvature of groundwater contours in Spikes Gulch reflects the idea that groundwater in the southeastern portion of the site is restricted to the drainage areas.

As indicated in Figure 4-17, groundwater flow is generally towards the northeast. Based on a northeasterly flow direction, upgradient wells for the Simplot Levy site would be located south and west of facility operations, while downgradient wells would be located north and east of facility operations. Wells L-6 and L-8 are located upgradient of facility operations. Wells L-9 and SP-1 are located downgradient of current facility operations approximately along groundwater flow paths from the upgradient wells. HL-5 is a downgradient well but there is no water in the alluvial aquifer upgradient of facility operations at this location for comparison.

4.5.2 Nitrate Trends

A trend analysis of nitrate concentrations at the nine wells located at the Simplot Levy Site was conducted as described in Section 1.3. Table 4-7 summarizes the data used in this analysis and includes some data set statistics (e.g., mean and maximum values), a summary of the trend analysis (e.g., the slope and confidence level of the line) and a description of the LOWESS pattern (e.g., increasing then decreasing). Time series graphs of nitrate concentrations and trends at each Simplot well are included in Appendix 3.

Table 4-7 lists the individual results of the trend analysis for each well. The results can be summarized as follows:

- 4 wells exhibit increasing trends, and
- 5 wells exhibit a statistically insignificant trend.

Statistically significant trends range from increasing at 0.33 ppm/yr (at L-10) to 4.90 ppm/yr (at HL-5). The site-wide average of all trends is approximately 1 ppm/yr while the average of statistically significant trends is approximately 2 ppm/yr.

Table 4-7 also lists the description of the LOWESS patterns for individual wells. The LOWESS patterns observed can be summarized as follows:

- 1 well shows an increasing pattern,
- 4 wells shows an increasing then decreasing pattern,
- 1 well shows an increasing pattern then levels off,
- 1 wells shows a basically flat pattern,
- 1 well shows a decreasing, increasing, then decreasing pattern, and
- 1 well shows a decrease then level pattern.

In summary, five of the wells (56%) exhibit a decreasing or recently decreasing LOWESS pattern, three wells (33%) exhibit an increasing or recently increasing pattern, and one well (11%) shows a basically flat pattern. The large percentage of recently decreasing LOWESS patterns at wells with overall increasing trends suggests nitrate concentrations at the site are beginning to decline after a longer period of increase.

Figure 4-18 is a graph of all nitrate data from the nine Simplot Levy Site wells, with a LOWESS line drawn through the data. It is evident from Figure 4-18 that the highest concentrations detected have occurred in the latter portions of the dataset. The six highest concentrations at the site are the last 6 values reported at well HL-5. The fact that HL-5 is downgradient of facility operations and exhibits the steepest increasing trends suggests

facility operations have affected groundwater quality. The LOWESS line has a slight upward slope from 2002 through 2004 then a slight decreasing slope through 2005.
Figure 4-19 includes the nitrate trends and LOWESS lines at each of the 9 Simplot Levy Site wells. The nine graphs are plotted at the same scale to allow a comparison of trends between wells. Figure 4-19 illustrates that nitrate concentrations at well L-9 increased at over 10 ppm/yr through about mid-2004 then decreased at approximately the same rate.

Figure 4-20 is a map view of the site illustrating the nitrate trends at each of the wells. Four out of nine wells exhibit statistically significant increasing trends. Three of the wells on the northern (downgradient) property boundary exhibit increasing trends. The upgradient wells exhibit statistically insignificant decreasing trends.

The fact that the downgradient wells exhibit increasing trends suggests onsite activities have impacted groundwater quality. The fact that downgradient concentrations were higher than upgradient concentrations prior to application of Simplot's wastewater in 2002 suggests the previous land use contributed to elevated groundwater nitrate concentrations. The fact that concentrations continued to increase during application of Simplot's wastewater suggests land application activities also contributed to elevated groundwater nitrate concentrations. A more thorough understanding of groundwater flow directions, velocities, and age could help determine the relative proportions of these contributions.

4.5.3 Average Nitrate Concentrations

Figure 4-21 illustrates the average nitrate concentrations at each of the Simplot Levy Site wells from 2003 through 2005, the time frame in which all wells were installed and sampled. In summary, average nitrate concentrations range from approximately 1 to 37 ppm, and are higher in the downgradient wells than in the upgradient wells.

The highest average nitrate concentration (37.4 ppm) is at downgradient well HL-5, located along the northern property boundary. The lowest average nitrate concentration (0.9 ppm) is at the upgradient well L-8, located along the southwest border of the property in Service Canyon. The second lowest average nitrate concentration is at the upgradient well L-6 located along the southwest border of the property in Spikes Gulch. Nitrate concentrations increase from upgradient to downgradient wells along groundwater flow paths through both Service Canyon and Spikes Gulch. The fact that average concentrations are lowest at upgradient wells and highest at downgradient wells indicates onsite activities have impacted groundwater.

4.5.4 Upgradient to Downgradient Comparisons

Figure 4-22(a) is a time series graph showing the nitrate concentrations at the upgradient wells L-8 and L-6 and the downgradient wells L-9 and SP-1. In addition to the individual data points connected by a thin line, thick LOWESS lines are drawn through the data to illustrate general patterns. Figure 4-22(a) shows upgradient concentrations are always less than 3 ppm while downgradient nitrate concentrations are generally between 15 and 25 ppm.

Figure 4-22(b) is a box and whisker plot summarizing the nitrate concentrations from the upgradient wells and the downgradient wells. Figure 4-22(b) shows the average upgradient nitrate concentration is approximately 1.5 ppm with half of the concentrations between 1 and 2 ppm. Figure 4-22(b) also shows the average downgradient nitrate concentration is approximately 22 ppm with half of the concentrations between 16 and 30 ppm.

Based on comparisons of nitrate concentrations at upgradient wells and downgradient wells, onsite activities have impacted groundwater quality. As indicated in Section 4.5.2, a more thorough understanding of the site's groundwater flow regime could help determine the relative proportions of impacts caused by traditional agricultural practices and the more recent and shorter duration land application of wastewater.

4.5.5 Comparison to Previous Analysis
Simplot Levy Site wells were not sampled during the timeframe of the previous analysis so no comparison is made.

4.5.6 Conclusions
Based on the discussion of the data for the Simplot Levy site presented above, the following conclusions have been made, and are grouped by topic:

Upgradient and Downgradient Wells
- Upgradient wells for the Simplot Levy Site include L-6 and L-8.
- Wells L-9 and SP-1 are downgradient wells approximately along flow paths from the upgradient wells.
- Well HL-5 is downgradient of facility operations but there is no water in the alluvial aquifer upgradient of facility operations at this location for comparison.

Nitrate Trends
- Nitrate trends are increasing at 44% of Simplot Levy Site wells.
- The site-wide average nitrate concentration is increasing 1 to 2 ppm/yr.
- Over half of the wells exhibit a decreasing or recently decreasing LOWESS pattern while a third of the wells exhibit an increasing or recently increasing pattern. The large percentage of recently decreasing LOWESS patterns at wells with overall increasing trends suggests nitrate concentrations at the site are beginning to decline after a longer period of increase.

Average Nitrate Concentrations
- The highest average nitrate concentration (36.7 ppm) is at downgradient well HL-5, located along the northern property boundary.
- The lowest average nitrate concentration (0.9 ppm) is at the upgradient well L-8, located along the southwest border of the property in Service Canyon.
- Nitrate concentrations increase from upgradient to downgradient wells along both Service Canyon and Spikes Gulch.
- The fact that average concentrations are lowest at upgradient wells and highest at downgradient wells indicates onsite activities have impacted groundwater.

Factors Affecting Nitrate Concentrations
- There is evidence suggesting facility operations have affected groundwater quality, such as:
    - downgradient wells have higher nitrate concentrations than upgradient wells,
    - the site-wide average trend is increasing at 1 to 2 ppm/yr
    - nitrate concentrations increase along groundwater flow paths through both Service Canyon and Spikes Gulch.
- The large percentage of recently decreasing LOWESS patterns at wells with overall increasing trends suggests nitrate concentrations at the site are beginning to decrease after a longer period of increase.
- A more thorough understanding of the site's groundwater flow regime could help determine the relative proportions of impacts caused by traditional agricultural practices and the more recent and shorter duration land application of wastewater.

Comparison to Previous Analysis
Simplot Levy Site wells were not sampled during the timeframe of the previous analysis so no comparison is made.

4.6 Recommendations

Based on the conclusions and discussion above, the following recommendation is made for all Simplot sites:

- In accordance with the Action Plan, it is recommended that a trend analysis of data from the same wells be conducted in 2010 to evaluate progress towards improving groundwater quality at the food processing wastewater land application sites.

The Simplot potato processing facility shut down in November 2004 so it is no longer generating or land applying food processing wastewater. The facility does, however, continue to apply some non-food processing wastewater and commercial fertilizer under a DEQ permit to land that has high groundwater nitrate concentrations. At those locations, the following recommendations apply.

- In order to gauge when the effects of BMP implementation will be observed as improving groundwater quality, it is recommended that funding be pursued to allow additional research into factors including: (1) quantifying the amount of nitrate that exists between the root zone and the water table, (2) the rate of nitrate transport through the unsaturated zone, and (3) more precisely quantifying groundwater flow velocity at the site.
- Due to the high percentage of increasing trends and impacts to groundwater from land use activities, it is recommended that BMP implementation to reduce the area-wide extent of elevated nitrate concentrations be continued and, when possible, improved. BMPs should include detailed procedures to:
    - establish appropriate crop specific nitrogen loading rates,
    - accurately quantify hydraulic loading from all sources,
    - document nutrient additions from all sources,
    - insure uniform sample acquisition and analysis,
    - characterize and monitor nitrogen concentration and movement in the soil column,
    - monitor moisture content and movement in the soil column, and
    - perform annual site specific analysis to identify farming activities and/or soil conditions that increase the potential for impact to groundwater.

5.0 HERMISTON FOODS SITE

5.1 Introduction

Hermiston Foods, LLC (Hermiston Foods) operates a vegetable processing plant and wastewater treatment facility near Hermiston, Oregon. The vegetable processing plant was constructed in 1990 and operates seasonally to process asparagus, peas, lima beans, potatoes, and carrots. The company's wastewater treatment facility includes a land application system located approximately one mile south of the plant. Hermiston Foods land applied approximately 227 million gallons of water (both wastewater and supplemental irrigation water) in 2005. Average values for the composite of Hermiston Food's wastewater and supplemental water in 2005 include:

- 1,306 mg/l Chemical Oxygen Demand (COD)
- 25 mg/l Total Kjeldahl Nitrogen (TKN)
- 0.12 mg/l Nitrate (NO_3)
- 11 mg/l ammonium (NH_4)
- 574 mg/l total dissolved solids (TDS)
- 70 mg/l potassium (K)
- 7 mg/l total phosphorus (P)

5.2 Hermiston Foods Site

The Hermiston Foods land application site is located approximately 3 miles south of the City of Hermiston, east of the junction of US Highway 395 and Feedville Road at property owned by the Windblown Ranch (Figure 1-2). The land application system at the Hermiston Foods site began in 1990. The wastewater is land applied at two 125-acre center pivot irrigation circles (one installed in 1990, the other installed in 1991) for the purpose of growing alfalfa and small grains. In addition, during the months of April through September, a portion of the wastewater is discharged to a 14.6 acre hybrid poplar tree plantation (installed in 1999). Prior to the land application system, the land occupied by the Hermiston Foods site was undeveloped.

When wastewater does not meet crop needs (typically from approximately April through October), supplemental irrigation water from an irrigation ditch is applied on the site.

The Hermiston Foods Site is located within the Deschutes-Umatilla Plateau physiographic province. The site generally exhibits gentle slopes of 0 to 5%. Soils at the site include well drained fine sandy loam and excessively drained fine sand. Topography at the Hermiston Foods Site ranges from approximately 650 to 700 feet above mean sea level.

Nearby surface water features include the Furnish Ditch (which delivers irrigation water to nearby fields) located northwest of the site, and an unnamed canal extending southwest from the Furnish Ditch that passes within approximately 300 feet of the northwest corner of the site and terminates approximately 800 feet west of the site into several ponds.

The average depth to water beneath the Hermiston Foods Site ranges from approximately 30 feet below land surface (at well MW-1; located in the southeastern corner of the site) to approximately 70 feet below land surface (at well MW-4 located in the northeastern corner of the site). The depth to water at well MW-2 averages approximately 55 feet below land surface but exceeds 85 feet below land surface when a nearby irrigation well is pumping. The site-wide average depth to water is approximately 50 feet below land surface.

5.2.1 Upgradient and Downgradient Wells

Factors affecting the groundwater flow direction at Hermiston Foods (including nearby pumping wells, surface water features, and basalt topography) are discussed in DEQ (2004). Two new wells (MW-7 and MW-8) were installed in 2004. MW-7 was installed at the request of DEQ while MW-8 was installed offsite to the north for informational purposes by Hermiston Foods.

Figure 5-1 is a potentiometric surface map using water levels from all 8 wells measured on January 27, 2005. These data were selected because potential effects of groundwater pumping should be minimal. It should be noted that wells MW-2, MW-3, and MW-5 were improperly located in DEQ (2004). The correct locations are indicated in this report.

It should also be noted that recent water levels collected from well MW-7 (sampled since August 2004) suggest the groundwater flow pattern(s) beneath the southern portion of the site may not yet be sufficiently assessed. In addition, personal communications between the author and the manager of the Stanfield Irrigation District revealed the ponds located west of the Hermiston Foods site were cleaned out in the fall of 2005 and fall of 2006. This likely increased the infiltration rate beneath the ponds and potentially altered the groundwater flow pattern(s) in the vicinity of the ponds. Future water level and water chemistry data will be evaluated to better assess the groundwater flow regime at the Hermiston Foods site. Additional data analysis may alter the current interpretation of upgradient and downgradient wells as described below.

As indicated in Figure 5-1, when the offsite irrigation well is not pumping, groundwater enters the site along the western and southern boundaries flowing east/northeast, but turns progressively more northward and exits the site along the northern boundary of the site flowing nearly due north. As discussed in DEQ (2004), pumping the offsite irrigation well appears to alter the flow direction in the northern portion of the site causing water to flow towards the pumped well and exit the site flowing northwestward.

Based on the groundwater flow direction indicated in Figure 5-1, upgradient wells for the Hermiston Foods site would be located south and west of facility operations, while downgradient wells would be located north and east of facility operations. Wells MW-3, MW-5, and MW-7 are located upgradient of current facility operations. Wells MW-4 and MW-6 are located downgradient of current facility operations.

Well MW-2 is located downgradient of well MW-3, but much of the land between the wells does not include any land application activities. When the offsite irrigation well is not pumping, groundwater apparently flows from well MW-3 towards MW-2 beneath the land that is not part of the Hermiston Foods site. However, when the offsite irrigation well is pumping, groundwater apparently flows towards the pumping well from all directions, including from a portion of the Hermiston Foods site. This change in groundwater flow direction indicates well MW-2 is sometimes downgradient from a portion of the Hermiston Foods site but is never entirely downgradient of the facility operations. Therefore, well MW-2 is not an adequate downgradient well for evaluating potential effects of facility operations. It is, however, very useful in evaluating the groundwater flow regime of the site.

5.2.2 Nitrate Trends

A trend analysis of nitrate concentrations at 6 of the 7 wells located at the Hermiston Foods site was conducted as described in Section 1.3. As of the end of 2005, not enough data had been collected from MW-7 to calculate a trend. Table 5-1 summarizes the data used in this analysis and includes some data set statistics (e.g., mean and maximum values), a summary of the trend analysis (e.g., the slope and confidence level of the line) and a description of the LOWESS pattern (e.g., increasing then decreasing). Time series graphs of nitrate concentrations and trends at each Hermiston Foods well are included in Appendix 4.

Table 5-1 lists the individual results of the trend analysis for each well. The results indicate 2 wells show increasing trends while 4 wells show decreasing trends. Trends range from increasing at 0.17 ppm/yr (at the downgradient well MW-4) to decreasing at 0.38 ppm/yr (at the downgradient well MW-6). The site-wide average nitrate trend is decreasing at approximately 0.08 ppm/yr (Table 5-1).

Table 5-1 also lists the description of the LOWESS patterns for individual wells. The LOWESS patterns observed at the MW-1 through MW-6 can be summarized as follows:

- 1 well shows a flat, then decreasing, then increasing pattern
- 1 well shows an increasing (then increasing less steeply) pattern

- 1 well shows an decreasing (then decreasing less steeply) pattern
- 1 well shows a flat, then decreasing, the leveling off pattern
- 2 wells show an increasing then decreasing pattern

In addition to wells MW-1 through MW-6 (that have 35 to 53 data points), a LOWESS line drawn through the 6 data points from MW-7 shows a slight increasing pattern.

In summary, 3 of the 7 wells exhibit consistently increasing or recently increasing LOWESS patterns while 4 wells exhibit consistently or recently decreasing patterns.
Figure 5-2 is a graph of all nitrate data from the 7 Hermiston Foods wells, with a LOWESS line drawn through the data. Figure 5-2 consists of many stacks of data points at approximately 3 month intervals. Each of these stacks of data represents one quarterly sampling event and contains one data point for each well sampled that event. It is evident from Figure 5-2 that the nitrate concentrations detected have not varied considerably since sampling began, but the highest concentrations have occurred in the early and middle portions of the dataset. The LOWESS line has a slight upward slope from 1991 through 2000 then decreases through 2005.

Figure 5-3 includes the nitrate trends and LOWESS lines at each of the 7 Hermiston Foods wells. The 7 graphs are plotted at the same scale to allow a comparison of trends between wells. Useful information can be gained by comparing trend lines with LOWESS lines. For example, Figure 5-3 illustrates that nitrate concentrations at well MW-2 increased for several years then decreased for several years.

Figure 5-4 is a map view of the site illustrating the nitrate trends at each of the wells. The 2 wells along the northern property boundary (i.e., MW-2 and MW-4) exhibit increasing trends while the other 4 wells with enough data to calculate a trend exhibit decreasing trends. As described above, MW-4 is located downgradient of current facility operations, as is therefore, an appropriate downgradient well. MW-2, however, is not an adequate downgradient well for evaluating potential effects of facility operations. The other appropriate downgradient well, MW-6, exhibits a decreasing trend. The upgradient wells exhibit decreasing trends.

The fact that upgradient wells exhibit decreasing trends while a downgradient well exhibits an increasing trend suggests the facility operations have impacted groundwater quality. However, the fact that one downgradient well (MW-6) exhibits a recently decreasing LOWESS line while the other downgradient well (MW-4) exhibits a less steeply increasing pattern suggests recent facility operations and/or offsite are having less of an impact on groundwater quality than before. The degree to which the impacts and improvements are attributable to the facility versus offsite activities is unknown.

5.2.3 Average Nitrate Concentrations

Figure 5-5 is a map view of the site illustrating the average nitrate concentrations at each of the Hermiston Foods wells. The averages in Figure 5-5 are from August 2004 through November 2005 (the timeframe in which all wells were installed and sampled). The averages in Table 5-1 use all data since each well was installed. In summary, average nitrate concentrations are highest in the southeastern portion of the property, and lowest in the northwestern portion of the property. Specifically, the highest average nitrate concentrations are at the cross gradient well MW-1 (9.6 ppm), followed by the downgradient well MW-6 (9.3 ppm). The lowest average nitrate concentration is at the upgradient well MW-3 (2.9 ppm). The lower nitrate concentrations at this well are likely in part the result of dilution by surface water from the nearby irrigation canal and ponds. The other two upgradient wells (MW-5 and MW-7) also exhibit lower average nitrate concentrations. Average nitrate concentrations at other wells range from 5.3 to 7.5 ppm.

5.2.4 Upgradient to Downgradient Comparisons

Figure 5-6(a) is a time series graph showing the nitrate concentrations at the upgradient wells MW-3, MW-5, and MW-7; and the downgradient wells MW-4 and MW-6. In addition to the individual data points connected by a thin line, thick LOWESS lines are drawn through the data to illustrate general patterns. MW-5 is approximately upgradient of MW-4 while MW-7 is approximately upgradient of MW-6; so comparing the nitrate concentrations between these sets of wells is an appropriate way to gauge potential impacts from facility operations. However, upgradient well MW-3 cannot be used for evaluating potential impacts from facility operations because the well has no associated downgradient well.

Figure 5-6(a) indicates upgradient and downgradient water quality were similar in the early 1990s (i.e., both LOWESS lines start at about 4 ppm). Both upgradient and downgradient concentrations increased from 1991 through about 2000, with downgradient concentrations increasing faster. Both upgradient and downgradient concentrations decreased from about 2000 through 2005, with downgradient concentrations remaining about 3 ppm higher.

Figure 5-6(b) shows well MW-6 generally has higher nitrate concentrations than MW-5, which has higher concentrations than MW-4, which has higher concentrations than MW-3. Because MW-5 is generally upgradient of MW-4; and MW-7 is generally upgradient of MW-6, upgradient/downgradient comparisons can be made with data from these wells. During the timeframe in which all four of these wells were installed and sampled (6 sampling events over 1.2 years), the downgradient wells exhibited higher nitrate concentrations than their associated upgradient wells 100% of the time. However, over the past 35 sampling events (8.5 years) the concentrations at the downgradient well MW-4 exceeded the concentrations at the upgradient well MW-5 only 40% of the time.

The fact that downgradient nitrate concentrations exceed upgradient nitrate concentrations suggests facility operations have affected groundwater quality. The recently decreasing LOWESS patterns of both upgradient and downgradient wells suggest water quality is beginning to improve.

5.2.5 Comparison to Previous Analysis

A comparison was made between the previous (through 2001) and current (through 2005) trend analyses. Changes in data set statistics as well as changes in the nitrate trends at Hermiston Foods are summarized in Table 5-2. These changes are interpreted as indications of improving or worsening water quality between 2001 and 2005[11].

Indications of improving water quality since the previous analysis include:

- Two-thirds of stations exhibited lower mean and median nitrate concentrations,
- 5 wells exhibited an improving trend while the 6^{th} well showed no change,
- The site wide average trend switched from increasing at 0.09 ppm/yr to decreasing at 0.08 ppm/yr.

The only indication of worsening water quality is that one well exhibited an increase in mean and median nitrate concentration.

In summary, more wells exhibit decreasing trends, fewer wells exhibit increasing trends, and the site-wide average trend switched from increasing to decreasing. The lower concentrations in recent years cause this change in long term trend.

5.2.6 Conclusions

Based on the discussion of the data for the Hermiston Foods site presented above, the following conclusions have been made, and are grouped by topic:

Upgradient and Downgradient Wells

- Upgradient wells for the Hermiston Foods site include MW-3, MW-5, and MW-7.
- Downgradient wells for the Hermiston Foods site include MW-6 and MW-4.
- MW-5 is approximately upgradient of MW-4.

[11] An "improving" trend is defined as either a steeper decreasing trend or a less steeply increasing trend. A "worsening" trend is defined as either a steeper increasing trend or a less steeply decreasing trend.

- MW-7 is approximately upgradient of MW-6.
- Well MW-2 is located downgradient of well MW-3, but much of the land between the wells does not include any land application activities.

Nitrate Trends

- Nitrate concentrations at the Hermiston Foods Site are generally decreasing, as evidenced by:
    - 67% of wells exhibit decreasing trends.
    - The site-wide average nitrate trend is decreasing at approximately 0.08 ppm/yr
    - 4 of 7 wells exhibit consistently or recently decreasing LOWESS patterns
    - The site as a whole exhibits a recently decreasing LOWESS pattern.

Average Nitrate Concentrations

- Average nitrate concentrations are highest (approximately 10 ppm) at the cross gradient well MW-1 and the downgradient well MW-6, and lowest (approximately 3 to 7 ppm) at the upgradient wells MW-3, MW-5, and MW-7.

Factors Affecting Nitrate Concentrations

- There is evidence suggesting facility operations have affected groundwater quality, such as:
    - average nitrate concentrations are higher at downgradient wells than upgradient wells,
    - upgradient wells exhibit decreasing trends while a downgradient well exhibits an increasing trend, and
    - downgradient concentrations increased at a steeper rate through the 1990s faster than upgradient concentrations.
- There is also evidence suggesting recent facility operations and offsite activities are having less of an impact on groundwater quality than before. The degree to which the improvements are attributable to the facility versus offsite activities is unknown. Indications of improving water quality include:
    - site-wide average trend switched from increasing to decreasing,
    - both upgradient and downgradient concentrations are decreasing from 2000 through 2005, and
    - one downgradient well (MW-6) exhibits a recently decreasing LOWESS line while the other downgradient well (MW-4) exhibits a less steeply increasing pattern.
- The fact that the cross gradient well MW-1 exhibits the second highest nitrate concentrations suggest offsite operations have impacted groundwater quality.
- Wells closer to leaky fresh water canals (e.g., MW-3) are more likely to exhibit lower nitrate concentrations due to dilution from the surface water.

Comparison to Previous Analysis

Nitrate concentrations for the site as a whole and at most wells are improving. Although one of the two downgradient wells exhibits an increasing trend, more wells are now exhibiting decreasing trends, fewer wells are exhibiting increasing trends, and the site-wide average trend is now decreasing.

5.3 Recommendations

Based on the conclusions and discussion above, the following recommendations are made:

- To maintain and potentially expand the observed water quality improvements, it is recommended that BMP implementation to reduce the area-wide extent of elevated nitrate concentrations be continued and, when possible, improved. BMPs should include detailed procedures to:
    - establish appropriate crop specific nitrogen loading rates,
    - accurately quantify hydraulic loading from all sources,
    - document nutrient additions from all sources,
    - insure uniform sample acquisition and analysis,
    - characterize and monitor nitrogen concentration and movement in the soil column,
    - monitor moisture content and movement in the soil column, and

    - perform annual site specific analysis to identify farming activities and/or soil conditions that increase the potential for impact to groundwater.
- In accordance with the Action Plan, it is recommended that a trend analysis of data from the same wells be conducted in 2010 to evaluate progress towards improving groundwater quality at the food processing wastewater land application sites.

6.0 MORSTARCH SITE

6.1 Introduction

The MorStarch Site (known as the Staley site in DEQ 2004) processes reclaimed potato starch into starch flakes for use in the production of paper products. MorStarch land applied approximately 8.5 million gallons of wastewater in 2005, with an average monthly flow of 0.7 million gallons. Average values for MorStarch's wastewater in 2005 include:

- 4,370 mg/l Chemical Oxygen Demand (COD)
- 200 mg/l Total Kjeldahl Nitrogen (TKN)
- 15.0 mg/l ammonia (NH_3)
- 5,709 mg/l total dissolved solids (TDS)
- 0.6 mg/l nitrate-nitrogen (NO_3)
- 1,675 mg/l chloride (Cl)
- 627 mg/l calcium (Ca)
- 193 mg/l sodium (Na)
- 35 mg/l magnesium (Mg)
- 263 mg/l potassium (K)
- 125 mg/l bicarbonate (HCO_3)
- 18 mg/l total phosphorus (P)
- 55 mg/l sulfate (SO_4)

6.2 MorStarch Site

The MorStarch Site is located on the western edge of the City of Stanfield, northwest of the junction of US Interstate 84 and US Highway 395 (Figure 1-2). The site is bounded by the City of Stanfield Wastewater Treatment Plant land application site to the north, municipal and commercial development (including the City of Stanfield Wastewater Treatment Plant) to the east, and the Umatilla River to the south and west. The land application system at the MorStarch Site began in 1977. The original land application area consisted of 8.9 acre tract (Field A), which received approximately 7 million gallons of wastewater annually. In early 1990, MorStarch expanded the land application acreage to approximately 40 acres by adding fields B (10.5 acres) and C (20 acres). Subsequently, fields E (12 acres) and F (16 acres) were added to the land application system. Currently, MorStarch applies the wastewater to 67.4 acres. Prior to the land application system, the land occupied by the MorStarch Site was used for agricultural purposes.

Wastewater from this facility is land applied daily on 67.4 acres of agricultural land where fescue and alfalfa hay are grown. When wastewater does not meet crop needs (typically from approximately April through October), supplemental irrigation water obtained from the Stanfield Drain and an infiltration well is applied on the site.

The MorStarch Site is located within the Umatilla River flood plain. The flood plain generally exhibits gentle slopes of 0 to 5%. Topography at the MorStarch Site ranges from approximately 570 to 590 feet above mean sea level.

Nearby surface water features include the Umatilla River (which forms the southern and western boundaries of the property), and the Stanfield Drain (which bisects the site). The Umatilla River flows west then north around the site. The Stanfield Drain flows west across the site where it empties into the Umatilla River. The Stanfield Drain is an unlined ditch excavated in the late 1920's to drain shallow groundwater beneath the irrigated land in the vicinity of, and northeast of Stanfield in the area known as Fourmile Gap (Kopacz, 2004). Groundwater seeps into the Drain at a rate sufficient to maintain flow year round within the lower 3 to 4 miles of the Drain (including the MorStarch Site).

The depth to water beneath the MorStarch Site ranges from approximately 9 feet below land surface (at well MW-3S; located in the western portion of the site near the Umatilla River) to approximately 18 feet below land surface (at well MW-1D located in the northeastern portion of the site). The site-wide average depth to water is approximately 13 feet below land surface.

6.2.1 Upgradient and Downgradient Wells

The conceptual model of the groundwater flow regime at the MorStarch site used by the facility to date involves the hydraulic connection of groundwater with the Umatilla River, but no substantial connection with the Stanfield Drain. The author believes the likelihood of potential hydraulic connection between groundwater and the Stanfield Drain is high and could affect the interpretation of groundwater flow paths at the site. A relatively small connection between the Stanfield Drain and groundwater could result in a groundwater divide beneath the Drain. Due to the uncertain nature of groundwater flow at this site, which affects the wells that can be called upgradient and downgradient, upgradient and downgradient wells were not identified in this report.

6.2.2 Nitrate Trends

A trend analysis of nitrate concentrations at the 10 wells located at the MorStarch site was conducted as described in Section 1.3. Table 6-1 summarizes the data used in this analysis and includes some data set statistics (e.g., mean and maximum values), a summary of the trend analysis (e.g., the slope and confidence level of the line) and a description of the LOWESS pattern (e.g., increasing then decreasing). Time series graphs of nitrate concentrations and trends at each MorStarch well are included in Appendix 5.

Table 6-1 lists the individual results of the trend analysis for each well. The results indicate 8 increasing trends, 1 decreasing trend, and 1 statistically insignificant trend. It should be noted that two of the wells showing increasing trends have not been sampled since May 1998. Trends range from decreasing at 0.12 ppm/yr (at MW-E2S) to increasing at 0.62 ppm/yr (at MW-1S). The site-wide average nitrate trend (i.e., the average of all 10 slopes as well as the average of the 8 wells still being sampled) is increasing at approximately 0.2 ppm/yr.

Table 6-1 also lists the description of the LOWESS patterns for individual wells. The LOWESS patterns observed can be summarized as follows:

- 2 wells show a increasing pattern
- 6 wells show an increasing then decreasing pattern
- 1 well shows an increasing then leveling off pattern
- 1 well shows a decreasing then increasing pattern

In summary, 6 of the 8 wells that are still sampled exhibit recently decreasing LOWESS patterns. The other wells exhibit either a recently leveling off pattern or a less steeply increasing pattern.

Figure 6-1 is a graph of all nitrate data from the 10 MorStarch wells, with a LOWESS line drawn through the data. Figure 6-1 consists of many stacks of data points at approximately 3 month intervals. Each of these stacks of data represents one quarterly sampling event and contains one data point for each well sampled that event. It is evident from Figure 6-1 that the highest concentrations detected have occurred in the middle portion of the dataset. The LOWESS line has an upward slope through the 1990s then flattens out and decreases slightly through 2005. This pattern reflects an overall increase then leveling off of nitrate concentrations at the site.

Figure 6-2 includes the nitrate trends and LOWESS lines at each of the 10 MorStarch wells. The 10 graphs are plotted at the same scale to allow a comparison of trends between wells. Useful information can be gained by comparing trend lines with LOWESS lines. For example, Figure 6-2 illustrates that nitrate concentrations at wells MW-1S, MW-5S, MW-6S, and MW-E2S increased for several years then decreased.

Figure 6-3 is a map view of the site illustrating the nitrate trends at each of the wells. 8 of the 10 wells exhibit increasing trends. One well exhibits a decreasing trend while the other exhibits a statistically insignificant trend. It is worth noting that the increasing trends at MW-1D and MW-3D are only through May 1998, when sampling was not longer required. The decreasing trend (-0.12 ppm/yr) is at well MW-E2S. The steepest increasing trend is at well MW-1S. It is worth noting that recent concentrations at MW-1S are decreasing, but the overall trend remains increasing.

The fact that most wells exhibit increasing trends but recently decreasing LOWESS lines suggest facility operations and offsite activities historically impacted groundwater quality, but now result in improving water quality. The degree to which the impacts and improvements are attributable to the facility versus offsite activities is unknown.

6.2.3 Average Nitrate Concentrations

Figure 6-4 illustrates the average nitrate concentrations at 8 of the MorStarch wells from 1994 through 2005, the timeframe in which all wells except MW-1D and MW-3D were installed and sampled. The averages at wells MW-1D and MW-3D are from 1994 through May 1998. Sampling is no longer required at wells MW-1D and MW-3D. The averages in Table 6-1 use all data since each well was installed. In summary, average nitrate concentrations are highest along the eastern property boundary, followed by the northern property boundary, and lowest near the southwestern property boundary.

The lowest average nitrate concentration is at well MW-2S (0.9 ppm). The lower nitrate concentrations at the southwestern portion of the site are likely in part the result of dilution by surface water "cutting the corner" of the Umatilla River meander[12]. The highest average nitrate concentration (9.0 ppm) is at well MW-1S. The source of nitrate at this well is unknown but may be from offsite.

6.2.4 Upgradient to Downgradient Comparisons

As explained in Section 6.2.1, due to the uncertain nature of groundwater flow at this site, upgradient and downgradient wells were not identified in this report. Therefore, a comparison of upgradient to downgradient nitrate concentrations is not made in this report.

6.2.5 Comparison to Previous Analysis

A comparison was made between the previous (through 2001) and current (through 2005) trend analyses. Changes in data set statistics as well as changes in the nitrate trends at the MorStarch Site are summarized in Table 6-2. These changes are interpreted as indications of improving or worsening water quality between 2001 and 2005[13].

Indications of improving water quality since the previous analysis include:

- slightly more wells exhibited lower mean nitrate concentrations than higher mean nitrate concentrations,
- 100% of the wells exhibited an improving trend, and
- the site-wide average trend decreased from increasing at 0.44 ppm/yr to 0.16 ppm/yr.

Indications of worsening water quality since the previous analysis include:

- 1 well exhibited a new maximum nitrate concentration while no wells exhibited a new minimum concentration, and
- more wells exhibited a higher median nitrate concentration than a lower median nitrate concentration.

In summary, although the majority of wells and the site as a whole exhibit increasing trends, the trends are increasing less steeply through 2005 than they did through 2001. The lower concentrations in recent years cause this change in long term trend.

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[12] As the Umatilla River approaches the meander at the southwestern portion of the site, some surface water is believed to "cut the corner". In other words, some water exits the channel by moving northwest, enters the groundwater system, crosses the southwest portion of the site, and re-enters the river channel.

[13] An "improving" trend is defined as either a steeper decreasing trend or a less steeply increasing trend. A "worsening" trend is defined as either a steeper increasing trend or a less steeply decreasing trend.

6.2.6 Conclusions

Based on the discussion of the data for the MorStarch site presented above, the following conclusions have been made, and are grouped by topic:

Upgradient and Downgradient Wells

- Due to the uncertain nature of groundwater flow at this site, which affects the wells that can be called upgradient and downgradient, upgradient and downgradient wells are not identified in this report.

Nitrate Trends

- Nitrate concentrations at the MorStarch Site are increasing over the entire data set, as evidenced by:
  - Most wells exhibit increasing trends.
  - Trends range from decreasing at 0.12 ppm/yr to increasing at 0.62 ppm/yr with the site-wide average nitrate trend increasing at approximately 0.2 ppm/yr.
- Nitrate concentrations at the MorStarch Site are decreasing in recent years, as evidenced by:
  - 6 of the 8 wells that are still sampled exhibit recently decreasing LOWESS patterns. The other wells exhibit either a recently leveling off pattern or a less steeply increasing pattern.
  - The highest concentrations occur in the middle portion of the dataset.

Average Nitrate Concentrations

- Average nitrate concentrations are highest along the eastern property boundary (approximately 4 to 9 ppm), followed by the northern property boundary (approximately 4 to 5 ppm), and lowest near the southwestern property boundary (approximately 1 ppm).
  - The lower nitrate concentrations at the southwestern portion of the site are likely in part the result of dilution by surface water “cutting the corner” of the Umatilla River meander.
  - The source of nitrate at the well with the highest nitrate concentration is unknown but may be from offsite.

Factors Affecting Nitrate Concentrations

- The fact that most wells exhibit increasing trends but recently decreasing LOWESS lines suggest facility operations and offsite activities historically impacted groundwater quality, but now result in improving water quality. The degree to which the impacts and improvements are attributable to the facility versus offsite activities is unknown.
- Wells closer to leaky fresh water canals and fresh water streams are more likely to exhibit lower nitrate concentrations due to dilution from the surface water.

Comparison to Previous Analysis

Although the majority of wells and the site as a whole exhibit increasing trends, the trends are increasing less steeply through 2005 than they did through 2001.

6.3 Recommendations

Based on the conclusions and discussion above, the following recommendations are made:

- If nitrate concentrations do not continue to decline as they have in recent years, the following recommendations apply:
  - additional characterization should be conducted to determine the degree of the suspected interconnection of the groundwater and the Stanfield Drain at the site, and where upgradient and downgradient wells would be located. Additional characterization could include the collection and evaluation of additional water level and water temperature data; a comparison of water levels with land surface and drain bottom elevations; and a more in-depth review of existing water quality data. If it is determined that additional upgradient and/or downgradient wells are needed, then the facility should install them.

- In order to gauge when the effects of BMP implementation will be observed as improving groundwater quality, it is recommended that funding be pursued to allow additional research into factors including: (1) quantifying the amount of nitrate that exists between the root zone and the water table, (2) the rate of nitrate transport through the unsaturated zone, and (3) more precisely quantifying groundwater flow velocity at the site.
- Additional characterization should be conducted to better define and delineate the potential source(s) of the contamination (e.g., upgradient sources and land application activities).

- Due to the high percentage of increasing trends and impacts to groundwater from land application activities throughout the GWMA, it is recommended that BMP implementation to reduce the area-wide extent of elevated nitrate concentrations be continued and, when possible, improved. BMPs should include detailed procedures to:
  - establish appropriate crop specific nitrogen loading rates,
  - accurately quantify hydraulic loading from all sources,
  - document nutrient additions from all sources,
  - insure uniform sample acquisition and analysis,
  - characterize and monitor nitrogen concentration and movement in the soil column,
  - monitor moisture content and movement in the soil column, and
  - perform annual site specific analysis to identify farming activities and/or soil conditions that increase the potential for impact to groundwater.
- In accordance with the Action Plan, it is recommended that a trend analysis of data from the same wells be conducted in 2010 to evaluate progress towards improving groundwater quality at the food processing wastewater land application sites.

7.0 SNACK ALLIANCE SITE

7.1 Introduction

Snack Alliance, Inc. (Snack Alliance, known as SnakCorp in DEQ, 2004) operates a potato chip and cheese puff processing plant and wastewater treatment facility near Hermiston, Oregon. The company operates the plant seasonally. In 2005, 37.6 million gallons of wastewater was land applied on approximately 301 acres of cropland owned and operated by Snack Alliance. Wastewater is generated from potato washing, peeling, slicing, waste elimination, and starch recovery. In addition, the company accepts approximately 5,000 gallons per day, or approximately 1.82 million gallons per year, of potato rinsate from the adjacent Bud Rich fresh pack facility.

Average values for Snack Alliance's wastewater include:

- 2,803 mg/l Chemical Oxygen Demand (COD)
- 177 mg/l Total Kjeldahl Nitrogen (TKN)

7.2 Snack Alliance Site

The Snack Alliance land application site is located approximately 3 miles south of the City of Hermiston, west of the junction of US Interstate 84 and Oregon 207 (Figure 1-2). The land application system at the Snack Alliance site began in 1992 and was operated by Columbia Sun, Inc. (until 10/92), then by Universal Frozen Foods (until 10/94), then by ConAgra (until 5/96), then by Snakcorp until 2005, and finally by Snack Alliance, Inc. The wastewater is land applied at up to six center pivot irrigation circles for the purpose of growing primarily alfalfa, but also cereal grains, grass, onions, potatoes, corn and turf grass. When wastewater does not meet crop needs (typically from approximately April through October), supplemental irrigation water obtained from the Westland Irrigation District system is applied on the site. Prior to the land application system, the land occupied by the Snack Alliance site was irrigated agricultural land.

The Snack Alliance Site is located within the Deschutes-Umatilla Plateau physiographic province. The site generally exhibits gentle slopes of 0 to 5%. Soils at the site are predominantly excessively drained loamy fine sand, but also include well drained silt loam. Topography at the Snack Alliance Site ranges from approximately 565 to 520 feet above mean sea level.

Nearby surface water features include the Umatilla River (which forms much of the northern property boundary), Butter Creek (which forms the southeastern property boundary), and a Westland Irrigation District canal (which forms a portion of the southern property boundary). The Umatilla River is perennial (i.e., it has flow all year) while Butter Creek and the canal are intermittent (i.e., they have flow only part of the year).

The average depth to water beneath the Snack Alliance Site ranges from approximately 29 feet below land surface (at well MW-4; located near the Umatilla River in the northern portion of the site) to approximately 47 feet below land surface (at well MW-1; located near the southern edge of the site).

7.2.1 Upgradient and Downgradient Wells

The groundwater flow direction at the Snack Alliance site is described in DEQ (2004). In general, groundwater flows northeast across the site toward the Umatilla River. Based on the groundwater flow direction, upgradient wells for the Snack Alliance site would be located south and perhaps west of facility operations, while downgradient wells would be located north and perhaps east of facility operations. Well MW-1 is located upgradient of current facility operations. Well MW-4 is located downgradient of current facility operations. Wells MW-2 and MW-3 are located within the land application area between fields.

Much of the site boundary consists of intermittent or perennial surface water bodies. However, the nature of the interaction between groundwater and surface water at the site is unknown. Although the relationship between groundwater and surface water could be assessed through the evaluation of groundwater and surface water levels, it is unlikely to affect the current interpretation of upgradient and downgradient wells.

7.2.2 Nitrate Trends

A trend analysis of nitrate concentrations at the 4 wells located at the Snack Alliance site was conducted as described in Section 1.3. Table 7-1 summarizes the data used in this analysis and includes some data set statistics (e.g., mean and maximum values), a summary of the trend analysis (e.g., the slope and confidence level of the line) and a description of the LOWESS pattern (e.g., increasing then decreasing). Time series graphs of nitrate concentrations and trends at each Snack Alliance well are included in Appendix 6.

Table 7-1 lists the individual results of the trend analysis for each well. The results indicate 3 wells show a decreasing trend and the other well shows a statistically insignificant trend. Statistically significant trends range from decreasing at 0.16 ppm/yr to decreasing at 1.14 ppm/yr. The statistically insignificant trend increases at 0.03 ppm/yr. The site-wide average nitrate trend is decreasing at approximately 0.4 to 0.6 ppm/yr (depending on whether or not the statistically insignificant trend is included) (Table 7-1).

Table 7-1 also lists the description of the LOWESS patterns for individual wells. The LOWESS patterns observed can be summarized as follows:

- 1 well shows a decreasing, then increasing, then leveling off pattern,
- 1 well shows an decreasing then decreasing steeper pattern, and
- 2 wells show an increasing then decreasing pattern.

In summary, most wells (including the interior and downgradient wells) exhibit consistently or recently decreasing LOWESS patterns. The upgradient well shows a recently flat LOWESS pattern.

Figure 7-1 is a graph of all nitrate data from the 4 Snack Alliance wells, with a LOWESS line drawn through the data. Figure 7-1 consists of many stacks of data points at approximately 3 month intervals. Each of these stacks of data represents one quarterly sampling event and contains one data point for each well sampled that event. It is evident from Figure 7-2 that the nitrate concentrations detected have not varied considerably since sampling began, but the highest concentrations have occurred at MW-4 in the middle and latter portion of the dataset. The LOWESS line has a fluctuating, nearly flat slope from 1994 through about 2001 then decreases through 2005.

The single highest concentration reported was 128.2 ppm at MW-4 in July 2004. This result is difficult to interpret. The second highest concentration reported at the site was 33.2 ppm at MW-4 in 2000. Resampling to confirm the anomalously high concentration was not conducted. The sample collected from this well the following quarter contained 6.84 ppm nitrate. The fact that conductivity and total dissolved solids concentrations were higher than normal in July 2004 suggests some real change in water quality. However, the fact that a near 100% conversion of the organic nitrogen in the wastewater to nitrate would be required to create such a high nitrate concentration in groundwater suggests this value does not represent a wastewater spill. Furthermore, the rapid return to “normal” nitrate values suggests a wastewater spill is unlikely.

Figure 7-2 includes the nitrate trends and LOWESS lines at each of the 4 Snack Alliance wells. The 4 graphs are plotted at the same scale to allow a comparison of trends between wells. Useful information can be gained by comparing trend lines with LOWESS lines. For example, Figure 7-2 illustrates that although the trend line shows nitrate concentrations at well MW-2 to be decreasing over time, the LOWESS line shows the concentrations increased for several years then began decreasing.

Figure 7-3 is a map view of the site illustrating the nitrate trends at each of the wells. The two intermediate wells (MW-2 and MW-3) and the downgradient well (MW-4) exhibit decreasing trends. The upgradient well (MW-1) exhibited a statistically insignificant trend (increasing at 0.03 ppm/yr).

The fact that the intermediate wells and the downgradient wells exhibit decreasing trends indicate groundwater quality is improving. The degree to which the improvements are attributable to the facility versus offsite activities is unknown.

7.2.3 Average Nitrate Concentrations
Figure 7-4 is a map view of the site illustrating the average nitrate concentrations at each of the Snack Alliance wells from August 1999 through November 2005, the timeframe in which all wells were installed and sampled. The averages in Table 7-1 use all data since each well was installed. In summary, average nitrate concentrations are lowest in the southern portion of the property at the upgradient well, and increase northward to the downgradient well. Specifically, the lowest average nitrate concentration (4.5 ppm) is at upgradient well MW-1, followed by the intermediate wells MW-3 (8.5 ppm) and MW-2 (9.52 ppm). The highest average nitrate concentration is at the downgradient well MW-4 (17.8 ppm).

The increase in average nitrate concentration across the site suggests facility operations have impacted groundwater quality.

7.2.4 Upgradient to Downgradient Comparisons
Figure 7-5(a) is a time series graph showing the nitrate concentrations at the upgradient well MW-1 and the downgradient well MW-4. In addition to the individual data points connected by a thin line, thick LOWESS lines are drawn through the data to illustrate general patterns. Figure 7-5(a) shows nitrate concentrations at well MW-1 decreased from 1995 through 1998, increased through 2001, and remained fairly stable through 2005. Figure 7-5(a) also shows that nitrate concentrations at MW-4 decreased from 2000 through 2002, then decreased more steeply through 2005. The difference between upgradient and downgradient concentrations has decreased over time. Downgradient concentrations are approaching upgradient concentrations. For example, downgradient concentrations were 6 to 30 ppm above upgradient concentrations in 2000 but only 1 to 4 ppm above upgradient concentrations in 2005.

Figure 7-5(b) is a box and whisker plot summarizing the nitrate concentrations from the upgradient well and the downgradient well. Figure 7-5(b) shows the nitrate concentrations are higher at the downgradient well MW-4 than at the upgradient well MW-1.

Based on comparison of nitrate concentrations at wells MW-1 and MW-4, facility operations affected groundwater quality in the past, but appear to be having smaller impacts in recent years.

7.2.5 Comparison to Previous Analysis
A comparison was made between the previous (through 2001) and current (through 2005) trend analyses. Changes in data set statistics as well as changes in the nitrate trends at Snack Alliance Site are summarized in Table 7-2. These changes are interpreted as indications of improving or worsening water quality between 2001 and 2005.

Indications of improving water quality since the previous analysis include:

- The downgradient well and one of the intermediate wells exhibited a new minimum nitrate concentration,
- The two intermediate wells exhibited a lower mean nitrate concentration,
- The two intermediate wells and the downgradient wells exhibited lower median nitrate concentrations,
- The downgradient well and one of the intermediate wells exhibited an improving trend,
- The site wide average trend decreased from -0.29 ppm/yr to -0.42 ppm/yr.

Indications of worsening water quality since the previous analysis include:

- The upgradient and the downgradient well exhibited a higher mean nitrate concentration, and
- The upgradient well and one of the intermediate wells exhibited a worsening trend.

In summary, more wells now exhibit statistically significant decreasing trends, most wells (including the downgradient well) exhibits a lower mean concentration, and the site-wide average trend decreasing steeper. The lower concentrations in recent years cause this change in long term trend.

7.2.6 Conclusions

Based on the discussion of the data for the Snack Alliance site presented above, the following conclusions have been made, and are grouped by topic:

Upgradient and Downgradient Wells

- Well MW-1 is located upgradient of current facility operations. Well MW-4 is located downgradient of current facility operations. Wells MW-2 and MW-3 are located within the land application area between fields.

Nitrate Trends

- Nitrate concentrations at the Snack Alliance Site are generally decreasing, as evidenced by:
    - 3 of 4 wells show a decreasing trend and the other well shows a statistically insignificant trend.
    - Trends (regardless of statistical significance) range from increasing at 0.03 ppm/yr to decreasing at 1.14 ppm/yr with the site-wide average nitrate trend decreasing at approximately 0.4 to 0.6 ppm/yr.
    - Most wells (including the interior and downgradient wells) exhibit consistently or recently decreasing LOWESS patterns. The upgradient well shows a recently flat LOWESS pattern.

Average Nitrate Concentrations

- Average nitrate concentrations are lowest in the southern portion of the property at the upgradient well (approximately 4 ppm), and increase northward to the downgradient well (approximately 18 ppm).

Factors Affecting Nitrate Concentrations

- The fact that average nitrate concentrations increase across the site from upgradient to downgradient suggests facility operations have historically impacted groundwater quality.
- The fact that the intermediate wells and the downgradient wells exhibit decreasing trends indicate groundwater quality is improving. The degree to which the improvements are attributable to the facility versus offsite activities is unknown.

Comparison to Previous Analysis

Nitrate concentrations for the site as a whole and at most wells are improving. More wells now exhibit statistically significant decreasing trends, most wells (including the downgradient well) exhibits a lower mean concentration, and the site-wide average trend decreasing steeper.

7.3 Recommendations

Based on the conclusions and discussion above, the following recommendations are made:

- To maintain and potentially expand the observed water quality improvements, it is recommended that BMP implementation to reduce the area-wide extent of elevated nitrate concentrations be continued and, when possible, improved. BMPs should include detailed procedures to:
    - establish appropriate crop specific nitrogen loading rates,
    - accurately quantify hydraulic loading from all sources,
    - document nutrient additions from all sources,
    - insure uniform sample acquisition and analysis,
    - characterize and monitor nitrogen concentration and movement in the soil column,
    - monitor moisture content and movement in the soil column, and
    - perform annual site specific analysis to identify farming activities and/or soil conditions that increase the potential for impact to groundwater.

Second Trend Analysis of Food Processor Land Application Sites in the LUB GWMA

- In accordance with the Action Plan, it is recommended that a trend analysis of data from the same wells be conducted in 2010 to evaluate progress towards improving groundwater quality at the food processing wastewater land application sites.

8.0 DISCUSSION

8.1 Summary of All Trends

Nitrate trends at 127 wells located at the 12 sites within the LUB GWMA that land applied food processing wastewater as of 2005 were calculated. Table 8-1 summarizes the nitrate trends and average nitrate concentrations by site. The table indicates that most wells (58%; 74 of 127) exhibited increasing trends while 20% of wells (25 of 127) exhibited decreasing trends, and 22% (28 of 127) exhibited statistically insignificant trends.

Additional observations made from Table 8-1 which highlight the overall picture of elevated and increasing nitrate concentrations include:

- the average slope of trends at each site ranged from decreasing at 0.67 ppm/yr to increasing at 2.9 ppm/yr
- 9 of 12 sites exhibited overall increasing trends
- the site-wide average for individual sites (which is the average nitrate concentrations at each well averaged over each site) ranged from 3.7 to 34.5 ppm
- the site-wide average for individual sites using only 2002 through 2005 data ranged from 4.1 to 36.1 ppm and was higher than using the entire data set at 7 of the 10 sites previously analyzed.
- 8 of 12 sites exhibited 2002 to 2005 site-wide average concentrations above the 7 ppm GWMA trigger level.

In addition to the 127 wells in Table 8-1, 2 wells downgradient of the ConAgra Madison Ranch site and 4 wells downgradient of the Simplot Plant site were also evaluated. Results from those wells are discussed in Sections 3.3 and 4.2, respectively.

Figure 8-1 provides a different way to compare all 127 trends. All 127 trends are illustrated both as a bar graph and as box plots. Figure 8-1(a) is a bar graph in which the length of the bar indicates the timeframe of the data evaluated, and the vertical position of the bar on the graph indicates the nitrate trend. Figure 8-1(b) is a box plot of the 99 statistically significant trends, the 28 statistically insignificant trends, and all 127 trends. As noted in Figure 8-1, 50% of the trends are between -0.1 and 0.6 ppm/yr, while 86% of the trends are between 2.0 to -0.50 ppm/yr.

The timeframe of the data used to calculate the 127 trends ranged from 2.75 to 18.5 years. The average timeframe was 11.7 years. Half of the wells had between 9.7 and 14.6 years of data. An examination of Figure 8-1(a) does not suggest a relationship between the length of the data set and the trend slope (i.e., the shorter time frames are not grouped together). In order to statistically evaluate the potential correlation between data set length and trend slope, the nonparametric Kendall's Tau correlation coefficient was calculated. The correlation coefficient indicates a very low coefficient (0.06; with a p-value of 0.31) indicating there is no correlation between data set length and trend slope.

In summary, the trend analysis indicates that nitrate concentrations are increasing at most wells, and at most sites. Furthermore, the average nitrate concentration at most sites exceeds the GWMA trigger level. However, the trend analysis does not by itself provide an indication of whether or not the nitrate contamination is the result of current facility operations. Other factors that can affect nitrate concentrations include historical facility activities, offsite activities (both current and historical), and the site's hydrogeology.

8.2 Comparison of All Trends

Nitrate trends and average nitrate concentrations at 113 wells from the 10 sites that were analyzed during both analyses are compared in Table 8-2[14]. Specifically, Table 8-2 compares the numbers of various types of trends (e.g., increasing or decreasing), the average trend slope, and the site-wide average nitrate concentration between the first and second trend analysis at each site. The summary at the bottom of Table 8-2 includes a comparison of the following aspects of the two analyses as well as the change between the two analyses:

- number of various types of trends (e.g., increasing or decreasing) at each site,
- average trend slope at each site, and
- the average of average nitrate concentrations at each well.

The Table 8-2 summary highlights the following indications of improving water quality between the two analyses:

- there were 4% fewer increasing trends and 15% more decreasing trends, and
- the average trend slope improved at 90% of the sites.

The Table 8-2 summary also highlights the following indication of worsening water quality between the two analyses.

- the site-wide average (i.e., the average of the average concentrations at each well) worsened at 60% of the sites.

In summary, while nitrate concentrations are increasing at most wells and at most sites, and average nitrate concentration at most sites exceeds the GWMA trigger level, the rate of increase is slower than it was during the previous analysis.

8.3 Factors Affecting the Timing of Groundwater Quality Improvement

Several factors affect the timing of groundwater quality improvement in the study area. These involve both hydrogeologic and cultural factors and include, but are not necessarily limited to, the following:

- *The source of aquifer recharge* – DEQ (1995) identifies potential sources of aquifer recharge to be precipitation, canal leakage, stream leakage, reservoir leakage, and deep percolation of applied irrigation water. The available data indicate that canal losses are a major source of recharge to the alluvial aquifer. Basin-wide recharge from deep percolation may be substantial but recharge rates probably vary widely depending upon irrigation practices. Recharge from reservoirs and streams may be significant but is of limited extent. Recharge from precipitation is probably negligible. In other words, because a significant percentage of aquifer recharge comes from irrigation water, much of the recharge is not pristine water but contains the agricultural chemicals that are, in part, the focus of this investigation.

- *Nitrogen in the unsaturated zone* – Past practices at some food processor land application sites included applying wastewater at rates significantly greater than agronomic rates. At those sites, considerable amounts of nitrate and ammonia may exist below the root zone and above the water table. The quantity of nitrogen present in this zone that is unavailable for plant uptake, but has not yet reached the groundwater system is unknown. Therefore, it is expected that, where present, this may continue to be a source of nitrate to groundwater even though BMPs have improved.

- *Nitrate in upgradient groundwater* – Contaminant concentrations at any well are influenced in part by the contaminant concentrations in upgradient groundwater. As this upgradient groundwater reaches a well, it provides a baseline of contamination that is then affected by activities nearer the well. Therefore, it is expected that some wells will exhibit upward nitrate trends prior to exhibiting downward nitrate trends

[14] Table 8-2 does not include data from the new well (MW-3a) at Port of Morrow Farm 1, the 6 wells from Port of Morrow Farm 3, the 9 wells from the Simplot Levy Site, the 4 wells offsite of the Simplot Plant Site (MW-56 through MW-59), and the two wells now considered downgradient of ConAgra Madison Ranch (MW-5 and MW-11).

because they are located downgradient of areas with greater contamination. When high enough, upgradient contamination can also mask lesser onsite contamination.

- *Groundwater flow velocity* – DEQ (1995) estimates the rate of groundwater movement ranges from 0.0002 to 8 feet per day in the study area. In addition, the groundwater flow velocity at specific locations could be affected by the interaction of canals, ditches, and other waterways. Therefore, groundwater can take many years (perhaps many decades) to travel through the aquifer and discharge into the Umatilla River or Columbia River. This slow movement of water beneath a site may be one reason that improved water quality is not being observed yet.

- *Continued application of wastewater* – Use of the food processing wastewater as a source of water and nutrients for plants is a good use of the product and can be a sound environmental choice when managed properly. However, food processor wastewater is a source of significant nitrate and must be continuously managed.

8.4 Potential Methods to Assess Current Facility Operations

At several food processing land application sites, downgradient wells have higher nitrate concentrations than upgradient wells, indicating facility operations have negatively affected groundwater quality in the past. At many of these facilities, the majority of wells exhibit increasing trends and consistently increasing and/or recently increasing LOWESS patterns, suggesting facility operations continue to impact groundwater quality. However, a definitive answer to the question "Are *current* facility operations negatively affecting groundwater quality?" is elusive. Although answering this question is beyond the scope of this report, the following discussion addresses some of the issues that would need to be considered when attempting to answer this question.

To evaluate whether or not current practices are sufficient to be protective of groundwater quality, groundwater samples could be "age dated" using tracers such as tritium or chlorofluorocarbons. Groundwater "age" refers to the time elapsed since recharge and isolation of the newly recharged water from the soil atmosphere. The age applies to the date of introduction of the tracer rather than the date of the water itself. Chemical and physical processes can also affect the tracer concentration. For this reason, the term "age" is normally qualified with the word "model" or "apparent", that is, "model age" or "apparent age" (USGS, 1999).

As an example of how age dating groundwater could be used to assess the effectiveness of current practices, consider the following example. Assuming practices presumed protective of groundwater were adopted 10 years ago, and if nitrate-rich groundwater beneath a facility was determined to be decades old, it would be reasonable to conclude that changes made within the last decade are not yet reflected in groundwater quality. On the other hand, if nitrate-rich groundwater beneath a facility was determined to be 5 years old, it would be reasonable to conclude that changes made within the last 10 years are not sufficiently protective of groundwater quality.

However, the inherent complexity, complications, and expense of determining the apparent age of groundwater can make using the technique undesirable.

In lieu of performing groundwater age dating, the effectiveness of BMPs could be assessed by a detailed evaluation of the site's hydrogeology, land use, and contaminant transport regime. This assessment would involve the evaluation of many factors, including:

- Depth to groundwater
    - the deeper the groundwater, the longer it will take water to percolate from land surface to the water table,
    - the deeper the groundwater, the larger the reservoir is for storing nitrate-rich water waiting to reach the water table,

- Effects of nearby surface water features
- Unusual precipitation events
- Crops grown at fields upgradient of sampled wells
  - Different crops have different hydraulic and nutrient requirements
  - As crops are rotated, so do crop requirements
  - Crop yield versus nutrients applied and residual soil nitrate
- Hydraulic loading
  - Amount and timing of fresh water application
  - Amount and timing of wastewater application
- Contaminant transport regime
  - Unsaturated zone flow velocity (i.e., how long does it take for nitrate applied at land surface to reach groundwater?)
  - Groundwater flow velocity (i.e., how long does it take for groundwater to travel from an upgradient well to a downgradient well?)
  - Physical and chemical processes affecting nitrate movement and concentrations

9.0 CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

Site-specific conclusions regarding each site's upgradient to downgradient well comparisons, nitrate trends and concentrations, factors affecting nitrate concentrations, and comparisons to the previous analysis are presented at the end of each facility's chapter. Based on the site-specific information, several overall conclusions were drawn. The major overall conclusions drawn from this study are:

- Nitrate concentrations are increasing at most wells, and at most sites.
- On the whole, the rate of increase is slower than it was during the previous analysis.
- The measure of Action Plan progress related to the land application of food processing wastewater (Section VIII, Item G.3.c), that states in part, that by December 2005, "monitoring data shows improving groundwater quality trends for nitrate" was not met.
- The trend analysis does not by itself provide an indication of whether or not the nitrate contamination is the result of current facility operations. Other factors that can affect nitrate trends include historical facility activities, offsite activities (both current and historical), and the site's hydrogeology.
- The timing of groundwater quality improvements is a result of several factors. Hydrogeologic and cultural factors include the source of aquifer recharge, nitrogen in the unsaturated zone, nitrate in upgradient groundwater, groundwater flow velocity, and the continued application of wastewater.
- Potential methods exist to assess current facility operations. These potential methods include "age dating" groundwater samples and/or performing a detailed evaluation of the site's hydrogeology, land use, and contaminant transport regime.

9.2 Recommendations

Both site-specific and general recommendations are made in this report. The site-specific recommendations involve additional assessment activities at several facilities in order to better define the site's groundwater flow regime and/or to determine the source of nitrate in groundwater. The general recommendations include:

- pursuing funding to gauge the effects of BMP implementation,
- continued and, when possible, expanded BMP implementation, and
- completion of the Action Plan-required trend analysis in 2010.

Although nitrate concentrations are increasing at most wells and most sites, there are some wells and sites where nitrate concentrations are decreasing. It is also recommended that DEQ and the food processors work together to identify what combination of factors produces the improving water quality trends, then apply those factors elsewhere, with the hope of improving water quality trends across the GWMA.

10.0 REFERENCES

Bethke, C.M., and T.M. Johnson, 2002. Paradox of groundwater age. *Geology*, February 2002. v. 30, no. 2, 107-110.

DEQ, 2004. Trend Analysis of Food Processor Land Application Sites in the Lower Umatilla Basin Groundwater Management Area.

DEQ, 1995. Hydrogeology, Groundwater Chemistry and Land Uses in the Lower Umatilla Basin Groundwater Management Area.

Frans, L.M., written communication. Unpublished article received April 6, 2006.

Helsel, D.R., 2005. Nondetects and Data Analysis: Statistics for Censored Environmental Data. John Wiley & Sons, Inc., Hoboken, New Jersey. 250 pg.

Helsel, D.R., Mueller, D.K., and Slack, J.R. 2006. Computer Program for the Kendall Family of Trend Tests. U.S. Geological Survey Scientific Investigations Report 2005-5275, 4 p.

Helsel, D.R., and L.M. Frans, 2006. Regional Kendall Test For Trend, *Environmental Science & Technology, Vol. 40, No. 13,* pg 4066-4073.

Kopacz, 2004. Personal communication on 3/17/04 with Ray Kopacz, Stanfield Irrigation District Manager.

SCS, 1983. Soil Survey of Morrow County Area, Oregon. United States Department of Agriculture Soil Conservation Service. December 1983.

USGS, 2006. The Reston Chlorofluorocarbon Laboratory. $^{3}H/^{3}He$ Dating Background. http://water.usgs.gov/lab/3h3he/background/

US Navy, 2006. Comprehensive Range Evaluation – NWSTF Boardman Preliminary Screening Synopsis Decision Point Two Report. NAVFAC Northwest, Silverdale, WA.

Table 2-1
Summary of Nitrate Trend Analyses - Port of Morrow Farm 1
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	Data Set Statistics								Trend Analysis Results		Trend Direction	LOWESS Pattern
	Starting Date	Ending Date	Min	Max	Mean	Median	n	% BDL	Slope (ppm/yr)	C.L.		
MW-1	Jun-87	Dec-05	11.2	42.6	24.9	22.9	72	0%	0.64	99%	Increasing	Basically flat then increasing
MW-2	Jun-87	Dec-05	4.81	47.0	24.9	25.0	67	0%	0.53	96%	Increasing	Increase then decrease
MW-3	Jun-87	Dec-04	0.07	95.4	17.9	4.3	60	0%	1.22	99%	Increasing	Flat, then increase, then decrease
MW-3a	Mar-02	Dec-05	3.2	6.0	4.0	3.8	16	0%	-0.10	39%	No Significant Trend	Flat, then decrease, then increase
MW-4	Jun-87	Dec-05	<0.08	43.2	9.3	5.5	72	1.4%	0.29	98%	Increasing	Increase, decrease, then increase
MW-5	Jun-87	Dec-05	6.98	36.0	21.5	22.1	72	0%	0.08	48%	No Significant Trend	Increase then decrease
MW-6	Jun-87	Jun-00	<0.08	9.7	0.8	0.5	47	15%	-0.03	82%	Decreasing	Decrease then increase
MW-7	Oct-91	Dec-05	9.75	39.0	20.1	15.2	57	0%	1.90	99%	Increasing	Decrease then increase
MW-8	Oct-91	Dec-05	6.48	54.5	35.1	36.2	57	0%	0.99	98%	Increasing	Increase then decrease
MW-9	Oct-91	Dec-05	5.2	34.5	20.3	21.5	57	0%	1.12	99%	Increasing	Increasing, then increasing less steep
MW-10	Oct-91	Dec-05	11.5	40.4	28.0	27.8	57	0%	1.46	99%	Increasing	Increasing
MW-11	Oct-91	Dec-05	5.35	50.5	31.2	31.6	57	0%	1.51	99%	Increasing	Increasing, increasing steeper, then level off
MW-SP1	Mar-95	Dec-05	27.8	53.6	35.0	33.9	40	0%	-0.80	99%	Decreasing	Increase then decrease
MW-SP2	Mar-96	Dec-05	29.8	49.9	38.7	38.2	40	0%	-1.51	99%	Decreasing	Decreasing

# of Increasing Trends ==>	9
# of Decreasing Trends ==>	3
# of Flat Trends ==>	0
# of Statistically Insignificant Trends ==>	2
Average slope of significant trends (ppm/yr) ==>	0.61
Average slope of all trends (ppm/yr) ==>	0.52

Notes:
Min = minimum, Max = maximum, n = number of samples
BDL = below detection limit, C.L. = confidence level

E:\LUB\LandApp\2006 Trend Analysis\[All Trends.xls]POM Farm1 thru 2005

Table 2-2
Comparison of Nitrate Data and Trends Between Analyses - Port of Morrow Farm 1
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	Change in Data Set Statistics					First Trend Analysis Results		Second Trend Analysis Results		Change in Trend		Change in Calculated Trend
	Min	Max	Mean	Median	n	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	
MW-1	0	0	2.2	2.8	15	0.21	< 80%	0.64	99%	0.43	Increase	From SI increasing to steeper increasing
MW-2	0	0	-0.4	0.3	15	1.65	99%	0.53	96%	-1.12	Decrease	From increasing to less steeply increasing
MW-3	0	0	-1.7	0.4	1	2.65	99%	1.22	99%	-1.43	Same	From increasing to less steeply increasing
MW-3a	Well not installed at the time of the first trend analysis							-0.10	39%	Well not installed at the time of the first trend analysis		
MW-4	0	0	0.1	-1.9	15	0.31	90%	0.29	98%	-0.02	Increase	From increasing to less steeply increasing
MW-5	0	0	0.9	0.5	17	0.67	99%	0.08	48%	-0.59	Decrease	From increasing to less steeply increasing
MW-6	0	0 *	0 *	0 *	-4 *	-0.025 *	80% *	-0.028 *	82% *	-0.003 *	Increase *	No change *
MW-7	0	9.8	-5.5	-1.3	16	0.41	90%	1.90	99%	1.50	Increase	From increasing to steeper increasing
MW-8	0	0	-1.1	0	16	2.48	99%	0.99	98%	-1.49	Decrease	From increasing to less steeply increasing
MW-9	0	1.4	-2.2	-3.3	16	1.41	99%	1.12	99%	-0.29	Same	From increasing to less steeply increasing
MW-10	0	0.3	-3.3	-3.9	16	1.51	99%	1.46	99%	-0.05	Same	From increasing to less steeply increasing
MW-11	0	3.5	-3.3	-3.7	15	2.24	99%	1.51	99%	-0.73	Same	From increasing to less steeply increasing
MW-SP1	3.6	0	2.9	3.0	17	0.67	< 80%	-0.80	99%	-1.47	Increase	From SI increasing to decreasing
MW-SP2	2.8	0	2.8	1.5	17	-0.25	< 80%	-1.51	99%	-1.26	Increase	From SI decreasing to decreasing

Summary of Differences

Minimum and Maximum
15% of stations (2 wells) exhibited a new minimum (2.8 to 3.6 ppm lower).
31% of stations (4 wells) exhibited new maximums (0.3 to 9.8 ppm higher).

Mean
54% of stations (7 wells) exhibited lower means (0.4 to 5.5 ppm lower)
38% of stations (5 wells) exhibited higher mean values (0.1 to 2.9 ppm higher).
8% of stations (1 well) was not sampled again so no change in mean.

Median
38% of stations (5 wells) exhibited lower median values (1.3 to 3.9 ppm lower).
15% of stations (2 wells) exhibited no change in median value
46% of stations (6 wells) exhibited an increase in median values (0.3 to 3.0 ppm higher).

Trend Slope
83% of stations (10 wells) exhibited improving trends
17% of stations (2 wells) exhibited worsening trends

Trend Confidence Level
33% of stations (4 wells) exhibited the same confidence level
25% of stations (3 wells) exhibited lower confidence levels
42% of wells (5 wells) exhibited increased confidence levels

Site-Wide Average Trend Slope
Decreased from 1.1 ppm/yr to 0.6 ppm/yr

E:\LUB\LandApp\2006 Trend Analysis\[All Trends.xls]POM Farm1 Comparison

* = A more robust method of dealing with censored values when estimating summary statistics and calculating trends was used in the second trend analysis.
The apparent difference in the MW-4 minimum value and all values from MW-6 reflects the difference in the statistical methods rather than an actual change in nitrate concentrations.
The detection limit for 4 samples from MW-6 could not be determined so those results were not included in the second trend analysis.

Table 2-3
Summary of Nitrate Trend Analyses - Port of Morrow Farm 2
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	Data Set Statistics									Trend Analysis Results		Trend Direction	LOWESS Pattern
	Starting Date	Ending Date	Min	Max	Mean	Median	Skewness	n	% BDL	Slope (ppm/yr)	C.L.		
MW-12	Dec-91	Dec-05	13	46.0	32.3	32.9	-0.67	56	0%	1.10	99%	Increasing	Increasing, then increasing less steeply
MW-13	Dec-91	Dec-05	16.8	61.6	44.4	45.9	-0.77	57	0%	1.05	99%	Increasing	Increasing then decreasing
MW-14	Dec-91	Dec-05	0.02	45.2	27.5	31.8	-0.43	57	0%	0.88	98%	Increasing	Increasing then decreasing
MW-14s	Jan-95	Dec-05	8.12	49.2	35.9	38.2	-1.53	28	0%	-0.03	0%	No Significant Trend	Increasing then decreasing
MW-15	Dec-91	Dec-05	9.7	56.7	39.8	43.4	-0.84	57	0%	1.94	99%	Increasing	Increasing, then increasing less steeply
MW-15s	Jan-95	Dec-05	15.5	55.2	40.2	42.7	-1.27	27	0%	3.02	99%	Increasing	Increasing, then increasing less steeply
MW-16	Dec-91	Dec-05	6.06	58.3	42.3	43.4	-0.73	57	0%	0.09	17%	No Significant Trend	Increasing then decreasing
MW-17	Dec-91	Dec-05	5.89	53.4	40.9	44.7	-1.59	57	0%	1.22	99%	Increasing	Increasing, then increasing less steeply
MW-18	Dec-91	Dec-05	0.03	14.8	7.4	6.7	0.06	57	0%	0.84	99%	Increasing	Increasing

# of Increasing Trends ==>	7
# of Decreasing Trends ==>	0
# of Flat Trends ==>	0
# of Statistically Insignificant Trends ==>	2
Average slope of significant trends (ppm/yr) ==>	1.4
Average slope of all trends (ppm/yr) ==>	1.1

Notes:
Min = minimum, Max = maximum, n = number of samples
BDL = below detection limit, C.L. = confidence level

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Table 2-4
Comparison of Nitrate Data and Trends Between Analyses - Port of Morrow Farm 2
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	Change in Data Set Statistics					First Trend Analysis Results		Second Trend Analysis Results		Change in Trend		Change in Calculated Trend
	Min	Max	Mean	Median	n	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	
MW-12	0	0.6	2.3	1.9	16	1.63	99%	1.10	99%	-0.53	same	from increasing to less steep increasing
MW-13	0	0	0.8	0	18	2.73	99%	1.05	99%	-1.68	same	from increasing to less steep increasing
MW-14	0	0	-0.2	-0.7	17	3.59	99%	0.88	98%	-2.71	slight decrease	from increasing to less steep increasing
MW-14s	0	0	-0.7	-1.3	6	2.27	80%	-0.03	0%	-2.31	decrease	from increasing toSI decreasing
MW-15	0	0.8	3.5	4.8	17	2.69	99%	1.94	99%	-0.75	same	from increasing to less steep increasing
MW-15s	0	0	1.6	3.2	6	3.85	99%	3.02	99%	-0.83	same	from increasing to less steep increasing
MW-16	0	0	-2.6	-7.0	18	2.63	99%	0.09	17%	-2.54	decrease	from increasing to less steep increasing
MW-17	0	0	1.7	1.5	17	2.32	99%	1.22	99%	-1.10	same	from increasing to less steep increasing
MW-18	0	0.4	1.8	1.5	17	0.89	99%	0.84	99%	-0.05	same	from increasing to less steep increasing

Summary of Differences

Minimum and Maximum
No stations exhibited a new minimum.
33% of stations (3 wells) exhibited new maximums (0.4 to 0.8 ppm higher).

Mean
33% of stations (3 wells) exhibited lower means (0.2 to 2.6 ppm lower)
67% of stations (6 wells) exhibited higher mean values (0.8 to 3.5 ppm higher).

Median
33% of stations (3 wells) exhibited lower median values (0.7 to 7 ppm lower).
11% of stations (1 well) exhibited no change in median value
56% of stations (5 wells) exhibited an increase in median values (1.5 to 4.8 ppm higher)

Trend Slope
100% of stations (9 wells) exhibited improving trends

Trend Confidence Level
67% of stations (6 wells) exhibited the same confidence level
33% of stations (3 wells) exhibited lower confidence levels

Site-Wide Average Trend Slope
Decreased from 2.5 ppm/yr to 1.1 ppm/yr

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Table 2-5
Summary of Nitrate Trend Analyses - Port of Morrow Farm 3
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	Data Set Statistics									Trend Analysis Results		Trend Direction	LOWESS Pattern
	Starting Date	Ending Date	Min	Max	Mean	Median	Skewness	n	% BDL	Slope (ppm/yr)	C.L.		
MW-19	Mar-02	Dec-05	11.5	22.4	15.9	14.5	0.87	16	0%	-2.00	97%	Decreasing	Decrease then increase
MW-20	Mar-02	Dec-05	10.1	42.3	20.2	18.4	1.40	16	0%	-3.17	99%	Decreasing	Increase then decrease
MW-21	Mar-02	Dec-05	13.6	37.6	26.0	26.5	-0.05	16	0%	6.92	99%	Increasing	Increase
MW-22	Mar-02	Dec-05	19.2	49.6	34.4	33.6	0.01	16	0%	7.51	99%	Increasing	Increase
MW-23	Mar-02	Dec-05	42.9	68.0	54.9	54.7	0.14	16	0%	5.02	99%	Increasing	Increase then level off
MW-24	Mar-02	Dec-05	42.1	52.9	46.7	46.6	0.42	16	0%	-0.21	0%	No Significant Trend	Decrease then increase

# of Increasing Trends ==>	3
# of Decreasing Trends ==>	2
# of Flat Trends ==>	0
# of Statistically Insignificant Trends ==>	1
Average slope of significant trends (ppm/yr) ==>	2.9
Average slope of all trends (ppm/yr) ==>	2.3

Notes:

Min = minimum, Max = maximum, n = number of samples

BDL = below detection limit, C.L. = confidence level

E:\LUB\LandApp\2006 Trend Analysis\[All Trends.xls]POM Farm3 thru 2005

Table 3-1
Summary of Nitrate Trend Analyses - ConAgra North Farm
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	Data Set Statistics								Trend Analysis Results		Trend Direction	LOWESS Pattern
	Starting Date	Ending Date	Min	Max	Mean	Median	n	% BDL	Slope (ppm/yr)	C.L.		
MW-1	Oct-95	Nov-05	2.14	56.6	17.3	15.8	40	0%	-0.36	75%	No Significant Trend	Decreasing
MW-2	Oct-95	Nov-05	15.1	46.1	19.1	18.4	40	0%	0.18	99%	Increasing	Basically flat (slight increase then slight decrease)
MW-3	Oct-95	Nov-05	7.53	50.4	9.8	8.4	41	0%	-0.17	99%	Decreasing	Basically flat (slight decrease)
MW-4	Oct-95	Nov-05	20.6	29.2	25.2	25.3	41	0%	0.25	99%	Increasing	Increase then slight decrease
MW-5	Nov-95	Nov-05	19.4	50.6	27.3	27.7	41	0%	0.61	99%	Increasing	Increasing
MW-6	Nov-95	Nov-05	3.09	9.2	6.0	5.9	41	0%	0.63	99%	Increasing	Increasing
MW-7	Oct-95	Nov-05	11.4	62.8	41.1	43.9	41	0%	3.67	99%	Increasing	Increasing, then start to level off
MW-8	Oct-95	Nov-05	7.92	129	51.3	49.5	41	0%	0.22	45%	No Significant Trend	Increasing then decreasing
MW-9	Oct-95	Nov-05	5.94	8.1	6.9	7.0	41	0%	-0.13	99%	Decreasing	Flat, then decreasing
MW-10	Jan-96	Nov-05	9.08	64.7	47.4	48.9	39	0%	0.04	7%	No Significant Trend	Basically flat (slight increase then slight decrease)

# of Increasing Trends ==>	5
# of Decreasing Trends ==>	2
# of Flat Trends ==>	0
# of Statistically Insignificant Trends ==>	3
Average slope of significant trends (ppm/yr) ==>	0.72
Average slope of all trends (ppm/yr) ==>	0.50

Notes:
Min = minimum, Max = maximum, n = number of samples
BDL = below detection limit, C.L. = confidence level

E:\LUB\LandApp\2006 Trend Analysis\[All Trends.xls]L-W North thru 2005

Table 3-2
Comparison of Nitrate Data and Trends Between Analyses - ConAgra North Farm
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	Change in Data Set Statistics					First Trend Analysis Results		Second Trend Analysis Results		Change in Trend		Change in Calculated Trend
	Min	Max	Mean	Median	n	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	
MW-1	-6.26	0	-2.2	-1.5	16	0.43	< 80%	-0.36	75%	-0.79	No change	From SI increasing to SI decreasing
MW-2	0	25.1	1.1	0.2	16	0.31	99%	0.18	99%	-0.13	No change	From increasing to less steeply increasing
MW-3	-0.37	0	-0.9	-0.4	16	-0.33	99%	-0.17	99%	0.17	No change	From decreasing to less steeply decreasing
MW-4	0	2.1	0.5	0.2	16	0.76	99%	0.25	99%	-0.52	No change	From increasing to less steeply increasing
MW-5	0	22.2	1.9	1.7	16	0.30	< 80%	0.61	99%	0.31	Increase	From SI increasing to steeper increasing
MW-6	0	1.0	1.2	1.4	16	0.60	99%	0.63	99%	0.03	No change	Essentially no change (very slight increase)
MW-7	0	7.0	5.3	4.8	16	6.93	99%	3.67	99%	-3.26	No change	From increasing to less steeply increasing
MW-8	0	58.6	1.6	-0.6	16	1.66	< 80%	0.22	45%	-1.43	No change	From SI increasing to less steeply SI increasing
MW-9	-0.28	0	-0.3	-0.1	16	-0.03	80%	-0.13	99%	-0.10	Increase	From decreasing to more steeply decreasing
MW-10	0	0	0.8	-0.2	16	0.78	80%	0.04	7%	-0.74	Decrease	From increasing to less steeply increasing

Summary of Differences

Minimum and Maximum
30% of stations (3 wells) exhibited a new minimum (0.28 to 6.26 ppm lower).
60% of stations (6 wells) exhibited new maximums (1.0 to 58.6 ppm higher).

Mean
30% of stations (3 wells) exhibited lower means (0.3 to 2.2 ppm lower)
70% of stations (7 wells) exhibited higher mean values (0.8 to 5.3 ppm higher).

Median
50% of stations (5 wells) exhibited lower median values (0.1 to 1.5 ppm lower).
50% of stations (5 wells) exhibited higher median values (0.2 to 4.8 ppm higher).

Trend Slope
70% of stations (7 wells) exhibited improving trends
20% of stations (2 wells) exhibited worsening trends
10% of stations (1 well) exhibited essentially the same trend (very slight worsening)

Trend Confidence Level
70% of stations (7 wells) exhibited the same confidence level
20% of stations (2 wells) exhibited a higher confidence level
10% of stations (1 wells) exhibited a lower confidence level

Site-Wide Average Trend Slope
Decreased from 1.14 ppm/yr to 0.50 ppm/yr

E:\LUB\LandApp\2006 Trend Analysis\[All Trends.xls]L-W NF Comparison

Table 3-3
Summary of Nitrate Trend Analyses - ConAgra Madison Ranch
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	Well Location	Data Set Statistics								Trend Analysis Results		Trend Direction	LOWESS Pattern
		Starting Date	Ending Date	Min	Max	Mean	Median	n	% BDL	Slope (ppm/yr)	C.L.		
MW-1	Onsite	Jan-96	Apr-00	2.93	7.44	5.9	6.4	7	0%	-0.14	< 80%	No Significant Trend	Increasing then decreasing
MW-2	Onsite	Nov-95	Dec-05	0.05	0.47	0.2	0.2	33	0%	0.009	99%	Increasing	Increasing, decreasing, then increasing
MW-3	Onsite	Jan-96	Dec-05	2.68	13.2	3.7	3.3	36	0%	0.11	99%	Increasing	Increasing
MW-4a	Onsite	Nov-95	Dec-05	0.65	1.11	0.9	0.9	36	0%	0.003	20%	No Significant Trend	Increasing then decreasing
MW-6	Onsite	Nov-95	Dec-05	8.37	40.9	23.9	25.9	37	0%	2.03	99%	Increasing	Increasing then increasing less steeply
MW-7	Onsite	Nov-95	Dec-05	0.34	1.05	0.5	0.4	37	0%	0.02	99%	Increasing	Flat then increasing
MW-8	Onsite	Nov-95	Dec-05	3.52	5.44	4.7	4.8	37	0%	0.08	99%	Increasing	Increasing then increasing less steeply
MW-9	Onsite	Nov-95	Dec-05	0.2	3.21	1.2	0.8	37	0%	0.20	99%	Increasing	Flat then increasing
MW-10	Onsite	Nov-95	Dec-05	2.9	14.3	6.9	6.1	37	0%	-0.47	99%	Decreasing	Increasing then decreasing
MW-12	Onsite	Nov-95	Sep-05	2.77	9.26	5.7	5.4	33	0%	0.22	95%	Increasing	Increasing, decreasing, then leveling off
MW-5	Offsite	Nov-95	Dec-05	5.04	26.1	8.4	7.4	38	0%	-0.48	99%	Decreasing	Decreasing
MW-11	Offsite	Nov-95	Dec-05	4.8	25.5	7.8	7.3	38	0%	-0.32	99%	Decreasing	Increasing then decreasing

# of Increasing Trends (onsite wells only) ==>	7
# of Decreasing Trends (onsite wells only) ==>	1
# of Flat Trends (onsite wells only) ==>	0
# of Statistically Insignificant Trends (onsite wells only) ==>	2
Average slope of significant trends (onsite wells only) ==>	0.28
Average slope of all trends (onsite wells only) ==>	0.21

Notes:
Min = minimum, Max = maximum, n = number of samples
BDL = below detection limit, C.L. = confidence level

E:\LUB\LandApp\2006 Trend Analysis\[All Trends.xls]L-W Madison thru 2005

Table 3-4
Comparison of Nitrate Data and Trends Between Analyses - ConAgra Madision Ranch
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	Well Location	Change in Data Set Statistics					First Trend Analysis Results		Second Trend Analysis Results		Change in Trend		Change in Calculated Trend
		Min *	Max	Mean	Median	n	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	
MW-1	Onsite	*0*	*0*	*0*	*0*	*0*	*-0.14*	*< 80%*	*-0.14*	*< 80%*	*0*	*Same*	*No change because no additional data*
MW-2	Onsite	0	0.02	0	0	13	0.012	95%	0.009	99%	-0.004	Increase	From increasing to less steeply increasing
MW-3	Onsite	0	0	0.1	0.1	13	0.05	95%	0.11	99%	0.07	Increase	From increasing to steeper increasing
MW-4a	Onsite	0	0	0	0	12	0.05	90%	0.003	20%	-0.047	Decrease	From increasing to SI less steeply increasing
MW-6	Onsite	0	0	4.7	8.0	13	3.16	99%	2.03	99%	-1.13	Same	From increasing to less steeply increasing
MW-7	Onsite	0	0.57	0.1	0	13	0.0	< 80%	0.02	99%	0.02	Increase	From SI flat trend to increasing trend
MW-8	Onsite	0	0.38	0.4	0.1	13	0.24	99%	0.08	99%	-0.16	Same	From increasing to less steeply increasing
MW-9	Onsite	0	0	0.4	0.1	13	0.04	95%	0.20	99%	0.16	Increase	From increasing to steeper increasing
MW-10	Onsite	0	0	-0.9	-1.9	13	-0.68	< 80%	-0.47	99%	0.22	Increase	From SI decreasing to less steeply decreasing
MW-12	Onsite	0	0	0.3	0.4	10	1.03	99%	0.22	95%	-0.81	Decrease	From increasing to less steeply increasing
MW-5	*Offsite*	*-1.20*	*0*	*-1.3*	*-1.2*	*14*	*-0.32*	*< 80%*	*-0.48*	*99%*	*-0.16*	*Increase*	*From SI decreasing to steeper decreasing*
MW-11	*Offsite*	*-0.62*	*0*	*-0.6*	*-0.7*	*13*	*0.05*	*< 80%*	*-0.32*	*99%*	*-0.37*	*Increase*	*From SI increasing to decreasing*

Summary of Differences ***(except MW-1 which has not been sampled since April 2000 & MW-5 and MW-11 which are now considered offsite wells)***

Minimum and Maximum
No stations exhibited a new minimum
33% of stations (3 wells) exhibited new maximums (0.02 to 0.57 ppm higher).

Mean
11% of stations (1 well) exhibited a lower mean (0.9 ppm lower)
67% of stations (6 wells) exhibited higher mean values (0.1 to 4.7 ppm higher).

Median
11% of stations (1 well) exhibited a lower median values (1.9 ppm lower).
33% of stations (3 wells) exhibited no change in median value
56% of stations (5 wells) exhibited an increase in median values (0.1 to 8 ppm higher)

Trend Slope
56% of stations (5 wells) exhibited improving trends
44% of stations (4 wells) exhibited worsening trends

Trend Confidence Level
22% of stations (2 wells) exhibited the same confidence level
56% of stations (5 wells) exhibited a higher confidence level
22% of stations (2 wells) exhibited a lower confidence level

Site-Wide Average Trend Slope
Decreased from 0.29 ppm/yr to 0.11 ppm/yr (if all 12 wells are compared)
Decreased from 0.38 ppm/yr to 0.21 ppm/yr (if only the 9 current onsite wells are compared

* = The October 1995 nitrate concentrations should have been trimmed from the data set during the previous analysis because November 1995 values are closer to mid-quarter. The October 1995 values were also anomalously low. The change in minimum concentrations is calculated after the October 1995 samples were deleted from the data set.

Table 4-1
Summary of Nitrate Trend Analyses - Simplot Plant Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	Data Set Statistics								Trend Analysis Results		Trend Direction	LOWESS Pattern
	Starting Date	Ending Date	Min	Max	Mean	Median	n	% BDL	Slope (ppm/yr)	C.L.		
MW-10S	Feb-92	Aug-05	0.05	44.9	4.5	1.2	54	26%	0.59	99%	Increasing	Increase, decrease, then increase steeper
MW-10D	Feb-92	Aug-05	0.05	4.9	0.4	1.0	54	54%	0	22%	No Significant Trend	Increase then level off
MW-11S	Feb-88	Nov-05	6.0	18.0	11.6	11.3	68	0%	-0.12	93%	Decreasing	Decrease, increase, then decrease
MW-11D	Feb-88	Nov-05	0.5	3.5	1.1	1.0	68	18%	0.07	99%	Increasing	Level, then increasing
MW-12	Feb-88	Aug-05	12.7	39.2	20.4	19.9	67	0%	0.03	30%	No Significant Trend	Basically level with some fluctuation
MW-13S	Nov-88	Nov-05	3.9	53.0	15.3	14.0	69	0%	0.05	31%	No Significant Trend	Slight decrease then slight increase
MW-13D	Nov-88	Aug-05	0.4	17.0	2.2	1.7	67	0%	0.03	96%	Increasing	Basically level
MW-16	Nov-88	Aug-05	0.2	100	15.4	3.1	68	40%	-2.40	99%	Decreasing	Decreasing then level
MW-17	Nov-88	Aug-05	0.02	31.4	0.9	1.0	66	46%	0	26%	No Significant Trend	Slight increase
MW-18	*Nov-88*	*May-96*	*0.50*	*99.3*	*8.2*	*2.6*	*31*	*29%*	*0.29*	*86%*	*Increasing*	*Increase then decrease*
MW-19	Nov-88	Nov-05	0.05	1.9	0.3	1.0	68	46%	0	40%	No Significant Trend	Increase then level off
MW-20	Nov-88	Aug-05	<1.0	43.3	13.3	11.8	68	10%	-1.46	99%	Decreasing	Decreasing
MW-21	Nov-88	Aug-05	0.05	8.9	0.9	1.0	68	46%	-0.10	94%	Decreasing	Basically level
MW-45	Feb-92	Aug-05	<1.0	48.3	9.8	4.1	54	33%	-1.95	99%	Decreasing	Decreasing then level
MW-46	Feb-96	Nov-04	5.1	13.2	8.6	8.6	26	0%	0.10	18%	No Significant Trend	Decrease then increase
MW-47	Feb-96	Feb-05	12.0	28.3	17.4	16.2	32	0%	0.22	27%	No Significant Trend	Increase then decrease
MW-48	Feb-96	Feb-05	17.4	45.8	33.2	36.1	36	0%	-2.82	99%	Decreasing	Increase then decrease
MW-49	Feb-96	Aug-05	<0.5	1.2	0.6	0.5	39	77%	-0.09	84%	Decreasing	Flat
MW-50	Feb-96	Nov-05	0.5	1.3	0.6	0.5	40	78%	-0.09	98%	Decreasing	Flat
MW-56	Feb-96	Nov-04	<1.0	31.8	9.0	8.6	25	4%	0.33	92%	Increasing	Slight increase
MW-57	Feb-96	Aug-05	1.0	18.5	7.6	6.5	39	0%	-0.20	94%	Decreasing	Basically level with some fluctuation
MW-58	May-96	Feb-05	<1.0	18.2	8.5	5.6	36	25%	0	25%	No Significant Trend	Decrease then increase
MW-59	Aug-96	Aug-05	0.5	1.1	<1.0	<1.0	37	84%	0	59%	No Significant Trend	Flat

# of Increasing Trends (onsite wells only) ==>	4
# of Decreasing Trends (onsite wells only) ==>	8
# of Flat Trends (onsite wells only) ==>	0
# of Statistically Insignificant Trends (onsite wells only) ==>	7
Average slope of significant trends at onsite wells (ppm/yr) ==>	-0.67
Average slope of all trends at onsite wells (ppm/yr) ==>	-0.40

Notes:

Min = minimum, Max = maximum, n = number of samples

BDL = below detection limit, C.L. = confidence level

For these calculations, values reported as BDL and those reported as equal to or less than one-half the highest detection limit were counted as BDL.

Wells MW-56 through MW-59 are offsite wells. All other wells are onsite wells.

E:\LUB\LandApp\2006 Trend Analysis\[All Trends.xls]Simplot Plant thru 2005

Table 4-2
Comparison of Nitrate Data and Trends Between Analyses - Simplot Plant Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	Change in Data Set Statistics					First Trend Analysis Results		Second Trend Analysis Results		Change in Trend		Change in Calculated Trend
	Min	Max	Mean	Median	n	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	
MW-10S	*	31.0	1.8	0.7	15	0	< 80%	0.59	99%	0.59	Increase	From SI flat to increasing
MW-10D	*	0	0	0.5	15	0	< 80%	0	22%	0	Same	No change
MW-11S	-1.2	0	-0.2	-0.3	16	-0.14	80%	-0.12	93%	0.02	Increase	From decreasing to slightly less steeply decreasing
MW-11D	0	1.1	0.3	0.2	16	0	< 80%	0.07	99%	0.07	Increase	From SI flat to increasing
MW-12	0	0	-0.2	0.1	15	0.10	< 80%	0.03	30%	-0.07	Same	From SI increasing to less steeply increasing SI trend
MW-13S	-5.0	0	-0.4	0.6	16	-0.13	< 80%	0.05	31%	0.18	Same	From SI decreasing to SI increasing
MW-13D	0	13.7	0.5	0.1	15	0.01	< 80%	0.03	96%	0.01	Increase	From SI increasing to increasing
MW-16	*	0	-4.4	-5.5	15	-2.39	99%	-2.40	99%	-0.01	Same	Essentially no change
MW-17	*	0	-0.4	0.5	14	0	< 80%	0	26%	0	Same	No change
MW-18	*	*0*	*0.0*	*0*	*0*	*0.22*	*80%*	*0.29*	*86%*	*0.07*	*Increase*	*No additional data to evaluate*
MW-19	*	0	-0.3	0.5	16	0	< 80%	0	40%	0	Same	No change
MW-20	*	0	-3.0	-2.8	15	-1.50	99%	-1.46	99%	0.04	Same	To slightly less steeply decreasing
MW-21	*	0	-0.4	0.5	15	0	99%	-0.10	94%	-0.10	Decrease	From flat to decreasing
MW-45	*	0	-3.4	-2.0	15	-2.92	99%	-1.95	99%	0.97	Same	From decreasing to less steeply decreasing
MW-46	0	2.1	0.4	0	6	-0.13	< 80%	0.100	18%	0.23	Same	From SI decreasing to SI increasing
MW-47	0	0	-0.7	-0.4	8	1.52	95%	0.22	27%	-1.30	Decrease	From increasing to less steeply increasing
MW-48	-13.1	0	-5.9	-4.4	12	-0.38	< 80%	-2.82	99%	-2.44	Increase	From SI decreasing to decreasing
MW-49	*	0	0	0	15	0	80%	-0.09 *	84%	-0.09 *	Increase	From flat to decreasing *
MW-50	0	0	0	0	16	0	95%	-0.09 *	98%	-0.09 *	Increase	From flat to decreasing *
MW-56	*	0	0	0.4	4	0.40	80%	0.33	92%	-0.07	Increase	To slightly less steeply increasing
MW-57	0	0.8	-0.2	-0.5	15	-0.26	< 80%	-0.20	94%	0.06	Increase	From SI decreasing to slightly less steeply decreasing
MW-58	*	1.3	-0.6	-4.0	13	-0.50	< 80%	0	25%	0.50	Same	From SI decreasing to SI flat
MW-59	0	0	*	*	15	0	< 80%	0	59%	0	Same	No change

Summary of Differences at Onsite Wells ***(except MW-18 which has not been sampled since May 1996)***

Minimum and Maximum

17% of stations (3 wells) exhibited a new minimum (1.2 to 13.1 ppm lower).
22% of stations (4 wells) exhibited new maximums (0.8 to 31.0 ppm higher).

Mean

61% of stations (11 wells) exhibited lower means (0.2 to 5.9 ppm lower)
22% of stations (4 wells) exhibited higher mean values (0.3 to 1.8 ppm higher).

Median

33% of stations (6 wells) exhibited lower median values (0.3 to 5.5 ppm lower).
17% of stations (3 wells) exhibited no change in median value
50% of stations (9 wells) exhibited an increase in median values (0.1 to 0.7 ppm higher)

Trend Slope

22% of stations (4 wells) exhibited improving trends
33% of stations (6 wells) exhibited worsening trends
50% of stations (8 wells) exhibited essentially no change in trend (less than 0.03 ppm/yr)

Trend Confidence Level

50% of stations (9 wells) exhibited the same confidence level
39% of stations (7 wells) exhibited a higher confidence level
11% of stations (2 wells) exhibited a lower confidence level

Site-Wide Average Trend Slope

Decreased from -0.30 ppm/yr to -0.44 ppm/yr

E:\LUB\LandApp\2006 Trend Analysis\[All Trends.xls]Simplot Plant Comparison

Notes:
* = A more robust method of dealing with censored values when estimating summary statistics and calculating trends was used in the second trend analysis.
Values marked with an asterisk (*) reflect differences in the statistical methods rather than an actual changes in nitrate concentrations.

Table 4-3
Summary of Nitrate Trend Analyses - Simplot Terrace Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	Data Set Statistics								Trend Analysis Results		Trend Direction	LOWESS Pattern
	Starting Date	Ending Date	Min	Max	Mean	Median	n	% BDL	Slope (ppm/yr)	C.L.		
MW-14	Nov-88	Aug-05	9.0	45.3	27.7	28.4	67	0%	1.80	99%	Increasing	Increasing
MW-15	*Nov-88*	*Feb-98*	*6.2*	*17.3*	*10.4*	*10.0*	*35*	*0%*	*0.73*	*99%*	*Increasing*	*Increasing with some fluctuation*
MW-22	Nov-88	Nov-05	10.3	34.1	24.9	26.2	67	0%	0.96	99%	Increasing	Increasing then level
MW-38	May-92	Aug-05	2.3	21.1	12.3	12.2	53	0%	0.97	99%	Increasing	Increasing with some fluctuation
MW-39	May-92	Aug-05	9.2	37.2	18.5	15.4	54	0%	-0.11	41%	No Significant Trend	Increase then decrease
MW-40	May-92	Nov-05	1.2	34.2	18.4	16.4	55	0%	1.70	99%	Increasing	Increasing
MW-51	Feb-96	Aug-05	9.0	22.9	17.5	19.0	39	0%	0.71	99%	Increasing	Increase then level off
MW-52	Feb-96	Nov-05	10.7	35.2	25.2	26.0	40	0%	0.41	50%	No Significant Trend	Increase then decrease
MW-53	Feb-96	Nov-05	20.8	72.3	54.6	58.1	40	0%	-2.07	99%	Decreasing	Increase then decrease
MW-54	Feb-96	Nov-05	14.7	24.8	19.7	20.0	40	0%	0.62	99%	Increasing	Increasing

# of Increasing Trends ==>	7
# of Decreasing Trends ==>	1
# of Flat Trends ==>	0
# of Statistically Insignificant Trends ==>	2
Average slope of significant trends (ppm/yr) ==>	0.68
Average slope of all trends (ppm/yr) ==>	0.57

Notes:
Min = minimum, Max = maximum, n = number of samples
BDL = below detection limit, C.L. = confidence level
For these calculations, values reported as BDL and those reported as equal to or less than one-half the highest detection limit were counted as BDL.

E:\LUB\LandApp\2006 Trend Analysis\[All Trends.xls]Simplot Terrace thru 2005

Table 4-4
Comparison of Nitrate Data and Trends Between Analyses - Simplot Terrace Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	Change in Data Set Statistics					First Trend Analysis Results		Second Trend Analysis Results		Change in Trend		Change in Calculated Trend
	Min	Max	Mean	Median	n	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	
MW-14	0	6.4	3.4	5	15	1.80	99%	1.80	99%	0	No change	No change
MW-15	*0*	*0*	*0*	*0*	*0*	*0.73*	*99%*	*0.73*	*99%*	*0*	No change	*No additional data to evaluate*
MW-22	0	1.7	1.7	4.1	16	1.38	99%	0.96	99%	-0.4	No change	From increasing to less steeply increasing
MW-38	0	2.4	2	0.7	15	0.95	99%	0.97	99%	0.03	No change	Essentially no change in increasing trend
MW-39	-3.3	0	-2.3	-2.9	15	1.80	99%	-0.11	41%	-1.91	Decrease	From increasing to SI decreasing
MW-40	-6.7	10.4	3.3	1.5	16	1.37	99%	1.70	99%	0.33	No change	From increasing to steeper increasing trend
MW-51	0	2.8	0.7	0	15	1.68	99%	0.71	99%	-0.96	No change	From increasing to less steeply increasing
MW-52	0	3.0	1.0	-0.2	16	2.25	95%	0.41	50%	-1.84	Decrease	From increasing to SI less steeply increasing trend
MW-53	0	0	-5.7	-5.2	16	0.95	< 80%	-2.07	99%	-3.02	Increase	From SI increasing trend to decreasing trend
MW-54	0	3.2	1.2	0.6	16	1.04	99%	0.62	99%	-0.42	No change	From increasing to less steeply increasing

Summary of Differences ***(except MW-15 which has not been sampled since February 1998)***

Minimum and Maximum

22% of stations (2 wells) exhibited a new minimum (3.3 to 6.7 ppm lower).
78% of stations (7 wells) exhibited new maximums (1.7 to 10.4 ppm higher).

Mean

22% of stations (2 wells) exhibited lower means (2.3 to 5.7 ppm lower)
78% of stations (7 wells) exhibited higher mean values (0.7 to 3.4 ppm higher).

Median

33% of stations (3 wells) exhibited lower median values (0.2 to 5.2 ppm lower).
11% of stations (1 well) exhibited no change in median value
56% of stations (5 wells) exhibited higher median values (0.6 to 5 ppm higher).

Trend Slope

67% of stations (6 wells) exhibited improving trends
11% of stations (1 well) exhibited a worsening trend
22% of stations (2 wells) exhibited essentially no change (less than 0.03 ppm/yr)

Trend Confidence Level

67% of stations (6 wells) exhibited the same confidence level
11% of stations (1 well) exhibited a higher confidence level
22% of stations (2 wells) exhibited a lower confidence level

Site-Wide Average Trend Slope

Decreased from 1.39 ppm/yr to 0.57 ppm/yr

E:\LUB\LandApp\2006 Trend Analysis\[All Trends.xls]Simpot Terrace Comparison

Table 4-5
Summary of Nitrate Trend Analyses - Simplot Expansion Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	Data Set Statistics								Trend Analysis Results		Trend Direction	LOWESS Pattern
	Starting Date	Ending Date	Min	Max	Mean	Median	n	% BDL	Slope (ppm/yr)	C.L.		
MW-23	May-90	Nov-05	4.8	13.2	9.2	9.0	60	0%	0.15	99%	Increasing	Increase then slight decrease
MW-24	May-90	Aug-05	3.8	12.3	7.7	7.5	53	0%	0.20	98%	Increasing	Increase then slight decrease
MW-25	May-90	Aug-05	3.5	13.8	7.7	7.5	56	0%	0.25	99%	Increasing	Increase then slight decrease
MW-26	May-90	Aug-05	2.4	17.8	9.6	9.6	48	0%	0.51	99%	Increasing	Increase then slight decrease
MW-27	May-90	Aug-05	2.6	13.4	7.3	7.3	48	0%	0.41	99%	Increasing	Increase then start to level off
MW-28	May-90	Aug-05	2.1	22.1	11.5	11.5	59	0%	0.56	99%	Increasing	Increase then decrease
MW-29	May-90	Nov-05	1.7	11.7	6.8	6.9	62	0%	0.30	99%	Increasing	Increase then slight decrease
MW-30	May-90	Aug-05	0.1	26.5	8.3	8.4	57	2%	0.55	99%	Increasing	Increasing with some fluctuation
MW-31	May-91	Nov-05	<1.0	20.0	9.8	9.7	59	2%	0.10	80%	Increasing	Increase then decrease
MW-32	May-91	Nov-05	4.2	11.8	7.8	7.8	59	0%	0.15	99%	Increasing	Increase then slight decrease
MW-33	May-91	Nov-05	3.6	13.1	8.0	8.4	58	0%	0.30	99%	Increasing	Increase then slight decrease
MW-34	May-91	Aug-05	4.0	24.5	7.9	6.9	58	0%	0.05	58%	No Significant Trend	Slight increase then slight decrease
MW-35	May-91	Nov-05	2.0	20.7	7.7	7.5	59	0%	0.05	54%	No Significant Trend	Increase then decrease
MW-36	May-91	Nov-05	2.7	8.8	6.0	6.7	59	0%	0.29	99%	Increasing	Increase then decrease
MW-37	May-91	Aug-05	<2.0	37.2	9.3	7.3	56	2%	0.66	99%	Increasing	Increase then decrease
MW-41	May-92	Nov-05	1.5	24.8	10.0	9.0	55	0%	1.04	99%	Increasing	Increase then decrease
MW-42	May-92	Nov-05	<2.0	15.3	9.9	9.5	52	2%	0.44	99%	Increasing	Level then increasing
MW-43	May-92	Nov-05	2.1	11.4	6.2	6.6	54	0%	0.54	99%	Increasing	Increasing with some fluctuation
MW-44	May-92	Nov-05	1.6	26.6	6.6	6.1	55	0%	0.24	99%	Increasing	Increase then start to level off
MW-55	*Feb-96*	*Nov-05*	*<1.0*	*19.8*	*17.2*	*17.7*	*39*	*3%*	*0.22*	*93%*	*Increasing*	*Increase, decrease, then increase*

# of Increasing Trends ==>	18
# of Decreasing Trends ==>	0
# of Flat Trends ==>	0
# of Statistically Insignificant Trends ==>	2
Average slope of significant trends (ppm/yr) ==>	0.38
Average slope of all trends (ppm/yr) ==>	0.35

Notes:

Min = minimum, Max = maximum, n = number of samples

BDL = below detection limit, C.L. = confidence level

For these calculations, values reported as BDL and those reported as equal to or less than one-half the highest detection limit were counted as BDL.

E:\LUB\LandApp\2006 Trend Analysis\[All Trends.xls]Simplot Expansion thru 2005

Table 4-6
Comparison of Nitrate Data and Trends Between Analyses - Simplot Expansion Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	Change in Data Set Statistics					First Trend Analysis Results		Second Trend Analysis Results		Change in Trend		Change in Calculated Trend
	Min *	Max	Mean	Median	n	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	
MW-23	0	0	0	0.1	15	0.25	99%	0.15	99%	-0.10	Same	From increasing to less steeply increasing trend
MW-24	0	0	0	0.1	10	0.40	99%	0.20	98%	-0.20	Decrease	From increasing to less steeply increasing trend
MW-25	0	0	0.1	0.1	12	0.43	99%	0.25	99%	-0.18	Same	From increasing to less steeply increasing trend
MW-26	0	0	0	0.2	9	0.94	99%	0.51	99%	-0.43	Same	From increasing to less steeply increasing trend
MW-27	0	0	0	0.3	10	0.48	99%	0.41	99%	-0.07	Same	From increasing to less steeply increasing trend
MW-28	0	0	0	0	14	1.16	99%	0.56	99%	-0.60	Same	From increasing to less steeply increasing trend
MW-29	0	0.7	0	0.4	16	0.47	99%	0.30	99%	-0.17	Same	From increasing to less steeply increasing trend
MW-30	-0.9	0	0.7	1.1	14	0.67	99%	0.55	99%	-0.12	Same	From increasing to less steeply increasing trend
MW-31	>-3.2	0	0	-0.6	16	0.58	99%	0.10	80%	-0.48	Decrease	From increasing to less steeply increasing trend
MW-32	0	0	0	0.2	16	0.35	99%	0.15	99%	-0.20	Same	From increasing to less steeply increasing trend
MW-33	0	0.3	0	0.4	16	0.53	99%	0.30	99%	-0.23	Same	From increasing to less steeply increasing trend
MW-34	0	0	0	-0.3	15	0.25	99%	0.05	58%	-0.20	Decrease	From increasing to SI less steeply increasing trend
MW-35	0	0	-0.3	-0.3	16	0.46	99%	0.05	54%	-0.41	Decrease	From increasing to less steeply increasing trend
MW-36	0	0	0.2	-0.2	16	0.56	99%	0.29	99%	-0.27	Same	From increasing to less steeply increasing trend
MW-37	*	0	0.9	1.6	15	1.08	99%	0.66	99%	-0.42	Same	From increasing to less steeply increasing trend
MW-41	0	0	1.3	5.1	16	2.02	99%	1.04	99%	-0.98	Same	From increasing to less steeply increasing trend
MW-42	*	4.0	1.3	1.2	16	0.07	< 80%	0.44	99%	0.38	Increase	From SI increasing to steeper increasing trend
MW-43	0	2.0	0.8	0.9	16	0.75	99%	0.54	99%	-0.21	Same	From increasing to less steeply increasing trend
MW-44	0	9.5	0.6	0.4	16	0.40	99%	0.24	99%	-0.16	Same	From increasing to less steeply increasing trend
MW-55	>-11.1	0	0.2	0.3	16	0.80	95%	0.22	93%	-0.58	Decrease	From increasing to less steeply increasing trend

Summary of Differences

Minimum and Maximum
15% of stations (3 wells) exhibited a new minimum (0.9 to >11.1 ppm lower).
25% of stations (5 wells) exhibited new maximums (0.3 to 9.5 ppm higher).

Mean
5% of stations (1 well) exhibited a lower mean (0.3 ppm lower)
45% of stations (9 wells) exhibited higher mean values (0.1 to 1.3 ppm higher).

Median
20% of stations (4 wells) exhibited lower median values (0.2 to 0.6 ppm lower).
75% of stations (15 wells) exhibited an increase in median values (0.1 to 5.1 ppm higher).

Trend Slope
95% of stations (19 wells) exhibited improving trends
5% of stations (1 well) exhibited a worsening trend

Trend Confidence Level
70% of stations (14 wells) exhibited the same confidence level
5% of stations (1 well) exhibited a higher confidence level
25% of stations (5 wells) exhibited a lower confidence level

Site-Wide Average Trend Slope
Decreased from 0.63 ppm/yr to 0.35 ppm/yr

E:\LUB\LandApp\2006 Trend Analysis\[All Trends.xls]Simplot Expansion Comparison

Notes:
* = A more robust method of dealing with censored values when estimating summary statistics and calculating trends was used in the second trend analysis.
Values marked with an asterisk (*) reflect differences in the statistical methods rather than an actual changes in nitrate concentrations.

Table 4-7
Summary of Nitrate Trend Analyses - Simplot Levy Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	Data Set Statistics								Trend Analysis Results		Trend Direction	LOWESS Pattern
	Starting Date	Ending Date	Min	Max	Mean	Median	n	% BDL	Slope (ppm/yr)	C.L.		
HL-3	May-02	Nov-05	7.8	25.6	12.4	9.3	15	0%	0.40	54%	No Significant Trend	Increase then decrease
HL-4	May-02	Nov-05	4.1	11.1	6.4	4.1	15	0%	1.13	99%	Increasing	Increasing
HL-5	Nov-02	Nov-05	6.6	47.7	36.7	36.1	15	0%	4.90	99%	Increasing	Level then increasing
L-6	Nov-02	Nov-05	1.1	2.8	2.0	1.9	15	0%	-0.35	0%	No Significant Trend	Decrease, increase, decrease
L-8	Aug-02	Nov-05	<1.0	1.3	0.9	0.9	15	64%	-0.20	70%	No Significant Trend	Basically flat
L-9	Aug-02	Nov-05	14.0	40.1	24.8	20.5	15	0%	2.07	73%	No Significant Trend	Increase then decrease
L-10	May-02	Nov-05	8.1	36.3	10.9	9.0	15	0%	0.33	86%	Increasing	Slight increase then decrease
L-11	May-02	Nov-05	12.8	21.9	18.1	17.8	15	0%	1.50	93%	Increasing	Decrease then increase
SP-1	Feb-03	Nov-05	7.5	33.8	17.7	17.4	11	0%	-0.25	50%	No Significant Trend	Decrease then level

# of Increasing Trends ==>	4
# of Decreasing Trends ==>	0
# of Flat Trends ==>	0
# of Statistically Insignificant Trends ==>	5
Average slope of significant trends (ppm/yr) ==>	1.97
Average slope of all trends (ppm/yr) ==>	1.06

Notes:
Min = minimum, Max = maximum, n = number of samples
BDL = below detection limit, C.L. = confidence level
For these calculations, values reported as BDL and those reported as equal to or less than one-half the highest detection limit were counted as BDL.

