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*Lake Goodwin Landfill*  
*2012 3<sup>rd</sup> Quarter Groundwater*  
*Monitoring Report*

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## 1.0 INTRODUCTION

The following report presents the third quarter ground water monitoring results for 2012 at the Lake Goodwin Landfill (*Lake Goodwin Landfill, Site*). The site is located immediately west of Frank Waters Road in northwestern Snohomish County, about one and one half (1.5) miles northwest of Lake Goodwin and about five-(5) miles south of Stanwood (*T31N, R4E, sections 17, 20 Willamette Meridian*). The landfill is located at 18520 Frank Waters Road, Stanwood, Washington, 98292. The location of the site relative to existing municipal improvements is shown on the **Vicinity Map** (*figure 1*).

The Snohomish Health District approved a new Sampling Analysis Plan in June, 2012. The changes include eliminating LG-03 from the analysis, reducing the suite of metals analyzed, and eliminating volatile organic compounds. This report reflects those changes.

### 1.1 BACKGROUND

The Lake Goodwin Landfill is sited within a former County gravel pit. Waste disposed at the landfill reportedly consisted of municipal waste, including garbage and demolition debris, and some industrial waste. Waste was placed in the landfill starting in the early 1960's under the direction of **Snohomish County's Road Maintenance Division**. The landfill was closed in September 1982. Upon closure a cover system was installed. The landfill is not lined nor does it have leachate or gas collection systems. The Lake Goodwin Landfill is currently permitted for post-closure monitoring by the **Snohomish Health District (SHD)** with a Solid Waste Facility Permit (SW-085, 2012). Monitoring results are reviewed by both the **SHD** and the **Department of Ecology**.

### 1.2 PERMIT INFORMATION

Monitoring activities at the landfill are governed by the Solid Waste Facility Permit SW-085 (*landfill permit, Snohomish Health District 2012*). This permit requires post-closure ground water monitoring on a quarterly basis until the facility has been shown to be stable and/or not harmful to human health or the environment. The **SHD** permits and evaluates post-closure conditions at the Lake Goodwin Landfill using the Snohomish Health District Sanitary Codes, Chapter 3.1, Solid Waste Handling Regulations; Chapter 173-304 WAC Minimum Functional Standards for Solid Waste; Chapter 173-200 WAC Water Quality Standards for Ground Waters;

and Chapter 246-290 WAC Drinking Water Regulations. There is an approved Sampling & Analysis Plan (SAP) for this landfill.

### 1.3 SITE DESCRIPTION AND PHYSICAL CONDITIONS

The closed landfill is approximately 11.5 acres in size and is part of a larger County owned parcel of land. The Lake Goodwin Landfill is bounded by private residential property or commercial forest to the south, west and north. The Frank Waters Road is located along the eastern side of the site. Access into the site is from a partially paved and partially graveled driveway off of the Frank Waters Road. Existing site improvements are shown on the **Site Map** (figure 2).

The Lake Goodwin Landfill is located on a topographic feature known as the Tulalip Plateau, a rolling upland area bounded by the Stillaguamish River to the north, the Puget Sound to the west and south, and by a topographic low called the Marysville Trough to the east. The general topography in the immediate vicinity of the site is typical of glaciated areas within western Washington State – gently rolling landscapes bisected by seasonal and/or year round drainages, creeks and rivers. Several small to medium sized lakes are found in the immediate vicinity of the site. Lake Martha, Lake Howard and Lake Goodwin are all located within a few miles of the Landfill. There are no named drainages, creeks or rivers located in the immediate vicinity of the site. Elevations in the immediate vicinity of the landfill range from approximately el. 320 to el. 380 feet above mean sea level. Relative to existing surrounding topography the landfill itself is approximately 60 ft high. It has been graded and slopes gently in a north to northeast direction. Site Topography is shown on the **Topographic Map** (figure 3). In most places the landfill cover is well vegetated with grass, clover and weeds. A few Douglas fir have naturally reseeded in the fill cover near the edge of the site. There are no stormwater detention ponds or leachate collection ponds located on the site.

### 1.4 LOCAL HYDROGEOLOGY

Surficial geology of the site area is shown on the **Geologic Map** (figure 4). Based on the Geologic Map and the site explorations, surficial geology at the landfill site consists of Advance Outwash (Qva) sands and gravels locally overlain by sandy silts to silty sands and gravels – Glacial Till (Qvt).

The Lake Goodwin Landfill is located on an upland area known as the Tulalip Plateau. Below the Tulalip Plateau the most productive aquifer is the Advance Outwash (Qva) aquifer which is

underlain by Transitional Bed (*Qtb*) silts and clays. Where overlain by Glacial Till (*Qvt*), the aquifer is confined. In the vicinity of the Lake Goodwin Landfill where Glacial Till (*Qvt*) is absent, ground water is unconfined. With the exception of the surficial Glacial Till (*Qvt*) found overlying the Advance Outwash (*Qva*) sands and gravels along the southern edge of the landfill (*LG-02*), permeable soils were encountered from the surface down in all site explorations at the landfill. Ground water elevations below the landfill ranged from el. 148 to el. 153 with a north to northwest gradient in an unconfined condition within the Advance Outwash (*Qva*) aquifer.

### 1.5 EXISTING MONITORING NETWORK

As outlined in the Solid Waste Facility Permit SW-085, quarterly monitoring of ground water is required at the Lake Goodwin Landfill. There are currently four-(4) ground water monitoring wells (*LG-01*, *LG-02*, *LG-04*, and *LG-05*) at the Lake Goodwin Landfill site that are read on a quarterly basis. Well locations are shown on the **Network Monitoring Map** (*figure 5*). Of these wells, one-(1) is considered to be an up-gradient well monitoring background ground water conditions in the immediate vicinity of the site (*LG-02*). The remaining three-(3) wells are located in and/or down gradient of the landfill (*LG-01*, and *LG-04* and *LG-05*) and monitor ground water conditions that may be impacted from the site. Second quarter monitoring results are discussed in section 2.0 below.

## 2.0 GROUND WATER MONITORING

Third quarter 2012 monitoring of the ground water wells at the Lake Goodwin Landfill was performed by **Snohomish County** personnel. Depth to water was measured and ground water samples were collected following approved sampling protocol. The following sections describe field procedures used and analytical results derived from the sampling event.

### 2.1 Ground Water Level Measurements

The depth to ground water within each well was measured prior to ground water sampling activities. The depth to ground water was measured using an electronic water level indicator in increments to the nearest 0.01 ft. as taken from a marked survey point on the top of each well casing.

**Third Quarter Ground Water Measurements** are shown in *Table 1* below. **Hydrographs** of the third quarter 2012 monitoring well readings are contained in *Appendix A* of this report. Third quarter well readings show a variable response to the lighter second quarter precipitation

(11.16") and a dryer start to the third quarter (2.54" as of 7/27/12). Variances from second quarter measurements are as much as 2.8 feet. Readings confirm that the aquifer is unconfined in the immediate vicinity of the site. The **Third Quarter Ground Water Contour Map** developed from the field data is shown in *Figure 6* of this report.

Measured precipitation at the Stanwood Weather Station (WA-SN-11 <http://www.cocorahs.org/state.aspx?state=wa>) during the third quarter monitoring period was 2.54" through July 27, 2012. For reference purposes, precipitation measured at station WA-SN-11 during the monitoring period has been included on the hydrographs.

**Table 1 – Third Quarter Groundwater Measurements and Elevations**

Well Numbers	Casing Elevation	3 <sup>rd</sup> Quarter Delta/Elevation	
LG-01	239.18	-1.31	156.86
LG-02	268.67	+0.97	155.27
LG-03	241.20	+2.83	156.08
LG-04	206.93	+1.15	153.43
LG-05	235.00	+0.76	154.3

## 2.2 Third Quarter Ground Water Sampling Event

Purging and sampling of each of the four-(4) sampled monitoring wells was performed during the third quarter by Snohomish County personnel in accordance with the facilities closure permit. Per the new SAP, ground water elevations were taken at LG-03 only. Approximately 2.1 to 3.5 gallons of water was purged from each well prior to sampling. Water samples were collected by slowly filling laboratory-supplied containers in such a manner as to reduce aeration. Sample containers were filled so that no headspace or air bubbles remained within the container. Samples were placed in coolers and packed in ice to keep samples at approximately 4C for delivery to the laboratory for testing. Samples were picked up by **Amtest** and taken to their Kirkland, WA laboratory for analysis of dissolved metals, volatile organic compounds (VOC's), and conventional chemistry parameters. Per the newly approved SAP, VOCs will no longer be part of the analysis program and certain metals have been excluded as well. Analytical Data is included in *Appendix B*, Ground Water Analytical Data of this report. The analytical data was compared to the maximum contaminant levels (MCL's). A complete statistical analysis of the data was also performed utilizing **DUMPStat**. Results are discussed below.

### 2.3 Evaluation of Third Quarter Ground Water Analytical Results

**Third Quarter Ground Water Test Results** for each well are summarized in *Table 2* below. Comparison of results to regulatory criteria (MCL's) shows:

**Third Quarter:** Other than pH and arsenic in all wells, there were no measured exceedances of the MCL's in any well except LG-05. There were measured exceedances of the MCL's for conductivity, nitrate nitrogen, pH, sodium, total dissolved solids and arsenic in well LG-05. No other dissolved metals were observed exceeding WAC level MCL's during this sampling event.

**Table 2 - Summary of Test Results – Third Quarter**

Well	3 <sup>rd</sup> Quarter 2012 Groundwater Standard Exceedances
LG-01	pH, arsenic
LG-02	pH, arsenic
LG-04	pH, arsenic
LG-05	Conductivity, nitrate nitrogen, pH, sodium, TDS, arsenic

### 2.4 Statistical Evaluation

State health regulations under which the Lake Goodwin Landfill closure is permitted require that the landfill "...shall not cause exceedances of *Chapter 173-200 WAC, Water Quality Standards for Groundwater*, and *Chapter 246-290 WAC, Drinking Water Regulations*." The intent of these state regulations is to limit the impact that a landfill will have on the surrounding ground water resources. Collected ground water samples are tested for Primary and Secondary Drinking Water Standards, and Dissolved Metals – and compared to the standards listed in the above referenced WAC's. Where an exceedance to the standards occurs, a statistical analysis is provided to determine the significance of the change or exceedance. Each of these exceedances has been statistically analyzed using **DUMPStat Software** (*version 2.1.9 by Robert D. Gibbons Lt., 2000*) per the *Subtitle D* regulations and as specifically referenced in the **U.S. EPA** guidance manual. Mean, standard deviation, prediction limits, and confidence values were calculated by **DUMPStat**.

The Sens Trend analysis test was performed for the entire data set stretching back to 1988 and the results of that analysis – increasing or decreasing trends are recorded on the spreadsheet in Appendix B. The trend analysis in Appendix C is run between 2005 and current time. This allows us to place multiple constituents on a single graph to better see any potential



correlation between the geochemistry and dissolved metals. Per Ecology and Snohomish Health District request, the prediction limit is updated in the first quarter of the year and subsequent data sets are compared against that prediction limit.

Based on the statistical analysis, exceedances to the prediction limits in all down-gradient wells were high for all of the conventional chemistry parameters and minimal for the dissolved metals. Calculated exceedances to the prediction limits in the first quarter are shown in *Table 3* below.

