CHAD DEVELOPMENT PROJECT

TECHNICAL SPECIFICATION

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1.0 SCOPE

1.1 This specification includes the technical requirements for the design, construction and operation of a landfill site to be used for both hazardous and non-hazardous solid waste disposal. The construction includes earthwork, access roads, and installation of a landfill with a composite liner and leachate collection system and monitoring wells. The operation includes maintaining each landfill cell, collecting leachate and monitoring leachate and monitor-well water quality during the Pre-Operation phase.

1.2 A pound sign (#) indicates that ESSO review/approval is required before design and/or construction is finalized or equipment is purchased.

1.3 An asterisk (*) indicates that additional information is required. This information is provided in other project documents or will be furnished during the detailed engineering phase.

2.0 SUMMARY OF ADDITIONAL REQUIREMENTS

2.1 The publications listed in Table 1 are incorporated by reference into this specification. Except as modified by the requirements specified herein, work covered by this specification shall conform to the applicable provisions of these publications.

TABLE 1

SPECIFICATIONS	
CCS	
4-10-1	Concrete Design and Construction
4-11-1	Chain Link Fencing
4-100-1	Roads and Area Paving
21-20-107	Soil Erosion Mitigation Specification
21-20-108	Environmental Impact Mitigation Specification
GPS	
008	Project Safety Requirements
011	Waste Management

CODES AND STANDARDS	
ASTM	
C136	Sieve or Screen Analysis of Fine & Coarse Aggregate
C478	Precast Reinforced Concrete Manhole Sections
D422	Test Method for Particle - Size Analysis of Soils.
D1140	Test Method for Amount of Material in Soils Finer Than the No. 200 (75-µm.) Mesh
D1557	Laboratory Compaction Characteristics of Soil Using Modified Effort [56,000 ft-lb/ft^3 (2700 kN-m/m^3)]
D2216	Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock
D3034	PSM Poly (Vinyl Chloride) PVC Sewer Pipe and Fittings (Perforated)
D4253	Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
D4254	Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density

TABLE 1 (CONT'D)

ASTM (cont'd)

D4318	Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
D5084	Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter
D5093	Standard Test Method for Field Measurement of Infiltration Rate Using a Double-Ring Infiltrometer with a Sealed-Inner Ring.

USCOE U.S. ARMY CORPS OF ENGINEERS
EM 1110 2-1906 Corps of Engineers Manual

Standard Methods for the Examination of Water and Wastewater
Mary Ann H. Franson, editor, American Public Health Association, 1995

3.0 PURPOSE OF SOLID WASTE LANDFILL

3.1 The solid waste landfill shall be designed, constructed and operated to accept the following:

*a. Solid wastes approved in the Contractor's Waste Management Plan in accordance with Section 30 of the Coordination Procedures and GPS-011.

b. All domestic and industrial solid wastes from the operating facility during its operating life cycle.

c. All potentially hazardous wastes such as batteries and incinerated medical wastes generated during operations and construction.

3.2 The design, construction and operating procedures of the solid waste landfill shall recognize the existence of an incinerator at the site during the operation phase.

3.3 All landfill cells used during the pre-operations phase shall be closed prior to turning care and custody of the facility over to ESSO.

4.0 SITE SELECTION

4.1 Initial Selection Criteria

The criteria for the selection of landfill sites shall be as follows:

a. Avoid residential areas, wetland, critical wildlife habitats, drainage courses and areas subject to seasonal flooding.

b. Sites shall not be chosen within the 100 year flood plain of a stream, river or lake.

c. The landfill shall not be located within 500 m (1640 ft.) of an airfield. This restriction is imposed to reduce bird hazard.

d. The landfill must be at least 300 m (1,000 ft.) from any non-intermittent water course or other permanent water-body.

e. The landfill shall not be constructed within 500 m (1640 ft.) radius of any water supply well.

f. The landfill shall not be located within 60 m (200 ft.) of geological fault areas.

g. Avoid locations which have unstable subgrades and are likely to provide poor foundation conditions or are threatened by massive earth movements (e.g. landslides).

h. The site shall have adequate room to accommodate the volume of wastes, berms, perimeter ditches, buffer zones, space for groundwater monitoring wells and access roads.

i. On the basis of hydrogeological investigations, the site shall have a vertical separation between the seasonal high water table and the landfill bottom of greater than 1.5 m (5 ft.).

j. The site shall not be located in a recharge area of an unconfined aquifer.

k. The material that underlies the landfill shall have a hydraulic conductivity of not more than 10^{-6} cm/s.

l. The site shall be located in an area where there will not be significant lateral transfer of mobilized contaminants in the groundwater.

m. The selected location shall be such that natural erosion or future land use will be unlikely to excavate or expose buried waste and where groundwater is not susceptible to contamination by leaching.

