Section 3
Bioreactor System Design

The design concept of the bioreactor system is to employ four application methods for increasing the moisture content of the waste in the landfill. The proposed primary application method is to use a pumping system to inject leachate and water into a series of horizontal injection trenches (HITs) and vertical injection wells (VIWs) constructed within the waste. The HITs will be installed at intermediate depths of the landfill whereas the VIWs will only be installed when final grades are obtained in order to avoid obstructing the disposal operation.

The pressurized system will provide extensive wetting of the waste and will reduce the potential for clogging by forcing the flow of liquid through the aggregates around the HITs and VIWs thereby scouring away biological growth. Each HIT and VIW will connect to a lateral force main that is connected to a main header pipe running up the side slope of the landfill. A force main installed along the perimeter of the landfill will carry flow from the leachate storage pond to the main header pipes. The leachate pond will also store river water pumped from the French Broad River.

The pressure system will be augmented by surficial gravity trenches (SGTs) and direct application at the working face. The SGTs are gravity trenches constructed approximately 10-feet below the final cover in locations that are impractical for installing HITs or VIWs (i.e.; too close to sideslopes for HIT or too shallow for VIWs). The SGTs will provide a more limited lateral extent of wetting as a result of lower pressures but they will be adequate for wetting the areas of waste located beyond the wetting range of the pressure system. The SGTs will be charged with water delivered by water trucks. The water trucks will use groundwater obtained from the onsite well located on the south side of the landfill. Water trucks will also be used to wet waste as it is placed at the working face. This will ensure that all waste placed in the landfill receives additional moisturization.

3.1 Advantages of the Proposed System

The proposed system provides the following advantages:

- It can be operated at any time. A subsurface system is not dependent on fair weather conditions for operation. Since the system is contained it is not affected by temperature, precipitation, or wind. As a result, the pumping system can be operated during inclement weather.

- It avoids interference with the disposal operation. The HIT, which will be installed at various intermediate stages of the filling operation, do not present obstructions to the landfill operators and therefore are not prone to damage caused by the compaction equipment and collection trucks. Spacing of the HIT are independent of the disposal operation because they are installed below grade. As a result they

can be spaced close together without impacting the movement of vehicles. This provides more thorough wetting of the waste. The installation of VIWs will be delayed until final grades are reached to maximize the wetting zone of each VIW and to avoid interference with the disposal operation.

- The combined wetting system offers a more thorough form of wetting over a shorter period of time. The timeframe for wetting the waste is greatly reduced by incorporating multiple methods of wetting. Pre-wetting the waste through direct application at the working face provides a jumpstart to the wetting process. In addition, the HIT/VIW injection system is capable of delivering high flow rates and will allow the target moisture content to be reached in less than three years. The use of a pumping system maximizes both the amount of liquid that can be injected and the amount of waste that is wetted because pressure systems can force liquid to penetrate farther into the surrounding waste.

- The bioreactor components can be used to collect gas. As gas generation occurs, the HITs, VIWs, and SGTs can be used to collect landfill gas when wetting is not being performed.

3.2 Horizontal Injection Trench and Vertical Injection Well Design and Layout

The subsurface component of the proposed system consists of HITs and VIWs distributed throughout the landfill. Details of the HIT and VIW are presented on Sheets 9 and 10, respectively. For the HITs, two-foot by three-foot trenches will be excavated at intermediate elevations over completed lifts and filled with NCDOT No.2 stone (1.5"-2.5" diameter). Tire shreds were also considered for use in the trenches as stated in Table 1 of the FPA but were not selected for the following reasons:

- Tire shreds are sensitive to overburden pressures due to the compressibility of the material and therefore can only be used in areas with less than 70 feet of waste without experiencing significant loss in void space.

- Tire shreds offer much less support as a bedding material and therefore significantly reduce the factor of safety against failure of the HDPE pipe.

A 6-inch, perforated, SDR 17, HDPE pipe will be installed in each HIT to distribute leachate and water. High density polyethylene (HDPE) was selected due to its ability to withstand settlement. The pipe will be perforated with 2 rows of 1/2-inch holes as shown in Detail G on Sheet 9.

To prevent side seepage and air intrusion, the head of each HIT will be set back at least 100-feet from the sideslope and sealed with a 5-ft x 5-ft x 3-ft compacted clay or bentonite augmented soil plug. A non-perforated pipe will be installed for the first

100 feet from the sideslope, penetrate the 3-foot thick clay plug, and connect to the perforated pipe in the HIT. The HIT set back will also increase stability within the landfill by maintaining an outer veneer of dry waste that will act as a resistive force against movement of the waste. The set back also ensures that a sufficient depth of waste is present over the injection areas to prevent significant pore pressure from building up.

