Table 4-8. Field Chemistry and Selected Laboratory Chemistry for Leachate Sampled from the West-Side Anaerobic Cell

PARAMETER	DATE:	2/14/2002	5/14/2002	6/20/2002	7/23/2002	8/13/2002	2/26/2003
Field Parameters:	**Units**						
pH		6.74	6.8	6.72	6.85	6.71	6.87
Electrical Conductivity	µS	3530	3851	3944	3899	3810	2320
Oxidation Reduction Potential	mV	-62	-46	-19	-38	-36	-56
Temperature	C	24.9	26.2	25.2	25.7	26.9	22.1
Dissolved Oxygen	mg/L	3.15	1.54	1.31	3.62	2.6	3.18
Total Dissolved Solids	ppm	2617	2871	2960	2965	2908	1703
General Chemistry:							
Bicarbonate Alkalinity	mg/L	1700	1780	1730	1710	1680	1000
Total Alkalinity as CO_3	mg/L	1700	1780	1730	1710	1680	1000
BOD	mg O/L	28	12	12	7.9	12	16
Chemical Oxygen Demand	mg O/L	350	300	274	270	262	98.1
Chloride	mg/L	187	333	358	341	366	196
Ammonia as N	mg/L	20.3	23.5	21.2	23.8	25	9.5
Nitrate-Nitrite as N	mg/L	0.016(tr)	<1.5	<0.03	<0.015	<0.015	0.022 (tr)
Total Kjeldahl Nitrogen	mg/L	32.6	31.1	31.5	31.4	31	13.8
Total Dissolved Solids @ 180 C	mg/L	2220	2320	2410	2310	2280	1320
Total (Non-Volatile) Organic Carbon	mg/L	112	85.2	86.5	82.7	78.1	28.3
Total Sulfide	mg/L	0.033(tr)	<0.014	<0.014	0.023 (tr)	<0.014	<0.0093
Dissolved Iron	mg/L	0.4	0.035(tr)*	1.9	0.59	0.11	0.15
Dissolved Magnesium	mg/L	198	343	NA	217	185	123
Dissolved Potassium	mg/L	55.2	58.6	NA	37.8	32.5	23.7

5 AEROBIC CELL

The aerobic cell occupies approximately 2.5 acres in the southeast quadrant of Phase 1, Module 6D.

5.1 Experimental

The experimental methods utilized are grouped into three categories: construction, monitoring, and operation. Each of these categories is discussed below.

5.1.1 Construction

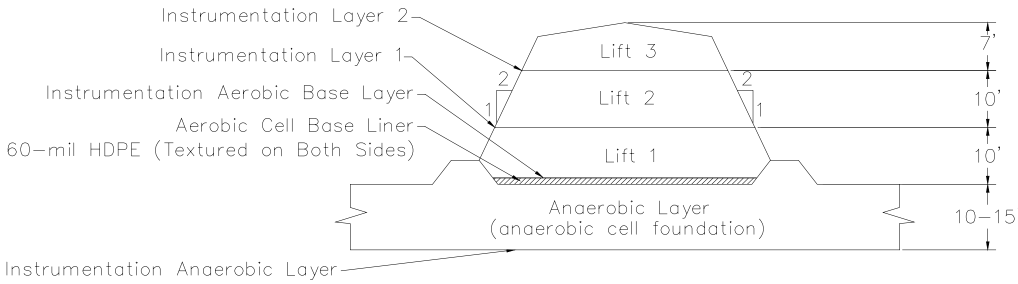
Construction of the aerobic cell can be generally broken down into five major tasks: waste placement, liquid addition, gas collection, air injection and surface liner installation. Each of the five tasks is discussed below. Refer to Appendix A, Table 5-1 for a summary of current monitoring data for the aerobic cell.

5.1.1.1 Waste Placement

Waste placement first began November 14, 2000 with an approximate 10-foot lift of waste placed on the Module 6D liner. This first lift of waste will act as a buffer between the Module 6D primary liner and the future aerobic cell. The waste was graded to promote drainage and a 60-mil HDPE geomembrane (Image 5-1) was installed to capture all leachate being generated by the aerobic cell. A sixteen-ounce geotextile was then placed on the membrane to act as a cushion for a shredded tire operations layer.