#4.2 Final Selection

After preliminary selection of alternative landfill sites by Contractor, detailed and site specific geotechnical, hydrological, hydrogeological and environmental investigations shall be carried out which form the basis of the final selection of the most appropriate site. Final site location requires ESSO approval.

5.0 DESIGN AND CONSTRUCTION CRITERIA

5.1 Site Preparation and Access Roads

5.1.1 The area inside the operational-zone fence shall be cleared. Clearing shall include the removal of all trees, bushes, and other vegetation, to within 150 mm (6 in.) above the natural grade. It shall also include the removal of dense growths of ground cover, matted dead vegetation, and rubbish resting on natural grade. Clearing shall also include the specified removal of any existing structures, foundations, buried service piping and conduits.

5.1.2 Areas to be excavated or areas that will have facilities installed over them shall be grubbed. Grubbing shall include the excavation and complete removal of tree stumps, also the excavation and removal of all other plant life including root structures, plus rubbish, to a depth not less than 150 mm

(6 in) below natural grade. Other minimum grubbing depth criteria supplemental to the 150 mm (6 in) minimum depth below natural grade requirements for grubbing are as follows for the following specific Work areas:

a. Drainage ditches shall be grubbed to a depth not less than 300 mm (1 ft) beneath the finished sides and bottom.

b. Roadway areas shall be grubbed to a depth not less than 900 mm (3 ft) below finished grade but not less than 600 mm (2 ft) below natural grade.

c. Embankment slopes shall be grubbed to a depth not less than 300 mm (1 ft) beneath the finished slope.

d. Areas for piping between process unit areas limits and ditches, and along roads, shall be grubbed to a depth not less than 600 mm (2 ft) below finished grade but not less than 150 mm (6 in) below natural grade.

5.1.3 All organic material from clearing and grubbing, including trees, stumps, roots, and brush shall be managed and disposed as specified in CCS 21-20-108.

5.1.4 Topsoil shall be stripped and stockpiled as indicated in CCS-21-20-107 and CCS-21-20-108.

5.1.5 Erosion control measures shall be implemented in accordance with the construction drawings and CCS-21-20-107. Mitigation measures specified in CCS 21-20-107 shall be installed as soon as practical.

The faces of cut and fill slopes, and surface of soil subject to rain, wind, and runoff disturbance shall be protected against erosion unless they are not subject to erosion due to the erosion-resistant character of the material.

5.1.6 An all-weather, gravel access road with a laterite base shall be provided to the landfill site. As a minimum, the access road shall be designed and constructed in accordance with CCS 4-100-1

5.1.7 The landfill site shall be accessible only when operation personnel are on duty. A chain link fence and gates shall be designed and constructed around the entire site in accordance with CCS 4-11-1. Gates shall include provisions for locking.

5.1.8 A minimum 30 m (100 ft.) buffer zone is required between the perimeter fence and the landfill.

5.2 Perimeter Dike and Outer Storm Water Ditch

A perimeter dike shall enclose the proposed landfill site. The perimeter dike shall consist of a 6 meter (20 ft.) wide buffer zone including a 3 meter (10 ft.) fire lane and a perimeter ditch to manage the storm water run-on. The finished elevation of the dike shall be set with due consideration to the thickness of compacted clay cap over each landfill cell after it has been completely filled and closed.

5.3 Landfill Area and Excavation

***5.3.1** The total volume of wastes to be disposed during the life span of the landfill shall be based on the volume of acceptable solid waste generated by construction personnel and activities during construction as well as any volume requirements stated in the Design Basis Manual. Waste minimization shall be implemented, wherever feasible in order to keep the landfill area to an absolute minimum.