The VIWs will be constructed with 36" diameter bore holes to depths within 10-feet of the bottom of the landfill. The VIWs will use NCDOT #4 stone and 8-inch slotted PVC pipe for the injection zone. Solid PVC pipe will extend 20-feet below the bottom of the final cover. The annular space around the solid pipe will be filled with bentonite to provide an airtight seal. The top of the VIWs will be mounted with a wellhead for gas collection and a valved stub out for connection to the injection system force main.

An overall view of the proposed layout for the HITs and VIWs is presented on Sheets 5 and 6. Vertical spacing for the HITs is every 30 feet and horizontal spacing between HITs is typically 100 feet. Horizontal spacing is reduced to 75-feet in some areas to allow better fit of the HITs in irregularly shaped footprints. Most of the VIWs are spaced approximately 100 feet apart. Some VIWs are spaced closer to accommodate the shape of the landfill.

The phased installation plan is presented on Sheets 2, 3, and 4. The HITs located in the first tier are generally aligned with the orientation of the leachate collection pipes in each cell to maximize the length of the HITs. Where possible the HIT are aligned in a north-south direction and access is provided to both ends of the HIT. This will provide a means of continued use of an HIT in the event a segment of a HIT is crushed or flooded.

The phasing plan is designed to minimize the waste footprint and maximize vertical placement of waste so that the HIT are covered and useable as soon as possible. For instance, in Phases 4-7 waste is placed in Cell 6 up to el. 2150 rather than expanding to Cell 7 at a lower elevation, thereby allowing activation of HITs 6-21.

The proposed layout is intended to provide even distribution of leachate and water in a cost-effective manner. The HIT alignments from one tier to the next are staggered so that each HIT is located approximately at the midpoint between the HIT in the tiers above and below. Offsetting the HIT in this manner will take advantage of the cascading effect that will occur as portions of the injected leachate and water follow preferential flow paths and migrate to the lower waste depths. This action will aid in wetting the areas of the waste that receive the least amount of moisture from the HIT in the tier below (i.e.; the waste that is located at the farthest horizontal distance from the points of injection). The effect is compounded as additional tiers of HIT are installed over an area.

This layout also provides good dispersal at relatively low injection pressures (10-15psi). Maintaining low injection pressures will prevent excessive pore pressure build up that can cause instability in the waste mass. Recorded injection pressures at the Dona Juana Landfill in Bogotá, Columbia were as high as 40 psi and are thought to have contributed to increases in pore pressure that resulted in a failure of the waste mass (Kavazanjian, Jr., 2001).

To account for settlement of the waste, the HIT will be constructed sloping downward from the side slope towards the center of the landfill at a 1 percent grade. The slope will be obtained in one of two ways:

- The landfill operators will grade the top of the waste lift at 1 percent prior excavating the HIT, or
- The HIT will be excavated progressively deeper from the side slope to the far end of the HIT at a 1 percent slope.

Sloping the HIT towards the center of the landfill will promote drainage of the leachate and water away from the side slopes, which will reduce the potential for seepage. Since settlement will be greatest at the center of the landfill and the least at the perimeter, the inward sloping of the trenches will be enhanced as settlement occurs. This will greatly reduce the potential for forming dips that may lead to flooding of the pipes. Avoiding flooding is important because the HIT will also be used to collect gas as described is Section 4.

The VIWs are located in areas of the landfill that are inaccessible to the HIT due to proximity of the sideslopes or the slope of the base grades. VIWs 1-30 will wet waste in the lower depths of existing Cells 1-3 where HITs were not installed. VIWs 31- 77 will wet areas of Cells 4, 5, 8, 9, and 10 that are not covered by the HITs.

3.3 Pumping System Design

The pumping station for injecting into the HITs and VIWs will be located at the existing leachate storage pond and use the existing slope riser pump station established for pumping to the leachate transfer vehicles. The existing pump will be replaced with a high flow pump that meets the hydraulic head requirements for pumping to the highest elevation HITs and VIWs. It will be equipped with a flowmeter to track the amount of liquid being injected.

Since the injection process is not hindered by weather it will occur on a daily basis. The primary concern will be making sure that adequate leachate is in the pond for the bioreactor operation. When compared to daily injection rates, the rate of leachate flow into the leachate storage pond is relatively small and will need to be supplemented with additional water.

