PHASE 2 REMEDIAL INVESTIGATION REPORT

HORN RAPIDS LANDFILL RICHLAND, WASHINGTON

Prepared for

City of Richland
Department of Public Works
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Phase 2 Remedial Investigation Report
Horn Rapids Landfill
Richland, Washington

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ACRONYMS AND ABBREVIATIONS

bgs	below ground surface
btoc	below top of casing
Ca	calcium
CAS	Columbia Analytical Services
cis-1,2-DCE	*cis*-1,2-dichloroethene
Cl	chloride
COC	chain-of-custody
CO_2	carbon dioxide
Shaw	Shaw-Environmental and Infrastructure, Inc.
FID	flame ionization detector
FS	feasibility study
GEM	GEM 500 landfill gas meter
HCO_3	bicarbonate
HDPE	high-density polyethylene
HRLF	Horn Rapids Landfill
K	potassium
LFG	landfill gas
MEK	2-butanone
meq/L	milliequivalents per liter
Mg	magnesium
MTCA	Model Toxics Control Act
µg/L	micrograms per liter
mg/L	milligrams per liter
MSW	municipal solid waste
Na	sodium
NO_3-N	nitrate as nitrogen
NSPS	New Source Performance Standards
1,1-DCA	1,1-dichloroethane
1,1-DCE	1,1-dichloroethene
1,2-DCA	1,2-dichloroethane
PCE	tetrachloroethene
PVC	polyvinyl chloride
QA/QC	quality assurance and quality control
RI	remedial investigation

ACRONYMS AND ABBREVIATIONS (Continued)

SO_4	sulfate
TCE	trichloroethene
TCFM	trichlorofluoromethane
TOC	total organic carbon
trans-1,2-DCE	*trans*-1,2-dichloroethene
UGWZ	upper groundwater zone
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compound
WAC	state of Washington Administrative Code
WDOE	Washington Department of Ecology

1 INTRODUCTION

This report presents the results of the second phase (phase 2) of a remedial investigation (RI) to assess the source of volatile organic compounds (VOCs) detected in groundwater samples collected from monitoring wells at the city of Richland's (City's) Horn Rapids Landfill (HRLF) in Richland, Washington (see Figure 1-1). The RI is being conducted in a phased manner. Phase 1 delineated the lateral extent of VOC impacted groundwater in the site area. Results of the phase 1 RI were reported in the July 2003 phase 1 report (Shaw, 2003), as summarized in Section 1.2. Field activities, findings, data evaluation, and recommendations of the phase 2 RI are presented in this report. The phase 2 RI focused on assessing the source of VOCs detected in groundwater samples collected from several site monitoring wells. Shaw-Environmental and Infrastructure, Inc. (Shaw) performed the phase 2 RI field and data interpretation activities, and prepared this report on behalf of the City.

This phase 2 RI report presents and evaluates the following information:

- Field and laboratory results collected in August and September 2003, consistent with the scope of work presented in the RI phase 1 report (Shaw, 2003), and as described in Section 2 of this report.

- Historical groundwater and leachate analytical data collected as part of HRLF's routine compliance monitoring program, consistent with requirements of the its Solid Waste Operating Permit #01-755T Section 4(F) and state of Washington Administrative Code (WAC) 173-351.

1.1 Site Description

The City completed construction of the HRLF in 1976, and has operated it since then as a municipal solid waste (MSW) landfill. The landfill is sited within a 275-acre parcel of City property, of which 47 acres are permitted for the disposal of MSW (Figure 1-1). The HRLF is bound by Twin Bridges Road (formerly Grosscup) on the west, Horn Rapids Road on the north, and State Route 240 on the south.

1.2 Background

In 1998, the City installed two groundwater monitoring wells (MW05 and MW06) inside the permitted disposal area, along the southeastern edge of the landfill's waste cells (see Figure 1-2). These wells were in addition to four existing monitoring wells (MW01 through MW04) located along the site boundary of the HRLF (Figure 1-2). Groundwater samples collected from wells MW05 and MW06 in May 1998 contained VOCs in excess of the State of Washington's Model Toxics Control Act (MTCA) limits specified in WAC 173-340. Detected VOCs included 1,1-dichloroethane (1,1-DCA), 1,1-dichloroethene (1,1-DCE), *cis*-1,2-dichloroethene (*cis*-1,2-DCE), 1,2-dichloroethane (1,2-DCA), benzene, methylene chloride, tetrachloroethene (PCE), trichloroethene (TCE), trichlorofluoromethane (TCFM), and vinyl chloride.

In response to these VOC detections, the City implemented an independent cleanup action under MTCA, consisting of a phased RI and feasibility study (FS), as required by WAC 173-340. The first phase of the RI (phase 1) was initiated in 2000, consistent with the RI work plan dated November 8, 2000 (IT, 2000), to assess the extent of VOC impacts detected in MW05 and MW06 groundwater samples. The phase 1 RI involved installing four monitoring wells (MW07, MW08, MW09 and MW10; see Figure 1-2) screened in the upper groundwater zone (UGWZ), collecting and analyzing groundwater samples from the new and existing site wells for five consecutive quarters, and evaluating and reporting the results to the Washington Department of Ecology (WDOE). Well MW07 was placed upgradient of the landfill's waste cells to refine the upgradient groundwater flow direction. Wells MW08 and MW09 were installed along the southern facility boundary to determine whether VOCs had migrated off site, and well MW10 was located north of wells MW05 and MW06 to evaluate the extent of groundwater impacts.

The draft RI report, submitted to the WDOE on October 28, 2002 (Shaw 2002), presented the phase 1 field and laboratory results, assessed the extent of VOC impacts, and concluded that VOCs detected in site groundwater may be attributed to an undocumented disposal area located northwest (upgradient) from the landfill's waste cells (see Figure 1-2). In its review of the October 2002 draft RI (WDOE, 2002), the DOE questioned this conclusion and required the City to propose additional investigative methods to assess whether site leachate and/or landfill gas (LFG) may be the source(s) of VOCs impacting site groundwater. The scope of work for the additional investigation was to be included in the final phase 1 RI report.

The final (revised) phase 1 RI report, dated July 7, 2003 (Shaw, 2003), contained a scope of work to evaluate if LFG and/or leachate are the source(s) of VOCs detected in site groundwater (phase 2 RI). Results of the phase 2 RI are presented in this report. The final phase 1 RI report also included results of a focused investigation performed by the City in February 2003 to delineate and characterize the undocumented upgradient waste disposal area located approximately 500 feet northwest of the northwest corner of the

current permitted area (Figure 1-2). The City investigated the site by excavating at seven locations within and around the undocumented disposal site. This investigation revealed that the undocumented waste disposal site consists of only a small amount of MSW (approximately 4,800 cubic yards), and there were no indications that hazardous waste had been disposed at this location. Consequently, it was concluded in the final phase 1 RI report that this site is likely not the source of the VOCs impacting site groundwater.

1.3 Report Organization

The remainder of this report is organized as follows:

- Section 2 describes phase 2 RI activities.
- Section 3 reports phase 2 RI field and laboratory results.
- Section 4 discusses finding and conclusions.
- Section 5 presents recommendations for assessing the feasibility of implementing active LFG collection as a method for mitigating the LFG source of VOCs.

Additional supporting information is attached in the following appendices:

- Appendix A: Exploratory boring log, probe construction detail, and supporting documentation for Gas Probe GP-12.
- Appendix B: Field documentation, including field sampling data sheets.
- Appendix C: Laboratory analytical reports, chain-of-custody (COC) forms, and results of the field and laboratory quality assurance/quality control (QA/QC) review.
- Appendix D: Geochemical diagrams for site groundwater and lysimeter fluid samples, including Piper (trilinear) and Stiff diagrams.
- Appendix E: Selected time-concentration plots for site groundwater and lysimeter fluid samples.

2 PHASE 2 REMEDIAL INVESTIGATION ACTIVITIES

Field and laboratory activities performed during this phase of work included the following:

- Drilling and installing a new nested gas probe (GP-12).
- Measuring LFG concentrations in gas probes GP-1(2)[1], GP-1(1), GP-2(2), GP-2(1), GP-5(3), GP-5(2), GP-5(1), GP-6(shallow), GP-6(deep), GP-9(2), GP-9(1), GP-12(shallow), GP-12(intermediate), and GP-12(deep).
- Performing depth-discrete landfill gas monitoring in MW05, MW06, and MW07.
- Collecting discrete headspace gas samples from MW05, MW06, MW07, and GP-12, and analyzing them for VOCs and fixed gases.

These activities, described in detail below, were all performed consistent with the phase 2 scope of work described in the phase 1 RI report (Shaw, 2003).

2.1 Drill and Install Gas Probe GP-12

Nested gas probe GP-12 was installed near monitoring well MW06 (see Figure 1-2) on August 11 and 12, 2003 by the drilling contractor Environmental West, Inc. of Spokane, Washington. The purpose was to determine if LFG is present in the unsaturated zone at depth and to evaluate variations in LFG concentrations with depth. A Shaw hydrogeologist observed and documented the installation and construction of the probe under the supervision of a Washington registered geologist. The work was performed consistent with the WAC Chapter 173-160 "Minimum Standards for Construction and Maintenance of Wells". A notice of the City's intent to drill the gas probe was filed with the WDOE before drilling and installing the probes (see Appendix A). Consistent with the requirements in WAC 173-160, the City obtained a variance from WDOE (included

[1] The parenthesized numbers within the represent distinct gas probes screened at specific intervals in the same borehole, denoted by the GP designation. The depth of each probe's screened interval is presented in Table 2-1. Typically, the (1) designation denotes the gas probe screened at the deepest interval in the borehole; higher parenthesized numbers, e.g., (2), designate probes screened at shallower depth intervals.

in Appendix A) approving the nested design of gas probe GP-12 before construction began.

2.1.1 Drilling and Sampling

The gas probe boring was drilled with an 8-inch-inside diameter casing advanced using an air rotary rig. The borehole was sampled at 5-foot intervals by collecting grab samples of soil cuttings generated during drilling. A Shaw hydrogeologist logged drill cuttings according to American Society for Testing Materials designation D 2487-92 (standard test method for classification of soils for engineering purposes). Data on soil type, moisture content, grain size, and color were recorded on field drilling log forms. An exploratory boring log presenting the field logging data is provided in Appendix A.

The probe was completed in the eolian and Pleistocene flood deposits underlying the facility. These deposits consist of fine to medium sand (with minor silt and fine gravel) to silty sand. The soil materials encountered during borehole drilling were consistent with previous subsurface investigations conducted at the landfill.

2.1.2 Gas Probe Design and Installation

Gas probe GP-12 is comprised of three individual probes, each screened at a discrete and unique depth, as shown in the probe construction detail provided in Appendix A. The three probes were constructed with 0.50-inch-diameter schedule 80 polyvinyl chloride (PVC) casing with 0.010-inch slot screens. All PVC casing sections and factory-slotted well screens were connected with flush-threaded couplings that are each fitted with a rubber O-ring. The bottom of the screen sections were fitted with threaded PVC end-caps, also fitted with rubber O-rings. All PVC gas probe casings, screens, and end caps were supplied by the drilling company in sealed plastic wrappers.

A filter pack consisting of pre-packaged, 10x20 graded sand was placed in the annular space around each screened section. The filter pack extended from approximately 2.5 feet below to 2.5 feet above each screen. The annular space above each filter pack was filled with granular bentonite that was hydrated in one-foot lifts. The probes were constructed with a lockable steel protective casing set in a concrete surface seal that extends from four inches above ground surface to 2 feet below ground surface (bgs). Three protective posts were installed around the casing and filled with concrete.

Each depth-discrete probe was fitted at the surface with a ½-inch PVC "pet-cock" valve threaded to a slip-fit adapter and wrapped with Teflon® tape. The adapter was in turn threaded to the top of each probe and fitted with a rubber O-ring. The "pet-cock" valves were positioned such that the valve controlling the deepest probe is lowest in the protective steel casing, the valve for the middle-depth probe is slightly higher, and the valve for the shallow-depth probe is positioned the highest. Each valve was also labeled

with a permanent marker indicating the relative position of the screen in the borehole. Gas probe construction information is provided in Appendix A.

2.1.3 Surveying

Gas probe GP-12 was surveyed by Horton Dennis and Associates, a Washington State registered land surveying firm. The elevation of the cover on the steel protective casing at each gas probe was surveyed to an accuracy of 0.01 feet relative to the North American vertical datum (1929). Location coordinates (northings and eastings) for the wells were surveyed to the center of the cover with an accuracy of 0.04 feet relative to the site project datum.

2.2 Depth-discrete Landfill Gas Monitoring, and Headspace Gas Sampling and Analysis

On September 18, 2003 Shaw performed the following LFG monitoring and sampling activities consistent with the phase 2 RI work plan: (1) depth-discrete monitoring of LFG concentrations (methane) within the casings of monitoring wells MW05, MW06 and MW07 (see Figure 1-2), (2) LFG gas monitoring in newly-installed nested gas probe GP-12 and site gas probes GP-1, GP-2, GP-5, GP-6, GP-9 (see Figure 1-2), and (3) headspace gas sampling for VOCs and fixed gases (methane, carbon dioxide [CO_2] and oxygen) in MW05, MW06, MW07, and the GP-12 intermediate-depth gas probe.

2.2.1 Monitoring Depth-discrete Landfill Gas in MW05, MW06, and MW07 Well Casing

Depth-discrete LFG monitoring was performed in the monitoring wells and gas probe using a GEM 500 LFG meter (GEM) instead of a flame ionization detector (FID), as specified in the scope of work presented in the phase 1 RI report (Shaw, 2003). This was because the total organic vapor (methane and VOCs) concentrations in the gas probes and monitoring wells frequently exceeded the FID's upper detection limit of 25,000 parts per million. The GEM measures percent methane concentrations, rather than the total organic vapors measured by a FID[2]. The GEM also measures oxygen and CO_2 concentrations (in percent).

To accommodate the depth-discrete gas monitoring, the dedicated 2-inch diameter Grundfos Rediflow™ submersible pump in wells MW05, MW06, and MW07 were removed and the top of the well casing was capped for several days before monitoring was performed. Before monitoring the wells, LFG concentrations were measured in the area around the security casing and immediately inside each well. Then, a stainless-steel

[2] The FID measures all combustible gases including methane and other VOCs.

drop tube was attached to ¼-inch (outside diameter) polyethylene tubing (drop-tube assembly) and lowered into each well casing to a depth directly above the water table. The upper end of the drop-tube assembly was connected to the GEM, which was field-calibrated to factory standards. The GEM's pump was used to evacuate air from the tubing before monitoring methane concentrations. The concentration of methane (in percent) was measured at 10-foot depth intervals as the tubing was lowered in each casing[3]. The time of measurement, depth of measurement, and methane concentration detected by the GEM were recorded on a field report form (Appendix B). The results of depth-discrete gas monitoring in the MW05, MW-06, and MW07 well casings are discussed in Section 3.1.1.

2.2.2 Monitoring Landfill Gas in Gas Probes

Gas monitoring was also performed in the following site gas probes: GP-1, GP-2, GP-5, GP-6, GP-9, and GP-12. All probes consist of either two or three clustered probes, with each probe completed at a different depth within the same borehole. Monitoring was performed by attaching the GEM directly to the sampling pet-cock valves attached to the top of each probe. Gas pressure, methane concentration, oxygen concentration, CO_2 concentration, and duration of purging were recorded for each probe on a field report form (see Appendix B). Results of gas probe monitoring are summarized in Table 2-1 and discussed in Section 3.1.1.

2.2.3 Collecting and Analyzing Headspace Gas Samples from Wells MW05, MW06, and MW07 and Gas Probe GP-12

Headspace gas samples were collected from just above the water table in each monitoring well where LFG monitoring was performed (MW05, MW06, and MW07) using the drop-tube assembly. The monitoring well gas samples were collected in a laboratory-supplied, stainless-steel vacuum Summa canister by connecting the canister to the upper end of the drop-tube assembly, then opening the Summa canister valve and allowing the vacuum within the canister to draw in the gas.

A gas sample was also collected from the intermediate-depth probe in the GP-12 borehole, screened from 49.5 to 59.5 feet bgs. The GP-12 intermediate-depth probe was selected for sampling because it had a high methane gas concentration (see Table 2-1). The GEM was attached to the intermediate-depth probe in GP-12 and use to purge air from the casing before the gas sample was collected. The LFG sample was collected from GP-12 probe by connecting a piece of polyethylene tubing directly to the pet-cock valve at the top of the PVC probe casing and then connecting the other end of the tubing

[3] The GEM pump was allowed to run approximately 180 seconds at each 10-foot depth interval before methane concentrations were measured.

to the Summa canister to allow the vacuum within the canister to draw in gas from the probe.

The four gas samples were submitted to Columbia Analytical Services, Inc. (CAS), in Canoga Park, California, under COC procedures. CAS analyzed the samples for the following:

- Fixed gases (hydrogen, oxygen+argon, nitrogen, carbon monoxide, methane, and CO_2) according to modified U.S. Environmental Protection Agency (USEPA) Method 3C (single injection) using a gas chromatograph equipped with a thermal conductivity detector.

- VOCs using combined gas chromatography/mass spectrometry according to USEPA method TO-15.

Laboratory reports, including COC documentation and laboratory QA/QC results, are provided in Appendix C. The analytical results are discussed in Section 3.2.

3 PHASE 2 REMEDIAL INVESTIGATION FIELD AND LABORATORY RESULTS

3.1 Landfill Gas Monitoring Results

3.1.1 Landfill Gas Probes

Methane concentrations measured in site gas probes GP-1, GP-2, GP-5, GP-6, GP-9, and GP-12 are presented in Table 2-1. Methane was not detected in GP-1 and GP-6. The highest methane concentrations were measured in gas probe GP-2(2) (see Table 2-1 for screen intervals for multiple completion gas probes) and the GP-12 intermediate-depth probe (25.0 percent and 16.3 percent respectively). Both probes are located along the southwestern edge of the waste cells (see Figure 1-2). Methane was also detected at a concentration of 11.9 percent in the deep probe installed in the GP-12 borehole. Lower concentrations of methane were measured in GP-5(1) and GP-5(2) (6.3 and 5.0 percent, respectively) on the northern side of the landfill and in GP-9(1) (5.2 percent) on the southern side of the waste cells.

3.1.2 Monitoring Wells MW05, MW06, and MW07

Depth-discrete methane concentrations measured in the well casings for MW05, MW06, and MW07 are presented in Table 3-1. The results show relatively uniform methane concentrations throughout each well casing. Methane was not detected in the protective steel security casing that house the top of each well casing. Results of methane monitoring in the well casings included the following:

- Methane concentrations in the MW05 well casing ranged from 1.2 percent at 10-feet below top of the casing (btoc), to a maximum concentration of 3.1 percent at 60 feet btoc. The methane concentration measured directly above the top of the groundwater surface in well MW05 (84.4 feet btoc), where the gas sample was collected, was 2.7 percent.

- Methane concentrations in the MW06 well casing ranged from 2.3 percent at 90 feet btoc to 5.5 percent at 40 feet btoc. The methane concentration measured directly above the top of the groundwater surface in well MW06 (100 feet btoc), where the gas sample was collected, was 4.4 percent.

- Methane concentrations in the MW07 well casing ranged from 14.5 percent at 91.5 feet btoc (directly above the top of the groundwater surface) to 16.6 percent at 20 feet btoc.

3.2 Analytical Results of Headspace Gas Samples

Laboratory analytical results of fixed gas concentrations (including methane, CO_2, oxygen+argon, and nitrogen) in headspace gas samples collected from MW05, MW06, MW07, and GP-12 (intermediate) are presented in Table 3-2. Consistent with field-measured LFG concentrations, these results show elevated methane concentrations in MW07 and GP-12 (11.9 and 16.7 percent, respectively). However, fixed gas analysis of the samples collected from MW05 and MW06 headspaces did not detect methane above the method reporting limits. VOC concentrations detected in MW05 and MW06 gas samples were also generally lower than samples analyzed from MW07 and GP-12 (middle), but in the same order of magnitude (see discussion below). Differences between the field and laboratory determined methane concentrations may be attributed to one of the following:

- Discrete gas samples collected for laboratory analysis from the MW05 and MW06 well casings are chemically different than the gas measured during field monitoring because additional purging using the GEM was performed before the Summa canister samples were collected.

- During gas monitoring in the wells, the pump on the GEM was continuously running, as the ¼-inch polyethylene tubing was lowered. The tubing was purged at each 5-foot interval. Typically, it took approximately 30 minutes to conduct all the measurements from the top to the bottom. It is possible that when the well screen is submerged, as they are in MW05 and MW06, additional air from around the well head may have been drawn into the well casing, potentially influencing gas compositions.

VOC analytical results for the headspace gas samples collected from MW05, MW06 and MW07, and GP-12 (intermediate) are presented in Table 3-3. Laboratory analytical reports are provided in Appendix C. 1,1-DCA, *cis*-1,2-DCE, methylene chloride, PCE, TCE, and vinyl chloride were detected in high concentrations in all four headspace gas samples (Table 3-3). Additional VOCs detected in all four headspace gas samples included benzene, chloroethane, 1,1-DCE, *trans*-1,2-dichloroethene (*trans*-1,2-DCE), and TCFM. Low levels of several other VOCs were also detected in one or more of the samples (see Table 3-3).

3.3 Evaluation of Groundwater and Lysimeter-Liquid Chemistry

An evaluation of the inorganic and organic chemistry of groundwater and lysimeter-liquid (leachate) samples was performed to assess if leachate is a possible source of VOCs

impacting groundwater samples collected from the selected site monitoring wells. Historical groundwater and leachate analytical data collected as part of HRLF's routine compliance monitoring program was evaluated using Piper (trilinear) and Stiff diagrams, and time-series trend plots.

3.3.1 Inorganic Chemistry

3.3.1.1 Piper (Trilinear) Diagrams

The geochemical composition of groundwater samples collected from site monitoring wells and liquid samples collected from the site lysimeters, represented by the common anions (i.e., carbonate, bicarbonate [HCO_3], sulfate [SO_4], and chloride [Cl]) and the major dissolved cations (i.e., calcium [Ca], magnesium [Mg], potassium [K], and sodium [Na]), are illustrated graphically using Piper (trilinear) diagrams. The anion and cation data (charge equivalents) are extrapolated onto the center quadrilateral (see Figures 3-1 and 3-2) to represent the overall ionic chemistry of the samples.

Piper (trilinear) diagrams were used to compare the relative concentrations of geochemical indicators (the common cations and anions) in groundwater collected from VOC-impacted monitoring wells MW05, MW06, and MW07, along with the chemistry of the other site monitoring wells (Figures 3-1 and 3-2). Piper diagrams plotting historical ionic chemistry data for each individual monitoring well and lysimeter are also provided in Appendix D.

Dissolved Ca, minor Na and Mg, are the principal cations in groundwater collected from the site monitoring wells, including MW05, MW06, and MW07. The principal anion in groundwater collected from all wells is HCO_3. The ionic chemistry of site groundwater samples is relatively consistent, except for MW02 groundwater (see Figure 3-2). The variation in anionic chemistry of groundwater samples collected from well MW02 is derived primarily from a spike in the Cl concentrations from the beginning of 1999 through the first quarter of 2000 (see trend plot in Appendix E). Except for MW02 groundwater, the Piper diagrams (Figures 3-1 and 3-2) show that samples collected from different site monitoring wells screened in the UGWZ have a similar ionic chemistry, and therefore their cation and anion concentrations plot in a cluster on the diagrams.

Figure 3-1 also shows recent (since 2001) historical ionic chemistry data for liquid samples (representative of site leachate) collected from the four site lysimeters (Port 1 through Port 4). Relative to site groundwater, landfill leachate samples are typically characterized by significantly higher cation and anion concentrations and different relative proportions of ionic constituents (see Table 3-4). The lysimeter liquid samples have a distinct ionic chemistry characterized by a relatively higher percentage of chloride than groundwater (see Figure 3-1).

The Piper diagrams (Figures 3-1 and 3-2) show the following:

- MW05, MW-06, and MW07 groundwater samples are predominantly rich in Ca and HCO_3, and do not exhibit significant temporal or spatial variation in their ionic composition.

- Lysimeter liquid samples contain a slightly higher portion of Mg and are generally more Cl-rich relative to the groundwater samples. The Piper diagram (Figure 3-1) shows that the anionic composition of the lysimeter samples has changed over time, becoming richer in Cl. Increasing trends in Cl concentrations are most pronounced in samples collected from the Port 3 and 4 lysimeters (see time concentration plot in Appendix E).

- MW05, MW-06, and MW07 groundwater samples do not plot on a mixing line between the background groundwater samples (as defined by the ionic chemistry of groundwater from upgradient monitoring wells MW01 and MW07) and the lysimeter samples. Mixing between groundwater and leachate would be represented as data points on a straight line, joining clusters of data representing the ionic compositions of unimpacted (background) groundwater and leachate. The groundwater samples would also likely show increasing Cl concentrations if they were impacted by site leachate (represented by the lysimeter samples).

3.3.1.2 Stiff Diagrams

Whereas Piper diagrams illustrate the relative concentrations of the major cations and anions in groundwater and leachate samples, Stiff diagrams provide absolute concentrations of these constituents (in milliequivalents per liter [meq/L]). Stiff diagrams are polygons constructed by connecting the concentrations of the major ions, arranged in an ordered sequence. The resultant polygon graphically represents the ionic chemistry of each water sample, which can be compared using its shape and the magnitude of the parameter concentrations.

Stiff diagrams generated for groundwater samples collected from the site monitoring wells and liquid samples collected from the lysimeters (Appendix D) confirm the geochemical compositions represented by the Piper diagrams. As the Stiff diagrams indicate, site groundwater samples are uniformly characterized by high Ca and HCO_3 concentrations, with lesser amounts of Mg and Cl (except for MW02 samples as previously discussed). The shape of the Stiff diagrams for the lysimeter samples (1) differ from those for the site groundwater samples, (2) reflect higher Cl and Mg concentrations compared to site groundwater samples, and (3) illustrate their generally higher parameter concentrations (see meq/L scales on top and bottom of plots in Appendix D). These differences in the shapes of the Stiff plots between the groundwater and lysimeter samples suggest that leachate has not affected site groundwater samples.

3.3.1.3 Time-series Trend Plots

Time-series plots (provided in Appendix E) were prepared for a subset of inorganic constituents which may indicate that groundwater collected from VOC-impacted wells MW05, MW06, and MW07 has been affected by either leachate or LFG.

The inorganic constituents Cl, nitrate as nitrogen (NO_3-N), Na, and total organic carbon (TOC) are potentially indicative of a leachate release to groundwater because they (or ammonia in the case of NO_3-N) are detected at elevated concentrations in lysimeter liquid samples relative to groundwater (see Tables 3-4 and 3-5). Cl is a particularly good leachate indicator because it behaves in a conservative manner in groundwater and is present in high concentrations in site leachate samples. Conversely, ammonia oxidizes to NO_3-N in typical groundwater conditions. Therefore, if ammonia concentrations are high in leachate, as they are at the HRLF, then elevated NO_3-N concentrations in groundwater samples collected from downgradient monitoring wells may be evidence of a leachate release. However, it should be noted that elevated NO_3-N concentrations in groundwater can be associated with agricultural activities. Increasing Na concentrations in downgradient groundwater can also indicate a leachate release because Na is comparatively soluble and often detected at elevated concentrations in leachate. Na is also naturally occurring and changes in its concentrations in groundwater may be attributed to natural processes.

Inorganic constituents whose concentrations could be affected by the interaction of LFG with groundwater are pH, alkalinity, and Ca (Tuchfeld et. al., 1998). This is attributed to the dissolution of gaseous CO_2, present in relatively high concentrations in LFG (see Table 3-2), into groundwater. The dissolved CO_2 lowers the pH of the groundwater, which in turn increases alkalinity. Because anion and cation charge equivalents must stay in balance as pH changes, increasing alkalinity in groundwater also increases the Ca concentration. It is important to note that a release of leachate into groundwater may also have a similar influence on pH and alkalinity.

Time-concentration diagrams plotting historical analytical results for inorganic leachate and LFG indicator parameters in groundwater samples collected from MW05, MW06, and MW07, along with upgradient and cross-gradient wells MW01 and MW02, (Appendix E) show the following:

- The pH of MW05, MW06, and MW07 groundwater is decreasing.
- Ca and alkalinity concentrations in MW04, MW05 and MW06 groundwater samples are increasing.

- As previously discussed in Section 3.3.1.1, Cl concentrations in MW04, MW05 and MW06 groundwater samples have either remained constant or shown slightly increasing trend. Cl concentrations in hydraulically upgradient well MW-01 have also increased.

- Leachate indicator parameters NO_3-N (ammonia) and TOC were either not detected, or detected at very low concentrations.

3.3.2 VOC Analytical Results

Historical VOCs concentrations detected in groundwater samples collected from monitoring wells MW05, MW06, and MW07 are summarized in Table 3-3. Table 3-3 also presents the concentrations of VOCs detected in headspace gas samples collected from the GP-12 and monitoring well casings, and in liquid samples collected from the site lysimeters.

As previously discussed in Section 1.2, VOCs detected most frequently and in the highest concentrations in MW05, MW06, and MW07 groundwater samples include PCE, *cis*-1,2-DCE, 1,1-DCA, TCE, vinyl chloride, methylene chloride, benzene, and TCFM. In considering the source of VOCs detected in these groundwater samples, it is interesting to note that all these VOCs were also detected most frequently and in the highest concentrations in headspace gas samples collected from the MW05, MW06, and MW07 well casings and from gas probe GP-12 (see Table 3-3). Although many of the same VOCs were also detected in liquid samples collected from the site lysimeters (see Table 3-3), a subset of VOCs frequently detected in the lysimeters samples at high concentrations were either not detected in any of the MW05, MW06, and MW07 groundwater samples or headspace gas samples, or detected infrequently and at low concentrations in these samples. VOCs detected in high concentration in the lysimeters samples but not in groundwater are 2-butanone (MEK), carbon disulfide, ethylbenzene, 4-methyl-2-pentanone, toluene, and total xylenes.

4 FINDINGS AND CONCLUSIONS

4.1 Source of VOCs Impacting Site Groundwater

Phase 2 RI field and laboratory results, along with historical inorganic and VOC analytical results of groundwater and lysimeter liquid samples, indicate that LFG, not leachate, is the likely source of VOCs impacting site groundwater at the HRLF. Phase 2 RI results that support LFG as the source and transport mechanism for VOCs impacting site groundwater include the following:

- Significant concentrations of LFG (as measured in GP-12) occur in the shallow (unsaturated) subsurface to a depth of at least 90 feet bgs in the MW06 area. Furthermore, high concentrations of LFG were detected in the PVC casings of VOC-impacted groundwater monitoring wells MW05, MW06, and MW07.

- VOCs were detected in groundwater samples collected from monitoring well MW07, which is interpreted to be hydraulically upgradient from the waste cells (see Figure 4-1). LFG was detected in the MW07 well casing and the groundwater samples collected from this well contain the same suite of VOCs as those detected in groundwater collected from other site monitoring well and in headspace gas samples. A leachate release to groundwater would not likely impact an upgradient monitoring well.

- The same suite of VOCs detected most frequently and in the highest concentrations in groundwater samples collected from MW05, MW06, and MW07 was also detected in headspace gas samples collected from the casing of these wells and from gas probe GP-12 (see Table 3-3). Furthermore, a subset of VOCs frequently detected in the lysimeters samples (representative of site leachate) at high concentrations were either not detected in any of the MW05, MW06, and MW07 groundwater samples, or detected infrequently and at low concentrations in groundwater.

- Geochemical evaluation of groundwater and lysimeter liquid samples generally show changes in inorganic chemistry in VOC-impacted wells that are reflective of the interaction of LFG, not leachate, with site groundwater including the following:

  - Piper and Stiff diagrams indicate that groundwater collected from MW05, MW06, and MW07 do not have chemical compositions similar to that of landfill leachate represented by liquid samples collected from the site lysimeters. The Piper diagrams also reveal that leachate is not mixing with the MW05, MW06, and MW07 groundwater.

  - Changes in the pH (decreasing trend), and in alkalinity and Ca concentrations (increasing trends) are indicative of the interaction of LFG with groundwater

Further evidence supporting LFG as the source of VOCs impacting site groundwater is derived from analytical results of dissolved methane concentrations in groundwater samples collected since 2001, as part of HRLF's compliance monitoring program (see Table 4-1). Dissolved methane was consistently detected in VOC-impacted groundwater samples collected from MW05, MW06, MW7 and MW10, indicating that LFG is interacting with groundwater at these locations.

4.2 Mechanism for LFG Infiltration into Groundwater

LFG typically impacts groundwater by either direct contact with groundwater in the capillary fringe near the water table, or by impacting vadose water that is later introduced to groundwater by recharge events. However, high LFG concentrations in some site monitoring wells had introduced the possibility that the wells might represent the pathway whereby LFG is migrating down to the groundwater surface where it eventually impacts groundwater (intrawell mechanism). To assess whether this mechanism is occurring, Shaw evaluated site monitoring well designs, groundwater elevations, and the distribution of LFG. The results of this evaluation, discussed below, indicate that VOC impacts detected in site groundwater samples is likely not from an intrawell mechanism.

There are two potential mechanisms for LFG to migrate into the monitoring well casings at HRLF. The most likely and effective mechanism is infiltration of LFG through an exposed section of the well screen, when the water level is below the top of the screen. A second mechanism involves LFG migration through (1) imperfections in the annular seal, (2) defects in the well casing, and/or (3) at joints between casing sections, which generally are not air tight. A third mechanism, which Shaw has documented to occur at other sites, may be near-surface infiltration of LFG into the protective surface casing,

where it then enters the well casing. However, because no significant LFG was detected around the HRLF monitoring wells at ground surface, or inside the top of the well casings, this mechanism does not appear to be a contributory factor.

Review of site well-construction details and June 2003 groundwater elevations indicate that the higher methane concentrations detected in the MW07 well casing is likely attributed to LFG migrating through a six-foot-long section of the well screen, which is exposed to the vadose zone above the top of the groundwater surface (see Table 4-2). This allows LFG present in the vadose zone surrounding the well screen to easily enter the casing, much like a gas probe. The top of the well screens in monitoring wells MW08, MW09 and MW10 were also above the groundwater surface in June 2003 (see Table 4-2), however, methane concentrations were not measured in these wells as part of the phase 2 RI.

Conversely, the lower concentrations of methane detected in the MW05 and MW06 well casings are likely a result of their entire screen sections being below the top of the groundwater surface (see Table 4-2). High concentrations of methane (16.3 and 11.9 percent) were detected in the vadose zone adjacent to well MW06, in the intermediate and deep gas probes at GP-12. However, LFG in the vicinity of MW-06 cannot effectively migrate into the well as easily as a gas probe, or as in MW07. It is likely that infiltration of LGF in the MW05 and MW06 well casings is through imperfections in the annular seal and through joints and potential defects (if present) in the well casing.

The following field and laboratory results of the RI phase 1 and 2 investigations indicate that the VOC impacts detected in monitoring well groundwater samples are likely from the vertical migration of LFG through the unsaturated soil to the capillary fringe zone and not attributed to intrawell effects:

- High methane concentrations in gas probes screened deep in the vadose zone indicate that LFG has effectively migrated down to the top of the groundwater surface.

- VOC concentrations detected in groundwater samples from well MW07, which contained significantly higher methane concentrations than in MW05 and MW06, are consistent with VOC concentrations detected in MW05 and MW06 groundwater, which have submerged well-screens.

5 RECOMMENDATIONS

Results of the RI discussed in this report suggest that LFG is a likely source of VOC impacting groundwater beneath the HRLF. Consequently, Shaw recommends performing a pilot-scale LFG extraction test to assess the feasibility of implementing active LFG collection as a method for mitigating the LFG source of VOCs, and ultimately reducing VOCs concentrations in groundwater. If the pilot test demonstrates that gas collection is a feasible option for controlling LFG, then (1) site-specific information derived from the extraction test will be used for modeling landfill gas generation and designing a gas collection and control system (GCCS) and (2) the pilot-scale test can be expanded to include a feasibility assessment of alternative final cover systems that may be constructed in conjunction with an active GCCS.

This section describes the design of a pilot LFG extraction test and procedures for performing the pilot test.

5.1 Perform Pilot LFG Extraction Test

Designing a GCCS generally involves modeling LFG generation and extraction rates using site-specific information as input parameters (as discussed in Section 5.1.4). However, before modeling LFG generation at HRLF, Shaw recommends performing an additional field investigation to demonstrate the potential effectiveness of an active GCCS and refine the LFG generation model input parameters. The additional field investigation involves conducting a pilot LFG extraction test for the following purposes:

- Quantify actual LFG generation rates from the landfill.
- More accurately predict LFG quality and composition.
- Determine the actual radius of influence for a typical LFG extraction well.
- Estimate the site-specific rate constant for methane-generation.
- Refine well spacing design criteria for the GCCS.
- Potentially demonstrate the effectiveness of reducing LFG concentrations in the existing monitoring systems.

5.1.1 Install Gas Extraction Well and Monitoring Probes

The pilot extraction test will involve installing a gas extraction (test) well and monitoring (observation) probes (pilot system), in general compliance with the USEPA's New Source Performance Standards (NSPS) requirements for Tier 3 emissions estimates (USEPA, 1996). The pilot system will consist of one vertical LFG extraction well drilled to the bottom of waste and four observation gas probes installed in waste surrounding the new extraction well. The location of the pilot system will be selected after reviewing site-specific information on the age, distribution, depth, and composition of waste.

The pilot extraction well will be designed and constructed so that it could be incorporated into the final GCCS and used for long-term LFG collection. The extraction well will be constructed using 6-inch-diameter, high-density polyethylene (HDPE) casing. The perforated section of the HDPE casing will extend from 20 feet below the waste surface to the well's total depth. A detail of the proposed gas extraction well is provided in Figure 5-1. After the extraction well is installed, a temporary header pipe will be attached to the top of the well casing and connected to a temporary blower. The header will be equipped with monitoring points that will allow measurement of LFG quality, flow rate, temperature, and pressure. The observation probes will be installed at variable horizontal distances from the well (e.g., 50, 100, 225, and 300 feet) and constructed with the same perforated interval as the pilot extraction well (see Figure 5-2).

5.1.2 Perform Baseline Monitoring

After the extraction well and observation probes are installed and before the pilot extraction test is performed, baseline static gas pressure and gas composition (percent methane, CO_2, and oxygen) will be measured in the observation probes. A GEM, calibrated to factory standards, will be used to measure gas composition.

Additional baseline monitoring will include measuring gas compositions in a series of hand-driven bar holes advanced into the waste. The bar holes will cover a 200-foot by 200-foot square area centered on the proposed extraction well. Bar hole probe locations will be spaced approximately 100 feet apart (9 locations). The bar hole monitoring data will help predict the potential sustained LFG flow rate from the extraction well during performance of the pilot test.

Bar hole probes will be constructed by driving a 0.5-inch-diameter steel rod attached to a slide hammer to a depth of approximately 5 feet below the waste surface. Bar hole probes will not be advanced farther than 5-feet below the surface. PVC tubing, 5-feet-long and 0.375 inches in diameter, will be inserted into each bar hole, leaving 6 inches of open hole below the bottom of the tubing and 6 inches of tubing above ground surface. The tubing will be sealed in place by tamping surface soil around it. The upper end of the tubing will be connected to the GEM, which will be used to evacuate air from

the tubing before gas compositions are monitored measured using the GEM. The tubing will be clamped closed after each purging and monitoring of the probe to prevent atmospheric air from entering the tubing and diluting the gas concentrations in the probes.

5.1.3 Perform Pilot Extraction Test

After baseline monitoring is complete, the pilot extraction test will be conducted, consistent with USEPA's NSPS requirements for Tier 3 emissions estimates (USEPA, 1996). First a vacuum will be applied to the extraction well with the temporary blower. Gas composition and temperature will be monitored every 20 minutes over an eight-hour period to determine a steady-state extraction rate (applied vacuum) at which the gas composition is between 40 and 45 percent methane.

The vacuum extraction test will then be performed at the steady-state flow rate for a minimum of 96 hours. Methane concentrations in the extraction well will be monitored during the test to verify that a gas composition between 40 and 45 percent methane is sustained. If the methane concentration deviates outside this required range, the flow will be adjusted until the required methane concentration is reestablished, and the extraction test will be restarted (USEPA, 1996).

Throughout the duration of the pilot test, static pressure (vacuum) and methane concentrations will be monitored periodically in the observation probes, bar hole probes, and selected out-of-waste gas probes and groundwater monitoring wells. A discrete gas sample from the pilot extraction well will also be collected for VOC analysis to characterize the type and concentrations of VOCs in the LFG source area.

5.1.4 Model LFG Generation

Results of the pilot extraction test, along with site-specific information on the type, quantity, extent, and depth of waste at HRLF, will provide the basis for estimating LFG generation (and extraction) rates from the major landfill area(s) over time using Shaw's proprietary LFG Model (LFGM), which includes the USEPA's Clean Air Act model. Site-specific information, obtained by reviewing available as-built information and design reports regarding site development at HRLF, will include the following:

- Depth, mass, and location of in-place waste.
- Projections of future waste to be placed in the current 46-acre landfill footprint.
- Estimated waste composition, including percentages of organic (such as food, garden, and paper waste) and inorganic waste.
- Estimated waste moisture content.

The LFG extraction estimate can also be used to estimate condensate generation volumes, and to determine required LFG extraction and treatment equipment, including header piping sizes.

Based on results of the pilot extraction test, refined LFG modeling results, and air-quality compliance requirements, an overall GCCS design can be developed that incorporates existing conditions at the landfill and makes provisions for incremental construction phasing of the GCCS in coordination with continued filling of the 46-acre landfill to its designed final grades.

5.1.5 Prepare Report

Following completion of pilot extraction test, the data will be evaluated and a report will be prepared for submittal to WDOE and the local health district. The report will include the following:

- LGF extraction well and observation gas probe construction details.
- Tables summarizing extraction test monitoring results.
- An analysis of the extraction test results and LFG generation modeling results.
- Recommendations for the next phase of work.

LIMITATIONS

The services described in this report were performed consistent with generally accepted professional consulting principles and practices. No other warranty, expressed or implied, is made. These services were performed consistent with our agreement with our client. This report is solely for the use and information of our client unless otherwise noted. Any reliance on this report by a third party is at such party's sole risk.

Opinions and recommendations contained in this report apply to conditions existing when services were performed and are intended only for the client, purposes, locations, time frames, and project parameters indicated. We are not responsible for the impacts of any changes in environmental standards, practices, or regulations subsequent to performance of services. We do not warrant the accuracy of information supplied by others, or the use of separated portions of this report.

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TABLES

Table 2-1
Field-Measured Major Gas Concentrations
in Gas Probes
Horn Rapids Landfill

Gas Probe Designation	Screened Interval (feet-bgs)	Units / Date	Methane (%)	Oxygen (%)	Carbon Dioxide (%)	Purge time (seconds)
GP-1(2)[1]	8.5 - 10	9-18-03	0.0	17.7	2.2	180
GP-1(1)	16.5 - 18	9-18-03	0.0	16.9	2.7	180
GP-2(2)	18.5 - 20	9-18-03	25.0	0.3	31.2	180
GP-2(1)	36.5 - 38	9-18-03	19.1	0.2	28.9	180
GP-5(3)	18.5 - 20	9-18-03	0.2	12.3	7.7	180
GP-5(2)	36.5 - 38	9-18-03	5.0	0.4	25.1	180
GP-5(1)	56.5 -58	9-18-03	6.3	0.3	26.5	360
GP-6(shallow)	11-15	9-18-03	0.0	13.0	8.2	360
GP-6(deep)	26-30	9-18-03	0.0	7.7	14.3	540
GP-9(2)	11 - 16	9-18-03	0.0	10.5	9.2	180
GP-9(1)	26 - 30	9-18-03	5.2	0.2	21.2	180
GP-12(shallow)	22.5 -35.5	9-18-03	0.3	2.4	19.2	360
GP-12(intermediate)	35.5 - 49.5	9-18-03	16.3	0.0	26.2	720
GP-12(deep)	76.5 - 89.5	9-18-03	11.9	0.0	24.8	960

Notes: % = percent of total atmospheric gases; bgs = below ground surface

[1] = the number within the parenthesis represents a distinct screen interval for multiple completion gas probes.

Table 3-1:
Depth-Discrete Methane Concentrations in MW05, MW06, and MW07 Well Casings
Horn Rapids Landfill

Measurement Depth (feet, btoc)	Methane Concentration (percent)		
	MW05	MW06	MW07
In security casing	0.0	0-2	0.0
10	1.2	3.1	16.2
20	2.3	4.0	16.6
30	2.7	5.4	16.4
40	3.0	5.5	16.4
50	3.0	4.7	15.9
60	3.1	3.9	15.3
70	3.0	3.1	14.9
80	2.9	2.7	14.7
90	----	2.3	14.5
Above groundwater surface	2.7[a]	4.4[b]	14.5[c]

Notes: *btoc = below top of casing: ; ---- = not measured. % = percent of total atmospheric gases. Methane gas concentrations measured with a LandTec GEM 500 landfill gas meter on September 18, 2003.

[a] MW05 groundwater surface at 84.39 feet btoc.

[b] MW06 groundwater surface at 98.98 feet btoc.

[c] MW07 groundwater surface at 91.45 feet btoc.

Table 3-2
Fixed Gas Concentrations in MW05, MW06 MW07, and GP-12 Gas Samples
Horn Rapids Landfill

Sample Location	Sampling Date	Fixed Gas Concentrations (%, v/v)			
		Methane	Carbon Dioxide	Oxygen + Argon	Nitrogen
GP-12 (intermediate)	9/18/2003	16.7	28.2	0.710	54.5
MW05 (~84 feet-bgs)	9/18/2003	<0.127	6.09	16.8	77.1
MW06 (~98 feet-bgs)	9/18/2003	<0.298	0.621	22.2	77.2
MW07 (~91 feet-bgs)	9/18/2003	11.9	27.9	3.99	56.2

Notes: % = percent; v/v = volume of constituent divided by total sample volume; < = less than the method reporting limit show to the right of this symbol; bgs = below ground surface)

Table 3-3
VOCs Detected in Groundwater, Landfill Gas, and Lysimeter Liquid Samples
Horn Rapids Landfill

Sample Location	Date Collected	Tetra-chloro-ethene	cis-1,2-Dichloro-ethene	Trichloro-fluoro-methane	1,1-Dichloro-ethane	Tri-chloro-ethene	Vinyl Chloride	Chloro-ethane	Methylene chloride	trans-1,2 Dichloro-ethene	Benzene	1,1-Dichloro-ethene	Trichloro-trifluoro-ethane	Carbon Disulfide	1,1,1-Trichloro-ethane	Acetone	2-Butaaone (MEK)	Chloro-methane	1,2-Dichloro-propane	1,2-Di-chloro-ethane	Toluene	Total Xylenes	Ethyl-benzene	Chloro-form	1,4-Dichloro-benzene	4-Methyl-2-pent-anone	Styrene	Acrylo-nitrile
H.L. Coeffcients		0.017	0.0041	0.097	0.0056	0.01	0.027	0.011	0.0022	0.0094	0.0056	0.026	0.097	0.03	0.017	0.000039	0.000027	0.024	0.0028	0.00098	0.00166	0.0073	0.0079	0.0037	0.0019	0.00014	0.0028	0.000088
Landfill Gas (parts per billion by volume [ppbV])																												
MW05	18-Sep-03	150	360	29	260	120	190	120	61	12	5.5	34	7.4	8.7	9.5	ND	ND	ND	2.7	4.4	ND	ND	ND	ND	ND	ND	ND	NT
MW06	18-Sep-03	8.7	48	0.74	42	13	47	86	4.1	5	4.4	5.7	ND	44	ND	91	10	3.1	ND	ND	8.9	1.6	ND	ND	ND	ND	ND	NT
MW07	18-Sep-03	1300	1100	720	240	220	190	420	360	52	68	45	44	ND	110	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NT
GP012	18-Sep-03	2700	810	28	570	540	480	51	43	79	30	33	15	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NT
Groundwater (micrograms per liter [ug/L])																												
MW05	18-May-98	24.5	30.9	1.4	20.2	11.8	0.8	ND	15.4	ND	0.8	0.6	NT	ND	1.6	ND	ND	1.3	0.7	1.1	ND	ND	ND	0.5	ND	ND	ND	ND
	30-Jun-98	18.2	29.9	1.5	19.7	10.1	1.1	ND	19.9	0.5	1.3	0.5	NT	ND	1.5	ND	ND	ND	0.6	1	ND	ND	ND	ND	ND	ND	ND	ND
	30-Jun-98	19.2	28.5	ND	19.6	8	ND	ND	10.9	ND	0.8	ND	NT	ND	1.3	ND	ND	ND	ND	1.1	ND	ND	ND	ND	ND	ND	ND	ND
	10-Aug-98	22	34	1.7	22	12	1.3	ND	15	ND	1.8	0.5	NT	ND	1.7	ND	ND	ND	0.7	1.1	ND	ND	ND	ND	0.5	ND	ND	ND
	16-Nov-98	33.6	44.3	2.2	ND	15.6	2.1	ND	26.5	ND	2.1	0.7	NT	ND	2.3	11.9	ND	ND	ND	1.3	ND	ND	ND	ND	0.6	ND	ND	ND
	26-Jan-99	11.5	11	ND	2.9	0.9	0.6	ND	1	ND	2.4	0.6	NT	ND	1.1	10.1	ND	ND	ND	2.1	ND	ND	ND	ND	ND	ND	ND	ND
	12-May-99	36.2	44.4	2	28.1	17.5	ND	ND	13.8	ND	2.8	1.7	NT	ND	2.1	16.2	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	5-Oct-99	30.8	52.6	ND	26.7	16.5	2.9	ND	ND	ND	2.7	ND	NT	ND	1.9	9.6	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	21-Dec-99	22	ND	ND	24	11	ND	ND	NE	ND	2	ND	NT	ND	ND	20	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	8-Feb-00	23.8	48.2	ND	20.8	10.1	1.3	ND	ND	ND	2.1	ND	NT	ND	1	12.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	16-May-00	25	37	2	22	13	3	2	12	ND	2	1	NT	ND	1	ND	ND	ND	ND	2	ND	ND	ND	ND	ND	ND	ND	ND
	30-Aug-00	31	49	ND	25	13	4.8	ND	15	1.4	1.4	1.7	NT	ND	1.6	ND	ND	ND	ND	2.3	ND	ND	ND	ND	ND	ND	ND	ND
	5-Dec-00	29	48	3.5	23	13	4.4	1.2	14	ND	ND	ND	NT	ND	ND	ND	ND	ND	ND	1.8	ND	ND	ND	ND	ND	ND	ND	ND
	10-Apr-01	26	48	3.7	22	13	4.5	1.6	12	ND	ND	ND	NT	ND	ND	ND	ND	ND	ND	1.2	ND	ND	ND	ND	ND	ND	ND	ND
	25-Jul-01	23	99	3.7	42	9	11	ND	20	ND	ND	ND	NT	ND	ND	ND	ND	ND	ND	ND	ND	1.2	ND	ND	ND	ND	ND	ND
	16-Oct-01	22	45	4	20	8.5	4.9	ND	8.8	ND	ND	ND	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	18-Dec-01	21	67	ND	27	5.5	7.3	ND	12	ND	ND	ND	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	20-Mar-02	22	63	ND	30	5.3	7.6	ND	12	ND	ND	ND	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	3-Jul-02	24	59	3.8	24	8.9	7.8	2.6	8.2	ND	ND	ND	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	15-Oct-02	18	34	ND	16	11	2.7	ND	7.2	ND	1.4	ND	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	17-Dec-02	18.4	36.4	1.2	17.6	9.8	10	2.1	8.1	ND	0.7	1.1	NT	ND	0.5	ND	ND	ND	0.5	1.2	ND	ND	ND	ND	ND	ND	ND	ND
	26-Mar-03	24	35	ND	17	13	4.4	ND	3.5	ND	1.6	ND	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	11-Jun-03	19	32	ND	14	10	5.1	ND	3.4	ND	ND	ND	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW06	18-May-98	36.5	21.6	0.5	32.4	13.6	0.6	ND	14.2	0.7	0.7	0.6	NT	ND	0.5	ND	ND	1.3	0.7	1.5	ND	ND	ND	ND	ND	ND	ND	ND
	7-Jul-98	32.1	24.6	0.6	33.6	13.5	1.2	ND	9.4	0.9	2.5	ND	NT	ND	0.5	ND	ND	ND	0.7	1.5	ND	ND	ND	ND	ND	ND	ND	ND
	7-Jul-98	35	22.2	ND	32.7	12.7	ND	ND	8.8	1.3	1.8	ND	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	10-Aug-98	36	28	0.5	36	15	1.5	ND	7.9	1.1	3.3	0.5	NT	ND	0.5	ND	ND	ND	0.7	1.7	ND	ND	ND	ND	ND	ND	ND	ND
	16-Nov-98	43.5	35.8	0.5	ND	17.9	3.1	ND	10	1.4	4.1	0.8	NT	ND	0.6	25	ND	ND	0.8	2.3	ND	ND	ND	ND	ND	ND	ND	ND
	26-Jan-99	34	16.5	ND	6.9	0.9	0.8	ND	ND	0.7	2.5	0.7	NT	ND	ND	ND	ND	ND	ND	0.9	1.5	ND	ND	ND	ND	ND	ND	ND
	12-May-99	55.5	34.9	0.5	42.2	20.3	3.5	1	2.3	0.8	4.5	ND	NT	ND	2.1	22.8	ND	ND	ND	0.6	ND	ND	ND	ND	ND	ND	ND	ND
	5-Oct-99	52.7	48.7	ND	47.8	22.2	6	ND	6.6	ND	5.3	ND	NT	ND	0.5	17.4	ND	ND	ND	3.5	ND	ND	ND	ND	ND	ND	ND	ND
	21-Dec-99	45	1.8	ND	42	17	ND	ND	4.9	ND	ND	ND	NT	ND	0.5	ND	ND	ND	ND	3.5	ND	ND	ND	ND	ND	ND	ND	ND
	8-Feb-00	48.6	38.1	ND	41.9	18.9	4.1	ND	1.2	ND	6	ND	NT	ND	ND	14.9	ND	ND	ND	1.8	ND	ND	ND	ND	ND	ND	ND	ND
	16-May-00	45	40	ND	38	21	5	1	5	ND	5	1	NT	ND	ND	ND	ND	ND	ND	2	ND	ND	ND	ND	ND	ND	ND	ND
	30-Aug-00	71	58	ND	54	25	8	ND	5.1	3.8	6.7	2.2	NT	ND	ND	ND	ND	ND	ND	3.5	ND	ND	ND	ND	ND	ND	ND	ND
	5-Dec-00	66	59	ND	50	28	6.4	ND	4	2.5	6	ND	NT	ND	ND	ND	ND	ND	ND	2.7	ND	ND	ND	ND	ND	ND	ND	ND
	10-Apr-01	67	57	ND	46	28	6.7	ND	3.2	2.6	5.6	ND	NT	4.9	ND	ND	ND	ND	ND	2.3	ND	ND	ND	ND	ND	ND	ND	ND
	25-Jul-01	63	120	ND	87	22	13	ND	8.7	ND	7.7	ND	NT	ND	ND	ND	ND	ND	ND	ND	ND	5.3	ND	ND	ND	ND	ND	ND
	16-Oct-01	79	63	ND	45	27	8.4	ND	2	2.6	5.8	ND	NT	ND	ND	ND	ND	ND	ND	1.7	ND	ND	ND	ND	ND	ND	ND	ND
	18-Dec-01	61	89	ND	64	16	12	ND	5.4	ND	ND	ND	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	20-Mar-02	82	88	ND	61	16	11	ND	3.4	4.8	6.5	ND	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	3-Jul-02	77	99	ND	63	28	15	ND	2.6	4.8	5.7	1.6	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	15-Oct-02	77	49	ND	35	34	5.5	ND	ND	2.9	6.3	1.1	NT	ND	ND	ND	ND	ND	ND	1.8	ND	ND	ND	ND	ND	ND	ND	ND
	17-Dec-02	47.3	43.8	0.5	35.2	28.2	16.9	1.3	3.3	3.5	4.6	1.5	NT	ND	ND	ND	ND	ND	0.7	1.7	ND	ND	ND	ND	ND	ND	ND	ND
	26-Mar-03	78	50	ND	36	37	8.1	ND	ND	3.1	6.7	ND	NT	ND	ND	ND	ND	ND	ND	1.3	ND	ND	ND	ND	ND	ND	ND	ND
	11-Jun-03	94	53	ND	31	33	9.3	ND	ND	3	4.4	ND	NT	ND	ND	ND	ND	ND	ND	1.4	ND	ND	ND	ND	ND	ND	ND	ND