#5.3.2 All excavation material shall be processed and separated. Material meeting the grain size distribution indicated in Table 2 shall be retained and stockpiled for daily cover material. Those materials which are not needed for backfill or are unsuitable for daily cover shall be disposed of by the Contractor at a location approved by ESSO.

TABLE 2

Cover Material Gradation

SIEVE SIZE	PERCENT PASSING
12 mm (1/2 in.)	100
5 mm (No. 4)	90-100
2 mm (No. 10)	45-80
0.075 mm (No. 2000	8-98
Clay (0.002 mm)	8-50

5.3.3 All excavations shall be kept free of standing water at all times. Dewatering equipment such as pumps and hoses shall be provided and operated by Contractor to remove water from excavated areas.

5.4 Side Slope of Landfill and Berm Sides

Safe side slopes shall be constructed. A slope stability analysis shall be performed for both excavated side slopes and above-ground embankments to verify the structural integrity of a cut slope or berm. The design configuration shall be evaluated for its stability under all potential hydraulic and loading conditions.

5.5 Liner Design and Construction

5.5.1 A non-hazardous landfill shall have 300mm (1 ft.) of protective soil over a leachate collection system which shall overlie a composite liner as defined in 5.5.3.

5.5.2 A hazardous landfill shall have 300mm (1 ft.) of protective soil over a leachate collection system which overlies a minimum 0.75 mm (30 mil.) Flexible Membrane Liner (FML). FML components consisting of High Density Polyethylene (HDPE) shall be at least 1.5 mm (60 mil) thick. The FML shall overlie a secondary leachate collection system. The secondary leachate collection system shall overlie a composite liner as defined in 5.5.3.

5.5.3 For purposes of this specification, "Composite Liner" means a system consisting of two components; the upper component must consist of a minimum 0.75 mm (30 mil) Flexible Membrane Liner (FML) and the lower component must consist of at least a 600 mm (2 ft) layer of compacted soil with a hydraulic conductivity of no more than $1X10^{-7}$ cm/sec ($3.94x10^{-8}$ in/sec). FML components consisting of High Density Polyethylene (HDPE) shall be at least 1.5 mm (60 mil) thick. The FML component must be installed in direct and uniform contact with the compacted soil component. The panel layout plan shall be made in advance so that travel of heavy equipment on the liner can be avoided. Vehicles shall not be allowed on completed liners. Seaming of panels shall be completed in accordance with manufacturer's recommendations.

5.5.4 If groundwater is encountered in disposal excavations, or in cases where excavations extend below the seasonal high-water table, material with a weight equivalent to 300 mm (1 ft.) of compacted clay liner for every 600 mm (2 ft.) of static water head shall be used as a basis for the construction of a liner between the deposited solid waste and the groundwater. The total thickness of this liner shall consist of no less than 900 mm (3 ft.) of soil with a permeability coefficient of no more than $1x10^{-7}$ cm/sec ($3.94x10^{-8}$ in/sec), a liquid limit of no less than 30, a plasticity index of no less than 15, and a percent passing Number 200 sieve of no less than 30. Pressure release systems may be used to reduce the amount of liner support required.

5.5.5 The subgrade for placement of the clay portion of the composite liner shall be compacted in accordance with the following standards:

a. Cohesive soils - 95 percent of the Modified Maximum Proctor Dry Density (MMPDD) in accordance with ASTM D1557.

b. Non-cohesive soils - 80 percent of relative density per ASTM D4253 and ASTM D4254.

5.5.6 Material for the clay portion of the composite liner shall be uniform with clods, rocks, and stones no larger than 25 mm (1 in.) and that total no more than 10% by weight. Disking and tilling of the material shall be performed as required to break up large clods. In all cases, soil clods shall be reduced to the smallest size necessary to achieve the coefficient of permeability reported by the testing laboratory and to destroy any macrostructure evidenced after the compaction of the clods under density-controlled conditions. Rock content shall not be a detriment to the integrity of the overlaying geomembrane.

5.5.7 The liner soil material shall be placed in lifts not exceeding 150 mm (6 in.). The surface of the previous lift shall be scarified before the next layer is added. Liner soil material shall not be compacted with a bulldozer or any track-mobilized equipment unless it is used to pull a pad-footed or prong-footed roller. Each new lift shall be fully compacted to the previous lift to form a monolithic unit. The liner soil material shall be compacted to 97% of the MMPDD according to ASTM D1557.

