Lake Goodwin Landfill 2010 1st Quarter Groundwater Monitoring Report

Photo taken 8/1/08

Contents

Table of Tables

List of Figures

Table of Appendices

1.0 INTRODUCTION

The following report presents the first quarter ground water monitoring results for 2010 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*).

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 <u>Solid Waste Facility Permit</u> (*SW-085, 2009*). 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 <u>Solid Waste Facility Permit SW-085</u> (*landfill permit, Snohomish Health District 2009*). 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 <u>Snohomish Health District Sanitary Codes</u>, *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.*

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 locally referred to as the Tulalip Plateau, a rolling upland area bounded by the Stillaquamish 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 site. 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 GEOLOGY

Surficial geology of the site area has been mapped by the **USGS** and is shown on the "Geologic Map of the Stanwood Quadrangle, Snohomish County, Wa." by J.P. Minard dated 1985. Surficial geologic units mapped in the vicinity of the project site are typical for glaciated landscapes throughout Snohomish County. As shown on the **Geologic Map** (*figure 4*), Vashon Glacial Till (*Qvt*) and Vashon Advance Outwash (*Qva*) are the predominately mapped surficial geologic units in the immediate vicinity of the project site.

Glacial Till (*Qvt*) consists of a nonsorted mixture of silt, sand and gravel deposited as a lodgment till below the Vashon aged glaciers as they advanced through this area. The deposits are generally very compact and where undisturbed will have a consistency similar to concrete. In this area Glacial Till (*Qvt*) is fairly sandy, with significant amounts of gravels and cobbles. Glacial Till (*Qvt*) is generally considered to be an aquiclude, not readily transmitting ground water through it. Locally, ground water may travel through and along discontinuous lenses of sand and gravel or through sandier portions of the Glacial Till (*Qvt*) within the upper couple of feet of the section. However, these discontinuous lenses of sand and gravel are difficult to characterize or quantify and are not considered to be reliable sources of ground water.

Advance Outwash (*Qva*) consists primarily of fine- to coarse-grained layers of sand and gravel deposited as the Vashon aged glaciers advanced into this area. At depth, these deposits can contain significant amounts of silt and/or clay. There is a gradational contact with the underlying Transitional Beds (*Qtb*) found below this geologic unit, with the silt/clay beds becoming thicker and more predominant with depth. The Advance Outwash (*Qva*) sands and gravels are generally very compact, having been overridden by thousands of feet of glacial ice. Advance Outwash (*Qva*) sands and gravels contain significant amounts of ground water and because of their relative shallow stratigraphic depth throughout the County, are the predominant source for ground water.

Glacial Till (*Qvt*) was encountered within one upgradient well at the site (*LG-02*). The Glacial Till (*Qvt*) was overlying basal Advance Outwash (*Qva*) sands and gravels. All other explorations at the site (*LG-01, LG-03, LG-04 and LG-05*) encountered only and were completed within Advance Outwash (*Qva*) sands and gravels. Several of the test borings were terminated in the gradational zone at the base of the Advance Outwash (*Qva*) unit.

1.5 HYDROGEOLOGY

Hydrogeologic conditions in the vicinity of the landfill have been studied by many including **EPA, USGS** and the **Army Corps of Engineers**. In the early to late 1980's, the **Seven Lakes Water Association** petitioned the **EPA** for consideration of a sole source aquifer area that included the landfill site. This petition was made in order to protect their rapidly degrading ground water resource which was the only source of ground water for the residents of the area at that time. The **EPA** consulted with the **USGS**, who, upon closer investigation, recommended that the boundaries of the proposed sole source aquifer be expanded to include a much larger area, which was renamed the Tulalip Sole Source Aquifer. The **USGS** expanded the boundaries of the Seven Lakes proposed sole source aquifer in order to protect the recharge source for a deep aquifer, found below the Tulalip Plateau and a larger area of Snohomish County. Recharge areas for this deep aquifer were determined to be located along the west margins of the Cascade Mountains. This deep aquifer is within pre-Glacial Undifferentiated Sands and Gravels (*Qu*) that are found stratigraphically lower than the Advance Outwash (*Qva*) aquifer. A thick sequence of Transitional Bed (*Qtb*) silts and clays act as an aquitard between the Advance Outwash (*Qva*) and Undifferentiated (*Qu*) aquifers. The petition for the Tulalip Sole Source Aquifer was eventually denied because other sources of water were available for domestic and commercial use over a large portion of the area.

Hydrogeologic conditions at the landfill were investigated by **Converse Consultants NW**. The results of their investigations were reported in their study titled "Hydrogeologic Study, Lake Goodwin Landfill" dated July 1991. Subsequent site explorations were completed by **Golder Associates** and were documented in their report titled "Snohomish County Lake Goodwin Landfill" dated December 1991. With the exception of the surficial Glacial Till (*Qvt*) found overlying Advance Outwash (*Qva*) sands and gravels in LG-02, permeable soils were encountered from the surface down in all site explorations. Ground water was found within the Advance Outwash (*Qva*) sands and gravels ranging between approximate elevations el. 148 and el. 153 during the reporting time period. The Advance Outwash (*Qva*) ground water flow direction was found to be in the north-northeast direction below the landfill at a calculated velocity of about 1.6 ft./day.

1.6 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 is currently a total of five-(*5*) ground water monitoring wells (*LG-01 thru 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 up-gradient wells monitoring background ground water conditions in the immediate vicinity of the site (*LG-02*). The remaining four-(*4*) wells are located in and/or down gradient of the landfill (*LG-01, and LG-03 thru LG-05*) and monitor ground water conditions that may be impacted from the site. First quarter monitoring results are discussed in section 2.0 below.

2.0 GROUND WATER MONITORING

First quarter 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. In order to avoid cross contamination between wells, the electronic indicator probe and cable are decontaminated between uses.

First Quarter Ground Water Measurements are shown in *Table 1* below. **Hydrographs** of the first quarter 2010 monitoring well readings are contained in *Appendix A* of this report. Based on the ground water readings, small fluctuations in the ground water gradient below the site were observed. Overall ground water elevations remained fairly constant between the monitoring events. Readings suggest that the aquifer is unconfined in the immediate vicinity of the site. The **First Quarter Ground Water Contour Map** developed from the field data is shown in *Figure 6* of this report.

Measured precipitation at the Arlington Airport during the first quarter monitoring period was 14.3". For reference purposes, precipitation measured at the Arlington Airport during the monitoring period has been included on the hydrographs.

Table 1 First Quarter Groundwater Measurements and Elevations

Well Numbers	Casing Elevation	1st Quarter Reading/Elevation	
LG-01	239.18	87.72	151.46
LG-02	268.99	NA	NA
LG-03	241.20	90.61	150.59
LG-04	206.93	57.71	149.22
LG-05	235.00	85.02	149.98

Note: NA readings were deemed unreliable upon review

2.2 First Quarter Ground Water Sampling Event

Purging and sampling of each of the five-(5) monitoring wells was performed during the first quarter by **Snohomish County** personnel in accordance with the facilities closure permit. Approximately 1.5 to 3.0 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 40C 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. **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 First Quarter Ground Water Analytical Results

First Quarter Ground Water Test Results for each well are summarized in *Table 2* below. A comparison of results to regulatory criteria shows:

First Quarter: Elevated conductivity levels above 700 micro ohms per centimeter (*umhos/cm*) and dissolved sodium levels above 20 mg/l were found in down gradient wells LG-03 and LG-05. Arsenic was also slightly elevated in LG-02 during this sampling event. No VOC's were detected in any well during this sampling event.

Table 2 Summary of Test Results - First Quarter

Well	First Quarter 2010 Exceedances
LG-01	pH
LG-02	pH
LG-03	Conductivity, pH, Sodium
LG-04	pH
LG-05	Conductivity, Nitrate, Sodium

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, Dissolved Metals and Volatile Organic Compounds – 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.

The items listed in *Table 2* exceeded the most stringent of the criteria in each **WAC**. Each of these exceedances has been statistically analyzed using **DUMPStat Software** (*version 2.1.8 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**.

Based on the statistical analysis, exceedances to the prediction limits were high for all of the conventional chemistry parameters, fairly minimal for the dissolved metals and there were no exceedances in the VOC's at any well. Calculated exceedances to the prediction limits in the first quarter are shown in *Table 3* below.

Table 3 Statistical Summary - First Quarter Limit Exceedances for 2010

Well	First Quarter 2010 Exceedances
LG-01	Alkalinity, Bicarbonate, Calcium, Conductivity, Magnesium, Nitrate, pH, Potassium, Sulfate, Barium, Selenium
LG-02	pH
LG-03	Alkalinity, Ammonia, Bicarbonate, Calcium, Chloride, Conductivity, Magnesium, Nitrate, pH, Potassium, Sodium, Sulfate, Barium
LG-04	Calcium, pH, Barium
LG-05	Alkalinity, Ammonia, Bicarbonate, Calcium, Chloride, Conductivity, Magnesium, Nitrate, Potassium, Sulfate, Barium

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

3.0 SUMMARY AND RECOMMENDATIONS

The ground water data collected during the 2010 first quarter sampling events indicates the following:

- VOC's were not detected in any monitoring well during the sampling event.
- Measured conductivity was well above background levels (*LG-02*) in all down gradient wells during this sampling event. Conductivity levels observed at wells LG-03 and LG-05 were nearly twice as high as those in the surrounding wells during this sampling event.
- pH levels were not significantly low or significantly high in any of the wells - but did show slight variations from the normal range during this sampling event.
- Statistical analysis did show significant impacts to wells LG-03 and LG-05. Lesser impacts where indicated in wells LG-01 and LG-04. Alkalinity appears to be increasing significantly in all wells, including up gradient well LG-02. Time series plots based on the **DUMPStat** analysis indicates that the majority of the other impact trends are decreasing in the monitoring wells at this time.
- There were very minimal impacts to the ground water from dissolved metals. Occasional small hits were recorded in the wells that were limited to: Arsenic, Barium, Iron, Nickel and Selenium.

3.1 CONCLUSIONS/RECOMMENDATIONS

First quarter 2010 data indicates that there is a leachate impact to the underlying Advance Outwash (*Qva*) ground water 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. The data also suggests that the leachate plume extends beyond the landfill boundaries following the ground water gradient to the north-northeast.

Quarterly monitoring of the landfill will continue through 2010.

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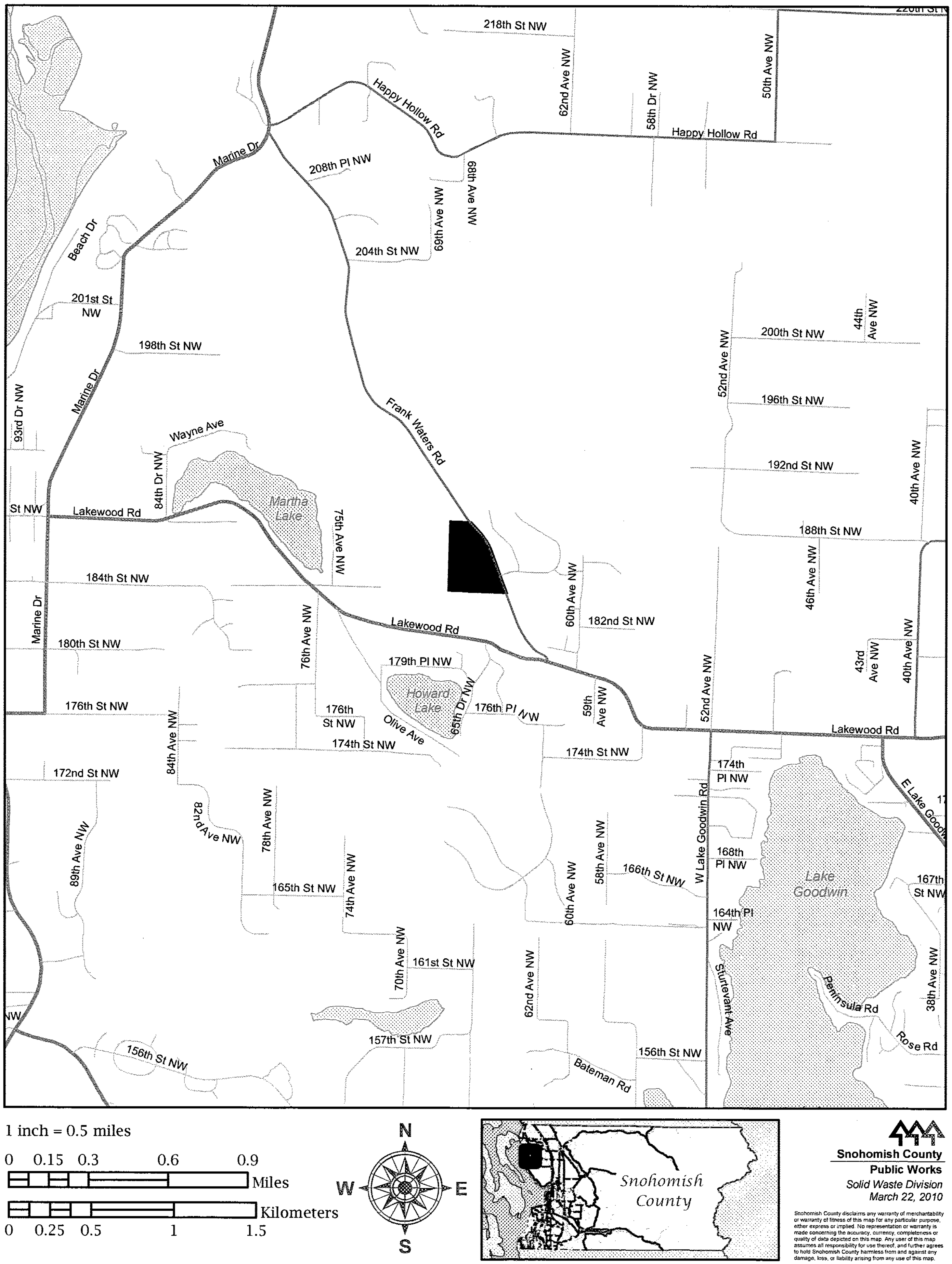
Kirk R. Bailey, LEG, LHG
SCPW – Engineering Services

May 11, 2010

State of Washington
Hydrogeologist
868
Licensed Geologist
KIRK R. BAILEY
5/11/10

Figure 1

Lake Goodwin Landfill

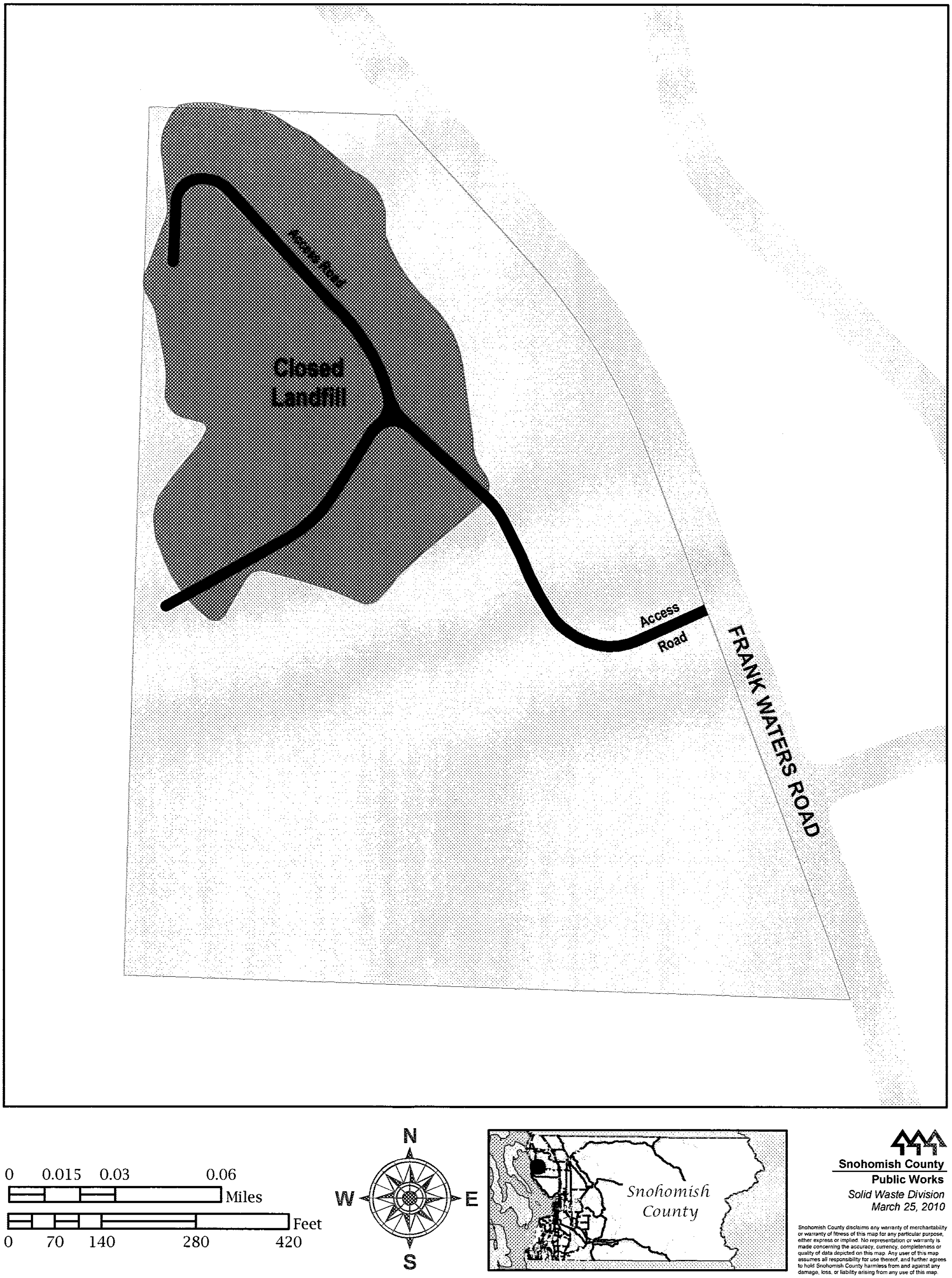


Snohomish County
Public Works
Solid Waste Division
March 22, 2010

Snohomish County disclaims any warranty of merchantability or warranty of fitness of this map for any particular purpose, either express or implied. No representation or warranty is made concerning the accuracy, currency, completeness or quality of data depicted on this map. Any user of this map assumes all responsibility for use thereof, and further agrees to hold Snohomish County harmless from and against any damage, loss, or liability arising from any use of this map.