E:\LUB\LandApp\2006 Trend Analysis\[All Trends.xls]Simplot Levy Site thru 2005

Table 5-1
Summary of Nitrate Trend Analyses - Hermiston Foods Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	Data Set Statistics								Trend Analysis Results		Trend Direction	LOWESS Pattern
	Starting Date	Ending Date	Min	Max	Mean	Median	n	% BDL	Slope (ppm/yr)	C.L.		
MW-1	Apr-91	Nov-05	7.3	13.0	10.2	10.0	53	0%	-0.12	98%	Decreasing	Decreasing, then decreasing less steeply
MW-2	Apr-91	Nov-05	0.8	16.6	7.9	7.6	50	0%	0.08	99%	Increasing	Increasing then decreasing
MW-3	Apr-91	Nov-05	2.4	9.2	3.9	3.9	53	0%	-0.09	99%	Decreasing	Slight increase, then decreasing
MW-4	Apr-91	Nov-05	0.6	8.1	6.1	6.2	53	0%	0.17	99%	Increasing	Increasing then increasing less steeply
MW-5	May-97	Nov-05	4.5	13.0	7.1	6.8	35	0%	-0.16	99%	Decreasing	Flat, then decreasing, then increasing
MW-6	May-97	Nov-05	7.5	14.5	10.5	9.9	35	0%	-0.38	99%	Decreasing	Flat, then decreasing, then leveling off
MW-7	Aug-04	Nov-05	4.9	5.5	5.3	5.4	6	0%	not enough data to calculate a trend			Increasing

# of Increasing Trends ==>	2
# of Decreasing Trends ==>	4
# of Flat Trends ==>	0
# of Statistically Insignificant Trends ==>	0
Average slope of significant trends (ppm/yr) ==>	-0.08
Average slope of all trends (ppm/yr) ==>	-0.08

Notes:

Min = minimum, Max = maximum, n = number of samples

BDL = below detection limit, C.L. = confidence level

E:\LUB\LandApp\2006 Trend Analysis\[All Trends.xls]HF thru 2005

Table 5-2
Comparison of Nitrate Data and Trends Between Analyses - Hermiston Foods Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	Change in Data Set Statistics					First Trend Analysis Results		Second Trend Analysis Results		Change in Trend		Change in Calculated Trend
	Min	Max	Mean	Median	n	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	
MW-1	0	0	-0.2	-0.3	17	-0.12	< 80%	-0.12	98%	0	Higher	No change
MW-2	0	0	0	0	16	0.29	99%	0.08	99%	-0.20	Same	From increasing to less steeply increasing
MW-3	0	0	-0.4	-0.2	17	-0.01	< 80%	-0.09	99%	-0.08	Higher	From SI decreasing to steeper decreasing
MW-4	0	0	0.3	0.3	17	0.29	99%	0.17	99%	-0.12	Same	From increasing to less steeply increasing
MW-5	0	0	-0.5	-0.5	17	-0.01	< 80%	-0.16	99%	-0.15	Higher	From SI decreasing to steeper decreasing
MW-6	0	0	-0.8	-1.7	17	0.12	< 80%	-0.38	99%	-0.50	Higher	From SI increasing to decreasing
MW-7	This well was not installed at the time of the first trend analysis											

Summary of Differences

Minimum and Maximum

No stations exhibited a new minimum or maximum concentration.

Mean

67% of stations (4 wells) exhibited lower means (0.2 to 0.8 ppm lower).
17% of stations (1 well) exhibited a higher mean value (0.3 ppm higher).
17% of stations (1 well) exhibited a no change in mean value.

Median

67% of stations (4 wells) exhibited lower median values (0.2 to 1.7 ppm lower).
17% of stations (1 well) exhibited no change in median value.
17% of stations (1 well) exhibited an increase in median value (0.3 ppm higher).

Trend Slope

83% of stations (5 wells) exhibited improving trends
17% of stations (1 well) no change in trend

Trend Confidence Level

33% of stations (2 wells) exhibited the same confidence level
67% of stations (4 wells) exhibited a higher confidence level

Site-Wide Average Trend Slope

Decreased from 0.09 ppm/yr to -0.08 ppm/yr

E:\LUB\LandApp\2006 Trend Analysis\[All Trends.xls]HF Comparison

Table 6-1
Summary of Nitrate Trend Analyses - MorStarch Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	Data Set Statistics									Trend Analysis Results		Trend Direction	LOWESS Pattern
	Starting Date	Ending Date	Min	Max	Mean	Median	Skewness	n	% BDL	Slope (ppm/yr)	C.L.		
MW-1S	Aug-89	Nov-05	<0.5	23.8	9.0	8.5	0.35	60	3%	0.62	99%	Increasing	Increasing then decreasing
MW-1D	*Aug-89*	*May-98*	*<0.5*	*6.5*	*2.3*	*2.0*	*1.55*	*31*	*3%*	*0.28*	*99%*	*Increasing*	*Increasing*
MW-2S	Aug-89	Nov-05	<0.048	4.5	0.9	0.6	2.52	61	8%	-0.01	66%	No Significant Trend	Increasing then decreasing
MW-3S	Aug-89	Nov-05	<0.2	5.5	1.3	1.1	2.69	61	2%	0.03	93%	Increasing	Increasing then decreasing
MW-3D	*Aug-89*	*May-98*	*<0.5*	*5.5*	*1.2*	*1.0*	*3.08*	*31*	*10%*	*0.07*	*98%*	*Increasing*	*Decreasing then increasing*
MW-4S	Aug-89	Nov-05	<0.5	10.0	3.6	3.5	0.95	61	3%	0.15	99%	Increasing	Increasing then increasing less steeply
MW-5S	Aug-89	Nov-05	<0.5	16.4	4.9	4.6	1.52	61	5%	0.21	99%	Increasing	Increasing then decreasing
MW-6S	Apr-94	Nov-05	2.11	6.8	3.9	3.8	0.76	47	0%	0.11	99%	Increasing	Increasing then decreasing
MW-E1S	Apr-94	Nov-05	2.20	12.8	5.5	5.6	1.01	47	0%	0.26	99%	Increasing	Increasing then leveling off
MW-E2S	Apr-94	Nov-05	0.30	8.4	4.3	3.6	0.41	47	0%	-0.12	92%	Decreasing	Increasing then decreasing

# of Increasing Trends ==>	8
# of Decreasing Trends ==>	1
# of Flat Trends ==>	0
# of Statistically Insignificant Trends ==>	1
Average slope of significant trends (ppm/yr) ==>	0.18
Average slope of all trends (ppm/yr) ==>	0.16

Notes:
Min = minimum, Max = maximum, n = number of samples
C.L. = confidence level
Sampling is no longer required at wells MW-1D and MW-3D

E:\LUB\LandApp\2006 Trend Analysis\[All Trends.xls]Staley thru 2005

Table 6-2
Comparison of Nitrate Data and Trends Between Analyses - MorStarch Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	Change in Data Set Statistics					First Trend Analysis Results		Second Trend Analysis Results		Change in Trend		Change in Calculated Trend
	Min	Max	Mean	Median	n	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	
MW-1S	0 *	0	0.2	0.8	12	1.41	99%	0.62	99%	-0.79	same	From increasing to less steeply increasing
MW-1D	*0 **	*0*	*0*	*-0.2 ****	*-2 ****	*0.28*	*99%*	*0.28*	*99%*	*0*	*same*	*no change*
MW-2S	0 *	0	-0.1	-0.1	14	0.06	99%	-0.01	66%	-0.07	decrease	From increasing to SI decreasing
MW-3S	0 *	0	-0.1	-0.1	14	0.10	99%	0.03	93%	-0.08	decrease	From increasing to less steeply increasing
MW-3D	*0 **	*0*	*0*	*0*	*2 ****	*0.03*	*80%*	*0.07*	*98%*	*0.03*	*increase*	*The apparent increase in slope is due to the addition of four previously unavailable samples to the data set.*
MW-4S	0 *	0	0.1	0.3	18	0.28	99%	0.15	99%	-0.13	same	From increasing to less steeply increasing
MW-5S	0 *	-3 **	-0.3	0.2	13	0.56	99%	0.21	99%	-0.35	same	From increasing to less steeply increasing
MW-6S	0	0	0	0.2	14	0.39	99%	0.11	99%	-0.28	same	From increasing to less steeply increasing
MW-E1S	0	4.8	0.6	0.8	14	0.44	99%	0.26	99%	-0.19	same	From increasing to less steeply increasing
MW-E2S	0	0	-0.5	-1.4	14	0.25	99%	-0.12	92%	-0.37	decrease	From increasing to decreasing

Summary of Differences ***(excluding MW-1D and MW-3D because no additional samples were collected since the first analysis)***

Minimum and Maximum
No wells exhibited new minimum concentrations.
12% of stations (1 well) exhibited a new maximum (4.8 ppm higher).

Mean
50% of stations (4 wells) exhibited lower means (0.1 to 0.5 ppm lower)
38% of stations (3 wells) exhibited higher mean values (0.1 to 0.6 ppm higher).
12% of stations (1 well) exhibited no change in mean concentration.

Median
38% of stations (3 wells) exhibited lower median values (0.1 to 1.4 ppm lower).
62% of stations (5 wells) exhibited an increase in median values (0.2 to 0.8 ppm higher).

Trend Slope
100% of stations (8 wells) exhibited improving trends

Trend Confidence Level
62% of stations (5 wells) exhibited the same confidence level
38% of stations (3 wells) exhibited lower confidence levels

Site-Wide Average Trend Slope
Decreased from 0.44 ppm/yr to 0.16 ppm/yr

E:\LUB\LandApp\2006 Trend Analysis\[All Trends.xls]Staley Comparison

* = A more robust method of dealing with censored values when estimating summary statistics and calculating trends was used in the second trend analysis.
The apparent difference in minimum values from MW-1s, MW-1d, MW2s, MW-3s, MW-3d, MW-4s, and MW-5s reflects the difference in the statistical methods rather than an acutal change in nitrate concentrations

** = The previous analysis indicated the maximum was 19.4 ppm which was a "resample" after the original 16.4 ppm result.
Because the 16.4 ppm result is closer to the middle of the quarter, the 19.4 ppm result should have been trimmed from the data set during the previous analysis.

*** = Two data points from MW-1D and MW-3D used in the first analysis were trimmed from the dataset for the second analysis because they were multiple data points within the same quarter.
For MW-3D, four data points that were not available during the first analysis are now available. The addition of four points and the elimination of 2 points results in a net gain of 2 points.
For MW-1D, the elimination of two data points caused the median value to be slightly lower.

Table 7-1
Summary of Nitrate Trend Analyses - Snack Alliance Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	Data Set Statistics								Trend Analysis Results		Trend Direction	LOWESS Pattern
	Starting Date	Ending Date	Min	Max	Mean	Median	n	% BDL	Slope (ppm/yr)	C.L.		
MW-1	Nov-94	Nov-05	0.7	11.1	4.1	3.8	45	0%	0.03	9%	No Significant Trend	Decrease, then increase, then level off
MW-2	Nov-94	Nov-05	1.3	16.3	10.0	10.0	45	0%	-0.16	85%	Decreasing	Increase then decrease
MW-3	Nov-94	Nov-05	4.2	20.0	9.7	9.8	45	0%	-0.42	99%	Decreasing	Increase then decrease
MW-4	Aug-99	Nov-05	6.0	128.2	17.8	11.1	26	0%	-1.14	97%	Decreasing	Decrease then decrease steeper

# of Increasing Trends ==>	0
# of Decreasing Trends ==>	3
# of Flat Trends ==>	0
# of Statistically Insignificant Trends ==>	1
Average slope of significant trends (ppm/yr) ==>	-0.57
Average slope of all trends (ppm/yr) ==>	-0.42

Notes:
Min = minimum, Max = maximum, n = number of samples
BDL = below detection limit, C.L. = confidence level
For these calculations, values reported as BDL and those reported as equal to or less than one-half the highest detection limit were counted as BDL.

E:\LUB\LandApp\2006 Trend Analysis\[All Trends.xls]Snakcorp thru 2005

Table 7-2
Comparison of Nitrate Data and Trends Between Analyses - Snack Alliance Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	Change in Data Set Statistics					First Trend Analysis Results		Second Trend Analysis Results		Change in Trend		Change in Calculated Trend
	Min	Max	Mean	Median	n	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	
MW-1	0	0	0.4	0.9	16	-0.28	<80%	0.03	<80%	0.31	same	From SI decreasing to SI increasing
MW-2	-5.45	0	-0.5	-0.7	16	0.01	<80%	-0.16	85%	-0.17	increase	From SI increasing to decreasing
MW-3	0	0	-0.6	-0.3	16	-0.64	95%	-0.42	99%	0.22	increase	From decreasing to less steeply decreasing
MW-4	-0.77	95	1.2	-6.3	16	-0.25	<80%	-1.14	97%	-0.89	increase	From SI decreasing to steeper decreasing

Summary of Differences

Minimum and Maximum
50% of stations (2 wells) exhibited new minimums (0.8 to 5.5 ppm lower).
25% of stations (1 well) exhibited a new maximum (95 ppm higher).

Mean
50% of stations (2 wells) exhibited lower means (0.5 to 0.6 ppm lower)
50% of stations (2 wells) exhibited higher mean values (0.4 to 1.2 ppm higher).

Median
75% of stations (3 wells) exhibited lower median values (0.3 to 6.3 ppm lower).
25% of stations (1 wells) exhibited an increase in median values (0.9 ppm higher).

Trend Slope
50% of stations (2 wells) exhibited improving trends
50% of stations (2 wells) exhibited worsening trends

Trend Confidence Level
75% of stations (3 wells) exhibited higher confidence levels
25% of stations (1 wells) exhibited the same confidence level

Site-Wide Average Trend Slope
Decreased from -0.29 ppm/yr to -0.42 ppm/yr

E:\LUB\LandApp\2006 Trend Analysis\[All Trends.xls]SnakCorp Comparison

Table 8-1
Summary of Trends and Average Concentrations by Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Site	*# of Wells*	*Increasing Trends*		*Decreasing Trends*		*Flat Trends*		*Statistically Insignificant Trends*		*Average slope of trends (ppm/yr)*		*Average of Average Nitrate Concentrations at Each Well (ppm)*	*2002 to 2005 Site-Wide Average Concentration (ppm)*
		#	*%*	*#*	*%*	*#*	*%*	*#*	*%*	*Stat. Sig.*	*All*		
Port of Morrow (Farm 1)	14	9	64%	3	21%	0	0%	2	14%	0.61	0.52	22.3	26.1
Port of Morrow (Farm 2)	9	7	78%	0	0%	0	0%	2	22%	1.40	1.10	34.5	36.1
Port of Morrow (Farm 3)	6	3	50%	2	33%	0	0%	1	17%	2.90	2.30	33.0	33.0
ConAgra (North Farm)	10	5	50%	2	20%	0	0%	3	30%	0.72	0.50	25.1	26.5
ConAgra (Madison Ranches)	10	7	70%	1	10%	0	0%	2	20%	0.28	0.21	5.4	5.4
Simplot (Plant Site)	19	4	21%	8	42%	0	0%	7	37%	-0.67	-0.40	8.7	6.0
Simplot (Expansion Site)	20	18	90%	0	0%	0	0%	2	10%	0.38	0.35	8.7	9.6
Simplot (Terrace Site)	10	7	70%	1	10%	0	0%	2	20%	0.68	0.57	22.9	26.7
Simplot (Levy Site)	9	4	44%	0	0%	0	0%	5	56%	1.97	1.06	14.4	14.4
Hermiston Foods	6	2	33%	4	67%	0	0%	0	0%	-0.08	-0.08	7.3	7.0
MorStarch Site	10	8	80%	1	10%	0	0%	1	10%	0.18	0.16	3.7	4.1
Snack Alliance	4	0	0%	3	75%	0	0%	1	25%	-0.57	-0.42	10.4	10.2
Totals by Well	***127***	***74***	***58%***	***25***	***20%***	0	0%	***28***	***22%***				

Steepest Decreasing Trend At A Well = *-3.17 ppm/yr*
Steepest Increasing Trend At A Well = *7.51 ppm/yr*

In addition to the 127 wells indicated above, four wells near the Simplot Plant site were also analyzed. Results indicated 1 increasing, 1 decreasing, and 2 statistically insignificant wells.
In addition to the 127 wells indicated above, two former ConAgra Madison Ranch wells (now considered offsite) were also analyzed. Results indicated 2 decreasing trends.
In addition to the 127 wells indicated above, one well at the Hermiston Foods site does not yet have enough data to evaluate a trend.

Table 8-2
Comparison of Results Between Analyses
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

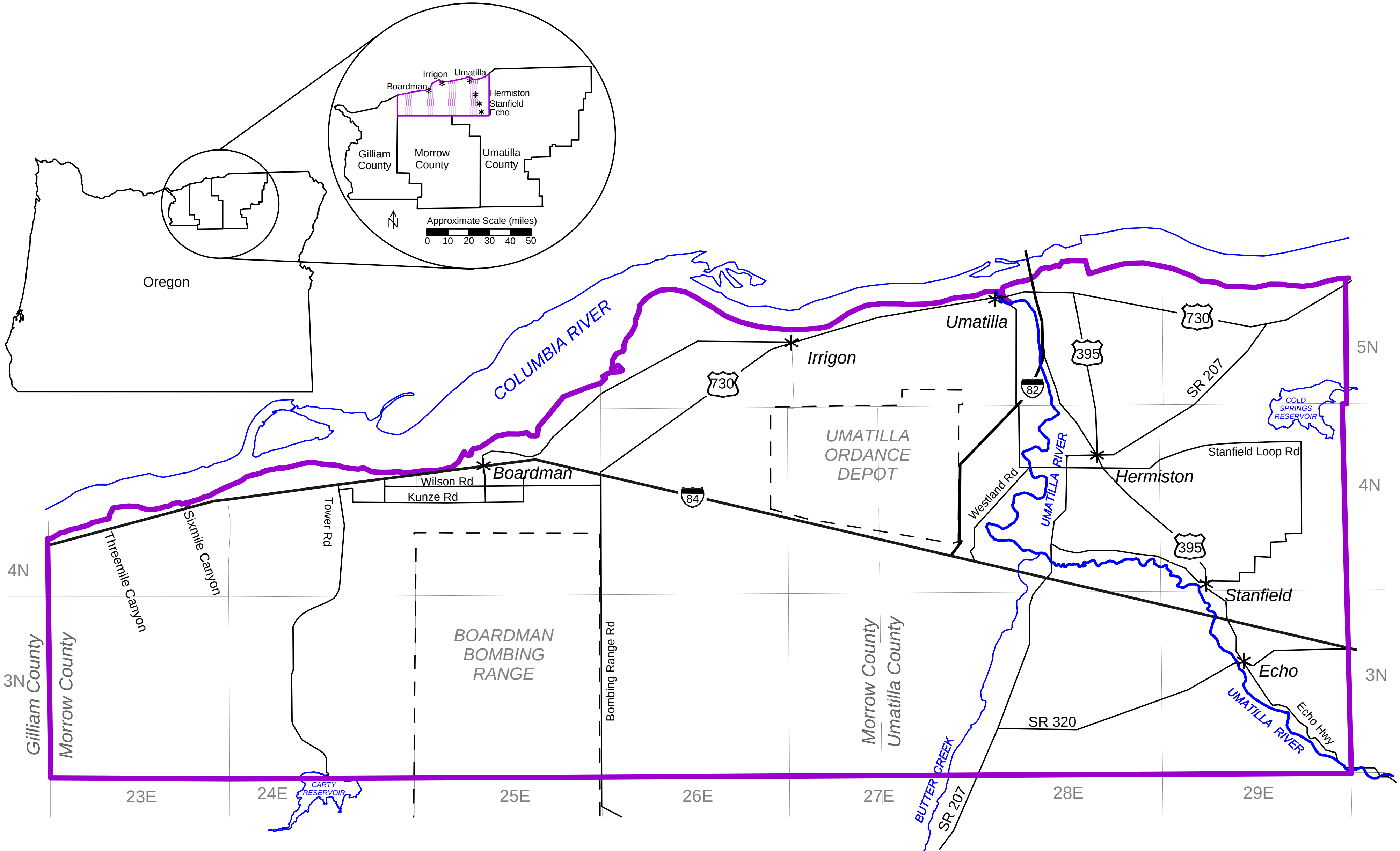
Site	*# of Increasing Trends*			*# of Decreasing Trends*			*# of Flat Trends*			*# of Statistically Insignificant Trends*			*Average trend slope (ppm/yr)*			*Average of average Nitrate Concentration at Each Well (ppm)*		
	thru 2001	*thru 2005*	*Change*	*thru 2001*	*thru 2005*	*Change*	*thru 2001*	*thru 2005*	*Change*	*thru 2001*	*thru 2005*	*Change*	*thru 2001*	*thru 2005*	*Change*	*thru 2001*	*thru 2005*	*Change*
Port of Morrow (Farm 1)	9	9	0	1	3	2	0	0	0	3	1	-2	1.33	0.61	-0.72	23.0	22.3	-0.7
Port of Morrow (Farm 2)	9	7	-2	0	0	0	0	0	0	0	2	2	2.51	1.40	-1.11	33.6	34.5	0.9
ConAgra (North Farm)	5	5	0	2	2	0	0	0	0	3	3	0	1.45	0.72	-0.73	24.2	25.1	0.9
ConAgra (Madison Ranches)	7	7	0	0	3	3	0	0	0	5	2	-3	0.47	0.14	-0.33	5.6	5.8	0.2
Simplot (Plant Site)	2	4	2	4	8	4	3	0	-3	10	7	-3	-0.60	-0.67	-0.07	9.5	8.7	-0.8
Simplot (Expansion Site)	19	18	-1	0	0	0	0	0	0	1	2	1	0.66	0.38	-0.28	8.4	8.7	0.3
Simplot (Terrace Site)	9	7	-2	0	1	1	0	0	0	1	2	1	1.44	0.68	-0.76	22.4	22.9	0.5
Hermiston Foods	2	2	0	0	4	4	0	0	0	4	0	-4	0.29	-0.08	-0.37	7.9	7.3	-0.6
MorStarch Site	10	8	-2	0	1	1	0	0	0	0	1	1	0.38	0.18	-0.20	3.7	3.7	0.0
Snack Alliance	0	0	0	1	3	2	0	0	0	3	1	-2	-0.64	-0.57	0.07	10.3	10.4	0.1
Totals by Well	***72***	***67***	***-5***	***8***	***25***	***17***	***3***	0	***-3***	***30***	***21***	-9						
Percentages by Well	***64%***	***59%***	***-4%***	***7%***	***22%***	***15%***	***3%***	0%	***-3%***	***27%***	***19%***	-8%						

Summary

Item	*Result of Analysis through 2005*	*Difference Between Analyses*
Number of Increasing and Decreasing Trends	67 increasing trends; 25 decreasing trends	4% fewer increasing trends; 15% more decreasing trends
Average Trend Slope at 10 Sites	Increasing at 7 sites; decreasing at 3 sites	Improved at 9 sites; worsened at 1 site
Average of average nitrate concentration at each well	Exceeded 7 ppm GWMA trigger level at 8 of 10 sites	Improved at 3 sites; worsened at 6 sites

Note: This comparison uses information from the 113 wells and 10 sites analyzed during both analyses.
Two ConAgra Madison Ranch site wells are now considered offsite wells but are included in this table for comparison consistency.
The two former ConAgra Madison Ranch site wells exhibited statistically insignificant trends during the first analysis and decreasing trends during the second analysis.

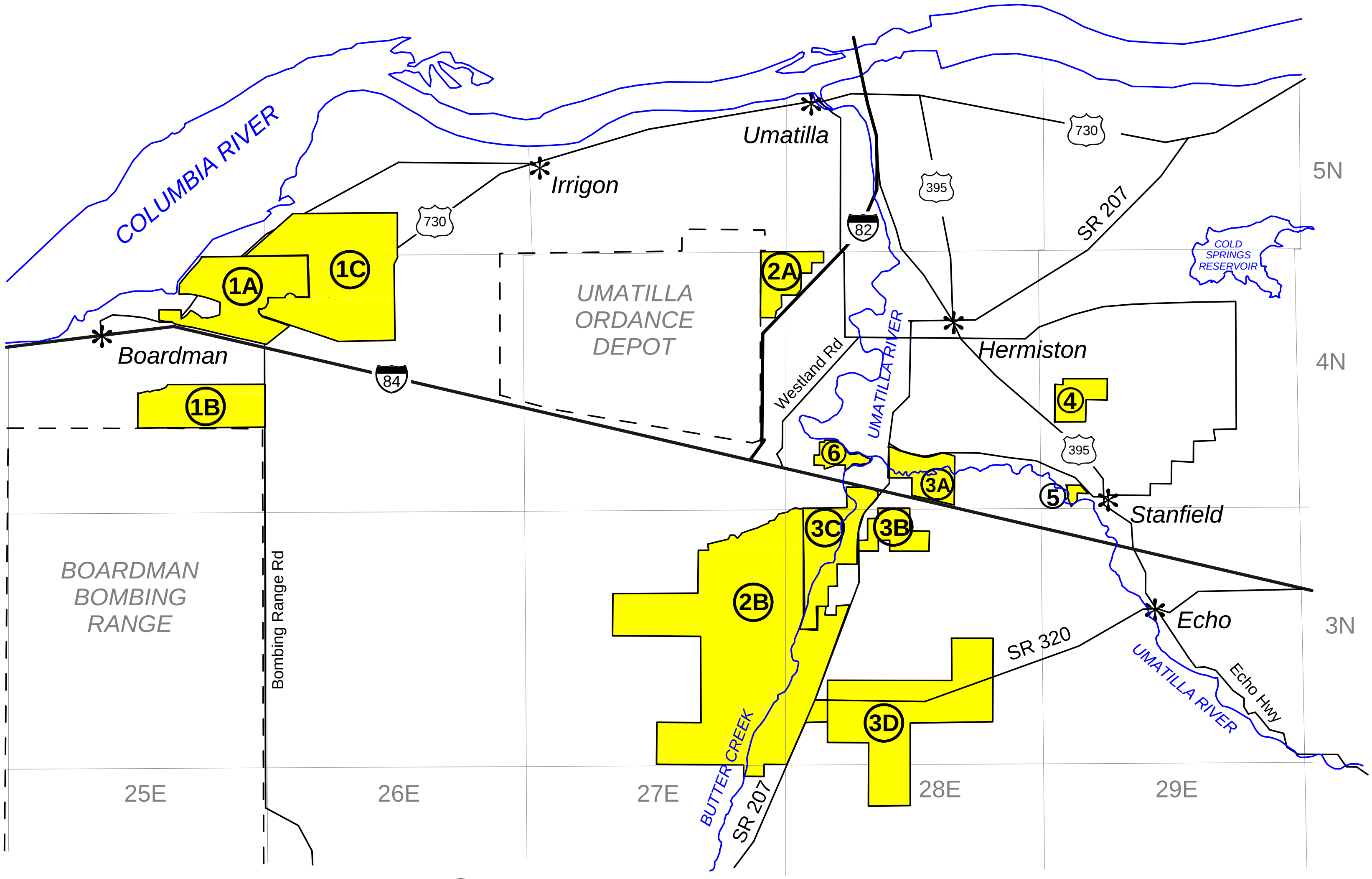
Figure 1-1
Location and Boundaries of Lower Umatilla Basin Groundwater Management Area
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



Lower Umatilla Basin Groundwater Management Area Boundaries

North: Columbia River
South: 2N/3N Township Boundary
East: 29E/30E Range Boundary
West: 22E/23E Range Boundary (also the Morrow / Gilliam County line)

Figure 1-2
Location of Food Processor Land Application Sites in the LUBGWMA
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



1A Port of Morrow Farm 1
1B Port of Morrow Farm 2
1C Port of Morrow Farm 3
2A ConAgra North Farm
2B ConAgra Madison Ranch
3A Simplot Plant Site
3B Simplot Terrace Site
3C Simplot Expansion Site
3D Simplot Levy Site
4 Hermiston Foods Site
5 MorStarch Site
6 Snack Alliance Site

Approximate Scale (miles)
0 1 2 3

Figure 2-1
Well Locations and Surface Water Bodies - Port of Morrow Farms
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

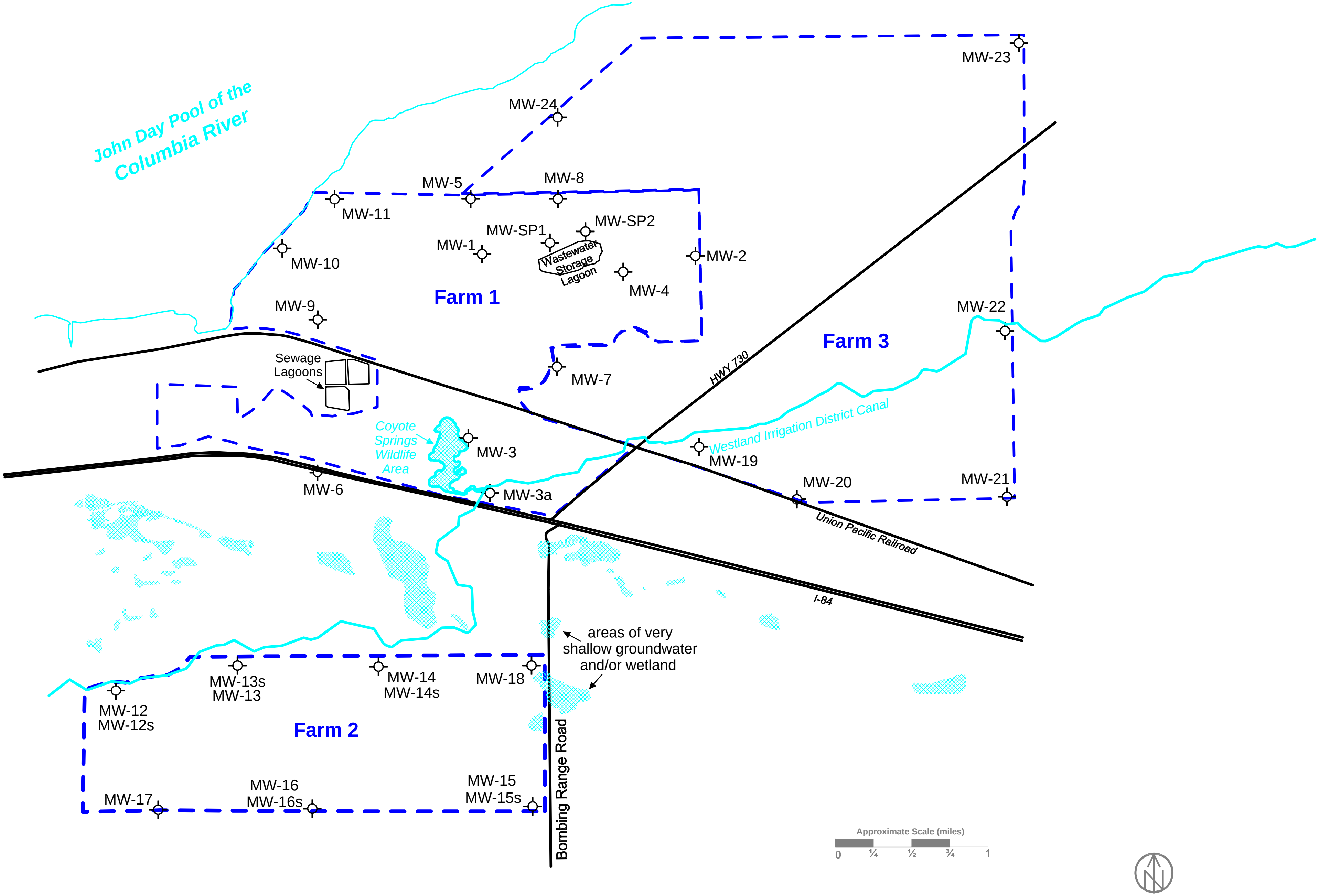
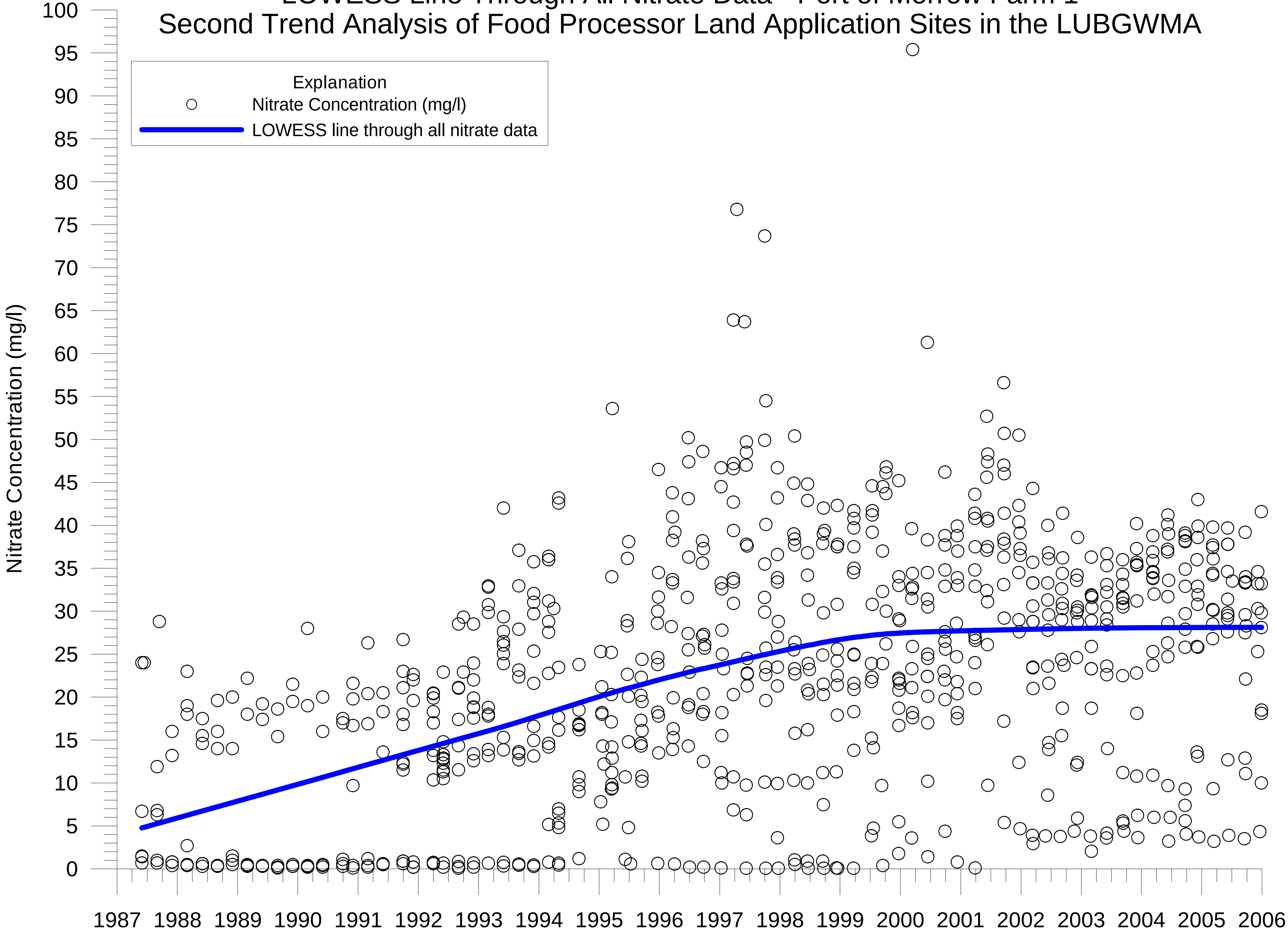
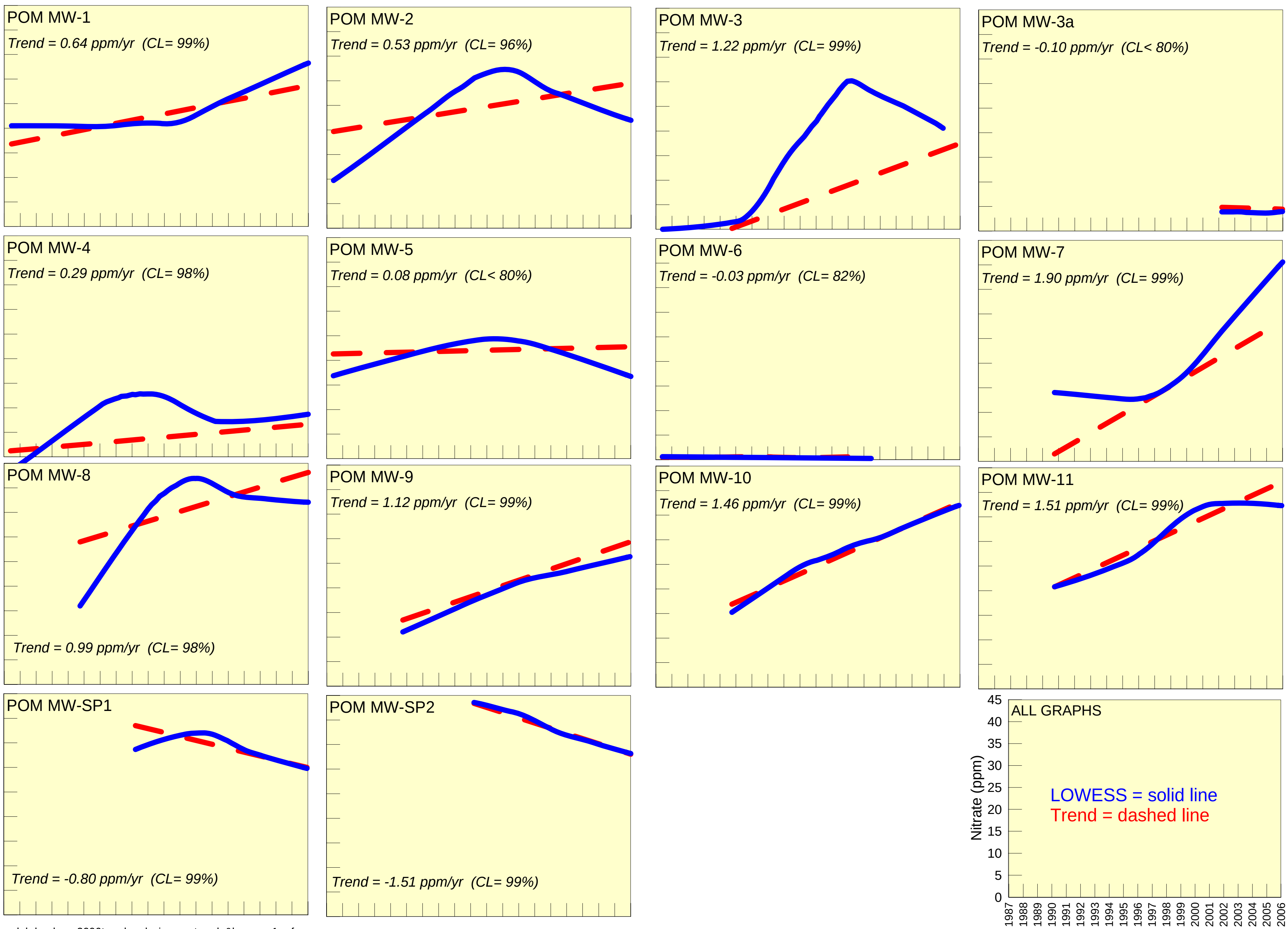


Figure 2-2
LOWESS Line Through All Nitrate Data - Port of Morrow Farm 1
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp 2006trendanalysis pom alldatafarm1.grf

Figure 2-3
LOWESS Lines and Trend Lines Through Nitrate Data - Port of Morrow Farm 1
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp 2006trendanalysis pom trends&lowess_1.grf

Figure 2-4
Nitrate Trends - Port of Morrow Farms
Second Trend Analysis of Food Processor Land Application Sites
in the LUBGWMA

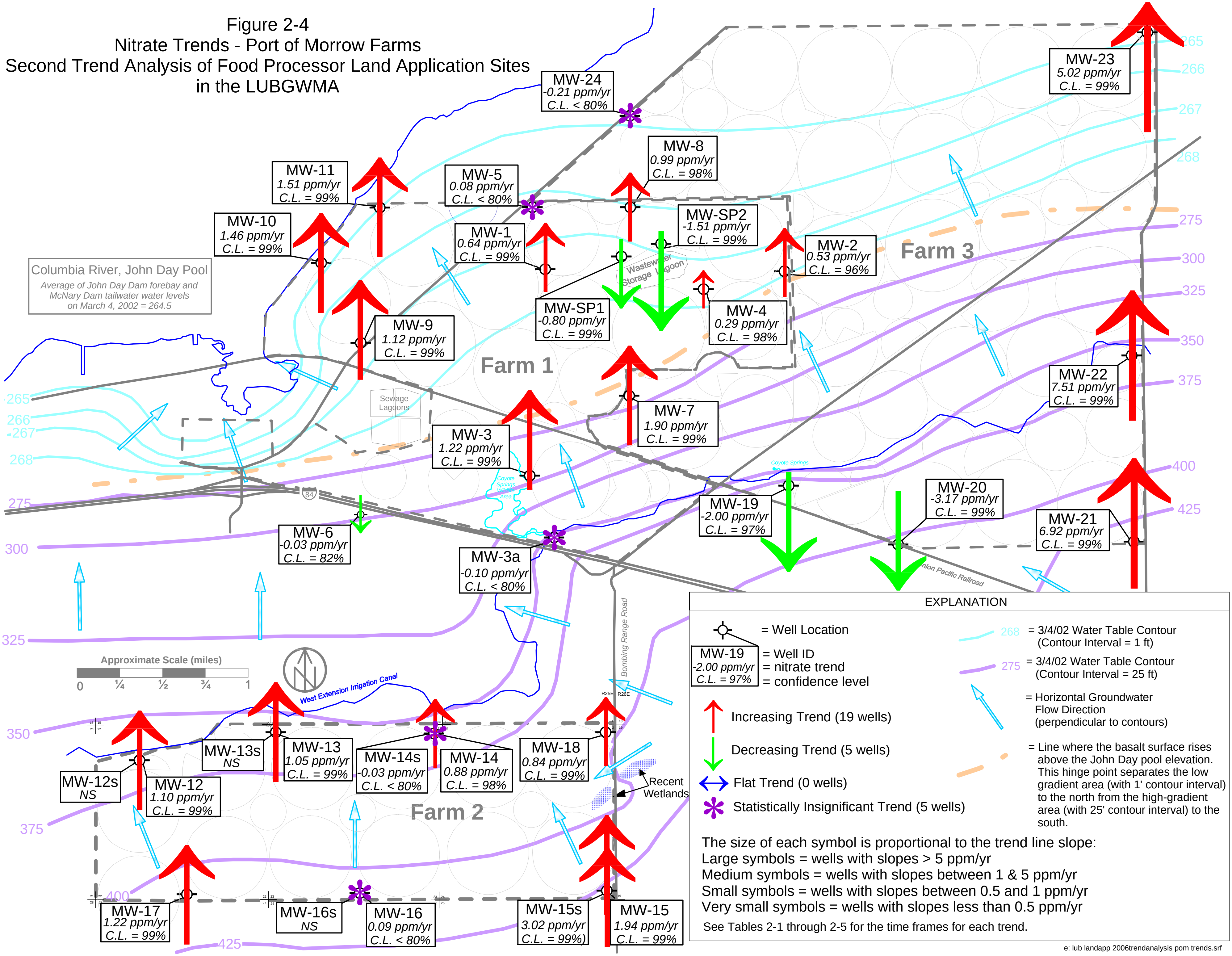


Figure 2-5
Average Nitrate Concentrations - Port of Morrow Farms
Second Trend Analysis of Food Processor Land Application Sites
in the LUBGWMA

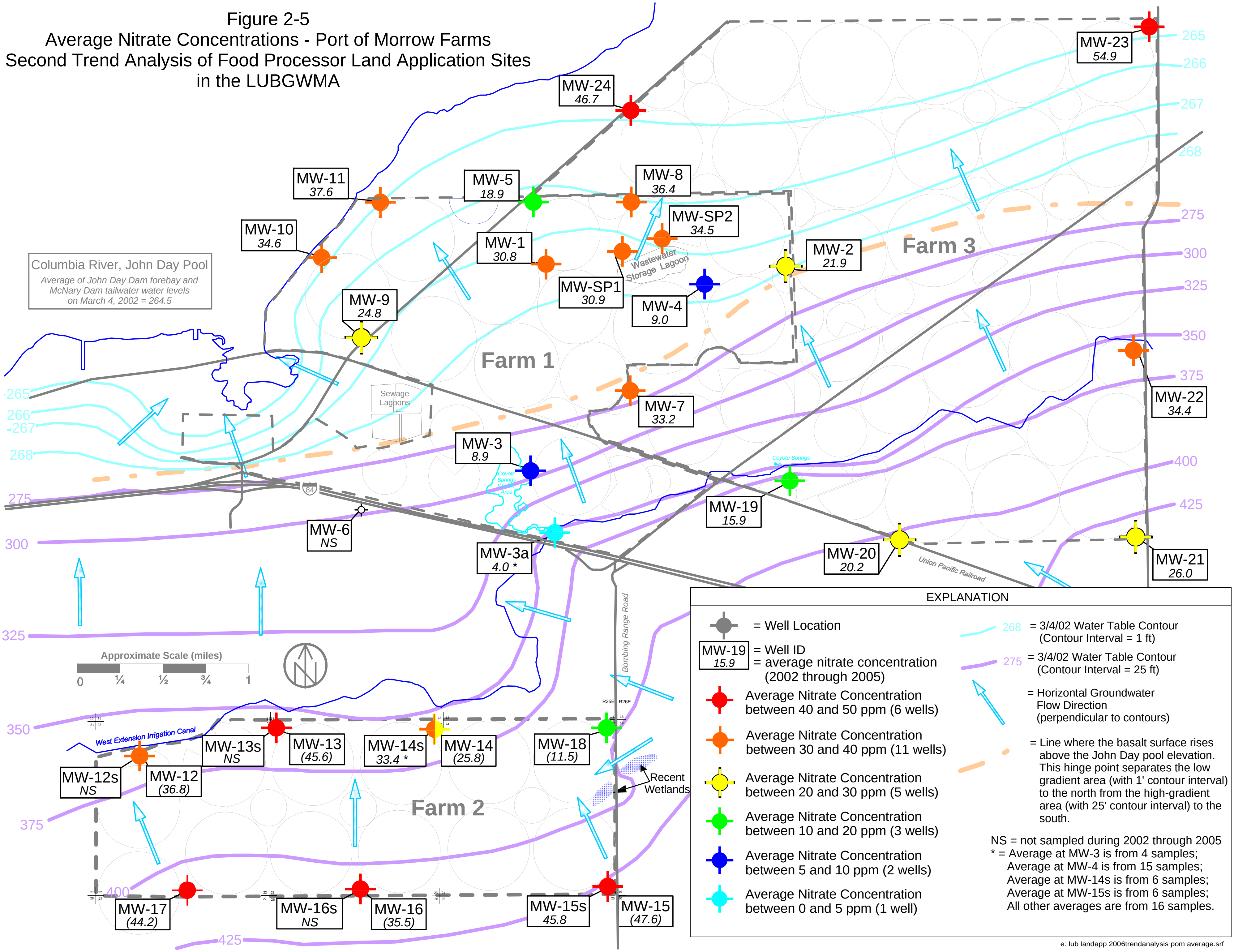
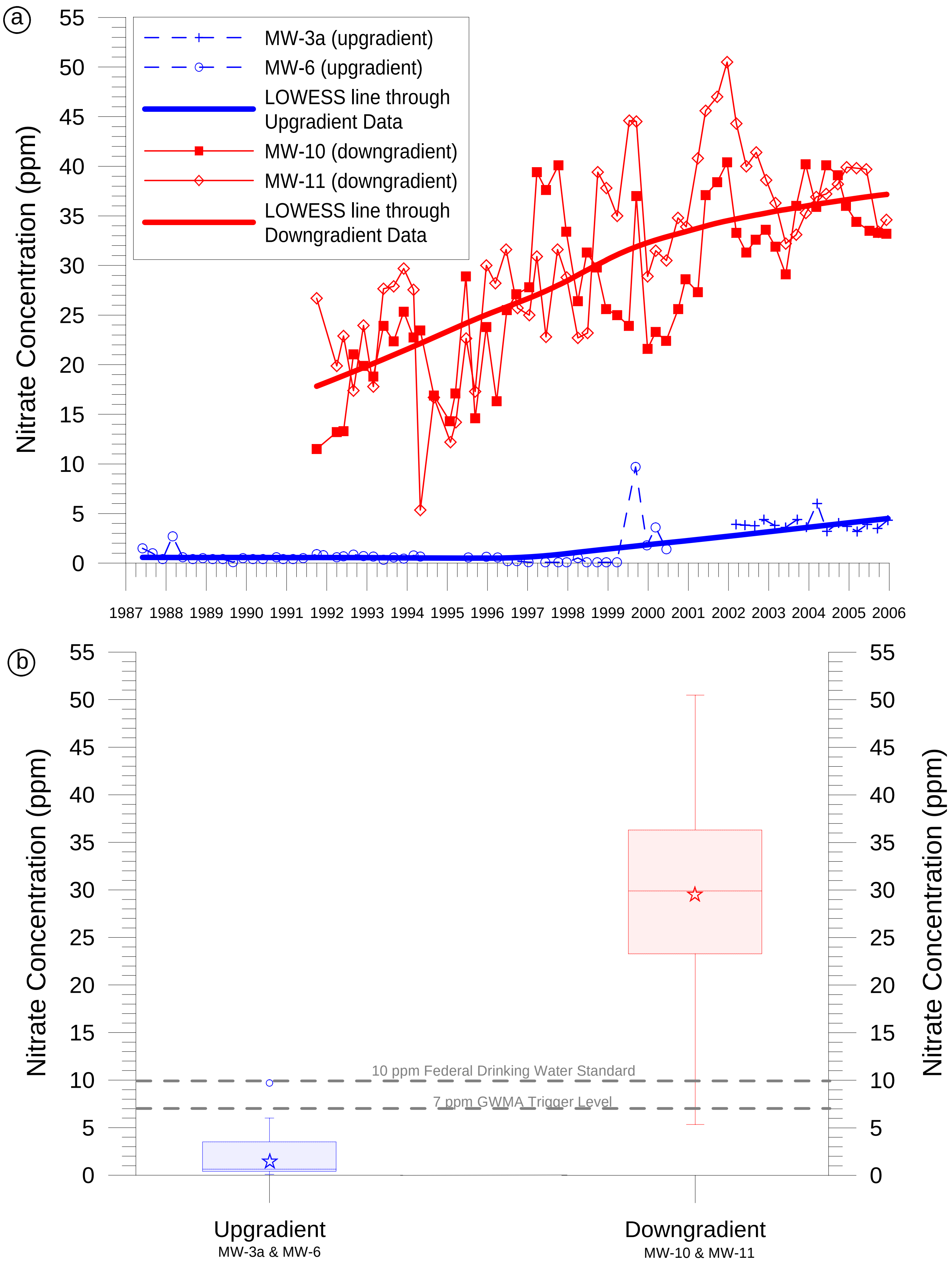
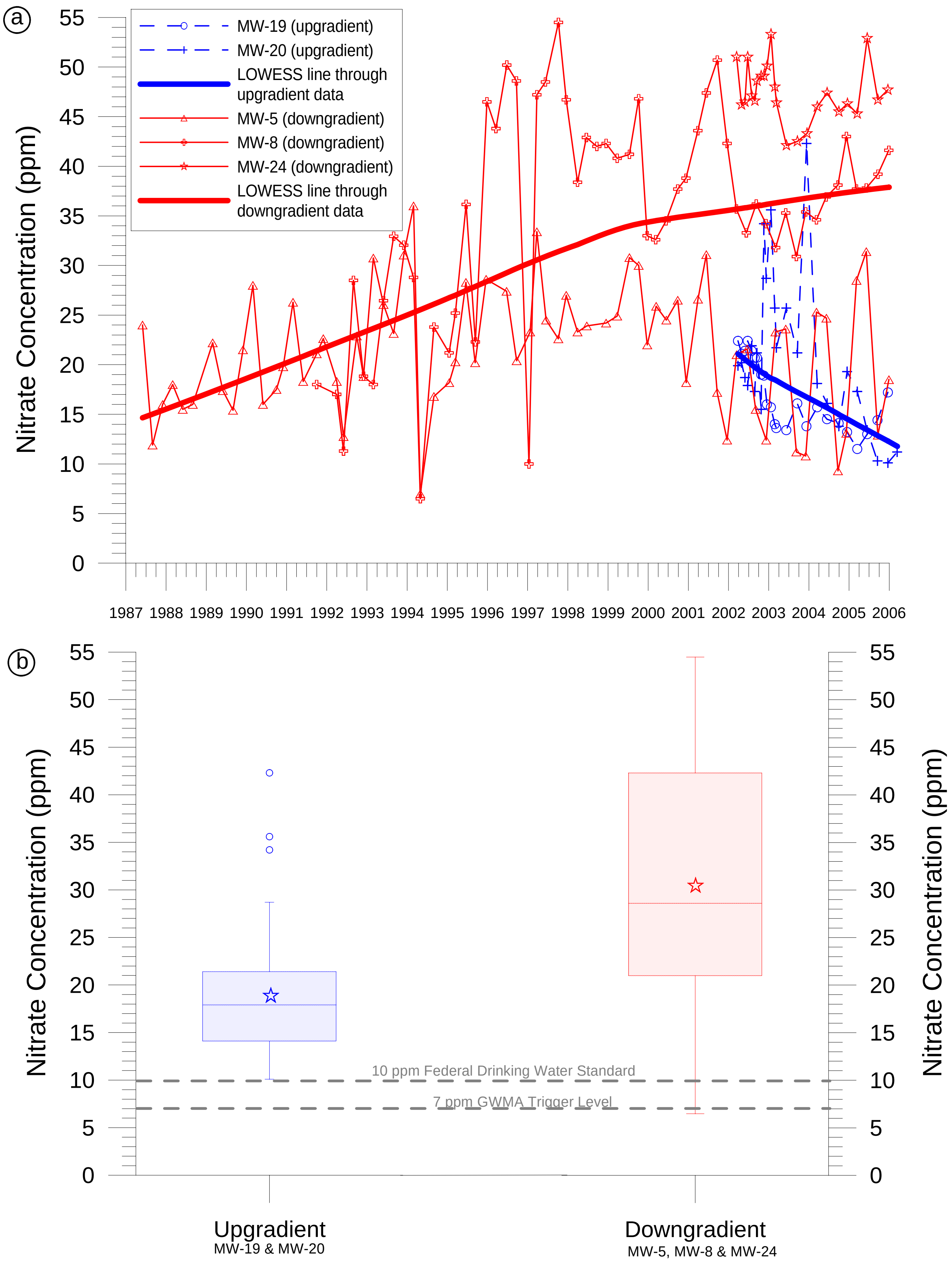


Figure 2-6
Upgradient vs. Downgradient Nitrate Comparisons
Western Portion of Port of Morrow Farm 1
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



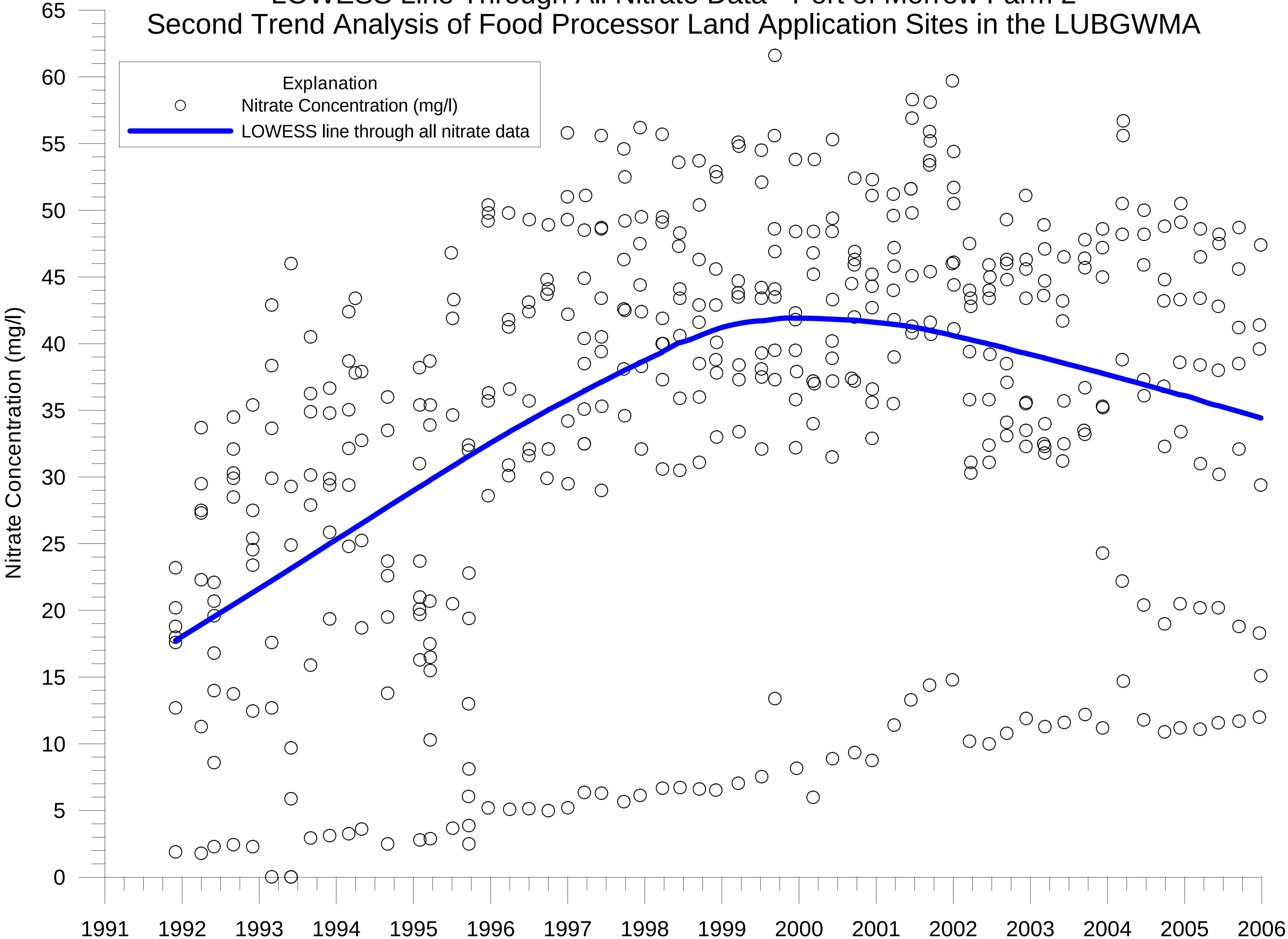
e: lub landapp 2006trendanalysis pom upvsdnFm1W.grf

Figure 2-7
Upgradient vs. Downgradient Nitrate Comparisons
Eastern Portion of Port of Morrow Farm 1 & Western Portion of Farm 3
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



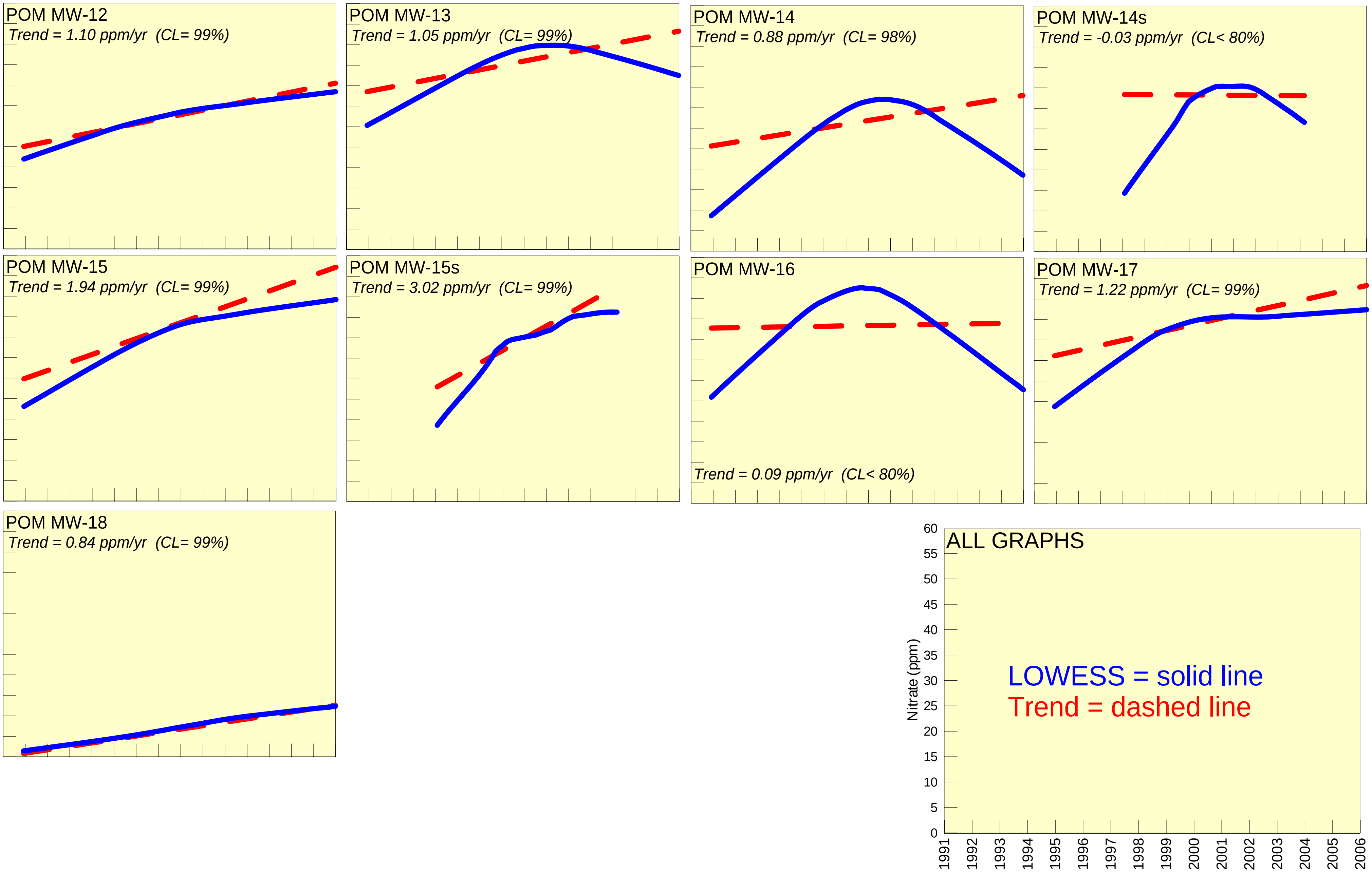
e: lub landapp 2006trendanalysis pom up vs dn Fm1 E & Fm 3 W.grf

Figure 2-8
LOWESS Line Through All Nitrate Data - Port of Morrow Farm 2
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



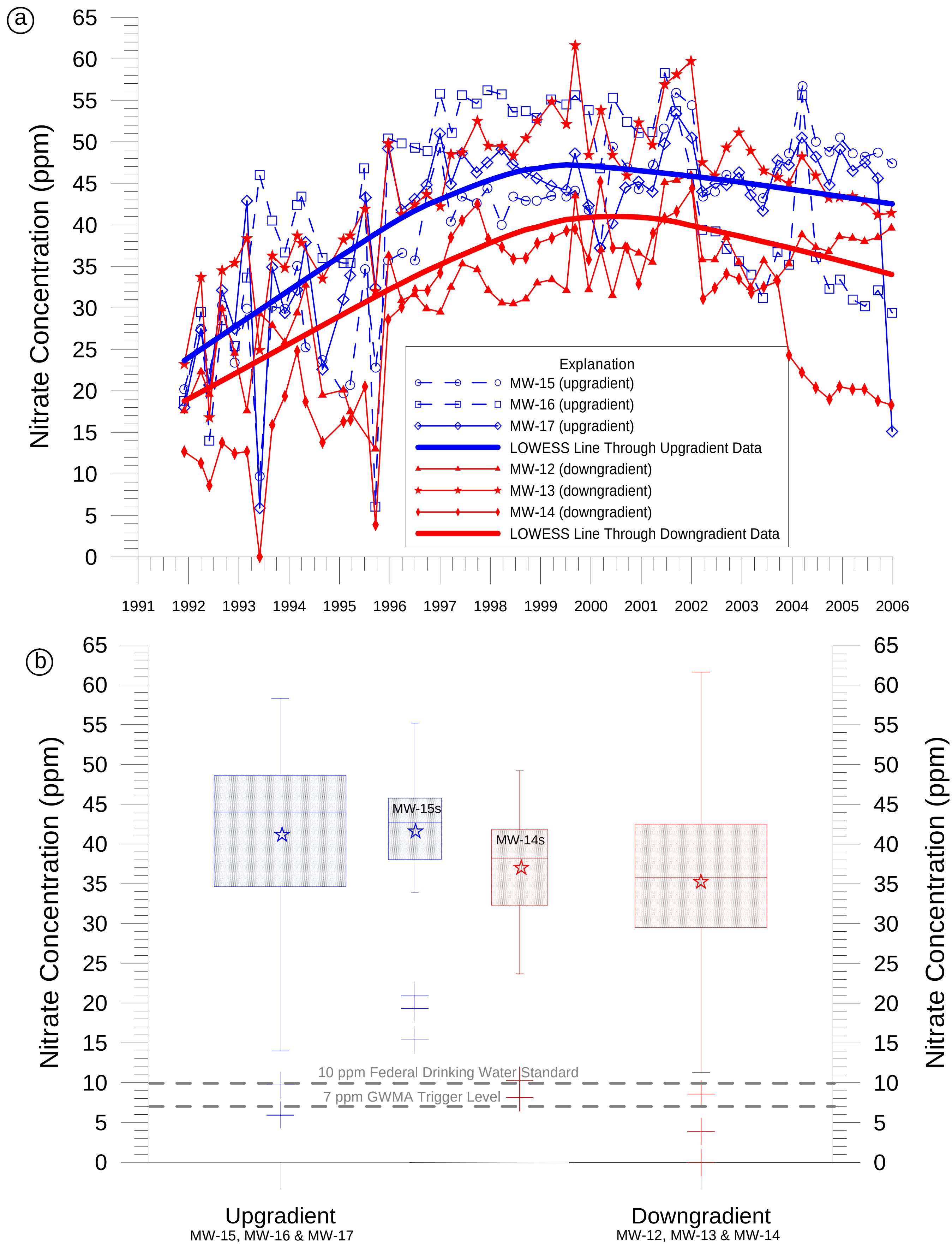
e: lub landapp 2006trendanalysis pom alldatafarm2.grf

Figure 2-9
LOWESS Lines and Trend Lines Through Nitrate Data - Port of Morrow Farm 2
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



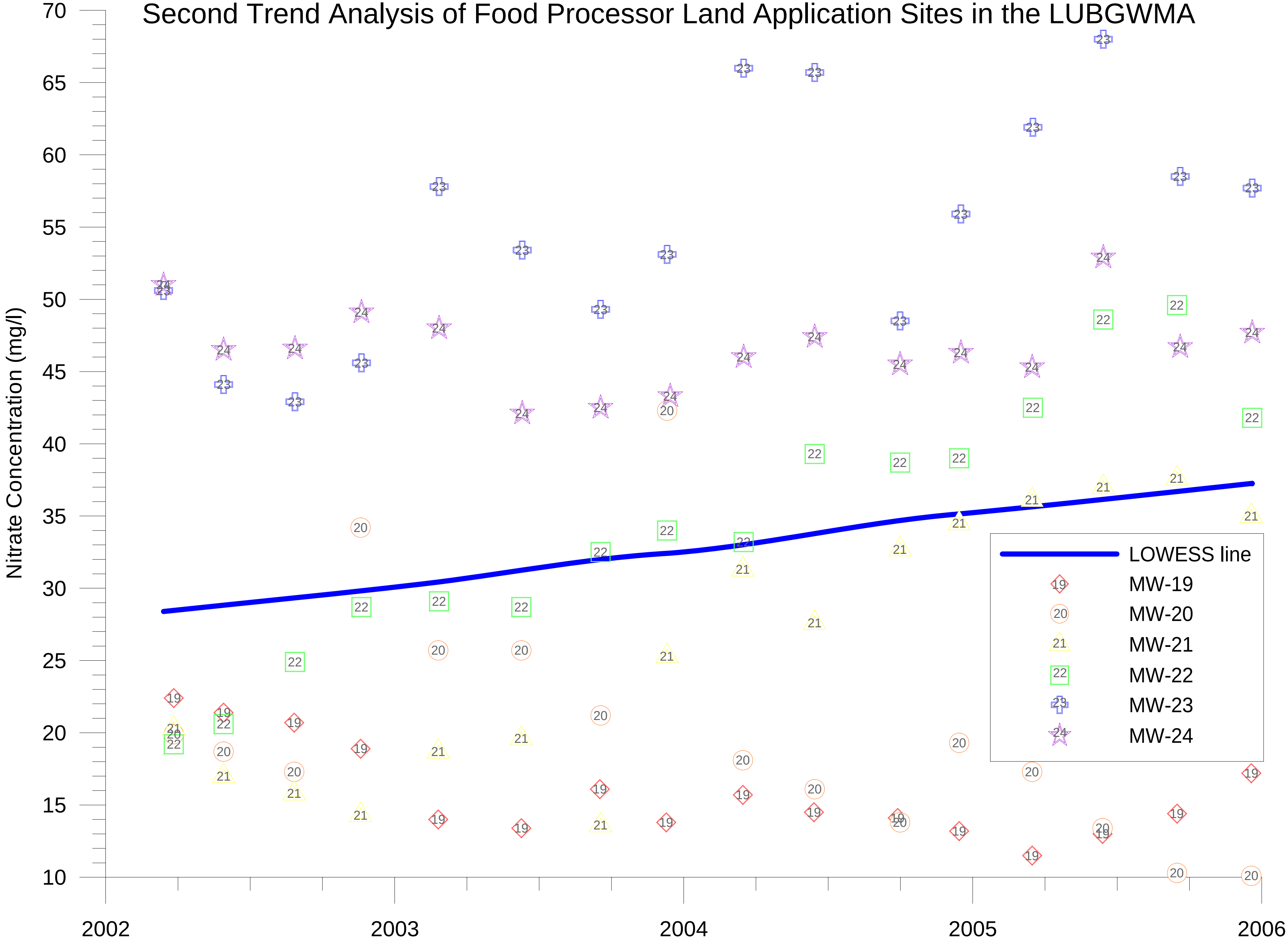
e: lub landapp 2006trendanalysis pom trends&lowess_2.grf

Figure 2-10
Upgradient vs. Downgradient Nitrate Comparisons - Port of Morrow Farm 2
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp 2006trendanalysis pom up vs dn 2.grf

Figure 2-11
LOWESS Line Through All Nitrate Data - Port of Morrow Farm 3
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp 2006trendanalysis pom alldatafarm3.grf

Figure 2-12
LOWESS Lines and Trend Lines Through Nitrate Data - Port of Morrow Farm 3
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

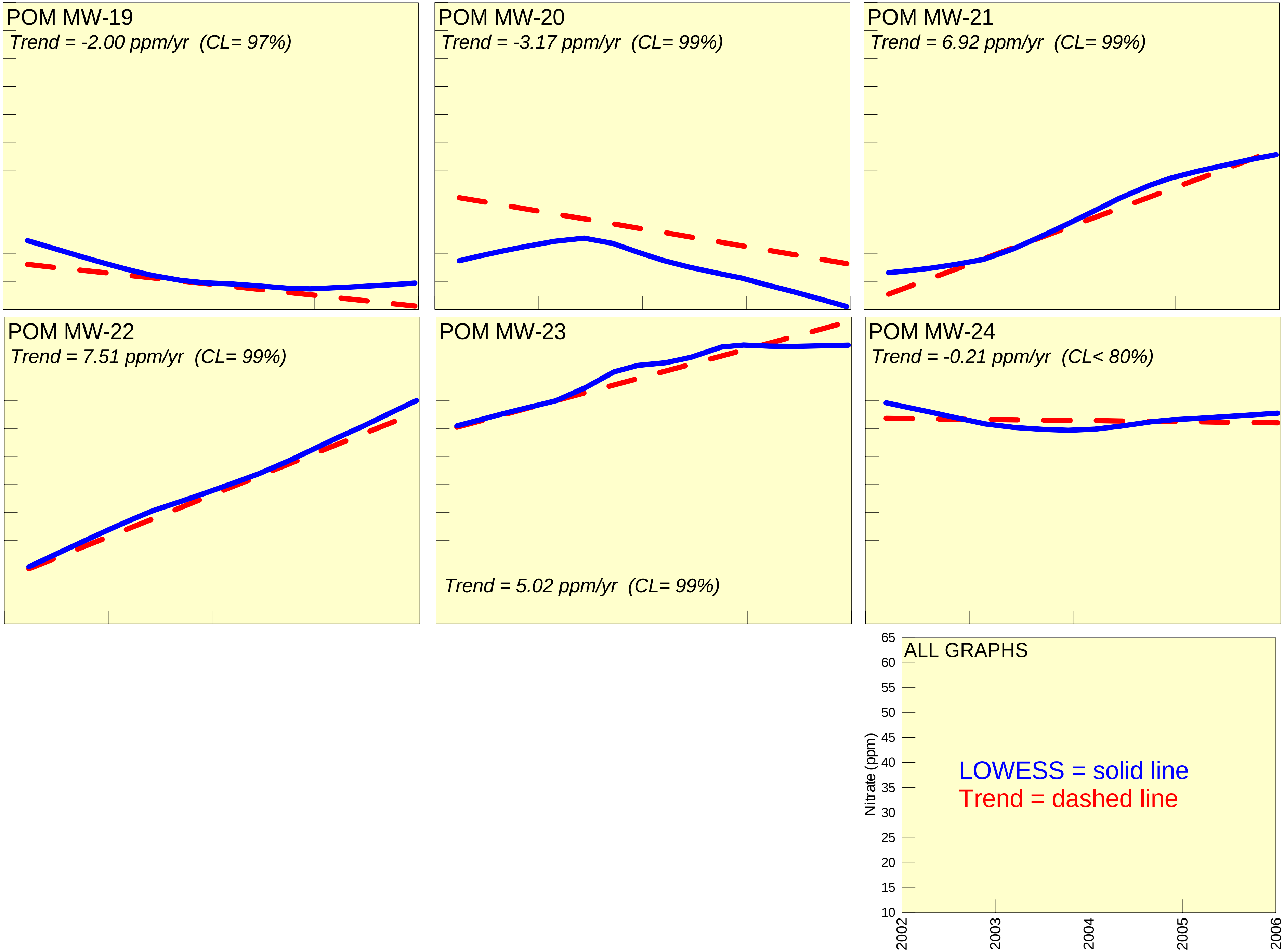


Figure 3-1
LOWESS Line Through All Nitrate Data - ConAgra North Farm
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

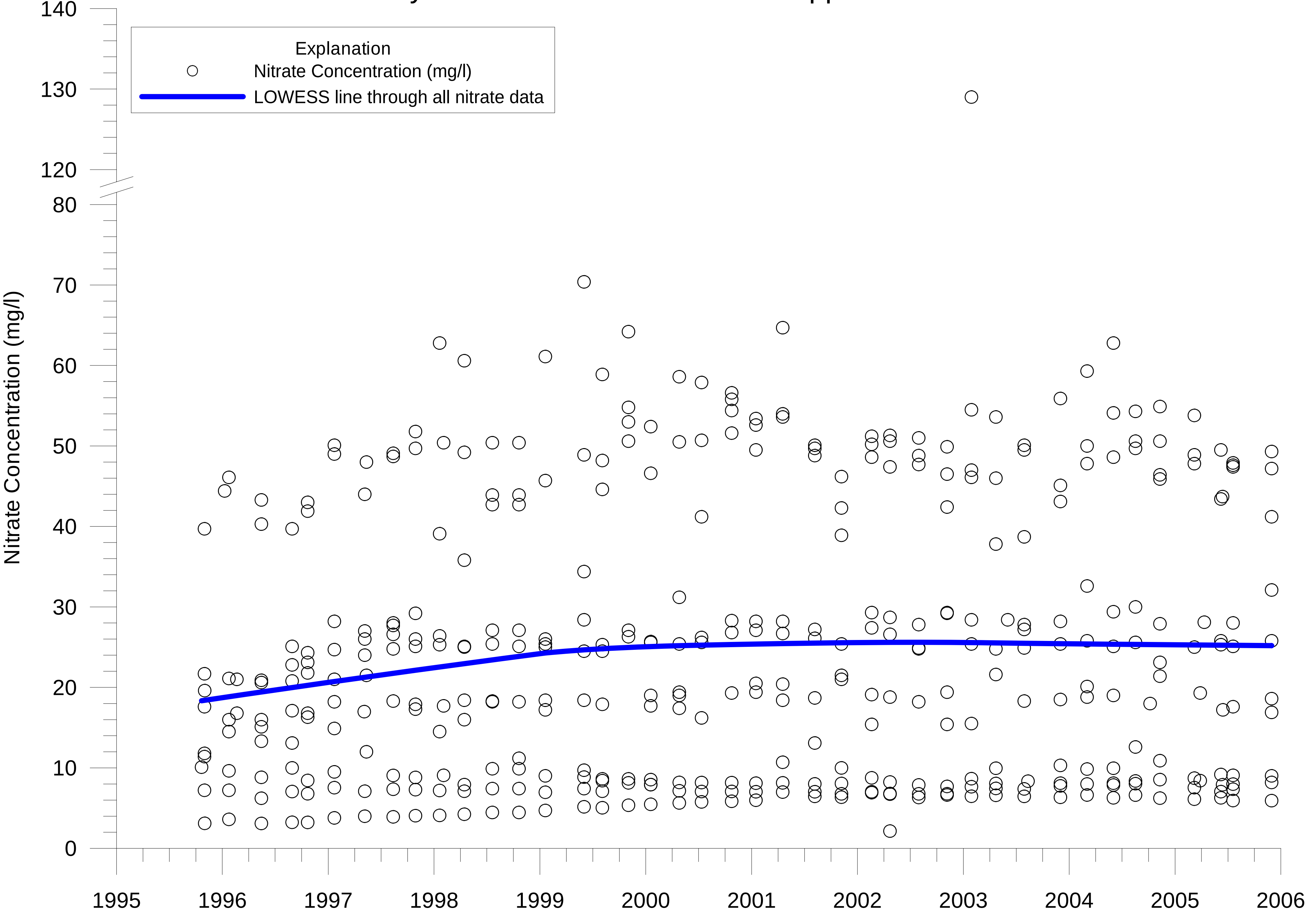
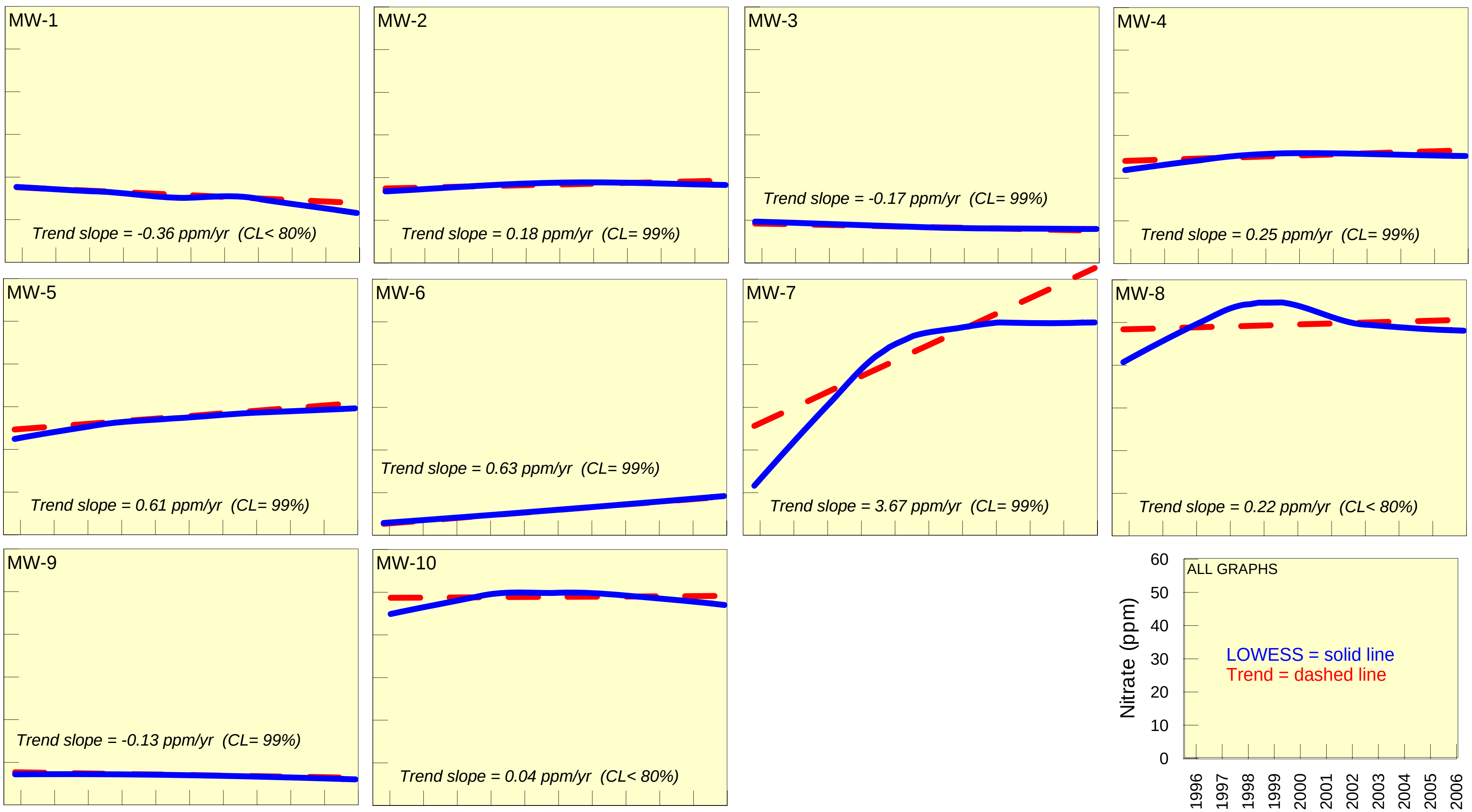


Figure 3-2
LOWESS Lines and Trend Lines Through Nitrate Data - ConAgra North Farm
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp 2006trendanalysis lw alltrend&lowess_nf.grf

Figure 3-3
Nitrate Trends - ConAgra North Farm
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

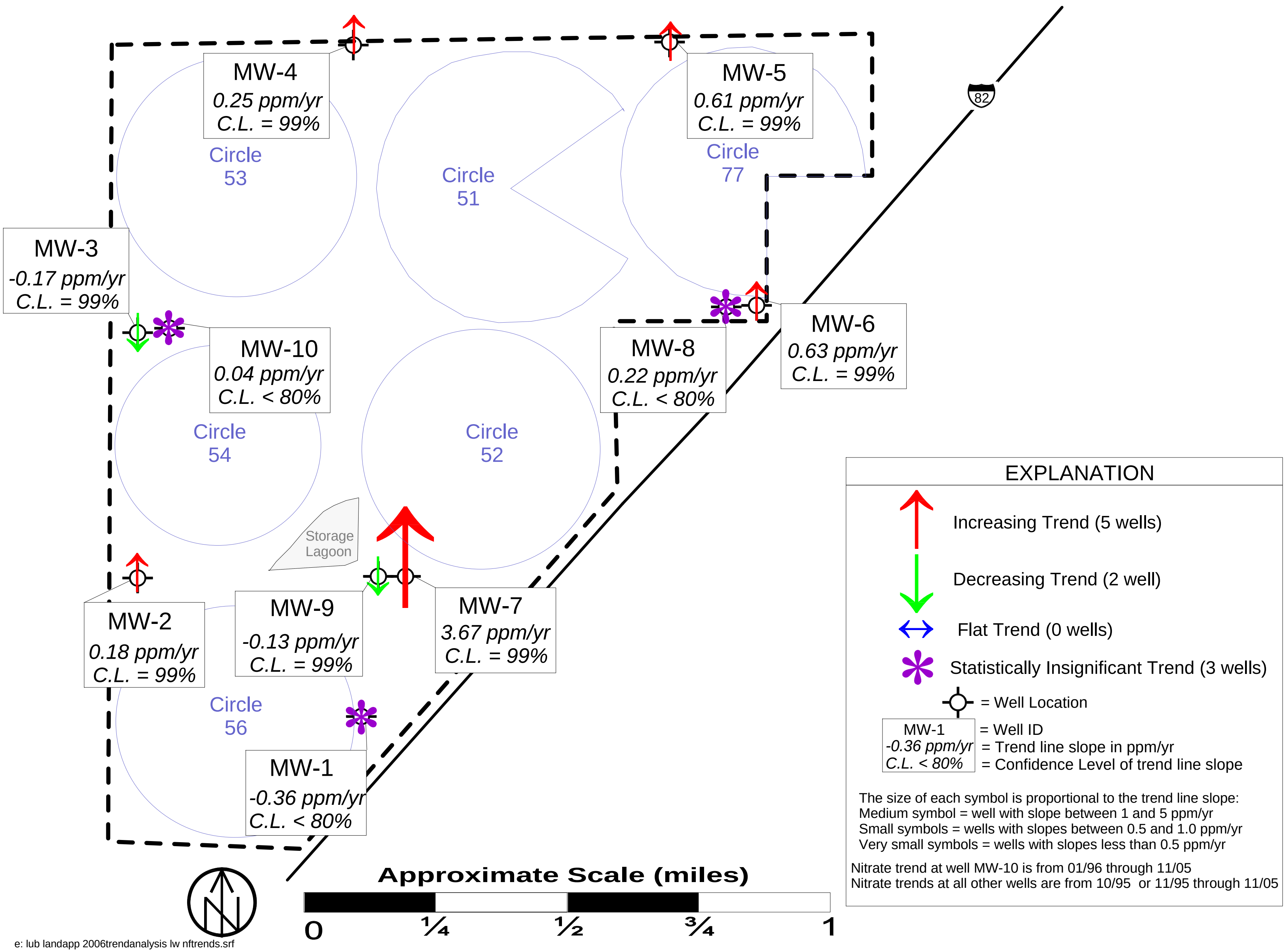
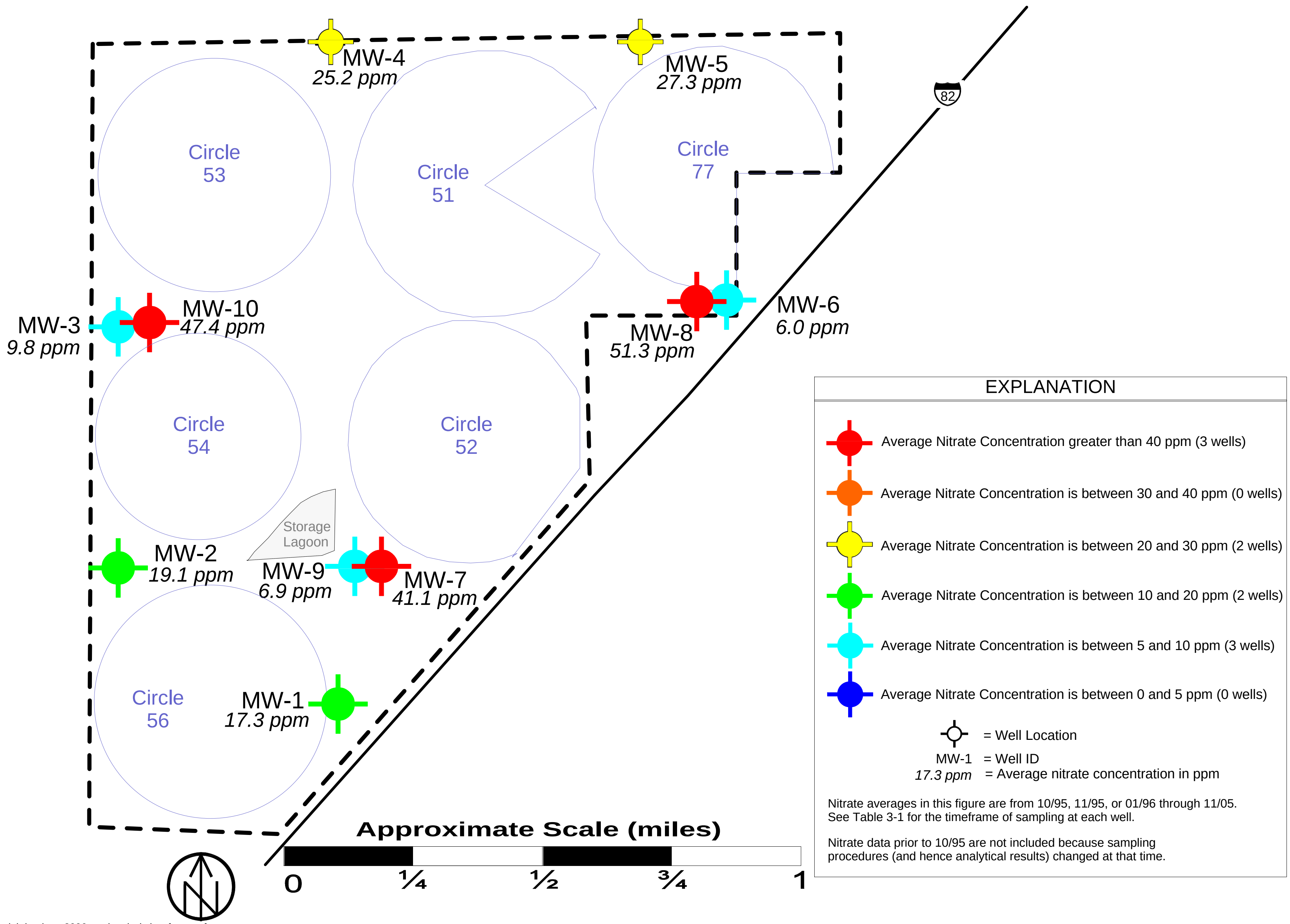
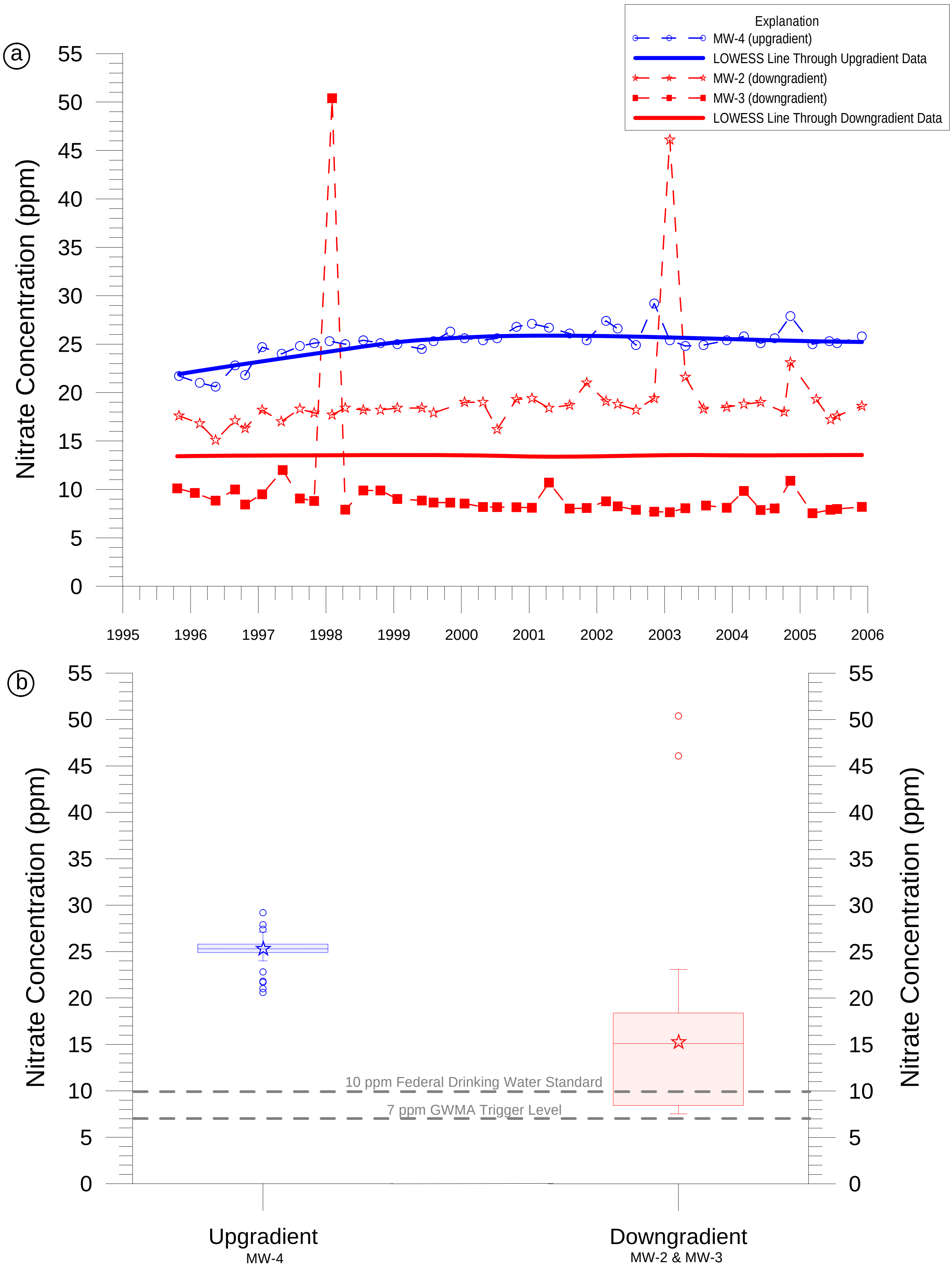


Figure 3-4
Average Nitrate Concentrations - ConAgra North Farm
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



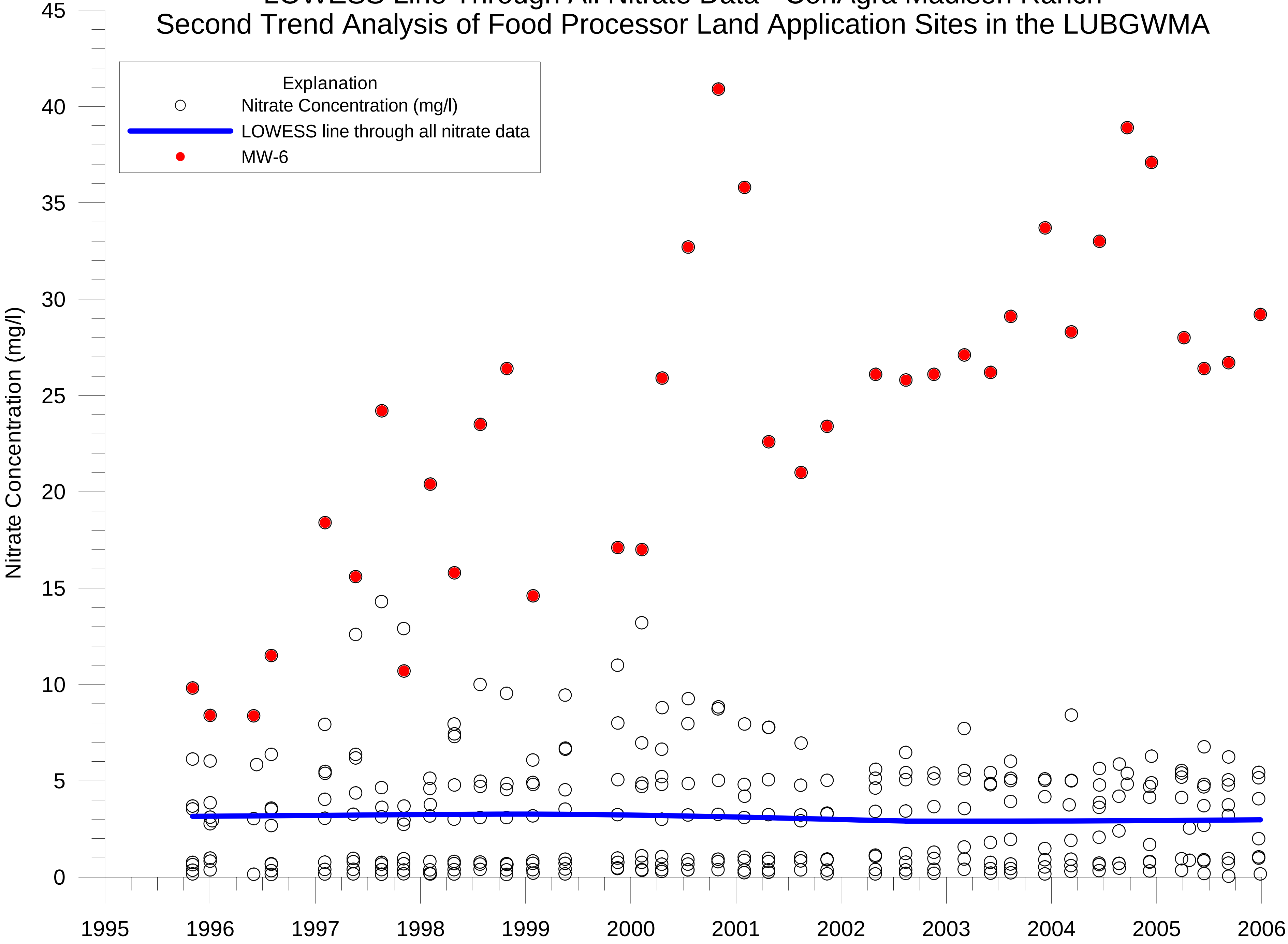
e: lub landapp 2006trendanalysis lw nfavgs.srf

Figure 3-5
Upgradient vs. Downgradient Nitrate Comparisons - ConAgra North Farm
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp 2006trendanalysis lw up vs dn NF.grf

Figure 3-6
LOWESS Line Through All Nitrate Data - ConAgra Madison Ranch
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp 2006trendanalsys lw all data mr 10well.grf

Figure 3-7
LOWESS Lines and Trend Lines Through Nitrate Data - ConAgra Madison Ranch
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

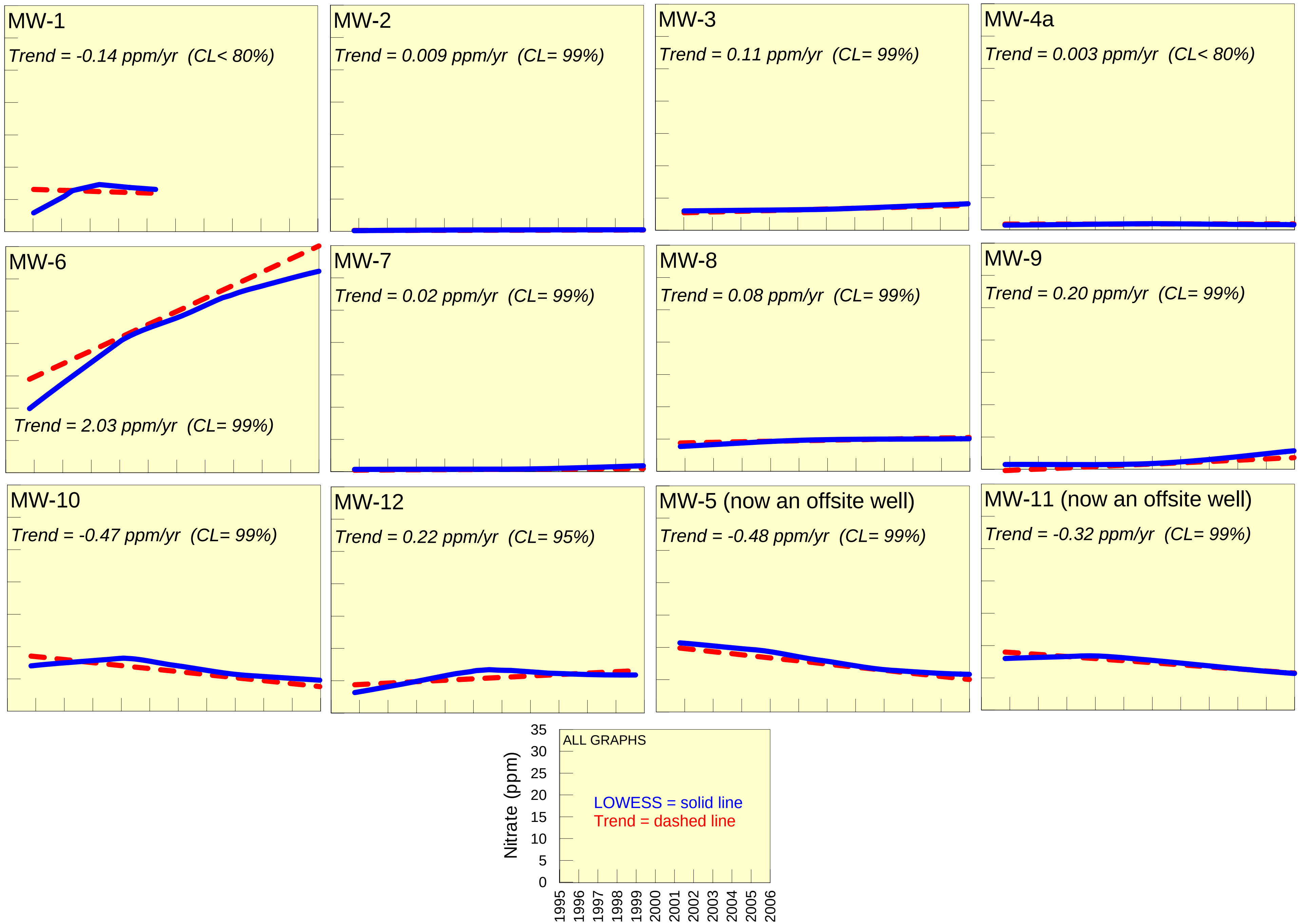


Figure 3-8
Nitrate Trends - ConAgra Madison Ranch
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

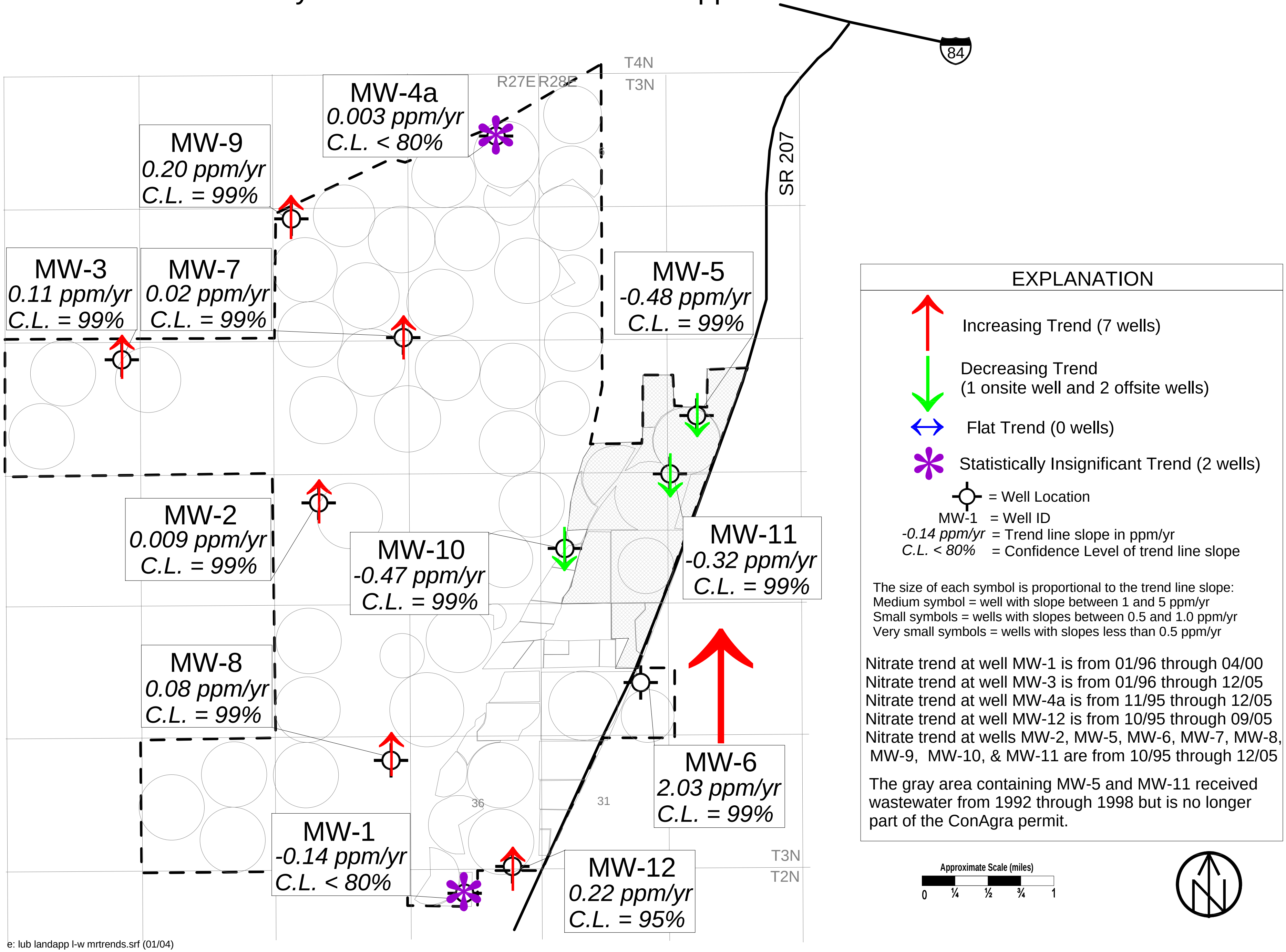
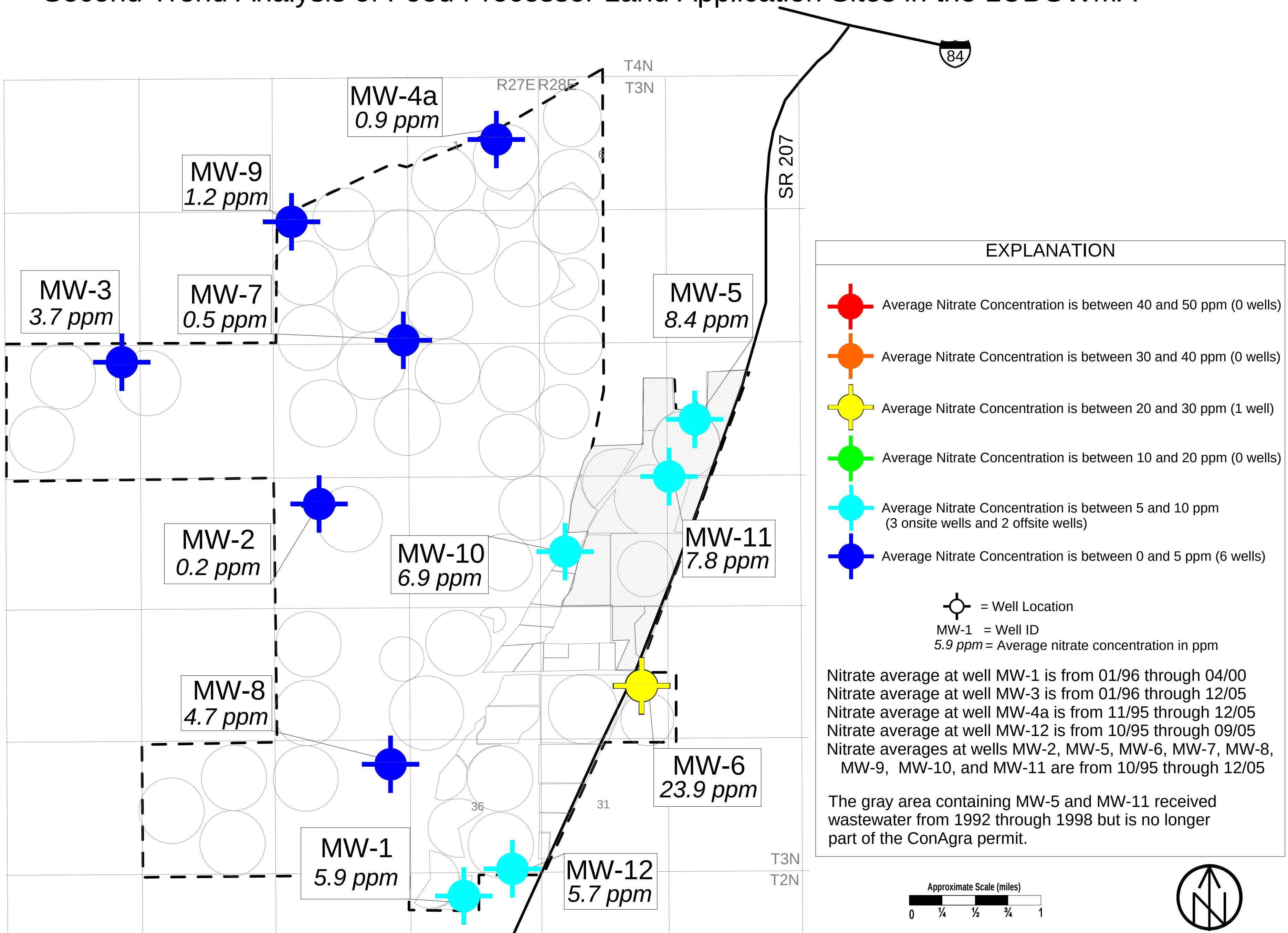
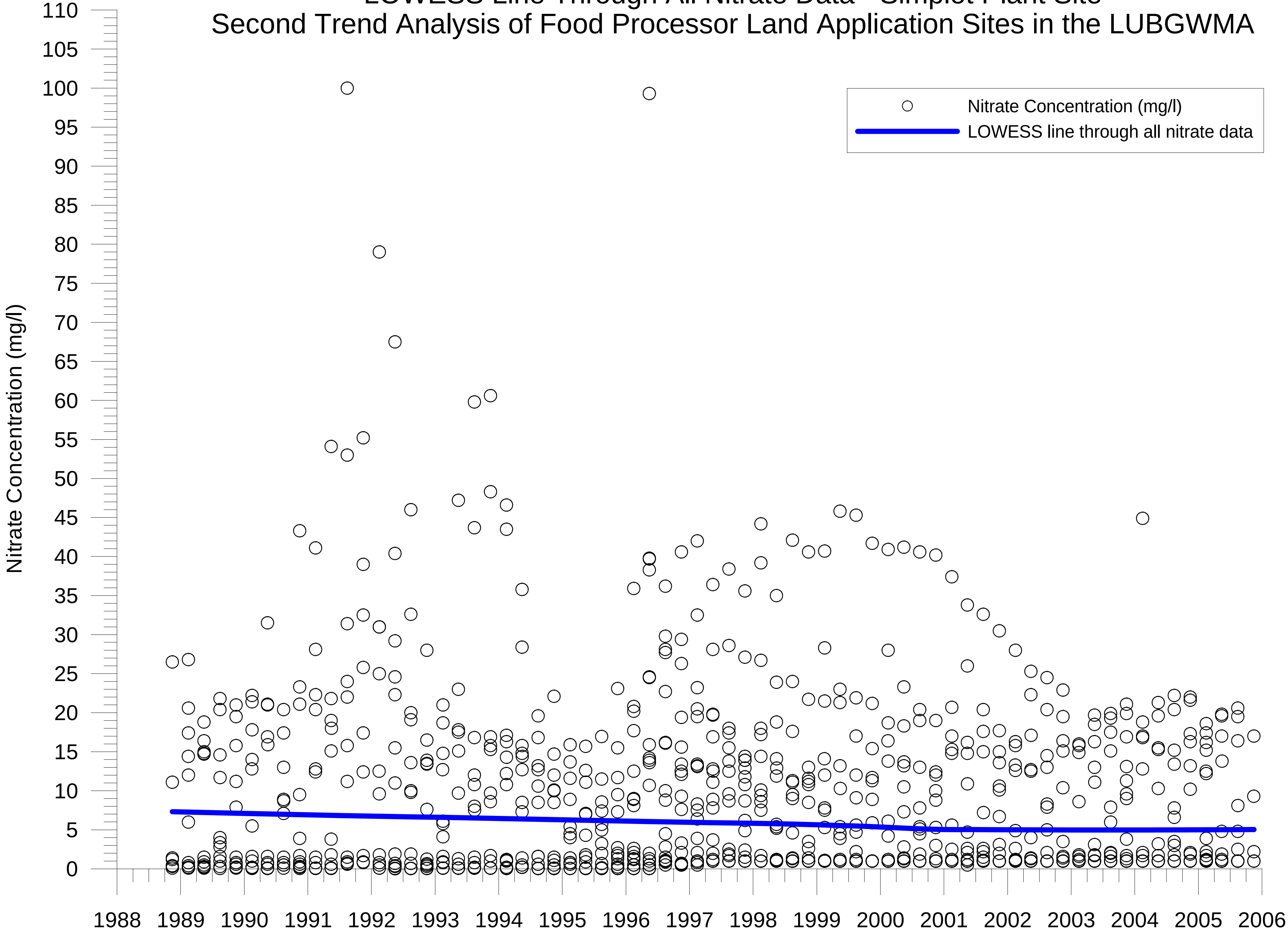