**Table 3 - Statistical Summary - Third Quarter Prediction Limit Exceedances for 2012**

Well	3 <sup>rd</sup> Quarter 2012 Exceedances
LG-01	Alkalinity, Bicarbonate, conductivity, magnesium, nitrate, pH, potassium, sulfate, barium, manganese
LG-02	pH, Sulfate
LG-04	Bicarbonate, calcium, conductivity, magnesium, pH, potassium, sulfate, barium
LG-05	Alkalinity, bicarbonate, calcium, chloride, conductivity, magnesium, nitrate, pH, potassium, sodium, sulfate, TDS, barium, manganese

**Stiff Diagrams, Trilinear Diagrams and Statistically Significant Trends Analyses** results are included in *Appendix C* of this report.

### **3.0 GAS PROBE MEASUREMENTS**

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We reported in our SAP and to SHD that neighbors removed / damaged the bar hole probes at the Lake Goodwin Landfill. In fall 2012, we will re-install gas bar hole probes and measure the gas pressure in the landfill cap. We will repeat this study annually and report the results in the annual report.

### **4.0 SUMMARY AND RECOMMENDATIONS**

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The ground water data collected during the 2012 third quarter sampling events indicates the following:

- Ground water elevations below the landfill remained fairly consistent during this quarter. Based on the well readings, the apparent ground water elevation of all wells has been steadily rising since 2005.
- Measured conductivity was above background levels (LG-02) in all down gradient wells during this sampling event. The conductivity level observed at well LG-05 was significantly higher than the surrounding wells during this sampling event.
- Statistical analysis did show significant impacts to well LG-05. Lesser impacts were indicated in wells LG-01 and LG-04. Time series plots based on the **DUMPStat** analysis

indicates that there were more significant decreasing trends (11) than increasing trends (8) during this sampling event.

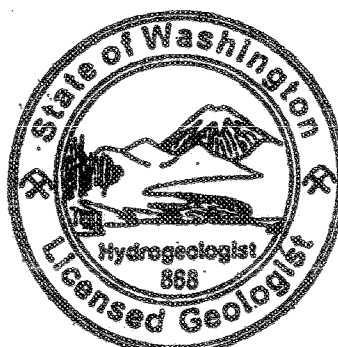
- There were very minimal impacts to the ground water from dissolved metals. Small exceedances to the calculated prediction limits for barium, and manganese, were found in the down-gradient wells.
- The arsenic level in the "Intermediate Guidance for the Ground Water Quality Standards" is so low that every well exceeded it, including background well LG-02. Due to the natural background levels of arsenic in the ground water around the Lake Goodwin Landfill, this parameter is no longer a good indication of potential arsenic impacts to the groundwater caused by the landfill.

#### 4.1 CONCLUSIONS/RECOMMENDATIONS

Third quarter 2012 data indicates a continued moderate leachate impact to the underlying Advance Outwash (Qva) aquifer below the Lake Goodwin Landfill. Statistical analysis indicates a large number of significantly decreasing trends which would suggest that the leachate impact to the ground water below the landfill is decreasing at this time, however, five-(5) increasing trends have been monitored in down gradient well LG-01. The data also suggests that the leachate plume impacting ground water extends beyond the landfill boundaries following the ground water gradient to the north-northeast through LG-05.

#### 4.2 SIGNATURES and CERTIFICATIONS

  
Kirk R. Bailey, LEG, LHG  
SCPW – Engineering Services



  
Deanna Carveth  
SCPW – Solid Waste Division

KIRK R. BAILEY

August 13, 2012

Figure 1

# Lake Goodwin Landfill

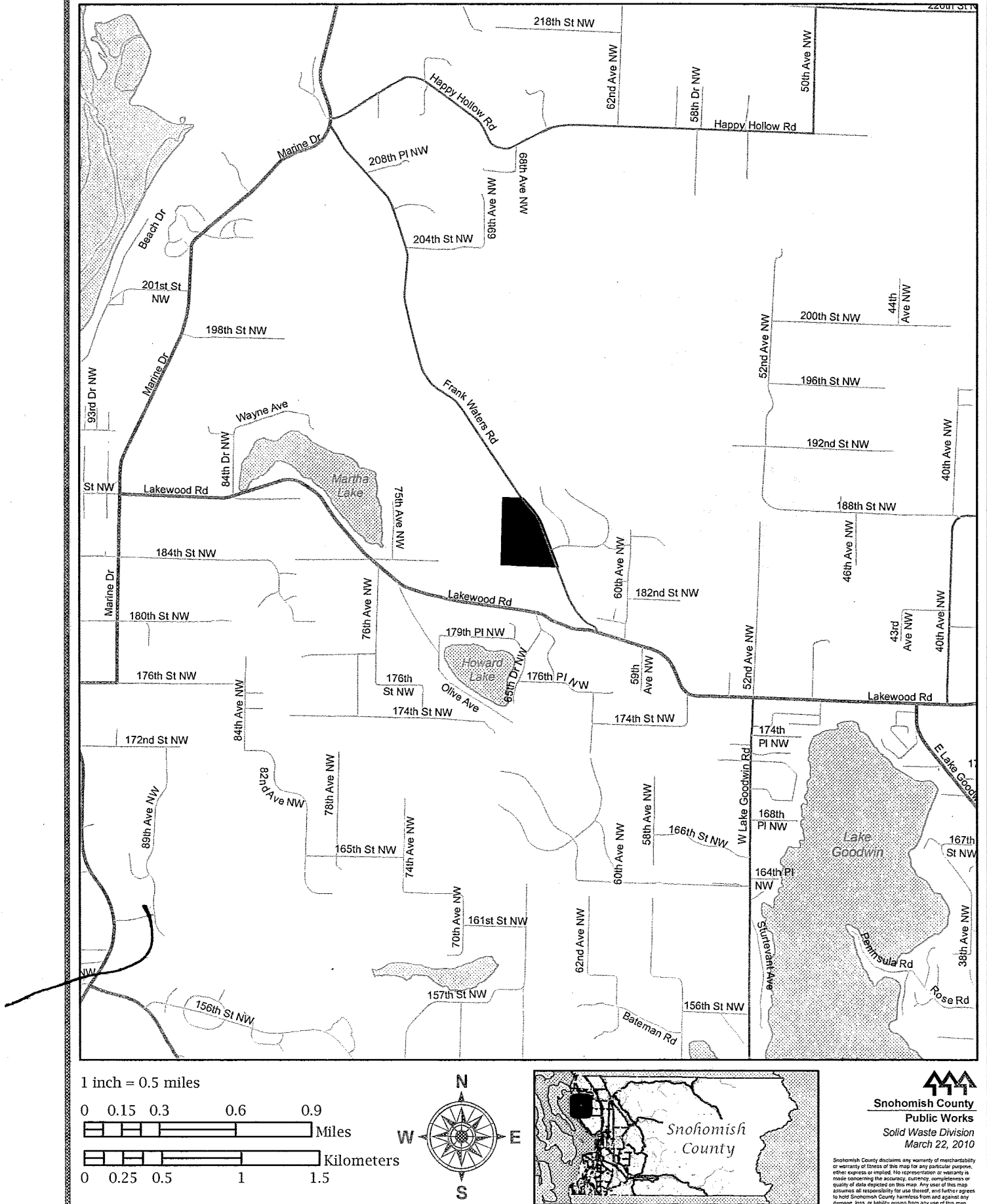
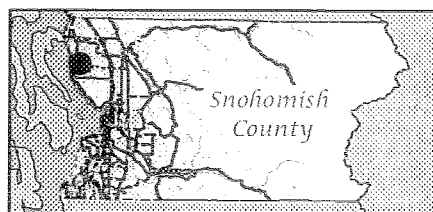
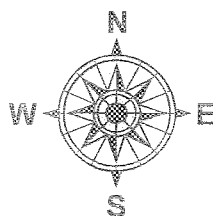
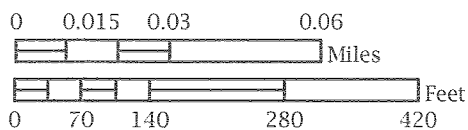
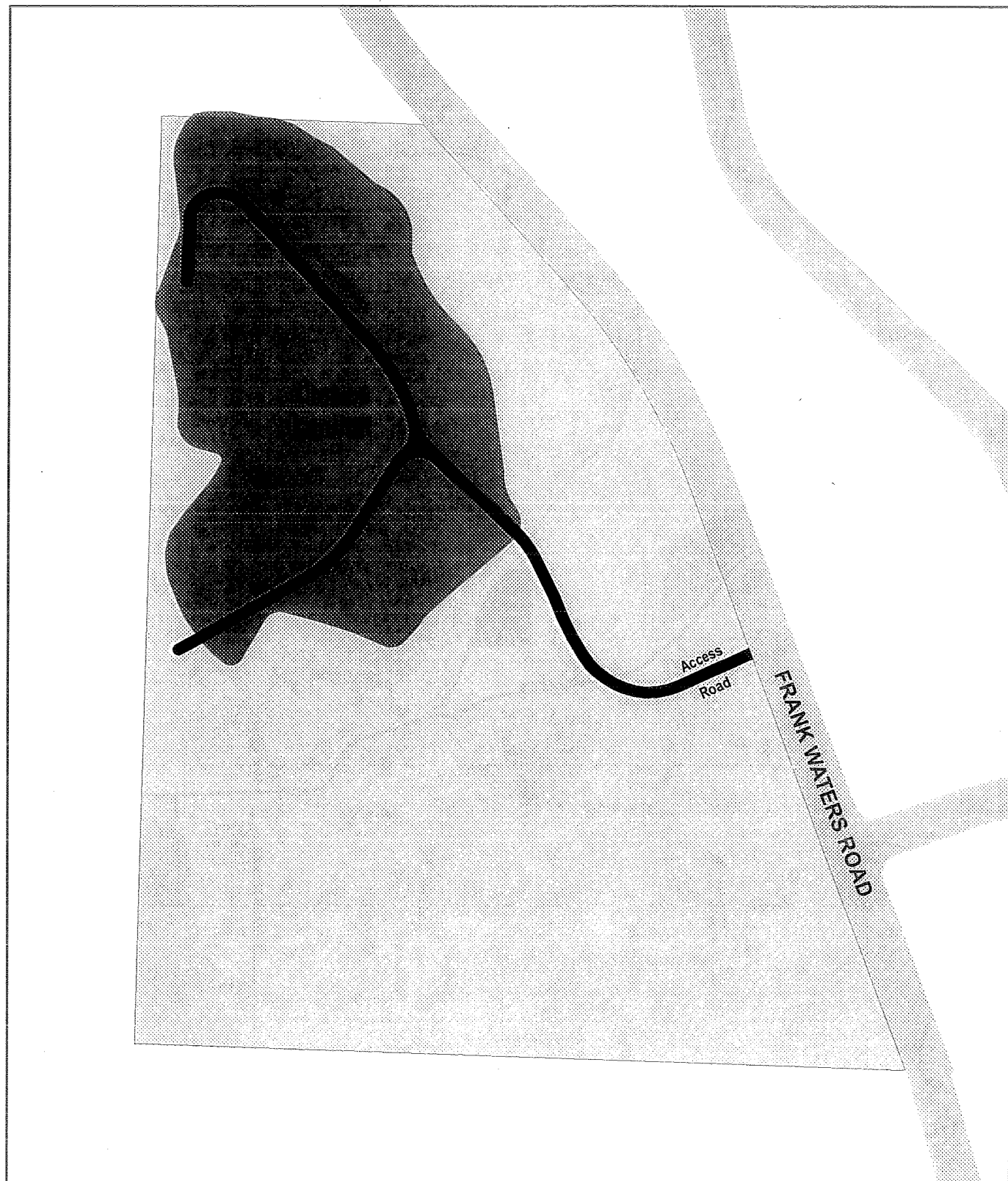