DOC (4).max

Table 3-3
VOCs Detected in Groundwater, Landfill Gas, and Lysimeter Liquid Samples
Horn Rapids Landfill

Sample Location	Date Collected	Tetra-chloro-ethene	cis-1,2-Dichloro-ethene	Trichloro-fluoro-methane	1,1-Dichloro-ethane	Tri-chloro-ethene	Vinyl Chloride	Chloro-ethane	Methylene chloride	trans-1,2 Dichloro-ethene	Benzene	1,1-Dichloro-ethene	Trichloro-trifluoro-ethane	Carbon Disulfide	1,1,1-Trichloro-ethane	Acetone	2-Butanone (MEK)	Chloro-methane	1,2-Dichloro-propane	1,2-Di-chloro-ethane	Toluene	Total Xylenes	Ethyl-benzene	Chloro-form	1,4-Dichloro-benzene	4-Methyl-2-pent-anone	Styrene	Acrylo-nitrile
MW07	10-Apr-01	**24**	**44**	**3.2**	**3.3**	**4.6**	ND	**1.4**	**17**	ND	ND	ND	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	25-Jul-01	**25**	**78**	ND	**11**	**3.7**	ND	**5**	**27**	ND	ND	ND	NT	ND	ND	ND	ND	ND	ND	ND	ND	--	ND	ND	ND	ND	ND	ND
	16-Oct-01	**29**	**51**	**3.9**	**5.3**	**4.1**	**1.8**	**3.4**	**10**	ND	ND	ND	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	18-Dec-01	**29**	**120**	ND	ND	**4.5**	ND	ND	**16**	ND	ND	ND	NT	ND	ND	ND	ND	ND	ND	ND	**13**	ND	ND	ND	ND	ND	ND	ND
	20-Mar-01	**35**	**49**	ND	**5**	**5.6**	ND	ND	**7.8**	ND	ND	ND	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	3-Jul-20	**41**	**74**	**5.4**	**7.8**	**6.1**	**3.8**	**4.9**	**10**	ND	ND	ND	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	15-Oct-02	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	ND	ND
	17-Dec-02	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	ND	ND
	26-Mar-03	**40**	**39**	ND	**6**	**9.2**	**1**	ND	**2.6**	ND	ND	ND	NT	ND	**1.1**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	11-Jun-03	**22**	**40**	ND	**5.4**	**5.2**	**2.2**	ND	ND	ND	ND	ND	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lysimeter Liquid Samples (ug/L)																												
Port 1	8-Jun-94	7	ND	**2**	**83**	**6**	**1**	**24**	**42**	ND	**10**	ND	NT	ND	**22**	ND	NT	ND	ND	ND	**2**	**9**	**1**	**2**	ND	**33**	ND	ND
	22-Feb-95	ND	ND	ND	ND	ND	ND	ND	NE	ND	ND	ND	NT	NT	ND	NT	NT	ND	ND	ND	ND	ND	ND	ND	ND	NT	ND	NT
	19-Jul-95	ND	ND	ND	**16**	ND	ND	**15**	**72**	ND	ND	ND	NT	ND	ND	ND	ND	ND	ND	ND	ND	**6**	ND	ND	ND	**7.9**	ND	ND
	12-Sep-96	**5**	ND	ND	**7**	ND	ND	ND	NE	ND	ND	ND	NT	ND	ND	NT	NT	ND	ND	ND	ND	ND	ND	ND	ND	NT	ND	NT
	15-Apr-97	ND	**38**	ND	**16**	ND	**21**	ND	NE	ND	**15**	ND	NT	ND	ND	**800**	**36000**	ND	ND	ND	ND	ND	ND	ND	ND	**310**	ND	ND
	8-Apr-98	**3**	**45**	ND	**9.9**	**1.8**	**9.3**	**11**	**4.7**	ND	**6.5**	**0.6**	NT	**73**	ND	**519**	**4060**	**3.6**	ND	**1.7**	**56**	**57**	**9.7**	ND	ND	**655**	ND	**8.7**
	21-Oct-98	**7.2**	**113.2**	ND	**78.5**	**5.3**	ND	**41.4**	**9.9**	ND	**11.3**	ND	NT	ND	ND	**152**	**5400**	**9.6**	ND	ND	**113**	**126.1**	**17.2**	ND	ND	**28.4**	ND	ND
	11-Jan-00	**6.4**	**96.3**	ND	**76.5**	**6.1**	**14**	**30.2**	**8.3**	**1.5**	**10.9**	ND	NT	ND	ND	**120**	**4200**	**7.5**	ND	**2.5**	**109**	**113.3**	**18.2**	ND	**2**	**22.3**	ND	ND
	8-Nov-00	**2.3**	**110**	ND	**13**	**1.1**	**25**	**28**	**5.1**	ND	**14**	**1**	NT	**11**	ND	**6.7**	**760**	**2.1**	ND	**2.8**	**140**	**80**	**22**	ND	ND	**31**	**2.1**	ND
	18-Jun-01	ND	**51**	ND	**8.2**	ND	**11**	**18**	**2.8**	ND	**5.5**	ND	NT	**6.2**	ND	**60**	**160**	ND	ND	**1.6**	**43**	**26**	**6.6**	ND	ND	**56**	ND	ND
	5-Dec-01	**2**	**110**	ND	**14**	ND	**11**	**30**	**8.8**	ND	**7.6**	ND	NT	**9.8**	ND	**54**	**79**	ND	ND	**3.4**	**77**	**78**	**16**	ND	ND	**580**	ND	ND
	19-Aug-02	ND	**44**	ND	ND	ND	ND	**12**	**2.5**	ND	**3.7**	**6.3**	NT	ND	ND	ND	ND	ND	ND	ND	**43**	**36**	**8**	ND	ND	**30**	ND	ND
	31-Dec-02	**2.7**	59.5	ND	9.2	**1.8**	51.3	27.3	**5.4**	ND	4.5	**1.8**	NT	ND	ND	**111**	**75.9**	**3**	ND	**1.6**	**34.5**	**56.5**	**7.4**	ND	ND	**189**	ND	ND
Port 2	22-Feb-95	**14**	**94**	ND	**110**	NT	ND	**24**	**83**	ND	**1.3**	ND	NT	ND	ND	NT	NT	ND	ND	**2.4**	**28**	**38**	**3.3**	ND	ND	NT	ND	ND
	12-Sep-96	ND	**142**	ND	**124**	ND	ND	**31**	**12**	ND	**10**	ND	NT	ND	ND	NT	NT	ND	ND	ND	**188**	**67**	**14**	ND	ND	NT	ND	ND
	15-Apr-97	ND	**31**	ND	**28**	ND	**7**	ND	ND	ND	ND	ND	NT	ND	ND	ND	ND	ND	ND	ND	**65**	**45**	**7**	ND	ND	**41**	ND	ND
	11-Jan-00	**1.9**	**52.8**	ND	**39.1**	**0.8**	**12.6**	**23.9**	**5.5**	ND	**9.9**	ND	NT	ND	ND	**8.2**	**52.3**	**1.8**	ND	**4**	**101**	**78.2**	**15.2**	ND	**2.1**	ND	ND	ND
Port 3	18-May-95	**9.8**	ND	ND	**16**	**7.4**	ND	**35**	**73**	ND	ND	ND	NT	**7.4**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	12-Sep-96	ND	**23**	ND	**19**	ND	ND	**8**	**6**	ND	ND	ND	NT	NT	ND	NT	NT	ND	ND	ND	**43**	**28**	**6**	ND	ND	NT	ND	ND
	15-Apr-97	ND	**38**	ND	**28**	ND	**21**	ND	ND	ND	**7**	ND	NT	ND	ND	**230**	**2000**	ND	ND	ND	**60**	**32**	**8**	ND	ND	**41**	ND	ND
	8-Apr-98	**1.7**	**36**	ND	**15**	**1.4**	**2.3**	**2.2**	**1.5**	ND	**6.2**	ND	NT	ND	**0.8**	ND	**52**	**3.1**	ND	**3**	**49**	**43**	**6.7**	ND	ND	**30**	ND	ND
	21-Oct-98	**6.8**	**89.4**	ND	**58.8**	**5.2**	**11.9**	**37.6**	**9.4**	ND	**13.8**	ND	NT	ND	ND	ND	**99.3**	**8.9**	ND	ND	**148**	**102**	**20.1**	ND	ND	**47.6**	ND	ND
	29-Jun-99	**1.4**	**63.2**	ND	**46.7**	**1.6**	**14**	**27.7**	**4.3**	ND	**10.5**	ND	NT	ND	ND	**12**	**14.5**	**1.5**	ND	**3.3**	**118**	**73.3**	**14.8**	ND	**1**	ND	ND	ND
	11-Jan-00	**3**	**58**	ND	**43.7**	**2**	**11.8**	**20.5**	**5.3**	ND	**12.3**	ND	NT	ND	ND	**10.9**	**13.6**	**1.9**	ND	**2.9**	**109**	**63.5**	**12.9**	ND	**1.8**	ND	ND	ND
	8-Nov-00	**1.6**	**73**	ND	**14**	ND	**9.2**	**25**	**5.2**	ND	**8.6**	ND	NT	ND	ND	ND	ND	**1.4**	ND	**3.3**	**66**	**42**	**11**	ND	ND	**160**	**1.6**	ND
	18-Jun-01	ND	**62**	ND	**11**	ND	**8.1**	**29**	**5.1**	ND	**8.4**	ND	NT	**6.4**	ND	ND	**20**	**3.4**	ND	**3.2**	**56**	**26**	**7.4**	ND	ND	**99**	ND	ND
	5-Dec-01	**2**	**120**	ND	**19**	ND	**8.5**	**44**	**11**	ND	**9.4**	**1.2**	NT	ND	ND	ND	ND	**5.7**	ND	ND	**64**	**49**	**12**	ND	ND	**95**	ND	ND
Port 4	8-Jun-94	**14**	**2**	**3**	**22**	**5**	ND	**11**	**106**	ND	ND	ND	NT	ND	**7**	ND	NT	ND	ND	**12**	**95**	**146**	**6**	ND	ND	**68**	ND	ND
	22-Feb-95	**15**	**1.6**	**4.3**	**28**	**4.8**	ND	**17**	**160**	ND	**1.1**	ND	NT	NT	ND	NT	NT	ND	ND	**7.4**	**46**	**25**	**4.4**	ND	ND	NT	ND	ND
	18-May-95	**14**	ND	ND	**23**	ND	ND	**23**	**150**	ND	ND	ND	NT	ND	ND	ND	ND	ND	ND	**6.1**	**9.4**	**7.6**	ND	ND	ND	ND	ND	ND
	19-Jul-95	**6**	ND	ND	**5.4**	**6.3**	ND	ND	**7.2**	ND	ND	ND	NT	ND	ND	ND	ND	ND	ND	ND	**<5**	**<5**	ND	ND	ND	ND	ND	ND
	12-Sep-96	**8**	ND	ND	**16**	ND	ND	ND	ND	ND	ND	ND	NT	NT	ND	NT	NT	ND	ND	ND	**23**	**16**	ND	ND	ND	NT	ND	ND
	15-Apr-97	**<5**	**160**	ND	**140**	**5**	**13**	**44**	**10**	ND	**15**	ND	NT	**85**	ND	ND	**430**	ND	ND	ND	**240**	**66**	**21**	ND	ND	**860**	ND	ND
	8-Apr-98	**3**	**110**	ND	**70**	**2.3**	**3.9**	**15**	**4.1**	ND	**11**	**0.7**	NT	**24**	ND	ND	**104**	**2.3**	ND	**3**	**135**	**71**	**14**	ND	**1.8**	**103**	**1.4**	ND
	29-Jun-99	**2.7**	**63.2**	ND	**101**	**2.1**	**19.1**	**30.3**	**7.8**	ND	**10.3**	ND	NT	ND	ND	**23.2**	**568**	**1.7**	ND	**3.7**	**110**	**113.8**	**16.7**	ND	**1.2**	ND	ND	ND
	11-Jan-00	**2.7**	**63.2**	ND	**101**	**2.1**	**19.1**	**30.3**	**7.8**	ND	**10.3**	ND	NT	ND	ND	**23.2**	**568**	**1.7**	ND	**3.7**	**110**	**113.8**	**16.7**	ND	**1.2**	ND	ND	ND
	8-Nov-00	**1.1**	**100**	ND	**51**	ND	**8.7**	**31**	**10**	ND	**8.2**	ND	NT	**11**	ND	ND	ND	**1.5**	ND	**3**	**77**	**45**	**12**	ND	**2.1**	**55**	**1.7**	ND
	18-Jun-01	**1.7**	**110**	ND	**53**	**1**	**8.6**	**50**	**11**	ND	**6.6**	ND	NT	**11**	ND	ND	**7.9**	**1.5**	ND	**3.1**	**37**	**37**	**11**	ND	**1.5**	**120**	ND	ND
	5-Dec-01	**2.8**	**280**	ND	**110**	ND	**12**	**84**	**21**	ND	**12**	**2.1**	NT	**4.6**	ND	ND	ND	**4.6**	ND	ND	**110**	**72**	**14**	ND	**3.2**	**360**	ND	ND
	19-Aug-02	**1.5**	**100**	ND	**36**	ND	ND	ND	**7.2**	ND	**5.8**	ND	NT	ND	ND	ND	ND	ND	ND	ND	**44**	**29**	**9.7**	ND	ND	**160**	ND	ND

Notes: ND = not detected, NT = not tested, BOLD results are detects, H.L. = Henry's Law dimensionless coefficients.

Table 3-4
Cations and Anions in MW05, MW06, and MW07
Groundwater and Lysimeter Liquid Samples
Horn Rapids Landfill

Sample Location	Date	Alkalinity (mg/L)	Bicarb-onate (mg/L)	Calcium (mg/L)	Chloride (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Potassium (mg/L)	Sodium (mg/L)	Sulfate (mg/L)
MW05	18-May-98	467	570	159	19.3	37.9	4.7	13.6	18.3	39.8
	30-Jun-98	469	572	149	19.3	30.3	0.09	9.88	17.9	40.6
	10-Aug-98	472	576	151	18.9	32	0.033	9.7	17.9	40.4
	16-Nov-98	238	290	155	20.2	32.3	0.021	10	18.3	39.3
	26-Jan-99	466	568	163	20.4	37	0.02	9.8	18.2	41
	12-May-99	478	583	149	19.9	33.7	0.015	9.7	17.7	41.9
	5-Oct-99	494	602	148	19.6	31.1	0.009	8.9	17.2	42.5
	21-Dec-99	480	585	44	22.5	22.9	0.018	9.8	18.8	46.2
	8-Feb-00	472	576	53	53.2	24.2	0.015	10	17.3	46
	16-May-00	477	477	168	20.8	34.6	0.0094	10.5	19.2	32.9
	30-Aug-00	710	710	150	18	35	0.012	11	19	38
	5-Dec-00	480	480	130	24	29	0.0082	9.1	18	65
	10-Apr-01	470	470	160	19	35	0.011	11	21	42
	25-Jul-01	480	480	170	20	34	0.011	9.8	18	43
	16-Oct-01	500	500	170	23	35	0.0082	6.8	18	44
	18-Dec-01	510	510	160	23	32	0.0088	9.3	17	44
	20-Mar-02	490	490	170	26	33	0.018	9	17	44
	3-Jul-02	470	470	170	23	38	0.016	11	21	42
	15-Oct-02	510	510	200	17	46	0.012	8.6	23	33
	17-Dec-02	510	510	160	23	36	0.0093	10	20	45
	26-Mar-03	480	480	150	25	33	0.0099	9.9	17	44
	11-Jun-03	670	670	170	39	36	0.015	11	20	49
MW06	18-May-98	475	579	151	12.4	37.8	1.2	16.3	25.1	32.7
	7-Jul-98	504	615	142	11.9	31.1	0.11	10.7	21.9	31.4
	10-Aug-98	514	627	149	11.9	33.1	0.101	10.5	21.4	31.6
	16-Nov-98	294	359	151	11.8	33	0.067	10.4	21.5	33.2
	26-Jan-99	538	656	164	11.7	38.6	0.057	10.6	22.4	32.9
	12-May-99	558	680	157	11.8	36.7	0.062	10.7	22.5	32.3
	5-Oct-99	566	690	159	12.3	34.2	0.062	10.1	21.1	32.8
	21-Dec-99	560	683	45	13.5	24.5	0.065	10.8	23.5	35.5
	8-Feb-00	544	663	54	14	25.8	0.069	10.8	21.4	36
	16-May-00	569	569	194	11.5	40.8	0.0396	12.1	25	38.8
	30-Aug-00	650	650	190	11	47	0.036	13	27	31
	5-Dec-00	620	620	160	11	35	0.025	11	23	34
	10-Apr-01	610	610	190	11	41	0.027	13	27	33
	25-Jul-01	610	610	200	15	41	0.023	11	24	35
	16-Oct-01	620	620	190	16	42	0.02	7.5	23	36
	18-Dec-01	630	630	180	15	39	0.021	11	24	34
	20-Mar-02	610	610	220	18	44	0.02	11	27	36
	3-Jul-02	630	630	200	16	45	0.022	13	27	35
	15-Oct-02	650	650	240	13	57	0.014	9.9	32	27
	17-Dec-02	650	650	190	17	43	0.0051	12	26	36
	26-Mar-03	630	630	170	17	39	0.012	11	23	37
	11-Jun-03	650	650	180	13	41	0.015	12	24	40

Table 3-4
Cations and Anions in MW05, MW06, and MW07
Groundwater and Lysimeter Liquid Samples
Horn Rapids Landfill

Sample Location	Date	Alkalinity (mg/L)	Bicarb-onate (mg/L)	Calcium (mg/L)	Chloride (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Potassium (mg/L)	Sodium (mg/L)	Sulfate (mg/L)	
MW07	20-Mar-01	740	740	290	77	58	0.01	11	31	84	
	10-Apr-01	560	560	230	59	43	0.13	11	27	74	
	25-Jul-01	580	580	240	56	44	0.033	11	25	75	
	16-Oct-01	750	750	280	60	55	0.034	9.5	28	82	
	18-Dec-01	740	740	260	54	48	0.013	11	27	76	
	3-Jul-02	710	710	290	57	57	0.011	13	31	79	
	26-Mar-03	730	730	230	68	47	0.0064	11	27	81	
	11-Jun-03	790	790	280	61	52	0.0091	12	29	80	
Port 1	8-Jun-94	ND	1180	206	20	82	9.9	25	54	5	U
	13-Oct-94	ND	1340	282	24	87	87	19	45	5	U
	22-Feb-95	ND	450	15	21	66	0.16	16	48	15	
	12-Sep-96	ND	1000	210	25	84	2.1	19	46	1	
	15-Apr-97	ND	1000	210	41	77	1.2	21	46	1	U
	23-Sep-97	ND	1200	240	55	81	1	20	49	1	U
	8-Apr-98	ND	880	244	64.6	74.7	4.6	17	35.9	1.06	
	21-Oct-98	ND	1050	368	391	132	11.3	23.1	46.7	0.21	
	11-Jan-00	ND	853	51.8	120	43.5	1.98	21	48.7	0.4	
	8-Nov-00	ND	220	76.5	68	30.3	0.849	5.07	12.8	0.8	U
	18-Jun-01	ND	300	100	87	25	2.3	4.4	12	0.25	
	5-Dec-01	ND	130	48	47	15	0.66	2.8	6.3	1.6	
	31-Dec-02	ND	ND	88	110	25	1.2	4.9	11	1.1	
Port 2	22-Feb-95	ND	880	170	30	49	6.5	17	33	4	
	18-May-95	ND	ND	190	51	56	7.6	18	34	5	
	19-Jul-95	ND	710	110	21	76	0.056	16	46	5	
	12-Sep-96	ND	1100	280	5.4	79	10	21	40	0.1	U
	15-Apr-97	ND	1100	260	190	90	7.8	20	58	1	U
	23-Sep-97	ND	1200	270	81	89	3.4	19	47	1	
	11-Jan-00	ND	63.6	ND	1439	138	53.5	45.9	53.8	28.2	
Port 3	18-May-95	ND	ND	97	22	75	1.8	22	48	25	
	12-Sep-96	ND	1100	250	16	92	4.8	21	46	0.1	U
	15-Apr-97	ND	1200	270	73	91	5.9	22	50	1	U
	23-Sep-97	ND	1100	250	250	89	8.2	17	57	1	U
	8-Apr-98	ND	1020	318	282	117	10.1	22.6	61.5	0.2	
	21-Oct-98	ND	1060	349	356	133	10.1	23.1	66.6	0.24	
	29-Jun-99	ND	1168	290	397	130	9.8	24	63	1.2	
	11-Jan-00	ND	1234	54.9	508	50.8	9.27	23.2	74.3	0.3	
	8-Nov-00	ND	920	228	500	92.2	7.2	13.4	43.1	0.8	U
	18-Jun-01	ND	980	370	550	130	9.5	26	79	0.45	
	5-Dec-01	ND	700	290	460	100	6.3	20	57	1	

Table 3-4
Cations and Anions in MW05, MW06, and MW07
Groundwater and Lysimeter Liquid Samples
Horn Rapids Landfill

Sample Location	Date	Alkalinity (mg/L)	Bicarb-onate (mg/L)	Calcium (mg/L)	Chloride (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Potassium (mg/L)	Sodium (mg/L)	Sulfate (mg/L)	
Port 4	8-Jun-94	ND	1190	242	106	91	4.4	26	60	5	U
	13-Oct-94	ND	1380	296	119	108	1.25	22	57	5	U
	22-Feb-95	ND	1400	290	140	110	4.8	19	59	1	U
	18-May-95	ND	ND	260	150	99	4.5	17	54	1	
	19-Jul-95	ND	1200	270	140	110	3	19	64	2	
	12-Sep-96	ND	1100	280	130	96	4	19	57	1	U
	15-Apr-97	ND	1000	290	190	86	12	22	45	1	U
	23-Sep-97	ND	1100	280	270	90	9.3	19	44	1	U
	8-Apr-98	ND	1020	348	325	120	12.3	23	44.5	0.1	U
	29-Jun-99	ND	1239	320	441	130	11	24	60	0.5	
	11-Jan-00	ND	1190	55.2	470	50.2	10.07	22.9	59.9	0.1	U
	8-Nov-00	ND	950	264	470	101	6.99	14.5	37.5	0.8	U
	18-Jun-01	ND	960	360	490	130	9.4	24	60	0.48	
	5-Dec-01	ND	920	380	550	130	8.4	24	59	0.16	

Note; mg/L = milligrams per liter, ND = no data, U = not detected at or above the method reporting limit.

Table 3-5
Leachate Indicator Parameters in
MW05, MW06 and MW07 Groundwater and Lysimeter Liquid Samples
Horn Rapids Landfill

Location	Date	Ammonia as N (mg/L)		Conductivity (µmhos/cm)	Nitrate as N (mg/L)		pH (SU)	TDS (mg/L)	TOC (mg/L)	
MW05	18-May-98	0.01	U	894	2.74		7.04	595	1	U
	30-Jun-98	0.5	U	851	2.72		6.8	598	5	
	10-Aug-98	0.018		873	2.87		6.83	598	9.4	
	16-Nov-98	0.012		967	3.02		6.72	603	24	
	26-Jan-99	0.026		1015	3.19		6.97	615	4.8	
	12-May-99	0.01	U	933	NT		6.89	605	1.7	
	5-Oct-99	0.01		1026	3.4		6.8	634	1	U
	21-Dec-99	0.02		1033	4		6.64	621	1	U
	8-Feb-00	0.03		1102	3.4		6.65	620	5.4	
	16-May-00	0.07		781	3.29		6.52	596	1.09	
	30-Aug-00	0.36		741	2.9		6.41	610	1	
	5-Dec-00	0.027		887	3.2		6.5	620	1.5	U
	10-Apr-01	0.048		813	3.2		6.58	610	1.5	U
	25-Jul-01	0.01	U	709	3.2		6.17	610	1.5	U
	16-Oct-01	0.03		889	3.6		6.77	600	1.3	
	18-Dec-01	0.14		756	3.4		6.27	600	2.1	
	20-Mar-02	0.73		761	3.4		6.44	600	4.4	
	3-Jul-02	0.43		1023	3.2		6.17	590	3.4	
	15-Oct-02	0.41		938	2.5		6.29	620	1.7	
	17-Dec-02	0.2		1069	3.3		6.29	610	1.9	
	26-Mar-03	0.33		1048	3.4		6.34	620	2.4	
	11-Jun-03	0.19		867	3.7		6.03	610	2.1	
MW06	18-May-98	0.01	U	885	0.21		7.18	581	1	U
	7-Jul-98	0.5	U	847	0.5	U	6.84	608	6.4	
	10-Aug-98	0.028		922	0.25		6.81	602	9.8	
	16-Nov-98	0.015		953	0.27		6.73	600	5	
	26-Jan-99	0.042		1033	0.33		6.82	637	9.6	
	12-May-99	0.01	U	1067	NT		6.89	627	3.2	
	5-Oct-99	0.01	U	1098	0.4		6.86	667	1	U
	21-Dec-99	0.01	U	1127	0.4		6.73	668	1	U
	8-Feb-00	0.03		1162	0.9		6.76	650	5	
	16-May-00	0.07		877	0.4		6.61	664	1.35	
	30-Aug-00	0.072		907	0.1	U	6.39	700	1.4	
	5-Dec-00	0.01	U	1027	0.39		6.51	710	1.5	U
	10-Apr-01	0.043		926	0.3		6.44	680	1.6	
	25-Jul-01	0.023		733	0.33		6.22	700	1.5	U
	16-Oct-01	0.03	U	1029	0.6		7.14	690	1.5	
	18-Dec-01	0.03	U	843	0.47		6.31	700	2	
	20-Mar-02	0.03	U	881	0.6		6.5	700	1.5	
	3-Jul-02	0.048		1113	0.48		6.27	690	1.8	
	15-Oct-02	0.045		1033	0.4		6.16	710	1.5	
	17-Dec-02	0.03	U	1203	0.52		6.15	710	1.6	
	26-Mar-03	0.1		1147	0.67		6.32	700	1.7	
	11-Jun-03	0.062		972	0.63		6.13	710	1.5	

Table 3-5
Leachate Indicator Parameters in
MW05, MW06 and MW07 Groundwater and Lysimeter Liquid Samples
Horn Rapids Landfill

Location	Date	Ammonia as N (mg/L)		Conductivity (µmhos/cm)		Nitrate as N (mg/L)		pH (SU)	TDS (mg/L)	TOC (mg/L)	
MW07	20-Mar-01	0.04		936		12		6.34	960	2.3	
	10-Apr-01	0.046		982		12		6.5	860	3.9	
	25-Jul-01	0.01	U	755		12		6.33	860	1.5	U
	16-Oct-01	0.047		974		12		6.43	960	3.3	
	18-Dec-01	0.049		928		11		6.09	950	2.5	
	3-Jul-02	0.048		1252		11		6.15	940	2.2	
	26-Mar-03	0.056		907		14		6.24	990	1.9	
	11-Jun-03	0.061		158		14		6.2	1000	1.9	
Port 1	29-Apr-94	NT		-10.5*		NT		6.5	NT	NT	
	8-Jun-94	0.14		-15.5*		0.01		6.8	1150	19.3	
	13-Oct-94	0.05	U	-16.9*		0.02		6.7	1230	23.2	
	22-Feb-95	0.04	U	-103.9*		n/a		8.2	330	14	
	18-May-95	NT		NT		NT		NT	NT	NT	
	19-Jul-95	NT		-35.1*		NT		7	NT	NT	
	12-Sep-96	0.2	U	NT		0.1	U	6.5	1200	46	
	15-Apr-97	7.9		2130		0.1	U	7.5	1200	200	
	23-Sep-97	5.5		2280		0.1	U	6.3	1500	280	
	8-Apr-98	NT		1155		NT		5.8	NT	NT	
	21-Oct-98	2.35		2550		0.1	U	6.4	1770	140	
	29-Jun-99	NT		NT		NT		NT	NT	NT	
	3-May-00	NT		NT		NT		NT	NT	NT	
	8-Nov-00	1.95		832		0.46		5.9	360	NT	
	18-Jun-01	0.70		1100		0.16		5.9	770	NT	
	5-Dec-01	2.1		429		0.13		4.9	250	NT	
	19-Aug-02	NT		802		NT		5.3	NT	NT	
	31-Dec-02	NT		NT		0.079		NT	NT	NT	
	0/11/00	3.1		1384		0.3		6	1358	150	
Port 2	29-Apr-94	NT		2.4*		NT		6.3	NT	NT	
	8-Jun-94	NT		NT		NT		NT	NT	NT	
	13-Oct-94	NT		NT		NT		NT	NT	NT	
	22-Feb-95	0.04	U	14.2*		NT		6.1	810	43	
	18-May-95	0.05		11.3*		0.05	U	6.2	1100	40	
	19-Jul-95	0.04	U	NT		0.05	U		850	28	
	12-Sep-96	1.8		-5.4*		0.01	U	6.3	1300	65	
	15-Apr-97	1.7		2560		0.2	U	7.3	1600	38	
	23-Sep-97	8.1		2200		0.1	U	6.5	1700	95	
	8-Apr-98	NT		NT		NT		NT	NT	NT	
	21-Oct-98	NT		NT		NT		NT	NT	NT	
	29-Jun-99	NT		NT		NT		NT	NT	NT	
	11-Jan-00	2.95		1535		1544		6.3	160	8.4	
	3-May-00	NT		NT		NT		NT	NT	NT	
	8-Nov-00	NT		NT		NT		NT	NT	NT	
	18-Jun-01	NT		NT		NT		NT	NT	NT	
Port 2	5-Dec-01	NT		NT		NT		NT	NT	NT	
	19-Aug-02	NT		NT		NT		NT	NT	NT	
	31-Dec-02	NT		NT		NT		NT	NT	NT	

Table 3-5
Leachate Indicator Parameters in
MW05, MW06 and MW07 Groundwater and Lysimeter Liquid Samples
Horn Rapids Landfill

Location	Date	Ammonia as N (mg/L)	Conductivity (µmhos/cm3)	Nitrate as N (mg/L)	pH (SU)	TDS (mg/L)	TOC (mg/L)
Port 3	29-Apr-94	NT	NT	NT	NT	NT	NT
	8-Jun-94	NT	NT	NT	NT	NT	NT
	13 Oct 94	NT	NT	NT	NT	NT	NT
	22-Feb-95	NT	NT	NT	NT	NT	NT
	18-May-95	0.04 U	-1.5*	n/a	6.4	840	27
	19-Jul-95	NT	NT	NT	NT	NT	NT
	12-Sep-96	0.2	-9.6*	0.01 U	6.4	1400	1400
	15-Apr-97	4.8	2250	0.1 U	7.4	1400	86
	23-Sep-97	2.6	2610	1 U	6.4	1800	40
	8-Apr-98	6.23	2550	0.1 U	6.4	1530	1 U
	21-Oct-98	2.75	2670	0.1 U	6.2	1690	160
	29-Jun-99	1.3	1903	0.1 U	6.2	727	48
	11-Jan-00	2.8	2530	0.1 U	6.1	1836	47
	3-May-00	NT	NT	NT	NT	NT	NT
	8-Nov-00	2.1	1220	0.10 U	5.2	1800	43
	18-Jun-01	1.7	2500	0.03 U	6.3	2000	54.5
	5-Dec-01	2.8	1136	0.03 U	5.7	1400	NT
	19-Aug-02	NT	NT	NT	NT	NT	NT
	31-Dec-02	NT	NT	NT	NT	NT	NT
Port 4	29-Apr-94	NT	NT	NT		NT	NT
	8-Jun-94	0.23	NT	0.01 U	6.6	1090	36.8
	13-Oct-94	0.06	-10.3*	0.02	6.6	1370	46.5
	22-Feb-95	0.36	-4.0*	NT	6.4	1700	92
	18-May-95	0.04 U	-2.7*	NT	6.4	1700	48
	19-Jul-95	0.05	-21.7*	0.05 U	6.8	1500	34
	12-Sep-96	0.2 U	-19.2*	0.1 U	6.5	1500	250
	15-Apr-97	1.4	2500	0.2 U	7.2	1600	69
	23-Sep-97	2.2	2620	1 U	6.4	1900	61
	8-Apr-98	5.58	2620	0.1 U	6.4	1630	1 U
	21-Oct-98	NT	NT	NT	NT	NT	NT
	29-Jun-99	1.5	2370	0.1 U	6.3	1837	90
	11-Jan-00	2.3	2410	0.1 U	6	1906	100
	3-May-00	NT	NT	NT	NT	NT	NT
	8-Nov-00	1.5	1720	0.1 U	5.5	1800	68
	18-Jun-01	1.8	2700	0.03 U	6.3	2000	67.5
	5-Dec-01	1.8	1149	0.03 U	5.6	1900	NT
	19-Aug-02	NT	905	NT	5.8	NT	NT
	31-Dec-02	NT	NT	NT		NT	NT

Notes: U = parameter not detected; NT = parameter not tested; mg/L = milligrams per liter; mmhos/cm3 = micromohs per cubic centimeter; SU = standard pH units; ** Specific Conductance units of measurement rel/mv .

Table 4-1
Dissolved Methane and Total VOC Concentrations
Groundwater Samples
Horn Rapids Landfill

Sample Location	Date Collected	Total VOCs (µg/L)	Methane (µg/L)
MW05	10-Apr-01	132	840
	25-Jul-01	208.9	1200
	16-Oct-01	113.2	990
	18-Dec-01	139.8	1300
	20-Mar-02	139.9	910
	3-Jul-02	138.3	840
	15-Oct-02	90.3	525
	17-Dec-02	107.6	458
	26-Mar-03	98.5	NT
	11-Jun-03	83.5	353
MW06	18-Dec-01	139.8	1300
	20-Mar-02	139.9	910
	3-Jul-02	138.3	840
	15-Oct-02	90.3	525
	17-Dec-02	107.6	458
	26-Mar-03	98.5	NT
	11-Jun-03	83.5	353
	10-Apr-01	223.3	3500
	25-Jul-01	326.7	5300
	16-Oct-01	234.5	4400
	18-Dec-01	247.4	5000
	20-Mar-02	272.7	4100
	3-Jul-02	296.7	8000
	15-Oct-02	212.6	2090
	17-Dec-02	188.5	1930
	26-Mar-03	220.2	NT
	11-Jun-03	229.1	2120

Note; µg/L = micrograms per liter, ND = not detected at or above the method detection limit, NT = not tested.

Sample Location	Date Collected	Total VOCs (µg/L)	Methane (µg/L)
MW07	20-Mar-01	102.4	13
	10-Apr-01	97.5	ND
	25-Jul-01	149.7	4.5
	16-Oct-01	108.5	1.2
	18-Dec-01	182.5	4.4
	19-Dec-01	182.5	4.4
	15-Oct-02	ND	NT
	17-Dec-02	ND	NT
	26-Mar-03	98.9	NT
	11-Jun-03	74.8	ND
MW10	10-Apr-01	50.2	2.3
	25-Jul-01	95.4	81
	16-Oct-01	38.9	0.0036
	18-Dec-01	104.8	75
	20-Mar-02	80.8	110
	3-Jul-02	74.8	98
	15-Oct-02	57.2	103
	17-Dec-02	58.2	82
	26-Mar-03	46.5	NT
	11-Jun-03	39.8	13

Table 4-2
Monitoring Well Construction and June 2003 Groundwater Elevation Information
Horn Rapids Landfill

Well ID	Date Installed	Top of Casing (ft, AMSL)	Total Well Depth (feet bgs)	Borehole Diameter (inches)	Casing/ Screen Material	Screen Top (feet bgs)	Screen Bottom (feet bgs)	Screen Length (feet)	Sand Pack Material	Sand Pack Top (ft, AMSL)	Sand Pack Bottom (ft, AMSL)	Bentonite Interval (feet bgs)	Groundwater Elevation (June 11, 2003) (ft, AMSL)	Height of Groundwater Surface Relative to Top of Screen[a] (feet)
MW01	18-Jun-87	486.33	136.8	6	2-inch ID SS	111.8	136.8	25.0	NA	377.9	345.0	0-106	384.04	11.84
MW02	18-Jun-87	466.35	121.7	6	2-inch ID SS	96.7	121.7	25	NA	375.1	340.1	0-89	381.65	14.25
MW03	18-Jun-87	477.93	129.8	6	2-inch ID SS	129.8	154.8	25	NA	375.6	343.7	0-100	381.58	35.68
MW04	18-Jun-87	459.17	110	6	2-inch ID SS	110.0	135	25	NA	375.5	344.2	0-81	381.32	34.62
MW05	4-May-98	466.59	100.5	8	2-inch ID sch 40 PVC	88.0	98	10	10/20 sand	382.21	362.21	0-81	381.89	6.68
MW06	4-May-98	481.19	115.5	8	2-inch ID sch 40 PVC	103.0	113	10	10/20 sand	382.77	360.77	0-95	382.00	7.23
MW07	16-Jan-01	475.68	105	6	2-inch ID sch 40 PVC	83.5	105	21.5	10/20 silica sand	388.5	368	0-84	383.58	**-5.92**
MW08	18-Jan-01	473.12	102	6	2-inch ID sch 40 PVC	84.5	99.5	15	10/20 silica sand	388.87	355.37	0-82	381.42	**-4.45**
MW09	22-Jan-01	487.4	115	6	2-inch ID sch 40 PVC	97.5	112.5	15	10/20 silica sand	391.27	397.77	0-93	381.74	**-5.53**
MW10	23-Jan-01	457.5	87	6	2-inch ID sch 40 PVC	69.5	84.5	15	10/20 silica sand	359.71	337.71	0-6	382.12	**-3.09**

Notes: ft=feet; bgs=below ground surface; AMSL=above mean sea level; ID=inside diameter; sch 40=schedule 40; PVC=poly vinyl chloride; SS=stainless steel; NA=not available; All screen slot sizes=0.010 inches

[a] Negative value indicates groundwater surface is below top of screened interval of well casing.

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FIGURES

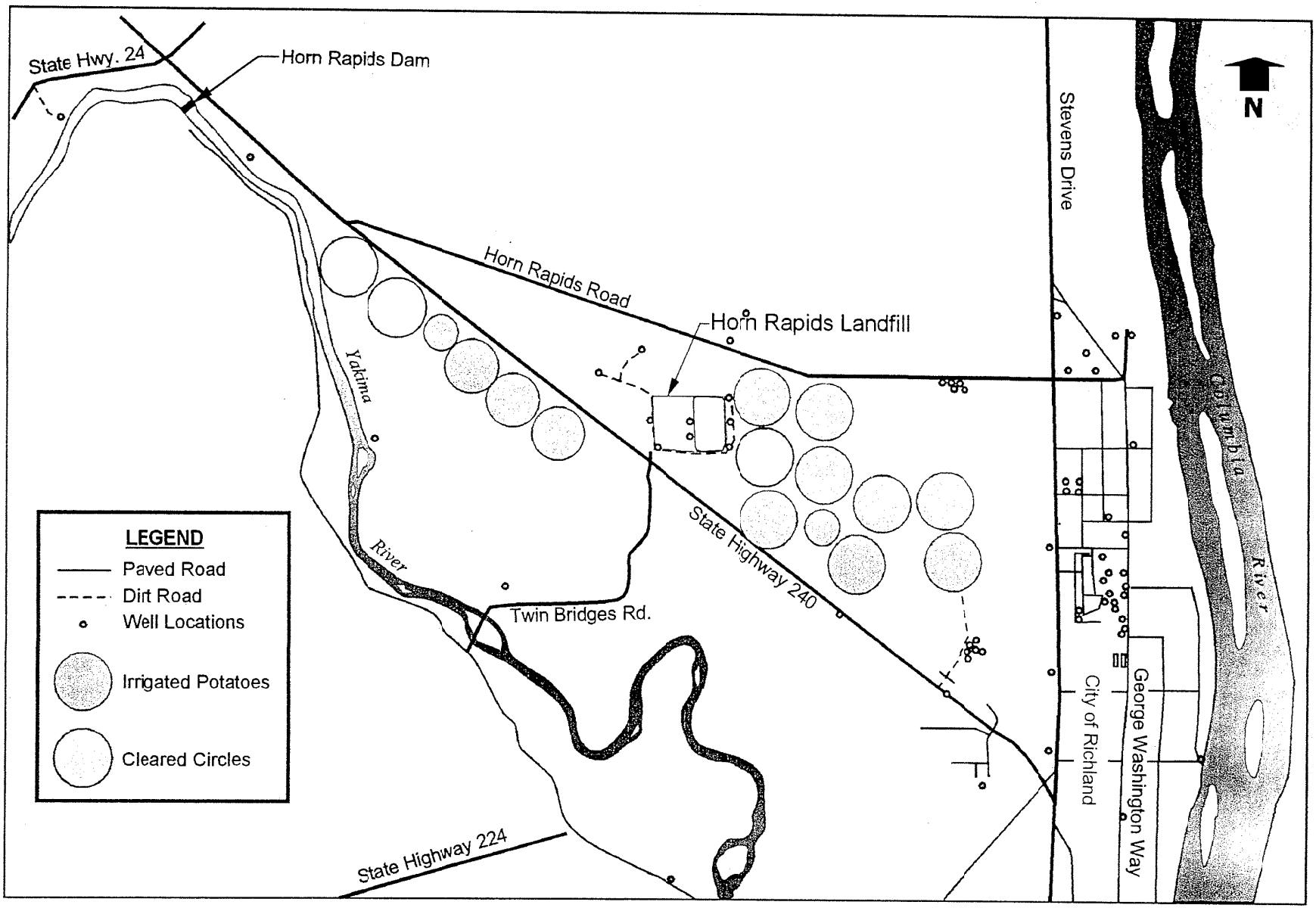

Figure 1-1: Site Location Map
Horn Rapids Landfill
Richland, Washington

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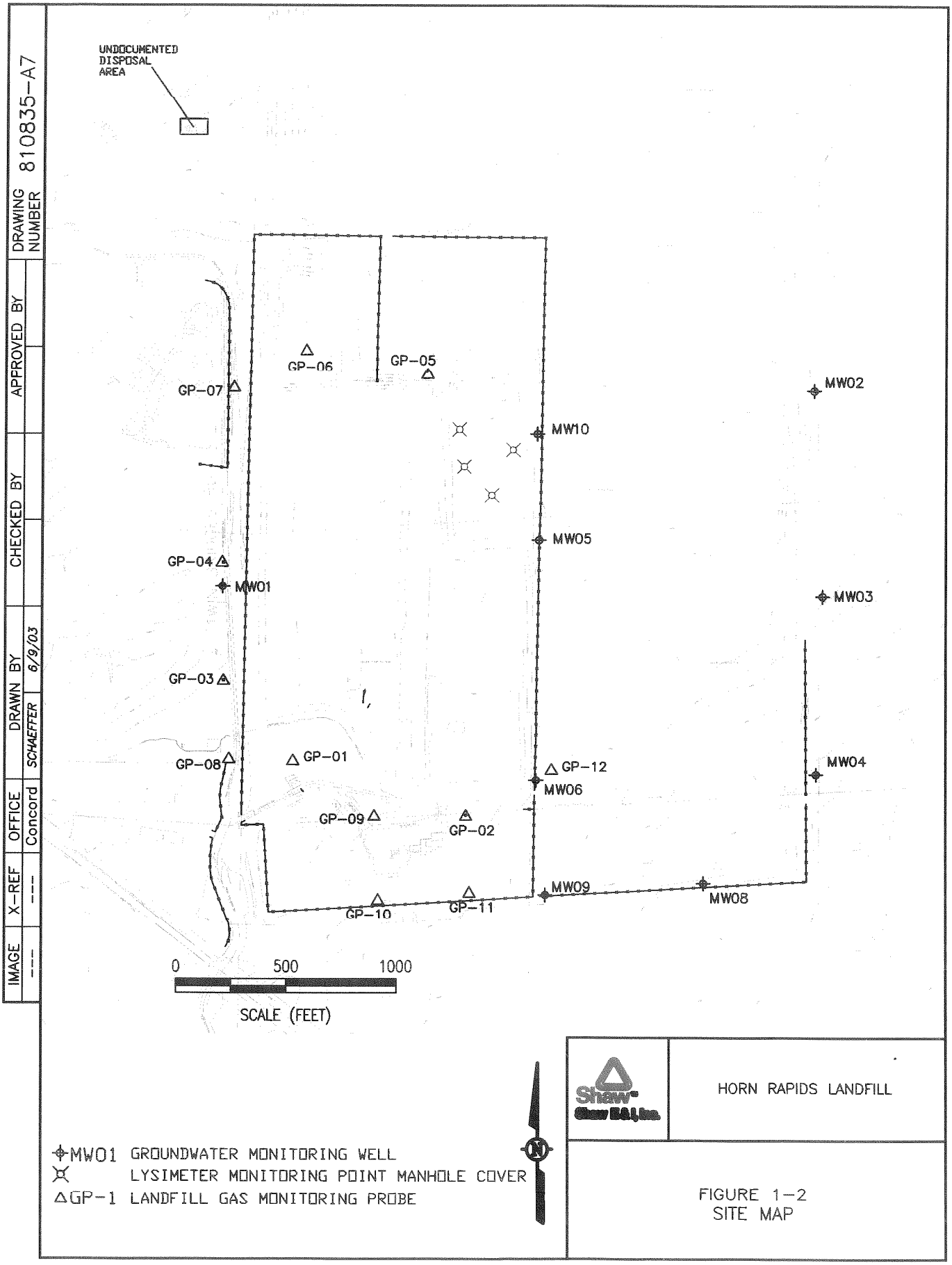
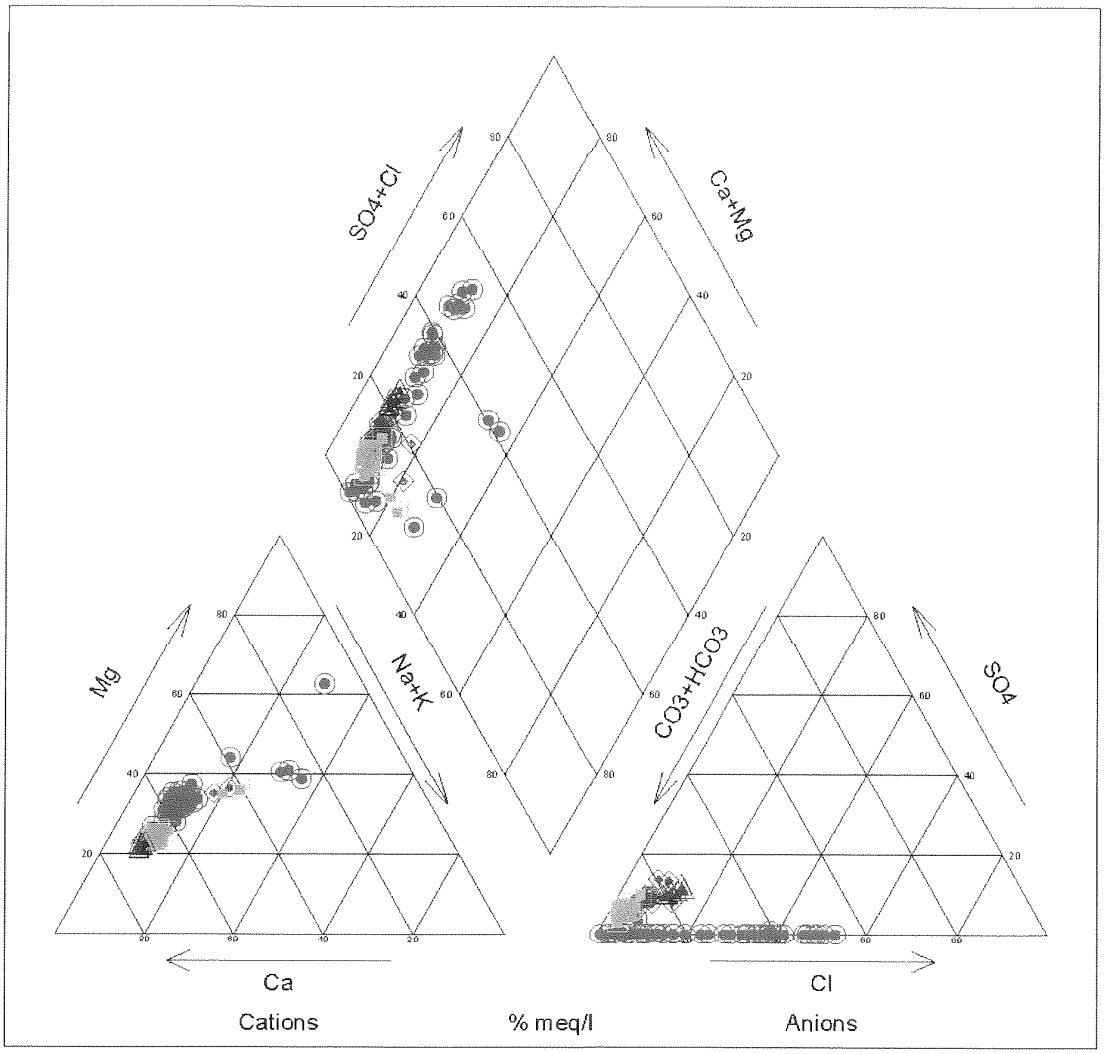

UNDOCUMENTED DISPOSAL AREA
GP-06
GP-05
GP-07
MW02
MW10
MW05
GP-04
MW01
MW03
GP-03
GP-01
GP-08
GP-12
MW06
MW04
GP-09
GP-02
MW09
MW08
GP-10
GP-11
0
500
1000
SCALE (FEET)
IMAGE

X-REF

OFFICE
Concord
DRAWN BY
SCHAEFFER
6/9/03
CHECKED BY
APPROVED BY
DRAWING NUMBER
810835-A7
MW01 GROUNDWATER MONITORING WELL
LYSIMETER MONITORING POINT MANHOLE COVER
GP-1 LANDFILL GAS MONITORING PROBE
N
Shaw
Shaw E&I, Inc.
HORN RAPIDS LANDFILL
FIGURE 1-2
SITE MAP

Figure 3-1
Piper (Trilinear) Diagram Showing Ionic Chemistry of MW05, MW06
and MW07 Groundwater Samples and Lysimeter Liquid Samples
Horn Rapids Landfill

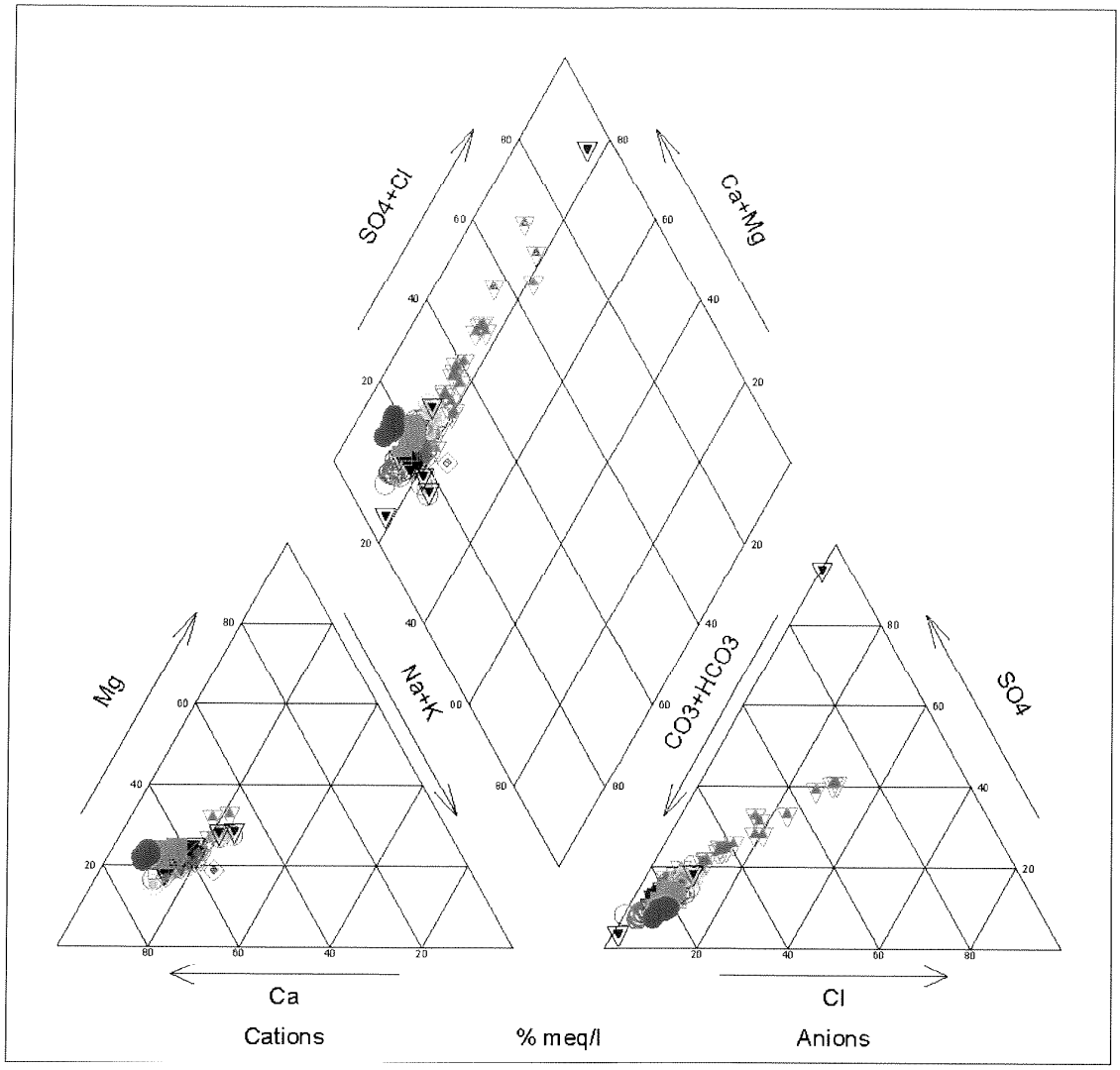


port 1	5/18/1994 - 6/08/1994	port 3	4/15/1997	port 4	12/21/1999 - 1/11/2000	MW05	10/16/2001	MW06	11/08/2000 - 12/05/2000
port 1	10/13/1994	port 3	9/23/1997	port 4	1/11/2000 - 2/08/2000	MW05	12/05/2001 - 12/18/2001	MW06	3/20/2001 - 4/10/2001
port 1	2/22/1995 - 3/01/1995	port 3	4/08/1998	port 4	11/08/2000 - 12/05/2000	MW05	3/20/2002	MW06	7/25/2001
port 1	8/15/1995 - 9/12/1995	port 3	10/21/1998 - 11/16/1998	port 4	6/18/2001	MW05	7/03/2002	MW06	10/16/2001
port 1	4/15/1997	port 3	6/29/1999	port 4	12/05/2001 - 12/18/2001	MW05	10/15/2002	MW06	12/05/2001 - 12/18/2001
port 1	9/23/1997	port 3	12/21/1999 - 1/11/2000	MW05	5/18/1998	MW05	12/17/2002 - 12/31/2002	MW06	3/20/2002
port 1	4/08/1998	port 3	1/11/2000 - 2/08/2000	MW05	6/30/1998 - 7/07/1998	MW05	3/26/2003	MW06	7/03/2002
port 1	10/21/1998 - 11/16/1998	port 3	11/08/2000 - 12/05/2000	MW05	8/10/1998	MW05	6/11/2003	MW06	10/15/2002
port 1	12/21/1999 - 1/11/2000	port 3	6/18/2001	MW05	10/21/1998 - 11/16/1998	MW06	5/18/1998	MW06	12/17/2002 - 12/31/2002
port 1	1/11/2000 - 2/08/2000	port 3	12/05/2001 - 12/18/2001	MW05	1/26/1999	MW06	6/30/1998 - 7/07/1998	MW06	3/26/2003
port 1	11/08/2000 - 12/05/2000	port 4	5/18/1994 - 6/08/1994	MW05	5/12/1999	MW06	8/10/1998	MW06	6/11/2003
port 1	6/18/2001	port 4	10/13/1994	MW05	10/05/1999	MW06	10/21/1998 - 11/16/1998	MW07	3/20/2001 - 4/10/2001
port 1	12/05/2001 - 12/18/2001	port 4	2/22/1995 - 3/01/1995	MW05	12/21/1999 - 1/11/2000	MW06	1/26/1999	MW07	7/25/2001
port 2	2/22/1995 - 3/01/1995	port 4	7/19/1995 - 7/21/1995	MW05	1/11/2000 - 2/08/2000	MW06	5/12/1999	MW07	10/16/2001
port 2	7/19/1995 - 7/21/1995	port 4	8/15/1995 - 9/12/1995	MW05	5/16/2000	MW06	10/05/1999	MW07	12/05/2001 - 12/18/2001
port 2	8/15/1995 - 9/12/1995	port 4	4/15/1997	MW05	8/30/2000	MW06	12/21/1999 - 1/11/2000	MW07	7/03/2002
port 2	4/15/1997	port 4	9/23/1997	MW05	11/08/2000 - 12/05/2000	MW06	1/11/2000 - 2/08/2000	MW07	3/26/2003
port 2	9/23/1997	port 4	4/08/1998	MW05	3/20/2001 - 4/10/2001	MW06	5/16/2000	MW07	6/11/2003
port 3	8/15/1995 - 9/12/1995	port 4	6/29/1999	MW05	7/25/2001	MW06	8/30/2000		

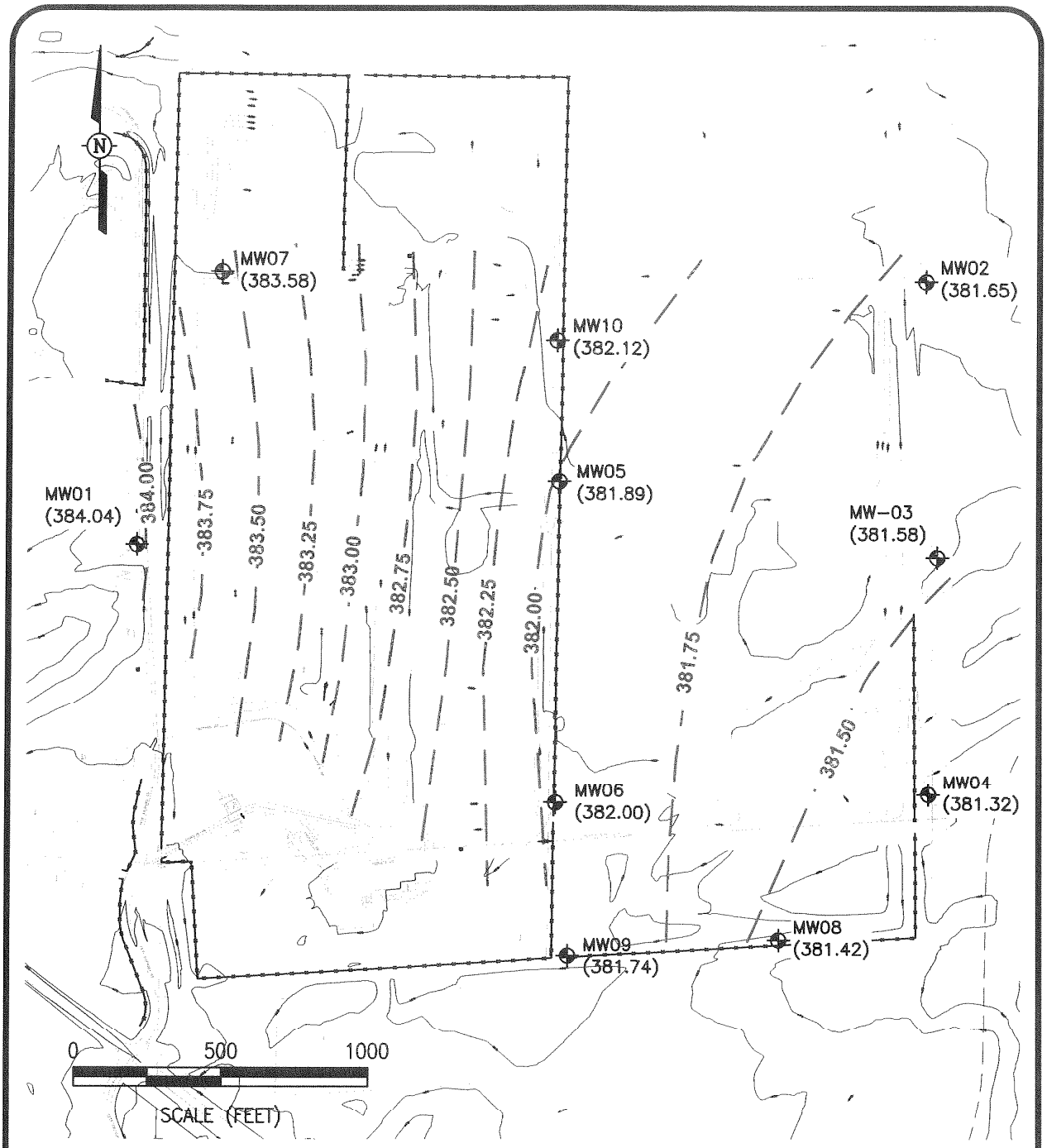
1

Prepared by: EMCON / OWT, Inc.