Figure 3-9
Average Nitrate Concentrations - ConAgra Madison Ranch
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp 2006trendanalysis lw mr_averages.srf

Figure 4-1
LOWESS Line Through All Nitrate Data - Simplot Plant Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp 2006trendanalysis simplot alldataterracesite.grf

Figure 4-2
LOWESS Lines and Trend Lines Through Nitrate Data - Simplot Plant Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

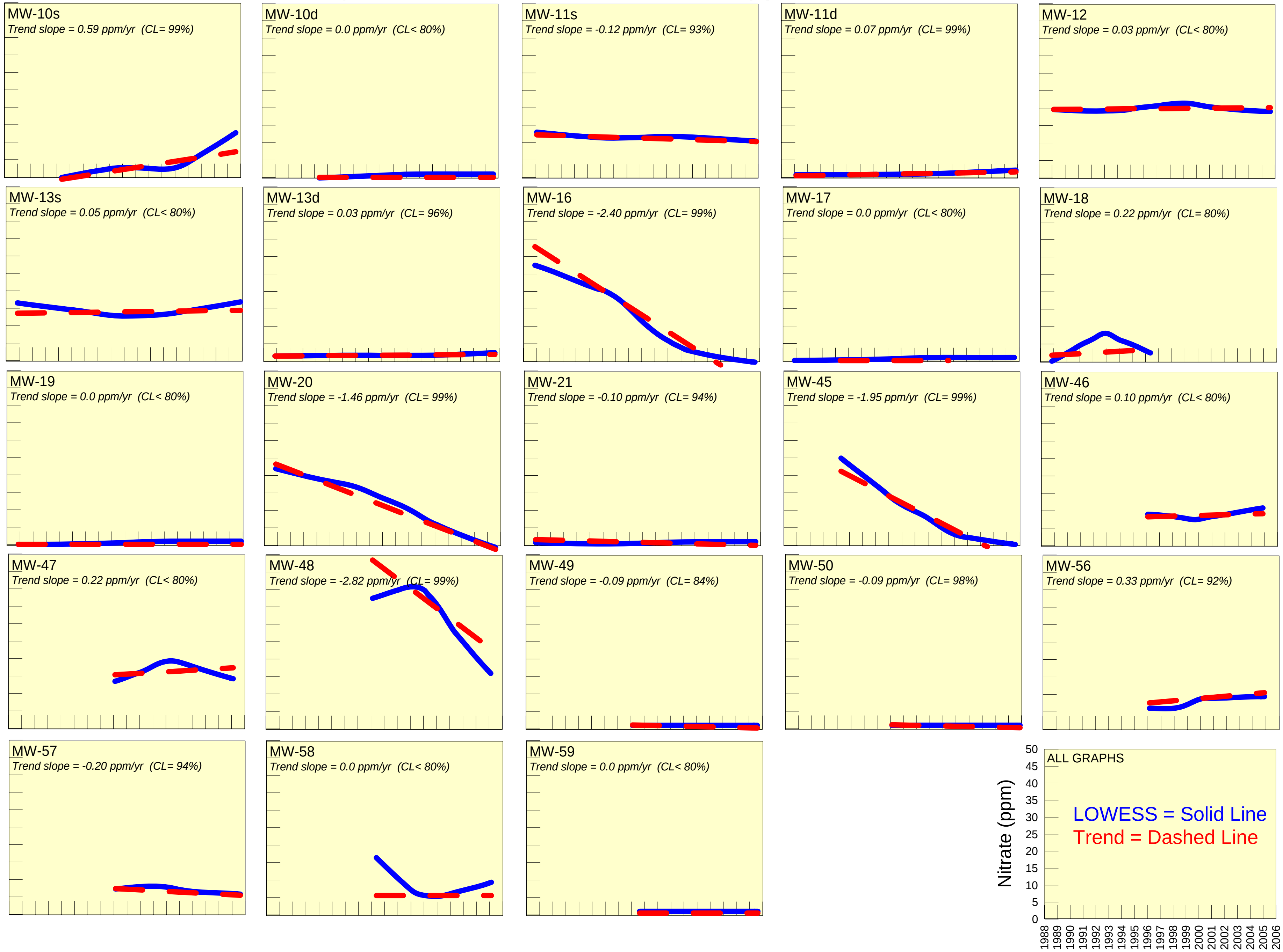
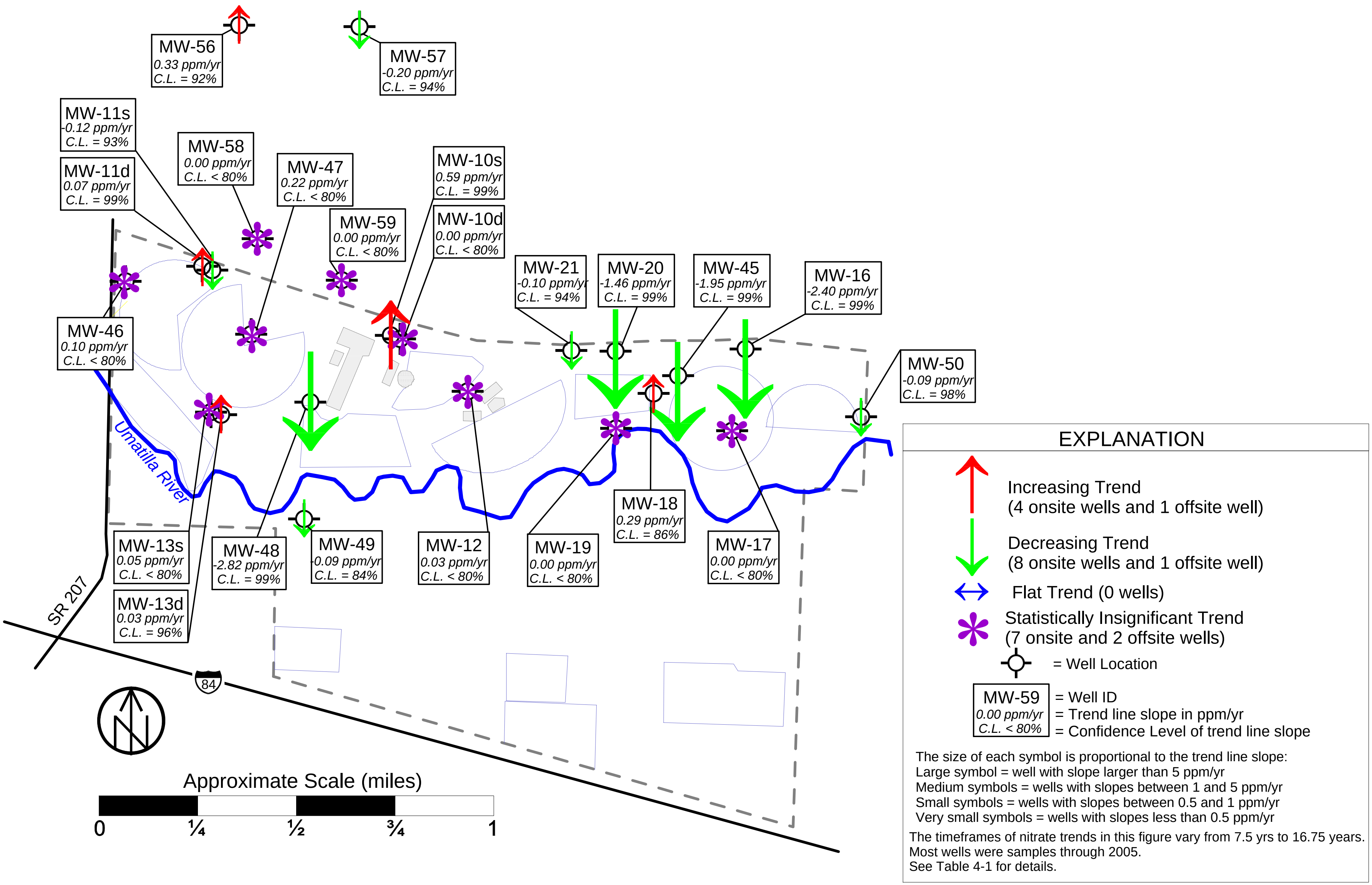
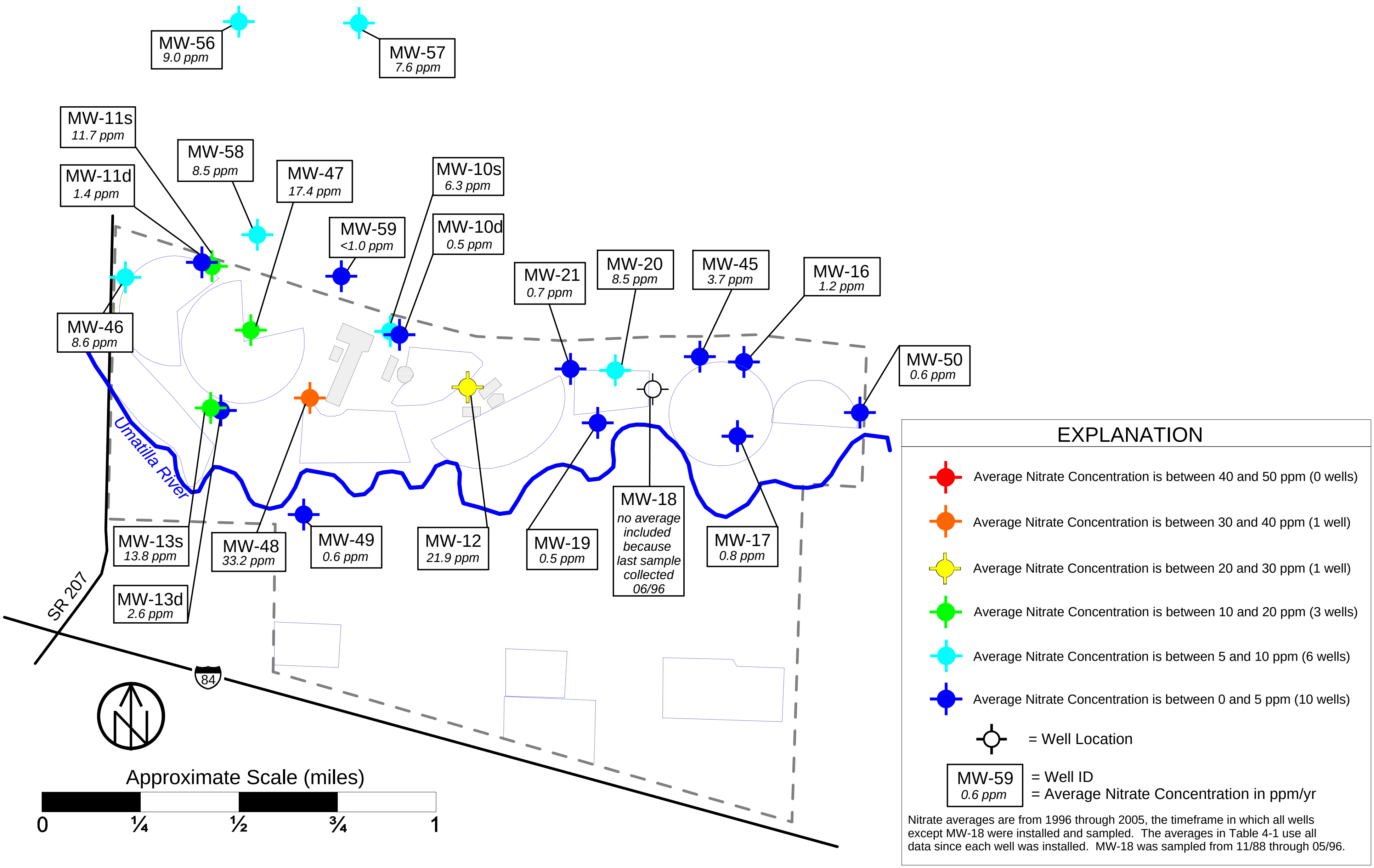


Figure 4-3
Nitrate Trends - Simplot Plant Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



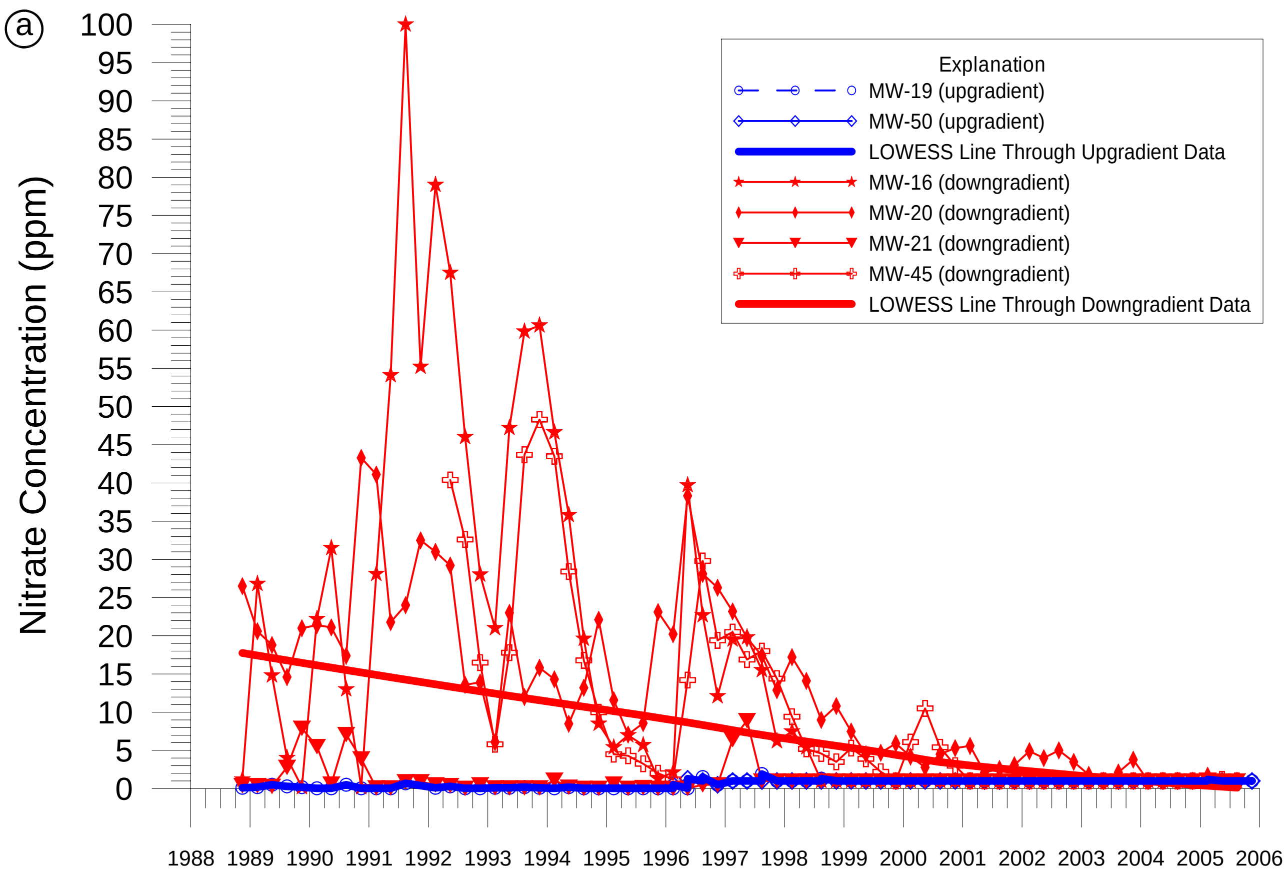
e: lub landapp 2006trendanalysis simplot plt_trends.srf

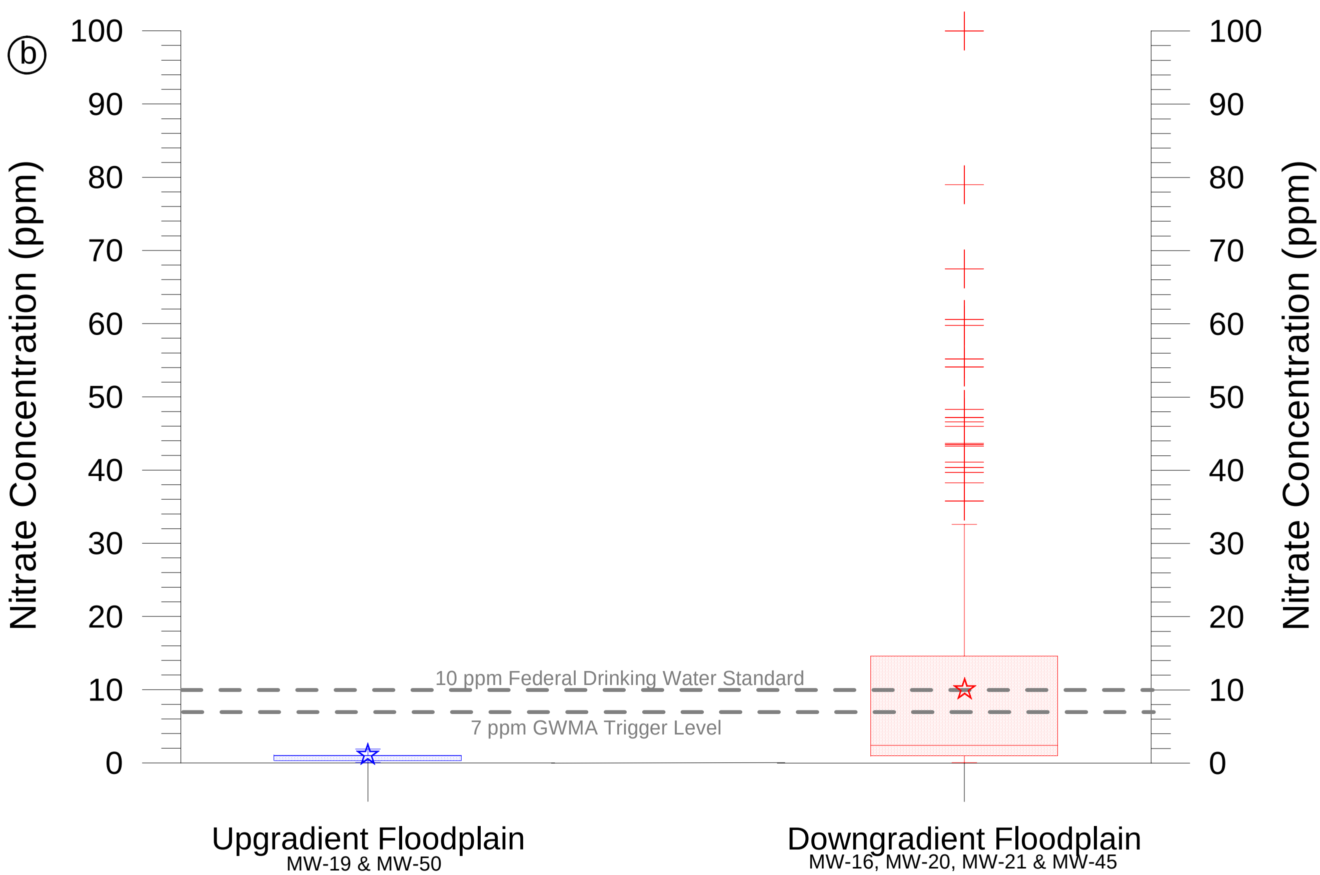
Figure 4-4
Average Nitrate Concentrations - Simplot Plant Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp 2006trendanalysis simplot plt_averages.srf

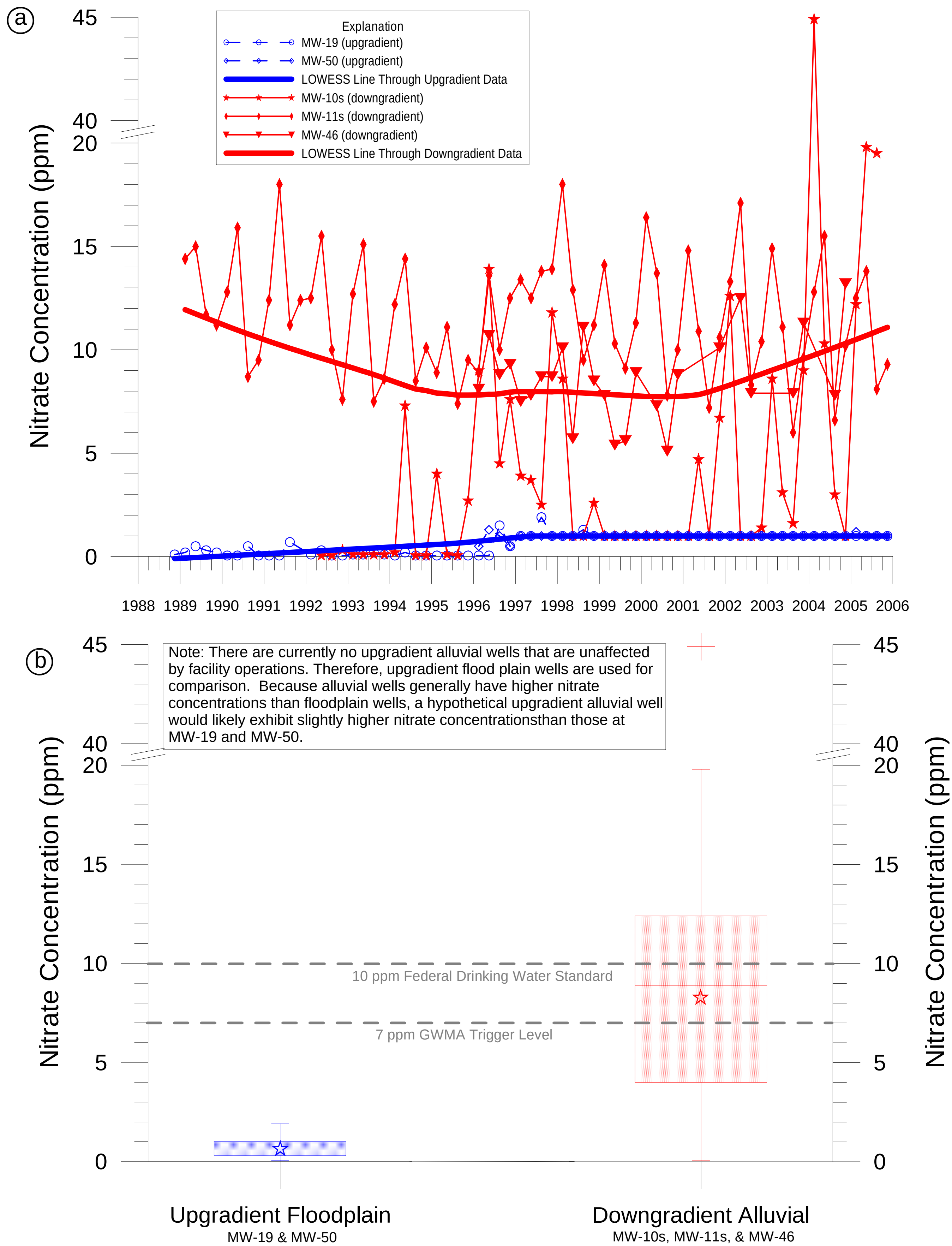
Figure 4-5
Upgradient vs. Downgradient Nitrate Comparisons - Simplot Plant Site Floodplain Wells
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA





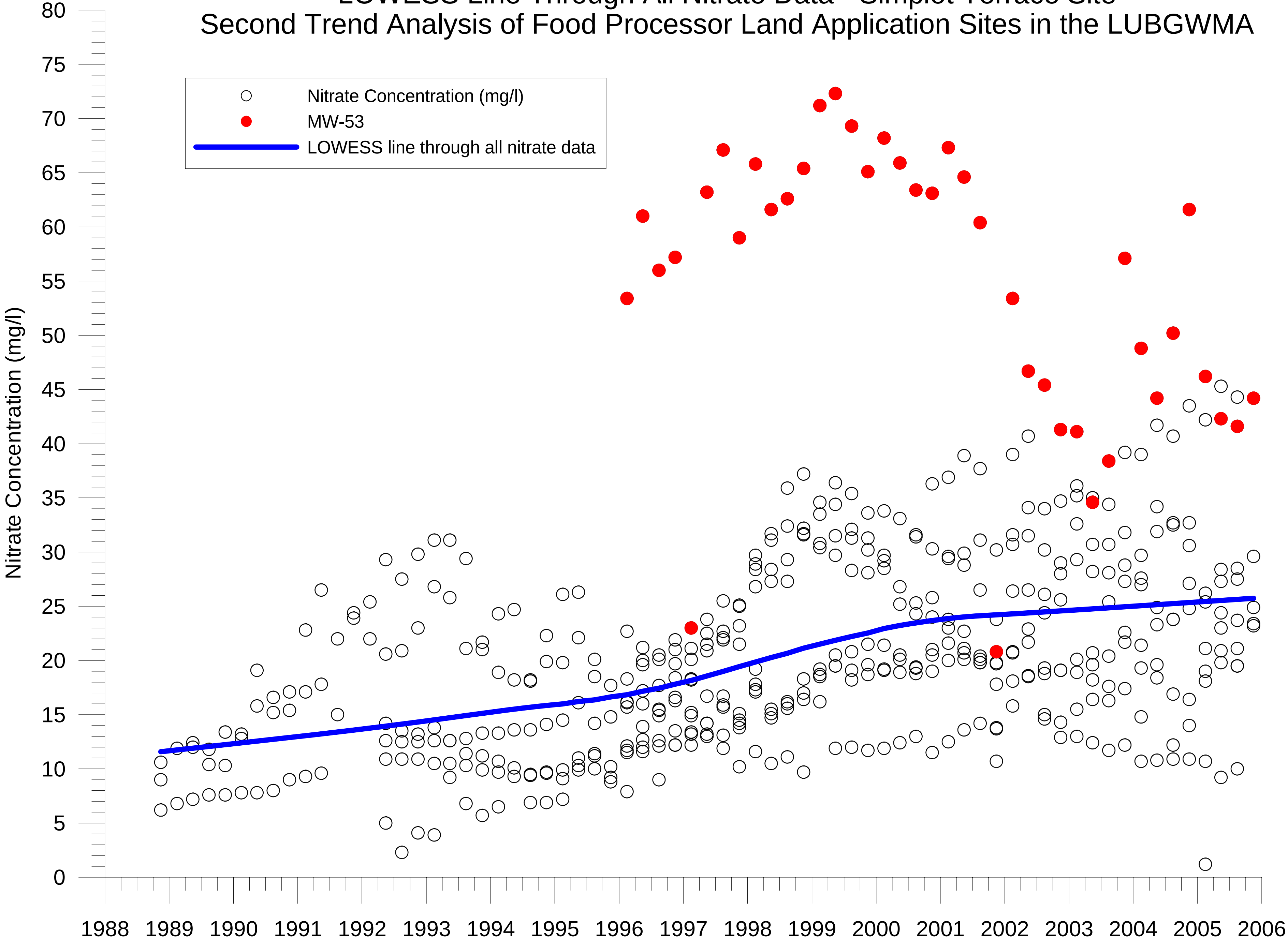
e: lub landapp 2006trendanalysis simplot up vs dn plant fp.grf

Figure 4-6
Upgradient vs. Downgradient Nitrate Comparisons - Simplot Plant Site Alluvial Wells
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



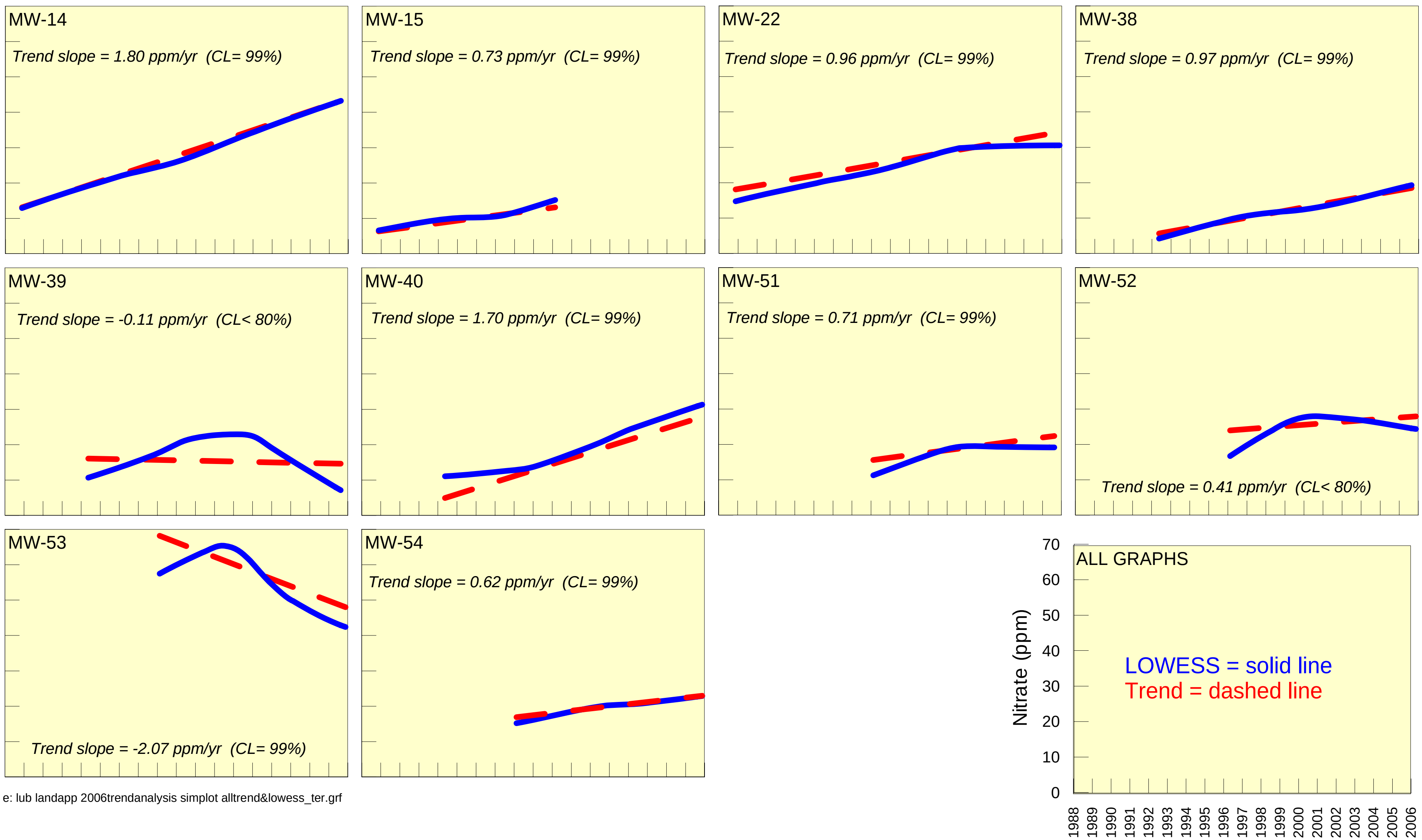
e: lub landapp 2006trendanalysis simplot up vs dn plant al.grf

Figure 4-7
LOWESS Line Through All Nitrate Data - Simplot Terrace Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp 2006trendanalysis simplot alldataterracesite.grf

Figure 4-8
LOWESS Lines and Trend Lines Through Nitrate Data - Simplot Terrace Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp 2006trendanalysis simplot alltrend&lowess_ter.grf

Figure 4-9
Nitrate Trends - Simplot Terrace Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

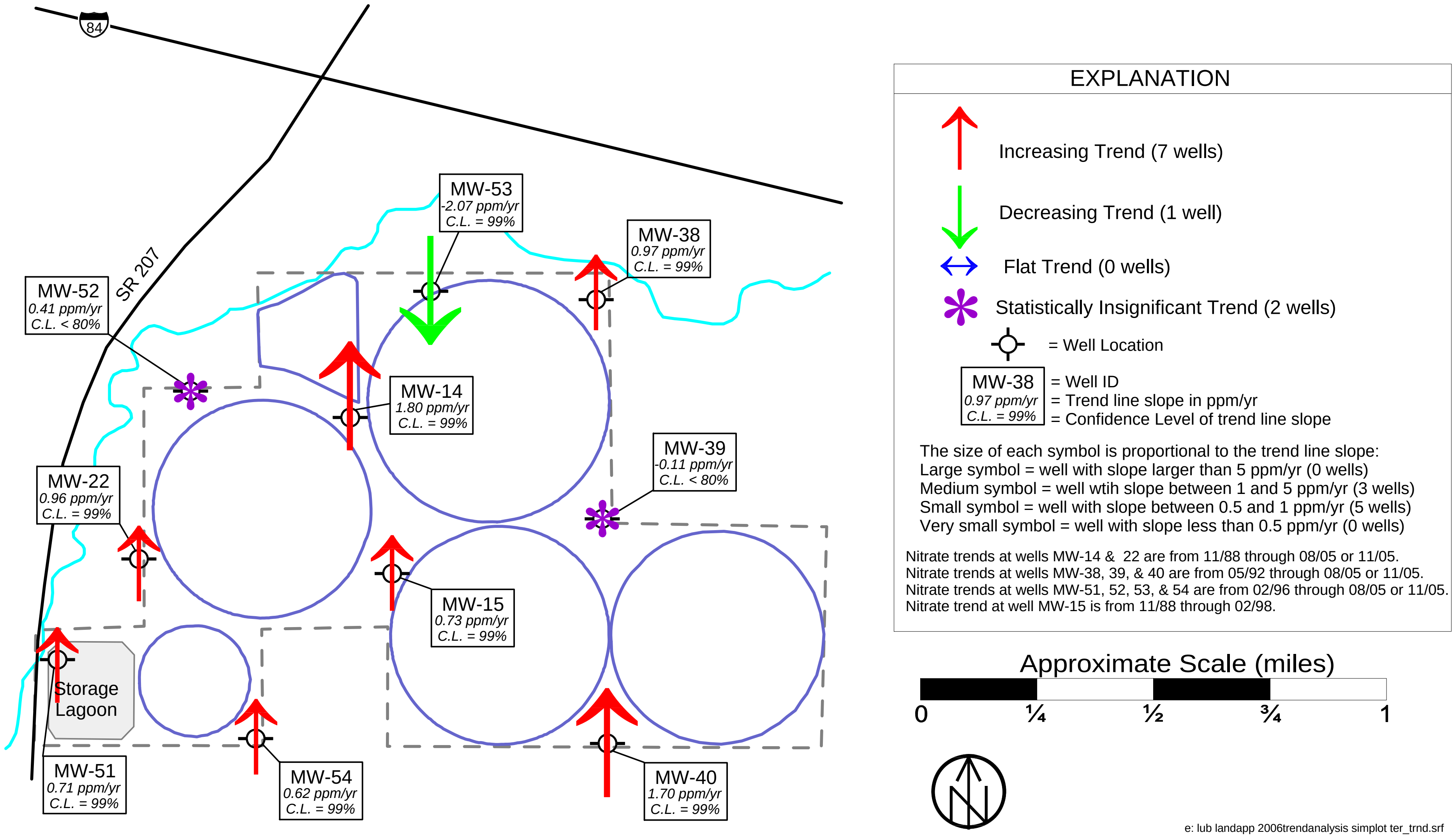
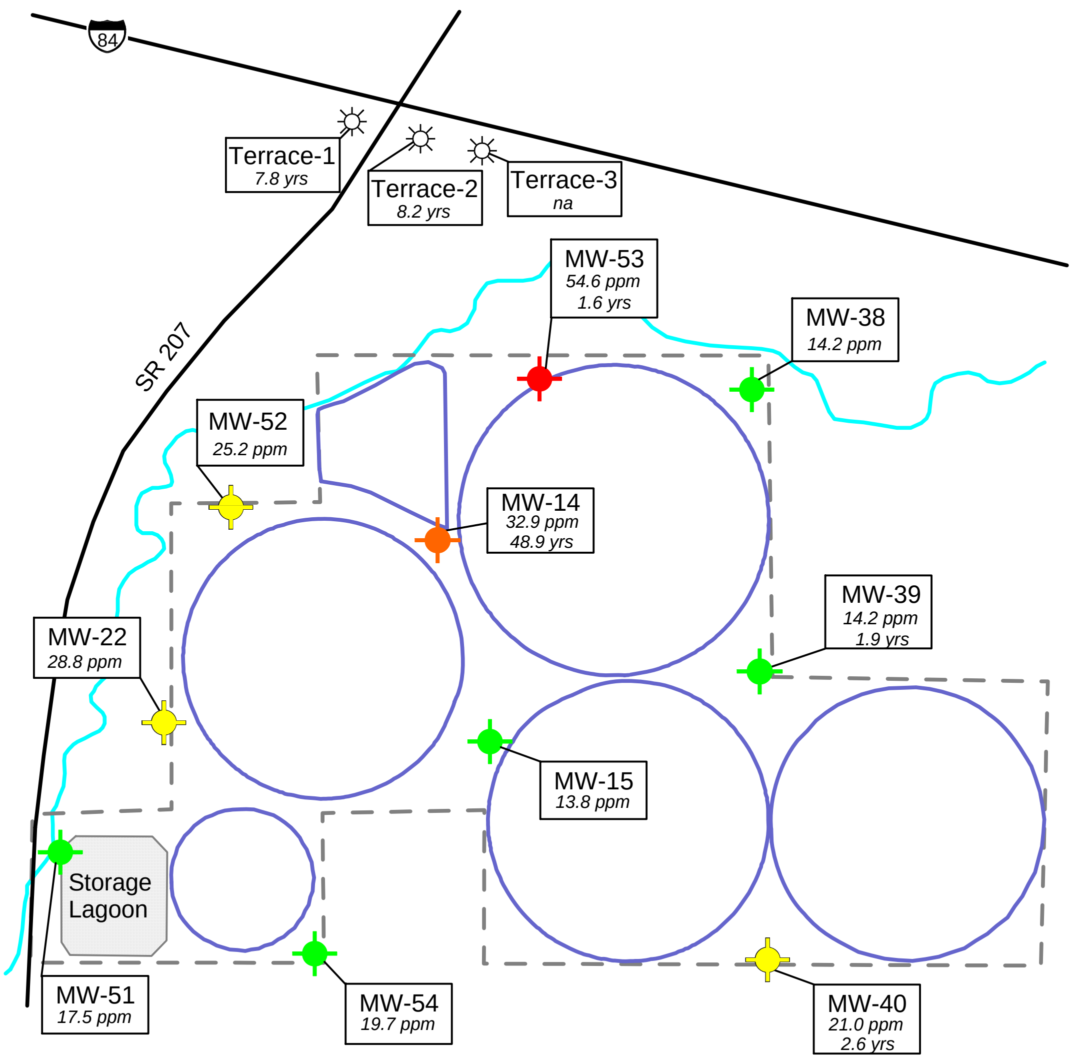


Figure 4-10
Average Nitrate Concentrations - Simplot Terrace Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



EXPLANATION

Average Nitrate Concentration greater than 40 ppm (1 well)

Average Nitrate Concentration is between 30 and 40 ppm (1 well)

Average Nitrate Concentration is between 20 and 30 ppm (3 wells)

Average Nitrate Concentration is between 10 and 20 ppm (5 wells)

Average Nitrate Concentration is between 5 and 10 ppm (0 wells)

Average Nitrate Concentration is between 0 and 5 ppm (0 wells)

= Location of Temporary Well used in USGS Study

= Well Location

MW-53 = Well ID
54.6 ppm = Average Nitrate Concentration in ppm
1.6 yrs = Apparent recharge age in years

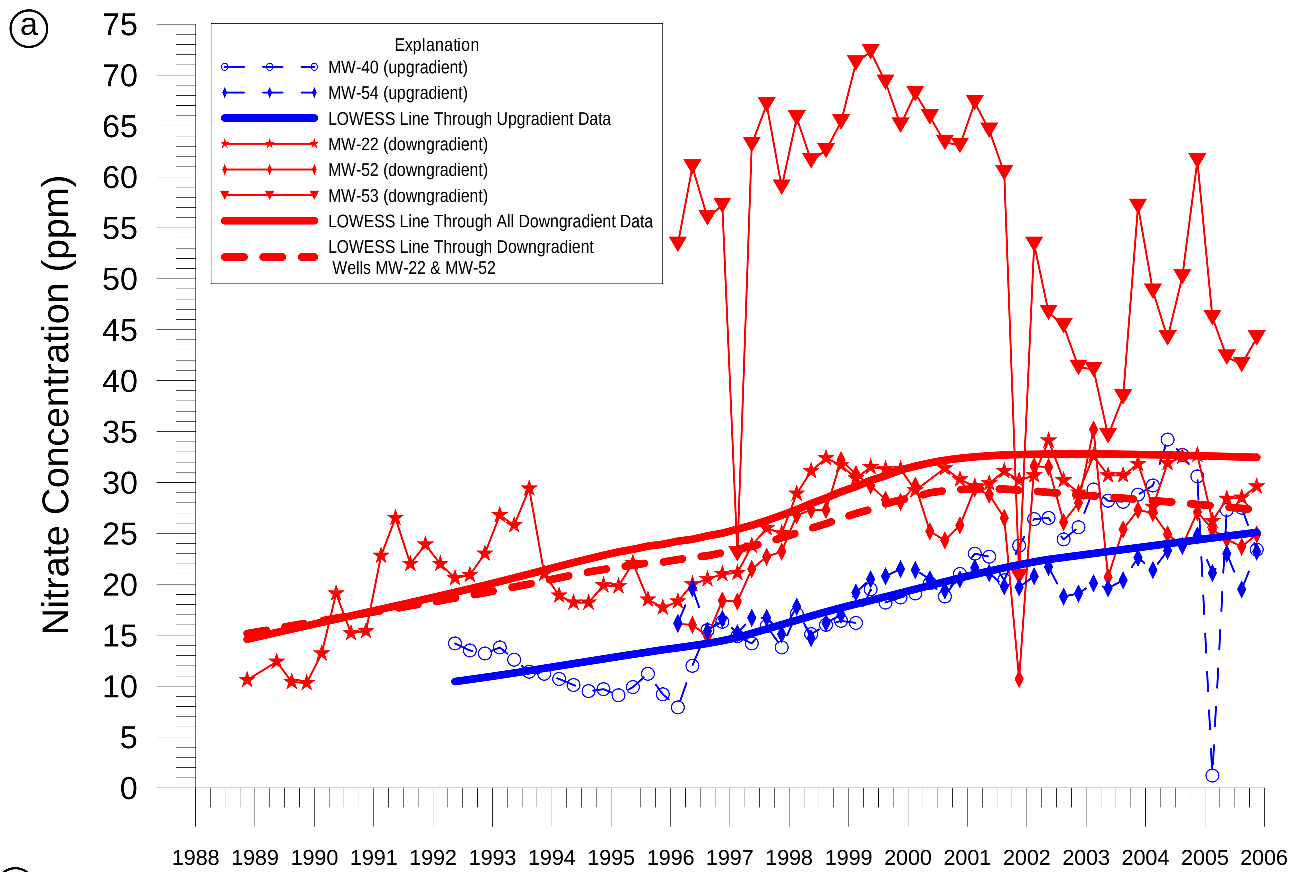
Nitrate averages for all wells except MW-15 are from 1996 through 2005, the timeframe in which all wells except MW-15 were installed and sampled. The average at MW-15 is from 1996 until Feb 1998. It was abandoned shortly thereafter. Due to the increasing trend there, an average over the same time frame as other wells would likely be higher than 14 ppm.

Approximate Scale (miles)

0 ¼ ½ ¾ 1

e: lub landapp 2006trendanalysis simplot ter_avg&age.srf

Figure 4-11
Upgradient vs. Downgradient Nitrate Comparisons - Simplot Terrace Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



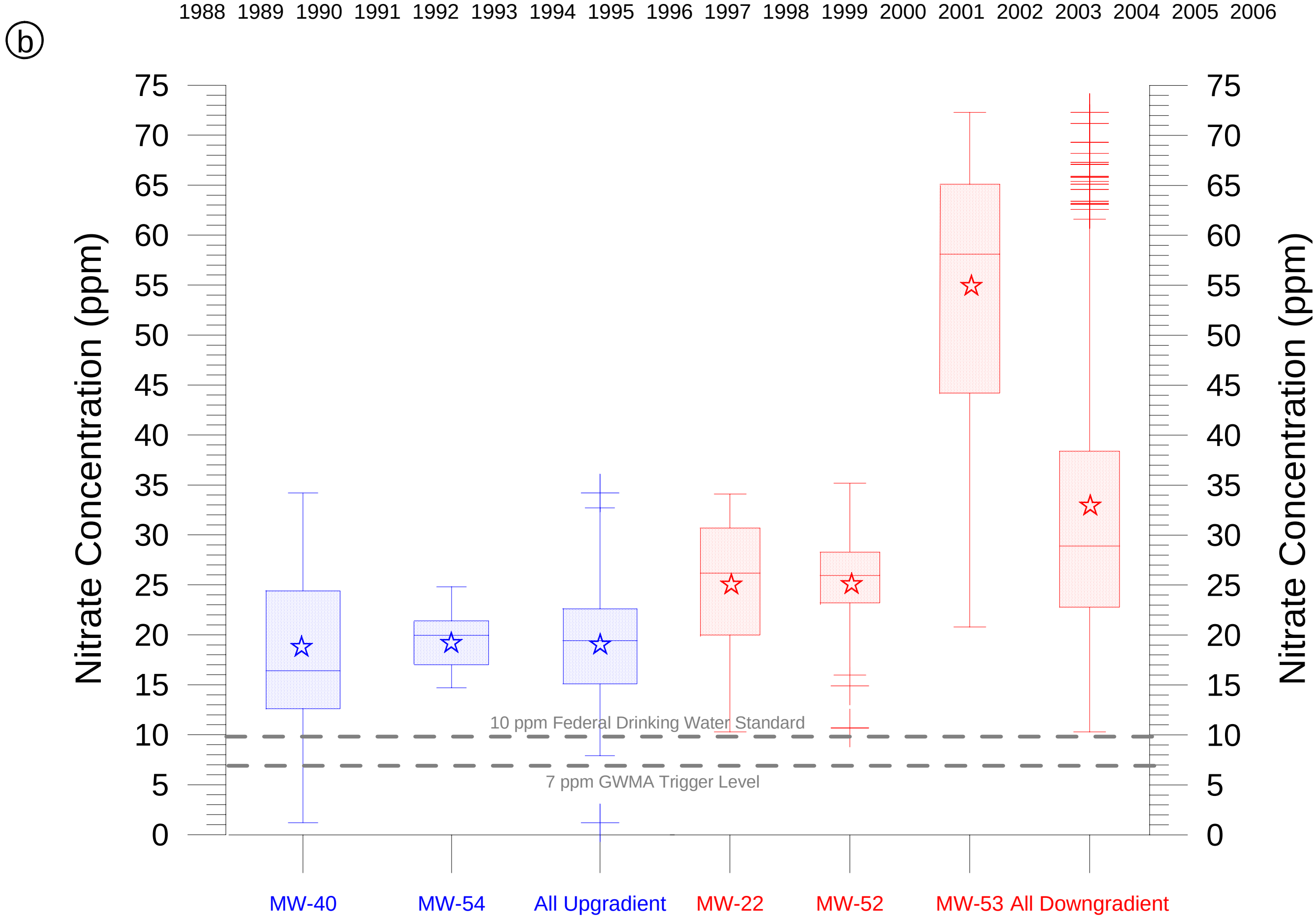
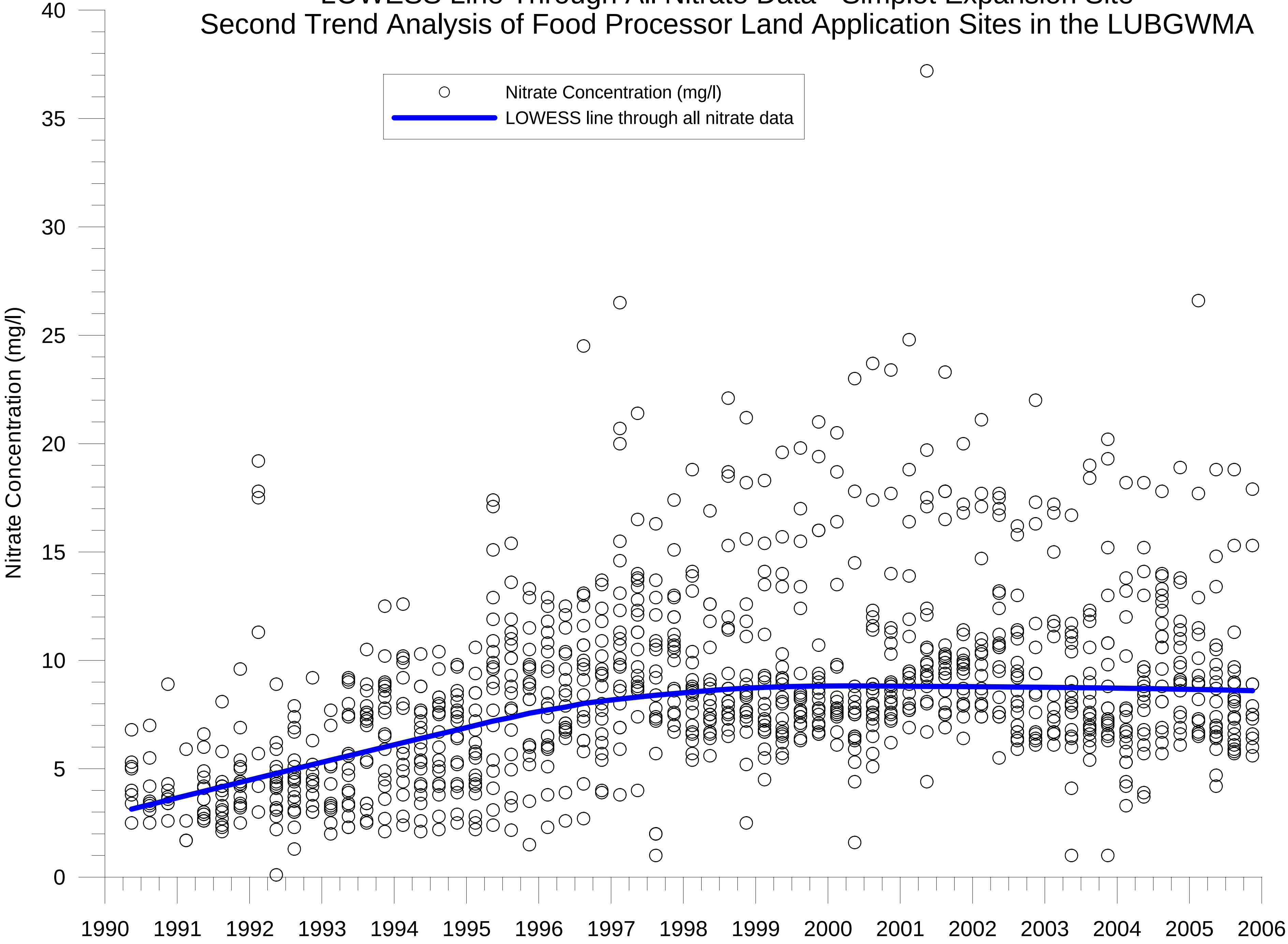


Figure 4-12
LOWESS Line Through All Nitrate Data - Simplot Expansion Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp 2006trendanalysis simplot alldataexpansionsite.grf

Figure 4-13
LOWESS Lines and Trend Lines Through Nitrate Data - Simplot Expansion Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

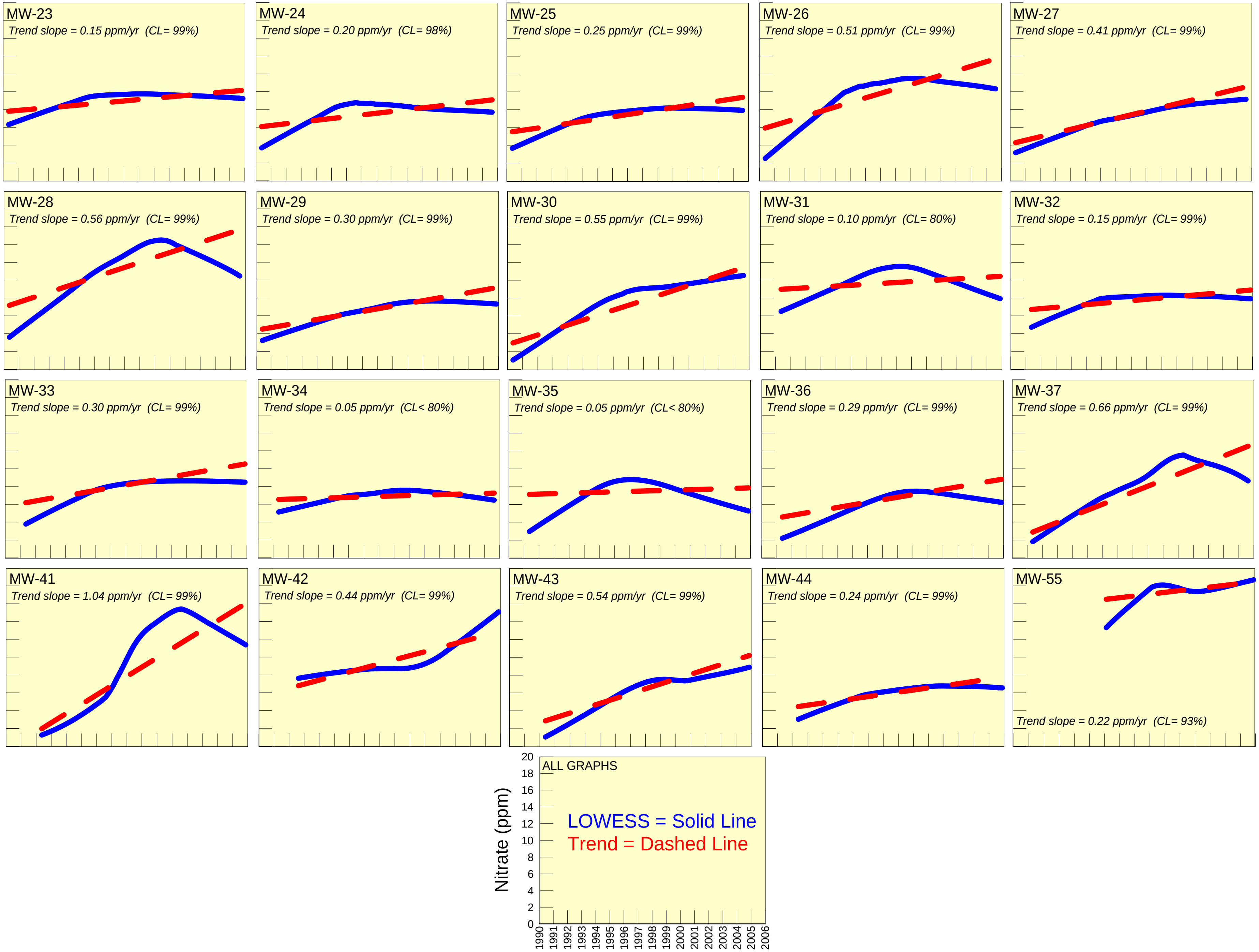


Figure 4-14
Nitrate Trends - Simplot Expansion Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

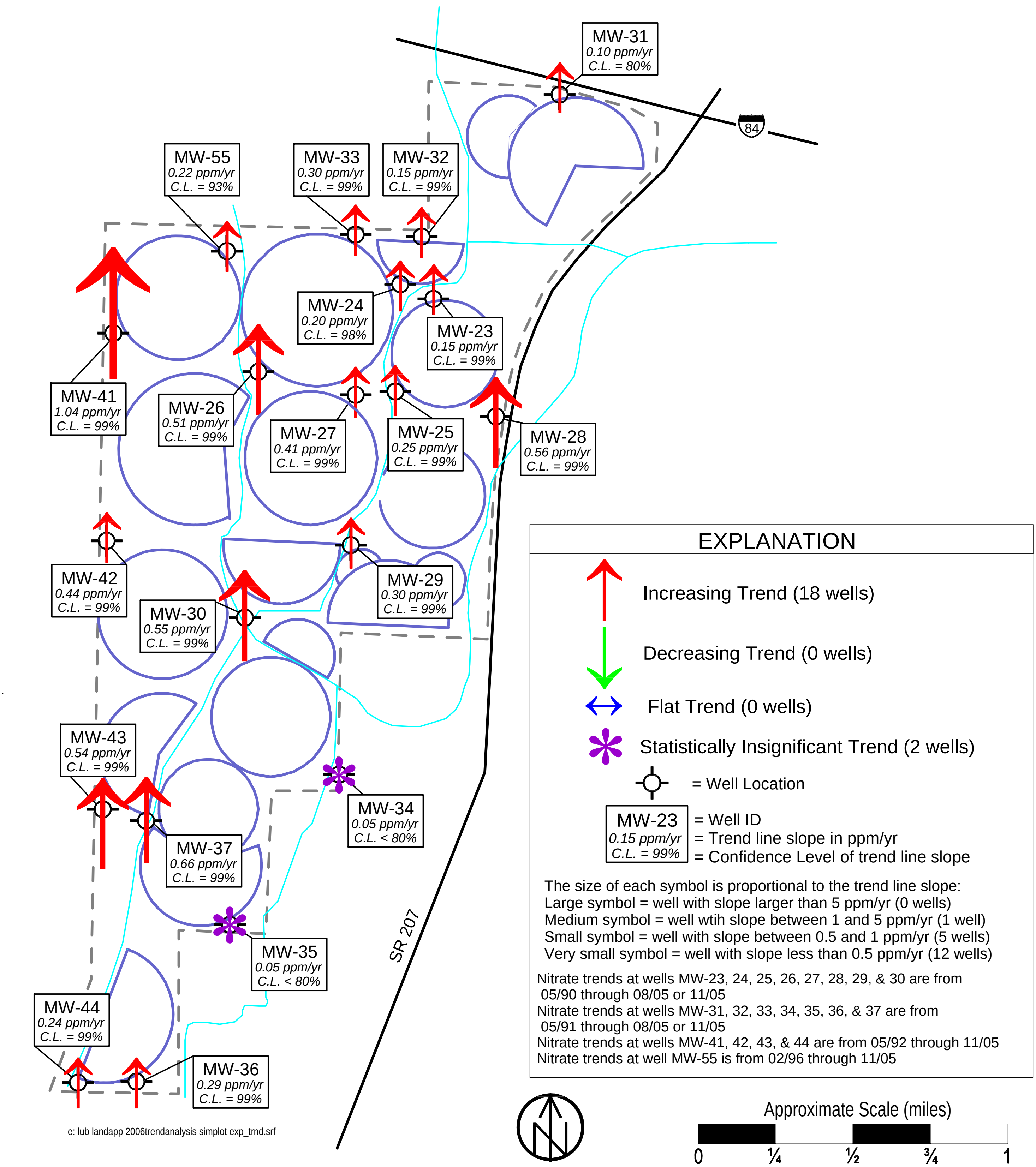


Figure 4-15
Average Nitrate Concentrations - Simplot Expansion Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

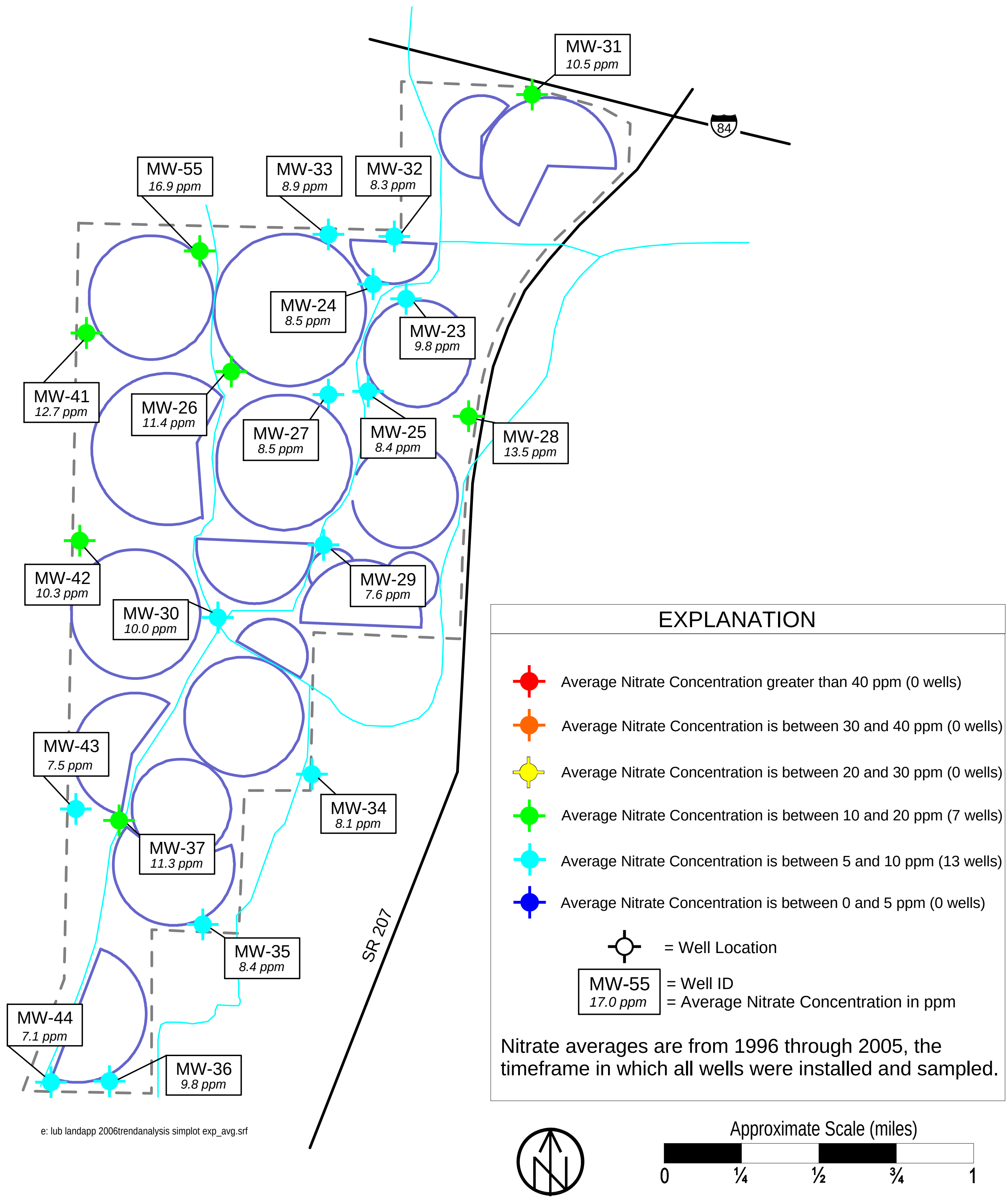
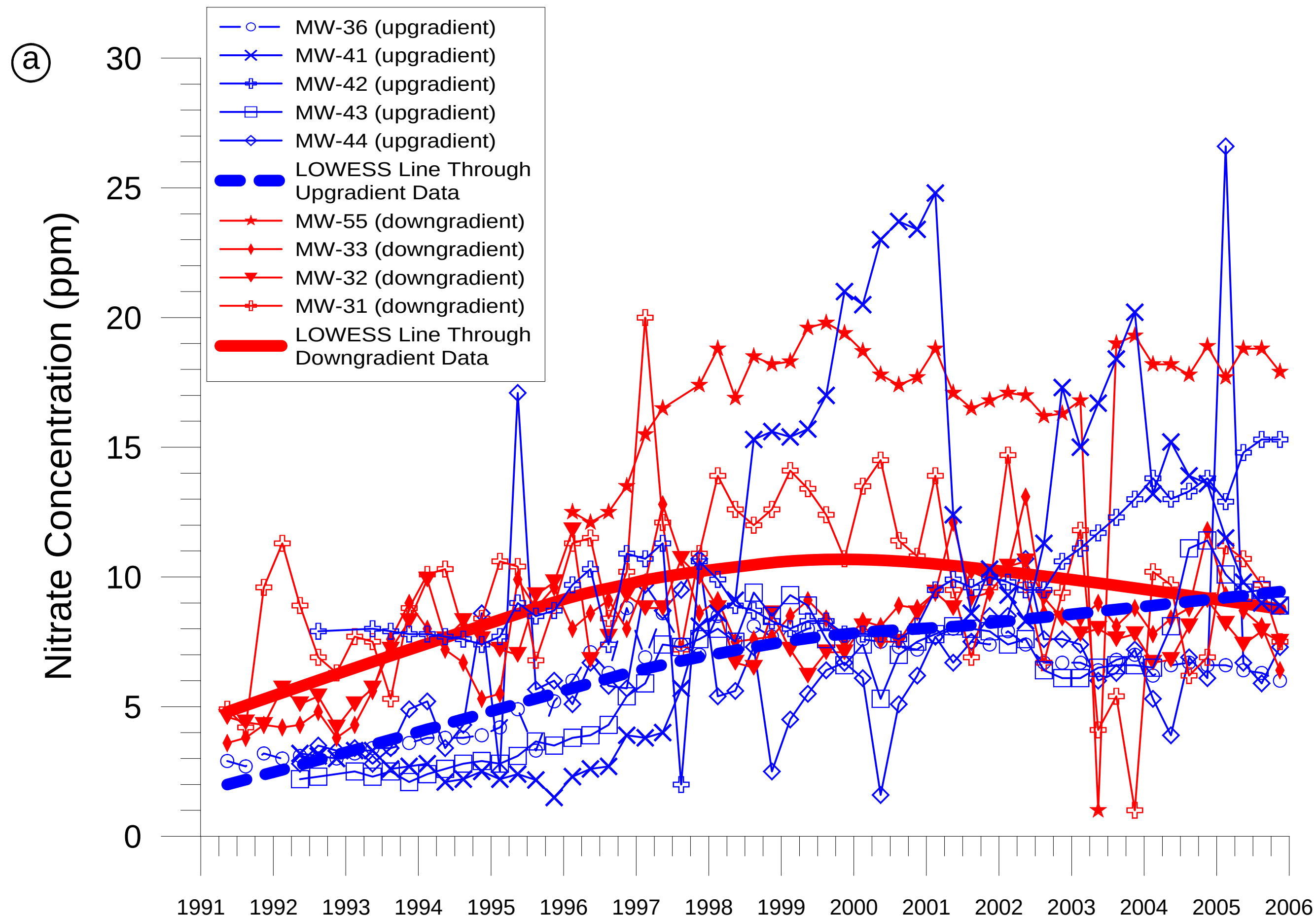
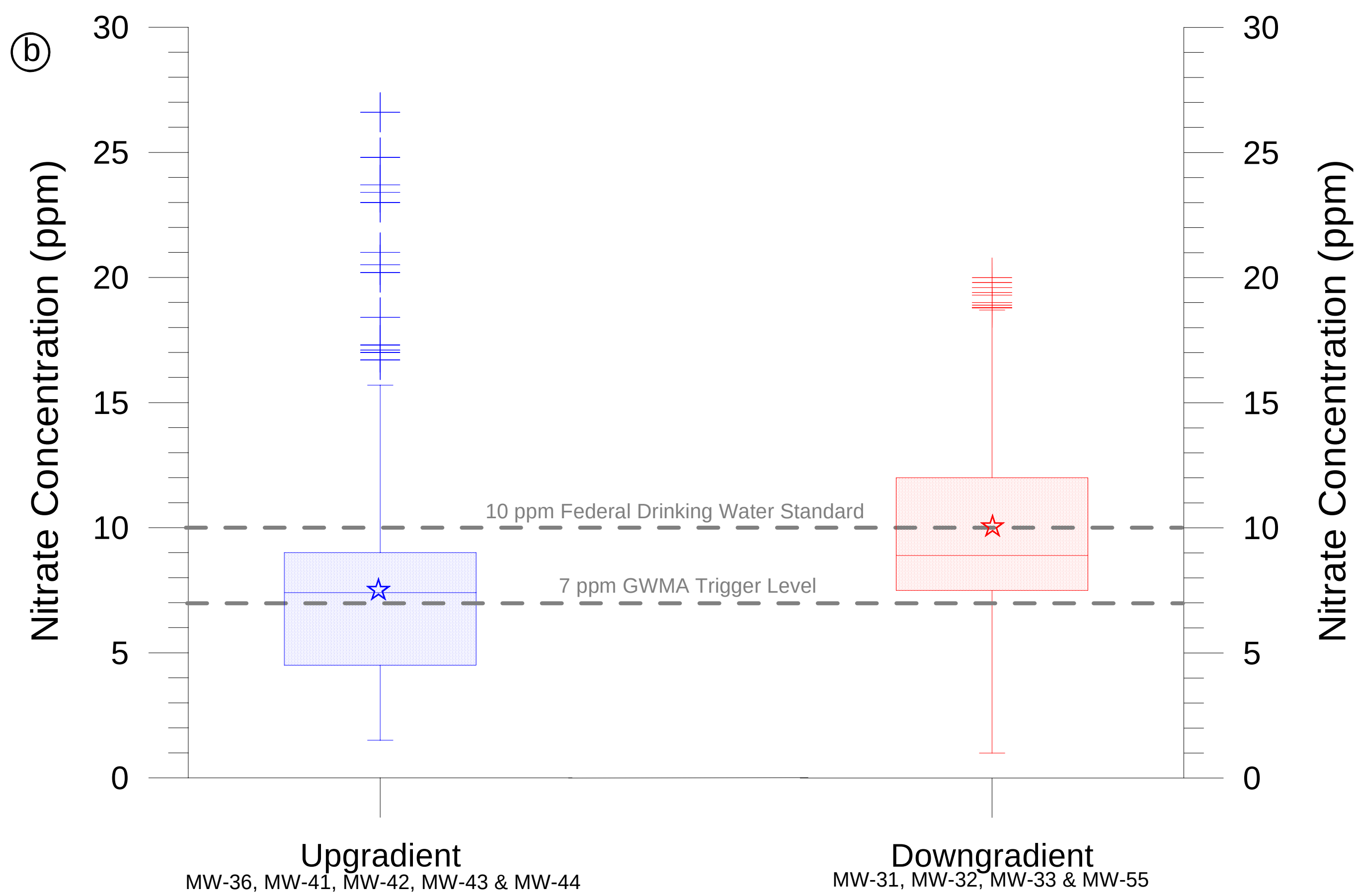


Figure 4-16
Upgradient vs. Downgradient Nitrate Comparisons - Simplot Expansion Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA





e: lub landapp simplot up vs dn expansion.grf

Figure 4-17
Second Quarter 2005 Water Levels - Simplot Levy Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

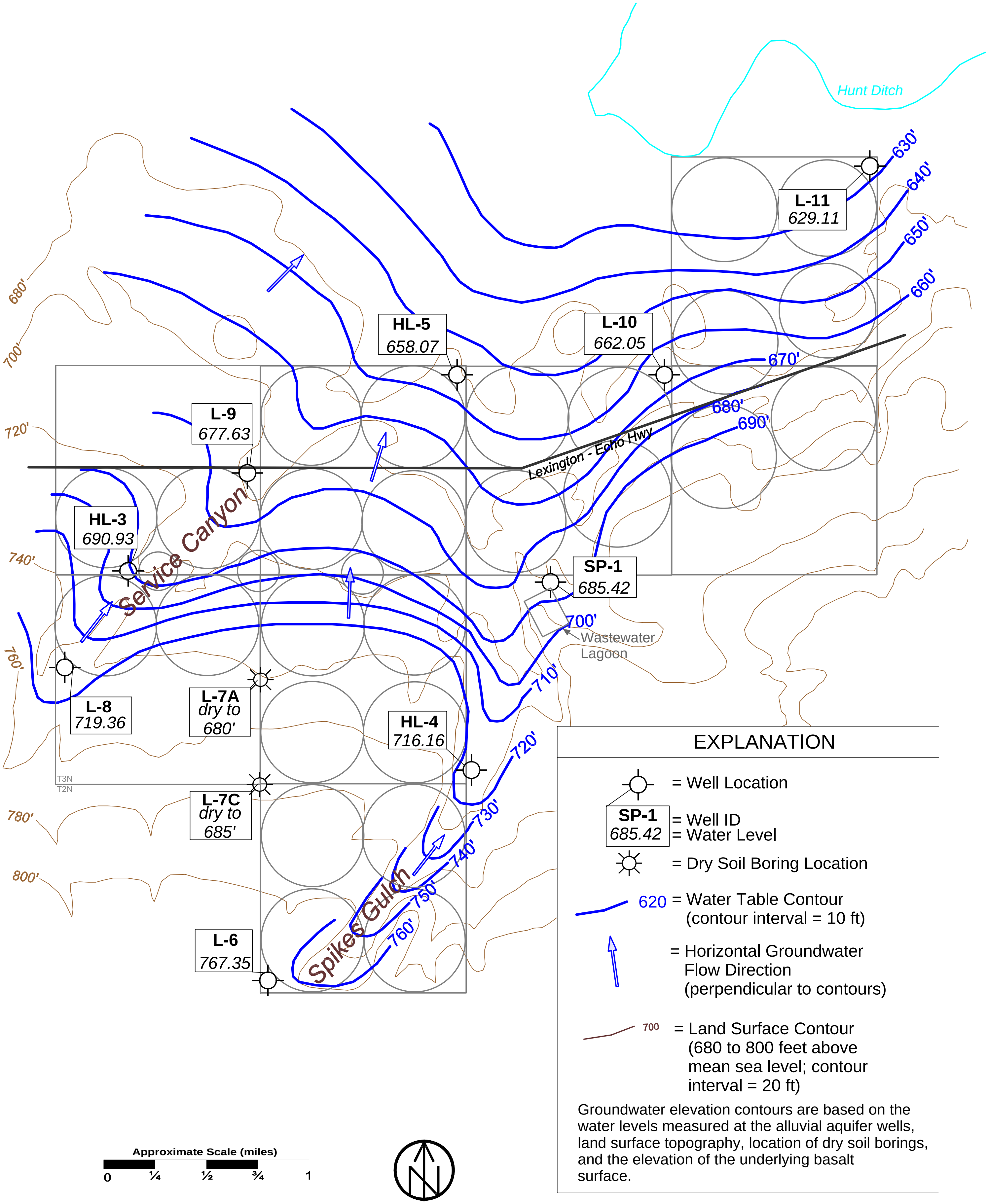
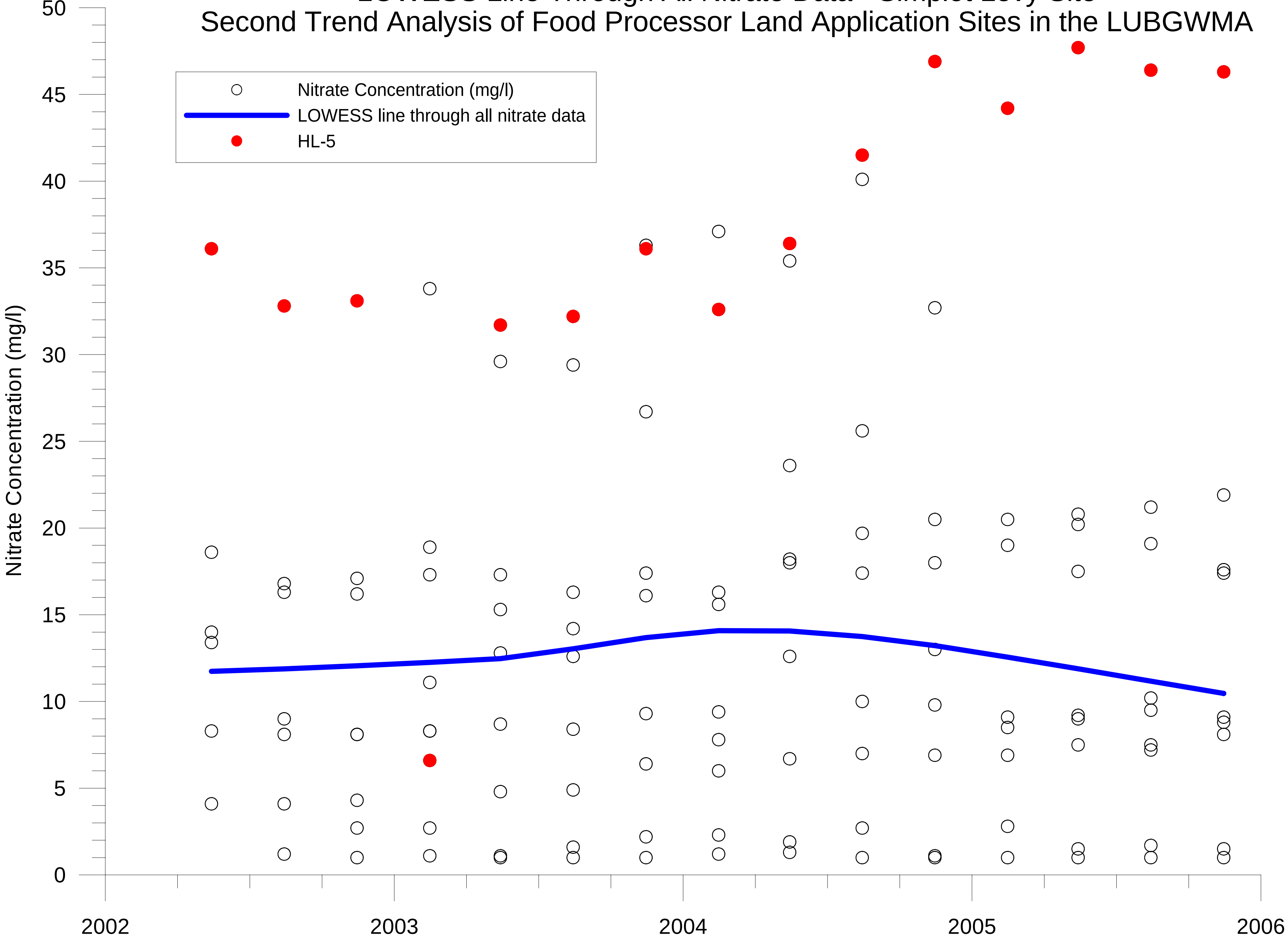
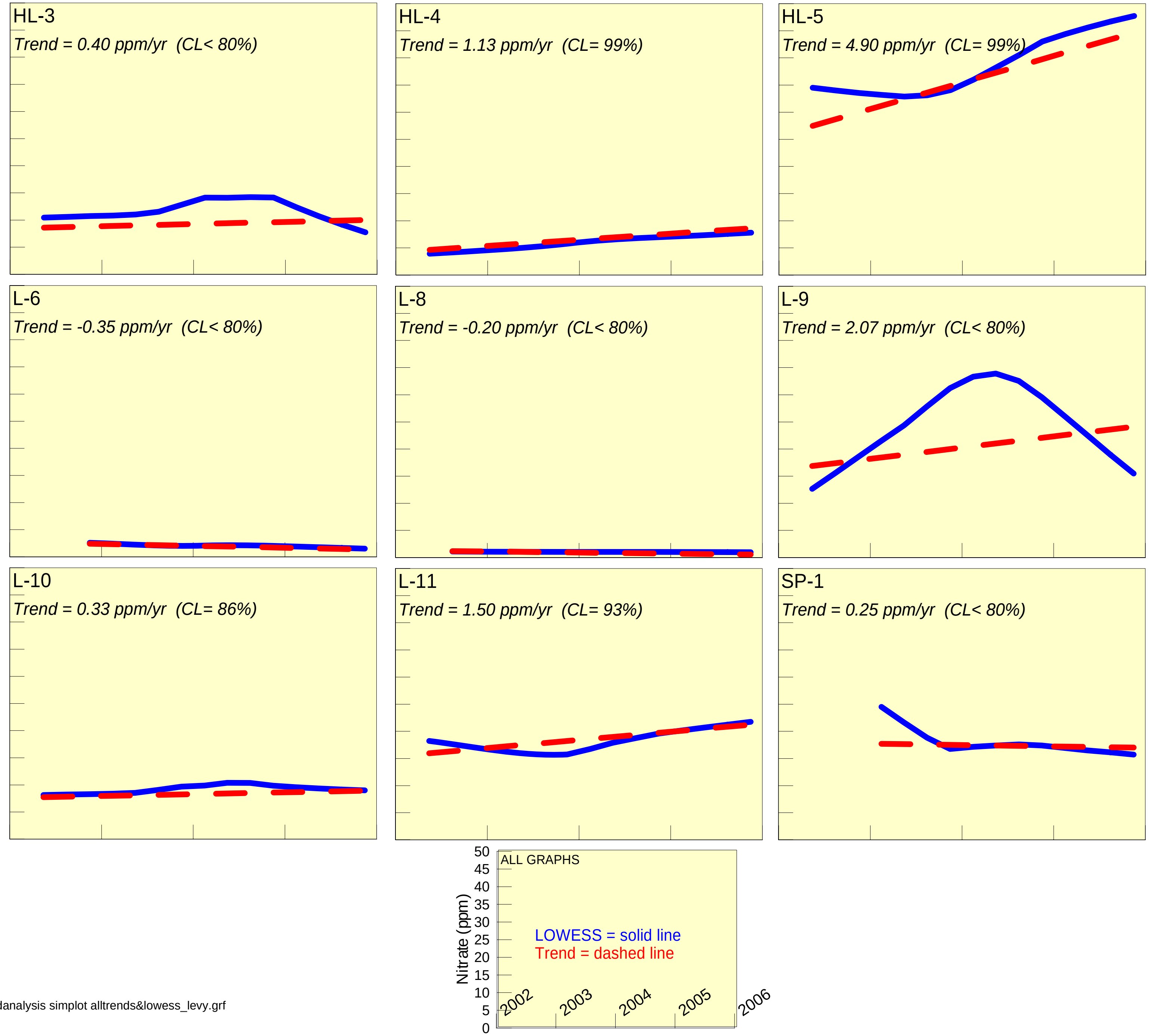


Figure 4-18
LOWESS Line Through All Nitrate Data - Simplot Levy Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp 2006trendanalysis simplot alldatalevysite.grf

Figure 4-19
LOWESS Lines and Trend Lines Through Nitrate Data - Simplot Levy Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp 2006trendanalysis simplot alltrends&lowess_levy.grf

Figure 4-20
Nitrate Trends - Simplot Levy Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

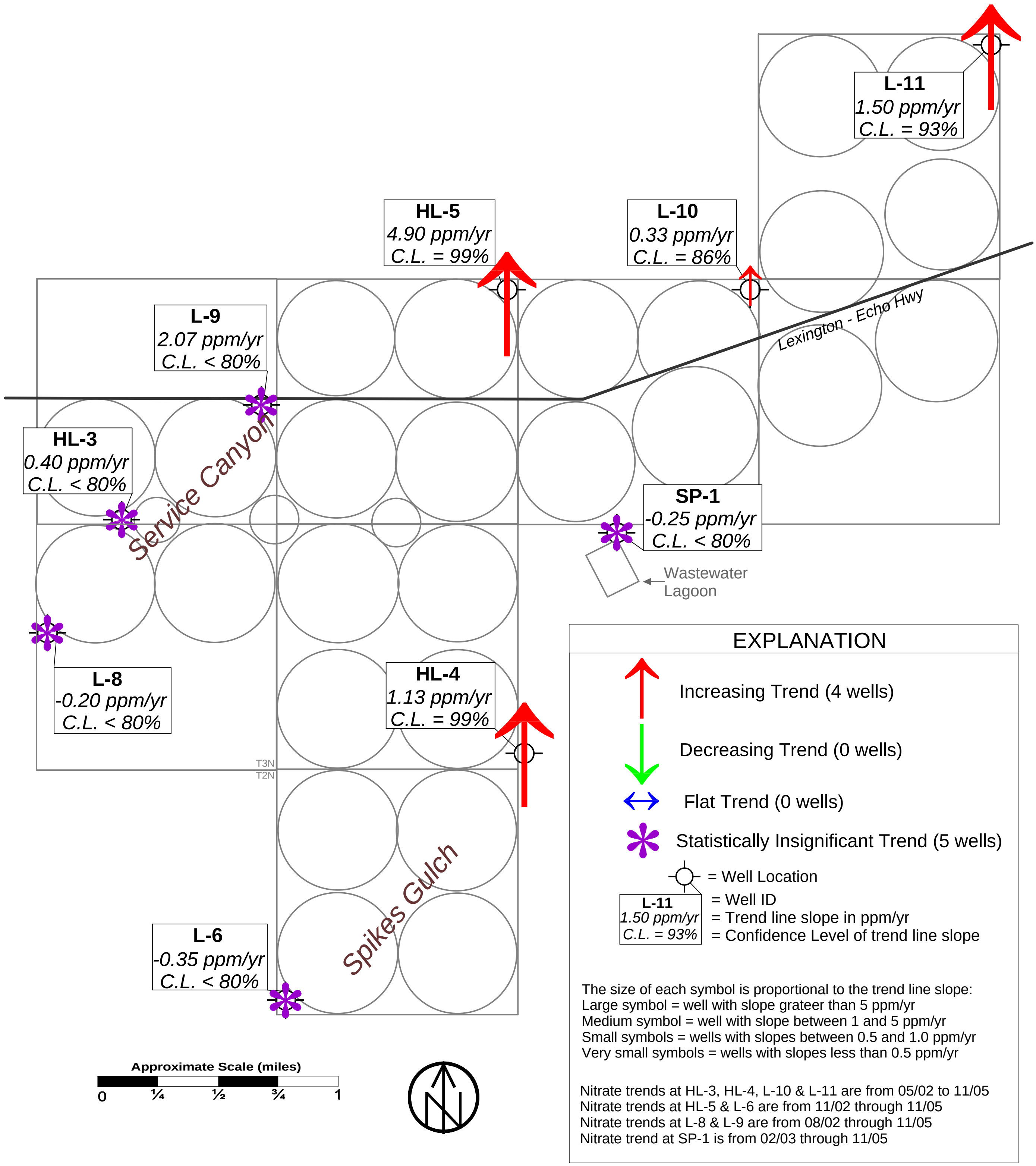


Figure 4-21
Average Nitrate Concentrations - Simplot Levy Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

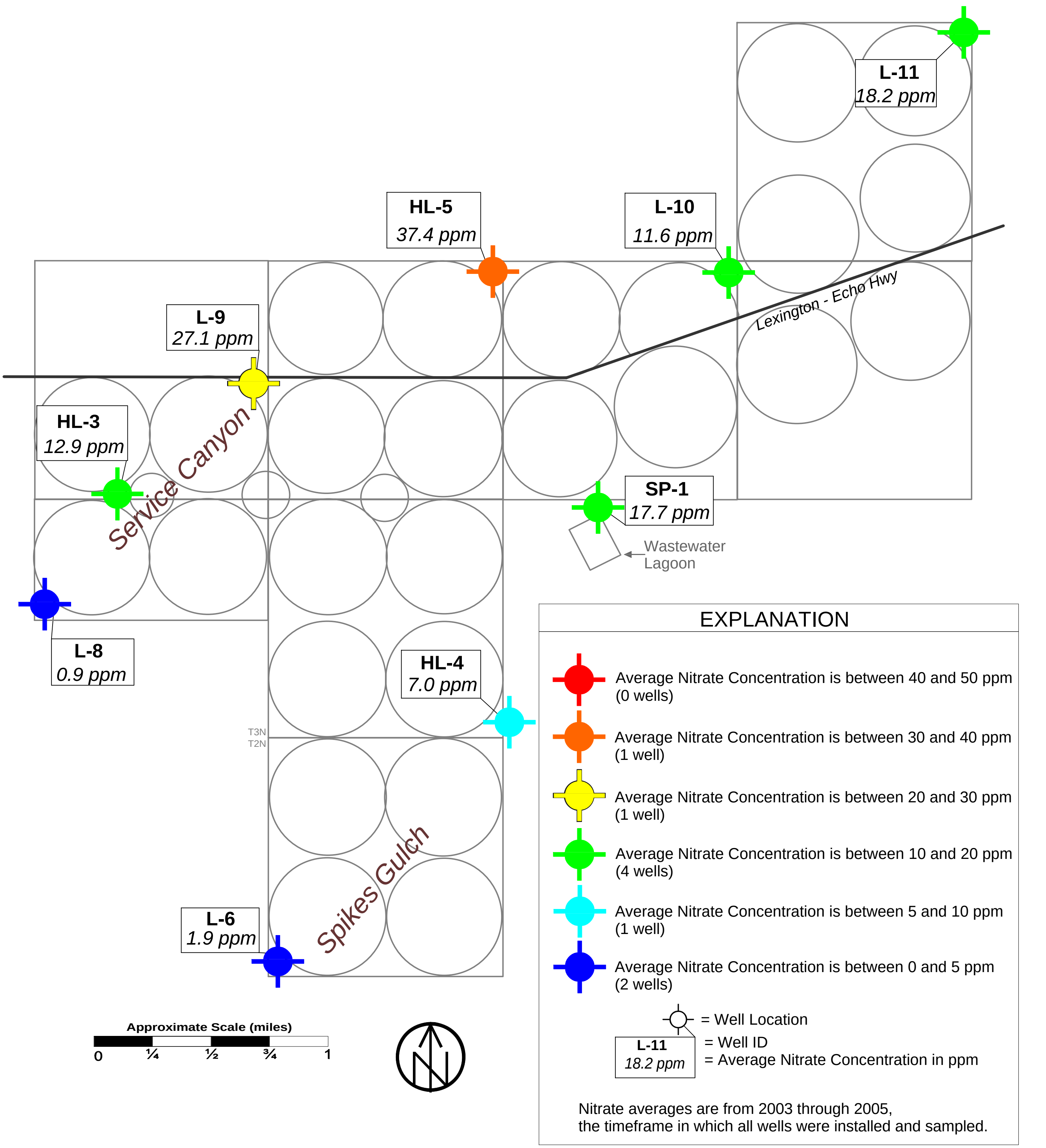
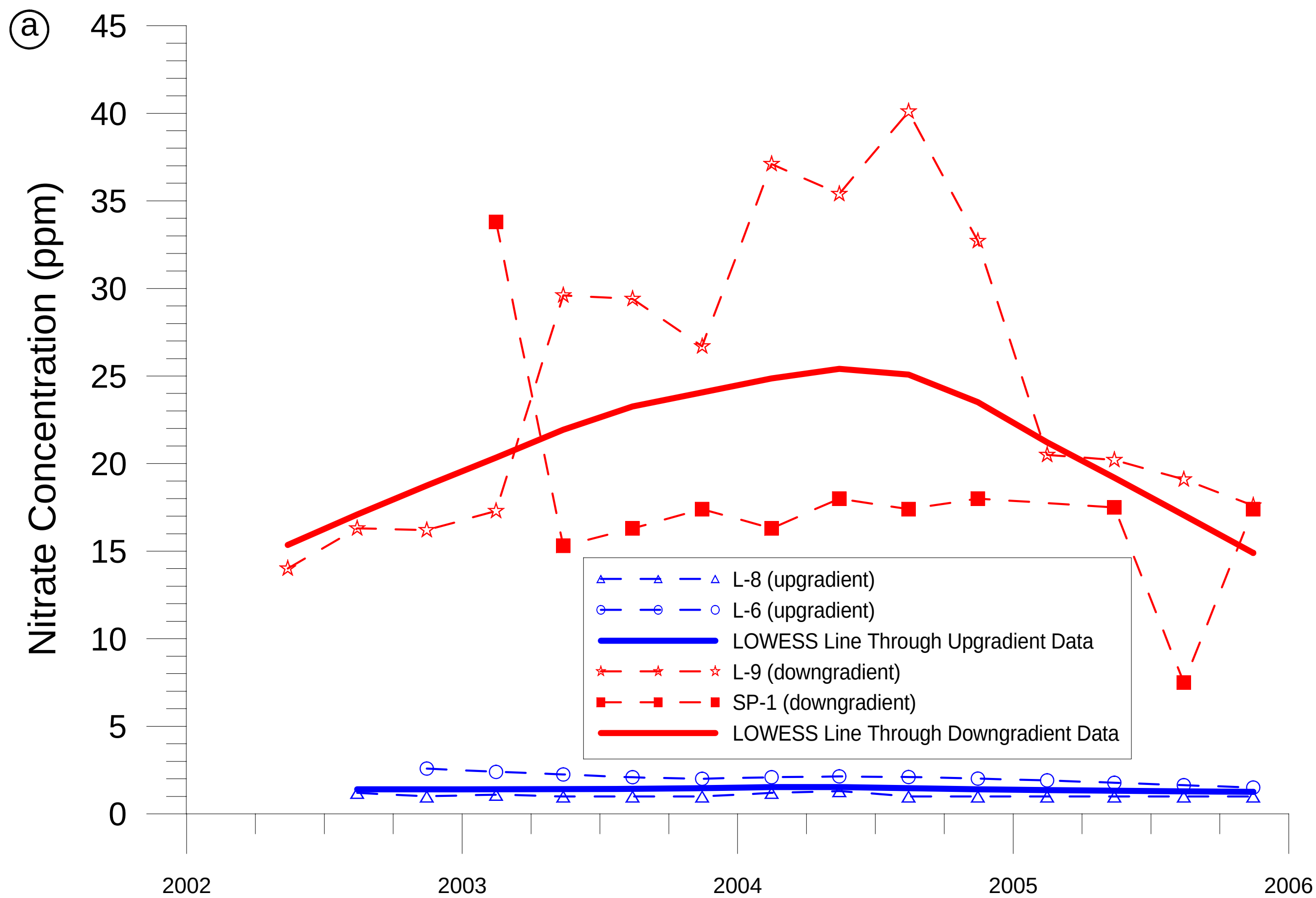
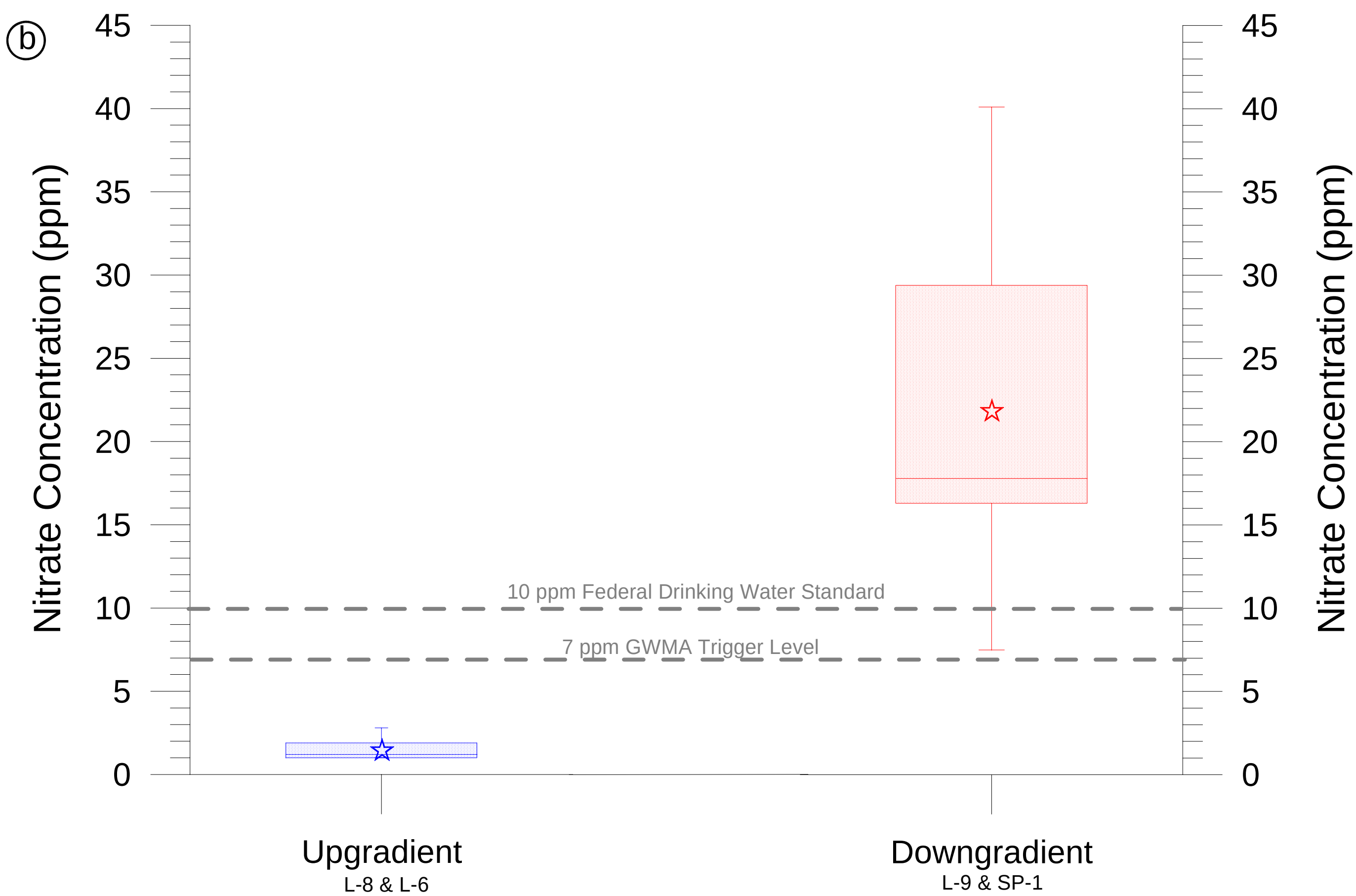


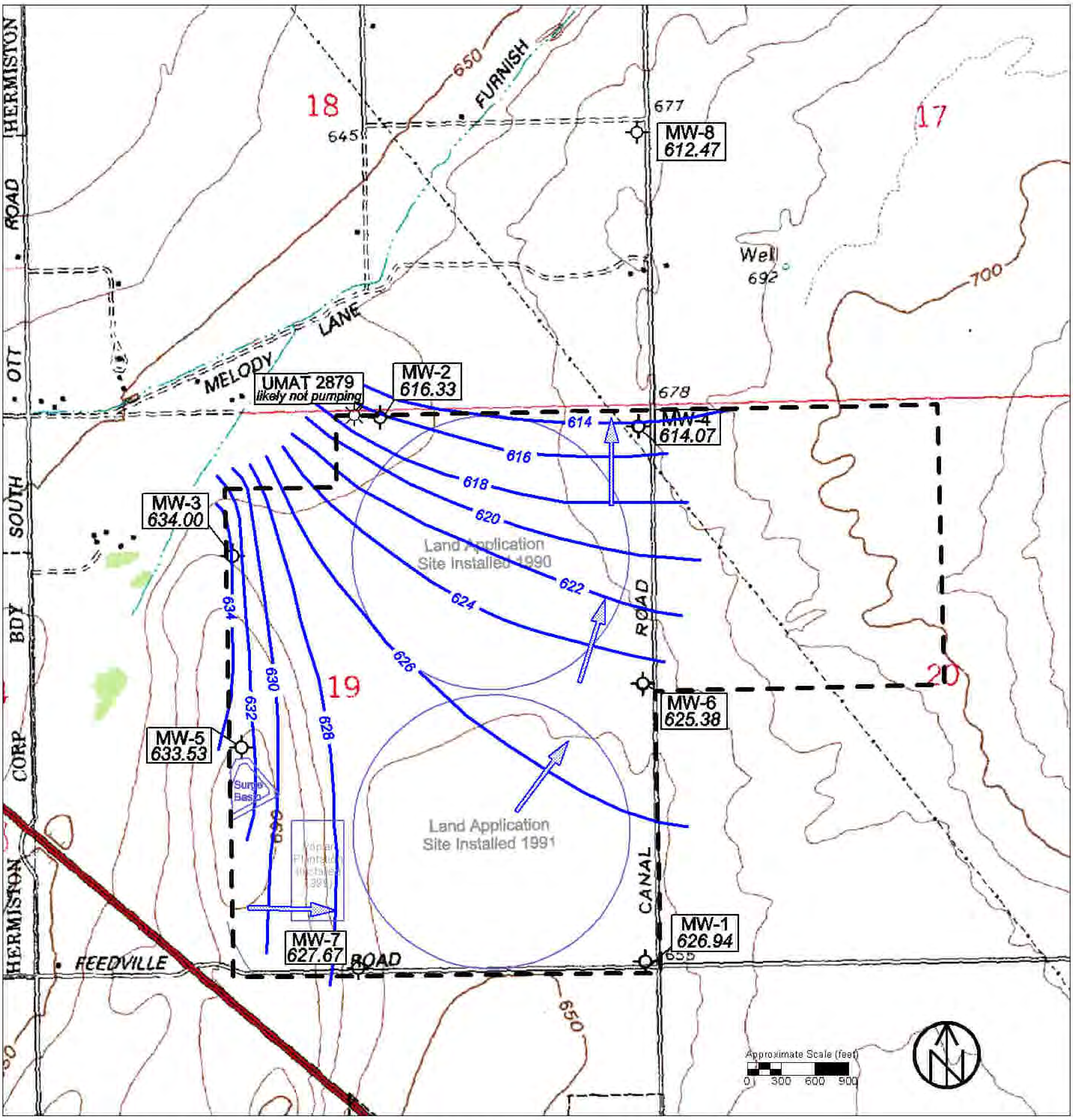
Figure 4-22
Upgradient vs. Downgradient Nitrate Comparisons - Simplot Levy Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA





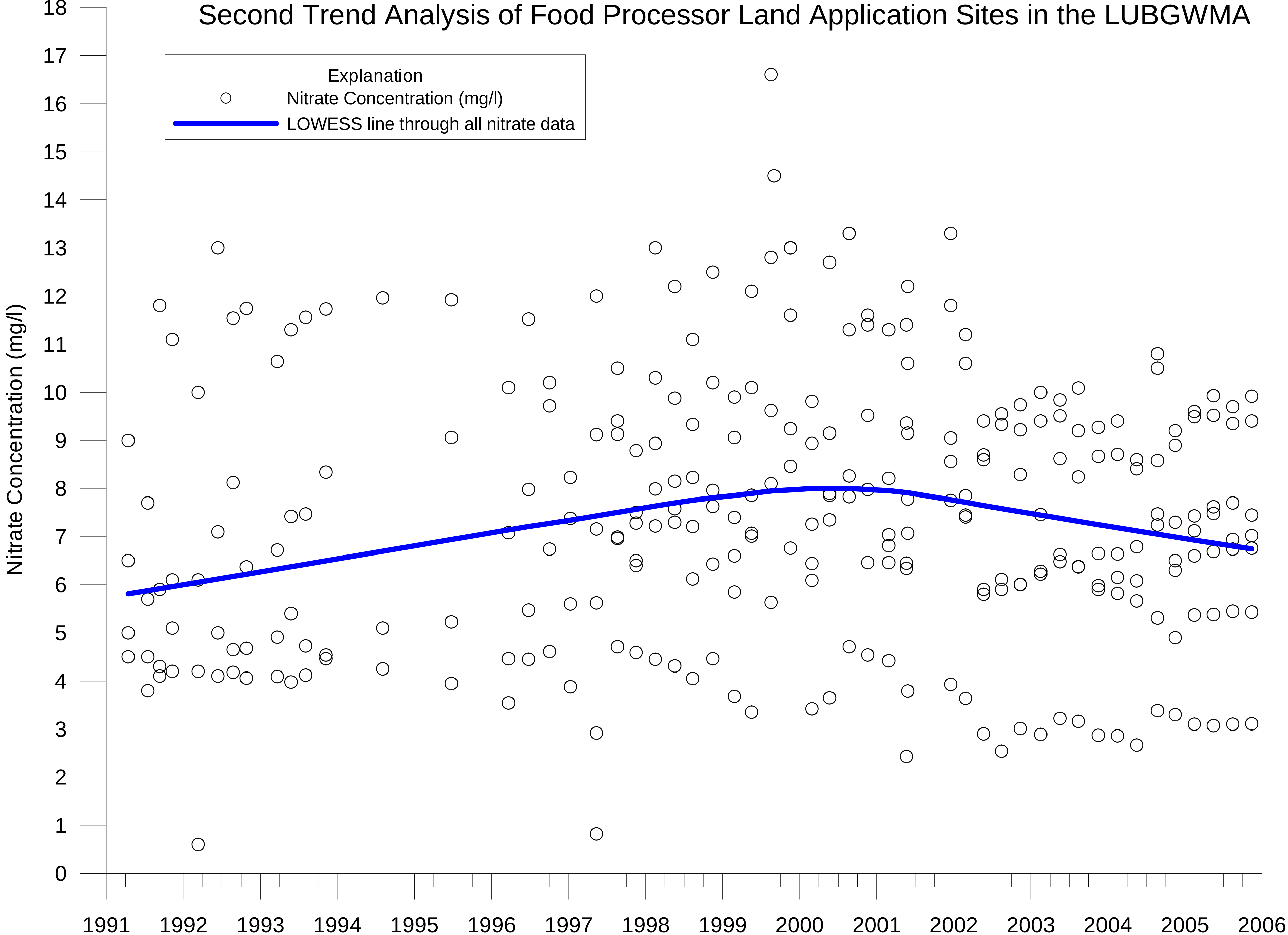
e: lub landapp 2006trendanalysis simplot upvsdnLevy.grf

Figure 5-1
Potentiometric Surface Map - Hermiston Foods Site
Second Trend Analysis of Food Processor Land Application Sites in the LUB GWMA



Note: Water levels from January 27, 2005 were selected for this map because potential effects of groundwater pumping and canal leakage should be minimal.

