2.0 REGULATORY AND ENVIRONMENTAL ASSESSMENTS

The City of Sioux Falls is committed to complying with all regulatory requirements for the design, construction, and operation of the SFRSL. In addition, it is recognized that regulatory requirements may not address all site-specific conditions and the City's local obligation to minimize risks to the public and the environment. The following section summarizes available information obtained on the physical setting of the landfill site as it pertains to characterizing and understanding conditions that play a role in the development and operation of a solid waste disposal facility. The subsequent sections assess regulatory compliance of the SFRSL in regards to permitting, design, monitoring, and closure.

2.1 PHYSICAL SETTING

The SFRSL is located along the southern boundary of Minnehaha County, South Dakota. The physical setting of the site is typical of that found in eastern South Dakota with the surficial conditions characteristic of a mid-continental glacial region. The site's geological and hydrogeological conditions have been evaluated at the SFRSL through a series of investigations conducted by local consulting firms and the South Dakota Geological Survey. Documents reviewed as part of this assessment include: Davis et al. (1997); Iles (1989); Huntingdon (September 28, 1995); LBG (January 23, 1996); LBG (January 24, 1996); LBG (August 13, 1996); LBG (August 14, 2001); LBG (March 2002); LBG (March 2003), LBG (January 31, 2003); and Maxim (October 18, 1995). In addition, miscellaneous soil boring logs, well construction diagrams, and site maps prepared between 1989 and 2002 by Twin City Testing (TCT), Huntingdon, Maxim, and LBG were also reviewed. Supplemental hydrogeological information was collected during the installation of the Cell 1 ground water monitoring system during May and June of 2003 (Earth Tech, July 2003).

Information compiled and tabulated on the physical setting is provided following this section. Existing soil boring logs and geotechnical data available for review are summarized in Tables A-1 and A-2, respectively, included in Appendix A. Existing monitoring well and piezometer data is presented in Table A-3. The following sections summarize the climate, physiography and topography, surface water hydrology, geology, hydrogeologic conditions, and local water usage as documented in previous reports, publications, and as updated in 2003.

2.1.1 Climate

Sioux Falls is located in the Big Sioux River Valley in southeast South Dakota. The National Oceanic and Atmospheric Administration (NOAA) website describes the climate as a continental type. There are frequent weather changes from day to day or week to week as the locality is visited by differing air masses. Cold air masses arrive from the interior of Canada, cool, dry air from the northern Pacific, warm, moist air from the Gulf of Mexico, or hot, dry air from the southwest.

Temperatures fluctuate frequently as cold air masses move in very rapidly. The winter months of December through February have experienced cold spells with average temperatures under 8 degrees and more than 60 consecutive days below 32 degrees. Temperatures of 100 degrees and above occur about one in every three years, and will most likely happen in July. Based on the 1951-1980 period, the average first occurrence of 32 degrees Fahrenheit in the fall is October 1 and the average last occurrence in the spring is May 10.

The average annual precipitation at Sioux Falls from 1951 to 1980 was 24.12 inches. Rainfall is heavier during the spring and summer with nearly 64 percent of the normal yearly precipitation falling during the growing season of April through August. One or two very heavy snows of 8 to 12 inches usually fall each winter. There is occasional flooding in the lower areas of Sioux Falls along the Big Sioux River and Skunk Creek. Runoff from the melting snow in the spring often causes substantial rises in the rivers.

Southerly winds prevail from late spring to early fall with northwest winds the remainder of the year. Strong winds of 70 mph with gusts to 90 mph have occurred.

2.1.2 Physiography and Topography

Minnehaha County lies on the southern flank of the Coteau des Prairies division of the Central Lowland Physiographic Province (Fenneman, 1931). The Coteau des Prairies consists of a highland or plateau of thick glacial deposits underlain by a small ridge of resistant shale and quartzite. Elevations in Minnehaha County range from 1,820 feet in the northwest to less than 1,270 feet in the southeast. The topography near the landfill is characterized by poorly drained uplands.

Based on the United States Geological Survey (USGS) topographic map (7.5 minute, Lennox quadrangle), the original slope of the landfill property varies from an elevation of 1,570 feet on the north-central edge of the property to less than 1,530 feet along the southern edge of the site. The site topographic map was updated in 2003 and incorporated past development. The undisturbed areas inside the landfill site are grass-covered and several rows of trees have been established to form shelterbelts at various locations. Excavations for landfill development extend to elevations as low as 1,480 feet.

2.1.3 Surface Water Hydrology

The Big Sioux River, which flows from north to south through central Minnehaha County, is the principal stream in eastern South Dakota. The Big Sioux River discharges to the Missouri River nearly 100 miles to the south. The nearest perennial stream to the landfill site is Skunk Creek, located more than 5 miles east of the site. The streams present in the vicinity of the landfill are intermittent and poorly defined with most stream flow derived from snowmelt and spring rains (Tomhave, 1992). An unnamed intermittent stream that carries drainage from Wall Lake (located about 2 miles northwest of the site) crosses the southwestern corner of the site and continues drainage toward the east along the southern boundary of the landfill.

The surface water features within a 1-mile radius of the landfill are primarily in the form of stock watering dams and natural wetland depressions. There are no natural lakes, ponds, or perennial streams within a 1-mile radius of the landfill. A sedimentation pond and several drainage ditches were constructed on-site as a part of surface water control features for the landfill.

2.1.4 Geology

2.1.4.1 Regional Geology

The Coteau des Prairies of the Central Lowland Physiographic Province developed because of the presence of resistant bedrock and subsequent glacial erosion and deposition. The resistant bedrock primarily consists of Sioux Quartzite that formed during Middle Proterozoic time and the Cretaceous-age Split Rock Creek Formation consisting of interbedded sands, siltstone, claystone, sandstone, bentonite, and lignite. The glacial deposits at the site overlie 30 to 50 feet of interbedded sedimentary rocks that make up the Split Rock Creek Formation (Tomhave, 1994). Underlying the Split Rock Creek Formation, the Sioux Quartzite Aquifer has an unknown thickness exceeding 1,000 feet and is a locally, well-fractured and jointed crystalline rock. The eroded bedrock surface is overlain by zero to over 300 feet of Quaternary sediments associated with various types of glacial deposits (Tomhave, 1994). Glacial deposits primarily represent pre-Illinoisan, Illinoisan, and Late Wisconsinan glacial advances and recessions during the Pleistocene epoch.

Near the SFRSL, the Pleistocene-age deposits range in thickness from 151 to 200 feet (Tomhave, 1994). On-site water well SFSL-1 was constructed in the glacial deposits of the Wall Lake Aquifer confirming the depth to bedrock exceeds 183 feet (LBG, 2001). Tomhave (1994) illustrates the local stratigraphy in south central Minnehaha County to include both Wisconsinan and pre-Illinoisan-aged glacial deposits overlying bedrock. Based on the geological cross-section from Tomhave (1994), a copy of which is provided in Appendix A of this report, the approximate elevations of the top of each stratigraphic unit, from oldest to youngest, are as follows:

- Wisconsinan till → ground surface
- Outwash → 1,460 feet
- Pre-Illinoisan till → 1,450 feet
- Pre-Illinoisan outwash → 1,405 feet
- Cretaceous Split Rock Creek Formation → 1,395 feet
- Pre-Cambrian Sioux Quartzite → 1,350 feet

Illinoisan till is described by Tomhave (1994) as being present in the eastern portion of Minnehaha County, but not in the vicinity of the SFRLF. Three distinct pre-Illinoisan tills units have been identified within the county, but they have not been differentiated near the landfill site. Based on the approximate top elevation at 1,450 feet as shown in Tomhave's cross-section (Appendix A), the pre-Illinoisan till may occur 80 to 120 feet below ground surface at the landfill site. Conversely, Davis et al. (1997) state the Wisconsinan till as having a thickness of 100 to 125 feet at the landfill site.

The composition of both the Wisconsinan and Illinoisan-aged glacial till is very similar consisting of a very compact, clay-rich matrix, reflecting the predominance of shale in the local Cretaceous bedrock. Tomhave (1994) stresses that distinguishing till units is very difficult and are most often separated using palesols, oxidations zones, outwash and loess deposits, electric log signatures, and stratigraphic position. He further states that locally the pre-Illinoisan till is often mantled by loess (i.e., sediment primarily composed of silt-sized particles).

The physical properties of the pre-Illinoisan till have not been described in detail in the publications and consultants reports reviewed. On the Active Area, Davis et al. (1997) indicates the uppermost till as being Late-Wisconsinan in age and occurring in three distinct zones:

- A weathered, highly-fractured zone to a depth of about 22 feet consisting of oxidized, yellowish brown to reddish-brown, clay.
- An intermediate, transition zone from a depth of 22 to 40 feet that is characterized by decreasing fracture density with depth.
- An unfractured, unweathered zone below a depth of 40 feet consisting of gray, plastic, unoxidized till.

Although Steece (1958) describes the Wisconsinan depositional environment near the landfill as that of an end moraine, Tomhave (1994) specifically indicates the till as being characteristic of a stagnation moraine with the typical knob and kettle topography as well as numerous lakes, sloughs, and closed depressions. The glacial till consists of a heterogeneous mixture of boulders, sand, silt, and clay. Davis et al. (1997), also describe some shallow surficial deposits at the SFRSL as containing ice-contact, alluvial, and lacustrine deposits.

2.1.4.2 Site Geology

Over 150 soil borings have been completed at the landfill site to characterize site conditions on both the Active and Expansion areas. Twenty-two of those soil borings were conducted by Davis et al. (1997), over an approximate 1-acre study area on the active site. A comprehensive list of available soil boring logs is provided as Table A-1 in Appendix A of this report. Available information on the soil boring locations is also provided on figures in Appendix A. Although the number of soil borings appears extensive, the soil boring logs do not apply a consistent logging procedure or classification that assists accurate correlation from log to log. Soil descriptions from about 50 of the soil borings logs (36 logs from the expansion site) were completed in accordance with the Unified Soil Classification System (USCS) as described in ASTM D2488 [Recommended Practice for Description of Soils (Visual-Manual Method)]. The remaining boring logs did not apply any recognized standard. In addition, prior to permitting the expansion in 1996, only limited geotechnical data from interval sampling was available to confirm visual descriptions made in the field. A summary of available geotechnical data is included as Table A-2 in Appendix A of this report. With the available information, it is difficult to compare visual properties, as well as physical properties, from log to log.

Both the Active and Expansion Areas include waste placed below the pre-development ground surface. As indicated in logs for the installation of the fluid monitoring points, the bottom of waste elevation in the unlined Active Area varies from approximately 1,490 to 1,550 feet. The proposed design of the Expansion Area includes base grade elevations ranging from approximately 1,480 to 1,500 feet. Because the soil above the bottom of the landfill will be largely excavated for the Expansion Area, characterization of the soils at or near the bottom of the landfill are critical for evaluating potential long-term impacts. In particular, soils making up the most likely pathway for ground water flow should be identified in proximity to the landfill (lateral and underlying) including those soils with higher permeability caused by depositional environment (sand or gravel) or secondary features such as weathering and fracturing. Ground water pathways in glacial environments may be more prevalent in features unique to interglacial periods (e.g., the time between the Wisconsinan and pre-Illinoisan), which are often distinguished by the presence of paleosols, oxidations zones, outwash deposits, and loess described by Tomhave (1994).

Based on the 150 soil boring logs listed in Appendix A, 37 soil borings have been completed on the Expansion Area. However, only six soil borings on the 160-acre expansion site extended below an elevation of 1,480 feet, the base elevation of Cell 1 and only two sets of geotechnical tests were performed from actual soil samples collected near the base grade for the expansion (Appendix A). Two soil borings (B-46 and B-47) were drilled to just below the 1,450-foot elevation on-site did not draw conclusions regarding depositional or secondary features that might contribute to ground water pathways. Soil boring log SB-46 describes six different lenses between 2- to 6-inches thick consisting of silt, silty sand, and sand, occurring at a depth between 74 to 84 feet (1,444 to 1,454 feet in elevation). Soil boring log SB-47 describes a similar sequence of sand and silty sand at 81 feet (1,451 feet in elevation). Based on the available publications and reports, the contact between the Wisconsinan and pre-Illinoisan tills (presumably below the base of the landfill) has not been defined on-site and the physical properties of the pre-Illinoisan till have not been described in publications.

All the till units described in previous on-site investigations primarily consisted of a clay matrix with silt, sand, and pebbles and occasional sand seams. Sand layers up to several feet thick have been encountered throughout the site, but most commonly in the upper or oxidized zone. However, four distinct sand bodies were encountered within the unoxidized till during the excavation of the 10-acres for Cell 1 (LBG, 2003a). Locations of the sand bodies are illustrated on a figure included in Appendix A. The bodies were sufficient in thickness to prompt the mobilization of a drill rig to investigate the thickness of the sand bodies. Although no soil boring logs or elevation data were provided, LBG indicates that one of the sand bodies had an approximate thickness of 40 feet; all sand bodies were over-excavated at the bottom the landfill by 4-feet to allow recompaction of clay. LBG described nearly vertical orientation of bedding planes at several locations within the sand bodies and concluded that they had been repositioned following their original fluvial deposition and were therefore discontinuous. Another explanation for the orientation of bedding planes includes collapse of fluvial deposits in association with glacial recession as adjacent ice blocks melted (Shaw, 1985).

Federal and state regulations require that the geology at all landfill sites be adequately defined to identify the most likely ground water flow pathways in the event there is a release of contaminants. At the SFRSL, geologic conditions below the proposed base of the Expansion Area are not sufficiently defined to identify preferential ground water flow paths. It is unknown whether the intervening outwash or pre-Illinoisan till illustrated by Tomhave (1994) was encountered in previous borings or whether the lenses and sand bodies encountered represent multiple advances within the Wisconsinan. It is also not certain as to the depositional environment and stratigraphic relationship of the sand bodies in Cell 1.

2.1.4.3 Cell 1 Supplemental Investigation

A supplemental investigation was conducted on the Expansion Site in May 2003 for the specific purpose of installing several piezometers for monitoring water levels and the placement of a ground water monitoring system for Cell 1. Specific results of the investigation will be presented as a separate Technical Memorandum (Earth Tech, in preparation). A summary of the supplemental investigation is included in this Section and in Section 2.1.5.4.

Soil samples were collected using a 5-foot long continuous sampler device. All samples were logged, classified, and geologically interpreted in the field by a geologist using the procedures described in ASTM D2488 (Standard Practice for Description and Identification of Soils, Visual-Manual Procedure). A soil laboratory testing program following ASTM standards was applied to characterize the site soils and assess the geotechnical and hydrogeologic properties of the soil. Soil boring data is summarized in Table A-1 in Appendix A. Geotechnical data is included in Table A-2 in Appendix A.

Preliminary observations confirmed the presence of the three distinct weathering zones described by Davis et al. (1997). Very few sand lenses or seams were encountered. In general, the oxidized till is described as a yellowish-brown to very dark brown, lean clay with sand (CL). The unoxidized till is generally described as a gray to very dark gray, lean clay with sand (CL).

2.1.5 Hydrogeology

2.1.5.1 Regional Hydrogeology

The uppermost geologic units of hydrologic interest include over 180 feet of Wisconsinan and pre-Illinoisan glacial deposits as well as the Sioux Quartzite Aquifer. The stratigraphic units are saturated to within a few feet of the ground surface.

The Sioux Quartzite underlies all of Minnehaha County. It exists under artesian pressure and provides a maximum yield of about 150 gallons per minute depending on the extent of local fracturing (Lindgren and Niehus, 1992). Seasonal fluctuations in water levels indicate that recharge to the bedrock aquifer is primarily from infiltration of snowmelt and rainfall in areas where the Sioux Quartzite is at or near land surface. Ground water flow is generally toward the south and southwest. Discharge is generally to wells and intervening glacial aquifers present within bedrock valleys. The Cretaceous Split Rock Creek Formation, which directly overlies the Sioux Quartzite, consists predominantly of siltstone, shale, and sandy clay in this portion of Minnehaha County and is not designated an aquifer (Lindgren and Niehus, 1992).

The pre-Illinoisan outwash lying above bedrock occurs locally and is designated the Wall Lake Aquifer (Lindgren and Niehus, 1992). It is described as a fine to coarse-grained, well-sorted quartzose sand and fine pebble gravel; locally the sand and gravel is interbedded with 2- to 3-foot clay layers. The Wall Lake Aquifer is confined and generally under artesian conditions. Where in contact with the Sioux Quartzite, the aquifer is recharged by infiltration of precipitation through fractures of the underlying metamorphic rock. Ground water flow in the Wall Lake Aquifer is generally toward the south-southwest in the vicinity of the landfill. Hydraulic conditions of the Wall Lake Aquifer vary but can yield water to wells up to 500 gallons per minute.

Hydraulic conductivities of the overlying pre-Illinoisan till have not been defined. The outwash that may occur locally along the contact between the Wisconsinan and pre-Illinoisan tills has also not been defined, but may contain secondary permeabilities and normal anisotropies possibly providing preferential flow paths.