Figure 3-2
Trilinear (Piper) Diagram Showing
Ionic Chemistry of MW01, MW02, MW03, MW04, MW08,
MW09 and MW10 Groundwater Samples
Horn Rapids Landfill



Prepared by: EMCON / OWT, Inc.



EXPLANATION

MW09 (381.74) MONITORING WELL GROUNDWATER ELEVATION (feet, AMSL)(JUNE 11, 2003)

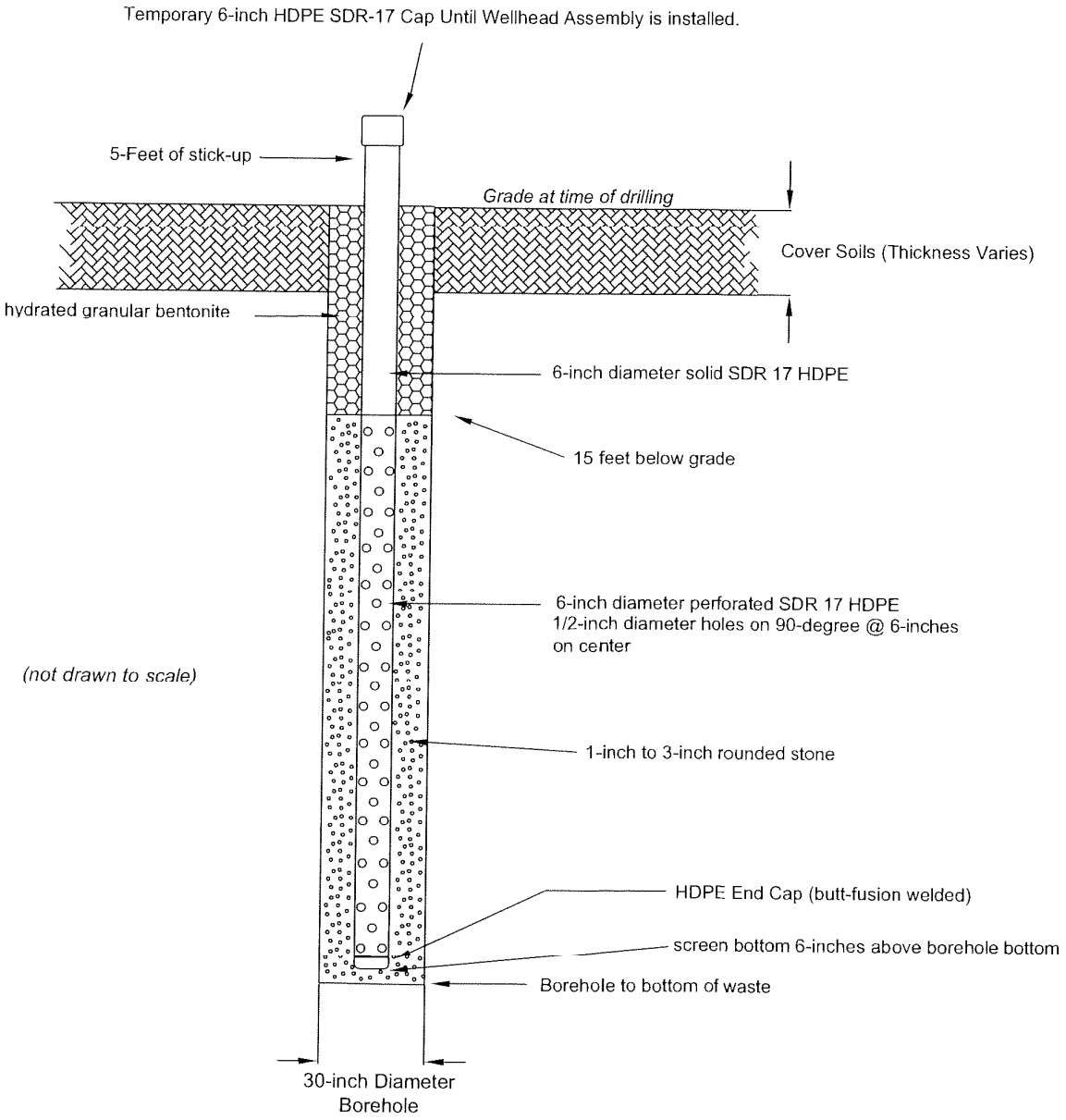
POTENTIOMETRIC SURFACE CONTOUR

EMCON/OWT, Inc.

DATE 12/18/03
DWN DPH
APP
REV
PROJECT NO. 810835

FIGURE 4-1
HORN RAPIDS LANDFILL
REMEDIAL INVESTIGATION
POTENTIOMETRIC SURFACE CONTOURS
JUNE 2003

XREF Files:rojects\Horn Rapids Landfill\maps\Horn Rapids WL (June 2004).dwg Layout: 8.5x11 Portrait User: dan.higgins Mar 31, 2004 - 9:43am IMAGE Files:
File: N:\Projects\Horn Rapids Landfill\maps\Horn Rapids WL (June 2004).dwg Layout: 8.5x11 Portrait User: dan.higgins Mar 31, 2004 - 9:43am



Proposed Landfill Gas Extraction Well for
Landfill Gas Collection Performance Test

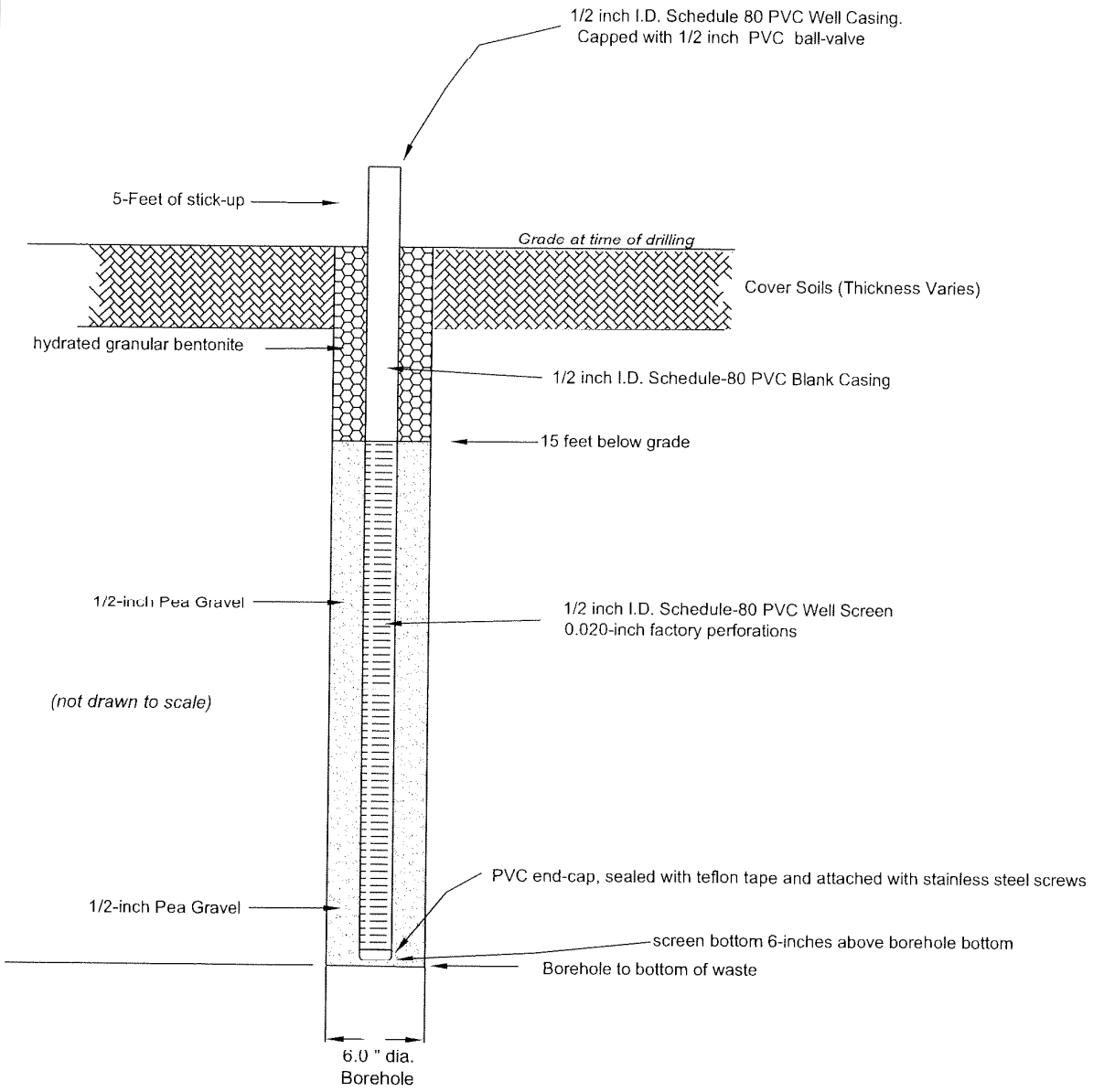
Shaw™ EMCON/OWT, Inc.

DATE 03/15/04
DWN DPH
APP
REV
PROJECT NO.
810835

FIGURE 5-1

HORN RAPIDS LANDFILL

PROPOSED LANDFILL GAS EXTRACTION WELL CONSTRUCTION DETAIL



Proposed Landfill Gas Monitoring Probe
for Landfill Gas Collection Performance
Monitoring Test

Shaw™ EMCON/OWT, Inc.

DATE 03/16/04
DWN DPH
APP
REV
PROJECT NO.
810835

FIGURE 5-2

HORN RAPIDS LANDFILL

PROPOSED LANDFILL GAS PROBE CONSTRUCTION DETAIL

APPENDIX A

GP-12 EXPLORATORY AND PROBE CONSTRUCTION DETAIL AND SUPPORTING DOCUMENTATION

LOG OF EXPLORATORY BORING

PROJECT NAME	City of Richland	BORING NO.	GP-12
LOCATION	Horn Rapids Landfill	PAGE	1 of 4
DRILLED BY	Environmental West, Inc.	REFERENCE ELEV.	481.0
DRILL METHOD	Air Rotary	TOTAL DEPTH	89.5'
LOGGED BY	D. Higgins	DATE COMPLETED	8/11/03

SAMPLE ID	BLOW COUNTS	METHANE (PERCENT)	GROUND WATER LEVEL	DEPTH IN FEET	SAMPLES	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION
								0 to 7.5 feet: SILTY SAND (SM); olive; fine sand; damp.
GRAB-S-1				5				**SILTY SAND (SM)**; olive; fine sand; damp.
								@ 7.5 feet: very easy drilling.
GRAB-S-2				10				**7.5 to 32.5 feet: SAND (SP)**; olive; 95 to 100 percent fine to medium sand; 0 to 5 percent fines; slightly damp. **SAND (SP)**; olive; 95 to 100 percent fine to medium sand; 0 to 5 percent fines; slightly damp.
GRAB-S-3				15				**SAND (SP)**; olive; 95 to 100 percent fine to medium sand; 0 to 5 percent fines; slightly damp.
GRAB-S-4				20				**SAND (SP)**; olive; 85 to 90 percent fine sand; 10 to 15 percent medium sand; less than 5 percent fines; slightly damp.
GRAB-S-5				25				**SAND (SP)**; olive; 85 to 90 percent fine sand; 10 to 15 percent medium sand; slightly damp. Damp sand does not return well through casing. Circulating air blowing into formation.
				30				

REMARKS

Scan borehole opening for methane at 37.5, 62.5 and 89.5 feet with LandTec GEM 500 for 120 seconds. None detected.

Shaw™ EMCON/OWT, INC.

HORN.gds:2.9/5/03.HORN...810.835/0200.0200

LOG OF EXPLORATORY BORING

PROJECT NAME	City of Richland	BORING NO.	GP-12
LOCATION	Horn Rapids Landfill	PAGE	2 of 4
DRILLED BY	Environmental West, Inc.	REFERENCE ELEV.	481.0
DRILL METHOD	Air Rotary	TOTAL DEPTH	89.5'
LOGGED BY	D. Higgins	DATE COMPLETED	8/11/03

SAMPLE ID	BLOW COUNTS	METHANE (PERCENT)	GROUND WATER LEVEL	DEPTH IN FEET	SAMPLES	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION
GRAB-S-6								**SAND (SP)**; olive; 80 percent medium sand; 20 percent fine sand; slightly damp.
								32.5 to 37.0 feet: SILTY SAND (SM); yellowish-brown; fine sand; dry.
GRAB-S-7				35				**SILTY SAND (SM)**; yellowish-brown; fine sand; dry.
		0.0						**37.0 to 72.0 feet: SAND (SP)**; yellowish-brown to olive; 90 to 100 percent fine to coarse sand; 0 to 10 percent fines; dry to slightly damp.
GRAB-S-8				40				**SAND (SP)**; olive; 50 percent medium sand; 40 percent fine sand; and 5 to 10 percent subangular coarse sand; less than 5 percent fines; slightly damp.
GRAB								Medium to coarse sand.
GRAB-S-9				45				**SAND (SP)**; olive; fine to medium sand; slightly damp. Minor subangular to angular coarse sand.
GRAB-S-10				50				**SAND (SP)**; olive; subangular to angular medium to coarse sand; 10 percent fine sand; slightly damp.
GRAB								Grain size changes to mostly silt and fine sand, and much drier.
GRAB-S-11				55				Same as above; minor subrounded fine gravel.
				60				

REMARKS

Scan borehole opening for methane at 37.5, 62.5 and 89.5 feet with LandTec GEM 500 for 120 seconds. None detected.

Shaw™ EMCON/OWT, INC.

HORN.gds:2.9/5/03.HORN...810.835/0200.0200

LOG OF EXPLORATORY BORING

PROJECT NAME	City of Richland	BORING NO.	GP-12
LOCATION	Horn Rapids Landfill	PAGE	3 of 4
DRILLED BY	Environmental West, Inc.	REFERENCE ELEV.	481.0
DRILL METHOD	Air Rotary	TOTAL DEPTH	89.5'
LOGGED BY	D. Higgins	DATE COMPLETED	8/11/03

SAMPLE ID	BLOW COUNTS	METHANE (PERCENT)	GROUND WATER LEVEL	DEPTH IN FEET	SAMPLES	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION
GRAB-S-12		0.0						**SAND (SP)**; olive; 80 percent medium sand; 20 percent fine sand; dry.
GRAB-S-13				65				**SAND (SP)**; yellowish-brown; 50 percent medium sand; 40 percent fine sand; 5 percent coarse sand; minor fines; dry.
GRAB-S-14				70				**SAND (SP)**; olive; 50 percent fine sand; 40 percent medium sand; 5 to 10 percent fines; dry.
GRAB								**72.0 to 78.0 feet: SAND (SW)**; yellowish; 65 to 70 percent medium sand; 15 to 20 percent fine sand; and 10 to 15 percent coarse sand, dry.
GRAB-S-15				75				Very dry well-graded sand. **SAND (SW)**; yellowish; 65 to 70 percent medium sand; 15 to 20 percent fine sand; and 10 to 15 percent coarse sand, dry.
GRAB-S-16				80				**78.0 to 86.0 feet: SAND (SP)**; yellowish-gray to yellowish-brown; 95 to 100 percent fine to medium sand; 0 to 5 percent fine gravel; dry. **SAND (SP)**; yellowish-gray; 65 to 70 percent subrounded coarse sand; 20 percent medium sand; 5 to 10 percent fine sand; minor fine gravel; dry.
GRAB								Fine sand, slightly damp.
GRAB-S-17				85				**SAND (SP)**; yellowish-brown; fine sand; dry.
GRAB-S-18		0.0		90				**86.0 to 89.5 feet: SAND (SP)**; yellowish-brown; 70 to 75 percent fine sand; 15 to 25 percent fine to medium subrounded gravel; 5 percent fines; dry.

REMARKS

Scan borehole opening for methane at 37.5, 62.5 and 89.5 feet with LandTec GEM 500 for 120 seconds. None detected.

Shaw™ EMCON/OWT, INC.

HORN.gds:2.9/5/03.HORN...810.835/0200.0200

LOG OF EXPLORATORY BORING

PROJECT NAME	City of Richland	BORING NO.	GP-12
LOCATION	Horn Rapids Landfill	PAGE	4 of 4
DRILLED BY	Environmental West, Inc.	REFERENCE ELEV.	481.0
DRILL METHOD	Air Rotary	TOTAL DEPTH	89.5'
LOGGED BY	D. Higgins	DATE COMPLETED	8/11/03

SAMPLE ID	BLOW COUNTS	METHANE (PERCENT)	GROUND WATER LEVEL	DEPTH IN FEET	SAMPLES	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION

95
100
105
110
115
120

Boring terminated at 89.5 feet below ground surface.

WELL COMPLETION DETAILS

0 to 22.5 feet: Three ½-inch-diameter, flush-threaded, Schedule 80 PVC blank riser pipes.

22.5 to 32.5 feet: Two ½-inch-diameter, flush-threaded, Schedule 80 PVC blank riser pipes, and one ½-inch-diameter, flush-threaded, Schedule 80 PVC well screen with 0.010-inch machined slots and ½-inch-diameter threaded end cap.

32.5 to 49.5 feet One ½-inch-diameter, flush-threaded, Schedule 80 PVC blank riser pipe, and one ½-inch-diameter, flush-threaded, Schedule 80 PVC well screen with 0.010-inch machined slots and ½-inch-diameter threaded end cap.

49.5 to 76.5 feet: ½-inch-diameter, flush-threaded, Schedule 80 PVC blank riser pipe.

76.5 to 89.5 feet: ½-inch-diameter, flush-threaded, Schedule 80 PVC well screen with 0.010-inch machined slots and ½-inch-diameter threaded end cap.

0 to 20.0 feet: Bentonite chips hydrated with potable water.

20.0 to 35.0 feet: 10-20 Colorado Silica Sand

35.0 to 47.0 feet: Bentonite chips hydrated with potable water.

47.0 to 62.0 feet: 10-20 Colorado Silica Sand10-20 Colorado Silica Sand.

62.0 to 74.0 feet: Bentonite chips hydrated with potable water.

74.0 to 89.5 feet: 10-20 Colorado Silica Sand10-20 Colorado Silica Sand.

Completed on surface with security casing set in concrete and three bollards.

PVC T-couplings used to separate casing within bentonite seal at 10 and 41 feet bgs.

REMARKS

Scan borehole opening for methane at 37.5, 62.5 and 89.5 feet with LandTec GEM 500 for 120 seconds. None detected.

Shaw™ EMCON/OWT, INC.

HORN.gds:2.9/5/03.HORN...810.835/0200.0200

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
15 West Yakima Avenue, Suite 200 • Yakima, Washington 98902-3452 • (509) 575-2490

August 18, 2003

Dale Landon
Shaw Environmental & Infrastructure
1045 Jadwin Ave., Suite C
Richland WA 99352

Dear Mr. Landon:

RE: Water Well Construction Variance to WAC 173-160-420 (3)

This letter is in response to your request for a variance from the resource protection well construction standards contained in Washington Administrative Code (WAC) 173-160, Minimum Standards for the Construction and Maintenance of Wells.

This variance request is to allow for an 8-inch diameter borehole to be drilled down to a depth of 89 feet, with three gas probes nested inside the borehole. The three gas probes will consist of ½ inch I.D. schedule 80 PVC well casings. The lower most gas probe screened section will be near the bottom of the borehole encapsulated in 15 feet of Colorado 10/20 sand. There will be a 12-foot thick bentonite seal above the sand up to the next screened section. This screened section will also be encapsulated in sand with another 12 feet of bentonite to seal between it and the upper screened section. The upper screened section will repeat the sand sequence, but will have 20 feet of bentonite sealing material between it and the concrete pad at the surface.

The gas probe borehole will be located within the property boundary of the Horn Rapids landfill. The gas probe well will be immediately down gradient from a 50 foot deep waste disposal pit, reported in a draft report by Hong West and Associates in 1990.

After studying the well log data, site plan, old report, and current gas probe proposal done by Department of Ecology employee, Gene Potts, a variance is hereby granted from WAC 173-160-420 (3), which states in part, "Nested resource protection wells are prohibited".

This variance is subject to the requirements set forth below:

1. This variance is for one gas probe resource protection well with three nested ½ inch PVC well casings installed in it, located in the SW¼ of Section 17, Township 10 N., Range 28 E.W.M., at the Horn Rapids Landfill.

2. The work shall be done by a licensed monitoring well drilling operator as set forth by WAC 173-162-040.

3. The well shall be constructed according to the construction details provided to this Department for the proposed GP-14 Gas Probe.

4. The well shall be decommissioned after the completion of the gas probe study.

If you have any questions regarding this variance, please contact Gene Potts at (509) 575-2639.

This Order may be appealed pursuant to RCW Chapter 43.21B. The person to whom this Order is issued, if he or she wishes to file an appeal, must file the appeal with the Pollution Control Hearings Board **within thirty (30) days of receipt of this Order.** Send the appeal to: Pollution Control Hearings Board, P.O. Box 40903, Olympia, Washington 98504-0903. At the same time, a copy of the appeal **must** be sent to: Department of Ecology, Water Resources Appeals Coordinator, P.O. Box 47600, Olympia, Washington 98504-7600. All others receiving notice of this Order, who wish to file an appeal, must file the appeal with the Pollution Control Hearings Board within **thirty (30) days of the date the Order was mailed.** The appeal must be filed, with both the Pollution Control Hearings Board and the Department of Ecology, in the same manner as described above.

Sincerely,

Robert F. Barwin, Section Manager
Water Resources Program

RFB:GP:gh
030821

cc: Marian Bruner, WR/HQ

NOTICE OF INTENT TO CONSTRUCT A MONITORING/RESOURCE PROTECTION WELL

Notification Number R 53440

WASHINGTON STATE DEPARTMENT OF ECOLOGY

This form and required fees MUST BE RECEIVED by the Department of Ecology 72 HOURS BEFORE you construct a well.

Submit one form and required fee (check or money order ONLY) for each job site. Mail this form to the Department of Ecology, Water Resources Program, Well Drilling Unit, PO Box 47600, Olympia WA 98504-7600. Instructions for filling out this form are printed on the back.

NOTE: PLEASE PRINT ALL ANSWERS. PROCESSING YOUR NOTICE OF INTENT MAY BE DELAYED IF ALL FIELDS OUTLINED IN THE (BOXES) ARE NOT FILLED IN COMPLETELY.

1. Property Owner City of Richland Phone No. 509-942-7387
Address (include city, state and zip) 840 Northgate, Richland, WA 99352

2. Consulting Firm (if different from #1) Emcon/OWT, Inc. Phone No. 503-603-1000
Address (include city, state and zip) 10300 SW Nimbus Ave., Portland, OR 97223

3. Well Location: SW 1/4-1/4 of the SW 1/4 Section 17 Township 10 N Range 28 E (EWM) or WWM (circle one)

4. Print COUNTY NAME of well location (DO NOT ABBREVIATE) Benton

5. Approx construction start date 8-7-03

Lattitude and Longitude (if available) NOTE: 1/4-1/4, 1/4, section, township and range are REQUIRED.

Lat Degrees _____ Lat Time _____ Horizontal collection method _____

Long Degrees _____ Long Time _____

6. Well Site Street Address 3102 Twin Bridges Rd., Richland, WA 99352

7. Tax parcel number _____

8. Contractor L & I Registration No. ENVIRWE101PP

9. Well Drilling Company Name Environmental West Exploration, Inc Phone No. 509-534-2740

10. Well Driller Name Randall Wilder License No. 2578

12. SEND THE ENTIRE FORM. The bottom portion of this notice will be validated in our office and sent back to the name and address contained on the address label. This is the proof of notification. Please fill out the portion below CAREFULLY.
NOTE: Please copy the Notification Number (located in the upper and lower right corner) and keep in a safe place. Please reference this number when communicating with the Department of Ecology.

Amt of payment: $40 per well

x 1 ***Number of wells to be constructed on this job site***

$ 40.00 ***Total Due and Amt Enclosed***

This notification number must be provided to your well driller: EM87

R 53440

RETURN NAME AND MAILING ADDRESS

Name Environmental West Exploration, Inc

Address P.O. Box 11095

City Spokane State WA Zip 99211

Client Name _____

Agency Validation

Date

ECY 040-22 (Rev. 2/01)
TOTAL P.02

STATE OF WASHINGTON

DEPARTMENT OF ECOLOGY

15 West Yakima, Suite 200 • Yakima, Washington 98902-3401 • (509) 575-2490

VARIANCE REQUEST
MINIMUM STANDARDS FOR WELL CONSTRUCTION

Requested By: Horn Rapids Land fill

Address: Richland Washington

Daytime Phone: Dan Higgins (Emcon) (503) 603-1065

Property Owner (if different): City of Richland

Site Location: SW ¼, Section 17, Township 10N N, Range 28E E.W.M.

Street Address: 840 Northgate Richland WA 99352

Well Driller/Company (if known) Layne Drilling

__Water Well X Resource Protection Well (Check One)

What construction standard can not be met? Request to construct a nested gas probe.

Reason why standard cannot be met. Include site map and distances from all known potential sources of contamination if setback variance is being requested.
Nested gas probe design allows more accurate depth-discrete gas concentration measurements from a distinct locale.

Proposed Construction (if applicable) Three gas probes, each at a discrete depth will be installed in one borehole. See attached schematic for details. Completed borehole will be approximately 9 feet above static water level.

Complete and return with your site map to: Department of Ecology
15 W Yakima Ave Ste 200

Yakima, WA 98902-3401

Attach additional pages if necessary.

variance12/96

DOC006.max

RESOURCE PROTECTION WELL REPORT

Notice of Intent No. R53440

(SUBMIT ONE WELL REPORT PER WELL INSTALLED)

Construction/Decommission *("x" in circle)*

- (X) Construction
- ( ) Decommission *Original Construction Notice of Intent Number* _____

Type of Well *("x" in circle)*

- (X) Resource Protection
- ( ) Geotech Soil Boring

Property Owner: City of Richland

Site Address: 3107 Twin Bridges Rd

Unique Ecology Well ID Tag No.: AHR 183

City: Richland County: Benton

Consulting Firm: Environmental Drilling, Inc

Location: SW 1/4 - 1/4 SW 1/4 Sec 17 Twn 10N R 28 (E/W/WWM) *circle one*

Driller or Trainee Name: Randall E Wilder

Lat/Long (s, t, r still REQUIRED) Lat Deg _____ Lat Min/Sec _____

Driller or Trainee Signature: [signature]

Long Deg _____ Long Min/Sec _____

Driller or Trainee License No. _____

Tax Parcel No. _____

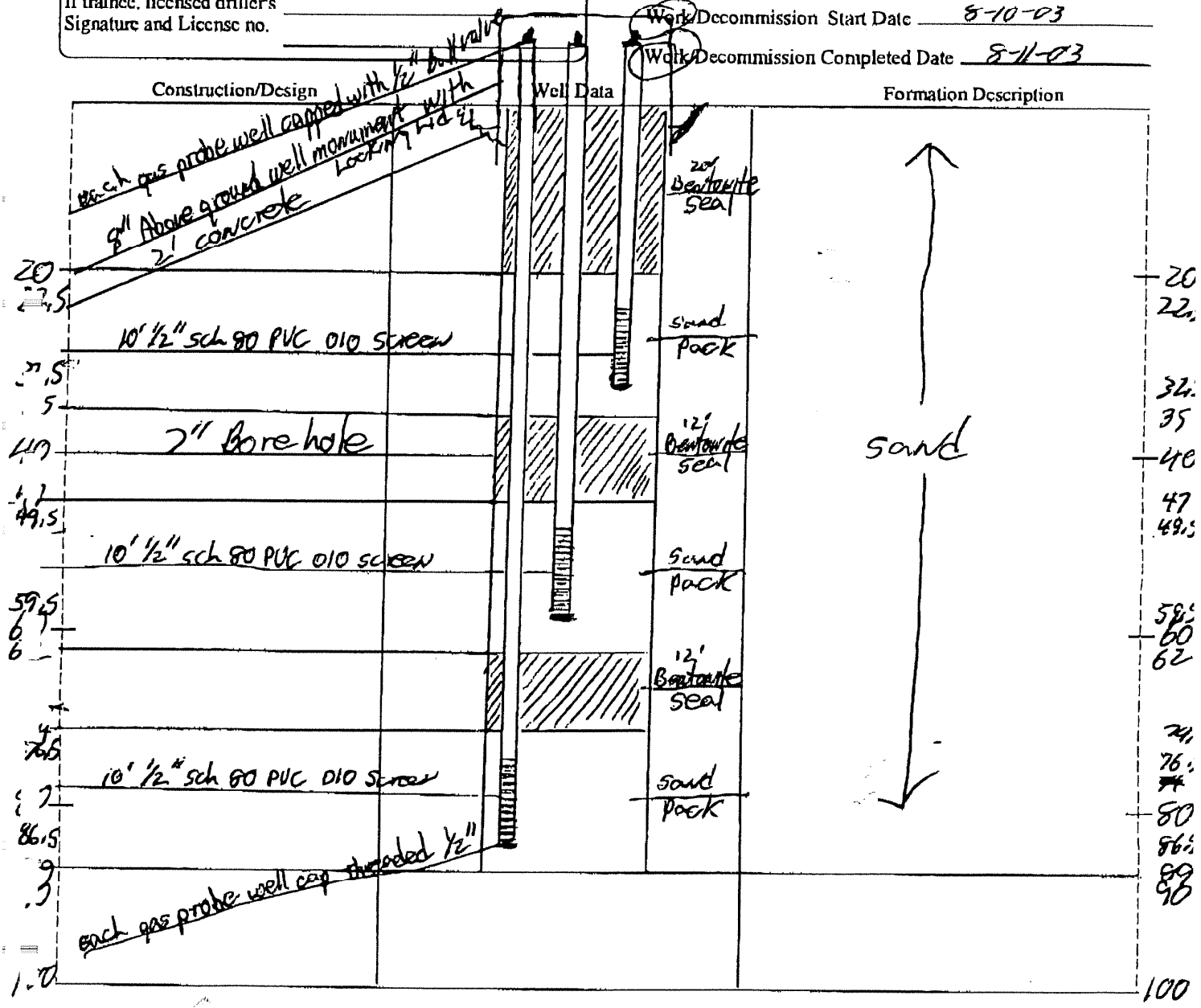
If trainee, licensed driller's Signature and License no. _____

Cased or Uncased Diameter _____ Static Level: No Water

Work/Decommission Start Date: 8-10-03

Work/Decommission Completed Date: 8-11-03

Construction/Design | Well Data | Formation Description



Scale 1"= _____ Page _____ of _____

ECY 050-12 (Rev 2/01)

TOTAL P.02

APPENDIX B

FIELD DOCUMENTATION

EMCON/OWT, Inc.
Field Report Form

Shaw™ EMCON/OWT, Inc.	Client: City of Richland Horn Rapids LF	Weather: Sunny, ~70°F
	Project: LFG monitoring 810835	
	Event: RIFS, Phase II	Date: 9/18/03
Prepared By: Jason Davendonis	Address: Richland, WA	Arrival: 9:06
		Departure: 14:25

- Arrived @ site and met w/ Steve McNutt. Brief site orientation w/ Steve.
- Performed LFG monitoring in MW-05, MW-06, and MW-07. Performed LFG profiling down each PVC well @ 10' intervals. Collected 3 discrete LFG samples (Summa).
- Measure LFG concentrations in new Gas probe (GP-12) and collected a sample (Summa) from the middle probe. Monitored LFG in other site gas probes.

Signed: Jason Davendonis

EMCON/OWT, Inc.
Field Report Form

Shaw™ EMCON/OWT, Inc.	Client: Horizon Heights City of Richland Project:	Weather: Cloudy, calm breeze, ~60°F
	Event:	Date: 9/18/03
Prepared By: Jason Davendorf	Address:	Arrival: Departure:

* New gas probe : GP-12 (or GP-14?) - No leak

		Pressure	CH_4	O_2	CO_2	Purge length
	Shallow:					
9:40		0.0"	0.3%	2.4%	19.2%	360 secs
9:46	Middle:	0.0"	16.3%	0.0%	26.2%	720 secs
9:56	Deep:	0.1"	11.9%	0.0%	24.8%	960 secs
	* Collected a discrete sample (Summa) from GP-12 middle probe @ 10:15		16.1%	0.0%	26.5%	
13:08	GP-6(S)	0.0"	0.0%	13.0%	8.2%	360 secs
13:14	GP-6(D)	0.1"	0.0%	7.7%	14.3%	540 secs
13:25	GP-1(1)	0.2"	0.0%	16.9%	2.7%	180 secs
13:28	GP-1(2)	0.6"	0.0%	17.7%	2.2%	180 secs
13:39	GP-2(1)	0.3"	19.1%	0.2%	28.9%	180 secs
13:42	GP-2(2)	0.5"	25.0%	0.3%	31.2%	180 secs
13:53	GP-5(1)	0.3"	6.3%	0.3%	26.5%	360 secs
14:00	GP-5(2)	0.0"	5.0% ~~0.0%~~	~~6.4%~~	25.2% ~~0.0%~~	180 secs
14:03	GP-5(3)	0.1"	0.2%	12.3%	7.7%	180 secs
14:13	GP-9(1)	0.6"	5.2%	0.2%	21.2%	180 secs
14:17	GP-9(2)	0.3"	0.0%	10.5%	9.2%	180 secs

Signed: Jason Davendorf

EMCON/OWT, Inc.
Field Report Form

Shaw™ EMCON/OWT, Inc.	Client: City of Richland Horn Rapids LF	Weather: Sunny, ~65°F
	Project:	
	Event:	Date: 9/18/03
Prepared By: Jason Davendonis	Address:	Arrival:
		Departure:

MW-6 DTW 98.98' @ 9:52 (2" stainless steel drop tube)

Time	Depth	PPM	CH_4%	Tubing marked = 73'
10:24	Security casing 0-2			# CH_4 level too high to use FID, measuring CH_4 @ values above 25,000 ppm. switched to GEM-500 for monitoring
10:30	10'	3.1		
10:33	20'	4.0		
10:36	30'	5.4		
10:39	40'	5.5		
10:42	50'	4.7		
10:46	60'	3.9		
10:49	70'	3.1		
10:52	80'	2.7		
10:55	90'	2.3		
1:57 ~~(98.98'~~) above WL		4.4		
1:00 11:00	~95'	2.9	CO_2	O_2
* 11:05	~97'	2.1	4.0	17.1%
↳ Summa Sample				

Signed: Jason Davendonis

EMCON/OWT, Inc.
Field Report Form

Shaw™ EMCON/OWT, Inc.	Client: Horn Rapids LF City of Richland Project:	Weather: Sunny, ~70°F
	Event:	Date: 9/18/03
Prepared By: Jason Dawendorf	Address:	Arrival: Departure:

MW-5 DTW 84.39' @ 11:25 (26" drop tube)

Time	Depth	ppm	CH4%	marker @80'
11:34	Screen tx casing		0.0	
11:36	10'		1.2	
11:39	20'		2.3	
11:41	30'		2.7	
11:44	40'		3.0	
11:47	50'		3.0	
11:49	60'		3.1	
11:52	70'		3.0	
11:54	80'		2.9	
(84.39)	WL		2.7	
*12:00	~80'		2.0	

	CO_2	O_2
	6.0	14.1

(Summa sample)

Signed: Jason Dawendorf

EMCON/OWT, Inc.
Field Report Form

Shaw™ EMCON/OWT, Inc.	Client:	Weather: Sunny ~75°F
	Project:	
	Event:	Date: 9/18/03
Prepared By: Jason Davendorf	Address:	Arrival:
		Departure:

MW-7 DTW 91.45' @ 12:19

Time	Depth	ppm	CH4%		
12:30	Security Casing		0.0		
12:32	10'		16.2		
12:35	20'		16.6		
12:38	30'		16.4		
12:40	40'		16.4		
12:43	50'		15.9		
12:46	60'		15.3		
12:49	70'		14.9		
12:52	80'		14.7		
12:54	90'		14.5		
12:57 (~91.45')	WL		14.5	CO_2	O_2
13:00	~87'		14.4	31.5	0.1
→ summa sample					

Signed: Jason Davendorf

Columbia Analytical Services INC.
An Employee - Owned Company

Air Quality Laboratory
2665 Park Center Drive, Suite D
Simi Valley, California 93065
Phone (805) 526-7161
Fax (805) 526-7270

Chain of Custody Record
Analytical Service Request

Client/Address: Shaw EMCON/OWT, Inc.
10300 SW Nimbus Ave. Suite B
Portland, OR 97223

Phone: (503) 603-1086 Fax: (503) 603-1001

Email: davendais@shawgp.com

Contact: Jason Davendais

Sampler (Signature): Jason Davendais

Project Name: Horn Rapids LF

Project Number: 810835 02000300

Sampling Location: Richland, WA

P.O. #/Billing Information: P.O. pending

CAS Project No.

Cooler / Blank Temp_____

Client Sample ID	Date Collected	Time Collected	Lab Sample No.	Type of Sample	Container ID (Serial #)	Flow Controller (Serial #)	Sample Volume (Liters)	Analysis: TO-15 *	Analysis: Fixed Gases	Expected Turnaround Time: 24 Hr 48Hr 3Day 4Day 5Day Standard (10 Business Days)	Comments (e.g., preservative or specific instructions)
GP-12 (middle)	9/18/13	10:15		Summa	SC00173			X	X		* 45 compound list
MW-5	9/18/13	12:00		Summa	SC00567			X	X		
MW-6	9/18/13	11:05		Summa	SC00051			X	X		
MW-7	9/18/13	13:00		Summa	SC00343			X	X		

Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:
Jason Davendais	9/19/13	13:40			
Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:
Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:

Additional Comments

DOC002.max

APPENDIX C

LABORATORY ANALYTICAL REPORTS, CHAIN-OF-CUSTODY FORMS, AND RESULTS OF FIELD AND LABORATORY QA/QC REVIEW
(Headspace Summa Canister Fixed Gas and VOC Results)

Headspace Summa Canister Fixed Gas and VOC Results

Columbia Analytical Services INC.
An Employee - Owned Company

RECD OCT 2 1 2003

LABORATORY REPORT

Client:	EMCON/OWT	Date of Report:	10/14/03
Address:	10300 SW Nimbus Avenue, Suite B	Date Received:	09/23/03
	Portland, OR 97223	CAS Project No:	P2302029
Contact:	Mr. Jason Davendonis	Purchase Order:	2112 OP

Client Project ID: Horn Rapids LF/810835 02000300

Four (4) Stainless Steel Summa Canisters labeled:

"GP-12 (middle)" "MW-5" "MW-6" "MW-7"

The samples were received at the laboratory under chain of custody on September 23, 2003. The samples were received intact. Please refer to the sample acceptance check form for additional information. The results reported herein are applicable only to the condition of the samples at the time that they were received at the laboratory.

Fixed Gases Analysis

The samples were analyzed for fixed gases (oxygen/argon, nitrogen, carbon monoxide, methane and carbon dioxide) according to modified EPA Method 3C (single injection) using a gas chromatograph equipped with a thermal conductivity detector (TCD).

Reviewed and Approved:

Svetlana Walsh
Analytical Chemist
Air Quality Laboratory

Reviewed and Approved:

Wade Henton
GC-VOA Team Leader
Air Quality Laboratory

NELAC Accredited
2665 Park Center Drive, Suite D • Simi Valley, California 93065
(805) 526-7161 1-800-695-7222 x13 Fax (805) 526-7270
ACIL Seal of Excellence Laboratory

Columbia Analytical Services INC.
An Employee - Owned Company

CAS Project No: P2302029

Volatile Organic Compound Analysis

The samples were also analyzed by combined gas chromatography/mass spectrometry (GC/MS) for volatile organic compounds. The analyses were performed according to the methodology outlined in EPA Method TO-15. The analyses were performed by gas chromatography/mass spectrometry, utilizing a direct cryogenic trapping technique. The analytical system used was comprised of a Hewlett Packard Model 5973 GC/MS/DS interfaced to a Tekmar AutoCan Elite whole air inlet system/cryogenic concentrator. A 100% Dimethylpolysiloxane capillary column (RT_X-1, Restek Corporation, Bellefonte, PA) was used to achieve chromatographic separation.

The results of analyses are given on the attached data sheets. All results are intended to be considered in their entirety, and Columbia Analytical Services, Inc. (CAS) is not responsible for utilization of less than the complete report.

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ACIL Seal of Excellence Laboratory

COLUMBIA ANALYTICAL SERVICES, INC.

RESULTS OF ANALYSIS

Client : **Emcon/OWT**
Client Sample ID: **GP-12 (middle)**
Client Project ID: **Horn Rapids LF/810835 02000300**

CAS Project ID: P2302029
CAS Sample ID: P2302029-001

Test Code: Modified EPA Method 3C
Instrument ID: HP5890/TCD #1
Analyst: Michele Hickman/Wade Henton
Sampling Media: Summa Canister
Test Notes:
Container ID: SC00173

Date Collected: 9/18/03
Date Received: 9/23/03
Date Analyzed: 9/24/03
Volume(s) Analyzed: 0.10 ml

Pi 1 = 0.0 Pf 1 = 3.5

D.F. = 1.24

CAS #	Compound	Result (%, v/v)	MRL (%, v/v)	Data Qualifier
7782-44-7 7440-37-1	Oxygen + Argon *	0.710	0.124	
7727-37-9	Nitrogen	54.5	0.124	
630-08-0	Carbon Monoxide	ND	0.124	
74-82-8	Methane	16.7	0.124	
124-38-9	Carbon Dioxide	28.2	0.124	

ND = Compound was analyzed for, but not detected above the **laboratory reporting limit**.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.
* = Coeluting Compounds

Verified By: RG Date: 10/7/03

02029SVG.RD1 - Sample

COLUMBIA ANALYTICAL SERVICES, INC.

RESULTS OF ANALYSIS

Client : **Emcon/OWT**
Client Sample ID: **GP-12 (middle)**
Client Project ID: **Horn Rapids LF/810835 02000300**

CAS Project ID: P2302029
CAS Sample ID: P2302029-001DUP

Test Code: Modified EPA Method 3C
Instrument ID: HP5890/TCD #1
Analyst: Michele Hickman/Wade Henton
Sampling Media: Summa Canister
Test Notes:
Container ID: SC00173

Date Collected: 9/18/03
Date Received: 9/23/03
Date Analyzed: 9/24/03
Volume(s) Analyzed: 0.10 ml

Pi 1 = 0.0 Pf 1 = 3.5

D.F. = 1.24

CAS #	Compound	Result (%, v/v)	MRL (%, v/v)	Data Qualifier
7782-44-7 7440-37-1	Oxygen + Argon *	0.699	0.124	
7727-37-9	Nitrogen	54.1	0.124	
630-08-0	Carbon Monoxide	ND	0.124	
74-82-8	Methane	16.6	0.124	
124-38-9	Carbon Dioxide	28.6	0.124	

ND = Compound was analyzed for, but not detected above the **laboratory reporting limit**.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.
* = Coeluting Compounds

Verified By: Re Date: 10/7/03

COLUMBIA ANALYTICAL SERVICES, INC.

RESULTS OF ANALYSIS

Client : **Emcon/OWT**
Client Sample ID: **MW-5**
Client Project ID: **Horn Rapids LF/810835 02000300**

CAS Project ID: P2302029
CAS Sample ID: P2302029-002

Test Code: Modified EPA Method 3C
Instrument ID: HP5890/TCD #1
Analyst: Michele Hickman/Wade Henton
Sampling Media: Summa Canister
Test Notes:
Container ID: SC00567

Date Collected: 9/18/03
Date Received: 9/23/03
Date Analyzed: 9/24/03
Volume(s) Analyzed: 0.10 ml

Pi 1 = -0.4 Pf 1 = 3.5

D.F. = 1.27

CAS #	Compound	Result (%, v/v)	MRL (%, v/v)	Data Qualifier
7782-44-7 7440-37-1	Oxygen + Argon *	16.8	0.127	
7727-37-9	Nitrogen	77.1	0.127	
630-08-0	Carbon Monoxide	ND	0.127	
74-82-8	Methane	ND	0.127	
124-38-9	Carbon Dioxide	6.09	0.127	

ND = Compound was analyzed for, but not detected above the **laboratory reporting limit**.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.
* = Coeluting Compounds

Verified By: RC Date: 10/7/03

COLUMBIA ANALYTICAL SERVICES, INC.

RESULTS OF ANALYSIS

Client : **Emcon/OWT**
Client Sample ID: **MW-6**
Client Project ID: **Horn Rapids LF/810835 02000300**

CAS Project ID: P2302029
CAS Sample ID: P2302029-003

Test Code: Modified EPA Method 3C
Instrument ID: HP5890/TCD #1
Analyst: Michele Hickman/Wade Henton
Sampling Media: Summa Canister
Test Notes:
Container ID: SC00051

Date Collected: 9/18/03
Date Received: 9/23/03
Date Analyzed: 9/24/03
Volume(s) Analyzed: 0.10 ml

Pi 1 = -8.6 Pf 1 = 3.5

D.F. = 2.98

CAS #	Compound	Result (%, v/v)	MRL (%, v/v)	Data Qualifier
7782-44-7 7440-37-1	Oxygen + Argon *	22.2	0.298	
7727-37-9	Nitrogen	77.2	0.298	
630-08-0	Carbon Monoxide	ND	0.298	
74-82-8	Methane	ND	0.298	
124-38-9	Carbon Dioxide	0.621	0.298	

ND = Compound was analyzed for, but not detected above the **laboratory reporting limit**.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.
* = Coeluting Compounds

Verified By: RG Date: 10/7/03

COLUMBIA ANALYTICAL SERVICES, INC.

RESULTS OF ANALYSIS

Client : **Emcon/OWT**
Client Sample ID: **MW-7**
Client Project ID: **Horn Rapids LF/810835 02000300**

CAS Project ID: P2302029
CAS Sample ID: P2302029-004

Test Code: Modified EPA Method 3C
Instrument ID: HP5890/TCD #1
Analyst: Michele Hickman/Wade Henton
Sampling Media: Summa Canister
Test Notes:
Container ID: SC00343

Date Collected: 9/18/03
Date Received: 9/23/03
Date Analyzed: 9/24/03
Volume(s) Analyzed: 0.10 ml

Pi 1 = -1.4 Pf 1 = 3.5

D.F. = 1.37

CAS #	Compound	Result (%, v/v)	MRL (%, v/v)	Data Qualifier
7782-44-7 7440-37-1	Oxygen + Argon *	3.99	0.137	
7727-37-9	Nitrogen	56.2	0.137	
630-08-0	Carbon Monoxide	ND	0.137	
74-82-8	Methane	11.9	0.137	
124-38-9	Carbon Dioxide	27.9	0.137	

ND = Compound was analyzed for, but not detected above the **laboratory reporting limit**.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.
* = Coeluting Compounds

Verified By: RG Date: 10/7/03

7

COLUMBIA ANALYTICAL SERVICES, INC.