Figure 5-2
LOWESS Line Through All Nitrate Data - Hermiston Foods Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp 2006trendanalysis hermiston foods all data.grf

Figure 5-3
LOWESS Lines and Trend Lines Through Nitrate Data - Hermiston Foods Site
Second Trend Analysis of Food Processor Land Application Sites in the LUB GWMA

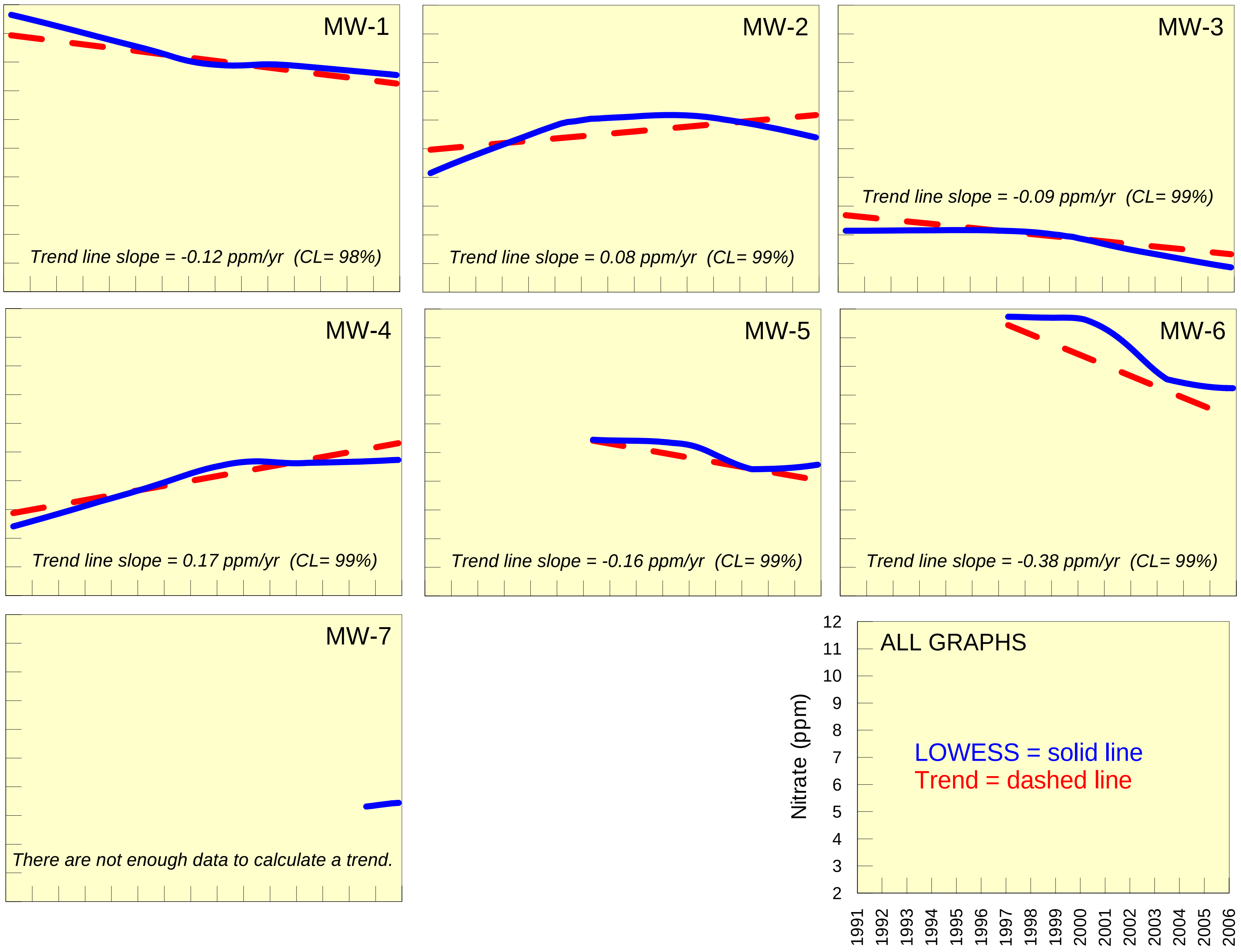


Figure 5-4
Nitrate Trends - Hermiston Foods Site
Second Trend Analysis of Food Processor Land Application Sites in the LUB GWMA

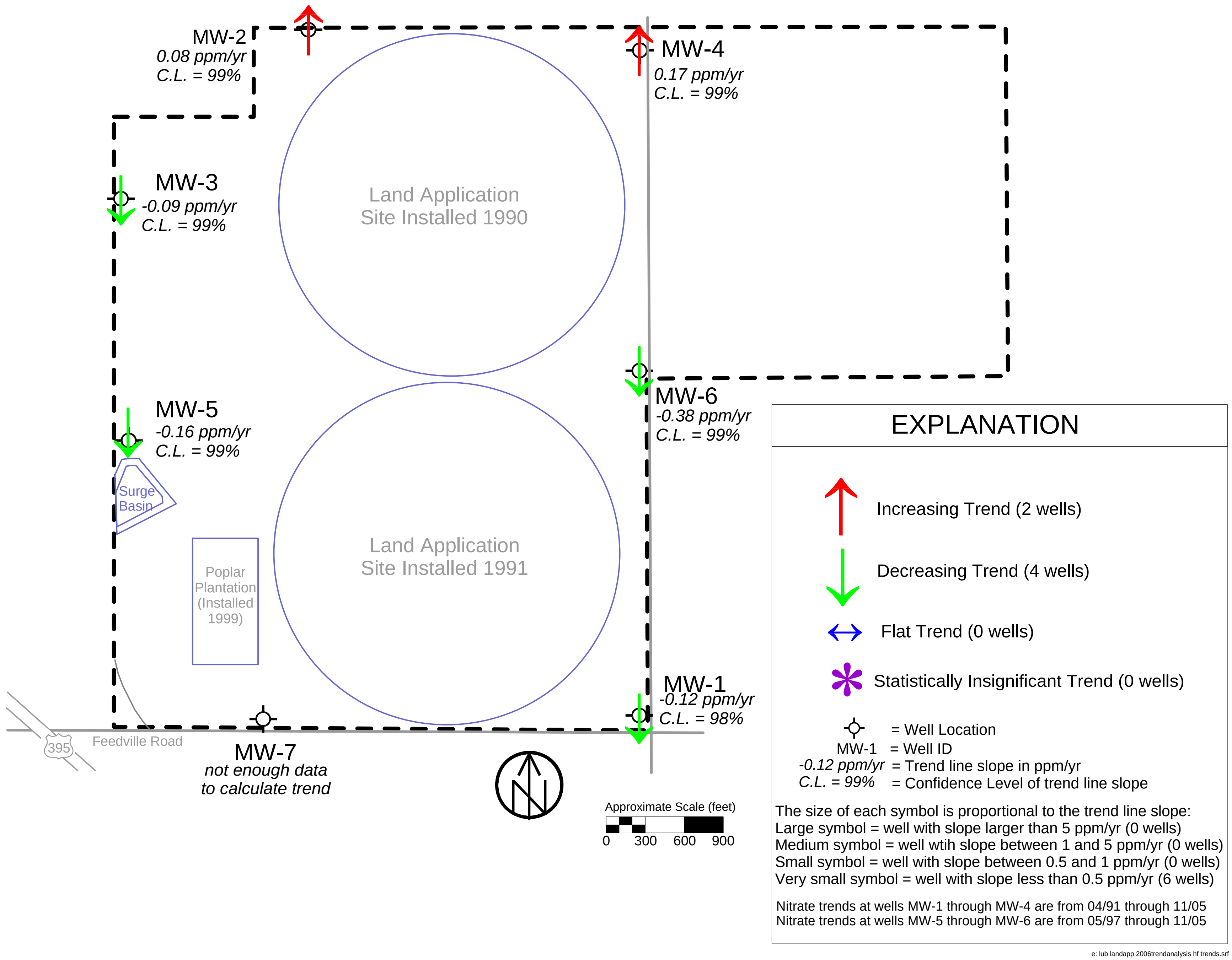
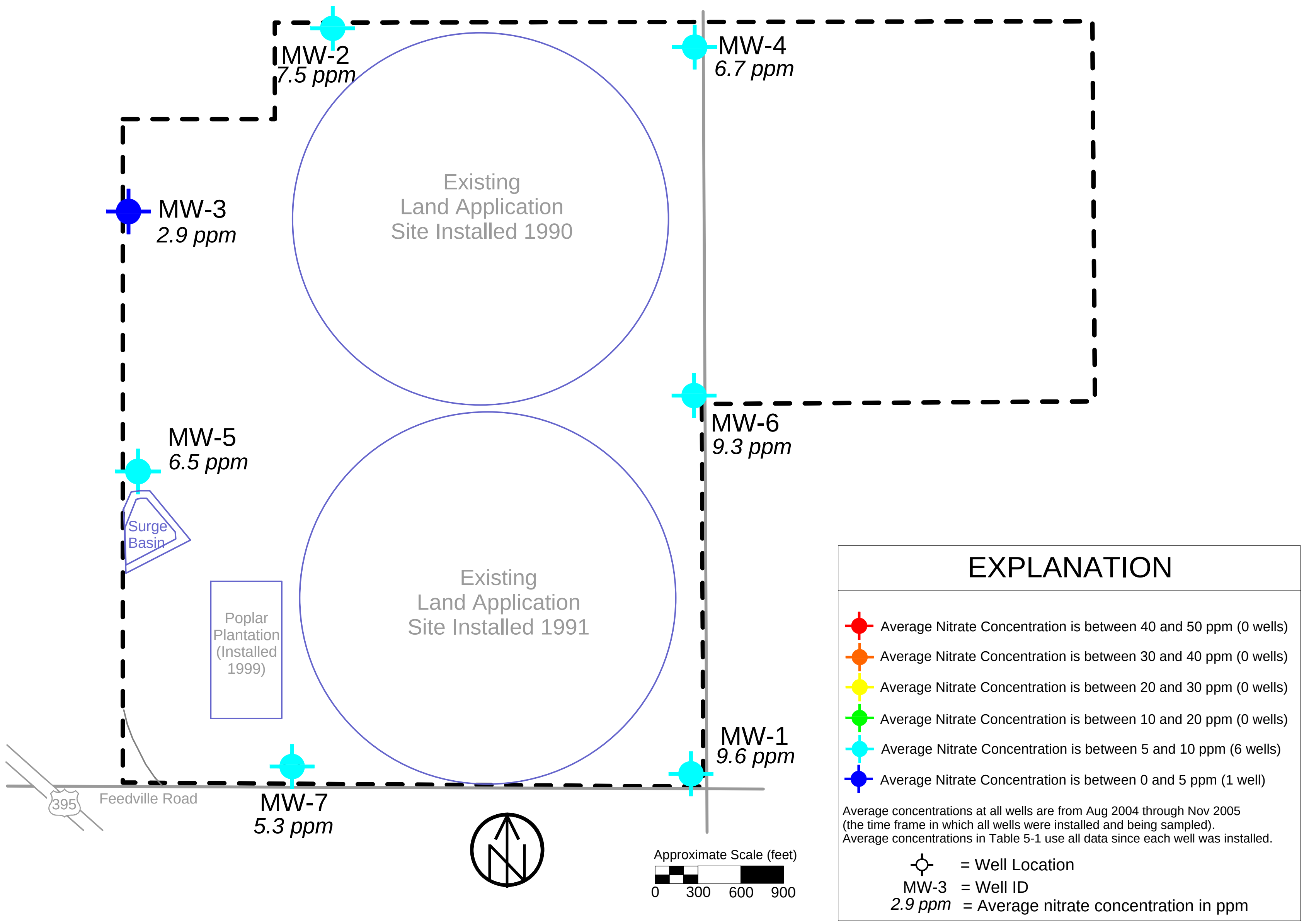
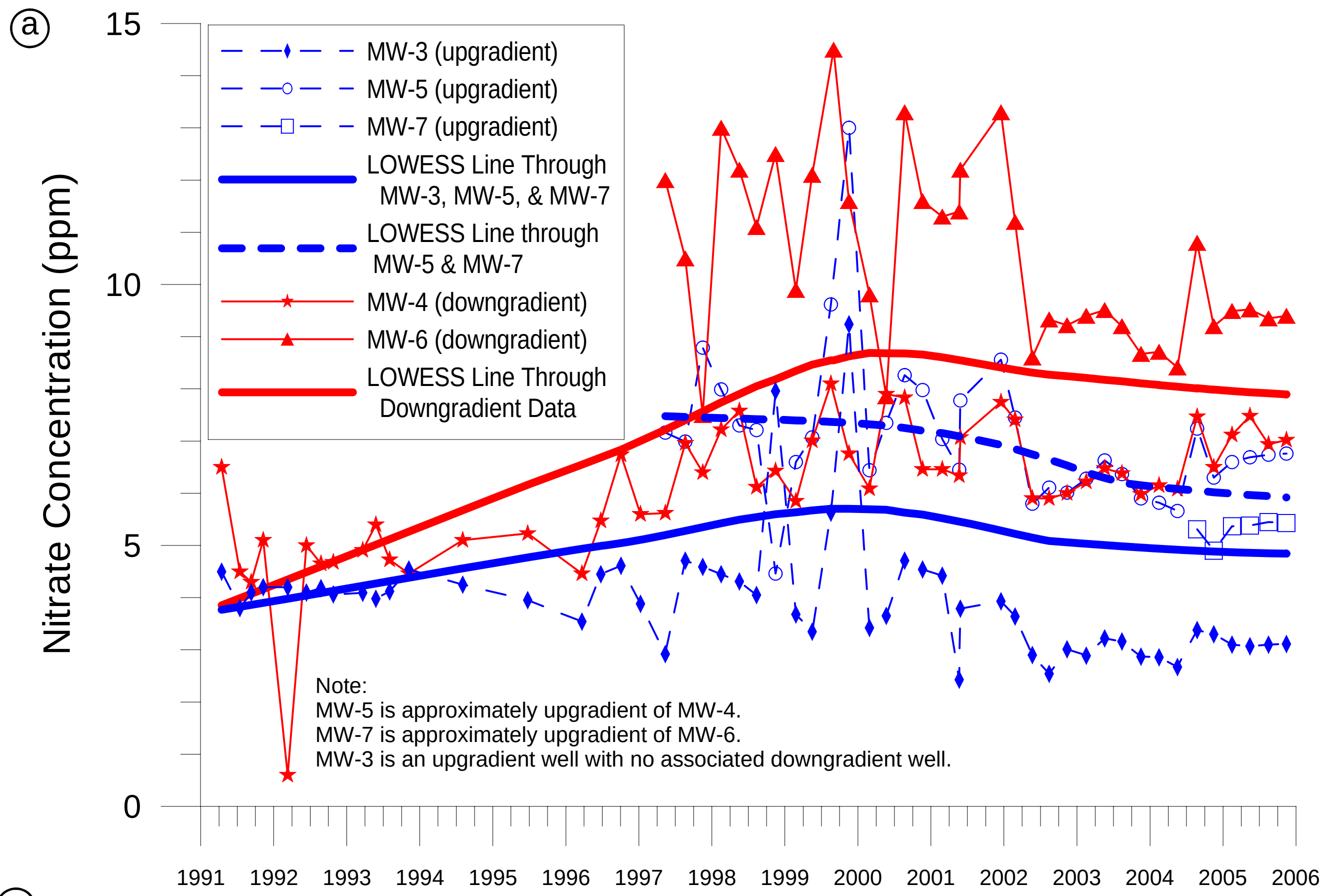


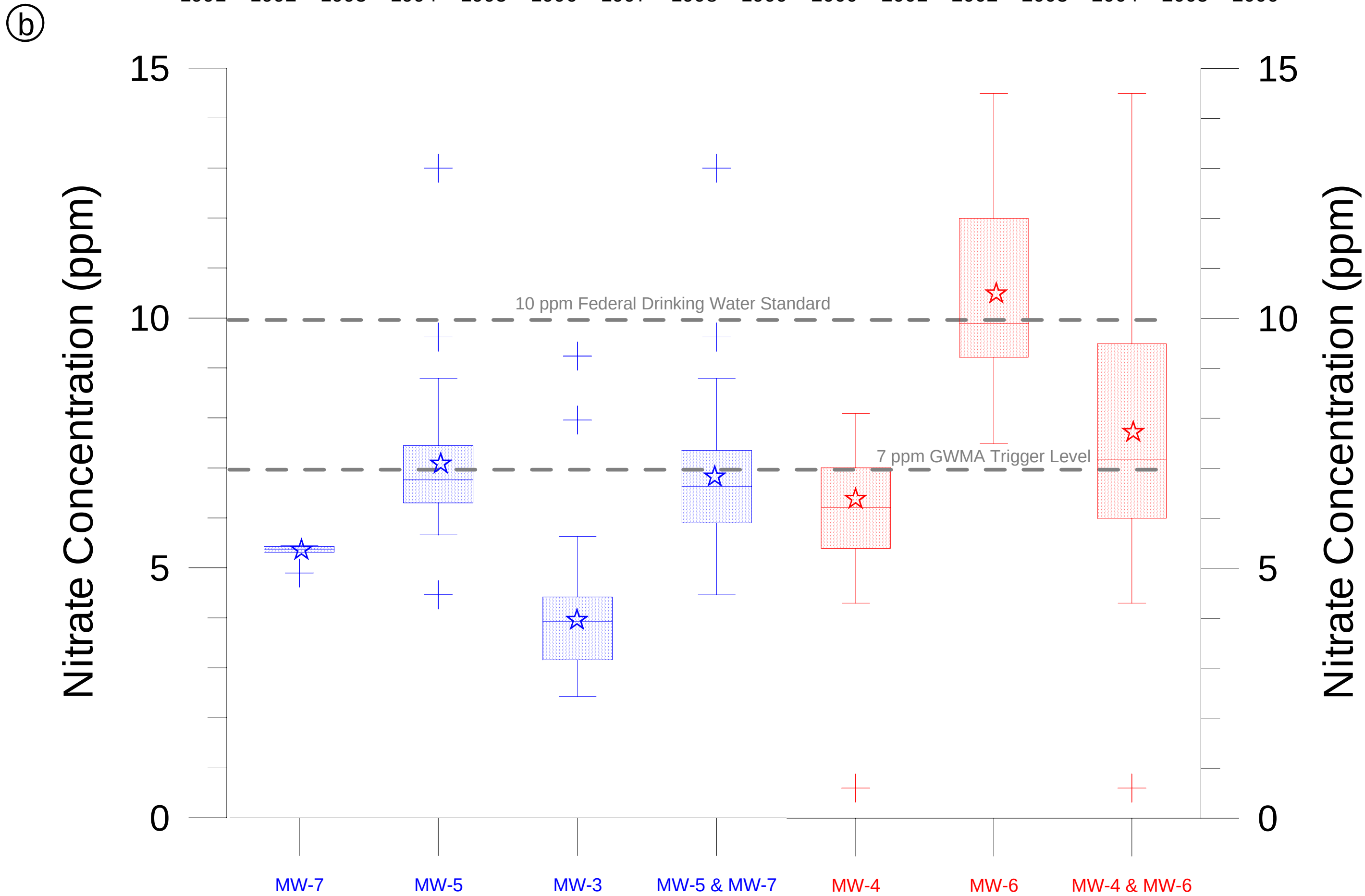
Figure 5-5
Average Nitrate Concentrations - Hermiston Foods Site
Second Trend Analysis of Food Processor Land Application Sites in the LUB GWMA



e: lub landapp 2006trendanalysis hf avg.srf

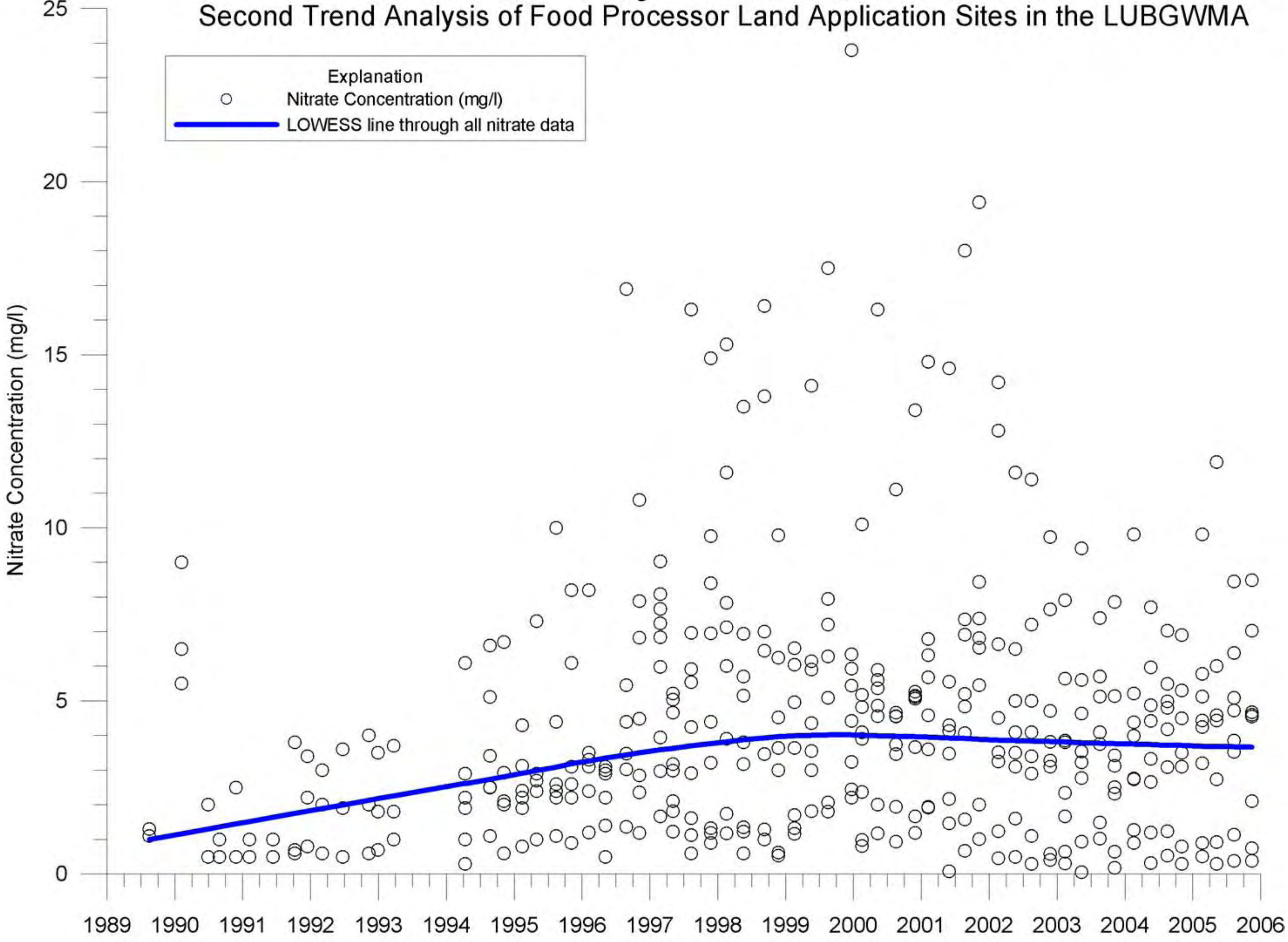
Figure 5-6
Upgradient vs. Downgradient Nitrate Comparisons - Hermiston Foods
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA





e: lub landapp 2006trendanalysis hf up vs dn.grf

Figure 6-1
LOWESS Line Through All Nitrate Data - MorStarch Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp 2006trendanalysis staley all data.grf

Figure 6-2
LOWESS Lines and Trend Lines Through Nitrate Data - MorStarch Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

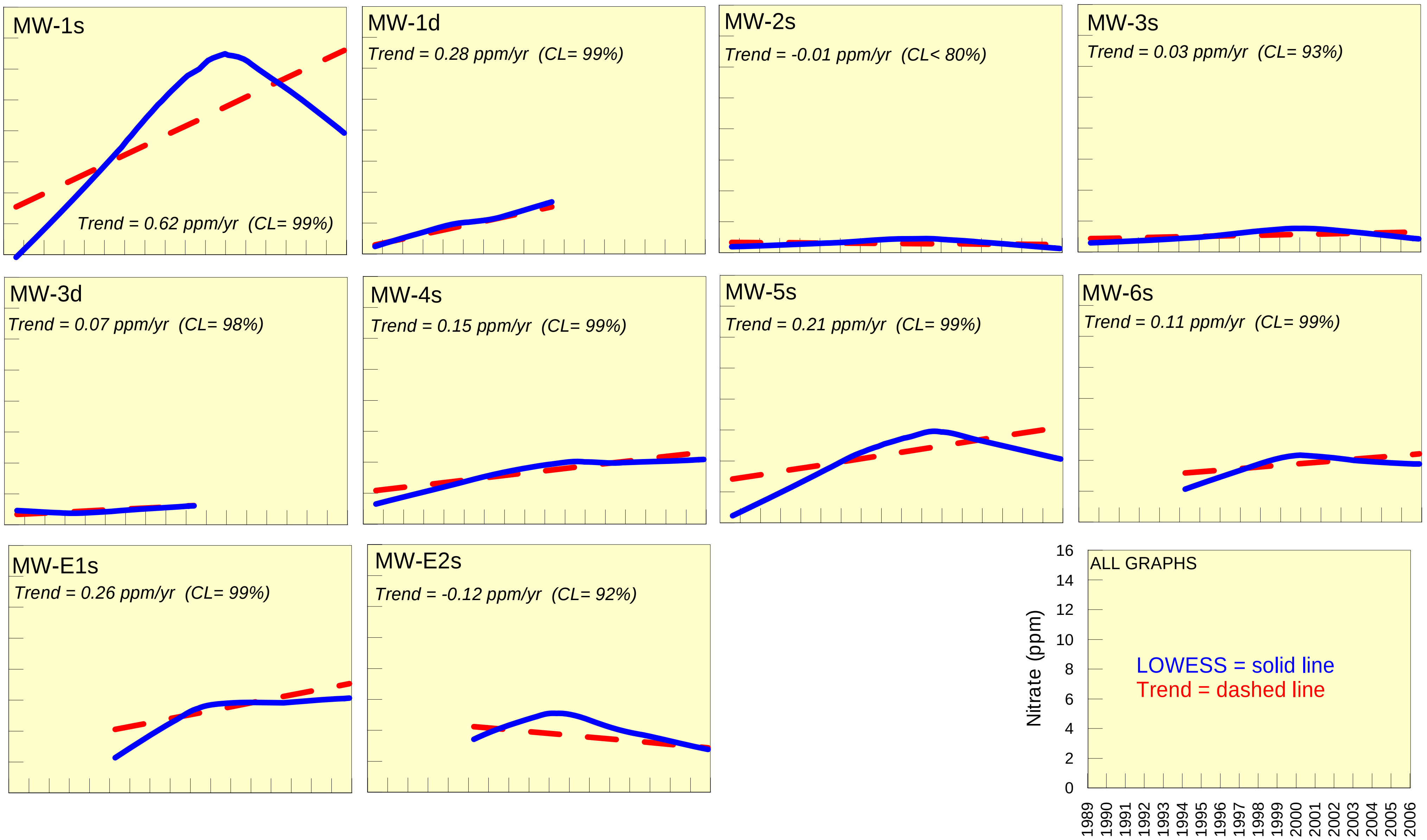


Figure 6-3
Nitrate Trends - MorStarch Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

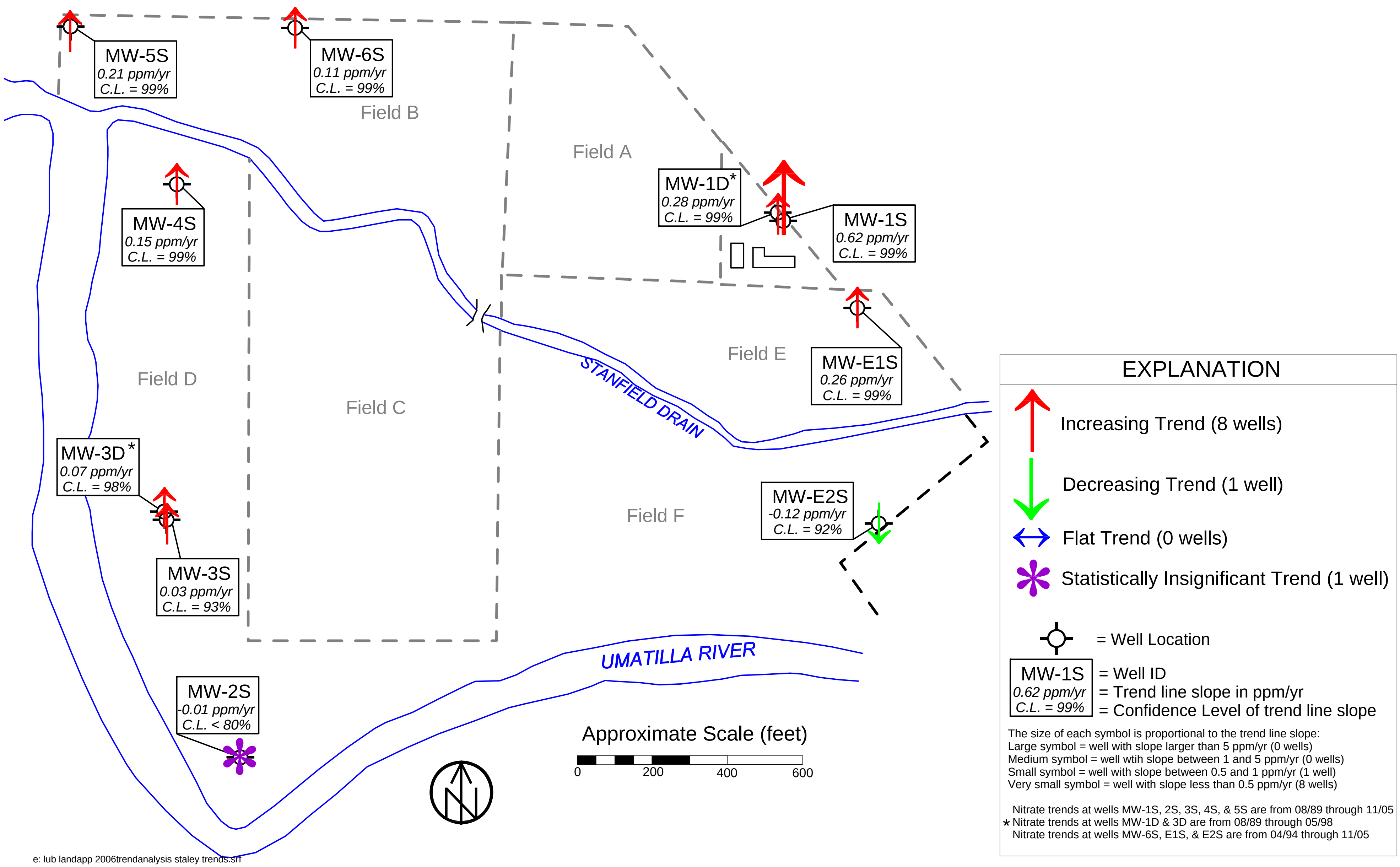


Figure 6-3
Nitrate Trends - MorStarch Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

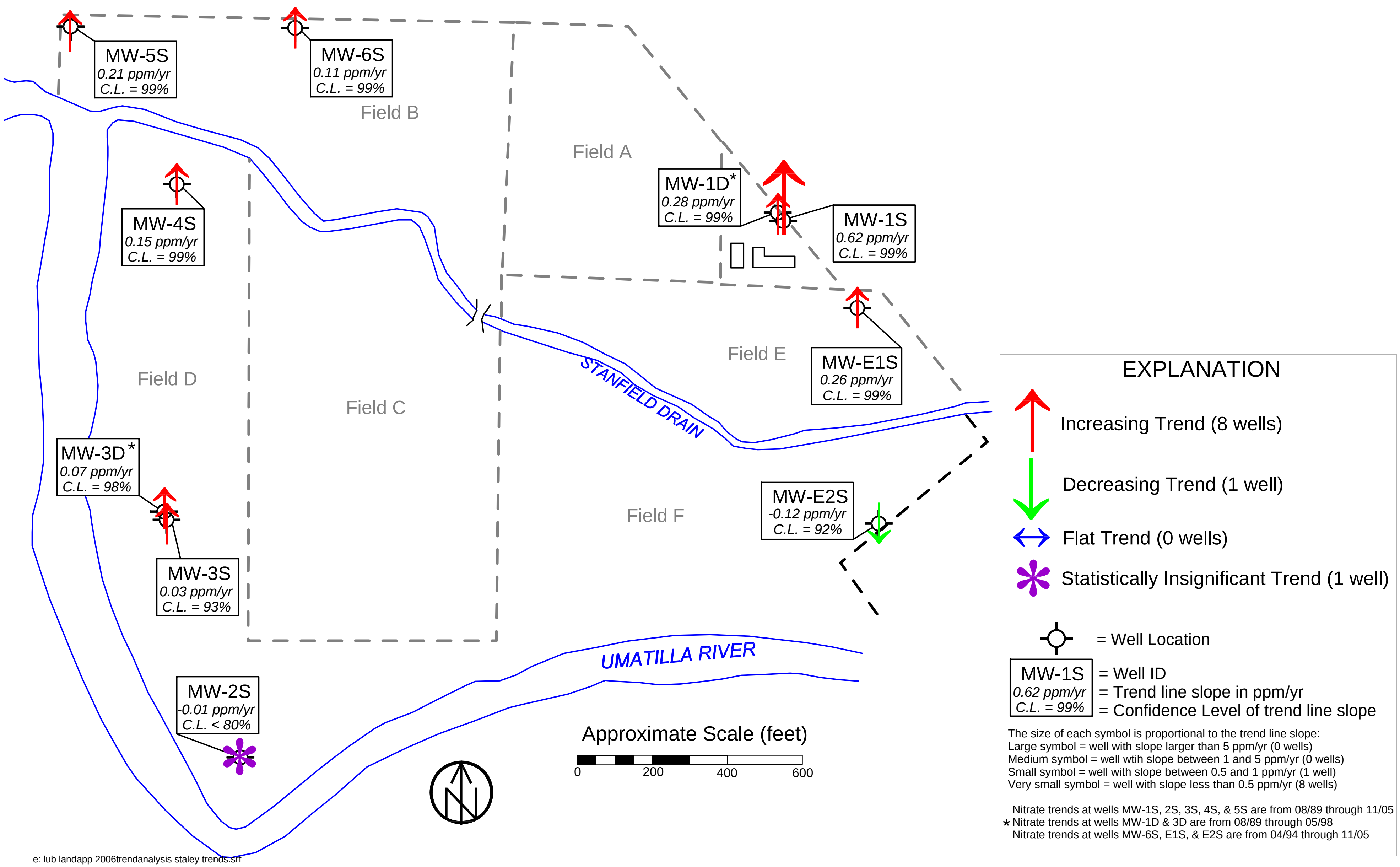
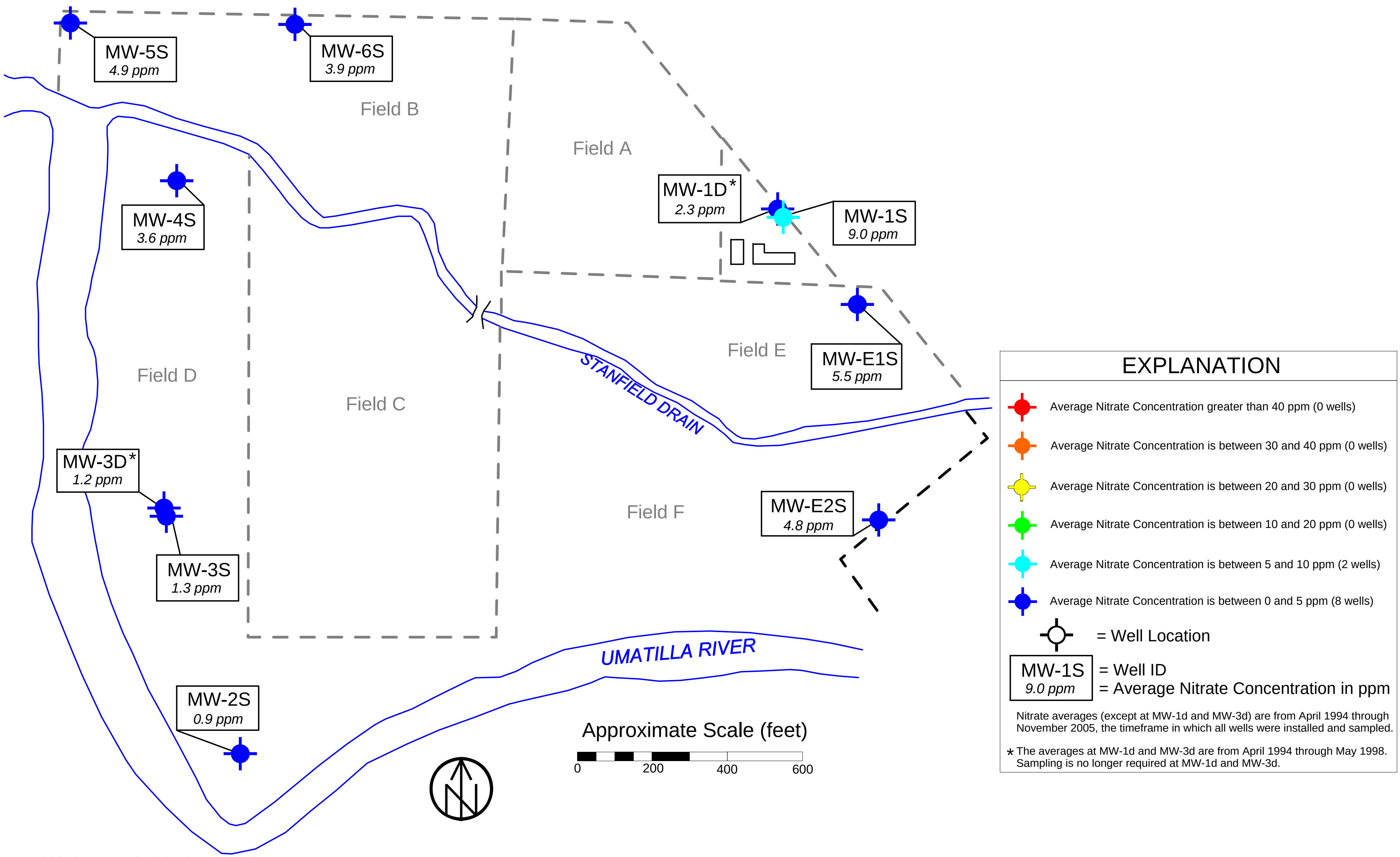
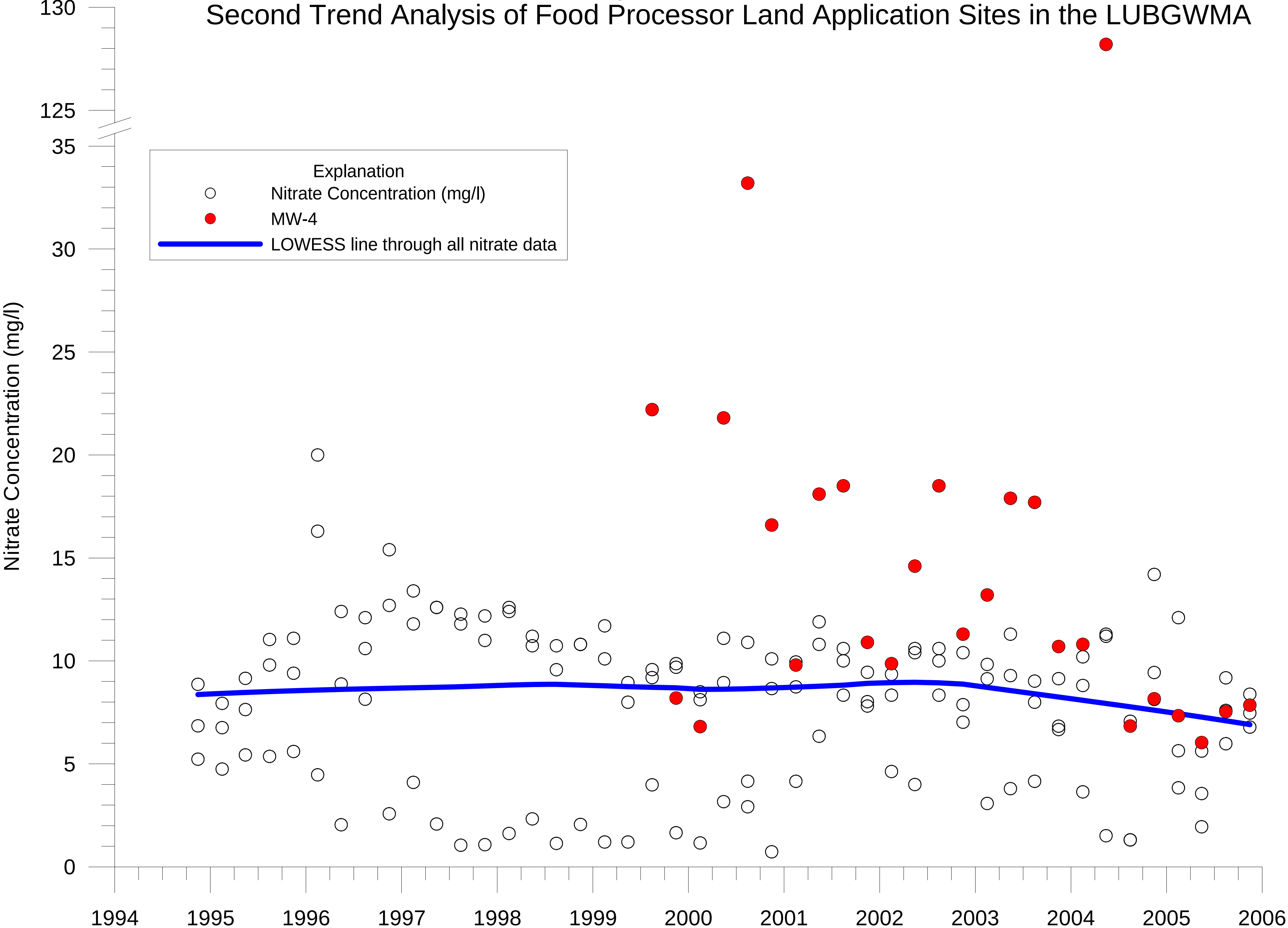


Figure 6-4
Average Nitrate Concentrations - MorStarch Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp 2006trendanalysis staley averages.srf

Figure 7-1
LOWESS Line Through All Nitrate Data - Snack Alliance Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp 2006trendanalysis snackcorp all data.grf

Figure 7-2
LOWESS Lines and Trend Lines Through Nitrate Data - Snack Alliance Site
Second Trend Analysis of Food Processor Land Application Sites in the LUB GWMA

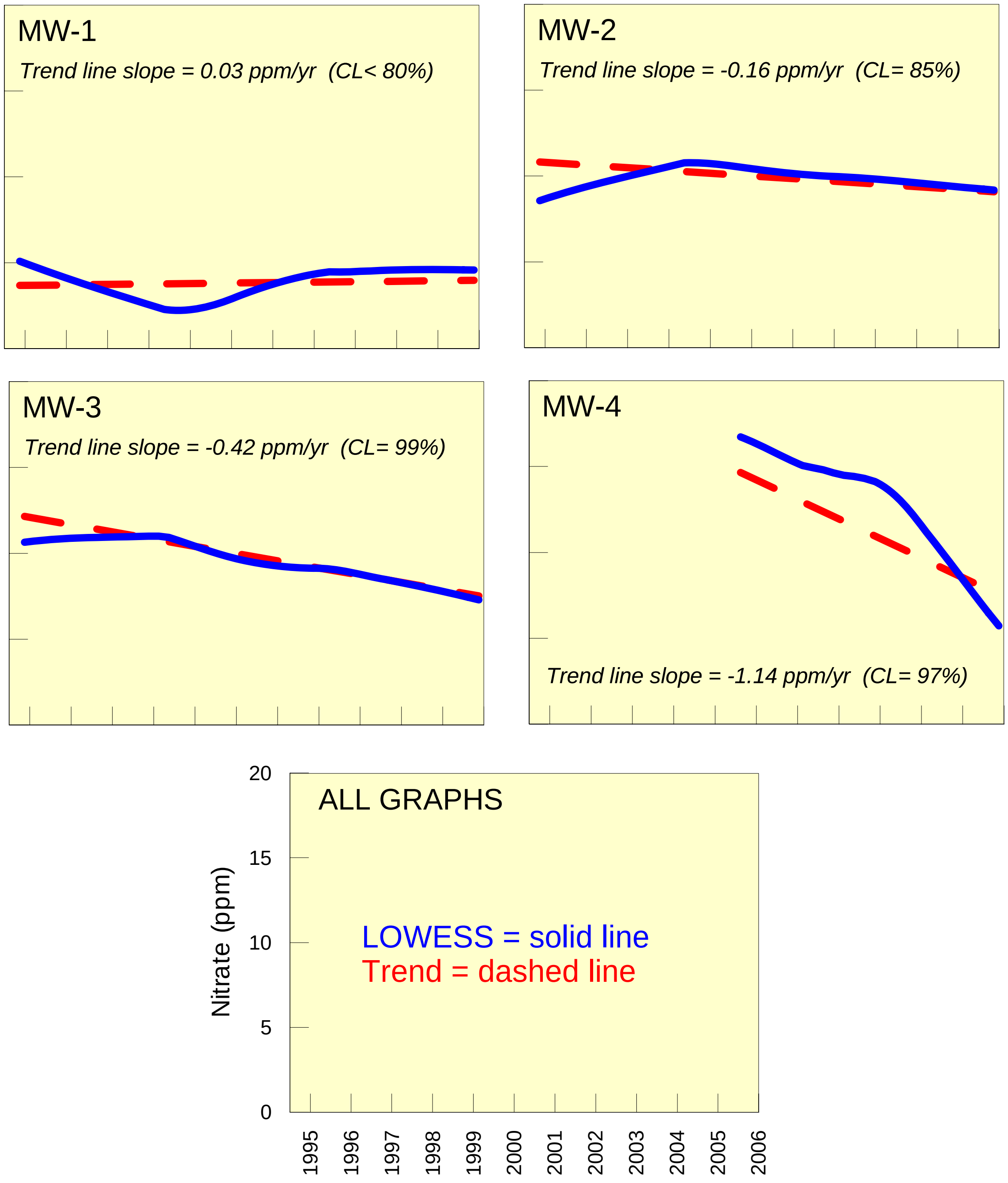


Figure 7-3
Nitrate Trends - Snack Alliance Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

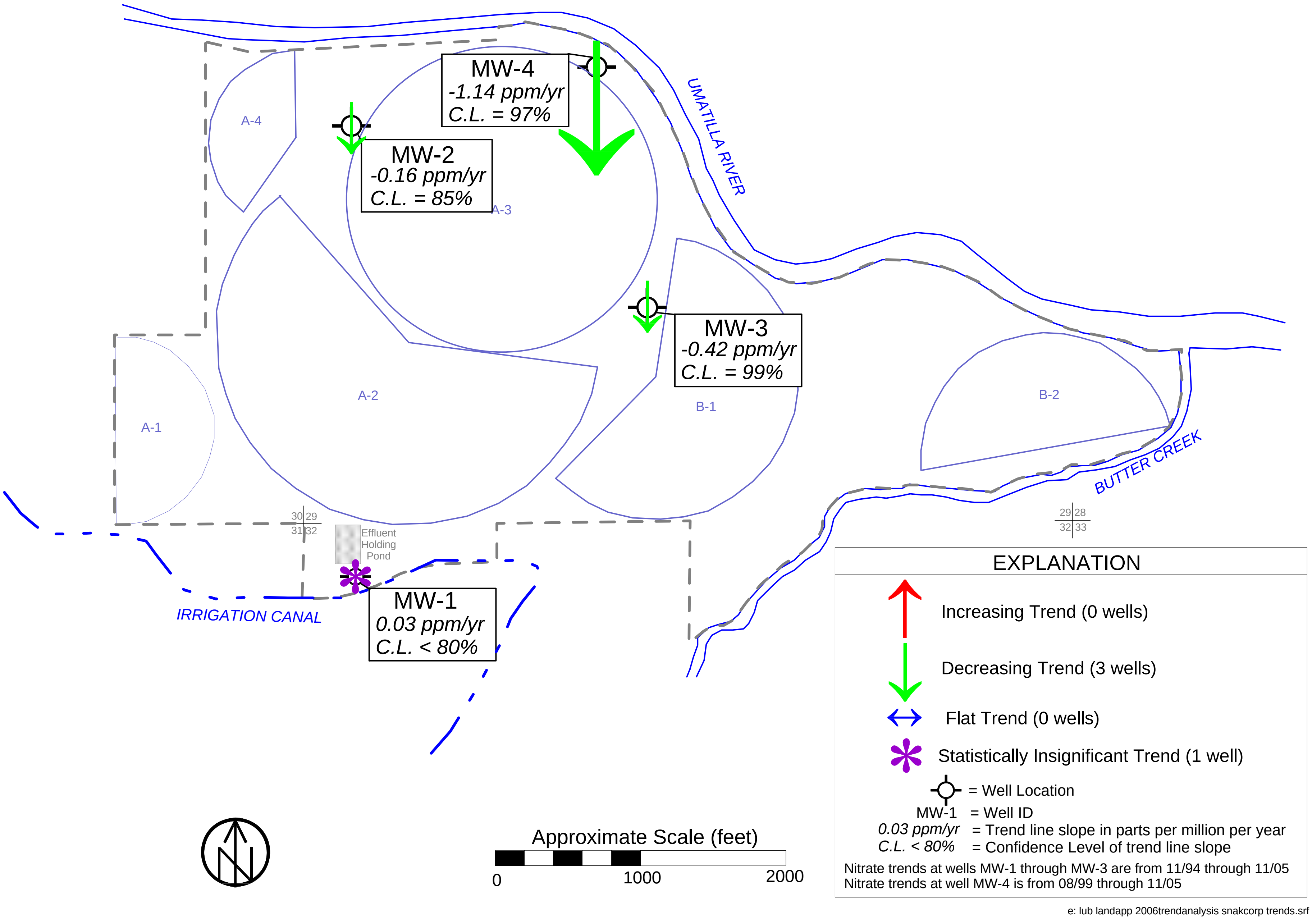


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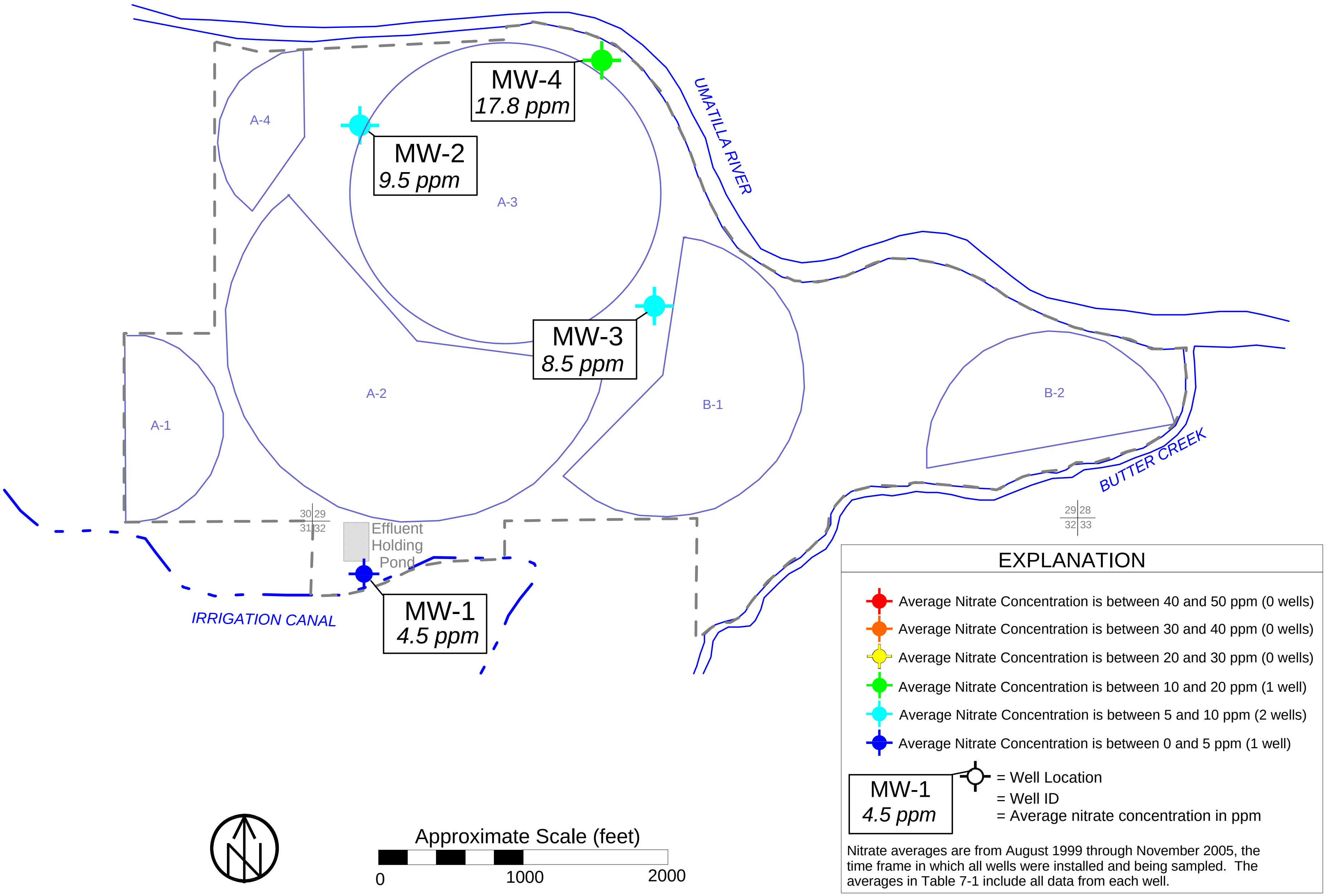
Figure 7-4
Average Nitrate Concentrations - Snack Alliance Site
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

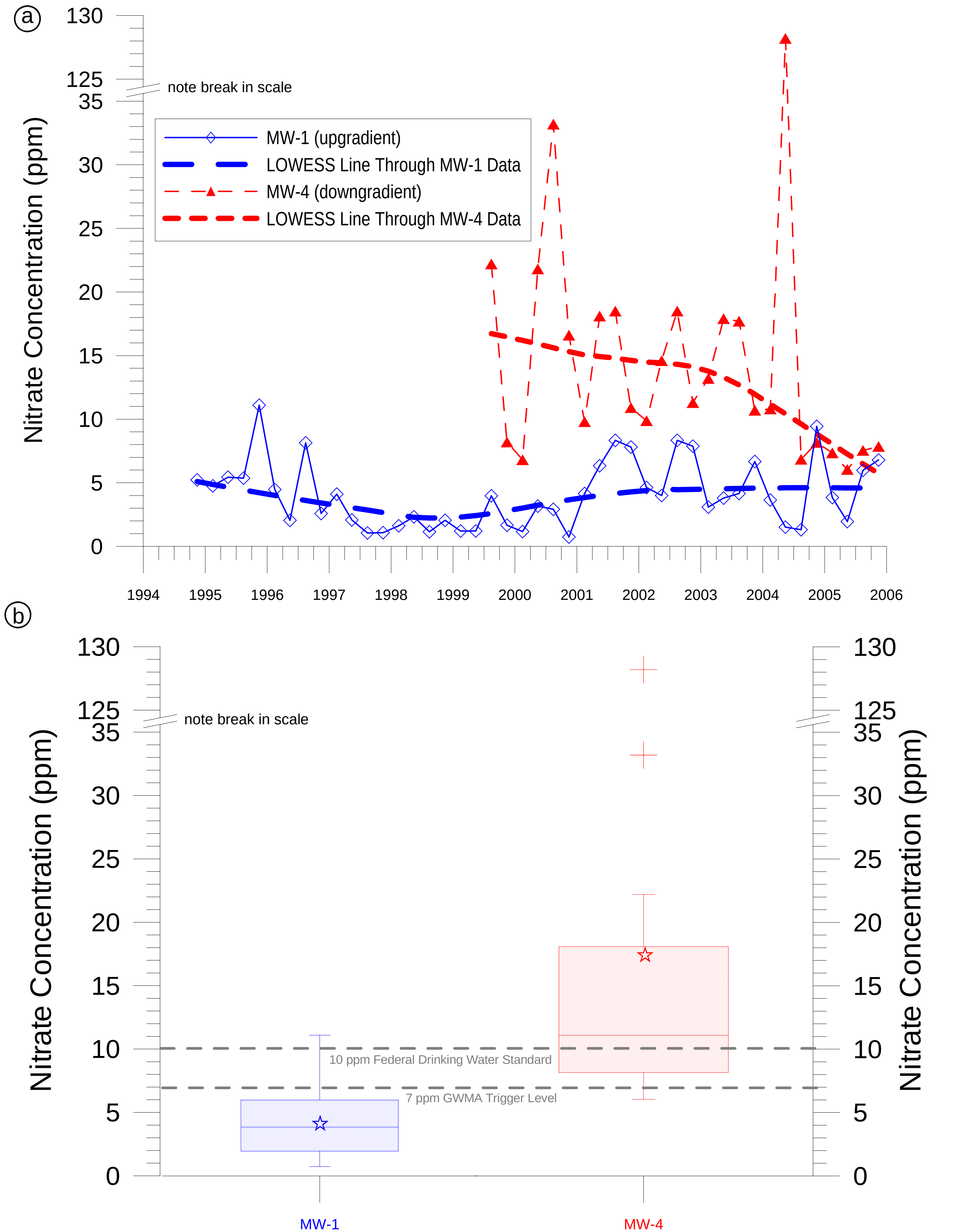


e: lub landapp 2006trendanalysis snakcorp avg.srf

Figure 7-5

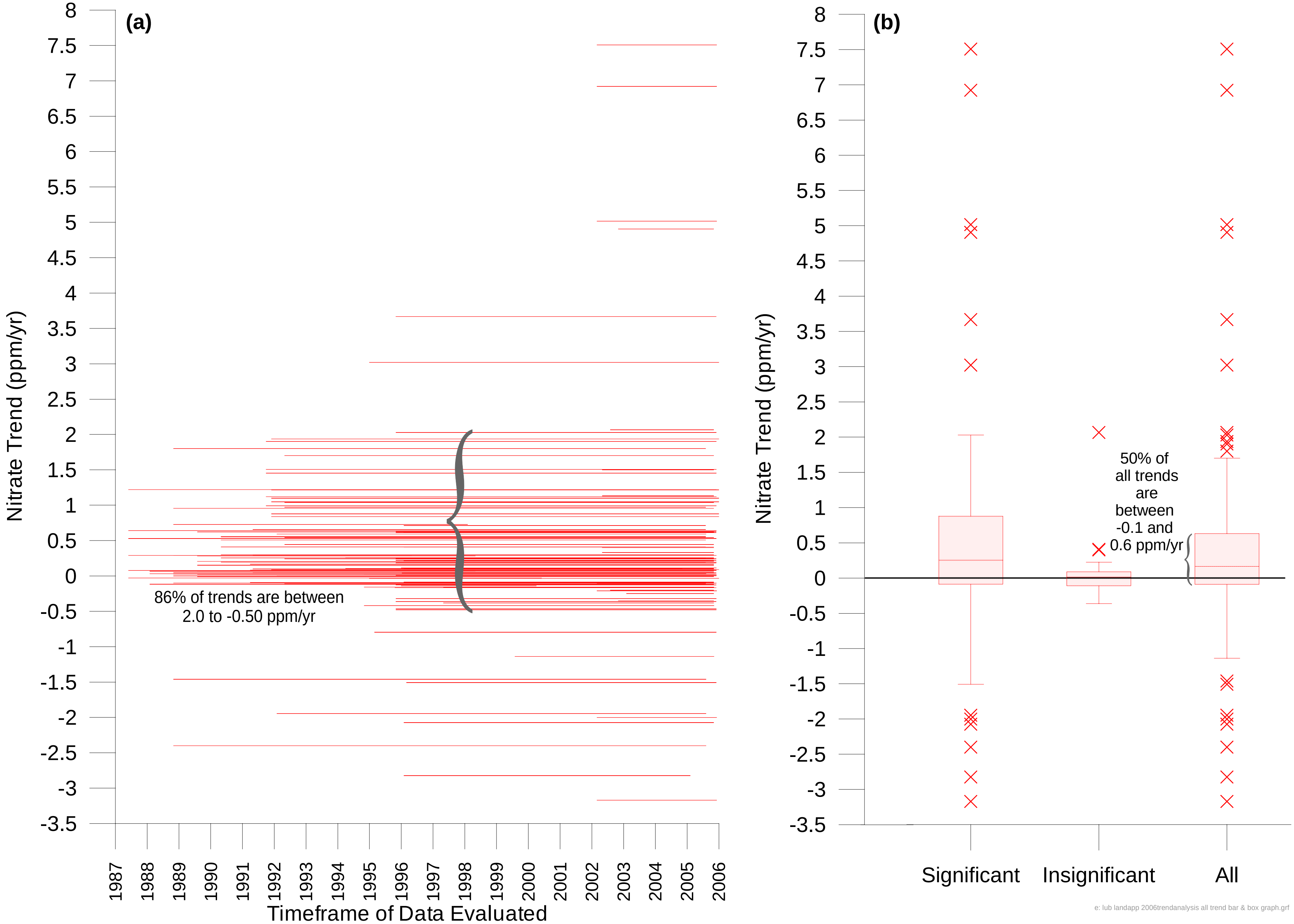
Upgradient vs. Downgradient Nitrate Comparisons - Snack Alliance Site

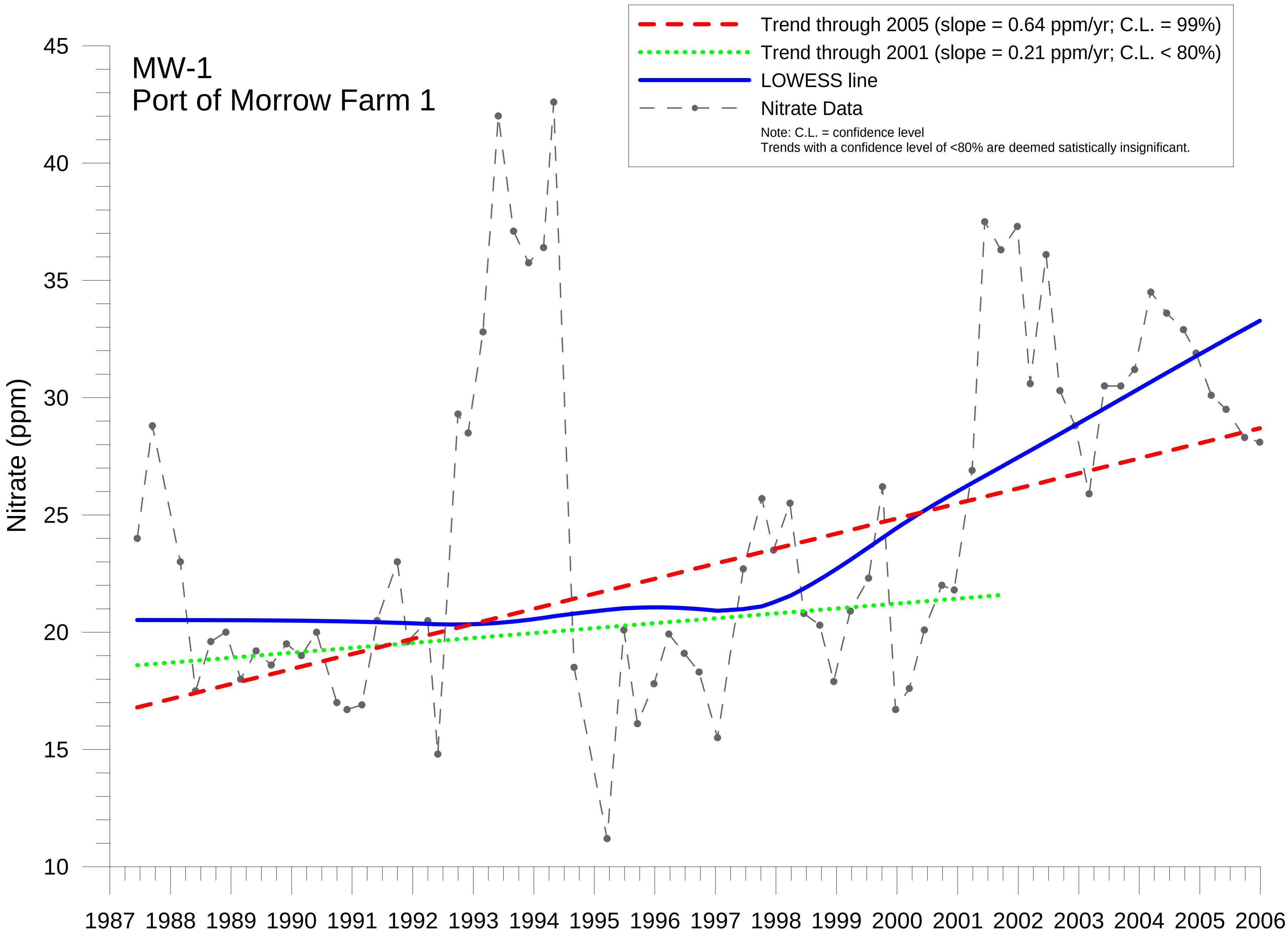
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp snakcorp up v dn.grf

Figure 8-1
Summary of All Trends
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA





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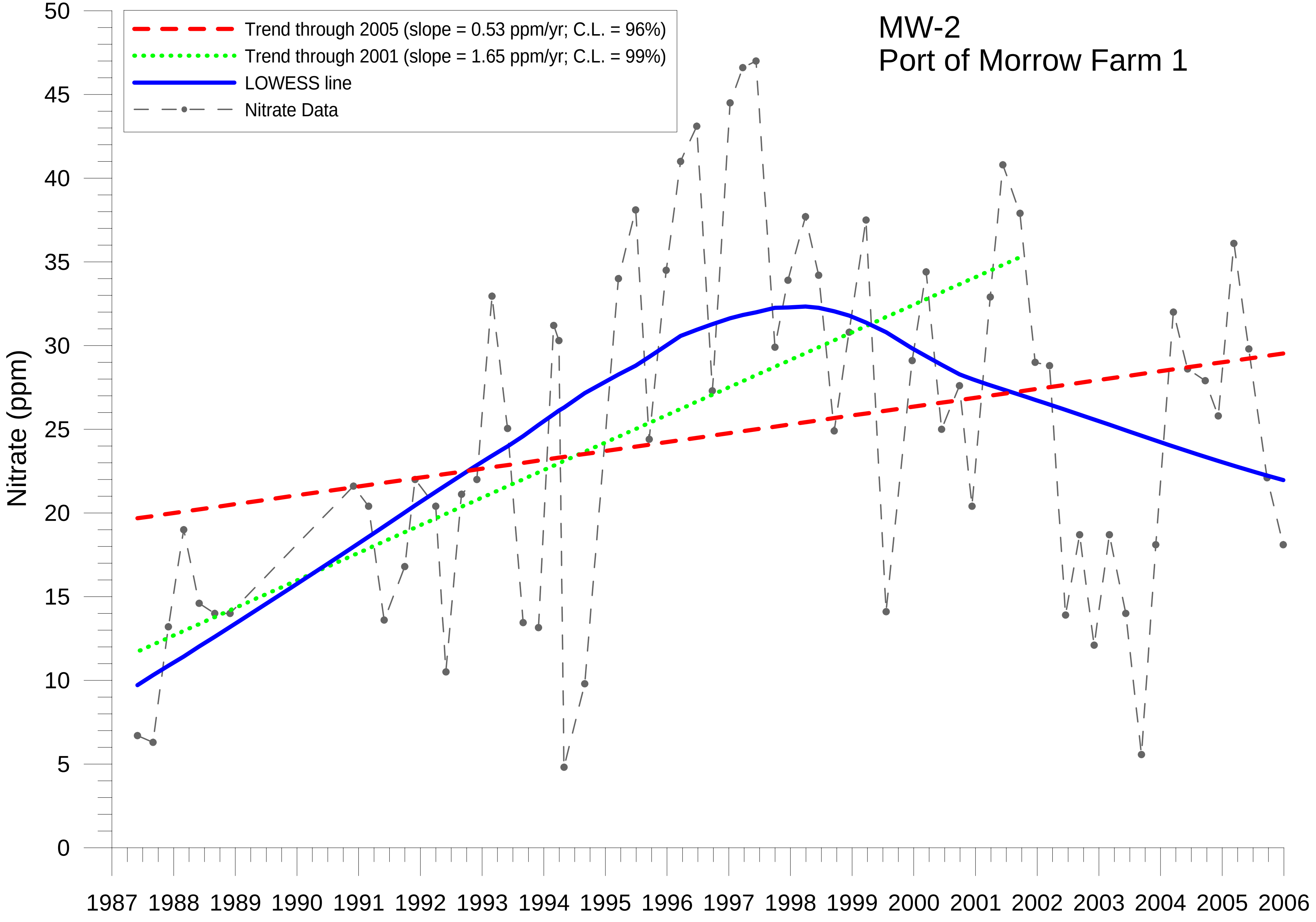

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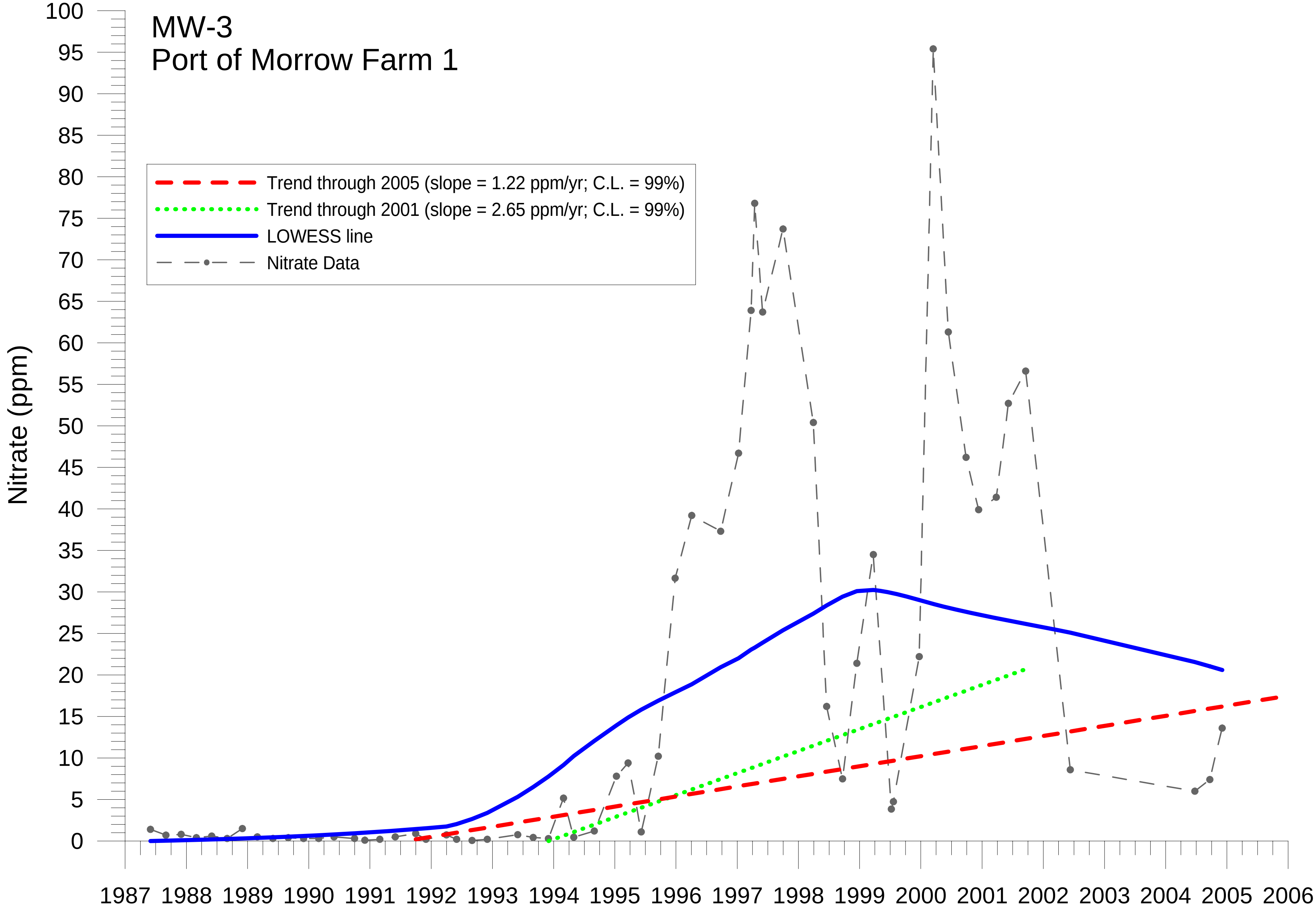

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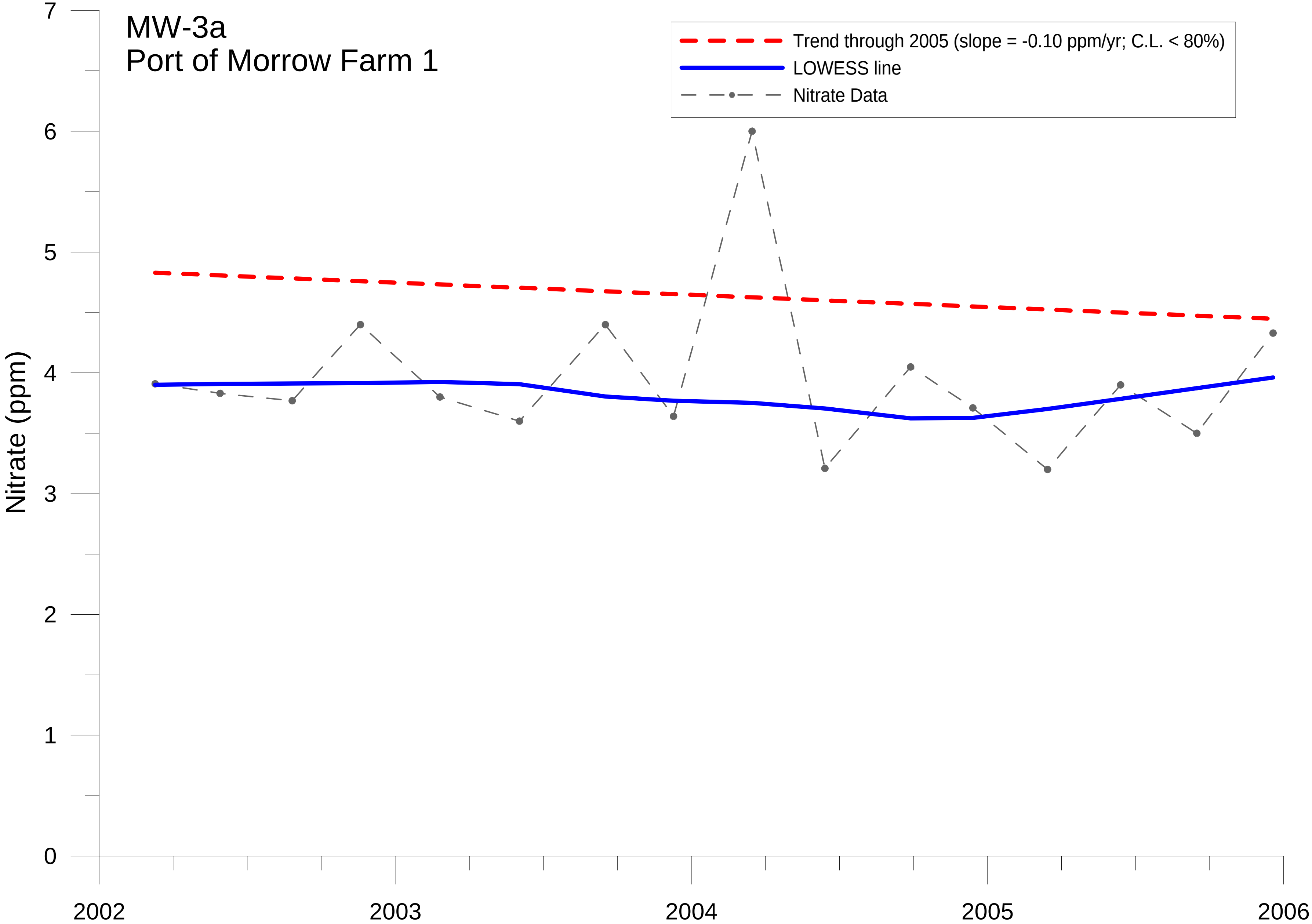

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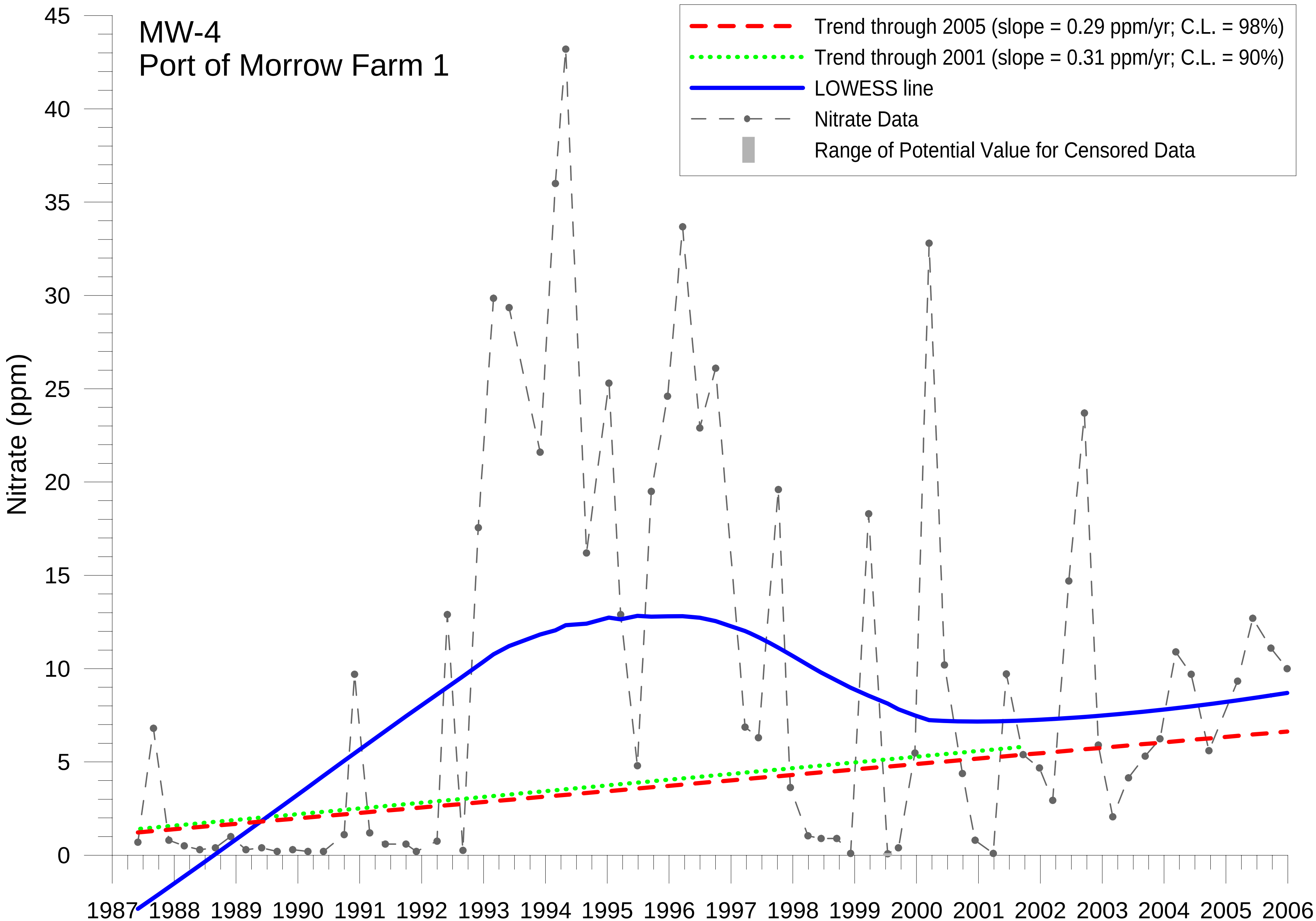

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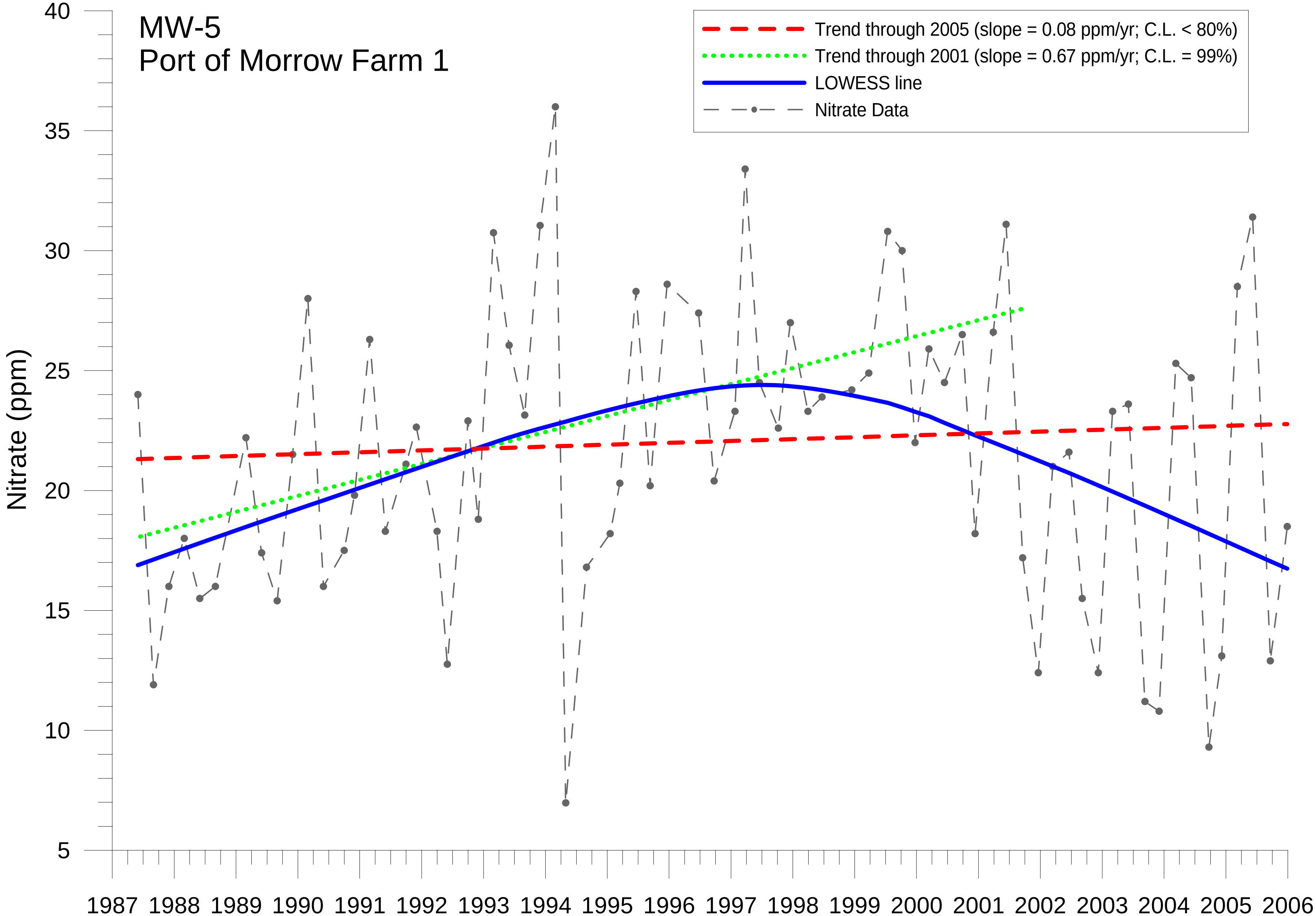

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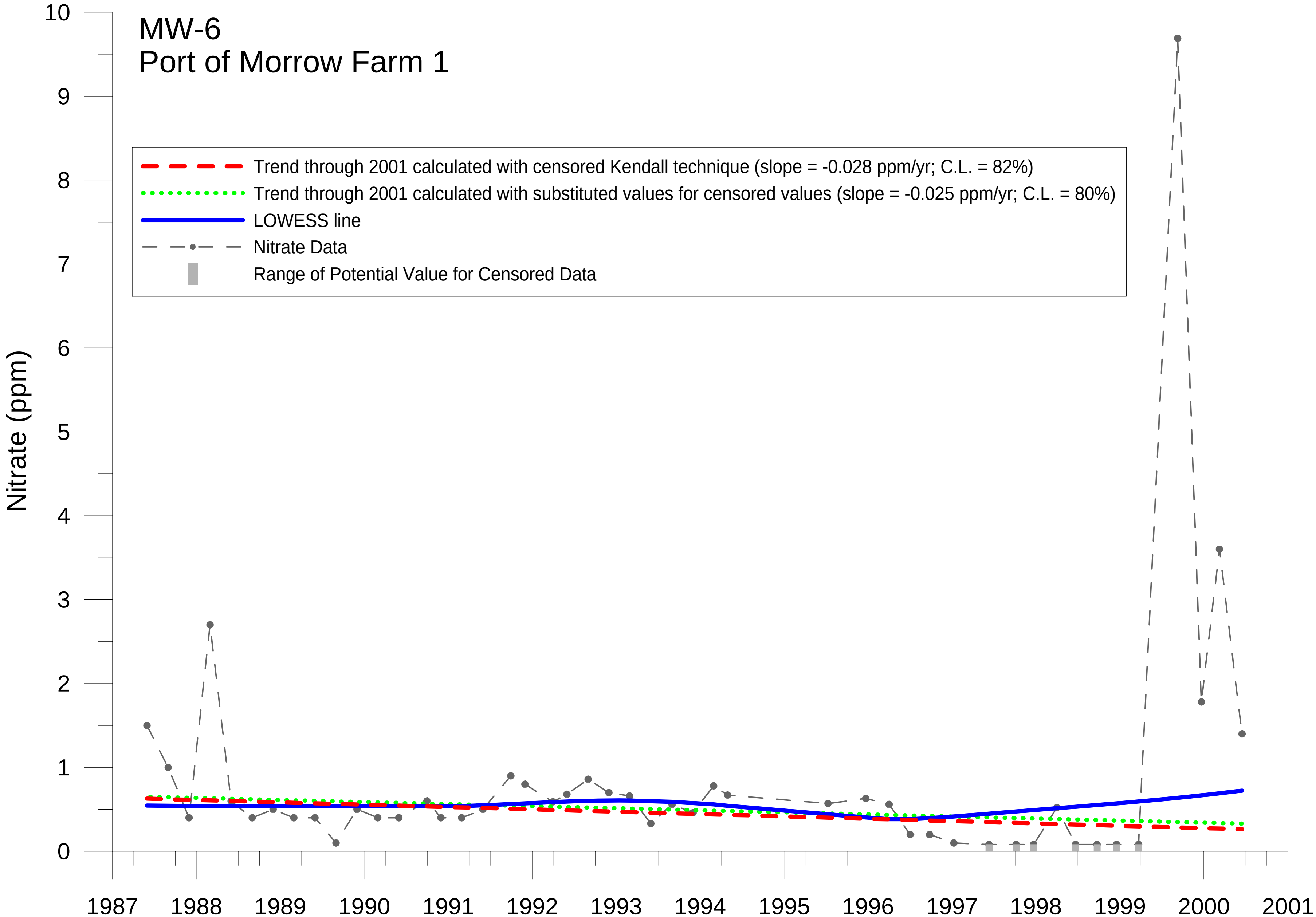

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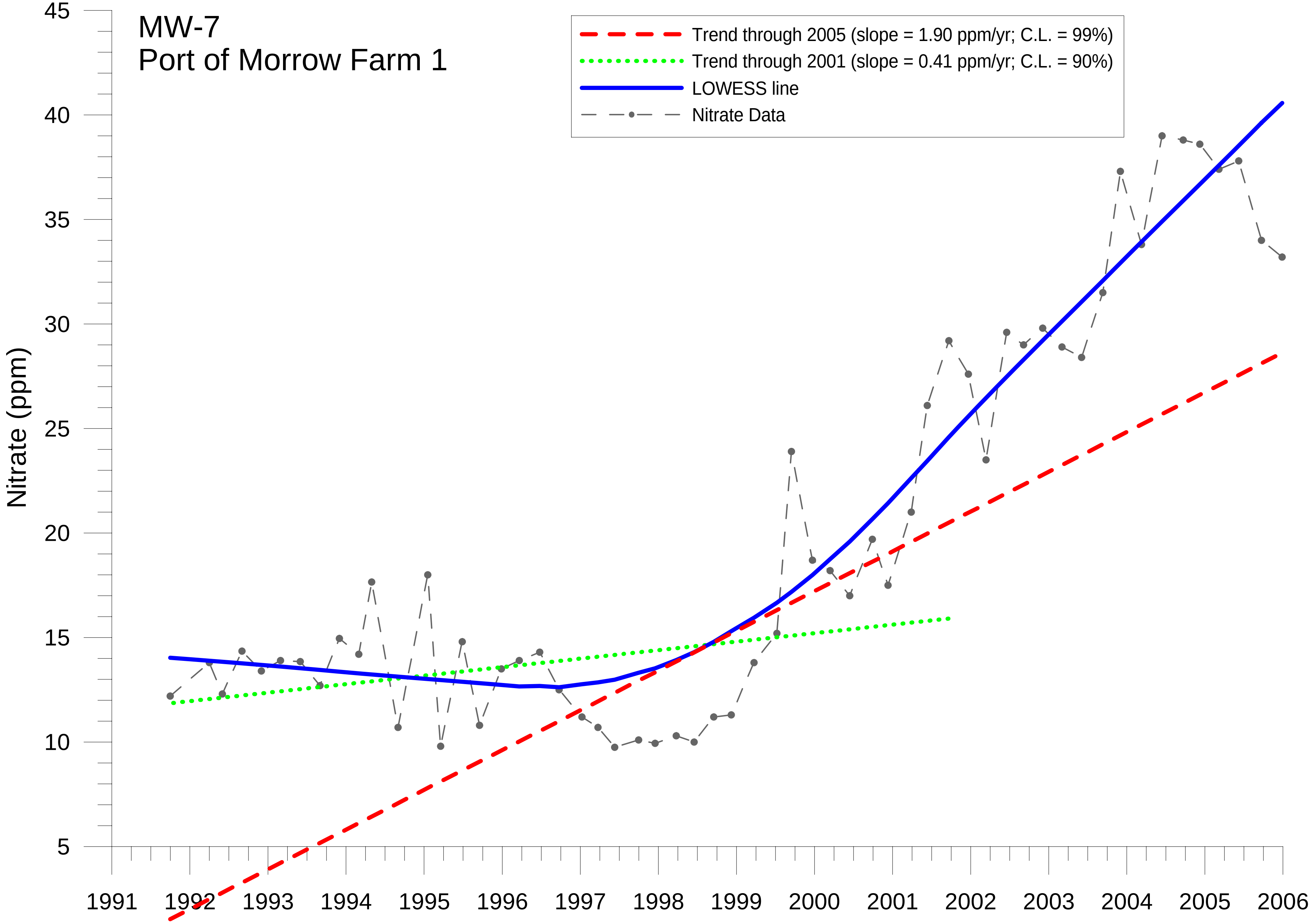

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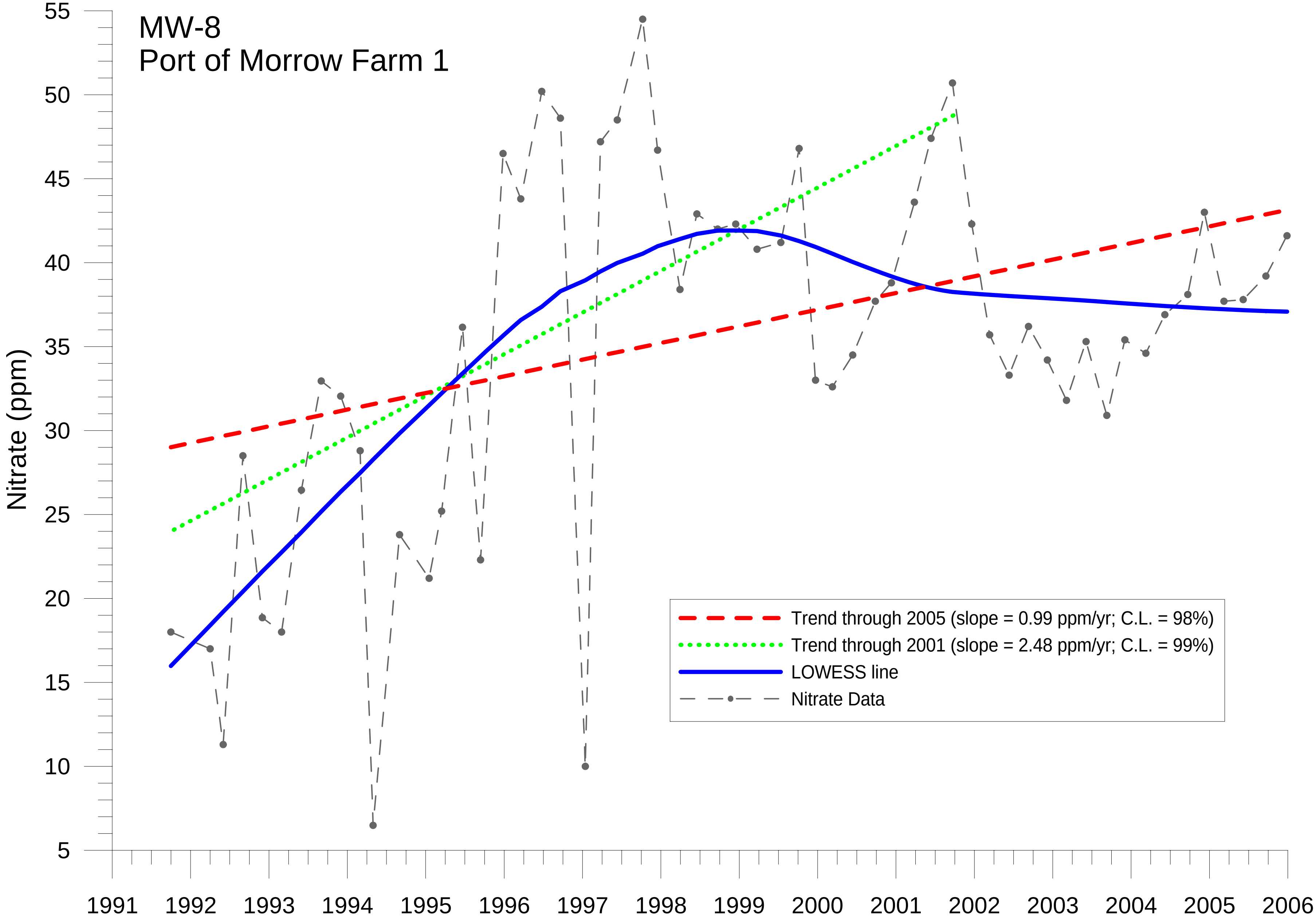

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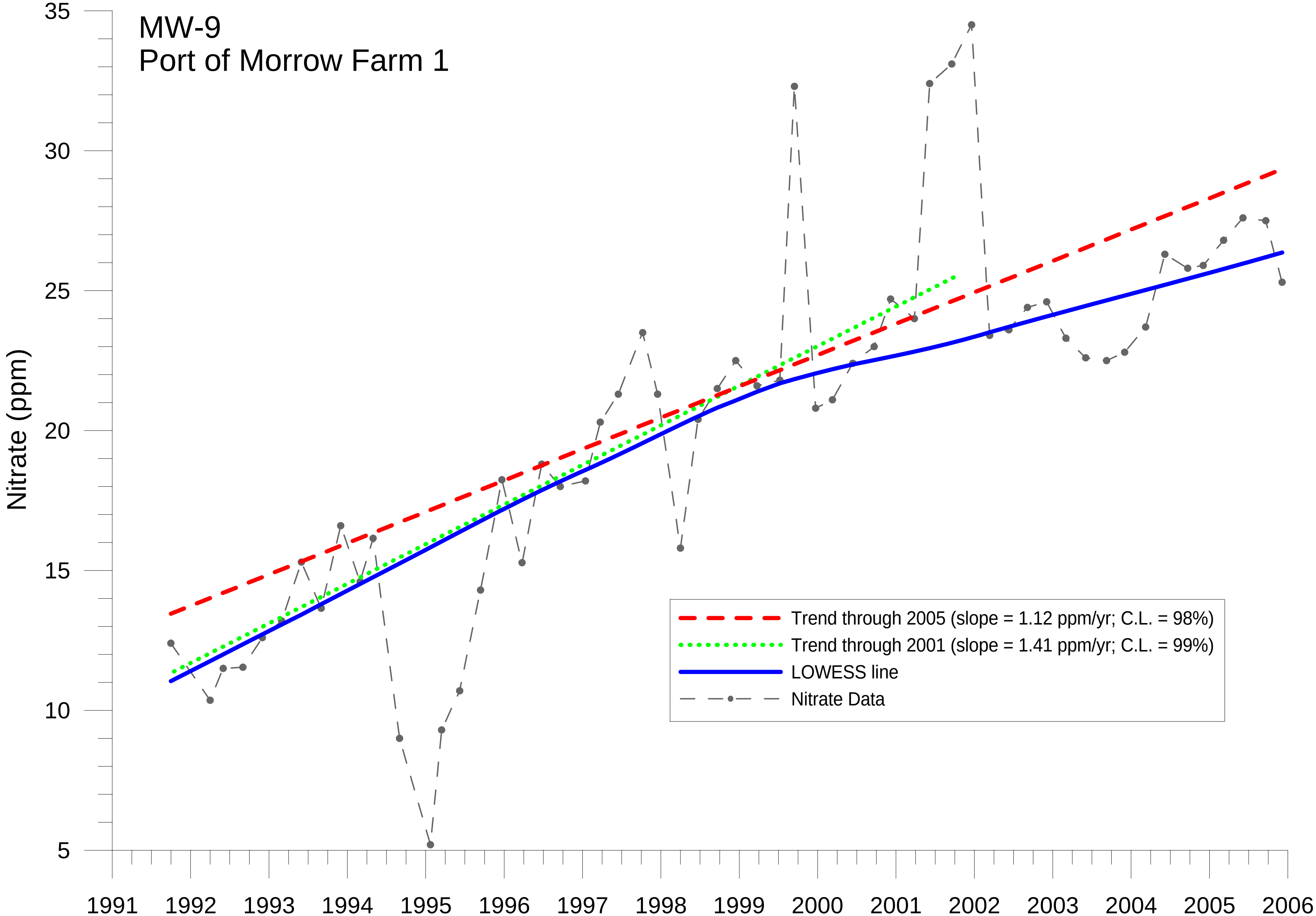

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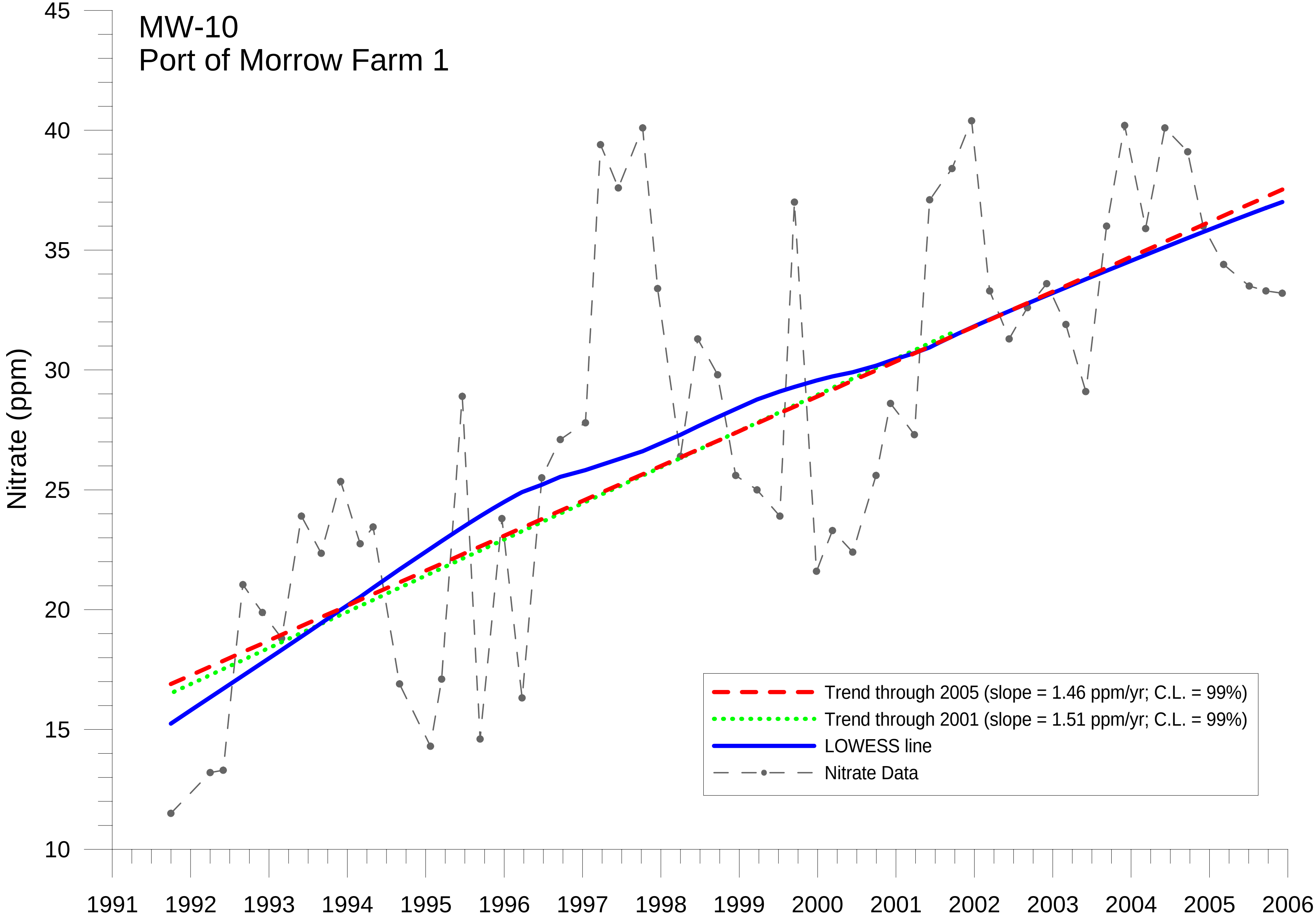

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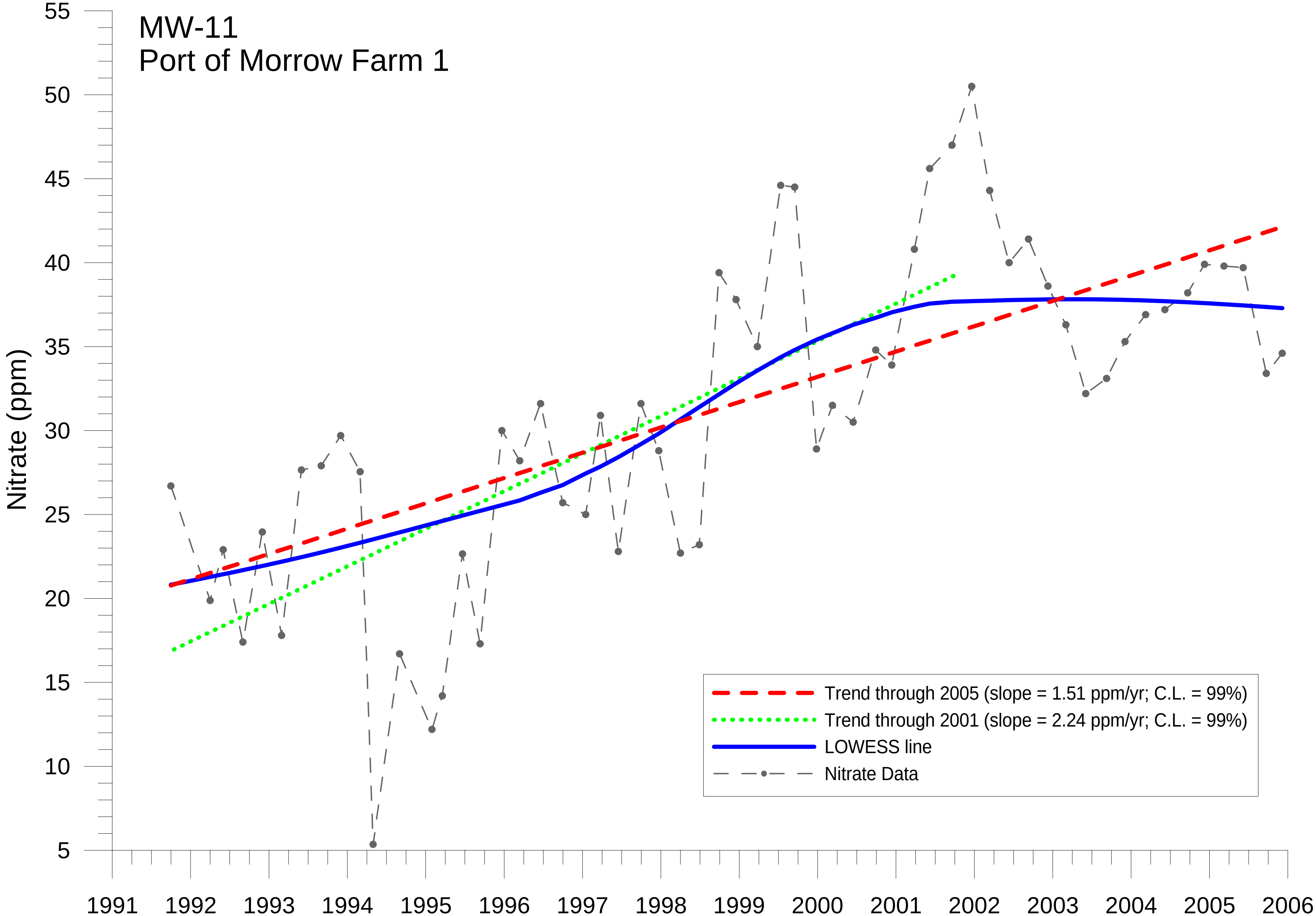

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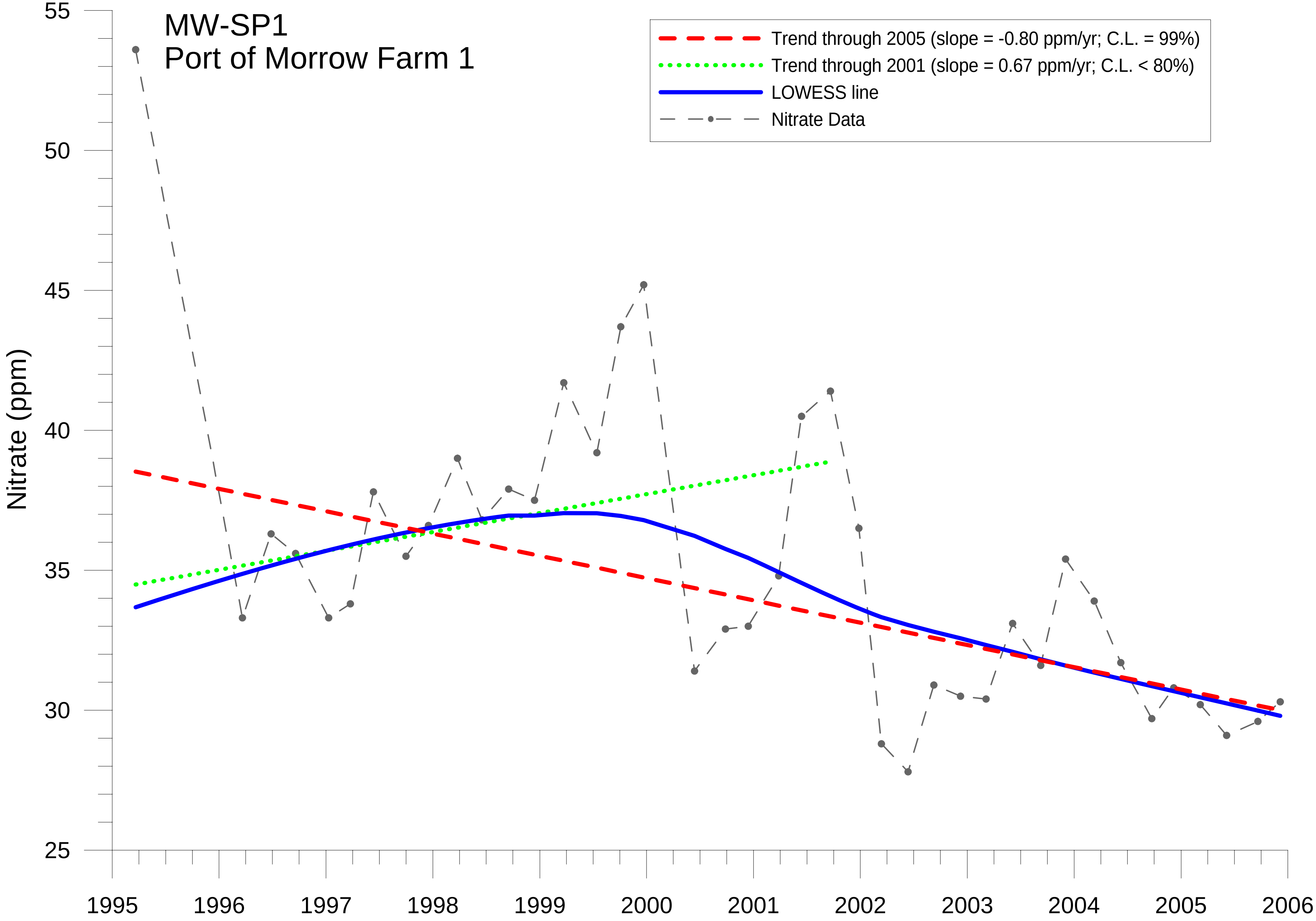

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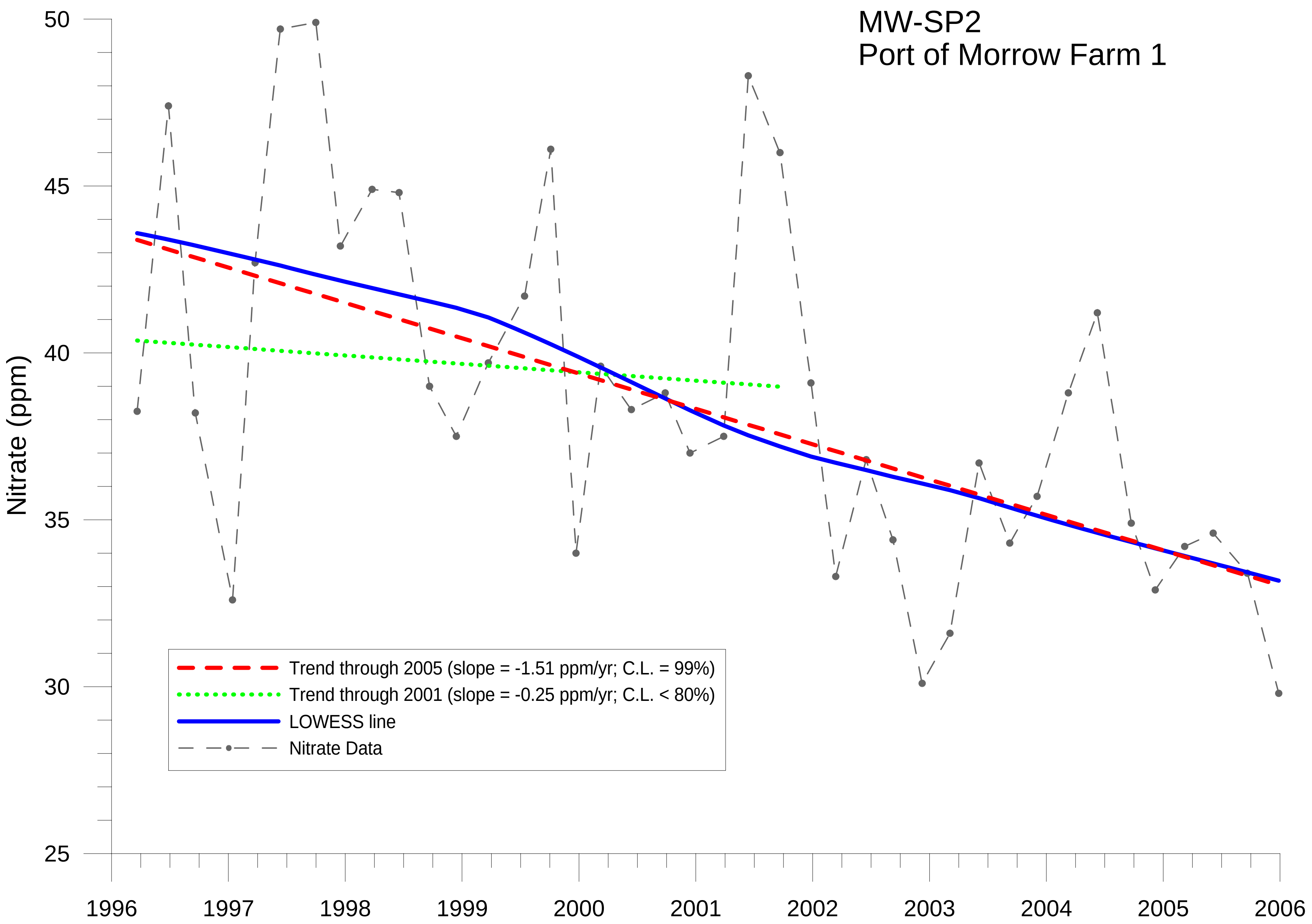

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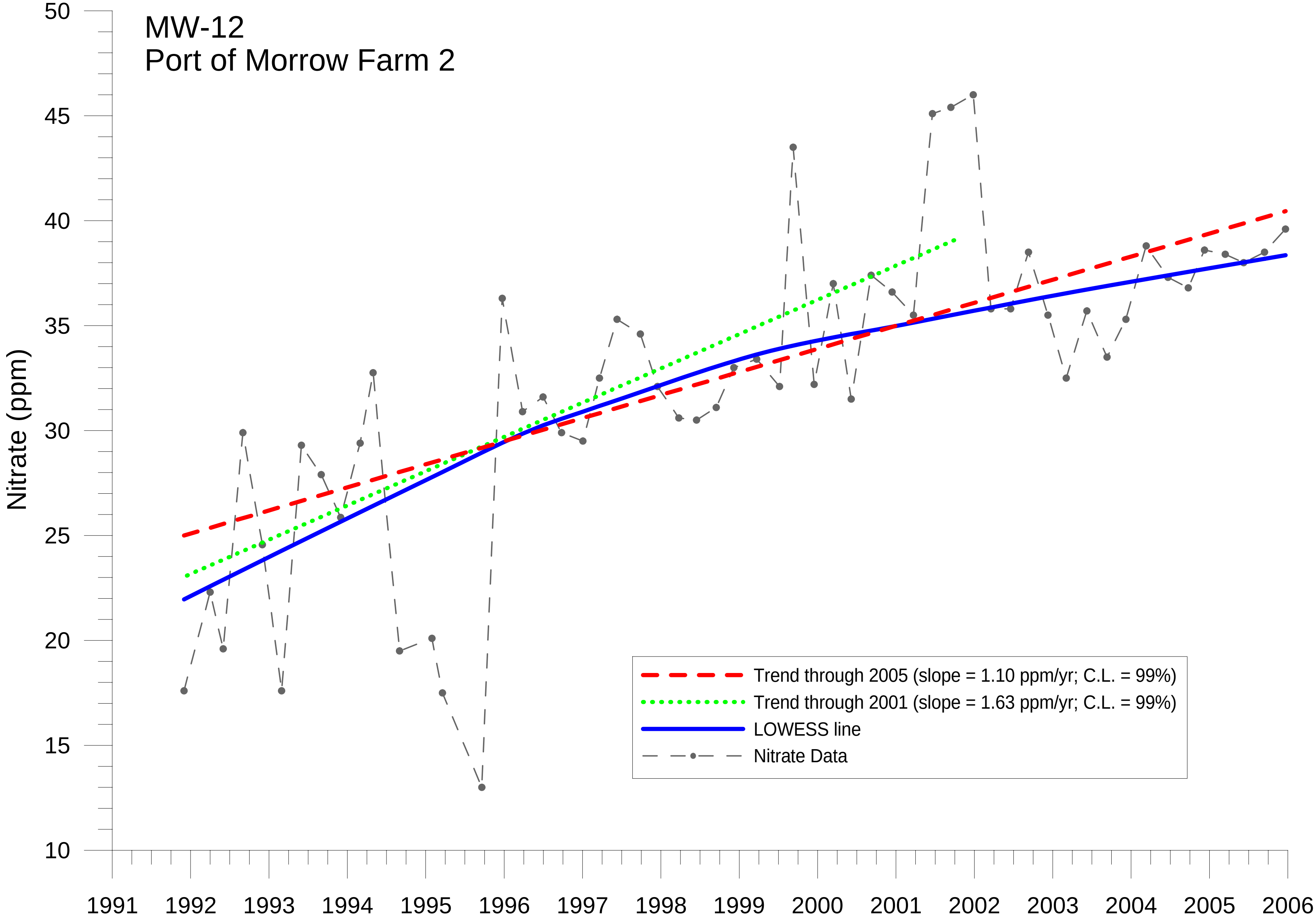

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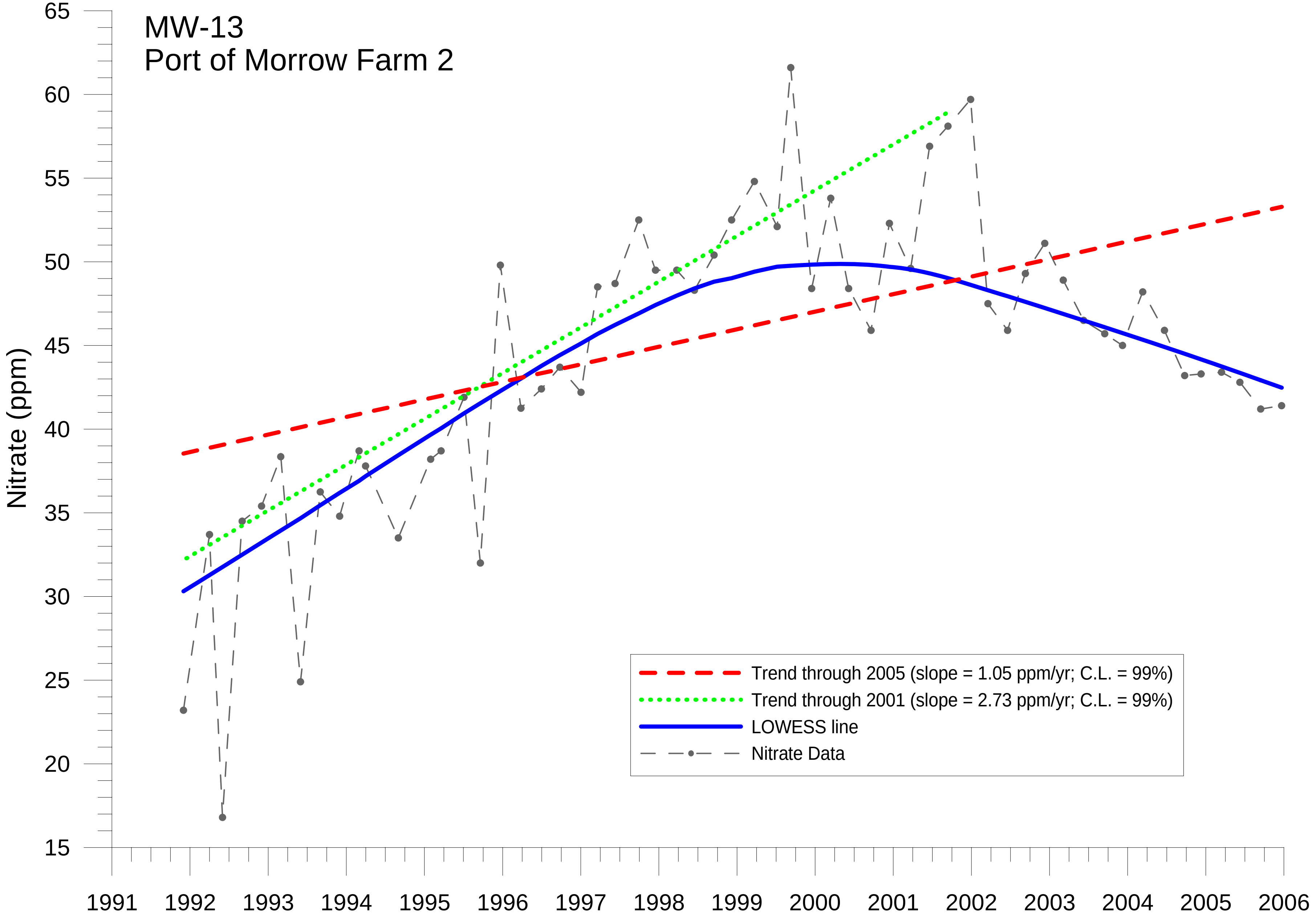