Ground water flow directions within the Wisconsinan till can vary widely since ground water contours at the water table are anticipated to mimic the undulating ground surface. Ground water flow directions and information on hydraulic conductivity obtain on the landfill site are presented in the following sections.

2.1.5.2 Local Water Usage

Water usage within a 1-mile radius of the facility is primarily for domestic and livestock use. The primary water source in the area is a rural water system operated by Minnehaha Community Water Corporation (LBG, 2001). The only documented water supply well within a 1-mile radius of the site was an on-site potable well (SFSL-1) screened within the Wall Lake Aquifer. However, the well was not used because of reportedly high hydrogen sulfide content and was proposed for abandonment in 2001. Information has not been obtained as to whether the well has been sealed in accordance with South Dakota requirements.

2.1.5.3 Site Hydrogeology

As part of previous investigations, over 70 wells or piezometers are currently present at the landfill site to evaluate and monitor ground water conditions. The 20 temporary wells installed by Davis et al. (1997) in their 1-acre study area on the active site were subsequently abandoned as the excavation area of the landfill expanded. A summary of existing well data is provided as Table A-3 in Appendix A. Well locations are also provided on figures in Appendix A. All wells are screened in Wisconsinan-age deposits. Some wells are screened across or near the water table, while others represent potentiometric conditions below the water table. Of the 70 wells/piezometers, 25 currently exist on the Expansion Area with about half of those monitoring water table conditions.

Ground Water Age Dating

Davis et al. (1997) conducted age dating on two ground water samples from each of four zones in the 1-acre study area on the active site. Ground water samples were not collected from any confirmed sand bodies. The results of age dating of ground water using both tritium and ^{14}C methods indicate a distribution of age as follows:

- Oxidized zone (15 to 20-foot depth) → Recent
- Transition zone (28-foot depth) → 9,300 to 12,100 years before present
- Unweathered zone (50 to 52-foot depth) → 17,900 to 19,100 years before present
- Unweathered zone (72 to 74-foot depth) → 10,900 to 21,800 years before present

It should be noted that the conditions present at the time of the investigation might no longer be characteristic of the site with the excavation of soils and exposure of the unweathered zone to the atmosphere, precipitation, and leachate at the bottom of the landfill.

Hydraulic Gradient

Previous investigations have contoured water level data reflective of both water table conditions and an undefined zone in the unoxidized till (Davis et al., 1997; Iles, 1989; LBG, 1996a; 1996b; 2002a; 2003b). In general, equipotential lines indicate a decrease in hydraulic head toward the south-southwest on both the Active Area and Expansion Area. Iles (1989) calculated a horizontal hydraulic gradient of the water table for the Active Area to range from 0.0124 to 0.0160 to the south-southwest. However, ground water interpretations presented by LBG (1996a; 1996b; 2002a; 2003b) do not present calculated horizontal hydraulic gradients (under the premise that any ground water movement is considered insignificant). LBG (January 23, 1996) states their ground water equipotential maps "… should not necessarily be construed as indicating lateral ground water flow is occurring…"

Vertical gradients were not evaluated by Iles (1989) or LBG (1996a; 1996b; 2002a; 2003b). Davis et al. (1997) calculated vertical gradients within the previously defined zones as follows:

- Weathered till → 0.041 upward to 0.042 downward
- Weathered-unweathered till boundary → 0.68 to 0.76 downward
- Unweathered till → 0.89 downward

Despite the presence of fractures and a subdued water level response to precipitation events, Davis et al. (1997) concludes that vertical movement in the transition zone between the weathered and unweathered tills is insignificant because of the ground water's age. Similarly, Davis et al. (1997) specifically maintains that ground water movement through the unweathered till is insignificant or nonexistent, but contends that additional research is needed to define horizontal ground water movement in the weathered till.

Hydraulic Conductivity

Hydraulic conductivity of the Wisconsinan-age deposits has been evaluated through in-situ rate-of-recovery (slug) and laboratory tests (LBG, 1996a; 1996b; Davis et al, 1997).

Based on 35 in-situ rate-of-recovery (slug) tests conducted on wells within the Wisconsinan-age deposits before 2003 [including 19 tests conducted on temporary wells by Davis et al. (1997)], hydraulic conductivities vary widely ranging from 6×10^{-3} cm/sec in imbedded sand units to 2×10^{-8} cm/sec in massive diamicton. Four temporary wells screened below an elevation of 1,500 feet on the active site were tested by Davis et al. (1997) with hydraulic conductivity estimates on the order of 1×10^{-8} cm/sec. One of the wells tested on the expansion site (MW-23un) was screened below an elevation of 1,500 feet with a hydraulic conductivity of 2.4×10^{-7} cm/sec. Such results are suspect given the low conductivity formations present at the site. For example, well development in low conductivity formations is difficult to complete, which can significantly impact slug test results (Butler, 1998). In addition, there is a greater potential for the slug test to be significantly affected by a well skin formed by the smearing of clay-sized particles on the walls of the borehole during drilling. Butler (1998) stresses that slug tests may only be a viable method to estimate hydraulic conductivity if the " . . . underlying mathematical models are appropriate representations of the governing physics," conditions difficult to overcome in low conductivity formations such as those at the SFRSL. Butler (1998) states that the hydraulic conductivity estimate obtained from a slug test should be viewed as a lower boundary. In other words, the hydraulic conductivity below the proposed base of the landfill in the Expansion Area should be viewed as somewhat greater than 2.4×10^{-7} cm/sec.

From previous studies, over 60 thin-walled (Shelby) tube samples or cores were collected and returned to the laboratory for analysis. Davis et al. (1997) recognized that it is difficult to collect, transport, and laboratory-test soil for hydraulic conductivity because of sample disturbance and inherent problems in the laboratory test methods. Results ranged from 3.2×10^{-4} to 2.5×10^{-9} cm/sec with the majority of results on the order of 1×10^{-8} to 1×10^{-9} cm/sec. Davis et al. (1997) concluded that the laboratory test results for hydraulic conductivity are one to two orders of magnitude lower than that determined by in-situ field methods, but did not offer an explanation. Clearly, comparison of the slug test results (horizontal hydraulic conductivity) and the laboratory tests (vertical hydraulic conductivity) indicates the glacial sediments were deposited horizontally creating an anisotropic condition for ground water flow. However, with the number of spatial distribution of tests, it is not clear if the presence of sand bodies creates heterogeneous conditions providing preferential ground water flow.

Average Linear Flow Velocity

Previous investigations did not calculate average linear flow velocity at the site to evaluate the presence of preferential ground water flow paths.

2.1.5.4 Cell 1 Supplemental Investigation

A supplemental investigation was conducted on the expansion site in May 2003 for the specific purpose of installing several piezometers for monitoring water levels and the placement of a ground water monitoring system for Cell 1. Specific results of the investigation will be presented as a separate Technical Memorandum (Earth Tech, in preparation). A summary of the supplemental investigation is included in this Section and in Section 2.1.4.3.

Three shallow wells with 15-foot screens were installed to monitor water levels as the ground water adjusts to the operation of the nearby zone-of-saturation landfill (Cell 1). Three deeper wells were installed adjacent to each of the shallow wells to evaluate ground water conditions at the base of the landfill. Well construction information is included in Table A-3, included in Appendix A. Preliminary observations confirmed the presence of three distinct weathering zones described by Davis et al. (1997). Very few sand lenses or seams were encountered except in the shallow well (MW-50P) located south of Cell 1. Wells MW-50un and MW-50P yielded sufficient water for well development although the wells continued to result in high suspended solids. The remaining wells did not yield sufficient water for adequate well development. The water levels continue to be monitored until equilibrium conditions are reached.

During additional field activities during July 2003, a complete round of water levels was collected on the wells listed in Table A-3 (Appendix A). It was discovered that several of the wells and/or piezometers on this list no longer exist. In some areas, the locations were currently being used for the stockpiling of soil and, in other areas, the wells could not be located. Wells that were apparently abandoned include over 15 piezometers on the Active Area previously installed by the SDGS and 5 peizometers/wells on the Expansion Site (P-2S/P-2S, P-4, MW-26ox, and MW-27ox). We are not aware if the wells were sealed and documented in accordance with South Dakota regulations. It was also noted during the July 2003 site work that soil around several wells was severely eroded at the base resulting in a casing stick-up of more than 5 feet above ground surface. In addition, wells were not always located at the positions illustrated on site maps.

As a result of the 2003 observations, it is recommended that the affected wells be repaired and maintained to provide a stick-up no more than 3.5-feet above the ground surface, the protective casings, protective posts, and concrete collar repaired, and the wells painted, labeled, and locked. In addition, wells should be re-surveyed as necessary to provide accurate location and elevation information for site characterization and development purposes.

2.1.5.5 Conceptual Ground Water Model

Within permitting and compliance reporting documents, LBG explicitly concluded that ground water movement is insignificant to nonexistent within and between the three glacial till zones defined at the site. Because of this conclusion, a conceptual model of the ground water regime has not been developed for the site. However, 40 CFR Part 258.51 stipulates that the number, spacing, and depths of the facility ground water monitoring system should be based on site characterization data including ground water flow rate, flow direction, and seasonal and temporal fluctuations in flow. Therefore, a conservative approach to meeting regulatory needs should apply a conceptual ground water flow model.

Applying basic hydrogeologic principles and available information, the conceptual shallow ground water flow system at the SFRSL site can be described as an unconfined, low permeability, unconsolidated flow system. The water table typically ranges from 5 to 10 feet below the ground surface. Given the thickness of the unconsolidated deposits and the poorly defined local stream patterns, no local hydraulic boundaries are present within the vicinity of the landfill site except for the shallowest ground water that may discharge to existing, intermittent drainageways.

The glacial deposits at the site overlie 30 to 50 feet of interbedded sedimentary rocks that make up the Split Rock Creek Formation (Tomhave, 1994). The Split Rock Creek Formation is predominantly, siltstone, shale, and sandy clay in this portion of Minnehaha County. Shale and marine clay typically have low hydraulic conductivities of 1×10^{-7} cm/sec or less (Freeze and Cherry, 1979); therefore, the Split Rock Creek Formation is not locally designated an aquifer (Lindgren and Niehus, 1992). Underlying the Split Rock Creek Formation, the Sioux Quartzite Aquifer has an unknown thickness exceeding 1,000 feet and is a locally, well-fractured and jointed crystalline rock. Freeze and Cherry (1979) estimate hydraulic conductivity of fractured metamorphic rock to range from 1×10^{-2} to 1×10^{-6} cm/sec. Where overlain by till, the bedrock units are generally under confined conditions.

The uppermost geologic units of hydrologic interest include over 180 feet of Wisconsinan and pre-Illinoisan glacial deposits. Based on illustrations by Tomhave (1994), the glacial deposits and their estimated thickness, from oldest to youngest, include: pre-Illinoisan outwash (10 feet), pre-Illinoisan till (45 feet), outwash (10 feet), and Wisconsinan Till (thickness varies by topography). The estimated top of pre-Illinoisan till elevation illustrated by Tomhave (1994) is 1,450 feet, approximately 80 to 120 feet below the ground surface at the landfill site.

The pre-Illinoisan outwash lying above bedrock occurs locally and is designated the Wall Lake Aquifer (Lindgren and Niehus, 1992). Hydraulic conditions of the Wall Lake Aquifer vary but can yield water to wells up to 500 gallons per minute. Hydraulic conductivities of the overlying pre-Illinoisan till have not been defined; however, the confining conditions provided to the Wall Lake Aquifer suggest that the hydraulic conductivity is on the low range for glacial till at less than 1×10^{-6} cm/sec (Freeze and Cherry, 1979). The outwash that may occur locally along the contact between the Wisconsinan and pre-Illinoisan tills has also not been defined. The contact between the Wisconsinan and pre-Illinoisan tills may contain secondary permeabilities and normal anisotropies, which may provide a preferential flow path. Based on in-situ rate-of-recovery tests conducted on wells within the Wisconsinan-age deposits, hydraulic conductivities vary widely ranging from 6×10^{-3} in imbedded sand units to 2×10^{-8} cm/sec in massive diamicton.

The stratigraphic units, including the Wisconsinan-age deposits, are saturated to within a few feet of the ground surface. Seasonal fluctuations in water levels indicate that recharge to the bedrock aquifers in Minnehaha County is from infiltration of snowmelt and rainfall in areas where the Sioux Quartzite is at or near land surface. The Wall Lake Aquifer is generally under artesian and confining conditions and, where in contact with the Sioux Quartzite, it is recharged by infiltration of precipitation through fractures of the underlying metamorphic rock. The low permeability of the glacial tills presents confining conditions for the Sioux Quartzite and Wall Lake Aquifers, locally protecting them from near surface contamination.

Precipitation is believed to be the major recharge for the shallow ground water flow system as evidenced by seasonal fluctuations at the water table; however, only a small portion of the total rainfall is anticipated to actually recharge the ground water on-site. However, the vertical and horizontal average linear flow velocities of the ground water at the SFRSL have not been quantified for evaluating predominant flow directions and flow rates. It is assumed that the flow at the water table would be predominantly horizontal given the horizontal gradients toward the intermittent stream located along the southern boundary of the landfill site. Some recharge would move laterally near the water table and discharge in a relatively short time within very localized flow systems near drainage ways. The intermittent streams located on and near the site indicate that discharge is primarily in the form of evapotranspiration. The low permeability of the upper units causes numerous small, local, and very shallow flow systems to develop, which are influenced by topography (such as wetlands, drainage ways, and landfill development), inhomogeneities (such as sand lenses), and the seasonal weather conditions. Movement in the shallow, local flow systems can be quite variable. Although the permeability is low, ground water movement does occur, with the majority of ground water flowing through fractures, inhomogeneities, and normal anisotropies, where present.

Throughout the year, a portion of the recharge continues to move downward. Within inhomogeneities or along the Wisconsinan/pre-Illinoisan till interface, the suspected higher permeability may provide for a preferential lateral pathway for ground water movement with horizontal flow toward the south, similar to that of the water table and the underlying Wall Lake Aquifer. As ground water flows horizontally through this zone, some water continues its downward movement into the pre-Illinoisan till and Wall Lake Aquifer below. The artesian pressure exhibited in the uppermost aquifer (Wall Lake Aquifer) indicates that shallow ground water will likely not enter the uppermost aquifer.

In summary, a portion of the water entering the site in the form of precipitation or by lateral ground water movement may be discharged at the water table through evapotranspiration during dry seasons. Some water continues downward to move laterally along preferred horizontal pathways or continues a downward movement to ultimately reach deeper aquifer units. During wet seasons, less water is lost to evapotranspiration and more water recharges the ground water flow system.

2.1.6 Conclusions and Recommendations

Based on the available information, the physical setting can be summarized as follows:

- The vicinity of the SFRSL is described as having a continental type climate with frequent weather changes. The average annual precipitation exceeds 24 inches. There is occasional flooding in the lower areas.

- Lying on the southern flank of the Coteau des Prairies, the poorly drained uplands consist of thick glacial deposits underlain by a small ridge of resistant shale and quartzite. The original slope of the landfill property varies from an elevation of 1,570 feet on the north-central edge of the property to less than 1,530 feet along the southern edge of the site. Excavations for landfill development extend to elevations as low as 1,480 feet.

- The streams present in the vicinity of the landfill are intermittent and poorly defined. An unnamed intermittent stream carrying drainage from Wall Lake crosses the southwestern corner of the site. The nearest perennial stream to the landfill site is Skunk Creek, located more than five miles east of the site.

- Depth to bedrock ranges from 150 to 200 feet in the area. The uppermost bedrock consists of 30 to 50 feet of the Split Rock Creek Formation comprised of interbedded sands, siltstone, claystone, sandstone, bentonite, and lignite. Underlying the Split Rock Creek Formation, the Sioux Quartzite has an unknown thickness exceeding 1,000 feet and is a locally, well-fractured and jointed crystalline rock.

- In the vicinity of the landfill, the bedrock is overlain by 150 to 200 feet of glacial deposits primarily representing pre-Illinoisan underlying the younger, Late Wisconsinan glacial deposits. The composition of both the Wisconsinan and pre-Illinoisan-aged glacial till is very similar consisting of a very compact, clay-rich matrix. It is difficult to distinguish till units, which are most often separated using palesols, oxidations zones, outwash and loess deposits, electric log signatures, and stratigraphic position.

- The Wisconsinan till forms a typical knob and kettle topography with numerous lakes, sloughs, and closed depressions. The glacial till consists of a heterogeneous mixture of boulders, sand, silt, and clay with some shallow surficial deposits containing ice-contact, alluvial and lacustrine deposits. At the SFRSL, the Late-Wisconsinan age deposits occurring three distinct zones: A weathered, highly fractured zone, an intermediate, transition zone, and an unfractured, unweathered zone.

- Published information suggests that the contact of the Wisconsinan/pre-Illinoisan till is at an approximate elevation of 1,460 feet, about 20 feet below the proposed base of the landfill.

