Table 5-8. Field Chemistry for Leachate Sampled from the Aerobic Cell

PARAMETER	DATE:	2/26/2002	3/27/2002	5/14/2002
Field Parameters:	**Units**			
PH		7.75	8.17	8.48
Electrical Conductivity	µmoh/cm	7026	7705	9048
Oxidation Reduction Potential	MV	195	195	127
Temperature	C	15.1	15.2	21.1
Dissolved Oxygen	mg/L	5.45	5.73	6.8
Total Dissolved Solids	ppm	5673	NA	7448
General Chemistry:				
Ammonia as N	mg/L	2.8	1.1	0.60(tr)
Bicarbonate	mg/L	1120	935	1020
BOD	mg O/L	3.3	5	89
Chemical Oxygen Demand	mg O/L	595	563	602
Chloride	mg/L	1610	1800	2290
Nitrate/Nitrite as N	mg/L	0.16	0.22	4.8(tr)
Total (Non-Volatile) Organic Carbon	mg/L	766	149	168
Total Alkalinity as CaCO3	mg/L	1120	935	1050
Total Dissolved Solids @ 180 C	mg/L	4810	5200	5640
Total Kjeldahl Nitrogen	mg/L	19.9	19.2	11.1
Total Sulfide	mg/L	<0.014	0.015(tr)	<0.014
Dissolved Iron	mg/L	0.32	0.084(tr)	0.34
Dissolved Magnesium	mg/L	273	260	220
Dissolved Potassium	mg/L	NA	66.1	47.8

NA=Not Analyzed

Analytical results show an increase in several parameters such as BOD, sulfate, chloride, and several metals (i.e. barium, calcium, and manganese, etc.). However, there has also been a decline in ammonia, total organic carbon, and several metals including magnesium, sodium, and VOC's. Additional data is needed for a thorough assessment of the leachate parameters. When leachate is generated in more sufficient quantities, it will be sampled for analytical testing.

6 MODULE 6D BASE LINER

The three bioreactor cells share a common composite liner system, designated the Module 6D primary liner. This composite liner system was constructed in 1999 and was designed to exceed the requirements of Title 27 of CCR and Subtitle D of the Federal guidelines.

6.1 Experimental

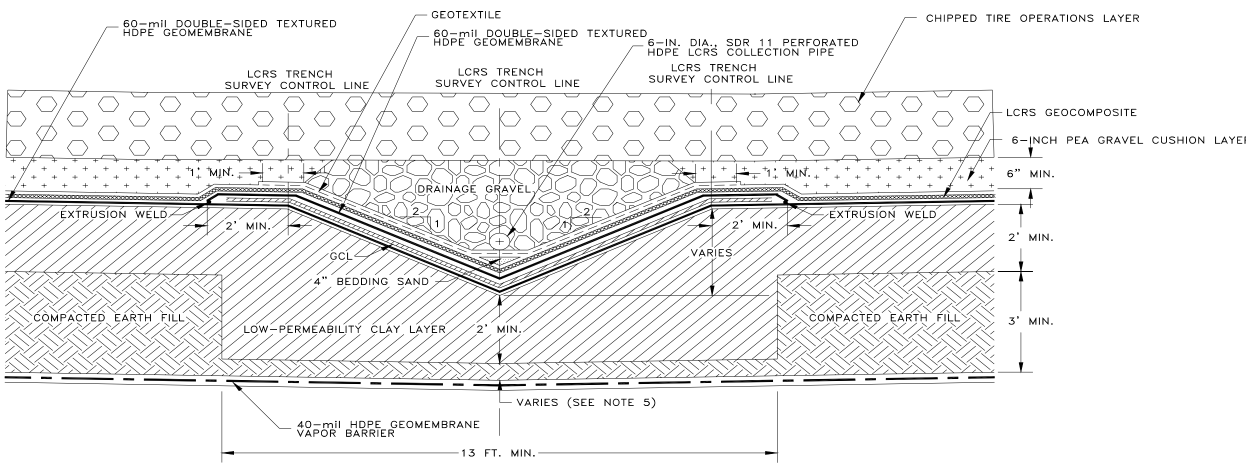
The experimental methods utilized are grouped into two categories: construction and monitoring. Each of these categories is discussed below.

6.1.1 Construction

Construction of the Module 6D primary liner system can generally be separated into two tasks: grading and base liner assembly.