Figure 2

# Lake Goodwin Landfill Site Map



**Snohomish County**  
**Public Works**  
 Solid Waste Division  
 March 25, 2010

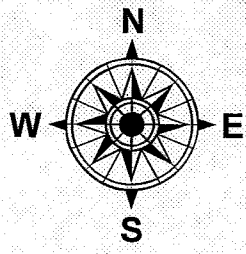
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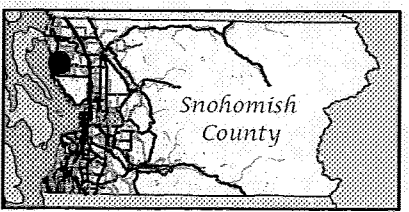
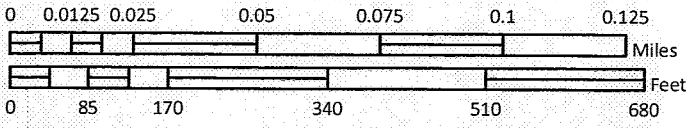
Figure 3

# Lake Goodwin Landfill Topography

- Map Features**
- Parcel Boundary
  - Subject Property Boundary
  - 5 Foot Contours



1 inch = 200 feet



**Snohomish County**  
Public Works  
Solid Waste Division  
March 23, 2010

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# Lake Goodwin Landfill Geologic Map

## Parcel Bound

## Geologic Description

Modified Land

Water

Vashon till (Qvt)

Vashon recessional outwash

Vashon advance outwash (Qva)

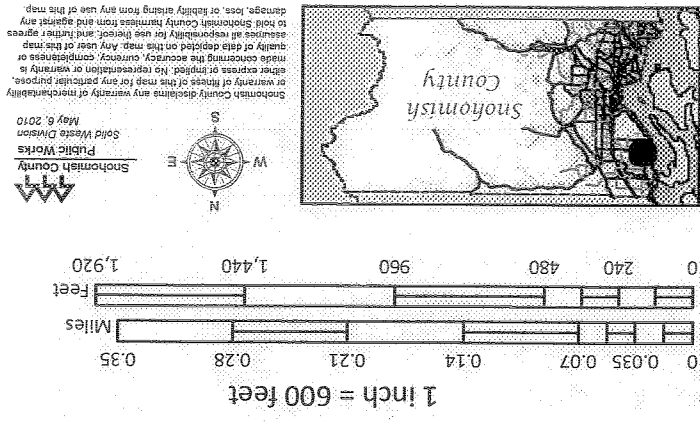




Figure 5

# Lake Goodwin Landfill Monitoring Network

## Map Features

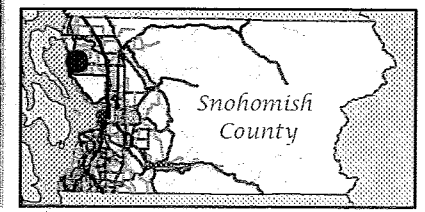
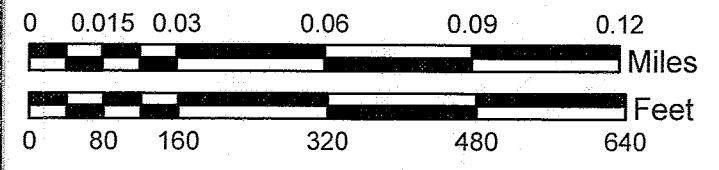
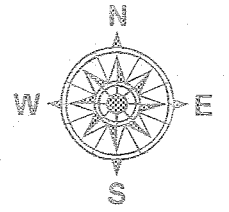
- Parcel Boundary
- Subject Property Boundary

## Aquifer Unit (Active Wells)

- Deep Aquifer

## Additional Sampling Points

- ▲ Bar Hole Punch Gas Probe



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Solid Waste Division  
March 2, 2012

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Figure 6

# Lake Goodwin Landfill

## Water Elevation Contours

### 3rd Quarter 2012

DIRECTION OF GROUNDWATER FLOW  
1.05 ft/day  
382 ft/year  
97.86 degrees to the positive x-axis

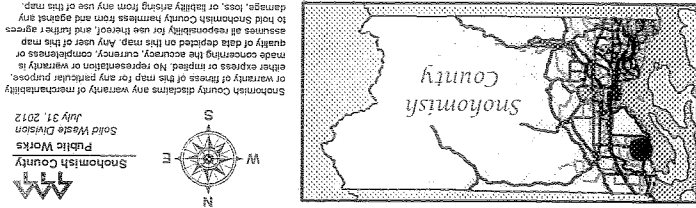
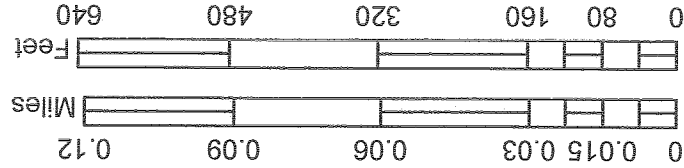
PARCEL BOUNDARY

SUBJECT PROPERTY BOUNDARY

1 FT CONTOUR

WELL LOCATION

WELL_ID	SAMP_DATE	MEAS_HEAD
LG-01	7/10/2012	156.86
LG-02	7/10/2012	155.59
LG-03	7/10/2012	156.08
LG-04	7/10/2012	153.43
LG-05	7/10/2012	154.30