- The geologic conditions below the landfill and the Wisconsinan/pre-Illinoisan contact should be better defined because ground water pathways in glacial environments may be more prevalent in features unique to interglacial periods. Only six soil borings and two sets of geotechnical tests from the 160-acre expansion site extend below an elevation of 1,480 feet, the base elevation of Cell 1.

- Four distinct sand bodies were encountered within the unoxidized till during the excavation of the Cell 1 expansion with one body up to 40 feet thick. It is unknown whether the sand bodies encountered or whether silt and sand seams encountered in other deeper borings represent the Wisconsinan/pre-Illinoisan contact or multiple advances within the Wisconsinan.

- The primary local water source in the area is a rural water system. Information has not been obtained as to whether a landfill well to the Wall Lake Aquifer was sealed in accordance with South Dakota requirements to prevent potential cross-contamination from near surface sources.

- The Sioux Quartzite Aquifer exists under artesian pressure and is recharged from infiltration of snowmelt and rainfall in areas where the Sioux Quartzite is at or near land surface. Discharge is generally to wells and intervening glacial aquifers present within bedrock valleys. The Cretaceous Split Rock Creek Formation is not designated an aquifer.

- The pre-Illinoisan outwash lying above bedrock occurs locally and is designated the Wall Lake Aquifer and is described as a sand and gravel. It is confined, under artesian conditions and recharged by infiltration from the Sioux Quartzite Aquifer. Hydraulic conditions of the overlying pre-Illinoisan till have not been defined.

- The outwash that may occur locally along the contact between the Wisconsinan and pre-Illinoisan tills has also not been defined, but may contain secondary permeabilities and normal anisotropies possibly providing preferential flow paths.

- Age dating of ground water resulted in a distribution of age as recent in the weathered till and 9,300 years old or greater in the transition zone and below.

- Ground water flow directions within the Wisconsinan till can vary widely since ground water contours at the water table are anticipated to mimic the undulating ground surface. Ground water contour lines indicate a decrease in hydraulic head toward the south-southwest on both the Active Area and Expansion Area. Horizontal hydraulic gradients of the water table on the Active Area range from 0.0124 to 0.0160 to the south-southwest. Recent site work does not present calculated horizontal hydraulic gradients under the premise that any ground water movement is considered insignificant.

- Vertical gradients on the active site were calculated to be low within the weathered till and varying from upward to downward. Gradients from the weathered till to the unweathered till and below were an order of magnitude greater ranging from 0.68 to 0.89 downward.

- Although hydraulic conductivities from slug tests conducted within the Wisconsinan deposits vary widely ranging from 6×10^{-3} cm/sec in imbedded sand units to 2×10^{-8} cm/sec in massive diamicton, the hydraulic conductivity estimate obtained should be viewed as a lower boundary.

- Based on laboratory permeability results, the glacial sediments were clearly deposited horizontally creating an anisotropic condition for ground water flow. However, it is not clear if the presence of sand bodies creates heterogeneous conditions that provide preferential flow paths.

- Previous investigations did not calculate average linear flow velocity at the site to evaluate the presence of preferential ground water flow paths.

- Problems exist with some existing wells. A number of well/piezometers used in previous investigations no longer exist. It is unknown whether the wells were sealed and documented in accordance with South Dakota regulations in order to prevent vertical conduits for potential near-surface contamination. Erosion has undermined the wellhead at some locations and some wells were not located on the positions illustrated on site maps.

Based on the above observations, the following specific recommendations are provided to improve the understanding of site conditions and how the physical setting may affect the development and operation of a solid waste disposal facility:

1. Existing wells should be repaired and maintained to provide adequate access (stick-up at approximately 3.5-feet above the ground surface), protective casings, protective posts, and concrete collars, and the wells should be painted, labeled, and locked.

2. All wells should be re-surveyed (location and ground and top of inner casing elevation) as necessary to provide accurate location and elevation information for site characterization and development purposes.

3. The geologic conditions below the landfill and the Wisconsinan/pre-Illinoisan contact should be defined to evaluate likely ground water pathways in features unique to interglacial periods.

4. Detailed soil boring logs, geotechnical data, and innovative technologies (e.g., surface geophysics, borehole geophysics) should be considered to define physical soil properties and depositional environment (i.e., subglacial, intraglacial, interglacial, resedimented, etc.).

5. Geologic cross-sections should be updated to incorporate newer site data, regional information, and interpretations as well as proposed landfill base grades.

6. Average linear flow velocities should be calculated in both the horizontal and vertical flow directions in order to define preferred ground water flow paths.

7. The conceptual ground water model should be updated to reflect any new information obtained.

In addition to the above recommendations, additional recommendations associated with site characterization issues are provided in Section 2.3 in regards to regulatory compliance and environmental monitoring.

2.2 PERMIT AND COMPLIANCE REVIEW

The SFRSL must obtain and comply with a number of federal, state, and local permits. The following sections present a review of the primary permits required for this facility. Included are the following:

- County Solid Waste Permit.
- State Solid Waste Permit.
- NPDES Permit.
- Wetlands and Waters of the State.
- Air Permits and Requirements.
- Local Zoning.

2.2.1 County Solid Waste Permit

The SFRSL has a Solid Waste Permit issued by Minnehaha County. The effective date of the permit is July 17, 2001. The term of the permit is five years and therefore expires July 17, 2006.

The permit authorizes use of the Expansion Area and new scale-house area for the purpose of operating a MSW landfill. The Active Area does not require a County solid waste permit since this portion of the property was considered an existing landfill when Minnehaha County passed their solid waste ordinance in 1991.

2.2.1.1 County Permit Review and Conditions

The permit has six specific conditions that are applied. A listing of these conditions, along with our current understanding of compliance is as follows:

Condition 1: A berming and landscaping plan shall be submitted to the Minnehaha Planning Department for staff approval.

We understand from the City that there is no record that the plan was ever completed or submitted to the County. Based on the activity map provided to us by the City as well as our observations of site conditions, there appears to be a well established plan at the site for landscaping including berms and shelterbelts. Documentation of the current conditions and submittal to the County may satisfy this permit condition.

Condition 2: A financial surety shall be required, however, said surety may be the same as that required by the state provided that Minnehaha County is notified of any intent to release the surety and concurs with the release.

The City has established a financial assurance fund for the facility. It is our understanding that the City submitted updated financial information to the County on June 13, 2003.

Condition 3: A copy of the design information, including the means employed to minimize potential impacts to surface or ground water shall be submitted to the Minnehaha County Planning Department for staff approval.

The City submitted a number of engineering reports to the County on October 2, 2001. The documents include the following:

- Sioux Falls Regional Sanitary Landfill Expansion Cell 1 Construction – Construction Documents Specifications, January 15, 2001.
- Sioux Falls Regional Sanitary Landfill Solid Waste Permit Renewal Application, August 14, 2001.
- Sioux Falls Regional Sanitary Landfill Closure/Post Closure Plan for Active Site, August 21, 2001.
- Sioux Falls Regional Sanitary Landfill Leachate Management Evaluation Report, August 2001.

The County Office of Planning and Zoning acknowledged receipt of these documents in a letter to the City dated June 13, 2003. The letter only indicates that the documents are "on file" and does not indicate whether they are approved or not.

Condition 4: A copy of the site closure and post-closure plan(s) shall be filed with the Minnehaha County Planning Department.

As indicated above, the Closure/Post Closure plan for the Active Area is on file with the County. We recommend that updated closure and post-closure plans, which include the Expansion Area, be developed and submitted.

Condition 5: A copy of the storm water management plan shall be filed with the Minnehaha County Planning Department.

The City indicated that a Storm Water Pollution Prevention Plan (HDR, 1993) was submitted and is on file with the County. This plan is in the process of being updated and will be resubmitted when it is completed. A storm water management plan is included with the closure plan of the Active Area (HDR, 2001b), however, the plan does not include the Expansion Area. At a minimum, a comprehensive storm water management plan should be prepared for the site, including the Expansion Area. This plan should then be submitted to the County.

Condition 6: This permit may not be transferred to any other party.

The SFRSL is in compliance with this condition.

2.2.1.2 Conclusions and Recommendations

There are a number of conditions included in the Minnehaha Solid Waste Permit. The conditions are typically requests for submittal of documents to the County Office of Planning and Zoning. With the exception of the berming/landscaping plan (Condition #1), it appears that all of the other required documents have been submitted to the County. The conditions indicate that some of the documents are to be "on file" with the County, implying that review and approval by County Staff is not required. Conditions #1 and #3 indicate that the berming/landscaping plan and the design information are to be submitted for "staff approval." We are not aware if the County has "approved" any of the documents submitted. We recommend that the City clarify this issue with County staff.

2.2.2 State Solid Waste Permit

The current Permit to Operate a Solid Waste Facility (Permit No. 02-26) was issued to the City of Sioux Falls by the South Dakota Department of Environment and Natural Resources (SDDENR) November 26, 2002. The permit carries a five-year term and therefore has an expiration date of November 26, 2007. In accordance with the Administrative Rules of South Dakota (ARSD) 74:27:08:11, an application for renewal of this permit must be submitted at least 90 days before the expiration date.

2.2.2.1 State Solid Waste Permit Review

The State Solid Waste Permit is the principal permit for the operation of this facility and is referred to throughout this Solid Waste Master Plan. The permit is broken down into five sections that are summarized in the following paragraphs.

General Requirements

The General Requirements (Section 1.0) of the state solid waste permit, among other things, incorporates by reference the permit application and supplemental documents. Specific documents are not referenced although presumably, this includes the permit renewal application prepared and submitted by the City's consultant in 2001 (LBG, 2001). The General Requirements describe the City's responsibilities for following the applicable laws and rules and potential penalties for not doing so. This section also outlines requirements for amending the permit resulting from significant deviation in the design of the facility and the SDDENR's right to incorporate administrative changes at any time. Reference is made to the approval of five variances included as attachments of the permit. The variances pertain to the following issues:

- Alternative Daily Cover.
- Floodplains.
- Distance to Residences, Other Buildings, Roads, and Parks.
- Wetlands.
- Liner Systems.

Further discussions of the approved variances are presented in other sections of this Solid Waste Master Plan.

Design and Construction Requirements

This section of the state solid waste permit (Section 2.0) references that portion of the ARSD pertaining to facility design and construction. It also authorizes the use of in-situ clay soils and the associated conditions for implementation of the alternative liner system in the Expansion Area. The permit outlines the requirements for review and approval of plans and specifications by the SDDENR before construction of landfill expansions or ancillary structures. Design issues associated with the in-situ liner are presented in this Solid Waste Master Plan in Section 2.4, Primary Containment Evaluation.

Operational Requirements

Section 3.0 of the state solid waste permit outlines the operational requirements. The permit references ARSD 74:27:13 pertaining to facility operation as well as the facility operation section of the solid waste permit renewal application (presumably LBG's 2001 document). Operational and related compliance issues that are covered under the permit are addressed in this Solid Waste Master Plan in Section 3.0, Operational Assessment and Issues.

Record Keeping and Reporting Requirements

Section 4.0 of the state solid waste permit also references ARSD 74:27:13:22, with regard to record keeping and reporting requirements. In summary, this lists the nature of the facility records that must be kept and made available to the SDDENR upon request. An annual report for ground water monitoring is required to be submitted by April 1 of the following year. A detailed discussion of the facility's annual report is included in Section 2.3 of this Solid Waste Master Plan.

Monitoring Requirements

The monitoring requirements in Section 5.0 of the state solid waste permit reference ARSD 74:27:12, ARSD 74:27:13, and ARSD 74:27:15. The permit establishes the schedule for ground water sampling and measurement of water levels. The approved chemical parameter list for ground water monitoring is also included. A detailed discussion of environmental monitoring and associated compliance issues is included in Section 2.3 of this Solid Waste Master Plan.

Financial Assurance Requirements

This portion of the state solid waste permit requires that the operator develop and maintain a financial assurance account. A discussion of financial assurance for the facility is included in Section 5.0 of this Solid Waste Master Plan.

2.2.2.2 Conclusions and Recommendations

The State Solid Waste Permit is the principal permit for the SFRSL and guides the operation of the facility. Although many of the permit conditions are subject to interpretation, we are aware of no significant compliance issues with the permit. This is based on our review of the available documents as well as conversations and meetings with SDDENR staff during the preparation of this report.

2.2.3 NPDES Permit

Earth Tech reviewed available documents provided by the City addressing NPDES permitting issues at the SFRSL. The following discussion provides a summary of the documents, our understanding of the status of compliance, and our recommendations.

2.2.3.1 NPDES Permit Review

The facility (under the name of Runge Sanitary Landfill) was issued coverage under a NPDES general storm water permit by the U.S. Environmental Protection Agency (USEPA) February 8, 1993. As a requirement of that permit, the facility developed a Storm Water Pollution Prevention Plan (HDR, 1993). In a letter dated January 12 1994, the USEPA indicates to the permittee that the SDDENR was given authority to administer the NPDES program (which includes storm water).

The SFRSL is currently regulated under Surface Water Discharge Permit for Storm Water Discharges Associated with Industrial Activities, General Permit #SDR 000000. This permit became effective December 16, 1997, and expired December 15, 2002. On November 4, 2002, the SDDENR issued a letter stating that their renewal permit has not been completed. They stated that any facility that submitted an Notice of Intent for Reauthorization (NOI) by December 15, 2003, would be allowed coverage under an administrative extension of the existing permit.

The City submitted a NOI and it was received by the SDDENR on December 13, 2002. We understand that recent conversations between City and SDDENR staff confirmed that the SFRSL is covered under the extended permit and the renewal permit will be issued shortly.

2.2.3.2 Conclusions and Recommendations

Based on our review of the available information pertaining to NPDES, we recommend the following:

- The SFRSL appears to be covered under the General Storm Water Discharge Permit #SDR 000000. If the City has not received written confirmation of this by December 2003, we recommend that the City contact the SDDENR for a status report of the permit schedule.

- Significant changes have occurred to the landfill operations since the development of the 1993 Storm Water Pollution Prevention Plan (HDR, 1993). This plan is typically a condition of the NPDES permit and should be updated to reflect current facility design, operations, as well as current permit requirements.

2.2.4 Wetlands and Waters of the State

Earth Tech has reviewed available documents provided by the City of Sioux Falls addressing Waters of the U.S. (including wetland) issues at the SFRSL. The following discussion provides a summary of the documents and our understanding of the status of permitting and mitigation along with our recommendations.

2.2.4.1 Wetland Permitting Framework

Section 404 of the Clean Water Act

The Federal Water Pollution Control Act Amendments of 1972 established the Section 404 Regulatory Program. At the federal level under Section 404 of the Clean Water Act (CWA) of 1977, the U.S. Army Corps of Engineers (USACE) oversees the permit program for the discharge of dredge or fill material into wetlands. The USACE administers the day-to-day program, including individual permit decisions and jurisdictional determinations, develops policy and guidance, and enforces Section 404 provisions.

Under Section 404, it is unlawful to discharge dredged or fill material into Waters of the U.S. without first receiving authorization (usually a permit) from the USACE, unless the discharge is covered under an exemption. The term “Waters of the U.S.” defines the extent of geographic jurisdiction of the Section 404 program. The term includes such waters as rivers, lakes, streams, tidal waters, and many wetlands. A discharge of dredged or fill material involves the physical placement of soil, sand, gravel, dredged material, or other such materials into the Waters of the U.S.

The U.S. Environmental Protection Agency (USEPA) develops and interprets environmental criteria used in evaluating Section 404 permit applications, determines scope of geographic jurisdiction, approves and oversees state assumption, identifies activities that are exempt, reviews/comments on individual permit applications, has authority to veto the Corps’ permit decisions (Section 404[c]), can elevate specific cases (Section 404[q]), and enforces Section 404 provisions.

The Section 404 permitting process requires review/authorization from a number of other state and federal agencies. In South Dakota, this includes the SDDENR, responsible for Section 401 Water Quality Certification, United States Fish and Wildlife Service (USFWS), the South Dakota Department of Game, Fish, and Wildlife (SDDGFW), and the South Dakota State Historic Preservation Officer (SHPO).

South Dakota Solid Waste Rules

According to the Administrative Rules of South Dakota ARSD 74:27:11:07, no municipal solid waste landfill facility shall be located in wetlands. A variance was received from the South Dakota Department of Environment and Natural Resources-Waste Management Program (SDDENR-WMP) for the construction of Phase 1 (in the Expansion Area) based on the following conditions: It was determined that wetlands existed within the permitted area of the landfill. Federal and state regulations and rules allow disturbance of wetlands, provided that the disturbance is minimal and/or the impact is mitigated by the construction of new wetlands or renovation of existing wetlands of equivalent value and use. The operator cannot disturb, drain, or otherwise destroy or impact any wetland in the permitted area until a wetland mitigation plan has been approved by appropriate governmental agencies and the plan implemented.