6.1.1.1 Grading

The base layer of Module D was constructed in a ridge and swale configuration, enabling the west-side 6-acre anaerobic cell to be hydraulically separated from the northeast anaerobic cell and the aerobic cell in the southeast quadrant. The base layer slopes 2 percent inward to two central collection v-notch trenches located on the southeast and southwest side of Module D (Detail 6-1). Each of the trenches drain at 1 percent to their respective leachate collection sumps located at the south side of the module.



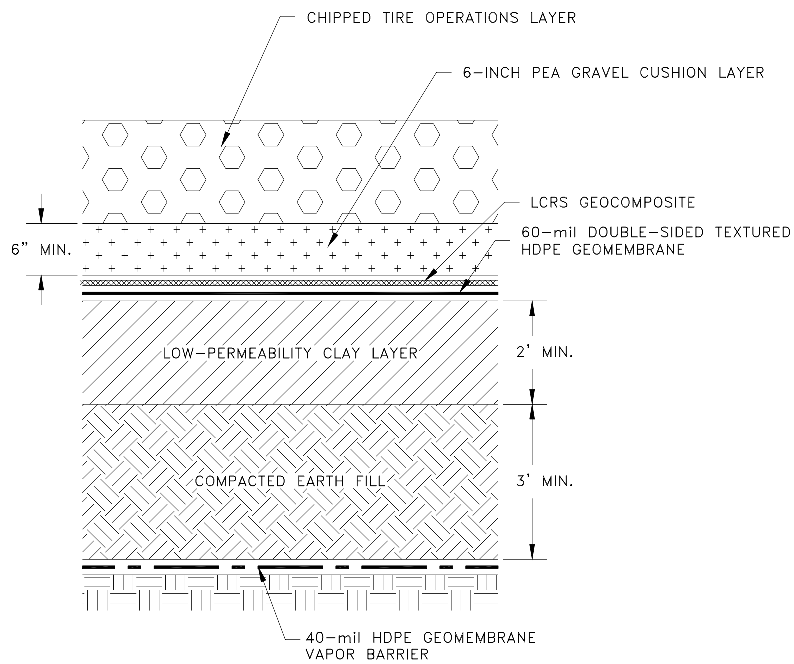
Detail 6-1. Module D Bottom Liner and Leachate Collection Trench Cross-Section

6.1.1.2 Base Liner Assembly

The liner is composed, from top to bottom, of the following materials: an operations/drainage layer consisting of 2 feet of chipped tires (permeability [k] > 1 centimeter per second [cm/s]) (Image 6-1), 6-inches of pea gravel, geocomposite drain net, a 60-mil high density polyethylene

Image 6-1: Shredded tire operations layer

(HDPE) geomembrane, a 2–foot-thick compacted clay liner (k < 6 x 10^{-9} cm/s), 3 feet of compacted earth fill (k < 1 x 10^{-8} cm/s), a 40-mil HDPE vapor barrier layer, and a clay subgrade with 90-percent (ASTM D1557) relative compaction[3] (Detail 6-2).



Detail 6-2. Module D Bottom Liner Cross-Section

6.1.2 Monitoring

Temperature, moisture, and pressure are monitored through an array of sensors placed within the waste and in the leachate collection and recovery system (LCRS). Each sensor location on the base layer received a temperature sensor (thermistor), a linear low-density polyethylene (LLDPE) tube, and selected locations received a PVC moisture sensor. For protection, each wire and tube was encased in either a 1.25-inch HDPE pipe or run inside the LFG collection piping. Refer to Appendix B, Detail 6-3 for sensor location diagram.

Sensors installed on the primary liner (prior to any waste placement) were placed on geocomposite and covered with pea gravel prior to the placement of the chipped tire operations layer. A summary of sensors installed on the base liner is provided in Appendix A, Table 6-1.