Figure 2

Lake Goodwin Landfill Site Map



Snohomish County
Public Works
Solid Waste Division
March 25, 2010

Figure 3

Lake Goodwin Landfill

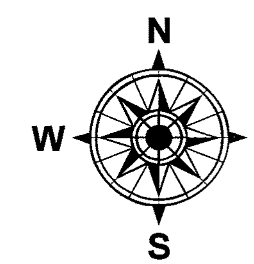
Topography

Map Features

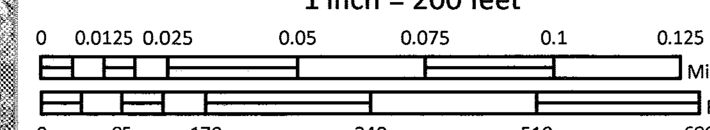
Parcel Boundary

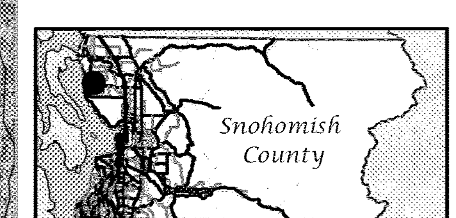
Subject Property Boundary

5 Foot Contours



1 inch = 200 feet





Snohomish County
Public Works
Solid Waste Division
March 23, 2010

Figure 3

Lake Goodwin Landfill

Topography

Map Features

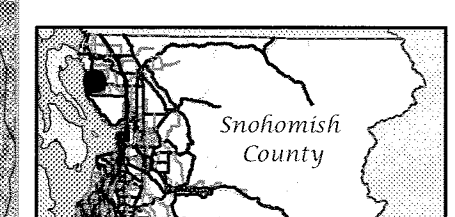
- Parcel Boundary
- Subject Property Boundary
- 5 Foot Contours

N
W E
S

1 inch = 200 feet

0 0.0125 0.025 0.05 0.075 0.1 0.125 Miles

0 85 170 340 510 680 Feet



Snohomish County
Public Works
Solid Waste Division
March 23, 2010

Figure 4

Lake Goodwin Landfill

Geologic Map

Map Features

Parcel Boundary

Subject Property Boundary

Geologic Description

Vashon advance outwash (Qva)

Vashon recessional outwash

Vashon till (Qvt)

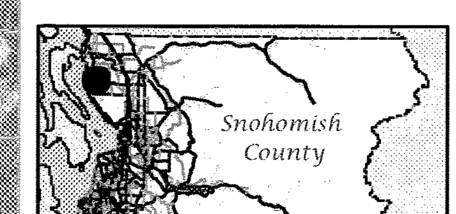
Water

Modified Land

1 inch = 600 feet

0 0.035 0.07 0.14 0.21 0.28 0.35 Miles

0 240 480 960 1,440 1,920 Feet



N S W E

Snohomish County
Public Works
Solid Waste Division
May 6, 2010

Figure 5

Lake Goodwin Landfill

Groundwater Monitoring Network

Map Features

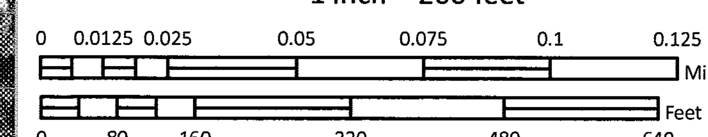
Parcel Boundary

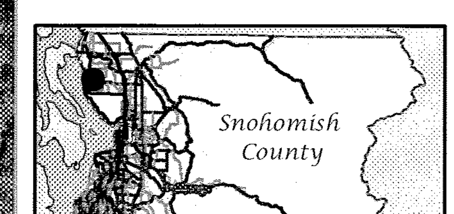
Subject Property Boundary

Aquifer Unit (Active Wells)

Deep Aquifer

1 inch = 200 feet





Snohomish County
Public Works
Solid Waste Division
April 15, 2010

Figure 6

Lake Goodwin Landfill

Water Elevation Contours 1st Quarter 2010

DIRECTION OF GROUNDWATER FLOW
2.31 ft/day
843 ft/year
75.27 degrees to the positive x-axis

PARCEL BOUNDARY

SUBJECT PROPERTY BOUNDARY

1 FT CONTOUR

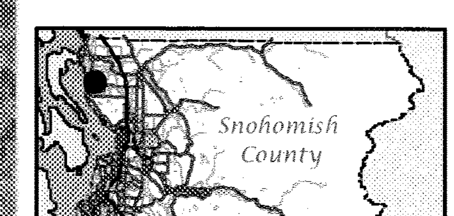
WELL LOCATION

WELL_ID	SAMP_DATE	MEAS_HEAD
LG-01	01/20/2010	151.56
LG-03	01/20/2010	150.59
LG-04	01/20/2010	149.22
LG-05	01/20/2010	149.98

1 inch = 200 feet

0 0.0125 0.025 0.05 0.075 0.1 0.125 Miles

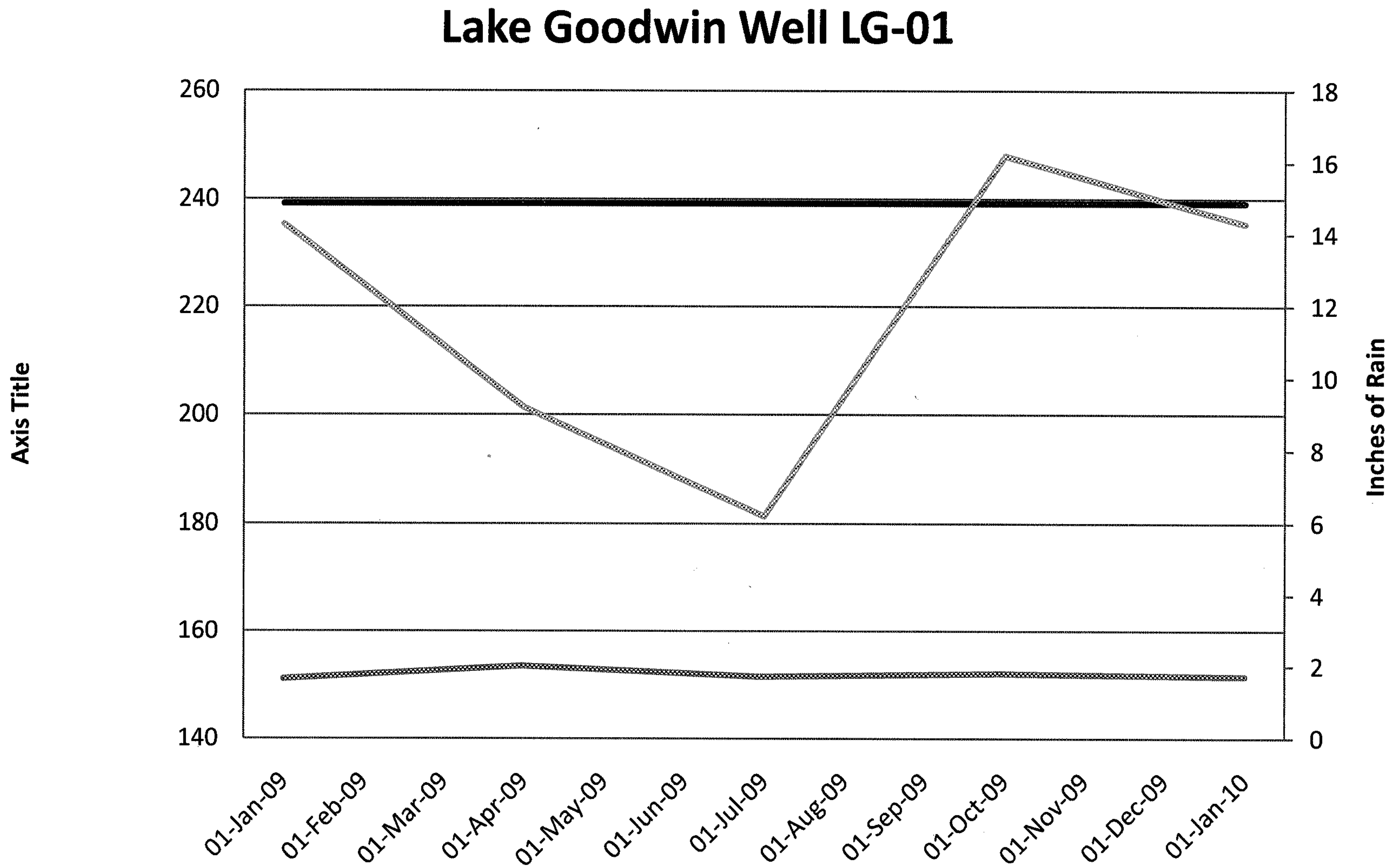
0 85 170 340 510 680 Feet



Snohomish County Public Works
Solid Waste Division
May 10, 2010

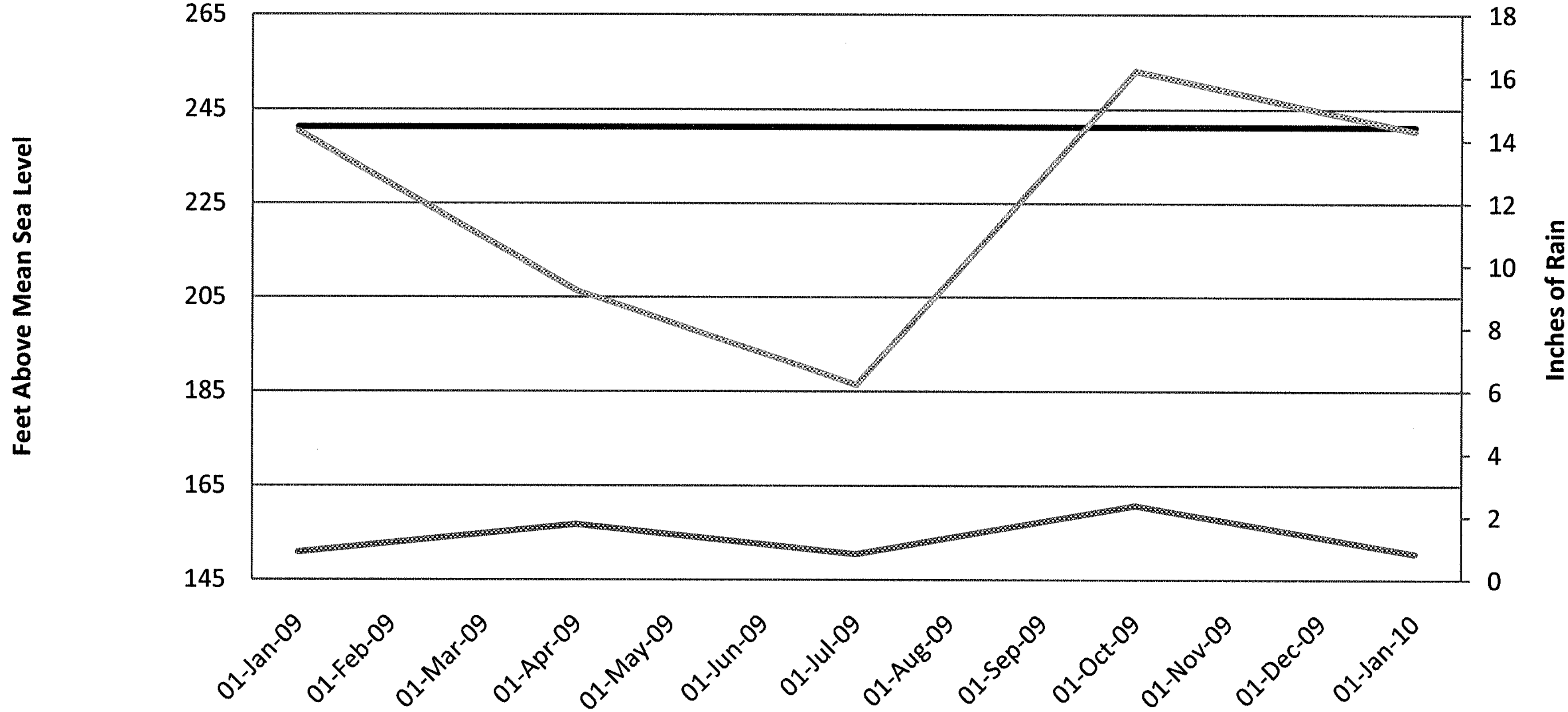
Appendix A

Hydrographs



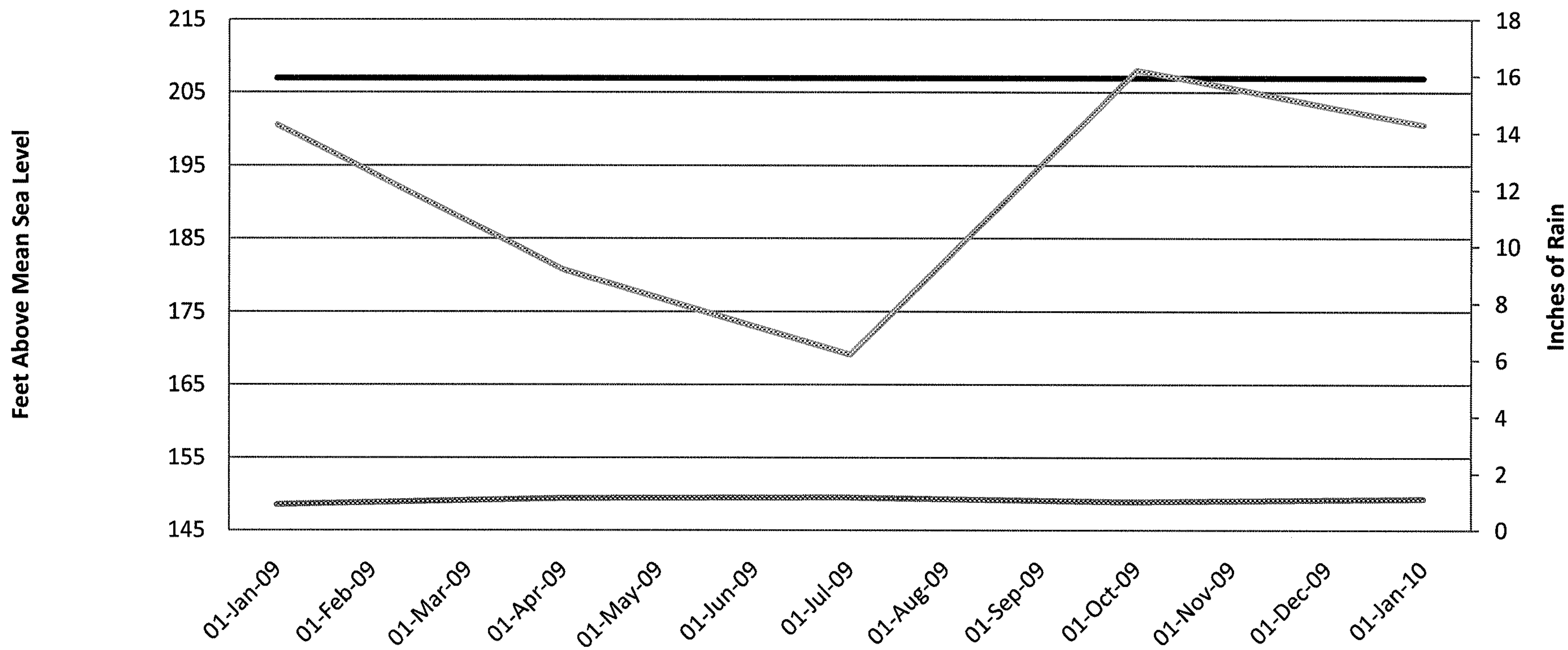
	27-Jan-09	21-Apr-09	29-Jul-09	08-Oct-09	20-Jan-10
Depth to Water	151.06	153.43	151.48	152.04	151.46
Well Casing	239.18	239.18	239.18	239.18	239.18
Precipitation	14.3	9.2	6.2	16.2	14.3

Lake Goodwin Well LG-03



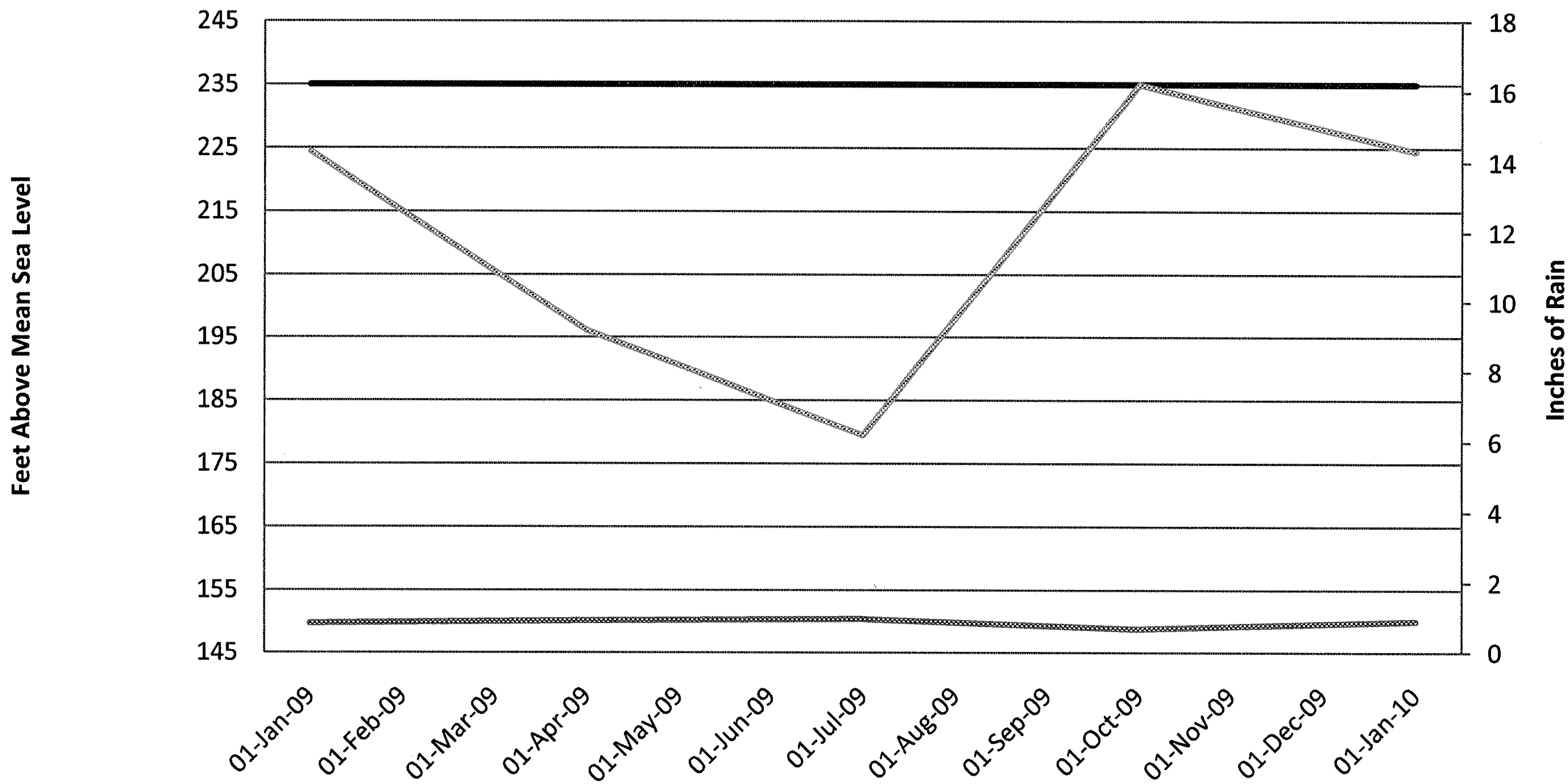
	27-Jan-09	21-Apr-09	29-Jul-09	08-Oct-09	20-Jan-10
Depth to Water	150.86	156.82	150.51	160.84	150.59
Well Casing	241.2	241.2	241.2	241.2	241.2
Precipitation	14.3	9.2	6.2	16.2	14.3

Lake Goodwin Well LG-04



	27-Jan-09	21-Apr-09	31-Jul-09	08-Oct-09	20-Jan-10
Depth to Water	148.5	149.34	149.46	148.84	149.22
Well Casing	206.93	206.93	206.93	206.93	206.93
Precipitation	14.3	9.2	6.2	16.2	14.3

Lake Goodwin Well LG-05



	27-Jan-09	21-Apr-09	29-Jul-09	08-Oct-09	20-Jan-10
MSL Water Level	149.71	150.11	150.39	148.79	149.98
Well Casing	235	235	235	235	235
Precipitation	14.3	9.2	6.2	16.2	14.3