2.2.4.2 Wetland Permit Review

Expansion Area - Wetland Permit Review

In December of 2000, the City and HDR Engineering, Inc. (HDR), completed a wetland delineation report for the proposed 160-acre Expansion Area. The delineation was performed in accordance with the USACE Manual for Delineating Wetlands (Environmental Laboratory 1987) and the Food Security Act (FSA) of 1985 methodology. The fieldwork was conducted on August 21 and 22, and November 6 and 7, 2000. Through the implementation of the FSA methodology, 26 areas containing mapping conventions of wetland signatures were identified. Upon field investigation, 16 areas were determined to have hydric soils and to be farmed wetlands. Additionally, four areas met wetland definitions based on the USACE 1987 Manual. The remaining six areas were determined not to meet the necessary criteria for either FSA or USACE 1987 Manual wetland delineations. In total, the delineation of the Expansion Area identified approximately 6.1 acres of jurisdictional wetlands. In addition to the wetlands, two other Waters of the U.S. were noted. Of the total 6.1 acres, it was determined that approximately 0.4 acres of wetlands would be impacted within the area of the proposed Phase I construction. We should note that the documents referred to "Phase I" and "Cell 1" interchangeably. The term "Phase I" includes the entire construction area of Cell 1 including sideslopes and roads that reside in portions of the adjacent cell areas.

To mitigate for the 0.4 acres of wetland lost as part of the Phase I construction, the City proposed to combine this with a mitigation project associated with an unrelated city street project. The City proposed to construct just over 2 acres of wetland mitigation in the South Western Avenue detention pond in the area located approximately 1 mile south of the junction of 267th Street and 464th Street. According to City documents, the South Western Avenue project impacted approximately 1 acre of wetlands. The remaining 1-plus acres of the mitigation would be reserved for either the wetland bank program or a future mitigation site. The USACE permitted the widening of the road, which involved the placement of fill into approximately 1 acre of wetland and the compensatory mitigation plan of the expansion of an existing wetland by excavation of upland approximately 1.5 acres in size.

A Section 404 permit application and mitigation plan regarding the 0.4-acre wetland impact was submitted to the USACE on January 22, 2001. A Nationwide Permit was granted by the USACE in a letter dated May 11, 2001. The Nationwide Permit number for the Cell 1 Expansion Site is 200130071 and was issued April 3, 2001.

In the May 11, 2001, letter to the City, the USACE indicates that the permit is valid until April 3, 2003. The Compliance Certification form should have been signed and returned to the USACE upon completion of the authorized work. It is our understanding that the mitigation work was not completed in the timeframe of the permit. We understand that the City plans to complete the mitigation in 2003.

Scale-House Construction - Wetland Permit Review

On June 12, 2001, HDR completed wetland delineations for the construction of a new scale facility north of the existing landfill. Construction of the scale facility required the expansion of road rights-of-way by 25 feet on both the east and west sides of the existing road. One wetland was impacted by the new scale facility. The total wetland area was 0.25 acres, but only 0.09 acres was impacted by the scale facility construction.

A Section 404 permit application was submitted to the USACE on June 29, 2001. On August 8, 2001, the USACE responded saying no Section 404 permit was required due to the SWANCC ruling (Solid Waste of Northern Cook County versus USACE) regarding isolated wetlands.

Entrance Road Construction - Wetland Permit Review

On January 9, 2002, HDR completed a wetland delineation report for the entrance road reconstruction north of the landfill. Wetland delineation was conducted on December 13, 2001, along the landfill access road located on the section line between Sections 34 and 35. According to the planned layout for the reconstruction of the access road, 4,187 square feet (0.096 acres) of wetlands would be impacted. Five wetlands were delineated and four were impacted by the road construction.

In January 2002 a Section 404 permit application was submitted to the USACE. On February 20, 2002, the USACE replied saying they don't have authority over the work area and that a Section 404 permit was not required due to the SWANCC ruling regarding isolated wetlands.

Buffer Area North and East of Active Area - Wetland Permit Review

On July 22, 2002, HDR completed a wetland delineation report for an 80 acre buffer area (Area 1) located north of the Active Area and a 40 acre buffer area (Area 2) located east of the Active Area. The wetland delineations were conducted on June 12 and 13, 2002. A portion of Area 1 along the road corridor had been previously delineated and the wetlands were determined to be non-jurisdictional isolated wetlands. Six wetlands were identified and delineated in Area 1. The documents indicated that all wetlands in Area 1 would be impacted, which included a total of 27,747 square feet (0.637 acres) of wetlands. The proposed project in Area 2 would impact approximately 12,675 square feet (0.291 acres) of existing wetland.

A Section 404 permit application was submitted to the USACE. On August 21, 2002, the USACE replied saying a Section 404 Permit was not required for grading with associated placement of fill into isolated wetlands in Areas 1 and 2 per the SWANCC ruling.

Farmed Wetlands

Several of the wetlands delineated by HDR were identified as FSA wetlands and were mapped by HDR using FSA methodology. Under the FSA Swampbuster program, wetlands that are identified as farmed wetlands are regulated by the Natural Resource Conservation Service (NRCS) as long as the wetlands occur on land in agricultural use. A NRCS map of farmed wetlands is included in the HDR report. The NRCS is responsible for the delineation of wetlands on agricultural land and the USEPA and USACE accept their delineations. However, on non-agricultural land the USACE is the lead federal agency responsible for delineations.

The CWA exempts from the Section 404 program discharges associated with normal farming, ranching, and forestry activities such as plowing, cultivating, minor drainage, and harvesting for the production of food, fiber, and forest products, or upland soil and water conservation practices (Section 404(f)(1)(A)). To be exempt, these activities must be part of an established, ongoing operation. For example, if a farmer has been plowing, planting, and harvesting in wetlands, he can continue to do so without the need for a Section 404 permit, so long as he does not convert the wetlands to dry land.

Grading activities (such as landfill development) that would change any area of Waters of the U.S., including wetlands, into dry land are typically not exempt. Minor drainage that is exempt under Section 404(f) is limited to discharges associated with the continuation of established wetland crop production (e.g., building rice levees) or the connection of upland crop drainage facilities to Waters of the U.S.

Section 404(f)(2) provides that discharges related to activities that change the use of the Waters of the U.S., including wetlands, and reduce the reach, or impair the flow or circulation of Waters of the U.S. are not exempted. This “recapture” provision involves a two-part test that results in an activity being considered not exempt when both parts are met: 1) does the activity represent a “new use” of the wetland, and 2) would the activity result in a “reduction in reach/impairment of flow or circulation” of Waters of the U.S.? Consequently, any discharge of dredged or fill material that results in the destruction of the wetlands character of an area (e.g., conversion to uplands due to new or expanded drainage) is considered a change in the Waters of the U.S., and by definition, a reduction of their reach and is not exempt under Section 404(f).

It should be emphasized that the use of Section 404(f) exemptions does not affect Section 404 jurisdiction. For example, the fact that an activity in wetlands is exempted as normal farming practices does not authorize the filling of the wetland for other uses without a review by the USACE to assess the need for Section 404 permit.

As a result, to ensure that all wetland permitting requirements are met, farmed wetlands that meet the wetland criteria should be identified in Section 404-related correspondence and applications. For example, Wetland 15b (0.14 acres) and wetland 12 (0.02 acres) met wetland criteria as described in the HDR Report, but were not included in the list of wetlands that would be filled by Phase 1 development. They may have been left off because they were considered farmed wetlands. However, filling a farmed wetland to create an upland for other use typically requires a 404 permit unless it is exempt under the SWANCC ruling as an isolated wetland or other criteria. This should be considered as part of future wetland impact assessment and permitting.

2.2.4.3 Waters of the United States

The HDR delineation report identified the channelized drainage ditch in the southwestern portion of the Expansion Area and the stock pond adjacent to it as Waters of the U.S. Based on conversations with Steve Naylor, USACE, the ditch running from Wetland 13 southward, including areas 15 a, b, c, and d would also likely be considered a Water of the U.S. for permitting purposes. A ditch can make previously isolated natural or manmade otherwise isolated wetlands Waters of the U.S. A distinct ditch (as opposed to a plow furrow) conveying water to a creek is a surface water connection and may be considered a Water of the U.S. This should be considered and discussed with the USACE as part of future permitting.

Relocation of Channelized Drainage (Southeast ¼ Section 34)

A drainageway crosses the southwest portion of the proposed Expansion Area. This includes a delineated 100-year floodplain that carries drainage from Wall Lake. The drainageway was channeled prior to the City taking ownership of the land. To fully develop this area for disposal, the drainageway would have to be rerouted.

Attachment C of the City of Sioux Falls Solid Waste Permit, dated November 26, 2002, is a copy of a floodplain variance for construction of the Expansion Area. The document stated that the operator does not plan to disturb or operate in this floodplain during the term of the permit. The variance also stated that, "federal and state regulations and rules allow lateral expansion of an existing municipal solid waste landfill (MSWL) within a floodplain. The operator must demonstrate that the MSWL will not restrict the flow of the 100-year floodplain, reduce the temporary water storage capacity of the floodplain, or result in washout of solid waste to pose a hazard to human health and the environment. The operator must place the demonstration in the operating record and notify the SDDENR-Water Management Program that it has been placed in the operating record. The operator will need to complete the demonstration prior to any landfill activities within the floodplain. Furthermore, the operational and design requirements of this permit are specifically designed to ensure that the operation of the landfill will not pose a hazard to human health or degrade the environment. The operator shall comply with the conditions of this permit."

According to Steve Naylor, USACE, and based on past experience, as a general rule the relocation of a channel is not viewed positively. However, there are specific case-by-case evaluations as to whether the relocation would be in the public's interest. In this case, the drainage has already been channelized and it is likely that the USACE would consider relocation, if meanders were incorporated to elongate and stabilize the drainage, more favorably. The conceptual design of future relocation should be discussed with the USACE and other agencies that would be involved in the Section 404 process such as the USFWS, SDDENR, and SDDGFP. The SHPO has already suggested a records search and survey of future expansion areas.

Stock Pond

Section 404 permitting procedures related to stock ponds can be complex. The construction of ponds for watering stock is exempt. Therefore, in some cases when they are eliminated it has been interpreted by the USACE that if the construction is exempt, the decommissioning is exempt. However, if the pond was built of previously existing wetlands or streams, the USACE may still have jurisdiction over the pond and require a 404 permit to fill it. In regard to ponds adjacent to waterways that are excavated rather than dammed, the USACE may require that a 404 permit be obtained if the area is not returned to original contours.

2.2.4.4 Conclusions and Recommendations

Based on the available documentation, it appears that permitting efforts for recent construction have been addressed. One major exception is the mitigation project and permit certification for the Cell 1 construction. The nationwide permit authorization for this project expired April 3, 2003. Since the mitigation project will not be completed until later in 2003, the City should contact the USACE to verify the status of the permit and the steps necessary to return to compliance.

For future site development, we recommend that a meeting be held with pertinent agencies to review anticipated permitting feasibility and identify any potential issues. As part of the agency coordination, the likelihood of obtaining permits related to full expansion and required mitigation and design features should be identified. The meeting could include an agency site review. Issues warranting discussion include:

- Wetland Mitigation: Determine current status of wetland mitigation and potential future needs. Assess the potential for on-site mitigation for future wetland impacts and wetland banking, possibly in association with the relocation of the drainage area identified as Area 19, or other site development.

- Floodplains: Discuss with agencies potential floodplain impacts and related permitting requirements related to development of the area identified as Area 19.

- Waters of the U.S.: Through coordination with the USACE, determine which ditches and drainages on site are Waters of the U.S. Wetlands identified as 15 a-d and 12, part of a ditch system that would likely be regulated as Waters of the U.S. regardless of whether they met wetland criteria. Discuss the feasibility and requirements related to the relocation of the channel identified as Area 19, as well as design criteria, such as meanders, that would increase the likelihood of permittability. Determine if the stock pond located in the Expansion Area would be exempt or require a permit.

- Farmed Wetlands: Discuss with agencies the permitting requirements related to development in areas identified as farmed wetlands. Farmed wetlands that meet the wetland criteria should be identified in Section 404-related correspondence and applications.

It is our understanding that a wetland mitigation project was under consideration in the buffer area east of the Active Site. This project was put on hold pending the results of this site review. Although little detail is available about this project at the present time, we have no major concerns about this project from a conceptual standpoint. If the City chooses, this project could proceed. We recommend that this project be closely coordinated with current and potential future groundwater monitoring and remediation activities that may occur in response to ground water contamination identified in this vicinity.

In addition to, or instead of, the mitigation project east of the Active Site, we recommend that the City consider a mitigation project associated with the relocation of the Wall Lake drainage ditch in the Expansion Area. Permitting of the ditch relocation may be made more acceptable to agencies if it was combined with a mitigation project that includes meanders to elongate and stabilize the drainage in a favorable way. This mitigation project is contingent on the City purchasing adjacent property to the south and west of the Expansion Area.

2.2.5 Air Permits and Requirements

Earth Tech has reviewed available documents addressing air quality compliance at the SFRSL. These documents include a Tier II NMOC Emission Rate Report (HDR, 1998) and a letter including updated NMOC calculations (HDR, 2000). The following discussion provides a summary of applicable regulations, our understanding of the status of compliance of the landfill, and our conclusions.

2.2.5.1 Regulatory Overview

Specific federal air quality regulations pursuant to 40 CFR 60 Subpart WWW (Landfill New Source Performance Standards, or NSPS) apply to landfills having a waste capacity of 2.5 million megagrams (Mg) or 2.5 million cubic meters (3.25 million cubic yards). These regulations apply to landfills constructed or modified after May 30, 1991. It is our assumption that the SFRSL is subject to these regulations.

Since the capacity of SFRSL exceeds the threshold of 3.25 million cubic yards, the site is subject to air permitting requirements regardless of the air emissions estimated for the site. Therefore the following air permitting requirements are applicable:

- Submittal of a Title V air permit application (in South Dakota, initial Title V permit applications were due April 21, 1996. The landfill's application would have been due 12 months after the site became subject to the NSPS).

- NSPS NMOC emission rate reports (annual or 5 year reports).

- Submittal of annual emission inventories.

- Annual compliance certifications (once a Title V Permit is issued).

- Semi-annual deviation reports (once a Title V Permit is issued).

The MSW Landfill NSPS requires landfills with annual air emissions of non-methane organic compounds (NMOC) greater than 50 Mg/yr (approximately 55 tons/yr) to collect and control landfill gas emissions. Landfills meeting this control criteria are also subject to National Emissions Standards for Hazardous Air Pollutants (NESHAP) for MSW Landfills. The NESHAP regulations were recently promulgated in January 2003 and address primarily administrative and reporting requirements.

To determine emissions and the applicability of installing a collection and control system pursuant to the NSPS, landfills subject to the NSPS have the option of calculating NMOC emissions using standard default values (Tier 1) or by site specific testing (Tier 2). The NSPS defaults used in the Tier 1 analysis are considered conservative. In the event that Tier 1 calculations predict NMOC emissions greater than 50 Mg/yr, within 180 days of the initial Tier I calculation a facility may determine its NMOC concentration in the landfill gas and recalculate NMOC emissions using the Tier 2 NMOC concentration.

There are currently no air quality permit requirements or control requirements for methane emissions. Methane is a greenhouse gas however and could be regulated in the future.

2.2.5.2 Regulatory Compliance Status

The SFRSL has a current waste capacity of 2.9275 million megagrams (Mg), not including the Expansion Area (HDR, 2000). Therefore, SFRSL is subject to the NSPS and therefore should have applied for a facility Title V application within 12 months of becoming subject to the NSPS.

South Dakota rules require Title V facilities to obtain either a preconstruction permit or Title V permit before beginning construction and to authorize operation of expansions. It is our understanding from the City that an air quality permit for the landfill has not been issued. The City made an application to the SDDENR in May 2003.

In addition to the air quality permit, the NSPS requires landfills to submit a Design Capacity Report by the earliest of either 30 days after beginning construction on an expansion, 90 days after receiving an air quality construction permit, or 30 days after waste is placed in an expansion. It is our understanding that a Design Capacity Report has not been submitted. Construction of Cell 1 in the Expansion Area was completed in 2002.

It is our understanding from the City that the SDDENR performed Tier 1 calculations for the facility in July 1997. The initial Tier 1 calculations "start the clock" on subsequent NSPS compliance activities and deadlines. In 1998, the City proceeded with Tier 2 testing (site-specific testing) for NMOCs to identify the site's average NMOC concentration in its landfill gas. Under the NSPS regulations, Sioux Falls is required to conduct verification of NMOC sampling programs (Tier 2) every 5 years. As required, Tier 2 testing was most recently performed in July 2003. Both of the 1998 and 2003 sampling events resulted in calculated NMOC emissions for the landfill below the 50 Mg/yr threshold where the NSPS requires gas collection and control. However, based on the calculations, the facility is expected to reach the 50 Mg/yr threshold in the year 2004.

2.2.5.3 Tier 2 Testing Results

1998 Testing Results

The 1998 testing resulted in an average NMOC concentration of 130 ppmv, as hexane (HDR, 2000). Those results suggested that if future annual waste acceptance rates remained fairly constant over the landfill's life and the site's NMOC concentration remains constant, the NSPS gas collection and control requirements would not apply. However, as evidenced by the 2003 test results, the measured NMOC concentrations can vary widely at a site and can vary over time.