RESULTS OF ANALYSIS

Client : **Emcon/OWT**
Client Sample ID: **Method Blank**
Client Project ID: **Horn Rapids LF/810835 02000300**

CAS Project ID: P2302029
CAS Sample ID: P030924-MB

Test Code: Modified EPA Method 3C
Instrument ID: HP5890/TCD #1
Analyst: Michele Hickman/Wade Henton
Sampling Media: Summa Canister
Test Notes:

Date Collected: NA
Date Received: NA
Date Analyzed: 9/24/03
Volume(s) Analyzed: 0.10 ml

D.F. = 1.00

CAS #	Compound	Result (%, v/v)	MRL (%, v/v)	Data Qualifier
7782-44-7 7440-37-1	Oxygen + Argon *	ND	0.100	
7727-37-9	Nitrogen	ND	0.100	
630-08-0	Carbon Monoxide	ND	0.100	
74-82-8	Methane	ND	0.100	
124-38-9	Carbon Dioxide	ND	0.100	

ND = Compound was analyzed for, but not detected above the **laboratory reporting limit**.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.
* = Coeluting Compounds

Verified By: RG Date: 10/7/03

02029SVG.RD1 - MBlank

COLUMBIA ANALYTICAL SERVICES, INC.

RESULTS OF ANALYSIS

Client: **Emcon/OWT**
Client Sample ID: **GP-12 (middle)**
Client Project ID: **Horn Rapids LF/810835 02000300**

CAS Project ID: P2302029
CAS Sample ID: P2302029-001

Test Code: Modified EPA TO-15
Instrument ID: Tekmar AUTOCAN/HP5973/HP6890/MS3
Analyst: Svetlana Walsh
Sampling Media: Summa Canister
Test Notes:
Container ID: SC00173

Date Collected: 9/18/03
Date Received: 9/23/03
Date(s) Analyzed: 9/29/03
Volume(s) Analyzed: 0.020 Liter(s)
0.0020 Liter(s)

Pi 1 = 0.0 Pf 1 = 3.5

D.F. = 1.24

CAS #	Compound	Result µg/m³	MRL µg/m³	Result ppbV	MRL ppbV	Data Qualifier
74-87-3	Chloromethane	ND	62	ND	30	
75-01-4	Vinyl Chloride	**1,200**	62	**480**	24	
74-83-9	Bromomethane	ND	62	ND	16	
75-00-3	Chloroethane	**130**	62	**51**	24	
67-64-1	Acetone	ND	310	ND	130	
75-69-4	Trichlorofluoromethane	**160**	62	**28**	11	
75-35-4	1,1-Dichloroethene	**130**	62	**33**	16	
75-09-2	Methylene chloride	**150**	62	**43**	18	
76-13-1	Trichlorotrifluoroethane	**110**	62	**15**	8.1	
75-15-0	Carbon Disulfide	ND	62	ND	20	
156-60-5	trans-1,2-Dichloroethene	**310**	62	**79**	16	
75-34-3	1,1-Dichloroethane	**2,300**	62	**570**	15	
1634-04-4	Methyl tert-Butyl Ether	ND	62	ND	17	
108-05-4	Vinyl Acetate	ND	62	ND	18	
78-93-3	2-Butanone (MEK)	ND	62	ND	21	
156-59-2	cis-1,2-Dichloroethene	**3,200**	62	**810**	16	
67-66-3	Chloroform	ND	62	ND	13	
107-06-2	1,2-Dichloroethane	ND	62	ND	15	
71-55-6	1,1,1-Trichloroethane	ND	62	ND	11	
71-43-2	Benzene	**97**	62	**30**	19	
56-23-5	Carbon Tetrachloride	ND	62	ND	9.9	
78-87-5	1,2-Dichloropropane	ND	62	ND	13	

ND = Compound was analyzed for, but not detected above the **laboratory reporting limit**.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.

Verified By: _____ Date: 10/7/03

Client: **Emcon/OWT**
Client Sample ID: **GP-12 (middle)**
Client Project ID: **Horn Rapids LF/810835 02000300**

CAS Project ID: P2302029
CAS Sample ID: P2302029-001

Test Code: Modified EPA TO-15
Instrument ID: Tekmar AUTOCAN/HP5973/HP6890/MS3
Analyst: Svetlana Walsh
Sampling Media: Summa Canister
Test Notes:
Container ID: SC00173

Date Collected: 9/18/03
Date Received: 9/23/03
Date(s) Analyzed: 9/29/03
Volume(s) Analyzed: 0.020 Liter(s)
0.0020 Liter(s)

Pi 1 = 0.0 Pf 1 = 3.5

D.F. = 1.24

CAS #	Compound	Result µg/m³	MRL µg/m³	Result ppbV	MRL ppbV	Data Qualifier
75-27-4	Bromodichloromethane	ND	62	ND	9.3	
79-01-6	Trichloroethene	**2,900**	62	**540**	12	
10061-01-5	cis-1,3-Dichloropropene	ND	62	ND	14	
108-10-1	4-Methyl-2-pentanone	ND	62	ND	15	
10061-02-6	trans-1,3-Dichloropropene	ND	62	ND	14	
79-00-5	1,1,2-Trichloroethane	ND	62	ND	11	
108-88-3	Toluene	ND	62	ND	16	
591-78-6	2-Hexanone	ND	62	ND	15	
124-48-1	Dibromochloromethane	ND	62	ND	7.3	
106-93-4	1,2-Dibromoethane	ND	62	ND	8.1	
127-18-4	Tetrachloroethene	**18,000**	62	**2,700**	9.1	
108-90-7	Chlorobenzene	ND	62	ND	13	
100-41-4	Ethylbenzene	ND	62	ND	14	
136777-61-2	*m,p* -Xylenes	ND	62	ND	14	
75-25-2	Bromoform	ND	62	ND	6.0	
100-42-5	Styrene	ND	62	ND	15	
95-47-6	o-Xylene	ND	62	ND	14	
79-34-5	1,1,2,2-Tetrachloroethane	ND	62	ND	9.0	
541-73-1	1,3-Dichlorobenzene	ND	62	ND	10	
106-46-7	1,4-Dichlorobenzene	ND	62	ND	10	
95-50-1	1,2-Dichlorobenzene	ND	62	ND	10	

ND = Compound was analyzed for, but not detected above the **laboratory reporting limit.**
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.

COLUMBIA ANALYTICAL SERVICES, INC.

RESULTS OF ANALYSIS

Client: **Emcon/OWT**
Client Sample ID: **MW-5**
Client Project ID: **Horn Rapids LF/810835 02000300**

CAS Project ID: P2302029
CAS Sample ID: P2302029-002

Test Code: Modified EPA TO-15
Instrument ID: Tekmar AUTOCAN/HP5973/HP6890/MS3
Analyst: Svetlana Walsh
Sampling Media: Summa Canister
Test Notes:
Container ID: SC00567

Date Collected: 9/18/03
Date Received: 9/23/03
Date(s) Analyzed: 9/29 - 9/30/03
Volume(s) Analyzed: 0.10 Liter(s)
0.0020 Liter(s)

Pi 1 = -0.4 Pf 1 = 3.5

D.F. = 1.27

CAS #	Compound	Result µg/m³	MRL µg/m³	Result ppbV	MRL ppbV	Data Qualifier
74-87-3	Chloromethane	ND	13	ND	6.2	
75-01-4	Vinyl Chloride	**490**	13	**190**	5.0	
74-83-9	Bromomethane	**99**	13	**26**	3.3	
75-00-3	Chloroethane	**310**	13	**120**	4.8	
67-64-1	Acetone	ND	64	ND	27	
75-69-4	Trichlorofluoromethane	**160**	13	**29**	2.3	
75-35-4	1,1-Dichloroethene	**140**	13	**34**	3.2	
75-09-2	Methylene chloride	**210**	13	**61**	3.7	
76-13-1	Trichlorotrifluoroethane	**57**	13	**7.4**	1.7	
75-15-0	Carbon Disulfide	**27**	13	**8.7**	4.1	
156-60-5	trans-1,2-Dichloroethene	**47**	13	**12**	3.2	
75-34-3	1,1-Dichloroethane	**1,000**	13	**260**	3.1	
1634-04-4	Methyl tert-Butyl Ether	ND	13	ND	3.5	
108-05-4	Vinyl Acetate	ND	13	ND	3.6	
78-93-3	2-Butanone (MEK)	ND	13	ND	4.3	
156-59-2	cis-1,2-Dichloroethene	**1,400**	13	**360**	3.2	
67-66-3	Chloroform	ND	13	ND	2.6	
107-06-2	1,2-Dichloroethane	**18**	13	**4.4**	3.1	
71-55-6	1,1,1-Trichloroethane	**52**	13	**9.5**	2.3	
71-43-2	Benzene	**18**	13	**5.5**	4.0	
56-23-5	Carbon Tetrachloride	ND	13	ND	2.0	
78-87-5	1,2-Dichloropropane	**13**	13	**2.7**	2.7	

ND = Compound was analyzed for, but not detected above the **laboratory reporting limit**.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.

Verified By: RC Date: 10/7/03

Client: **Emcon/OWT**
Client Sample ID: **MW-5**
Client Project ID: **Horn Rapids LF/810835 02000300**

CAS Project ID: P2302029
CAS Sample ID: P2302029-002

Test Code: Modified EPA TO-15
Instrument ID: Tekmar AUTOCAN/HP5973/HP6890/MS3
Analyst: Svetlana Walsh
Sampling Media: Summa Canister
Test Notes:
Container ID: SC00567

Date Collected: 9/18/03
Date Received: 9/23/03
Date(s) Analyzed: 9/29 - 9/30/03
Volume(s) Analyzed: 0.10 Liter(s)
0.0020 Liter(s)

Pi 1 = -0.4 Pf 1 = 3.5

D.F. = 1.27

CAS #	Compound	Result µg/m³	MRL µg/m³	Result ppbV	MRL ppbV	Data Qualifier
75-27-4	Bromodichloromethane	ND	13	ND	1.9	
79-01-6	Trichloroethene	**630**	13	**120**	2.4	
10061-01-5	cis-1,3-Dichloropropene	ND	13	ND	2.8	
108-10-1	4-Methyl-2-pentanone	ND	13	ND	3.1	
10061-02-6	trans-1,3-Dichloropropene	ND	13	ND	2.8	
79-00-5	1,1,2-Trichloroethane	ND	13	ND	2.3	
108-88-3	Toluene	ND	13	ND	3.4	
591-78-6	2-Hexanone	ND	13	ND	3.1	
124-48-1	Dibromochloromethane	ND	13	ND	1.5	
106-93-4	1,2-Dibromoethane	ND	13	ND	1.7	
127-18-4	Tetrachloroethene	**1,000**	13	**150**	1.9	
108-90-7	Chlorobenzene	ND	13	ND	2.8	
100-41-4	Ethylbenzene	ND	13	ND	2.9	
136777-61-2	*m,p* -Xylenes	ND	13	ND	2.9	
75-25-2	Bromoform	ND	13	ND	1.2	
100-42-5	Styrene	ND	13	ND	3.0	
95-47-6	o-Xylene	ND	13	ND	2.9	
79-34-5	1,1,2,2-Tetrachloroethane	ND	13	ND	1.9	
541-73-1	1,3-Dichlorobenzene	ND	13	ND	2.1	
106-46-7	1,4-Dichlorobenzene	ND	13	ND	2.1	
95-50-1	1,2-Dichlorobenzene	ND	13	ND	2.1	

ND = Compound was analyzed for, but not detected above the **laboratory reporting limit**.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.

COLUMBIA ANALYTICAL SERVICES, INC.

RESULTS OF ANALYSIS

Client: **Emcon/OWT**
Client Sample ID: **MW-6**
Client Project ID: **Horn Rapids LF/810835 02000300**

CAS Project ID: P2302029
CAS Sample ID: P2302029-003

Test Code: Modified EPA TO-15
Instrument ID: Tekmar AUTOCAN/HP5973/HP6890/MS3
Analyst: Svetlana Walsh
Sampling Media: Summa Canister
Test Notes:
Container ID: SC00051

Date Collected: 9/18/03
Date Received: 9/23/03
Date(s) Analyzed: 9/30/03
Volume(s) Analyzed: 1.00 Liter(s)

Pi 1 = -8.6 Pf 1 = 3.5

D.F. = 2.98

CAS #	Compound	Result µg/m³	MRL µg/m³	Result ppbV	MRL ppbV	Data Qualifier
74-87-3	Chloromethane	**6.3**	3.0	**3.1**	1.4	
75-01-4	Vinyl Chloride	**120**	3.0	**47**	1.2	
74-83-9	Bromomethane	ND	3.0	ND	0.77	
75-00-3	Chloroethane	**230**	3.0	**86**	1.1	
67-64-1	Acetone	**220**	15	**91**	6.3	
75-69-4	Trichlorofluoromethane	**4.1**	3.0	**0.74**	0.53	
75-35-4	1,1-Dichloroethene	**23**	3.0	**5.7**	0.75	
75-09-2	Methylene chloride	**14**	3.0	**4.1**	0.86	
76-13-1	Trichlorotrifluoroethane	ND	3.0	ND	0.39	
75-15-0	Carbon Disulfide	**140**	3.0	**44**	0.96	
156-60-5	trans-1,2-Dichloroethene	**20**	3.0	**5.0**	0.75	
75-34-3	1,1-Dichloroethane	**170**	3.0	**42**	0.74	
1634-04-4	Methyl tert-Butyl Ether	ND	3.0	ND	0.83	
108-05-4	Vinyl Acetate	ND	3.0	ND	0.85	
78-93-3	2-Butanone (MEK)	**31**	3.0	**10**	1.0	
156-59-2	cis-1,2-Dichloroethene	**190**	3.0	**48**	0.75	
67-66-3	Chloroform	ND	3.0	ND	0.61	
107-06-2	1,2-Dichloroethane	ND	3.0	ND	0.74	
71-55-6	1,1,1-Trichloroethane	ND	3.0	ND	0.55	
71-43-2	Benzene	**14**	3.0	**4.4**	0.93	
56-23-5	Carbon Tetrachloride	ND	3.0	ND	0.47	
78-87-5	1,2-Dichloropropane	ND	3.0	ND	0.65	

ND = Compound was analyzed for, but not detected above the **laboratory reporting limit**.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.

Verified By: RG Date: 10/7/03

Client: **Emcon/OWT**
Client Sample ID: **MW-6**
Client Project ID: **Horn Rapids LF/810835 02000300**

CAS Project ID: P2302029
CAS Sample ID: P2302029-003

Test Code: Modified EPA TO-15
Instrument ID: Tekmar AUTOCAN/HP5973/HP6890/MS3
Analyst: Svetlana Walsh
Sampling Media: Summa Canister
Test Notes:
Container ID: SC00051

Date Collected: 9/18/03
Date Received: 9/23/03
Date(s) Analyzed: 9/30/03
Volume(s) Analyzed: 1.00 Liter(s)

Pi 1 = -8.6 Pf 1 = 3.5

D.F. = 2.98

CAS #	Compound	Result µg/m³	MRL µg/m³	Result ppbV	MRL ppbV	Data Qualifier
75-27-4	Bromodichloromethane	ND	3.0	ND	0.44	
79-01-6	Trichloroethene	**68**	3.0	**13**	0.55	
10061-01-5	cis-1,3-Dichloropropene	ND	3.0	ND	0.66	
108-10-1	4-Methyl-2-pentanone	ND	3.0	ND	0.73	
10061-02-6	trans-1,3-Dichloropropene	ND	3.0	ND	0.66	
79-00-5	1,1,2-Trichloroethane	ND	3.0	ND	0.55	
108-88-3	Toluene	**33**	3.0	**8.9**	0.79	
591-78-6	2-Hexanone	ND	3.0	ND	0.73	
124-48-1	Dibromochloromethane	ND	3.0	ND	0.35	
106-93-4	1,2-Dibromoethane	ND	3.0	ND	0.39	
127-18-4	Tetrachloroethene	**59**	3.0	**8.7**	0.44	
108-90-7	Chlorobenzene	ND	3.0	ND	0.65	
100-41-4	Ethylbenzene	ND	3.0	ND	0.69	
136777-61-2	*m,p* -Xylenes	**6.8**	3.0	**1.6**	0.69	
75-25-2	Bromoform	ND	3.0	ND	0.29	
100-42-5	Styrene	ND	3.0	ND	0.70	
95-47-6	o-Xylene	ND	3.0	ND	0.69	
79-34-5	1,1,2,2-Tetrachloroethane	ND	3.0	ND	0.43	
541-73-1	1,3-Dichlorobenzene	ND	3.0	ND	0.50	
106-46-7	1,4-Dichlorobenzene	ND	3.0	ND	0.50	
95-50-1	1,2-Dichlorobenzene	ND	3.0	ND	0.50	

ND = Compound was analyzed for, but not detected above the **laboratory reporting limit**.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.

COLUMBIA ANALYTICAL SERVICES, INC.

RESULTS OF ANALYSIS

Client: **Emcon/OWT**
Client Sample ID: **MW-7**
Client Project ID: **Horn Rapids LF/810835 02000300**

CAS Project ID: P2302029
CAS Sample ID: P2302029-004

Test Code: Modified EPA TO-15
Instrument ID: Tekmar AUTOCAN/HP5973/HP6890/MS3
Analyst: Svetlana Walsh
Sampling Media: Summa Canister
Test Notes:
Container ID: SC00343

Date Collected: 9/18/03
Date Received: 9/23/03
Date(s) Analyzed: 9/29/03
Volume(s) Analyzed: 0.010 Liter(s)

Pi 1 = -1.4 Pf 1 = 3.5

D.F. = 1.37

CAS #	Compound	Result µg/m³	MRL µg/m³	Result ppbV	MRL ppbV	Data Qualifier
74-87-3	Chloromethane	ND	140	ND	66	
75-01-4	Vinyl Chloride	**470**	140	**190**	54	
74-83-9	Bromomethane	ND	140	ND	35	
75-00-3	Chloroethane	**1,100**	140	**420**	52	
67-64-1	Acetone	ND	690	ND	290	
75-69-4	Trichlorofluoromethane	**4,100**	140	**720**	24	
75-35-4	1,1-Dichloroethene	**180**	140	**45**	35	
75-09-2	Methylene chloride	**1,300**	140	**360**	39	
76-13-1	Trichlorotrifluoroethane	**340**	140	**44**	18	
75-15-0	Carbon Disulfide	ND	140	ND	44	
156-60-5	trans-1,2-Dichloroethene	**200**	140	**52**	35	
75-34-3	1,1-Dichloroethane	**970**	140	**240**	34	
1634-04-4	Methyl tert-Butyl Ether	ND	140	ND	38	
108-05-4	Vinyl Acetate	ND	140	ND	39	
78-93-3	2-Butanone (MEK)	ND	140	ND	46	
156-59-2	cis-1,2-Dichloroethene	**4,300**	140	**1,100**	35	
67-66-3	Chloroform	ND	140	ND	28	
107-06-2	1,2-Dichloroethane	ND	140	ND	34	
71-55-6	1,1,1-Trichloroethane	**580**	140	**110**	25	
71-43-2	Benzene	**220**	140	**68**	43	
56-23-5	Carbon Tetrachloride	ND	140	ND	22	
78-87-5	1,2-Dichloropropane	ND	140	ND	30	

ND = Compound was analyzed for, but not detected above the **laboratory reporting limit**.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.

Verified By: RG Date: 10/7/03

Client: **Emcon/OWT**
Client Sample ID: **MW-7**
Client Project ID: **Horn Rapids LF/810835 02000300**

CAS Project ID: P2302029
CAS Sample ID: P2302029-004

Test Code: Modified EPA TO-15
Instrument ID: Tekmar AUTOCAN/HP5973/HP6890/MS3
Analyst: Svetlana Walsh
Sampling Media: Summa Canister
Test Notes:
Container ID: SC00343

Date Collected: 9/18/03
Date Received: 9/23/03
Date(s) Analyzed: 9/29/03
Volume(s) Analyzed: 0.010 Liter(s)

Pi 1 = -1.4 Pf 1 = 3.5

D.F. = 1.37

CAS #	Compound	Result µg/m³	MRL µg/m³	Result ppbV	MRL ppbV	Data Qualifier
75-27-4	Bromodichloromethane	ND	140	ND	20	
79-01-6	Trichloroethene	**1,200**	140	**220**	26	
10061-01-5	cis-1,3-Dichloropropene	ND	140	ND	30	
108-10-1	4-Methyl-2-pentanone	ND	140	ND	33	
10061-02-6	trans-1,3-Dichloropropene	ND	140	ND	30	
79-00-5	1,1,2-Trichloroethane	ND	140	ND	25	
108-88-3	Toluene	ND	140	ND	36	
591-78-6	2-Hexanone	ND	140	ND	33	
124-48-1	Dibromochloromethane	ND	140	ND	16	
106-93-4	1,2-Dibromoethane	ND	140	ND	18	
127-18-4	Tetrachloroethene	**8,500**	140	**1,300**	20	
108-90-7	Chlorobenzene	ND	140	ND	30	
100-41-4	Ethylbenzene	ND	140	ND	32	
136777-61-2	*m,p* -Xylenes	ND	140	ND	32	
75-25-2	Bromoform	ND	140	ND	13	
100-42-5	Styrene	ND	140	ND	32	
95-47-6	o-Xylene	ND	140	ND	32	
79-34-5	1,1,2,2-Tetrachloroethane	ND	140	ND	20	
541-73-1	1,3-Dichlorobenzene	ND	140	ND	23	
106-46-7	1,4-Dichlorobenzene	ND	140	ND	23	
95-50-1	1,2-Dichlorobenzene	ND	140	ND	23	

ND = Compound was analyzed for, but not detected above the **laboratory reporting limit**.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.

Verified By: RG Date: 10/7/03

COLUMBIA ANALYTICAL SERVICES, INC.

RESULTS OF ANALYSIS

Client: **Emcon/OWT**
Client Sample ID: **Method Blank**
Client Project ID: **Horn Rapids LF/810835 02000300**

CAS Project ID: P2302029
CAS Sample ID: P030929-MB

Test Code: Modified EPA TO-15
Instrument ID: Tekmar AUTOCAN/HP5973/HP6890/MS3
Analyst: Svetlana Walsh
Sampling Media: Summa Canister
Test Notes:

Date Collected: NA
Date Received: NA
Date(s) Analyzed: 9/29/03
Volume(s) Analyzed: 1.00 Liter(s)

D.F. = 1.00

CAS #	Compound	Result µg/m³	MRL µg/m³	Result ppbV	MRL ppbV	Data Qualifier
74-87-3	Chloromethane	ND	1.0	ND	0.48	
75-01-4	Vinyl Chloride	ND	1.0	ND	0.39	
74-83-9	Bromomethane	ND	1.0	ND	0.26	
75-00-3	Chloroethane	ND	1.0	ND	0.38	
67-64-1	Acetone	ND	5.0	ND	2.1	
75-69-4	Trichlorofluoromethane	ND	1.0	ND	0.18	
75-35-4	1,1-Dichloroethene	ND	1.0	ND	0.25	
75-09-2	Methylene chloride	ND	1.0	ND	0.29	
76-13-1	Trichlorotrifluoroethane	ND	1.0	ND	0.13	
75-15-0	Carbon Disulfide	ND	1.0	ND	0.32	
156-60-5	trans-1,2-Dichloroethene	ND	1.0	ND	0.25	
75-34-3	1,1-Dichloroethane	ND	1.0	ND	0.25	
1634-04-4	Methyl tert-Butyl Ether	ND	1.0	ND	0.28	
108-05-4	Vinyl Acetate	ND	1.0	ND	0.28	
78-93-3	2-Butanone (MEK)	ND	1.0	ND	0.34	
156-59-2	cis-1,2-Dichloroethene	ND	1.0	ND	0.25	
67-66-3	Chloroform	ND	1.0	ND	0.20	
107-06-2	1,2-Dichloroethane	ND	1.0	ND	0.25	
71-55-6	1,1,1-Trichloroethane	ND	1.0	ND	0.18	
71-43-2	Benzene	ND	1.0	ND	0.31	
56-23-5	Carbon Tetrachloride	ND	1.0	ND	0.16	
78-87-5	1,2-Dichloropropane	ND	1.0	ND	0.22	

ND = Compound was analyzed for, but not detected above the **laboratory reporting limit**.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.

Verified By: RC Date: 10/7/03

Client: **Emcon/OWT**
Client Sample ID: **Method Blank**
Client Project ID: **Horn Rapids LF/810835 02000300**

CAS Project ID: P2302029
CAS Sample ID: P030929-MB

Test Code: Modified EPA TO-15
Instrument ID: Tekmar AUTOCAN/HP5973/HP6890/MS3
Analyst: Svetlana Walsh
Sampling Media: Summa Canister
Test Notes:

Date Collected: NA
Date Received: NA
Date(s) Analyzed: 9/29/03
Volume(s) Analyzed: 1.00 Liter(s)

D.F. = 1.00

CAS #	Compound	Result µg/m³	MRL µg/m³	Result ppbV	MRL ppbV	Data Qualifier
75-27-4	Bromodichloromethane	ND	1.0	ND	0.15	
79-01-6	Trichloroethene	ND	1.0	ND	0.19	
10061-01-5	cis-1,3-Dichloropropene	ND	1.0	ND	0.22	
108-10-1	4-Methyl-2-pentanone	ND	1.0	ND	0.24	
10061-02-6	trans-1,3-Dichloropropene	ND	1.0	ND	0.22	
79-00-5	1,1,2-Trichloroethane	ND	1.0	ND	0.18	
108-88-3	Toluene	ND	1.0	ND	0.27	
591-78-6	2-Hexanone	ND	1.0	ND	0.24	
124-48-1	Dibromochloromethane	ND	1.0	ND	0.12	
106-93-4	1,2-Dibromoethane	ND	1.0	ND	0.13	
127-18-4	Tetrachloroethene	ND	1.0	ND	0.15	
108-90-7	Chlorobenzene	ND	1.0	ND	0.22	
100-41-4	Ethylbenzene	ND	1.0	ND	0.23	
136777-61-2	*m,p* -Xylenes	ND	1.0	ND	0.23	
75-25-2	Bromoform	ND	1.0	ND	0.097	
100-42-5	Styrene	ND	1.0	ND	0.23	
95-47-6	o-Xylene	ND	1.0	ND	0.23	
79-34-5	1,1,2,2-Tetrachloroethane	ND	1.0	ND	0.15	
541-73-1	1,3-Dichlorobenzene	ND	1.0	ND	0.17	
106-46-7	1,4-Dichlorobenzene	ND	1.0	ND	0.17	
95-50-1	1,2-Dichlorobenzene	ND	1.0	ND	0.17	

ND = Compound was analyzed for, but not detected above the **laboratory reporting limit**.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.

Columbia Analytical Services, Inc.
Sample Acceptance Check Form

Client: Emcon/OWT Work order: P2302029

Project: Horn Rapids LF/810835 02000300

Sample(s) received on: 9/23/03 Date opened: 9/23/03 by: SM

Note: This form is used for all samples received by CAS. The use of this form for custody seals is strictly meant to indicate presence/absence and not as an indication of compliance or nonconformity. Thermal preservation and pH will only be evaluated either at the request of the client or as required by the method/SOP.

		Yes	No	N/A
1	Were **custody seals** on outside of cooler/Box?	☐	☒	☐
	Location of seal(s)? _____ Sealing Lid?	☐	☐	☒
	Were signature and date included?	☐	☐	☒
	Were seals intact?	☐	☐	☒
	Were custody seals on outside of sample container?	☐	☒	☐
	Location of seal(s)? _____ Sealing Lid?	☐	☐	☒
	Were signature and date included?	☐	☐	☒
	Were seals intact?	☐	☐	☒
2	Were **sample containers** properly marked with client sample ID?	☒	☐	☐
3	Did **sample containers** arrive in good condition?	☒	☐	☐
4	Were **chain-of-custody** papers used and filled out?	☒	☐	☐
5	Did **sample container labels** and/or tags agree with custody papers?	☒	☐	☐
6	Was **sample volume** received adequate for analysis?	☒	☐	☐
7	Are samples within specified holding times?	☒	☐	☐
8	Was proper **temperature** (thermal preservation) of cooler at receipt adhered to?	☐	☐	☒
	Cooler Temperature NA °C			
	Blank Temperature NA °C			
9	Is pH (acid) **preservation** necessary, according to method/SOP or Client specified information?	☐	☒	☐
	Is there a client indication that the submitted samples are **pH** (acid) preserved?	☐	☐	☒
	Were **VOA vials** checked for presence/absence of air bubbles?	☐	☐	☒
	Does the client/method/SOP require that the analyst check the sample pH and if necessary alter it?	☐	☐	☒
10	**Tubes:** Are the tubes capped and intact?	☐	☐	☒
	Do they contain moisture?	☐	☐	☒
11	**Badges:** Are the badges properly capped and intact?	☐	☐	☒
	Are dual bed badges separated and individually capped and intact?	☐	☐	☒

Lab Sample ID	Required pH	pH (as received, if required)	VOA Headspace (Presence/Absence)	Receipt / Preservation Comments
P2302029-001			NA	
P2302029-002			NA	
P2302029-003			NA	
P2302029-004			NA	

Explain any discrepancies: (include lab sample ID numbers):

Columbia Analytical Services INC.
An Employee - Owned Company

Air Quality Laboratory
2665 Park Center Drive, Suite D
Simi Valley, California 93065
Phone (805) 526-7161
Fax (805) 526-7270

Chain of Custody Record
Analytical Service Request

Client/Address: Shaw EMCON/OWT, Inc.
10300 SW Nimbus Ave. Suite B
Portland, OR 97223

Phone: (503) 603-1086 Fax: (503) 603-1001

Email: jdavendonis@shawgrp.com

Contact: Jason Davendonis

Sampler (Signature): Jason Davendonis

Project Name: Horn Rapids LF

Project Number: 810835 02000300

Sampling Location: Richland, WA

P.O. #/Billing Information: P.O. pending

CAS Project No.: P2302029

Client Sample ID	Date Collected	Time Collected	Lab Sample No.	Type of Sample	Container ID (Serial #)	Flow Controller (Serial #)	Sample Volume (Liters)	Analysis: TO-15 *	Analysis: Fixed Gases	Analysis	Analysis	Analysis	Expected Turnaround Time: 24 Hr 48Hr 3Day 4Day 5Day Standard (10 Business Days)	Comments (e.g., preservative or specific instructions)
GP-12 (middle)	9/18/03	10:15		Summa	SC00173			X	X					* 43 compounds
MW-5	9/18/03	12:00		Summa	SC00587			X	X					
MW-6	9/18/03	11:05		Summa	SC00051			X	X					
MW-7	9/18/03	13:00		Summa	SC00343			X	X					

Cooler / Blank
Temp_____

Comments
(e.g., preservative or specific instructions)

Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:
Jason Davendonis	9/19/03	13:40	Sharon Malone	9/23/03	11:00
Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:
Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:

Additional Comments

20

White Copy Accompanies Samples

DOC (3).max

EMCON/OWT, Inc. QA/QC Review
Landfill Gas- RISF Phase II Discrete LFG Sampling Event
Horn Rapids Landfill
CAS Report #P2302029

Sample: GP-12, MW-5, MW-6, and MW-7 (Summa canisters).

Reviewed Date: 10/17/2003 (JTD)
Sample Date: 09/18/2003
Sample Received Date: 09/23/2003

Modified EPA Method 3C (Fixed gases)

Method Blank	All analytes ND.
Duplicates	All RPDs within 10%.

EPA TO-15 (43 compound list)

Method Blank	All analytes ND.

Sample Volume

Adequate for analyzes.

Hold Times

All analytical holding times met.

Notes

The methane results for MW-5 and MW-6 reported by the lab were non-detect. However, the field data recorded prior to sampling showed methane concentrations of 2.0% and 2.1% for MW-5 and MW-6, respectively. On 10/14/2003 I called CAS (Kate Aguilera) to have them re-analyze the samples to confirm their results. CAS re-analysis confirmed their original results (10/15/2003).

Data Validation

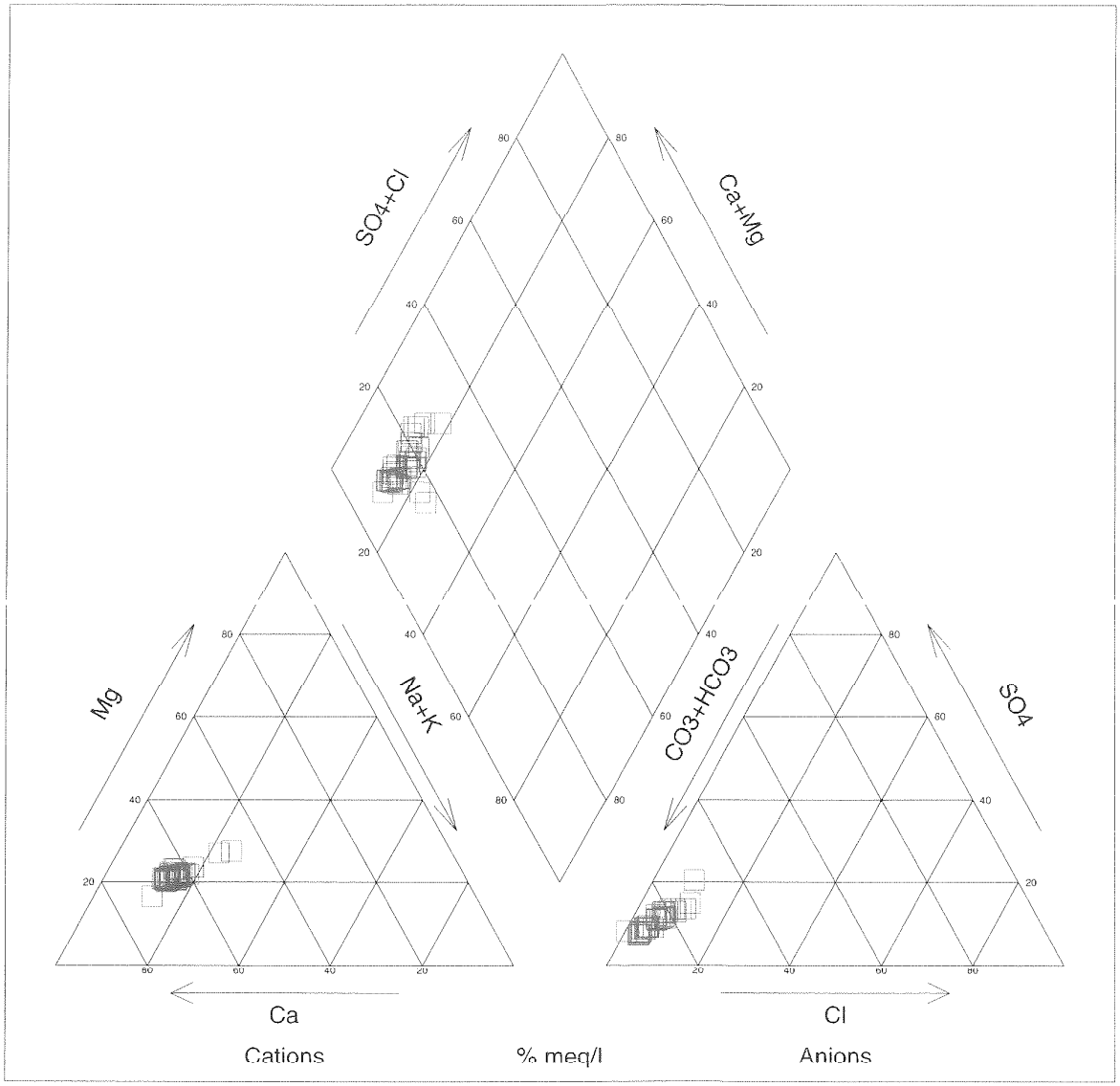
Upon final review of lab report #P2302029 for Horn Rapids Landfill, EMCON/OWT, Inc. finds the data to be valid for its intended use ***(10/17/2003 JTD)***.

APPENDIX D

GEOCHEMICAL PLOTS: PIPER (TRILINEAR) AND STIFF DIAGRAMS

Piper (Trilinear) Diagrams

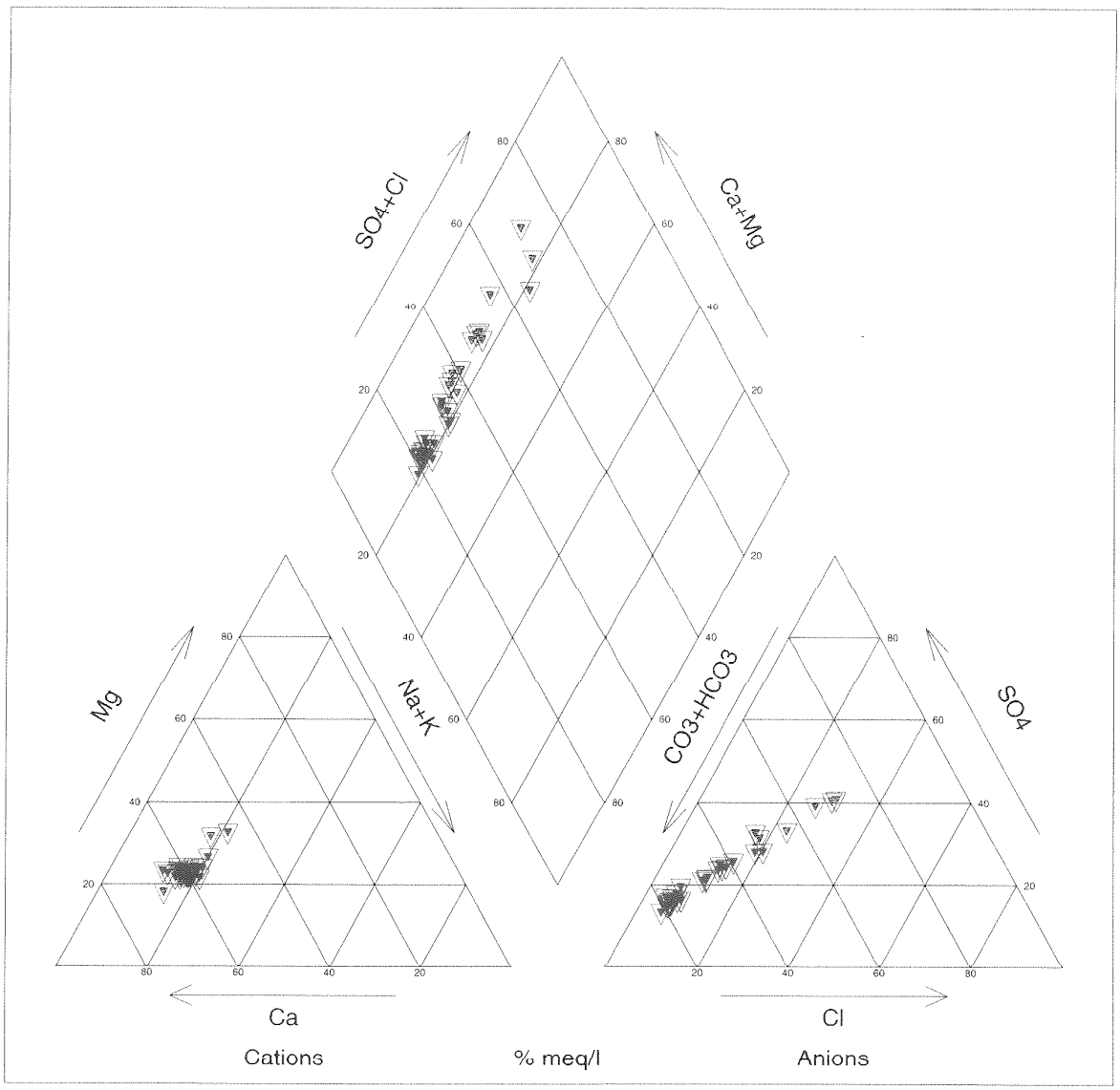
Horn Rapids Landfill; MW01



MW01 2/22/1995 - 3/01/1995	MW01 12/10/1997	MW01 11/08/2000 -12/05/2000
MW01 4/13/1995	MW01 2/24/1998	MW01 3/20/2001 - 4/10/2001
MW01 7/19/1995 - 7/21/1995	MW01 5/18/1998	MW01 7/25/2001
MW01 10/12/1995	MW01 8/10/1998	MW01 10/16/2001
MW01 12/27/1995	MW01 10/21/1998 -11/16/1998	MW01 12/05/2001 -12/18/2001
MW01 3/13/1996	MW01 1/26/1999	MW01 3/20/2002
MW01 5/30/1996	MW01 5/12/1999	MW01 7/03/2002
MW01 8/15/1996 - 9/12/1996	MW01 10/05/1999	MW01 10/15/2002
MW01 11/21/1996	MW01 12/21/1999 - 1/11/2000	MW01 12/17/2002 -12/31/2002
MW01 2/27/1997	MW01 1/11/2000 - 2/08/2000	MW01 3/26/2003
MW01 5/20/1997	MW01 5/16/2000	MW01 6/11/2003
MW01 8/14/1997	MW01 8/30/2000	

Prepared by: EMCON / OWT,Inc.

Horn Rapids Landfill; MW02



MW02 2/22/1995 - 3/01/1995	MW02 12/10/1997	MW02 11/08/2000 -12/05/2000
MW02 4/13/1995	MW02 2/24/1998	MW02 3/20/2001 - 4/10/2001
MW02 7/19/1995 - 7/21/1995	MW02 5/18/1998	MW02 7/25/2001
MW02 10/12/1995	MW02 8/10/1998	MW02 10/16/2001
MW02 12/27/1995	MW02 10/21/1998 -11/16/1998	MW02 12/05/2001 -12/18/2001
MW02 3/13/1996	MW02 1/26/1999	MW02 3/20/2002
MW02 5/30/1996	MW02 5/12/1999	MW02 7/03/2002
MW02 8/15/1996 - 9/12/1996	MW02 10/05/1999	MW02 10/15/2002
MW02 11/21/1996	MW02 12/21/1999 - 1/11/2000	MW02 12/17/2002 -12/31/2002
MW02 2/27/1997	MW02 1/11/2000 - 2/08/2000	MW02 3/26/2003
MW02 5/20/1997	MW02 5/16/2000	MW02 6/11/2003
MW02 8/14/1997	MW02 8/30/2000	

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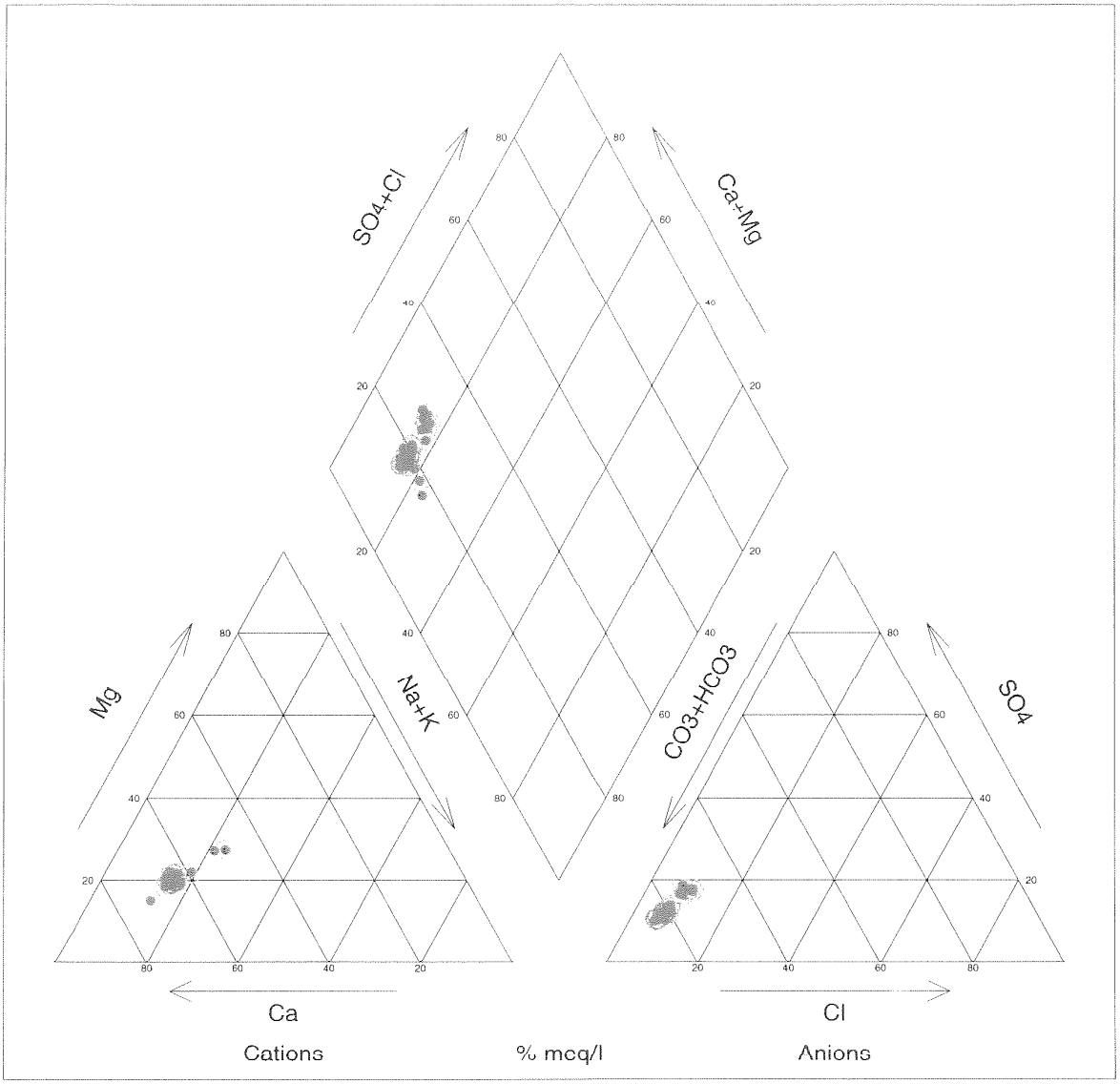
Horn Rapids Landfill; MW03



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MW03 4/13/1995	MW03 2/24/1998	MW03 3/20/2001 - 4/10/2001
MW03 7/19/1995 - 7/21/1995	MW03 5/18/1998	MW03 7/25/2001
MW03 10/12/1995	MW03 8/10/1998	MW03 10/16/2001
MW03 12/27/1995	MW03 10/21/1998 -11/16/1998	MW03 12/05/2001 -12/18/2001
MW03 3/13/1996	MW03 1/26/1999	MW03 3/20/2002
MW03 5/30/1996	MW03 5/12/1999	MW03 7/03/2002
MW03 8/15/1996 - 9/12/1996	MW03 10/05/1999	MW03 10/15/2002
MW03 11/21/1996	MW03 12/21/1999 - 1/11/2000	MW03 12/17/2002 -12/31/2002
MW03 2/27/1997	MW03 1/11/2000 - 2/08/2000	MW03 3/26/2003
MW03 5/20/1997	MW03 5/16/2000	MW03 6/11/2003
MW03 8/14/1997	MW03 8/30/2000	

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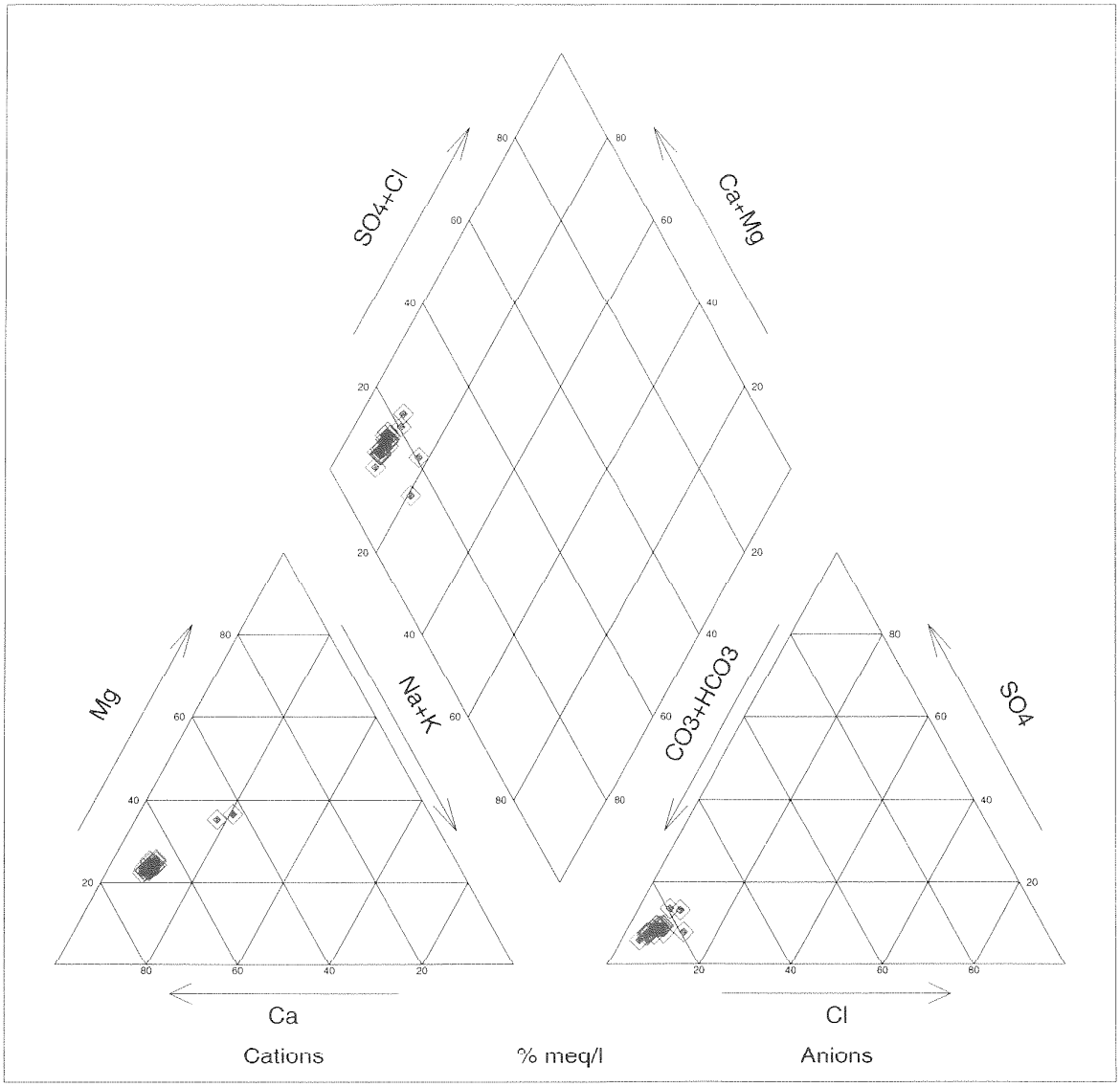
Horn Rapids Landfill; MW05



MW05	5/18/1998	MW05	11/08/2000 - 12/05/2000
MW05	6/30/1998 - 7/07/1998	MW05	3/20/2001 - 4/10/2001
MW05	8/10/1998	MW05	7/25/2001
MW05	10/21/1998 - 11/16/1998	MW05	10/16/2001
MW05	1/26/1999	MW05	12/05/2001 - 12/18/2001
MW05	5/12/1999	MW05	3/20/2002
MW05	10/05/1999	MW05	7/03/2002
MW05	12/21/1999 - 1/11/2000	MW05	10/15/2002
MW05	1/11/2000 - 2/08/2000	MW05	12/17/2002 - 12/31/2002
MW05	5/16/2000	MW05	3/26/2003
MW05	8/30/2000	MW05	6/11/2003

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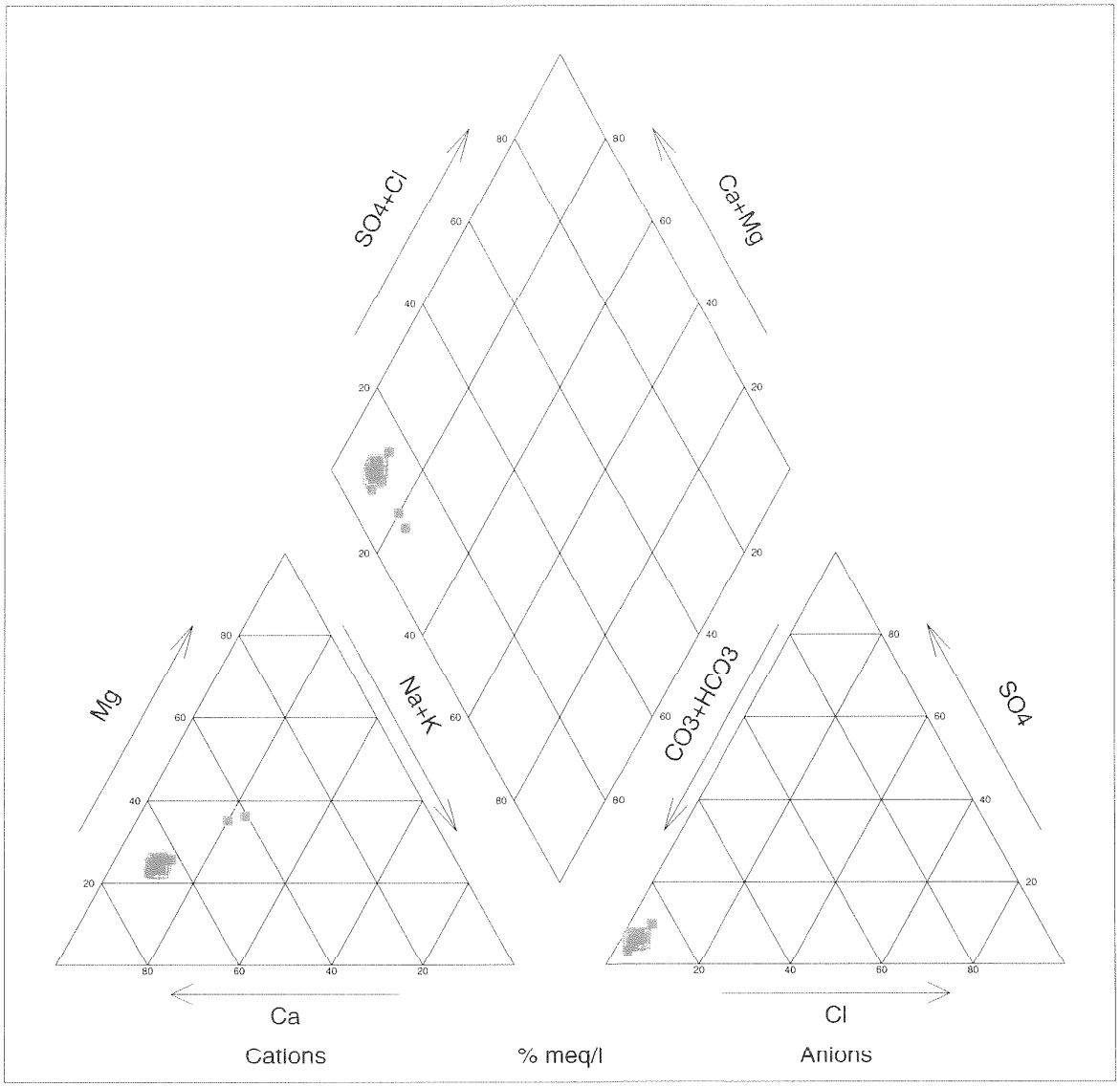
Horn Rapids Landfill; MW06