As part of the requirements specified under Waste Discharge Requirements in Order 5-00-134, Yolo County is required to monitor liquid buildup on the liner. Under typical landfilling, liquid buildup on a Class III composite liner system must be maintained to less than 1 foot. In order to gain approval from the California Regional Water Quality Control Board to operate Module 6D as a bioreactor, Yolo County must maintain less than 4-inches of liquid buildup on the Module 6D primary liner[4]. Head over the liner is monitored through a series of pressure transducers and sampling tubes either in or next to the leachate collection trenches (Appendix C, Figure 6-10). In

[3] Golder Associates, "Final Report, Construction Quality Assurance, Yolo County Central Landfill, WMU 6, Module D, Phase 1 Expansion", December 1999.
[4] California Regional Water Quality Control Board, Central Valley Region, "Waste Discharge Requirements for the Yolo County Central Landfill, No. 5-00-134", June 16, 2000.

addition, sampling tubes located on the Module 6D liner (designations 0-1 through 0-66) are utilized to monitor head over the liner.

6.1.2.1 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.

6.1.2.2 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.

6.1.2.3 Leachate Collection Trenches

Three LLDPE sampling tubes were installed in each of the leachate collection trenches (Image 6-2). The tubes were installed inside a 2-inch-diameter PVC pipe for protection, and terminate at different points along the trenches. The sampling tubes can be hooked up to the same "Magnahelic" pressure gage, which reads directly in inches-of-water.

Pressure transducers were installed at three locations adjacent to each leachate collection trench. Additionally, tubes were installed that terminate adjacent to each of the pressure transducer locations (Appendix B. Detail 6-2). The pressure transducers provide an output current between 4 and 20 milliamps, which is directly proportional to pressure. The pressure transducers installed on the Module 6D liner are Model PTX 1830 manufactured by Druck, Inc. Their pressure range is 0 to 1 pounds per square inch (psi) and has+0 an accuracy of ±1 percent of full scale.

Image 6-2: Pressure tubes installed in LCRS trench

6.2 Results And Discussion

Tubes located in the leachate collection trenches are referred to as trench liquid level (TLL) tubes. Pressure transducers and their accompanying tubes that are located adjacent to the leachate collection trenches are denoted as PT or PT-TUBE respectively.

6.2.1 Temperature

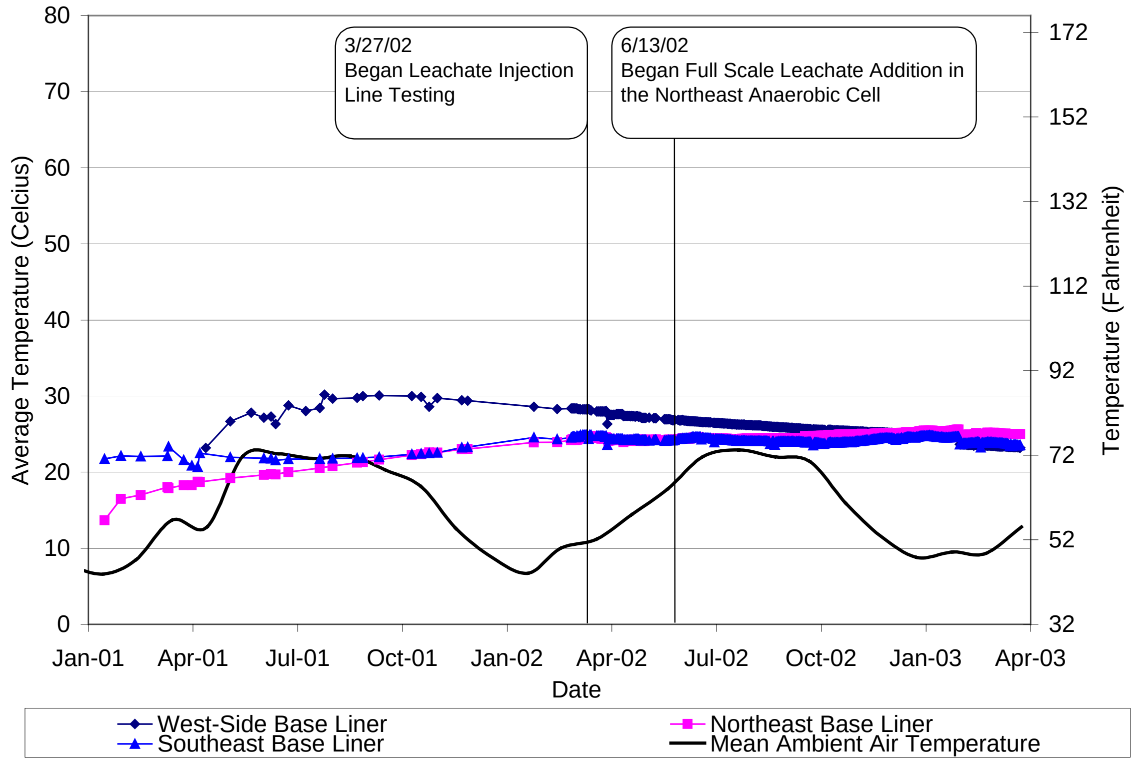
Temperature is monitored with thermistors manufactured by Quality Thermistor, Inc. Thermistors with a temperature range of 0°C to 100°C were chosen so they would be able to accommodate the temperature ranges expected in both the anaerobic and aerobic cells. Resistance was measured by the SCADA system 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 6-1 to 6-4. A summary of the results is presented below in Table 6-1 and Figure 6-5.