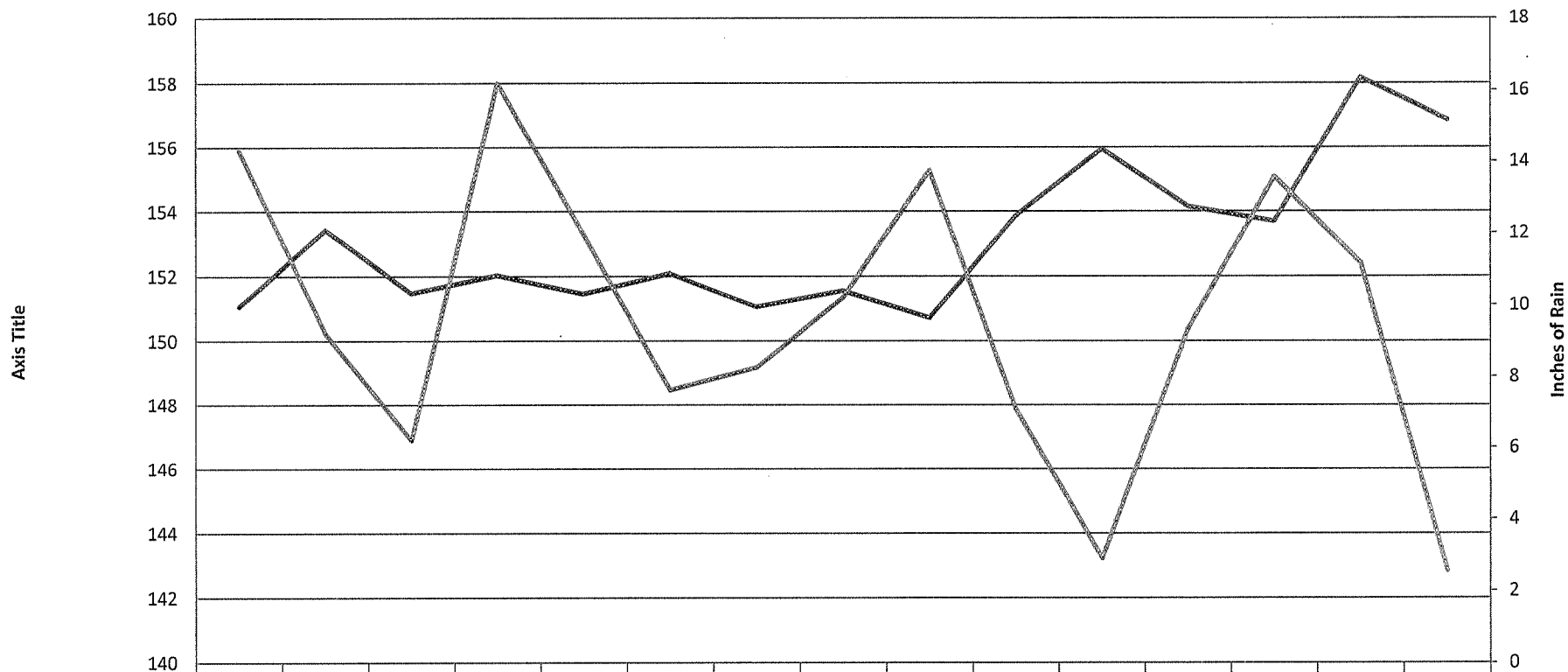


# Appendix A

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## Hydrographs

# Lake Goodwin Well LG-01

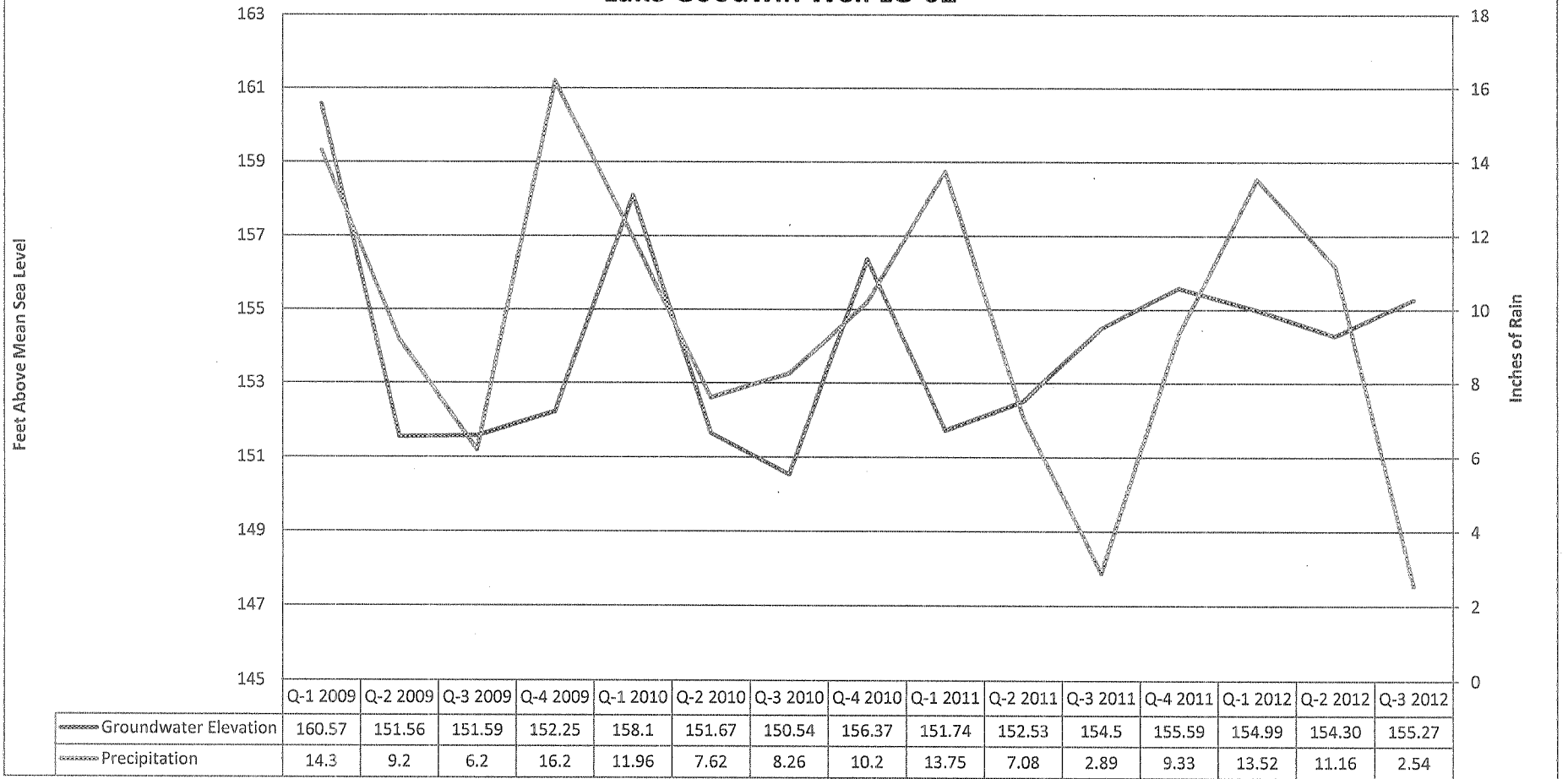


Axis Title

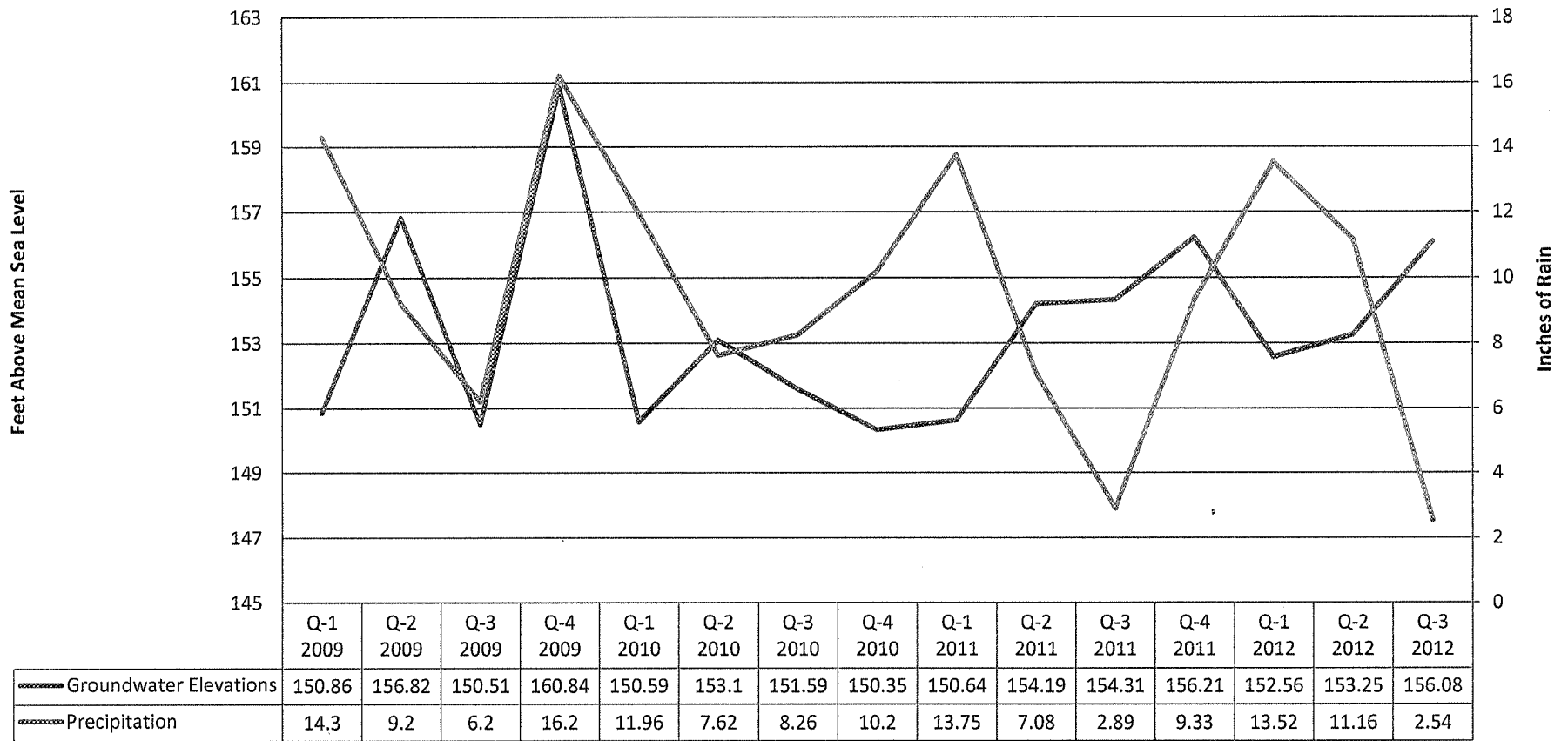
Depth to Water

Inches of Rain

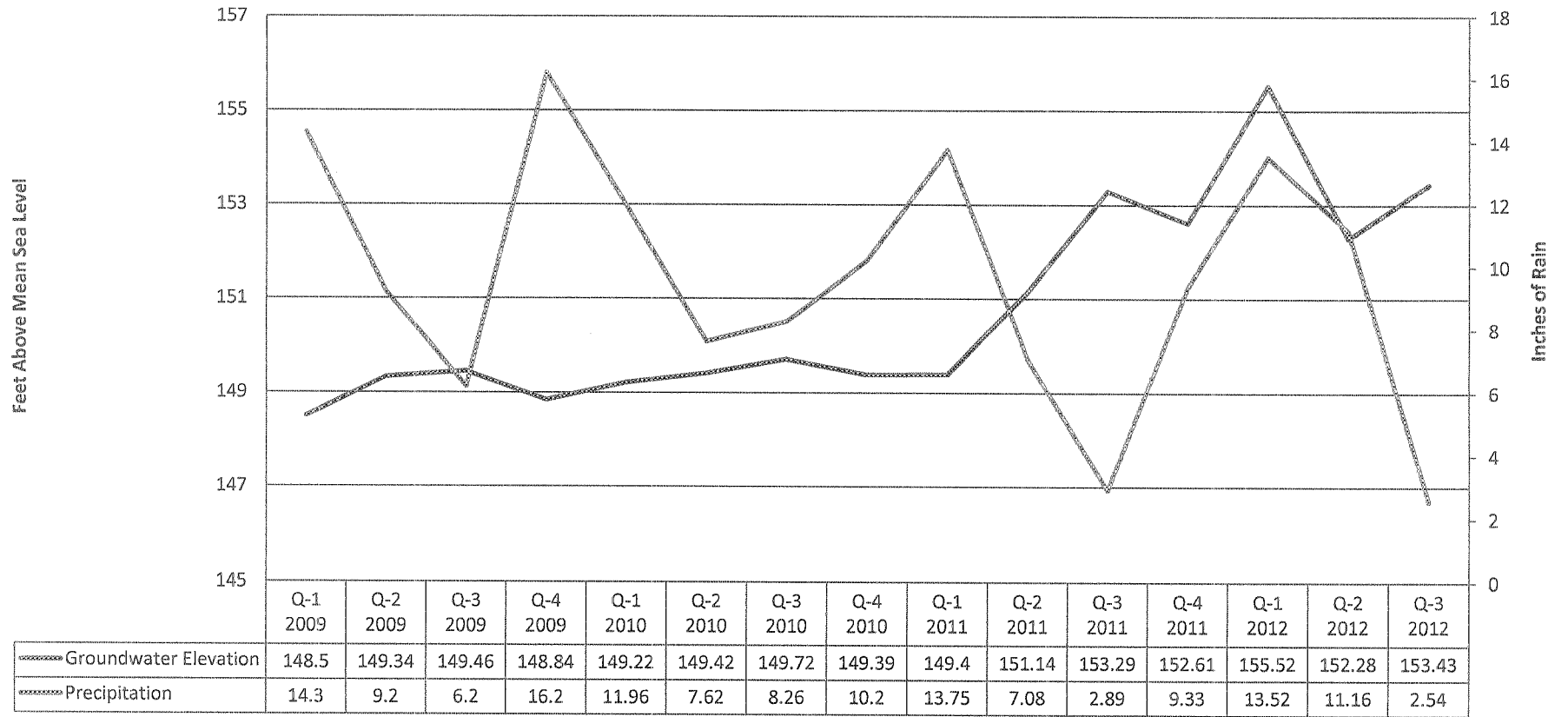
# Lake Goodwin Well LG-02



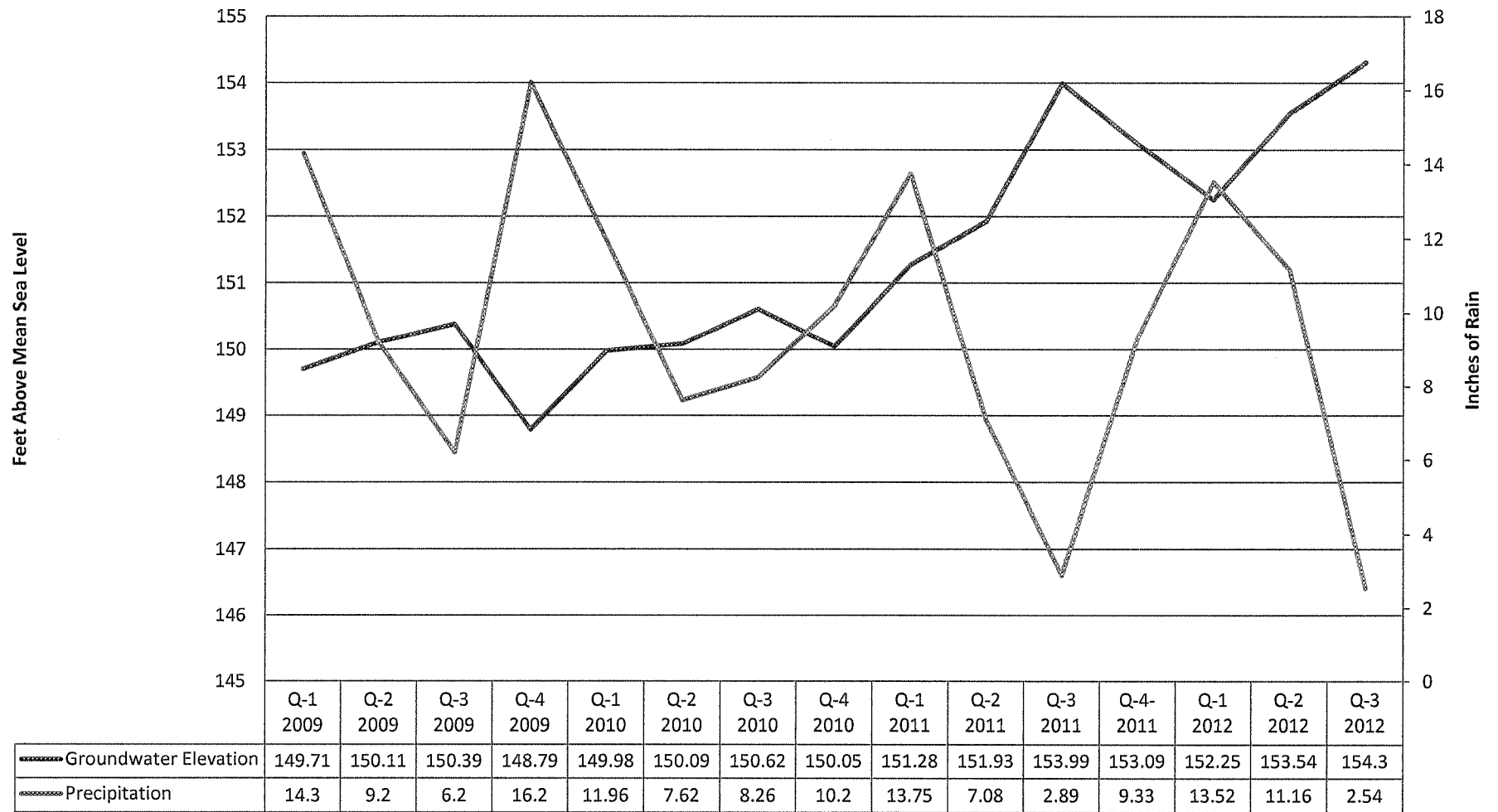
## Lake Goodwin Well LG-03



# Lake Goodwin Well LG-04



## Lake Goodwin Well LG-05



# Appendix B

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## Analytical Data

**Groundwater Statistical Summary: Third Quarter 2012 Lake Goodwin Landfill, Snohomish County, WA**

Statistical Method	No.	No.	Prediction Limit (a)	MCL	Downgradient												Upgradient			
	of	of			LG-01					LG-04				LG-05			LG-02			
	Samples	Detects			7/10/12	D	V	T	C	7/10/12	D	V	T	C	7/10/12	D	V	T	C	