MW06	5/18/1998	MW06	11/08/2000 - 12/05/2000
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MW06	10/21/1998 - 11/16/1998	MW06	10/16/2001
MW06	1/26/1999	MW06	12/05/2001 - 12/18/2001
MW06	5/12/1999	MW06	3/20/2002
MW06	10/05/1999	MW06	7/03/2002
MW06	12/21/1999 - 1/11/2000	MW06	10/15/2002
MW06	1/11/2000 - 2/08/2000	MW06	12/17/2002 - 12/31/2002
MW06	5/16/2000	MW06	3/26/2003
MW06	8/30/2000	MW06	6/11/2003

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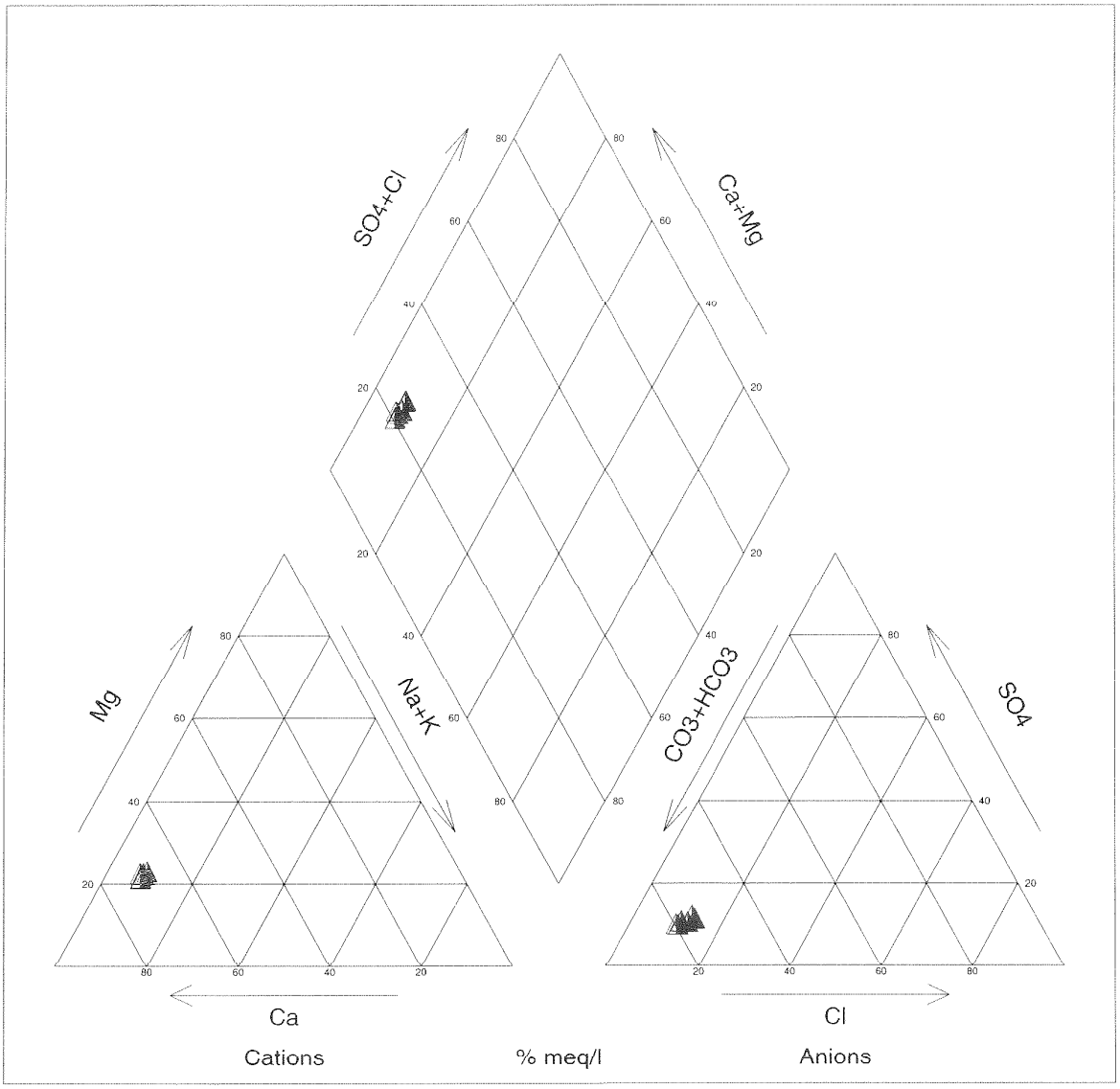
Horn Rapids Landfill; MW07



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MW07	7/25/2001	
MW07	10/16/2001	
MW07	12/05/2001 -	12/18/2001
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MW07	3/26/2003	
MW07	6/11/2003	

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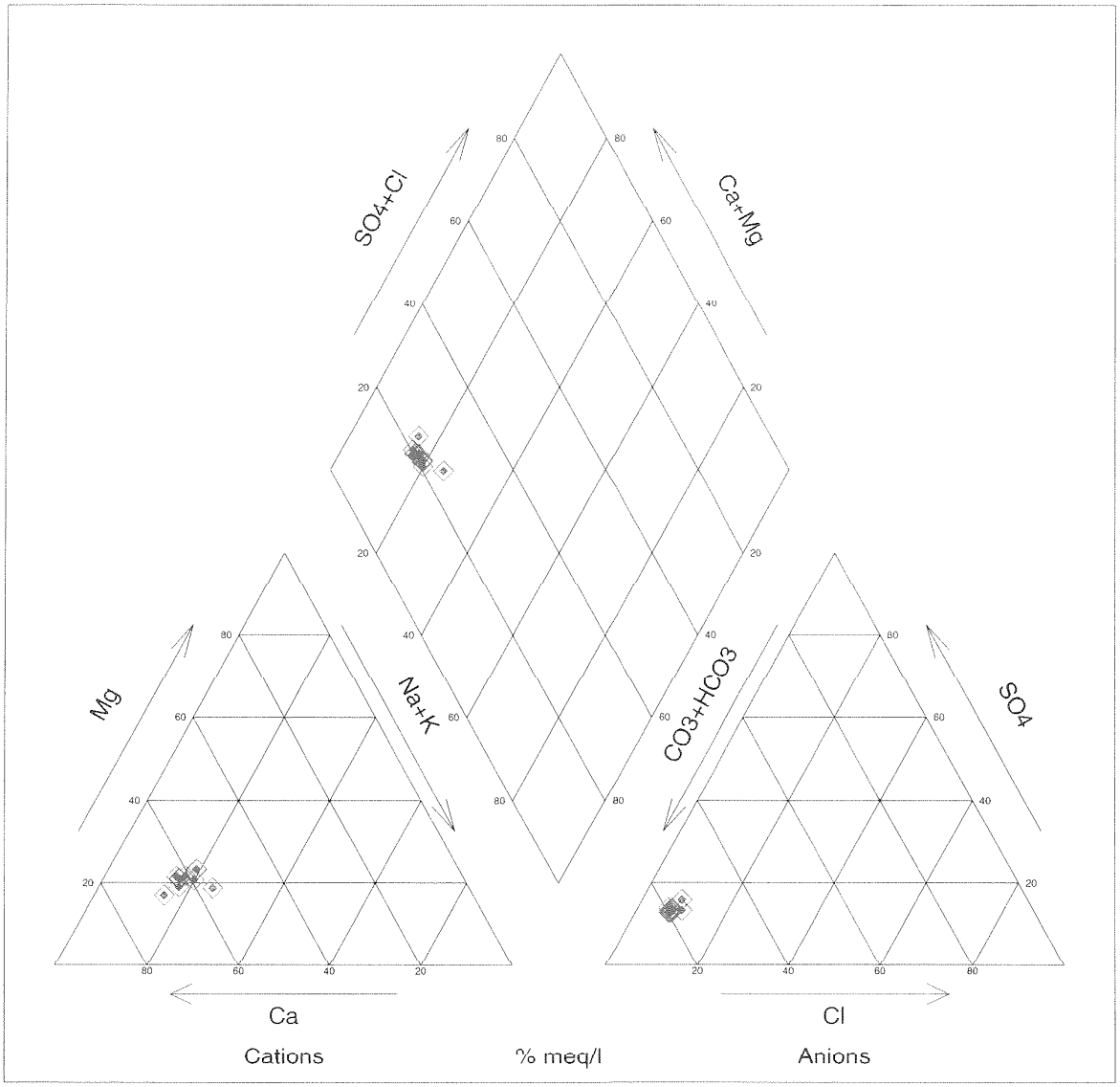
Horn Rapids Landfill; MW08



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MW08	10/16/2001		
MW08	12/05/2001 -12/18/2001		
MW08	3/20/2002		
MW08	7/03/2002		
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MW08	12/17/2002 -12/31/2002		

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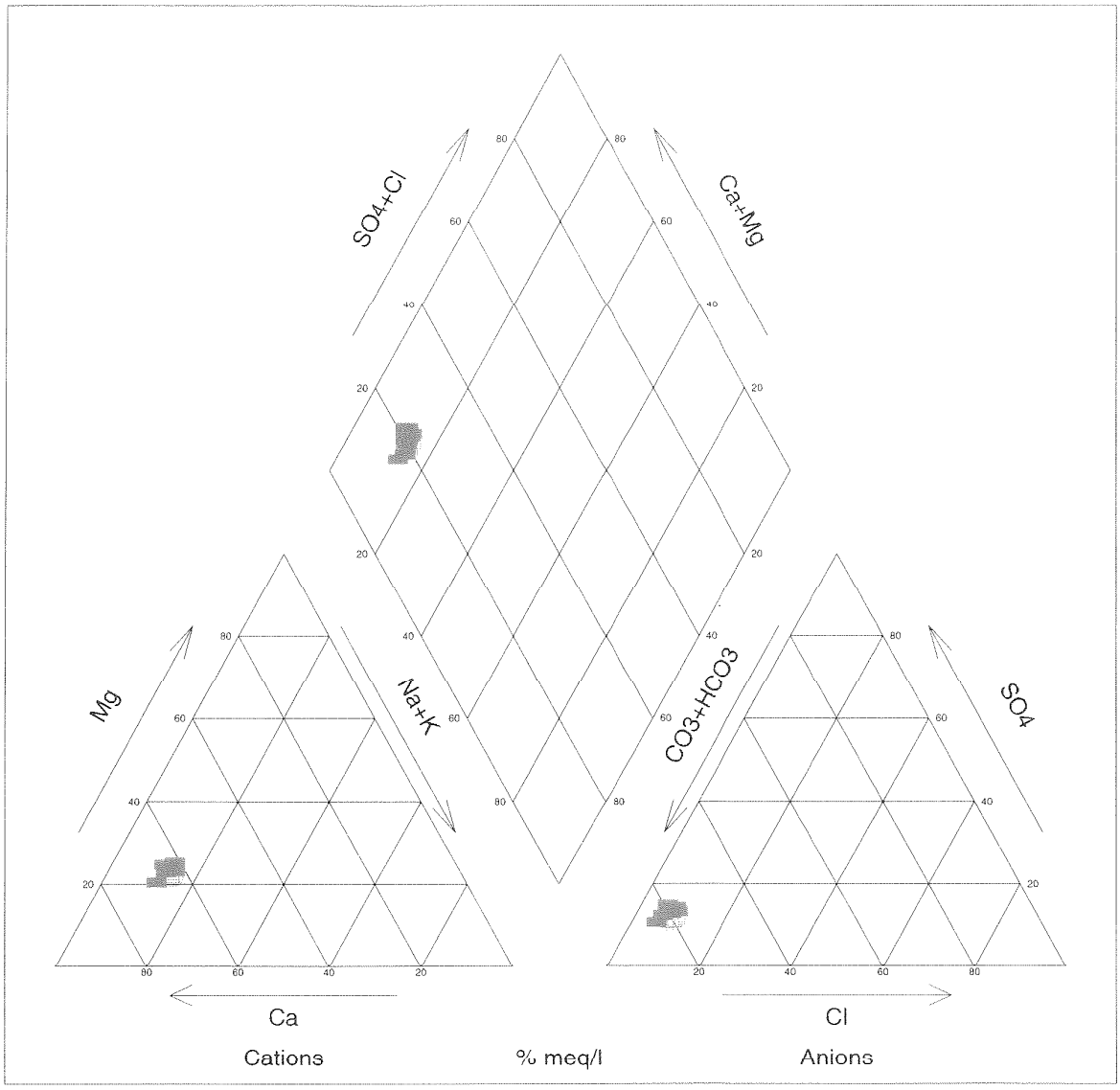
Horn Rapids Landfill; MW09



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MW09	7/25/2001	MW09	6/11/2003
MW09	10/16/2001		
MW09	12/05/2001 -12/18/2001		
MW09	3/20/2002		
MW09	7/03/2002		
MW09	10/15/2002		
MW09	12/17/2002 -12/31/2002		

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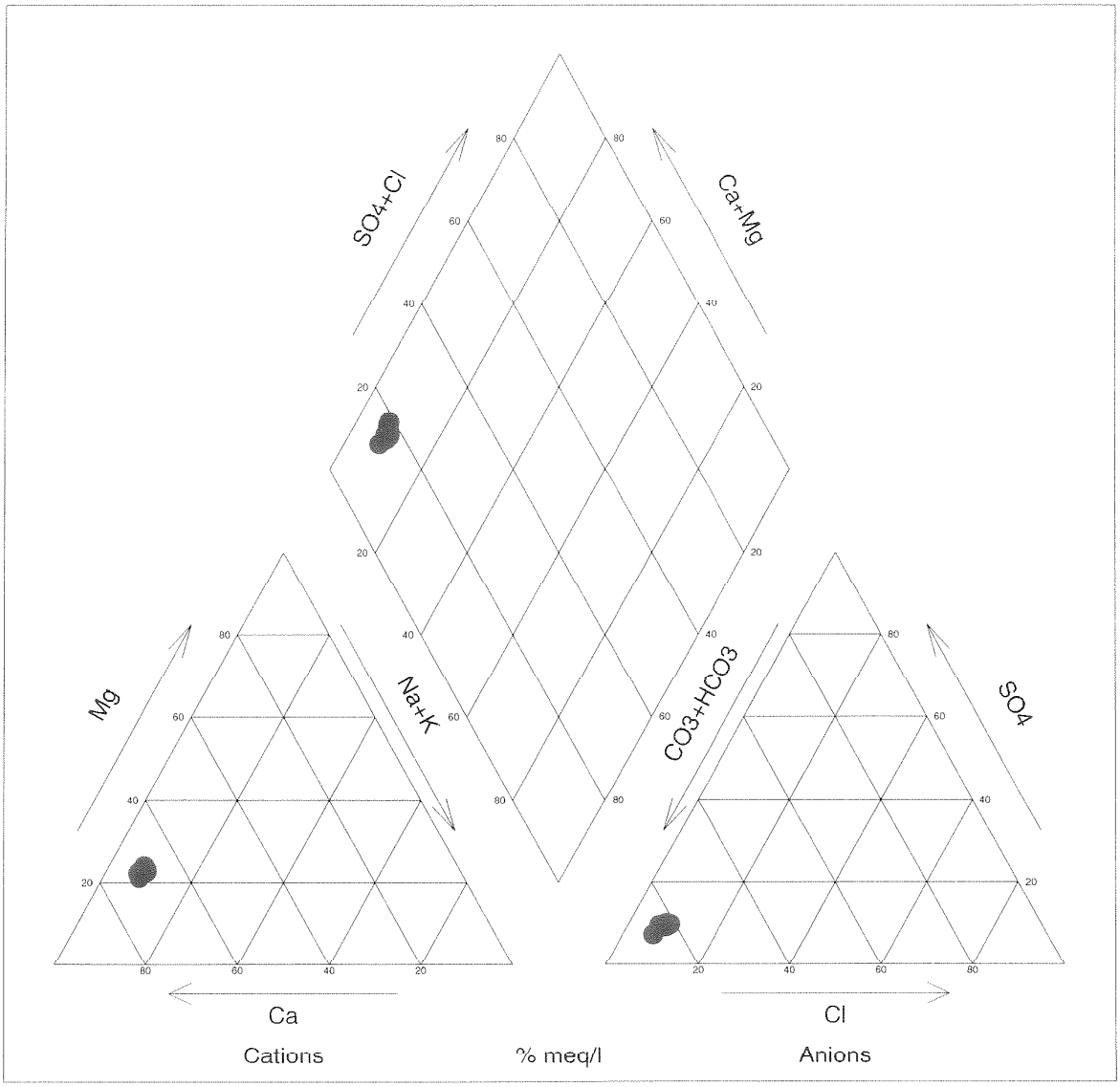
Horn Rapids Landfill; MW10



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MW10	12/05/2001 -12/18/2001		
MW10	3/20/2002		
MW10	7/03/2002		
MW10	10/15/2002		
MW10	12/17/2002 -12/31/2002		

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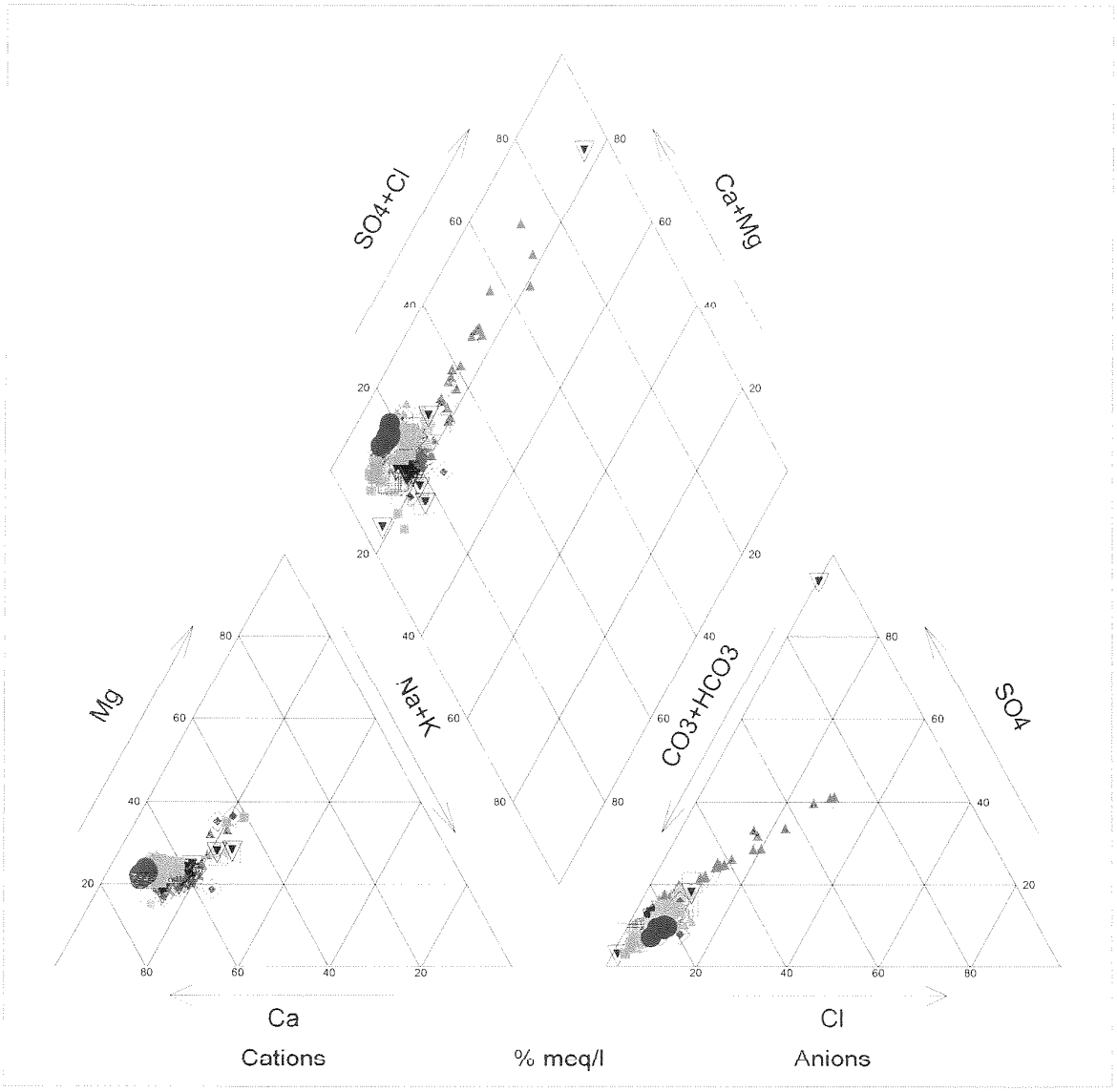
Horn Rapids Landfill: ALL



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MW01	4/13/1995	MW01	3/20/2002	MW02	5/16/2000	MW03	8/10/1998	MW04	11/21/1996	MW05	10/21/1998 - 11/16/1998	MW06	3/20/2001 - 4/10/2001	MW09	12/05/2001 - 12/18/2001
MW01	7/19/1995 - 7/21/1995	MW01	7/03/2002	MW02	8/30/2000	MW03	10/21/1998 - 11/16/1998	MW04	2/27/1997	MW05	1/19/1999 - 1/26/1999	MW06	7/25/2001	MW09	3/20/2002
MW01	10/12/1995	MW01	10/15/2002	MW02	11/08/2000 - 12/05/2000	MW03	1/19/1999 - 1/26/1999	MW04	5/20/1997	MW05	5/12/1999	MW06	9/16/2001 - 10/16/2001	MW09	7/03/2002
MW01	12/27/1995	MW01	12/17/2002 - 12/31/2002	MW02	3/20/2001 - 4/10/2001	MW03	5/12/1999	MW04	8/14/1997	MW05	10/05/1999	MW06	12/05/2001 - 12/18/2001	MW09	10/15/2002
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MW01	4/30/1996 - 5/30/1996	MW01	6/11/2003	MW02	9/16/2001 - 10/16/2001	MW03	12/21/1999 - 1/11/2000	MW04	2/24/1998	MW05	1/11/2000 - 2/08/2000	MW06	7/03/2002	MW09	3/26/2003
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MW01	2/27/1997	MW02	12/27/1995	MW02	12/17/2002 - 12/31/2002	MW03	3/20/2001 - 4/10/2001	MW04	5/12/1999	MW05	7/25/2001	MW07	3/20/2001 - 4/10/2001	MW10	12/05/2001 - 12/18/2001
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MW01	2/24/1998	MW02	7/31/1996 - 8/15/1996	MW03	4/13/1995	MW03	3/20/2002	MW04	5/16/2000	MW05	7/03/2002	MW07	7/03/2002	MW10	12/17/2002 - 12/31/2002
MW01	5/18/1998	MW02	8/15/1996 - 9/12/1996	MW03	7/19/1995 - 7/21/1995	MW03	7/03/2002	MW04	8/30/2000	MW05	10/15/2002	MW07	3/26/2003	MW10	3/26/2003
MW01	8/10/1998	MW02	11/21/1996	MW03	10/12/1995	MW03	10/15/2002	MW04	11/08/2000 - 12/05/2000	MW05	12/17/2002 - 12/31/2002	MW07	6/11/2003	MW10	6/11/2003
MW01	10/21/1998 - 11/16/1998	MW02	2/27/1997	MW03	12/27/1995	MW03	12/17/2002 - 12/31/2002	MW04	3/20/2001 - 4/10/2001	MW05	3/26/2003	MW08	3/20/2001 - 4/10/2001		
MW01	1/19/1999 - 1/26/1999	MW02	5/20/1997	MW03	2/29/1996 - 3/13/1996	MW03	3/26/2003	MW04	7/25/2001	MW05	6/11/2003	MW08	7/25/2001		
MW01	5/12/1999	MW02	8/14/1997	MW03	4/30/1996 - 5/30/1996	MW03	6/11/2003	MW04	9/16/2001 - 10/16/2001	MW06	5/18/1998	MW08	9/16/2001 - 10/16/2001		
MW01	10/05/1999	MW02	12/10/1997	MW03	5/30/1996 - 6/27/1996	MW04	2/22/1995 - 3/01/1995	MW04	12/05/2001 - 12/18/2001	MW06	6/19/1998 - 7/07/1998	MW08	12/05/2001 - 12/18/2001		
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MW01	9/16/2001 - 10/16/2001	MW02	12/21/1999 - 1/11/2000	MW03	2/24/1998	MW04	7/31/1996 - 8/15/1996	MW05	6/19/1998 - 7/07/1998	MW06	8/30/2000	MW09	7/25/2001		

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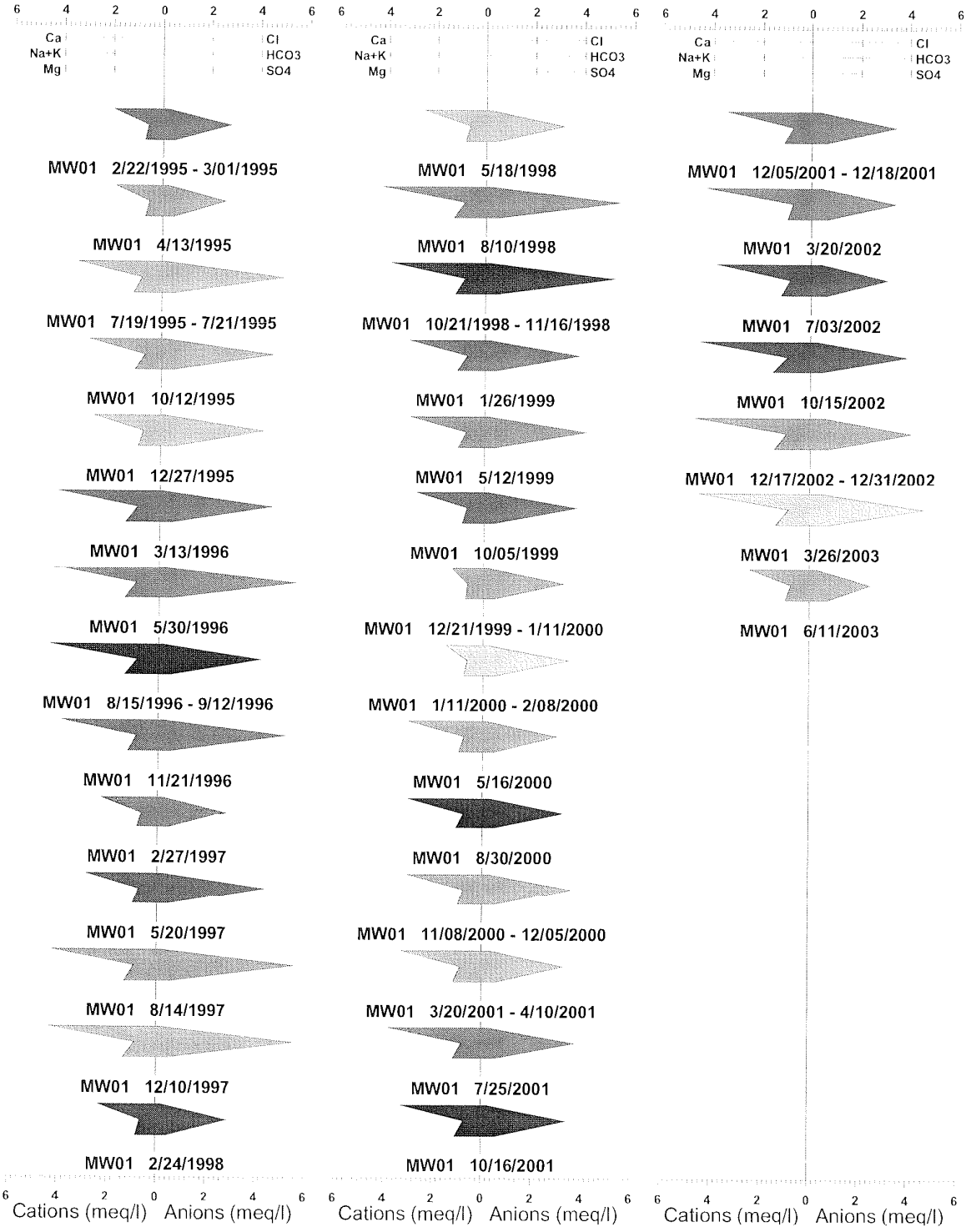
Stiff Diagrams

Horn Rapids Landfill



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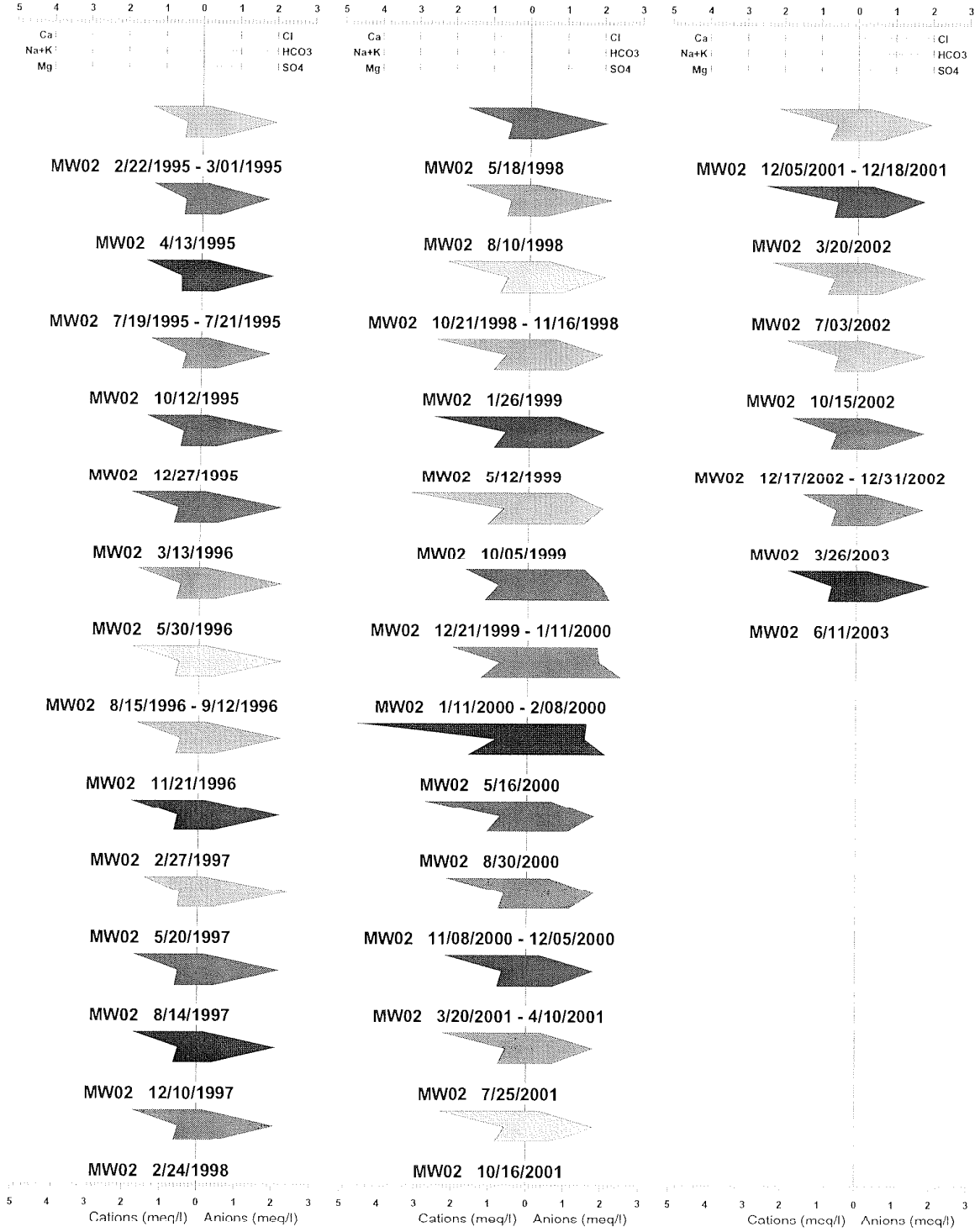
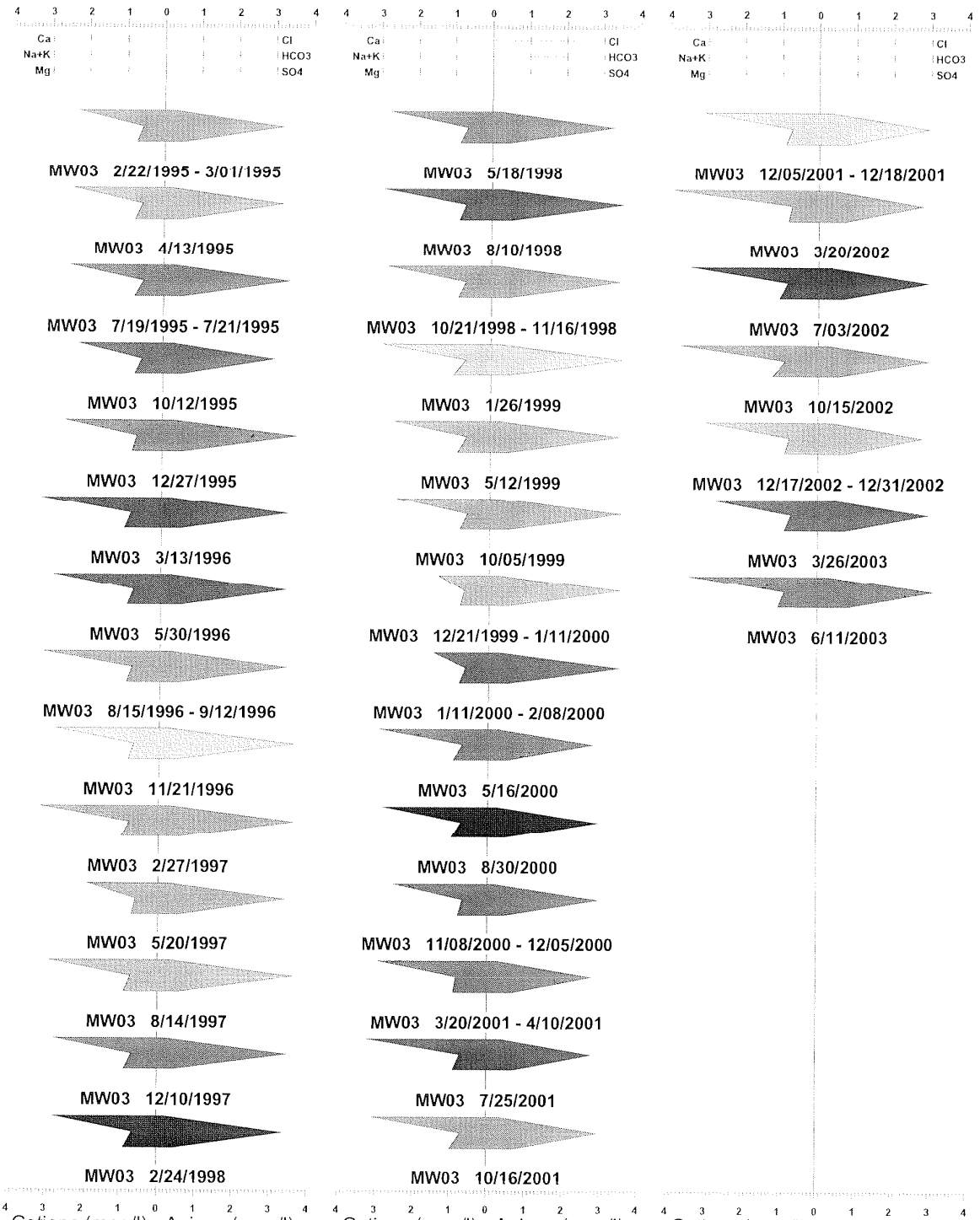
Prepared by: EMCON / OWT,Inc.

Horn Rapids Landfill



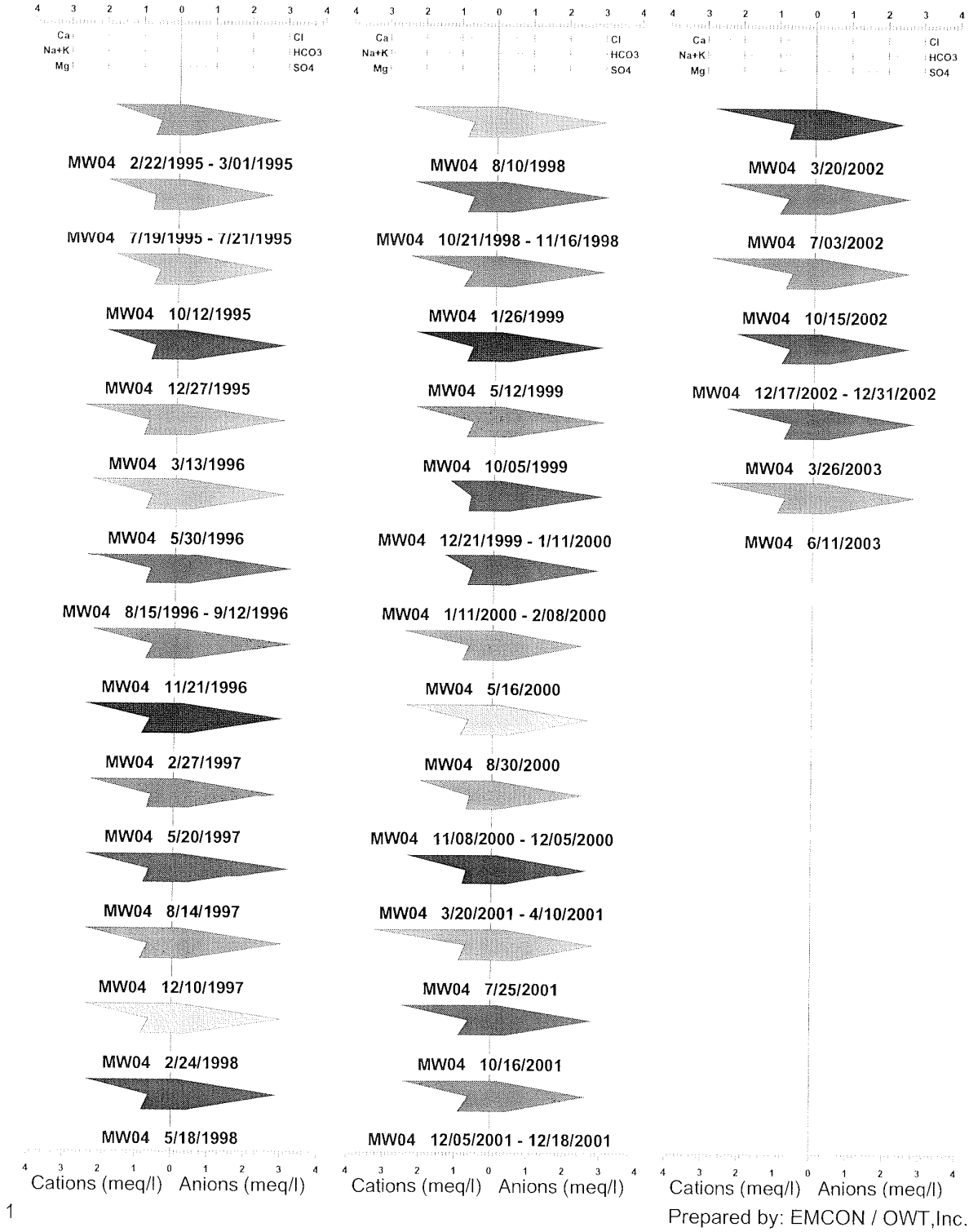
Prepared by: EMCON / OWT,Inc.

Horn Rapids Landfill



Prepared by: EMCON / OWT,Inc.

Horn Rapids Landfill



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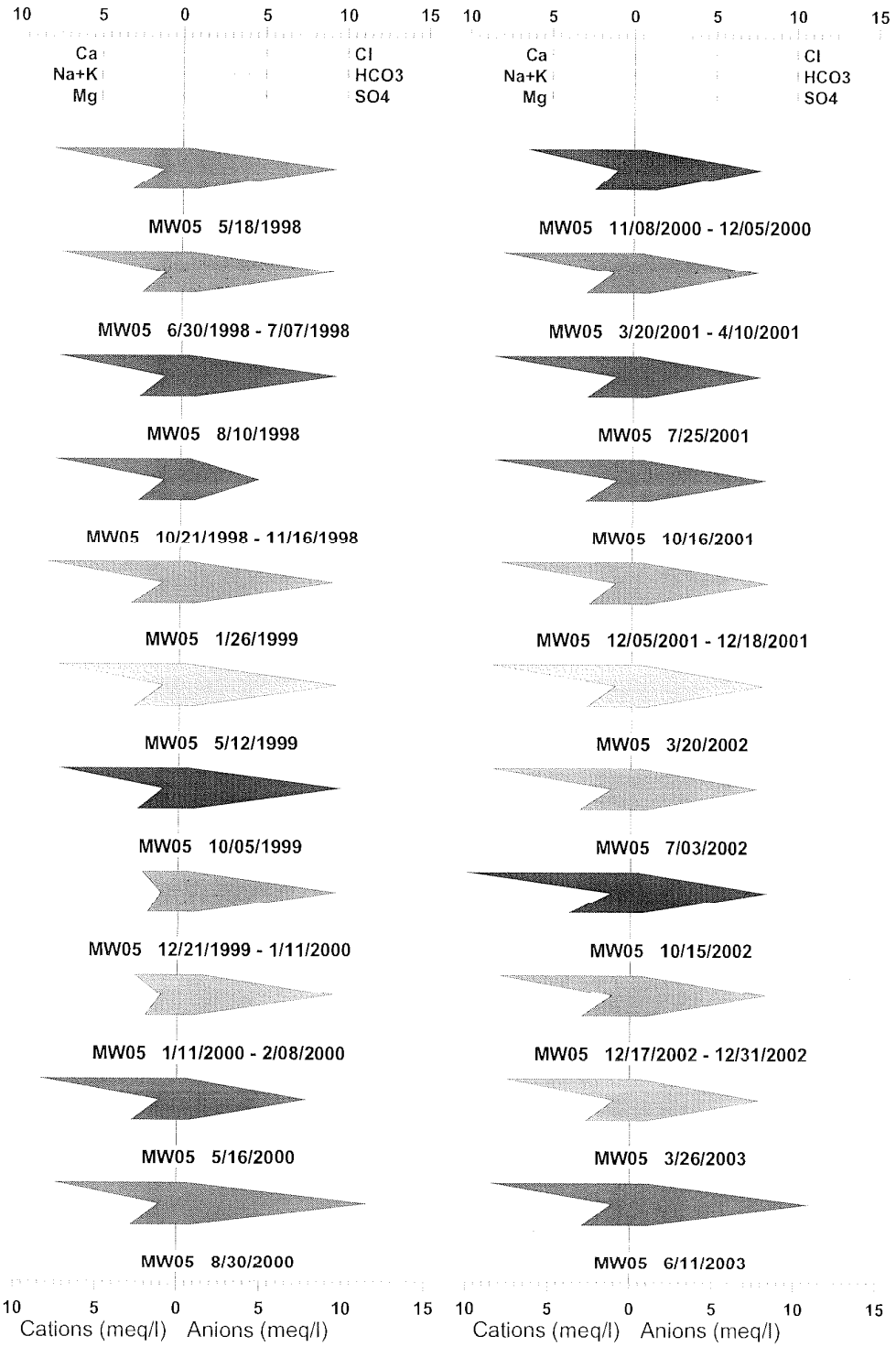
Prepared by: EMCON / OWT,Inc.

Horn Rapids Landfill



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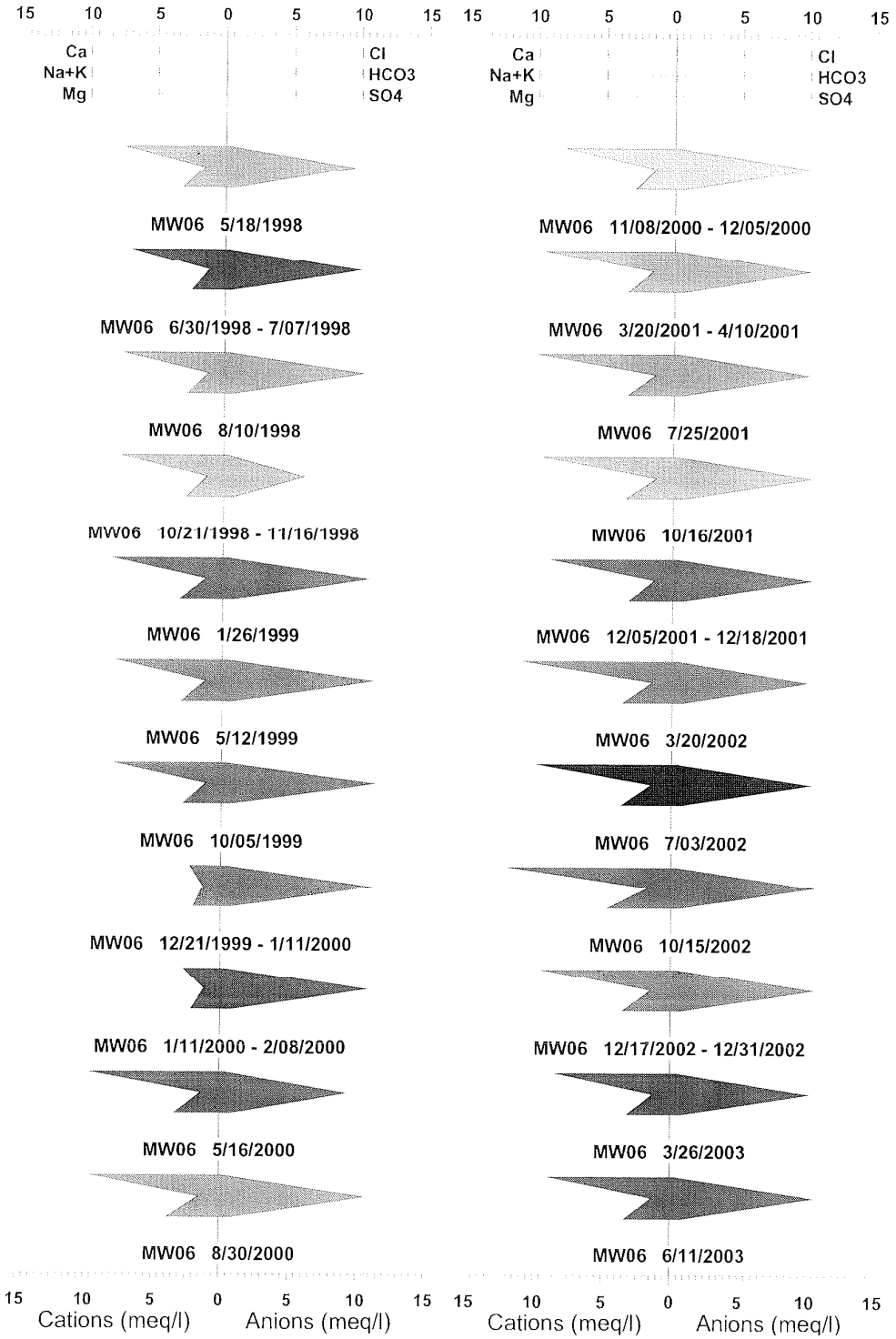
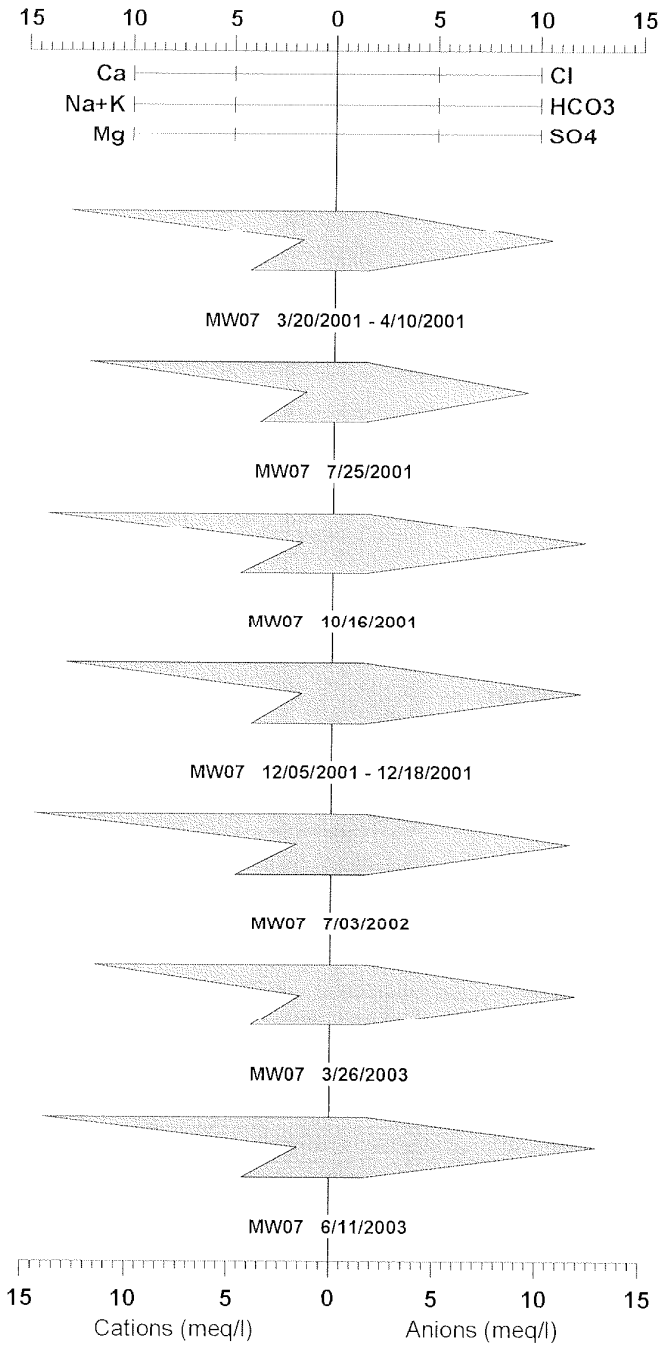
Prepared by: EMCON / OWT, Inc.

Horn Rapids Landfill



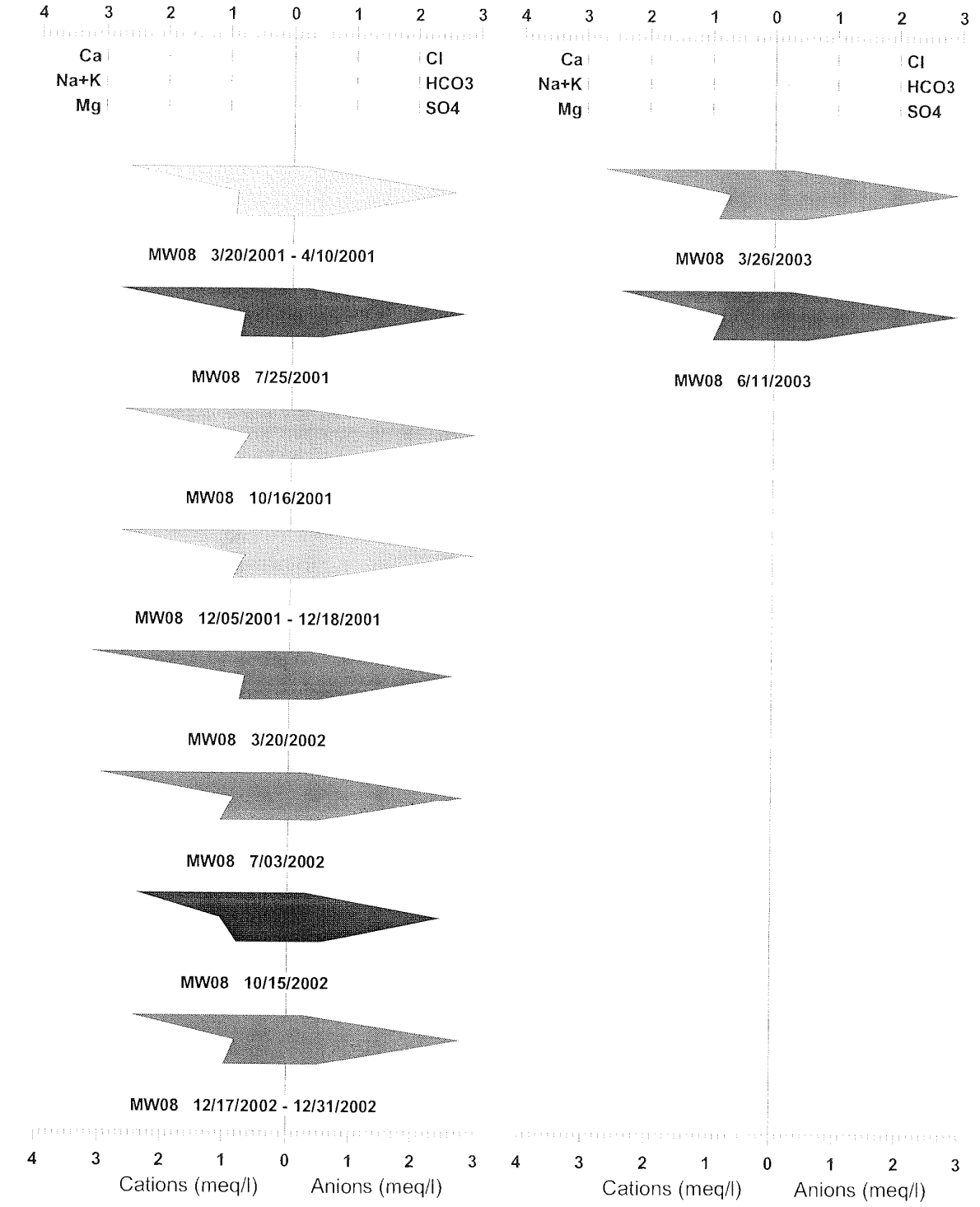
Prepared by: EMCON / OWT,Inc.