Table 6-1. Temperature Summary for the Base Liner

	Previous Reporting Period (10/1/02-12/31/02)			Current Reporting Period (01/01/03 to 03/31/03)		
Location	Minimum Temp. (°C)	Maximum Temp. (°C)	Average Temp. (°C)	Minimum Temp. (°C)	Maximum Temp. (°C)	Average Temp. (°C)
Northwest	11.3	30.6	27.3	8.2	30.1	24.0
Southwest	18.6	30.2	26.1	15.8	29.1	24.0
Northeast	13.5	29.8	24.5	12.2	30.8	25.2
Southeast	13.0	33.5	24.1	10.2	34.5	24.1

Figure 6-5. Average Temperatures on the Base Liner



6.2.2 Moisture

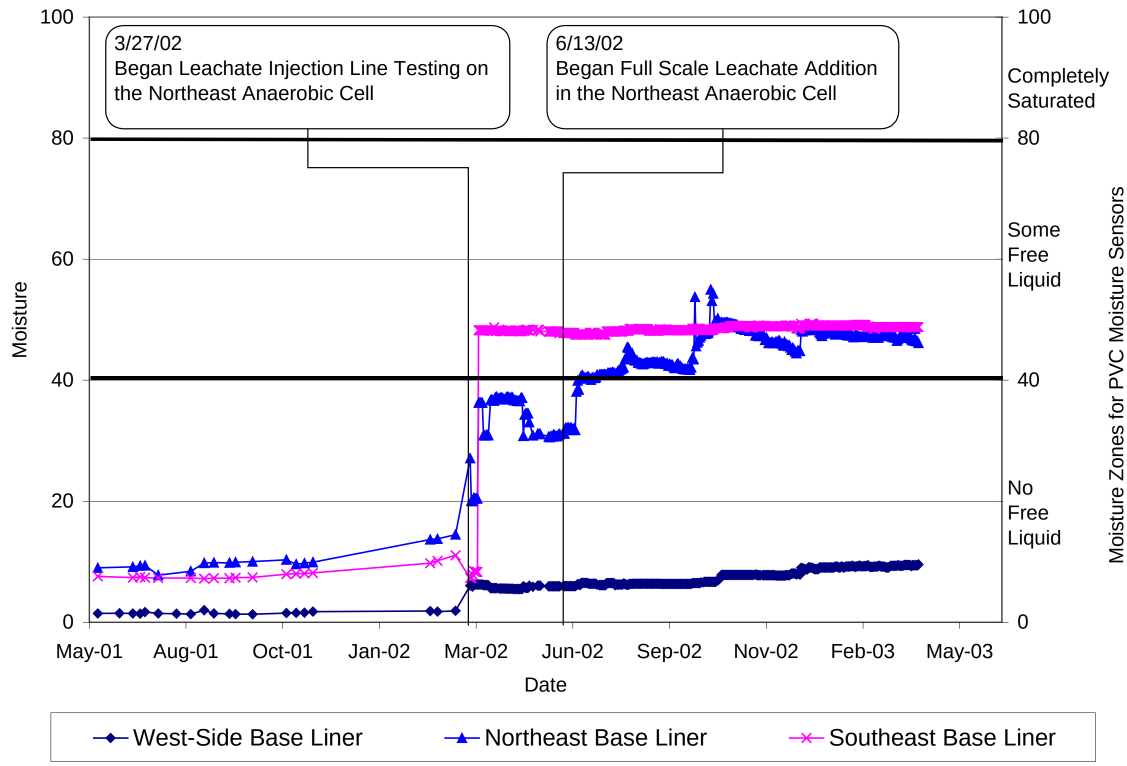
The SCADA system started electronically measuring moisture in March 2002. Due to a slight variation between how the SCADA system measures moisture compared to the manual meter, moisture readings generally increased a small fraction relative to their previous manually recorded readings. Because moisture data are unitless numbers that give a qualitative assessment rather than a quantitative measure, we feel that this slight change is not significant. 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.