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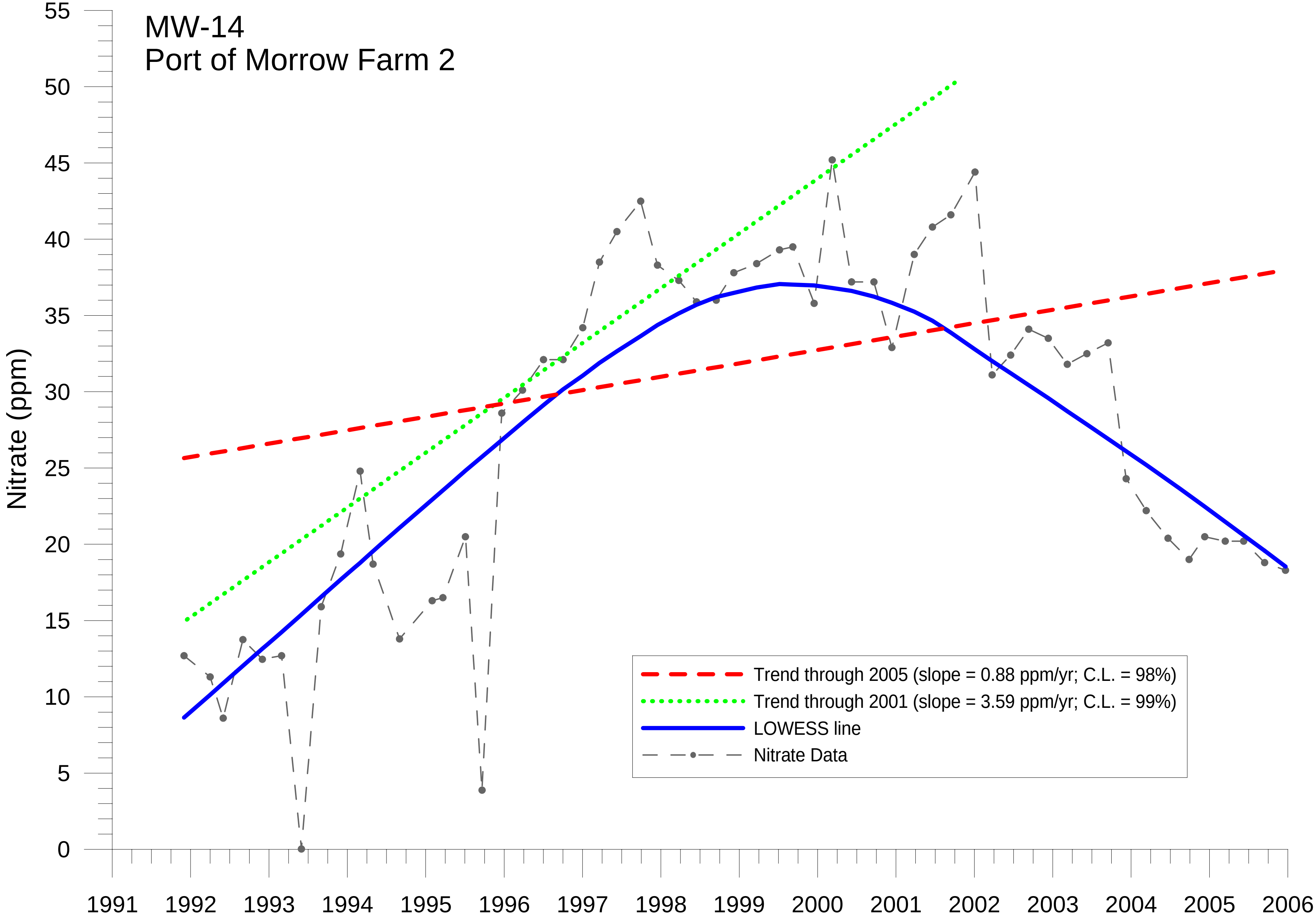

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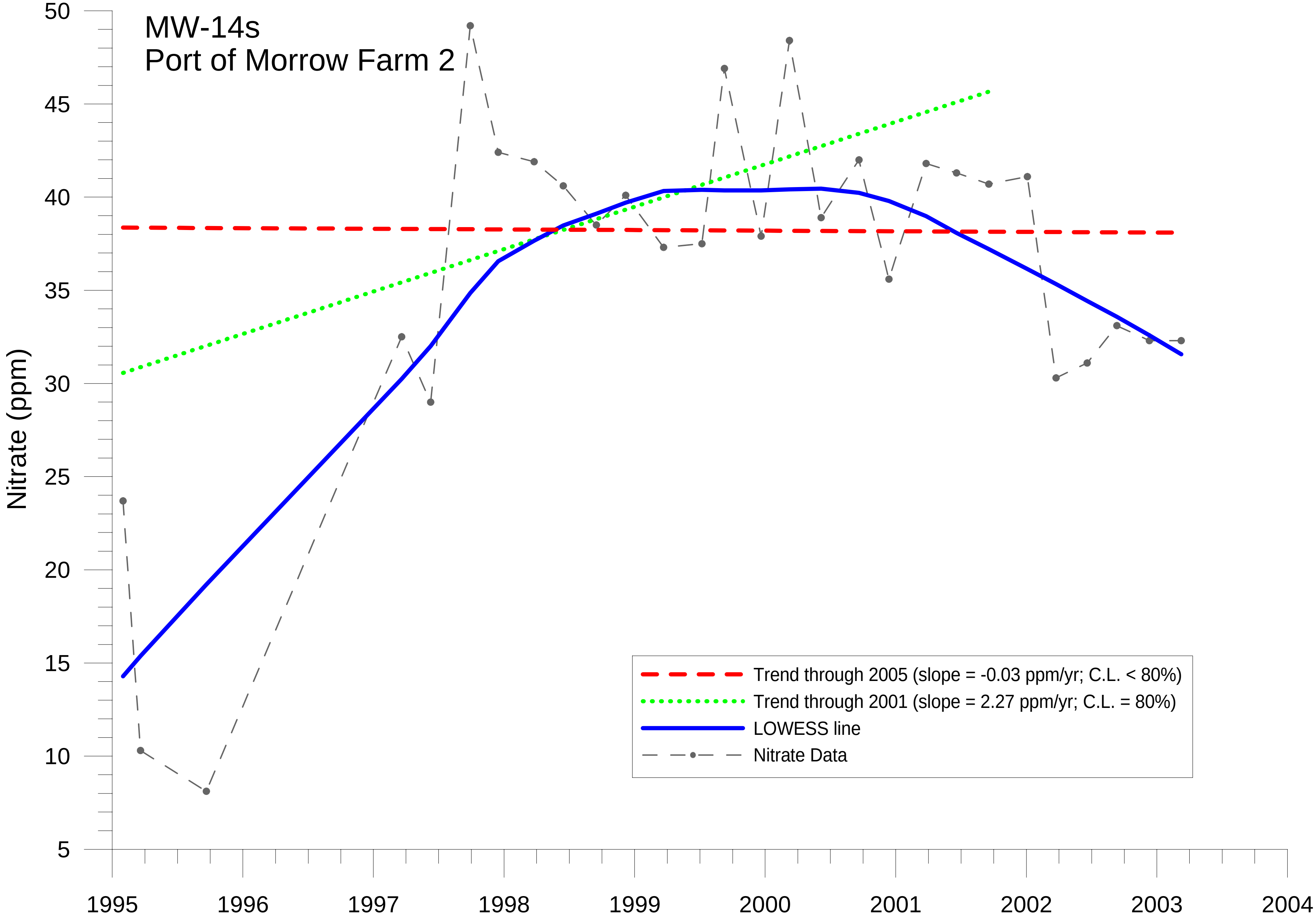

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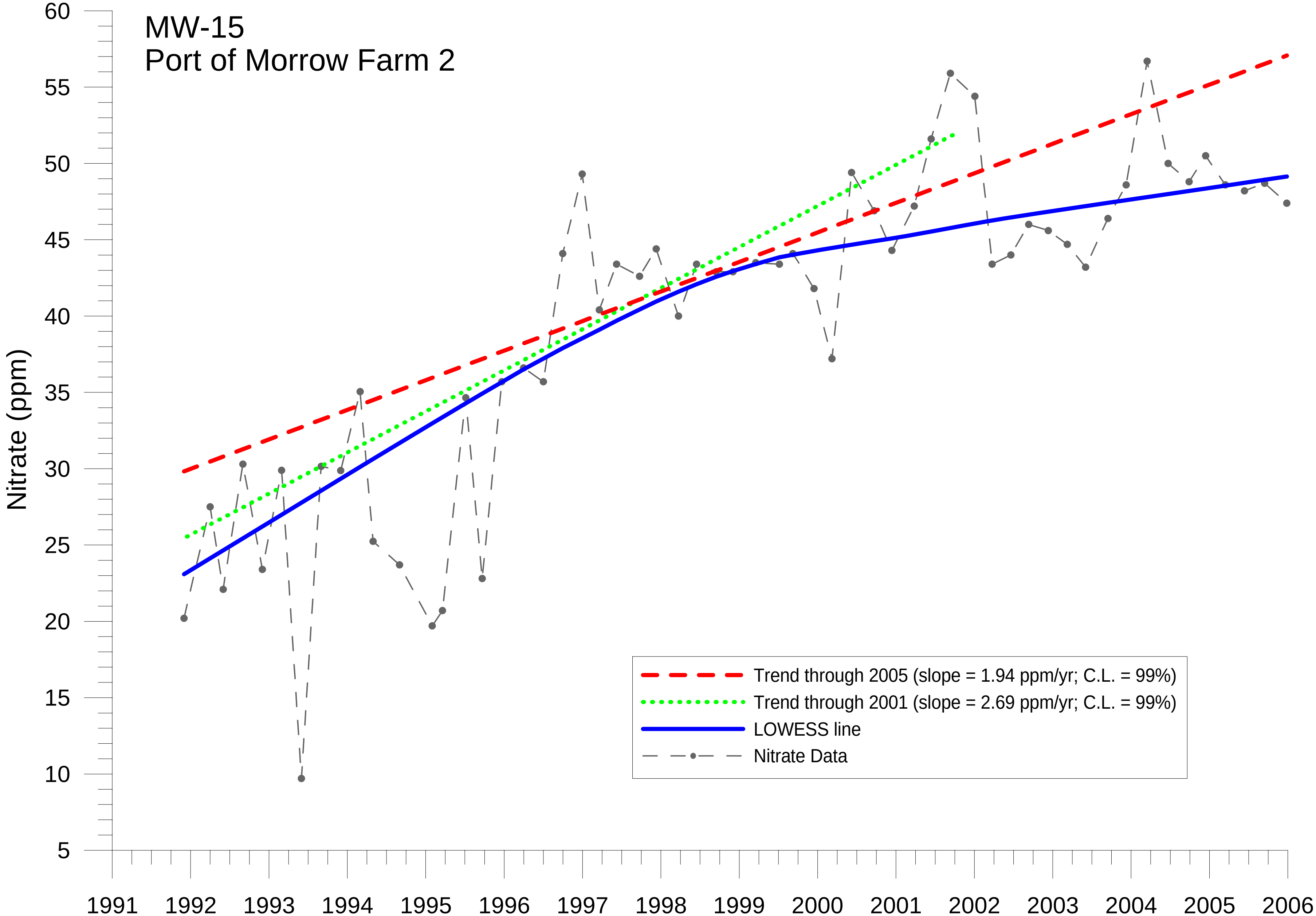

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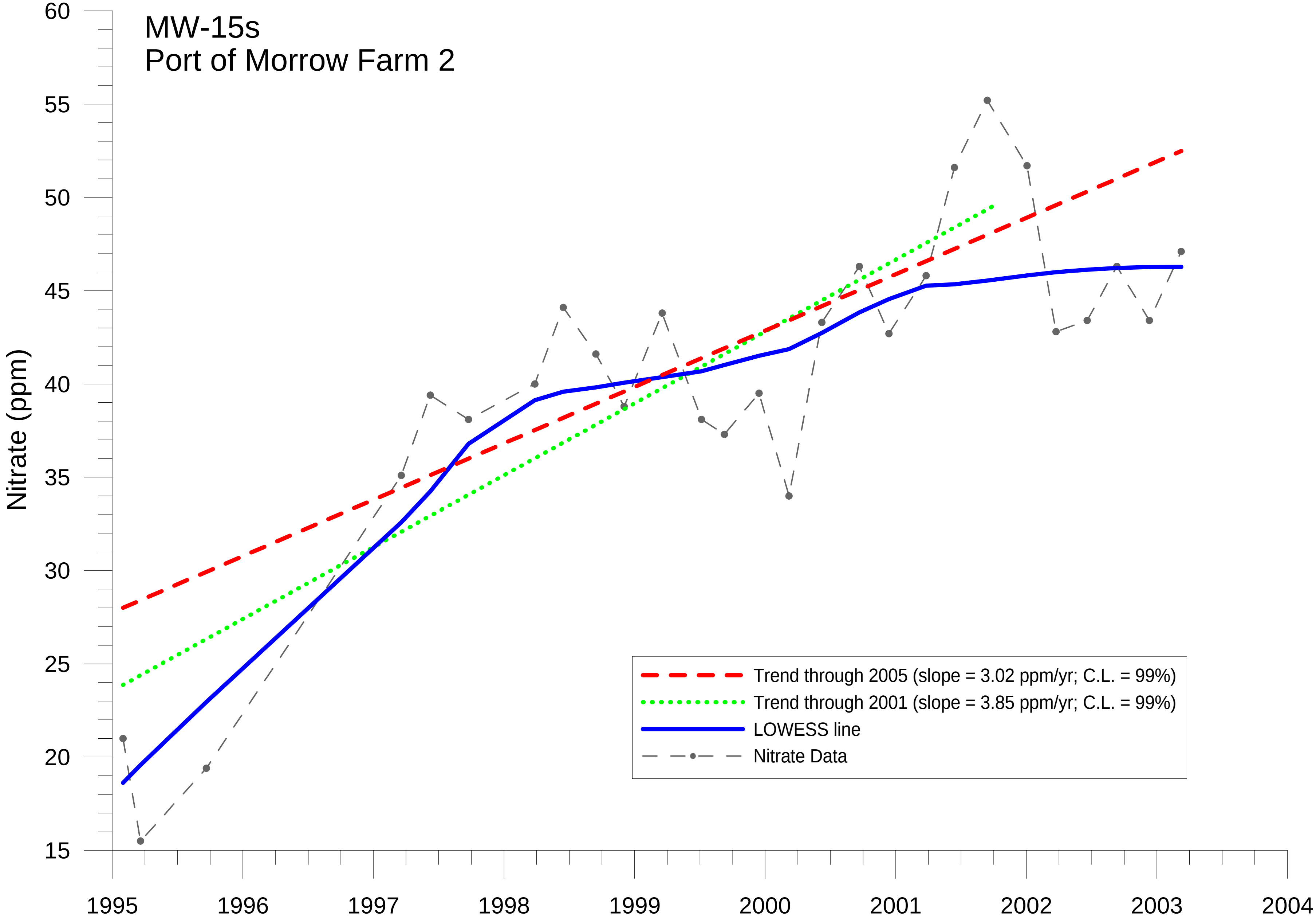

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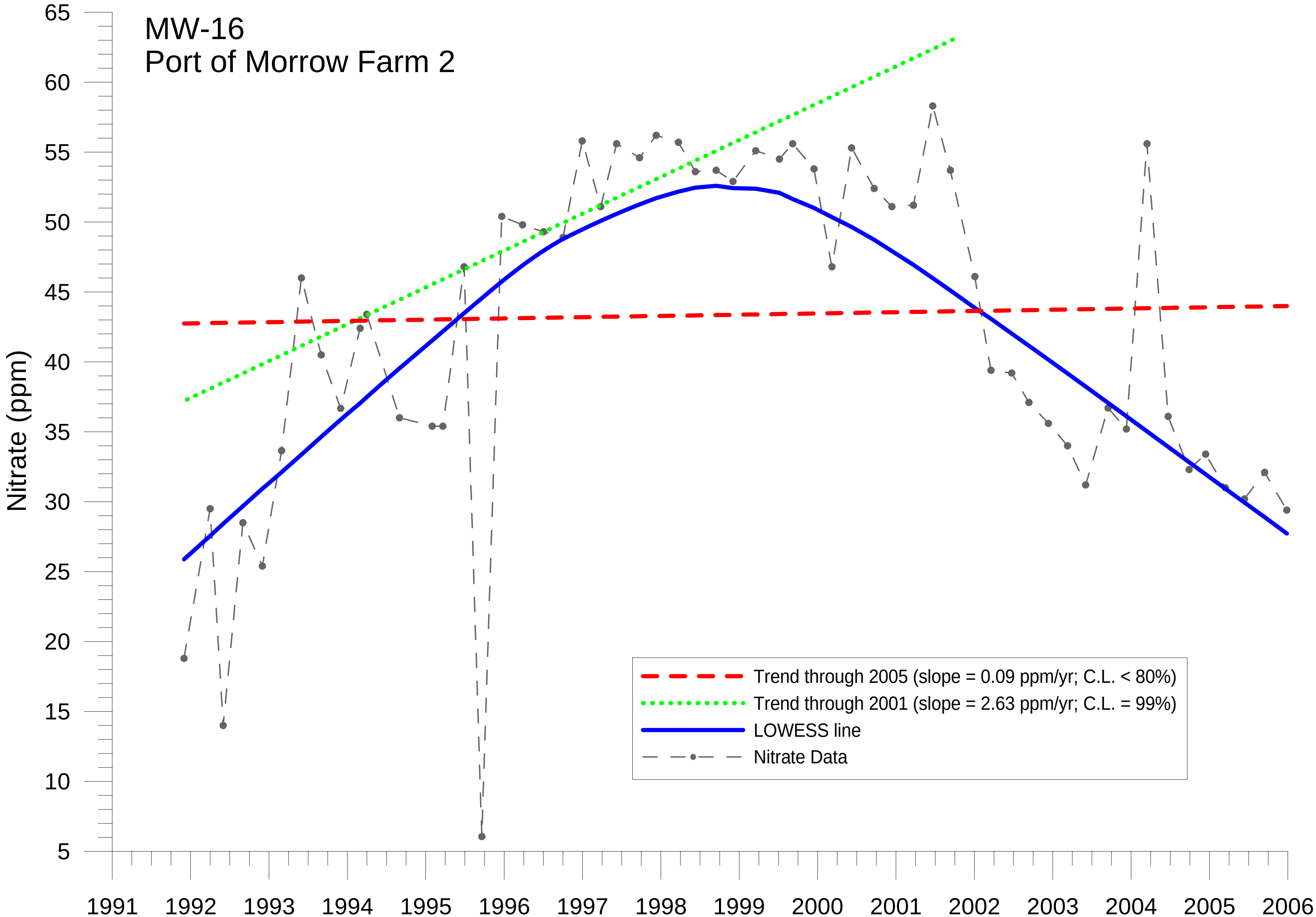

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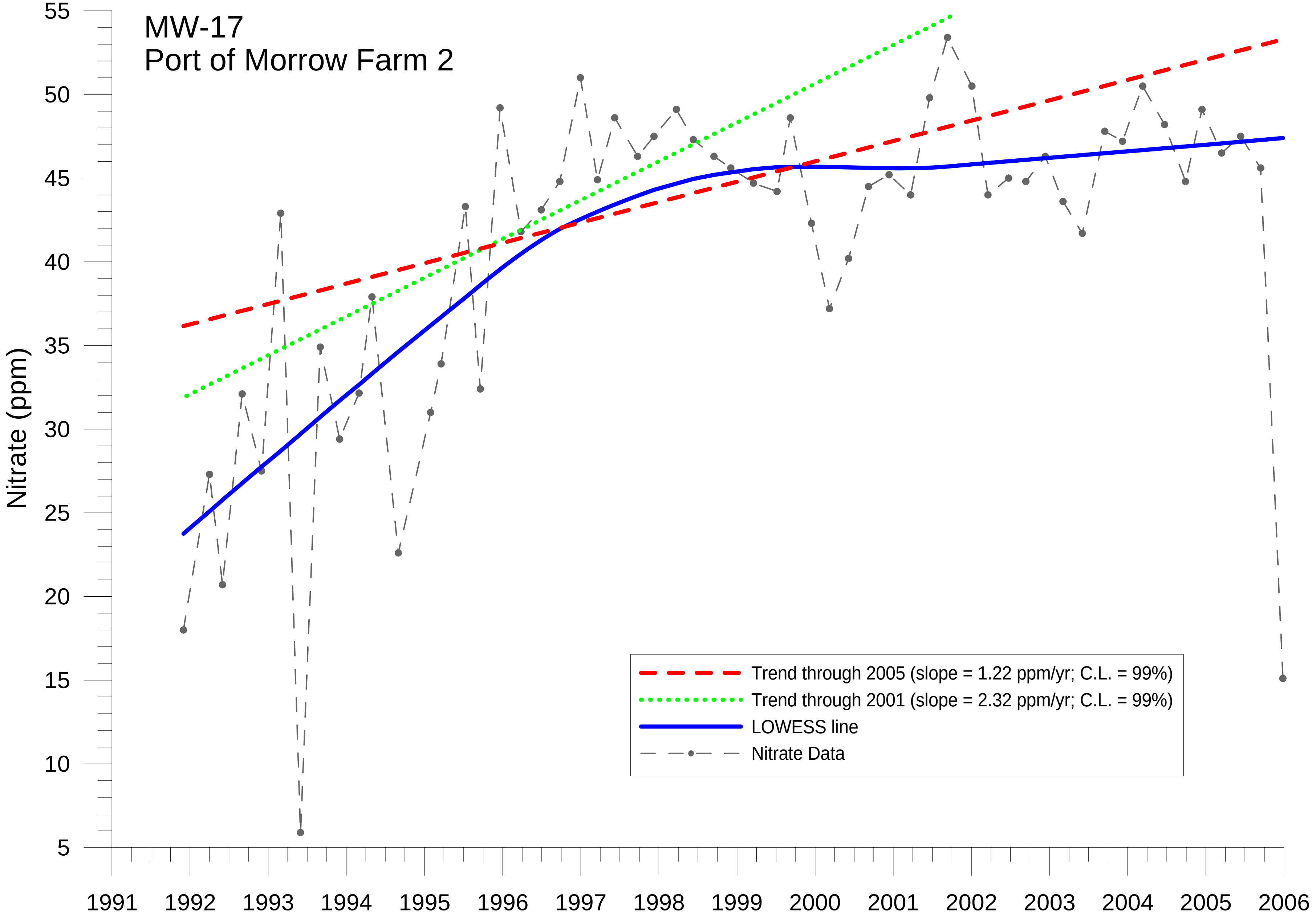
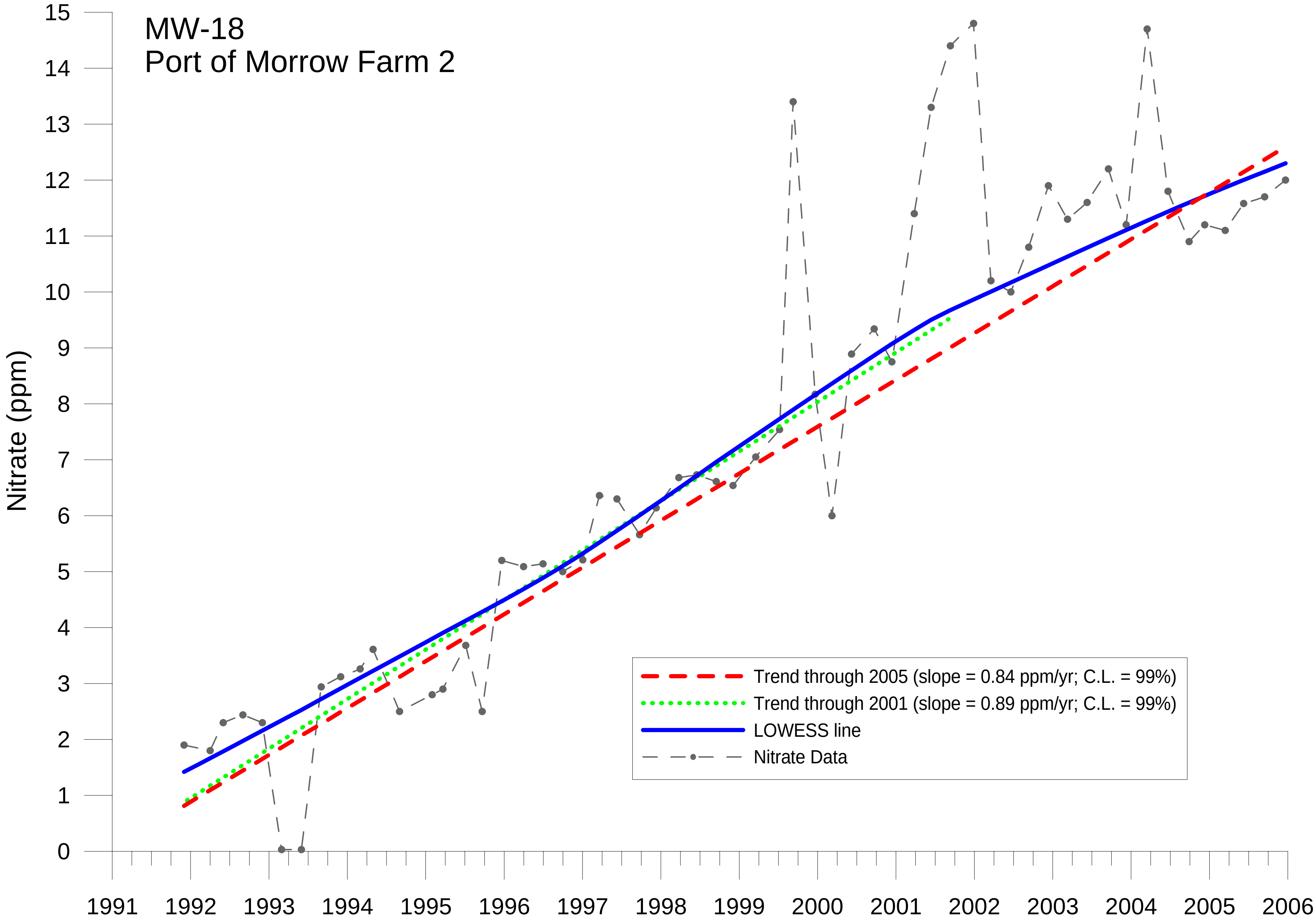
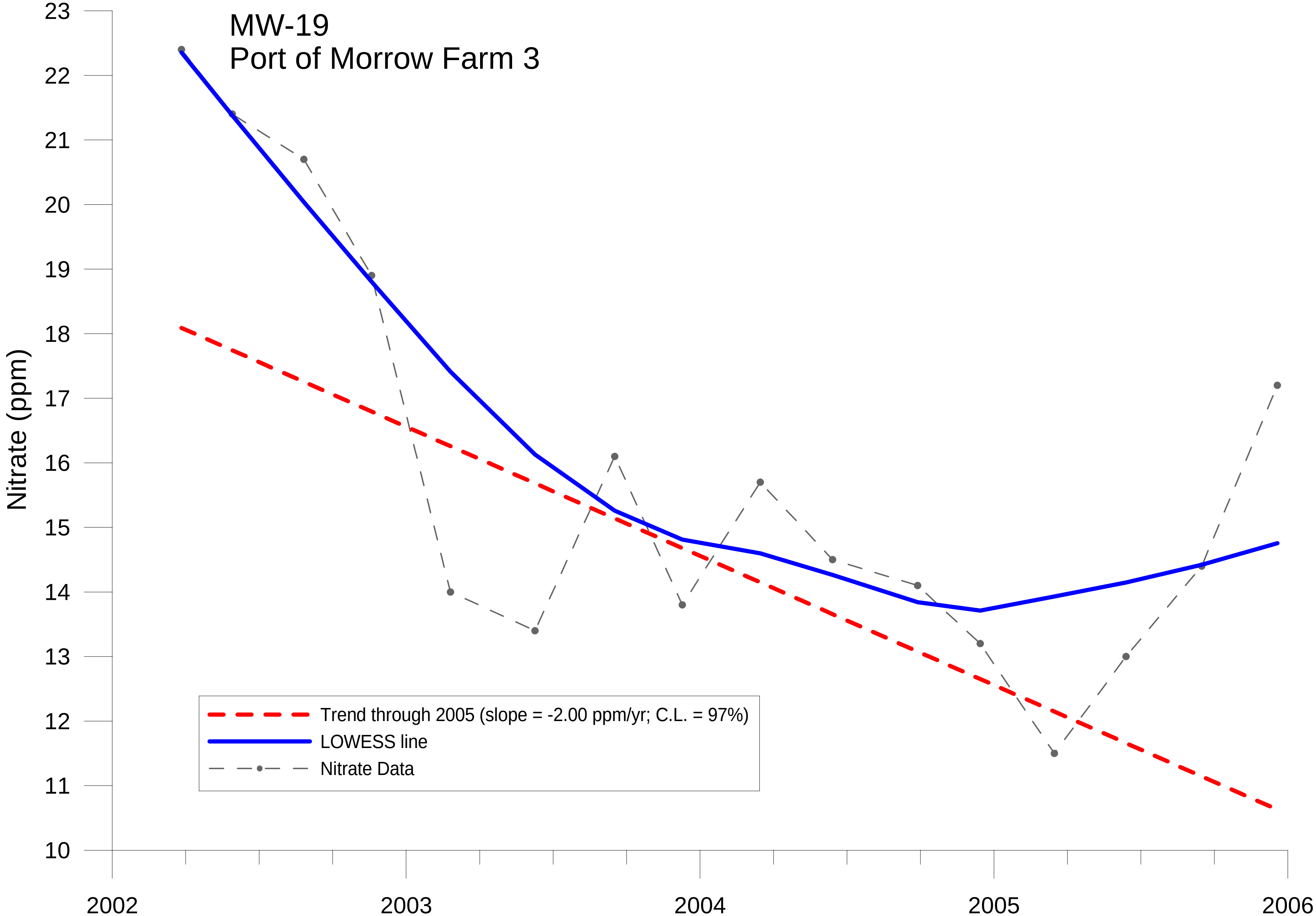


e:\lub\landapp\2006trendanalysispom*wellname*.grf



e:\lub\landapp\2006trendanalysispom*wellname*.grf



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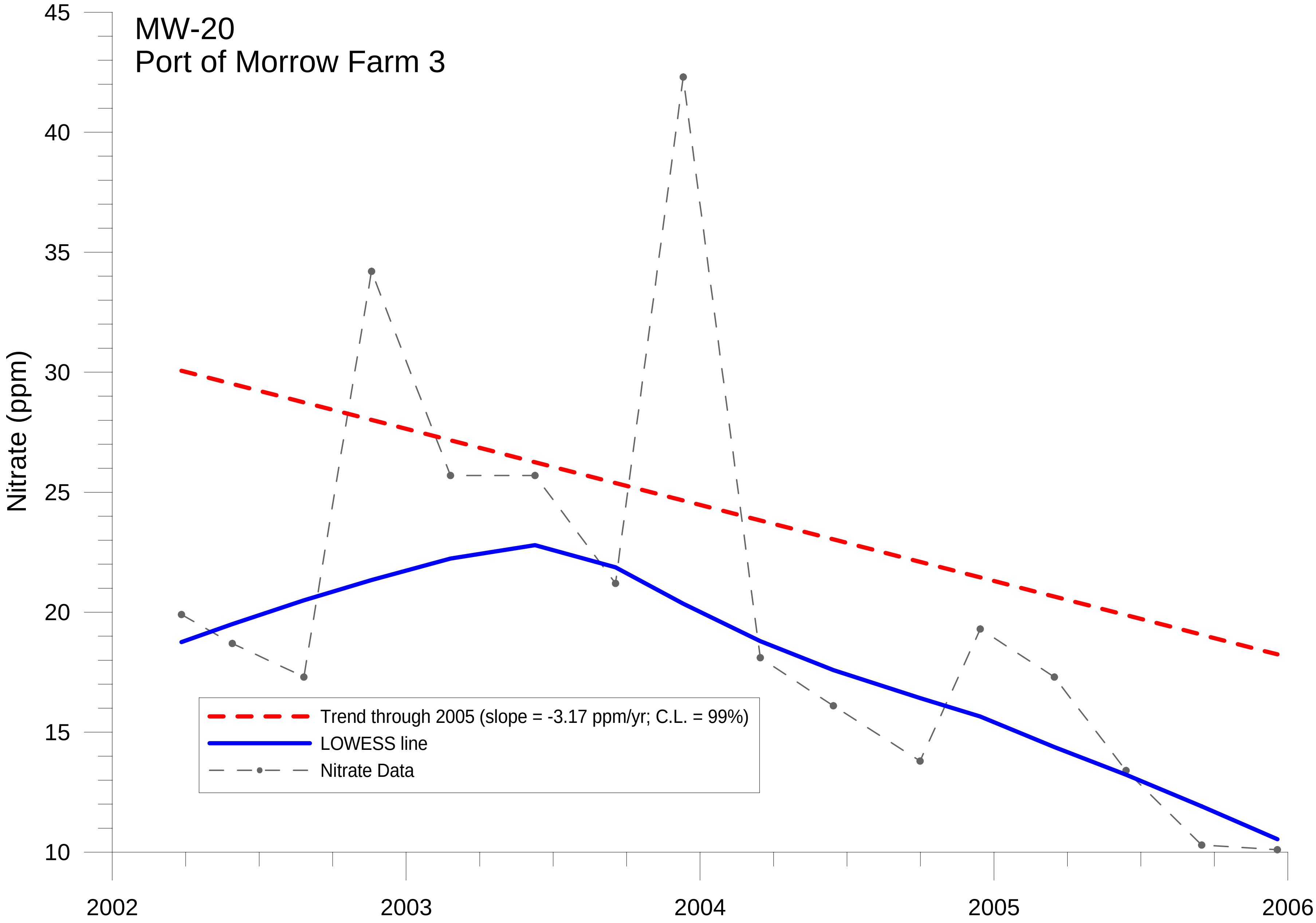
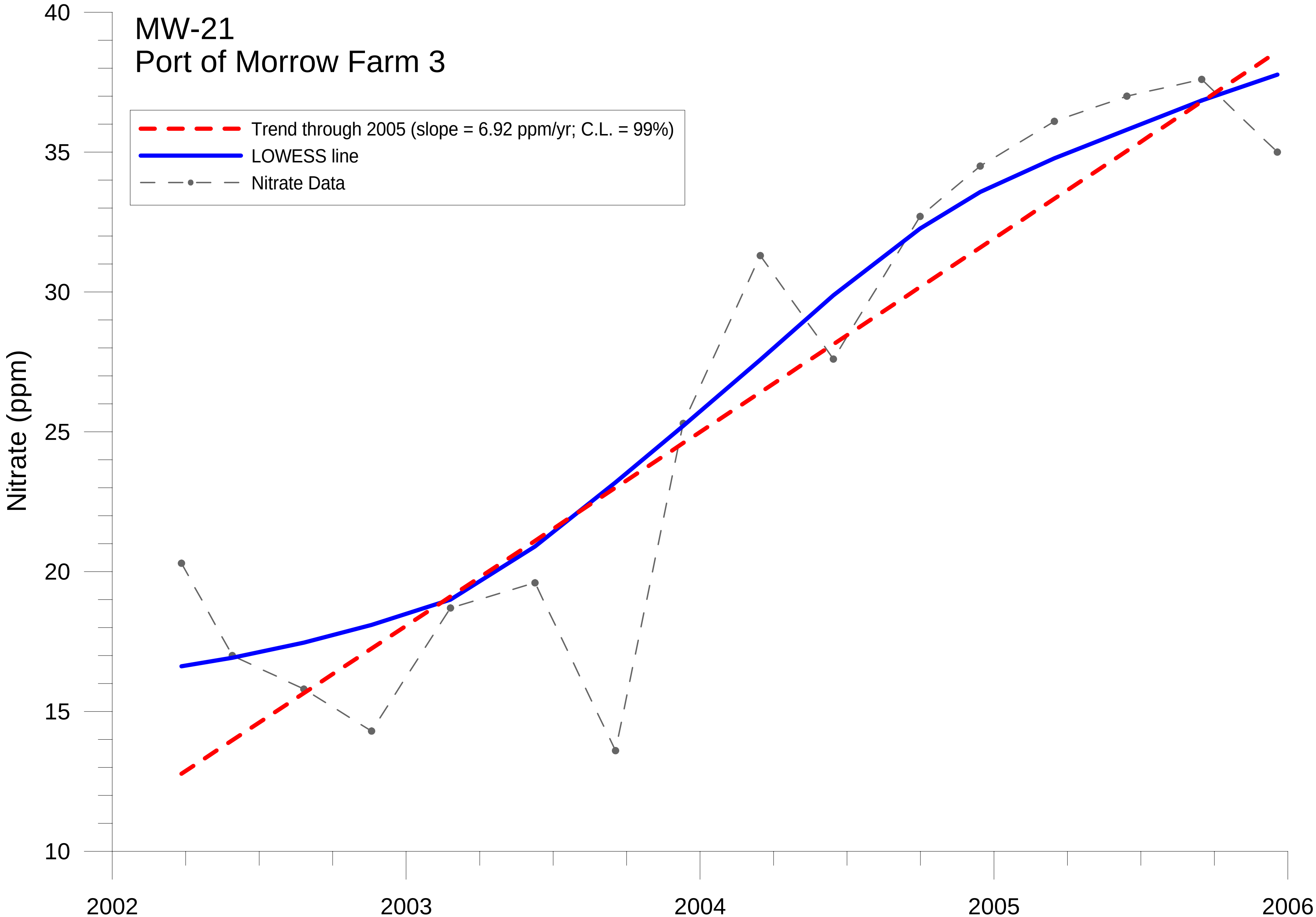
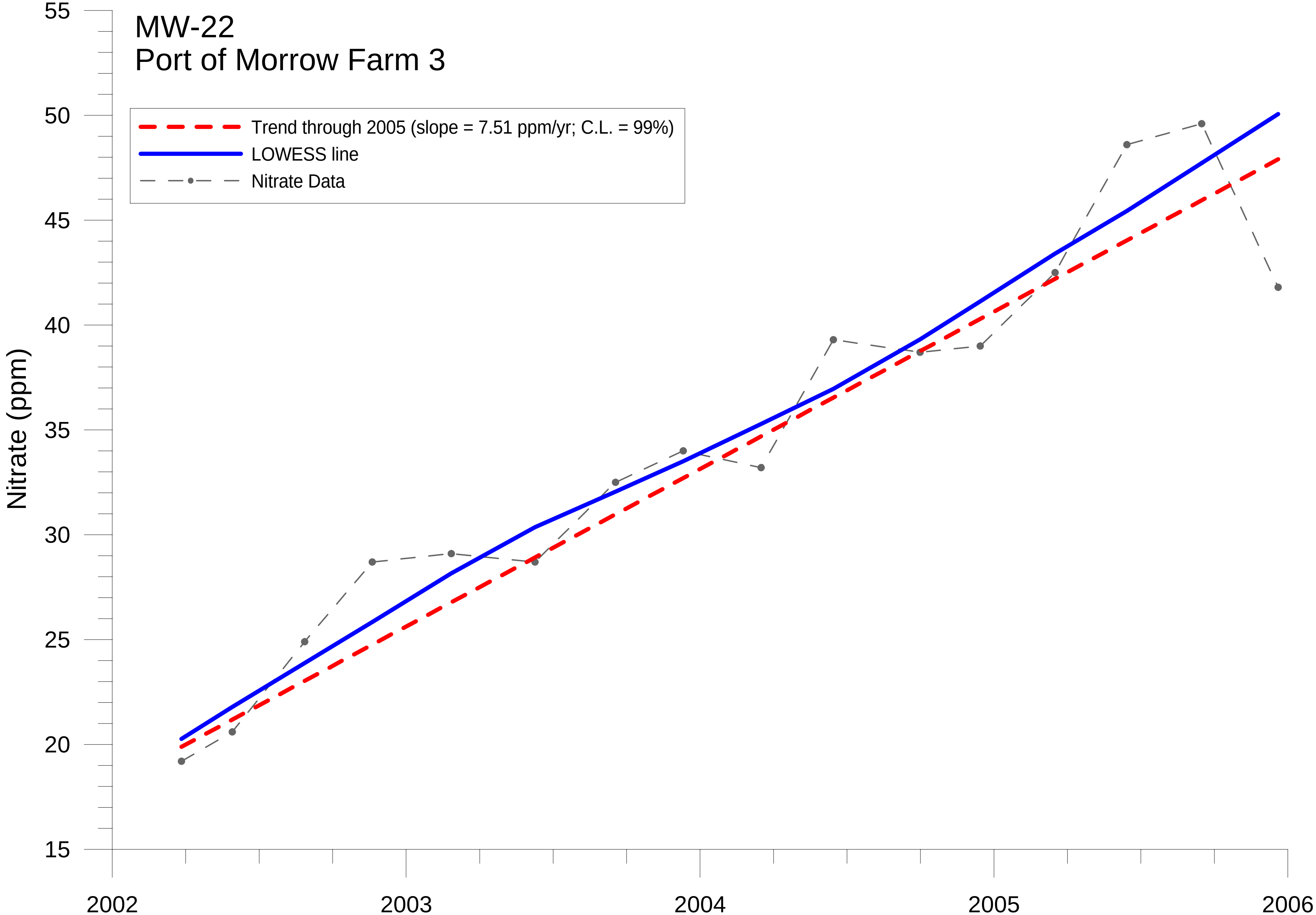


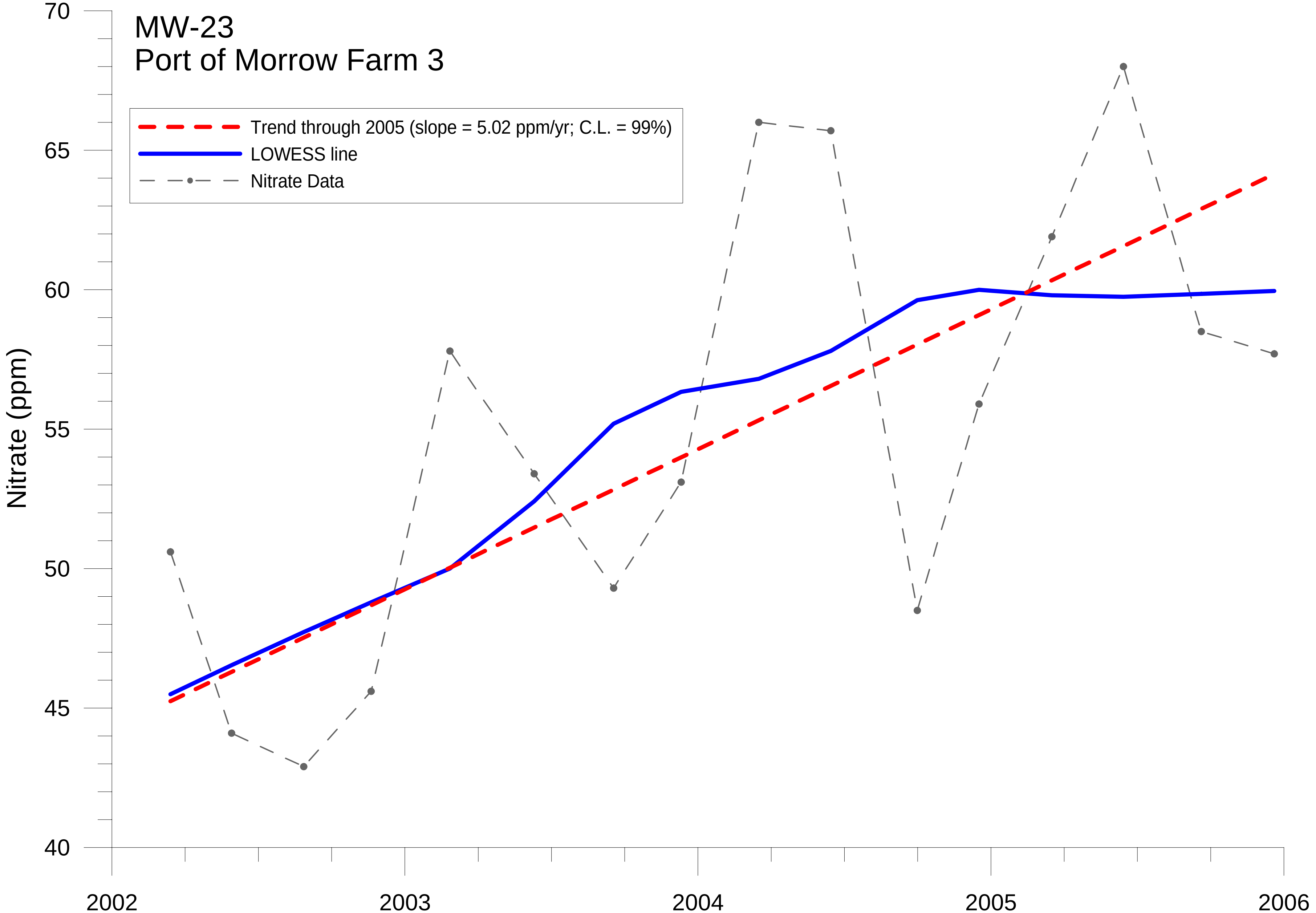
e:\lub\landapp\2006trendanalysispom*wellname*.grf



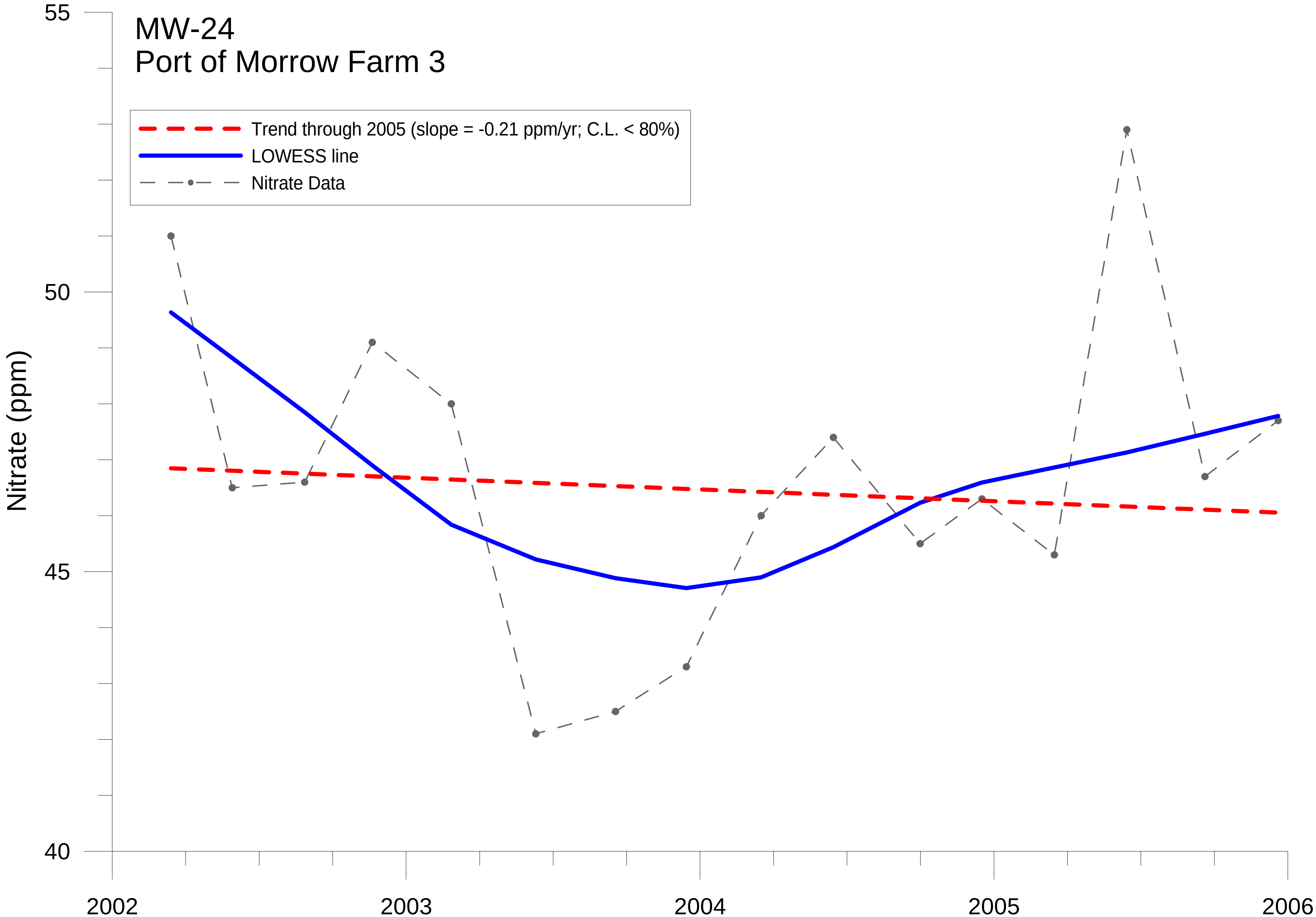
e:\lub\landapp\2006trendanalysispom*wellname*.grf



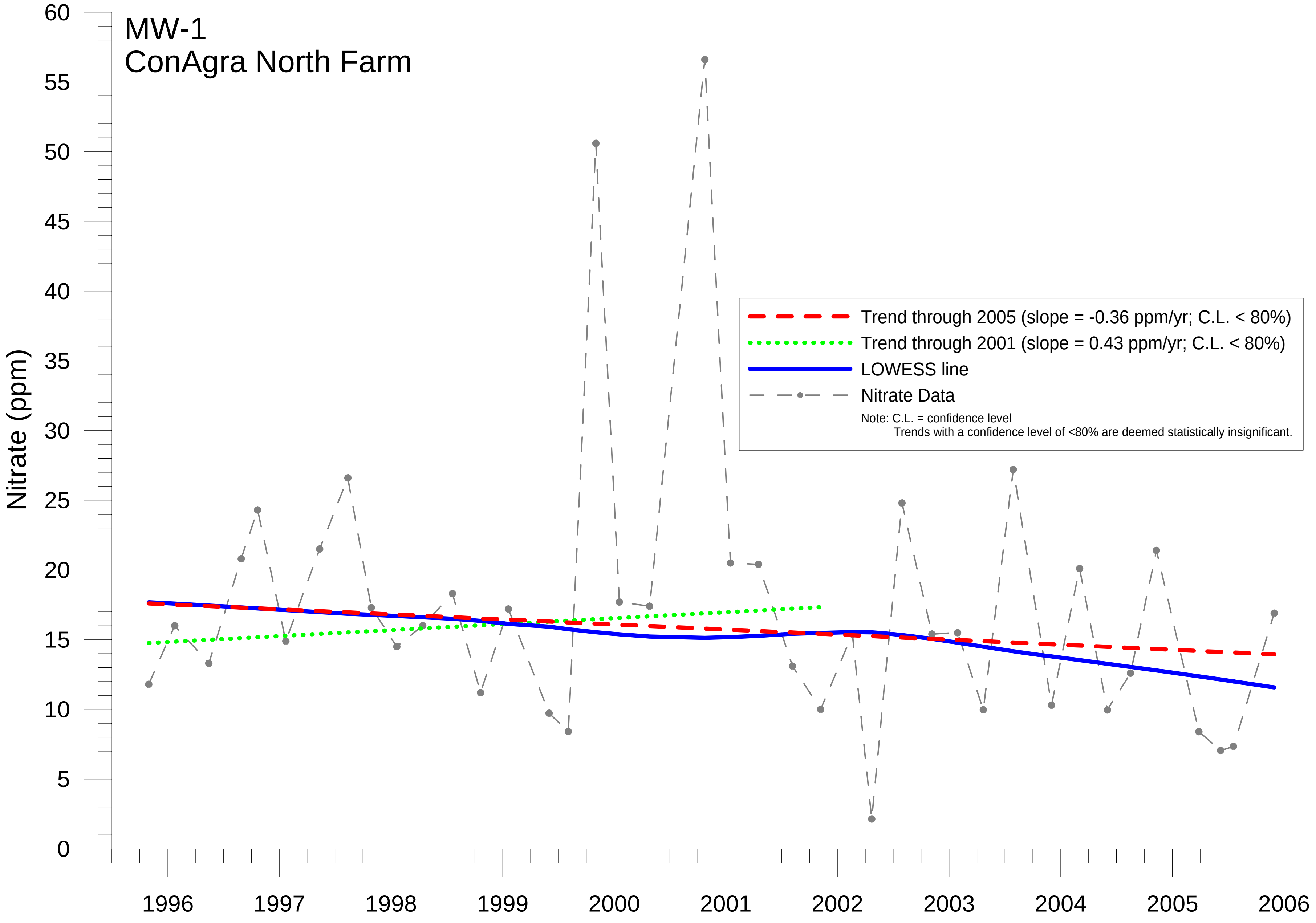
e:\lub\landapp\2006trendanalysispom*wellname*.grf



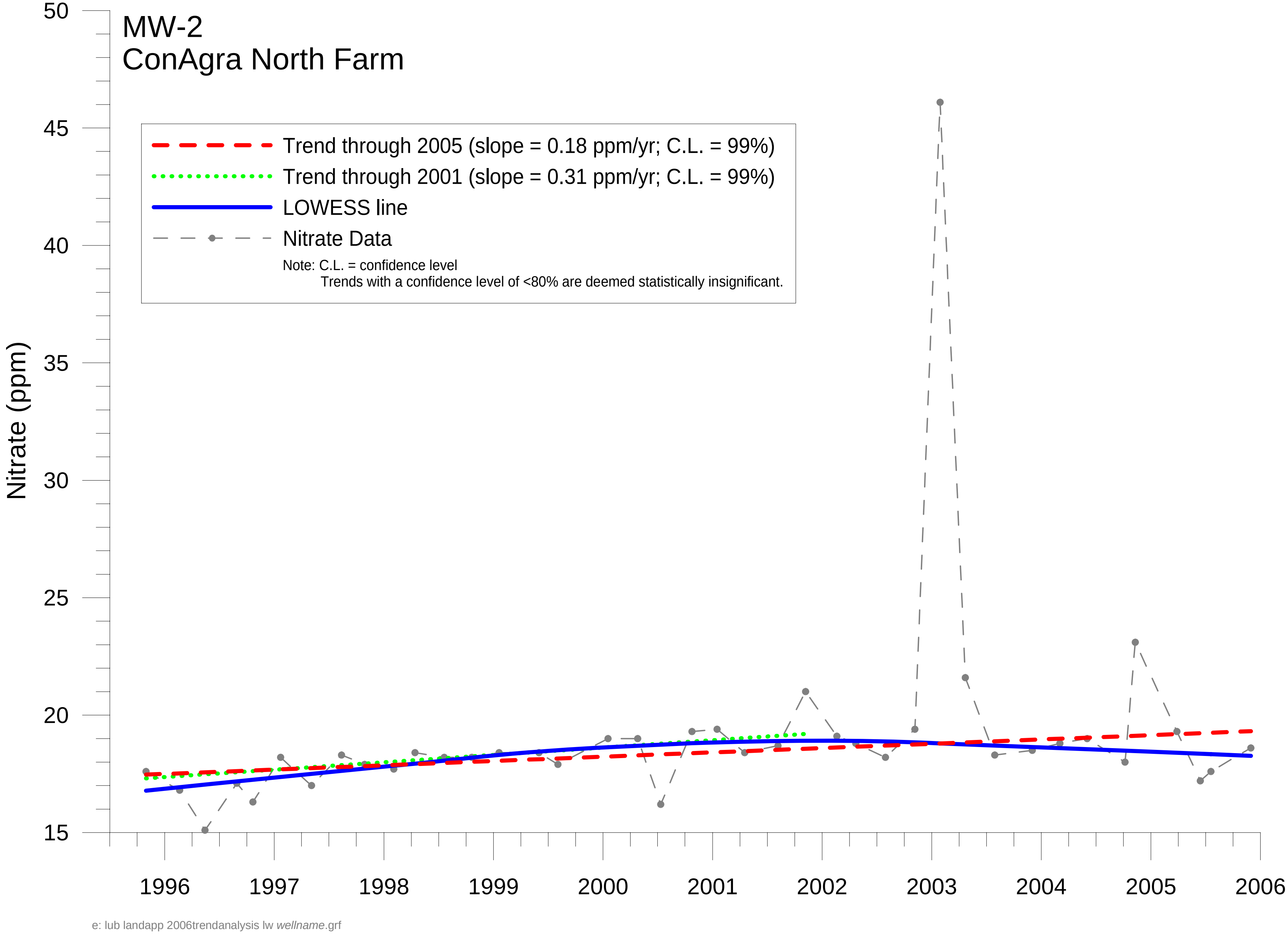
e:\lub\landapp\2006trendanalysispom*wellname*.grf



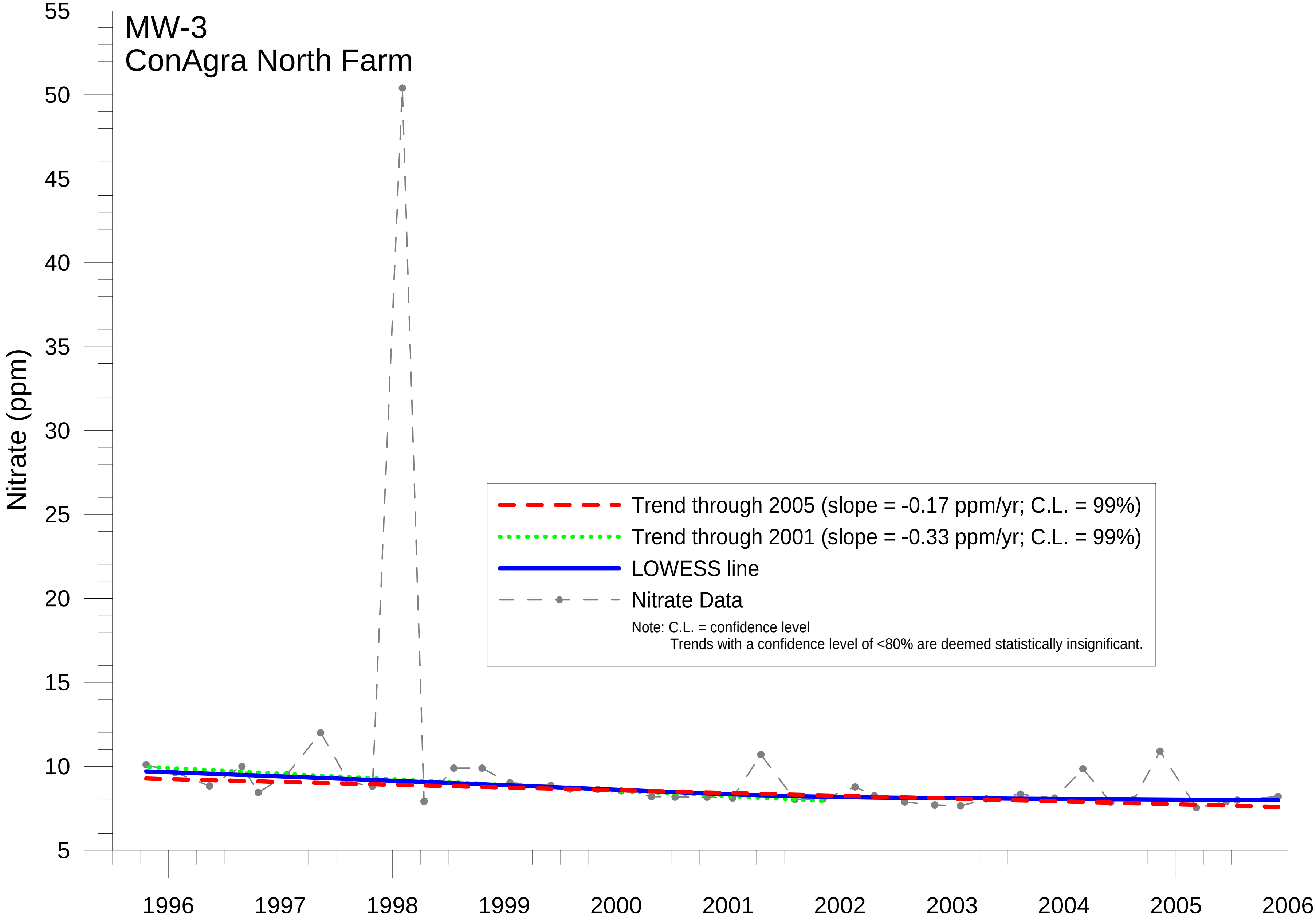
e:\lub\landapp\2006trendanalysispom*wellname*.grf



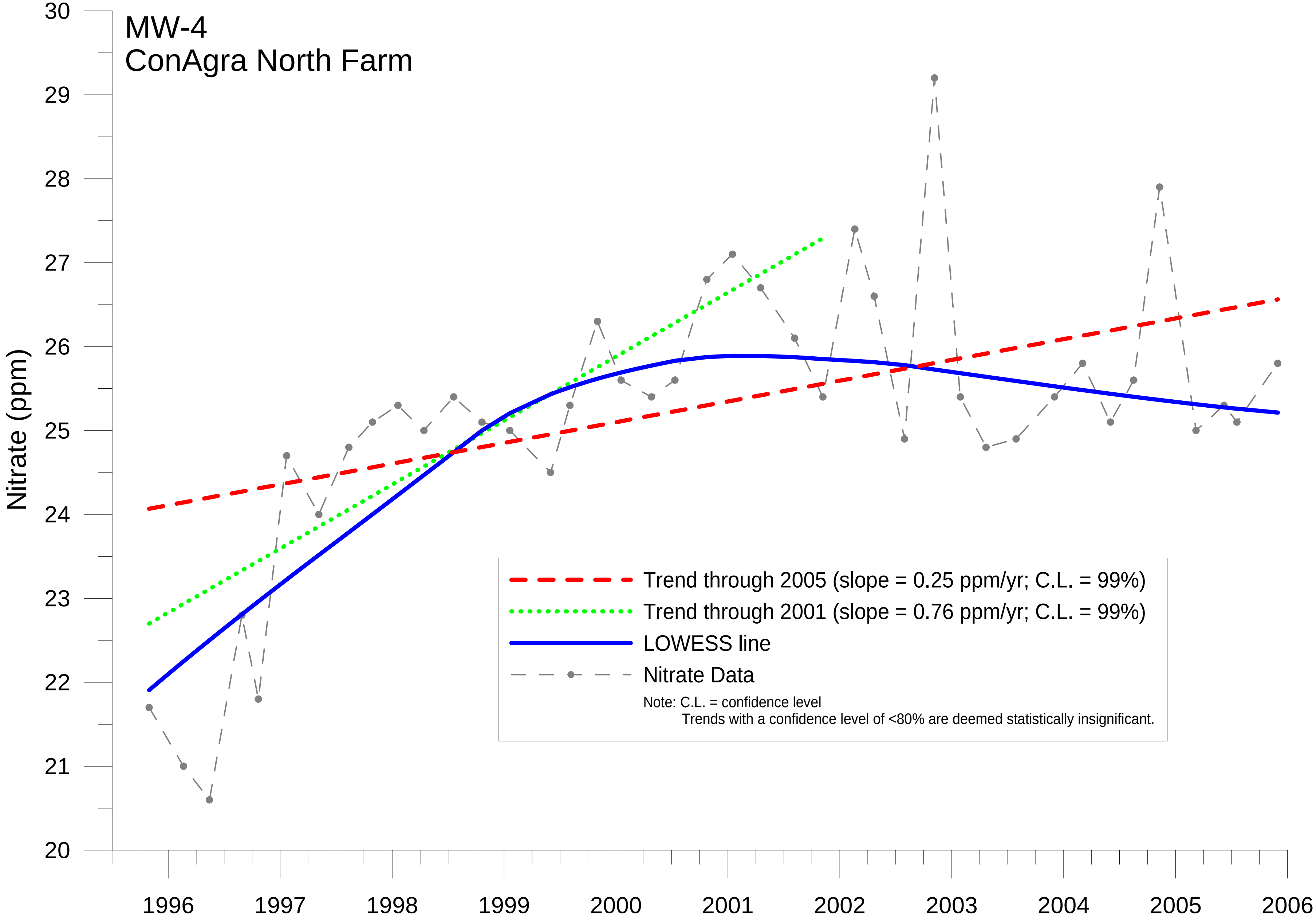
e: lub landapp 2006trendanalysis lw *wellname*.grf



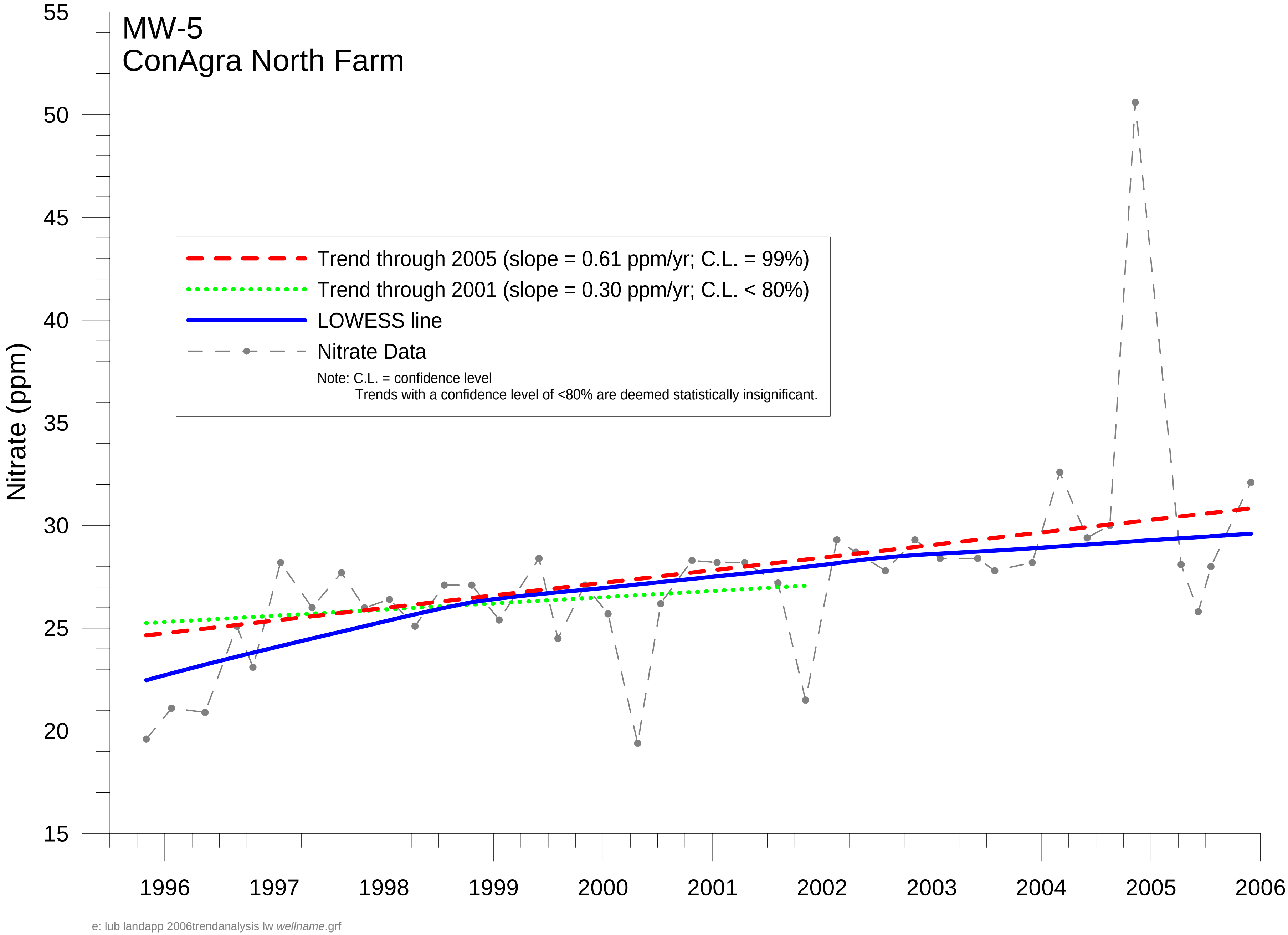
MW-2
ConAgra North Farm
Trend through 2005 (slope = 0.18 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.31 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Note: C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
50
45
40
35
30
25
20
15
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
e: lub landapp 2006trendanalysis lw *wellname*.grf



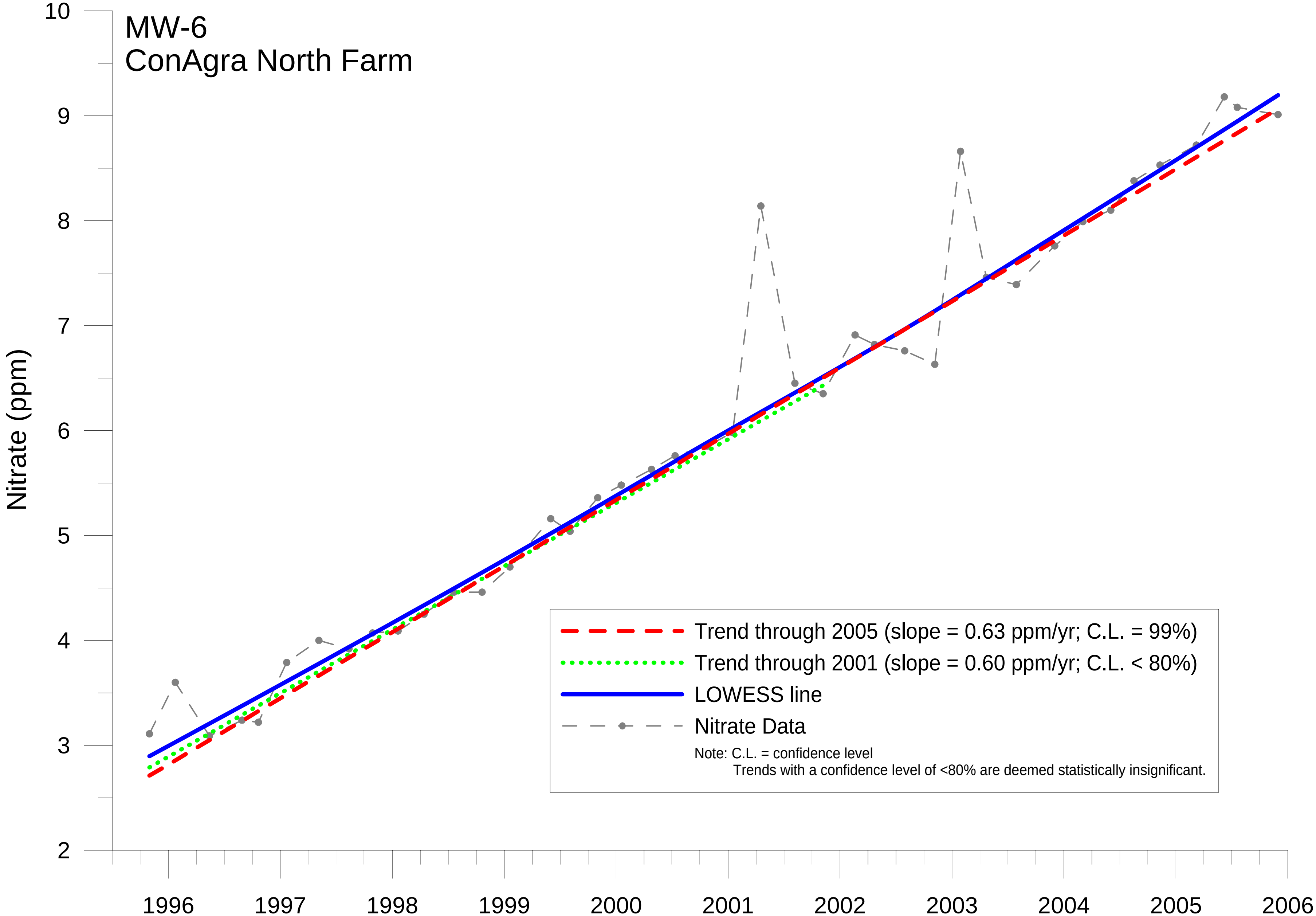
e: lub landapp 2006trendanalysis lw *wellname*.grf



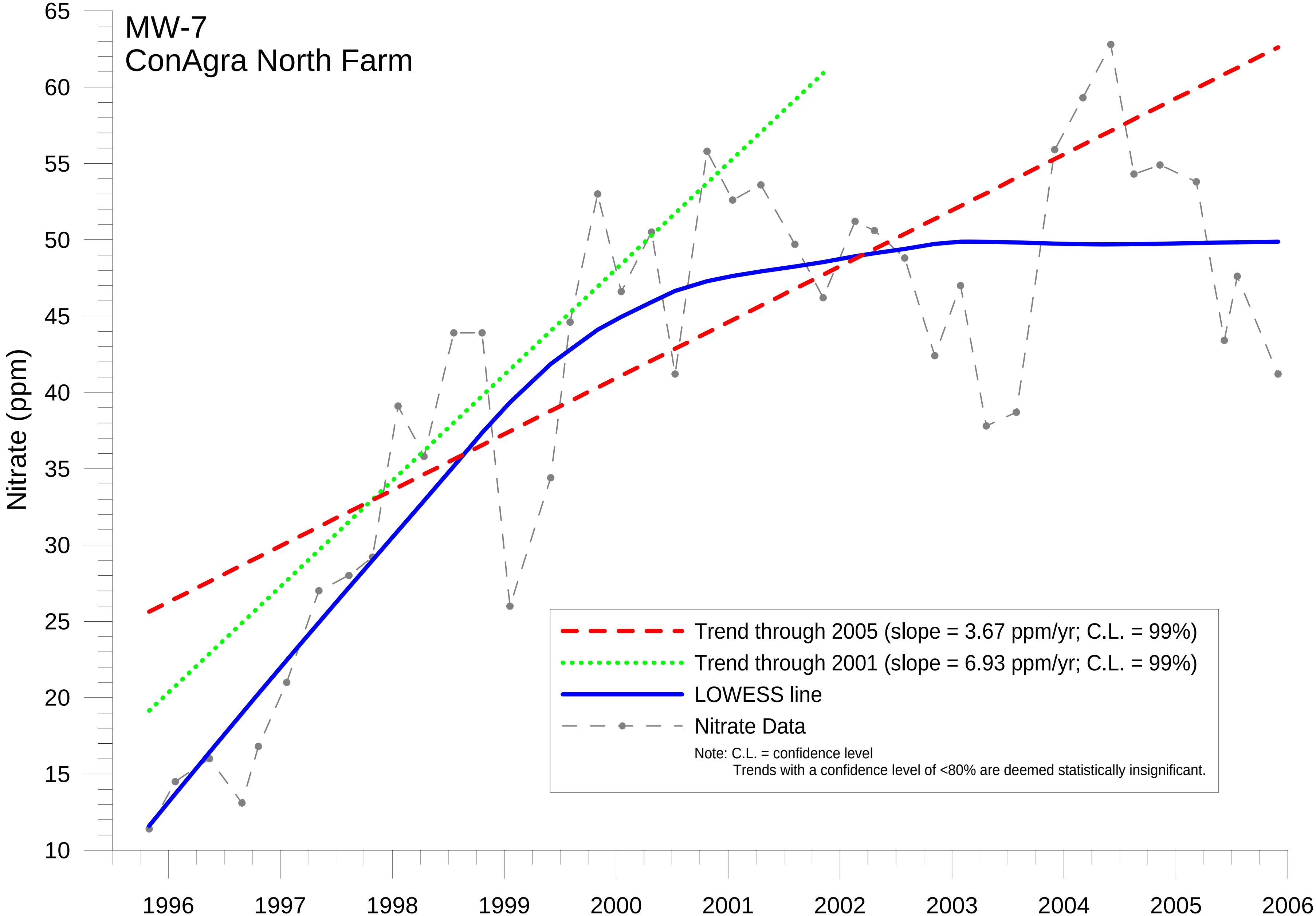
e: lub landapp 2006trendanalysis lw *wellname*.grf



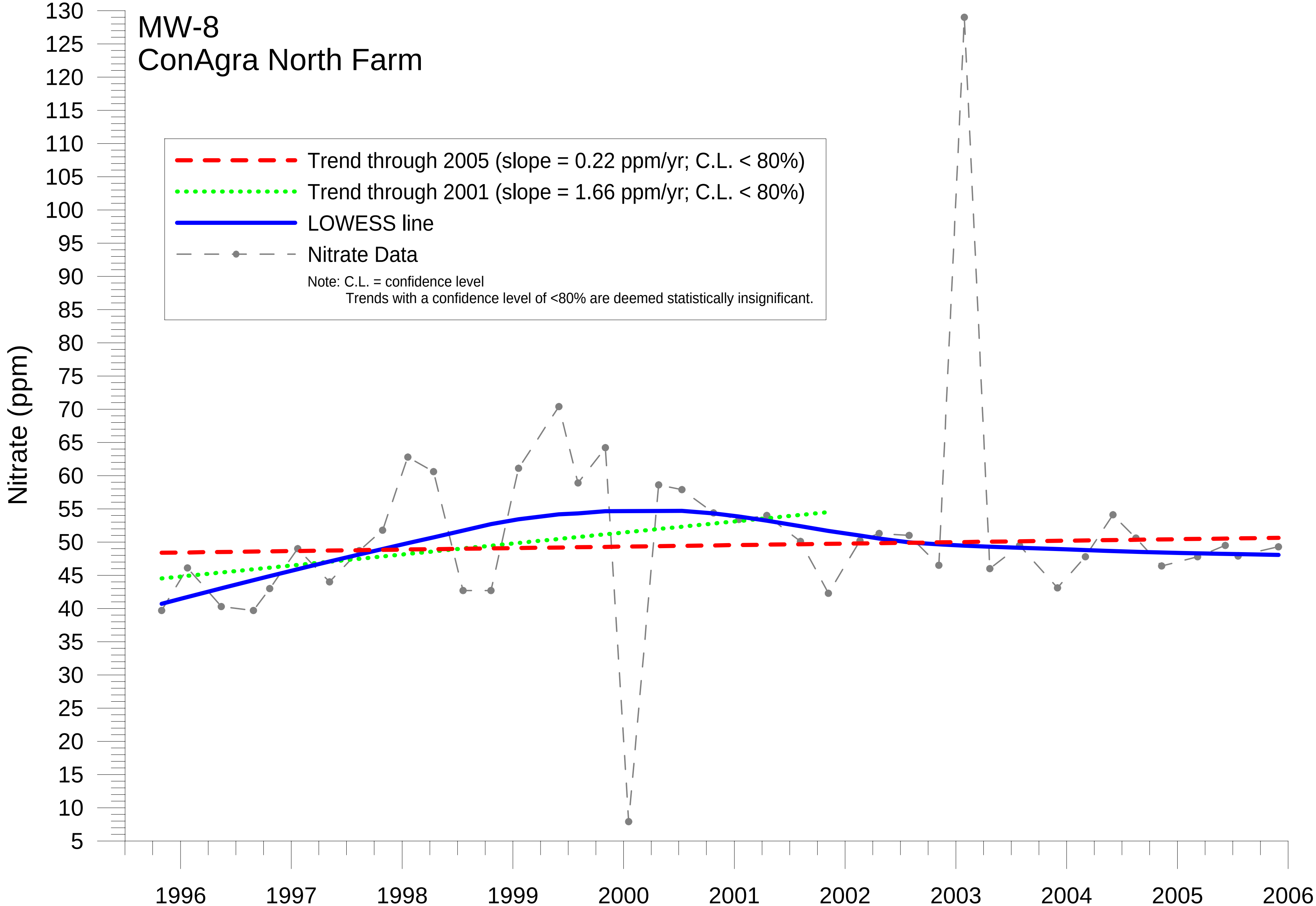
MW-5
ConAgra North Farm
Trend through 2005 (slope = 0.61 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.30 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Note: C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
55
50
45
40
35
30
25
20
15
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
e: lub landapp 2006trendanalysis lw *wellname*.grf



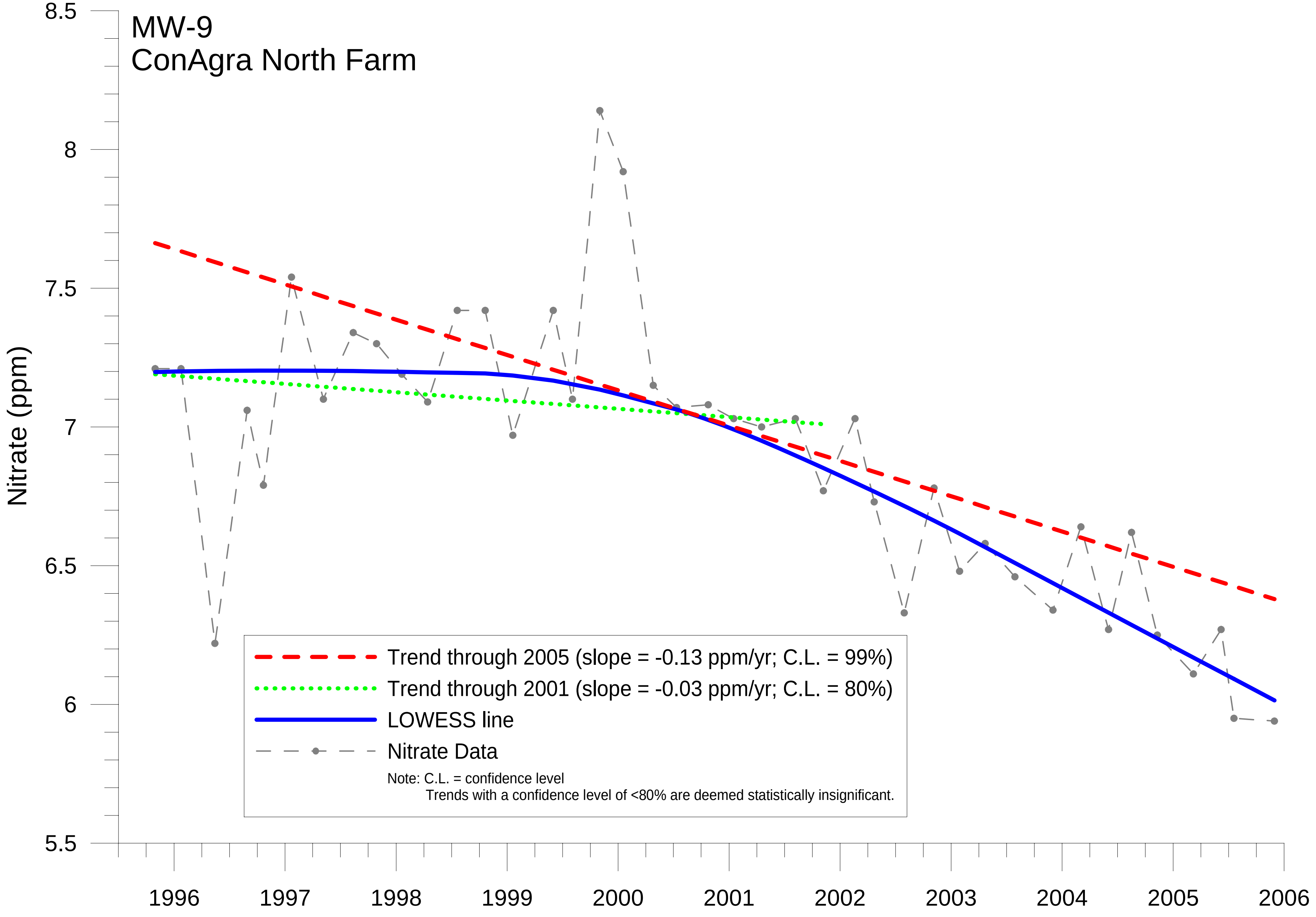
e: lub landapp 2006trendanalysis lw *wellname*.grf



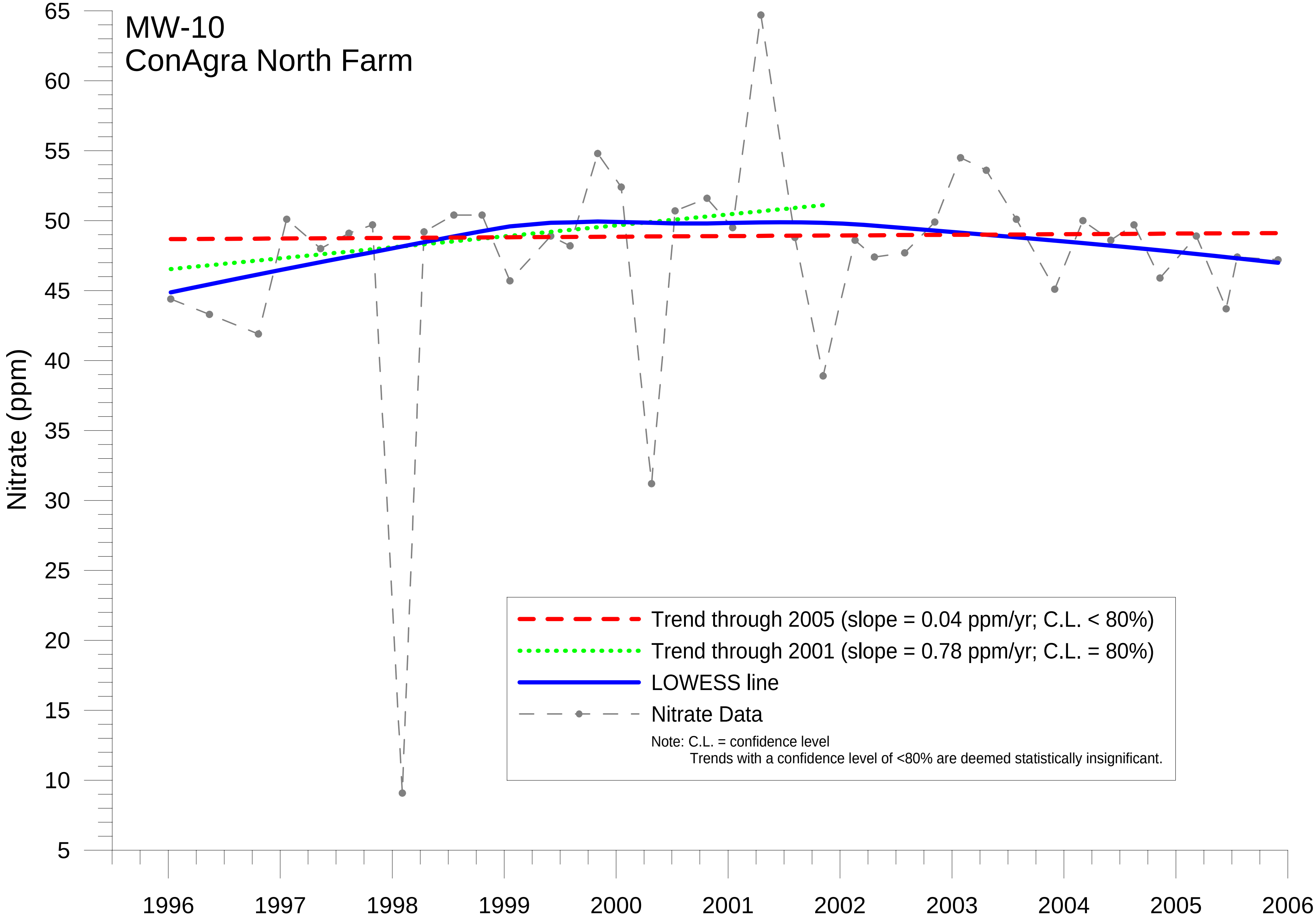
MW-7
ConAgra North Farm
Nitrate (ppm)
65
60
55
50
45
40
35
30
25
20
15
10
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 3.67 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 6.93 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Note: C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.



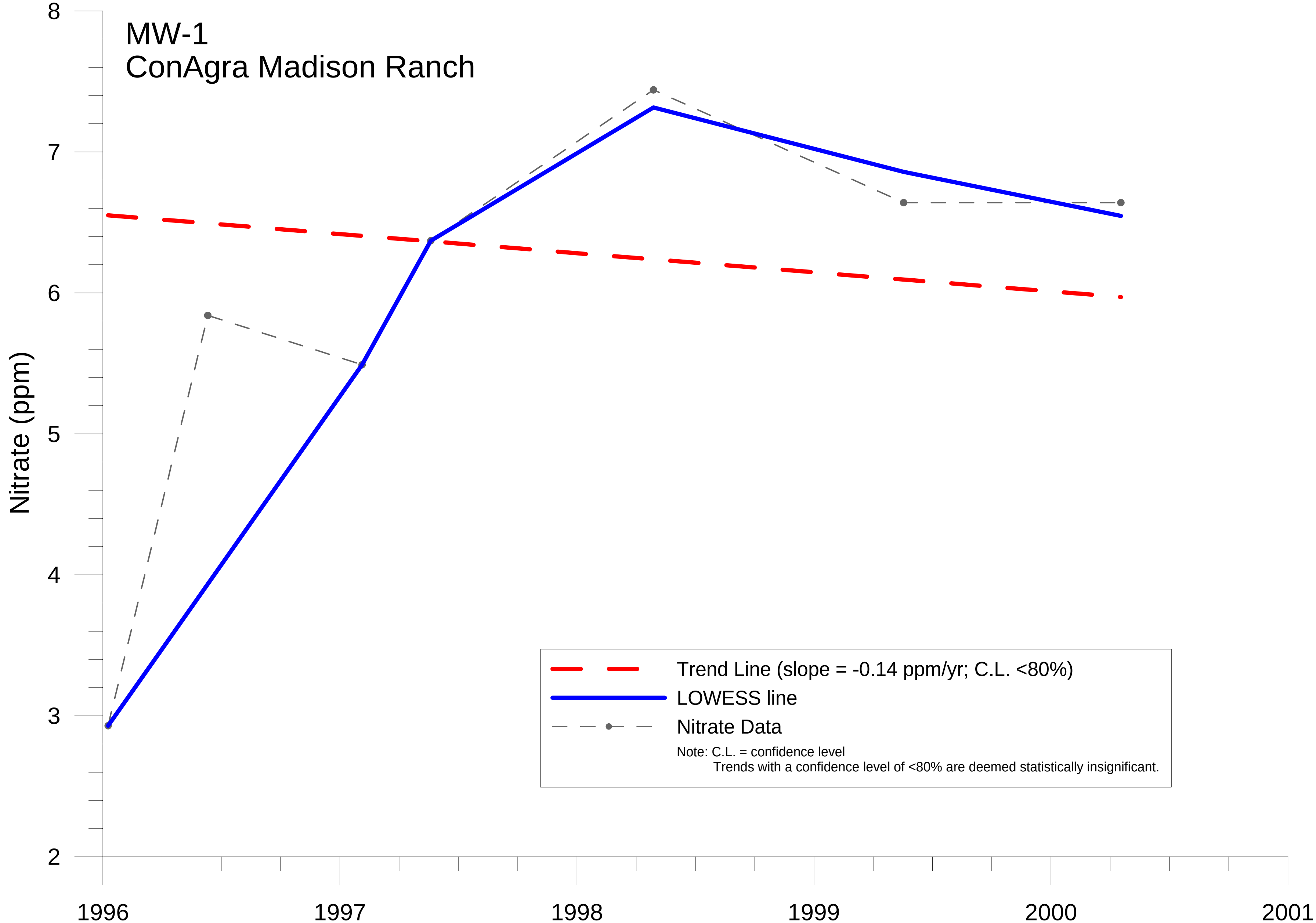
e: lub landapp 2006trendanalysis lw *wellname*.grf



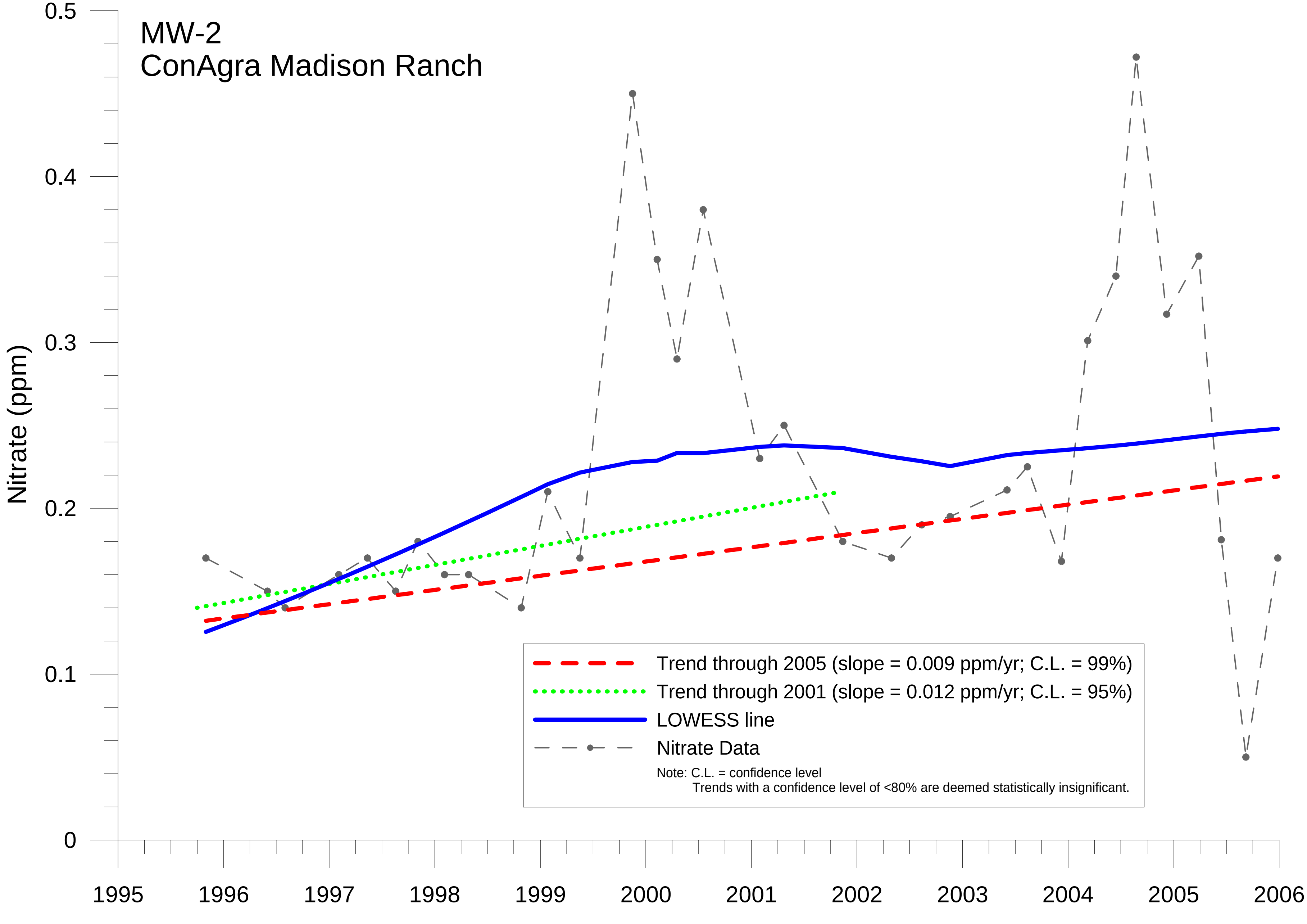
e: lub landapp 2006trendanalysis lw *wellname*.grf



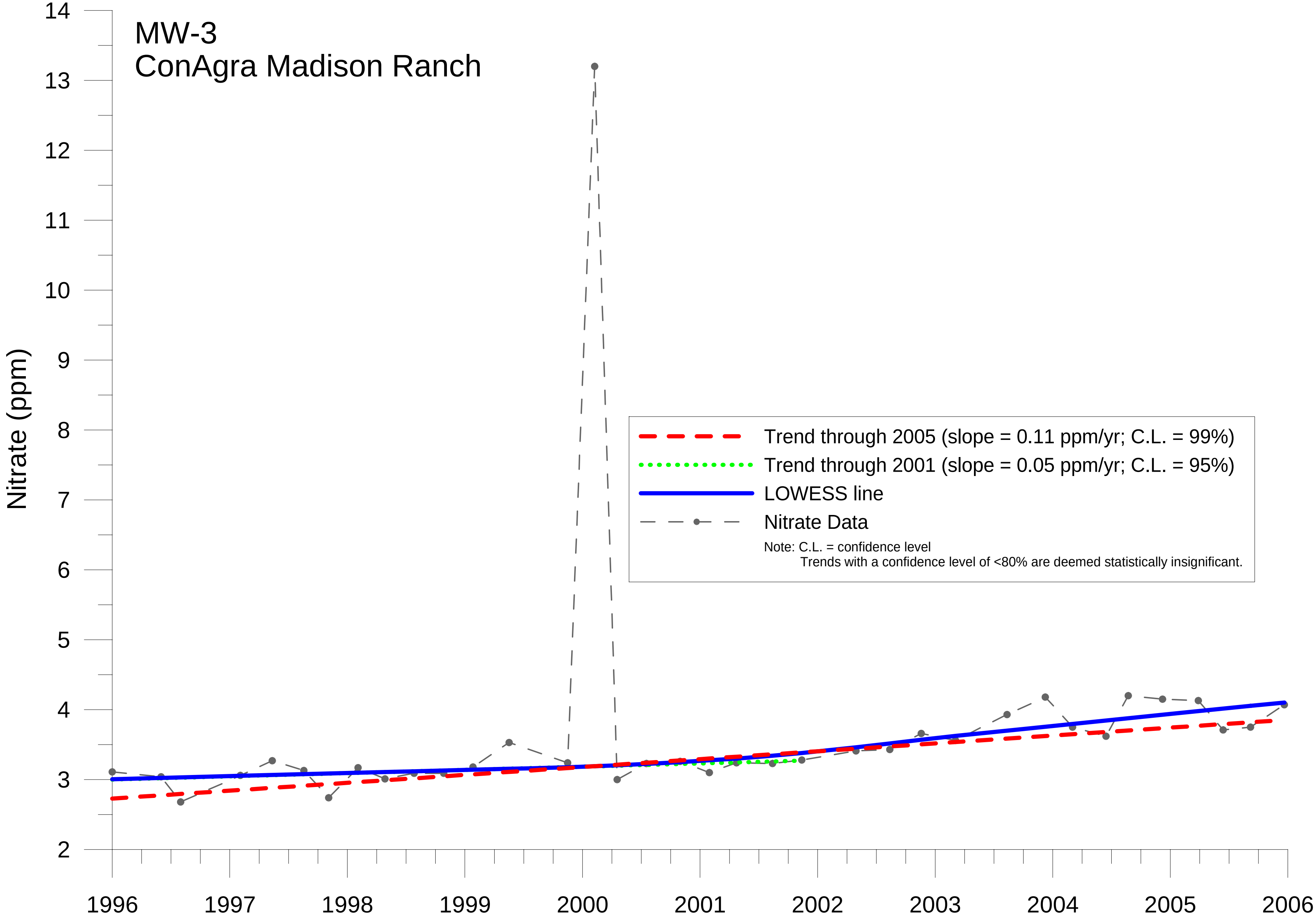
e: lub landapp 2006trendanalysis lw *wellname*.grf

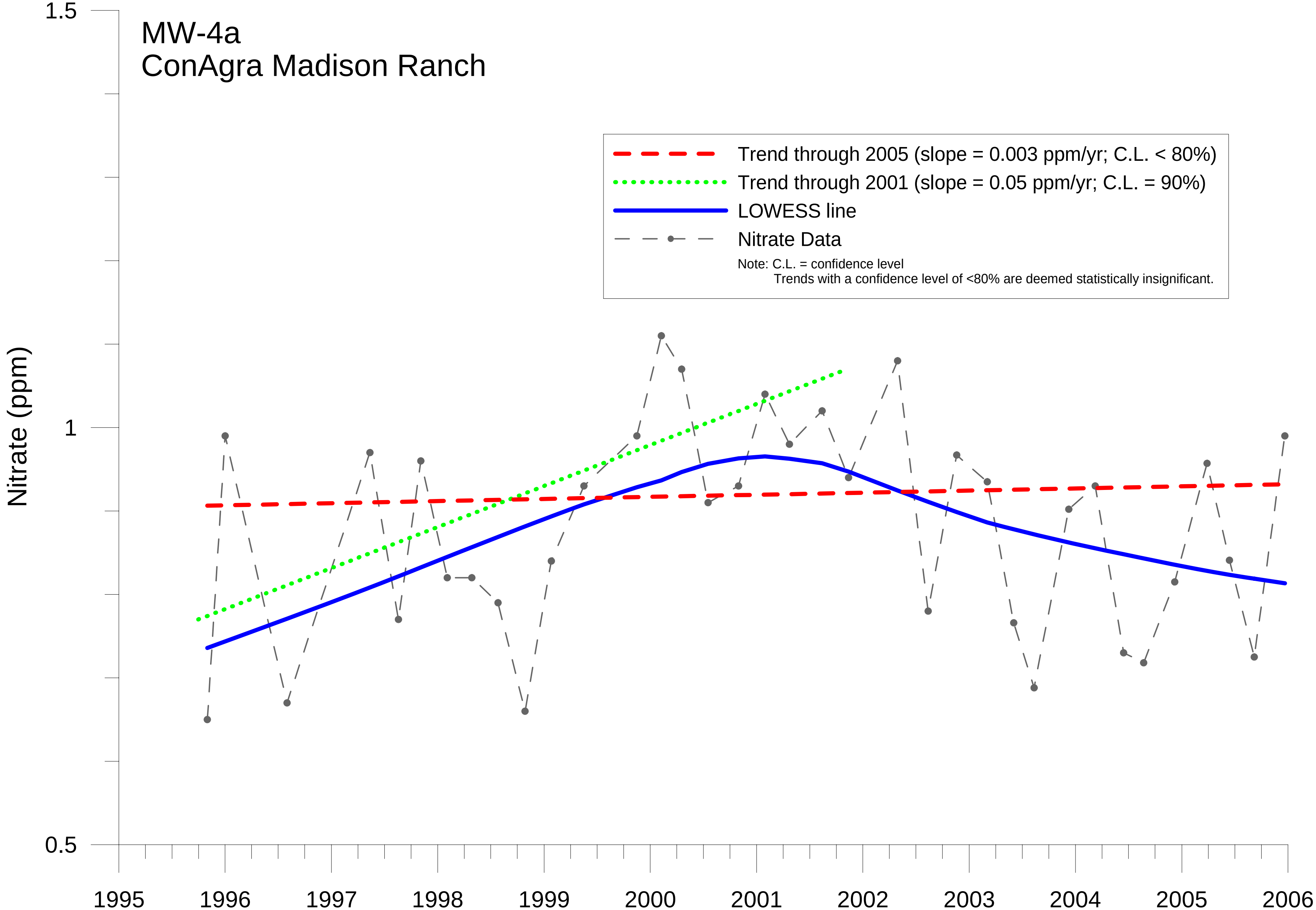


MW-1
ConAgra Madison Ranch
Nitrate (ppm)
8
7
6
5
4
3
2
1996
1997
1998
1999
2000
2001
Trend Line (slope = -0.14 ppm/yr; C.L. <80%)
LOWESS line
Nitrate Data
Note: C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

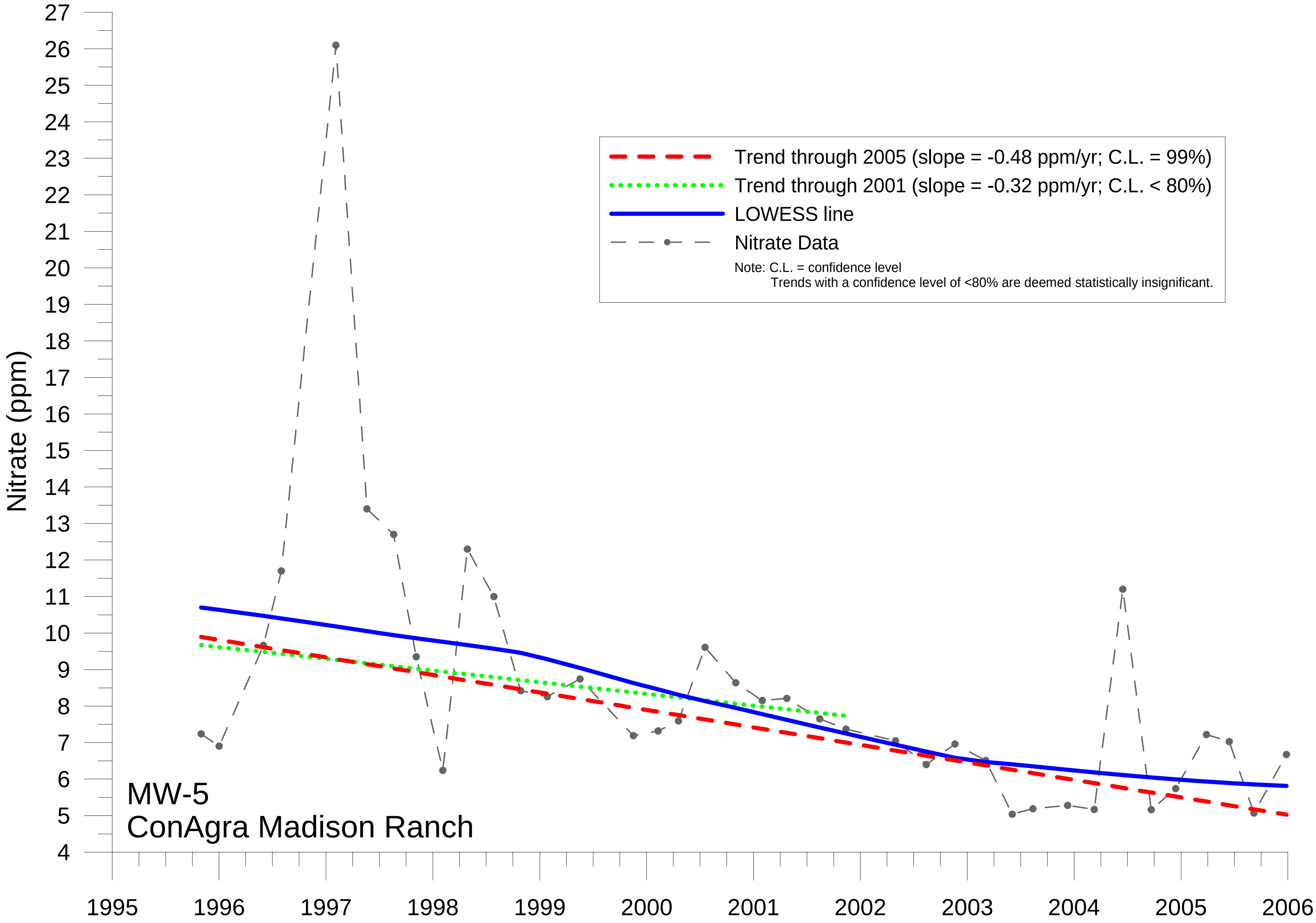


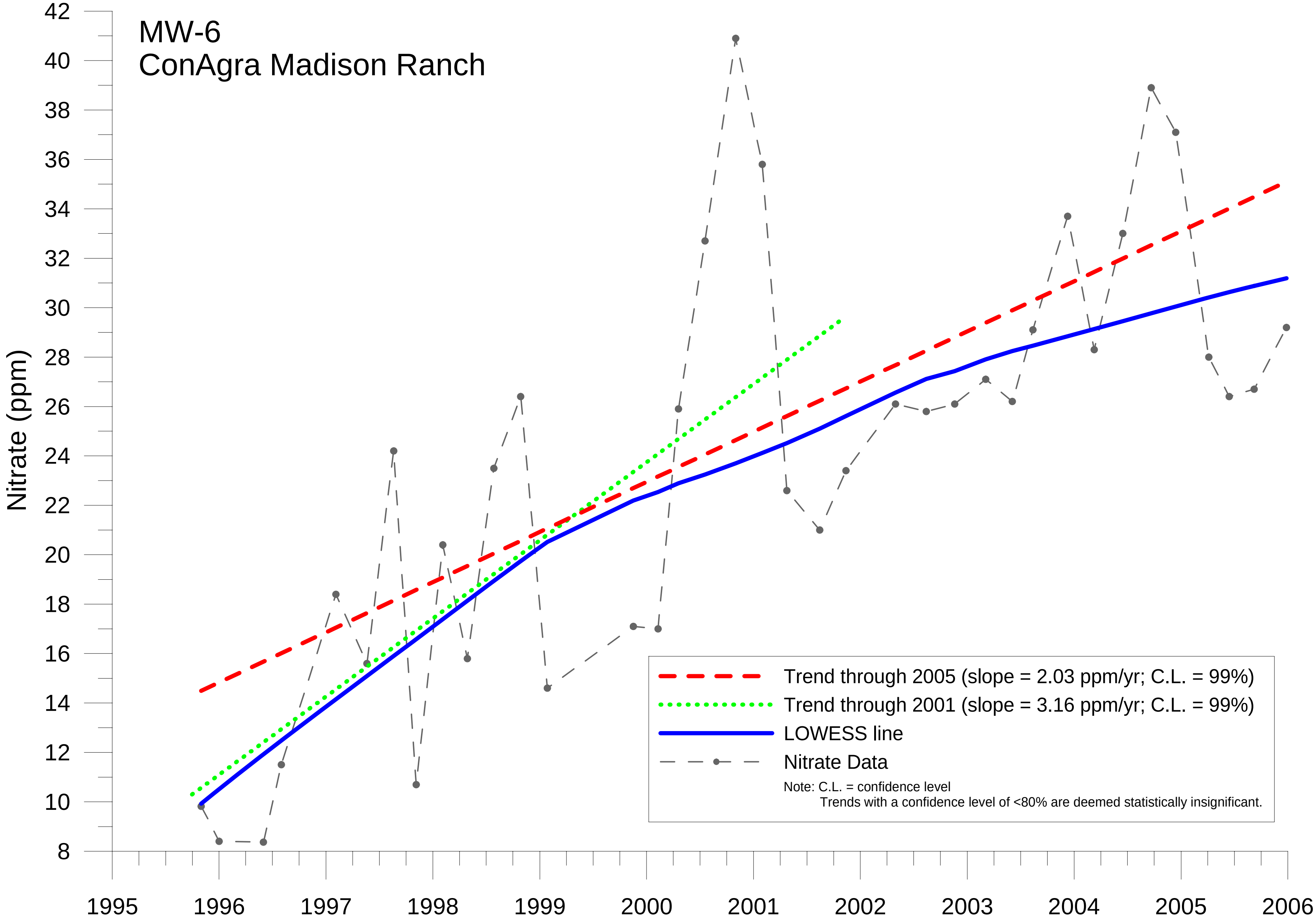
MW-2
ConAgra Madison Ranch
Nitrate (ppm)
0.5
0.4
0.3
0.2
0.1
0
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 0.009 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.012 ppm/yr; C.L. = 95%)
LOWESS line
Nitrate Data
Note: C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

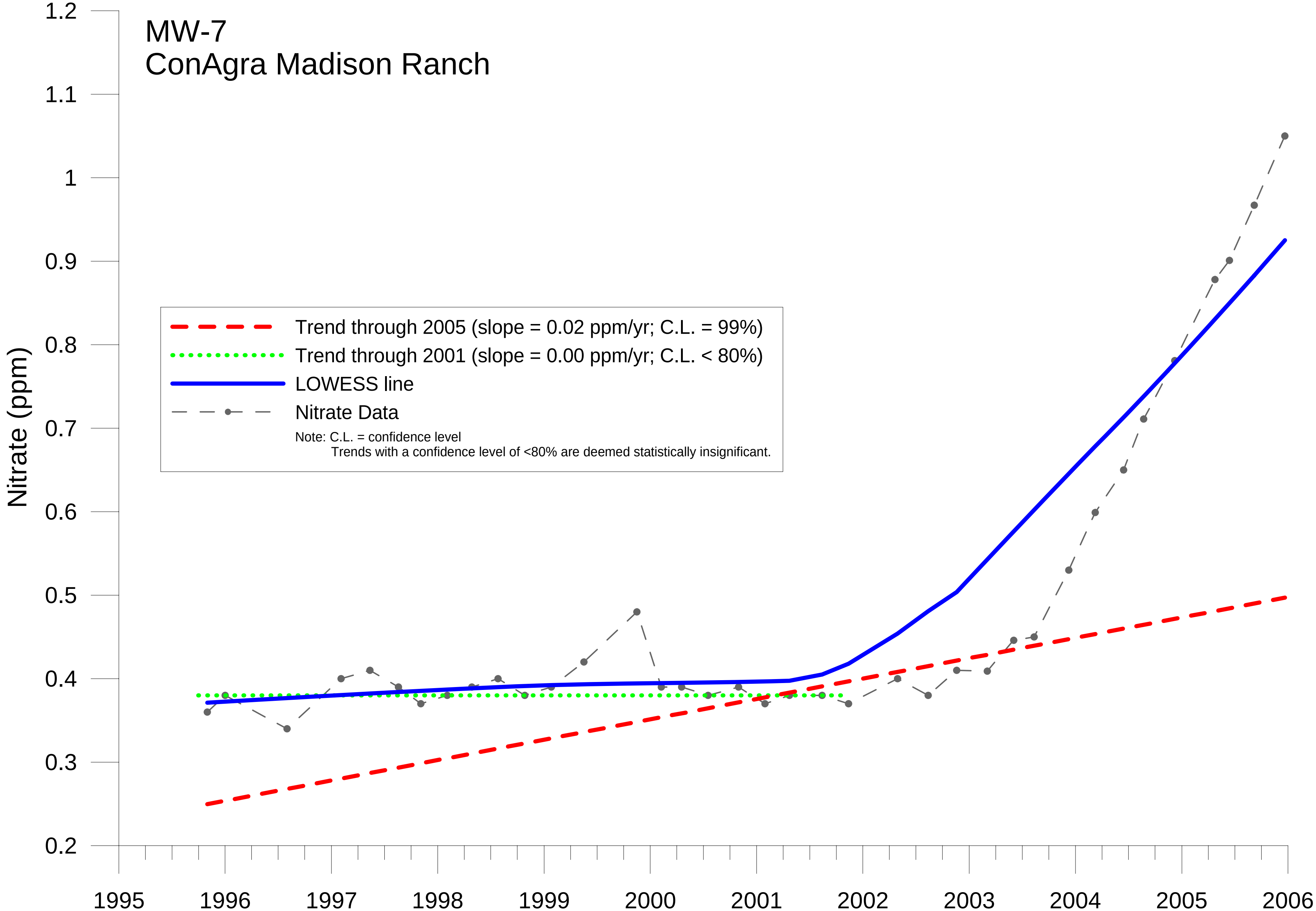

MW-3
ConAgra Madison Ranch
Nitrate (ppm)
14
13
12
11
10
9
8
7
6
5
4
3
2
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 0.11 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.05 ppm/yr; C.L. = 95%)
LOWESS line
Nitrate Data
Note: C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.