**CONVENTIONAL CHEMISTRY PARAMETERS**

(mg/L unless noted)

Alkalinity (as CaCO3)	normal	32	32	141.1815	--	160	V			140					300	V	I	N		110		I	N	
Ammonia Nitrogen	nonpar	28	8	0.056	--	0.005	U			0.005	U				0.005	U				0.005	U			
Bicarbonate	normal	32	32	130.7366	--	160	V			140	V		Y		300	V				110				
Calcium, Dissolved	normal	32	32	20.8776	--	20.7	P	I	N	21.9					42.08	V				20				
Chemical Oxygen Demand	nonpar	24	2	26	--	10	U			10	U				10	U				10	U			
Chloride	nonpar	32	32	9.4	250	6.1		I	Y	7.3					21	V				7				
Conductivity (umhos/cm)	normal	32	32	325.3534	700	370				330			D	N	880	V				280				
Magnesium, Dissolved	normal	32	32	19.5453	--	28.5	V	I	N	21.5	V				63.75	V				17.2				
Nitrate Nitrogen (mg-N/L)	nonpar	31	31	2.6	10	2.6		I	N	1.1					17.5	V				1.8				
Nitrite Nitrogen (mg-N/L)	nonpar	28	7	0.003	1	0.002	U			0.002	U				0.002	U		D	N	0.002	U			
pH (std units)	nonpar	32	32	6.7-7.75	6.5-8.5	5.69	E	D	N	5.48	V	D	N		5.48	E	D	N		6.06			D	N
Potassium, Dissolved	normal	32	32	3.443	--	3.72	V			3.52					6.955	V				3				
Sodium, Dissolved	nonpar	31	31	13.8	20	9.57		I	Y	9.7			D	N	38.65	V	D	N		9.11				
Sulfate	nonpar	32	32	16.2676	250	37	V			22			D	N	50.5	V	D	N		24				
Total Dissolved Solids	nonpar	32	32	550	500	250				230					550	P				190				
Total Organic Carbon	nonpar	32	14	13	--	0.5	U			0.5	U				2.3					0.5	U			

**DISSOLVED METALS**

EPA Methods 6010B/7131A (mg/L)

Arsenic	nonpar	27	27	0.078	0.01	0.000068				0.000525				0.00143					0.00357					
Barium	normal	27	27	0.0138	2	0.0182	V			0.0214	V	D	N	0.0594	V				0.0123		I	N		
Cadmium	nonpar	29	12	0.0002	0.005	0.000025	U			0.000025	U			0.000053	P				0.000025	U				
Chromium	normal	29	21	0.0102	0.1	0.0025				0.0014				0.0036					0.0046					
Cobalt	nonpar	32	5	0.008	--	0.001	U			0.001	U			0.001	U				0.001	U				
Copper	nonpar	28	9	0.004	1.3	0.001				0.002				0.003					0.003					
Iron	nonpar	32	5	0.031	0.3	0.005	U			0.005	U			0.026					0.005	U				
Manganese	nonpar	29	9	0.0061	0.05	0.0065	V			0.0052				0.0106	V				0.004					
Nickel	nonpar	32	0	0.005	0.1	0.005	U			0.005	U			0.005	U	P			0.005	U				
Zinc	normal	30	15	0.007	5	0.001	P			0.003				0.002					0.001	U				

D Column: U = Compound not detected in any sample; V Column: V = verified hit, E = exceedance, waiting verification; P = Passed, exceedance not verified

I means increasing trend, D means decreasing trend via Mann-Kendall Analysis; Ch? = a change in the trend analysis, N is no, Y is yes. Compared to previous quarter.

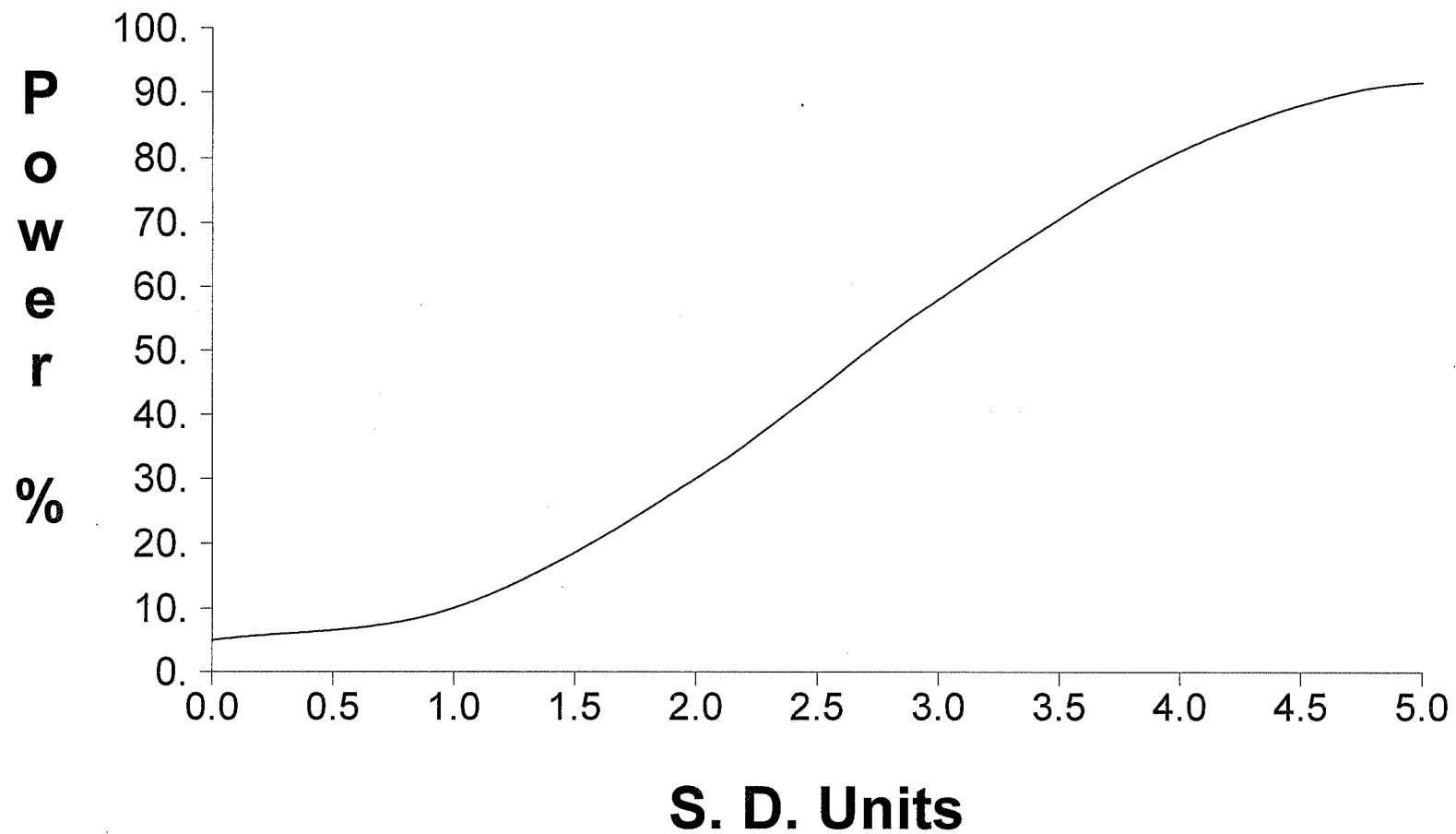


# Appendix C

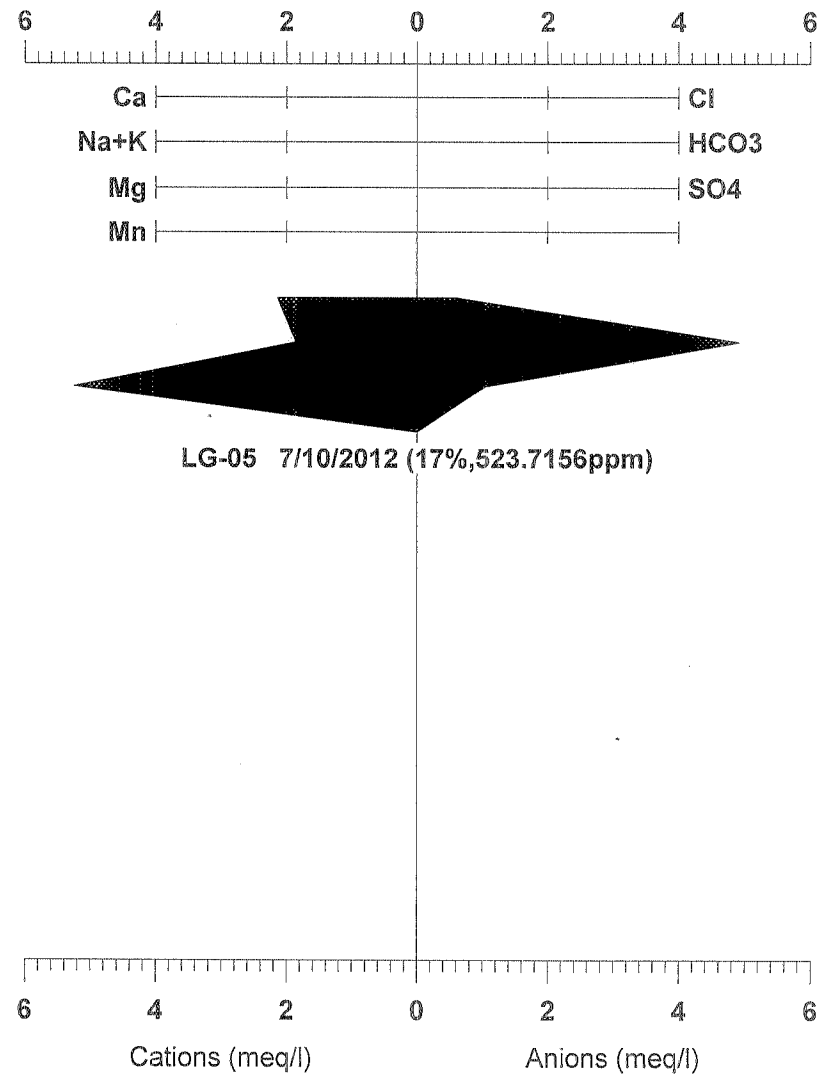
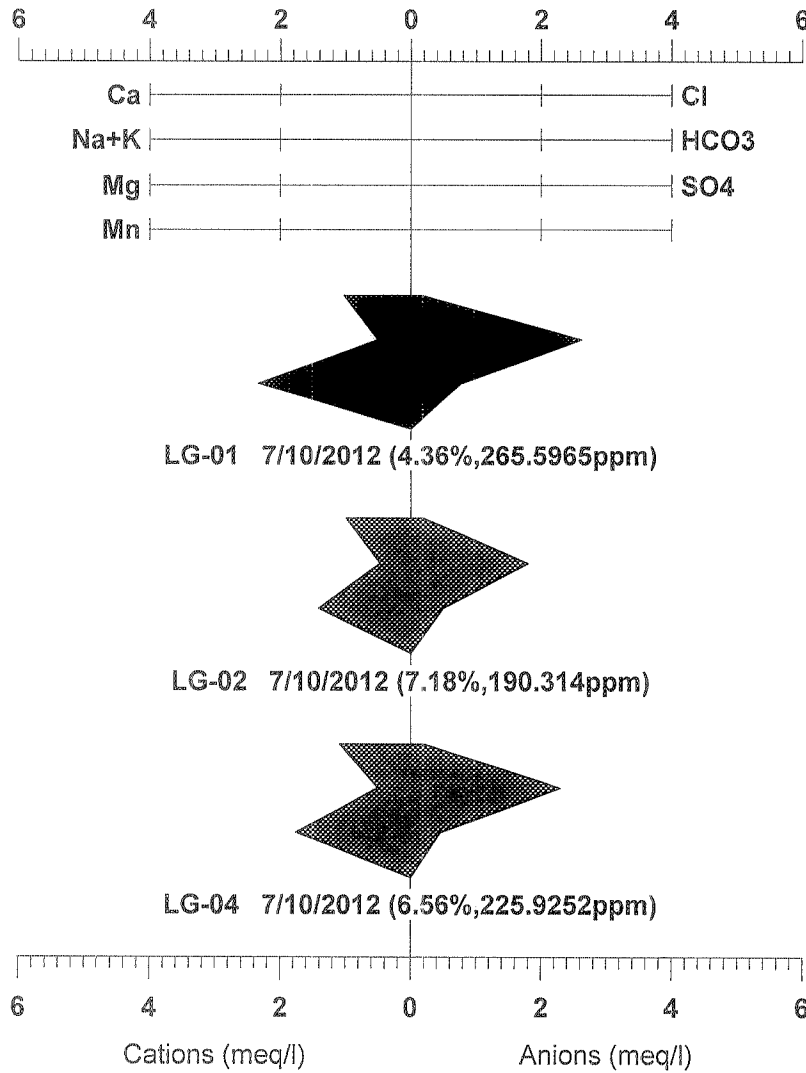
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## **Stiff, Tri-linear and Trend Analysis**