Moisture results are presented in Appendix C, Figures 6-6 to 6-8. A summary of the results is presented below in Table 6-2 and in Figure 6-9.

Table 6-2. PVC Moisture Summary for the Base Liner

	Previous Reporting Period (10/1/02 to 12/31/02)			Current Reporting Period (01/01/03 to 03/31/03)		
Location	**Minimum Moisture**	**Maximum Moisture**	**Average Moisture**	**Minimum Moisture**	**Maximum Moisture**	**Average Moisture**
West-Side	4.0	19.9	6.3	6.5	20.3	9.2
Northeast	22.3	94.4	42.5	26.6	88.2	47.5
Southeast	8.3	88.2	48.2	8.8	88.2	48.9

Figure 6-9. Average Moisture Levels on the Base Liner



6.2.3 Leachate Collection Trenches

Liquid level data adjacent to the leachate collection trenches is presented in Appendix C, Figure 6-10. Pressure transducers three and four shows increasing liquid levels that are not supported by data from other sensors. During the next quarter, pressure transducers three and four will be removed and tested. A summary of the results is presented below in Table 6-3.

Table 6-3. Leachate Level Summary for the Base Liner

	Previous Reporting Period (10/01/02 to 12/31/02)			Current Reporting Period (01/01/03 to 03/31/03)		
Pressure Transducer	Min. Level (In. of Water)	Max. Level (In. of Water)	Avg. Level (In. of Water)	Min. Level (In. of Water)	Max. Level (In. of Water)	Avg. Level (In. of Water)
1	0.25	0.34	0.31	0.22	0.40	0.30
2	0.26	0.43	0.28	0.32	0.62	0.46
3	0.95	1.99	0.95	1.4	2.02	1.85
4	0.00	0.22	0.11	0.01	1.55	0.43
5	0.31	0.47	0.39	0.29	0.48	0.37
6	0.00	0.16	0.14	0.01	0.15	0.04

7 SUPERVISORY CONTROL AND DATA ACQUISITION SYSTEM (SCADA)

The Supervisory Control and Data Acquisition (SCADA) system is used to monitor the various sensors and control the operation of the bioreactor. The field electronics are linked by radio signal to a computer located in our Woodland office.

7.1 Hardware Installation

The data collection hardware has been installed in a shed located at the southern limit of Module 6D. All instrumentation installed in the northeast anaerobic, west-side anaerobic, aerobic, and on the Module 6D composite liner will be connected to an Allen-Bradley central processor which is radio linked to a computer located in our woodland office.

Image 7-1: Completed hardware installation

7.2 Software Programming

The SCADA programming using Wonderware software is currently being developed by a consultant, A-TEEM Electrical Engineering. The first phase of the software development is

complete and encompasses data collection from the instrumentation installed on the Module 6D liner, northeast anaerobic, and south
east aerobic modules. Once the remaining instrumentation in the west-side anaerobic cell has been run the shed, it will be incorporated into the system. The following images provide an overview of the SCADA programming.