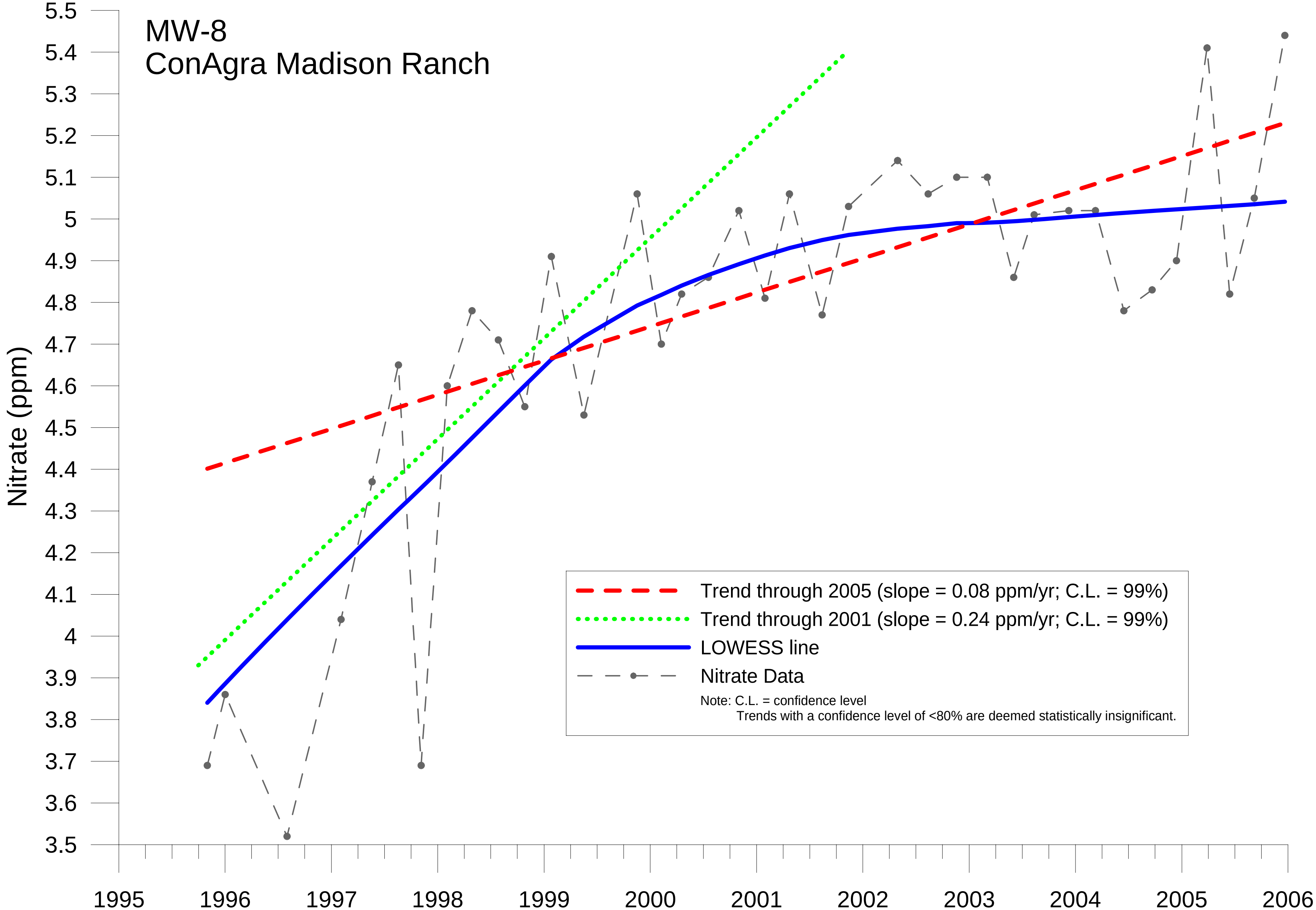
MW-4a
ConAgra Madison Ranch
Trend through 2005 (slope = 0.003 ppm/yr; C.L. < 80%)
Trend through 2001 (slope = 0.05 ppm/yr; C.L. = 90%)
LOWESS line
Nitrate Data
Note: C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
1.5
1
0.5
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006

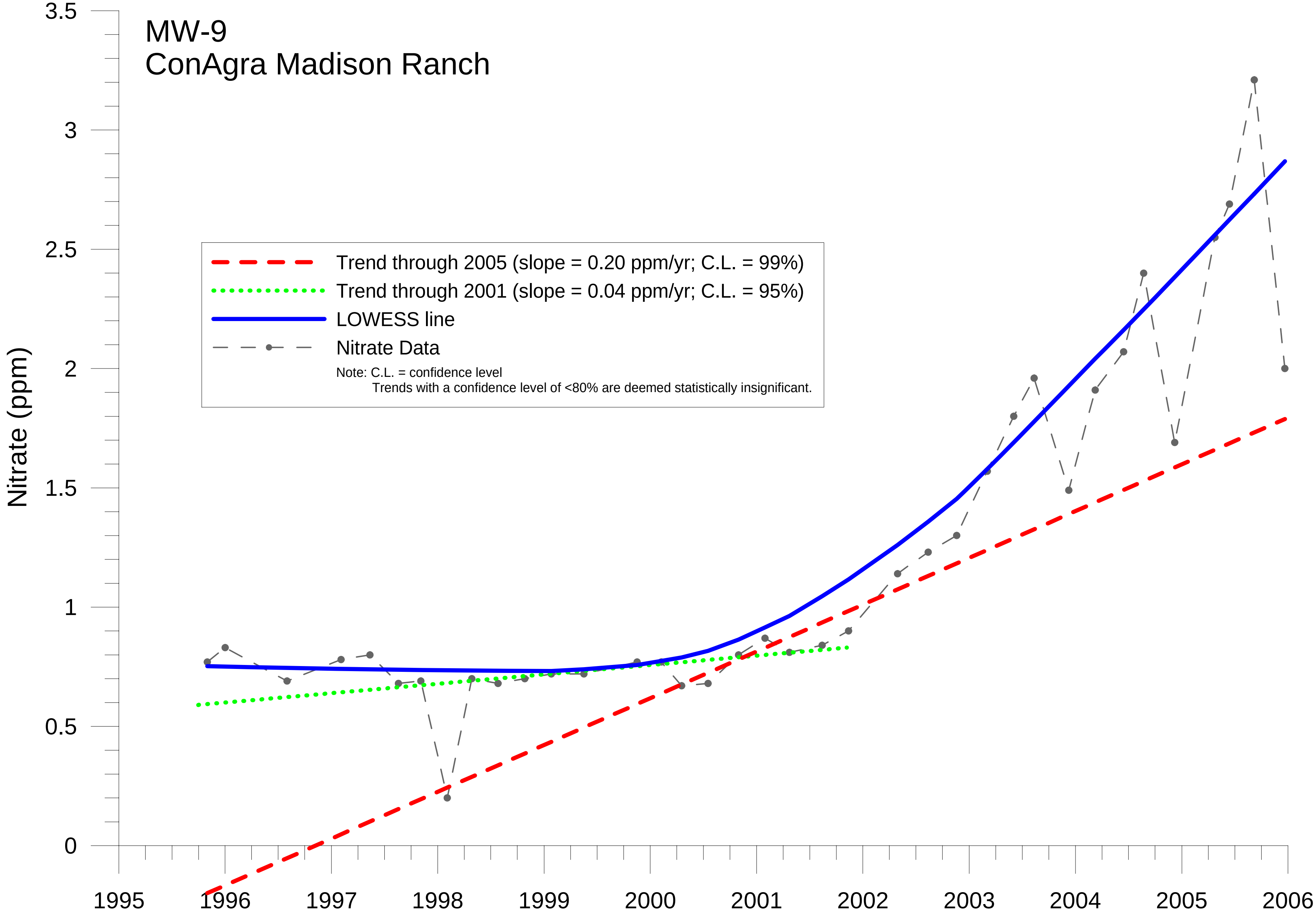

Trend through 2005 (slope = -0.48 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = -0.32 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Note: C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
MW-5
ConAgra Madison Ranch

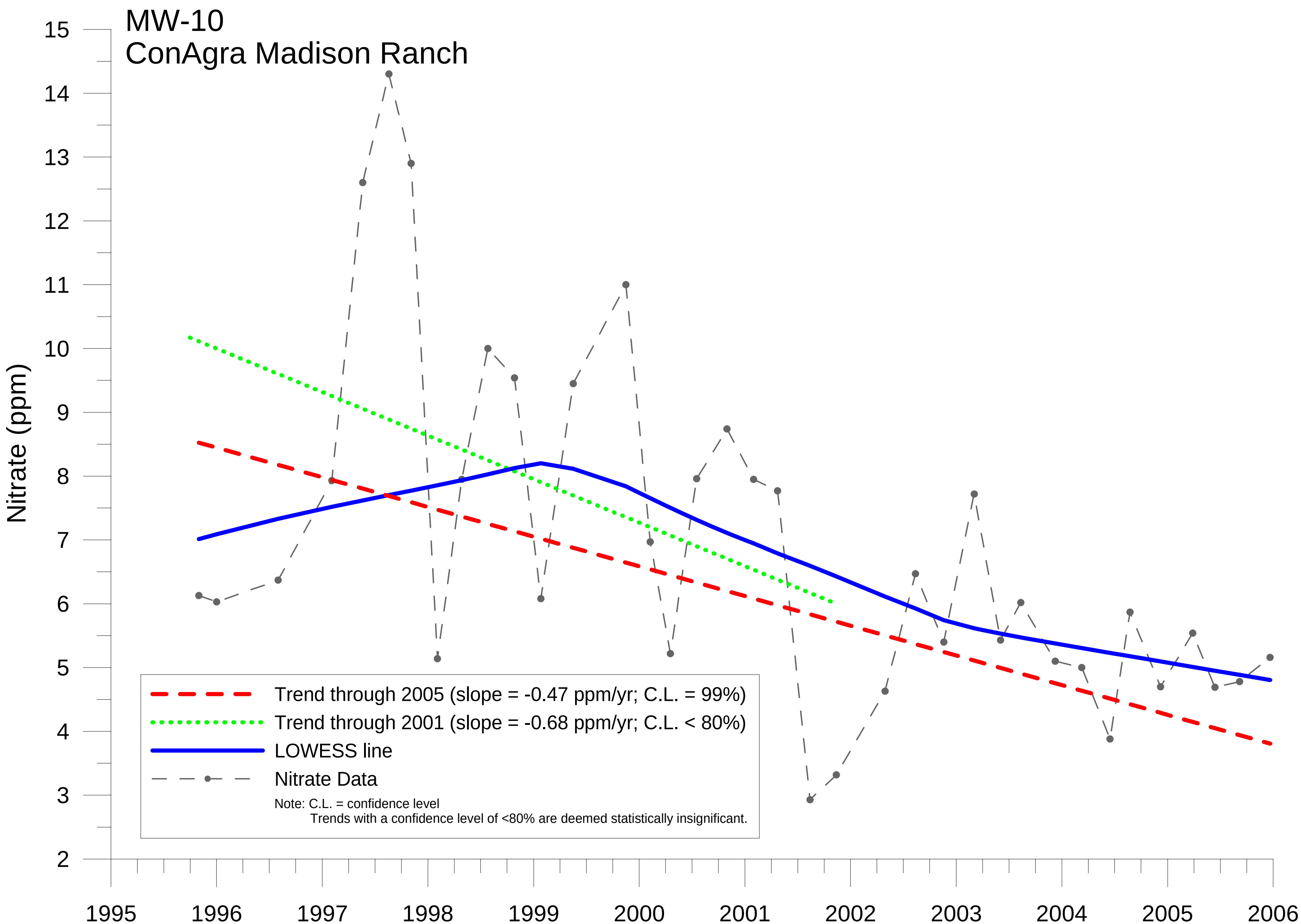

MW-6
ConAgra Madison Ranch
Nitrate (ppm)
42
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 2.03 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 3.16 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Note: C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.



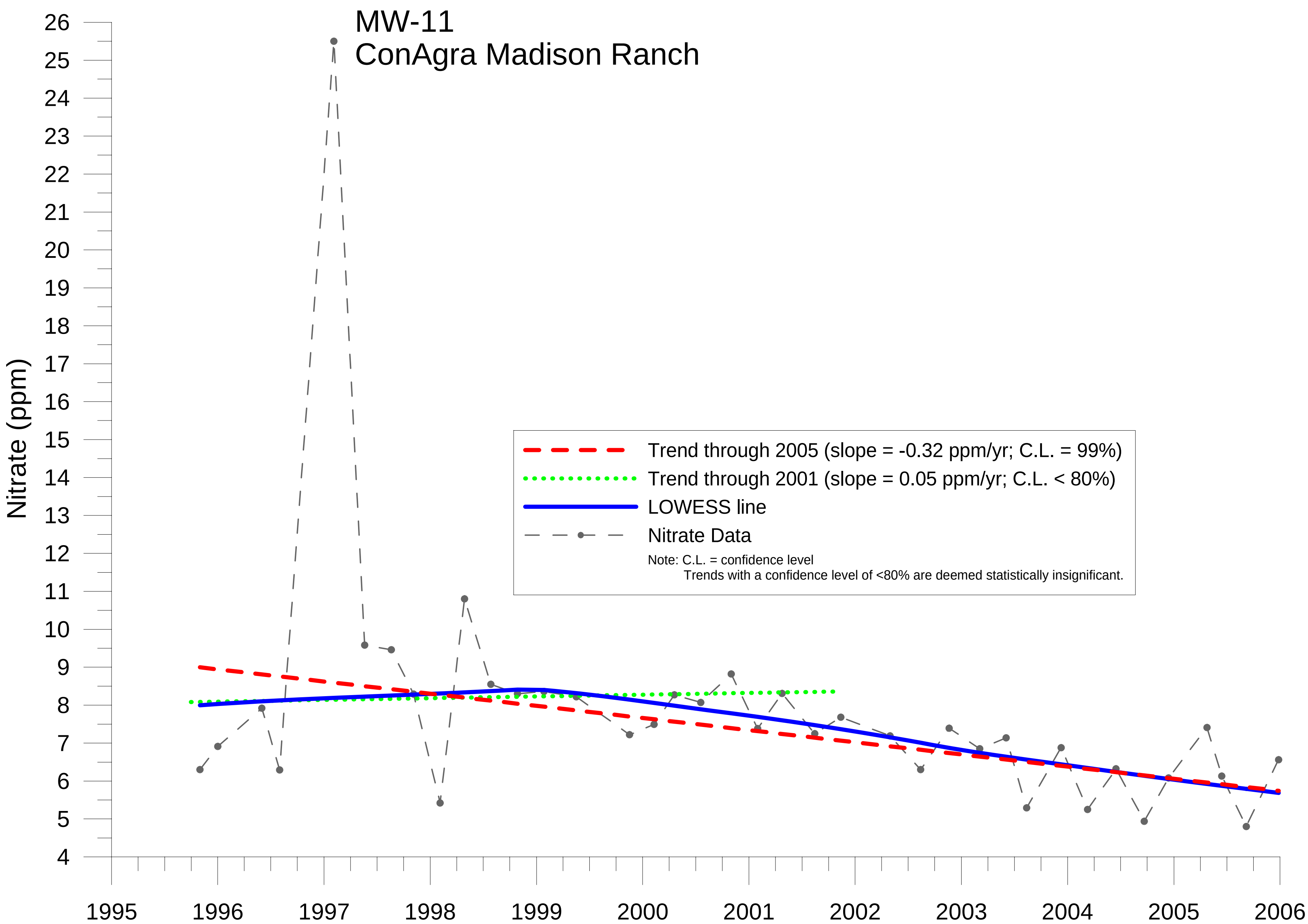
MW-7
ConAgra Madison Ranch
Nitrate (ppm)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 0.02 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.00 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Note: C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.


MW-8
ConAgra Madison Ranch
Nitrate (ppm)
5.5
5.4
5.3
5.2
5.1
5
4.9
4.8
4.7
4.6
4.5
4.4
4.3
4.2
4.1
4
3.9
3.8
3.7
3.6
3.5
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 0.08 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.24 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Note: C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

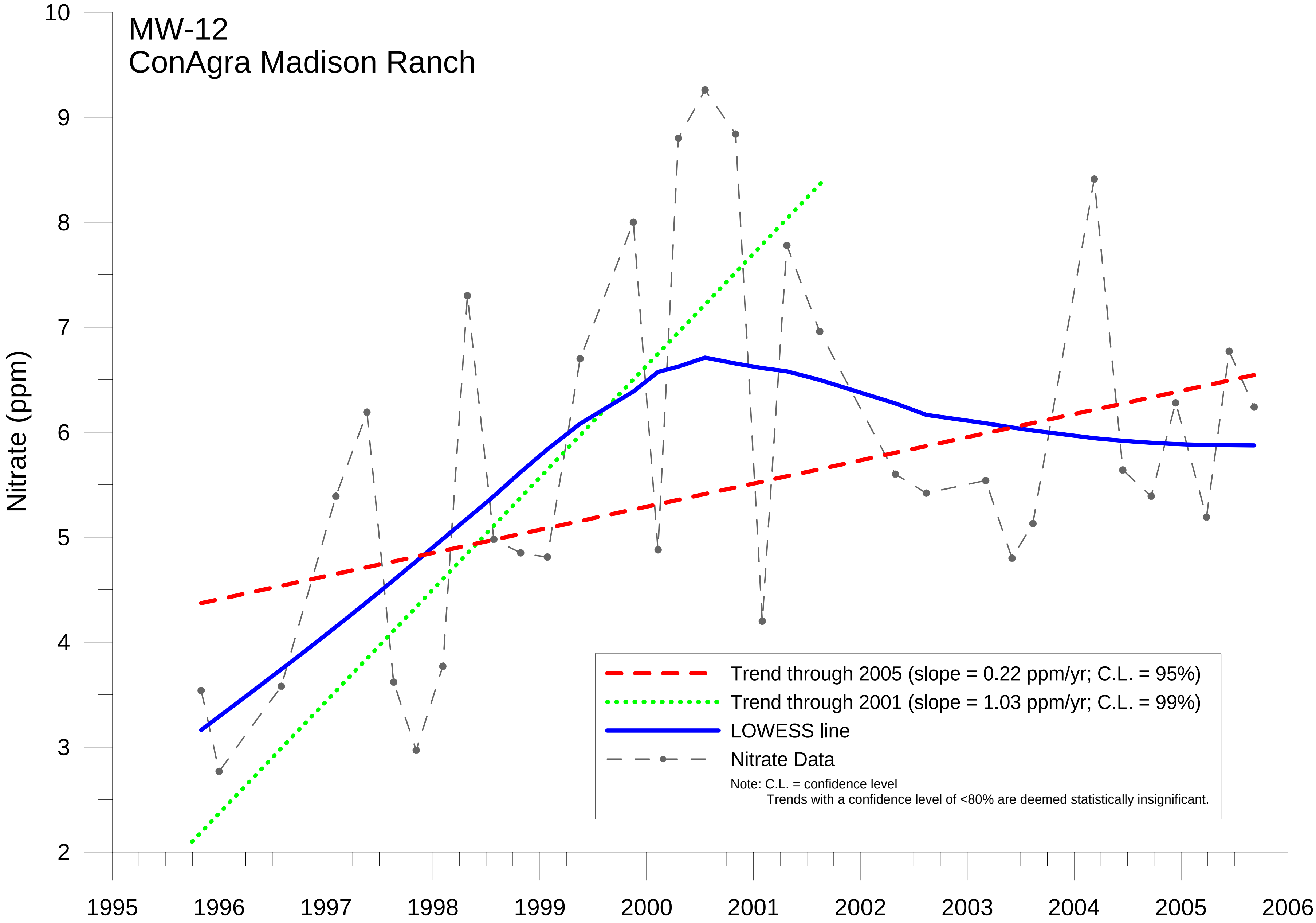

MW-9
ConAgra Madison Ranch
Trend through 2005 (slope = 0.20 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.04 ppm/yr; C.L. = 95%)
LOWESS line
Nitrate Data
Note: C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
0
0.5
1
1.5
2
2.5
3
3.5
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006



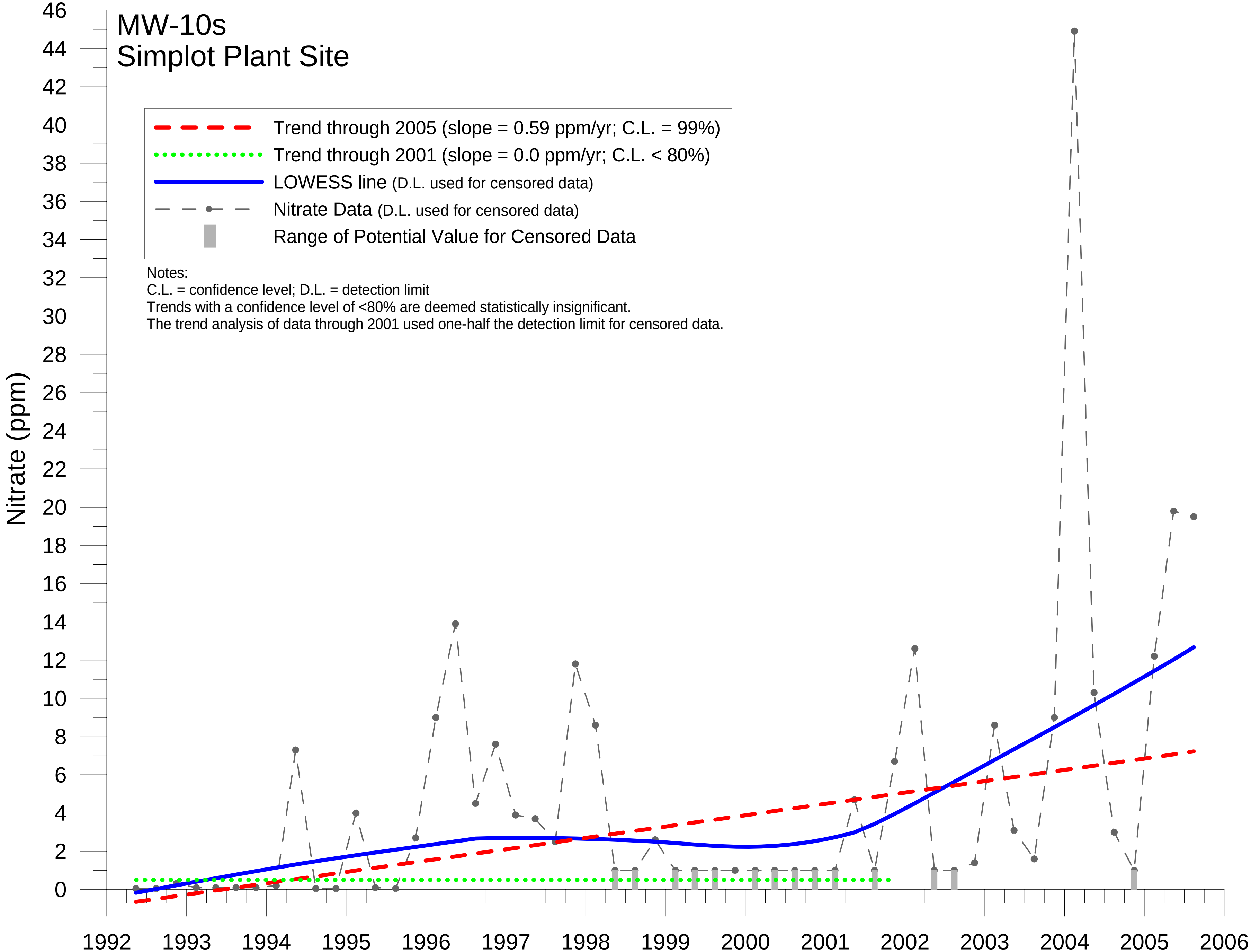
MW-10
ConAgra Madison Ranch
Nitrate (ppm)
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = -0.47 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = -0.68 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Note: C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.



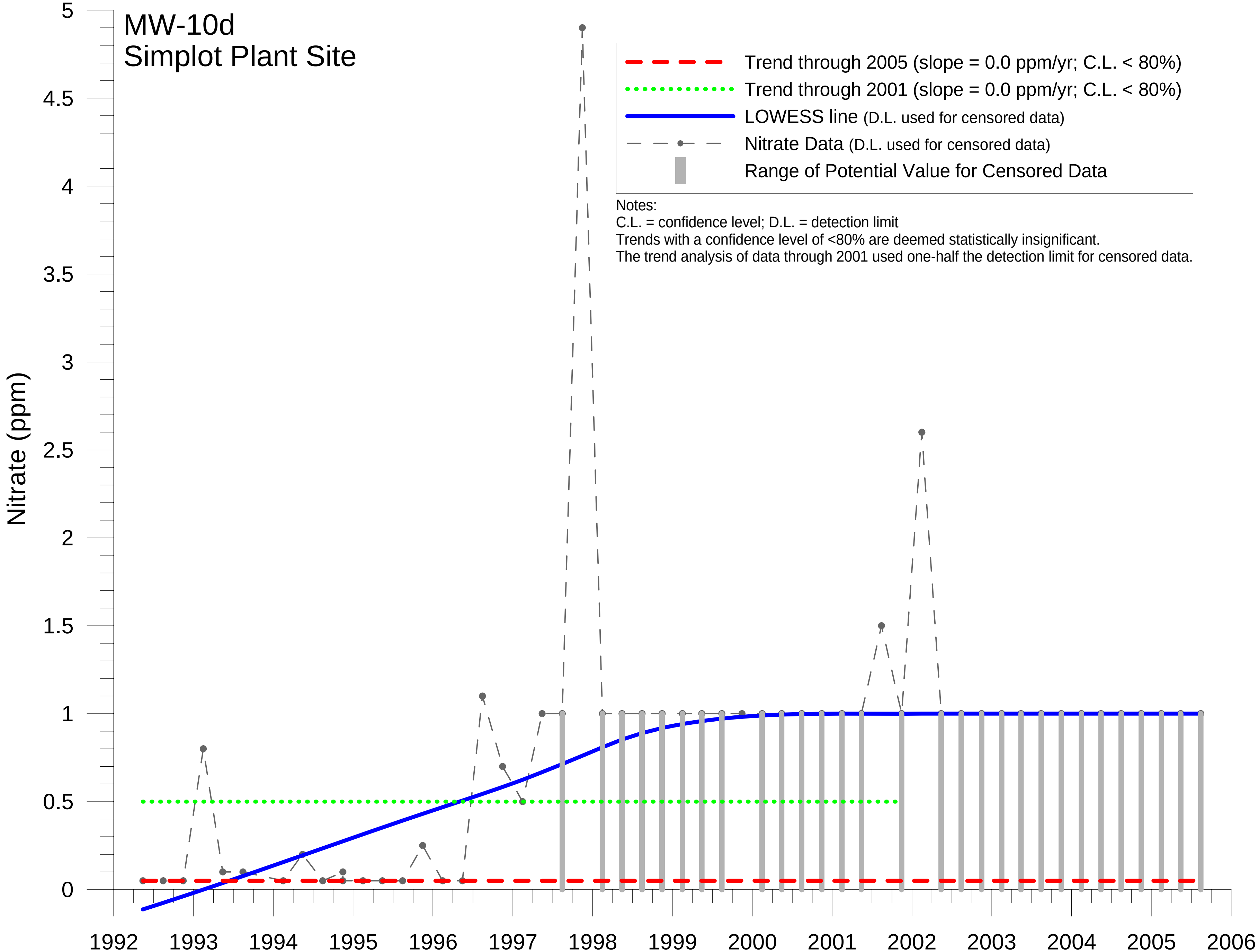
MW-11
ConAgra Madison Ranch
Nitrate (ppm)
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = -0.32 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.05 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Note: C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.



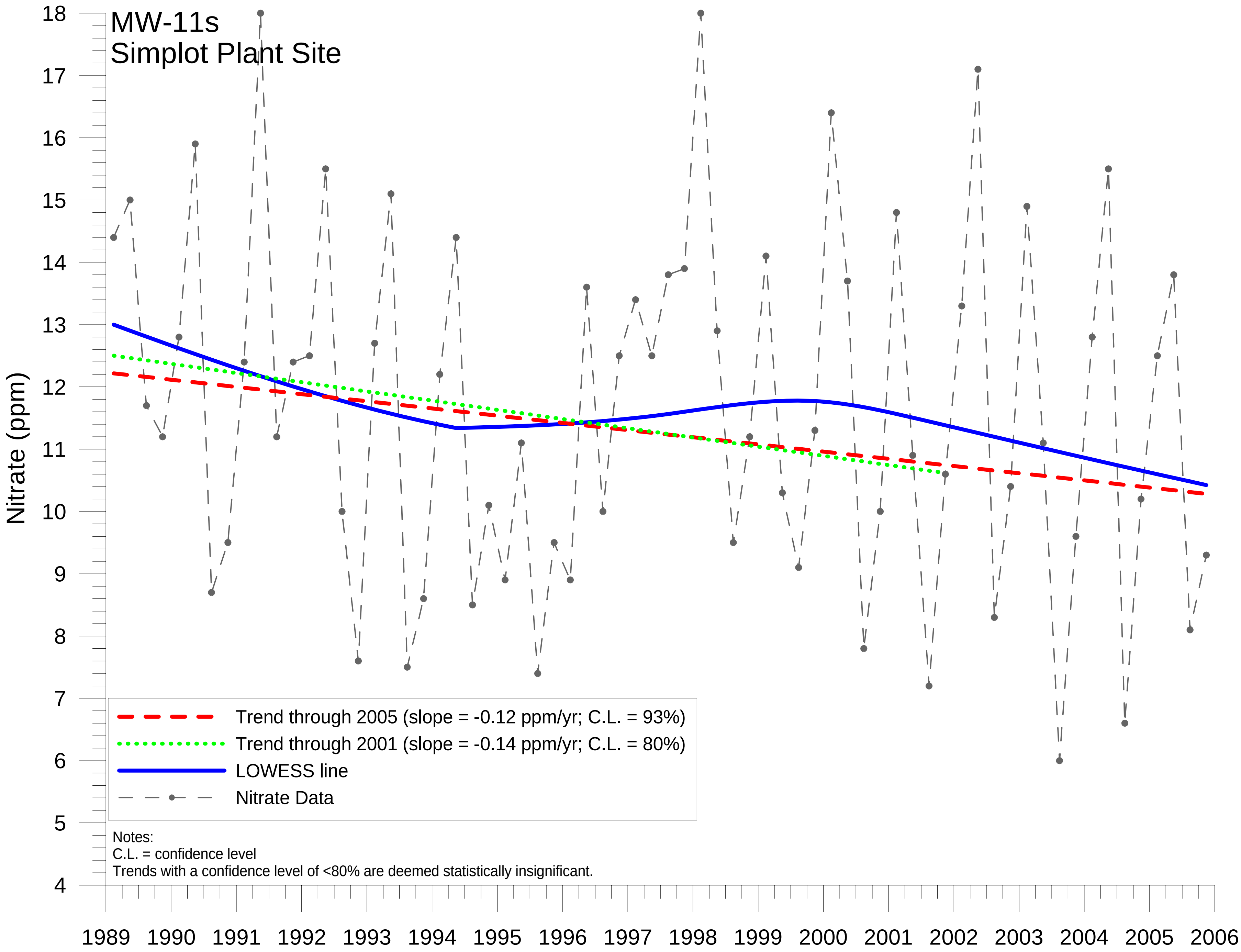
MW-12
ConAgra Madison Ranch
Nitrate (ppm)
10
9
8
7
6
5
4
3
2
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 0.22 ppm/yr; C.L. = 95%)
Trend through 2001 (slope = 1.03 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Note: C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

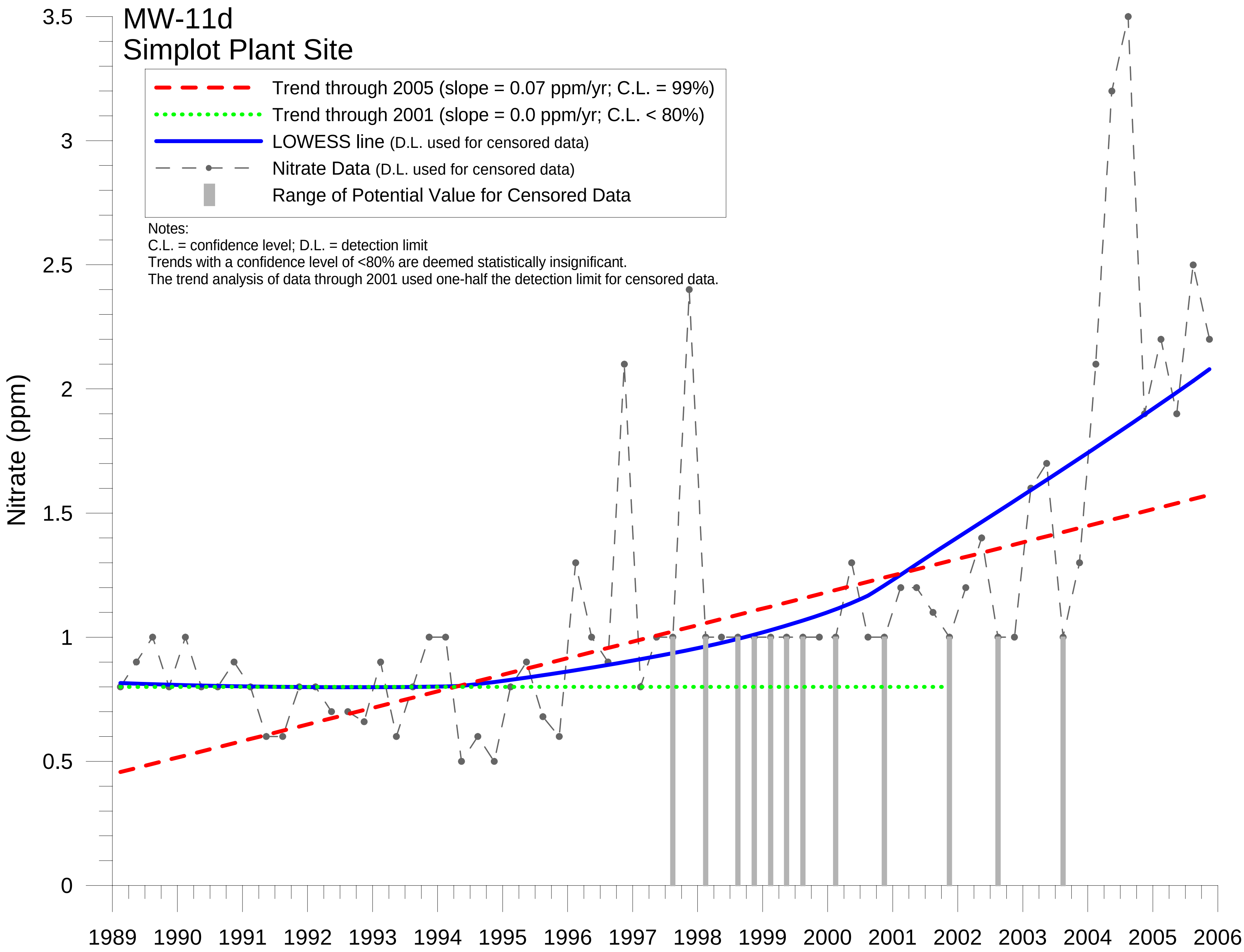


MW-10s
Simplot Plant Site
Trend through 2005 (slope = 0.59 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.0 ppm/yr; C.L. < 80%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level; D.L. = detection limit
Trends with a confidence level of <80% are deemed statistically insignificant.
The trend analysis of data through 2001 used one-half the detection limit for censored data.
Nitrate (ppm)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006

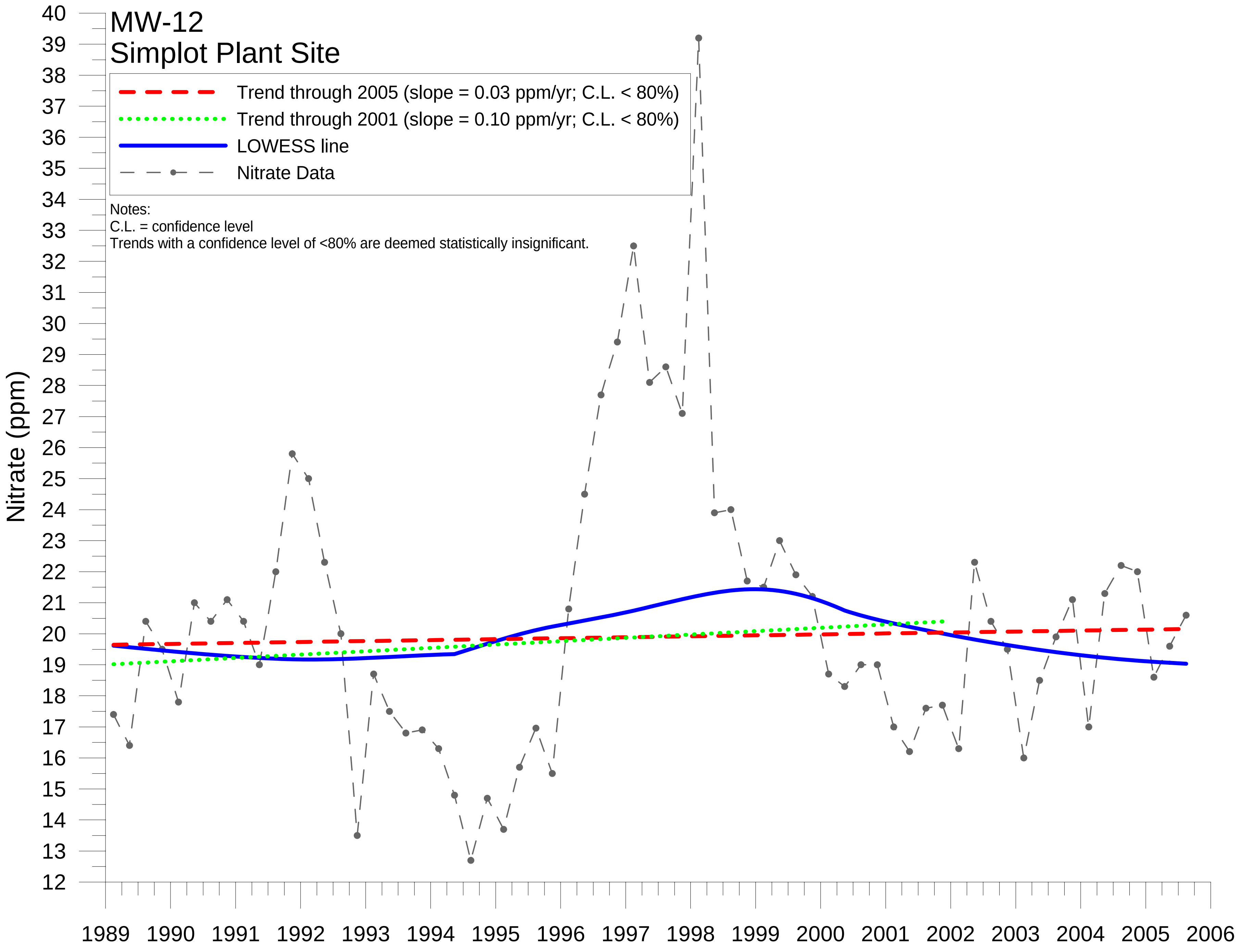


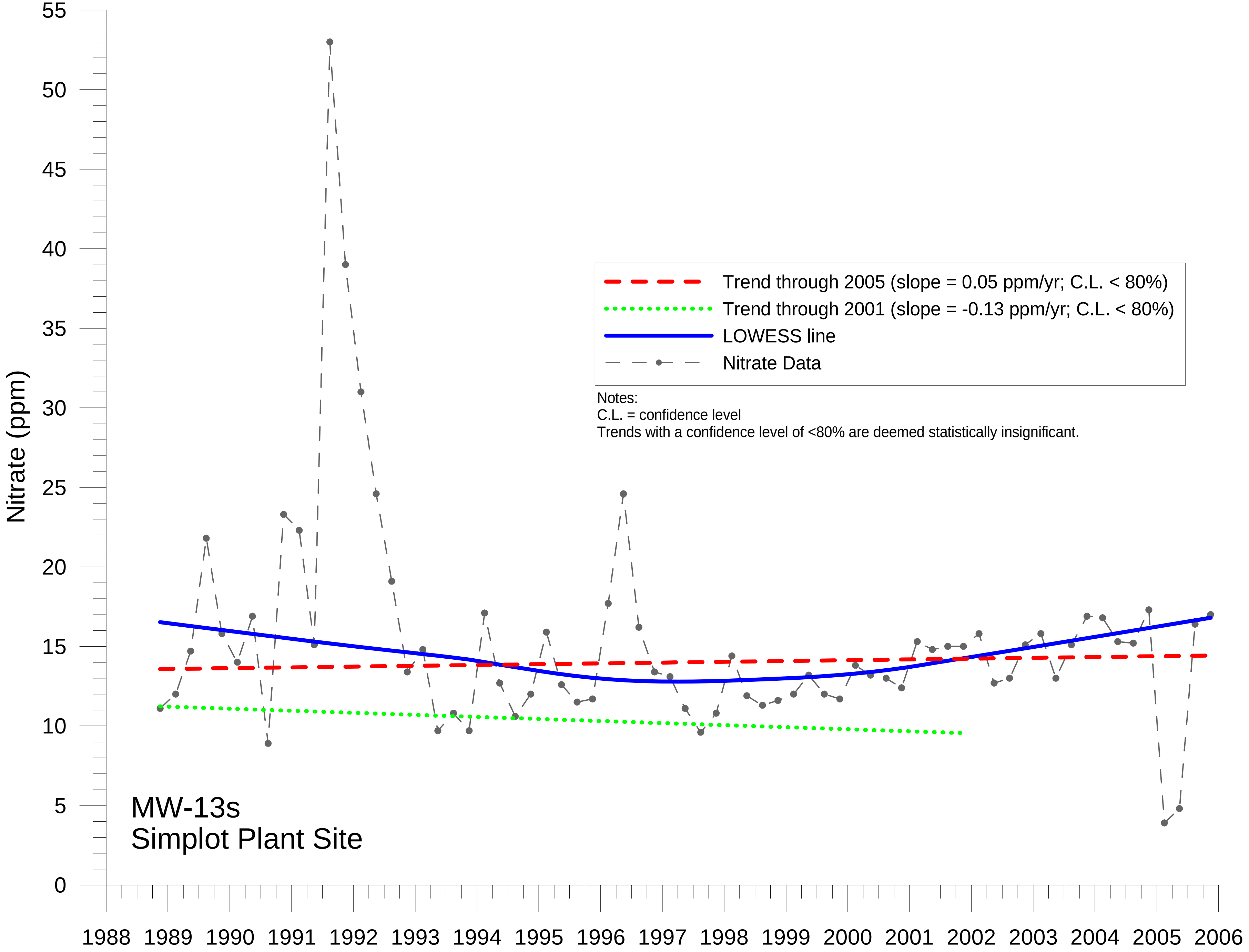
MW-10d
Simplot Plant Site
Trend through 2005 (slope = 0.0 ppm/yr; C.L. < 80%)
Trend through 2001 (slope = 0.0 ppm/yr; C.L. < 80%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level; D.L. = detection limit
Trends with a confidence level of <80% are deemed statistically insignificant.
The trend analysis of data through 2001 used one-half the detection limit for censored data.
Nitrate (ppm)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006


MW-11s
Simplot Plant Site
Nitrate (ppm)
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = -0.12 ppm/yr; C.L. = 93%)
Trend through 2001 (slope = -0.14 ppm/yr; C.L. = 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

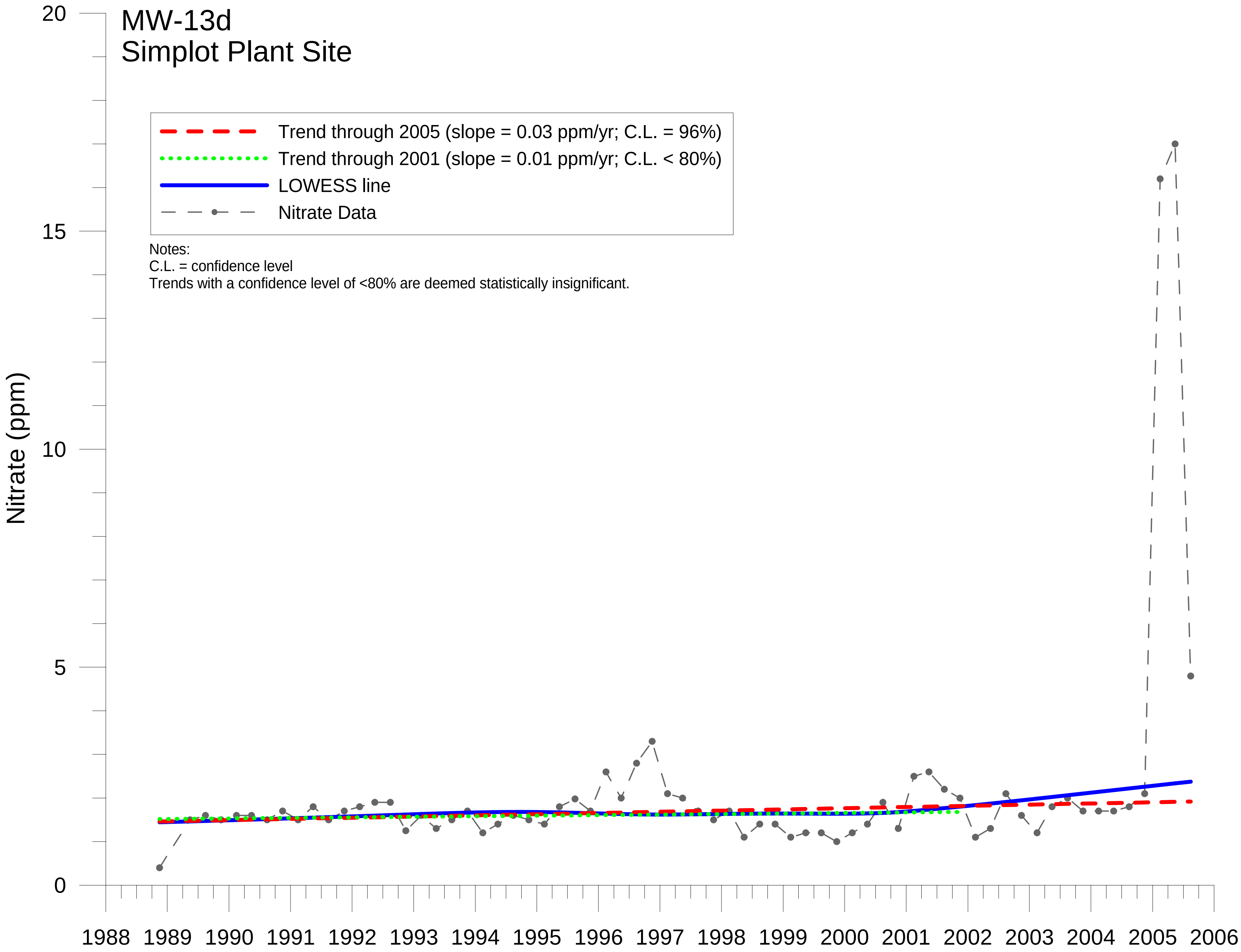


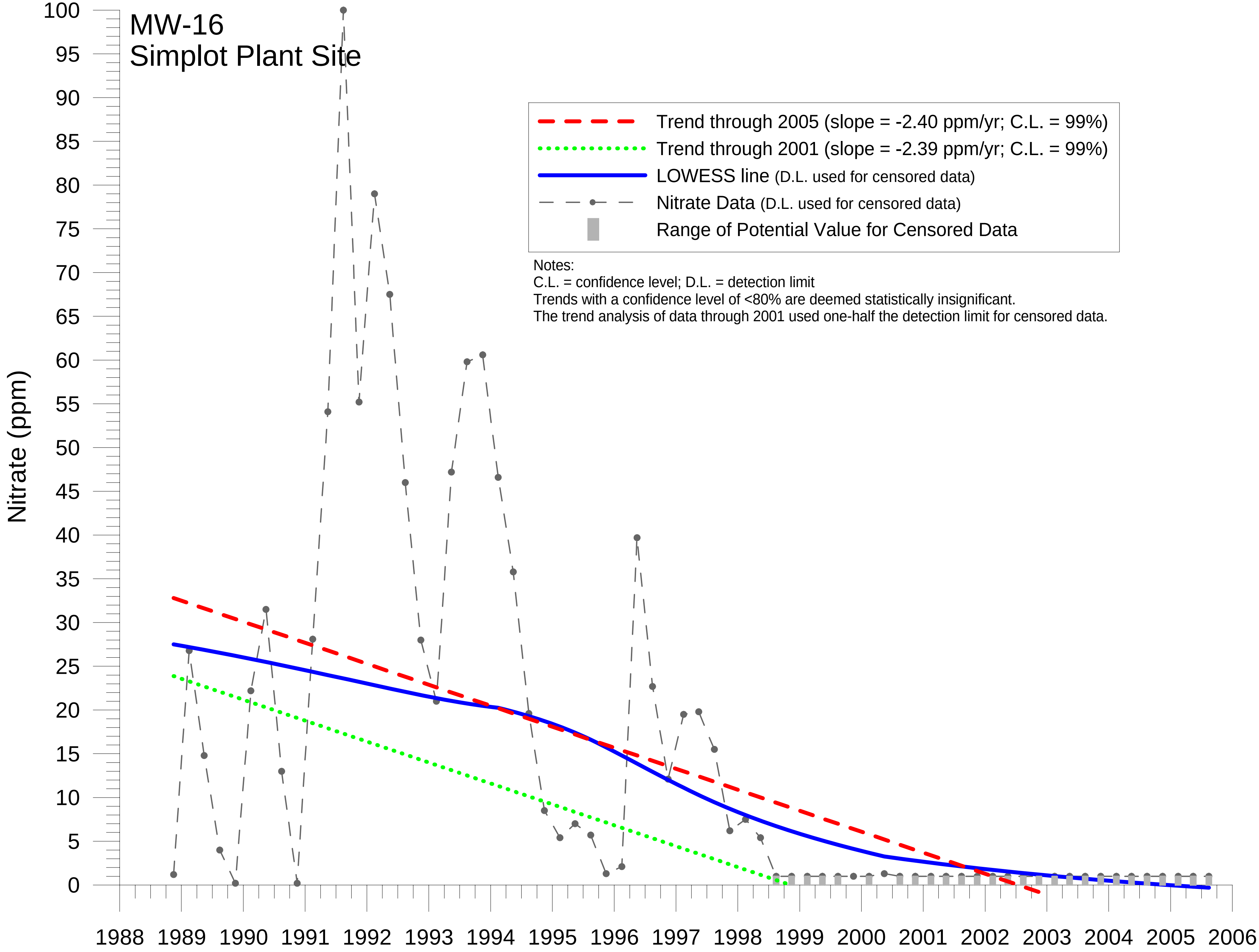
MW-11d
Simplot Plant Site
Trend through 2005 (slope = 0.07 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.0 ppm/yr; C.L. < 80%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level; D.L. = detection limit
Trends with a confidence level of <80% are deemed statistically insignificant.
The trend analysis of data through 2001 used one-half the detection limit for censored data.
Nitrate (ppm)
0
0.5
1
1.5
2
2.5
3
3.5
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006

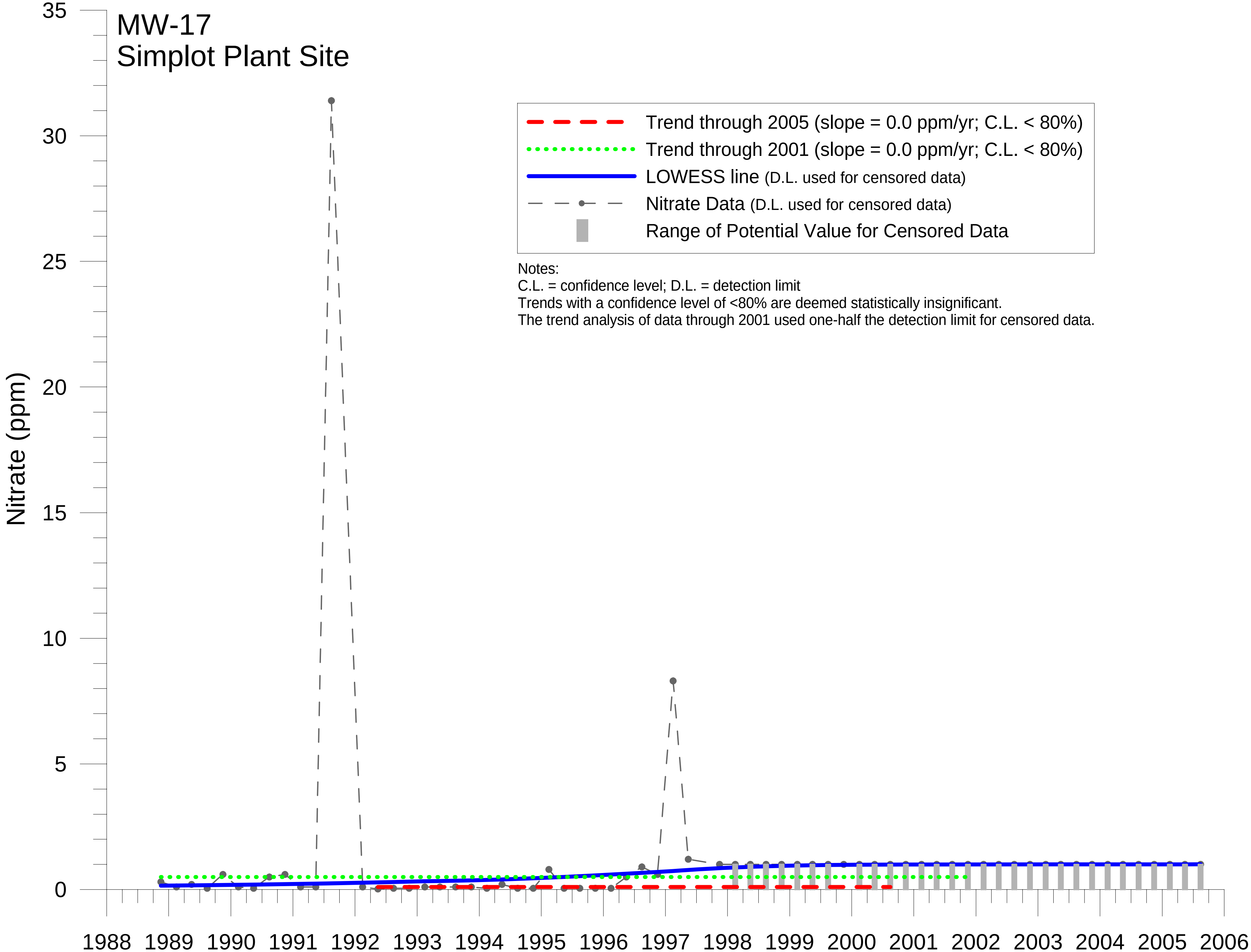

MW-12
Simplot Plant Site
Trend through 2005 (slope = 0.03 ppm/yr; C.L. < 80%)
Trend through 2001 (slope = 0.10 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
40
39
38
37
36
35
34
33
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006



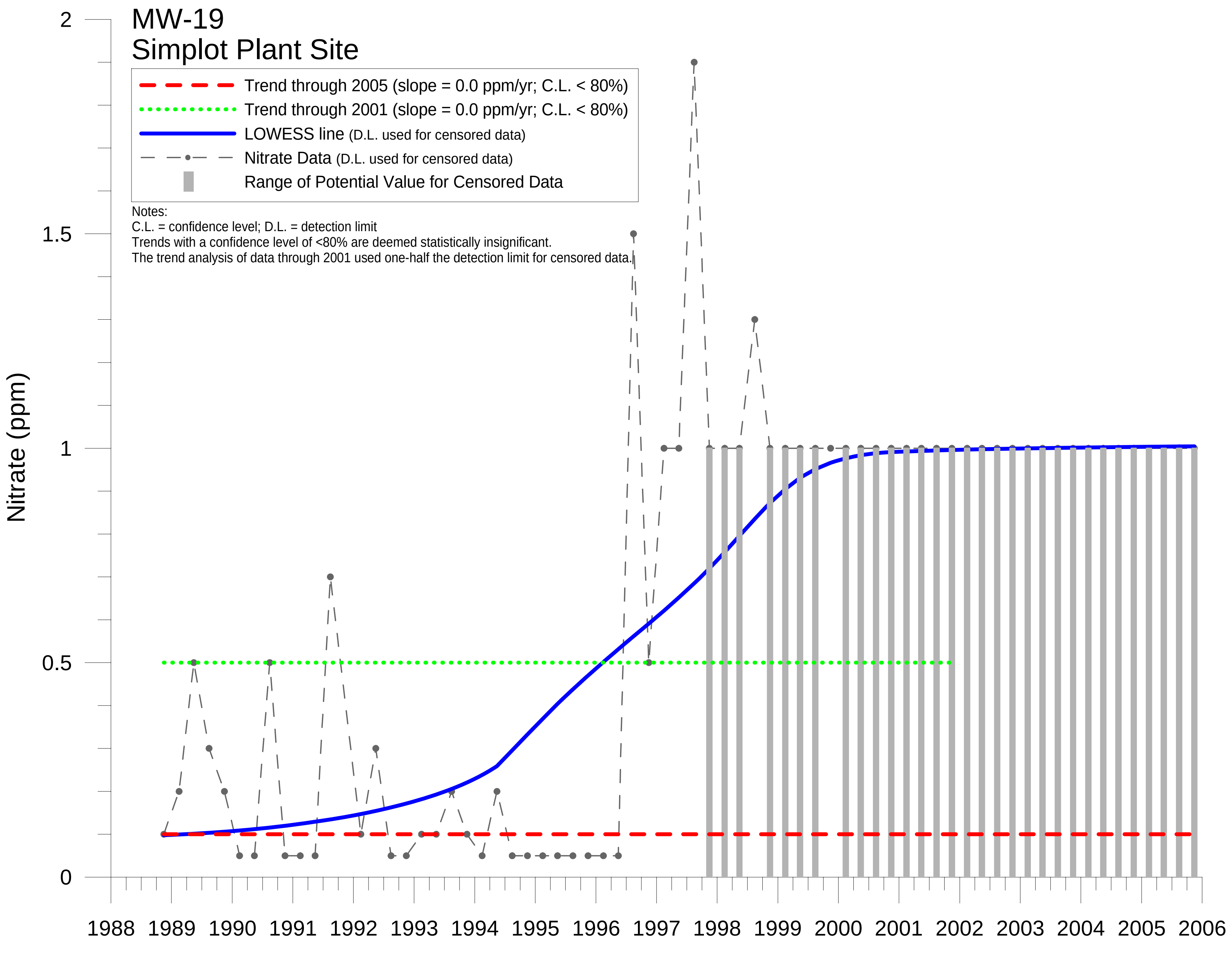
Nitrate (ppm)
55
50
45
40
35
30
25
20
15
10
5
0
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 0.05 ppm/yr; C.L. < 80%)
Trend through 2001 (slope = -0.13 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
MW-13s
Simplot Plant Site


MW-13d
Simplot Plant Site
Trend through 2005 (slope = 0.03 ppm/yr; C.L. = 96%)
Trend through 2001 (slope = 0.01 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
0
5
10
15
20
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006

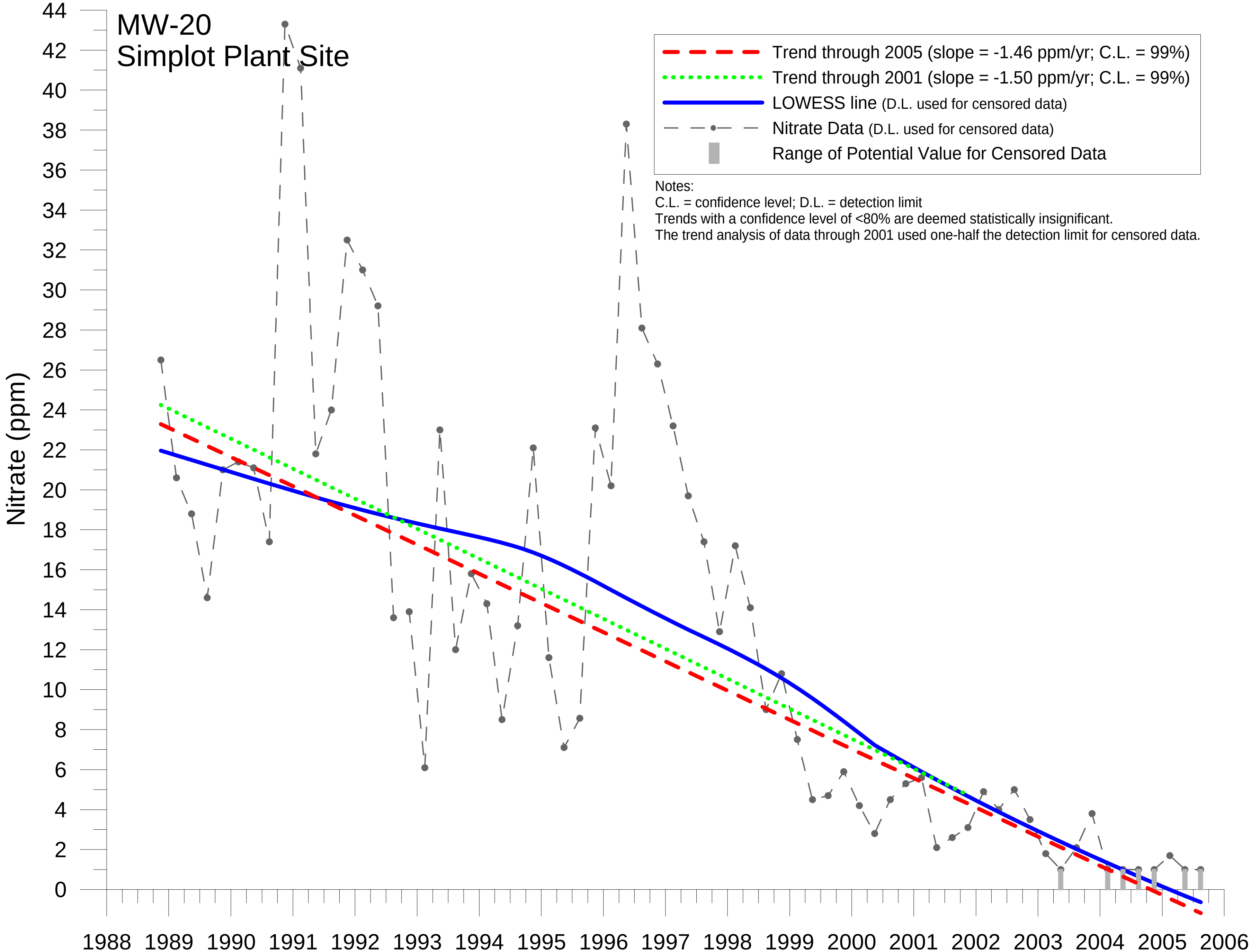

MW-16
Simplot Plant Site
Nitrate (ppm)
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = -2.40 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = -2.39 ppm/yr; C.L. = 99%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level; D.L. = detection limit
Trends with a confidence level of <80% are deemed statistically insignificant.
The trend analysis of data through 2001 used one-half the detection limit for censored data.

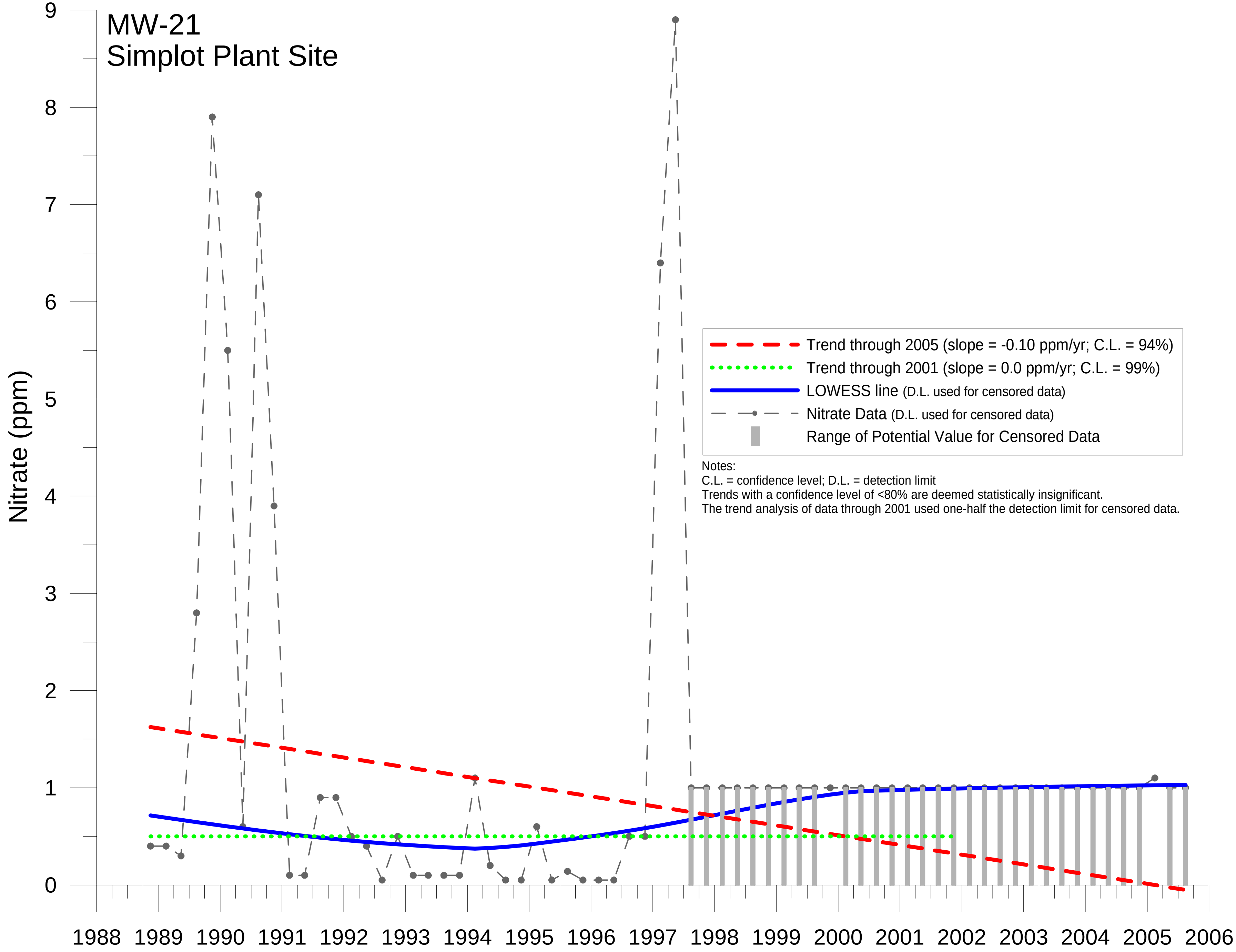


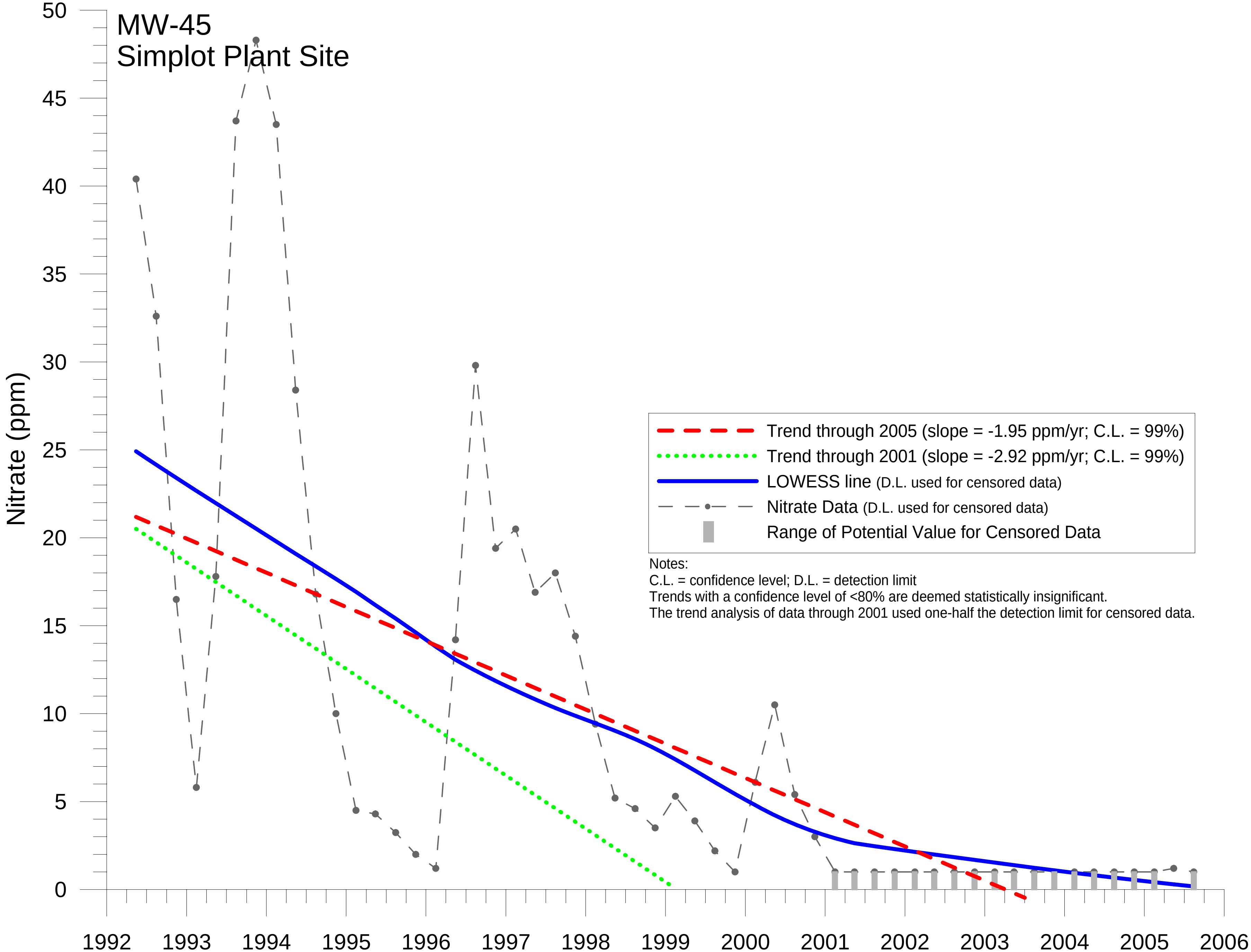
MW-17
Simplot Plant Site
Nitrate (ppm)
0
5
10
15
20
25
30
35
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 0.0 ppm/yr; C.L. < 80%)
Trend through 2001 (slope = 0.0 ppm/yr; C.L. < 80%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level; D.L. = detection limit
Trends with a confidence level of <80% are deemed statistically insignificant.
The trend analysis of data through 2001 used one-half the detection limit for censored data.

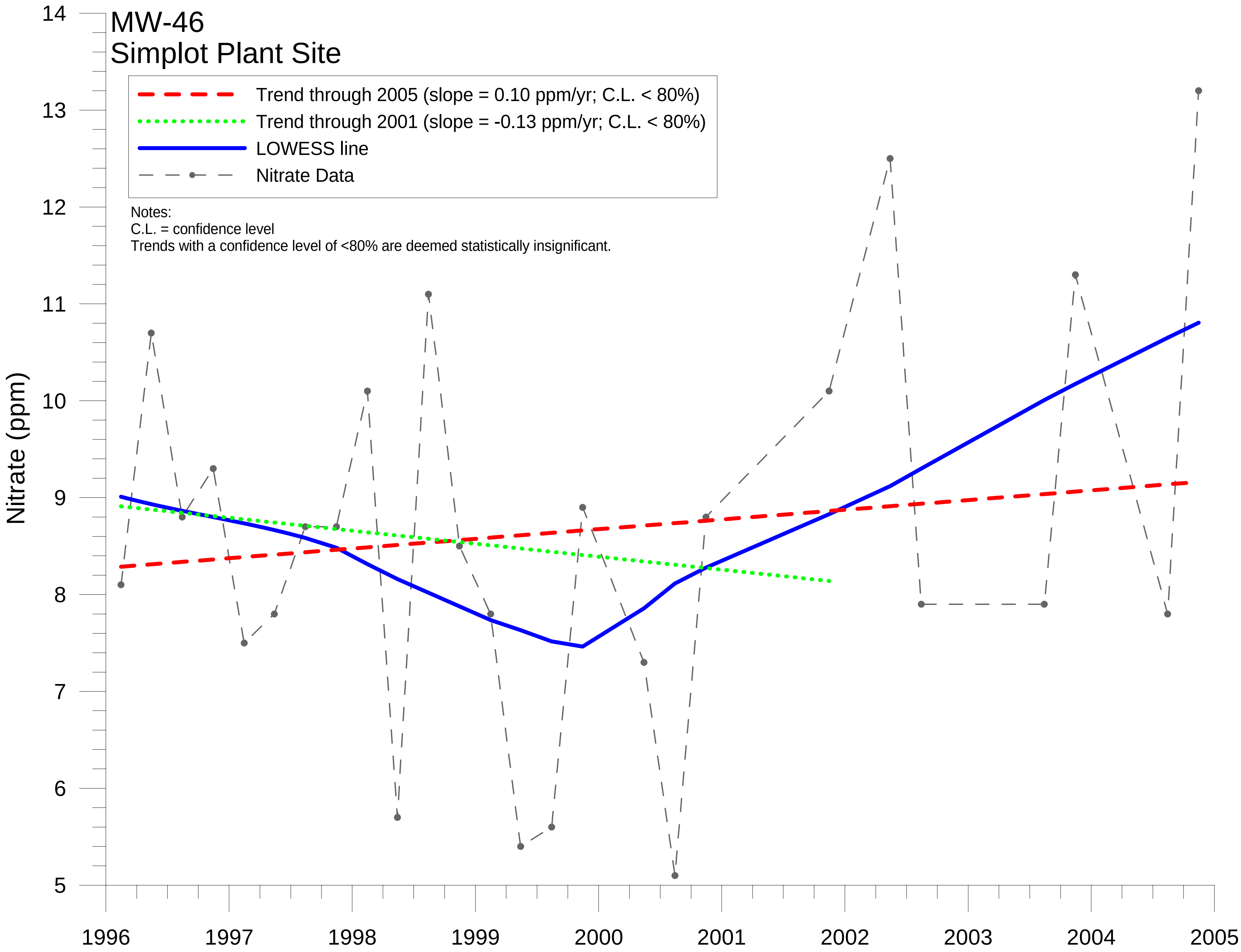


MW-19
Simplot Plant Site
Trend through 2005 (slope = 0.0 ppm/yr; C.L. < 80%)
Trend through 2001 (slope = 0.0 ppm/yr; C.L. < 80%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level; D.L. = detection limit
Trends with a confidence level of <80% are deemed statistically insignificant.
The trend analysis of data through 2001 used one-half the detection limit for censored data.
Nitrate (ppm)
2
1.5
1
0.5
0
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006

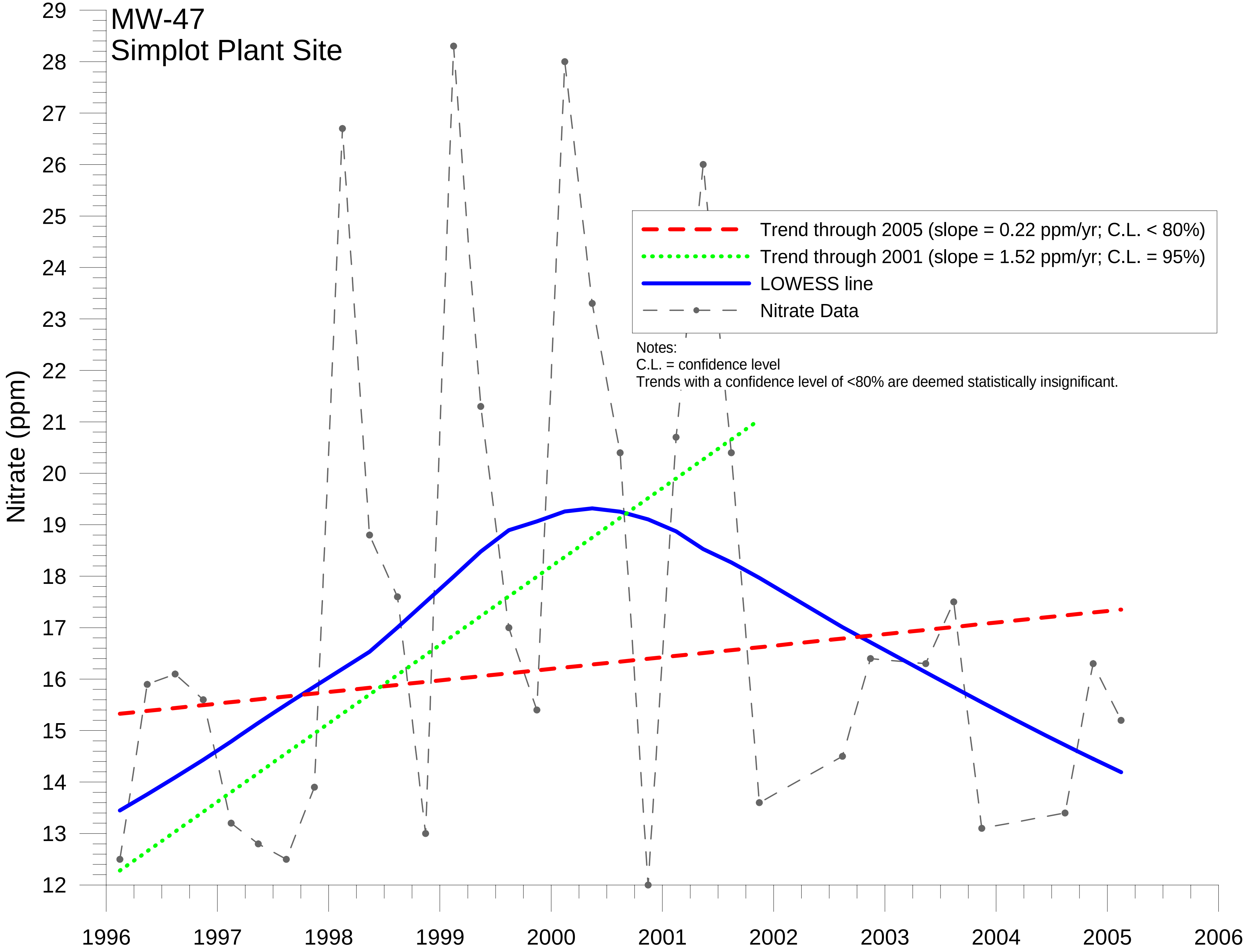

MW-20
Simplot Plant Site
Trend through 2005 (slope = -1.46 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = -1.50 ppm/yr; C.L. = 99%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level; D.L. = detection limit
Trends with a confidence level of <80% are deemed statistically insignificant.
The trend analysis of data through 2001 used one-half the detection limit for censored data.
Nitrate (ppm)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006

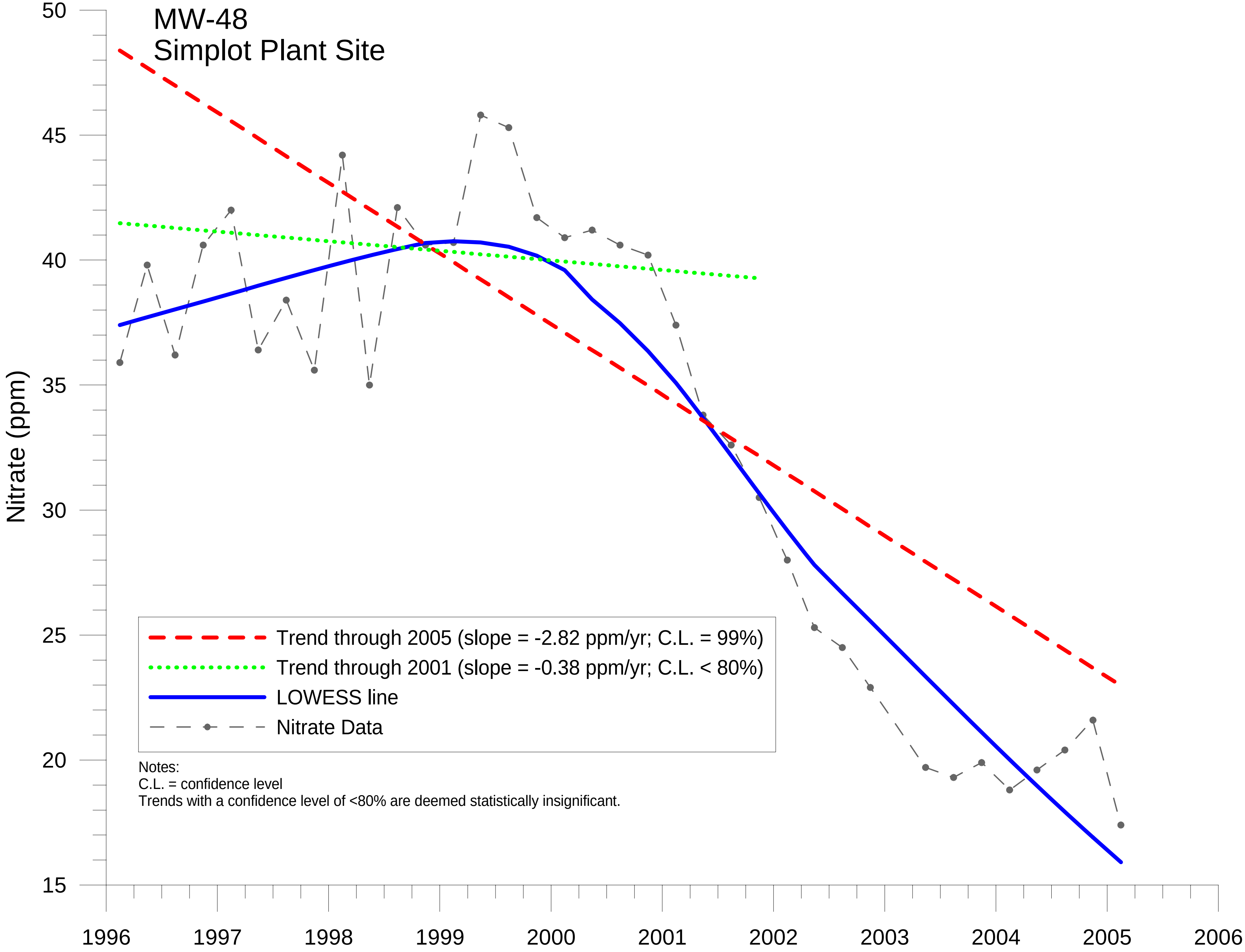

MW-21
Simplot Plant Site
Nitrate (ppm)
0
1
2
3
4
5
6
7
8
9
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = -0.10 ppm/yr; C.L. = 94%)
Trend through 2001 (slope = 0.0 ppm/yr; C.L. = 99%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level; D.L. = detection limit
Trends with a confidence level of <80% are deemed statistically insignificant.
The trend analysis of data through 2001 used one-half the detection limit for censored data.


MW-45
Simplot Plant Site
Nitrate (ppm)
0
5
10
15
20
25
30
35
40
45
50
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = -1.95 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = -2.92 ppm/yr; C.L. = 99%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level; D.L. = detection limit
Trends with a confidence level of <80% are deemed statistically insignificant.
The trend analysis of data through 2001 used one-half the detection limit for censored data.

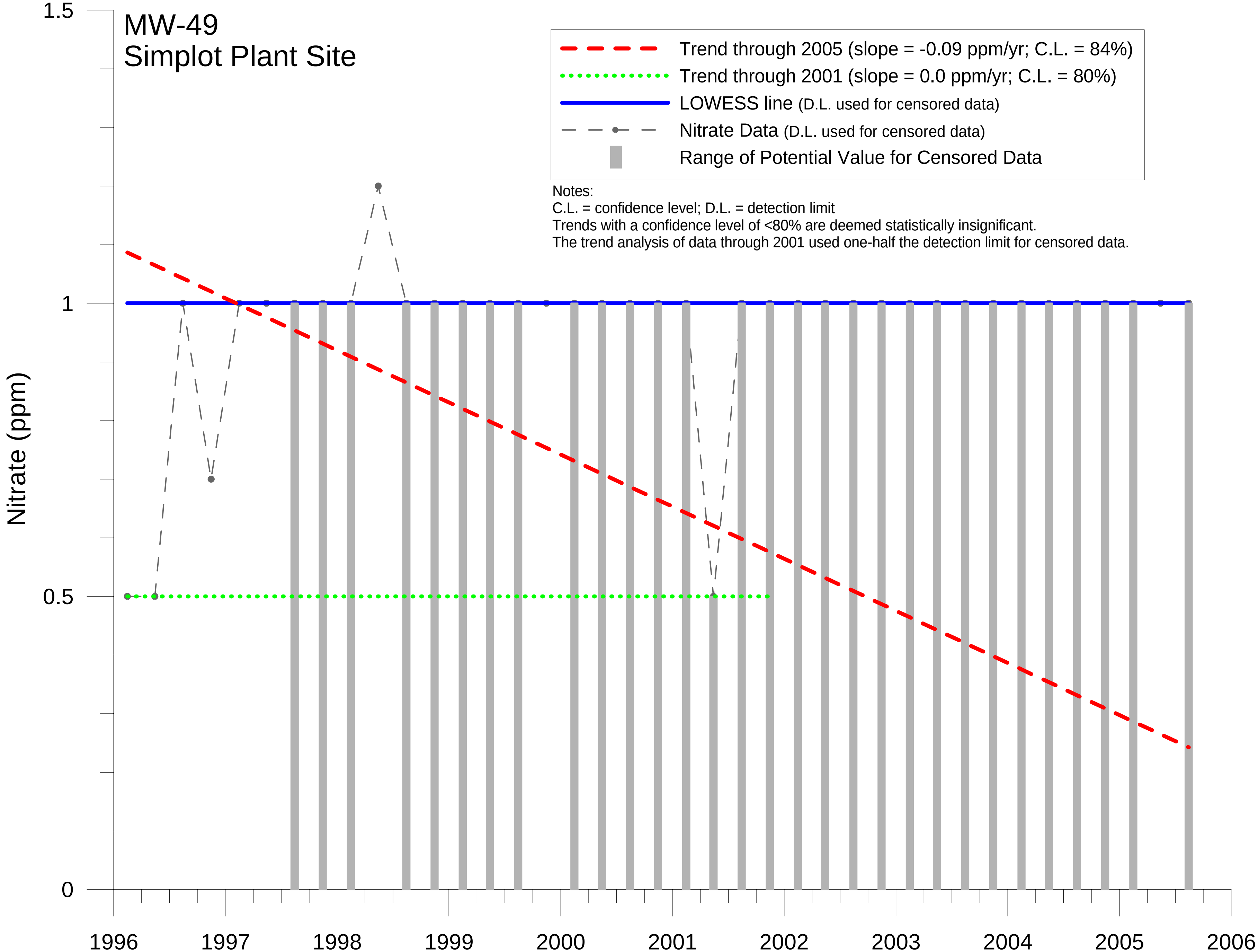


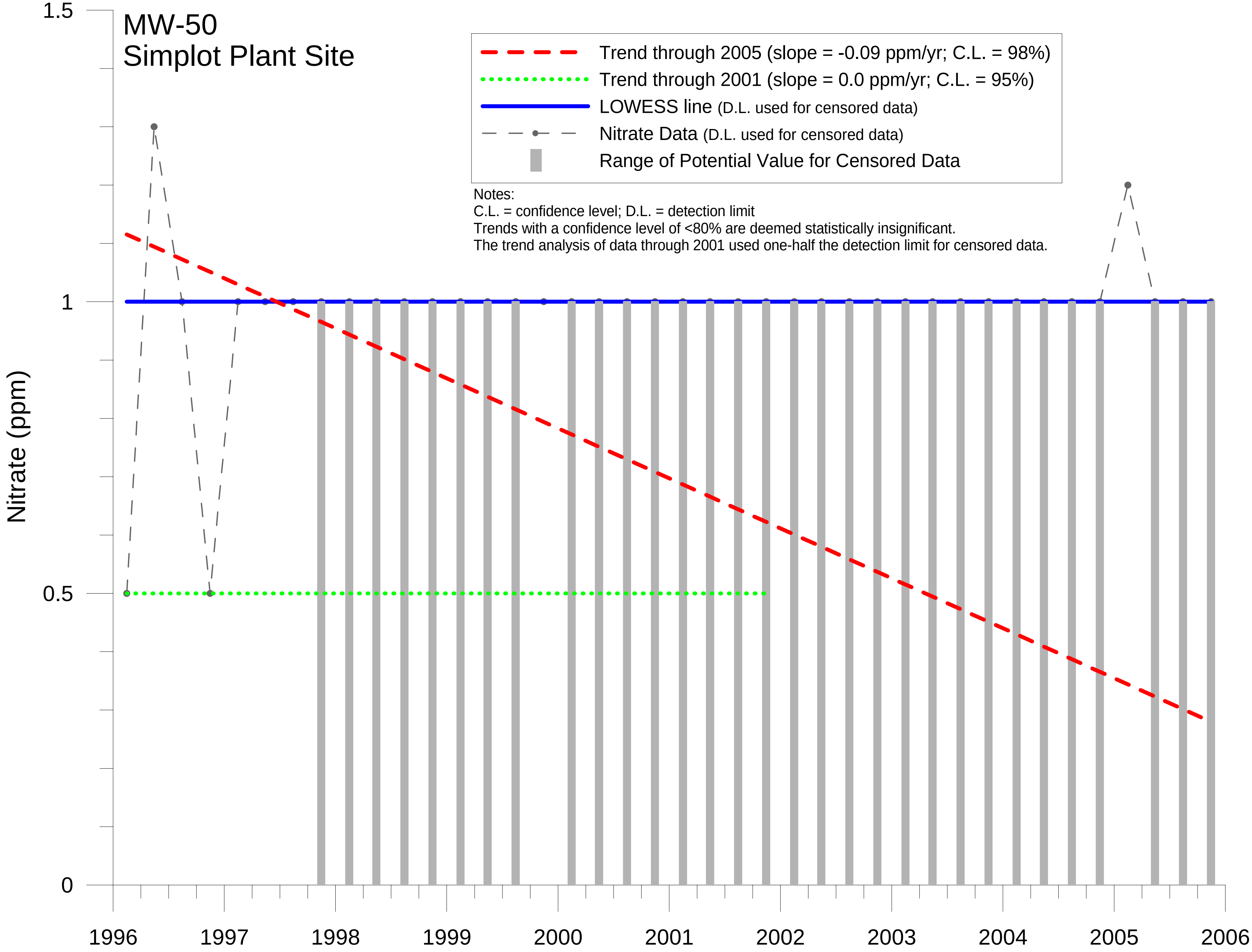
MW-46
Simplot Plant Site
Trend through 2005 (slope = 0.10 ppm/yr; C.L. < 80%)
Trend through 2001 (slope = -0.13 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
14
13
12
11
10
9
8
7
6
5
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005


MW-47
Simplot Plant Site
Nitrate (ppm)
Trend through 2005 (slope = 0.22 ppm/yr; C.L. < 80%)
Trend through 2001 (slope = 1.52 ppm/yr; C.L. = 95%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006

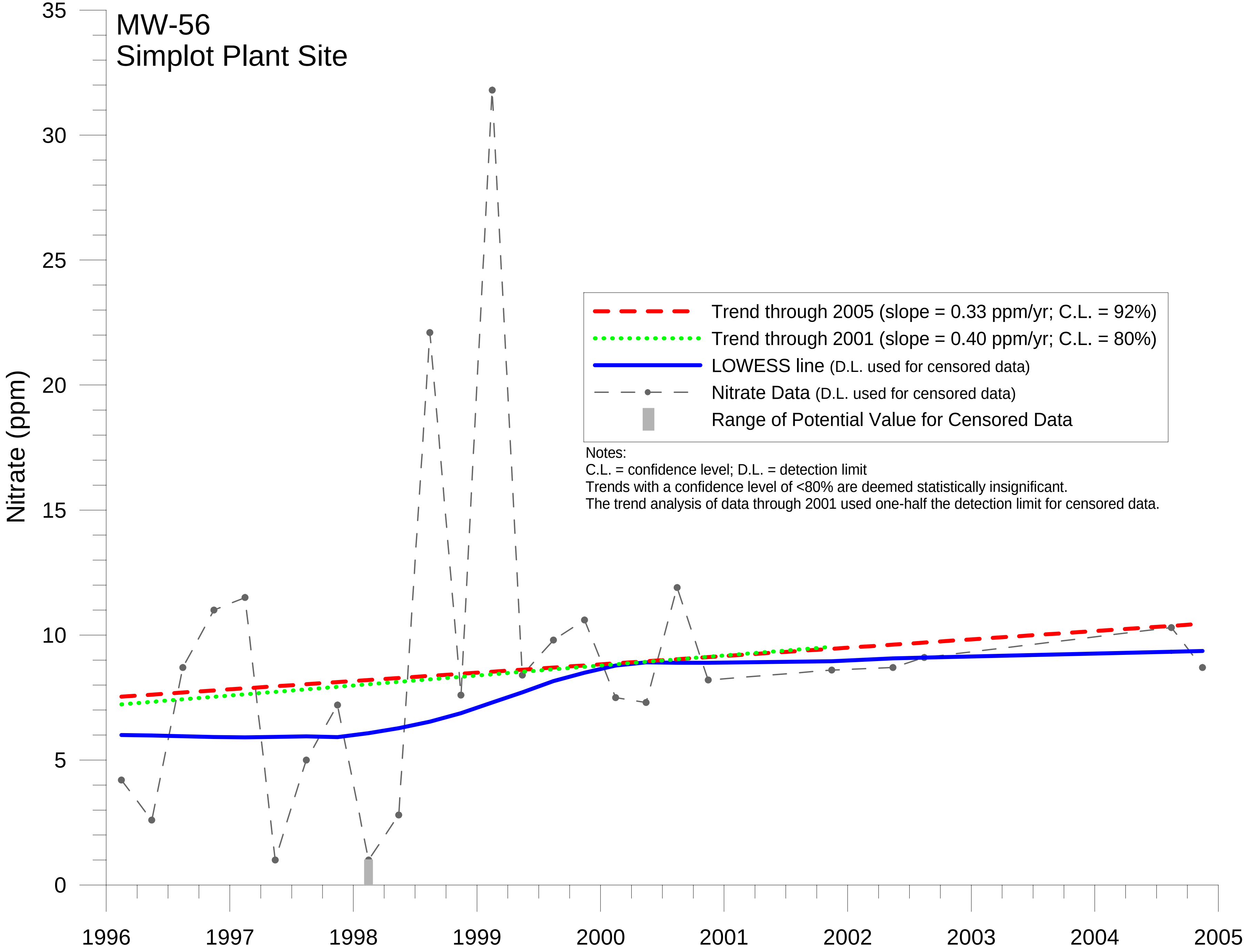


MW-48
Simplot Plant Site
Nitrate (ppm)
50
45
40
35
30
25
20
15
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = -2.82 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = -0.38 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

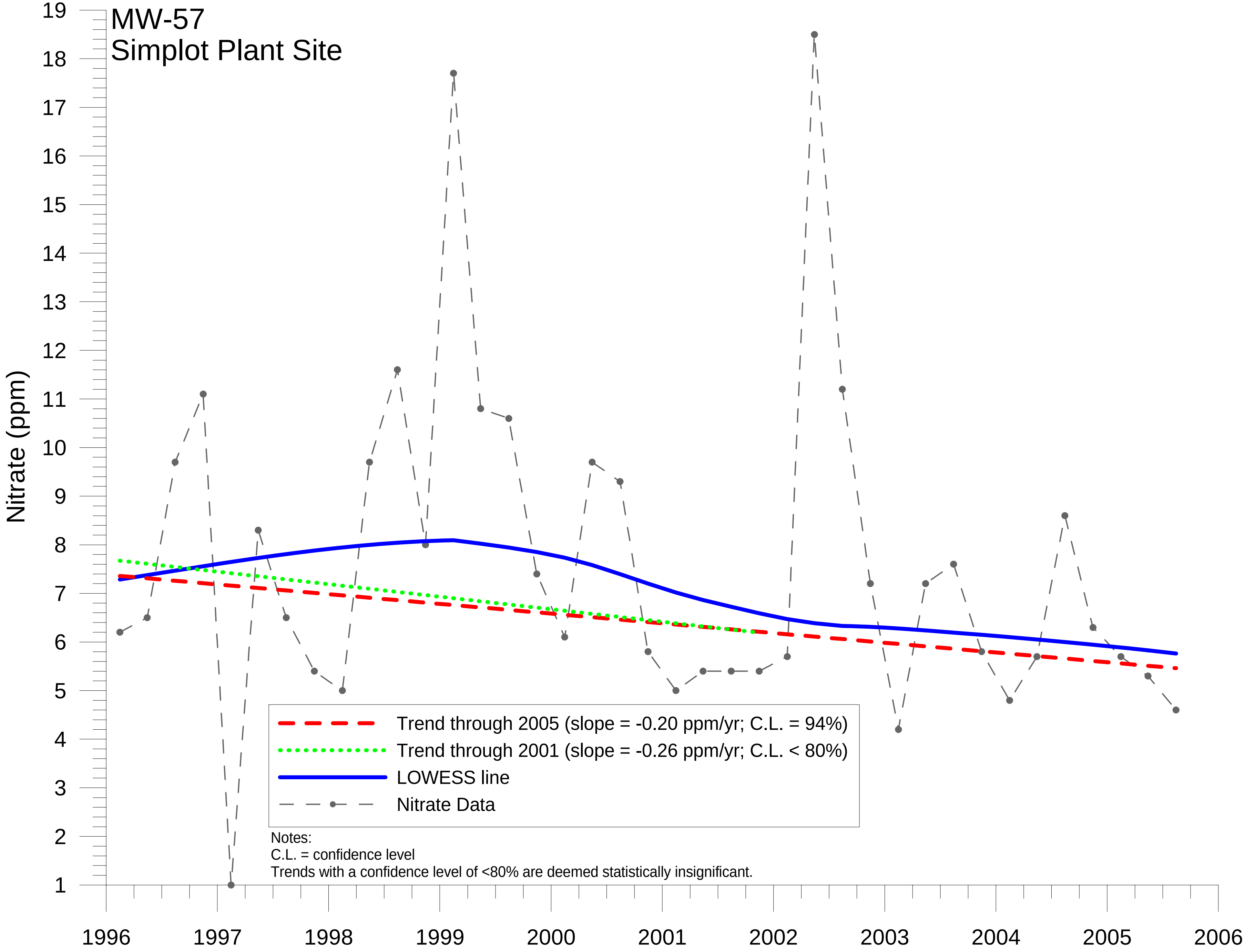

MW-49
Simplot Plant Site
Trend through 2005 (slope = -0.09 ppm/yr; C.L. = 84%)
Trend through 2001 (slope = 0.0 ppm/yr; C.L. = 80%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level; D.L. = detection limit
Trends with a confidence level of <80% are deemed statistically insignificant.
The trend analysis of data through 2001 used one-half the detection limit for censored data.
Nitrate (ppm)
1.5
1
0.5
0
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006



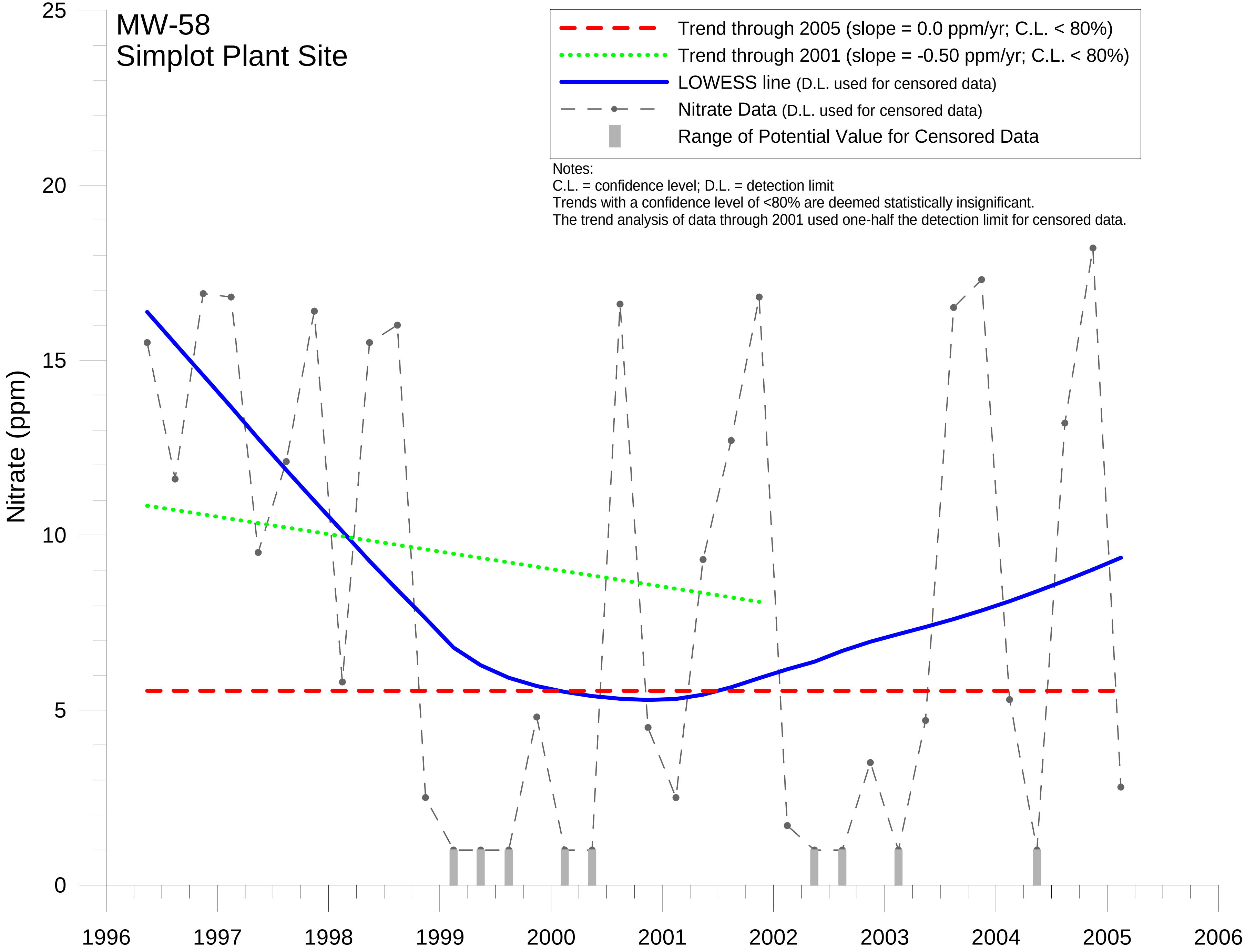
MW-50
Simplot Plant Site
Trend through 2005 (slope = -0.09 ppm/yr; C.L. = 98%)
Trend through 2001 (slope = 0.0 ppm/yr; C.L. = 95%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level; D.L. = detection limit
Trends with a confidence level of <80% are deemed statistically insignificant.
The trend analysis of data through 2001 used one-half the detection limit for censored data.
Nitrate (ppm)
1.5
1
0.5
0
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006



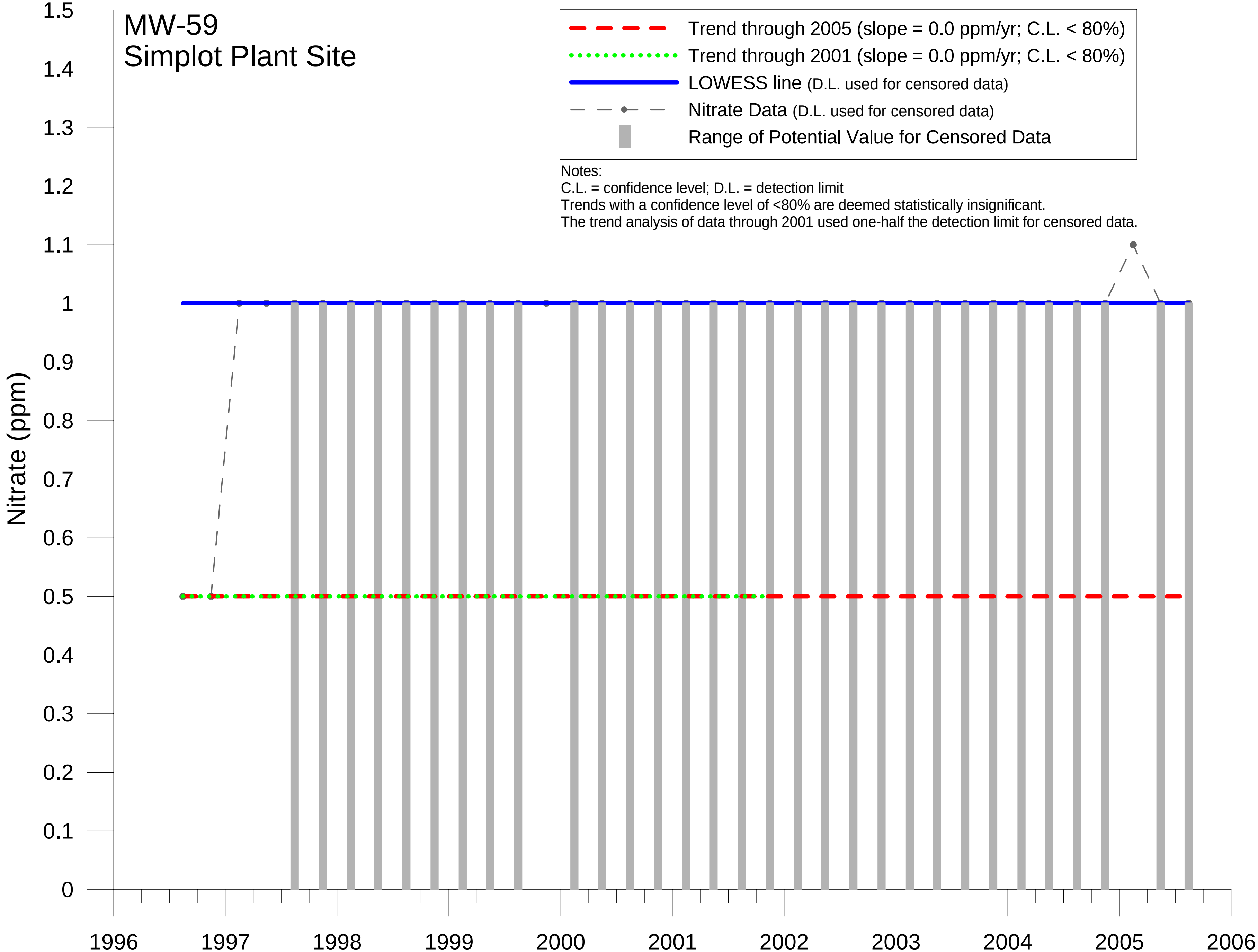
MW-56
Simplot Plant Site
Nitrate (ppm)
0
5
10
15
20
25
30
35
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
Trend through 2005 (slope = 0.33 ppm/yr; C.L. = 92%)
Trend through 2001 (slope = 0.40 ppm/yr; C.L. = 80%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level; D.L. = detection limit
Trends with a confidence level of <80% are deemed statistically insignificant.
The trend analysis of data through 2001 used one-half the detection limit for censored data.