Image 5-1: Aerobic liner ready for shredded tire operations layer and waste placement

Waste placement in the aerobic cell occurred between August 8, 2001 and September 26, 2001. Waste was placed in three 10-foot lifts with 2:1 side slopes on the north, east and west (internal side slopes), and a 3:1 side slope on the south (external side slope) as presented in Detail 5-1. Because of the limited tipping area of the aerobic cell, self-haul waste was excluded. The use of daily cover soil during waste filling was also minimized to aid in the overall permeability of the waste. Whenever possible, greenwaste or tarps were used as alternative daily cover (ADC) and, in the event soil was placed (for example, access roads or tipping pad), the soil was removed prior to placing the next lift of waste. To further aid permeability of the waste, compaction was restricted to only 1to 2 passes with a Caterpillar 826 compactor. Based on waste tonnage records and as-built topography, the in-place refuse density is approximately 800 pounds per cubic yard. Instrumentation Layers 1 and 2 were placed between lifts, and base layer instrumentation was installed on the aerobic cell base liner. A summary of sensors installed on each layer is provided in Appendix A, Table 5-2.



Detail 5-1. Aerobic Cell Cross Section Cell

5.1.1.2 Liquid Addition

Horizontal liquid injection lines were installed in each lift of waste. Injection lines within the waste (between lifts 1 and 2, 2 and 3) were placed horizontally (north to south) every 20 feet. Injection lines on top of lift 3 were placed east to west every 20 feet. Various combinations of 1¼-inch-diameter chlorinated polyvinyl chloride (CPVC) and 1¼-inch-diameter HDPE pipe were installed and perforated with $^{3}/_{32}$–inch-diameter holes spaced every 10 feet (Image 5-2). Because of the elevated temperatures expected in the aerobic cell, CPVC was installed a selected locations as a redundancy in the event the HDPE piping fails (CPVC is rated for service at temperatures up to 200^{o}F, however is approximately 4 times as expensive). A total of 4,780 feet of injection piping was installed with a total of 326 injection holes.

Image 5-2: Leachate injection laterals in trench

Each of the injection laterals will be connected to a 4-inch-diameter HDPE injection header. Flow rate and pressure will be monitored at each injection lateral. Leachate injection for each lateral will be monitored and controlled by individual solenoid valves connected to the SCADA system. A second redundant flow meter will monitor the total volume and flow rate being injected in the aerobic cell.

5.1.1.3 Air Collection

Horizontal air collection lines were installed between each lift of waste. Air collection lines consist of various combinations of alternating 4 and 6–inch-diameter CPVC pipe and 6 and 8–inch-diameter corrugated metal pipe (Image 5-3). Each air collection line utilizes shredded tires as the permeable media. The air collection lines between layers are spaced approximately 40 feet apart. A total of 1660 feet of horizontal air collection lines were installed. A summary of the air collection lines for the aerobic cell is shown in Appendix A, Table 5-3.

Each air collection line will be connected to a 12-inch-diameter air collection header that will convey the gas to and on-site blower and biofilter. Each air collection line will incorporate a pre-manufactured wellhead capable of controlling flow and monitoring flow rate, temperature and pressure. Construction of the blower station commenced in December 2002 and installation of piping from the blower station to the biofilter commenced in February 2003.

5.1.1.4 Surface Liner

Vector was retained to provide design, plans and specifications for a surface lining system, including a biofilter for the treatment of the aerobic off-gas.

Since the operation of an aerobic bioreactor at the Yolo County Central Landfill was first considered, two methods of air management for oxygen delivery have been discussed. One method is to push air into the landfill and the other is to apply a vacuum and draw air through the landfill. Both methods have advantages and disadvantages. However, Yolo County has decided that the best alternative is to leave the aerobic cell covered with soil and greenwaste (shredded yard waste), but without an impermeable geomembrane, so that air could be drawn through the waste by applying a vacuum. In this way, air will enter through the cell surface and migrate to horizontal pipelines to which a vacuum is applied. Alternate operations plans could include using some of the installed pipelines as vents and others for vacuum.

Yolo County had intended to cover the aerobic cell with an exposed geomembrane with a biofilter at the top of the cell to provide some treatment of the off-gas. However, the weight of the geomembrane that would have been placed on the aerobic cell along with the weight of a sandbag surface ballast system would result in a pressure equivalent to only 0.17 inches of water. Calculations indicate that the required pressure present in the cell to force the air through the waste, to the top of the cell, and through the biofilter would result in a great deal of ballooning of the surface liner. Additionally, the expected high settlement rate would create a great deal of maintenance difficulties for the geomembrane surface liner.