Appendix B

Analytical Data

TABLE 2
GROUNDWATER STATISTICAL SUMMARY: QUARTER 1 2010
LAKE GOODWIN LANDFILL
SNOHOMISH COUNTY, WASHINGTON

						Downgradient																				Upgradient				
	Statistical Method	No. of Samples	No. of Detects	Prediction Limit (a)	MCL	LG-01 1/20/10	D	V	Trend	Ch	LG-03 1/20/10	D	V	Trend	Ch	LG-04 1/20/10	D	V	Trend	Ch	LG-05 1/20/10	D	V	Trend	Ch	LG-02 1/20/10	D	V	Trend	Ch
CONVENTIONAL CHEMISTRY PARAMETERS (mg/L unless noted)																														
Alkalinity (as CaCO3)	nonpar	29	29	130	--	160		V			320		V	I	N	130					280		V			82			I	N
Ammonia Nitrogen	nonpar	72	31	0.1	--	0.114					0.125					0.093	U				0.114					0.013				
Bicarbonate	nonpar	29	29	130	--	160		V			320		V			130			D	N	280		V	D	N	82				
Calcium, Dissolved	normal	29	29	21.8028	--	27		V			44.1		V			23.1		E	D	N	39.6		V	D	N	16.5				
Chemical Oxygen DemaU	nonpar	61	9	26	--	16					10	U				10	U				10	U				10	U			
Chloride	lognor	75	75	11.2175	250	4.3					21		V	D	N	7			D	N	15		E			7.6				
Conductivity (umhos/cm)	normal	70	70	369.9207	700	430		E	I	N	800		V			340					800		V			230				
Magnesium, Dissolved	normal	28	28	20.3965	--	34.4		V			65.2		V			22		E	D	N	53.9		V	D	N	15				
Nitrate Nitrogen (mg-N/L)	nonpar	66	66	2.8	10	3.8		E	I		5.7		V	D	N	1.3					12		V			1.9			I	N
Nitrite Nitrogen (mg-N/L)	nonpar	71	16	0.012	1	0.003	U				0.003	U				0.003	U				0.003	U				0.002				
pH (std units)	nonpar	78	78	6.86- 8.71	6.5-8.5	6.19					6.24		V			5.92		V			6.62		V			6.45				
Potassium, Dissolved	normal	29	29	3.5087	--	4.03		V			5.67		V			3.33			D	N	6.19		V	D	N	2.69				
Sodium, Dissolved	nonpar	27	27	13.8	20	11.6			D	N	31.9		V			13.1			D	N	45.6		V	D	N	8.7				
Sulfate	lognor	75	75	17.9804	250	38		V			82		V			16					29		V			14			I	N
Total Dissolved Solids	nonpar	28	28	550	500	250					500			I	Y	190			D	N	490			D	N	160				
Total Organic Carbon	nonpar	75	25	13	--	2.1		P			3.7					1.7					5					2.7				
DISSOLVED METALS																														
EPA Methods 6010B/7131A (mg/L)																														
Antimony	nonpar	27	0	0.01	0.006	0.01	U				0.01	U				0.01	U				0.01	U				0.01	U			
Arsenic	nonpar	60	59	0.006	0.01	0.001	U				0.001	U				0.001	U				0.001					0.003				
Barium	nonpar	60	60	0.021	2	0.0219					0.051		V			0.0222					0.0558		V			0.01				
Beryllium	nonpar	26	0	0.0005	0.004	0.0005	U				0.0005	U				0.0005	U				0.0005	U				0.0005	U			
Cadmium	nonpar	62	11	0.002	0.005	0.00006					0.00008					0.00006					0.00004					0.00005				
Chromium	nonpar	61	32	0.015	0.1	0.001	U				0.001	U				0.001	U				0.001	U				0.001	U			
Cobalt	nonpar	26	6	0.008	--	0.001	U				0.001	U				0.001	U				0.001	U				0.001	U			
Copper	nonpar	59	15	0.008	1.3	0.001	U				0.003					0.002					0.001					0.002				
Iron	nonpar	74	17	0.14	0.3	0.005	U				0.005	U				0.005	U				0.008	U				0.005	U			
Lead	nonpar	62	4	0.002	0.015	0.001	U				0.001	U				0.001	U				0.001	U				0.001	U			
Manganese	nonpar	71	21	0.0136	0.05	0.0005	U				0.0005	U				0.0005	U				0.0005	U				0.0005	U			
Nickel	nonpar	63	1	0.01	0.1	0.005	U				0.01					0.005	U				0.005	U				0.005	U			
Selenium	nonpar	62	3	0.002	0.05	0.002					0.001	U				0.001	U				0.001	U				0.001				
Silver	nonpar	62	2	4.2501	0.1	0.0001	U				0.0001	U				0.0001	U				0.0001	U				0.0001	U			
Thallium	nonpar	26	0	0.001	0.002	0.001	U				0.001	U				0.001	U				0.001	U				0.001	U			
Vanadium	nonpar	27	6	0.01	--	0.005	U				0.005	U				0.005	U				0.005	U				0.005	U			
Zinc	nonpar	71	26	0.06	5	0.001	U				0.001	U				0.001	U				0.001	U				0.001	U			
VOLATILE ORGANIC COMPOUUS (VOCs)																														
EPA Method 8260 (µg/L)																														
1,1,1-Trichloroethane	Too Many Non-Detects			N/A	200	1	U				1	U				1	U				1	U				1	U			
1,1,2,2-Tetrachloroethane	Too Many Non-Detects			N/A	--	1	U				1	U				1	U				1	U				1	U			
1,1,2-Trichloroethane	Too Many Non-Detects			N/A	--	1	U				1	U				1	U				1	U				1	U			
1,1-Dichloroethane	Too Many Non-Detects			N/A	1	1	U				1	U				1	U				1	U				1	U			
1,1-Dichloroethylene	Too Many Non-Detects			N/A	7	1	U				1	U				1	U				1	U				1	U			
1,2,3-Trichloropropane	Too Many Non-Detects			N/A	--	1	U				1	U				1	U				1	U				1	U			
1,2-Dibromo-3-chloropropane	Too Many Non-Detects			N/A	5	5	U				5	U				5	U				5	U				5	U			
1,2-Dibromoethane	Too Many Non-Detects			N/A	1	1	U				1	U				1	U				1	U				1	U			
1,2-Dichlorobenzene	Too Many Non-Detects			N/A	600	1	U				1	U				1	U				1	U				1	U			
1,2-Dichloroethane	Too Many Non-Detects			N/A	5	1	U				1	U				1	U				1	U				1	U			
1,2-Dichloropropane	Too Many Non-Detects			N/A	5	1	U				1	U				1	U				1	U				1	U			
1,4-Dichlorobenzene	Too Many Non-Detects			N/A	75	4	U				4	U				4	U				4	U				4	U			
2-Butanone	Too Many Non-Detects			N/A	--	5	U				5	U				5	U				5	U				5	U			

TABLE 2
GROUNDWATER STATISTICAL SUMMARY: QUARTER 1 2010
LAKE GOODWIN LANDFILL
SNOHOMISH COUNTY, WASHINGTON

	Statistical Method	No. of Samples	No. of Detects	Prediction Limit (a)	MCL	Downgradient																				Upgradient				
						LG-01					LG-03					LG-04					LG-05					LG-02				
						1/20/10	D	V	Trend	Ch	1/20/10	D	V	Trend	Ch	1/20/10	D	V	Trend	Ch	1/20/10	D	V	Trend	Ch	1/20/10	D	V	Trend	Ch
2-Hexanone	Too Many Non-Detects			N/A	--	5	U				5	U				5	U				5	U				5	U			
4-Methyl-2-Pentanone (MIBK)	Too Many Non-Detects			N/A	--	5	U				5	U				5	U				5	U				5	U			
Acetone	Too Many Non-Detects			N/A	--	5	U				5	U				5	U				5	U				5	U			
Acrylonitrile	Too Many Non-Detects			N/A	5	5	U				5	U				5	U				5	U				5	U			
Benzene	Too Many Non-Detects			N/A	5	1	U				1	U				1	U				1	U				1	U			
Bromodichloromethane	Too Many Non-Detects			N/A	1	1	U				1	U				1	U				1	U				1	U			
Bromoform	Too Many Non-Detects			N/A	5	1	U				1	U				1	U				1	U				1	U			
Bromomethane	Too Many Non-Detects			N/A	--	1	U				1	U				1	U				1	U				1	U			
Carbon Disulfide	Too Many Non-Detects			N/A	--	1	U				1	U				1	U				1	U				1	U			
Carbon Tetrachloride	Too Many Non-Detects			N/A	5	1	U				1	U				1	U				1	U				1	U			
Chlorobenzene	Too Many Non-Detects			N/A	100	1	U				1	U				1	U				1	U				1	U			
Chlorodibromomethane	Too Many Non-Detects			N/A	1	1	U				1	U				1	U				1	U				1	U			
Chloroethane	Too Many Non-Detects			N/A	--	1	U				1	U				1	U				1	U				1	U			
Chloroform	Too Many Non-Detects			N/A	7	1	U				1	U				1	U				1	U				1	U			
Chloromethane	Too Many Non-Detects			N/A	--	1	U				1	U				1	U				1	U				1	U			
cis-1,2-Dichloroethene	Too Many Non-Detects			N/A	70	1	U				1	U				1	U				1	U				1	U			
cis-1,3-Dichloropropene	Too Many Non-Detects			N/A	--	1	U				1	U				1	U				1	U				1	U			
Dibromomethane	Too Many Non-Detects			N/A	--	1	U				1	U				1	U				1	U				1	U			
Ethyl Benzene	Too Many Non-Detects			N/A	700	1	U				1	U				1	U				1	U				1	U			
m,p-Xylene	Too Many Non-Detects			N/A	10000	1	U				1	U				1	U				1	U				1	U			
Methyl Iodide	Too Many Non-Detects			N/A	--	5	U				5	U				5	U				5	U				5	U			
Methylene Chloride	Too Many Non-Detects			N/A	5	1.5	U				1.5	U				1.5	U				1.5	U				1.5	U			
o-Xylene	Too Many Non-Detects			N/A	10000	1	U				1	U				1	U				1	U				1	U			
Styrene	Too Many Non-Detects			N/A	100	1	U				1	U				1	U				1	U				1	U			
Tetrachloroethylene	Too Many Non-Detects			N/A	5	1	U				1	U				1	U				1	U				1	U			
Toluene	Too Many Non-Detects			N/A	1000	1	U				1	U				1	U				1	U				1	U			
trans-1,2-Dichloroethene	Too Many Non-Detects			N/A	100	1	U				1	U				1	U				1	U				1	U			
trans-1,3-Dichloropropene	Too Many Non-Detects			N/A	--	1	U				1	U				1	U				1	U				1	U			
trans-1,4-Dichloro-2-butene	Too Many Non-Detects			N/A	--	5	U				5	U				5	U				5	U				5	U			
Trichlorethene (1,1,2-Trichloroethylene)	Too Many Non-Detects			N/A	5	1	U				1	U				1	U				1	U				1	U			
Trichlorofluoromethane	Too Many Non-Detects			N/A	--	1	U				1	U				1	U				1	U				1	U			
Vinyl Acetate	Too Many Non-Detects			N/A	--	5	U				5	U				5	U				5	U				5	U			
Vinyl Chloride	Too Many Non-Detects			N/A	2	0.2	U				0.2	U				0.2	U				0.2	U				0.2	U			

mg/L = milligrams per liter (ppm).
μg/L = micrograms per liter (ppb).
U = IUicates compouU was not detected at the given reporting limit.
Boxed cells iUicate an exceedance of prediction limit criteria.
Bold cells iUicate a detected compouU.
D Column: U = Compound not detected in any sample
V Column: V = verified hit, E = exceedance, waiting verification; P = Passed, exceedance not verified
(a) Prediction limit calculated using DUMPStat.
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.

TABLE 2
GROUNDWATER STATISTICAL SUMMARY: QUARTER 1 2010
LAKE GOODWIN LANDFILL
SNOHOMISH COUNTY, WASHINGTON

	Statistical Method	No. of Samples	No. of Detects	Prediction Limit (a)	MCL	SDWA	Downgradient LG-01 1/20/10	Trend	LG-03 1/20/10	Trend	LG-04 1/20/10	Trend	LG-05 1/20/10	Trend	Updradient LG-02 1/20/10	Trend
CONVENTIONAL CHEMISTRY PARAMETERS (mg/L unless noted)																
Alkalinity (as CaCO3)	nonpar	29	29	130	--	--	160		320	I	130		280		82	I
Ammonia Nitrogen	nonpar	72	31	0.1	--	--	0.114		0.125		0.093		0.114		0.013	
Bicarbonate	nonpar	29	29	130	--	--	160		320		130	D	280	D	82	
Calcium, Dissolved	normal	29	29	21.8028	--	--	27		44.1		23.1	D	39.6	D	16.5	
Chemical Oxygen DemaU	nonpar	61	9	26	--	--	16		10 U		10 U		10 U		10 U	
Chloride	lognor	75	75	11.2175	250	250	4.3		21	D	7	D	15		7.6	
CoUuctivity (umhos/cm)	normal	70	70	369.9207	700	--	430	I	800		340		800		230	
Magnesium, Dissolved	normal	28	28	20.3965	--	--	34.4		65.2		22	D	53.9	D	15	
Nitrate Nitrogen (mg-N/L)	nonpar	66	66	2.8	10	10	3.8	I	5.7	D	1.3		12		1.9	I
Nitrite Nitrogen (mg-N/L)	nonpar	71	16	0.012	1	1	0.003		0.003		0.003		0.003		0.002	
pH (std units)	nonpar	78	78	6.86- 8.71	6.5-8.5	6.5-8.5	6.19		6.24		5.92		6.62		6.45	
Potassium, Dissolved	normal	29	29	3.5087	--	--	4.03		5.67		3.33	D	6.19	D	2.69	
Sodium, Dissolved	nonpar	27	27	13.8	20	--	11.6	D	31.9		13.1	D	45.0	D	8.7	
Sulfate	lognor	75	75	17.9804	250	250	38		82		16		29		14	I
Total Dissolved Solids	nonpar	28	28	550	500	500	250		500	I	190	D	490	D	160	
Total Organic Carbon	nonpar	75	25	13	--	--	2.1		3.7		1.7		5		2.7	
DISSOLVED METALS																
EPA Methods 6010B/7131A (mg/L)																
Antimony	nonpar	27	0	0.01	0.05	0.006	0.01 U		0.01 U		0.01 U		0.01 U		0.01 U	
Arsenic	nonpar	60	59	0.006	0.001	0.01	0.001 U		0.001 U		0.001 U		0.001		0.003	
Barium	nonpar	60	60	0.021	1	2	0.0219		0.051		0.0222		0.0558		0.01	
Beryllium	nonpar	26	0	0.0005	0.004	0.004	0.0005 U		0.0005 U		0.0005 U		0.0005 U		0.0005 U	
Cadmium	nonpar	62	11	0.002	0.005	0.005	0.00006		0.00008		0.00006		0.00004		0.00005	
Chromium	nonpar	61	32	0.015	0.05	0.1	0.001 U		0.001 U		0.001 U		0.001 U		0.001 U	
Cobalt	nonpar	26	6	0.008	--	--	0.001 U		0.001 U		0.001 U		0.001 U		0.001 U	
Copper	nonpar	59	15	0.008	1	1.3	0.001 U		0.003		0.002		0.001		0.002	
Iron	nonpar	74	17	0.14	0.3	0.3	0.005 U		0.005 U		0.005 U		0.008		0.005 U	
Lead	nonpar	62	4	0.002	0.015	0.015	0.001 U		0.001 U		0.001 U		0.001 U		0.001 U	
Manganese	nonpar	71	21	0.0136	0.05	0.05	0.0005 U		0.0005 U		0.0005 U		0.0005 U		0.0005 U	
Nickel	nonpar	63	1	0.01	0.1	--	0.005 U		0.01		0.005 U		0.005 U		0.005 U	
Selenium	nonpar	62	3	0.002	0.005	0.05	0.002		0.001 U		0.001 U		0.001 U		0.001	
Silver	nonpar	62	2	4.2501	0.01	0.1	0.0001 U		0.0001 U		0.0001 U		0.0001 U		0.0001 U	
Thallium	nonpar	26	0	0.001	0.002	0.002	0.001 U		0.001 U		0.001 U		0.001 U		0.001 U	
Vanadium	nonpar	27	6	0.01	--	--	0.005 U		0.005 U		0.005 U		0.005 U		0.005 U	
Zinc	nonpar	71	26	0.06	5	5	0.001 U		0.001 U		0.001 U		0.001 U		0.001 U	
VOLATILE ORGANIC COMPOUUS (VOCs)																
EPA Method 8260 (µg/L)																
1,1,1-Trichloroethane	Too Many Non-Detects			N/A	200	200	1 U		1 U		1 U		1 U		1 U	
1,1,2,2-Tetrachloroethane	Too Many Non-Detects			N/A	--	--	1 U		1 U		1 U		1 U		1 U	
1,1,2-Trichloroethane	Too Many Non-Detects			N/A	--	--	1 U		1 U		1 U		1 U		1 U	
1,1-Dichloroethane	Too Many Non-Detects			N/A	1	--	1 U		1 U		1 U		1 U		1 U	
1,1-Dichloroethylene	Too Many Non-Detects			N/A	7	7	1 U		1 U		1 U		1 U		1 U	
1,2,3-Trichloropropane	Too Many Non-Detects			N/A	--	--	1 U		1 U		1 U		1 U		1 U	
1,2-Dibromo-3-chloropropane	Too Many Non-Detects			N/A	5	0.2	5 U		5 U		5 U		5 U		5 U	