#5.5.8 Unless Alternate construction procedures are approved in writing by ESSO, all constructed liners shall be keyed into an underlying formation of sufficient strength to ensure stability of the constructed lining.

5.6 High Permeability Sand Layer for Drainage

A highly permeable sand layer shall be placed over the composite liner. The thickness of the layer shall be such that it provides a maximum of 300 mm (12 in.) of leachate head above the liner. The sand drainage layer shall have a minimum slope of 2%. The drainage layer serves two functions:

a. Drain the leachate away from the underside of the waste.
b. Protect the composite liner.

5.7 Leachate Collection System

5.7.1 The leachate collection system shall be designed to maintain less than 300 mm (12 in.) depth of leachate or "head" above the liner during the operating life of the landfill and through the closure and post closure periods.

5.7.2 The leachate collection and removal systems shall be:

a. constructed of materials that are chemically resistant to the leachate expected to be generated,
b. built of sufficient strength and thickness to prevent collapse under the pressures exerted by overlaying wastes, waste cover materials, and by any equipment at the landfill; and
c. designed and operated to function through the scheduled closure period of the solid waste landfill.

5.7.3 The leachate collection system shall consist of a number of perforated pipes (as per ASTM D3034, if the criteria of 5.7.2 are satisfied), with protective filter wrapping material, laid into the sand drainage layer.

5.7.4 The leachate collection system shall be designed and installed with the following characteristics:

a. A trench shall be provided for the perforated pipes with 150 mm (6 in.) depth of cover of sand over the pipe.

b. The drain pipes shall have not less than 2% slope.

c. Size and horizontal spacing of the drain pipes shall be sufficient to control leachate levels to within the limits specified above.

d. The perforated pipe shall be wrapped in a woven polyethylene fabric such as Nicolon #66339, manufactured by Nicolon B.V., or equal as approved by ESSO.

e. Leachate collection lines that penetrate the liner shall have an antiseep collar. A minimum of 1.5m (5 ft.) of compacted clay shall be placed around the collar in all directions.

f. Pipe materials shall be clean and free of defects when placed in trench. The Contractor shall not allow heavy equipment to travel over the newly installed leachate pipe during construction.

g. Collection sumps shall be provided to capture leachates for treatment. Separate sumps shall be provided for hazardous and non-hazardous landfills. Separate sumps shall be provided for primary and secondary leachate collection systems in the hazardous landfill

h. Collection sumps shall be sized to collect the maximum volume of leachate expected during a leachate monitoring period specified in the "Operating Procedures" Section 6.0 of this specification.

i. The collection sump shall be a water-tight concrete structure with a water-tight, chemical-resistant liner. The design and construction of the collection sump shall be in accordance with CCS 4-10-1.

5.8 Run-On and Run-Off Control

5.8.1 Run-on control prevents rain water from flowing into the active portion of the landfill. Run-on control structures such as ditches, dikes and culverts shall be capable of preventing flow on to the active portion of the landfill during peak discharge from at least a 25 year storm.

5.8.2 Run-off control is the management of precipitation which falls on the landfill site so as to minimize the amount of rain water that gets in contact with waste or leachate. The run-off management system shall collect and control at least the water volume resulting from a 24-hour, 25-year storm. This shall be achieved in either of two ways:

a. Keeping the active landfill cells small and by providing adequate grading so that run-off is controlled and diverted away from the working area.

b. Collecting and discharging run-off from the inactive portion of the landfill as storm water, thus reducing the overall leachate volume to be treated.

5.8.3 For erosion control, up-gradient and down-gradient ditches, berms, rip rap, pavements or combinations thereof shall be used as necessary to achieve run-off and run-on control.

5.8.4 Collection and holding facilities (e.g., sumps or basins) associated with run-on or run-off control system must be emptied or otherwise managed expeditiously after storms to maintain design capacity of the system.

5.9 Preparation of Landfill Cells

One landfill cell of each landfill type (hazardous and non-hazardous) shall be opened at a time. The bottom of each cell shall be sloped for drainage away from the waste material. A temporary berm of approximately 0.6m to 0.9m (2 ft. to 3 ft.) in width shall be installed for isolation from previous cells.

5.10 Gas Venting System

A minimum of one passive gas vent shall be provided per cell to prevent the build-up of gas pressure beneath the cover.