Yolo County developed a design for a geomembrane surface liner for the aerobic cell and advertised for bids on the construction. The bids received were very expensive and not within the budget of the project. As a result of both the technical and economic difficulties encountered, it was decided that leaving the aerobic cell without a geomembrane liner is the preferred approach.

5.1.2 Monitoring

Temperature, moisture, leachate quantity and quality, and air pressure and composition are monitored through an array of sensors placed within the waste (Image 5-4) and in the leachate collection and recovery system (LCRS).

Image 5-4: Moisture, temperature, and tube installation

Each sensor location received a temperature sensor (thermistor), a moisture sensor (a PVC moisture sensor and in some cases a gypsum block) and a linear low-density polyethylene (LLDPE) tube. For protection, each wire and tube was encased in a 1.25-inch-diameter HDPE pipe. Refer to Appendix B, Details 5-2 through 5-5 for sensor location diagrams.

Sensors on instrumentation Layers 0.5, 1, and 2 were placed on a bedding of greenwaste (shredded yard waste), or bin fines (fine pieces of greenwaste). Sensors installed on the primary liner (prior to any waste placement) were placed on the geotextile and covered with pea gravel prior to the placement of the shredded tire operations layer.

5.1.2.1 Temperature

Temperature is monitored with thermistors manufactured by Quality Thermistor, Inc. Thermistors with a temperature range of 0°C to 100°C were chosen to accommodate the temperature ranges expected in both the anaerobic and aerobic cells. To prevent corrosion, each thermistor was encased in epoxy and set in a stainless steel sleeve. All field wiring connections were made by first soldering the connection, then covering each solder joint with adhesive-lined heat shrink tubing, and then encasing the joint in electrical epoxy. Changes in temperature are measured by the change in thermistor resistivity (ohms). As temperature increases, thermistor resistance decreases.

5.1.2.2 Moisture

Moisture levels are measured with polyvinyl chloride (PVC) moisture sensors and gypsum blocks. Both the PVC moisture sensors and gypsum blocks are read utilizing the same meter. The PVC sensors are perforated 2-inch-diameter PVC pipes with two stainless steel screws spaced 8 inches apart and attached to wires to form a circuit that includes the gravel filled pipe. The PVC sensors were designed by Yolo County and used successfully during the pilot scale project. The PVC moisture sensor can provide a general, qualitative assessment of the waste's moisture content. A reading of 0 to 40 equates to no free liquid, 40 to 80 equates to some free liquid, and 80 to 100 means completely saturated conditions.

The gypsum blocks are manufactured by Electronics Unlimited and are typically used for soil moisture determinations in agricultural applications. Gypsum blocks establish equilibrium with the media in which they are placed and are, therefore, reliable at tracking increases in the soil's moisture content. However, the gypsum block can take considerable time to dry and therefore may not reflect the drying of the surrounding environment.

5.1.2.3 Leachate Quantity and Quality

Leachate that is generated from the aerobic cell will drain to a separate leachate sump installed on top of the eastside Module D leachate collection sump (Image 5-5). A dedicated pump is then used to remove the leachate and pump it to one of the on-site leachate storage ponds. A flow meter will measure rate and total volume pumped from the sump.

Image 5-5: Aerobic sump installed and ready for backfill

Leachate is monitored for the following field parameters: pH, electrical conductivity, dissolved oxygen, oxidation-reduction potential, and temperature. When leachate is generated in sufficient quantities, the following parameters will be analyzed by a laboratory: dissolved solids, biochemical oxygen demand, chemical oxygen demand, organic carbon, nutrients (NH_3, TKN, TP), common ions, heavy metals and organic priority pollutants. For the first year, monitoring will be conducted monthly for the first six months and quarterly for the following six months. After the first year, monitoring will be conducted semi-annually (pH, conductivity, and flow rate will continue to be monitored on a monthly basis as required by the State of California's amended Waste Discharge Requirements in Order 5-00-134).

5.1.2.4 Pressure

Pressure within the aerobic cell is monitored with ¼-inch inner diameter and $^{3}/_{8}$-inch outer diameter LLDPE sampling tubes. Each tube can be attached to a pressure gage and supplemental air source. By first purging the tube with the air source (to remove any liquid blockages), and then reading the pressure, an accurate gas and/or water pressure can be measured at each sensor location.

5.1.2.5 Landfill Gas Composition and Flow

Landfill gas composition and flow are measured from the pre-manufactured well heads utilizing a GEM-500 combustible gas meter, manufactured by LANDTEC. The GEM-500 is capable of measuring methane (either as a percent by volume or percent of the lower explosive limit), carbon dioxide, and oxygen. A reading for "balance" gas is also provided, which is assumed to be nitrogen.