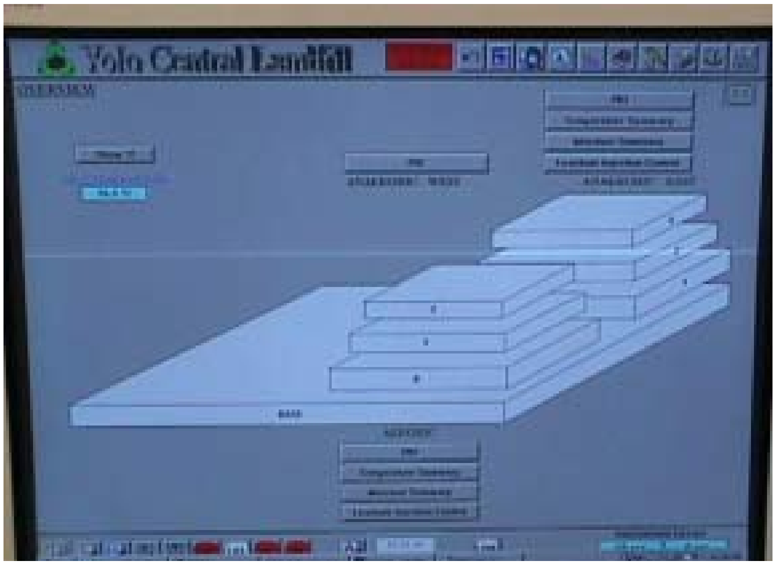


Image 7-2: SCADA overview screen. From here you can access each layer within the bioreactor cells.

Image 7-3: NE anaerobic cell, layer 2 screen depicting temperature and moisture data.

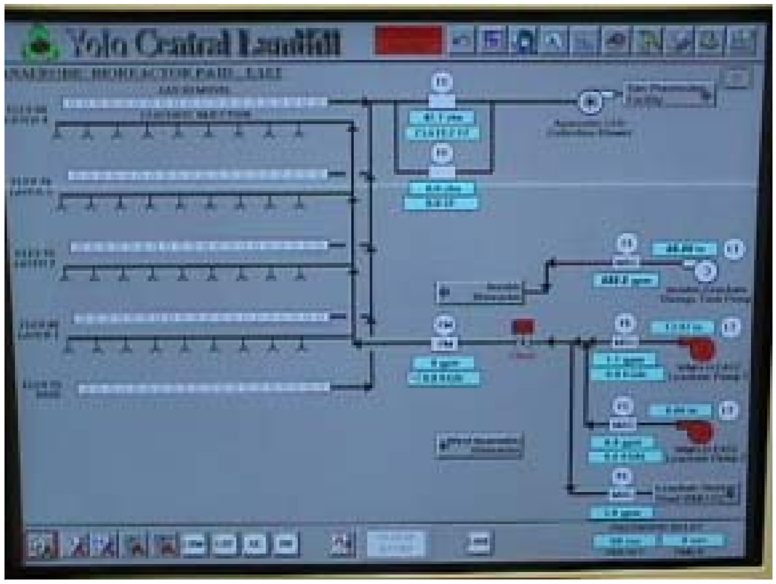


Image 7-4: Piping overview screen, displaying flows from the various meters. This screen can also be used to access leachate injection controls.

Image 7-5: NE anaerobic bioreactor layer 3 and 4 leachate injection control.

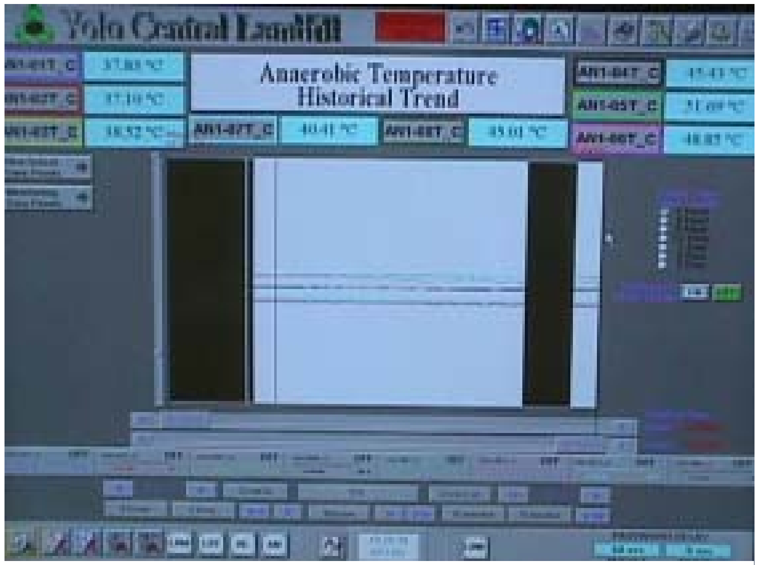


Image 7-6: Historical data can be graphed and displayed directly on the screen.