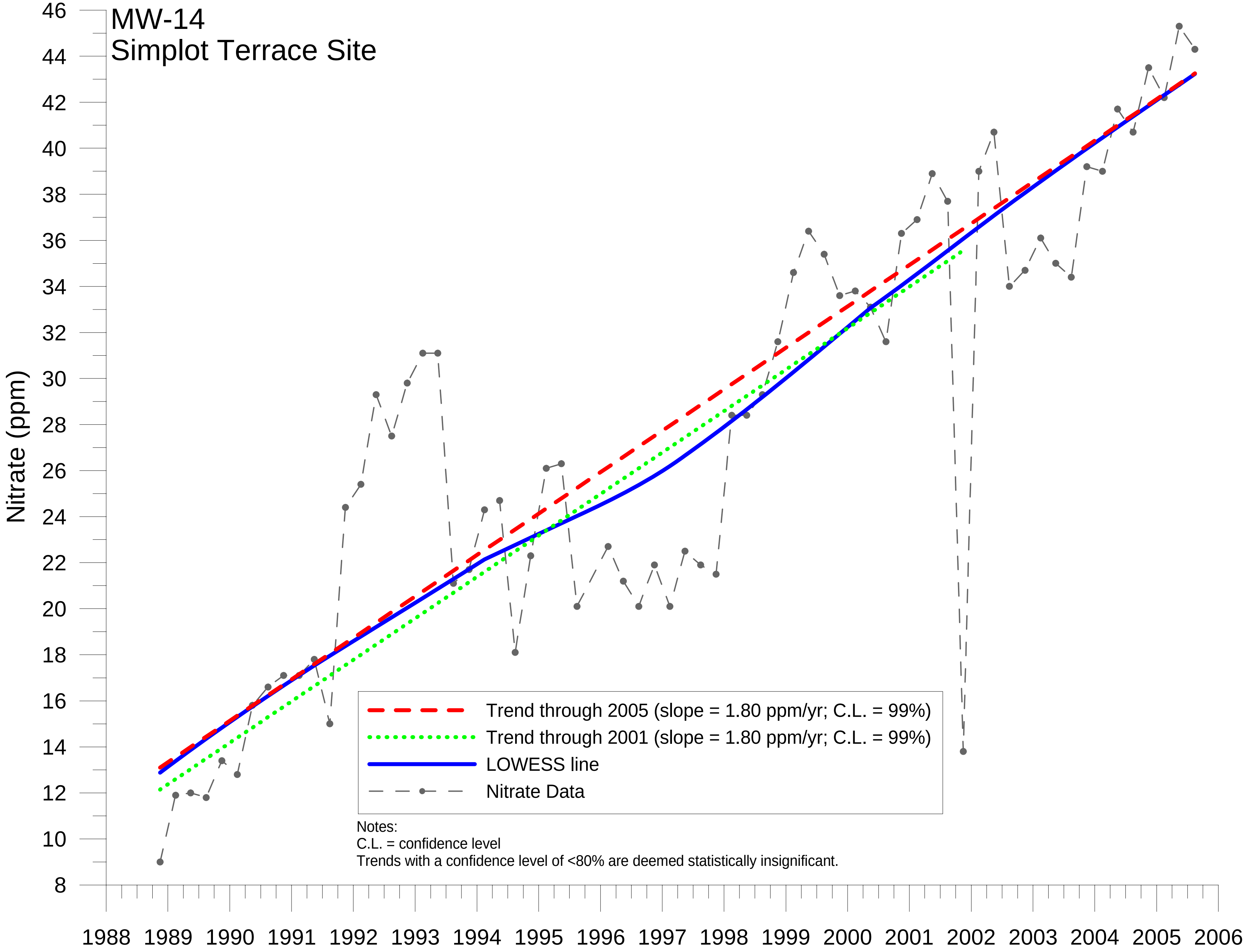


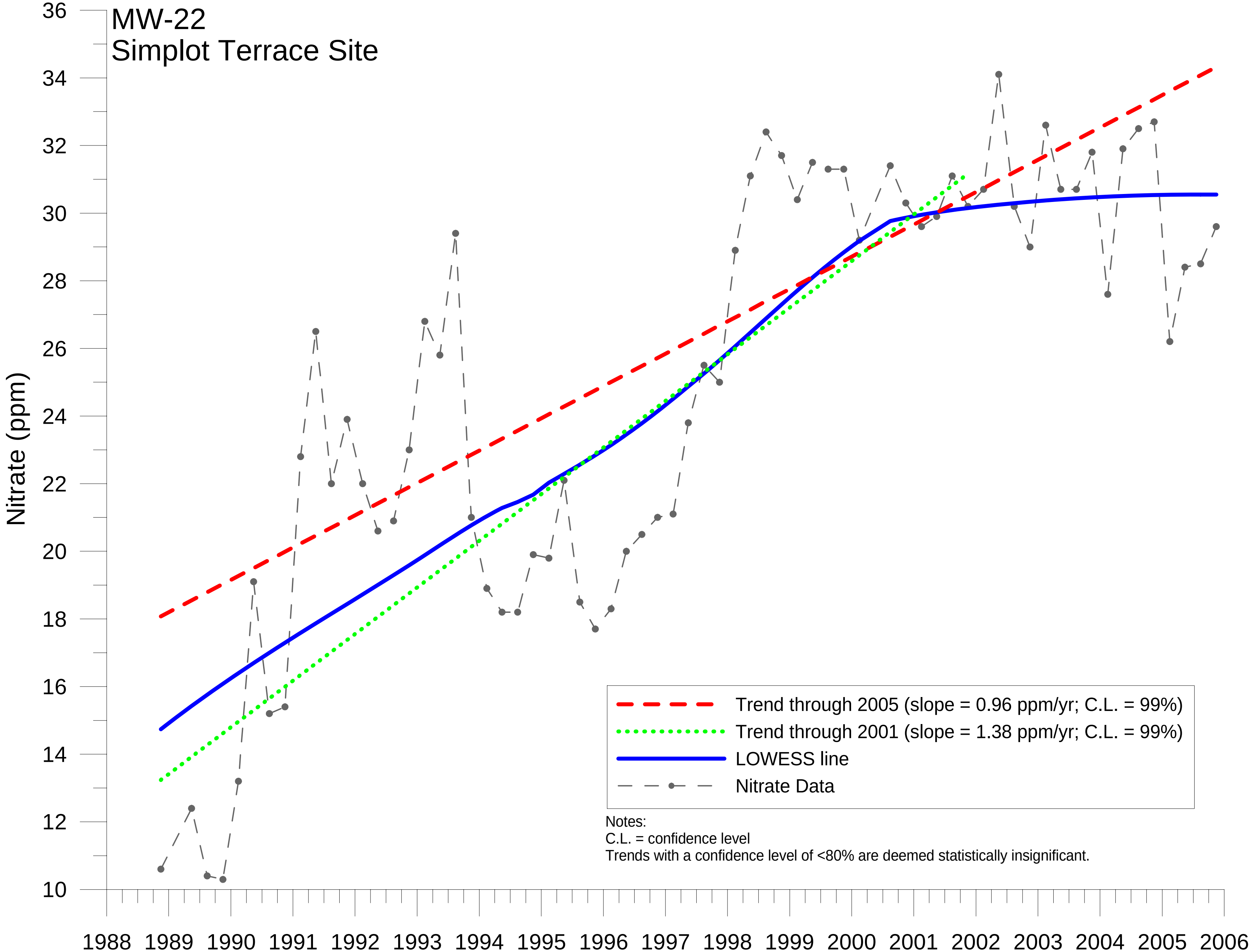
MW-57
Simplot Plant Site
Nitrate (ppm)
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = -0.20 ppm/yr; C.L. = 94%)
Trend through 2001 (slope = -0.26 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

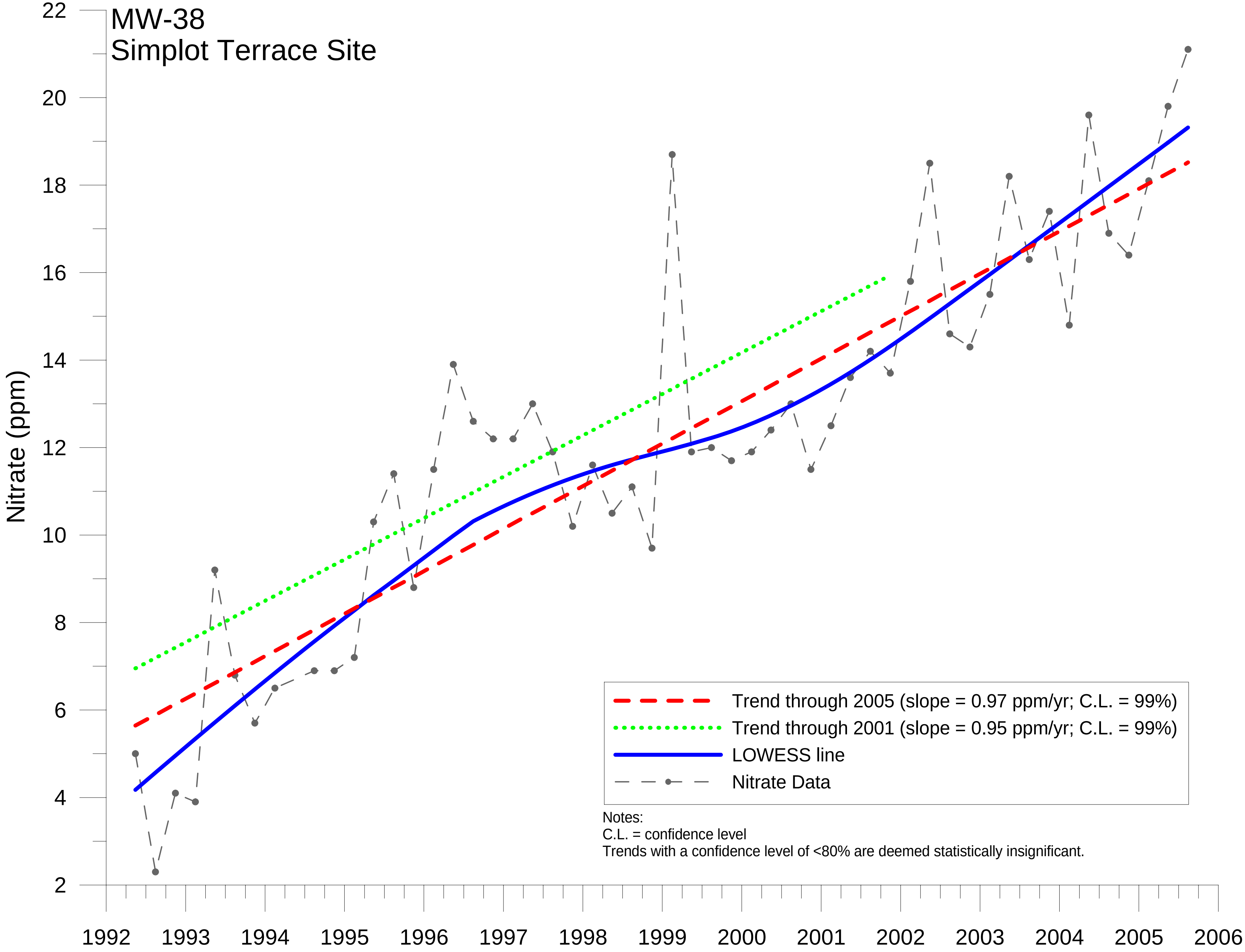


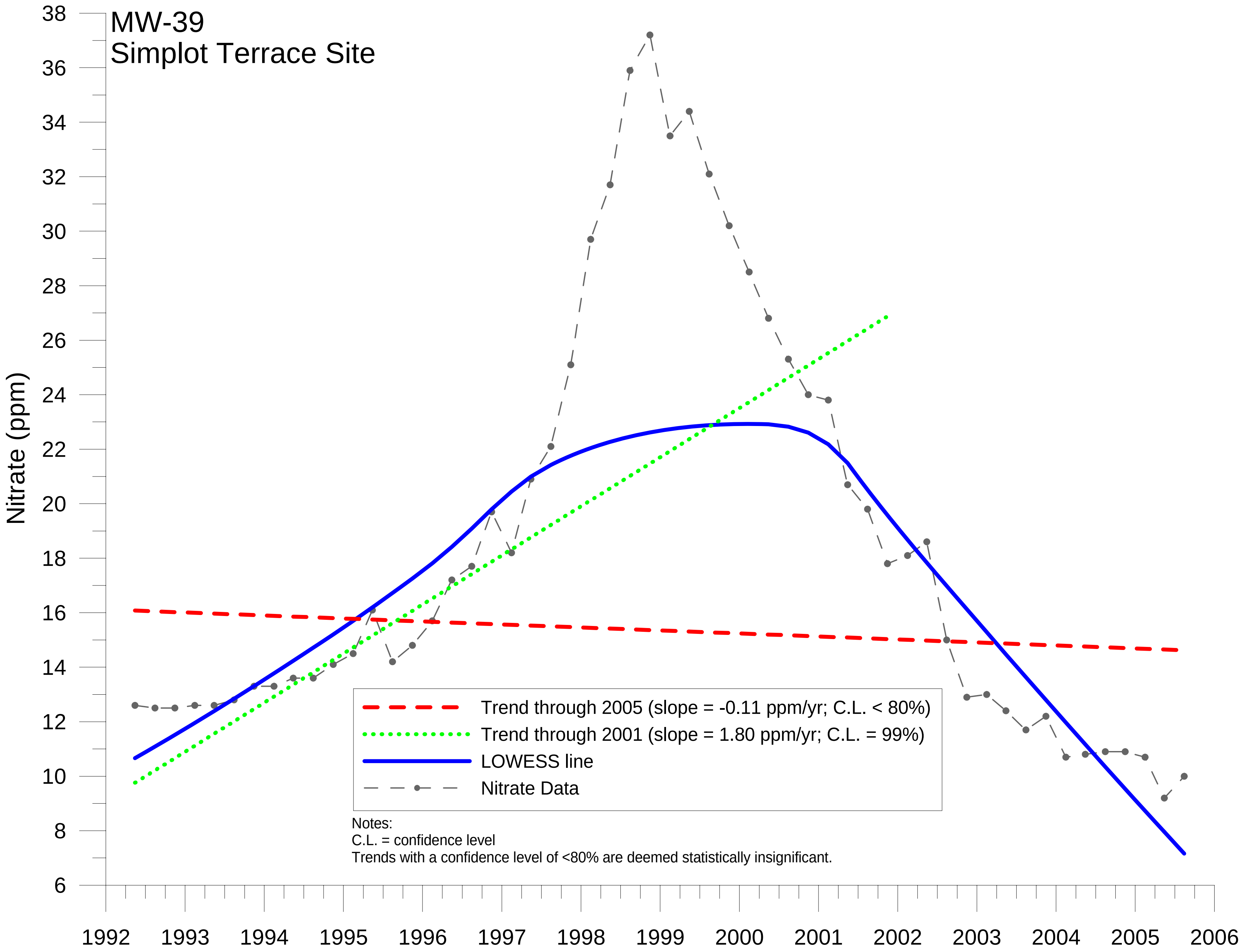
MW-58
Simplot Plant Site
Trend through 2005 (slope = 0.0 ppm/yr; C.L. < 80%)
Trend through 2001 (slope = -0.50 ppm/yr; C.L. < 80%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level; D.L. = detection limit
Trends with a confidence level of <80% are deemed statistically insignificant.
The trend analysis of data through 2001 used one-half the detection limit for censored data.
Nitrate (ppm)
0
5
10
15
20
25
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006


MW-59
Simplot Plant Site
Trend through 2005 (slope = 0.0 ppm/yr; C.L. < 80%)
Trend through 2001 (slope = 0.0 ppm/yr; C.L. < 80%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level; D.L. = detection limit
Trends with a confidence level of <80% are deemed statistically insignificant.
The trend analysis of data through 2001 used one-half the detection limit for censored data.
Nitrate (ppm)
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006

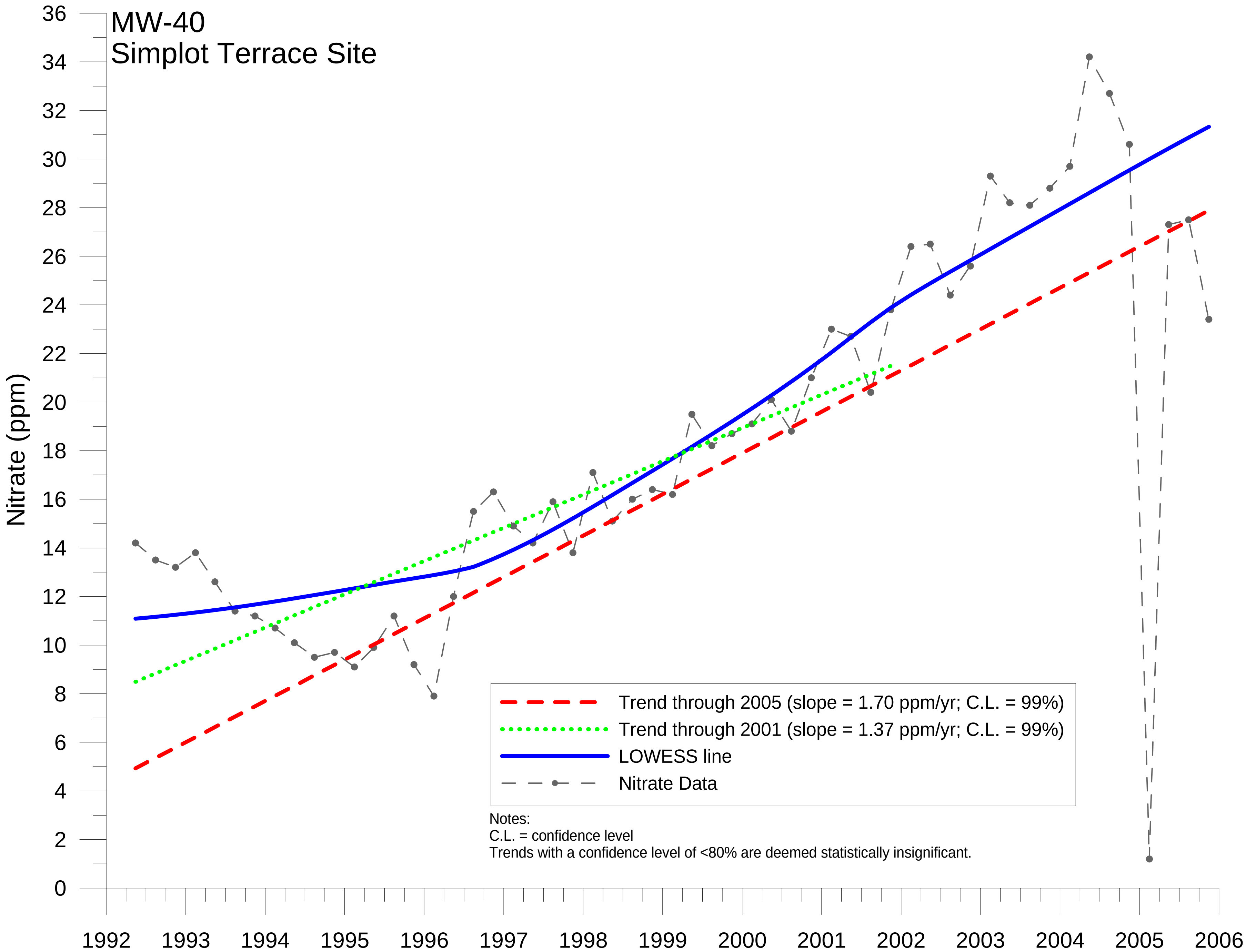

MW-14
Simplot Terrace Site
Nitrate (ppm)
46
44
42
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 1.80 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 1.80 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.


MW-22
Simplot Terrace Site
Nitrate (ppm)
36
34
32
30
28
26
24
22
20
18
16
14
12
10
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 0.96 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 1.38 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

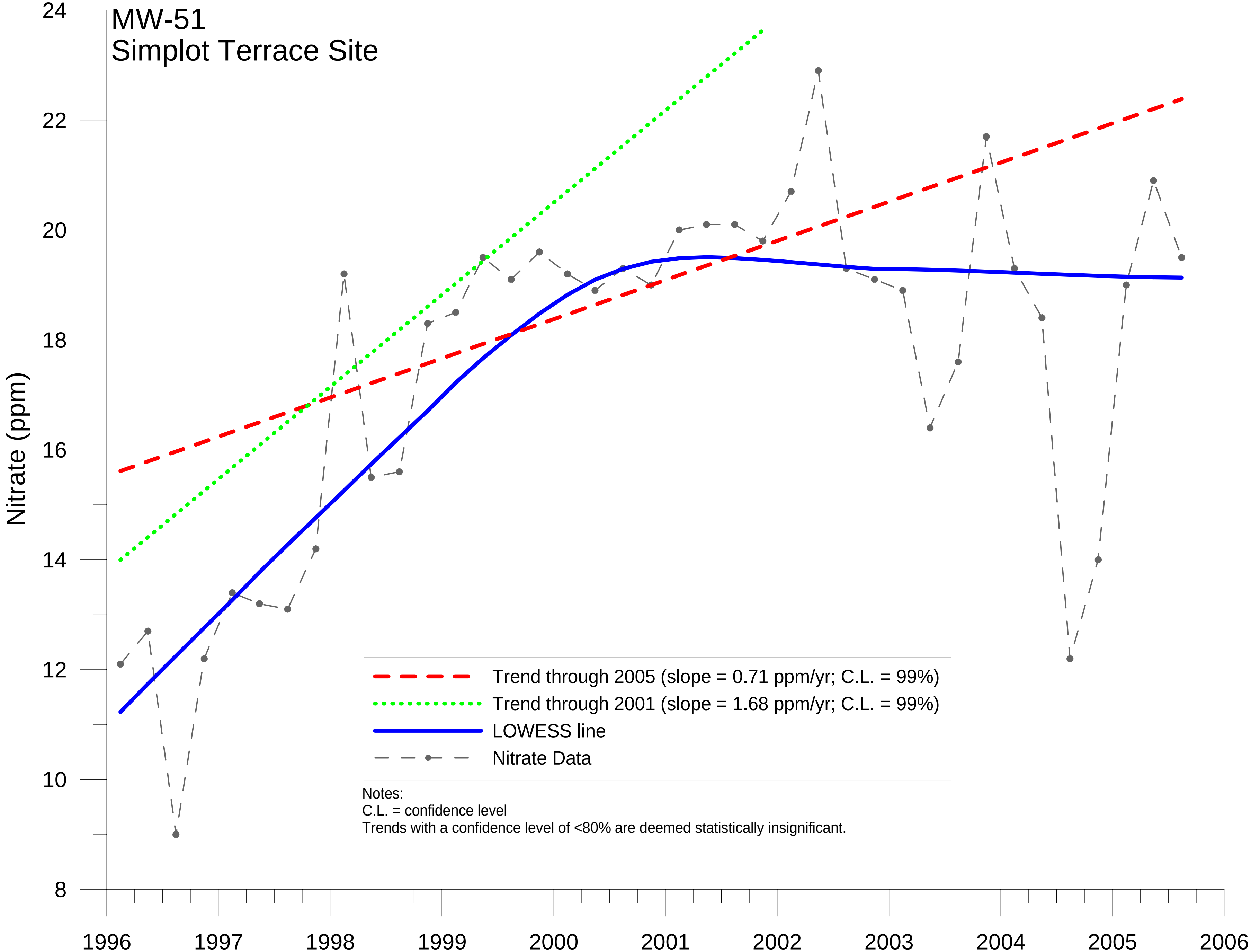

MW-38
Simplot Terrace Site
Nitrate (ppm)
22
20
18
16
14
12
10
8
6
4
2
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 0.97 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.95 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.



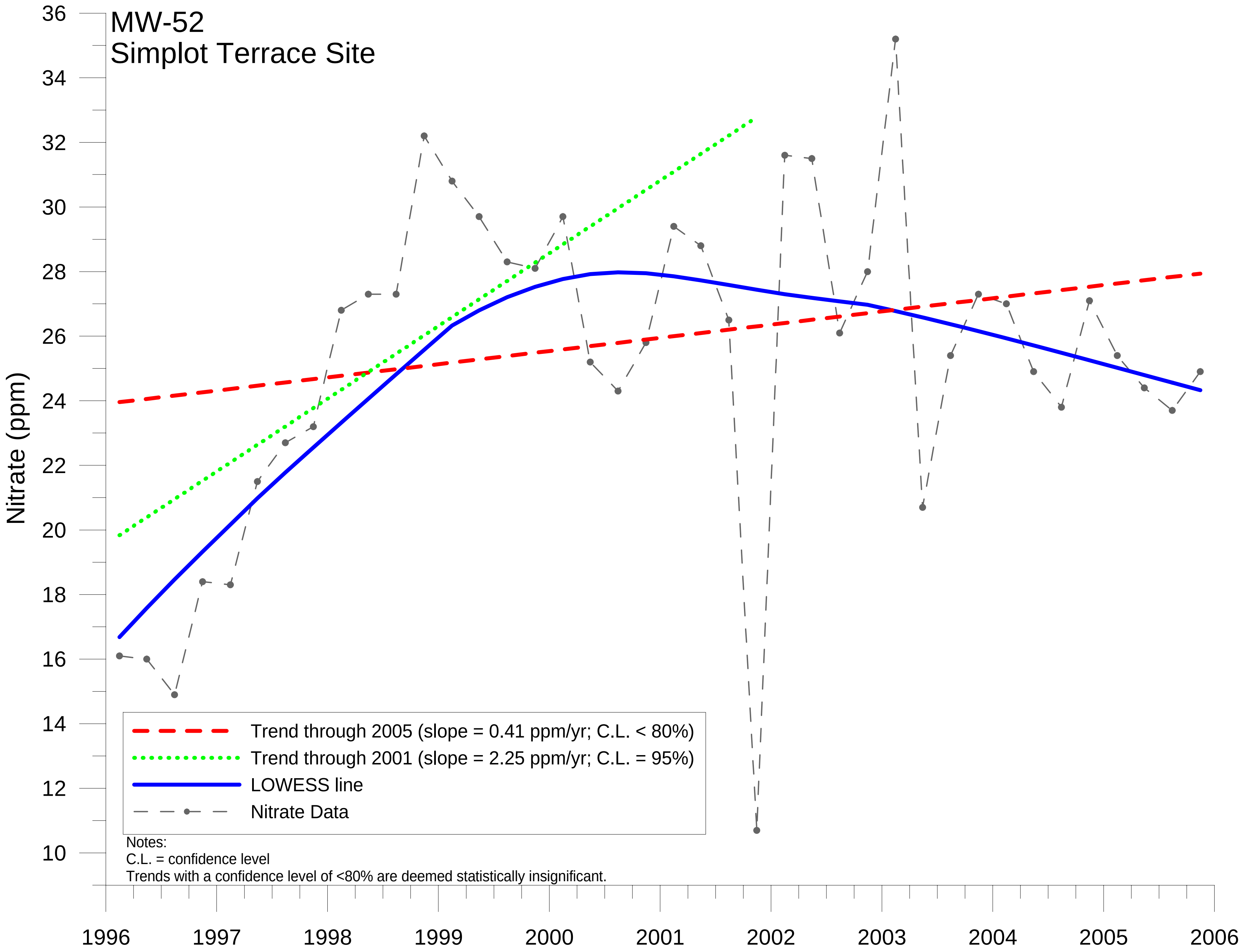
MW-39
Simplot Terrace Site
Nitrate (ppm)
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = -0.11 ppm/yr; C.L. < 80%)
Trend through 2001 (slope = 1.80 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.



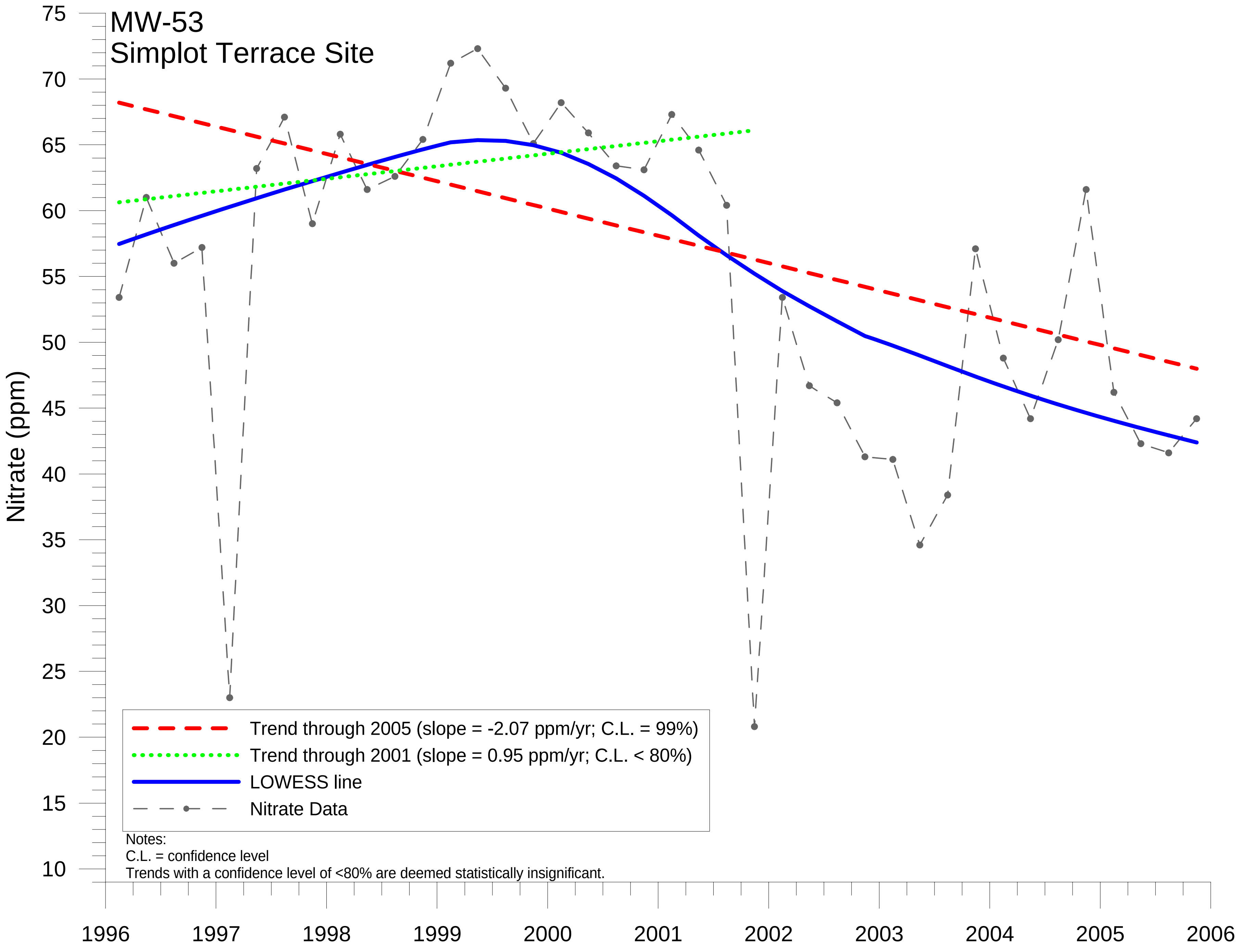
MW-40
Simplot Terrace Site
Nitrate (ppm)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 1.70 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 1.37 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.



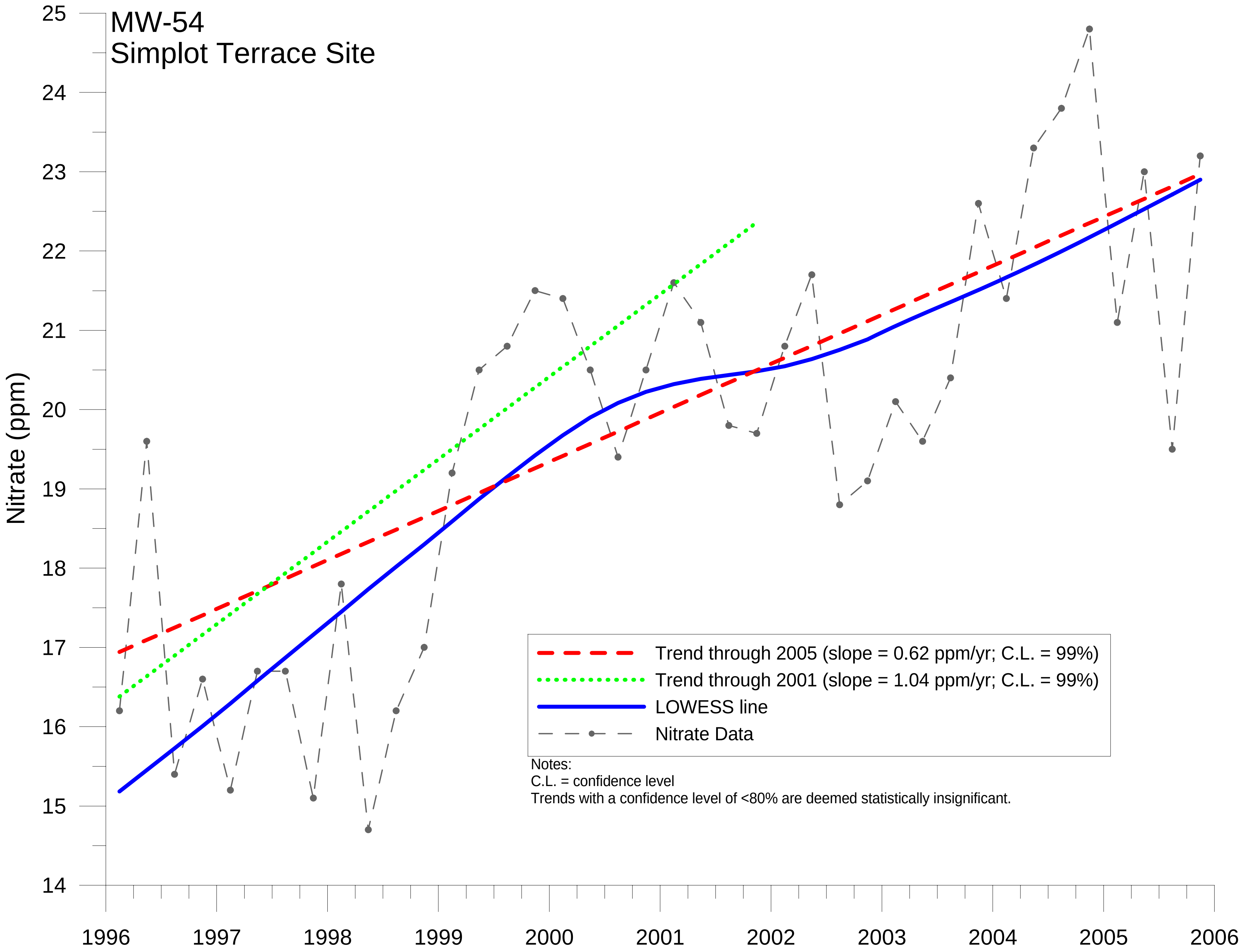
MW-51
Simplot Terrace Site
Nitrate (ppm)
24
22
20
18
16
14
12
10
8
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 0.71 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 1.68 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

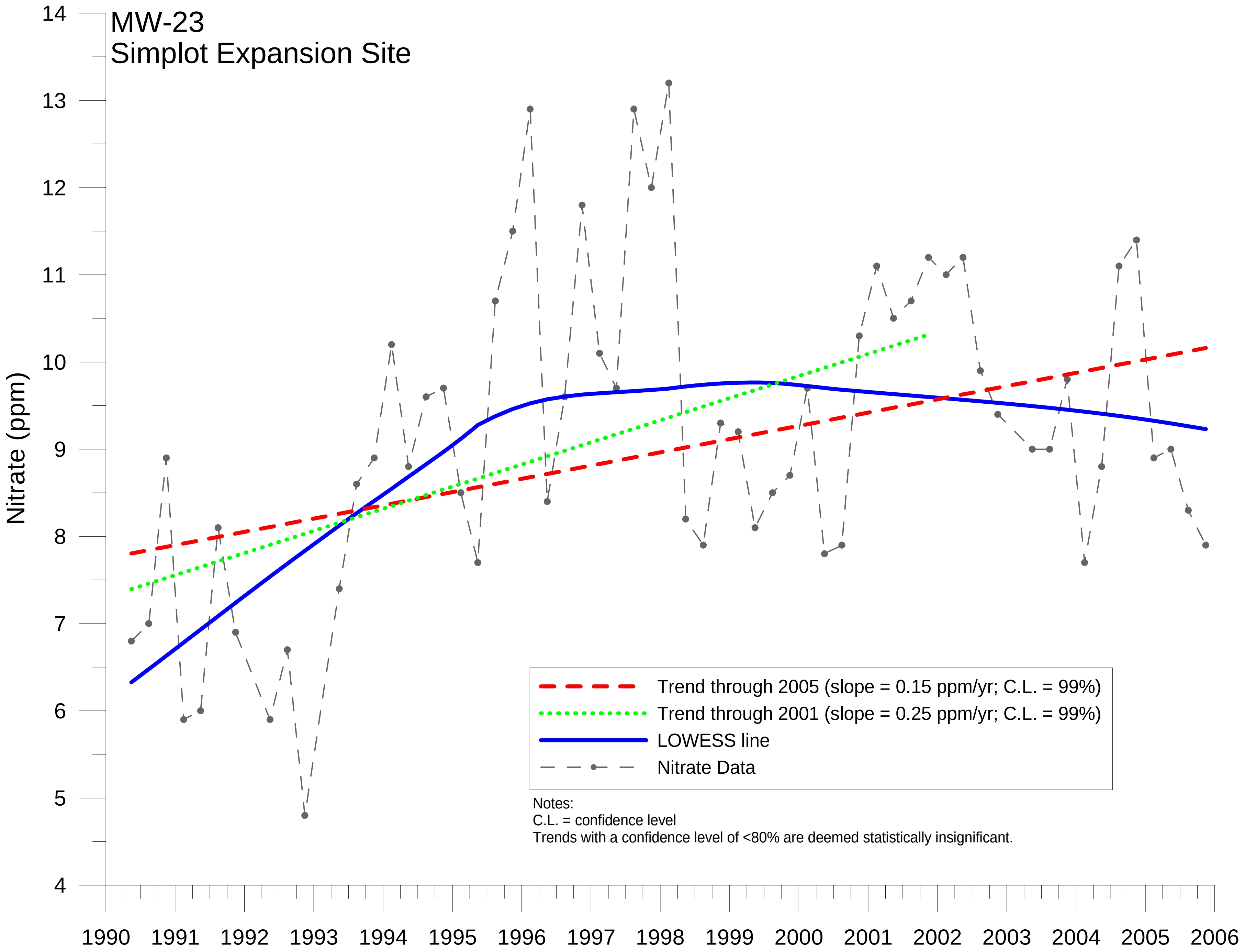


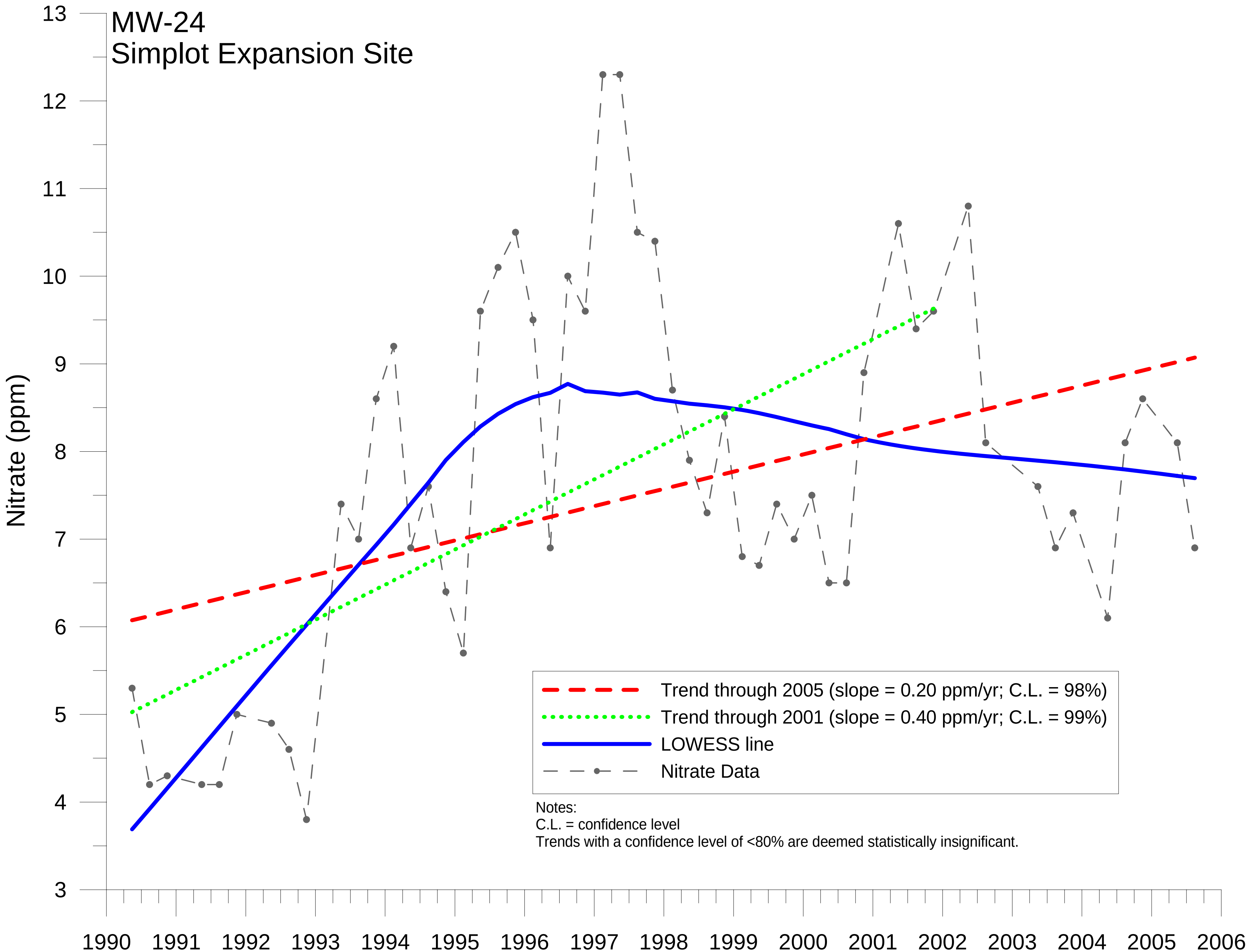
MW-52
Simplot Terrace Site
Nitrate (ppm)
36
34
32
30
28
26
24
22
20
18
16
14
12
10
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 0.41 ppm/yr; C.L. < 80%)
Trend through 2001 (slope = 2.25 ppm/yr; C.L. = 95%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

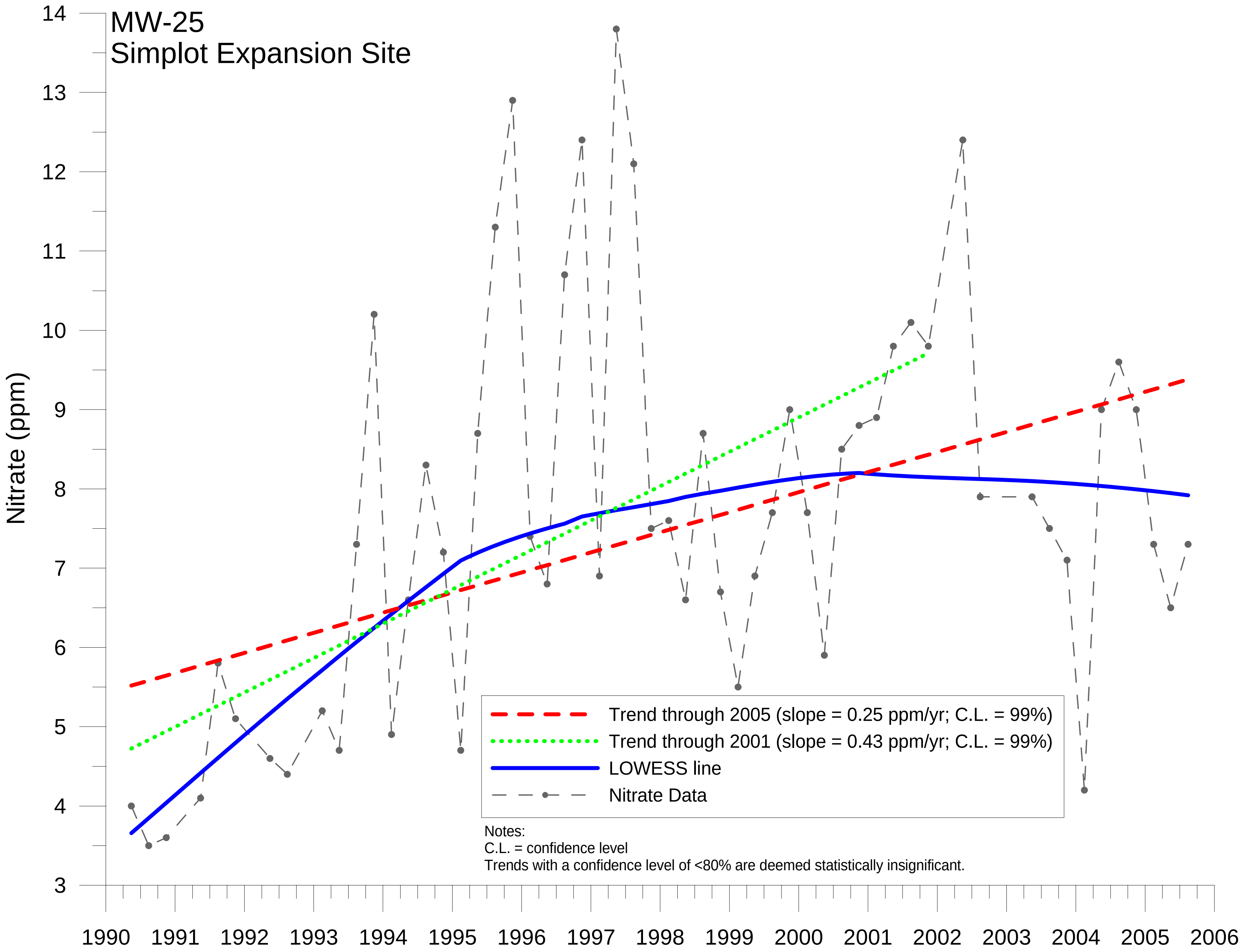


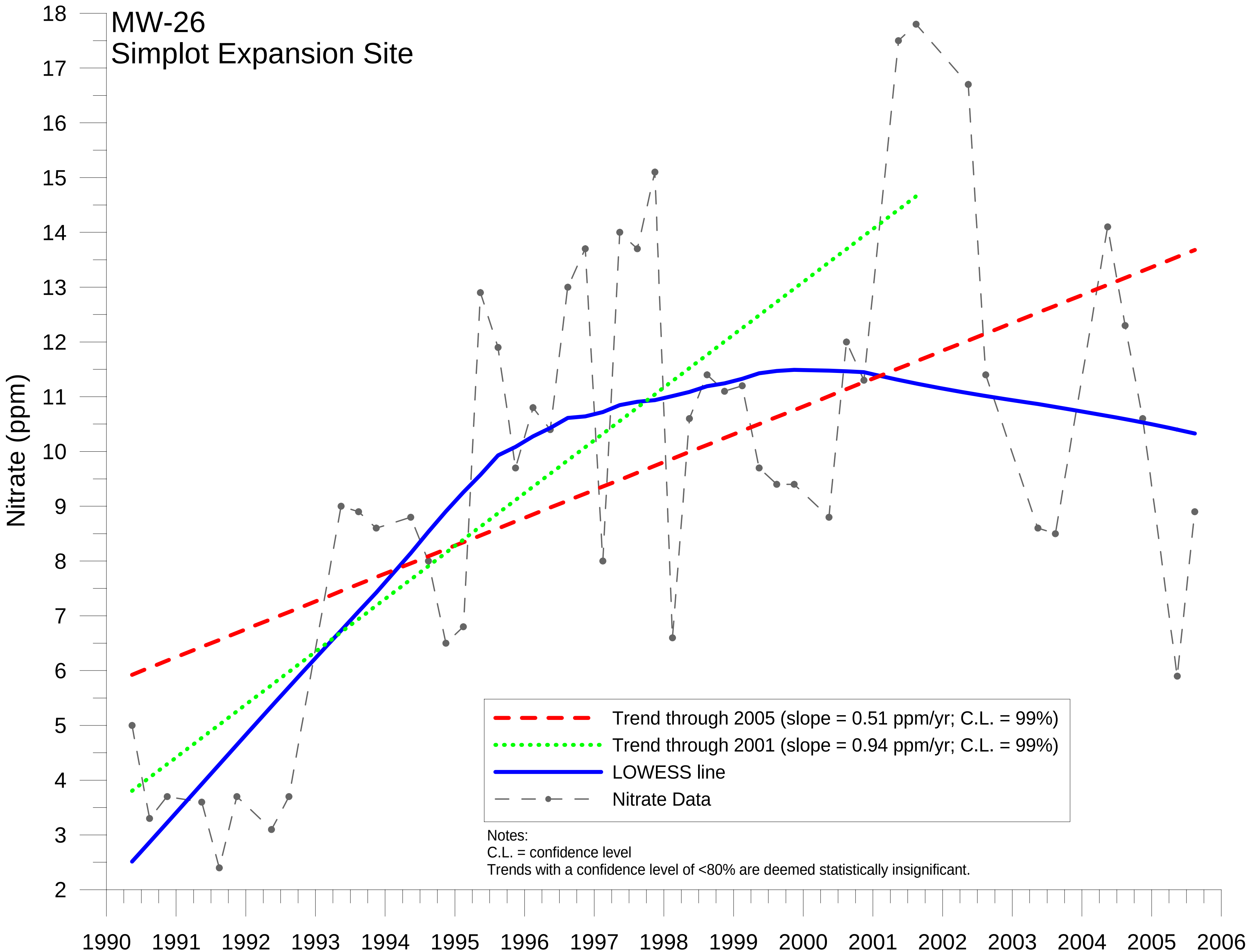
MW-53
Simplot Terrace Site
Nitrate (ppm)
75
70
65
60
55
50
45
40
35
30
25
20
15
10
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = -2.07 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.95 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.


MW-54
Simplot Terrace Site
Nitrate (ppm)
25
24
23
22
21
20
19
18
17
16
15
14
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 0.62 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 1.04 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

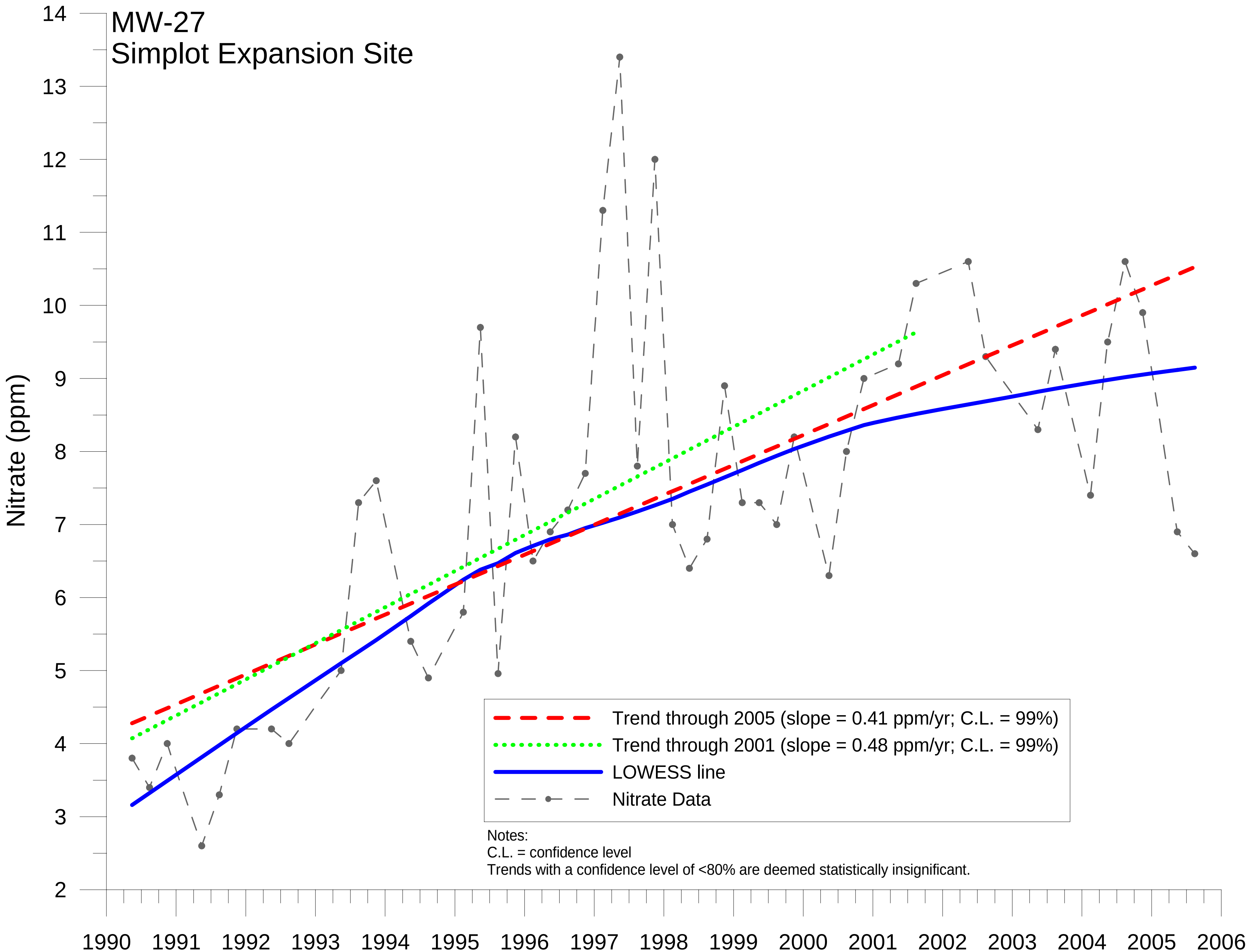

MW-23
Simplot Expansion Site
Nitrate (ppm)
14
13
12
11
10
9
8
7
6
5
4
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 0.15 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.25 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.


MW-24
Simplot Expansion Site
Nitrate (ppm)
13
12
11
10
9
8
7
6
5
4
3
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 0.20 ppm/yr; C.L. = 98%)
Trend through 2001 (slope = 0.40 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

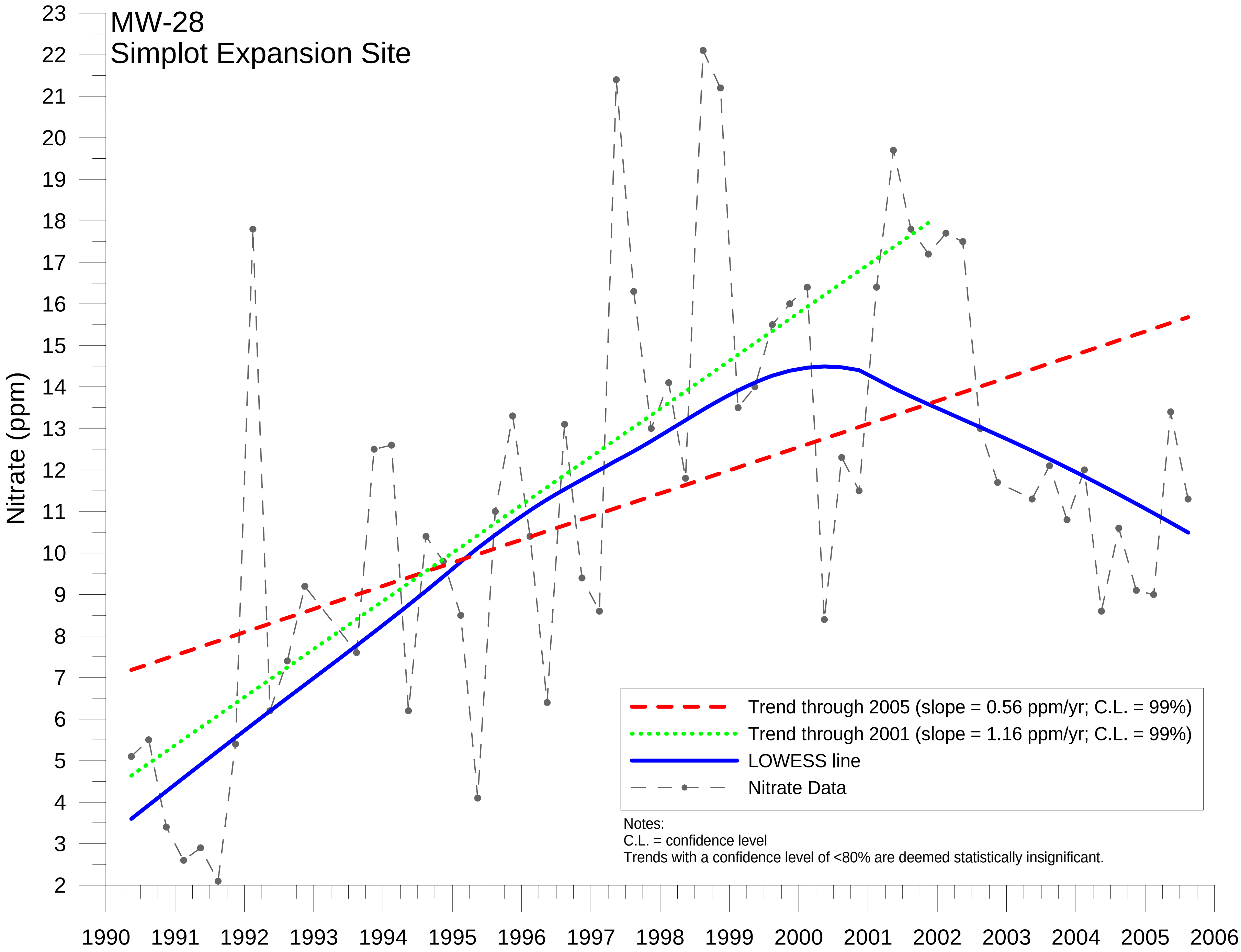

MW-25
Simplot Expansion Site
Nitrate (ppm)
14
13
12
11
10
9
8
7
6
5
4
3
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 0.25 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.43 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.



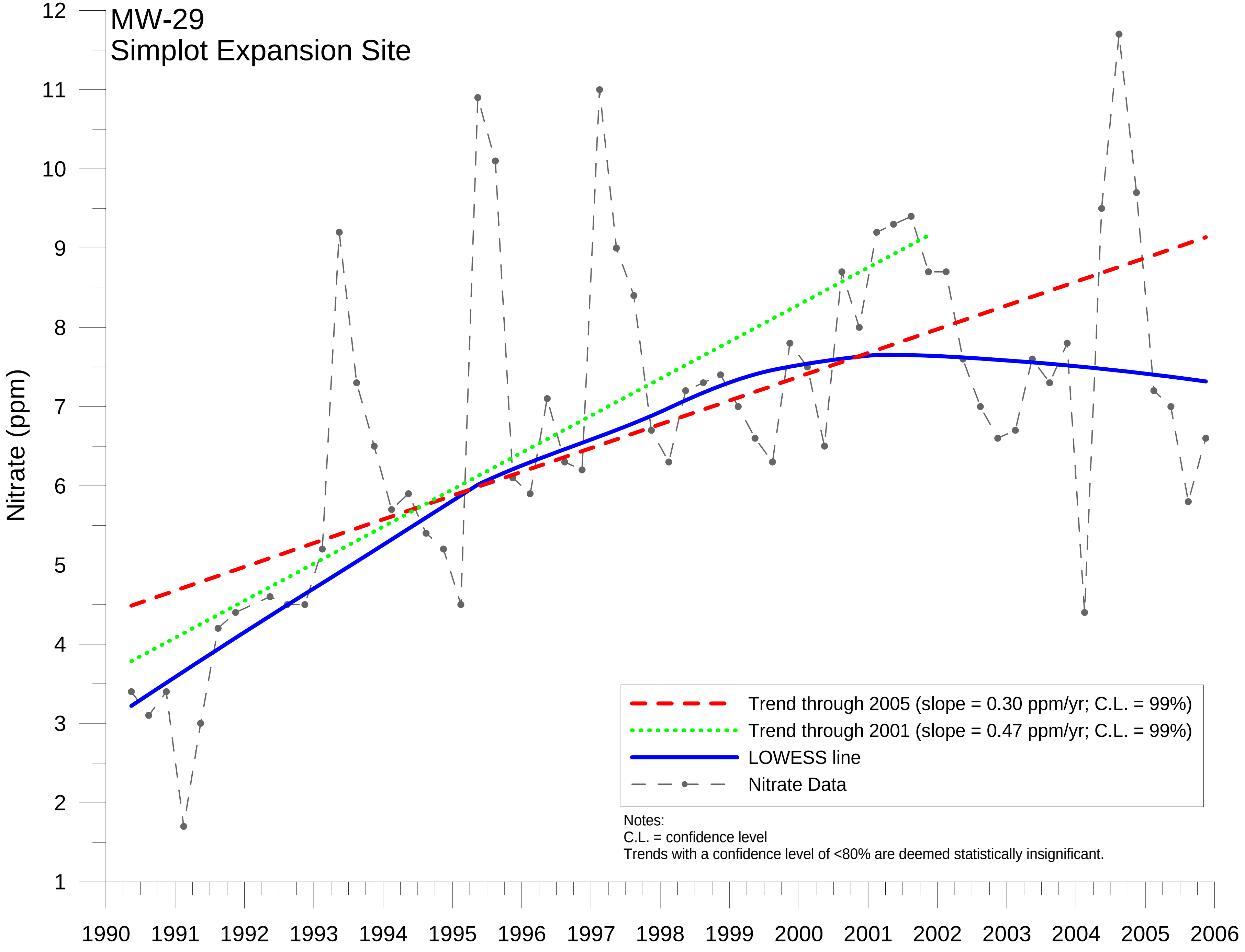
MW-26
Simplot Expansion Site
Nitrate (ppm)
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 0.51 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.94 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.



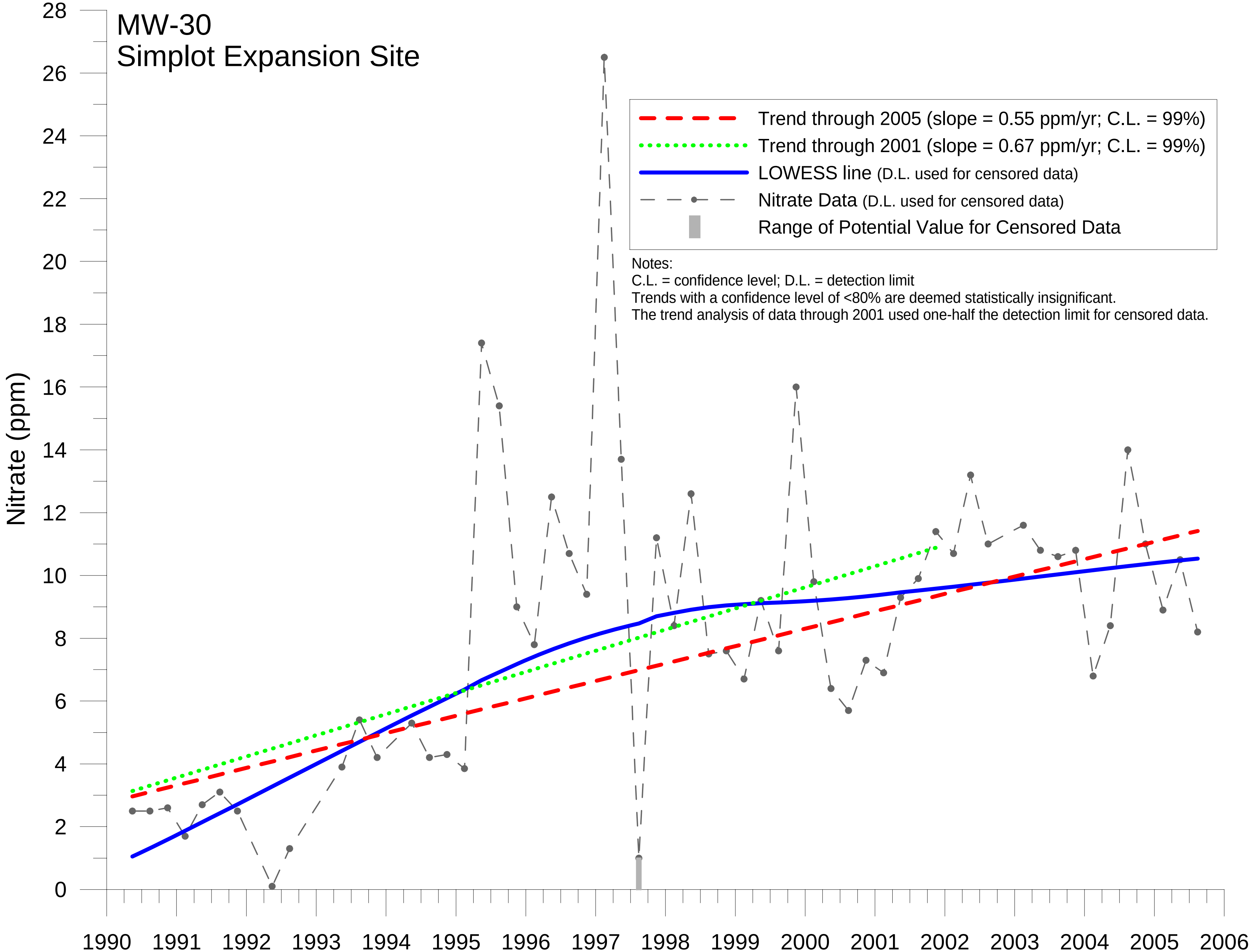
MW-27
Simplot Expansion Site
Nitrate (ppm)
14
13
12
11
10
9
8
7
6
5
4
3
2
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 0.41 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.48 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

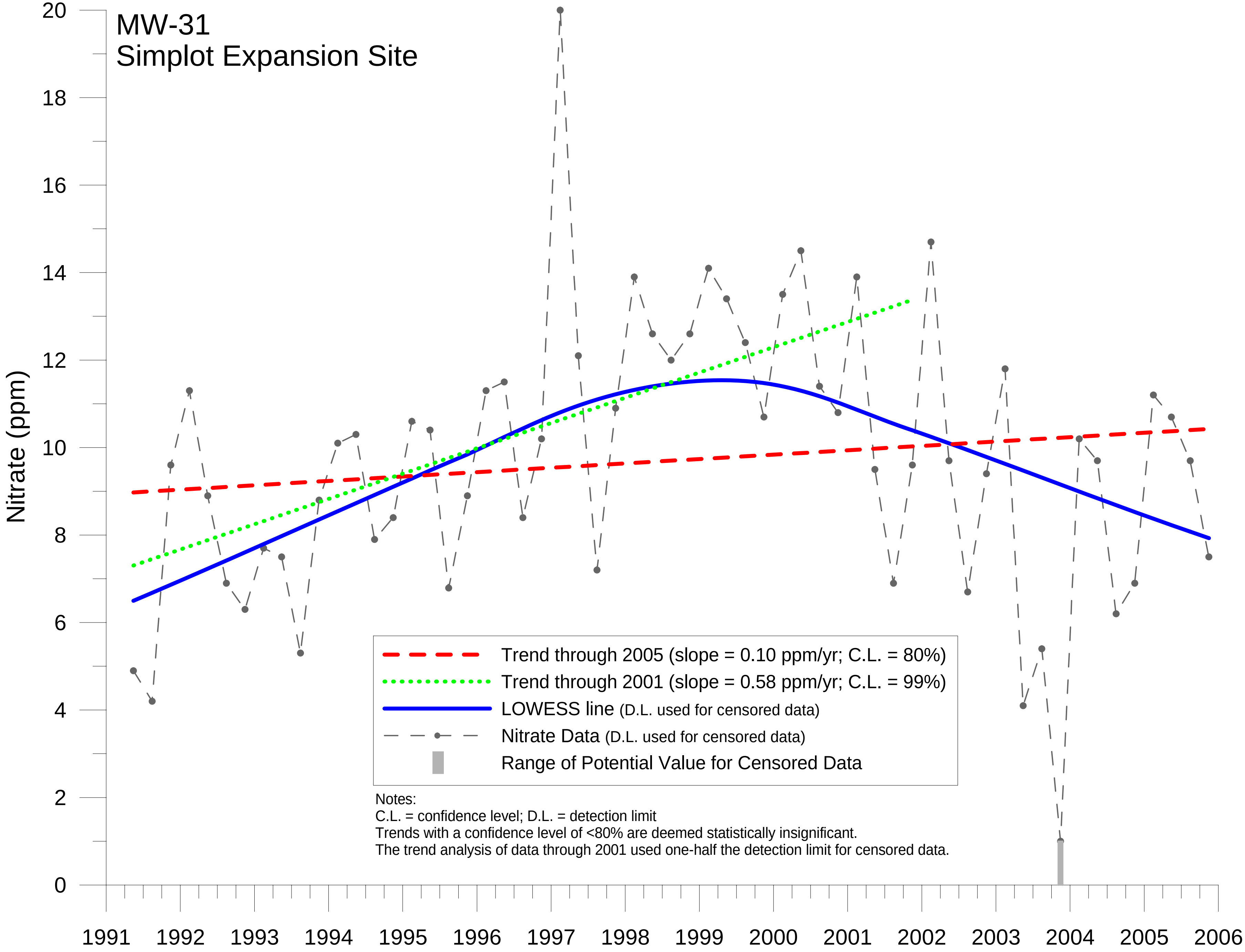


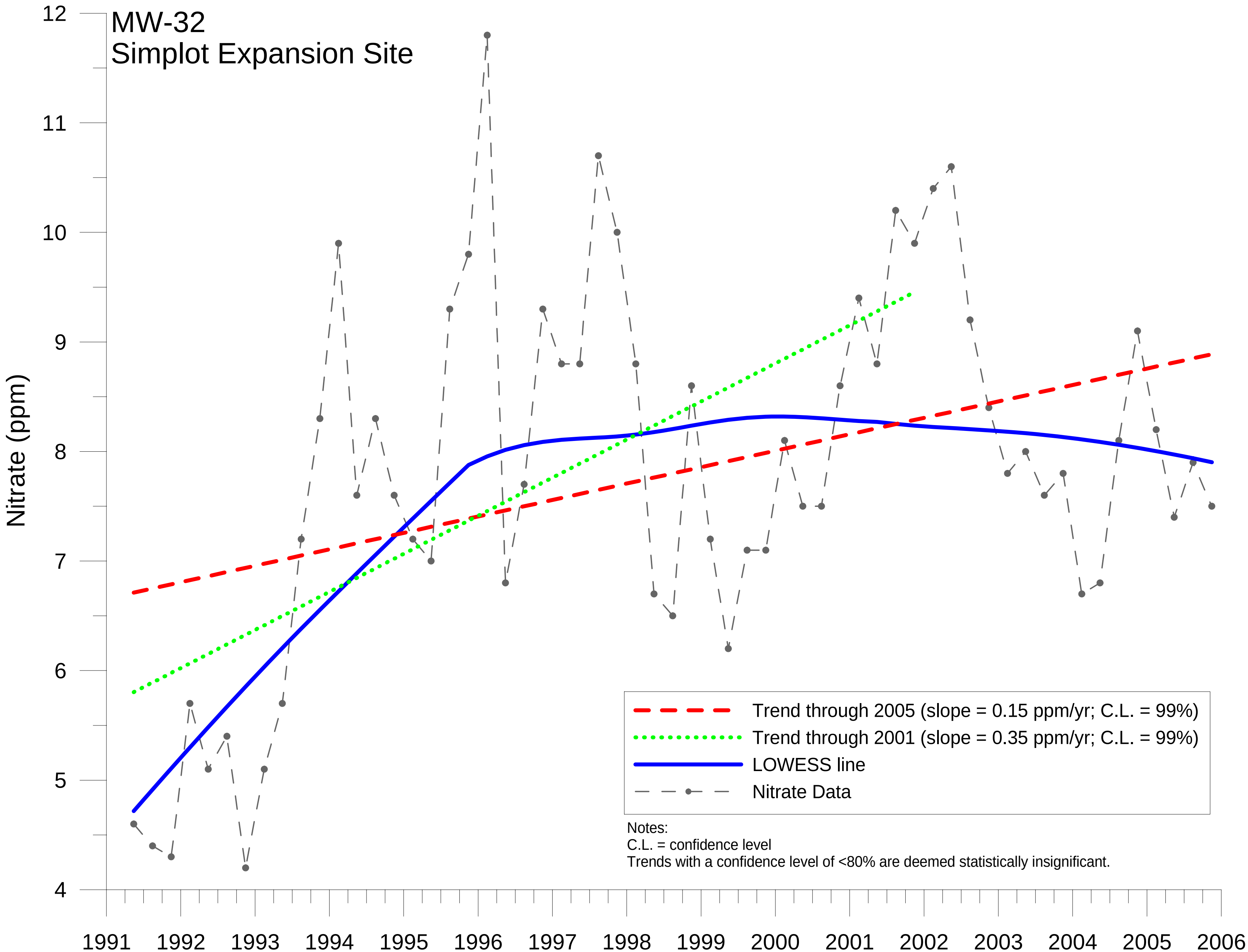
MW-28
Simplot Expansion Site
Nitrate (ppm)
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 0.56 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 1.16 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

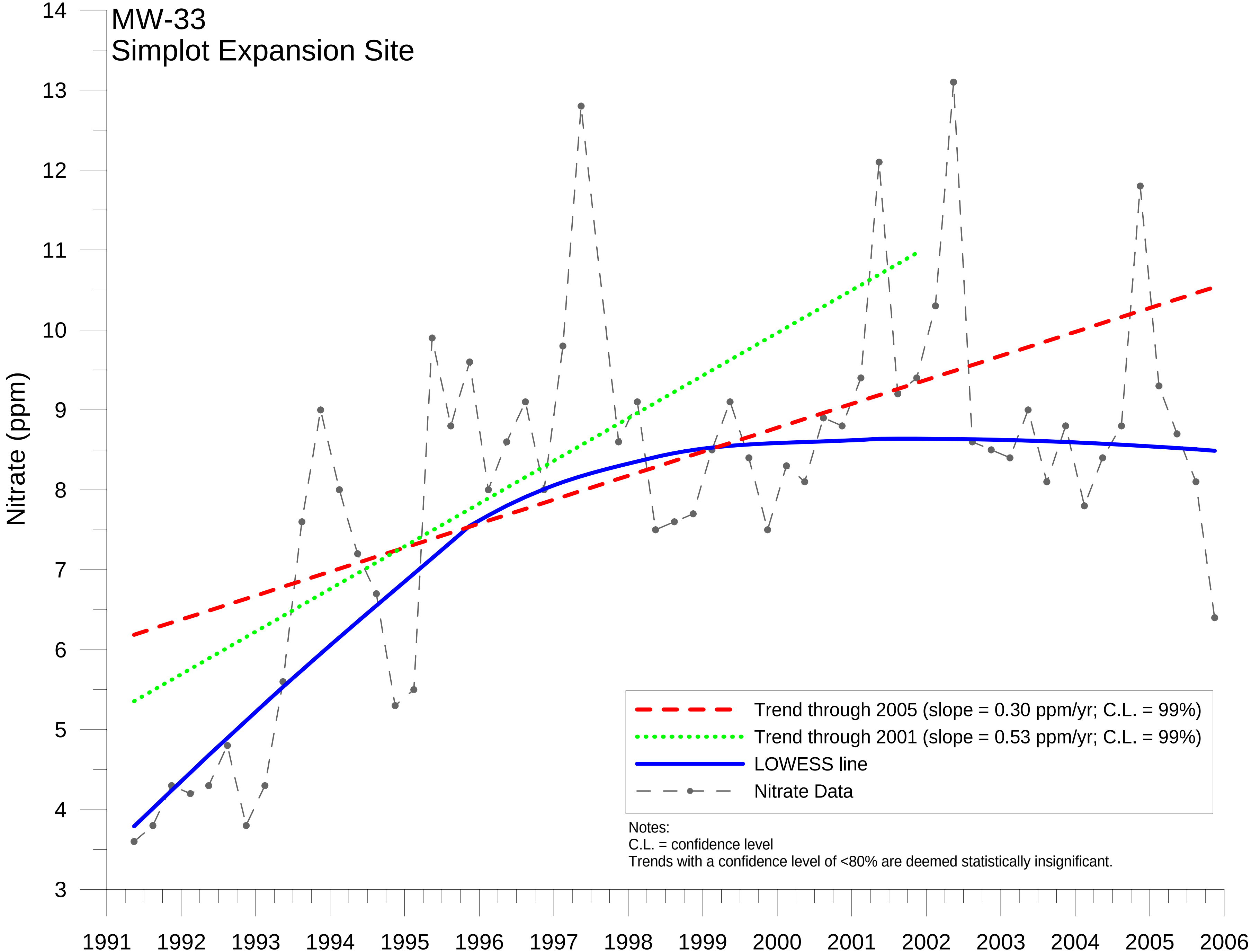


Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

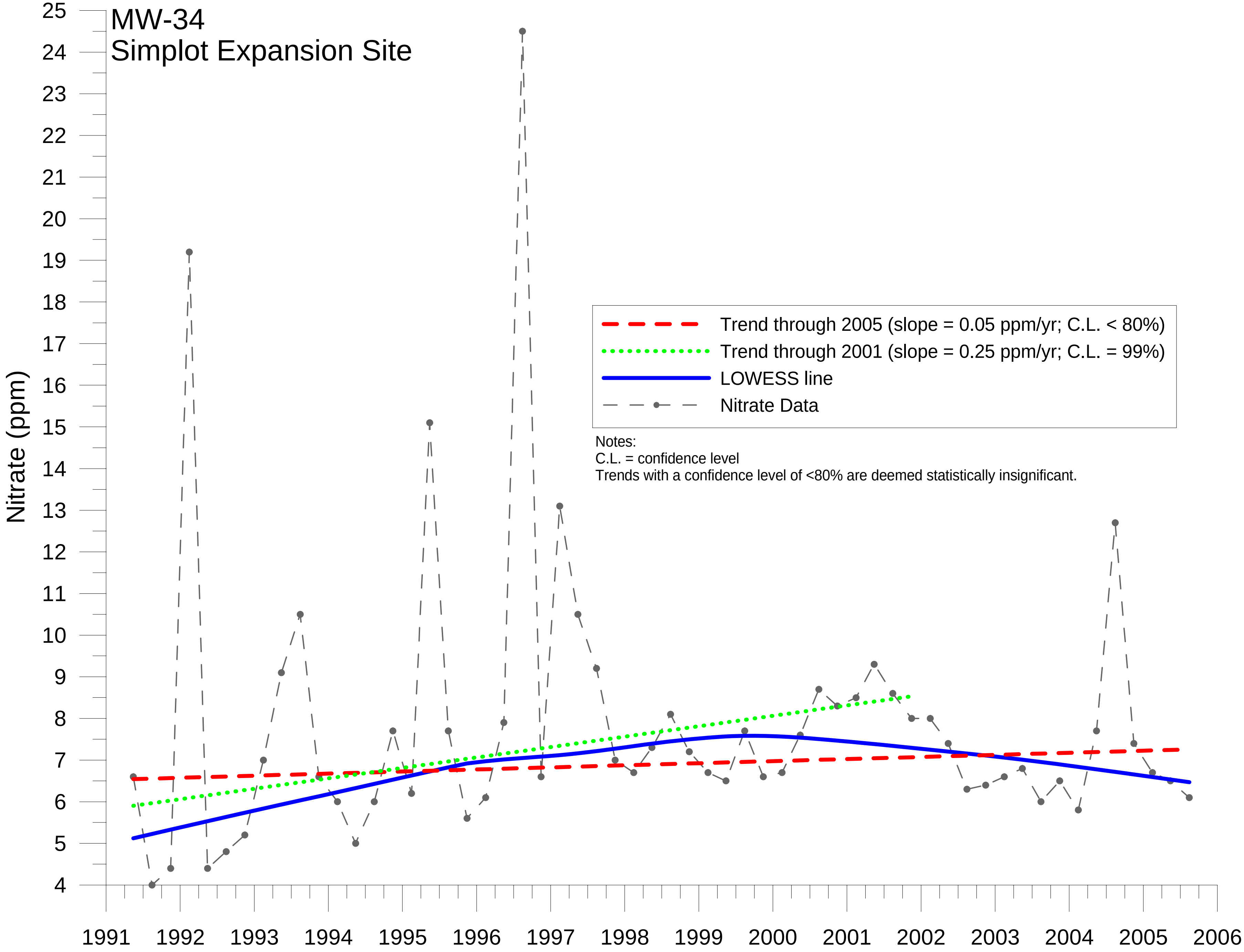

MW-30
Simplot Expansion Site
Nitrate (ppm)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 0.55 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.67 ppm/yr; C.L. = 99%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level; D.L. = detection limit
Trends with a confidence level of <80% are deemed statistically insignificant.
The trend analysis of data through 2001 used one-half the detection limit for censored data.


MW-31
Simplot Expansion Site
Nitrate (ppm)
0
2
4
6
8
10
12
14
16
18
20
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 0.10 ppm/yr; C.L. = 80%)
Trend through 2001 (slope = 0.58 ppm/yr; C.L. = 99%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level; D.L. = detection limit
Trends with a confidence level of <80% are deemed statistically insignificant.
The trend analysis of data through 2001 used one-half the detection limit for censored data.

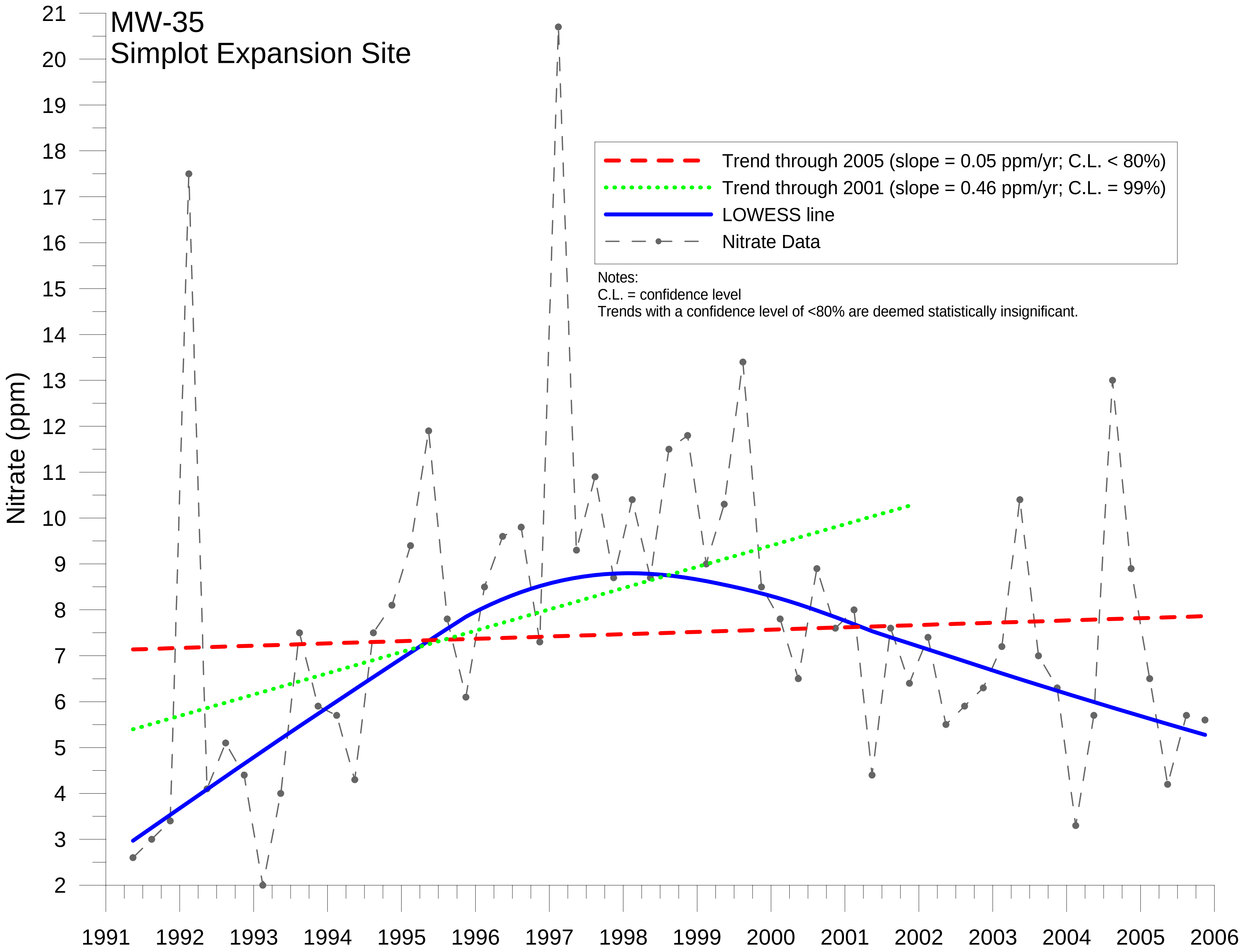

MW-32
Simplot Expansion Site
Nitrate (ppm)
12
11
10
9
8
7
6
5
4
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 0.15 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.35 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

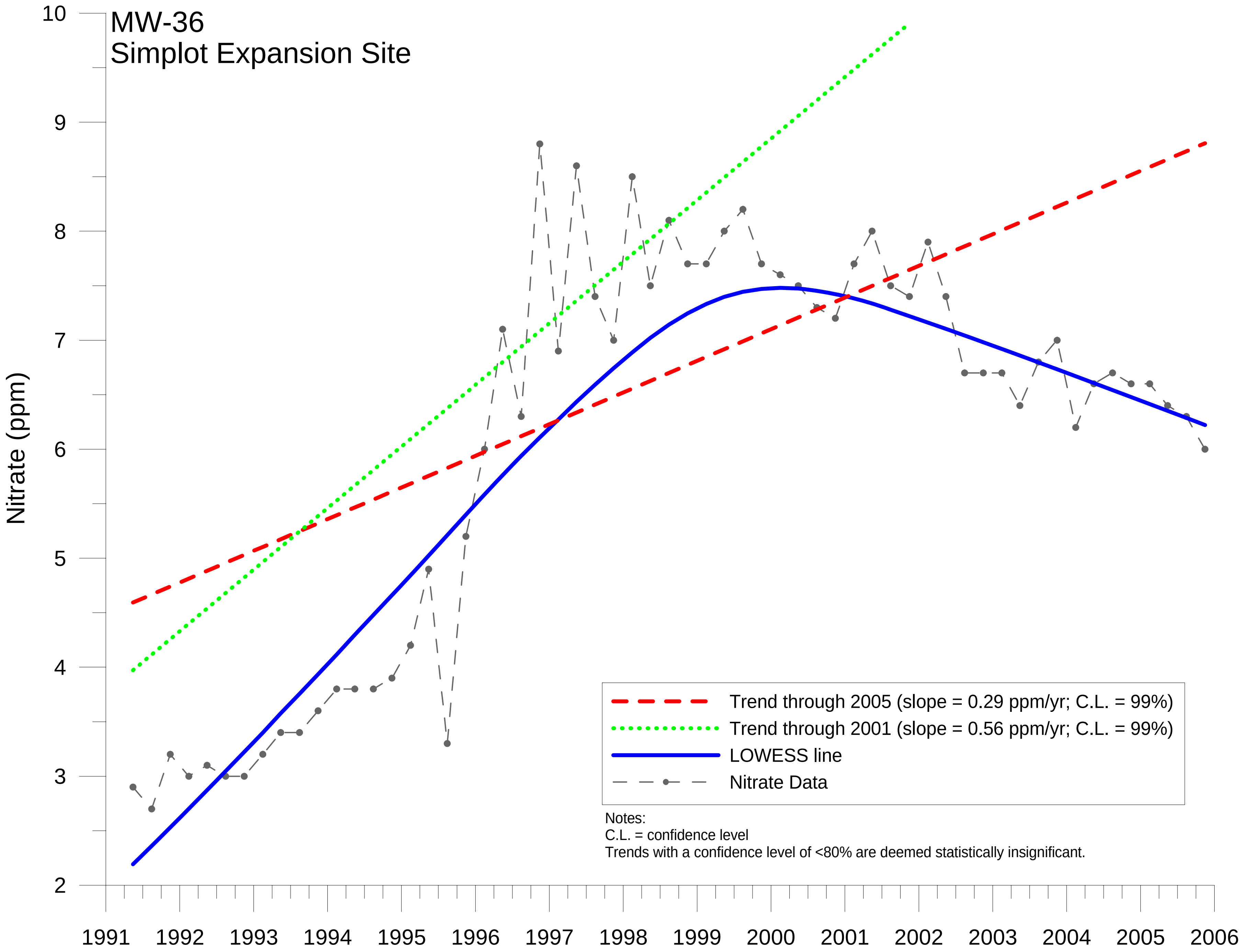


MW-33
Simplot Expansion Site
Nitrate (ppm)
14
13
12
11
10
9
8
7
6
5
4
3
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 0.30 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.53 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

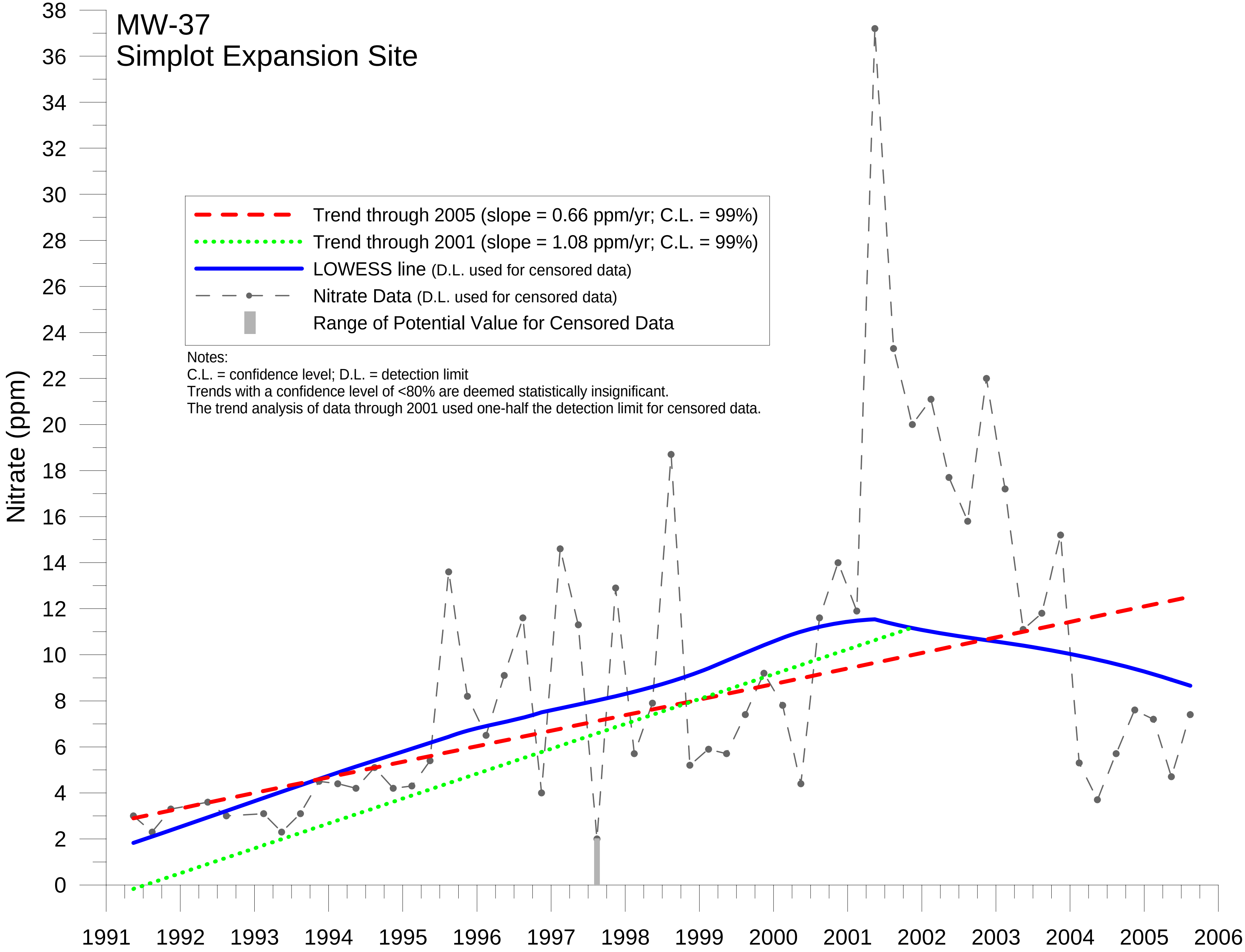


MW-34
Simplot Expansion Site
Nitrate (ppm)
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 0.05 ppm/yr; C.L. < 80%)
Trend through 2001 (slope = 0.25 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

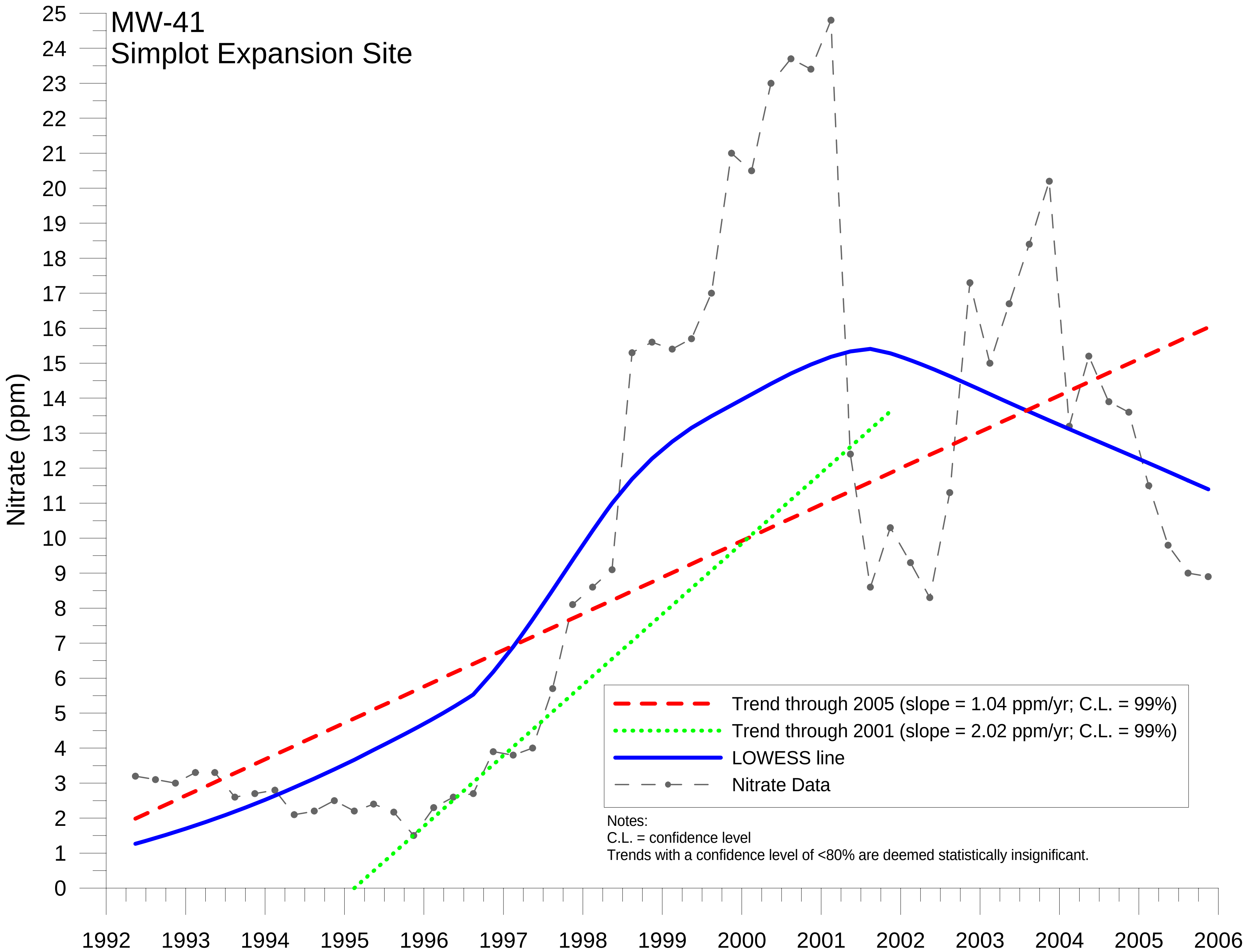

MW-35
Simplot Expansion Site
Nitrate (ppm)
Trend through 2005 (slope = 0.05 ppm/yr; C.L. < 80%)
Trend through 2001 (slope = 0.46 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006

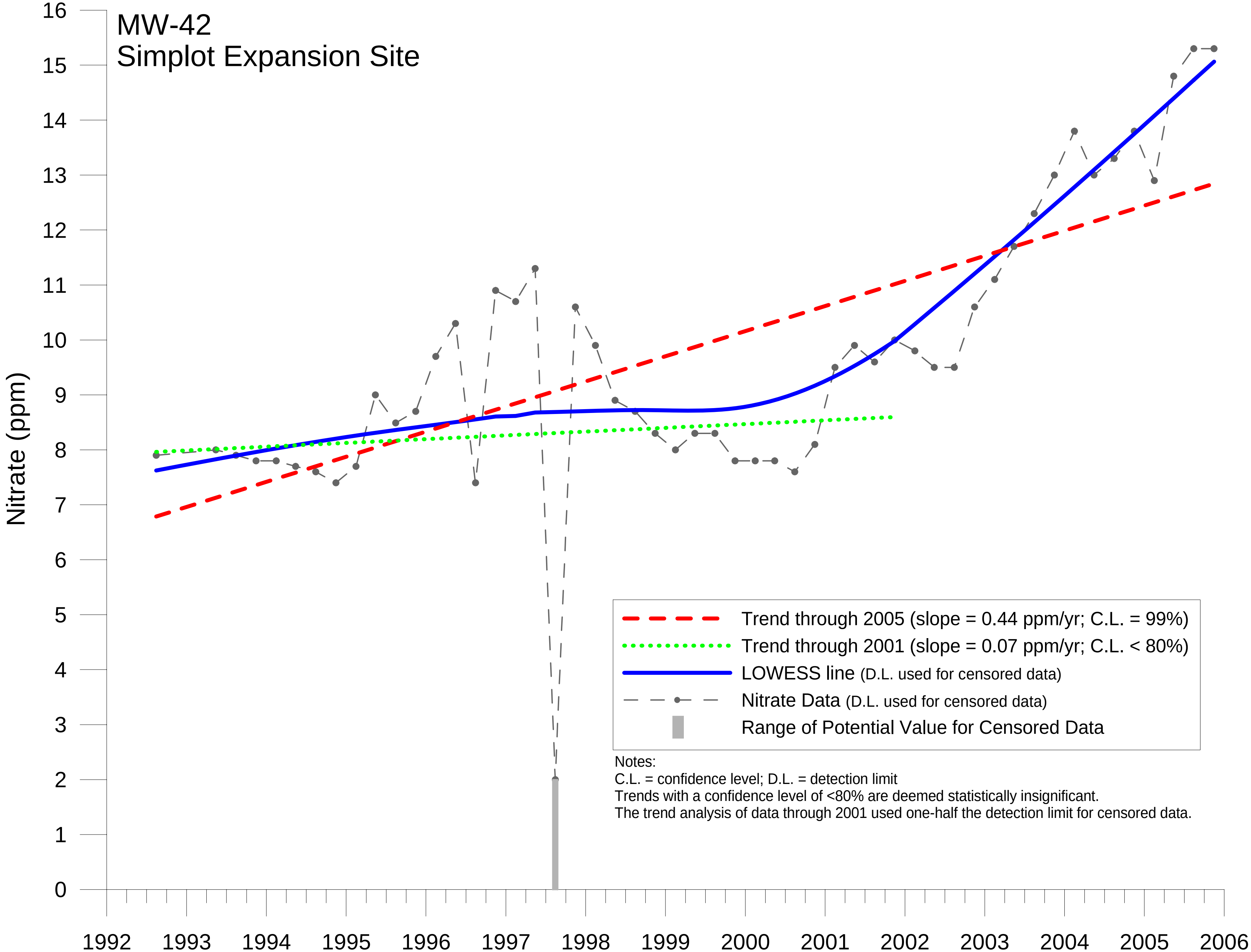


MW-36
Simplot Expansion Site
Nitrate (ppm)
10
9
8
7
6
5
4
3
2
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 0.29 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.56 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

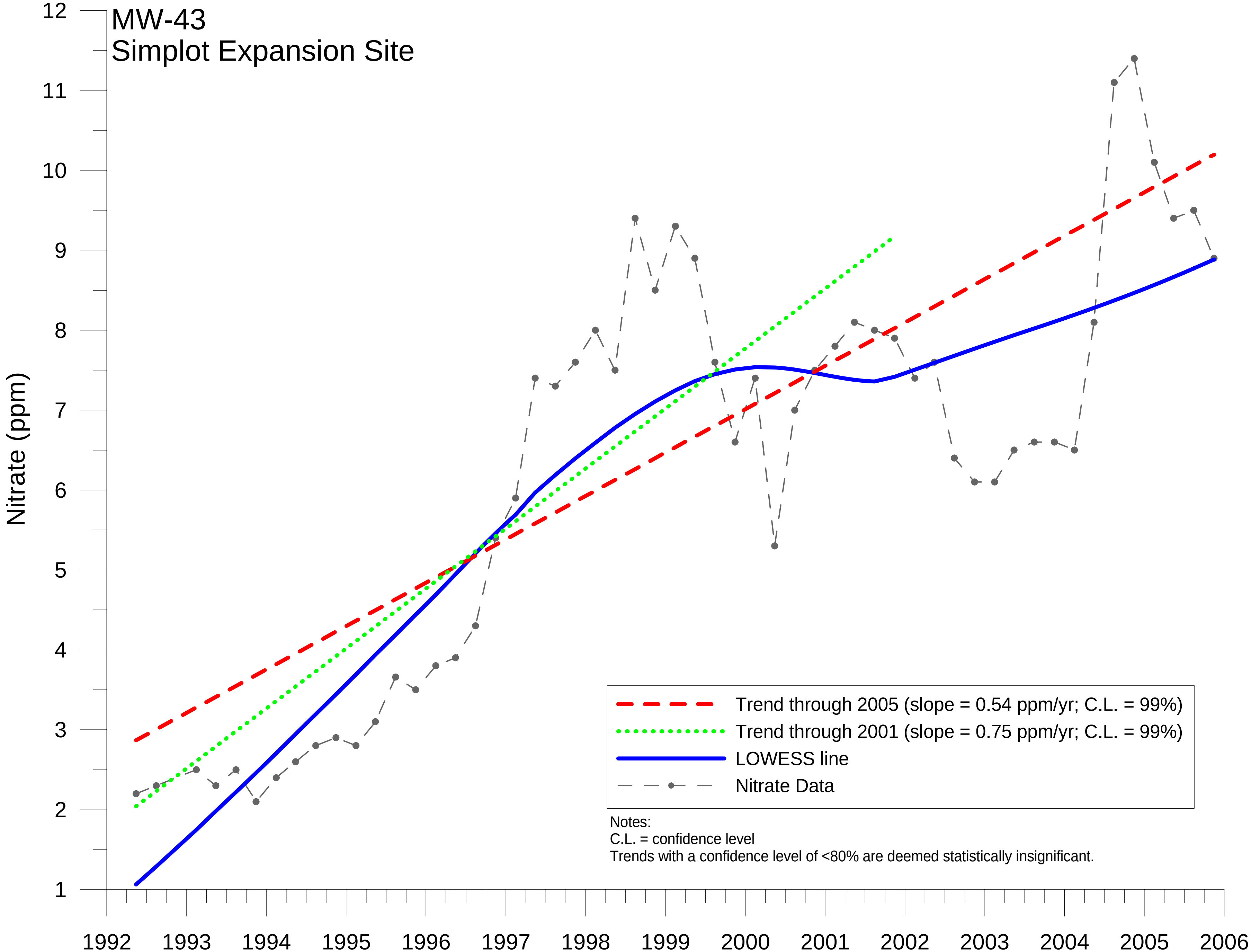


MW-37
Simplot Expansion Site
Trend through 2005 (slope = 0.66 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 1.08 ppm/yr; C.L. = 99%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level; D.L. = detection limit
Trends with a confidence level of <80% are deemed statistically insignificant.
The trend analysis of data through 2001 used one-half the detection limit for censored data.
Nitrate (ppm)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006

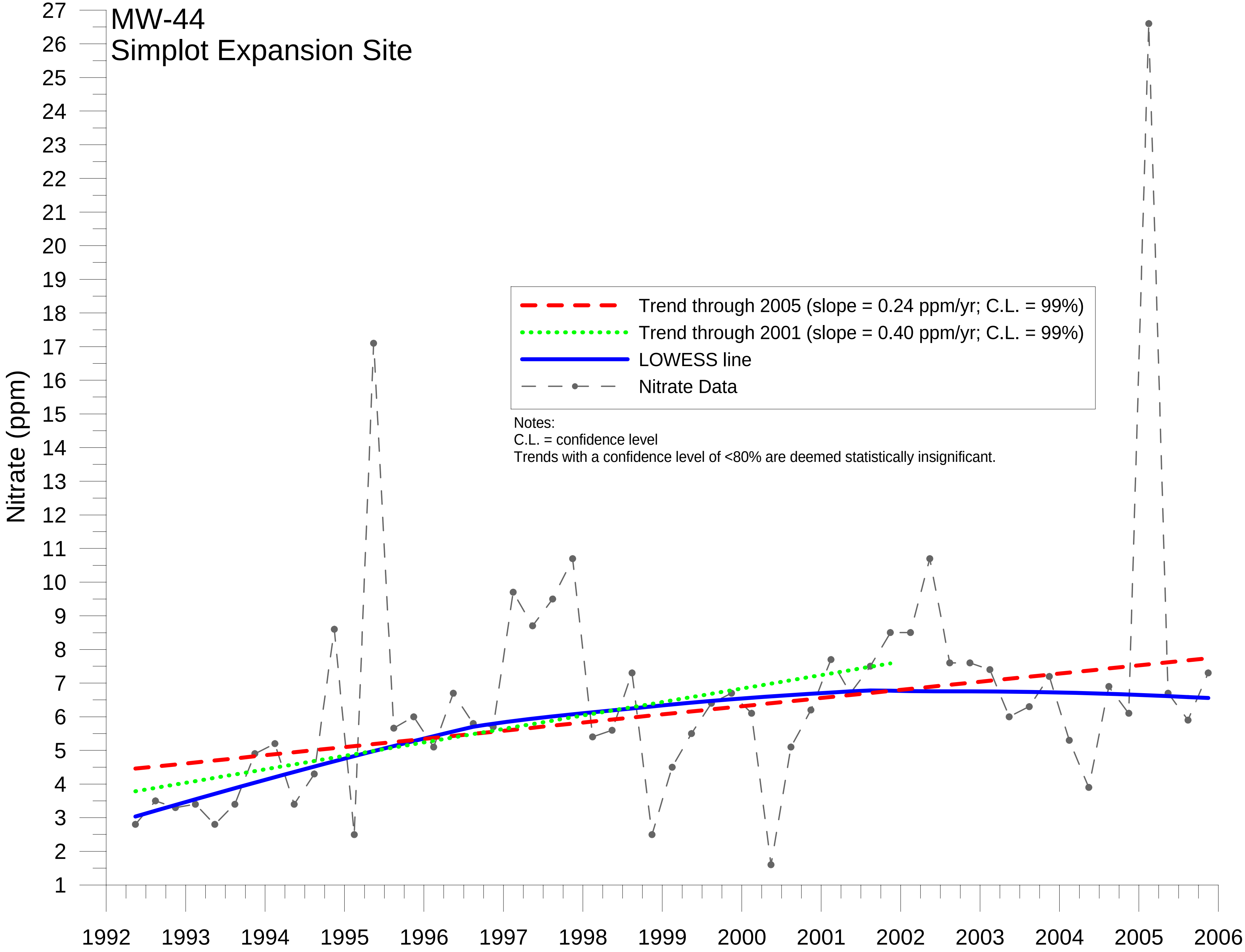

MW-41
Simplot Expansion Site
Nitrate (ppm)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 1.04 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 2.02 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

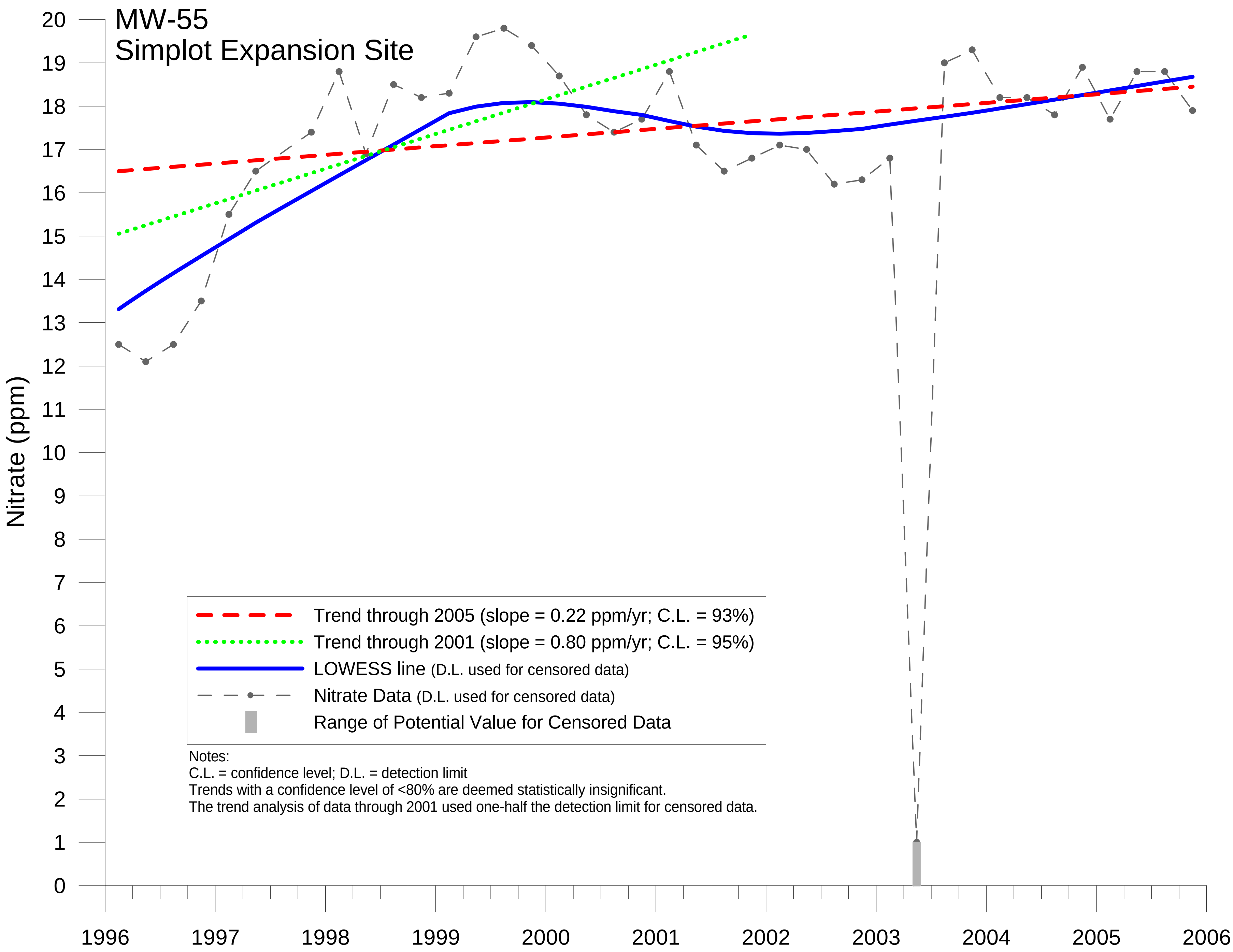


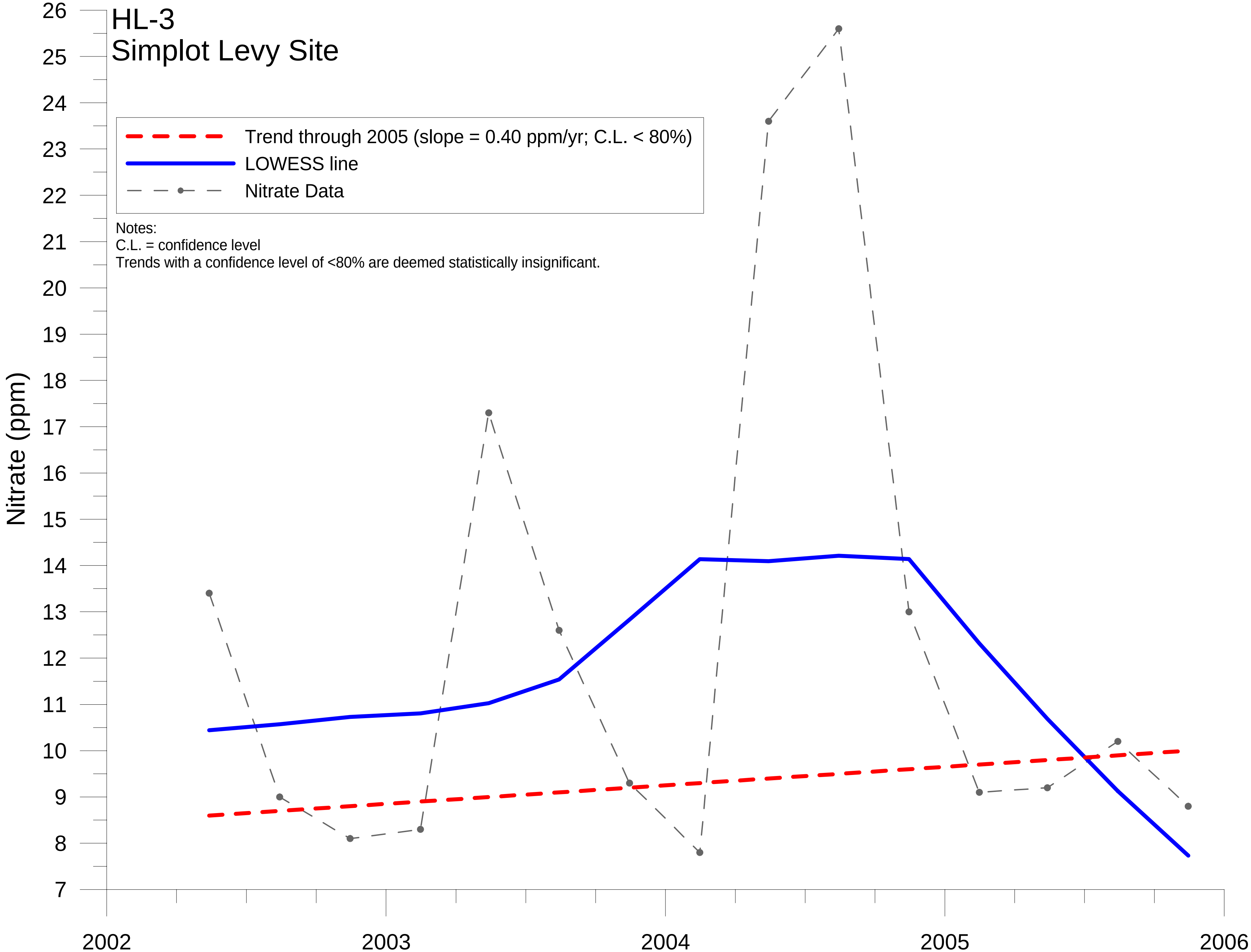
MW-42
Simplot Expansion Site
Nitrate (ppm)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 0.44 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.07 ppm/yr; C.L. < 80%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level; D.L. = detection limit
Trends with a confidence level of <80% are deemed statistically insignificant.
The trend analysis of data through 2001 used one-half the detection limit for censored data.