5.1.2.6 Waste Sampling

Yolo County conducted the first waste sampling event for the aerobic cell on June 5, 2002. Waste was sampled to quantify the methane generation potential of the waste. Waste was drilled to an approximate depth of 30 feet with samples taken at 5-foot intervals. Waste will be sampled from the aerobic cell annually for the next two years to monitor the progress of waste decomposition and compare actual methane generation to laboratory methane generation.

5.1.2.7 Surface Scan

Under current federal guidelines (40 CFR 60.752), landfills exceeding a specific size must monitor for methane surface emissions and any reading in excess of 500 PPM (40 CFR 60.755 (c)) requires corrective action to be taken. The Yolo County Central Landfill is not currently required to test for methane surface emissions, however, as part of the FPA, the County has proposed to conduct quarterly surface scans to demonstrate the emissions (or lack of) from a controlled bioreactor landfill.

Methane concentrations are monitored with a model TVA-1000 Flame Ionization Detector (FID)/ Photo Ionization Detector (PID) instrument. Under the FID setting, the TVA-1000 is capable of detecting methane in the parts-per-million (PPM) range and has an accuracy of ± 2.5 PPM or 25 percent of the reading, whichever is greater. In the event significant methane was detected, the unit could be switched to PID mode to detect volatile organic compounds (VOC). Methane surface concentrations are monitored along the perimeter of the collection area and along a pattern that transverses the landfill at 15 meter intervals. Due to high winds and inclement weather, the surface scan scheduled for December 2002 was postponed until January 2003. The March 2003 aerobic cell surface scan was postponed until April 2003 due to an insufficient supply of hydrogen (needed for the FID) shipped with the instrument. . A summary of the surface scans performed on the aerobic cell is presented below in Table 5-4.

Table 5-4. Summary of Surface Scans Performed on the Aerobic Cell

Surface Scan No.	Date	Max. Emissions Detected	Location of Max. Emissions
1	April 3, 2002	No fugitive emissions detected	Not applicable
2	June 6, 2002	8 ppm	Along the western perimeter of the cell
3	September 20, 2002	3 ppm	South face of the cell near the leachate collection sump
4	January 7, 2003	0.9 ppm	South face of the cell along a gas collection lateral.

The extremely low surface emissions detected from the aerobic cell are not surprising given the low moisture content of the waste (very little water has been added) and full scale operation of the cell has not commenced. Once operation begins, future surface scans should be able to demonstrate the surface emission potential of an aerobic bioreactor landfill.

The detection of surface emissions may also be due to landfill operations in nearby areas. While background concentrations were monitored prior to conducting the surface scan, changes in wind currents could have transported methane from adjacent areas. During June 2002 and September 2002, grading and waste filling activities in the adjacent west-side 6-acre area could have promoted the detection of gas emissions in the aerobic cell. Additionally, activities from Module D Phase II construction (which involved exposing waste form an adjacent unit to facilitate base liner installation) could have promoted the detection of gas emissions during the September 2002 surface scan. The surface emissions detected on the south face in January 2003 was due to a loose flex hose along a gas collection lateral that was immediately tightened.

The true methane emissions detected are also a function of the accuracy of the surface scan equipment. The TVA-1000 FID instrument has an accuracy of ±25 percent of reading or ±2.5 ppm, whichever is greater, from 1.0 to 10,000 ppm. Thus many of the surface emissions are outside (below) the accuracy range and thereby assumed to be negligible.

5.1.3 Operation

Operation of the aerobic cell as a bioreactor will begin once the air collection system, leachate recirculation systems, and SCADA control systems are complete. At this time, we anticipate bioreactor operation to begin by the end of June 2003.

5.1.3.1 Leachate Recirculation

Initially, large volumes of liquid will be added to bring the waste to field capacity (Image 5-6). Once field capacity has been reached, only enough liquid to maintain field capacity will be added. We anticipate that greater volumes of liquid (compared to the anaerobic cells) will be necessary to maintain field capacity due to the removal of liquid by the air collection system.

Image 5-6: Aerobic leachate injection header and lateral

5.1.3.2 Air Collection
Air collection will begin as soon as the necessary piping, blower, and biofilter is installed, which is anticipated to be in May 2003.