2003 Testing Results

The 2003 testing resulted in an average NMOC concentration of 501 ppmv, as hexane. This results in an NMOC emission rate of 49.6 Mg for the year 2003. Based on the waste acceptance for 2002 (the landfill gas generation calculations assume there is a 1-year pause before waste starts to decompose and emit gas), the facility will exceed the 50 Mg/yr threshold in 2004.

The difference in the 1998 results and the 2003 results is not surprising. Samples from the 1998 Tier 2 testing were collected around the perimeter of the main Active Area, apparently because the upper 40 feet of waste in the central portion of this area was placed relatively recently, within two years of the testing (1996 and 1997). The methodology actually requires that 2 samples per hectare be obtained from all areas of waste that are two years old or older. The 2003 sampling event included areas of the landfill not sampled previously. This included areas in the central portion of the landfill.

2.2.5.4 Conclusions and Recommendations

It is our understanding that the City recently (May 2003) applied for a Title V permit for the landfill that includes both the Active Area and the Expansion Area. The City should also verify with the SDDENR if a Design Capacity Report is needed for the Expansion Area. The rules require this report within 30 days after beginning construction on an expansion.

Although the July 2003 Tier 2 testing indicates that collection and control of landfill gas is not currently required under the NSPS, calculations indicate that the threshold for this may be reached in 2004. The landfill has three options to continue compliance with the air quality rules. Tier 2 testing can be performed again in 2004. If the testing results in a lower NMOC concentration, the landfill may avoid having to install a gas collection system. Comparatively, further Tier 2 testing is much less expensive than the other options. However, if the results of the new Teir 2 testing are the same or higher, Tier 3 of the NSPS will be triggered. Tier 3 testing is used to determine a gas generation rate from the landfilled waste. This testing involves drilling and installing several wells into the landfill. Tier 3 testing would cost more than Tier 2 testing would, but would be less than installing a gas collection system. Once the gas generation rate is determined, the NMOC emissions are recalculated. If the results still show greater than 50 Mg/yr emission, a collection system would be required. The third option is for the landfill to install a gas collection system at this time, and dispense with performing further gas sampling.

In addition to the NSPS compliance issues, we believe there are other tangible and intangible benefits that a landfill gas collection system could facilitate for the City. Potential benefits could include the following:

- Collection of landfill gas may present opportunities for beneficial use such as generation of electricity or heat.

- Collection and control of landfill gas may complement efforts to remove leachate from the Active Area. That is, gas wells could also be used for leachate removal and the accompanying header system could be used for conveyance of leachate to storage tanks or ponds.

- Regardless of NMOC concentrations, methane is also a powerful greenhouse gas. Although methane emissions are currently unregulated, collection and control of landfill gas will reduce a significant source of these emissions, particularly if the gas is beneficially used and results in offset of fossil fuels.

- Landfill gas extraction systems assist in removing and destroying volatile organic compounds from the waste mass and reduces the potential for these compounds to migrate in gaseous form and to leach into groundwater. Landfill gas extraction systems are known to reduce the risk of groundwater contamination.

- Collection and control of landfill gas will mitigate potential problems with odors.

- Collection and control of landfill gas will mitigate potential problems of gas migration off-site or to adjacent structures.

- Collection and control of landfill gas will reduce the risk of gas seeps through the landfill cover that could result in stressed vegetation and increased cover maintenance.

Further discussion of the above issues and implementation of a landfill gas collection and control system are addressed in Section 4.0 of this report.

2.2.6 Zoning Review

Zoning issues for the landfill and surrounding properties are presented in the 2001 Permit Renewal Application (LBG, 2001). Information contained in the document outlines the specific zoning ordinances applicable to the facility. The following is a summary of the information presented.

The area surrounding the facility is primarily utilized for agricultural purposes. Several groupings of single-family homes are also present. The facility and the adjoining properties are zoned “A-1,” Agricultural. Within a 1 mile radius of the site, there is a small area zoned “RR,” Rural Residential.

Local zoning ordinances control property usage in Minnehaha County. Landfills are subject to conditional use permitting in an A-1 district. The following is the status of the conditional use permits for the facility. The information was taken or paraphrased from a letter to the Sioux Falls Health Department from the Minnehaha County dated June 26, 2001.

Active Area (SW¼ Section 35-T101N-R15W)

This is the original portion of the landfill that was begun in the 1970s. The area was approved by conditional use permit #78-1 on March 13, 1978. That conditional use permit carries with the land and continues as long as the use of the property for a landfill continues. This portion of the property was considered an existing landfill when Minnehaha County passed their solid waste ordinance in 1991 and does not require a County solid waste permit.

Expansion Area (SE¼ Section 34-T101N-R51W)

The Expansion Area received zoning approval from Minnehaha County under conditional use permit #95-22 and was approved by the Minnehaha Planning Commission on June 26, 1995. That permit continues in effect as long as the City continues to meet the permit conditions and continues the use of the property for a landfill use. The solid waste permit #95-1 for the Expansion Area was also approved by the Minnehaha County Commission July 26, 2001. The renewal permit will be effective for 5 years from its effective date of July 17, 2001.

Scale-House Area
(S400’ E75’ N¼ Section 34-T101N-R51W and S400’ W75’ NW¼ Section 35-T101N-R51W)

This area that includes the new scale-house was approved by the Minnehaha County Planning Commission on June 25, 2001, as conditional use permit #01-58, which amended conditional use permit #95-22. That conditional use permit will continue in effect provided that the City continues to meet the permit requirements. This area was also added to the County Solid Waste Permit under permit #01-03 approved by the County Commission on June 26, 2001.

2.3 ENVIRONMENTAL MONITORING EVALUATION

Environmental monitoring is conducted at a waste disposal facility to evaluate the potential impacts and their risk to surrounding water resources including ground water and surface water. In addition, to ensure safety, landfill gas is monitored to prevent accumulation of methane in nearby structures and possible off-site migration. The following regulatory documents were reviewed as part of the evaluation of environmental monitoring at the SFRSL:

- Permit to Operate a Solid Waste Facility, Solid Waste Permit Number 02-26 issued to the City of Sioux Falls, November 26, 2002.

- Administrative Rules of South Dakota (ARSD) 74:27.

- 40 Code of Federal Regulations (CFR) Part 258 (Resource Conservation and Recovery Act-RCRA, Subtitle D).

- U.S. EPA, November 1993, Solid Waste Disposal Facility Criteria Technical Manual (for achieving compliance with 40 CFR Part 258), EPA530-R-93-017.

The results of the evaluation are discussed in the following sections in reference to regulatory compliance.

2.3.1 Solid Waste Permit Number 02-26 (SDDENR-WMP)

The requirements provided in Section 5.0 of the facility solid waste permit are listed below. Each requirement is followed by a discussion concerning the status of compliance.

5.01 The operator shall monitor leachate, ground water, surface water, methane gas, and perform any other testing and/or monitoring required by ARSD 74:27:12, ARSD 74:27:13, and ARSD 74:27:15.

The 2001 and 2002 annual reports (LBG, March 2002; LBG, March 2003) provided a discussion on the monitoring results for ground water and methane gas. The annual reports did not provide information on leachate or surface water monitoring. Based on correspondence with the City, Storm Water Discharge Monitoring Reports have been submitted to the SDDENR during 7 of the last 10 years. The requirement for monitoring of leachate refers to leachate collected from a lined Subtitled D cell. Leachate monitoring is being provided as part of a proactive process to address leachate head levels in the Active Area (pre-Subtitle D area). The state supports the City's efforts in this regard and has not placed mandates or reporting requirements at this time. The reports were not reviewed by Earth Tech. Specific discussion on ARSD requirements is provided in the following section.

5.02 The operator shall monitor ground water quality and ground water levels throughout the active closure, post-closure phases of the facility. This shall be in accordance with the ARSD 74:27:19 and the SDDENR-WMP approved ground water monitoring plan. This includes:

- *Semi-annual measurement of ground water levels in all designated wells.*

- *Semi-annual sampling and analysis of all designated wells for the parameters listed in Attachment A of this permit.*

The results of the required measurements, sampling and analysis shall be maintained in the facility's operating record and included in the annual ground water monitoring report.

The SDDENR approved a ground water monitoring plan in a letter dated June 10, 2002. A proposed change and a summary of the ground water monitoring plan was submitted to the SDDENR in a letter from LBG dated November 25, 2002 (LBG, 2002b). Although we have not reviewed all correspondence pertaining to the ground water monitoring plan, we understand from the City that the amended plan was approved by the SDDENR as submitted.

In general, the current monitoring program appears to meet the minimum monitoring requirements of the facility permit. The 2001 and 2002 annual reports (LBG, March 2002; LBG; March 2003) indicate that water levels have been measured in most wells on a quarterly basis over the past 10 years; no explanation was provided as to why water levels are occasionally not available in some wells. Compliance with ARSD 74:27:19 is discussed in a following section.

5.03 The ground water monitoring system and monitoring program are considered adjustable and subject to revision as construction and operation of the facility progresses, as site conditions change, or as test results from the ground water monitoring dictate. The operator shall submit to and receive written approval from SDDENR-WMP, for any proposed changes in the monitoring system prior to implementation. SDDENR-WMP reserves the right to require changes in the monitoring systems and programs as needed without public notice.

In the November 25, 2002, letter to the SDDENR from LBG (LBG, 2002b), modifications to the monitoring system were proposed in accordance with the facility permit. Although we have not reviewed all written correspondence, we understand from the City that the amended plan was approved by the SDDENR as submitted. Presumably, the approval does not include the proposed changes for filtered metals as requested in the 2001 annual report (LBG, March 2002).

5.04 The operator shall measure methane gas concentrations quarterly in all buildings and at the property boundaries, and in accordance with ARSD 74:27:13:26.

The 2001 and 2002 annual reports (LBG, March 2002; LBG, March 2003) presents the results from quarterly methane monitoring from monitoring wells, along property lines, and in on-site buildings. No detectable concentrations of methane were reported.

5.05 All monitoring and sampling data, results, and measurements referenced in this section are subject to the record keeping requirements of Section 4.0 of this permit.

Section 4 of the permit outlines steps and requirements for operations including contingency action and an annual report submittal to the SDDENR-WMP by April 1 of the following year. Based on the documents provided, it appears that this requirement is met each year by the annual monitoring reports prepared by LBG.

2.3.2 Administrative Rules of South Dakota

Specific monitoring requirements described in the ARSD are summarized as follows by comments as to the facility's status of compliance:

<u>ARSD 74:27:12:19 Ground water monitoring systems</u>: Stipulates the incorporation of a ground water monitoring system that meets applicable provisions of Chapter 74:27:19 and follows a ground water monitoring plan describing the monitoring system, monitoring parameters, and monitoring frequencies.

The SDDENR approved a ground water monitoring plan in a letter dated June 10, 2002. A proposed change and a summary of the ground water monitoring plan was submitted to the SDDENR in a letter from LBG dated November 25, 2002 (LBG, 2002b). Although we have not reviewed all written correspondence, we understand from the City that the amended plan was approved by the SDDENR as submitted. Compliance with ARSD 74:27:19 is discussed in a subsequent section below.

<u>ARSD 74:27:13:16 Monitoring</u>: Requires all monitoring systems be operated and maintained throughout the active life and post-closure period.

This requirement is not applicable at this time.

<u>ARSD 74:27:13:26 Methane gas monitoring</u>: Requires measurement of methane gas concentrations quarterly in all buildings and in soils or air at the property boundaries.

As stated in the previous section, the 2001 and 2002 annual reports (LBG, 2002a; LBG, 2003) presents the results from quarterly methane monitoring from monitoring wells, along property lines, and in on-site buildings. No detectable concentrations of methane were reported.

<u>ARSD 74:27:15:09 Post-Closure Plan</u>: Stipulates a written post-closure plan be prepared that includes a description of monitoring activities during the post-closure period.

The Closure/Post-Closure Plan (HDR, 2001b) outlines post-closure activities at the facility including maintaining the facility monitoring activities.

<u>ARSD 74:27:19 Ground water monitoring</u>: Outlines the ground water monitoring requirements at facility including detection monitoring systems, parameters, frequency, and procedures. Detection monitoring systems must be located to determine ambient ground water quality and to detect migration of leachate constituents from a facility. At least three wells must be located immediately downgradient of the waste disposal areas and installed by a well driller licensed in South Dakota. Monitoring parameters shall ensure an accurate representation of ground water quality with, at a minimum, analysis conducted for the parameters listed 40 CFR Part 258. Frequency of monitoring should occur semi-annually with four independent samples collected during the first semi-annual sampling period for new wells. Sampling procedures must comply with ARSD 74:54:01:06 except that field filtering (dissolved) is not allowed for metals analysis. A qualified ground water scientist or engineer licensed in South Dakota must certify that the ground water monitoring system meets the requirements of 40 CFR Part 258.

As stated above, the SDDENR approved a ground water monitoring plan in a letter dated June 10, 2002. A proposed change and a summary of the ground water monitoring plan was submitted to the SDDENR in a letter from LBG (LBG, 2002b). The letter prepared by LBG lists the following tasks as the ground water monitoring plan:

- Obtaining ground water elevation data from 30 monitoring wells on a semi-annual basis.

- Obtaining ground water samples from background wells MW-11, MW-17, MW-21ox, MW-23ox, MW-25ox, and MW-39ox and compliance wells MW-5, MW-7R, MW-13R, MW-18, MW-20, MW-22ox, MW-42ox, MW-44ox, MW-45ox, MW-47ox, and MW-48ox on a semi-annual basis.

- Analyzing the samples for the presence and concentration of RCRA Subtitle D Appendix I constituents, dissolved metals (filtered samples) from Table 1 of ARSD 74:54:01:04 and chlorides.

In general, the current monitoring program appears to meet the minimum monitoring requirements of the facility permit. The 2001 and 2002 annual reports (LBG, 2002a; LBG, 2003b) indicate that water levels have been measured in most wells on a quarterly basis over the past 10 years; no explanation was provided as to why water levels are occasionally not available in some wells. There does appear to be ambient water quality data from several upgradient wells and the number of downgradient wells available at the facility would meet the three-well minimum requirement. The parameter list does meet requirements. However, 40 CFR Part 258 (Subtitle D) and ARSD 74:27:19:06 do not allow ground water samples for metals analysis to be filtered. It is not known if the SDDENR has approved the monitoring for filtered metals for the SFRSL.

The annual reports do not reference certification by a qualified ground water scientist or engineer. Sampling procedures are summarized in the annual report, but well-specific information is limited.

ARSD 74:27:20 Assessment monitoring: *Required at facilities that have detected a statistically significant increase in concentration of one or more parameters.*

The 2001 and 2002 annual reports (LBG 2002a; 2003b) presents that several wells indicate ground water contamination, but the report does not refer to the need or the status of assessment monitoring. We understand from the City that the SDDENR has not determined or notified the SFRSL that assessment monitoring is required at this facility.

2.3.3 40 CFR Part 258

Specific monitoring requirements described in 40 CFR Part 258 are summarized below followed by comments as to the facility's status of compliance:

40 CFR Part 258.23 Explosive gases control: Describes monitoring requirements for facilities such as the type and frequency of monitoring that must be determined based on soil conditions, hydrogeologic conditions, hydraulic conditions, and the location of structures and the property boundary.

The monitoring described in the 2001 and 2002 annual reports (LBG, 2002a; 2003b) meets the frequency criteria and indicates structures are monitored. However, it is unclear whether the type and frequency of monitoring in wells and along property boundaries are based on soil, hydrogeologic, or hydraulic conditions. Monitoring wells may or may not provide adequate monitoring points for methane based upon the screened interval and the static water level in the well. Above ground monitoring at the property boundary does not take into consideration the soil, hydrogeologic, or hydraulic conditions.

<u>40 CFR Part 258.50 Applicability</u>: Allows federal requirements to be suspended by the State of South Dakota based on site-specific measurements and contaminant fate and transport predictions.

Although the State of South Dakota can suspend portions of the rules, the ARSD 74:27:19:03 specifically states that the ground water monitoring system must meet the requirements of 40 CFR Part 258.

<u>40 CFR Part 258.51 Ground water monitoring systems</u>: Monitoring systems should be placed in the operating record and certified by a qualified ground water scientist. Ground water monitoring systems must consist of a sufficient number of wells to yield ground water samples from the uppermost aquifer. When physical obstacles preclude monitoring the relevant point of compliance, the monitoring system may be installed at the closest practicable distance hydraulically downgradient ensuring detection of ground water contamination in the uppermost aquifer. Well construction should meet industry standards. Wells should provide representative background (or upgradient) data and represent the quality of ground water passing the relevant point of compliance as specified by the State of South Dakota (a maximum of 150 meters from waste). Monitoring systems should be based on orientation of landfill units, hydrogeologic setting, site history, engineering design, and type of waste. The number, spacing, and depths of monitoring systems should be based on site characterization data including: aquifer thickness, ground water flow rate, flow direction, and seasonal and temporal fluctuations in flow. Characterization should include definition of the geologic units in reference to thickness, stratigraphy, lithology, hydraulic conductivities, porosities, and effective porosities.