## False Positive and False Negative Rates for Current Upgradient vs. Downgradient Monitoring Program



# Goodwin Landfill

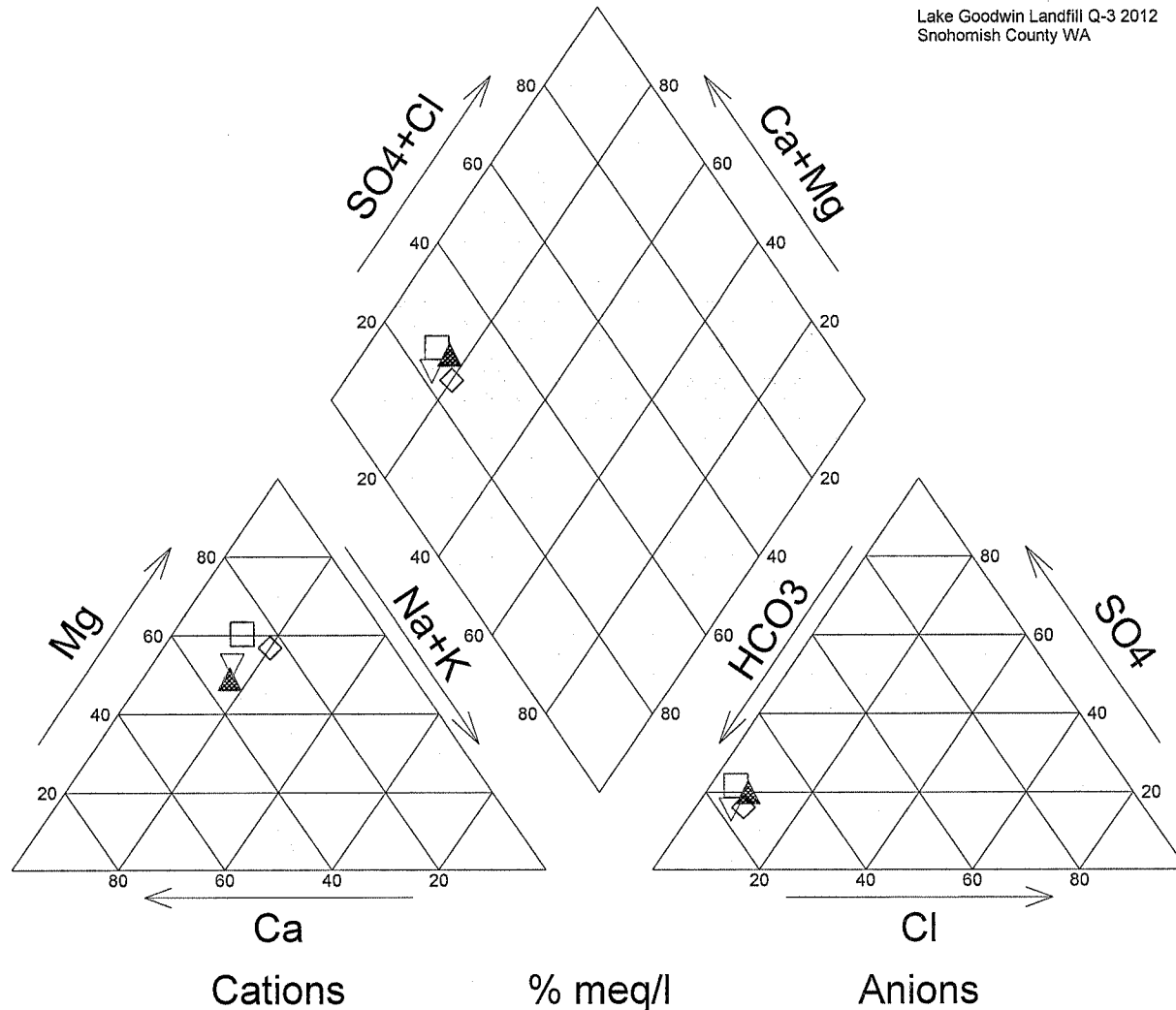


Prepared by: Snohomish County Solid Waste

## Goodwin Landfill

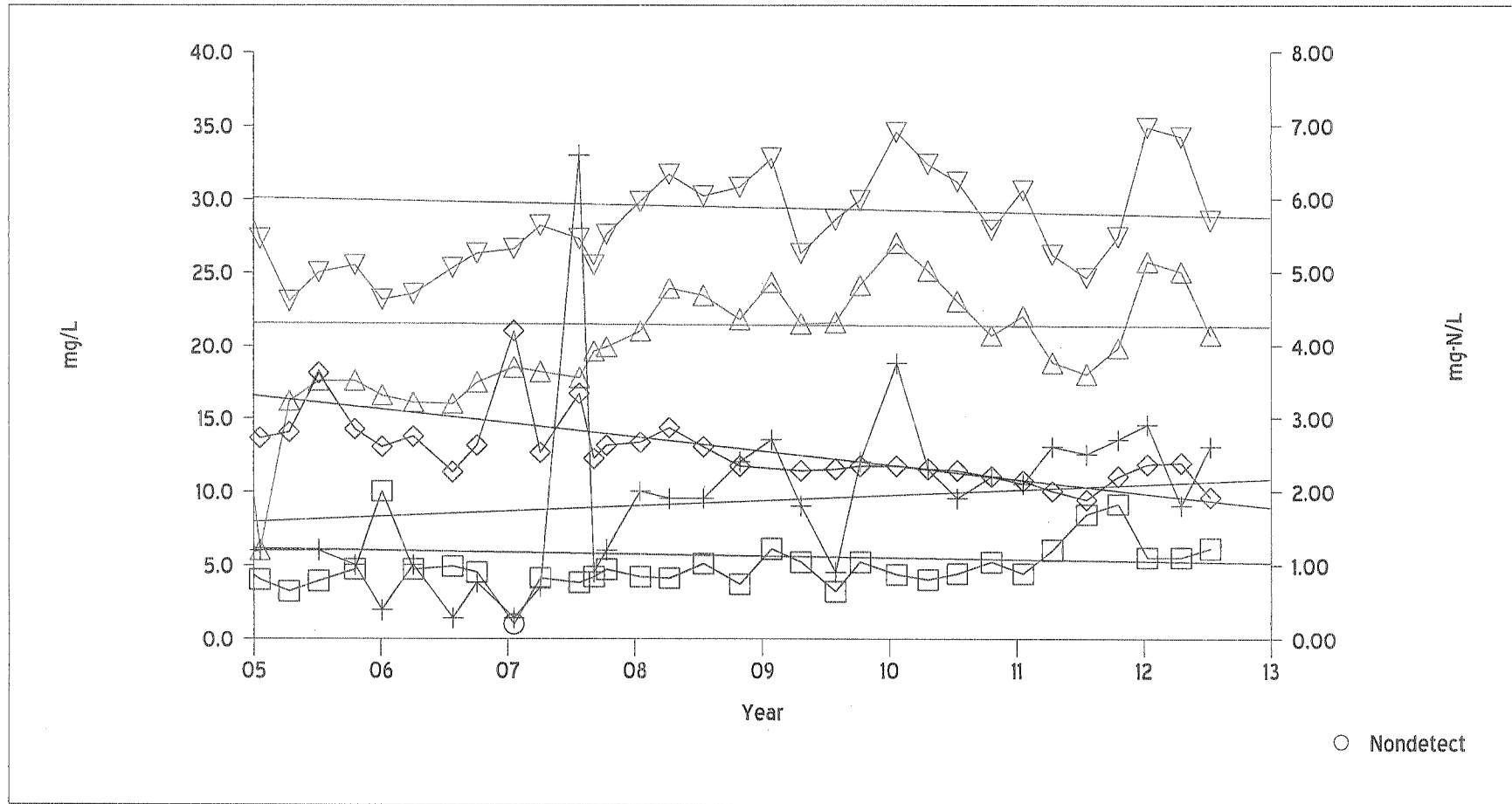
□ LG-01	7/10/2012 (4.36%, 265.59ppm)
▲ LG-02	7/10/2012 (7.17%, 190.31ppm)
▽ LG-04	7/10/2012 (6.56%, 225.92ppm)
◇ LG-05	7/10/2012 (17%, 523.705ppm)

Lake Goodwin Landfill Q-3 2012  
Snohomish County WA



# **Goodwin Landfill**

Time Series Plot for LG-01



□ Chloride (cc: -.204)  
 △ Dissolved calcium (cc: -.022)  
 ▽ Dissolved magnesium (cc: -.111)  
 ◇ Dissolved sodium (cc: -.794)