TABLE 2
GROUNDWATER STATISTICAL SUMMARY: QUARTER 1 2010
LAKE GOODWIN LANDFILL
SNOHOMISH COUNTY, WASHINGTON

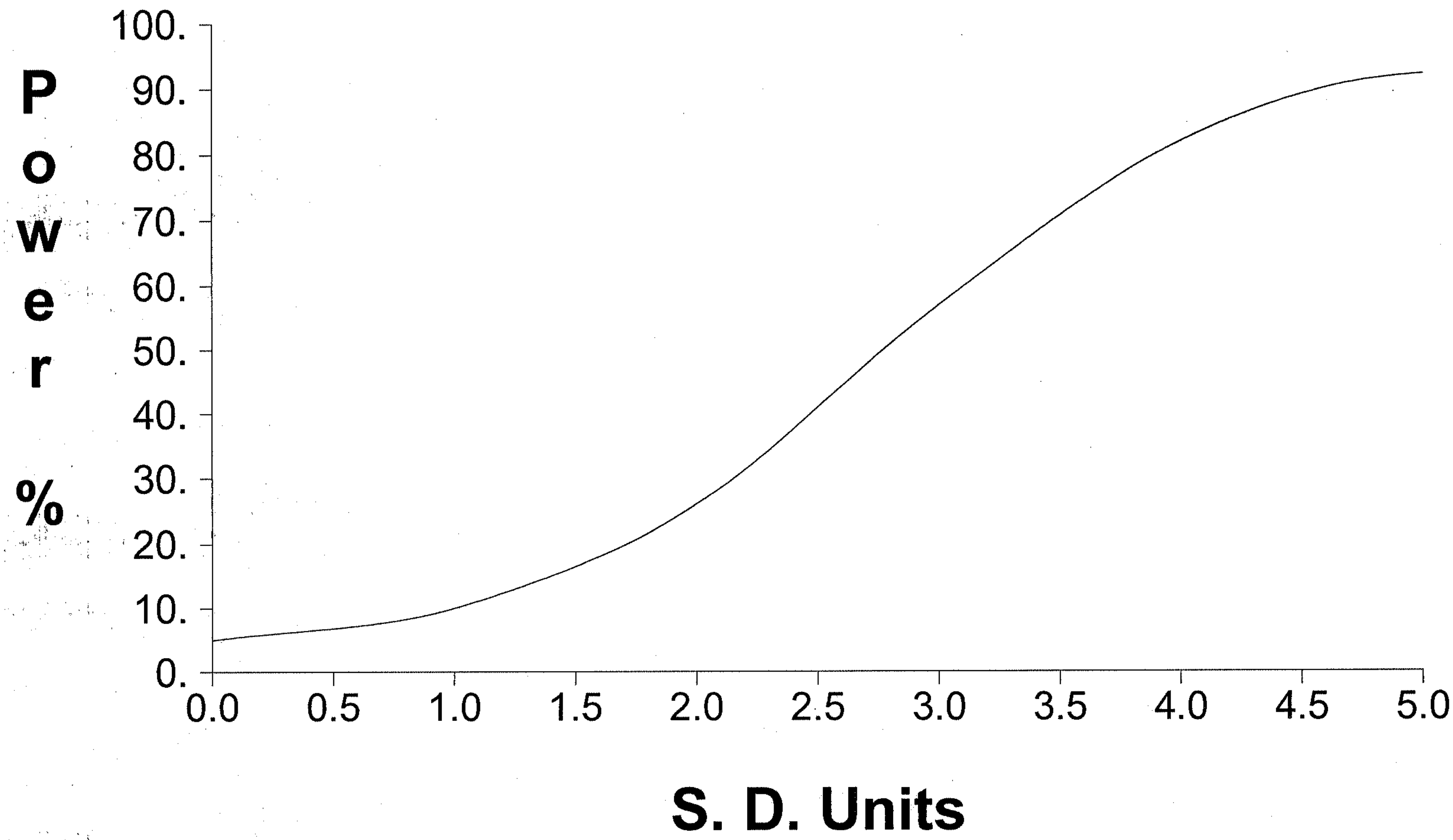
	Statistical Method	No. of Samples	No. of Detects	Prediction Limit (a)	MCL	SDWA	Downgradient								Updradient	
							LG-01		LG-03		LG-04		LG-05		LG-02	
							1/20/10	Trend	1/20/10	Trend	1/20/10	Trend	1/20/10	Trend	1/20/10	Trend
1,2-Dibromoethane	Too Many Non-Detects			N/A	1	--	1 U		1 U		1 U		1 U		1 U	
1,2-Dichlorobenzene	Too Many Non-Detects			N/A	--	75	1 U		1 U		1 U		1 U		1 U	
1,2-Dichloroethane	Too Many Non-Detects			N/A	1	5	1 U		1 U		1 U		1 U		1 U	
1,2-Dichloropropane	Too Many Non-Detects			N/A	1	5	1 U		1 U		1 U		1 U		1 U	
1,4-Dichlorobenzene	Too Many Non-Detects			N/A	4	600	4 U		4 U		4 U		4 U		4 U	
2-Butanone	Too Many Non-Detects			N/A	--	--	5 U		5 U		5 U		5 U		5 U	
2-Hexanone	Too Many Non-Detects			N/A	--	--	5 U		5 U		5 U		5 U		5 U	
4-Methyl-2-Pentanone (MIBK)	Too Many Non-Detects			N/A	--	--	5 U		5 U		5 U		5 U		5 U	
Acetone	Too Many Non-Detects			N/A	--	--	5 U		5 U		5 U		5 U		5 U	
Acrylonitrile	Too Many Non-Detects			N/A	5	--	5 U		5 U		5 U		5 U		5 U	
Benzene	Too Many Non-Detects			N/A	1	5	1 U		1 U		1 U		1 U		1 U	
Bromodichloromethane	Too Many Non-Detects			N/A	1	--	1 U		1 U		1 U		1 U		1 U	
Bromoform	Too Many Non-Detects			N/A	5	--	1 U		1 U		1 U		1 U		1 U	
Bromomethane	Too Many Non-Detects			N/A	--	--	1 U		1 U		1 U		1 U		1 U	
Carbon Disulfide	Too Many Non-Detects			N/A	--	--	1 U		1 U		1 U		1 U		1 U	
Carbon Tetrachloride	Too Many Non-Detects			N/A	1	5	1 U		1 U		1 U		1 U		1 U	
Chlorobenzene	Too Many Non-Detects			N/A	100	100	1 U		1 U		1 U		1 U		1 U	
Chlorodibromomethane	Too Many Non-Detects			N/A	1	--	1 U		1 U		1 U		1 U		1 U	
Chloroethane	Too Many Non-Detects			N/A	--	--	1 U		1 U		1 U		1 U		1 U	
Chloroform	Too Many Non-Detects			N/A	7	--	1 U		1 U		1 U		1 U		1 U	
Chloromethane	Too Many Non-Detects			N/A	--	--	1 U		1 U		1 U		1 U		1 U	
cis-1,2-Dichloroethene	Too Many Non-Detects			N/A	70	70	1 U		1 U		1 U		1 U		1 U	
cis-1,3-Dichloropropene	Too Many Non-Detects			N/A	--	--	1 U		1 U		1 U		1 U		1 U	
Dibromomethane	Too Many Non-Detects			N/A	--	--	1 U		1 U		1 U		1 U		1 U	
Ethyl Benzene	Too Many Non-Detects			N/A	700	700	1 U		1 U		1 U		1 U		1 U	
m,p-Xylene	Too Many Non-Detects			N/A	10000	--	1 U		1 U		1 U		1 U		1 U	
Methyl Iodide	Too Many Non-Detects			N/A	--	--	5 U		5 U		5 U		5 U		5 U	
Methylene Chloride	Too Many Non-Detects			N/A	5	--	1.5 U		1.5 U		1.5 U		1.5 U		1.5 U	
o-Xylene	Too Many Non-Detects			N/A	10000	--	1 U		1 U		1 U		1 U		1 U	
Styrene	Too Many Non-Detects			N/A	100	100	1 U		1 U		1 U		1 U		1 U	
Tetrachloroethylene	Too Many Non-Detects			N/A	1	5	1 U		1 U		1 U		1 U		1 U	
Toluene	Too Many Non-Detects			N/A	1	1	1 U		1 U		1 U		1 U		1 U	
trans-1,2-Dichloroethene	Too Many Non-Detects			N/A	100	100	1 U		1 U		1 U		1 U		1 U	
trans-1,3-Dichloropropene	Too Many Non-Detects			N/A	--	--	1 U		1 U		1 U		1 U		1 U	
trans-1,4-Dichloro-2-butene	Too Many Non-Detects			N/A	--	--	5 U		5 U		5 U		5 U		5 U	
Trichlorethene (1,1,2-Trichloroethylene)	Too Many Non-Detects			N/A	3	--	1 U		1 U		1 U		1 U		1 U	
Trichlorofluoromethane	Too Many Non-Detects			N/A	--	--	1 U		1 U		1 U		1 U		1 U	
Vinyl Acetate	Too Many Non-Detects			N/A	--	--	5 U		5 U		5 U		5 U		5 U	
Vinyl Chloride	Too Many Non-Detects			N/A	0.2	--	0.2 U		0.2 U		0.2 U		0.2 U		0.2 U	

mg/L = milligrams per liter (ppm).
μg/L = micrograms per liter (ppb).
U = IUicates compouU was not detected at the given reporting limit.
Boxed cells iUicate an exceedance of prediction limit criteria.
Bold cells iUicate a detected compouU.
U = Compound not detected in any sample; a valid prediction limit is not available for this compound.
(a) Prediction limit calculated using DUMPStat.
I means increasing trend, D means decreasing trend via Mann-Kendall Analysis

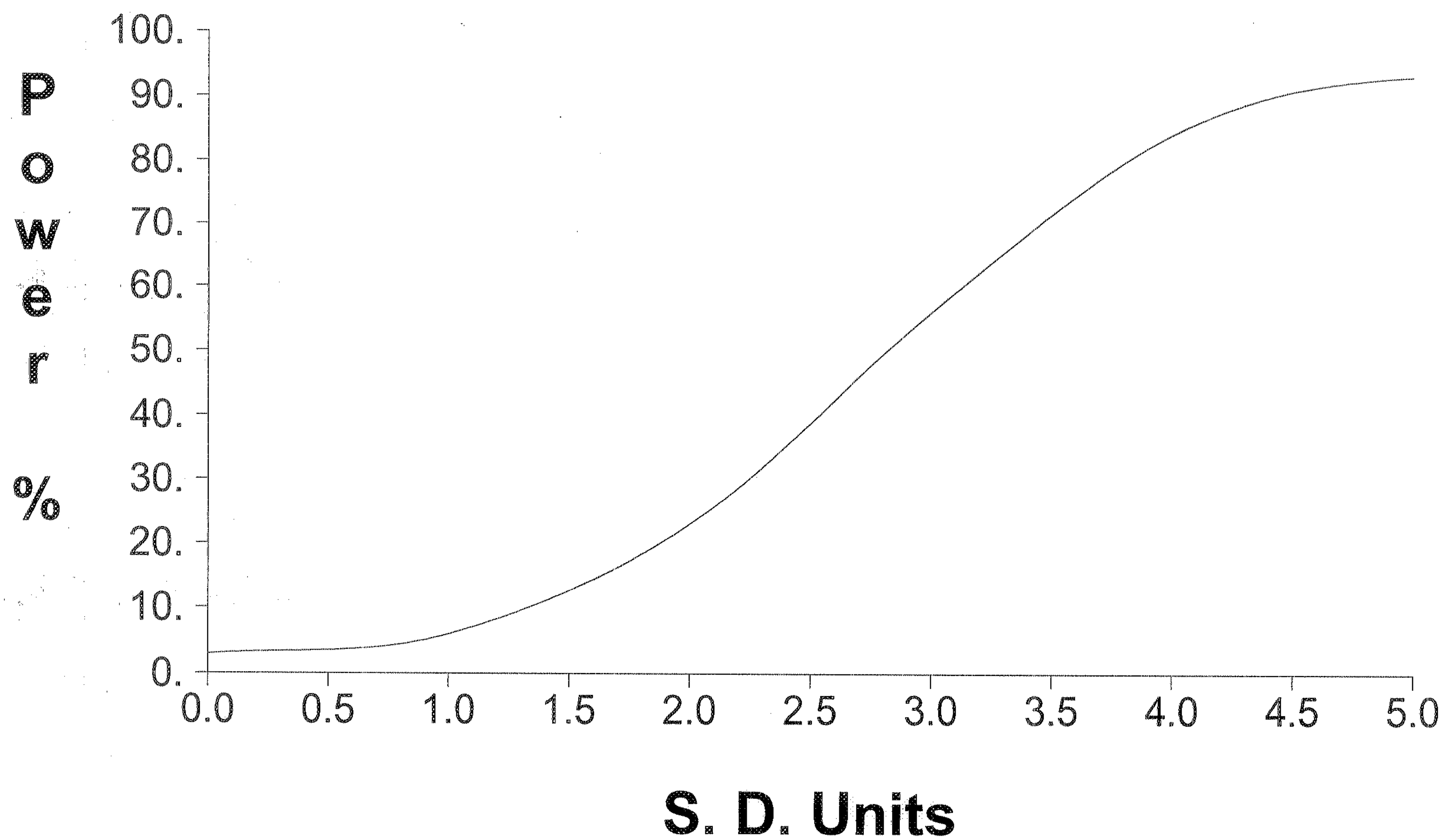
Appendix C

Stiff, Tri-linear and Trend Analysis

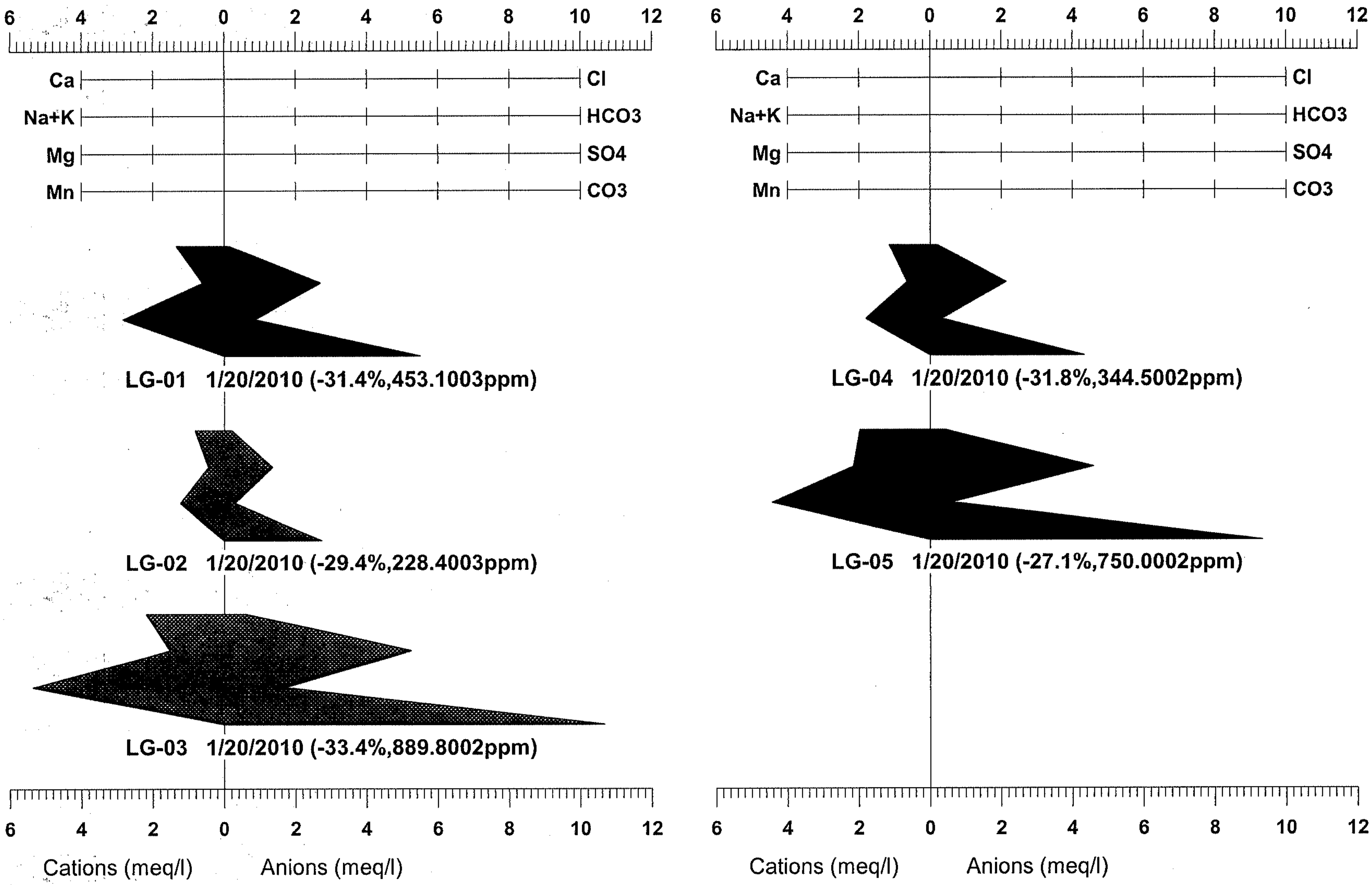
False Positive and False Negative Rates for Current Upgradient vs. Downgradient Monitoring Program



False Positive and False Negative Rates for Current Intra-Well Prediction Limits Monitoring Program



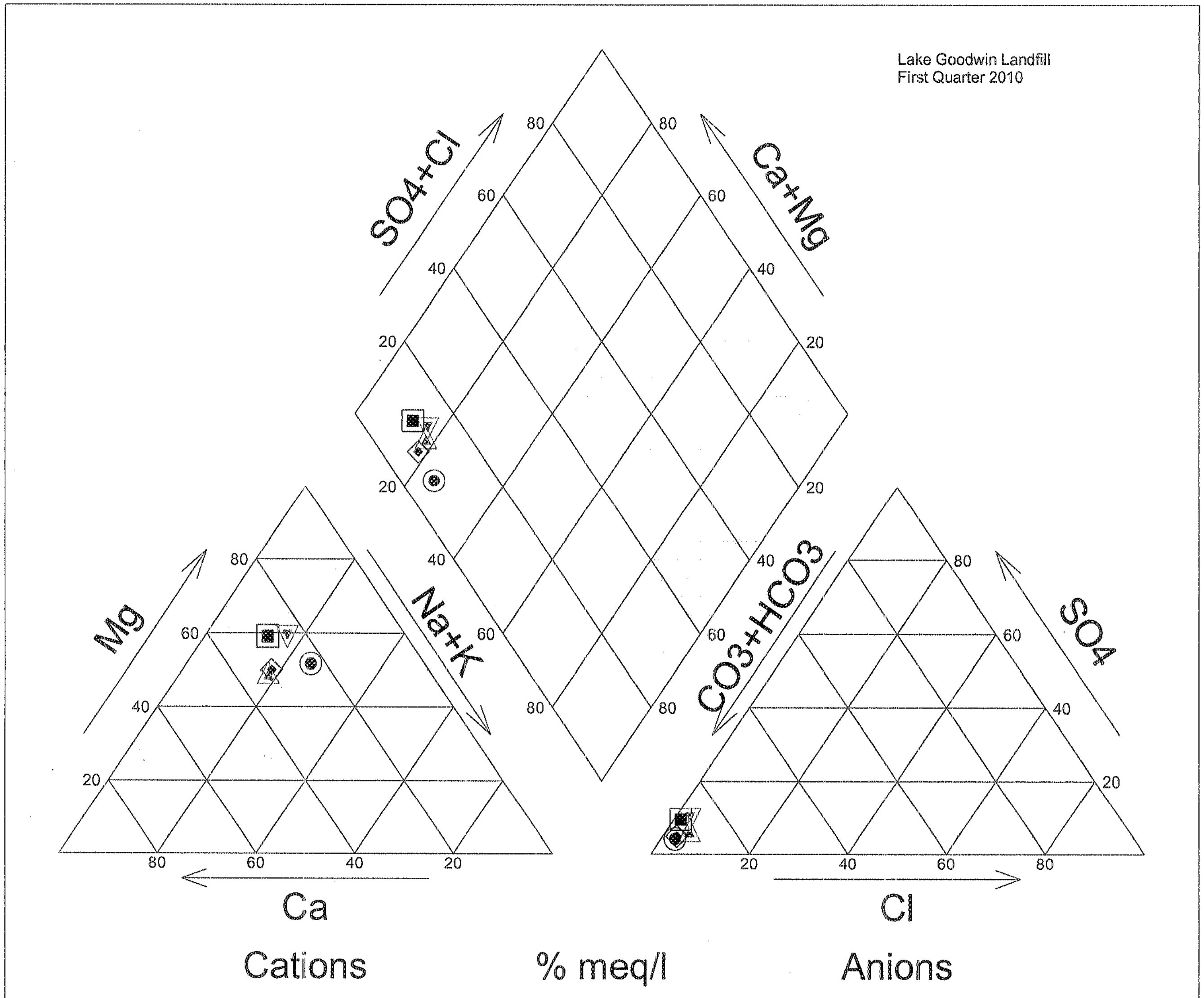
Goodwin Landfill



Prepared by: Snohomish County Solid Waste

Goodwin Landfill

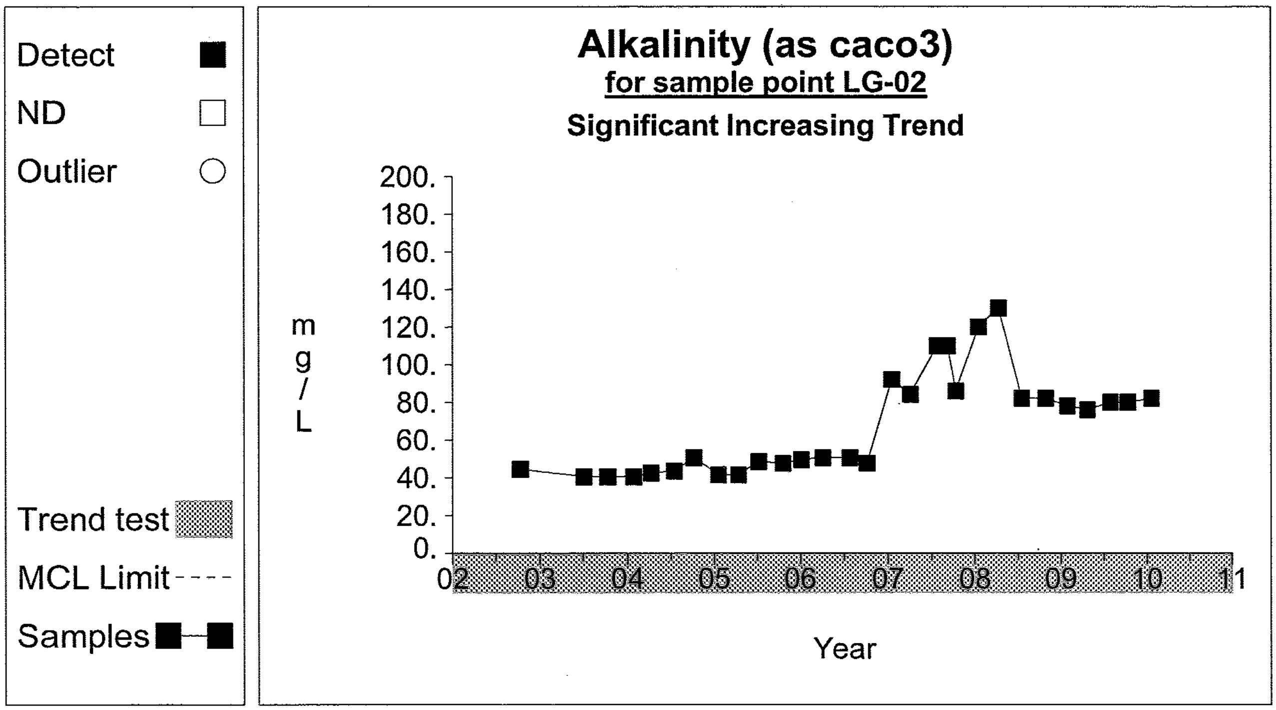
⊠	LG-01	1/20/2010 (-31.4%,453.1ppm)
△	LG-02	1/20/2010 (-29.4%,228.4ppm)
▽	LG-03	1/20/2010 (-33.4%,889.8ppm)
◇	LG-04	1/20/2010 (-31.8%,344.5ppm)
⊙	LG-05	1/20/2010 (-27.1%,750ppm)