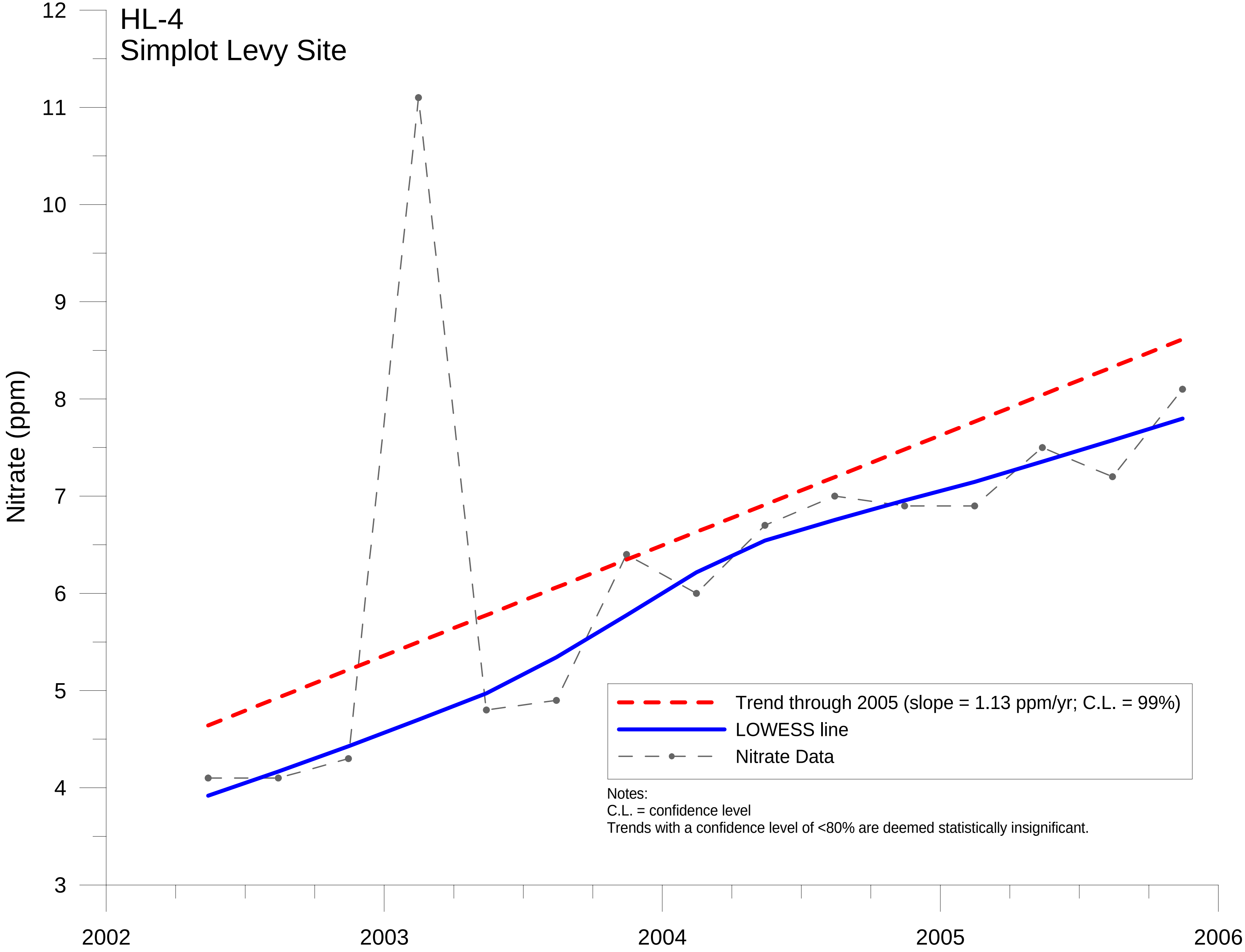


MW-43
Simplot Expansion Site
Nitrate (ppm)
1
2
3
4
5
6
7
8
9
10
11
12
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 0.54 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.75 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

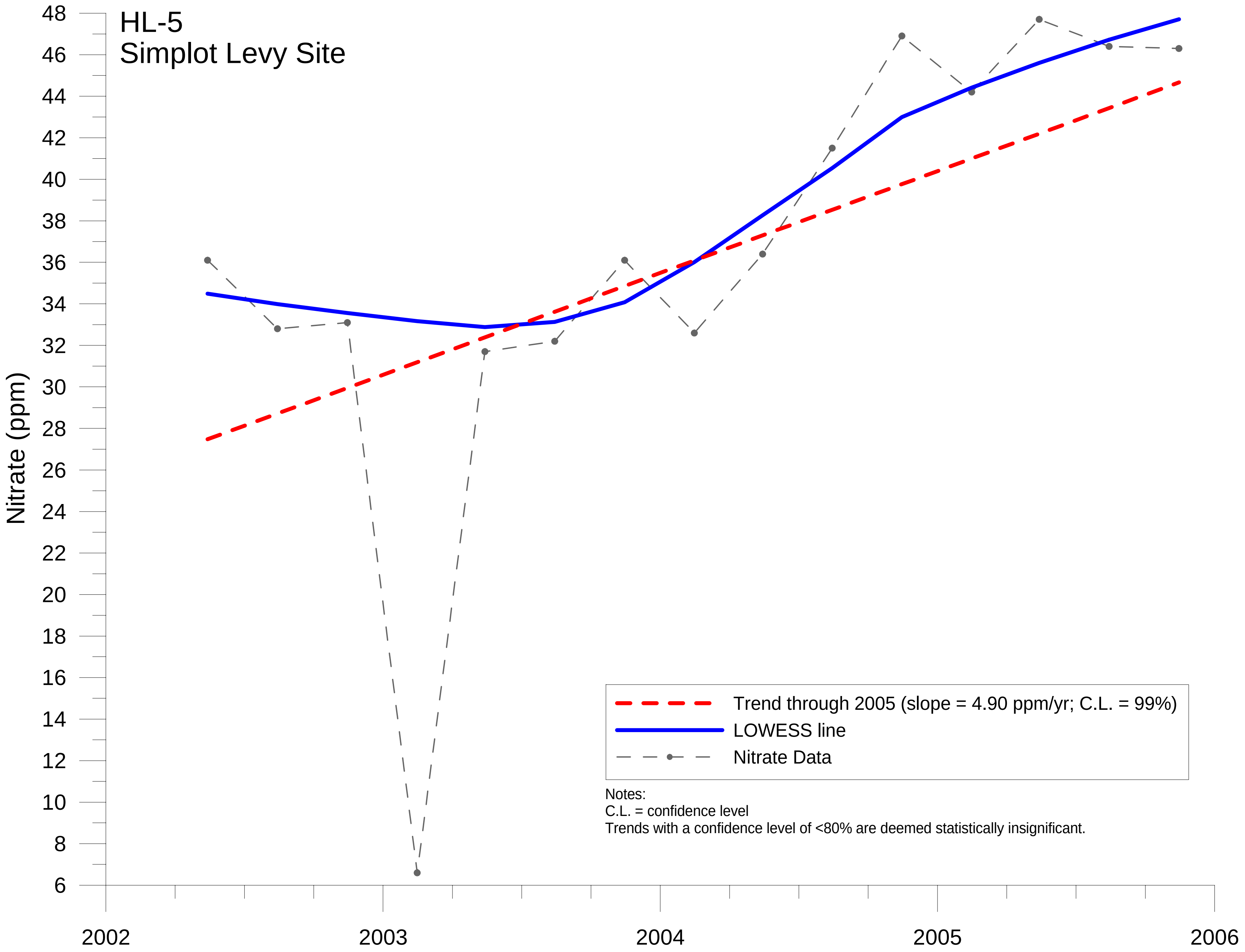

MW-44
Simplot Expansion Site
Nitrate (ppm)
Trend through 2005 (slope = 0.24 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.40 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27

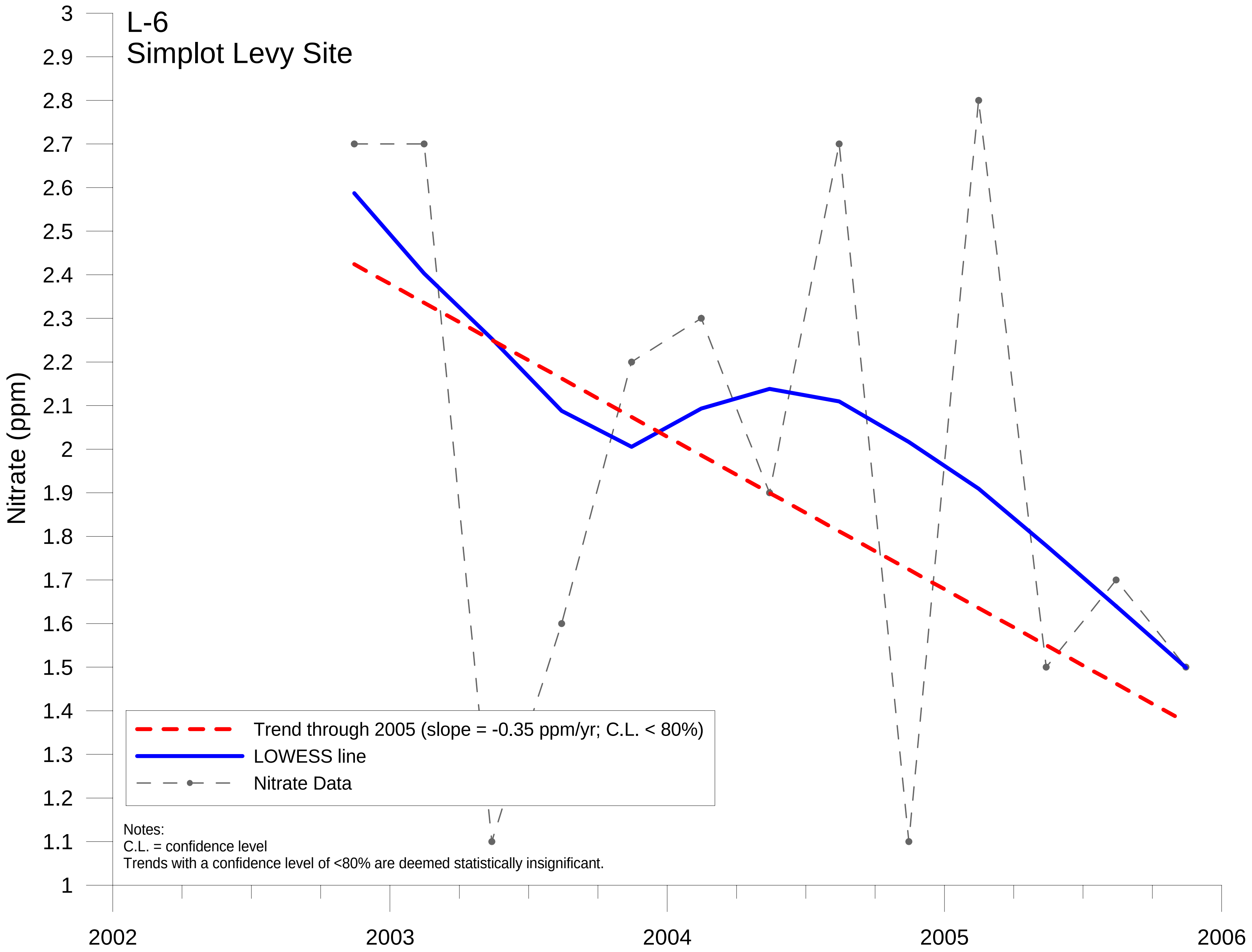

MW-55
Simplot Expansion Site
Nitrate (ppm)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 0.22 ppm/yr; C.L. = 93%)
Trend through 2001 (slope = 0.80 ppm/yr; C.L. = 95%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level; D.L. = detection limit
Trends with a confidence level of <80% are deemed statistically insignificant.
The trend analysis of data through 2001 used one-half the detection limit for censored data.

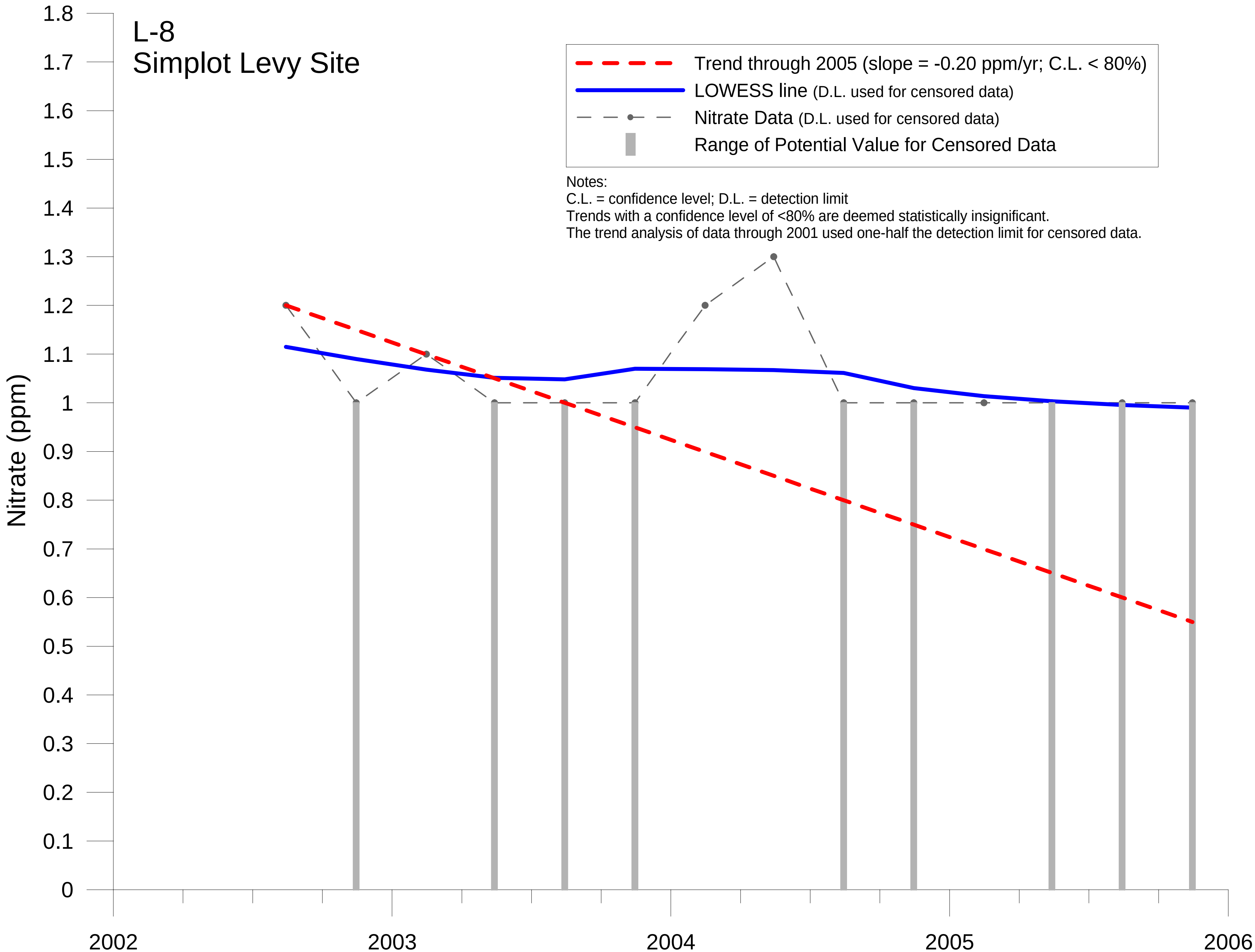

HL-3
Simplot Levy Site
Trend through 2005 (slope = 0.40 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
2002
2003
2004
2005
2006



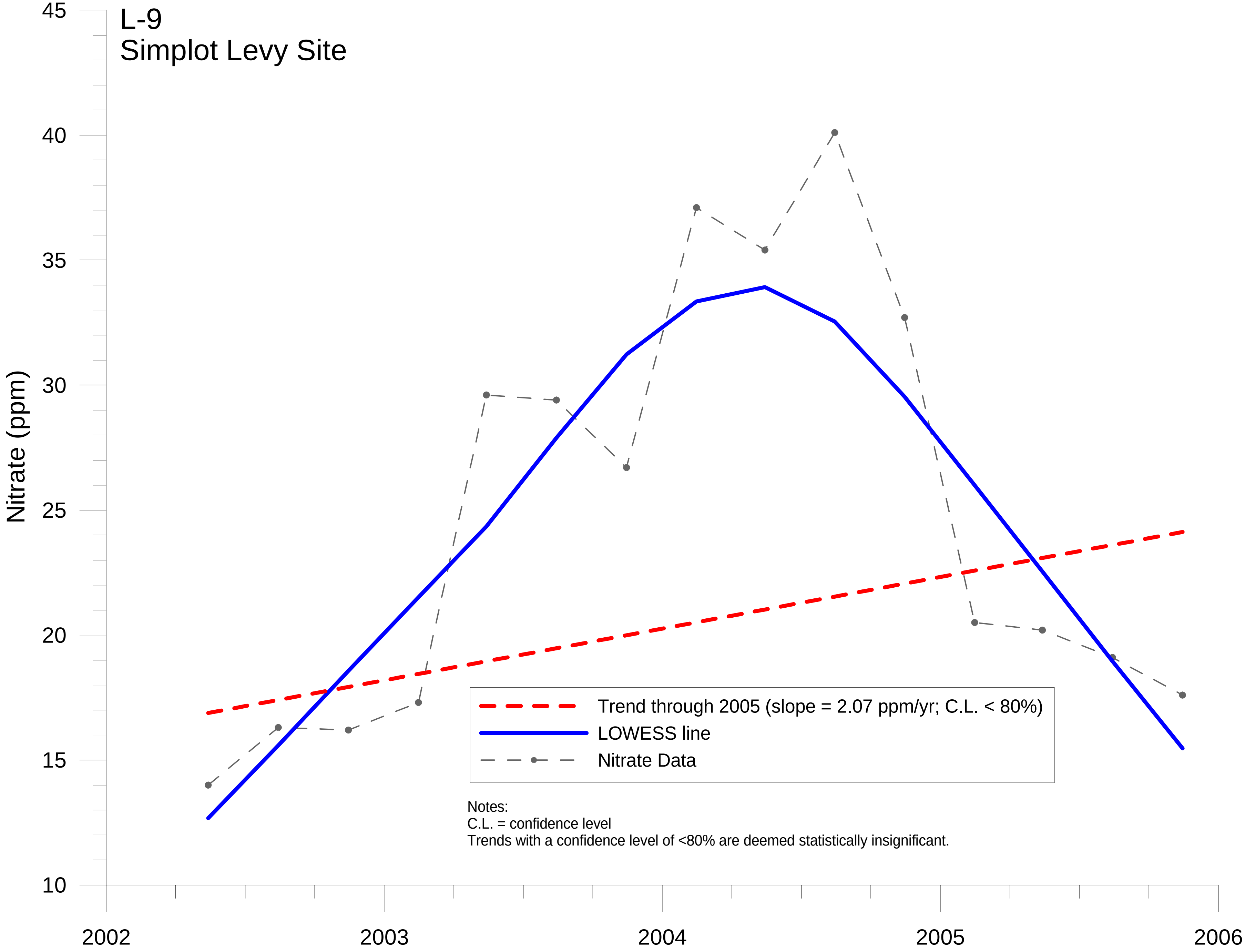
HL-4
Simplot Levy Site
Nitrate (ppm)
12
11
10
9
8
7
6
5
4
3
2002
2003
2004
2005
2006
Trend through 2005 (slope = 1.13 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.


HL-5
Simplot Levy Site
Nitrate (ppm)
48
46
44
42
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
2002
2003
2004
2005
2006
Trend through 2005 (slope = 4.90 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

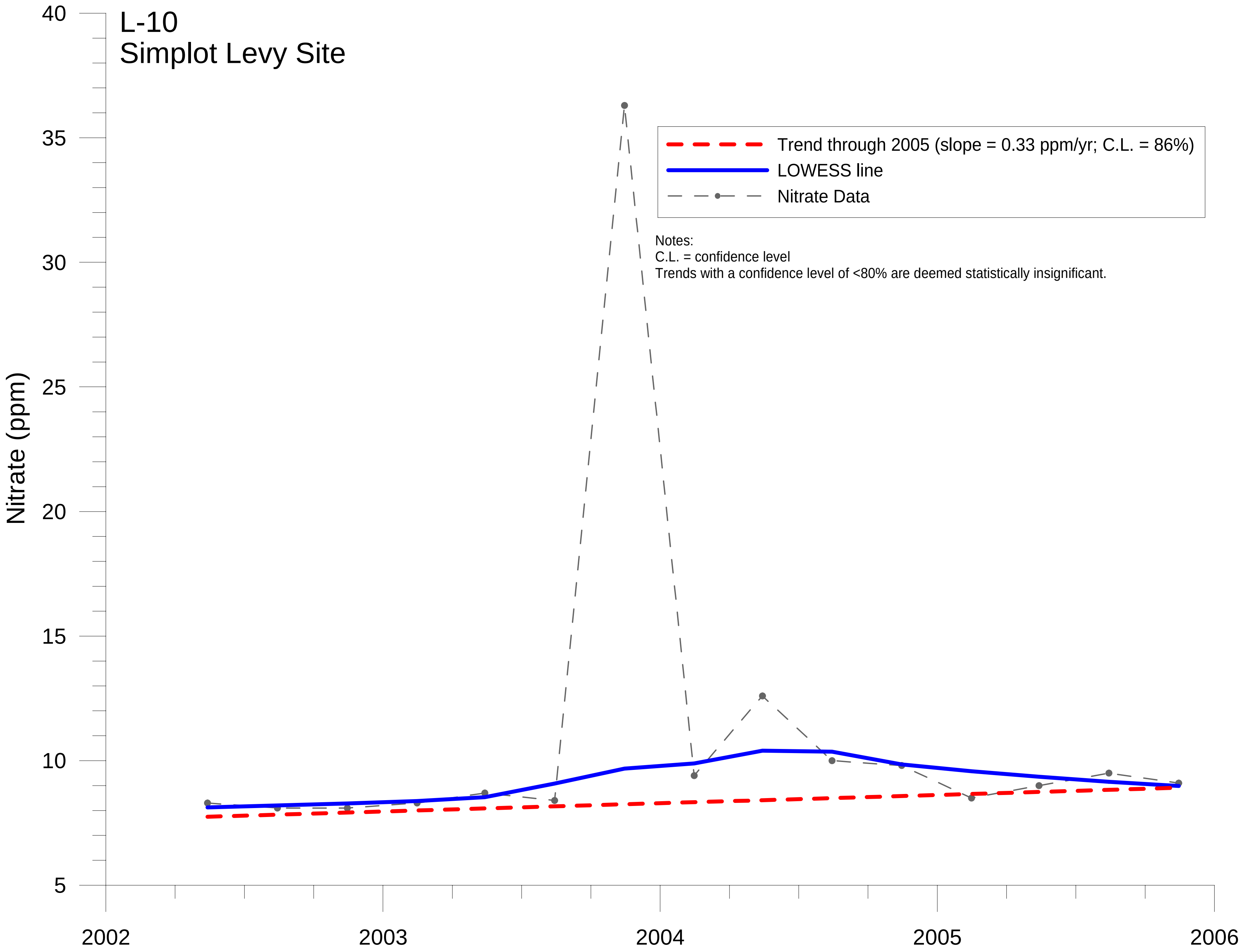

L-6
Simplot Levy Site
Nitrate (ppm)
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
2002
2003
2004
2005
2006
Trend through 2005 (slope = -0.35 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.



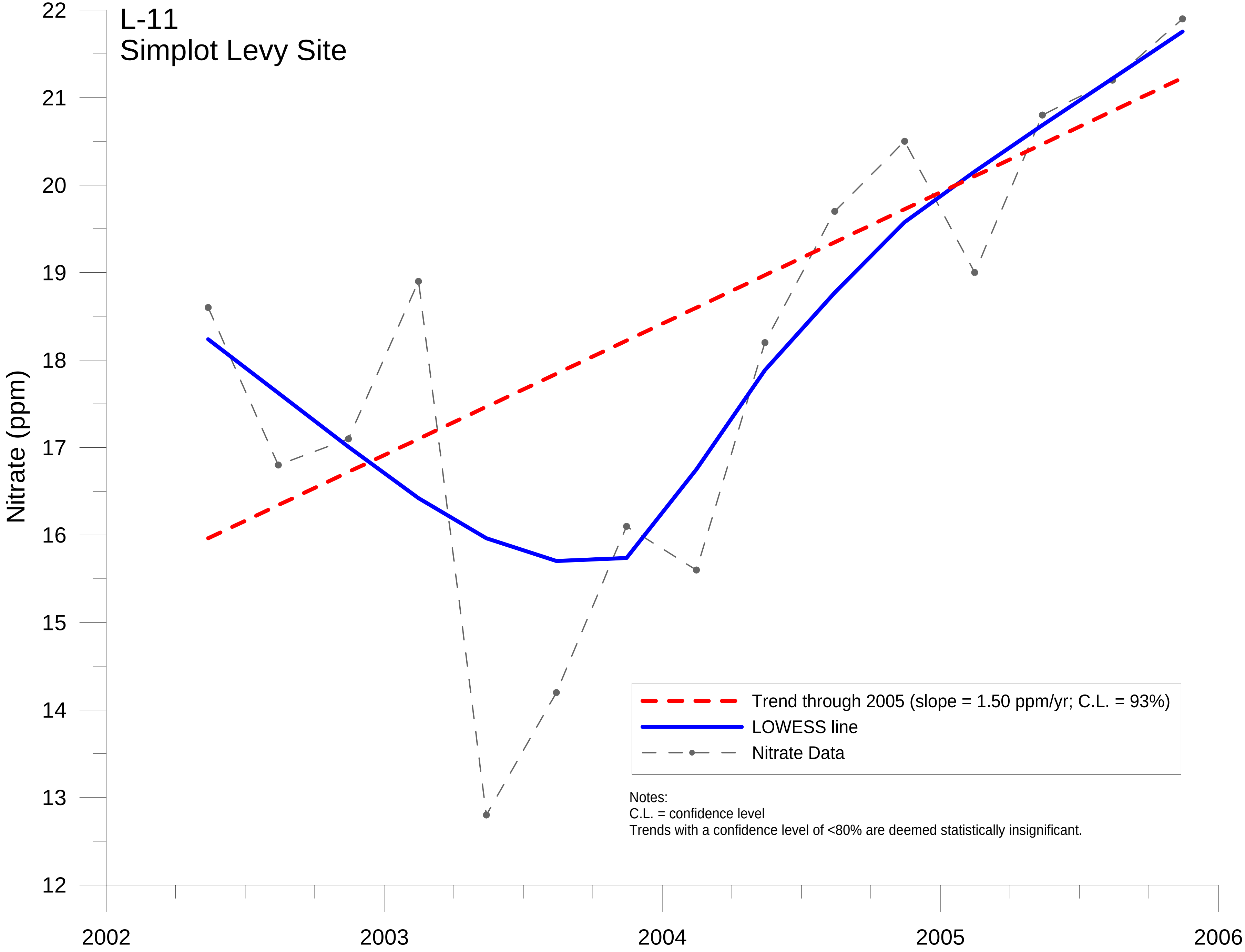
L-8
Simplot Levy Site
Trend through 2005 (slope = -0.20 ppm/yr; C.L. < 80%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level; D.L. = detection limit
Trends with a confidence level of <80% are deemed statistically insignificant.
The trend analysis of data through 2001 used one-half the detection limit for censored data.
Nitrate (ppm)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
2002
2003
2004
2005
2006

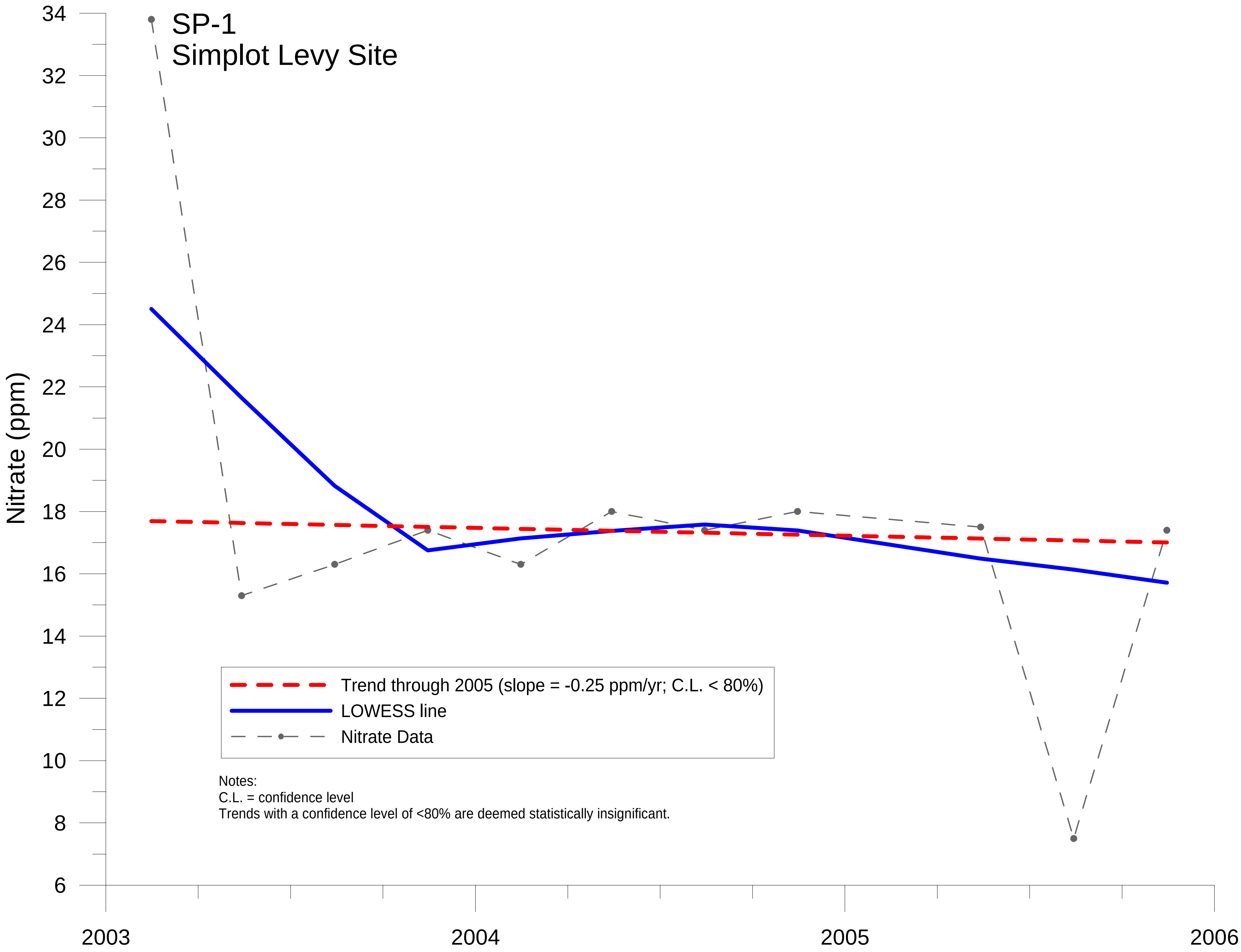


L-9
Simplot Levy Site
Nitrate (ppm)
45
40
35
30
25
20
15
10
2002
2003
2004
2005
2006
Trend through 2005 (slope = 2.07 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

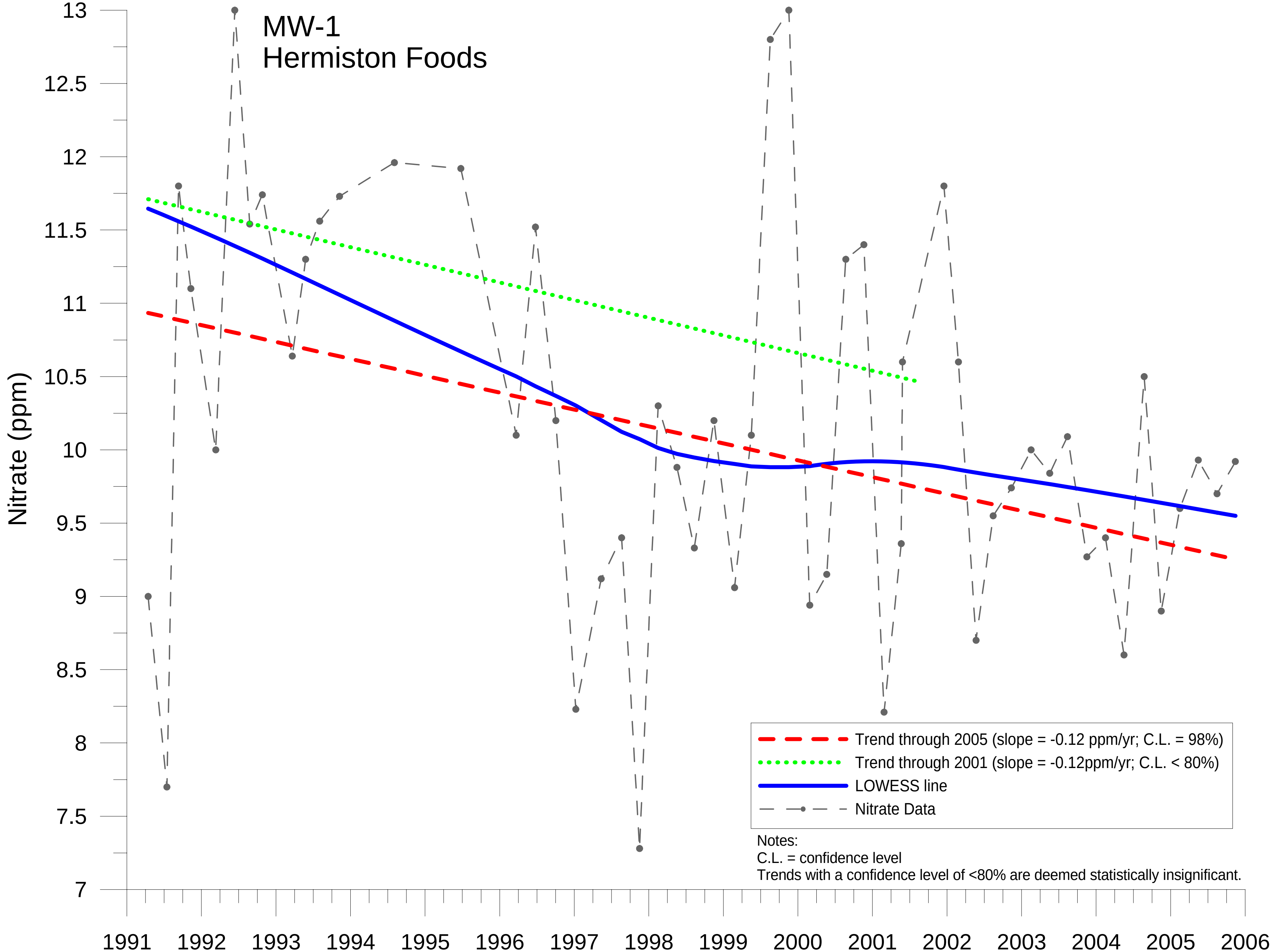


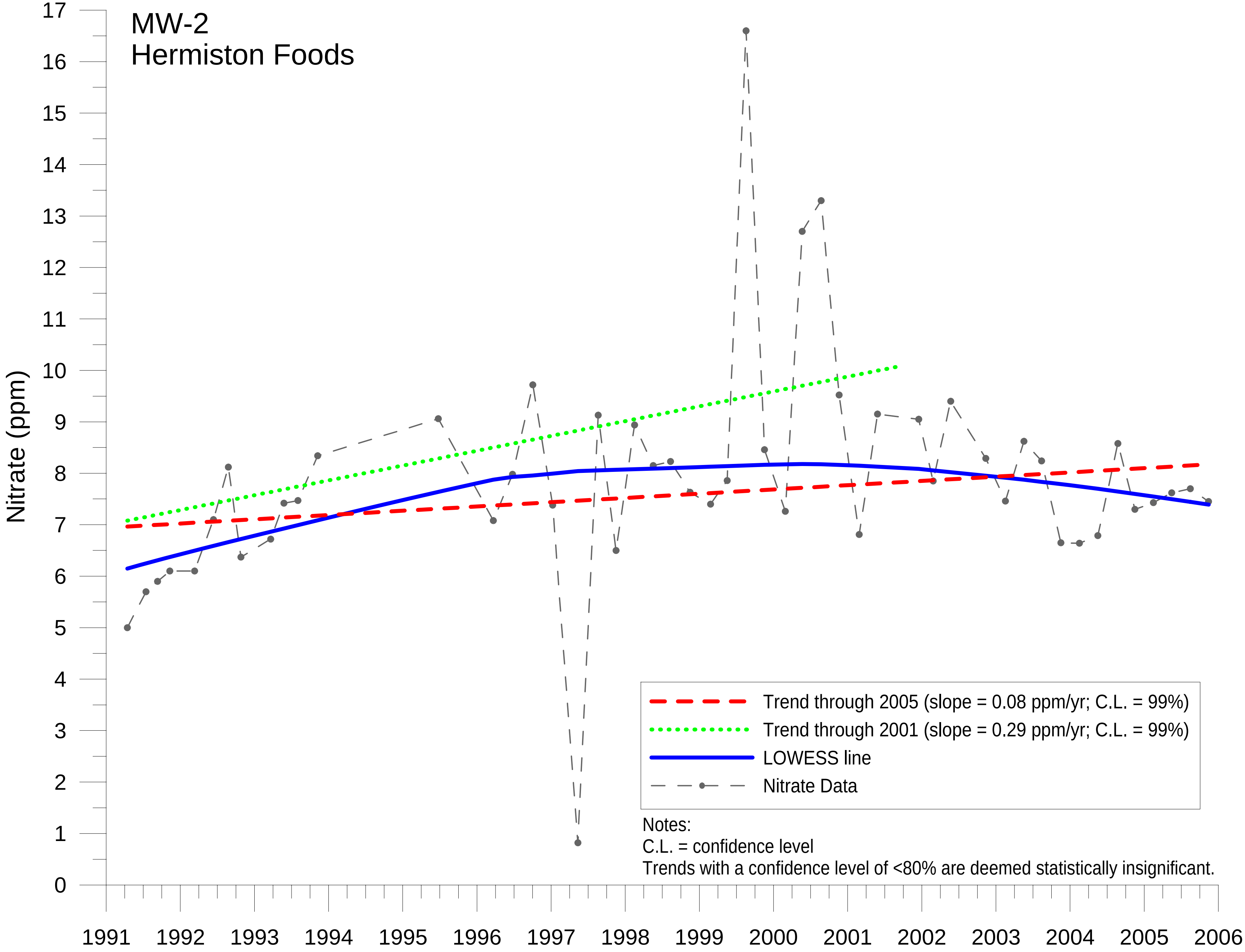
L-10
Simplot Levy Site
Trend through 2005 (slope = 0.33 ppm/yr; C.L. = 86%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
40
35
30
25
20
15
10
5
2002
2003
2004
2005
2006


L-11
Simplot Levy Site
Nitrate (ppm)
22
21
20
19
18
17
16
15
14
13
12
2002
2003
2004
2005
2006
Trend through 2005 (slope = 1.50 ppm/yr; C.L. = 93%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

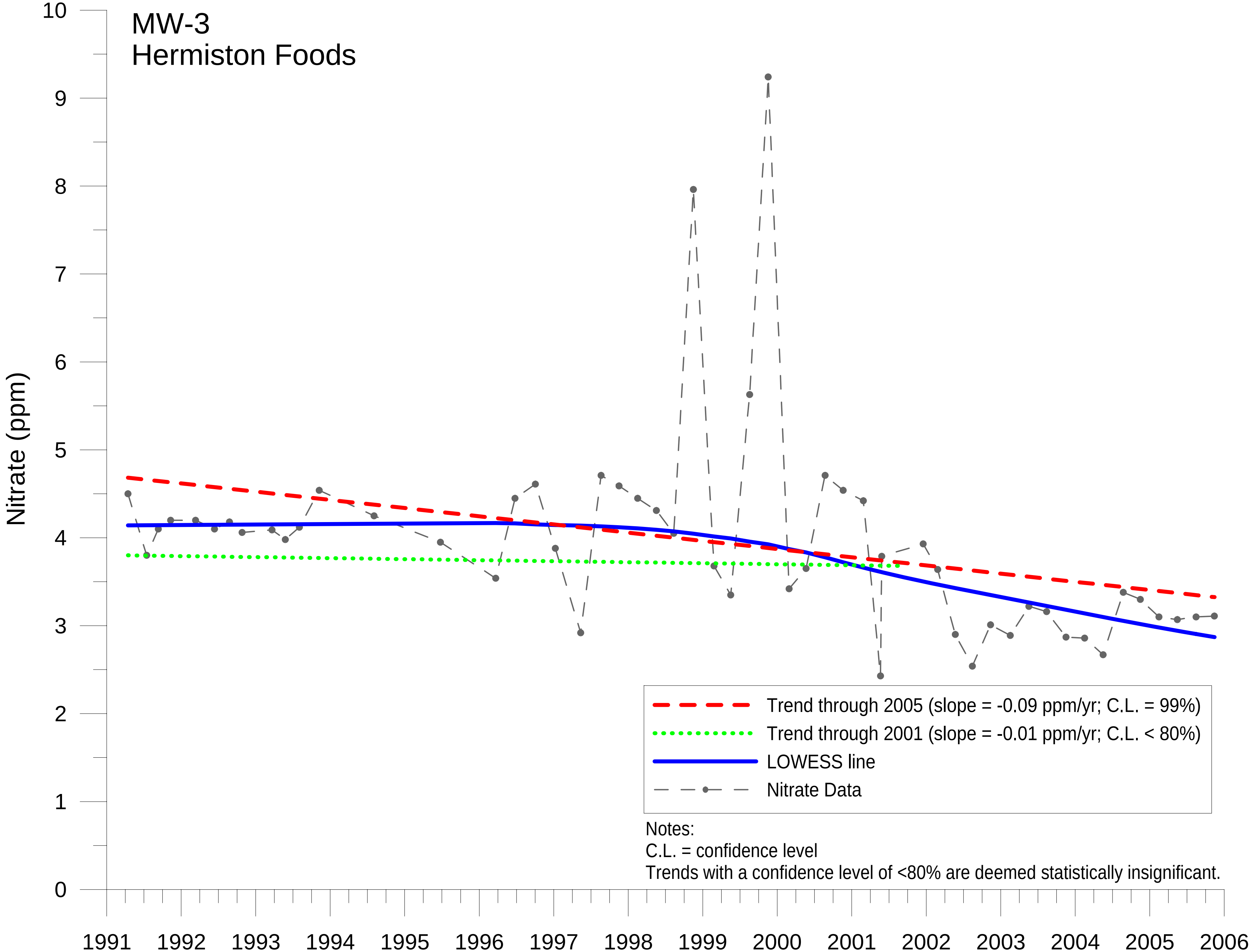


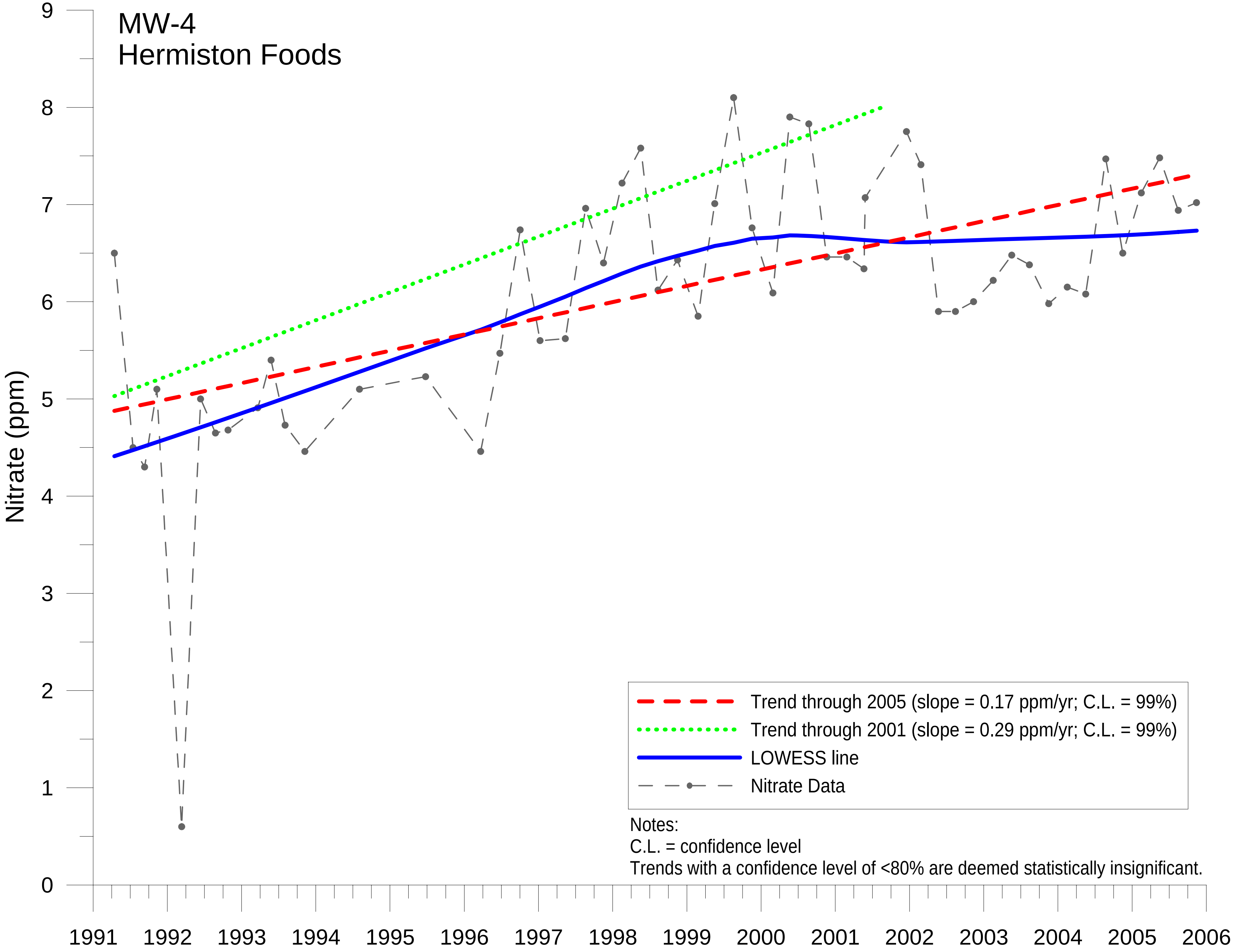
SP-1
Simplot Levy Site
Nitrate (ppm)
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
2003
2004
2005
2006
Trend through 2005 (slope = -0.25 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.


MW-1
Hermiston Foods
Nitrate (ppm)
13
12.5
12
11.5
11
10.5
10
9.5
9
8.5
8
7.5
7
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = -0.12 ppm/yr; C.L. = 98%)
Trend through 2001 (slope = -0.12ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

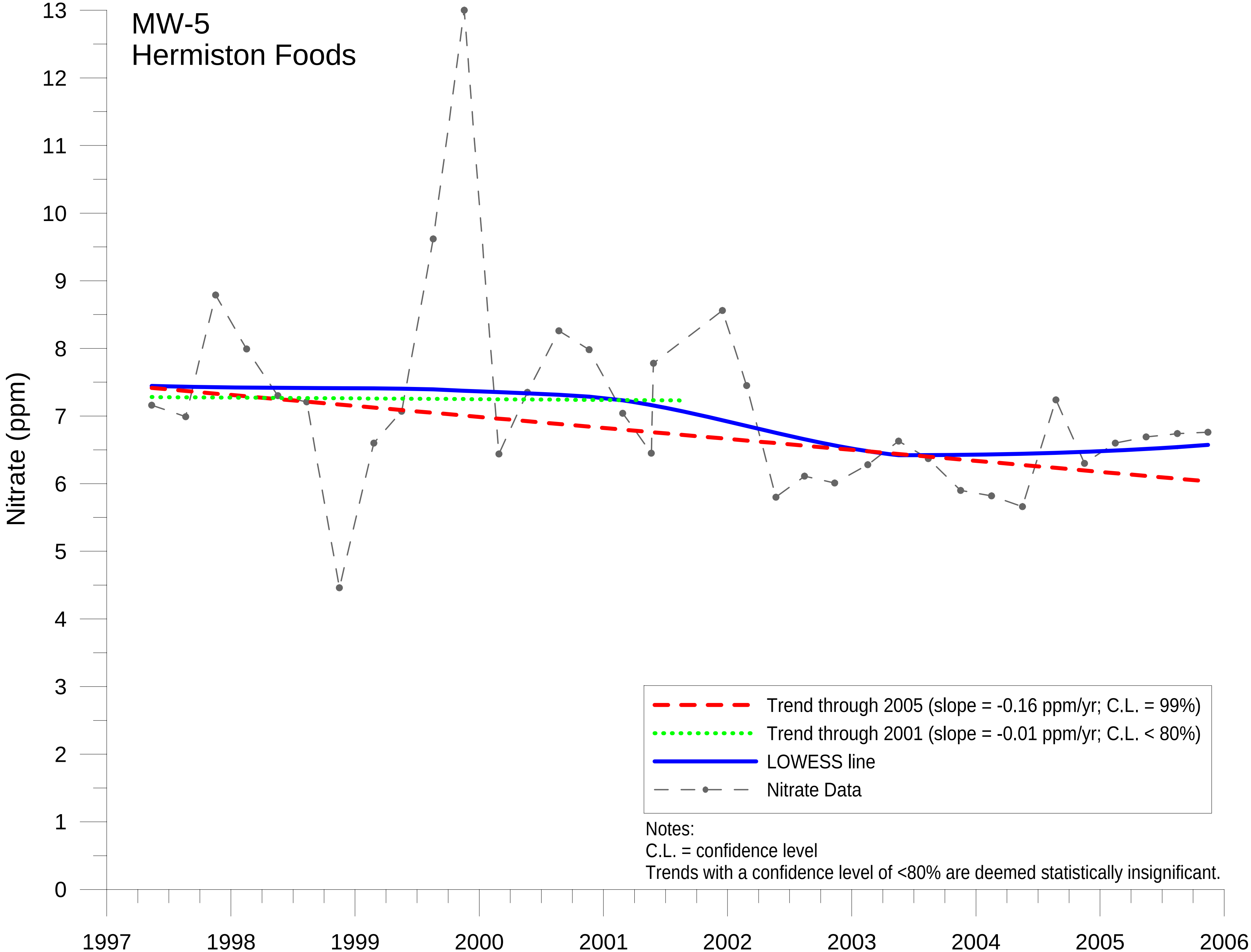


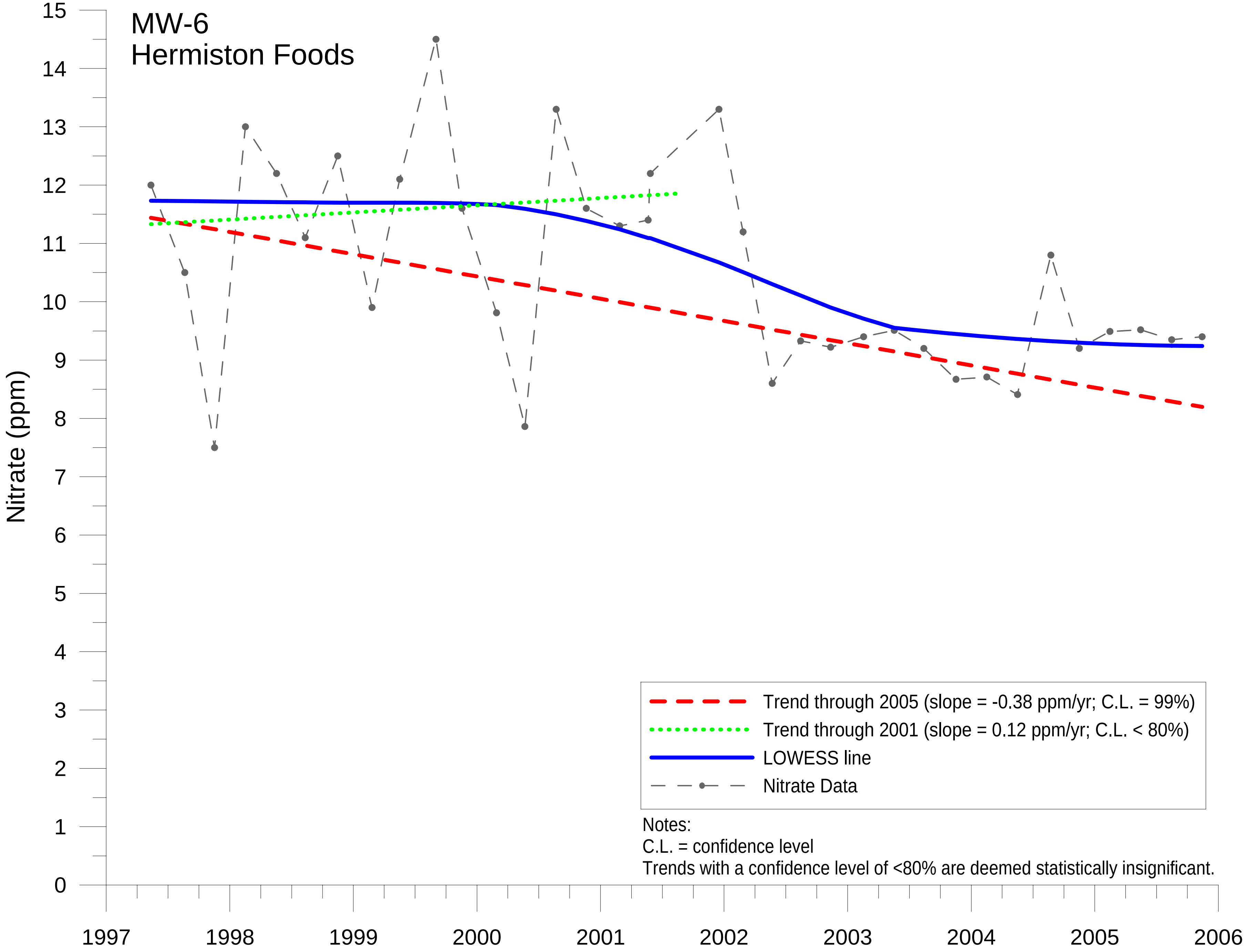
MW-2
Hermiston Foods
Nitrate (ppm)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 0.08 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.29 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

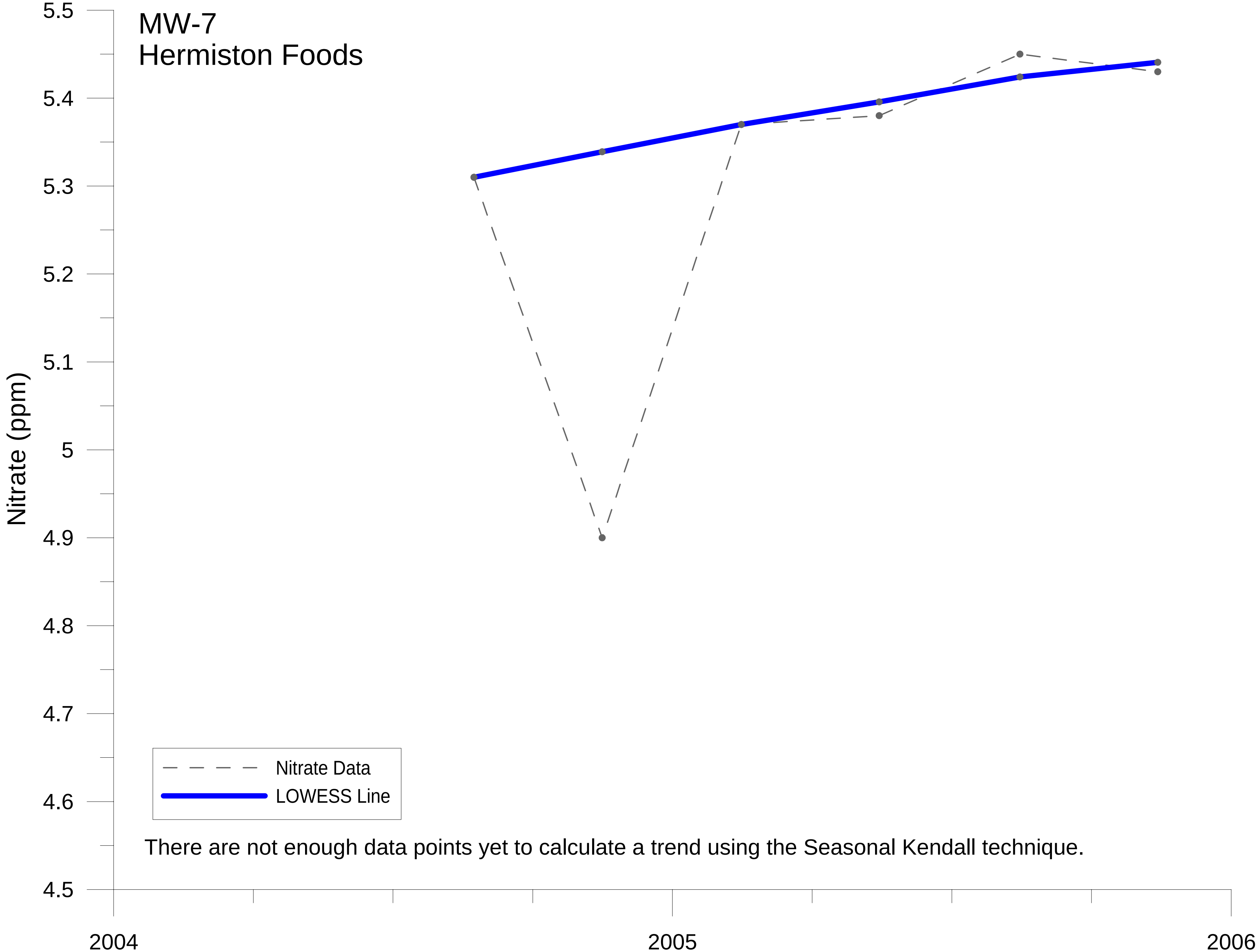

MW-3
Hermiston Foods
Nitrate (ppm)
10
9
8
7
6
5
4
3
2
1
0
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = -0.09 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = -0.01 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.



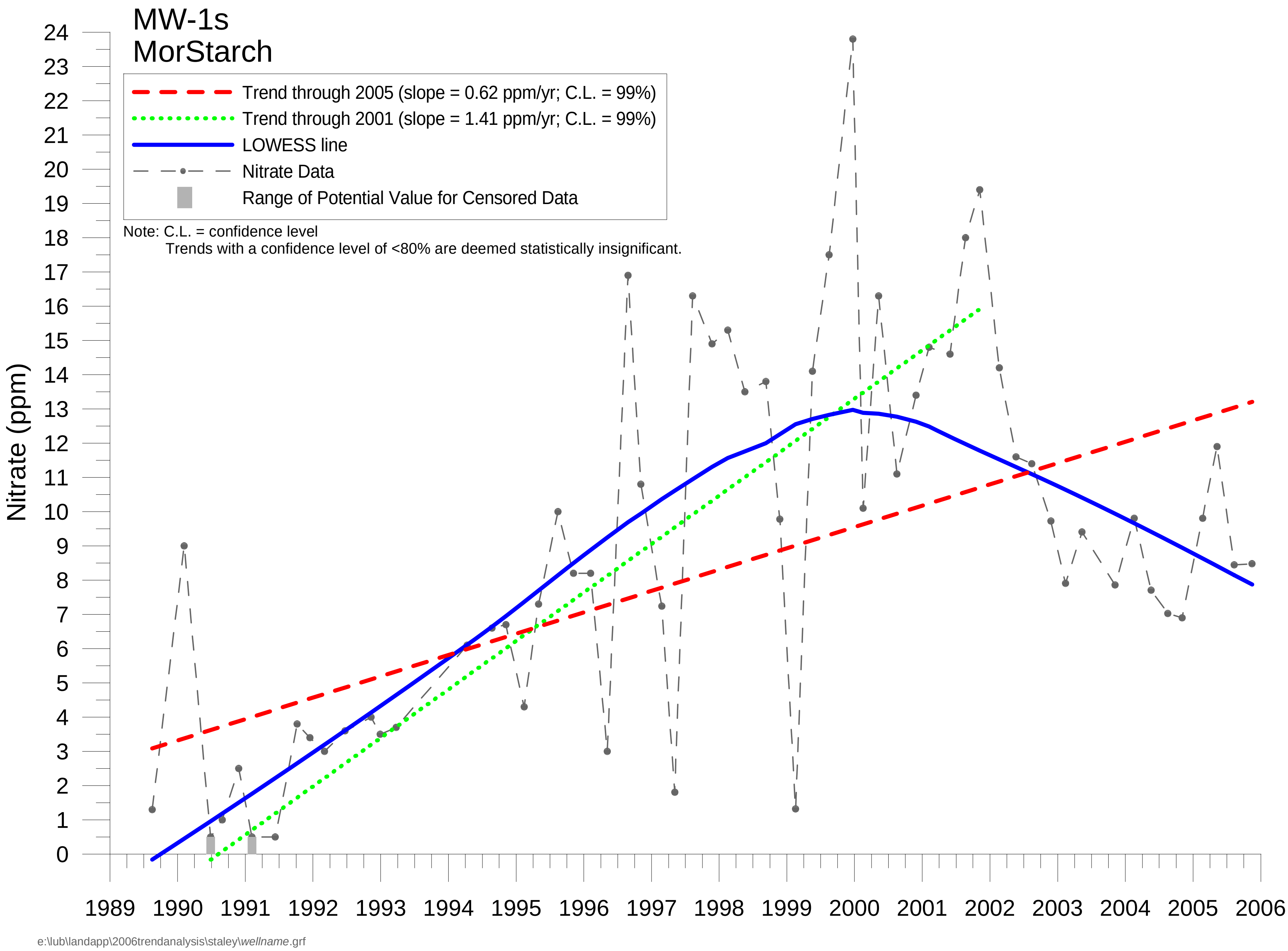
MW-4
Hermiston Foods
Nitrate (ppm)
0
1
2
3
4
5
6
7
8
9
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 0.17 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.29 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.


MW-5
Hermiston Foods
Nitrate (ppm)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = -0.16 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = -0.01 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

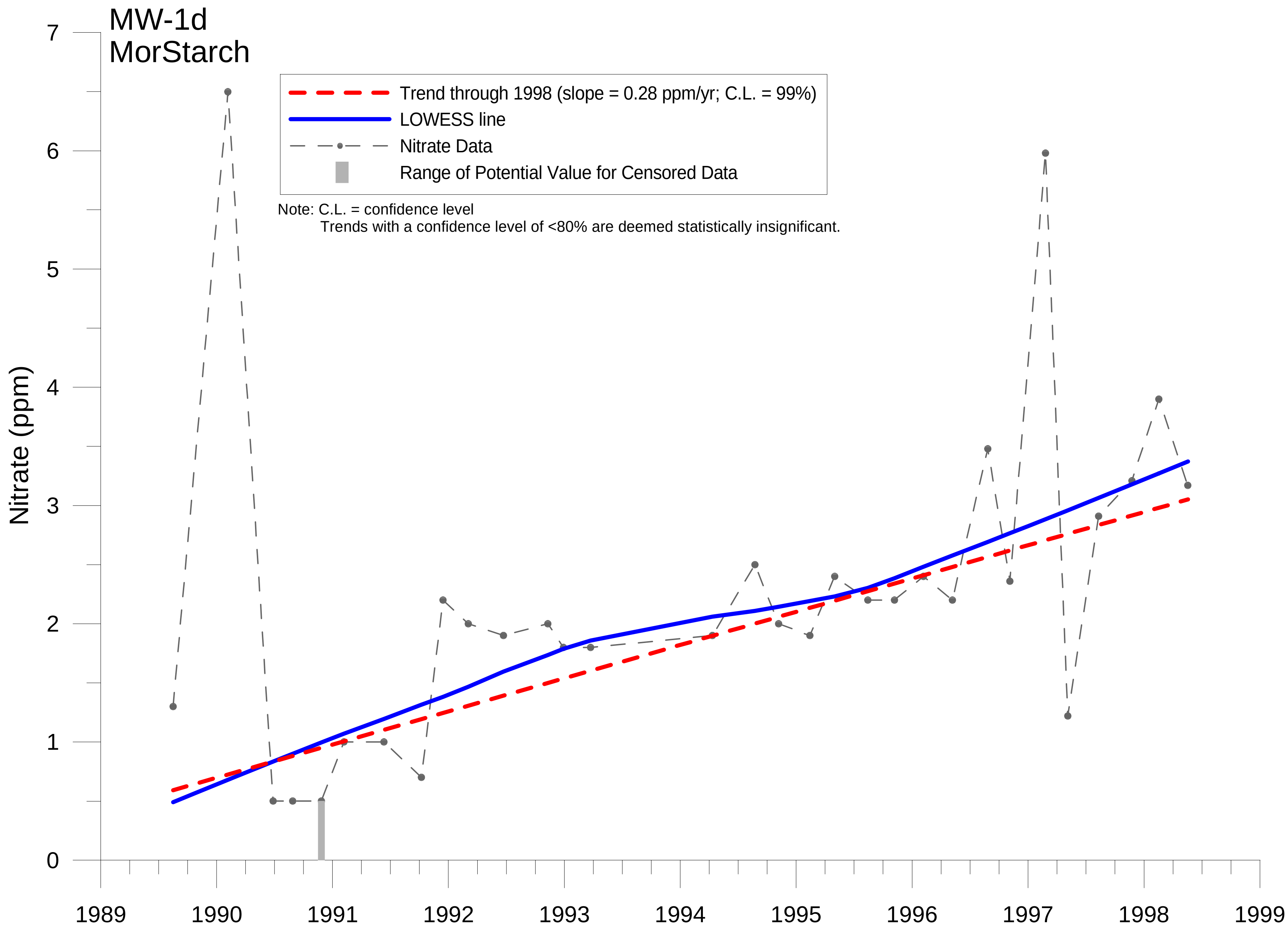

MW-6
Hermiston Foods
Nitrate (ppm)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = -0.38 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.12 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.



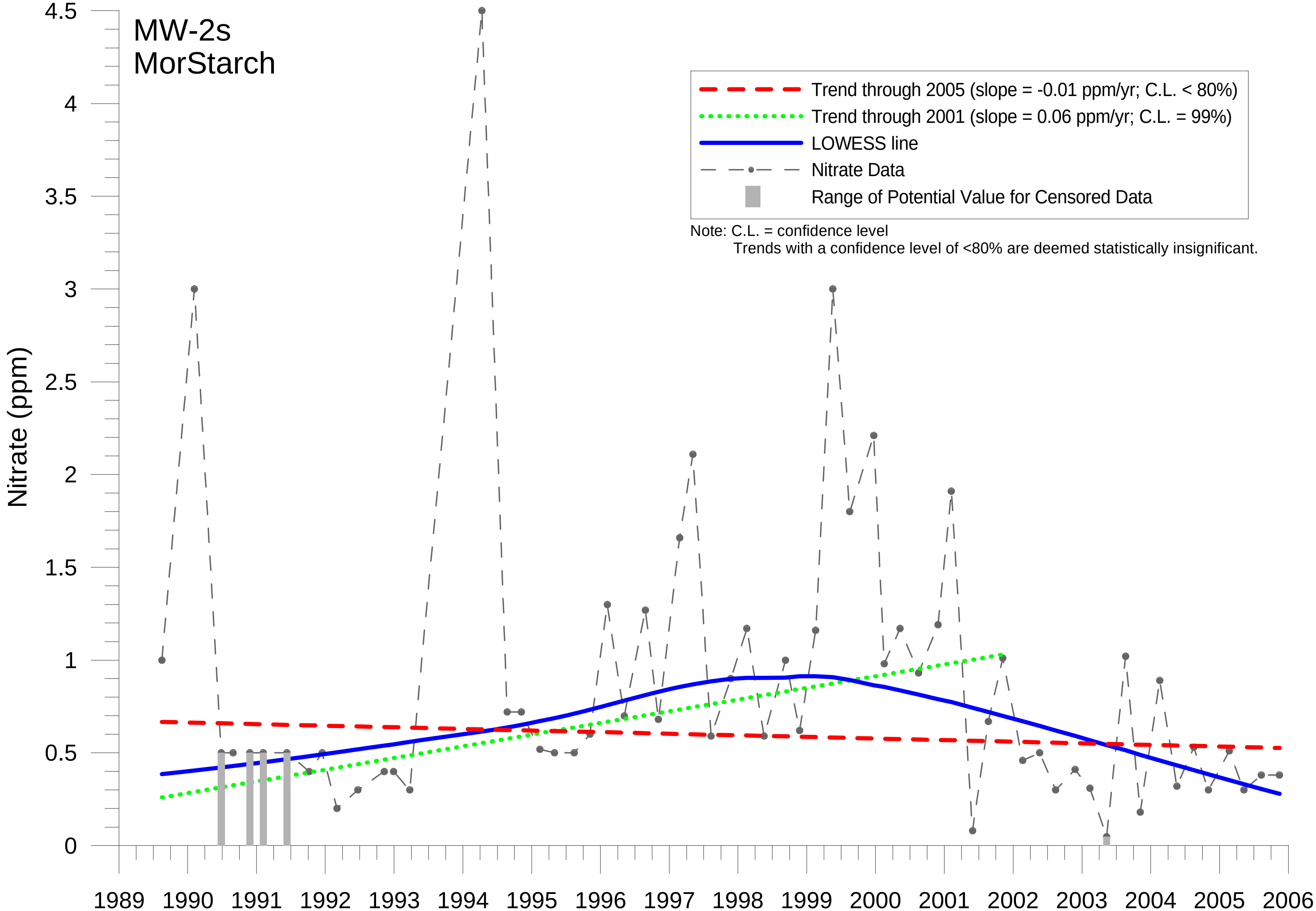
MW-7
Hermiston Foods
Nitrate (ppm)
5.5
5.4
5.3
5.2
5.1
5
4.9
4.8
4.7
4.6
4.5
2004
2005
2006
Nitrate Data
LOWESS Line
There are not enough data points yet to calculate a trend using the Seasonal Kendall technique.



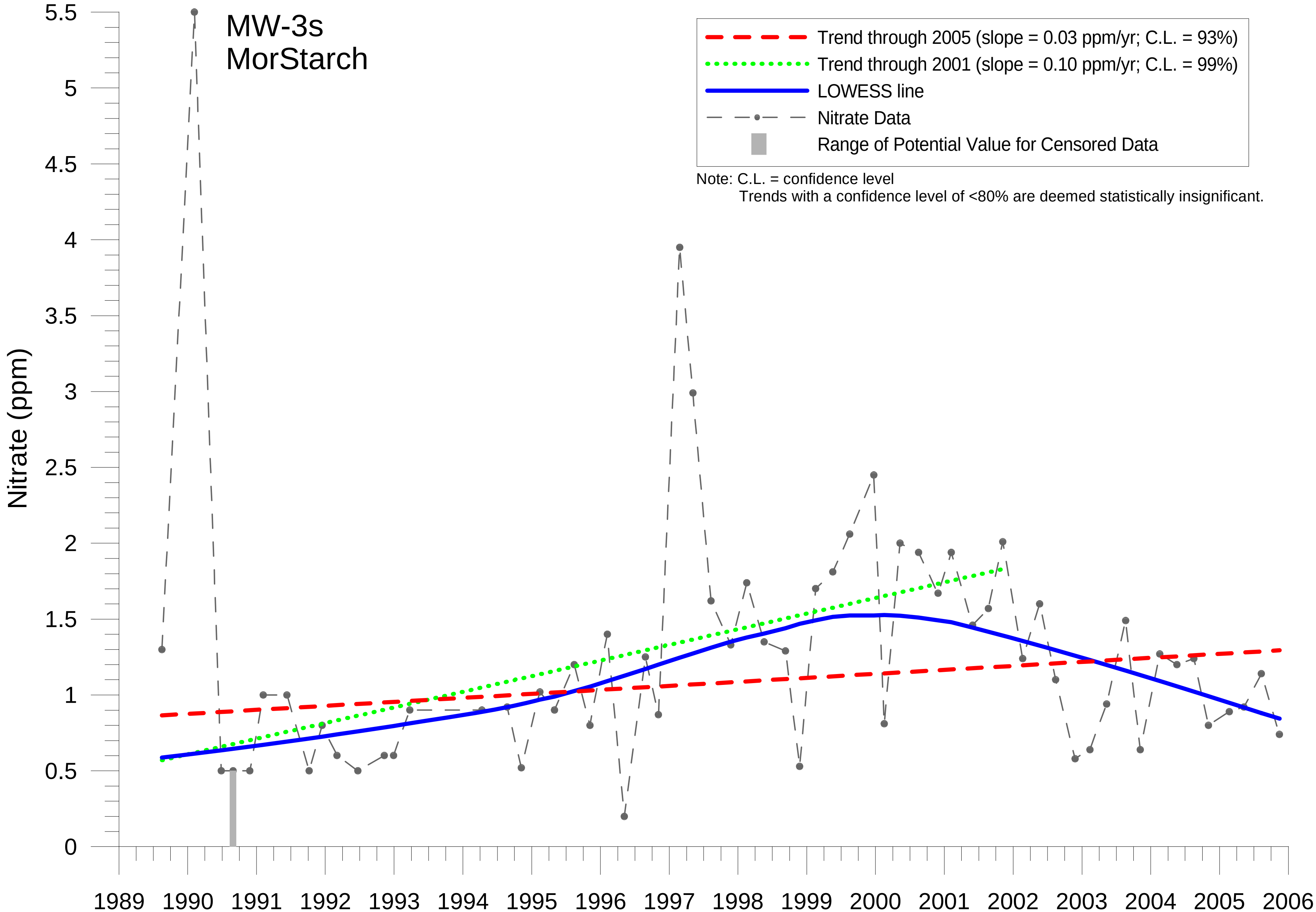
MW-1s
MorStarch
Trend through 2005 (slope = 0.62 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 1.41 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Range of Potential Value for Censored Data
Note: C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006
e:\lub\landapp\2006trendanalysis\staley\wellname.grf



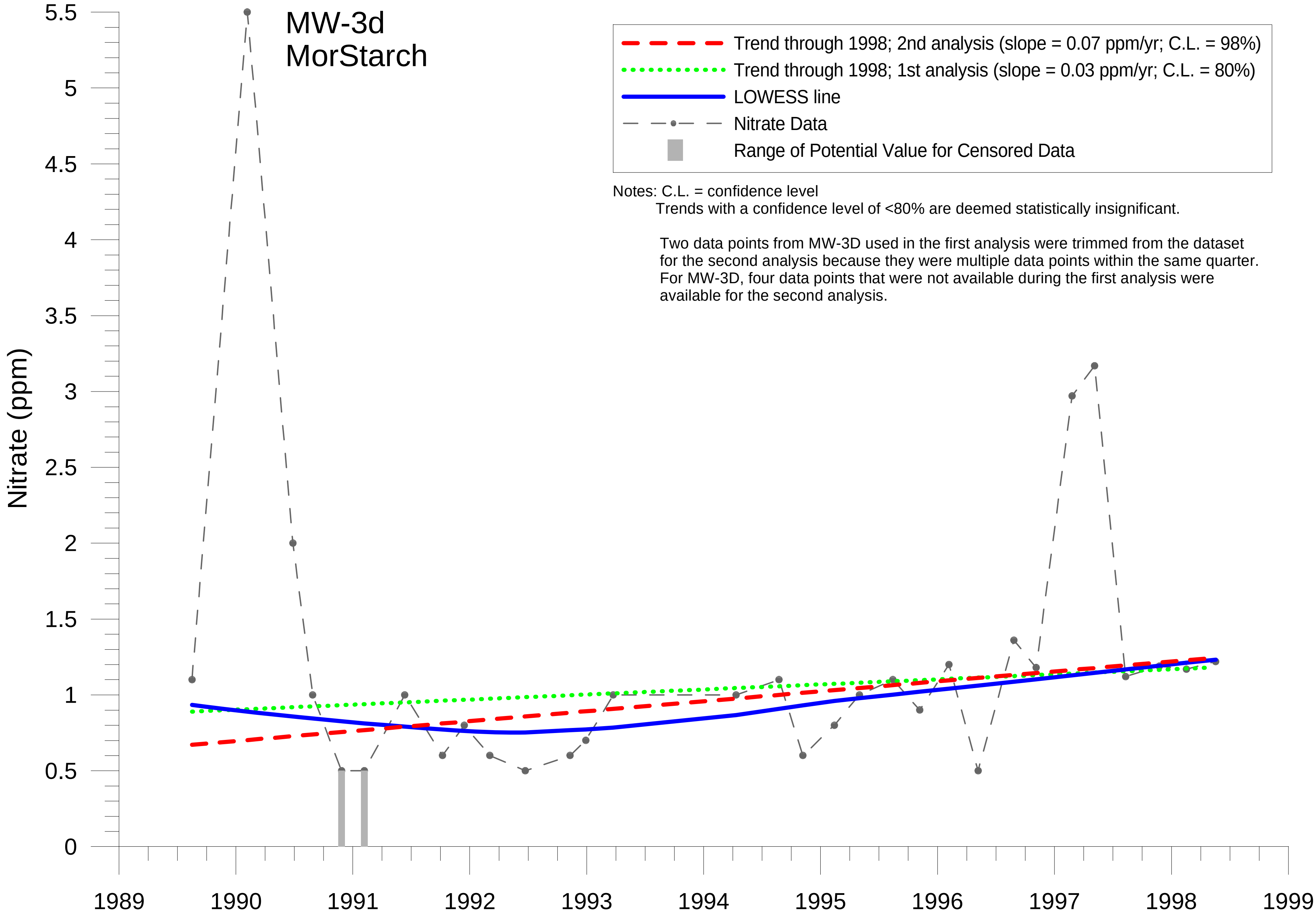
e:\lub\landapp\2006trendanalysis\staley*wellname*.grf



e:\lub\landapp\2006trendanalysis\staley*wellname*.grf



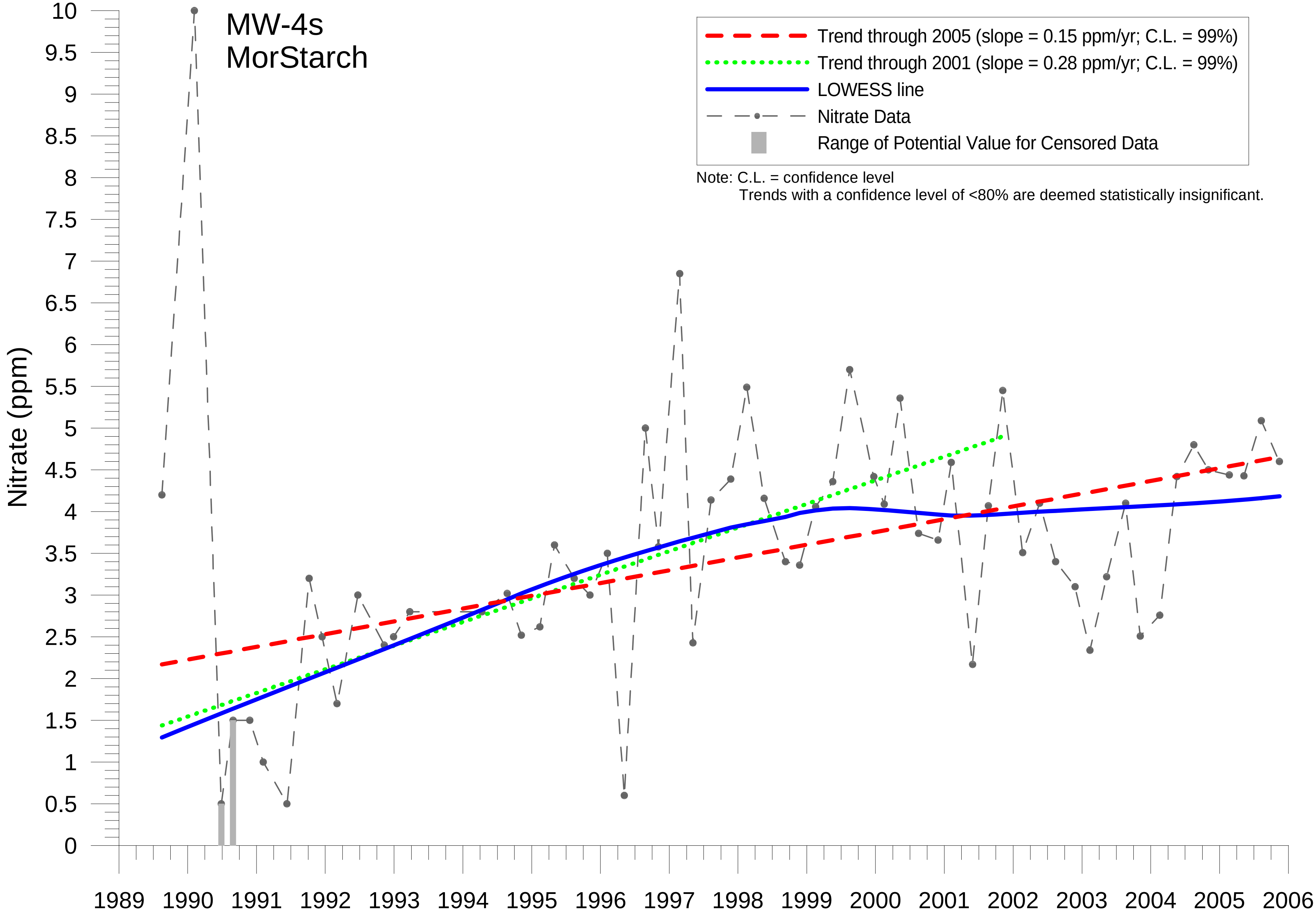
e:\lub\landapp\2006trendanalysis\staley*wellname*.grf



Notes: C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

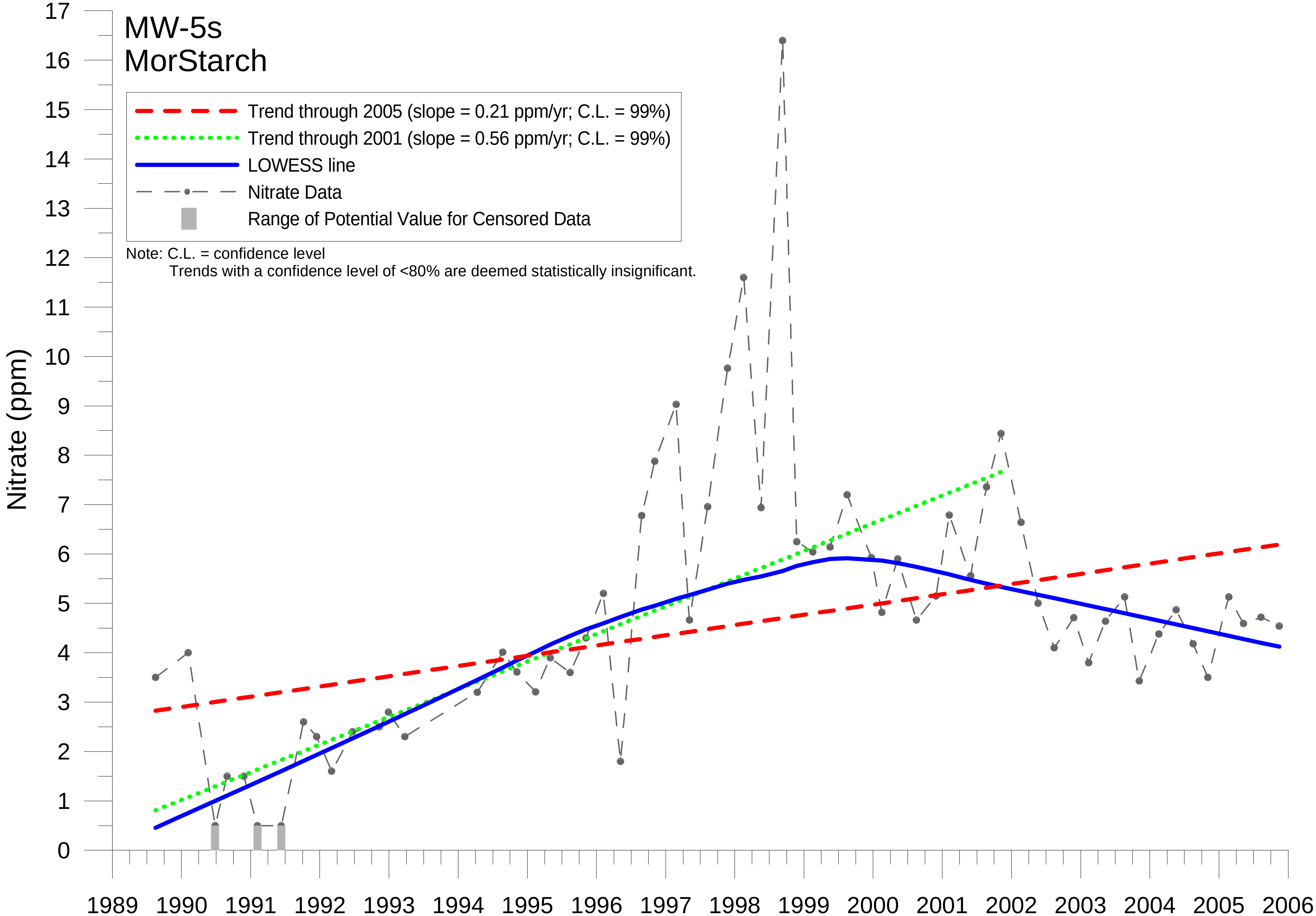
Two data points from MW-3D used in the first analysis were trimmed from the dataset for the second analysis because they were multiple data points within the same quarter. For MW-3D, four data points that were not available during the first analysis were available for the second analysis.

e:\lub\landapp\2006trendanalysis\staley*wellname*.grf

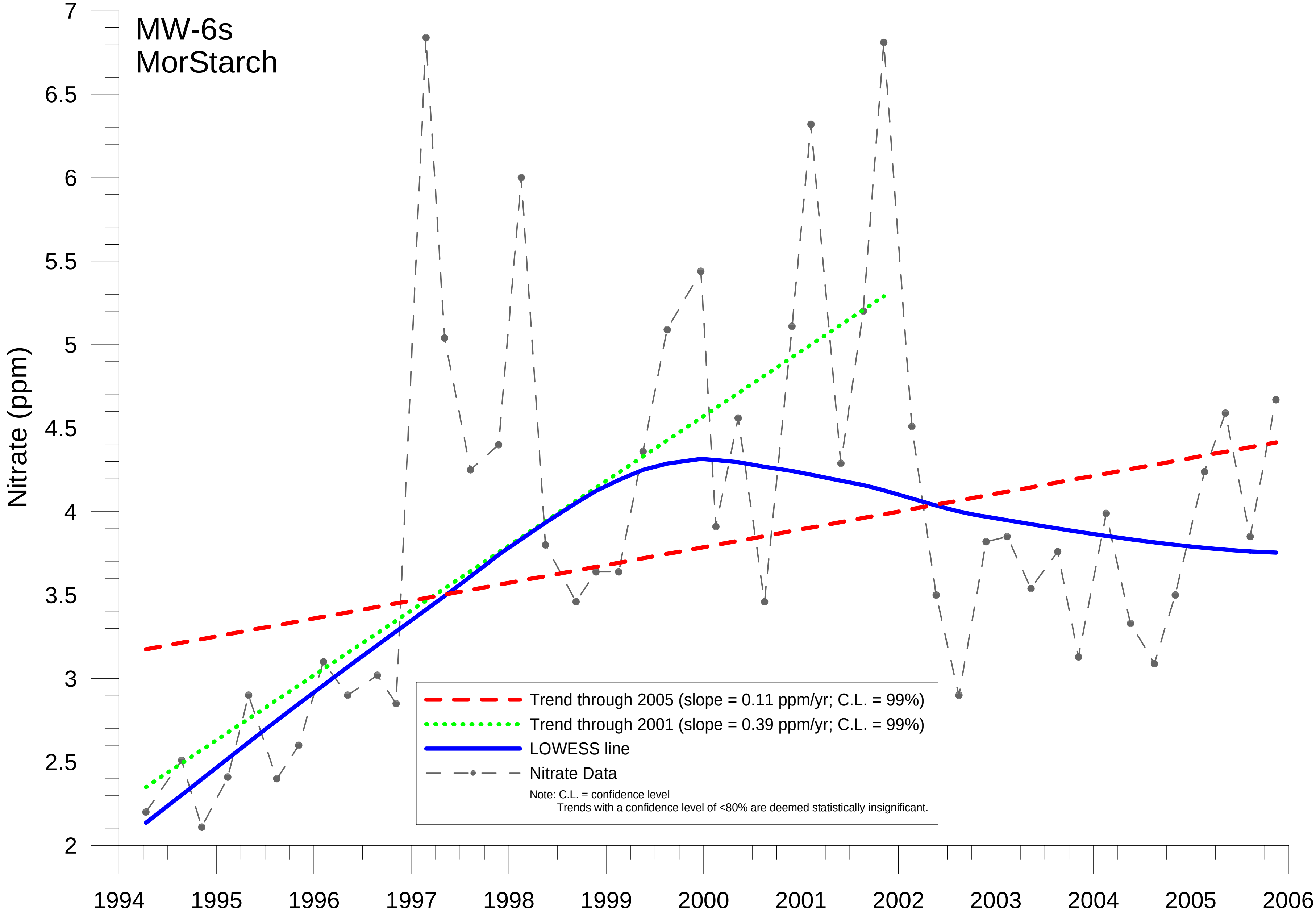


Note: C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

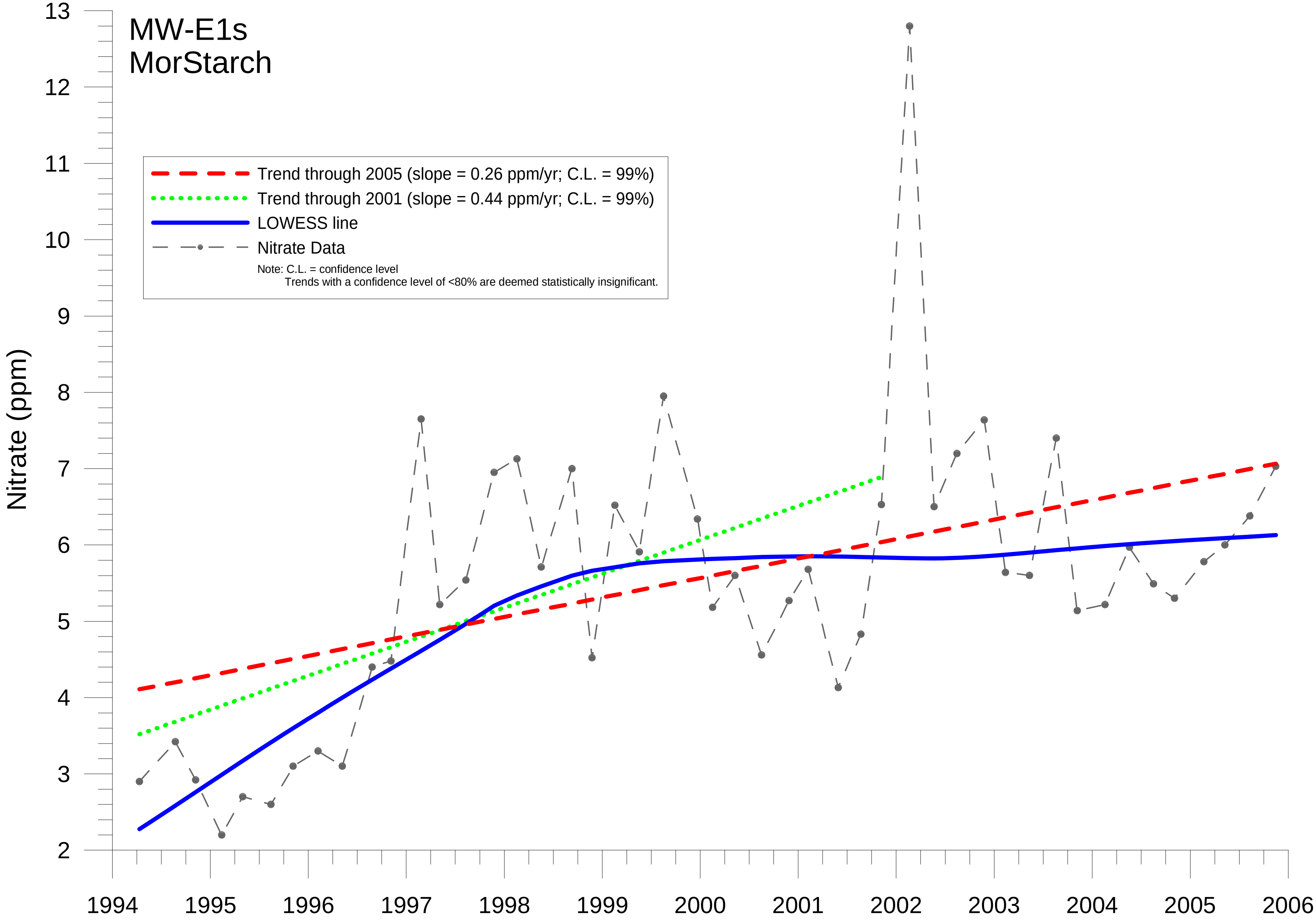
e:\lub\landapp\2006trendanalysis\staley*wellname*.grf

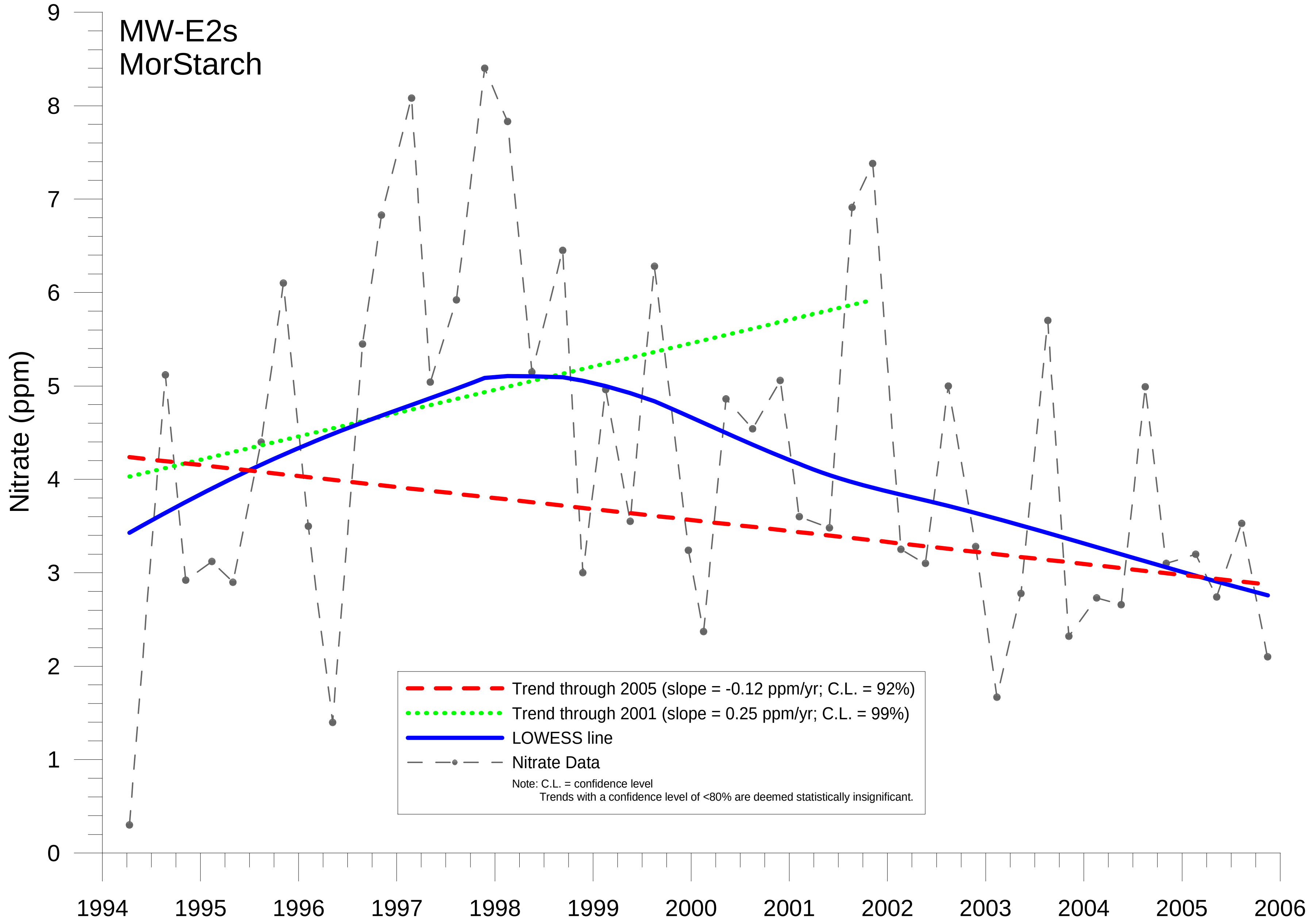


e:\lub\landapp\2006trendanalysis\staley*wellname*.grf

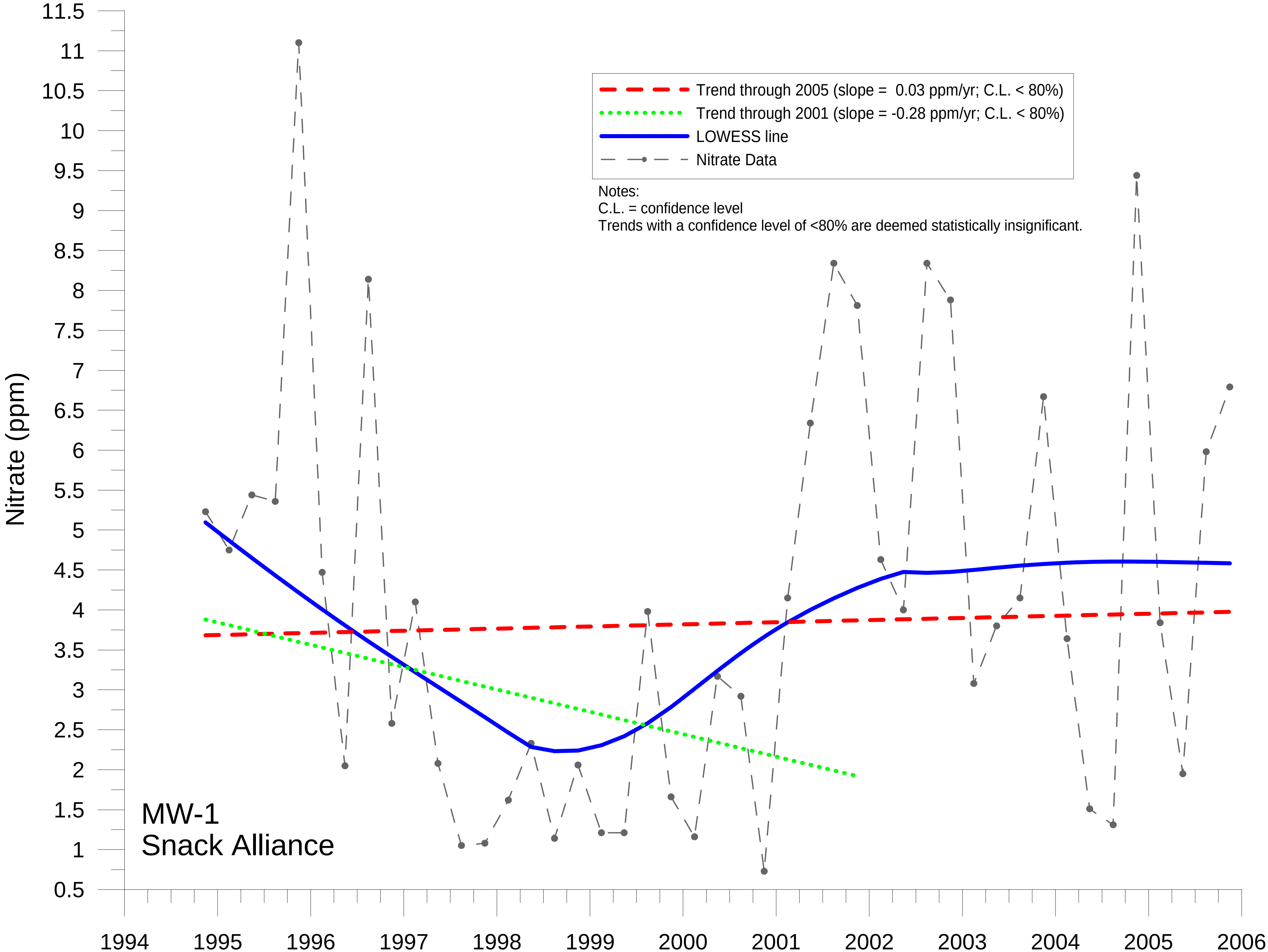


MW-6s
MorStarch
Nitrate (ppm)
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = 0.11 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.39 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Note: C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

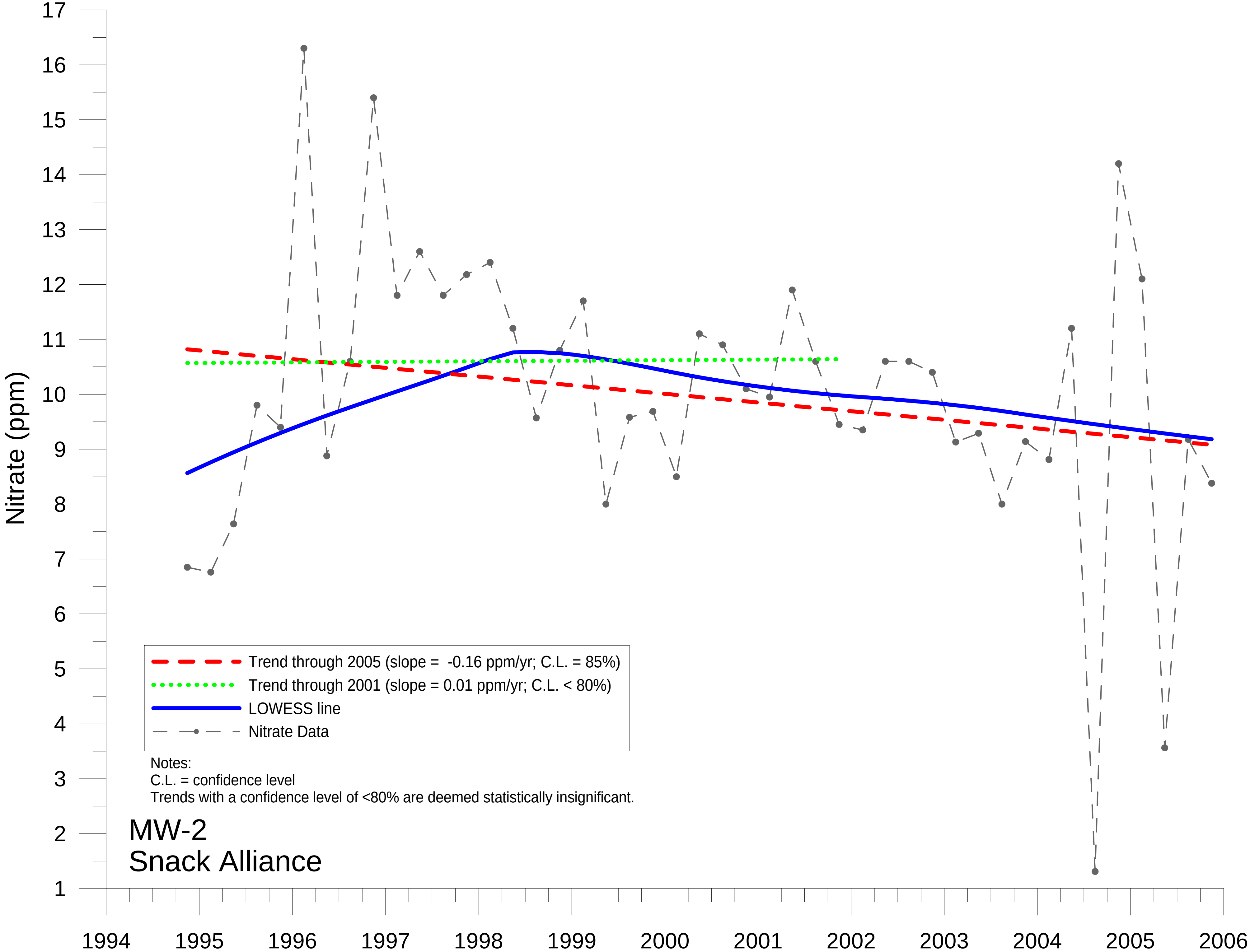

MW-E1s
MorStarch
Trend through 2005 (slope = 0.26 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.44 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Note: C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
13
12
11
10
9
8
7
6
5
4
3
2
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006

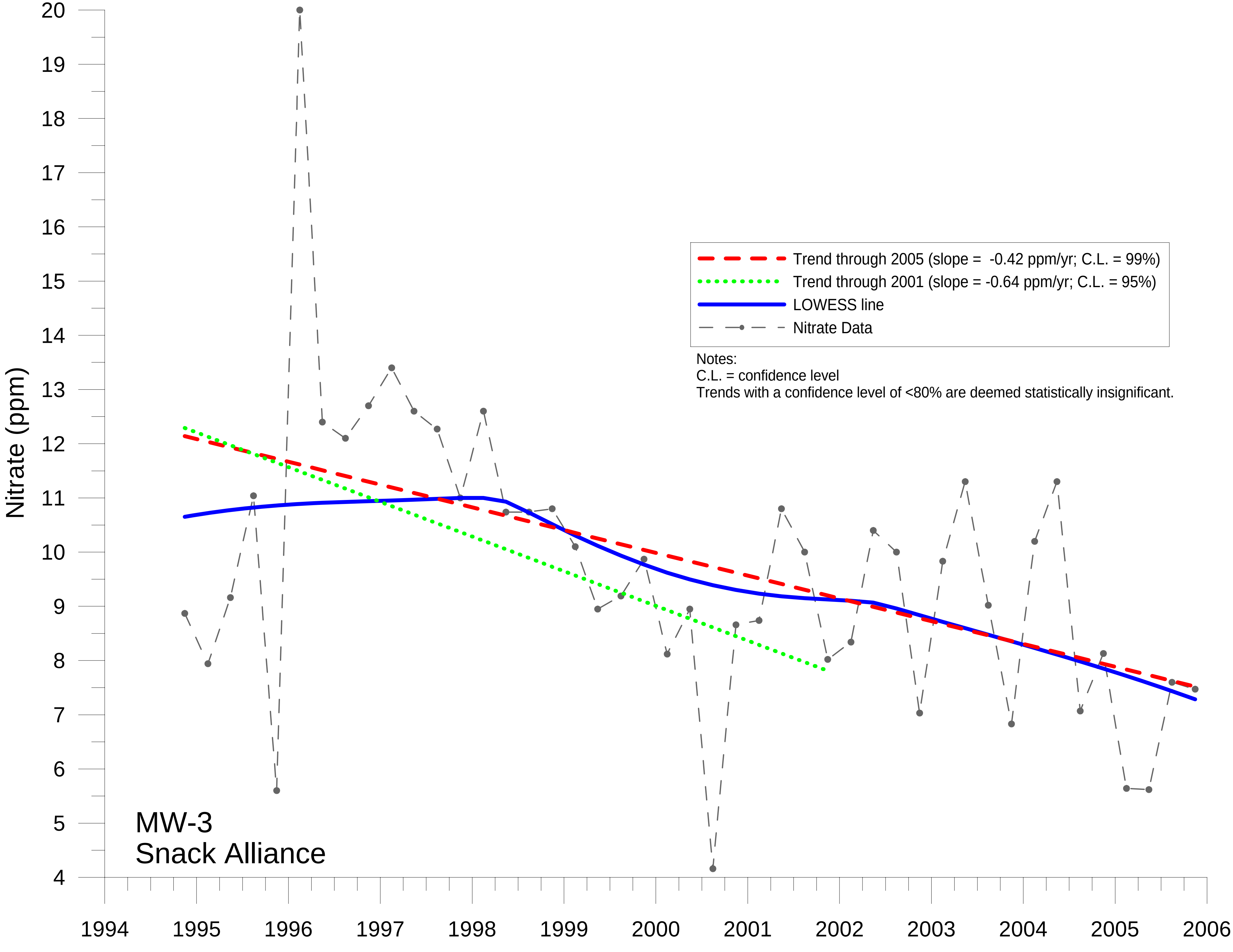


MW-E2s
MorStarch
Nitrate (ppm)
0
1
2
3
4
5
6
7
8
9
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = -0.12 ppm/yr; C.L. = 92%)
Trend through 2001 (slope = 0.25 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Note: C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

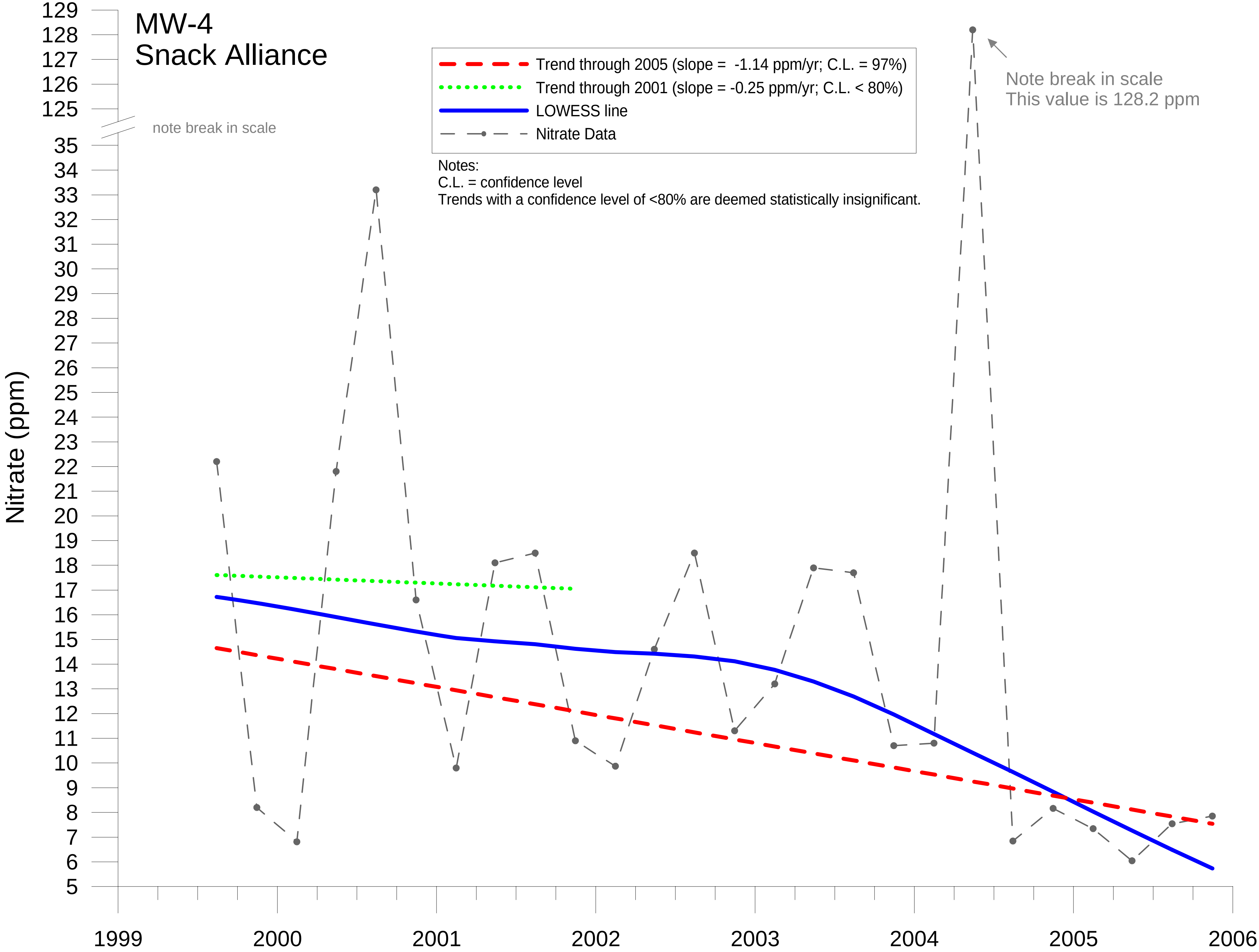


Trend through 2005 (slope = 0.03 ppm/yr; C.L. < 80%)
Trend through 2001 (slope = -0.28 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
11.5
11
10.5
10
9.5
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
MW-1
Snack Alliance


Nitrate (ppm)
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = -0.16 ppm/yr; C.L. = 85%)
Trend through 2001 (slope = 0.01 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
MW-2
Snack Alliance



Nitrate (ppm)
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = -0.42 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = -0.64 ppm/yr; C.L. = 95%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
MW-3
Snack Alliance



MW-4
Snack Alliance
Trend through 2005 (slope = -1.14 ppm/yr; C.L. = 97%)
Trend through 2001 (slope = -0.25 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
note break in scale
Note break in scale
This value is 128.2 ppm
Nitrate (ppm)
129
128
127
126
125
35
34
33
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
1999
2000
2001
2002
2003
2004
2005
2006