Horn Rapids Landfill



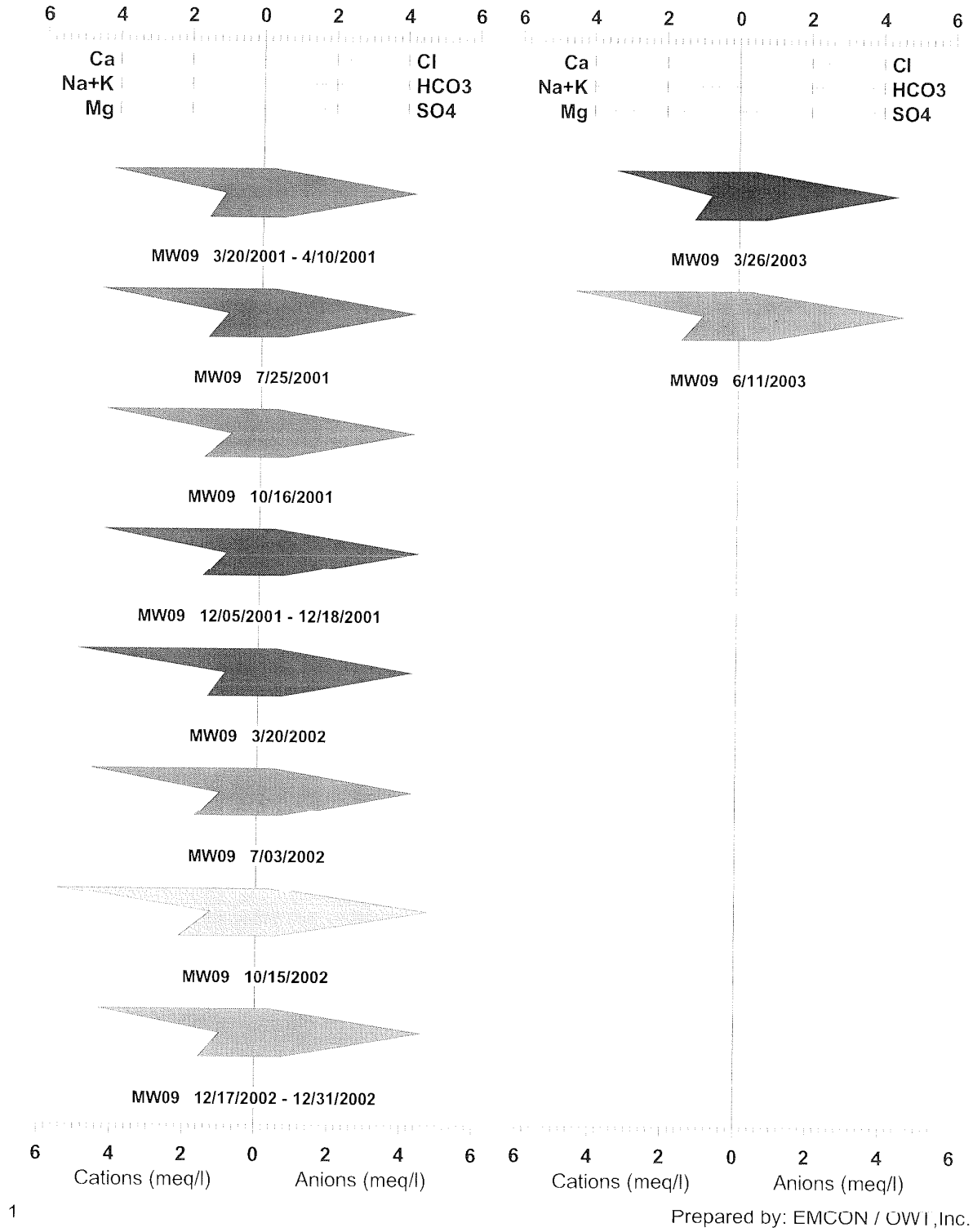
Prepared by: EMCON / OWT, Inc.

Horn Rapids Landfill



Prepared by: EMCON / OWT,Inc.

Horn Rapids Landfill



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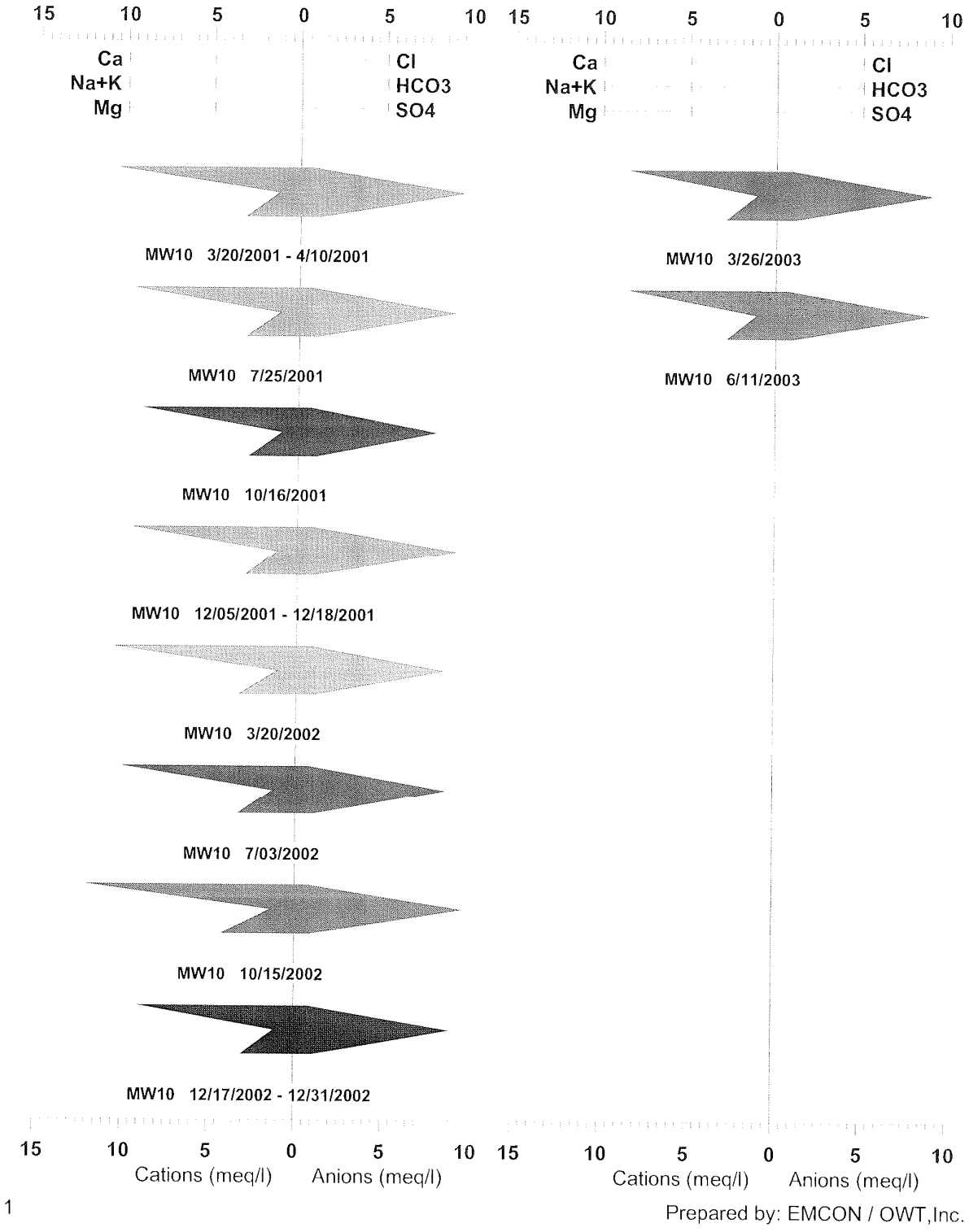
Prepared by: EMCON / OWT, Inc.

Horn Rapids Landfill



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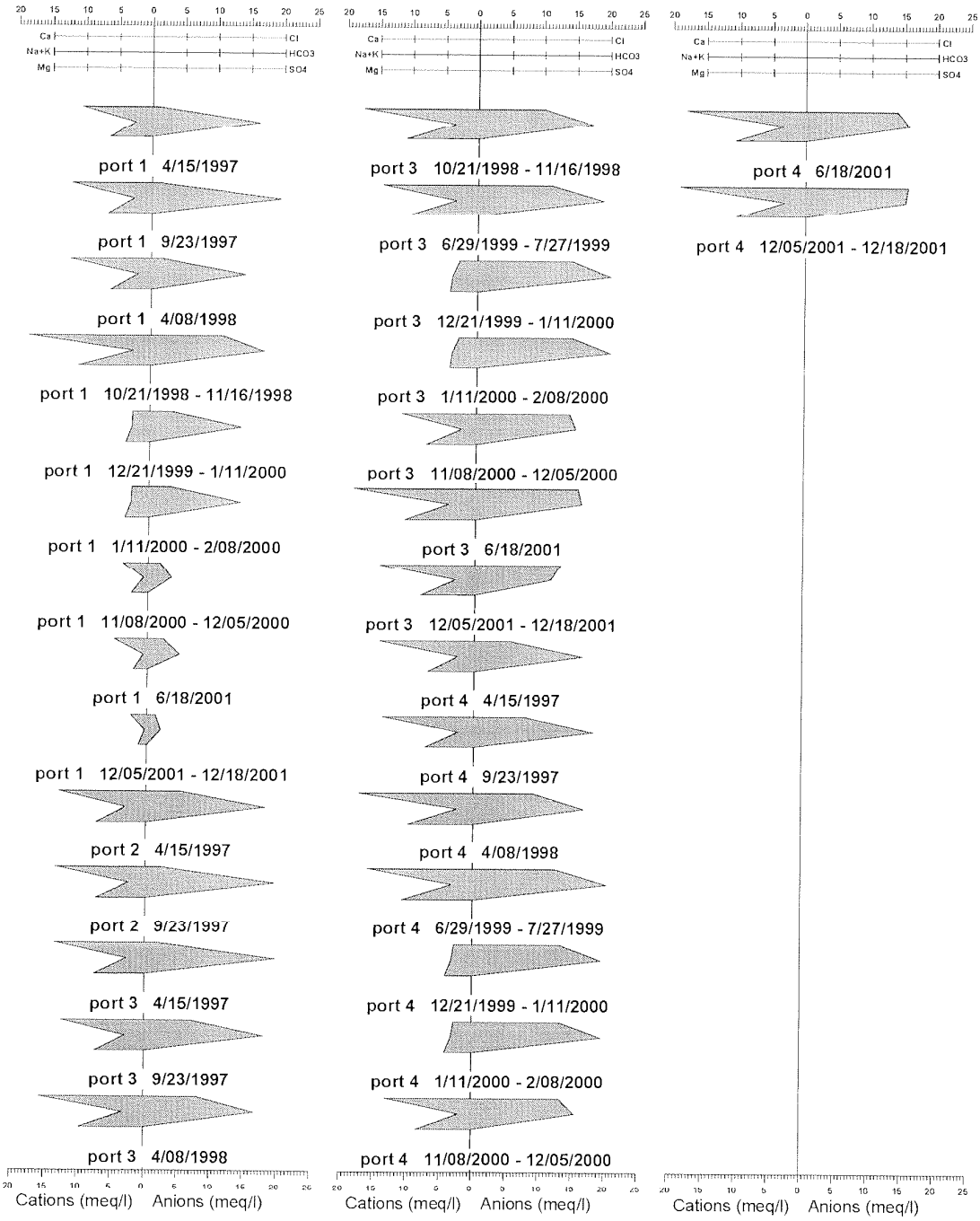
Prepared by: EMCON / OWT,Inc.

Horn Rapids Landfill



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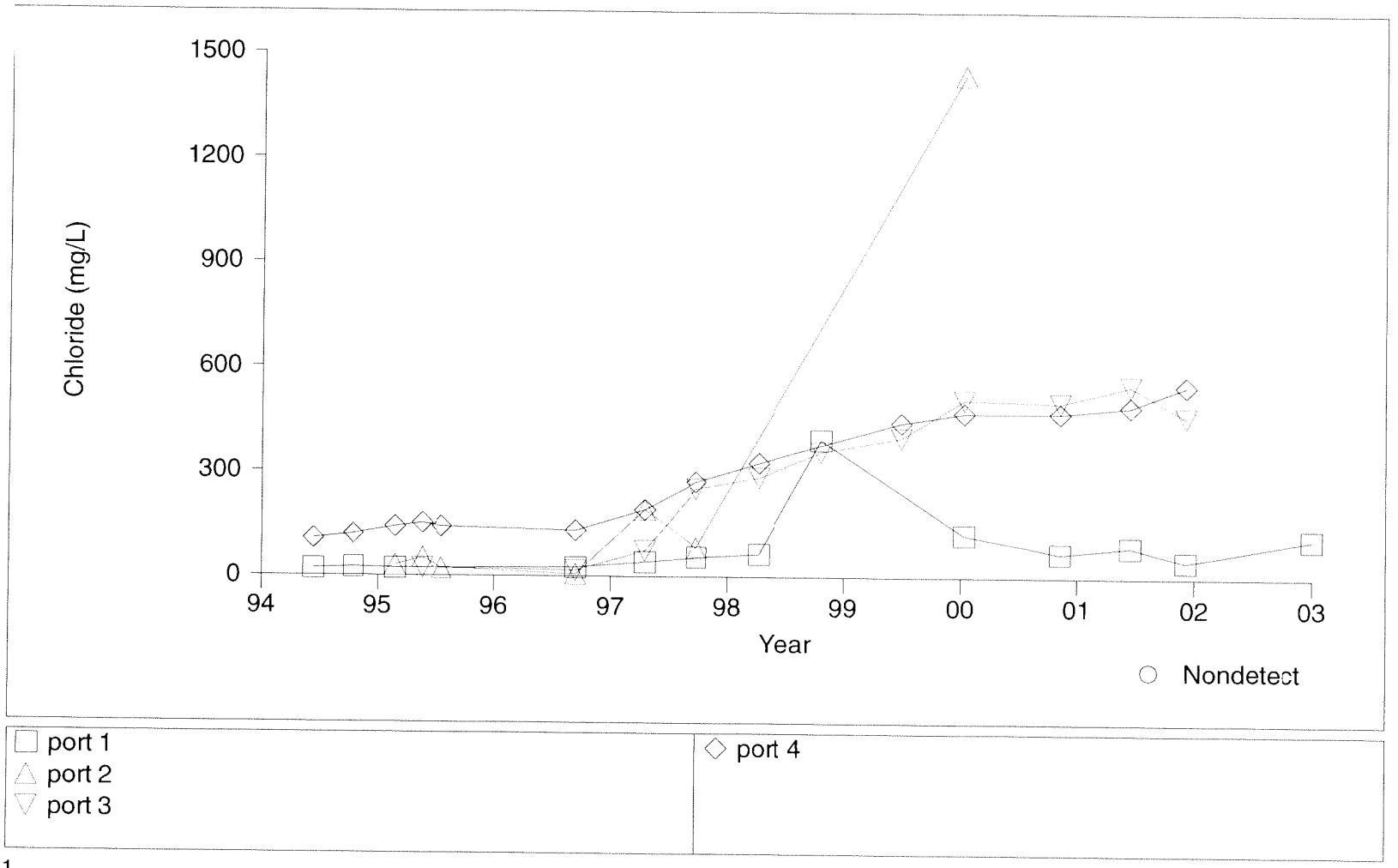
APPENDIX E
TIME-CONCENTRATION DIAGRAMS FOR SITE GROUNDWATER AND LYSIMETER LIQUID SAMPLES

Horn Rapids Landfill

Time Series Plot for Chloride



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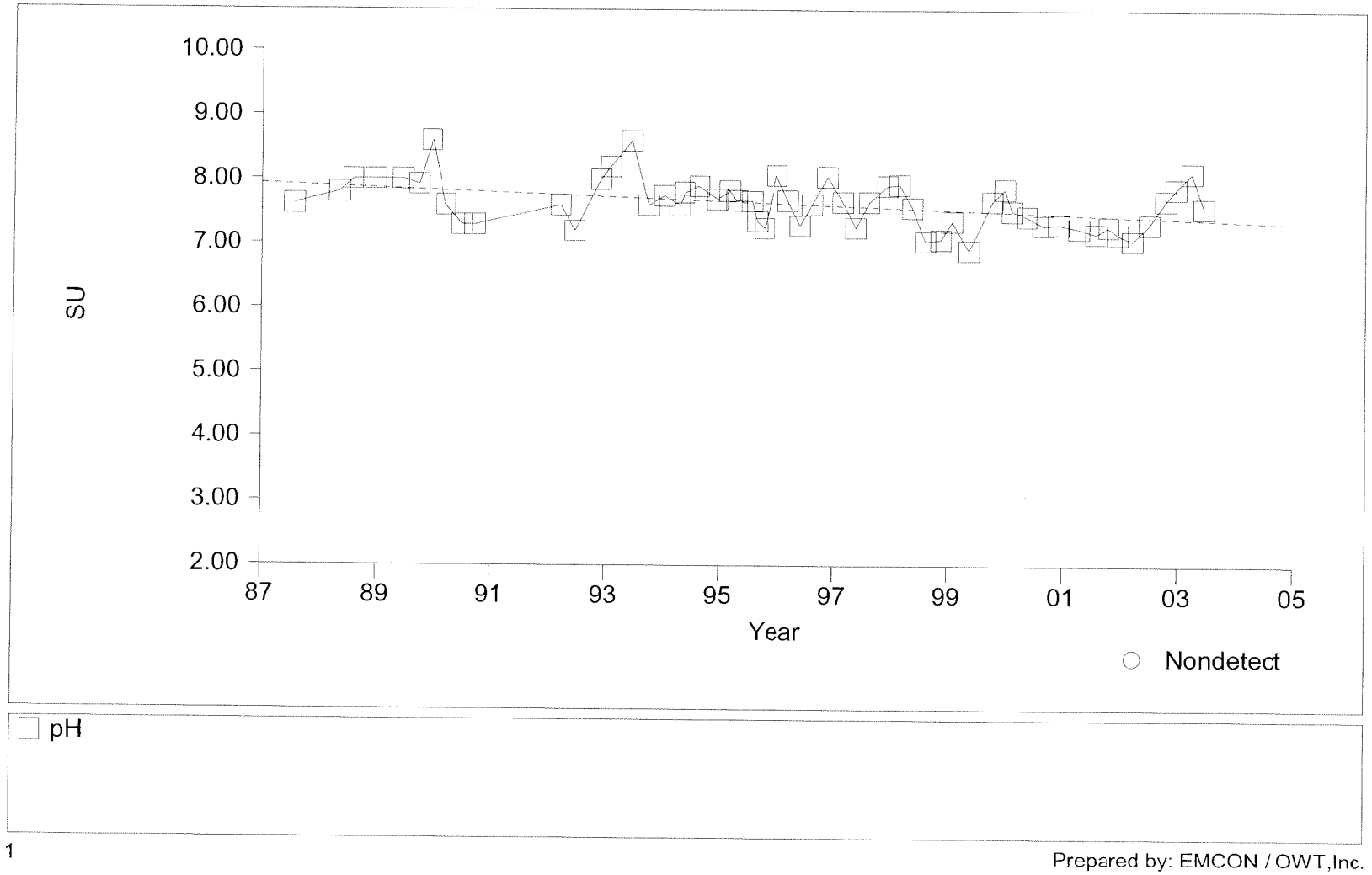
Horn Rapids Landfill

Time Series Plot for MW02



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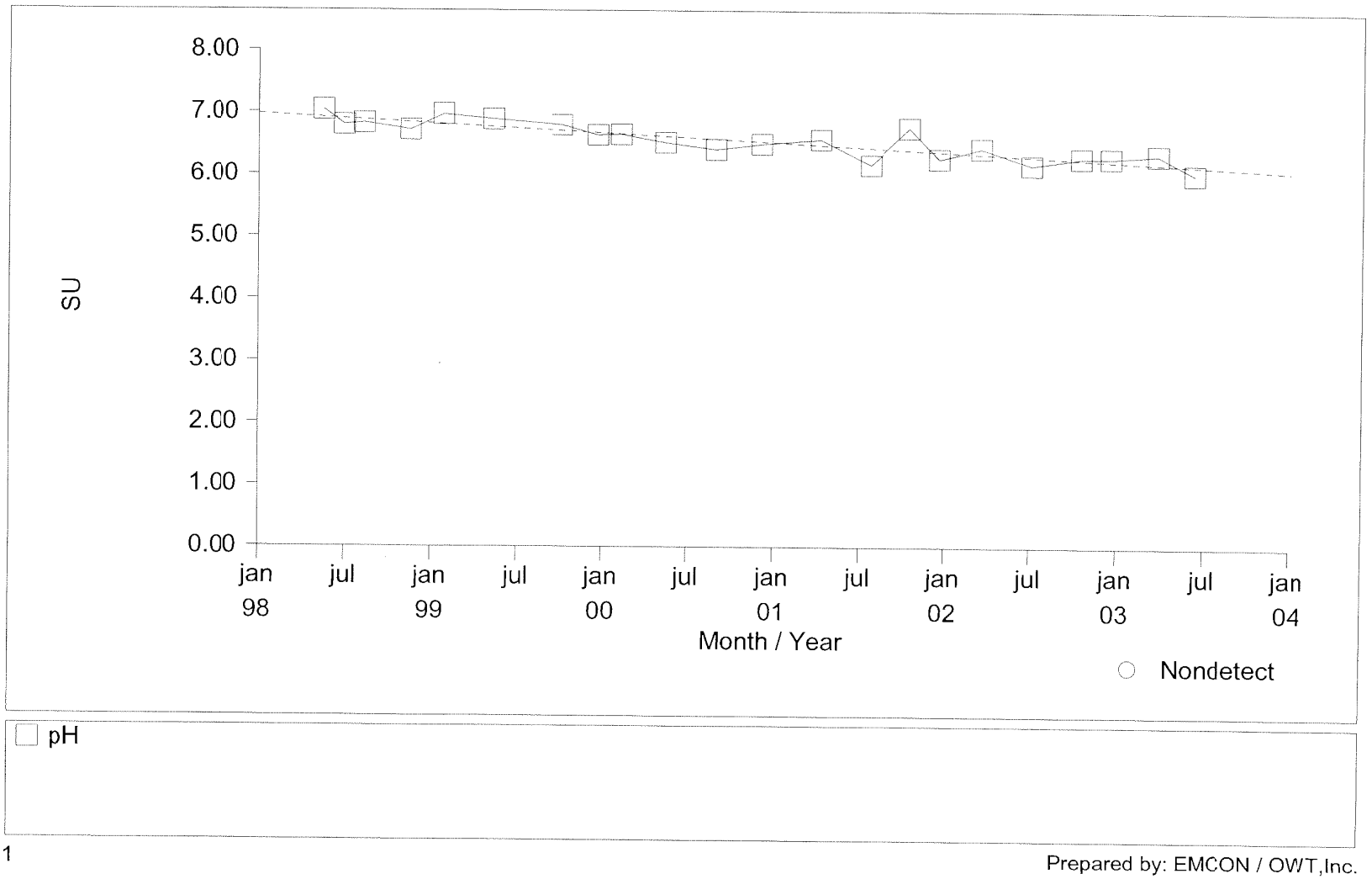
Prepared by: EMCON / OWT,Inc.

Horn Rapids Landfill

Time Series Plot for MW05



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Prepared by: EMCON / OWT,Inc.

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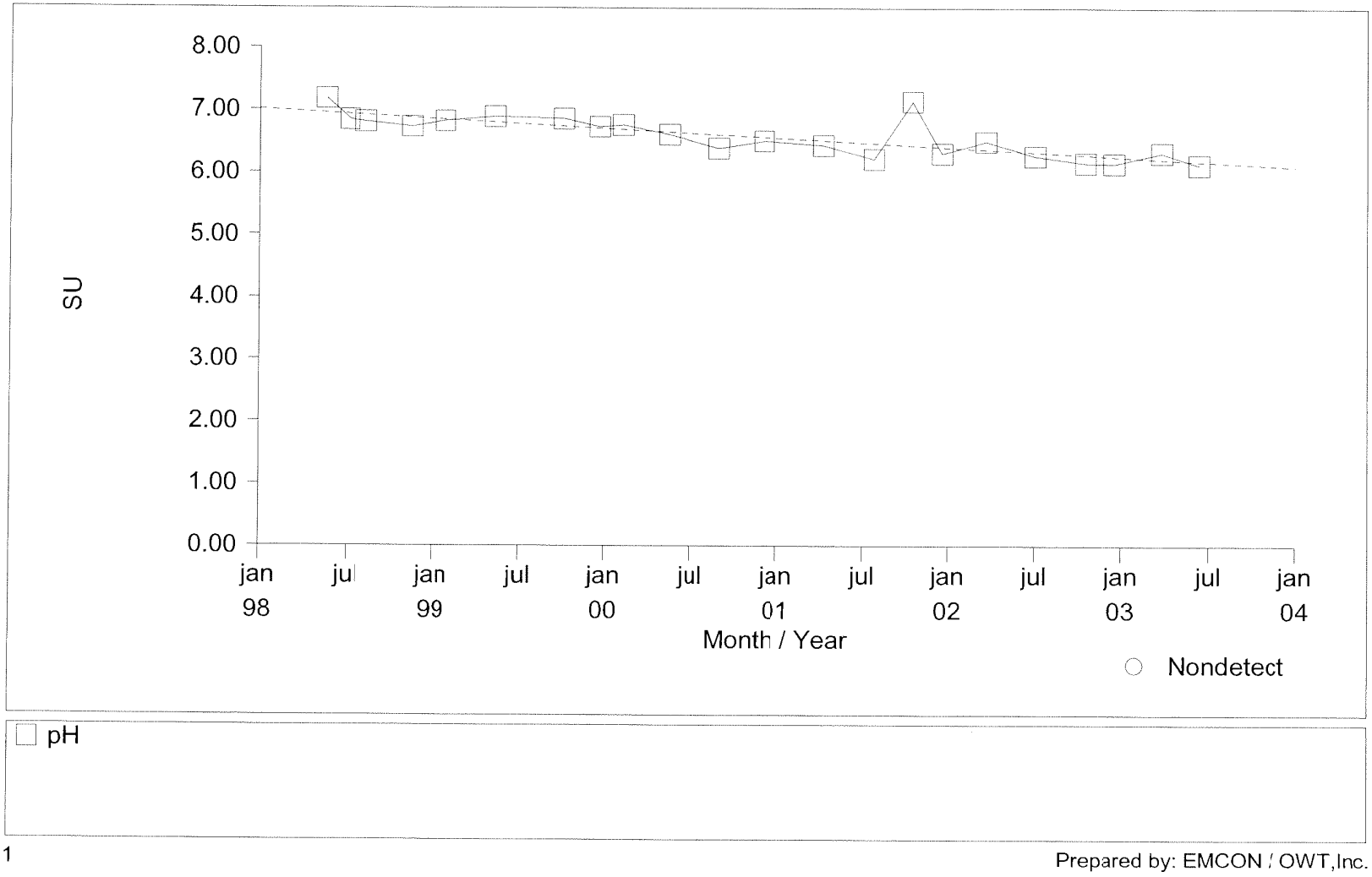
Horn Rapids Landfill

Time Series Plot for MW06



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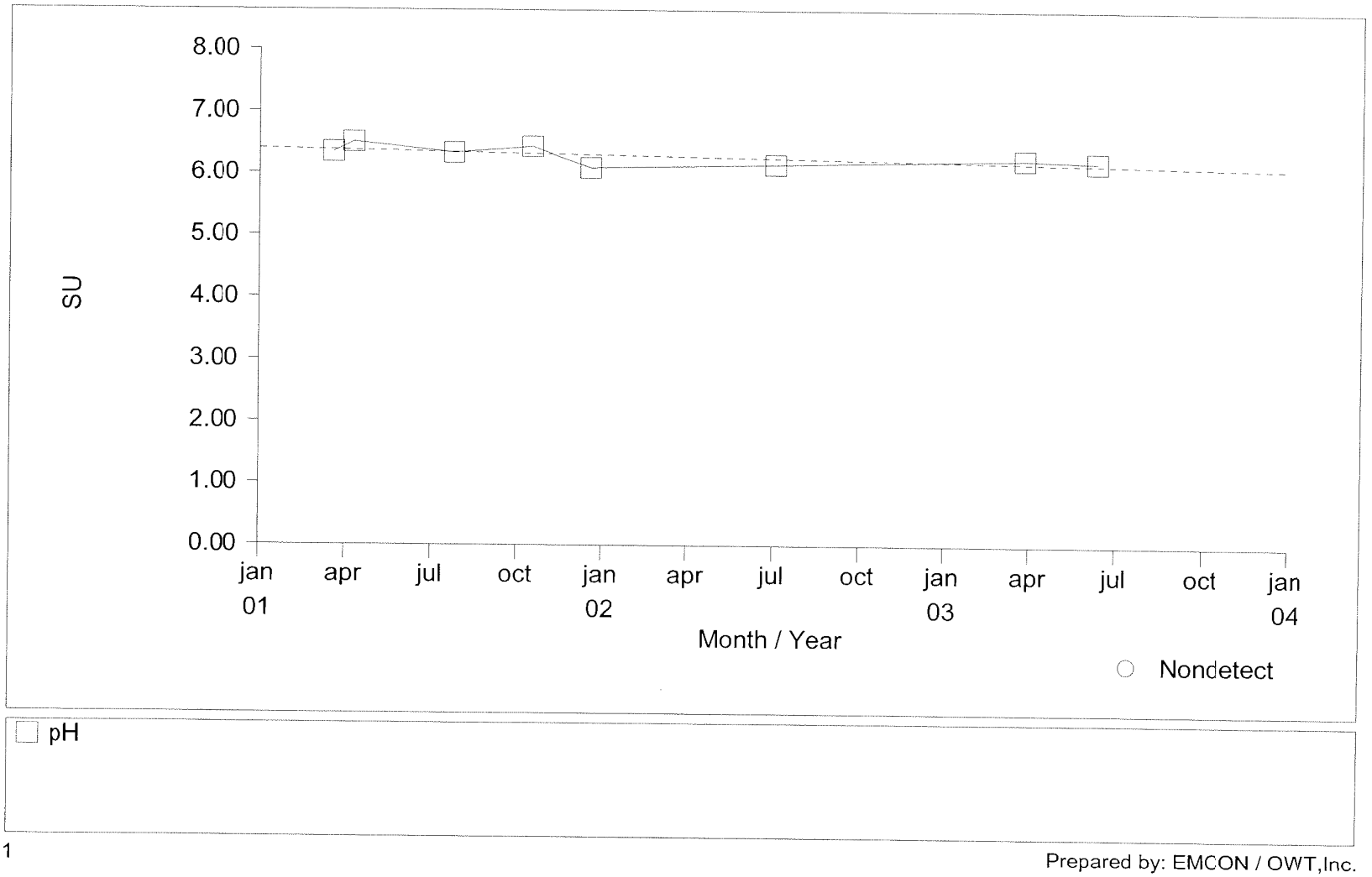
Horn Rapids Landfill

Time Series Plot for MW07



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Prepared by: EMCON / OWT,Inc.

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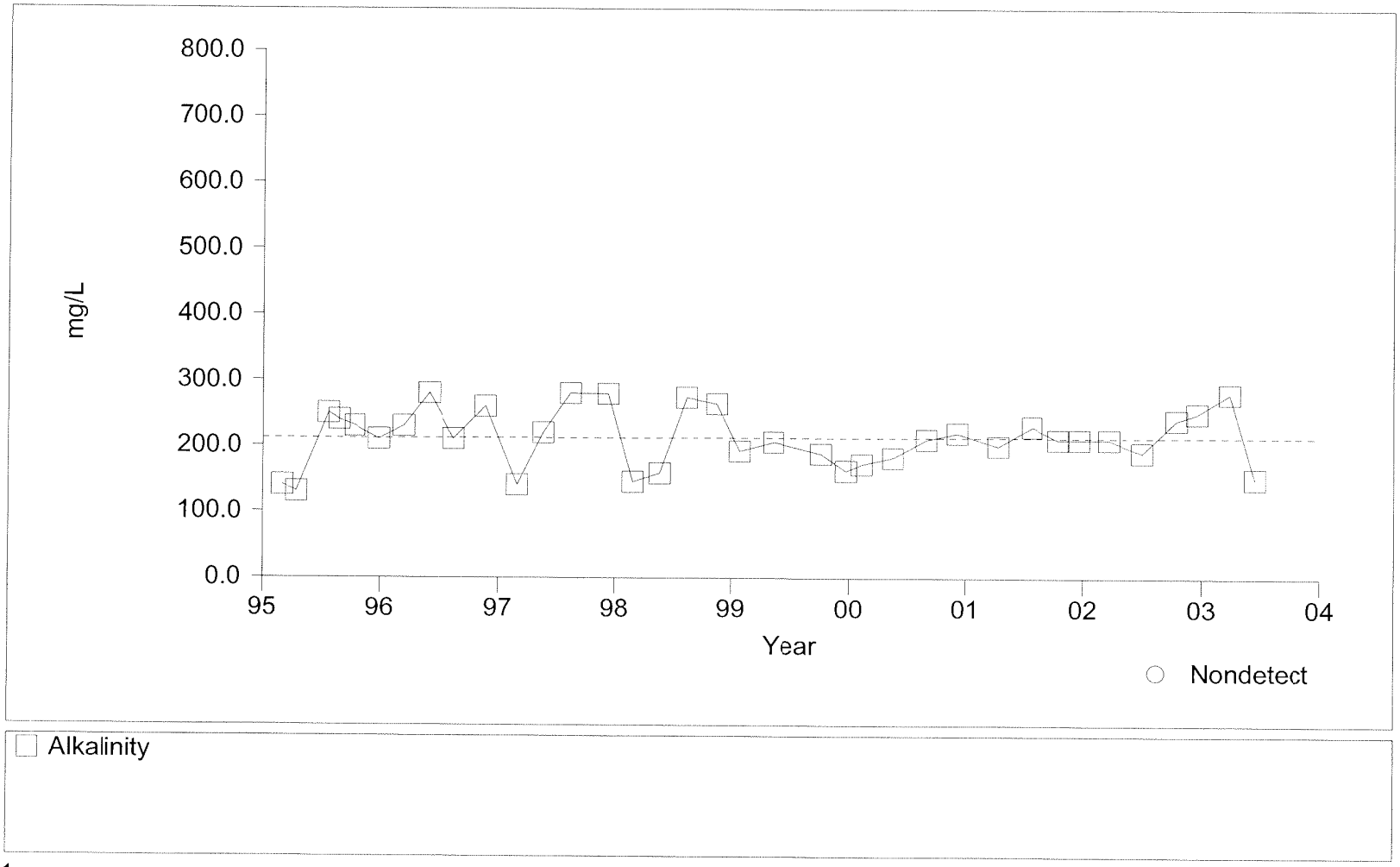
Horn Rapids Landfill

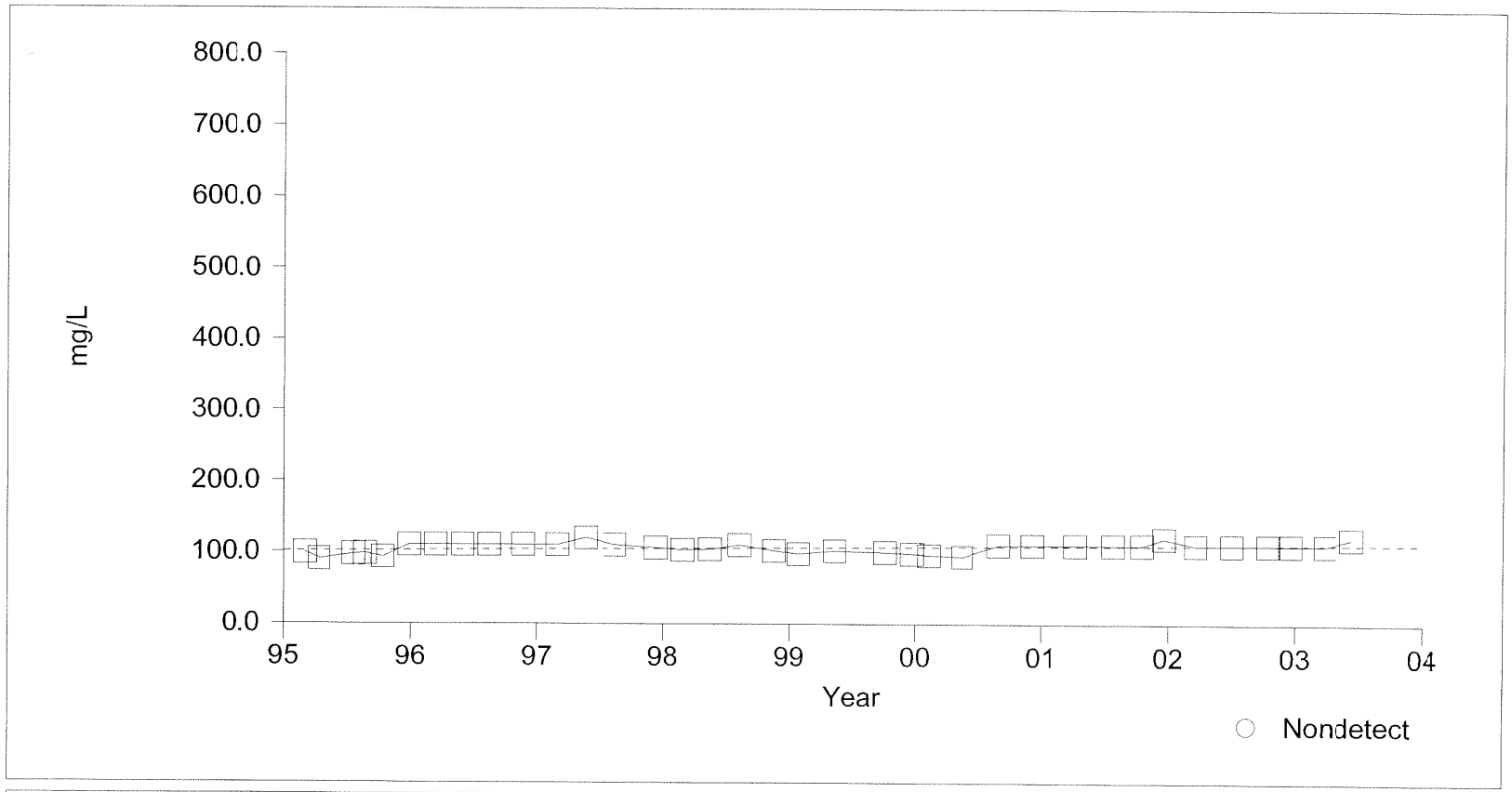
Time Series Plot for MW01



Prepared by: EMCON / OWT,Inc.

Horn Rapids Landfill

Time Series Plot for MW02

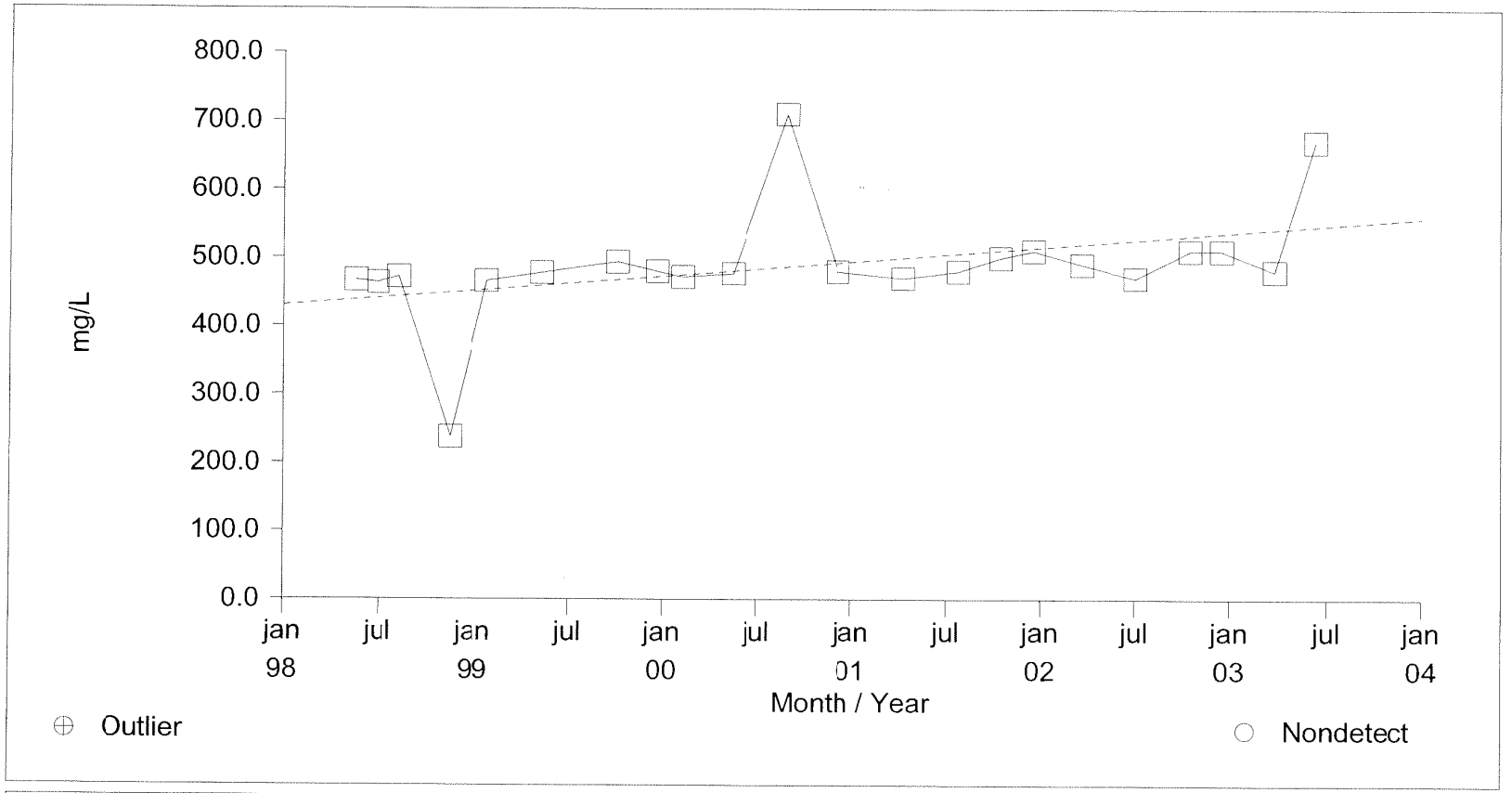


DOC.max

Prepared by: EMCON / OWT,Inc.

Horn Rapids Landfill

Time Series Plot for MW05



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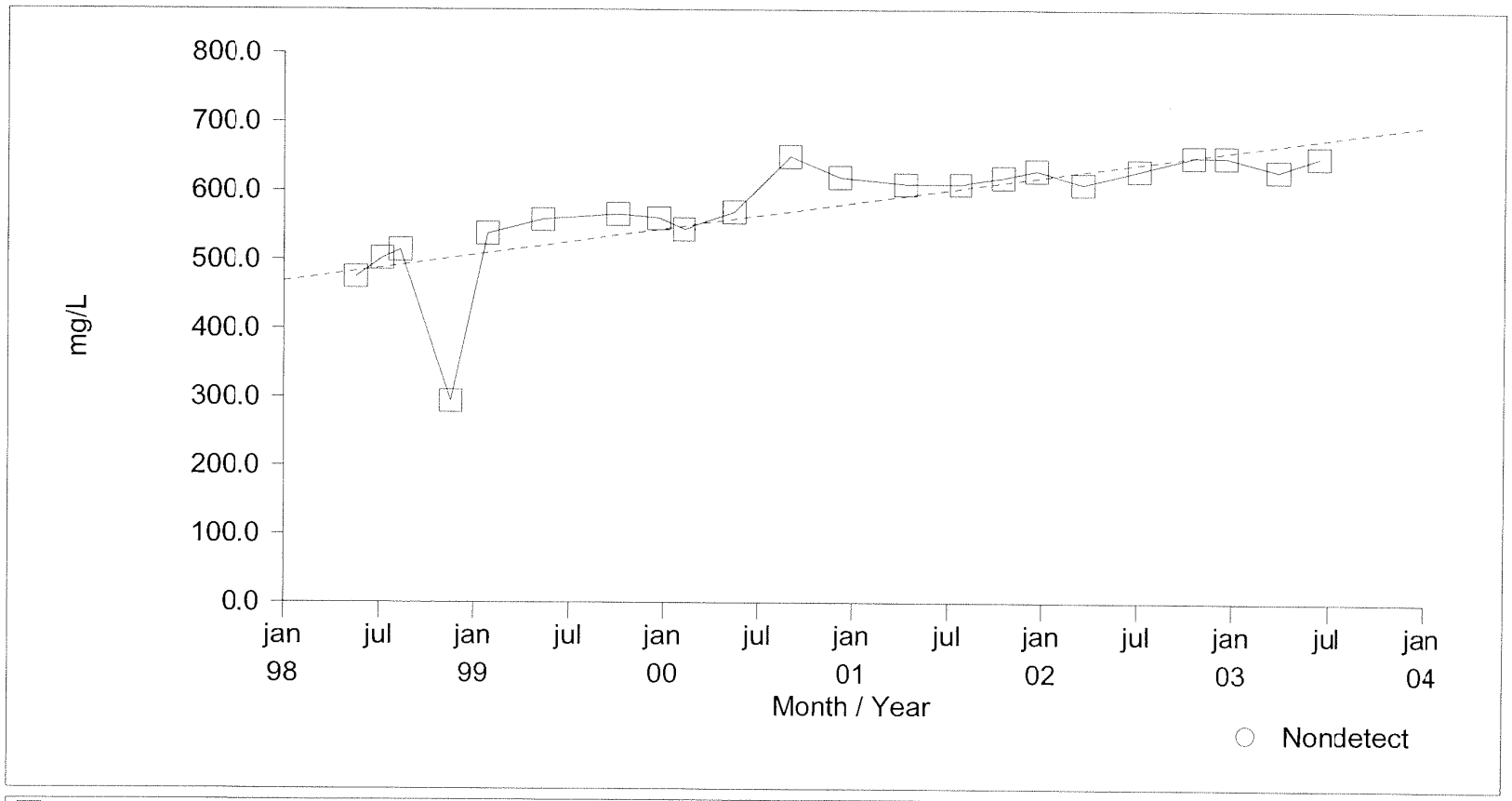
Prepared by: EMCON / OWT, Inc.

Horn Rapids Landfill

Time Series Plot for MW06



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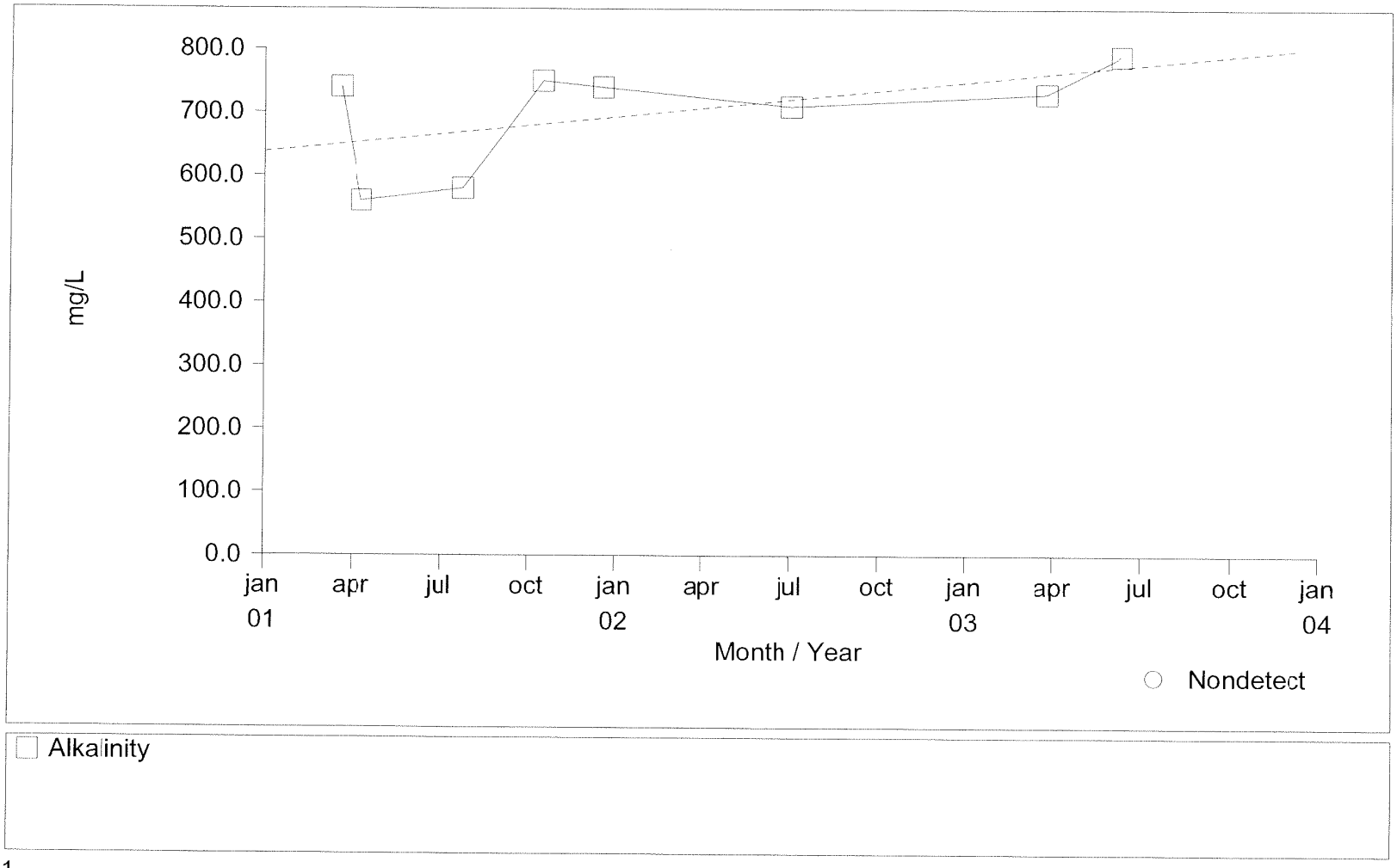
Prepared by: EMCON / OWT,Inc.

Horn Rapids Landfill

Time Series Plot for MW07



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Prepared by: EMCON / OWT,Irc.

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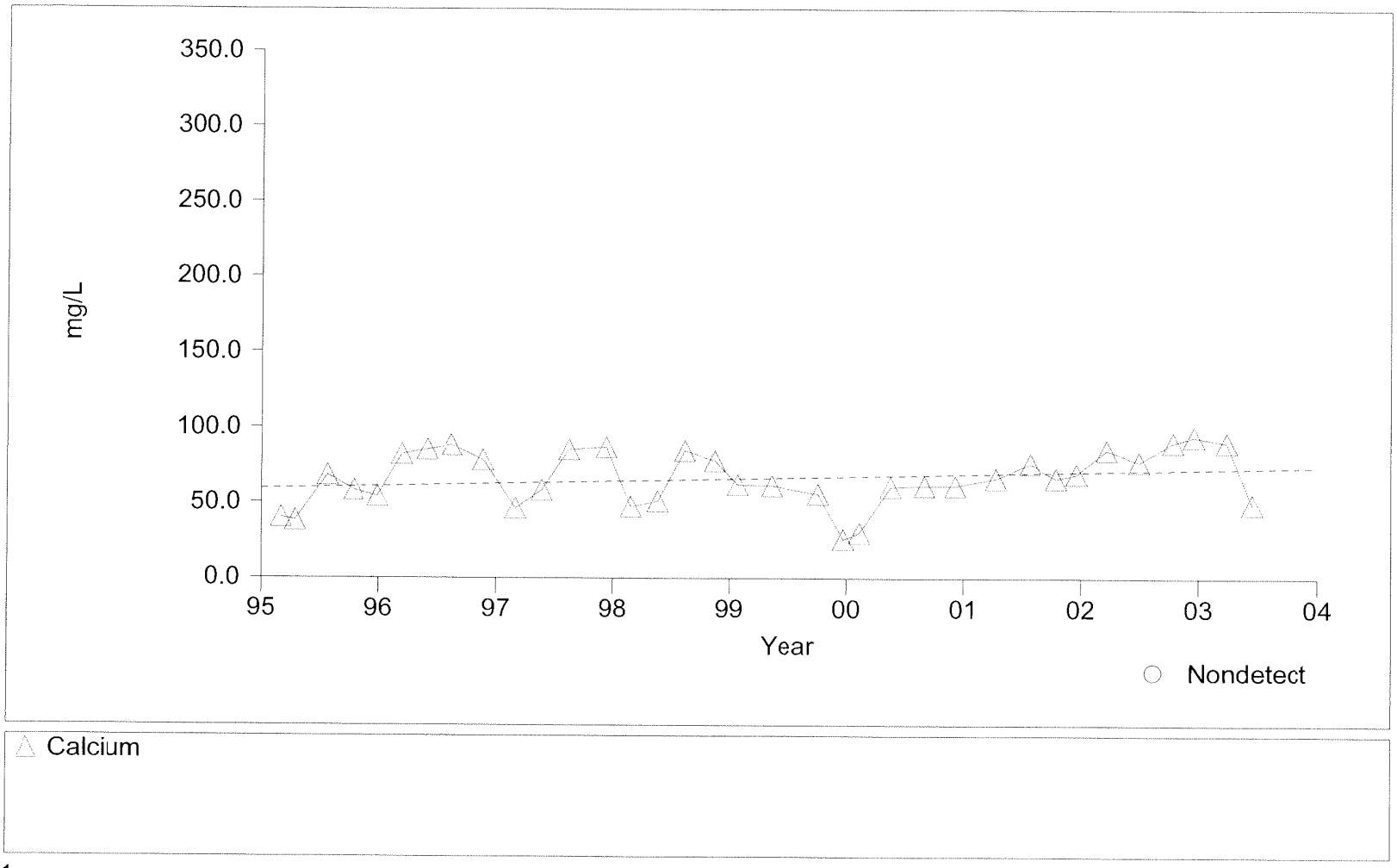
Horn Rapids Landfill

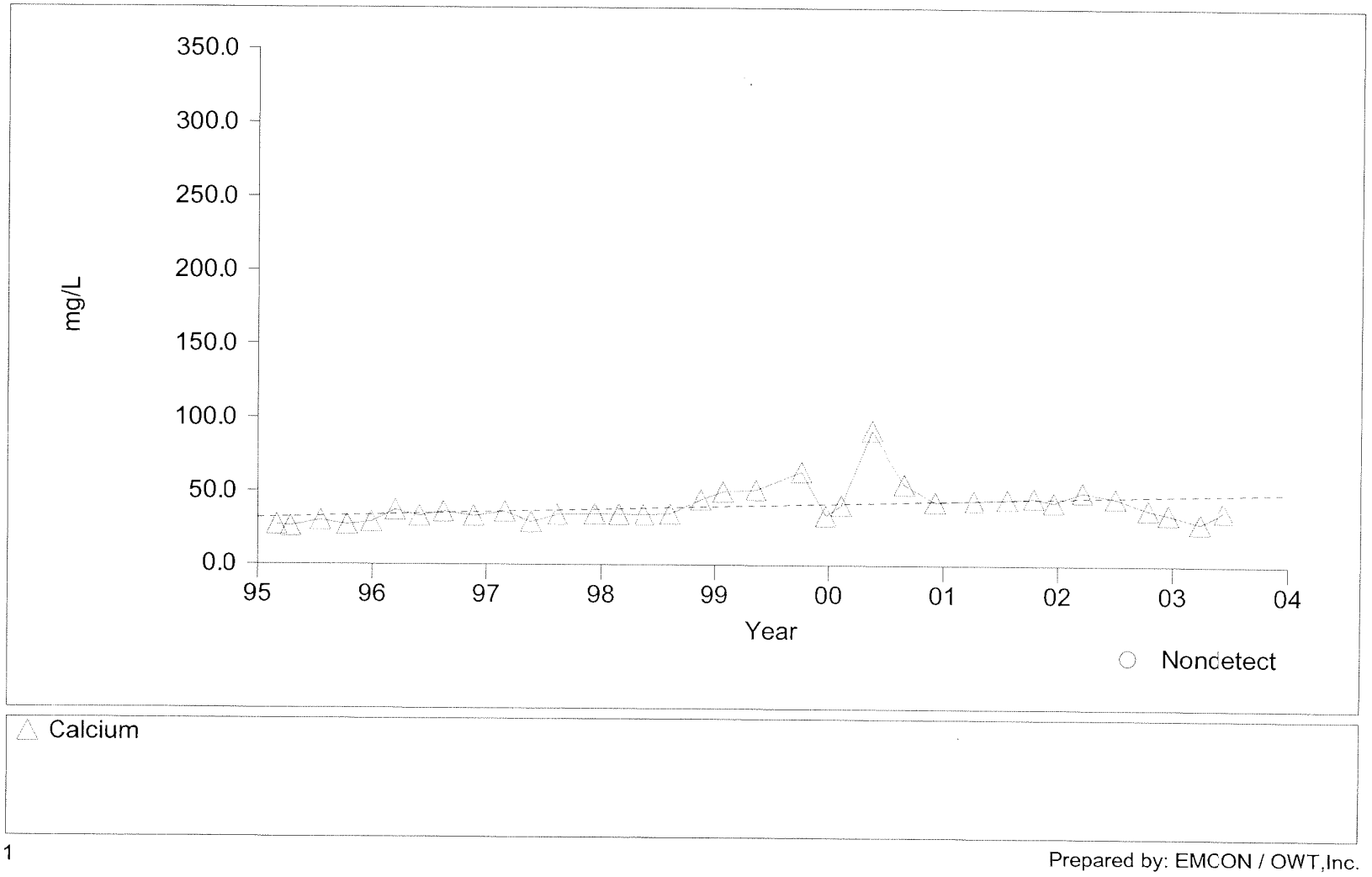
Time Series Plot for MW01



Prepared by: EMCON / OWT, Inc.