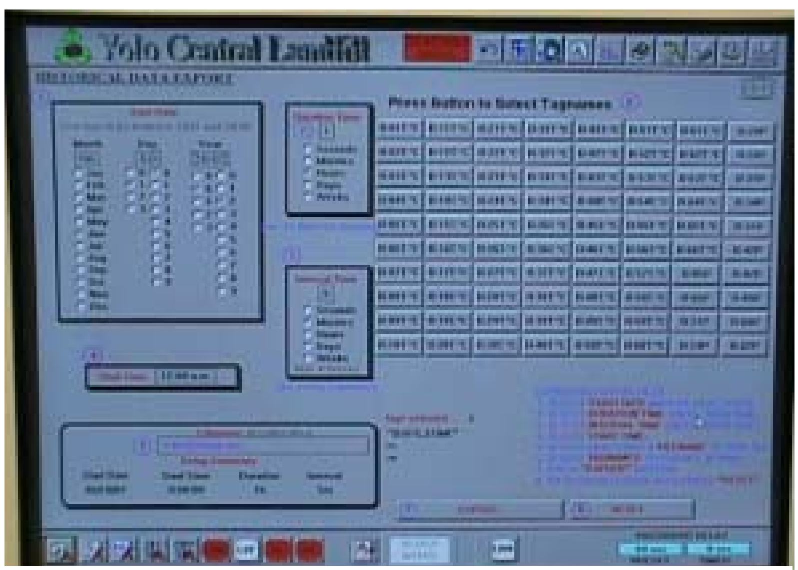


Image 7-7: Historical data export screen. Data is exported to a database for manipulation and graphing

8 CONCLUSION

With the construction complete, and full-scale operation underway, the response of the northeast anaerobic cell is generally as expected. Moisture sensors are indicating that injected liquid is being distributed relatively uniformly. Temperatures within the cell are normal and within the range necessary for anaerobic decomposition.

Gas production has steadily increased over time (and we expect it to continue to increase over the next year). Methane totaling 22.3 x 10^6 scf has been removed from 65,104 tons of waste in the northeast cell and 5.3 x 10^6 scf has been removed from 166,294 tons of waste in the west-side cell. VOC levels within the landfill gas from the northeast cell have decreased and surface emissions from the module are virtually non-existent.

Fugitive surface emissions from the aerobic cell remain extremely low. Because liquid addition has not commenced in the aerobic cell, its full potential at eliminating fugitive surface emissions has yet to be evaluated. Additionally, methane surface emissions (minus background readings) from the northeast 3.5-acre cell are extremely low, and essentially negligible. Two major items that are responsible for this effective control of surface emissions are the following: 1) The installation of a synthetic cover over the entire cell, and 2) The use of an active landfill gas extraction system. Higher methane emissions have been detected from the west-side anaerobic cell. These emissions are attributed to the west-side cell undergoing waste placement during the surface scans performed from June 2002 to September 2002 and emissions due to unsealed areas were piping penetrates the surface liner. We expect to detect lower fugitive surface emissions in the future due to the completion of the gas extraction system.

Final construction of the aerobic blower facilities continued during this reporting period. The components of the aerobic blower station have been installed and the electrical work associated with the blower station have been completed. Installation of piping from the blower station to the biofilter began in February 2003 and construction of the biofilter is scheduled to begin in April 2003.

9 REFERENCES

1. Vector Engineering, “Design Report for the Surface Liners of the Module D Phase 1 Bioreactors at the Yolo County Central Landfill”, October 2001.

2. Yazdani, R., Moore, R. Dahl. K. and D. Augenstein 1998 Yolo County Controlled Landfill Bioreactor Project. Yolo County Public Works and I E M, Inc. Yolo County Public Works and I E M, Inc. report to the Urban Consortium Energy Foundation (UCETF) and the Western Regional Biomass Energy Program, USDOE.

3. Golder Associates, “Final Report, Construction Quality Assurance, Yolo County Central Landfill, WMU 6, Module D, Phase 1 Expansion”, December 1999.

4. California Regional Water Quality Control Board, Central Valley Region, “Waste Discharge Requirements for the Yolo County Central Landfill, No. 5-00-134”, June 16, 2000.

5. Yolo County, IEM, SWANA, EPA, Final Project Agreement for the Yolo County Accelerated Anaerobic and Aerobic Composting (Bioreactor) Project, September 14, 2000.

6. Tchobanoglous et al, “Integrated Solid Waste Management, Engineering Principles and management Issues”, McGraw-Hill, 1993.