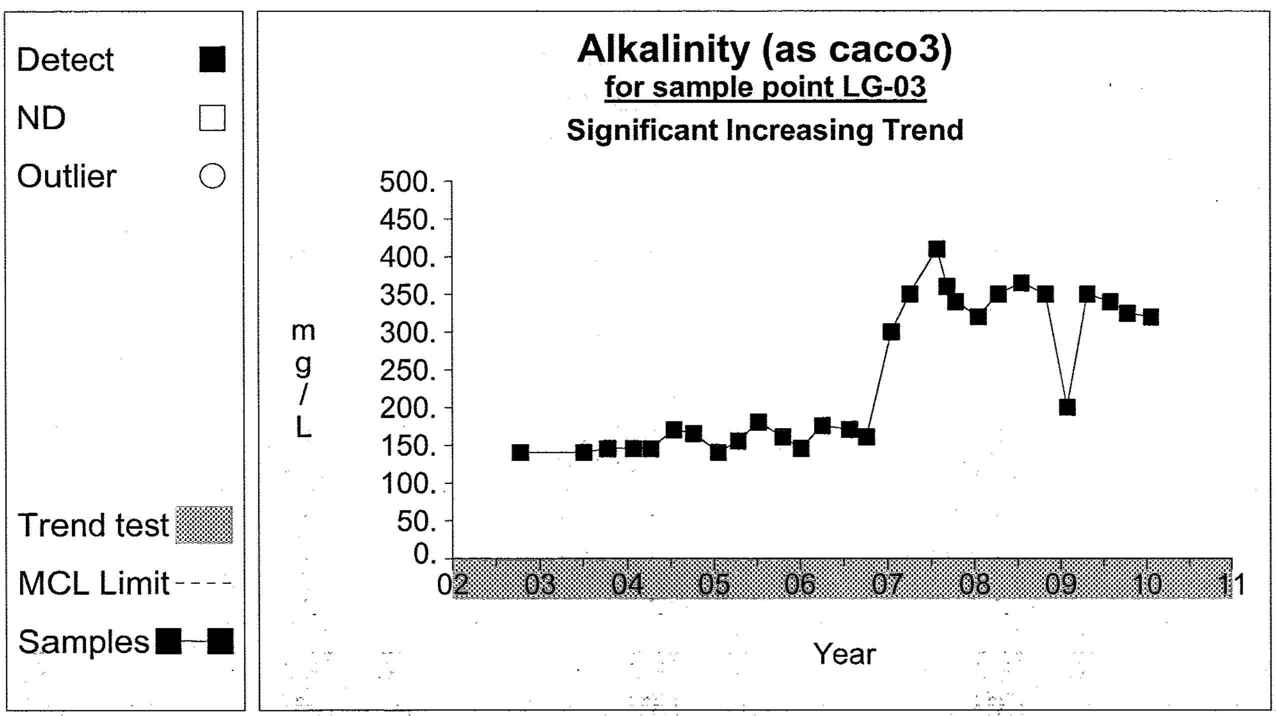
1

Prepared by: Snohomish County Solid Waste

Time Series

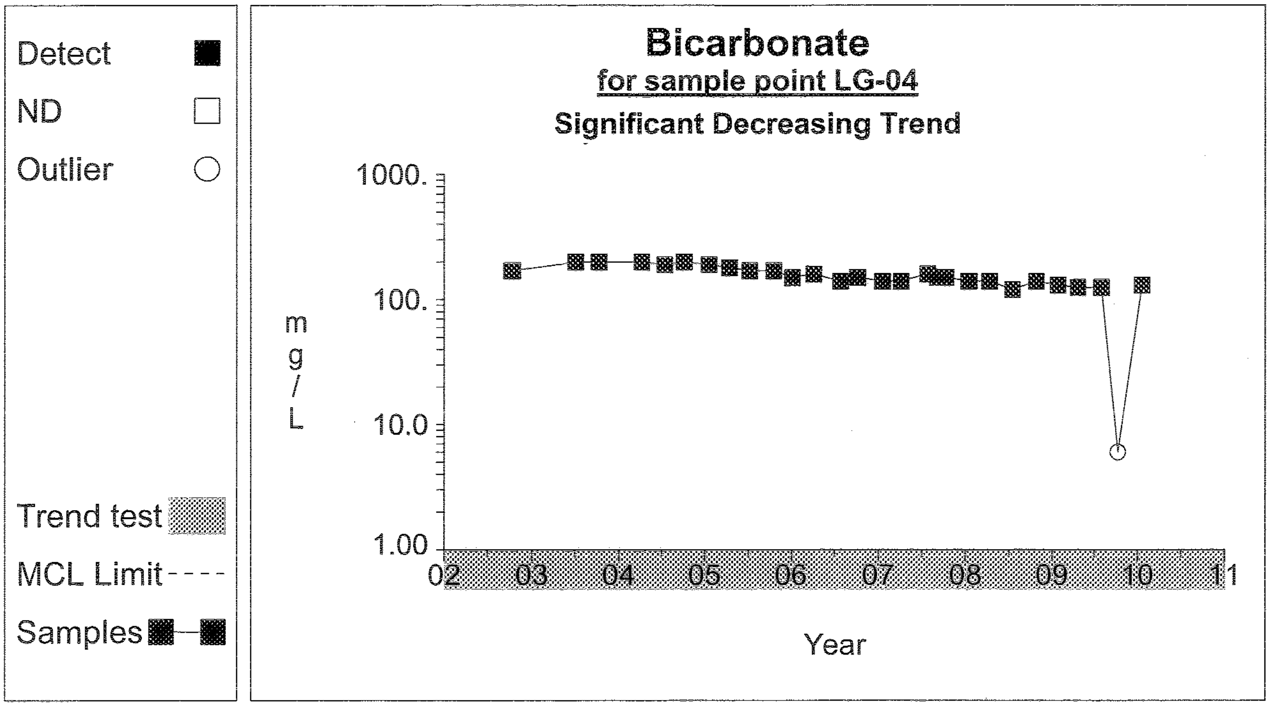


Graph 2

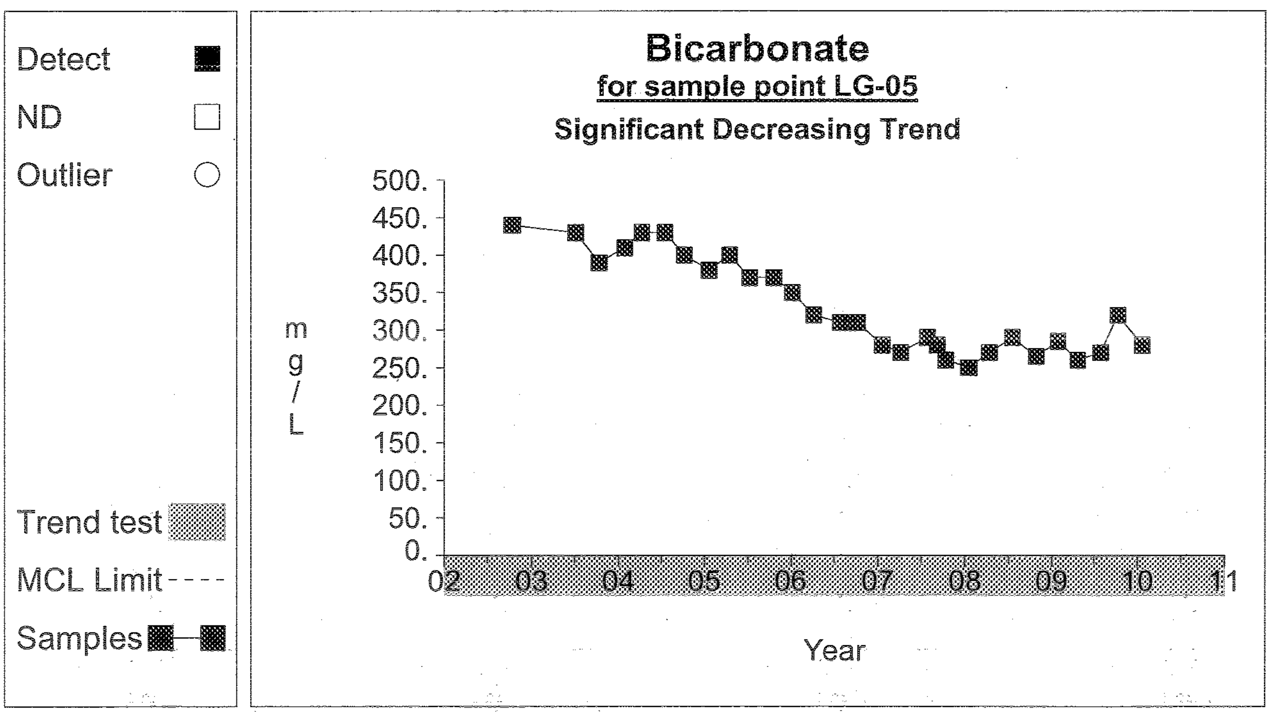


Graph 3

Time Series

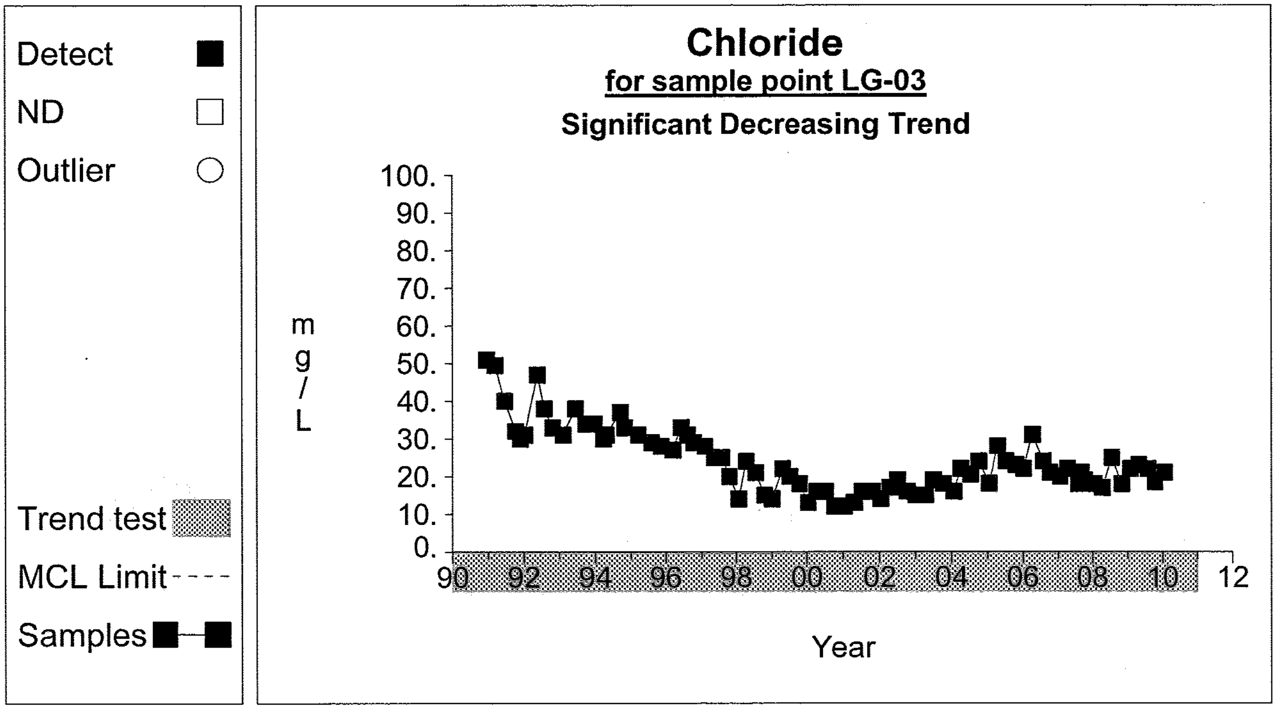


Graph 14

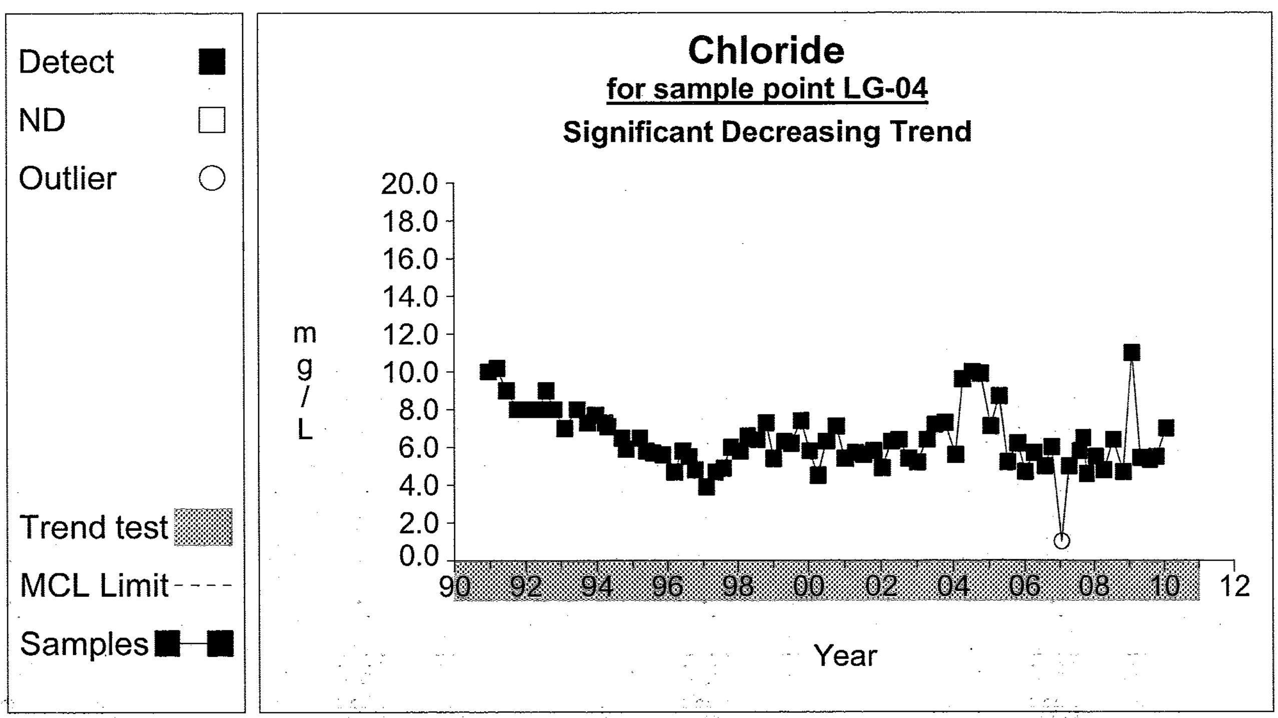


Graph 15

Time Series

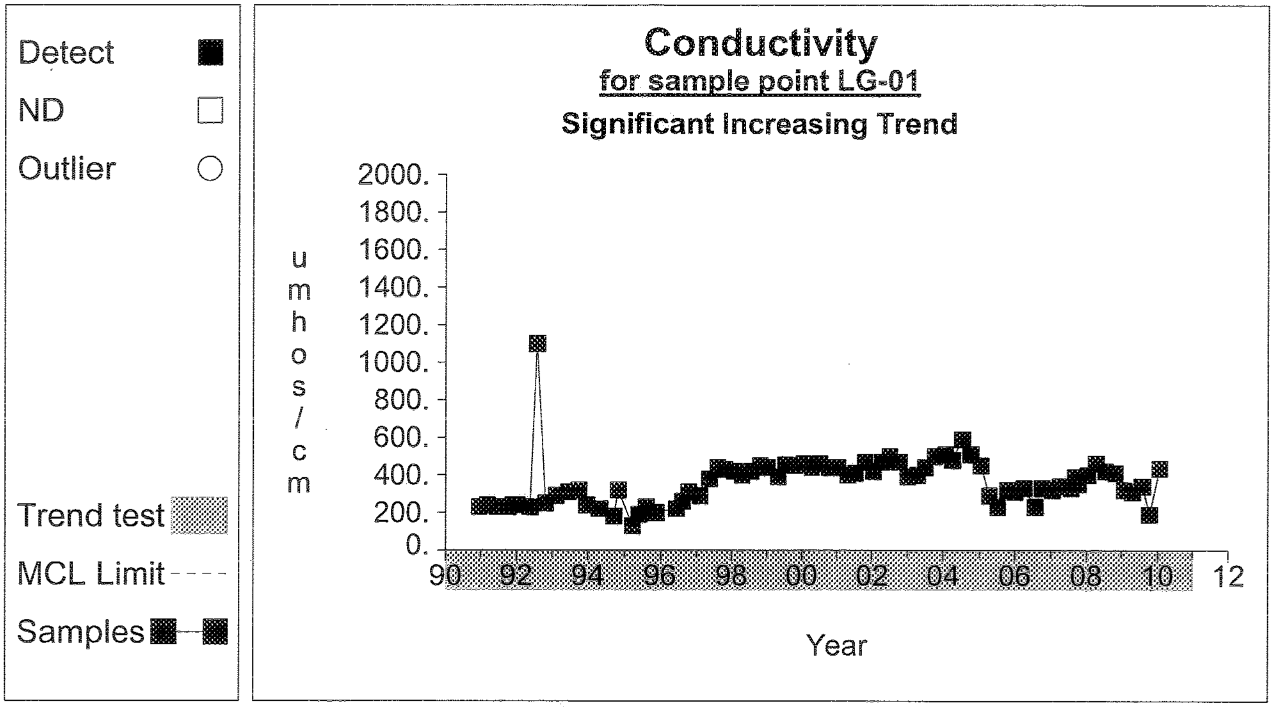


Graph 23

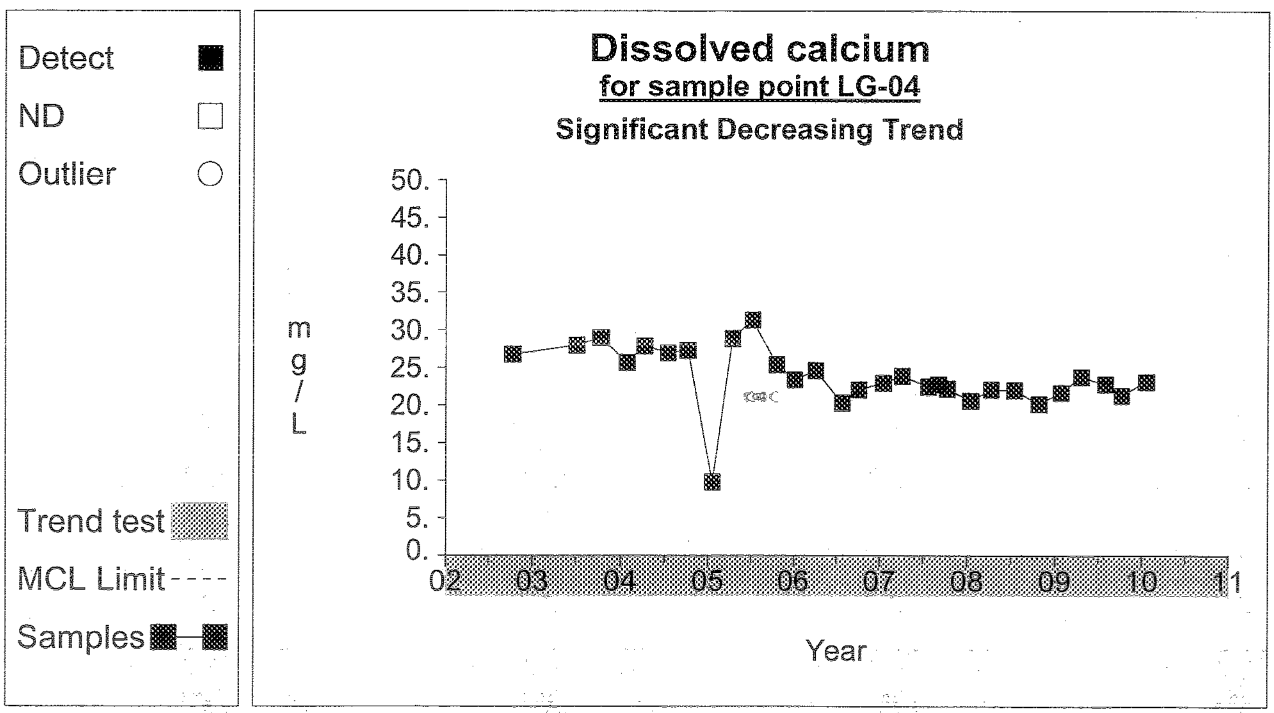