Horn Rapids Landfill

Time Series Plot for MW02



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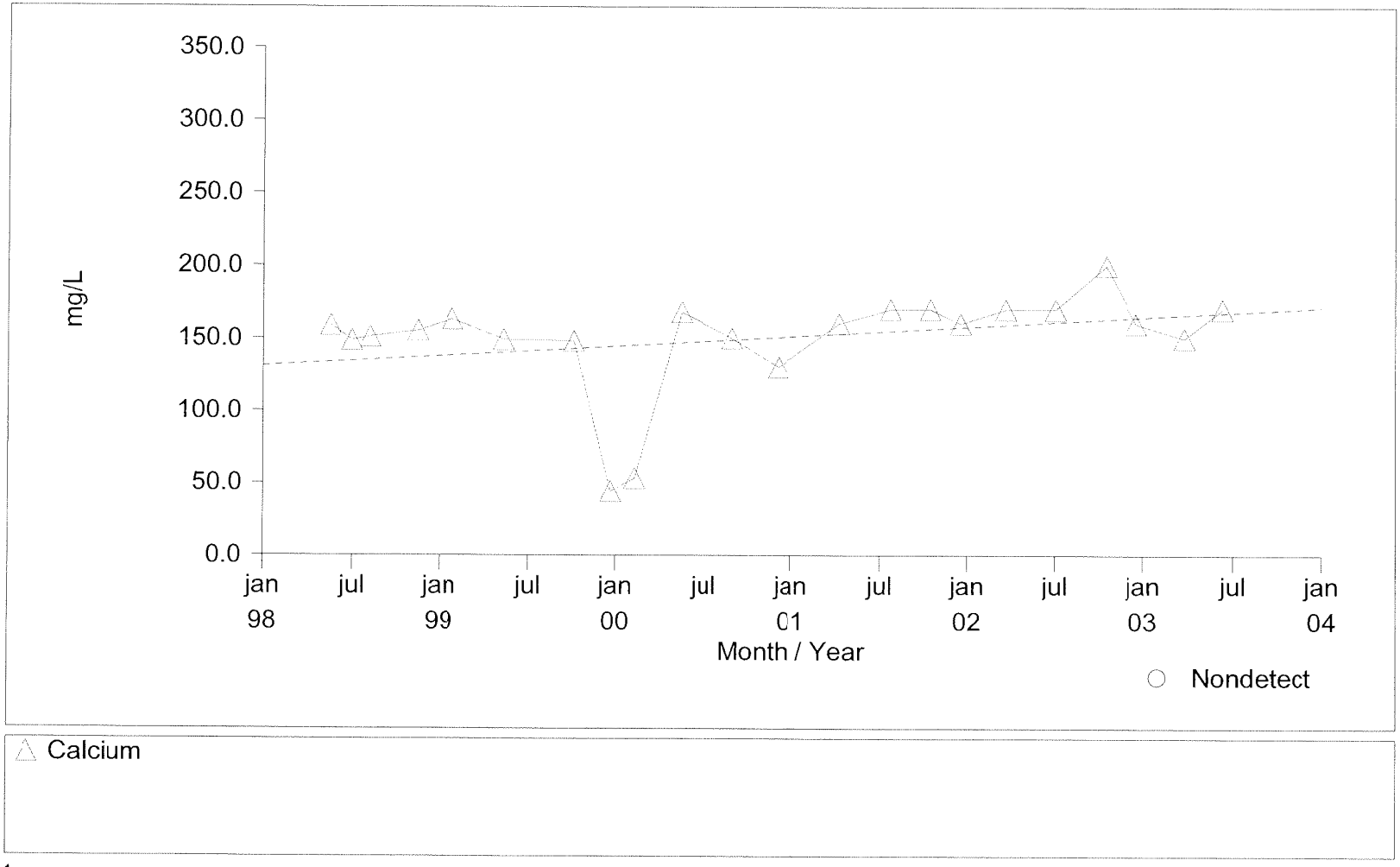
Prepared by: EMCON / OWT,Inc.

DOC.max

Horn Rapids Landfill

Time Series Plot for MW05



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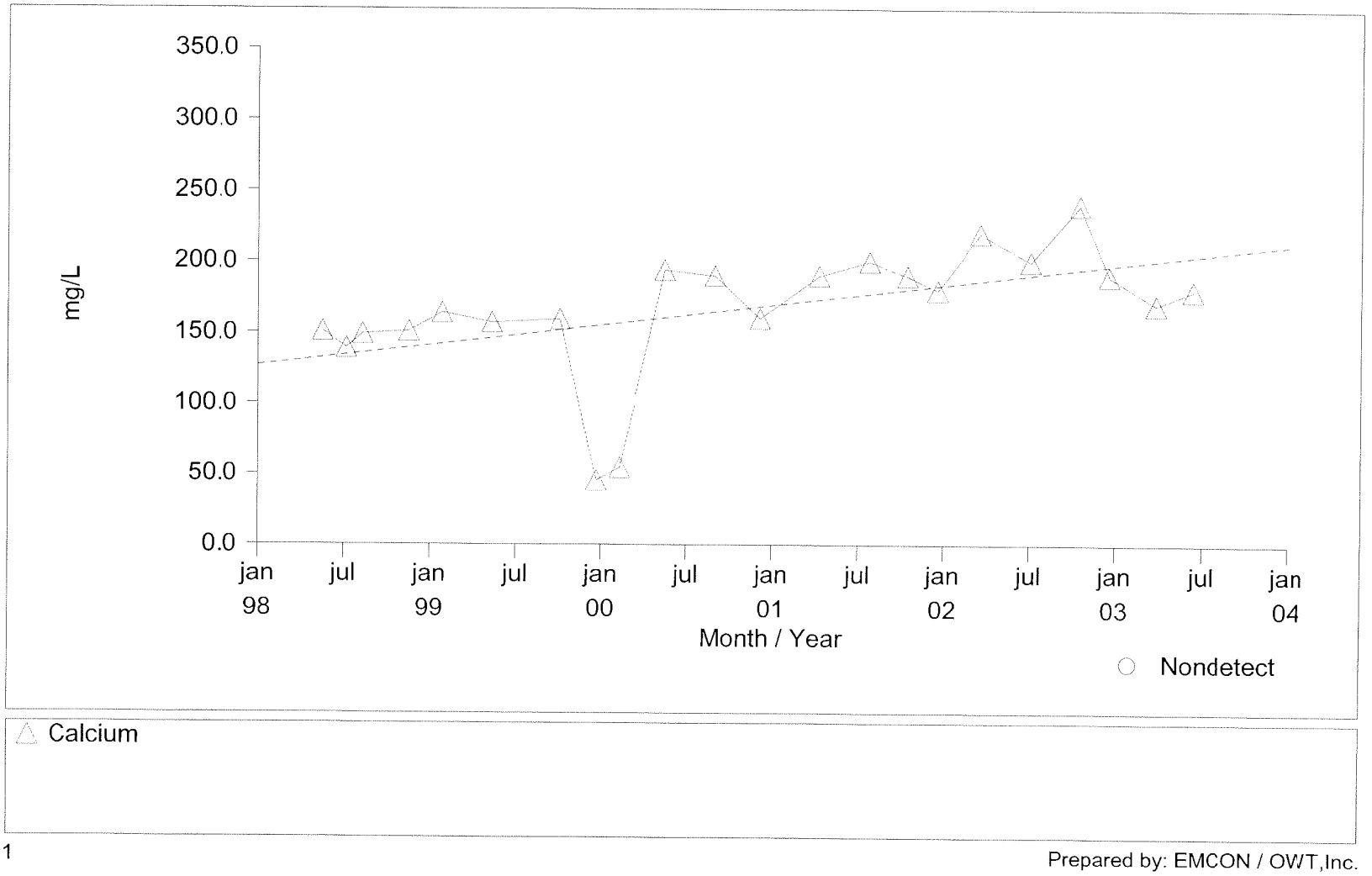
Prepared by: EMCON / OWT, Inc.

Horn Rapids Landfill

Time Series Plot for MW06



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Prepared by: EMCON / OWT,Inc.

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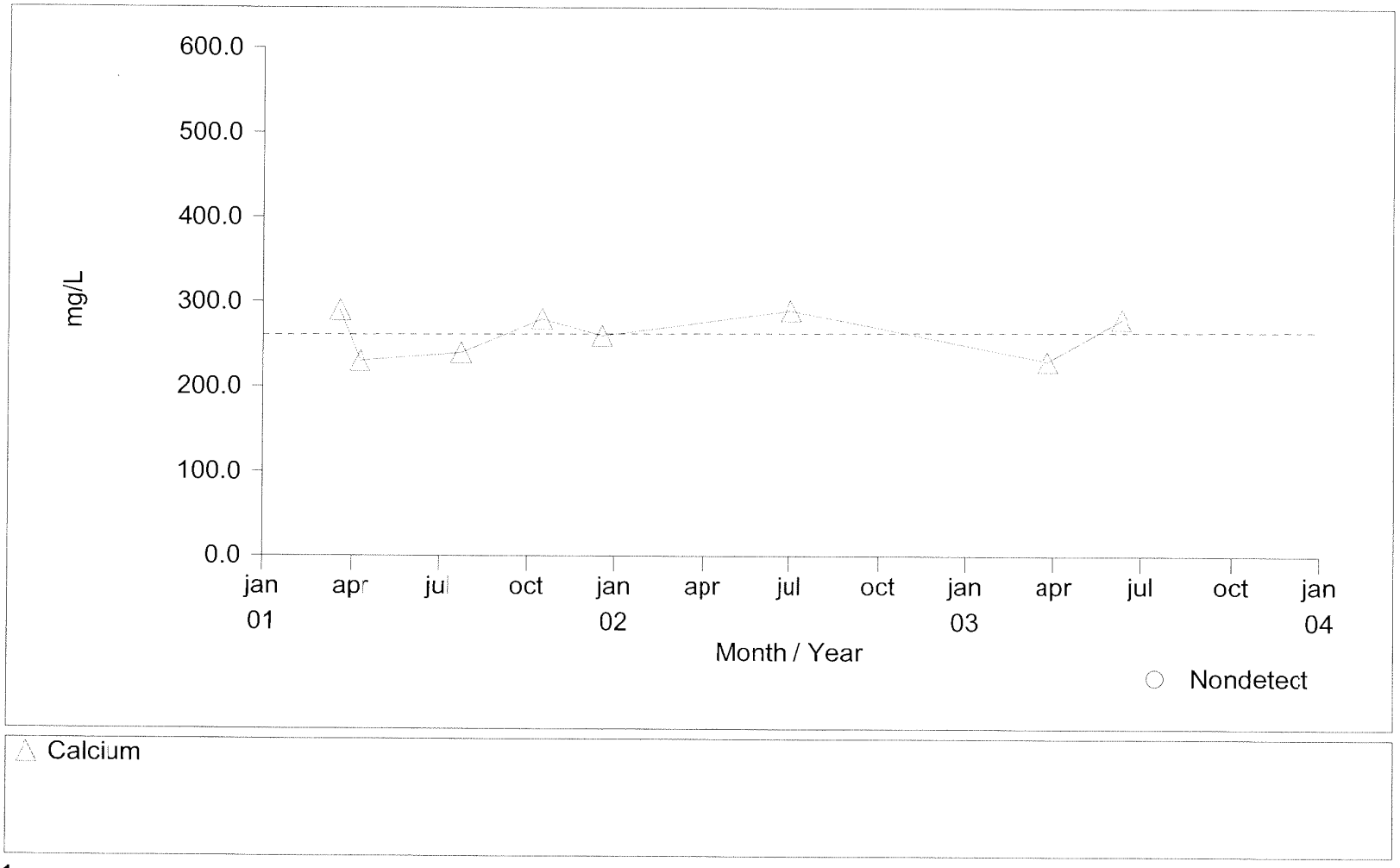
Horn Rapids Landfill

Time Series Plot for MW07



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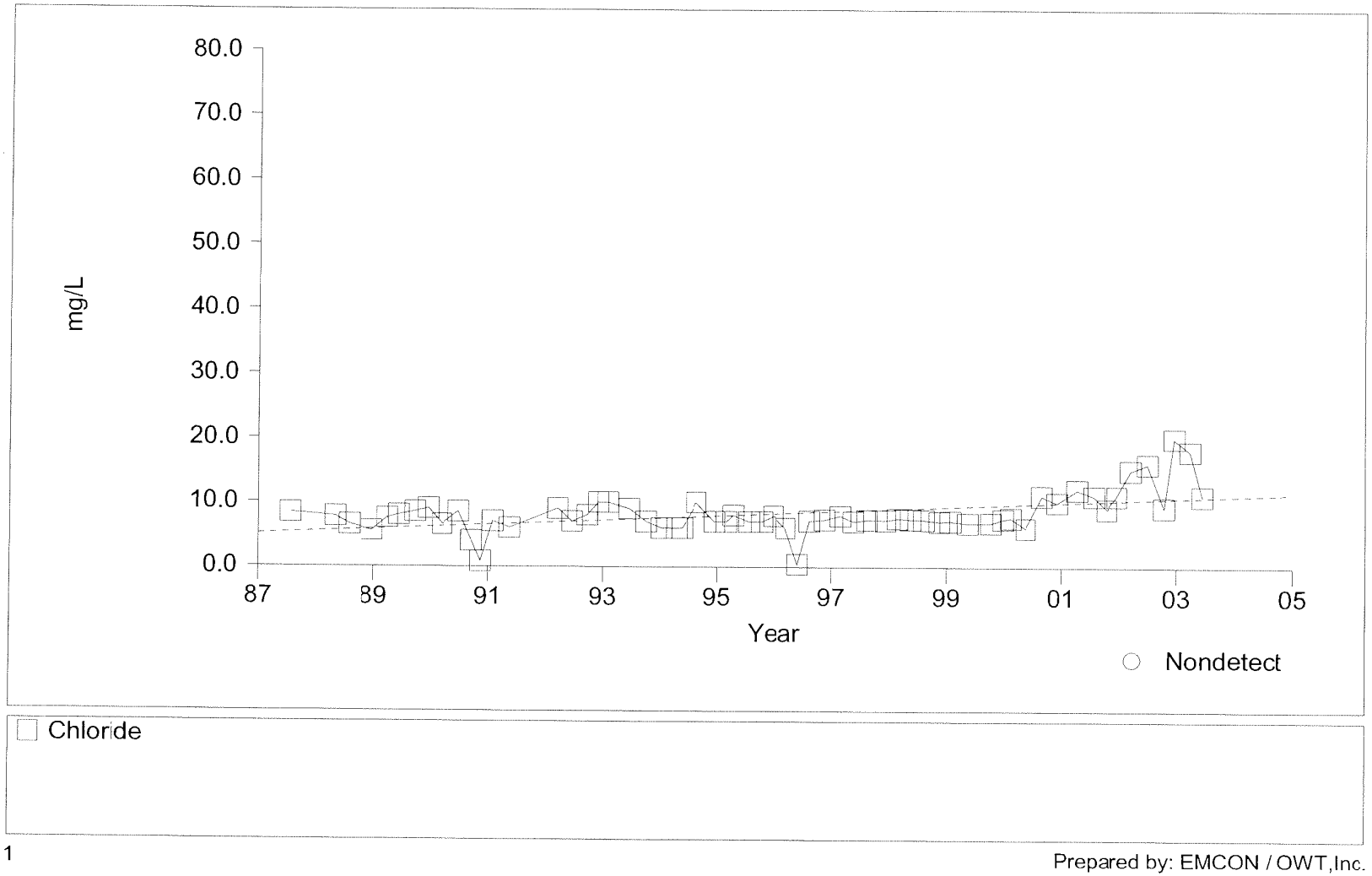
Prepared by: EMCON / OWT,Inc.

Horn Rapids Landfill

Time Series Plot for MW01



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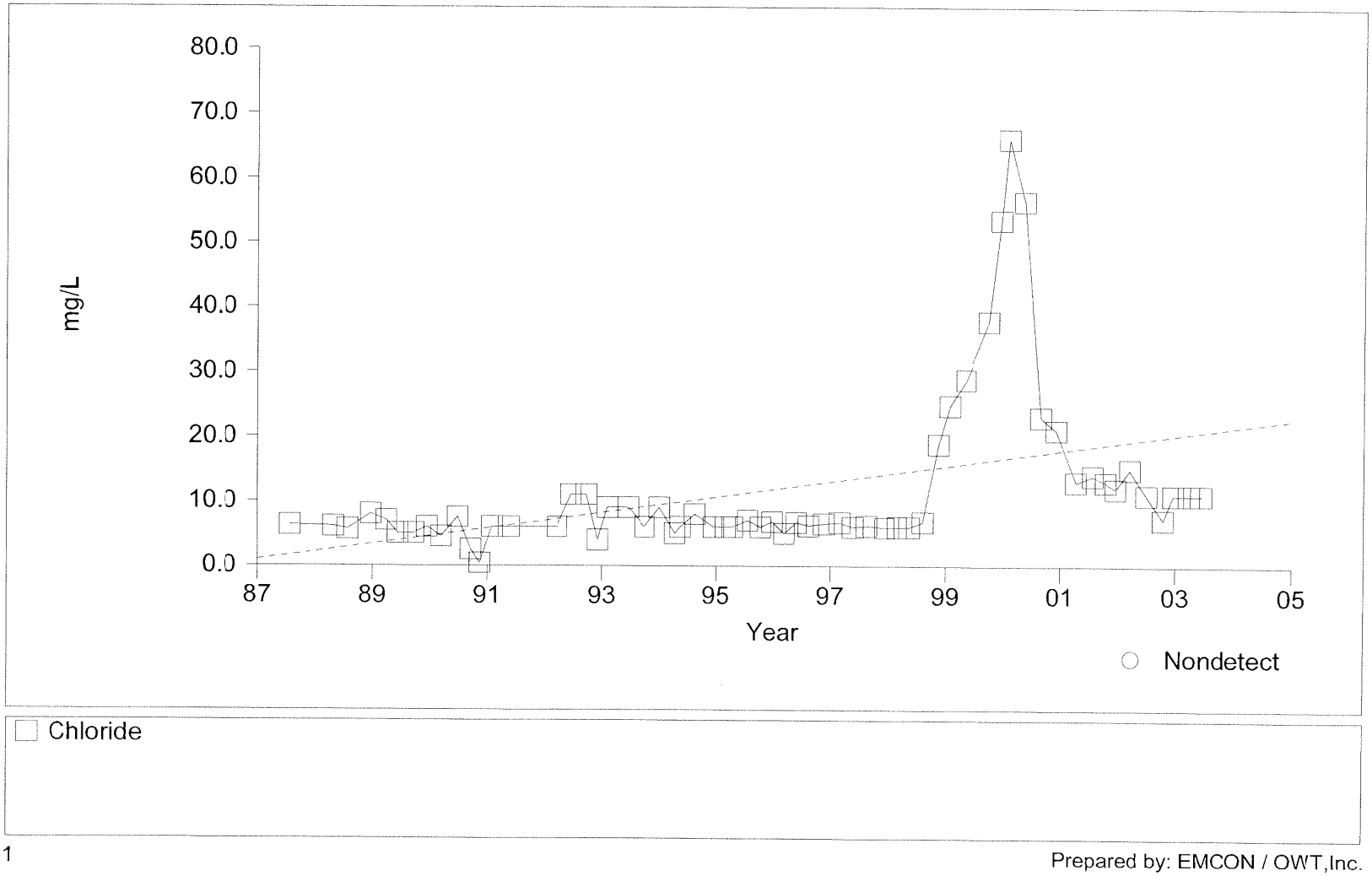
Prepared by: EMCON / OWT, Inc.

Horn Rapids Landfill

Time Series Plot for MW02



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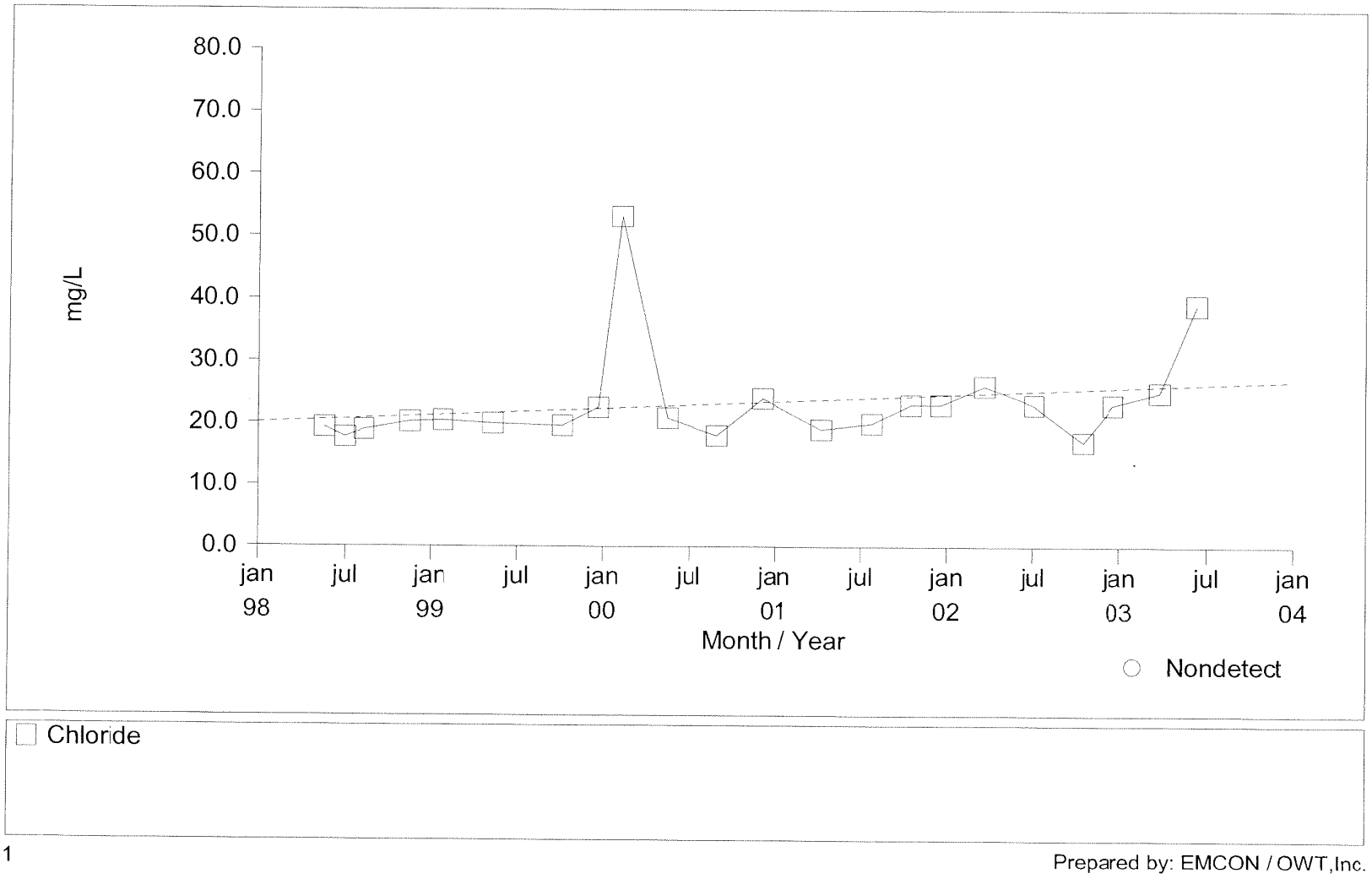
Prepared by: EMCON / OWT,Inc.

Horn Rapids Landfill

Time Series Plot for MW05



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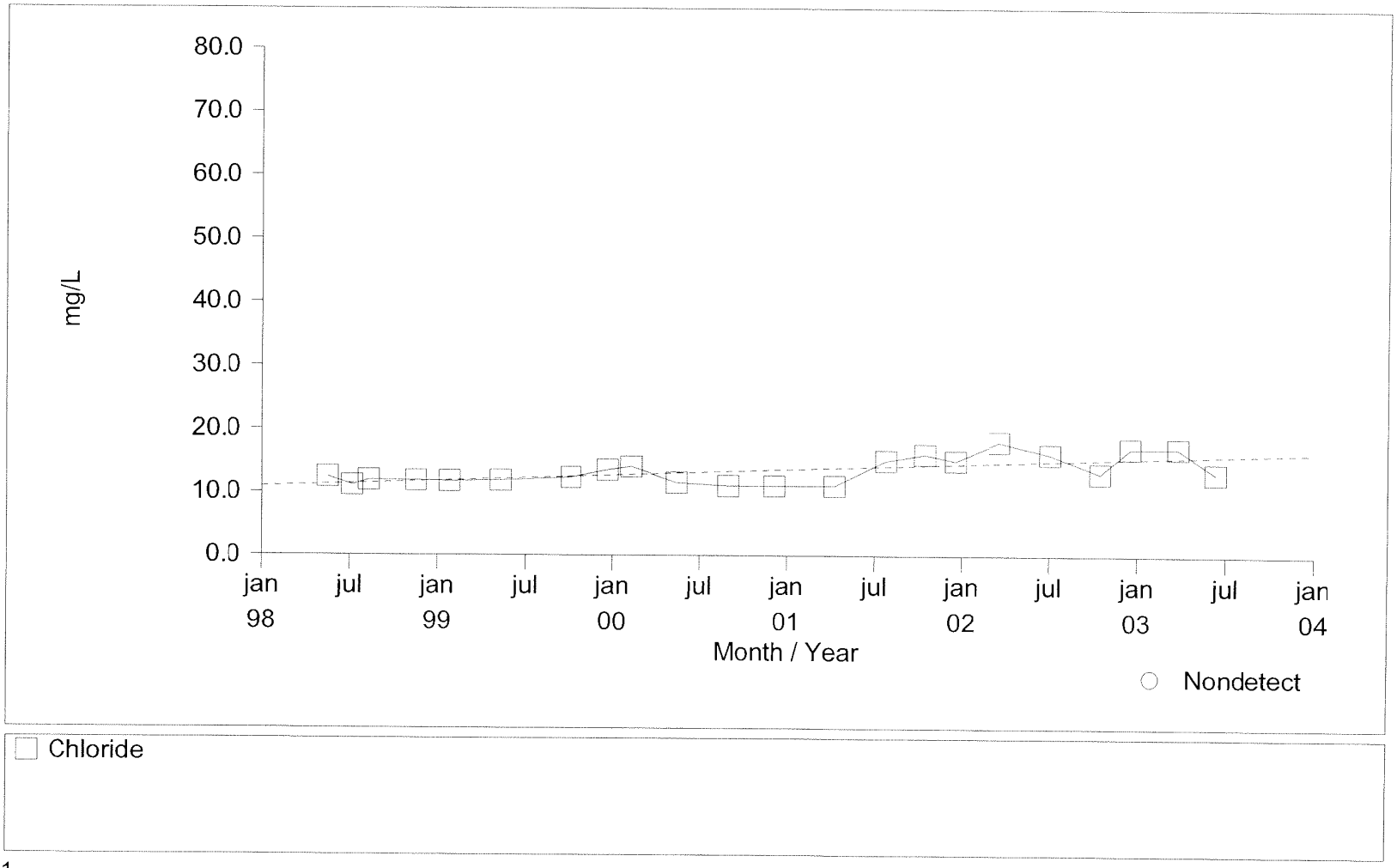
Prepared by: EMCON / OWT, Inc.

Horn Rapids Landfill

Time Series Plot for MW06



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Prepared by: EMCON / OWT,Inc.

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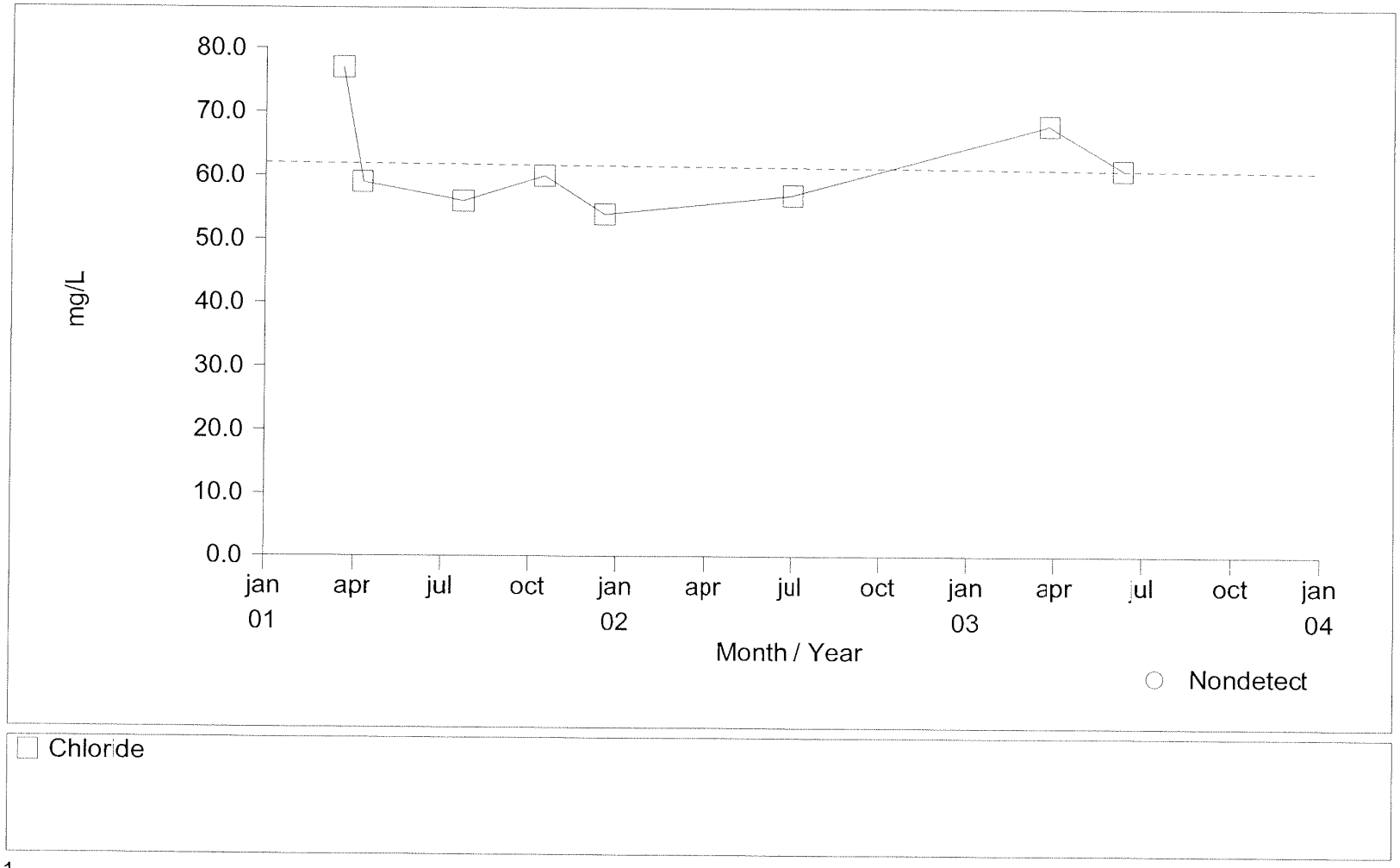
Horn Rapids Landfill

Time Series Plot for MW07



Prepared by: EMCON / OWT, Inc.

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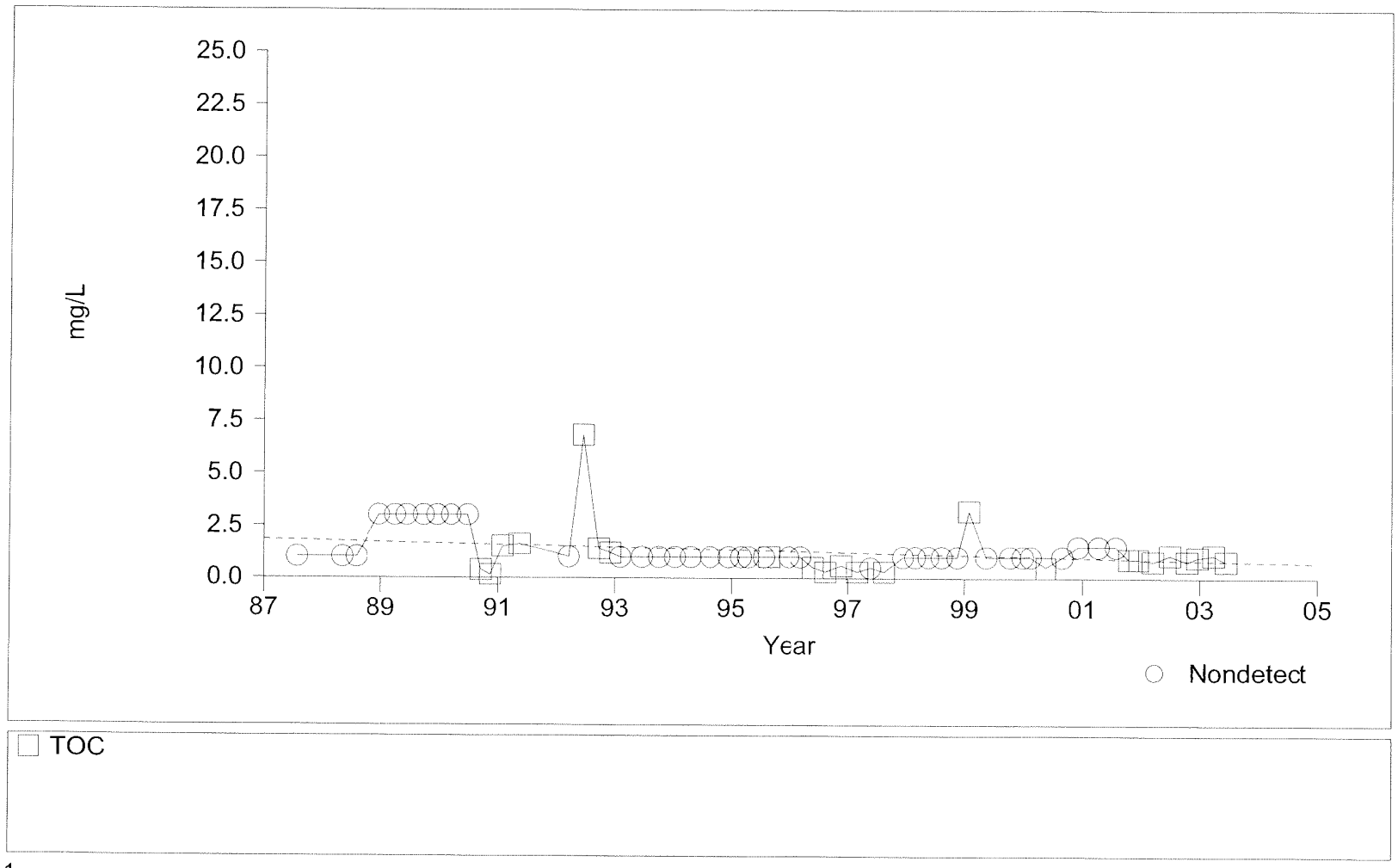
Horn Rapids Landfill

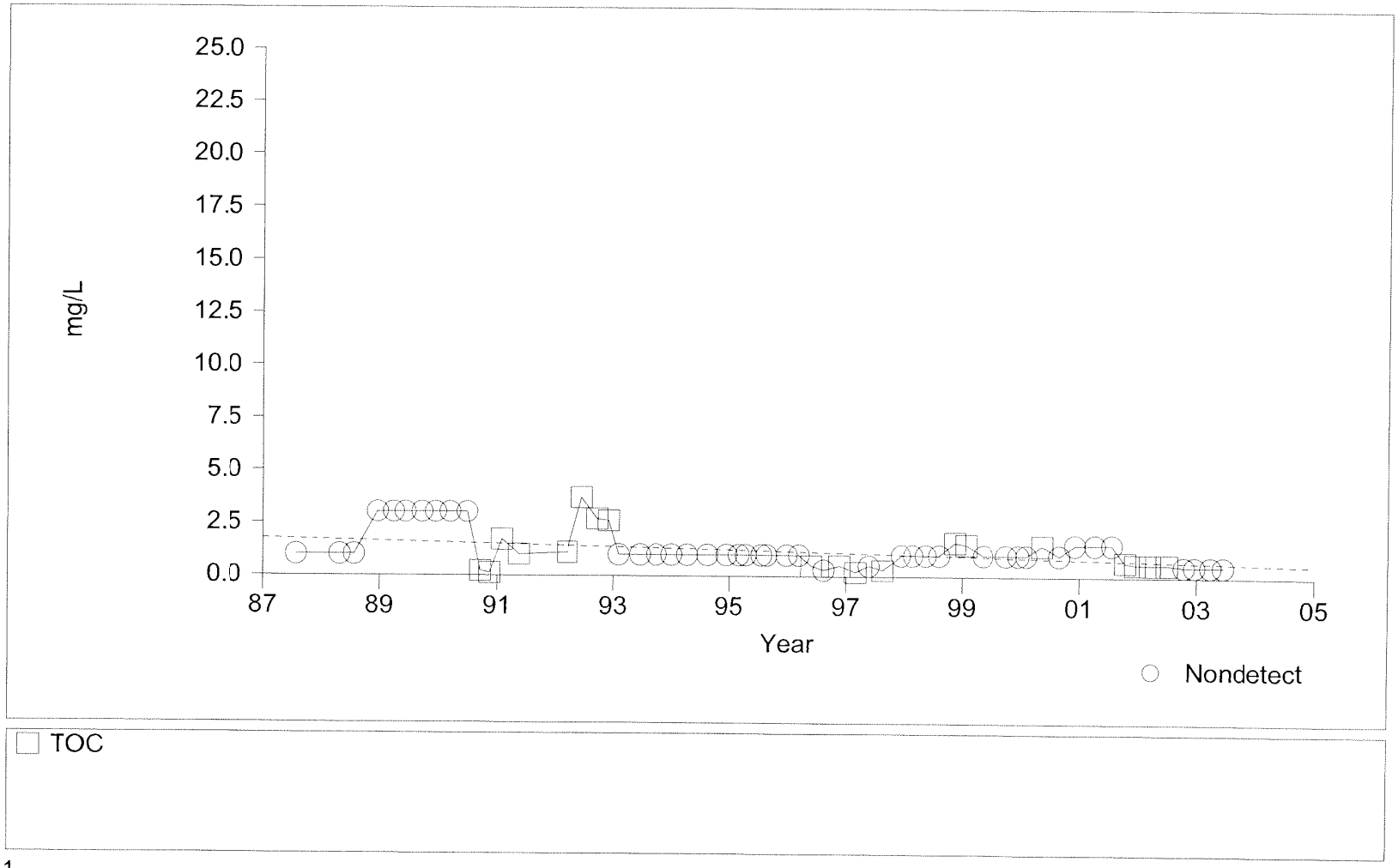
Time Series Plot for MW01



Prepared by: EMCON / OWT, Inc.

Horn Rapids Landfill

Time Series Plot for MW02



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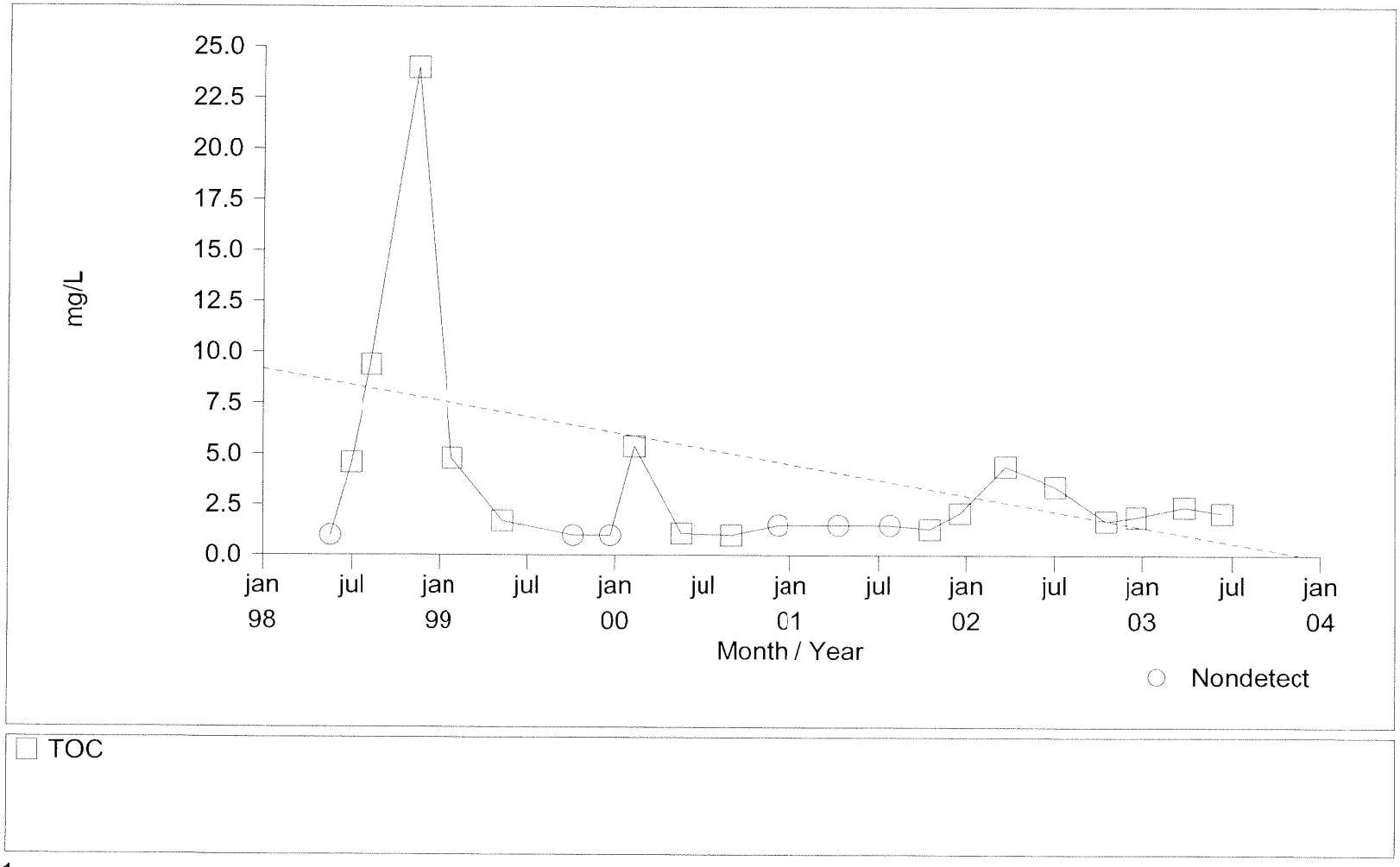
Prepared by: EMCON / OWT,Inc.

Horn Rapids Landfill

Time Series Plot for MW05



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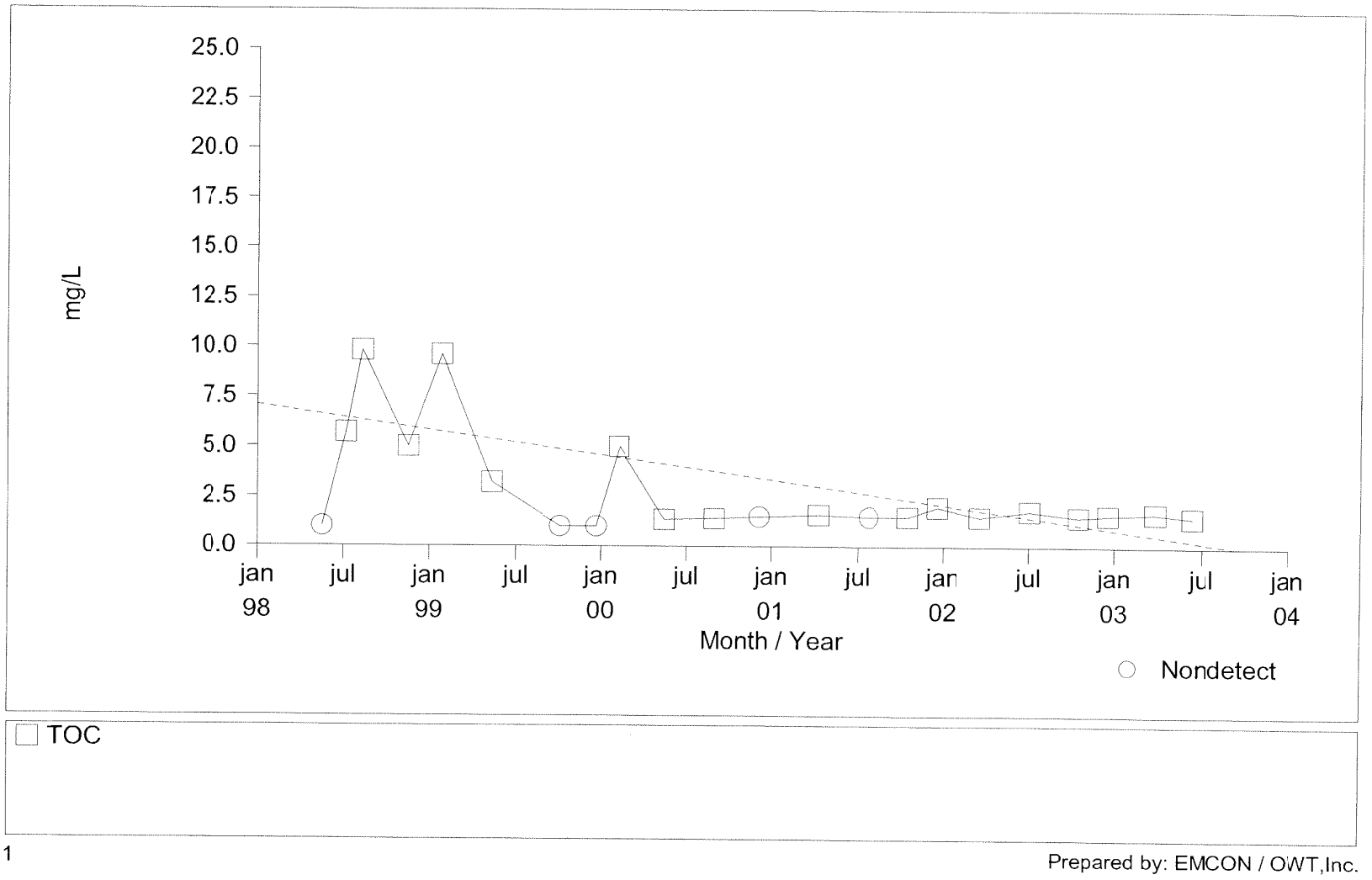
Prepared by: EMCON / OWT, Inc.

Horn Rapids Landfill

Time Series Plot for MW06



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Prepared by: EMCON / OWT,Inc.

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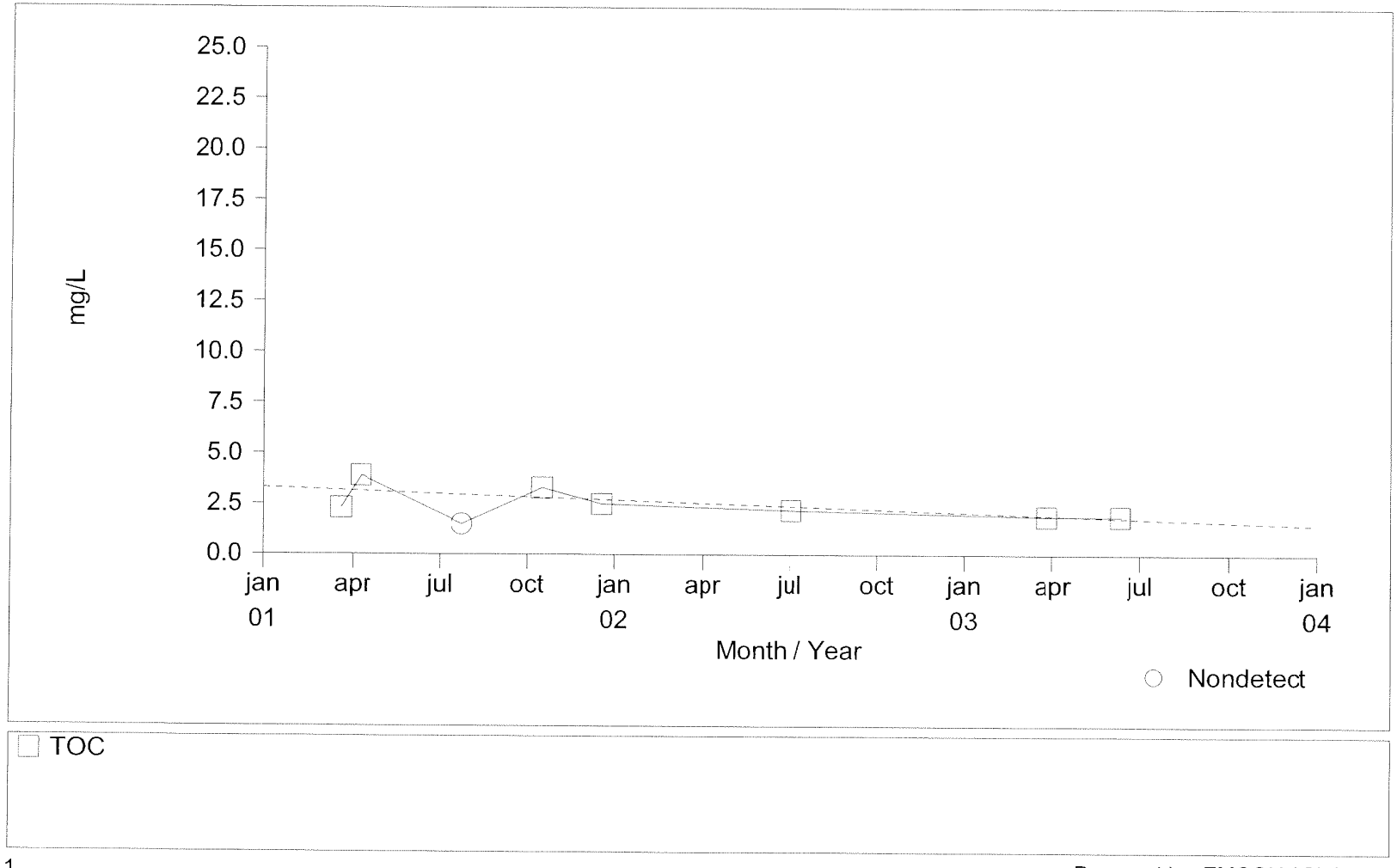
Horn Rapids Landfill

Time Series Plot for MW07



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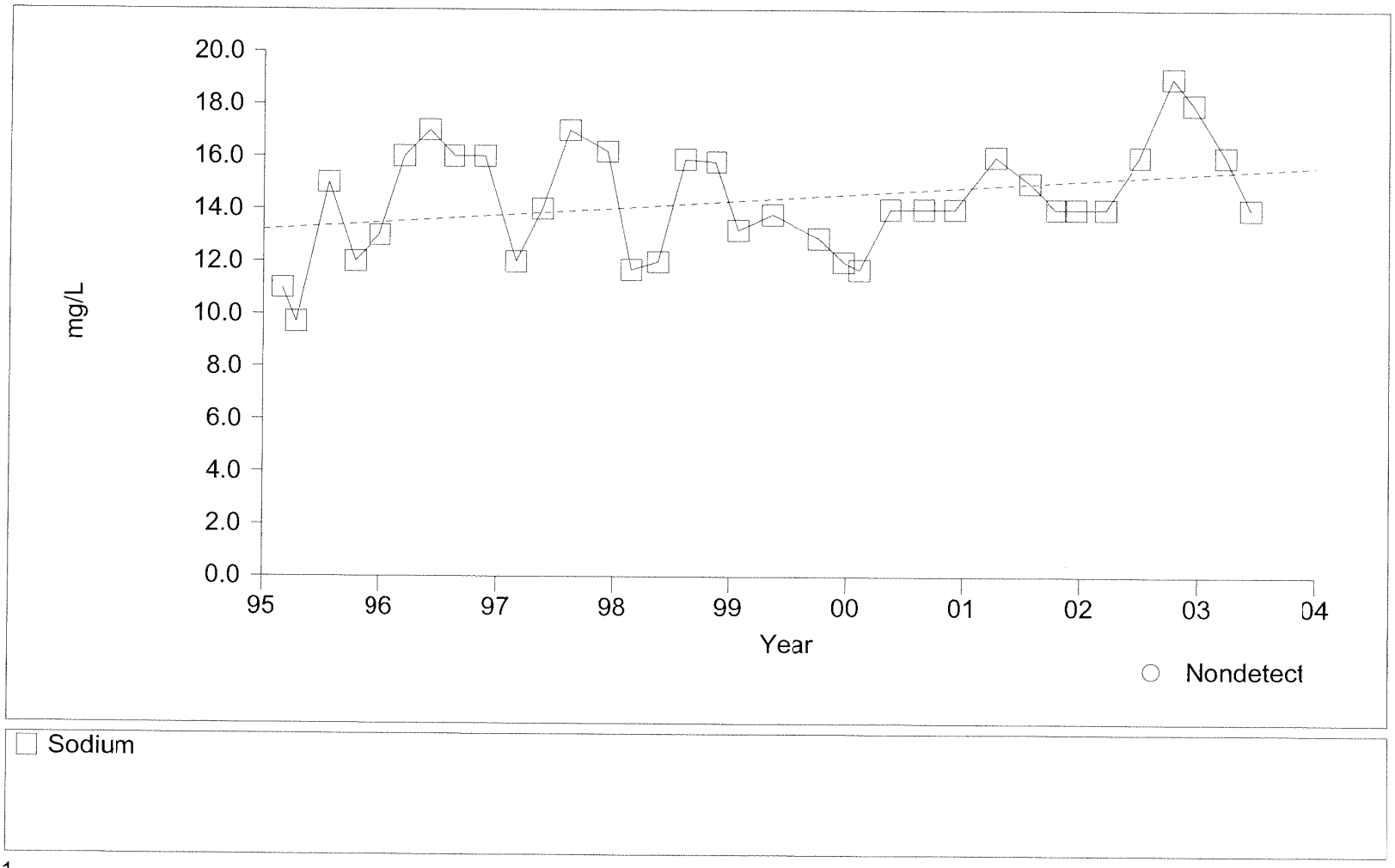
Prepared by: EMCON / OWT, Inc.