5.2 Results And Discussion
Sensor names are represented numerically by the instrumentation layer in which the sensor is located and by the assigned sensor number. The base layer is represented by a 0, Layer 1 is represented by a 1, and so forth. The complete name of the sensor is denoted by the layer number – the sensor number . For example, the second sensor on Layer 1 is named 1-02.

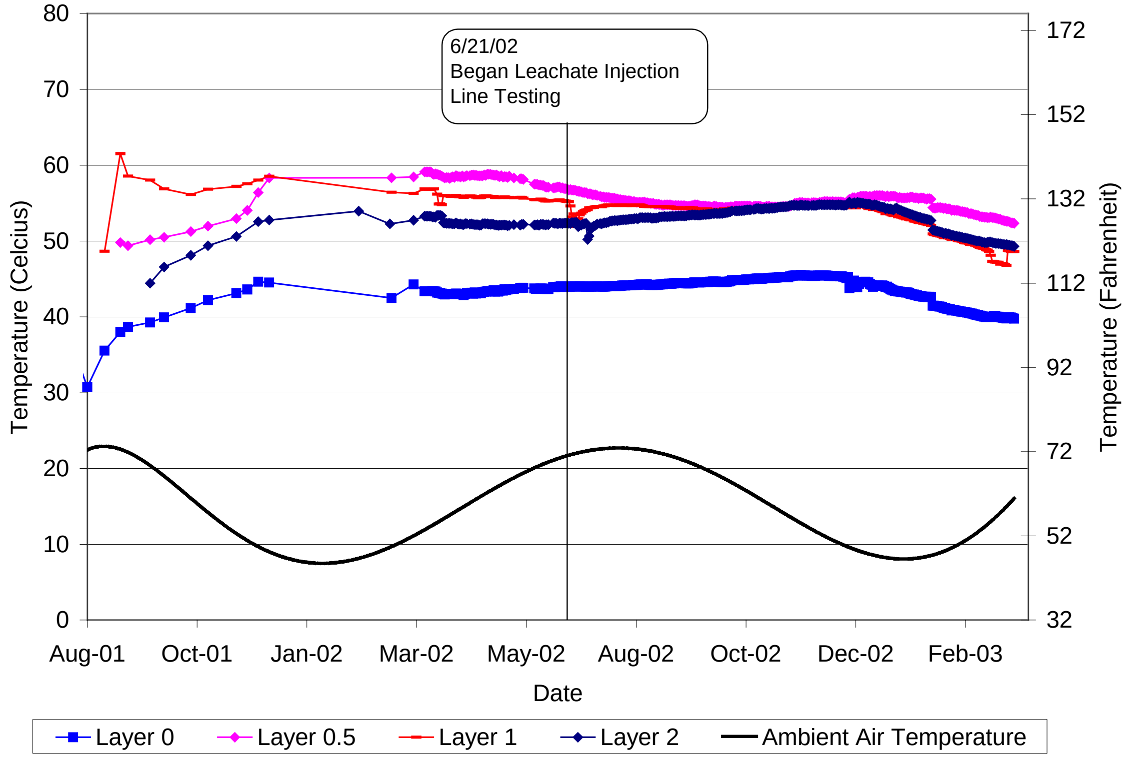
5.2.1 Temperature
Temperature is monitored with thermistors manufactured by Quality Thermistor, Inc. Thermistors with a temperature range of 0°C to 100°C were chosen so they would be able to accommodate the temperature ranges expected in both the anaerobic and aerobic cells. Resistance was measured by the SCADA system located in the instrumentation shed starting in March 2002. Resistance was previously measured manually by connecting the sensor wires to a 26 III Multimeter manufactured by Fluke Corporation.

Temperature results are presented in Appendix C, Figures 5-1 to 5-4. A summary of the results is presented below in Table 5-5 and Figure 5-5.

Table 5-5. Temperature Summary for the Aerobic Cell

	Previous Reporting Period (10/1/02 to 12/31/02)			Current Reporting Period (01/01/03 to 03/31/03)		
Layer	**Minimum Temp. (°C)**	**Maximum Temp. (°C)**	**Average Temp. (°C)**	**Minimum Temp. (°C)**	**Maximum Temp. (°C)**	**Average Temp. (°C)**
0	30.6	61.9	44.3	25.4	61.2	41.6
0.5	50.2	61.3	55.1	47.3	61.5	54.4
1	35.7	73.2	54.4	17.4	72.1	51.0
2	44.2	72.4	53.0	34.5	72.2	51.7