Graph 24

Time Series

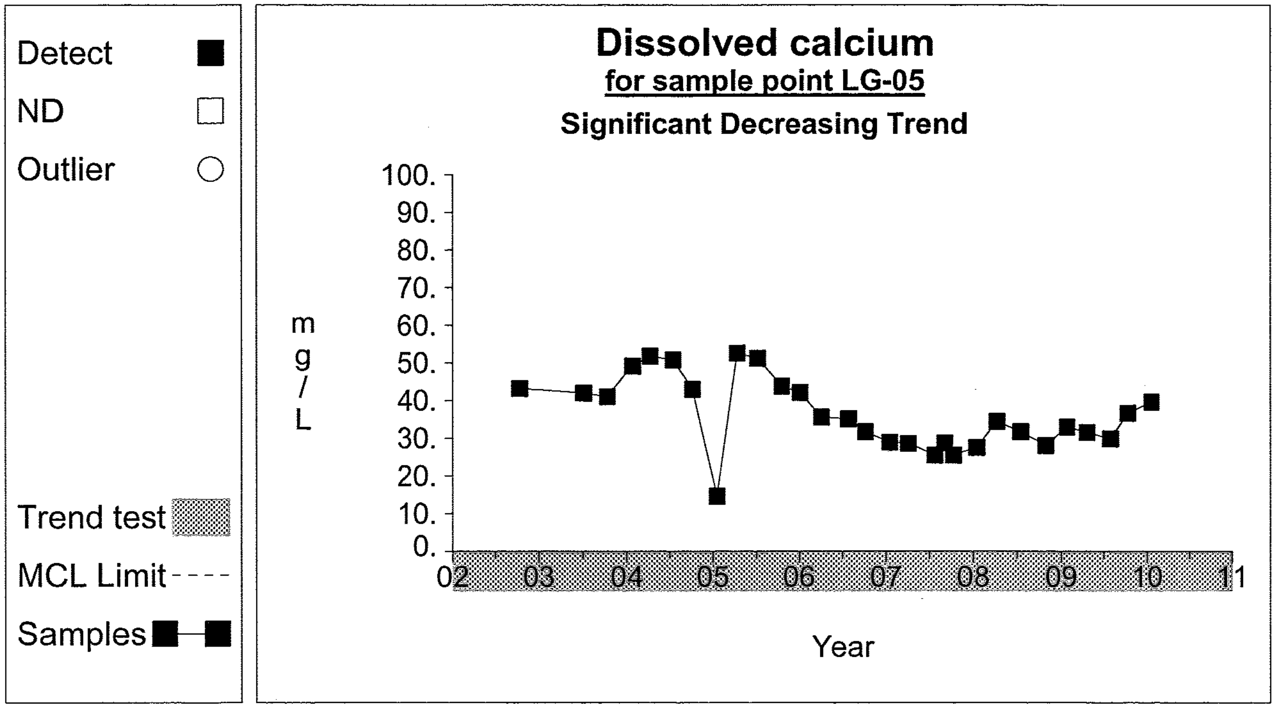


Graph 26



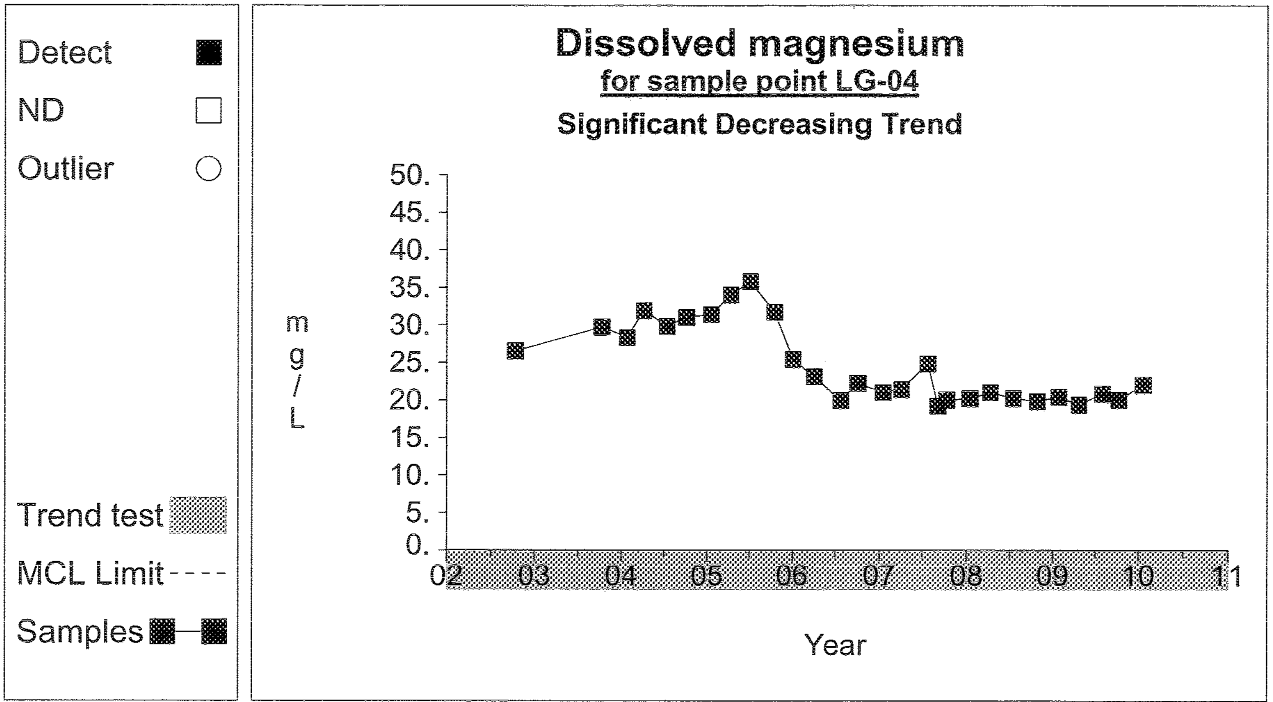
Graph 64

Time Series

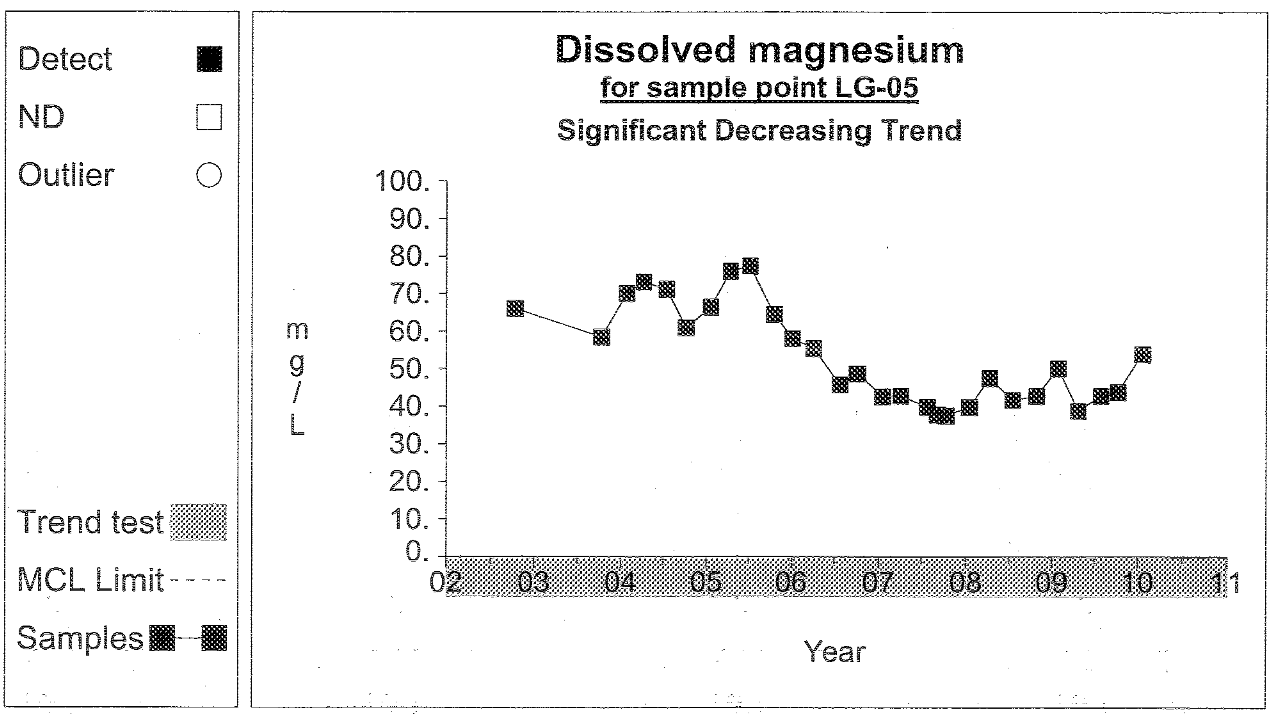


Graph 65

Time Series

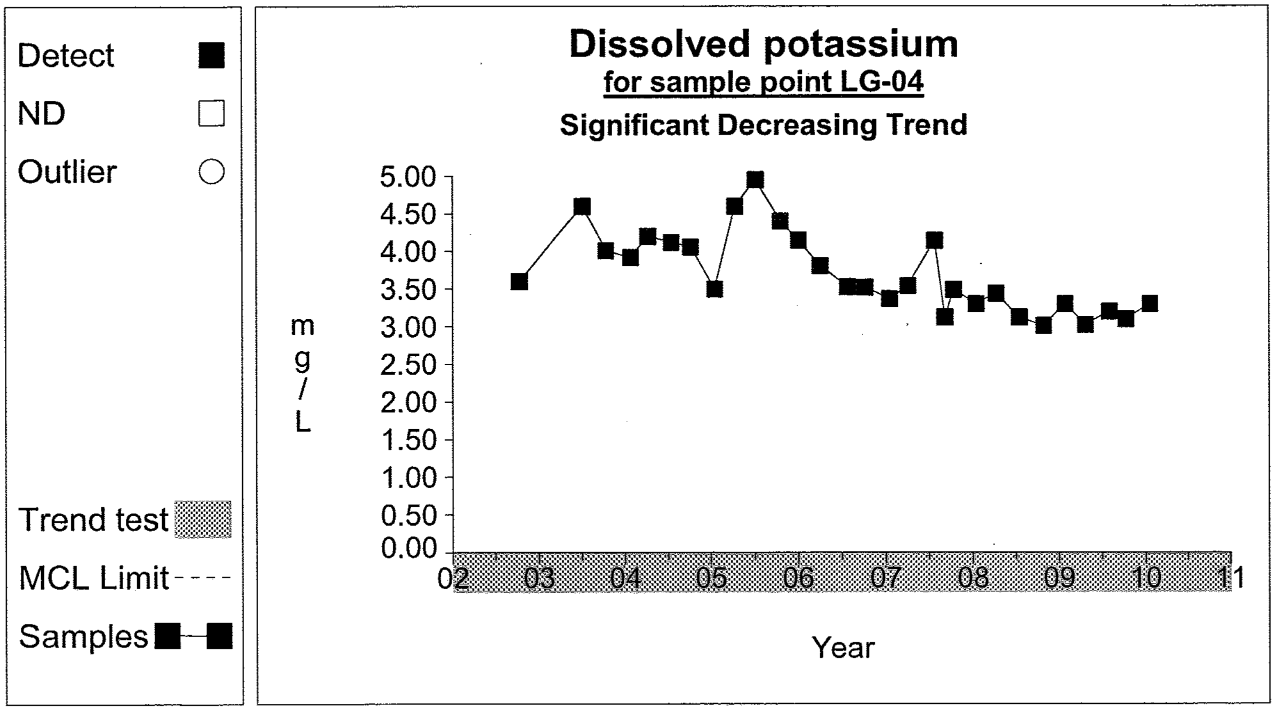


Graph 94

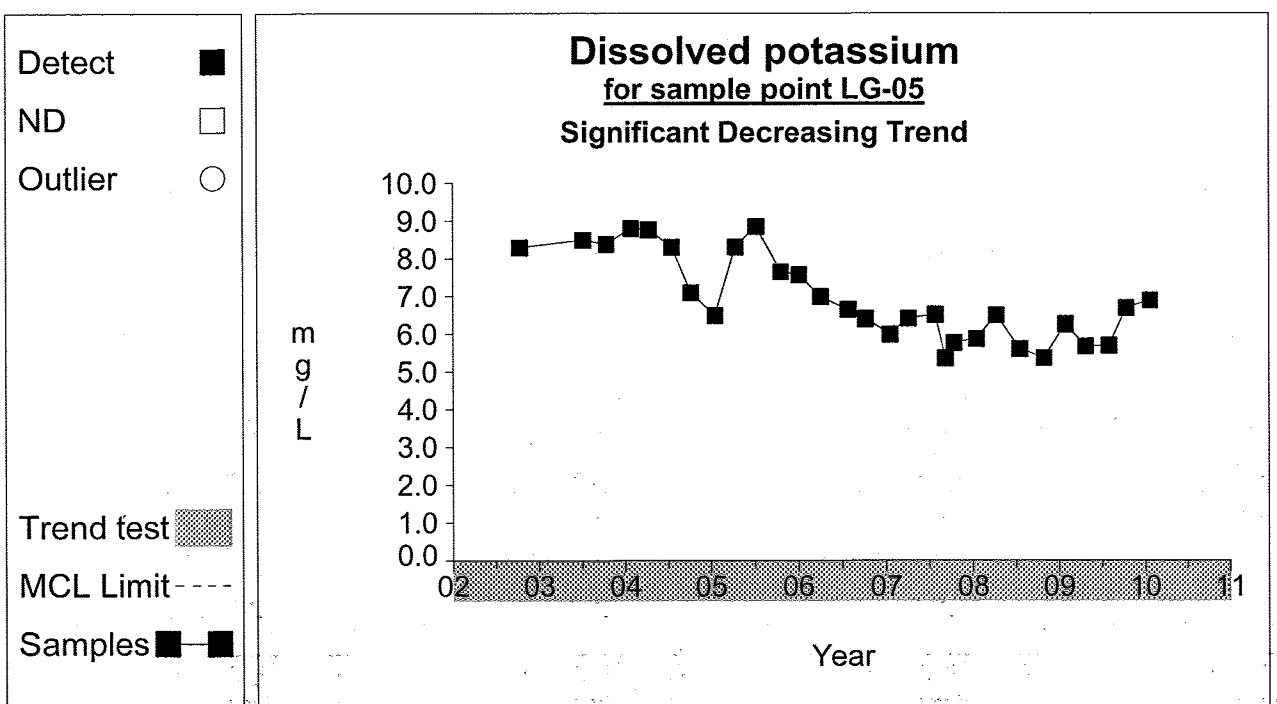


Graph 95

Time Series

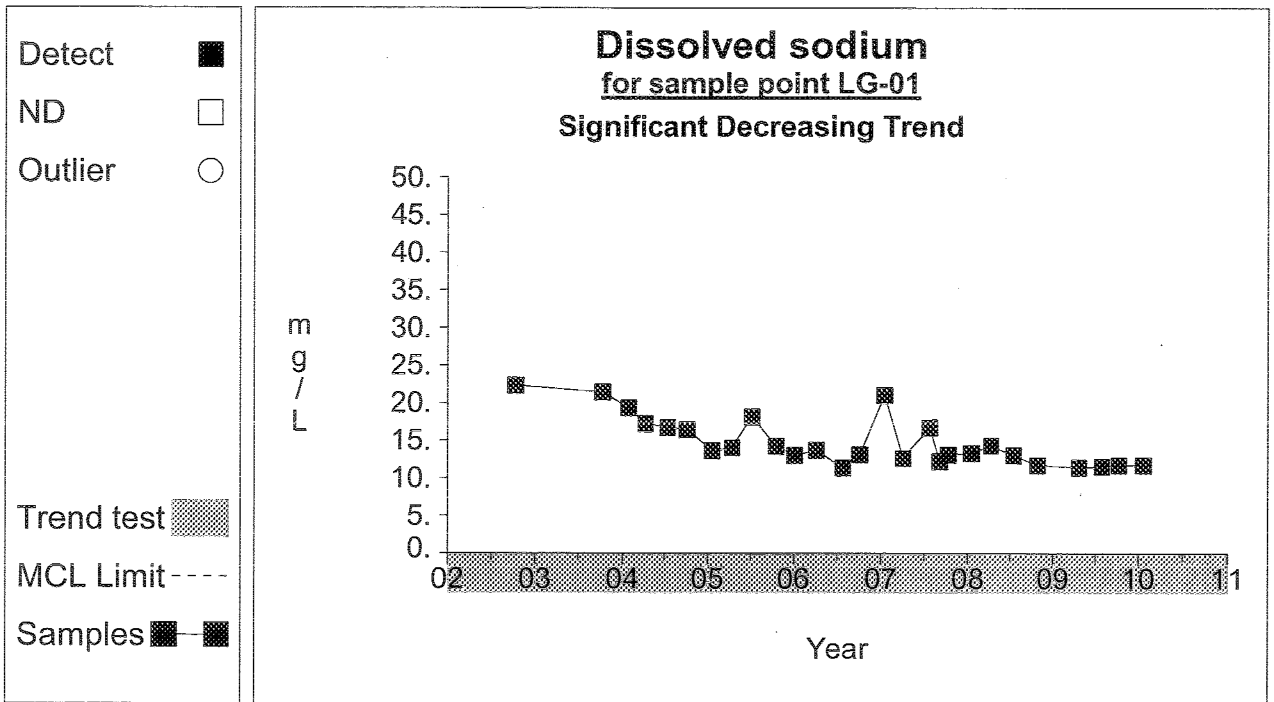


Graph 109