The proposed plan is to pump water from the French Broad River to the leachate storage pond. The proposed location of the pump station and the routing of the force main from the French Broad River are shown on Sheet 8. The proposed location, which is due south of the landfill, resides on riverfront property owned by Buncombe County. To avoid excavation of or boring under Hwy 251, the proposed routing of the force main is to run the pipe through an existing box culvert located near the proposed pump station location (This will also avoid the need to apply for a highway encroachment permit from NCDOT). There is an electrical line on the landfill property that runs near the junction of Hwy 251 and the entrance of the landfill construction road that will provide a convenient power source for the pump station. Prior to constructing the pump station the County is required to obtain 404 certification from the Army Corps of Engineers using Nationwide Permit No. 13 and corresponding 401 certification from the NCDENR Division of Water Quality. This permit requires the County to minimize damage to the riverbank and to restore the disturbed riverbank following construction. Investigation of other potential permit requirements revealed that a withdrawal permit is required by NCDENR for quantities exceeding 100,000 gpd. At this time it is not anticipated that the daily withdrawal for the bioreactor operation will exceed 100,000 gallons therefore this permit is not required. Notification of the river withdrawal is required by the Federal Energy Regulatory Commission to ensure that it does not impact any hydroelectric facilities. CDM's preliminary investigation did not reveal any hydroelectric facilities on the French Broad River.

The pond will be monitored to ensure that a sufficient quantity of leachate and/or water is available before each pumping event. Remote operation of the pump station located at the French Broad River will allow the operators to add water to the leachate pond as required. Level controls in the pond are being considered for automation of this operation.

As stated on page 17 of the FPA, the existing leachate storage pond is designed for the ultimate build-out of the landfill. Analysis of the bioreactor system storage requirements shows that the pond's storage capacity of over 1 million gallons is more than ample to serve the bioreactor injection process. Therefore additional storage capacity is not anticipated. The proposed force main consists of 4 and 6-inch, SDR 17, HDPE pipe. As shown on Sheet 8, the alignment of the force main will follow the perimeter of the landfill along the containment berm. The header systems are divided into ten networks. The configuration of the networks was determined based on the phasing plan for the HIT and VIW installations.

As stated on page 17 of the FPA, the County will retain its pre-treatment permit and leachate hauling capability as a contingency to the onsite management of leachate.

A series of 4-inch diameter lateral force mains will transmit flow from the main header pipes to the HITs and VIWs for each of the ten networks. A ball valve and

pressure gauge will be installed at each HIT and VIW connection to provide control and monitoring of the injection process. The connection details are show in Detail C on Sheet 9 for the HIT and in Detail A on Sheet 10 for the VIW. Valves located at the base of the trunk lines of each network provide additional control of the operation. The entire injection system can be shut off by closing the two valves located nearest the leachate pond.

3.4 Surficial Gravity Trenches

SGTs will be installed in the perimeter areas of the landfill as shown on Sheets 5 and 6. These areas contain shallow depths of waste that cannot be serviced by the injection system. The majority of the SGTs are located on the west and south sides of the landfill where the cell base grades slope upward toward the center of the landfill. The construction of the SGTs will be the same as the HITs with the exception of the inlet piping which will extend vertically from the trench (refer to Detail B on Sheet 10).

3.5 Impact on the Leachate Collection System

Much of the additional liquid applied to the waste using the techniques described above will be absorbed and retained in the waste mass. However, due to the heterogeneous nature of the waste, flow paths will be created that will allow some of the leachate and water to migrate to the leachate collection system. In addition, the weight of the additional liquid will increase the density of the waste through compression. This will also cause some additional flow to the leachate collection system.

HELP model runs were performed during the design stage of the landfill to ensure that the leachate collection has sufficient capacity to maintain a hydraulic head of 12-inches or less at all times. The leachate collection system, which consists of 24-inches of fast draining aggregate placed on slopes that exceed 10%, was determined to maintain an extremely low hydraulic head on the liner system.

A revised HELP model run was performed as part of this report to account for the additional liquid resulting from the bioreactor operation. The HELP model run assumes 60-feet of waste with 12-inches of intermediate cover and 100% of the leachate recirculated. This scenario presents the greatest potential for head buildup on the liner for the bioreactor operation since the depth of waste is at a minimum (i.e.; the first level of HIT are installed at 30-feet above the liner but are not activated until an additional 30-feet of waste is placed over the HIT. Direct application at the working face is considered to be minor). The moisture content of the waste was assumed to be initially 25% and reach field capacity at 45%. The model was not run past the saturation point since the bioreactor system is designed to cease the wetting process at the point when field capacity is achieved. The result of the HELP model run (refer to Appendix A) demonstrates that the leachate collection system will not be

impacted by the bioreactor operation. For peak conditions, the hydraulic head on the liner system is not expected to exceed 0.1 inches.