Figure 5-5. Average Temperatures for the Aerobic Cell



5.2.2 Moisture

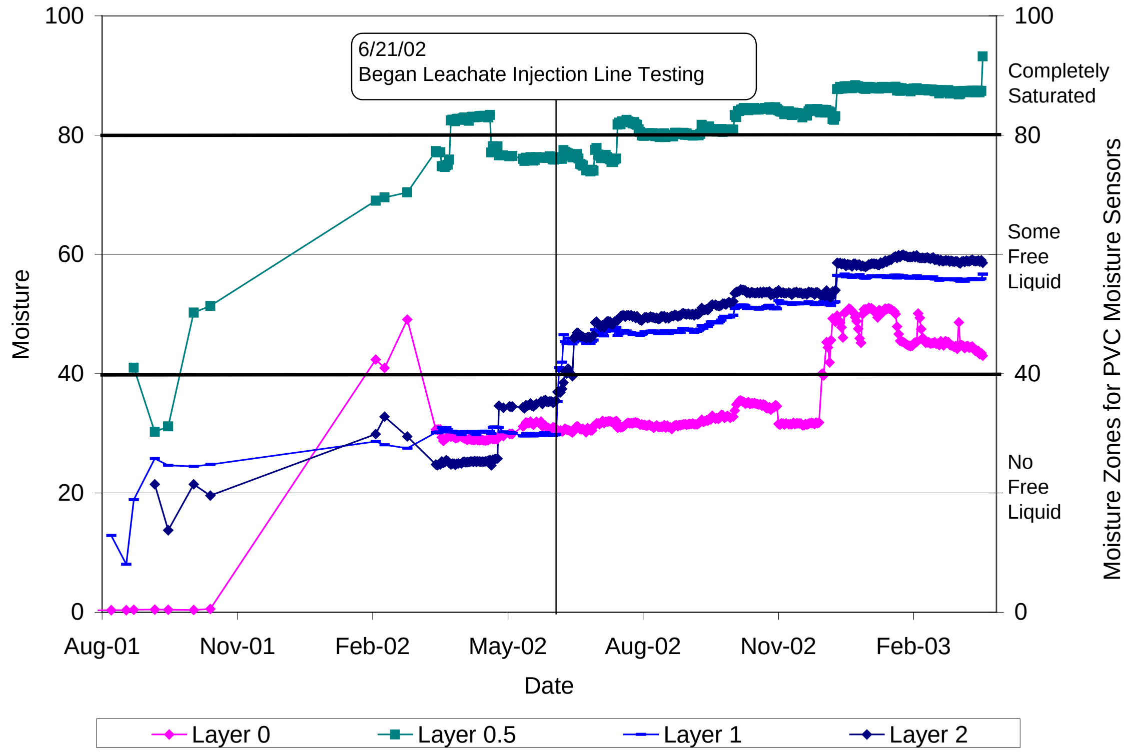
The SCADA system started electronically measuring moisture in March 2002. Moisture was previously measured manually with a Model MM 4 moisture meter manufactured by Electronics Unlimited. During the pilot scale project, Yolo County conducted laboratory tests with the PVC sensors to determine the relationship between the multimeter readings and the presence of free liquid in the PVC sensor. It was determined that a meter reading of less than 40 corresponded to an absence of free liquid. A reading between 40 and 80 corresponds to the presence of free liquid in the PVC pipe but less than saturated conditions. Readings of greater than 80 indicate saturated conditions; i.e. the PVC sensor is full of liquid.

PVC moisture results are presented in Appendix C, Figures 5-6 to 5-9. A summary of the results is presented below in Table 5-6 and Figure 5-10.

Table 5-6. PVC Moisture Summary for the Aerobic Cell

	Previous Reporting Period (10/1/02 to 12/31/02)			Current Reporting Period (01/01/03 to 03/31/03)		
Layer	**Minimum Moisture**	**Maximum Moisture**	**Average Moisture**	**Minimum Moisture**	**Maximum Moisture**	**Average Moisture**
0	3.0	94.8	31.5	3.2	46.9	94.8
0.5	76.3	94.1	79.1	80.2	94.4	87.2
1	10.6	90.2	46.8	10.3	89.9	56.1
2	7.0	89.9	49.3	6.2	90.6	58.9

Figure 5-10. Average Moisture Levels for the Aerobic Cell



5.2.3 Leachate Quantity And Quality

Leachate was last sampled in May 2002 for analytical testing. Analytical results are presented in Appendix E, Table 5-7. Field chemistry and selected analytical results are presented below in Table 5-8. Leachate will be sampled on a monthly basis once liquid addition commences.