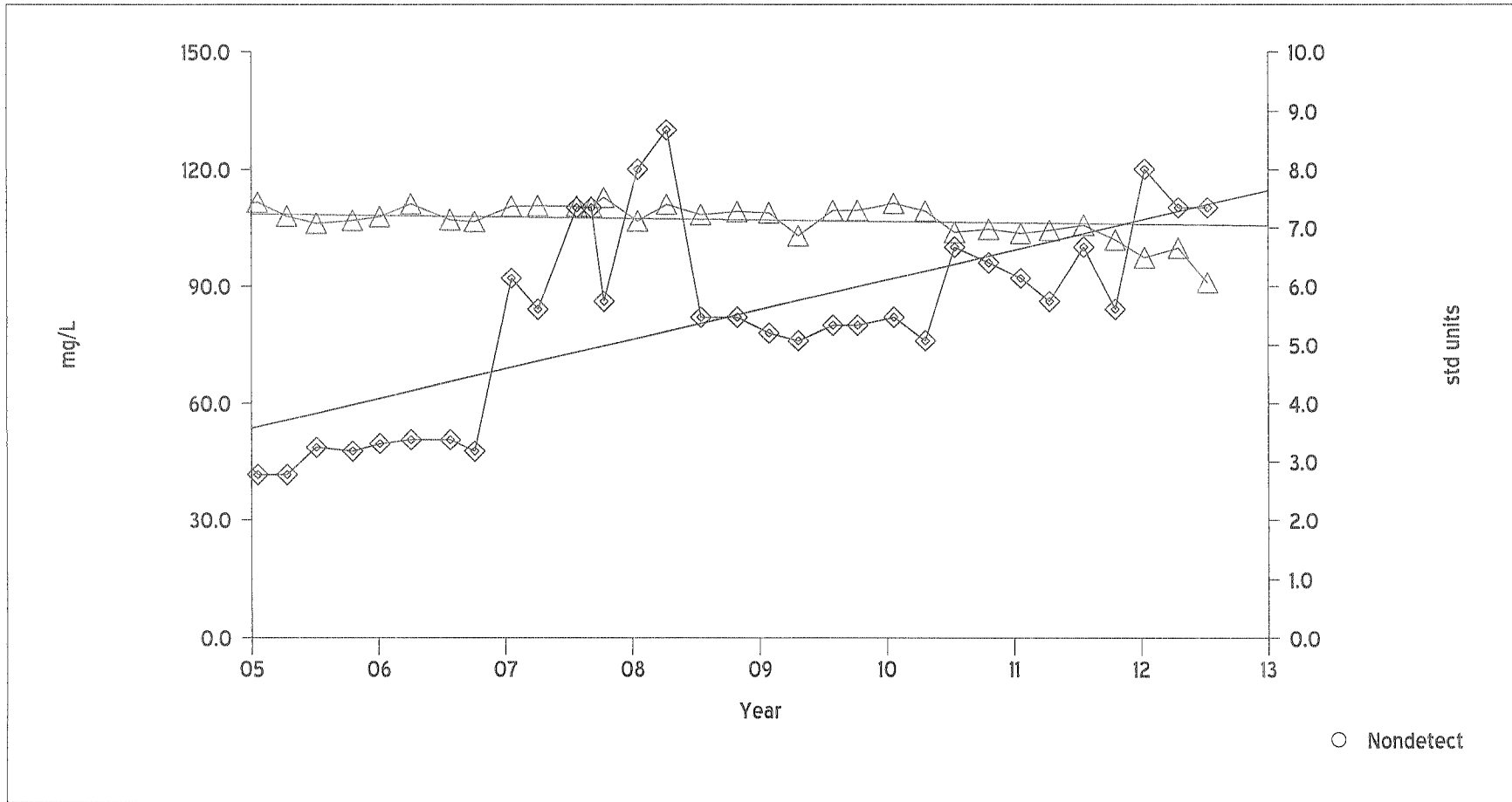
+ Nitrate nitrogen (cc: .484)

### Time Series Plot for LG-01



# Goodwin Landfill

Time Series Plot for LG-02

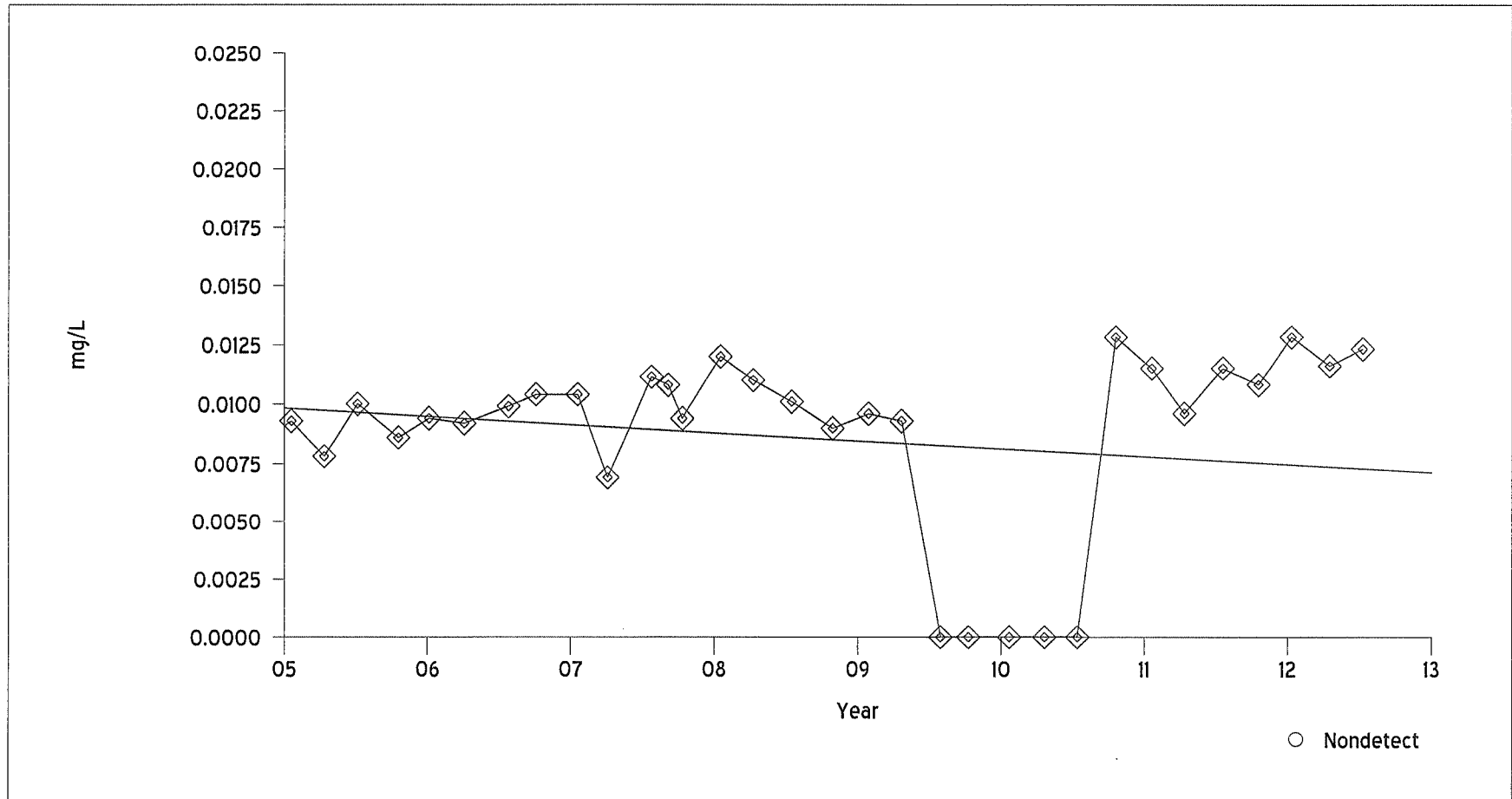


◆ Alkalinity (as cacO3) (cc: .773)

△ pH (cc: -.456)

## Goodwin Landfill

Time Series Plot for LG-02



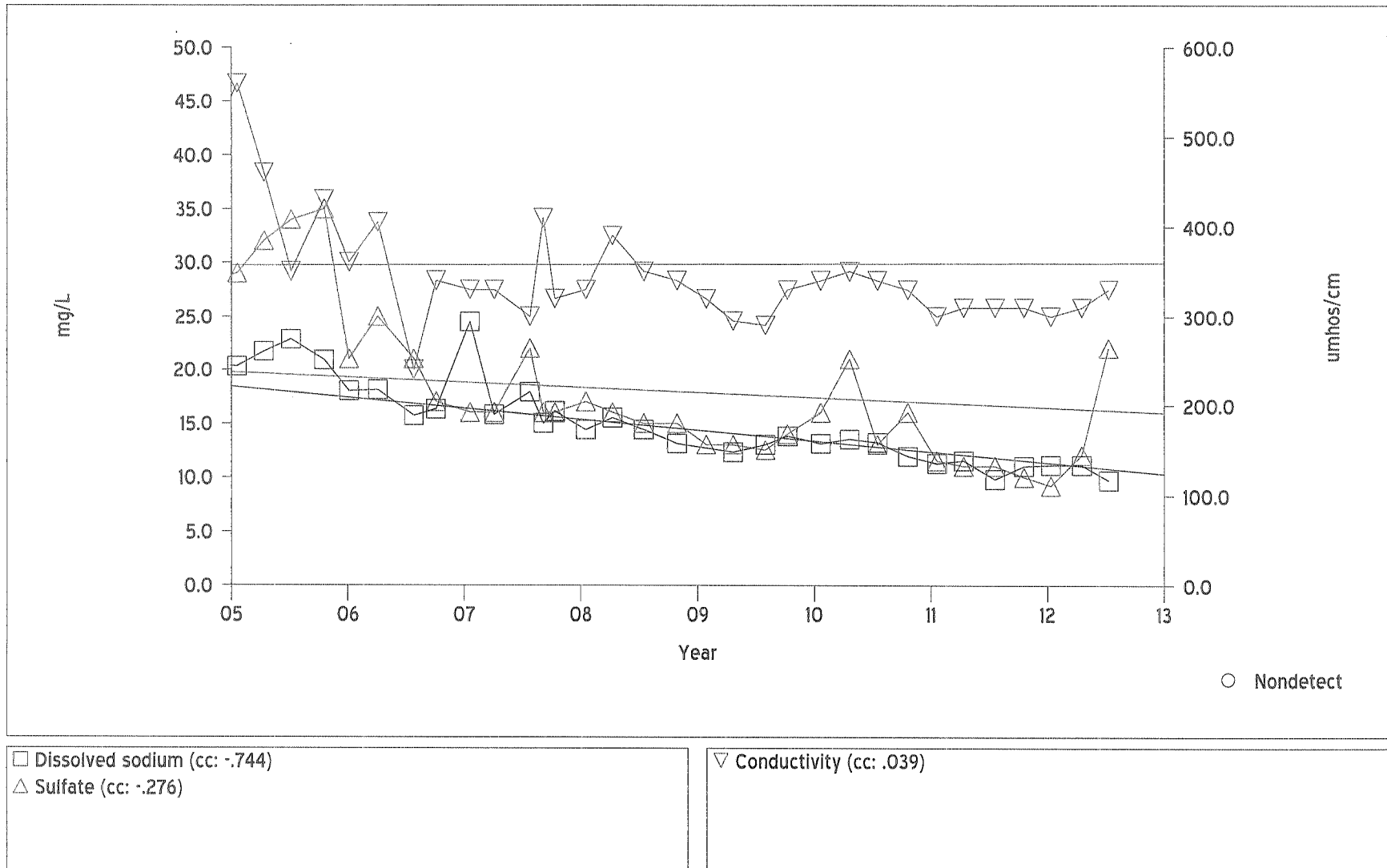
◆ Dissolved barium (cc: -.426)