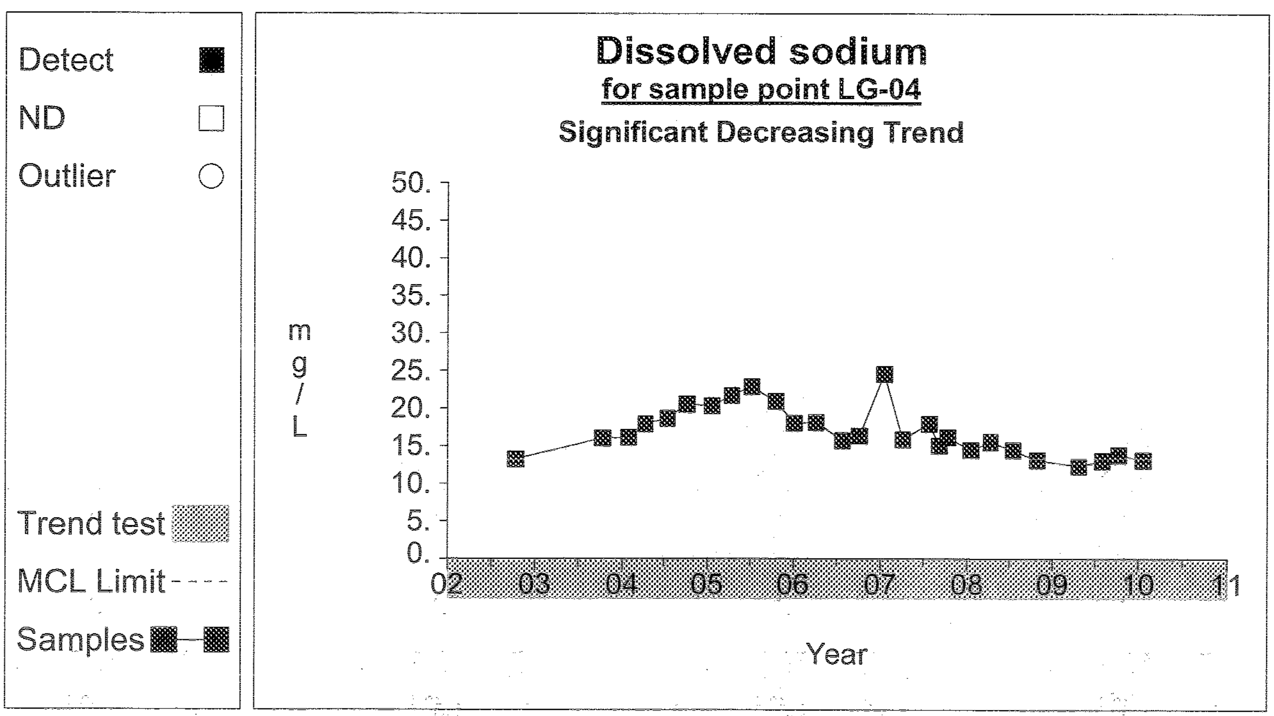


Graph 110

Time Series

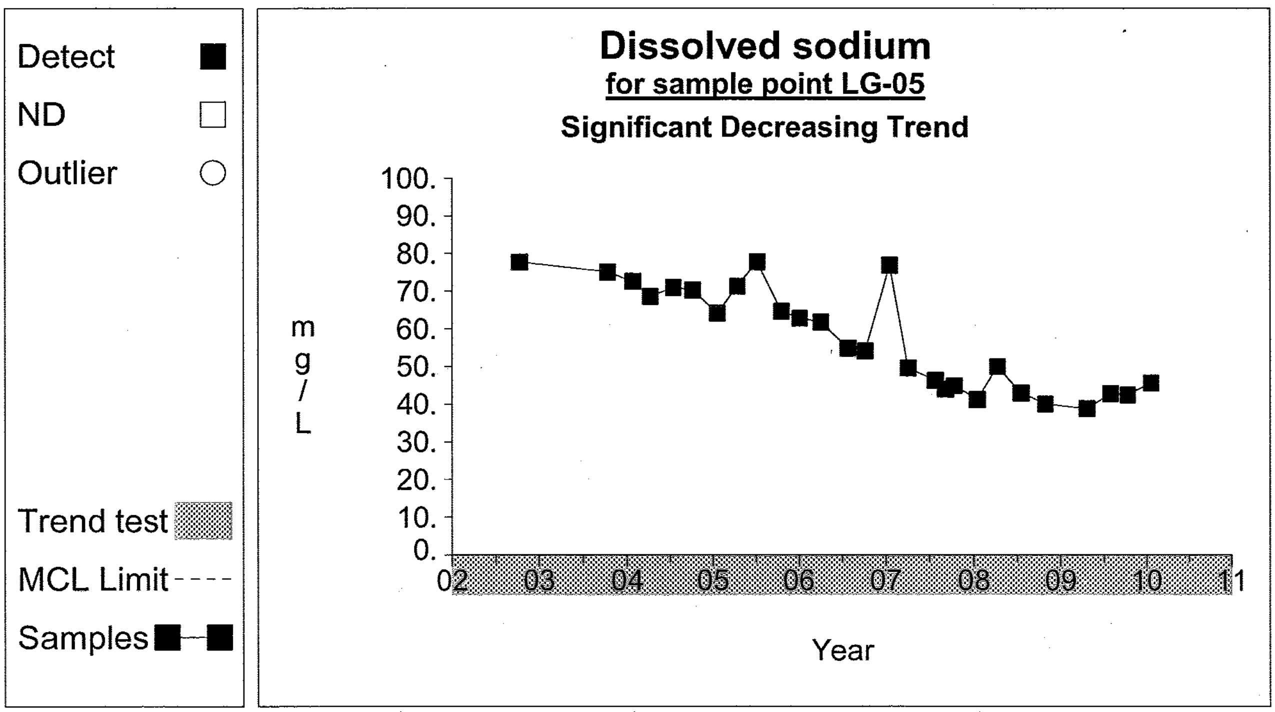


Graph 121



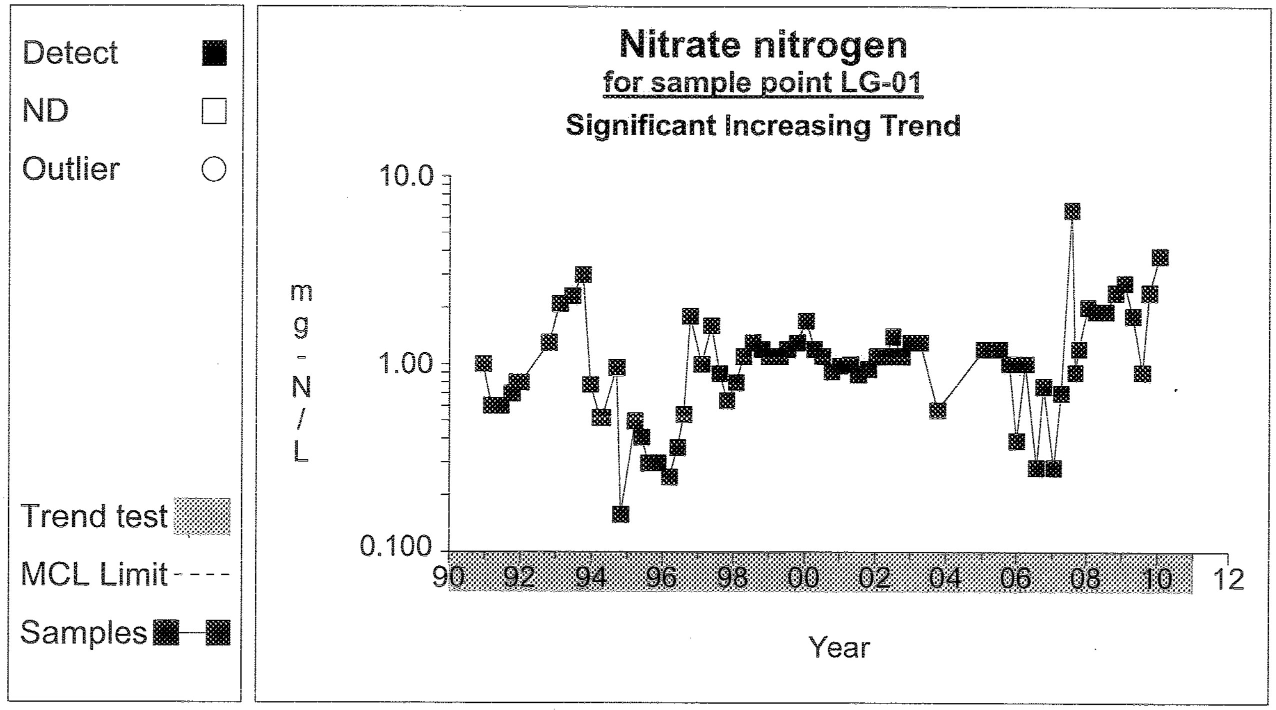
Graph 124

Time Series

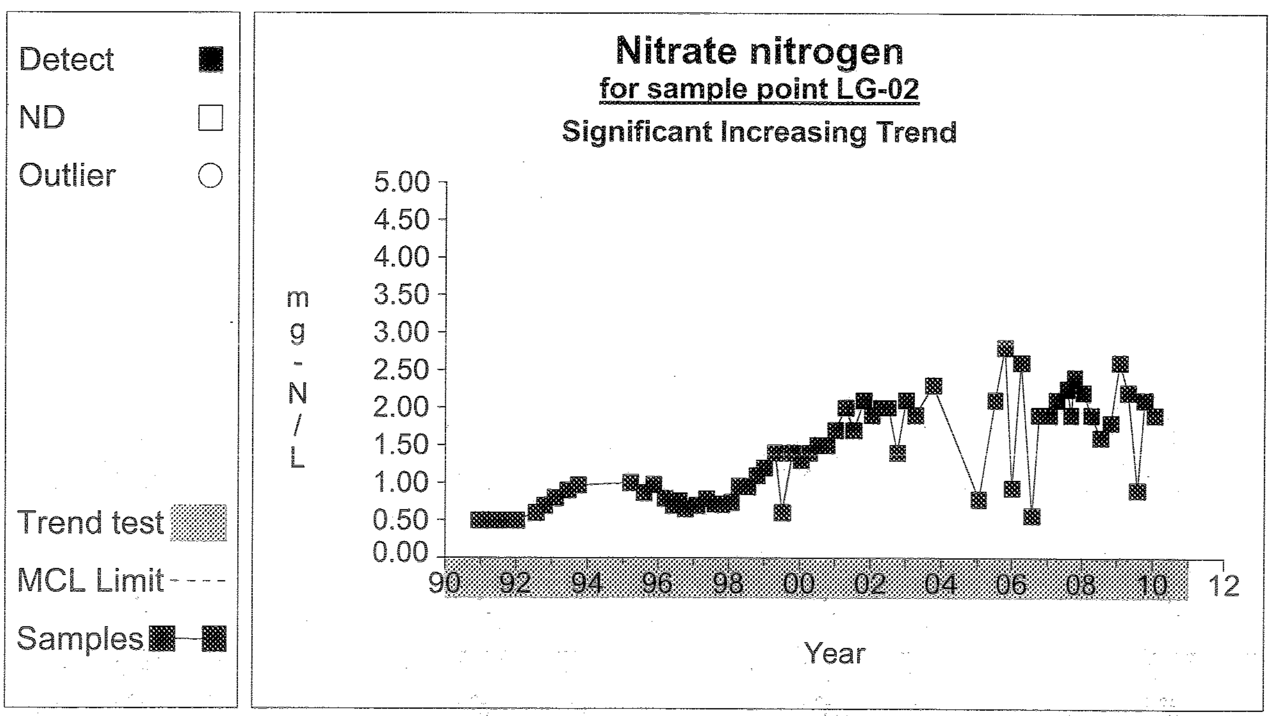


Graph 125

Time Series

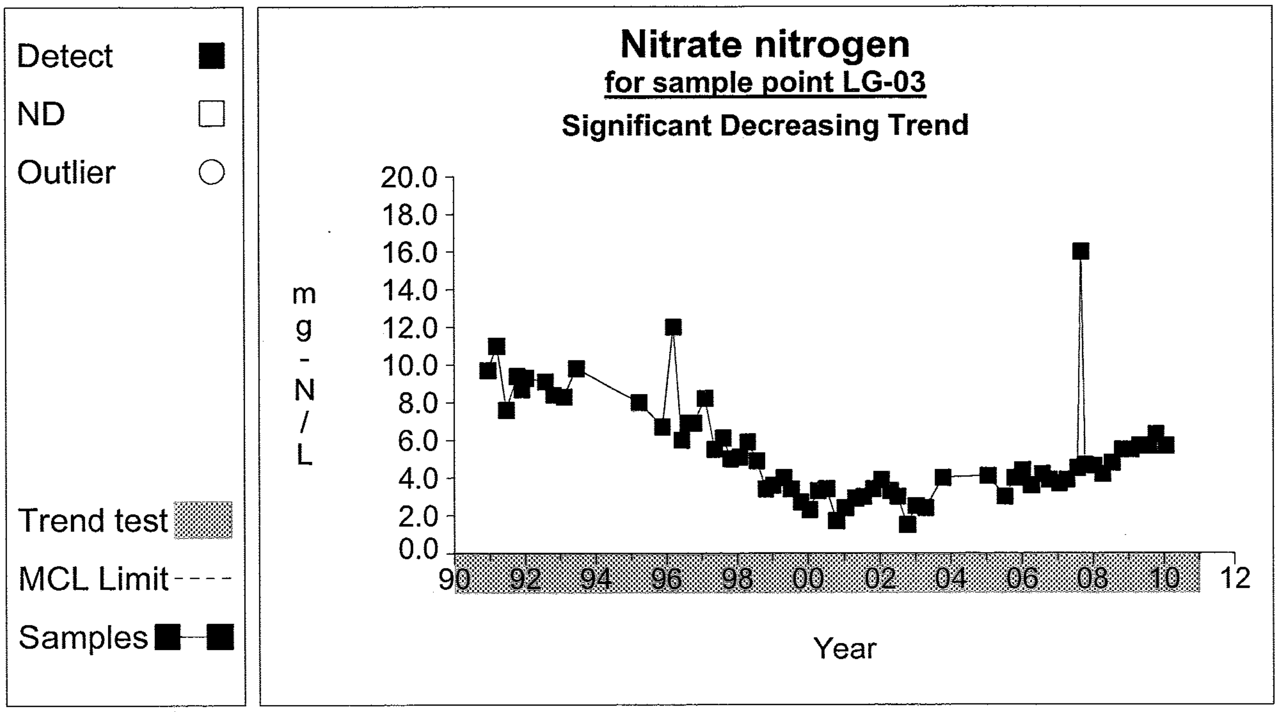


Graph 141

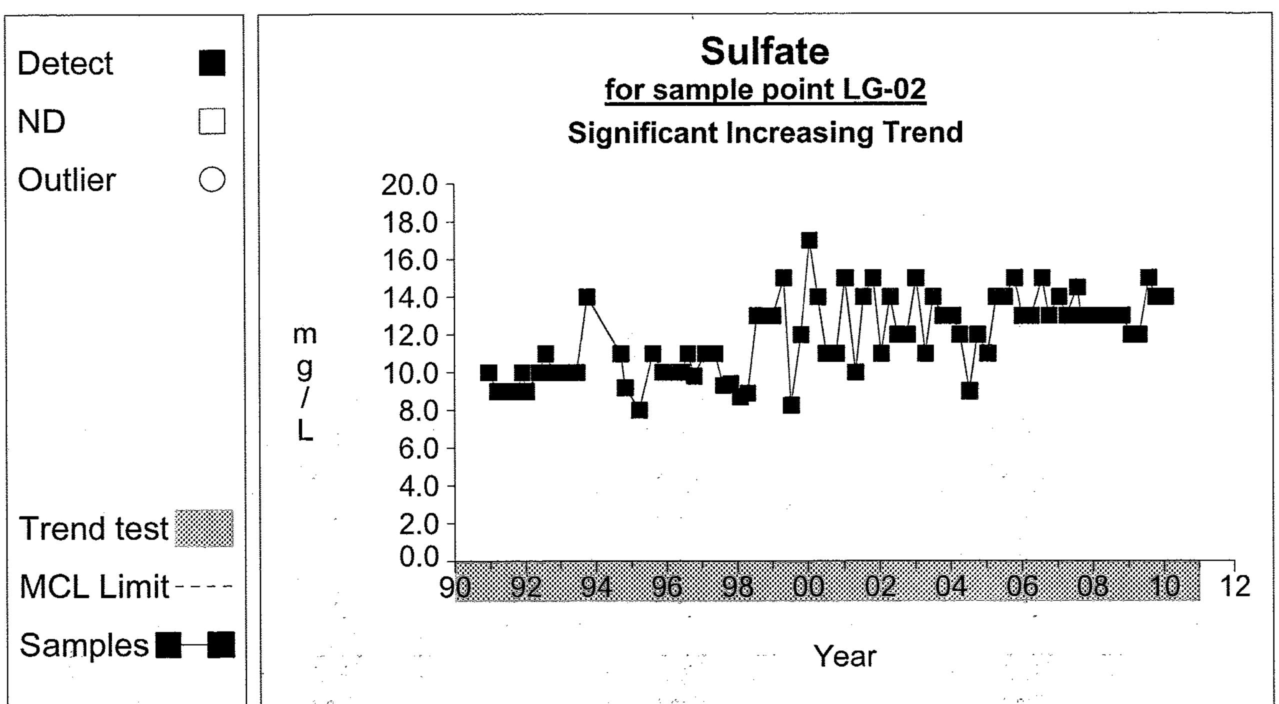


Graph 142

Time Series

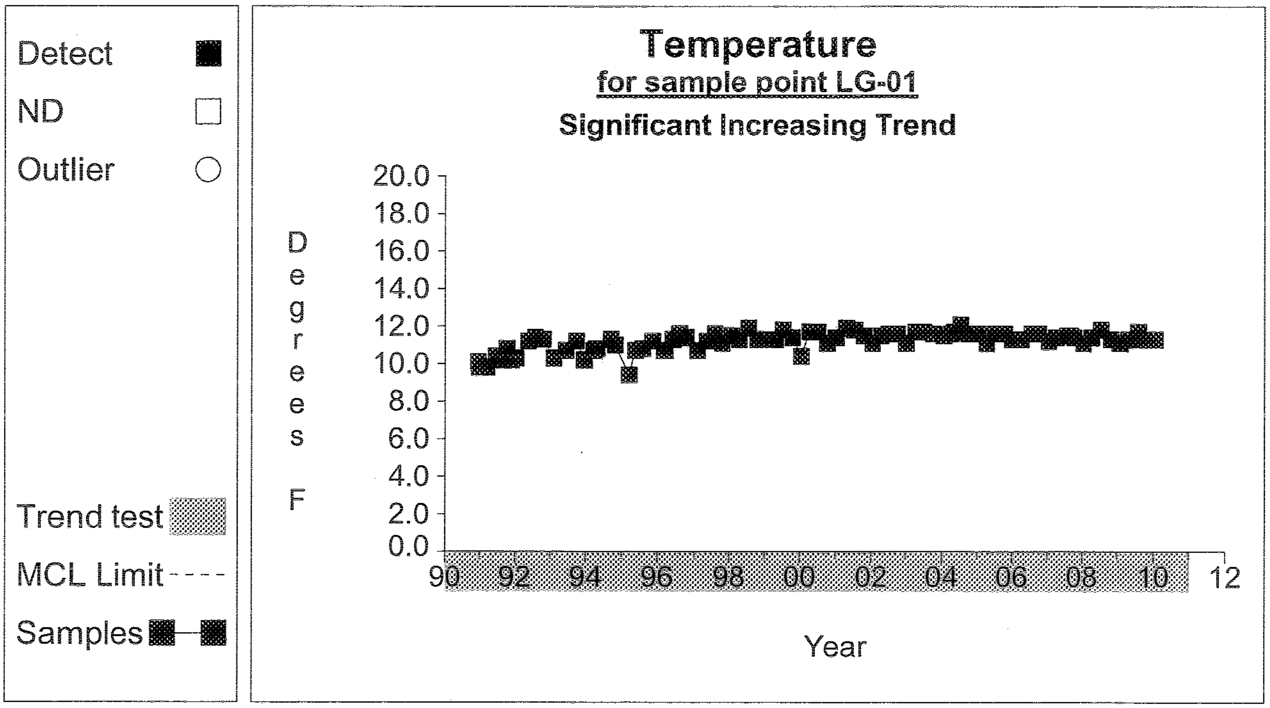