As stated in the preceding sections, the SDDENR approved a ground water monitoring plan in a letter dated June 10, 2002. A proposed change and a summary of the ground water monitoring plan was submitted to the SDDENR in a letter from LBG dated November 25, 2002 (LBG, 2002b). We understand from the City that the amended plan was approved as submitted. The ground water monitoring plan presumably meets the requirement of the operating record. However, the ground water monitoring plan in the November 25, 2002, letter does not provide certification or confirmation that the SDDENR has accepted the Wall Lake aquifer as the relevant point of compliance for the facility. It appears that all wells constructed between 1989 and 2002 meet minimum well construction requirements of the current South Dakota SDDENR Water Well Code.

Because the Wall Lake aquifer is greater than 150 feet below ground surface, monitoring the Wall Lake aquifer would not meet other technical considerations. The U.S. EPA's Technical Manual for Solid Waste Disposal Facility Criteria for 40 CFR Part 258 (U.S. EPA, November 1993) states:

- The objective of a ground water monitoring system is to intercept ground water that has been contaminated by leachate.

- Early contaminant detection is important to allow sufficient time for corrective measures to be developed and implemented before sensitive receptors are significantly affected.

Therefore, the closest practicable distance hydraulically downgradient is the weathered till hydrostratigraphic unit bounded by underlying low permeability clays. Monitoring and corrective action within the water table hydrostratigraphic unit would ensure protection of the uppermost aquifer.

Based on the November 25, 2002, ground water monitoring plan (LBG, 2002b), six wells were proposed for monitoring that would meet the criteria of upgradient wells. Typically, one well from each geologic unit would be sufficient for defining upgradient water quality. Therefore, the proposed background monitoring is exceeding regulatory requirements.

The available information (LBG, 1996a; 1996b; 1996c) indicates that the bottom of the waste (or proposed bottom of waste) in both the existing Active Area and the Expansion Area is approximately 30 to 60 feet below the water table. Downgradient wells at this site should be positioned to monitor a landfill below the water table (landfill orientation and engineering design criteria) and along preferred ground water flow paths within the low permeability glacial tills (hydrogeologic setting criteria). In disposal areas where leachate has been allowed to build-up within the landfill, there is a risk of leachate migration into both shallow ground water (lateral migration) and deeper ground water (downward migration at the landfill base) and therefore, the monitoring of both water table and deeper wells would be appropriate. Up to six-nested wells meet these criteria in the existing waste disposal areas. In the Expansion Area where leachate will be managed 12-inches or less above the bottom liner, the greatest risk of leachate migration is through the base of the landfill and monitoring deeper wells near the base of the landfill would be appropriate. Prior to the Cell 1 supplemental investigation in May 2003, only two wells met this criterion in the Expansion Area and these wells were not located downgradient of the first 10-acre cell (Cell 1).

The basis for the number, depth, and spacing of downgradient monitoring wells is not clear as presented in the amended ground water monitoring plan dated November 25, 2002 (LBG, 2002b). Although several wells were installed to define oxidized versus unoxidized ground water conditions, the available reports (Iles, 1989; Maxim, 1995; LBG, 1996a; 1996b) do not adequately characterize the site in reference to ground water flow rate and flow direction. Instead, the hydrogeologic assessment report for the Expansion Area (LBG, 1996b) states that the prepared ground water contour maps "should not be construed as indicating lateral ground water flow is occurring." Furthermore, Maxim (1995) concludes that based on the age of the ground water, there is very little ground water flow occurring in the vertical direction. Although the hydraulic conductivity of the oxidized and unoxidized tills does not appear to be conducive to yield significant quantities of ground water, contaminants are present in both units (probably from diffusion). Monitoring results from wells MW-19 and MW-19I in the central and northeast corner of the site verifies that ground water movement occurs and contaminants are able to migrate in the absence of significant sands.

Sufficient information appears to be available to adequately define hydrogeologic parameters at the water table such as ground water flow rate, flow direction, and seasonal and temporal fluctuations in flow. However, the limitations on the available data are related to interpretation and the following additional information:

- Well locations screened below the proposed base of the landfill expansion, and/or at the contact between the Wisconsinan and pre-Illinoisan-aged tills.
- In-situ hydraulic conductivity data for the over 350 acres (only 16 of the 70 wells were tested).
- Documentation of lithology in terms of grain-size distribution and Atterberg limits (the results from only four samples were available at the time of facility permitting).
- Use of the lithology to estimate porosity and effective porosity.

Although ground water maps are routinely generated (LBG, 1996a; 1996b; 2002a; 2003b), they do not consistently and accurately interpolate between data points. Location-specific flow rates and directions are not defined under the premise that any ground water movement is considered insignificant. Groundwater contours and water levels are not used to quantify horizontal and vertical gradients and the hydraulic conductivities are not used in conjunction with gradients to estimate the specific discharge and average linear flow velocities. This information is critical for the evaluation of contaminant fate and transport within the ground water system to allow appropriate corrective action measures to be designed.

40 CFR Part 258.53 Ground water sampling and analysis requirements: States that the monitoring system placed in the operating record should include consistent sampling and analysis procedures including techniques and procedures for sample collection, preservation and shipment, Chain-of-Custody control, analytical procedures, and quality assurance/quality control (QA/QC). The monitoring program should include methods that accurately measure hazardous constituents and be protective of human health and the environment. Monitoring must determine the rate and direction of ground water flow for each sampling event. Sampling should include background or upgradient data. The operating record should specify the proposed statistical method and evaluate data to determine if a statistically significant increase has occurred.

The ground water monitoring plan proposed in the November 25, 2002, letter (LBG, 2002b) does not outline procedures for sample collection, preservation and shipment, Chain-of-Custody control, analytical procedures, and QA/QC. Based on the information provided in the 2002 annual report (LBG, 2003b), sampling procedures are summarized and well-specific information limited. Modifications to field and the Chain-of-Custody forms were not completed per U.S. EPA guidance and the state of practice with edits blacked out and unreadable. However, the 2001 and 2002 annual reports (LBG, 2002a; 2003b) suggest that analytical methods are inconsistent and inadequate. The method detection limits vary over time and are often higher than the baseline causing a nondetect to be reported as a statistically significant increase.

In reference to QA/QC, field blank samples were analyzed to assure contaminants are not introduced from field equipment. Similarly, laboratory blanks and matrix spikes were used by the laboratory to evaluate quality control in the laboratory. However, trip blanks and duplicate samples were applied inconsistently to assure contaminants are not introduced during transport and to assure repeatability of the laboratory results. In addition, the applied analytical methods do not appear to be adequate for evaluating human health criteria because the detection limits for at least three parameters (antimony, beryllium, and thallium) appear to routinely exceed drinking water standards. Although the application of statistical methods appears thorough, it does not sufficiently distinguish natural occurring metals.

40 CFR Part 258.54 Detection monitoring program: Outlines the need for semi-annual detection monitoring for parameters in Appendix I. Alternative parameters and frequencies may be proposed based on waste constituents, pre-development water chemistry, lithology, hydraulic conductivity, ground water flow rates, distance to wells, and resource value of aquifer.

As stated above, the SDDENR approved a ground water monitoring plan in a letter dated June 10, 2002, and LBG proposed modifications to the plan in 2002 (LBG, 2002b). In general, the current monitoring program in reference to frequency of monitoring and the list of analytical parameters appear to meet the minimum monitoring requirements of the facility permit. Other than the addition of chloride to the analytical list, very little information is provided in the amended ground water monitoring plan (LBG, 2002b) letter regarding the rational to the list of parameters or the frequency of monitoring.

40 CFR Part 258.54 Assessment monitoring program: Outlines the procedures and timelines to follow should statistically significant increase over background has occurred.

The 2001 and 2002 annual reports (LBG, 2002a; 2003b) presents that several wells indicate ground water contamination, but the report does not refer to the need or the status of assessment monitoring. Based on correspondence with the City, the SDDENR has not determined or notified the SFRSL that assessment monitoring is required at this facility.

2.3.4 Conclusions and Recommendations

Based on our review of available documents and our understanding of state and federal regulations, the following regulated issues appear to be consistent with the minimum regulatory requirements:

- Methane monitoring frequency.
- Ground water analytical parameters.
- Annual reporting.
- Monitoring portions of the Closure/Post-Closure Plan.
- Number of ground water samples for ambient water quality.
- Well construction.
- Laboratory QA/QC procedures.

However, information that is absent in the documents reviewed include:

- Methane monitoring in soil.
- Trip blank analytical results.
- Duplicate sample analytical results.
- Chain-of-custody documentation per U.S. EPA guidance.
- Facility compliance in reference to assessment monitoring.

In conclusion, the following observations were made concerning environmental monitoring at the SFRSL:

- Although the State of South Dakota can suspend portions of the rules, the ARSD 74:27:19:03 specifically states that the ground water monitoring system must meet the requirements of 40 CFR Part 258.

- Monitoring wells may or may not provide adequate monitoring points for methane based upon the screened interval and the static water level in the well. Above ground monitoring at the property boundary does not take into consideration the soil, hydrogeologic, or hydraulic conditions.

- The Wall Lake aquifer represents the uppermost aquifer and therefore, meets the designation of the relevant point of compliance. However, due to site-specific technical considerations and physical obstacles to monitoring this deep aquifer, the closest practicable distance for monitoring hydraulically downgradient of the disposal areas and still ensure protection of the uppermost aquifer is the water table hydrostratigraphic unit.

- The permitting documents do not adequately characterize the site in reference to ground water flow rate and flow direction. Although the hydraulic conductivity of the oxidized and unoxidized tills does not appear to be conducive to yield significant quantities of ground water, the presence of contaminants in ground water in several wells in the central and northeast corner of the site verifies that ground water movement occurs and contaminants are able to migrate in the absence of significant sands.

- Sufficient information appears to be available to adequately define hydrogeologic parameters such as ground water flow rate, flow direction, and seasonal and temporal fluctuations in flow. The limitations on the available data appear to be related to interpretation; however, adequacy of the monitoring systems could be substantiated with additional information on wells screened below the landfill expansion (including the contact between the Wisconsinan and pre-llinoisan-ged till), in-situ hydraulic conductivity data, lithology, and effective porosity.

- Not all available water level data is interpolated to define location-specific flow rates and directions. In addition, the contours and water levels are not used to quantify horizontal and vertical gradients and the hydraulic conductivities are not used in conjunction with gradients to estimate the specific discharge and average linear flow velocities.

- The basis for the number, depth, and spacing of downgradient monitoring wells is not clear.

- In disposal areas where leachate has been allowed to build-up within the landfill, there is a risk of leachate migration into both shallow ground water (lateral migration) and deeper ground water (downward migration at the landfill base) and therefore, the monitoring of both water table and deeper wells would be appropriate.

- In the expansion disposal area where leachate is or will be managed 12-inches or less above the bottom liner, the greatest risk of leachate migration is through the base of the landfill and monitoring deeper wells near the base of the landfill would be appropriate.

- The six nested wells in the Expansion Area that meet site-specific monitoring criteria are not adequate for monitoring the along potential preferential flow paths below the base of the landfill. Wells in May 2003 address this issue for Cell 1.

- Analytical methods are inconsistent and inadequate and cause failure in the application of statistical methods.

- Analytical methods do not appear to be adequate for evaluating human health criteria because the detection limits for at least three parameters (antimony, beryllium, and thallium) appear to routinely exceed drinking water standards.

- Although the application of statistical methods appears thorough, it does not sufficiently distinguish natural occurring metals.

Based on the above observations and conclusions, the following recommendations are made concerning environmental monitoring at the SFRSL:

1. Establish specific, permanent gas probes along property boundaries to evaluate methane migration.

2. Improve the characterization of site geology and hydrogeology to establish likely ground water flow paths, particularly below the proposed base grades in the Expansion Area. (See Section 2.1.6)

3. Prepare a site-specific monitoring plan ground water, surface water, leachate, and methane to outline all regulatory requirements pertaining to facility monitoring to be used by the City as well as those contracted to complete the work. To be of greater use to the facility and meet state of practice, the ground water monitoring plan should include additional information as follows:

    - Relevant point of compliance.

    - Monitoring network.

    - Monitoring frequency.

    - Monitoring parameters.

    - Statistical Methods.

    - Monitoring procedures including:

        - Sample collection.
        - Sample preservation and shipment.
        - Chain-of-Custody control.
        - Analytical methods.
        - QA/QC.
        - Certification of monitoring plan.

2.4 PRIMARY CONTAINMENT EVALUATION

The SFRSL was re-issued their permit to operate a solid waste facility by the SDDENR on November 26, 2002. Of the information outlined in the permit, one permit condition authorizes the use of an alternative liner system in lieu of a standard Subtitle D composite liner (40 CFR Part 258).

2.4.1 Design and Construction Requirements

The Administrative Rules of South Dakota (ARSD) 74:27:12:17 provides that the alternative liner system demonstrate compliance with 74:27:12:02. This rule states "facilities must be designed and constructed to protect human health and prevent degradation of the environment, including ambient groundwater quality, surface water quality, and air quality." Item 2.02 of the facility Solid Waste Permit authorizes the use of in-situ clay soils as an alternative liner system with the following conditions:

- A qualified third-party Professional Geologist or equivalent, experienced in the hydrogeology of glacial till, is present on-site during cell excavation to ensure that the in-situ clay soils are of the characteristics stated in the permit application.

- Any discontinuities in the in-situ soil, or any soil material which is more permeable than 1×10^{-7} cm/sec are over-excavated as necessary and an engineered soil liner with a permeability of no more than 1×10^{-7} cm/sec be constructed in that area.

- The outside sidewalls of the cell(s) are lined with a synthetic liner no more permeable than 1×10^{-7} cm/sec.

2.4.2 Liner Soil Characterization

The SFRSL lies within the Central Lowland Physiographic Province near the border between what is termed the James River Lowland and Coteau des Prairies. This area is characterized by the low plateau of thick glacial deposits underlain by a small ridge of resistant Cretaceous shale. The unoxidized till of the Wisconsinan-aged deposits is the in-situ soil thought to meet the criteria for the facility's in-situ liner.

Soils used for engineered liners must exhibit geotechnical properties conducive to achieving the required permeability and the liner must be constructed using procedures that attempt to assure uniform and continuous physical properties across the facility. Similarly, the uniformity, continuity, and the geotechnical properties of the in-situ unoxidized till should also be demonstrated if it is to be used in place of an engineered liner.

The glacial deposits that make up the soils at the SFRSL have been defined by about 150 soil boring locations over an approximate 350-acre area. Given that the expansion design includes base grades that range in elevation from approximately 1,480 to 1,500 feet, about six of those soil borings were extended to a depth below an elevation of 1,480 feet in the proximity of the 160-acre Expansion Area. Although geotechnical tests demonstrate a grain-size distribution and permeability similar to an engineered liner, only two sets of geotechnical tests were performed from actual soil samples collected at or below the proposed base grade. Similarly, standard penetration test data is only available below the proposed base grades at four locations on the Expansion Area. Furthermore, only one well screened below the proposed base grade was subjected to in-situ hydraulic conductivity testing with a result of 2.4×10^{-7} cm/sec, slightly higher than the 1×10^{-7} cm/sec criteria. The available geotechnical data and permeability data does not appear to adequately characterize the geotechnical properties over a 160-acre area.

Although glacial till units can be uniform when laid down within certain depositional environments (Kemmis et al., 1979), the available data is not sufficient to confirm its uniformity and continuity at this site. The soil boring logs completed over the years are not detailed enough and do not apply a consistent logging procedure or classification from log to log such as the Unified Soil Classification System (USCS) or that described in ASTM D2488; therefore, it is difficult to even compare visual properties from log to log. Without supporting geotechnical data, the variability of the glacial till unit on the site produces doubt concerning its uniformity and continuity.

2.4.3 Ground Water Inflow

Although the lateral infiltration of ground water into the landfill through the sidewalls will be restricted by a geosynthetic clay liner (GCL), the permeability of a clay base may allow measurable infiltration to occur. During excavation of trenches on the Active Area, Davis et al, (1997) observed "significant accumulations of sand" in isolated pockets above the elevation of 1,500 feet that were saturated and were ultimately pumped for hours or several days after they were encountered by heavy equipment. Similarly, the sand bodies encountered at the base of the Cell 1 excavation (below 1,480 to 1,485 feet) were pumped for several weeks after they were encountered (LBG, 2003a). Because the expansion design includes base grades that range approximately 35 to 55 feet below the water table, the water removed from below the liner during construction is anticipated to eventually recharge. Excavation for each landfill cell below the water table and maintenance of 12-inches or less of head on the liner by the leachate collection system will ultimately induce an inward gradient. The induced gradient will promote inward flow to be intercepted by the leachate collection system.