○ Nondetect



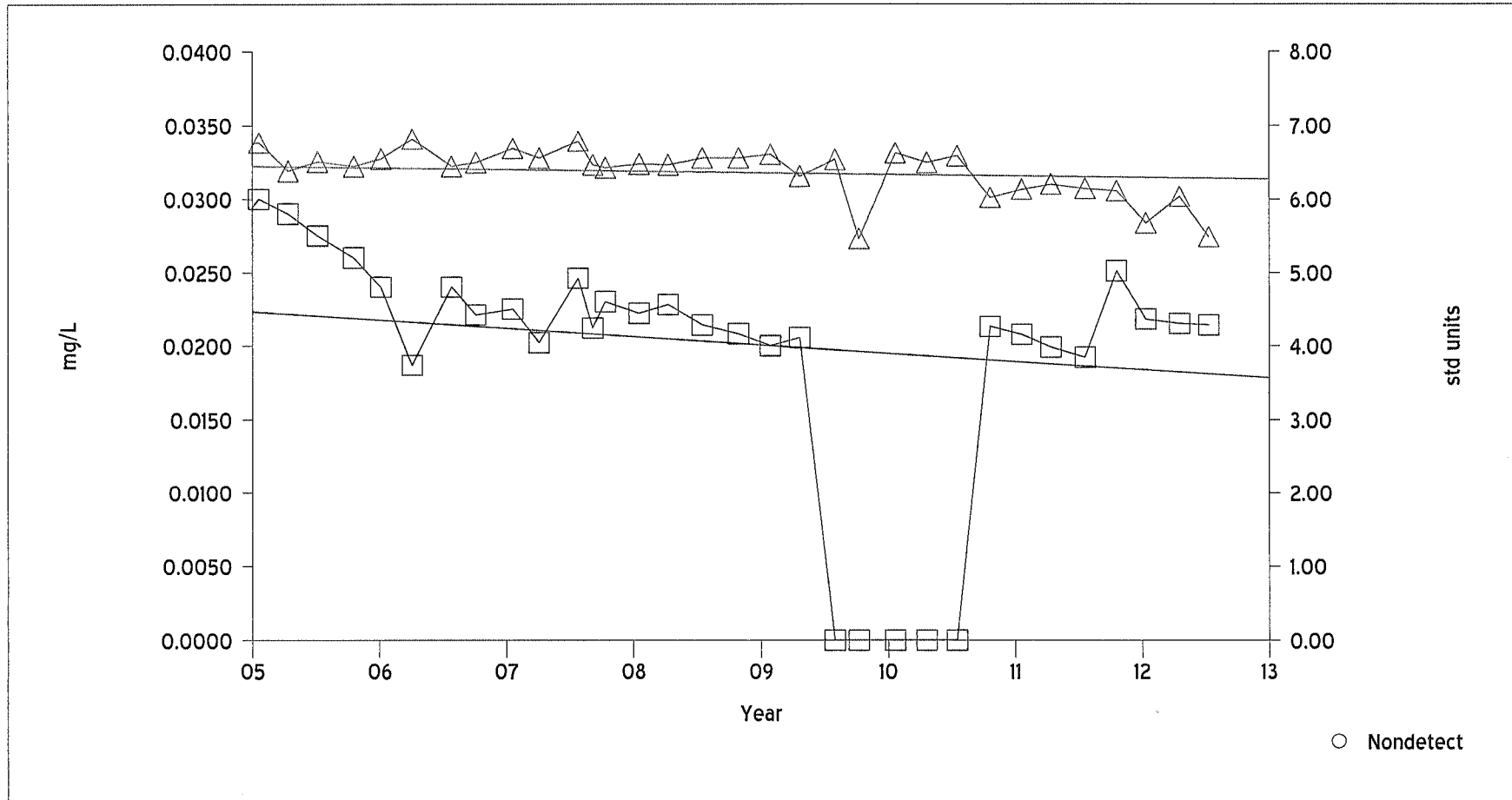
# Goodwin Landfill

Time Series Plot for LG-04



# Goodwin Landfill

Time Series Plot for LG-04



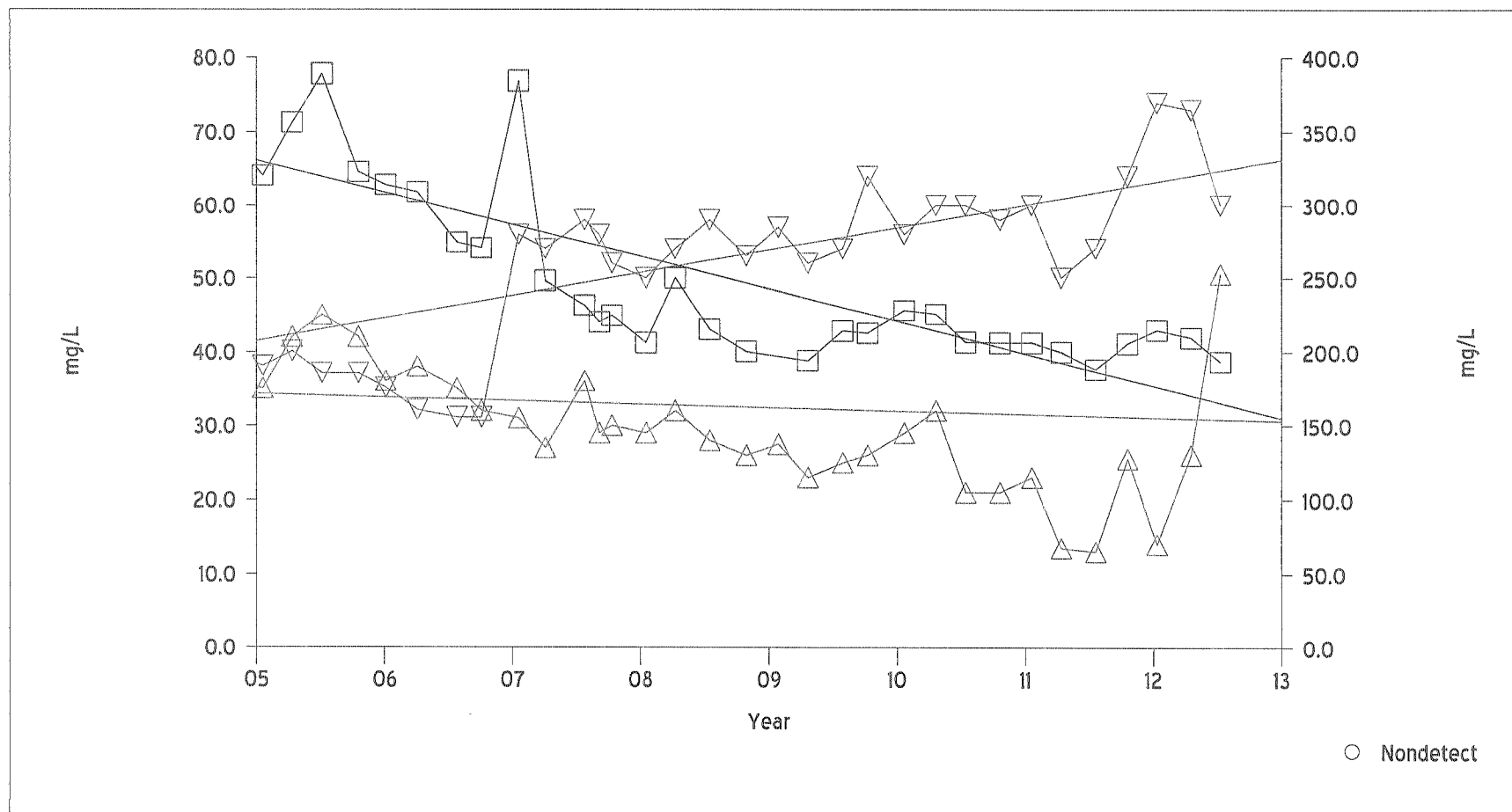
□ Dissolved barium (cc: -.397)

△ pH (cc: -.485)

○ Nondetect

# **Goodwin Landfill**

Time Series Plot for LG-05



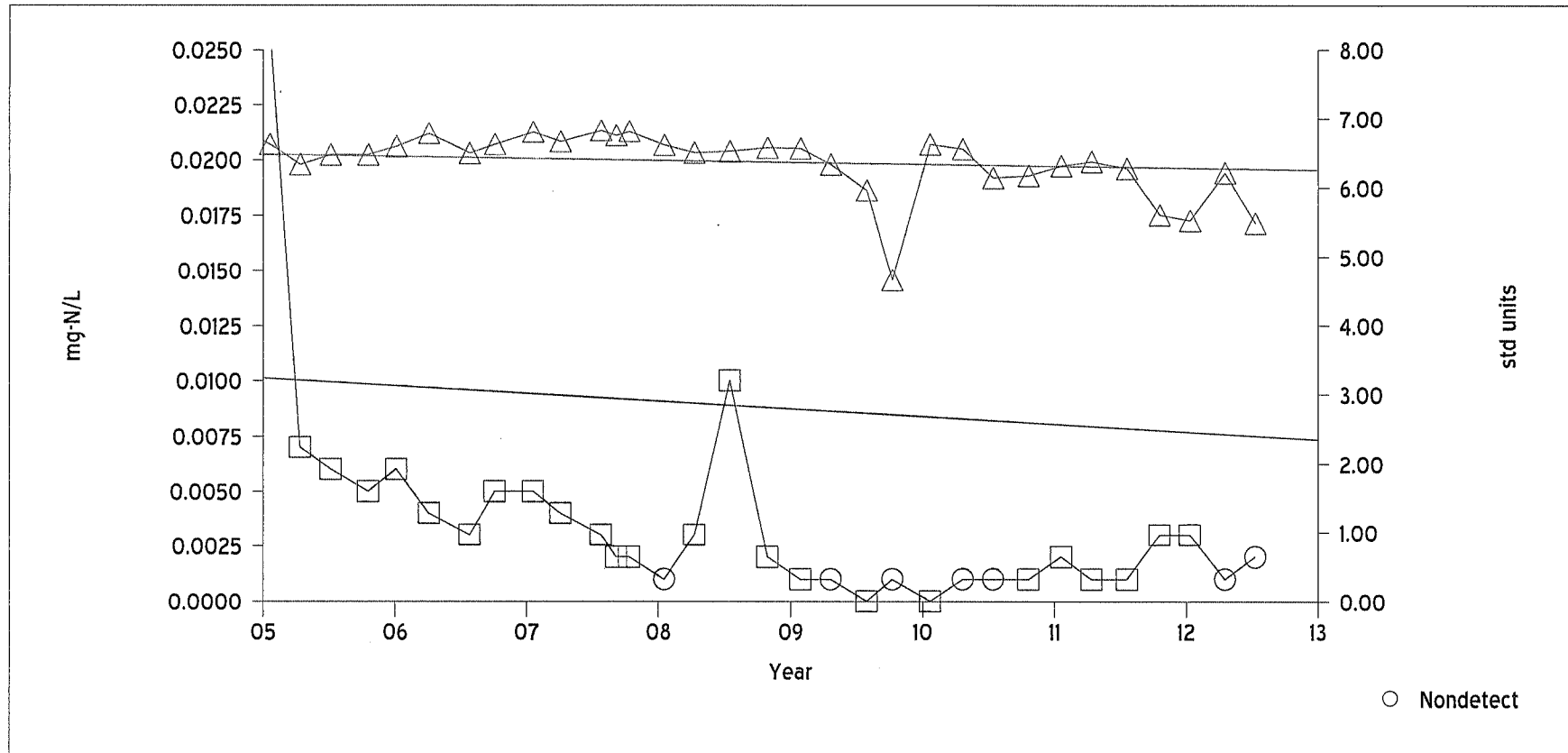
□ Dissolved sodium (cc: -.878)  
 △ Sulfate (cc: -.254)

▽ Alkalinity (as  $\text{CaCO}_3$ ) (cc: .782)

○ Nondetect

# **Goodwin Landfill**

Time Series Plot for LG-05



□ Nitrite nitrogen (cc: -.203)

△ pH (cc: -.469)

Offscale Points

□ Nitrite nitrogen on 1/17/2005 was 0.026 mg-N/L