Graph 143

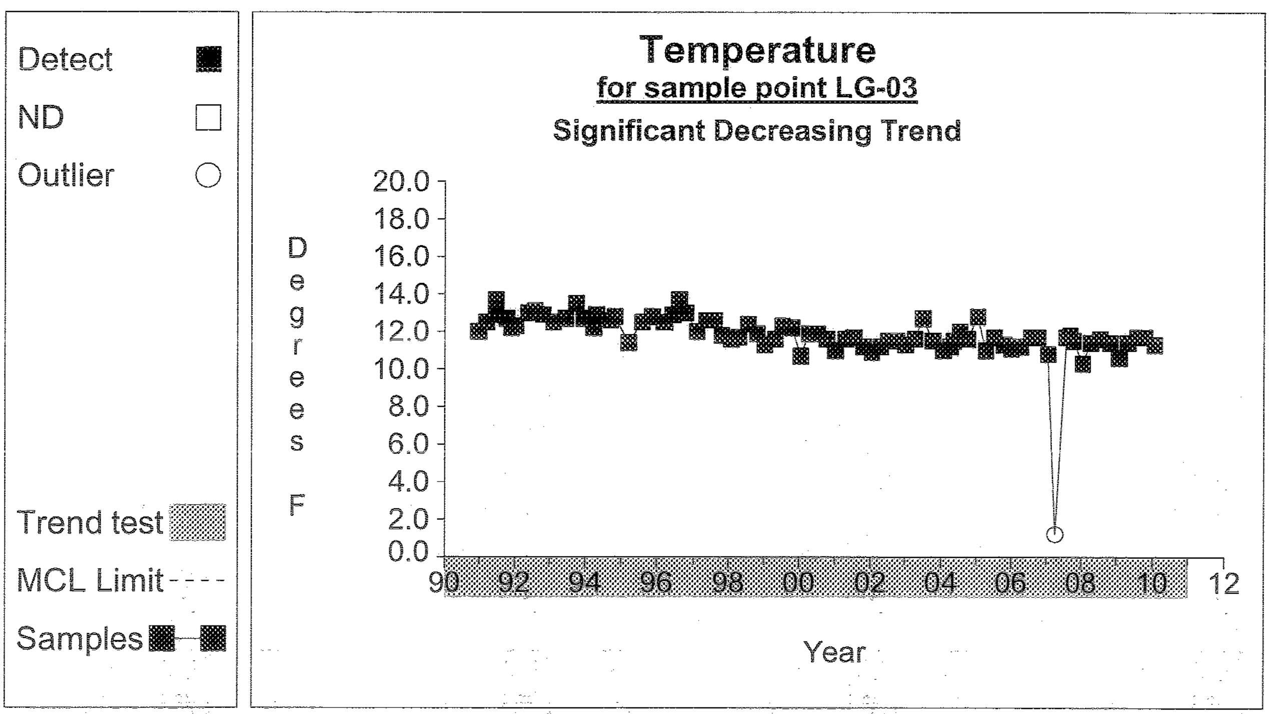


Graph 162

Time Series

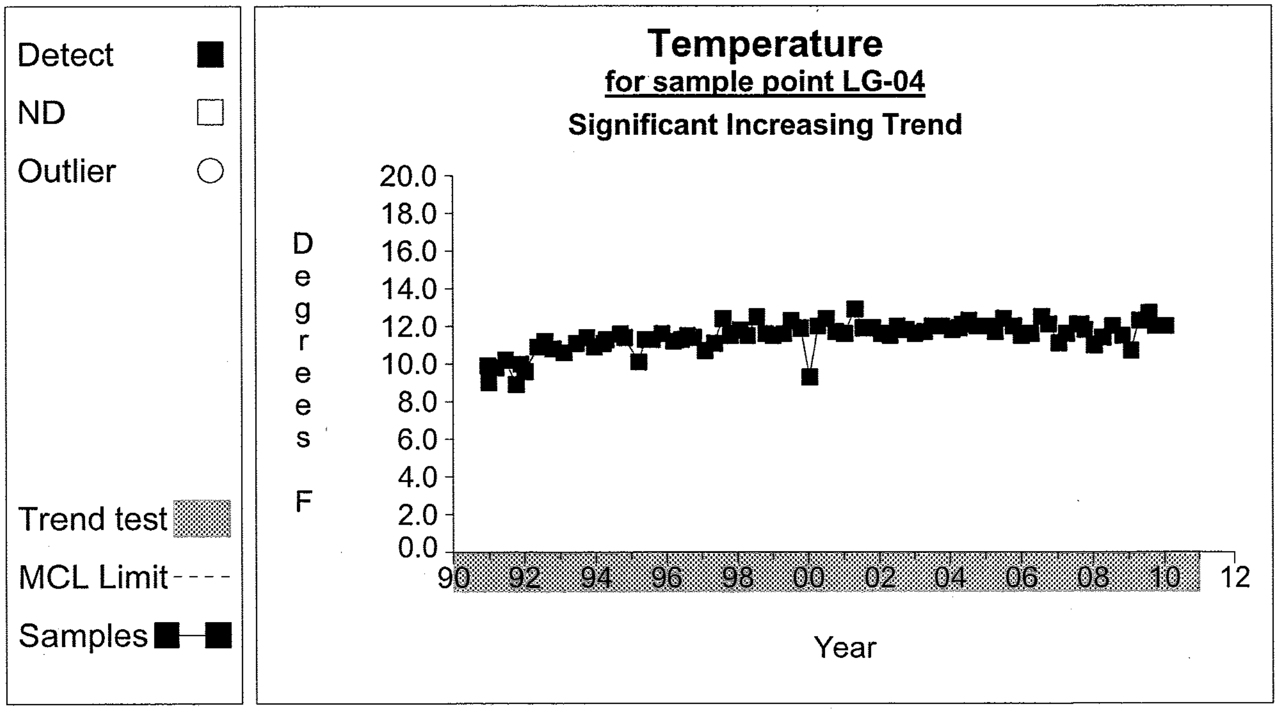


Graph 166

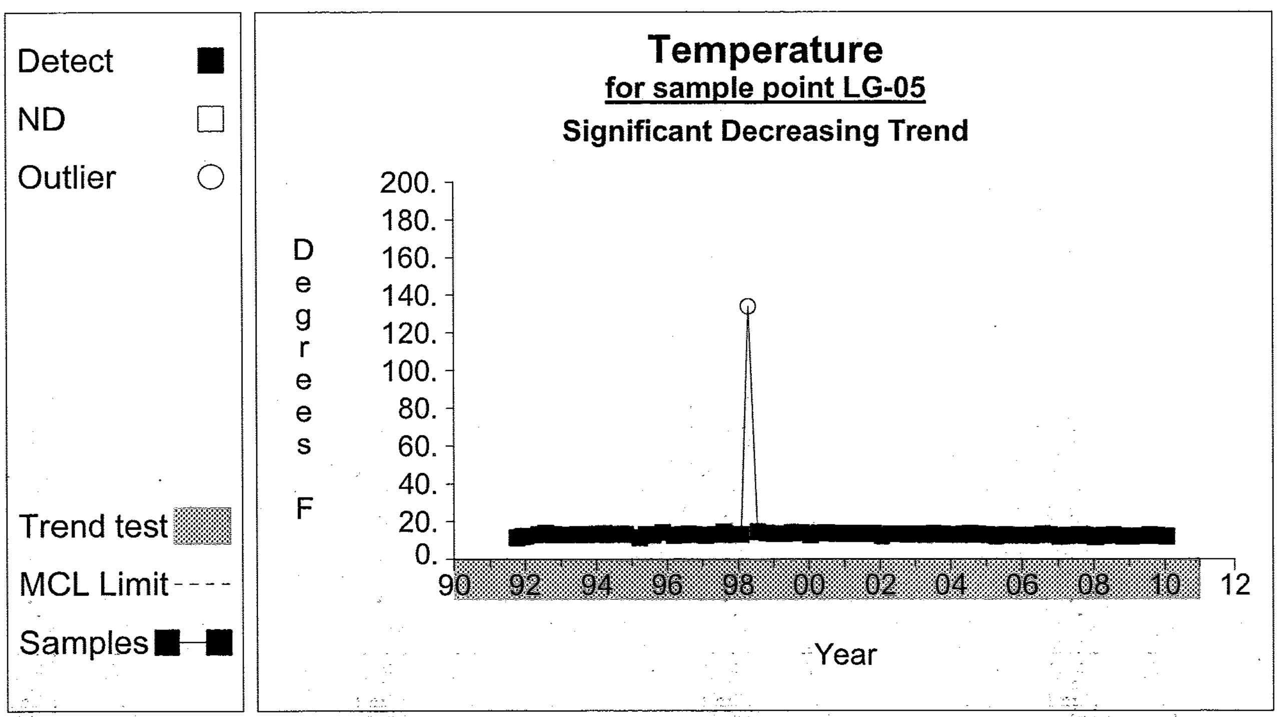


Graph 168

Time Series

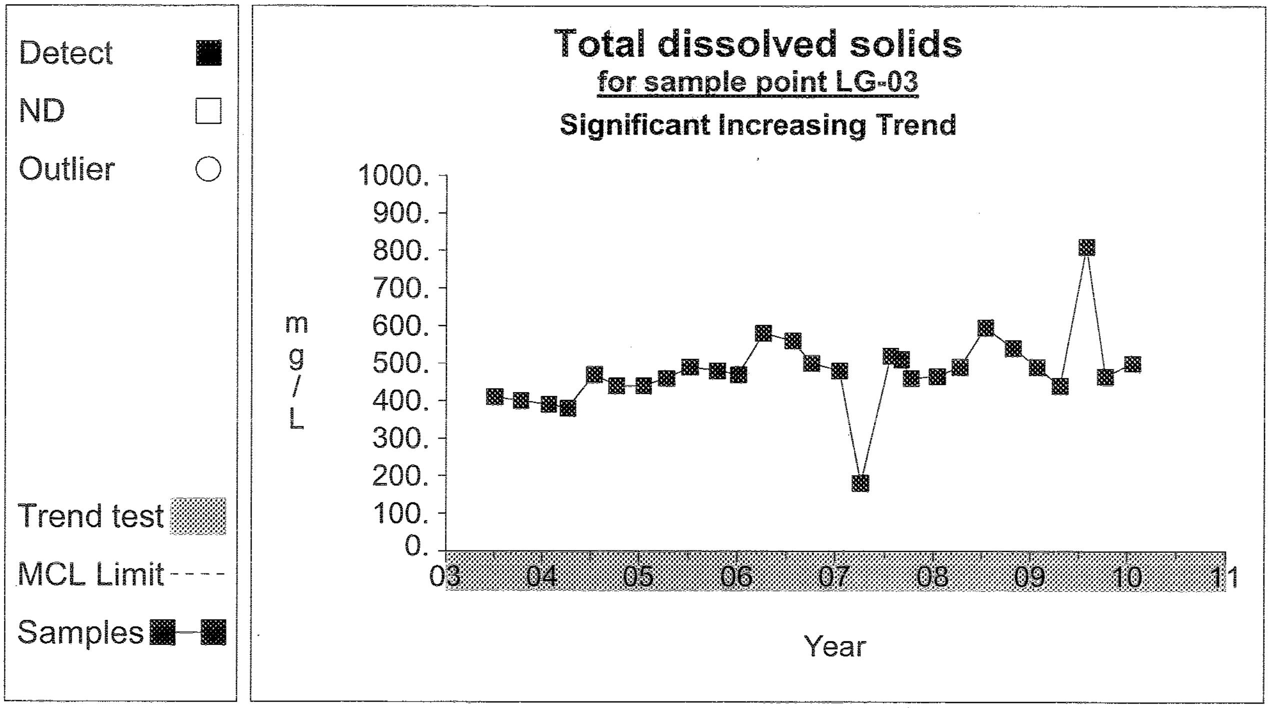


Graph 169

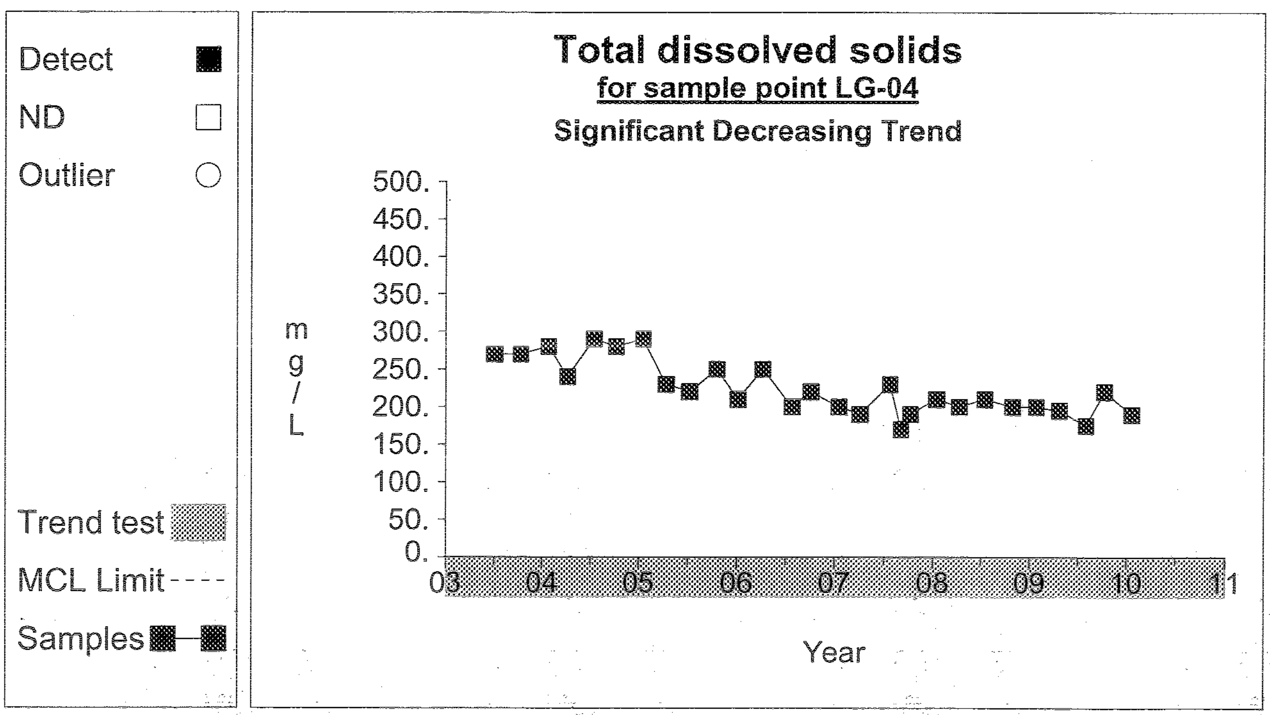


Graph 170

Time Series

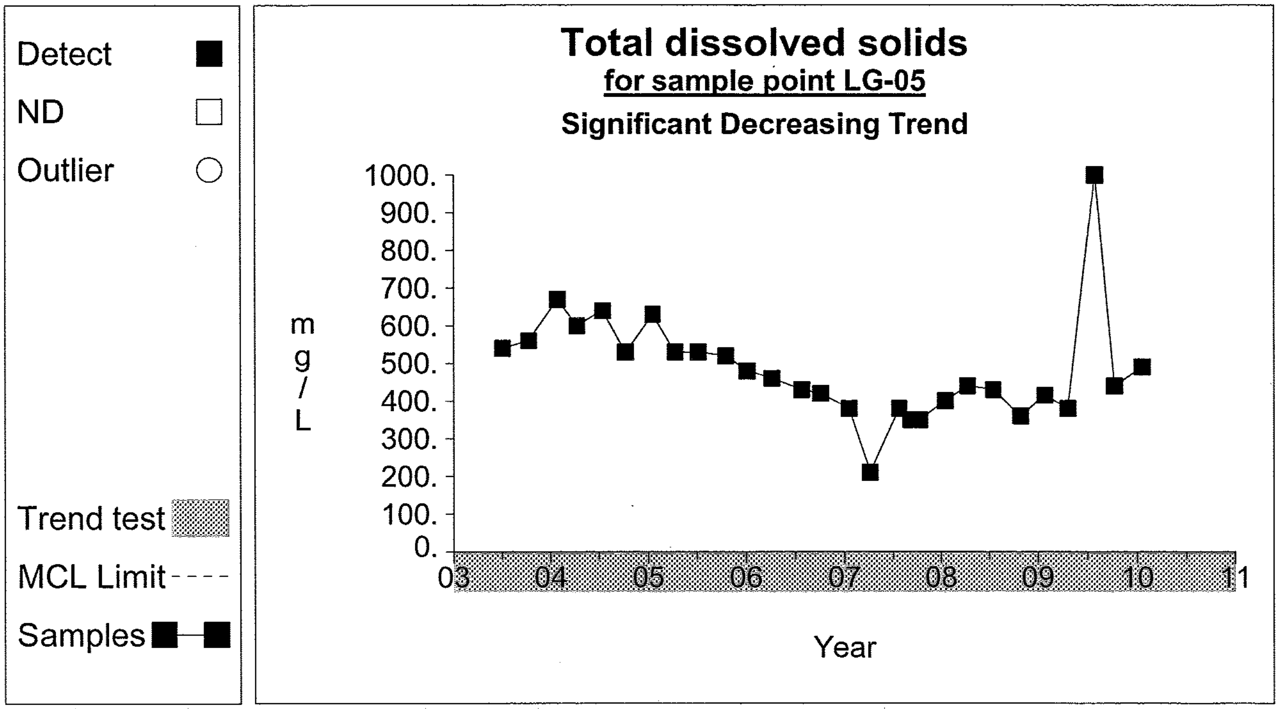


Graph 173



Graph 174

Time Series



Graph 175