It has been our experience at Brown County Sanitary Landfill (Aberdeen, South Dakota) under similar landfill conditions over the past 10 years that the potentiometric surface below the landfill has decreased because of the landfill construction and operation. The decrease in the potentiometric surface is probably due to a significant decrease in pressure head on the underlying soils as the saturated soils are removed and replaced with unsaturated waste. Reasonably, it would appear that a hydraulic head or gradient would be less than that currently measured between the liner elevation and the potentiometric surface.

Although the contribution of inflow at the Sioux Falls landfill to the overall leachate stream is difficult to predict, it should be noted that inflow could have some impact on the site, both operationally and financially.

2.4.4 Cell 1 Construction Documentation

Construction of Cell 1 was started in May 2001 and was completed in June 2002. A construction quality assurance plan (CQAP) was prepared and implemented for the project by HDR Engineering, Inc. (HDR, 2001a). LBG acted as a geologic consultant to HDR during the construction.

According to HDR's documentation report (HDR, 2003), the excavation of the cell was performed primarily by use of scrapers. When the excavation work neared the elevation of the in-situ liner, a representative of LBG performed observations to verify that the soil conditions complied with the construction documents and the permit. The documentation report states that soils identified as unsuitable were subcut 4 feet below the liner grade and replaced with recompacted clay.

During the construction, LBG identified four separate "sand bodies" at the base elevation of the cell. The conditions are documented in LBG's observation report (LBG, 2003a), which is included as an appendix to HDR's Construction Quality Assurance Report (HDR, 2003). A sketch provided in the observation report (also included in Appendix A of this report) indicates that the granular soils were present over more than one acre of cell bottom. The report indicates that soil borings performed at the time of construction encountered sand in one or more of the identified areas to a depth of approximately 15 feet below the base grade of the landfill. Boring logs were not included in the report.

2.4.4.1 Subcut Depth Criteria

The CQAP (HDR, 2001a) states, "unsuitable materials at the base of the landfill will be removed to a depth recommended by the Geologist (LBG) and replaced with compacted clay soils." The CQAP does not state if all unsuitable soil should be removed nor does it specify a minimum subcut depth. The 1996 solid waste permit application (LBG, 1996c) makes reference to the 4-foot subcut in the Construction Quality Plan, however the 2001 application (LBG, 2001) does not. It is our understanding that Cell 1 was constructed under the 1996 permit conditions.

2.4.4.2 Permeability Documentation of Clay Backfill

The documentation report (HDR, 2003) indicates that areas of the base of the landfill that were unsuitable were subcut and replaced with a 4-foot thick recompacted clay liner. Consistent with the CQAP (HDR, 2001a), the clay liner was indirectly tested for permeability using the "Daniel Method." The Daniel Method is a method of determining whether acceptable permeability is obtained based on water content and dry unit weight measurements. The recommended approach (Daniel, 1990) is based on defining water content-density requirements for a broad, but representative, range of compactive energy, and relating those requirements to hydraulic conductivity. The recommended procedure involves compaction and permeation of five to six soil samples at each of three different compactive efforts, or a total of 15 to 18 compaction/permeability tests for each type of soil to be investigated. Based on this data, an "acceptable zone" for moisture/density field measurements is established. The primary advantage of this method is to establish set criteria before construction begins, provide an easy way to verify compliance, and to allow greater flexibility in compaction and moisture conditions during placement of the material.

It is our opinion that the documentation report (HDR, 2003) is not conclusive in demonstrating that the specified permeability (1×10^{-7} cm/sec) was achieved in the recompacted areas of the liner. As stated in the report, the "acceptable zone" was initially established using only two hydraulic conductivity tests as opposed to the 15 to 18 tests recommended by the Daniel method. Initially, six of the nine moisture/density tests taken of the recompacted liner fell outside of the previously defined "acceptable zone." Several months after the construction was complete, three additional permeability tests were performed on samples to be used to "further define the acceptable zone." It is unclear how this data was applied to the Daniel method, but the documentation report uses it to interpret a "potential acceptable zone." The report states that using the "potential acceptable zone as a reasonable indication of acceptance, all but one of the nine (moisture/density) tests (taken of the compacted liner) passed." As mentioned in the documentation report, none of the three permeability tests conducted after the construction was completed met the requirement of 1×10^{-7} cm/sec or less.

2.4.4.3 Granular Drainage Layer

The granular drainage layer at the bottom of the landfill is intended to collect and convey leachate to a perforated leachate collection pipe and sump. The granular material must be sufficiently permeable to prevent buildup of head on the liner greater than 12-inches. The documentation report (HDR, 2003) and contract documents (HDR, 2000) indicated that the drainage layer material above the liner was to have permeability no less than 1×10^{-2} cm/sec. The CQAP (HDR, 2001a) indicates that the minimum testing frequency of the granular material for particle size (including p200) is one test per 1,500 cubic yards of material placed. One hydraulic conductivity test was required per borrow source.

Test reports for the granular drainage layer were not provided in the documentation report. The only reference to test results for the material was included in the field representative's daily notes taken on July 10, 2001. The representative indicated that the supplier (Mryl & Roys) reported that the permeability test for the granular layer was 1.3×10^{-3} cm/sec. This result is nearly an order of magnitude slower than what was specified. Without the actual test reports, it is unclear if the field representative's notes accurately report the permeability of the material that was placed. If it is accurate, the result may affect the calculated performance of the liner system that was presented in previous landfill permit applications (and amendments) and engineering studies regarding leachate management.

2.4.5 Cell 1 Supplemental Investigation

Earth Tech conducted further investigations of the Cell 1 in-situ liner and ground water monitoring system in May 2003. The analysis of this work is not yet complete and will be reported under separate cover. In addition to installing a more conservative ground water monitoring system for the cell, the investigation included sampling of soils at the bottom of Cell 1 to confirm that no significant sand bodies are present in areas that were not previously subcut and replaced with compacted clay during the initial construction. Direct push sampling was conducted at 12 locations to a minimum depth of 4 feet below the clay surface (5 feet below the surface of the granular drainage layer). The locations of the direct push borings are shown on a figure included in Appendix A.

The direct push sampling encountered fairly homogeneous dark gray lean clay at 7 of the 12 locations. Lenses or layers of sand were encountered within the clay at five locations, generally located on the eastern and western boundaries of the cell. Of the five test holes where sand was encountered, the sand was described as thin (1 mm) lenses at two locations (probes #1 and #5). Two other test holes had one- to two-inch lenses of sand present (probes #8 and #11). A 12-inch layer of sand was encountered 2 feet below the surface of the clay at one location (probe #10).

2.4.6 Conclusions and Recommendations

During the construction of Cell 1, significant sand bodies were encountered at and below the base of the landfill. Although visible portions of this material were subcut 4 feet and replaced with clay, it was not possible to know if adequate liner materials existed beneath the other portions of the cell unless either the in-situ soils were removed and replaced with an engineered liner, or sufficient characterization through drilling and probing was performed. The direct push probes performed in May 2003 identified sand seams and layers within relatively close proximity to the bottom of the cell in areas that were not previously subcut and replaced with clay.

The facility permit requires that any discontinuities in the in-situ soil, or any soil material that is more permeable than 1×10^{-7} cm/sec be over-excavated as necessary and an engineered soil liner with a permeability of no more than 1×10^{-7} cm/sec be constructed in that area. The permit language is not specific in how the presence of discontinuities and permeable soils should be addressed when they are present within close proximity below the liner surface but are not visible at the design base grade. Based on discussions with SDDENR staff at a meeting with the City on June 20, 2003, it is their opinion that the construction for Cell 1 met permit requirements for the in-situ liner.

2.4.6.1 Cell 1 Development Recommendations

Considerable investment has been made by the City in the construction of Cell 1. This includes substantial effort taken during the construction to remove sand that was encountered at the base of the landfill and to replace it with up to 4 feet of compacted clay. The presence of sand seams in areas that were not subcut does present some risk to the integrity of the liner system. However, we should note that investigations did not encounter sand seams at the most critical locations of the cell, which are along the leachate line trench and sump.

If the apparent uncertainty and potential risk associated with the construction are acceptable to the City, we recommend that the development and filling of Cell 1 proceed. To minimize potential risks, we recommend that Cell 1 not be used as a leachate collection point for upgradient cells. That is, the leachate collection system currently in Cell 1 will only service Cell 1. In comparison to the other cells, Cell 1 is considered to be relatively small in terms of waste capacity. The size has a direct bearing on the amount of leachate that can be generated, thus minimizing potential environmental and compliance risks associated with development of this cell. Future Cell 2 should be redesigned such that it has its own sump and leachate collection system that also services future upgradient Cell 3.

2.4.6.2 Future Cell Development Recommendations

The use of in-situ liner for future cell development is not recommended. Based on the current available information, there is no reason to believe that conditions similar to those encountered in the Cell 1 construction will not be encountered during the construction of one or more future cells. If the design remains unchanged, it is reasonable to assume that the liner for future cells will consist of a combination of in-situ soils and engineered clay liner (resulting from subcuts of unsuitable material). A uniform thickness of low permeable material cannot be assured under these conditions. The only way this can be assured is by requiring an engineered liner that completely covers the base grade and is integral to the sidewall liner.

Section 2.02 of the SDDENR Solid Waste Permit indicates that the operator "may" use in-situ clay soils as an alternative liner system. Presumably, the permit does not restrict more conservative liner systems (although a permit modification may be necessary in some cases). For future construction in the Expansion Area, we recommend that a more conservative liner system be implemented. The designs for a more conservative liner appropriate for this site will vary. Ultimately, the design that is chosen by the City will be based on cost versus the relative benefit in increased environmental protection.

What would be considered the "industry standard" liner system is described in the ARSD 74:27:12:17 (what the SDDENR requires if an alternative liner is not approved). This consists of a composite liner having a 60 mil geomembrane underlain by two feet of compacted clay with permeability of 1×10^{-7} cm/sec or less. It is our opinion that this type of liner is appropriate for this site.

If the City chooses to, other alternative liner systems, less conservative than the composite system described above, may be used. The sidewall liner, as constructed in Cell 1, appears to be well designed and provides reasonable environmental protection. For the base of the landfill, an alternative liner consisting of 4-foot thick compacted clay could be considered. This liner would be more conservative than the in-situ liner and offer more assurance that a uniform thickness of low permeable material is present beneath the waste. In lieu of subcutting the full 4 foot depth, the design could include in-place scarification and compaction of the bottom one foot, assuming that predominately clay soils are encountered. As required by the facility permit, the compacted clay liner should be designed for a permeability of no greater than 1×10^{-7} cm/sec. To meet this criterion throughout the liner, we recommend the following:

- Place liner soils in no greater than 8-inch thick loose lifts.

- Material distribution throughout should be free of lenses, pockets, streaks, or layers of material differing substantially in texture or gradation from surrounding material.

- Use a sheepsfoot compacter that fully penetrates the depth of the loose lift. The sheepsfoot is intended to break up and homogenize the clods to minimize the formation of flow paths along clod boundaries. Use of scrapers or other heavy equipment that are not designed for compaction provides inconsistent compactive energy and unpredictable results.

- The “Daniels Method” was used in previous site construction to verify permeability results. If this method is used in future construction, we recommend that the method be followed to assure that compliance is met. If the method is not followed, we would recommend a more traditional approach that involves specifying a moisture range and minimum dry density along with permeability conformance testing. Alternatively, a properly documented test pad could be used to document field permeability.

- Clay should be compacted wet of the optimum moisture content in order to achieve the lowest permeability. However, if the clay is too wet, then it may be difficult to place and may rut excessively. If necessary, moisture conditioning may be required to reach the proper moisture content. Conditioning may be performed by disking the clay lift to allow drying or by adding water to increase moisture.

- Uniformly distribute moisture and disc each lift of clay material prior to compaction.

- Once the clay is placed, care must be taken so that the integrity of the liner is not compromised by either vehicular traffic or adverse weather. The overlying drainage layer (or in the case of a composite liner, the geomembrane) needs to be placed as soon as practical to prevent drying and desiccation cracking.

2.5 CLOSURE/POST-CLOSURE CARE PLAN EVALUATION

The City's current Closure/Post-Closure Care Plan for the landfill was reviewed. The plan was prepared by HDR Engineering (HDR) and is dated August 2001. The intent of the evaluation was to:

- Identify inconsistencies with applicable rules and regulations.
- Determine consistency of the plan with current processes and operations.
- Identify potential deficiencies in the plans.

2.5.1 Summary of Plan

The Closure/Post-Closure Care Plan (Plan) prepared by HDR provides a description of activities, schedules, and features related to closure and post-closure care of the Active Area of the facility. The Expansion Area is not included in this Plan. For closure and post-closure of the Expansion Area, the Plan makes reference to the Permit Application (presumably the most recent application dated August 2001).

In summary, the Plan for the Active Area presents the following items:

- Description of waste types, quantities, and closure schedule.
- Administrative procedures for closure and post closure activities.
- A description of engineering features included in closure of the facility such as capping system, surface water management, leachate management, gas management, etc.
- Post-closure monitoring and maintenance requirements.
- Cost estimates for closure and post-closure activities.

The Plan indicates that the MSW portion of the Active Area is nearly at capacity and will be closed in phases over a several year period, concluding in 2006. Disposal of C&D on the Active Area would continue in restricted use areas and over side slopes of the MSW disposal boundary until the final closure grades are achieved. The Plan indicates that the majority of the C&D area will be closed by 2018. Based on current acceptance rates, the Plan indicates that the Asbestos area could remain open through 2070.

As mentioned previously, the Plan does not specifically address the Expansion Area but rather, makes a single reference to other engineering reports and permitting documents. These include the landfill permit application (LBG, 2001), a leachate management evaluation report (HDR, 2001c), and "other documents prepared as part of the design, construction, operation and repermitting."

2.5.2 Compliance of Plan with Rules

The requirements for the Closure/Post-Closure Care plan are contained in ARSD 74:27:15. Based on review of the available documents, it appears that for the Active Area, the Plan meets the requirements of the ARSD. However, for the Expansion Area, reference to other engineering documents, specified and unspecified, does not constitute a Closure/Post-Closure Plan in accordance with the ARSD.

The Closure/Post-Closure plan is a required element of a solid waste disposal permit application (ARSD 74:27:09:03:5) as well as a Minnehaha County permit condition. A comprehensive Plan should be developed that includes both the Active Areas and the Expansion Area.

2.5.3 Consistency of Plan with Current Operations

The Plan (HDR, 2001b) outlines a closure schedule of the pre-Subtitle D MSW areas in the Active Area that started in 2002 and concludes in 2005. Final cover was applied to 25 acres in Phase 1 in 2002. It appears that closure of Phases II and III (approximately 32 acres and 14 acres, respectively) are consistent with the Plan and will likely be at final capacity and ready for closure in 2004 and 2005. An updated survey of the area would be required to more accurately determine the remaining capacity and time of closure.

The Plan indicates a closure date of 2006 for the area including the emergency cell. Since the emergency cell is separate from other MSW areas, it cannot achieve final contours of the facility without placement of C&D around and on top of the area. Technically, final closure of the emergency cells as well as intermediate slopes of the primary pre-Subtitle D MSW landfill will not occur until the areas are filled to final contours with C&D material. Based on discussions with SDDENR staff, it is acceptable to apply one foot of intermediate cover to these areas as an interim measure while developing the area with C&D material.

Another inconsistency with the closure schedule is that the Plan indicates that the last receipt of MSW in the Active Area is anticipated to occur around year 2003. Upon closing a landfill unit, ARSD 74:27:15:03 requires that the owner or operator complete closure activities within 180 days of the last receipt of waste. To comply with the ARSD, the Plan schedule should have initiated closure in year 2003 or 2004 for Phases II, III, and V. At this time, sufficient survey information is not available to accurately determine the remaining capacity of the MSW area, however it is expected that capacity is available beyond year 2003. The majority of the waste flow of MSW to the Active Area will likely shift to the Expansion Area as soon as it is operational. We assume that there will be a transition period when some MSW will continue to be directed to the Active Area in order to achieve the permitted grades for final closure.

The Plan indicates that Phase IV (the large C&D area located in the southwest quadrant) may close between year 2012 and 2018. Phase VI (the asbestos area) would close between year 2060 and 2070, presumably based on the amount of asbestos waste accepted (not C&D). The Plan does not include details on how these closure dates were calculated. Based on available 2001 survey data, we conservatively estimated that the combined volume of all restricted use areas in the Active Site are sufficient to provide C&D capacity (at least 45 years) well past the remaining operational life of the MSW disposal areas in the Active and Expansion Areas. A current site survey, accurate delineation of the disposal areas, and updated Closure Plan is necessary to more accurately estimate remaining capacity.

2.5.4 Closure Schedule

Proposed Schedule for Active Area Closure

The proposed closure phases for the Active Area are shown on Figure 2-1, included at the end of this section. The areas of the phases are approximations. Closure of Phases I, II, and III generally reflect HDR's Plan. For the remaining portion of the Active Area, we recommend that sequencing of closure and the areas of the closure be modified from the Plan as indicated on Figure 2-1. Phase IV includes the C&D area that is currently under development. As outlined in Section 3.0, Operational Assessment and Issues, we recommend that the compost site be moved from this area. This will allow continuous development of the existing C&D pit, which will maximize disposal capacity. During development of Phase IV, the Phase V area would have intermediate cover and could still be used for other site needs such as petroleum contaminated soils treatment, temporary storage of materials or stockpiles, continued use for asbestos disposal, and temporary placement of landfill gas collection infrastructure (it is expected that active gas extraction will also occur in the Emergency Cell).