#5.11 Soils and Liner Quality Control Plan

Before landfill construction begins, Contractor shall have an ESSO approved Soils and Liner Quality Control Plan (SLQCP). The SLQCP must be included in the Site Development Plan to provide operating personnel adequate procedural guidance for assuring continuous compliance with groundwater protection requirements. The plan shall specify construction methods employing good engineering practices for compaction of clay soils to form a liner as well as the installation and testing of an FML. Quality control testing and reporting shall also be discussed.

The SLQCP shall include the following information:

a. Proposed dewatering plans, where applicable.

b. Constructed liner details, where applicable shall be depicted on cross-sections of a typical trench showing the slope, widths, and thickness for compaction lifts. The amount of compaction shall be expressed as a percentage of a predetermined laboratory density.

c. Soil and liner quality control testing procedures, including sampling frequency. All field sampling and testing, both during construction and after completion, shall be performed by the Contractor acting in compliance with the provisions of local government regulations and project environmental and quality control standards.

5.12 Soil and Liner Testing

Soil liner quality control testing frequencies and procedures shall be in accordance with the following:

5.12.1 All field sampling and testing, both during construction and after completion of the lining, shall be performed by a qualified professional experienced in geotechnical engineering and/or engineering geology, or under his direct supervision.

5.12.2 All liners shall have continuous on-site inspection during construction by the Contractor.

5.12.3 Clay liners density shall be expressed as a percentage of a maximum dry density based on a compaction test. The clay liner, after compaction, shall be proven by soils laboratory testing to provide a coefficient of permeability of $1x10^{-7}$ cm/sec ($3.94x10^{-8}$ in/sec) or less.

#5.12.4 The SLQCP shall define the frequency of testing for coefficient of permeability, sieve analysis, Atterberg limits, density, moisture content and thickness verification. These frequencies shall be expressed in numbers of tests per specific area of liner per lift or specific thickness of liner, unless an alternate frequency is approved by ESSO.

#5.12.5 Unless otherwise approved by ESSO, all soil tests performed on any in-situ or constructed soil liners shall be in accordance with the following standards:

a. Laboratory permeability tests shall be run using tap water or 0.05N solution of $CaSO_4$ and not distilled water. All test data must be submitted on permeability tests regardless of test method used. At a minimum, the calculations of the last data set reported for each sample and the resultant coefficient of permeability shall be reported as supporting data. Tests shall be either constant head with back pressure (Appendix VII of EM 1110-2-1906; or ASTM D5084) or falling head (Appendix VII of EM 1110-2-1906).

b. Sieve analysis with +1,200, to -200 sieves (ASTM D422 or ASTM D1140, as applicable).

c. Atterberg limits (ASTM D4318).

d. Moisture-density relations (ASTM D1557).

e. Moisture content (ASTM D2216).

5.12.6 All soils used as constructed liners shall have the following minimum values verified by testing in a soils laboratory:

a. plasticity index equal to or greater than 30;

b. percent passing 200 mesh sieve (-200) equal to or greater than 30%;
c. percent passing 25mm (1 in.) screen equal to 100%;
d. coefficient of permeability less than or equal to $1x10^{-7}$ cm/sec ($3.94x10^{-8}$ in/sec.).

#5.12.7 Permeability tests for providing the suitability of soils to be used in constructing clay liners shall be performed in the laboratory using the procedures and guidance of 5.12.5(a). Field quality control must be provided by field density tests based on predetermined moisture-density compaction curves, Atterberg limits, and laboratory permeabilities of undisturbed field samples of compacted liner soils, unless an alternate plan is approved by ESSO.

#5.12.8 Field permeability testing of in situ soils or constructed soil liners shall be in accordance with ASTM D5093 for those soil liners which are in the floor of the excavation and a suitable variation approved by ESSO for the sidewalls.

5.12.9 Soil and liner density shall be expressed as a percentage of the maximum dry density and at the corresponding optimum moisture content specified as appropriate by an engineer experienced in geotechnical engineering. These soils, after compaction, shall upon testing either in the laboratory or as a test pad in the field demonstrate a coefficient of permeability no greater than $1x10^{-7}$ cm/sec ($3.94x10^{-8}$ in/sec.).