Horn Rapids Landfill

Time Series Plot for MW01



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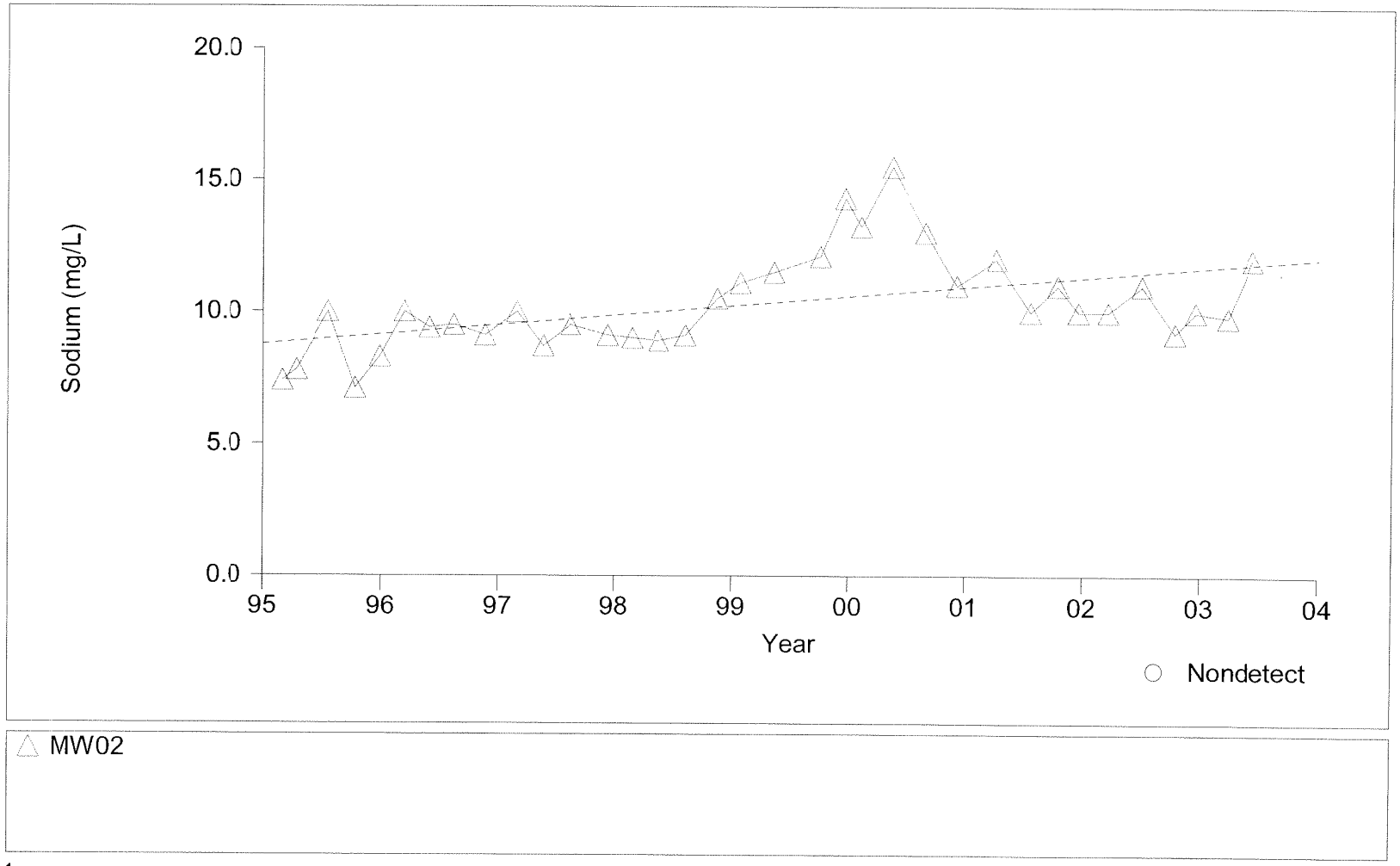
Prepared by: EMCON / OWT,Inc.

Horn Rapids Landfill

Time Series Plot for Sodium



Prepared by: EMCON / OWT,Inc.

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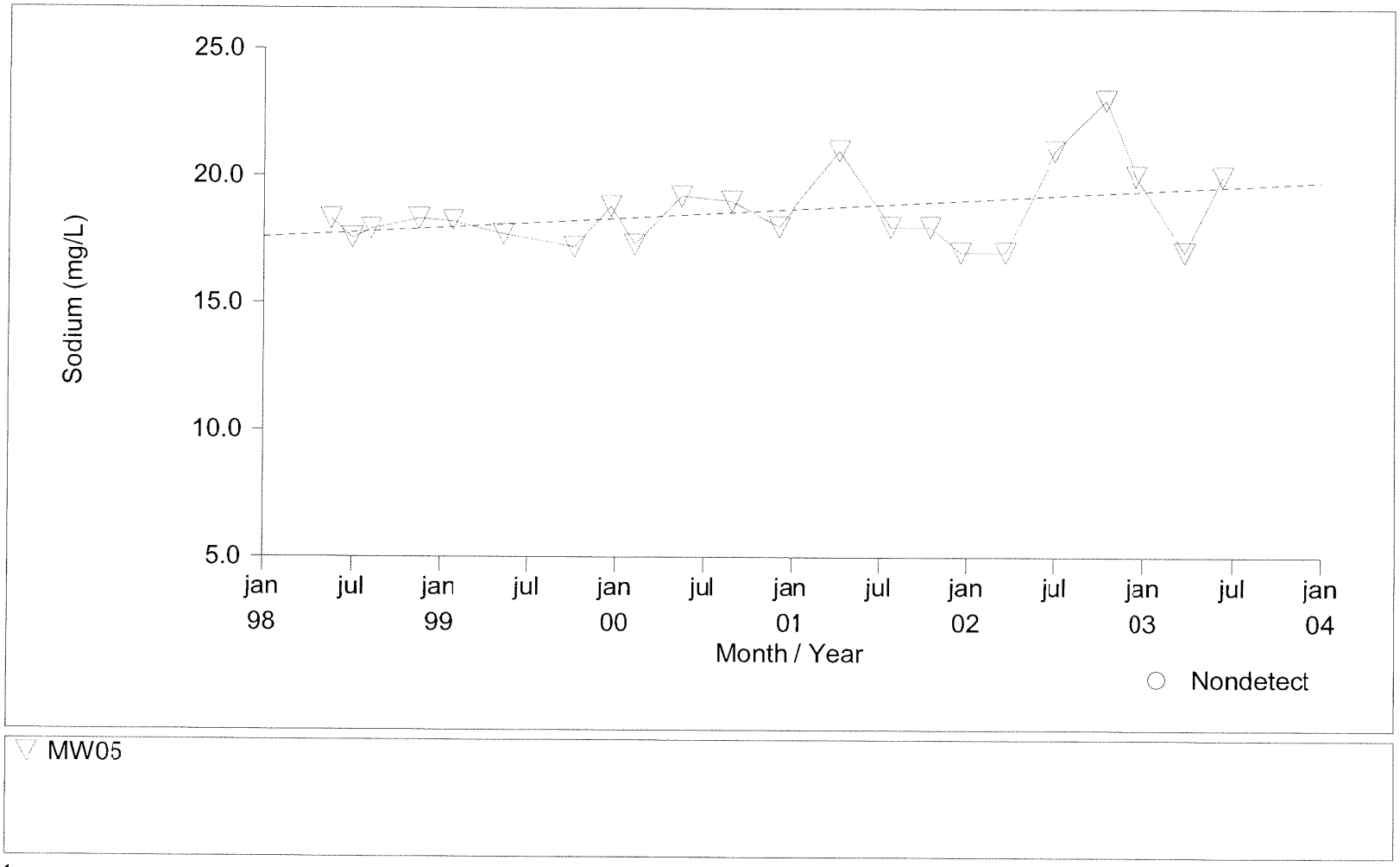
Horn Rapids Landfill

Time Series Plot for Sodium



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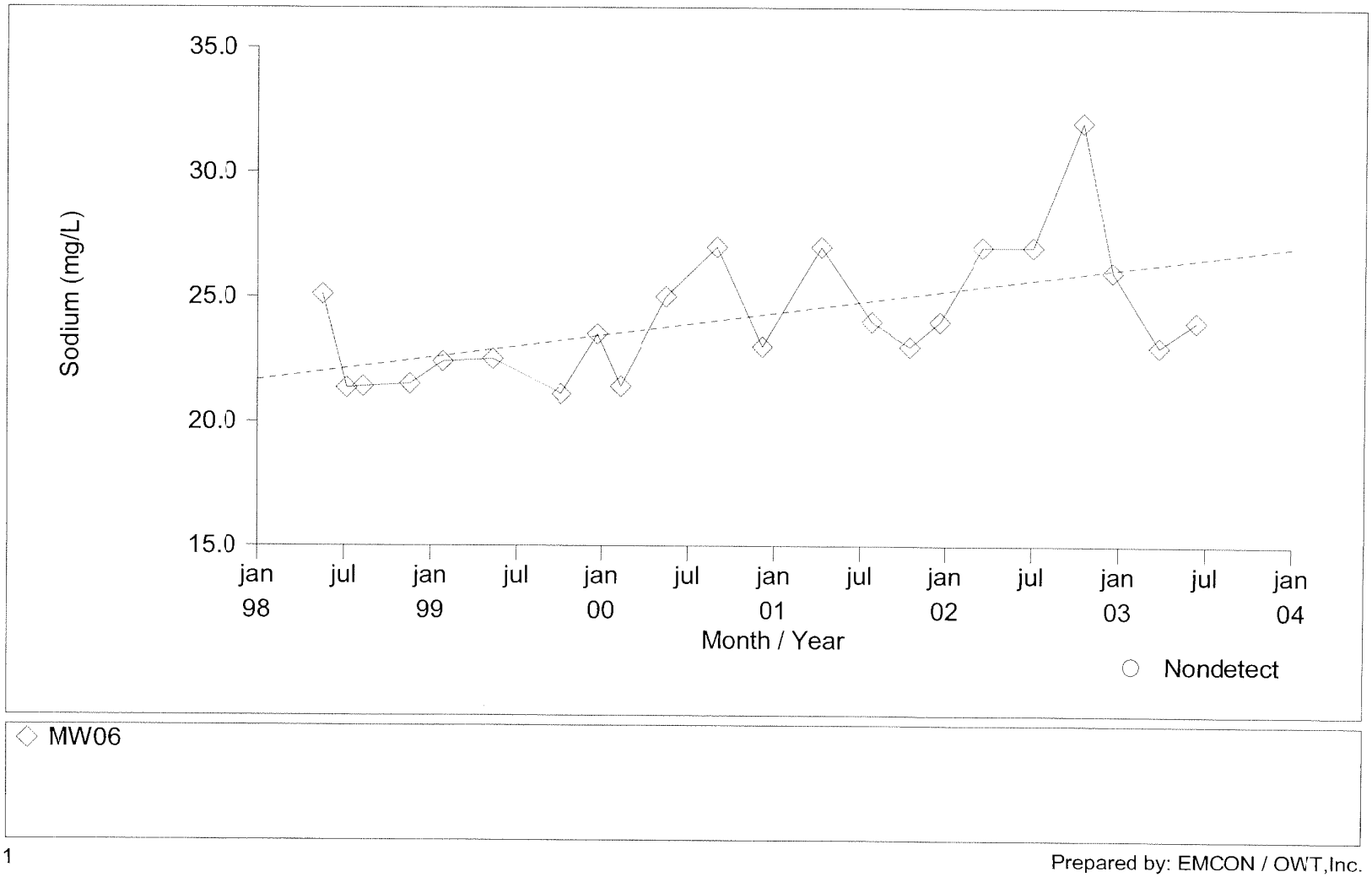
Prepared by: EMCON / OWT,Inc.

Horn Rapids Landfill

Time Series Plot for Sodium



Prepared by: EMCON / OWT,Inc.

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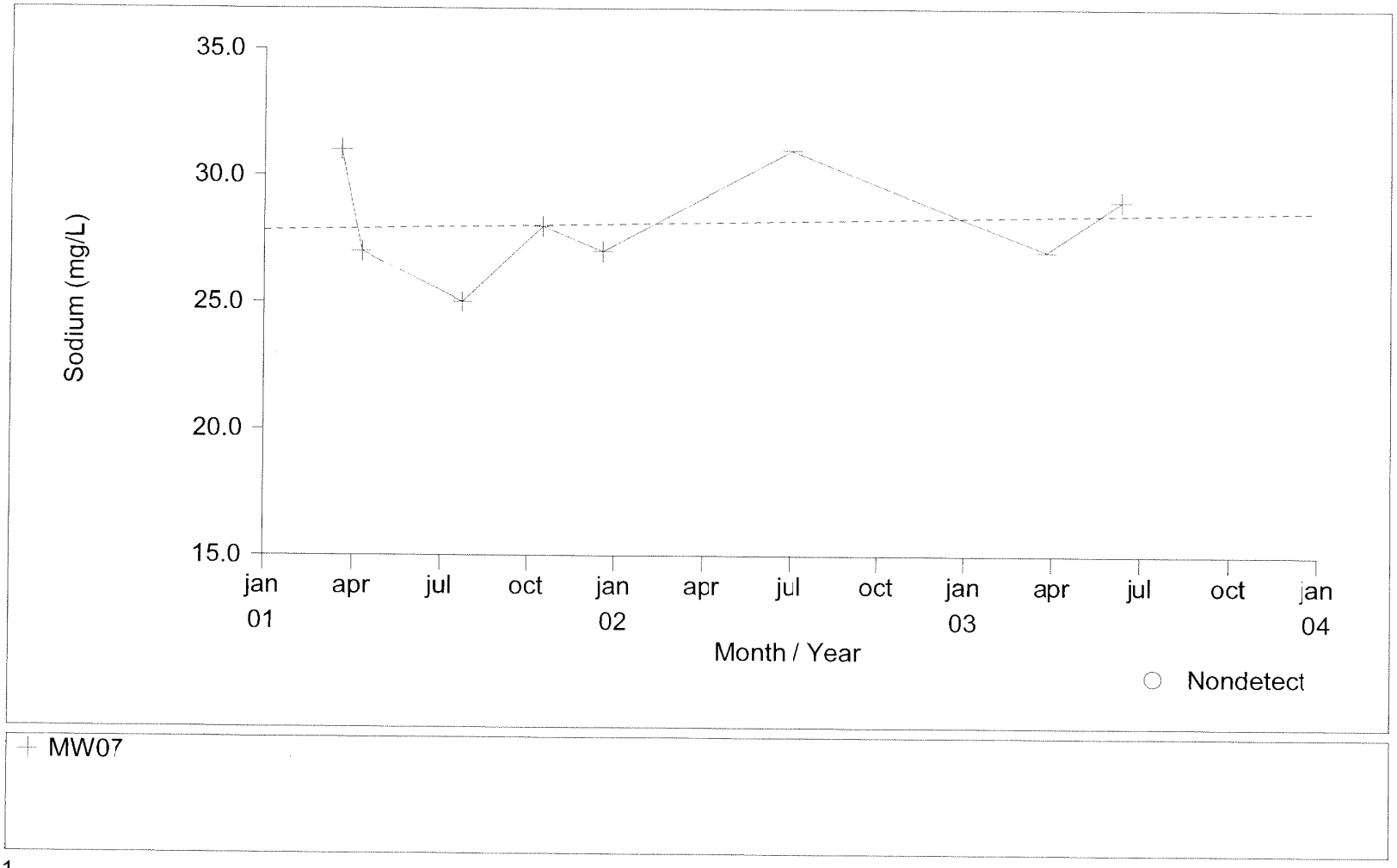
Horn Rapids Landfill

Time Series Plot for Sodium



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Prepared by: EMCON / OWT, Inc.

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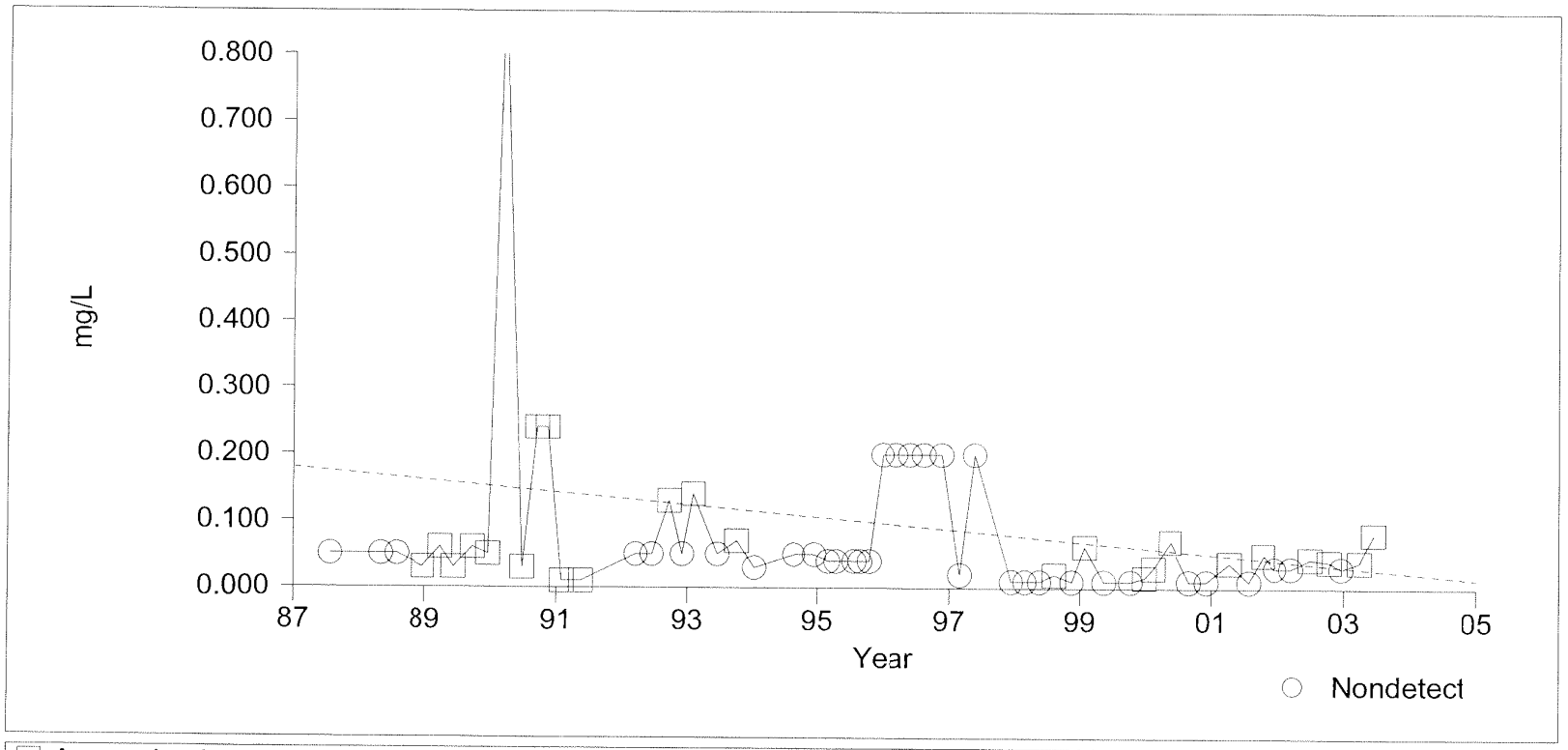
Horn Rapids Landfill

Time Series Plot for MW01



☐ Ammonia nitrogen

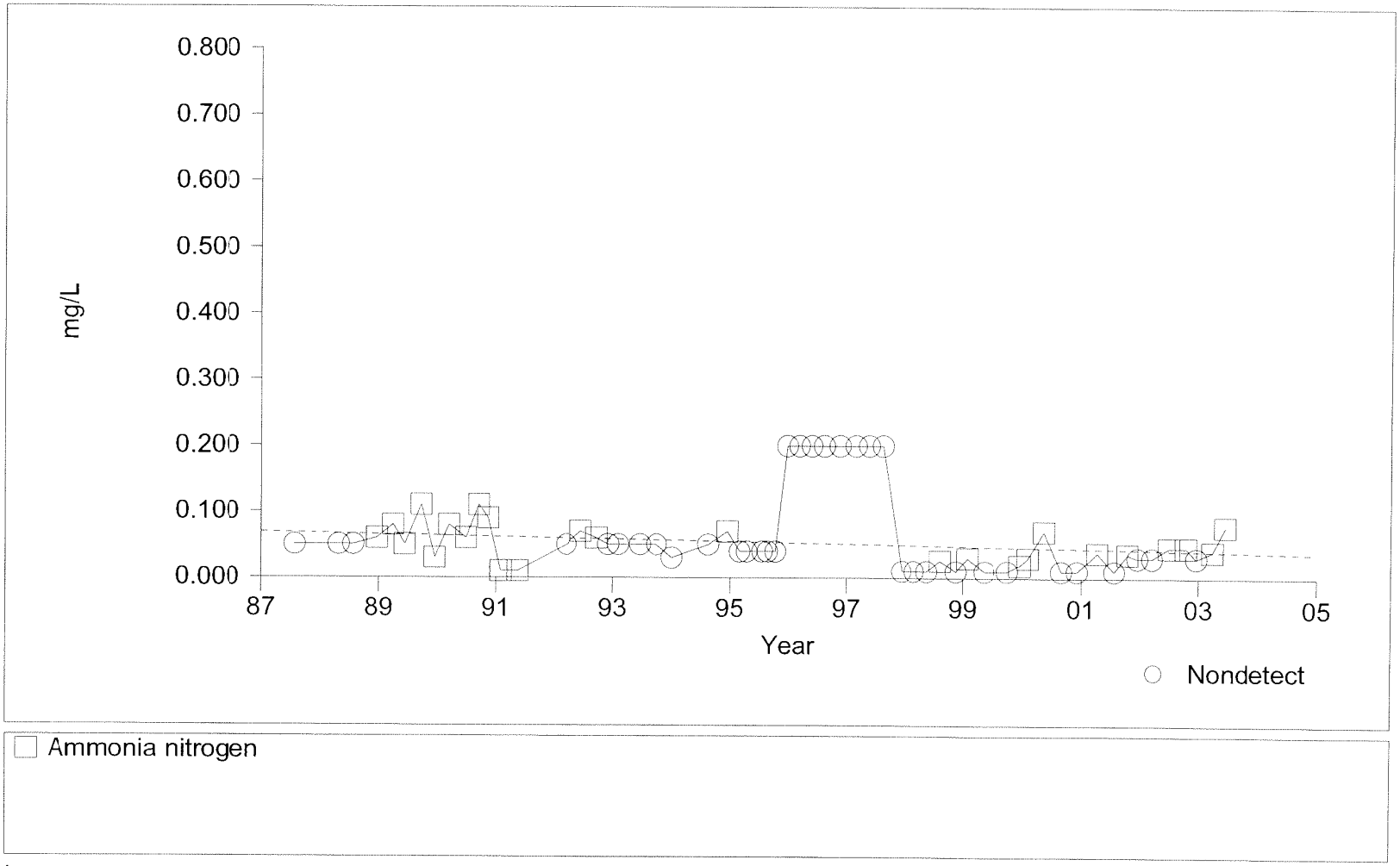
Offscale Points

☐ Ammonia nitrogen on 3/12/1990 was 0.9599999 mg/L

Prepared by: EMCON / OWT,Inc.

Horn Rapids Landfill

Time Series Plot for MW02



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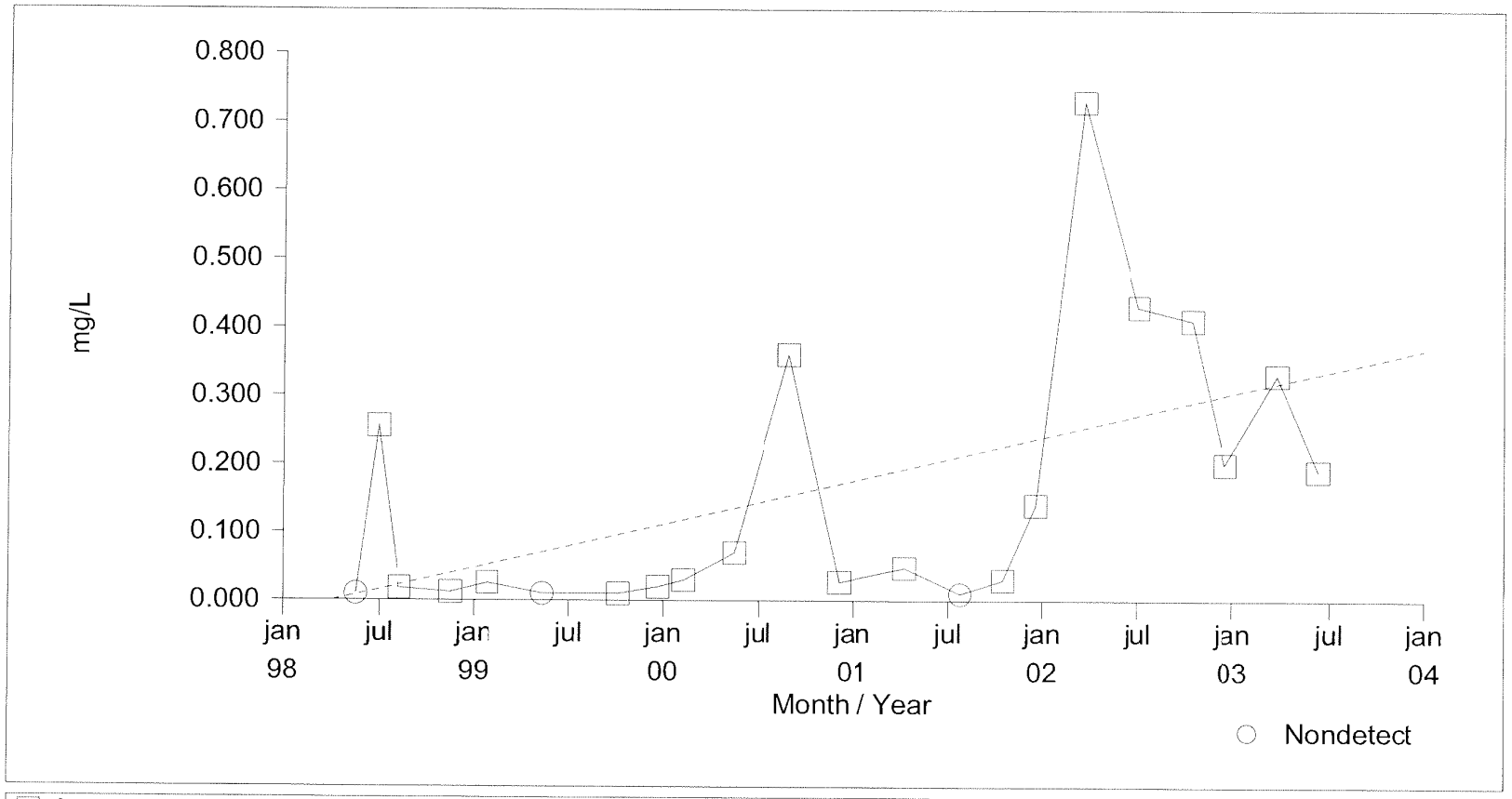
Prepared by: EMCON / OWT,Inc.

Horn Rapids Landfill

Time Series Plot for MW05



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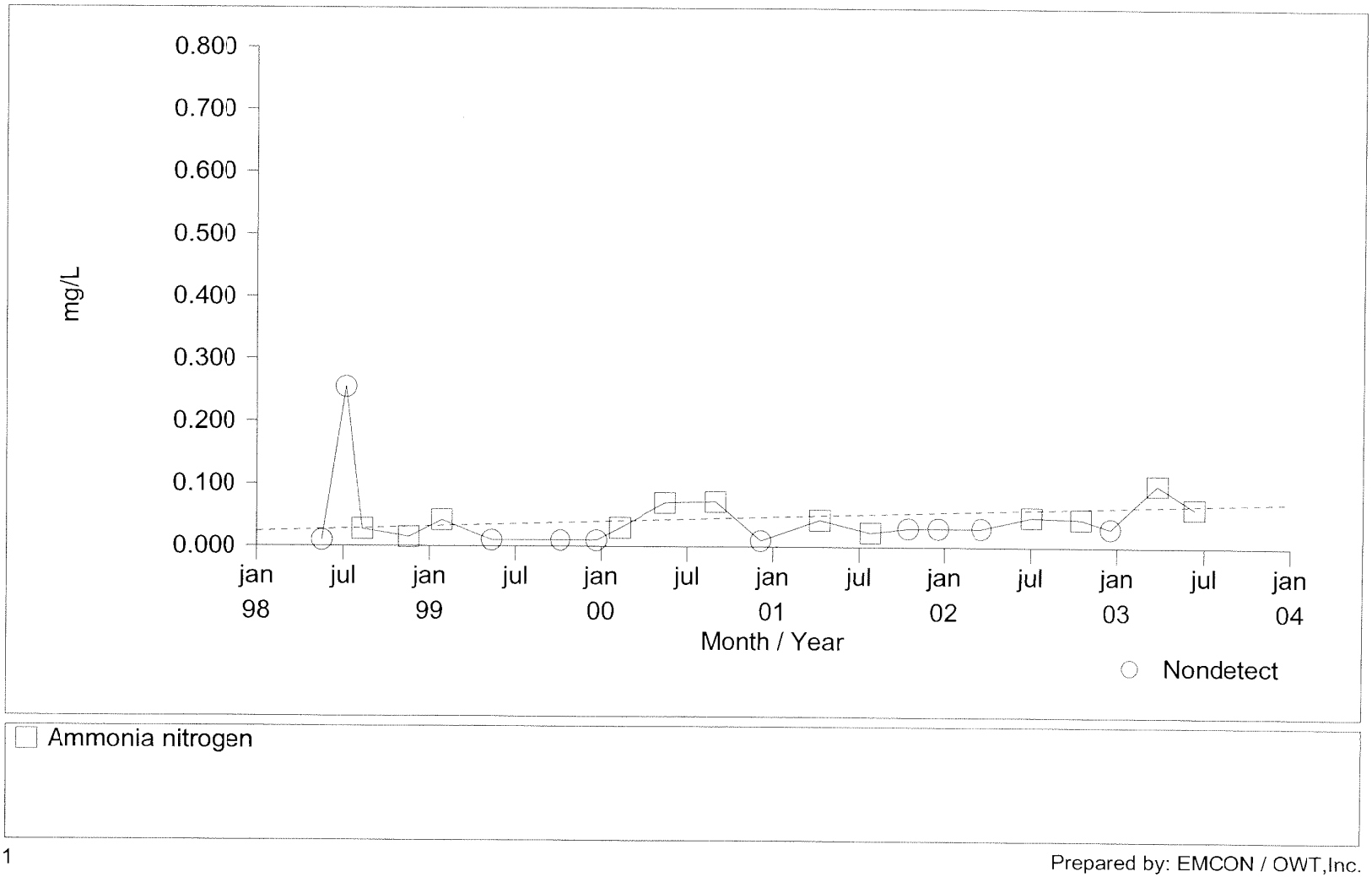
Prepared by: EMCON / OWT, Inc.

Horn Rapids Landfill

Time Series Plot for MW06



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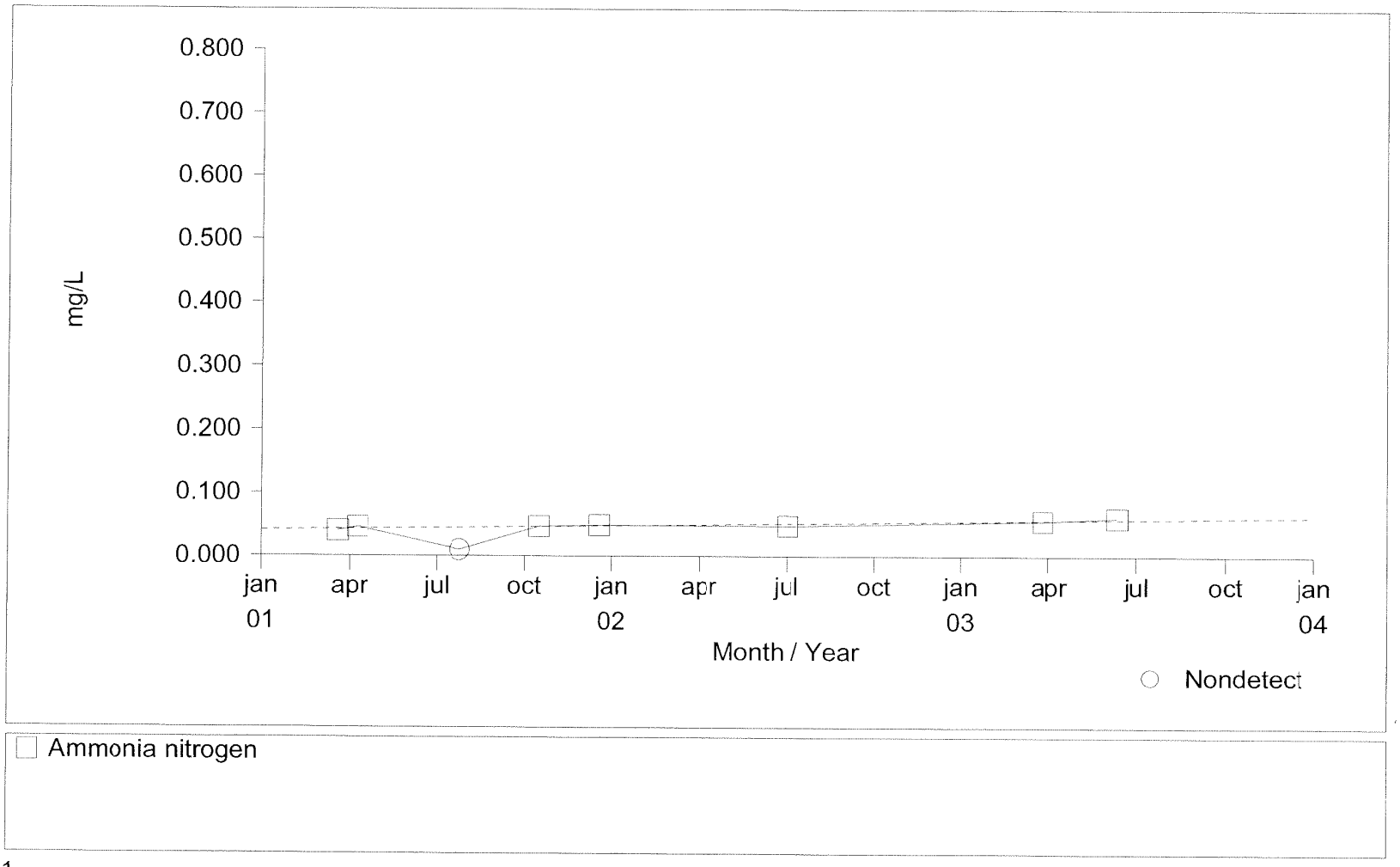
Prepared by: EMCON / OWT,Inc.

Horn Rapids Landfill

Time Series Plot for MW07



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Prepared by: EMCON / OWT, Inc.

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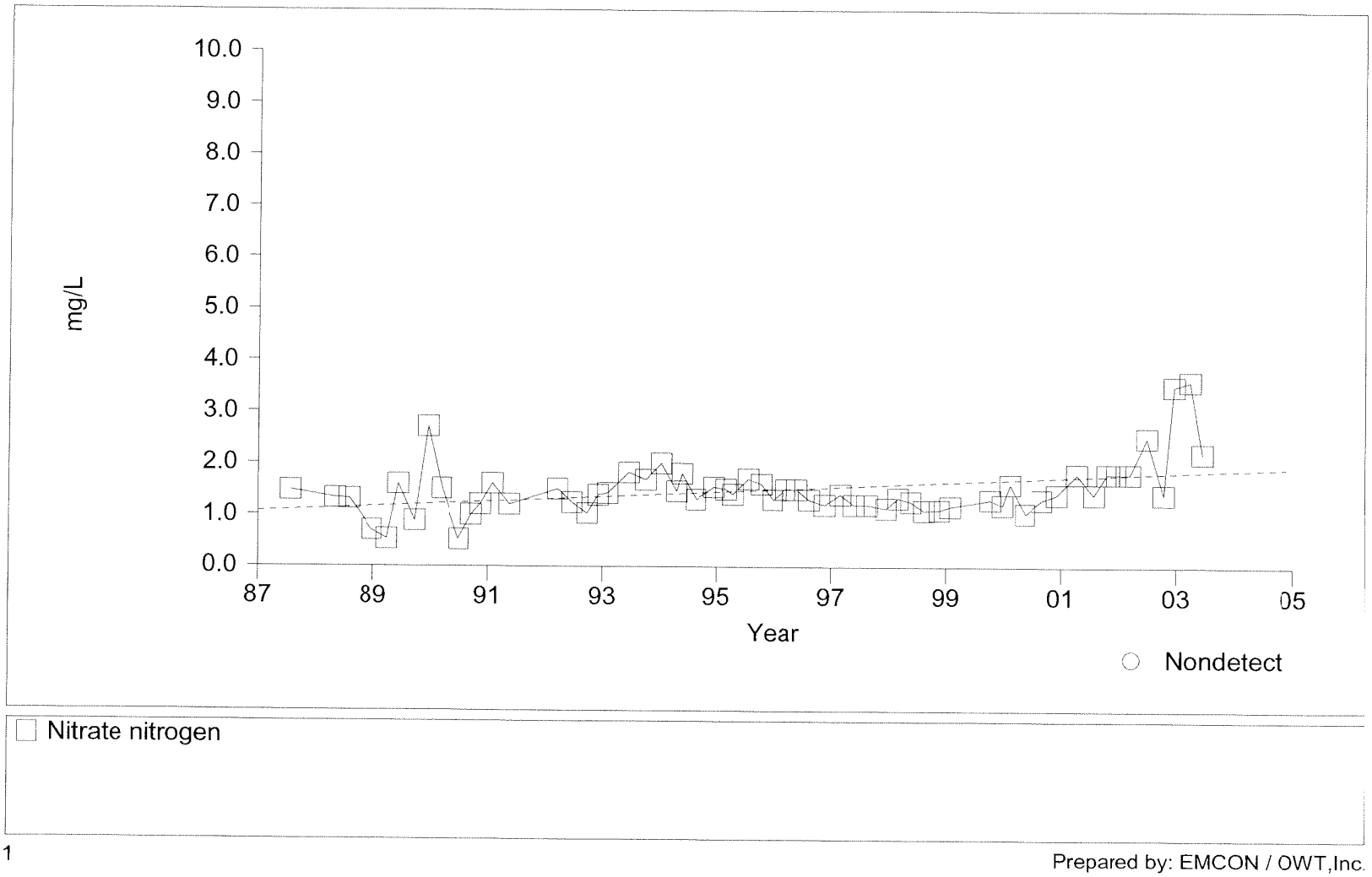
Horn Rapids Landfill

Time Series Plot for MW01



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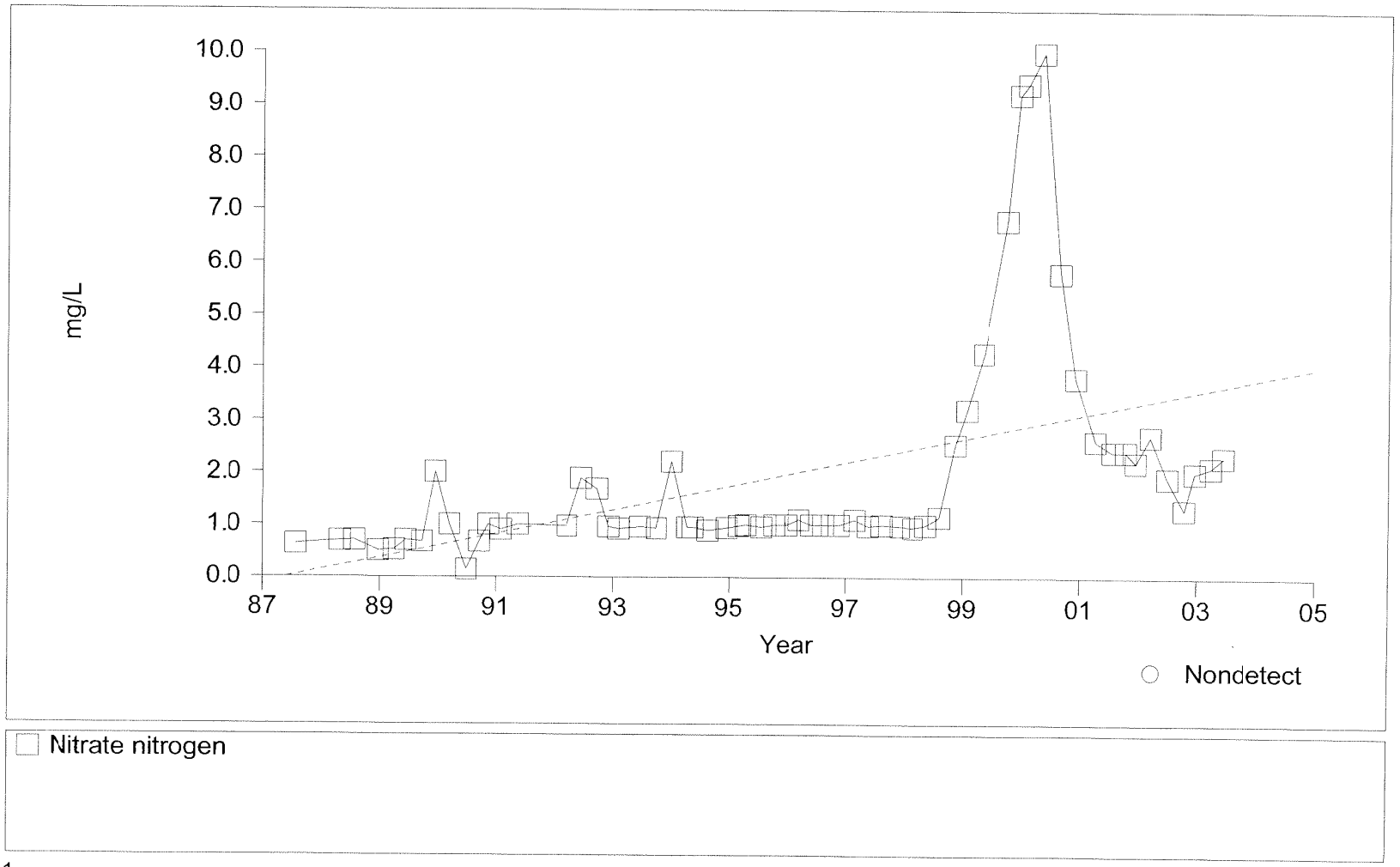
Prepared by: EMCON / OWT,Inc.

Horn Rapids Landfill

Time Series Plot for MW02



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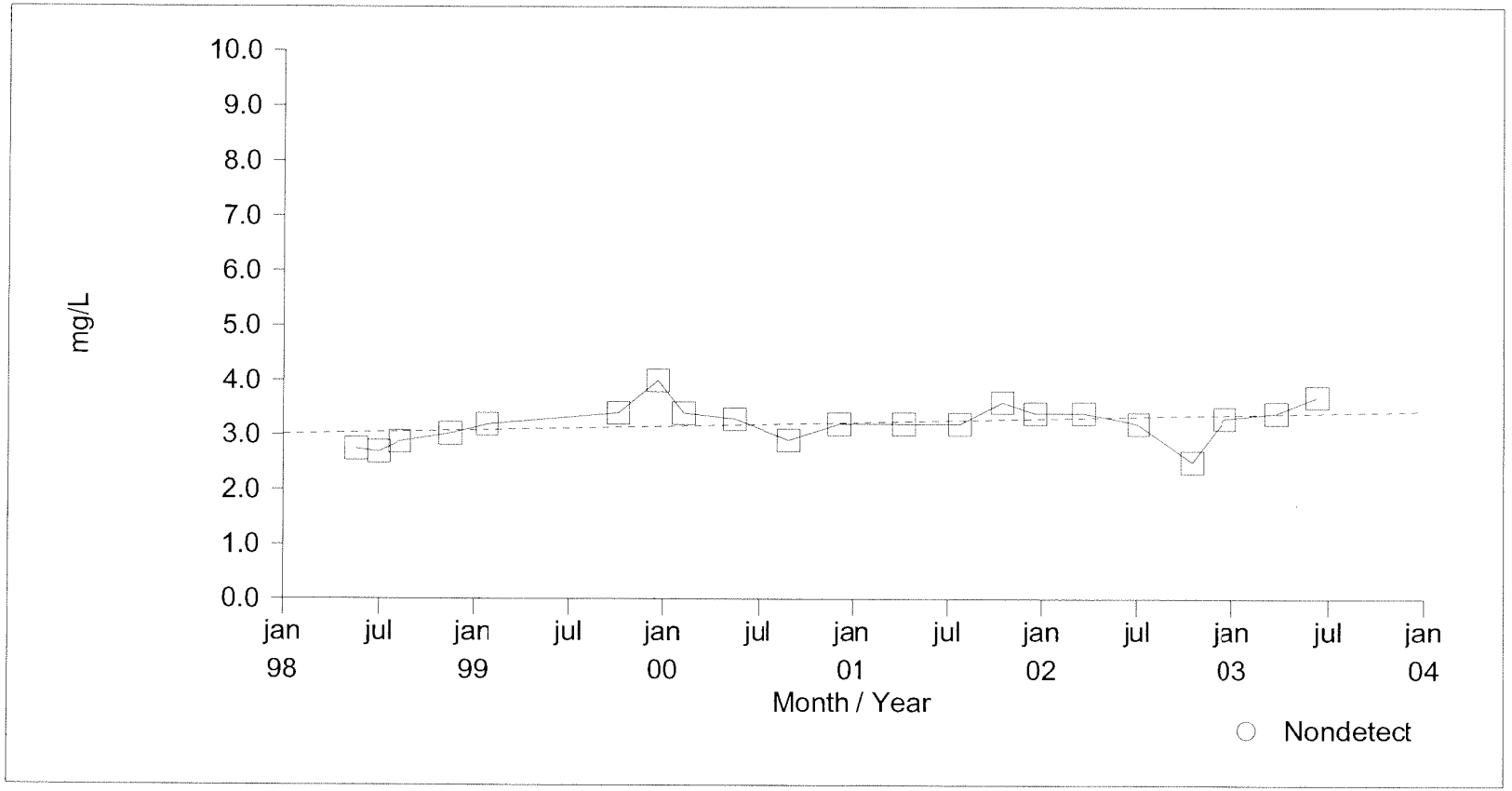
Prepared by: EMCON / OWT,Inc.

Horn Rapids Landfill

Time Series Plot for MW05



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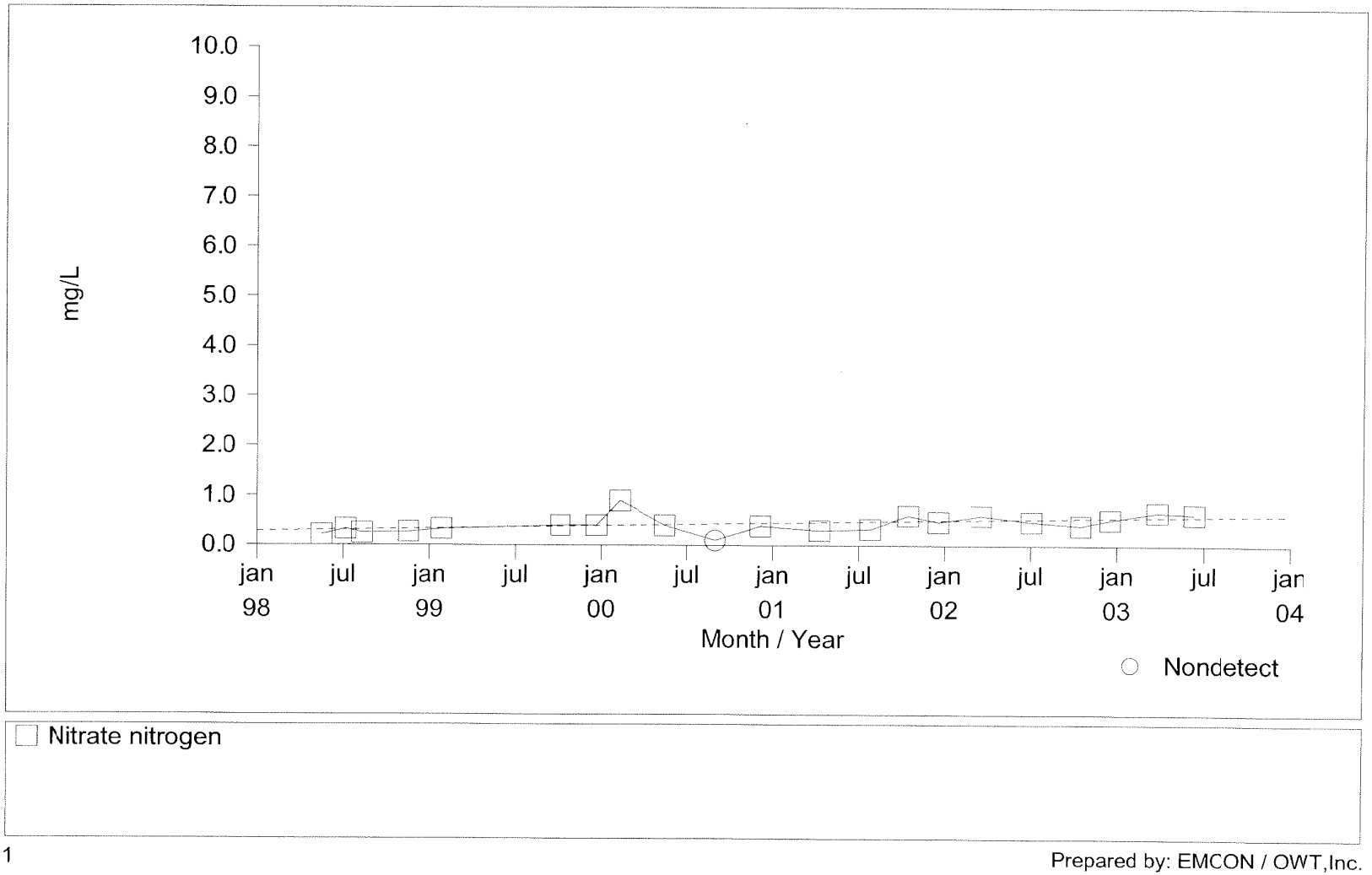
Prepared by: EMCON / OWT, Inc.

Horn Rapids Landfill

Time Series Plot for MW06



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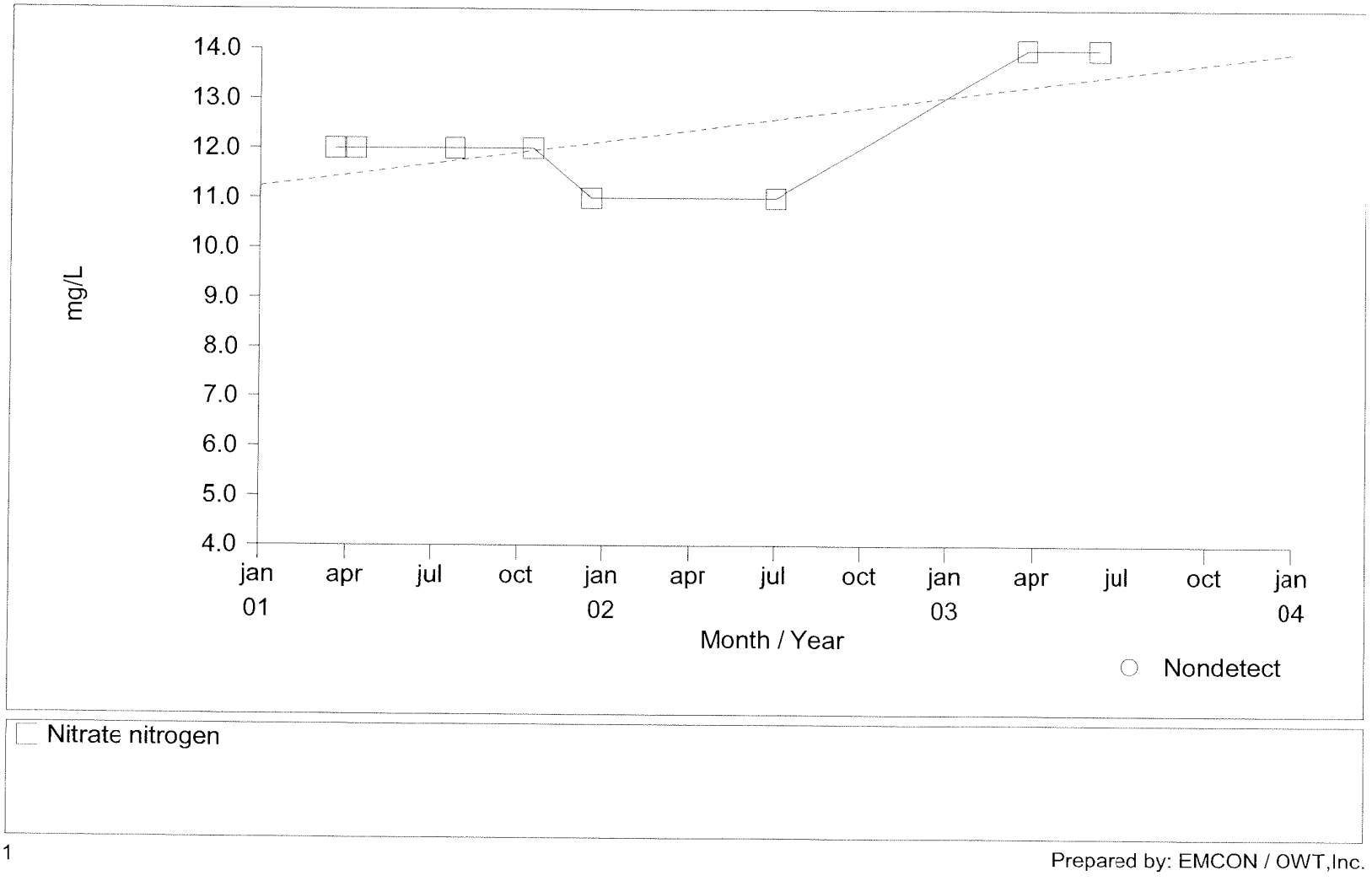
Prepared by: EMCON / OWT, Inc.

Horn Rapids Landfill

Time Series Plot for MW07



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Prepared by: EMCON / OWT,Inc.