Proposed Schedule for Expansion Area Closure

Although the Plan did not address closure of Expansion Area, a proposed schedule was included in the Leachate Management Plan (HDR, 2001c). That document proposed 12 closure phases over the 34-year landfill life. Based on our review of the development plans, we propose that the number of Phases be reduced from 12 to 10. This is intended to improve efficiency and control cost by enlarging some of the phases so that construction would occur in more reasonably sized areas. The proposed closure phases for the Expansion Area are shown on Figure 2-2, included at the end of this section. Note that construction of the first closure phase will not occur until the time that Cell 5 is active. From that time forward, with one exception (Phase 4), a closure phase is planned to occur at the time of development of each successive Cell.

2.5.5 Closure Design Issues

Based on review of HDR's Plan and other documents associated with SFRSL, there are a number of design issues associated with closure that should be considered in future permitting efforts and Plan revisions.

2.5.5.1 Active Area Waste Boundaries

During the process of developing this report, the City surveyed actual boundaries of waste within the Active Area. This survey is documented on an "activity map" that the City prepared July 18, 2003. The closure contours that were developed for the Plan (HDR, 2001b) were prepared without the benefit of this information.

The proposed waste boundary used in the Plan on the west side of the Active Area is highly irregular. This was presumably done during preparation of the existing Plan to avoid existing site structures and to maximize landfill capacity. In practice, construction of final slopes with sharp jogs is not recommended due to construction difficulty and the potential problems with long-term maintenance caused by channeling and erosion.

Future Plan revisions should take into account current topographic conditions, location of existing waste units, and placement of infrastructure (i.e., the proposed leachate loadout facility).

2.5.5.2 Cover Design

Active Area Cover Design

The permitted cover section for the Active Area is 18 inches of soil with permeability of 1×10^{-5} cm/sec or less covered with six inches of topsoil. Additional reduction in infiltration and resulting leachate generation could be realized by increasing the thickness of the cover. Considering the surplus of on-site clay soils, we recommend that the City consider increasing the cover thickness for future closure construction. Increasing the thickness by just six inches in the remaining areas to be closed (Phases II through V) will use approximately 100,000 cubic yards of additional soil.

Expansion Area Cover Design

The permitted final cover of the Expansion Area consists of 2 feet of clay soil placed in 1-foot lifts to permeability of 1×10^{-7} cm/sec or less. The compacted clay soil will be covered by a 1-foot granular drainage layer and 1 foot of topsoil or other material suitable to support vegetative growth. This permitted cover design exceeds the final cover standards outlined in ARSD 74:27:12:21. It is our opinion that the minimum requirements of ARSD are not adequate for this site and we support the use of the more conservative permitted cover system in the Expansion Area. However, obtaining permeability of 1×10^{-7} cm/sec or less on a cover can be difficult. The documentation report for construction of Cell 1 in the Expansion Area (HDR, 2003) suggested difficulty in achieving this standard (and that construction presumably occurred on a stable subgrade). Although low permeability is the goal, for future compliance reasons, the City should consider proposing to raise the permeability requirement (such as to 1×10^{-6} cm/sec) as part of future repermitting efforts. Construction dollars may be better spent providing a thicker layer of soil on top of the drainage layer that would result in a better rooting zone for vegetation.

2.5.5.3 Slopes

Vertical Expansion of Active Area

Regardless of the obvious benefit of gaining disposal capacity, it is our opinion that vertical expansion of the Active Area for the expressed purpose of increasing final slopes at the top of the landfill would be extremely beneficial. The current Plan provides for a final top slope of 2 percent with a slope length of 900 feet. In our experience, slopes this shallow are difficult to build and maintain. On a landfill, they are not sufficient to overcome the eventual subsidence of waste, resulting in ponded areas. On landfills with similar slopes, it is not uncommon to see wetlands forming on subsided areas. To help ensure positive drainage off of the landfill cap, a minimum slope of 5 percent is recommended.

It is our understanding the City and SDDENR agreed in principle that future waste filling would be done in the Expansion Area and no additional vertical expansion would be considered for the Active Area. We recommend that the City consider revisiting this issue with the SDDENR prior to closure of Phases II and III.

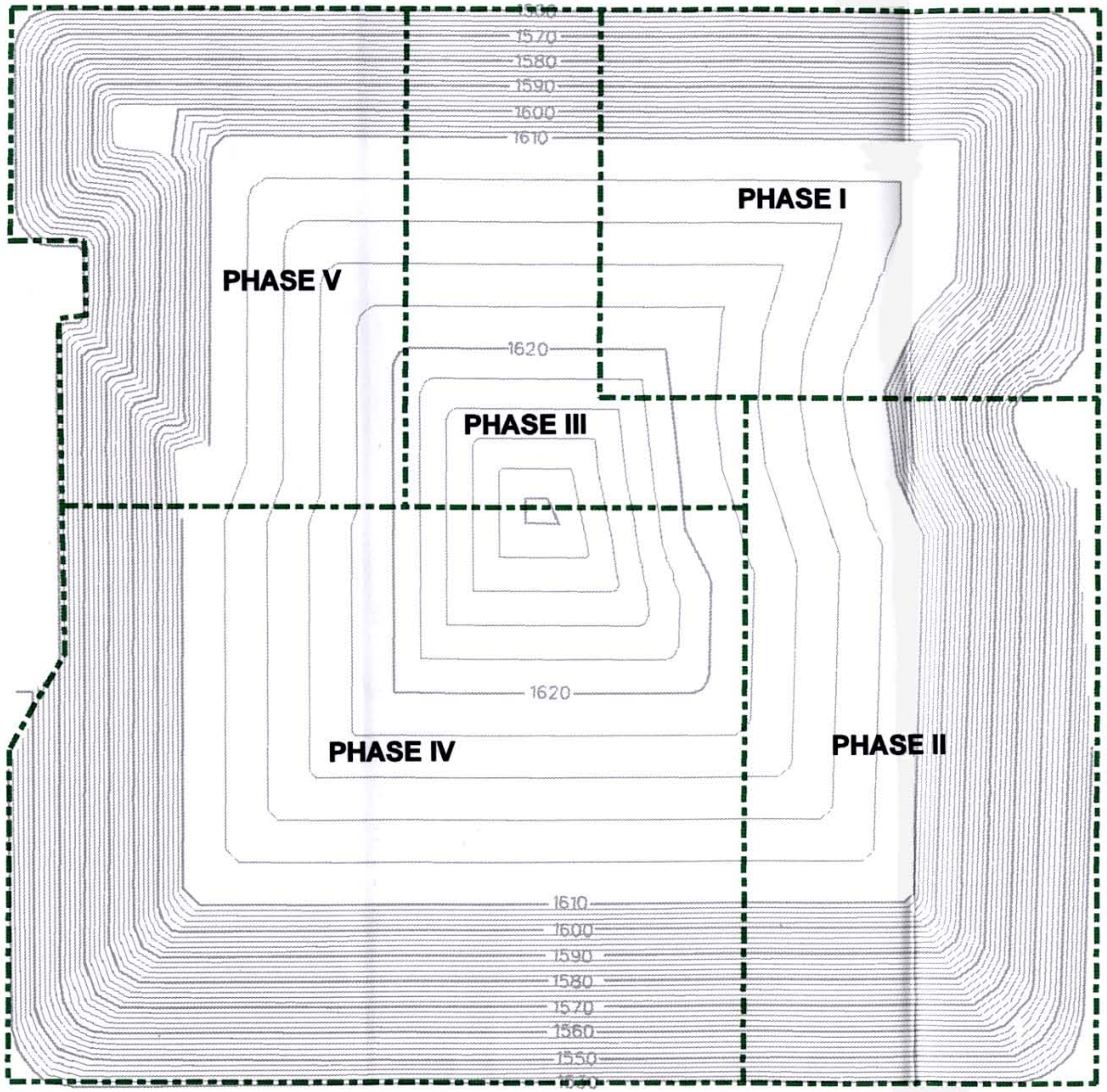
Redesign of Slopes in Expansion Area

Similar to the Active Area, the top slope on the Expansion Area is minimal. The development plan included in the 2001 permit application provides for a final top slope of 2.6 percent with a slope length of 1,080 feet. Also, a 300 foot portion of the top slope is only 1.3 percent. For reasons similar to those outlined above for the Active Area, we recommend that the design of the Expansion Area be modified to provide minimum slopes of 5 percent.

2.5.6 Conclusions and Recommendations

We recommend that the Closure/Postclosure Plan be updated to address the entire facility, including the Active Site and the Expansion Area. This updated Plan should be a comprehensive engineering document that is based on current surveyed site conditions. The drawings for the closure plan should be detailed enough so that they can be used by the operator for closure construction and staking of the final waste grades. For a complete design, the closure plan should include a complete analysis of storm water management features, including detailed location and design of all permanent surface water conveyance structures including; ditches, berms, letdown structures, culverts, and storm sewers. As approved by the City, the updated Plan could address the design issues discussed in Section 2.5.5 including:

- Revising waste boundaries in the Active Area.
- Modifying the cover section design in both the Active and Expansion Areas.
- Modifying top slopes in both the Active and Expansion Areas.



LEGEND

1570	PROPOSED GRADES
▬ ▪ ▬ ▪ ▬	PHASE CLOSURE BOUNDARY

CLOSURE PHASE	YEAR	AREA CLOSED
I	2002	24 ACRES
II	2004	32 ACRES
III	2005	14 ACRES
IV	2030	54 ACRES
V	2048	23 ACRES

NOTES:

1. CLOSURE PLAN BASE MAP IS FROM "CLOSURE/POST-CLOSURE PLAN FOR ACTIVE SITE" (HDR, 2001). THE AREAS AND PROGRESSION OF THE PHASED CLOSURE HAVE BEEN MODIFIED PER RECOMMENDATIONS OF THE MASTER PLAN. THE ESTIMATED YEAR OF CLOSURE IS BASED ON SITE LIFE ESTIMATES CONTAINED IN THE HDR REPORT AND APPROXIMATION BY EARTH TECH.

2. THE FINAL CLOSURE CONTOURS SHOWN ON THIS PLAN SHOULD BE CONSIDERED APPROXIMATE. MINOR MODIFICATIONS OF THE WASTE BOUNDARIES (PARTICULARLY ON THE WEST SIDE) WILL BE REQUIRED DUE TO CURRENT SURVEYED WASTE BOUNDARIES AND FUTURE PLANNED USES (I.E., LEACHATE STORAGE AND LOADOUT AREA, FLARE STATION ETC.).

3. AREAS OF PHASE CLOSURE ARE APPROXIMATE. A CURRENT SITE TOPOGRAPHICAL SURVEY, ALONG WITH CORRESPONDING DETAILED AND UPDATED CLOSURE PLAN WILL BE REQUIRED TO ACCURATELY DEPICT CLOSURE PHASES.

N

APPROXIMATE SCALE: 1" = 300'

E A R T H T E C H

FIGURE 2-1
CLOSURE PHASING FOR ACTIVE AREA

SOLID WASTE MASTER PLAN
CITY OF SIOUX FALLS, SOUTH DAKOTA
SIOUX FALLS REGIONAL LANDFILL

OCTOBER 2003

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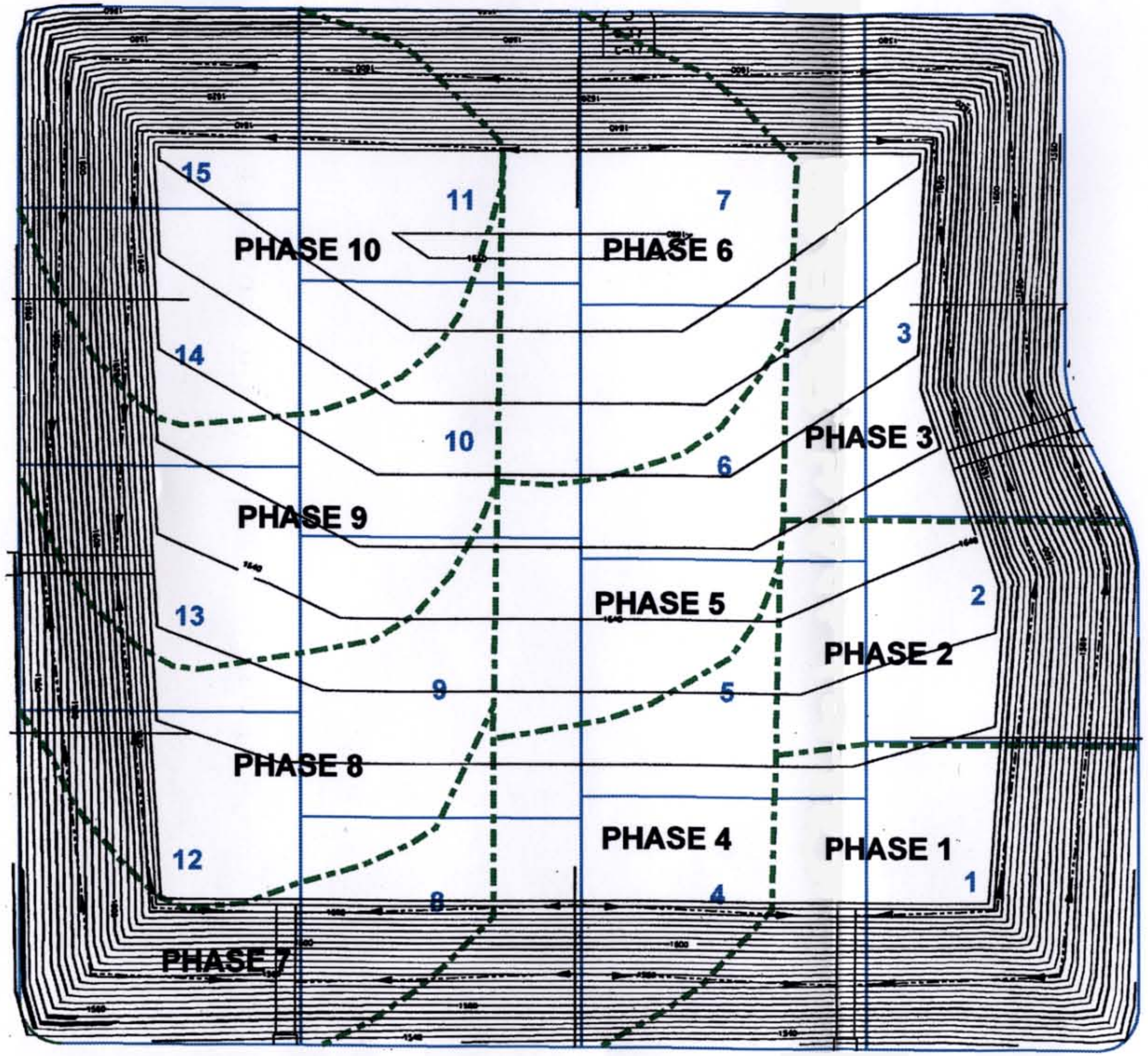

LEGEND

PHASE CLOSURE BOUNDARY

CELL BOUNDARY

CLOSURE PHASE	CONDITION	YEAR	AREA CLOSED
1	CELL 5 ACTIVE	2014	12.9 ACRES
2	CELL 6 ACTIVE	2017	9.0 ACRES
3	CELL 7 ACTIVE	2020	17.3 ACRES
4	CELL 9 ACTIVE	2025	11.2 ACRES
5	CELL 10 ACTIVE	2027	7.6 ACRES
6	CELL 11 ACTIVE	2030	13.3 ACRES
7	CELL 12 ACTIVE	2032	9.0 ACRES
8	CELL 13 ACTIVE	2034	12.1 ACRES
9	CELL 14 ACTIVE	2036	12.2 ACRES
10	FINAL CLOSURE	2038	17.1 ACRES

NOTE:

1. CLOSURE PLAN BASE MAP IS FROM "SIOUX FALLS REGIONAL LANDFILL LATERAL EXPANSION DISPOSAL AREA FILLING PLAN" (HDR, 2001). AREAS AND PROGRESSION OF PHASED CLOSURE HAVE BEEN MODIFIED PER RECOMMENDATIONS OF THE MASTER PLAN. THE ESTIMATED YEAR OF CLOSURE IS BASED ON SITE LIFE ESTIMATES CONTAINED IN THE HDR FILLING PLAN.

N

APPROXIMATE SCALE: 1" = 300'

EARTH TECH

FIGURE 2-2
CLOSURE PHASING FOR EXPANSION AREA

SOLID WASTE MASTER PLAN
CITY OF SIOUX FALLS, SOUTH DAKOTA
SIOUX FALLS REGIONAL LANDFILL

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