5.12.10 All quality control testing of soil liners shall be performed during the construction of the liner. In no instance shall any quality control field or laboratory testing be undertaken after completion of liner construction, except for that testing which is required of the final constructed lift, confirmation of liner thickness, or cover material thickness.

5.12.11 All soil testing and evaluation of either in situ soil or constructed soil liners shall be complete prior to installing the leachate collection system.

5.13 Soils and Liner Evaluation Report (SLER) and Flexible Membrane Liner Evaluation Report (FMLER)

#5.13.1 Prior to the disposal of solid waste in any trench, or on any area, excavation, or unprotected surface, a SLER and a FMLER shall be prepared by Contractor and submitted to ESSO for approval. Each SLER shall be prepared in accordance with the approved SLQCP. Any deviation from an approved SLQCP shall have prior written approval from ESSO. The SLER and FMLER shall report and summarize the results of tests performed to satisfy the requirements of the SLQCP. Any deficiencies found and remedial actions taken to bring the liners into compliance shall be noted.

#5.13.2 Markers shall be placed on site at the landfill facility so that all disposal areas for which a SLER has been submitted and approved by ESSO are readily determinable. Such markers are to provide site workers immediate knowledge at all times of the extent of approved disposal areas. These markers shall be located so that they are not destroyed during operations.

#5.13.3 Contractor shall provided sufficient documentation to ESSO to assure that the potential for contamination of waters is minimized. If ESSO determines that the SLER is incomplete or that the test data provided are insufficient to support the evaluation conclusions, additional test data or other information may be required, and use of the trench or disposal area shall not be allowed until such additional data are received, reviewed, and approved. Each SLER shall be signed by the Contractor.

5.13.4 The surface of a constructed soil liner should be covered with a layer of solid waste within a period of six months to mitigate the effects of surface erosion and rutting due to traffic. Liner surfaces not covered with waste within six months shall be checked by the Contractor, who shall then submit a letter report on its findings to ESSO. Any required repairs shall be performed promptly. A new SLER shall be submitted on the new construction for all liners that need repair due to damage.

#5.14 Groundwater Monitoring Systems

A groundwater monitoring system shall be installed that consists of a sufficient number of monitoring wells, installed at appropriate locations and depths, to yield representative groundwater samples from the uppermost aquifer, defined as the geologic formation nearest the natural ground surface that is an aquifer. This includes lower aquifers that are hydraulically interconnected with this aquifer within the facility's property boundary.

The design of the groundwater monitoring system, including the number, spacing, and depths of monitoring wells or other sampling points, shall be certified by a qualified groundwater scientist. The design shall be based on site specific technical information that must include a thorough characterization of:

a. aquifer thickness;

b. groundwater flow rate;

c. groundwater flow direction including seasonal and temporal fluctuation in flow, effect of site construction and operations on groundwater flow direction and rates;

d. and thickness, stratigraphy, lithology, and hydraulic characteristics of saturated and unsaturated geologic, and fill material overlying the uppermost aquifer, materials of the uppermost aquifer, and materials of the lower confining unit of

the uppermost aquifer. A geologic unit is any distinct or definable native rock or soil stratum.

Background wells shall be installed to allow determination of the quality of background groundwater that has not been affected by leakage from a unit. A determination of background quality may include sampling of wells that are not hydraulically upgradient of the waste management area if hydrogeologic conditions do not allow the Contractor to determine which wells are hydraulically upgradient. Alternatively, sampling at other wells can be performed if it will provide a better indication of background groundwater quality than is possible from upgradient wells. The downgradient monitoring system shall include monitoring wells installed to allow determination of the quality of groundwater passing the relevant point of compliance. The point of compliance is defined as the vertical surface located no more than 500 feet from the hydraulically downgradient limit of the waste management unit boundary, extending down through the uppermost aquifer underlying the landfill area, and located on land owned by ESSO. The final design of the groundwater monitoring system shall be submitted to ESSO for approval.

The downgradient monitoring system shall be installed to ensure the detection of groundwater contamination in the uppermost aquifer.

5.15 Monitoring Wells

Monitoring well installation and development shall be supervised by a qualified geologist or engineer.

#5.15.1 Drilling

Monitoring wells shall be drilled by a method that shall allow installation of the casing, screen, etc., and that shall not introduce contaminants into the borehole or casing. Drilling techniques used for boring shall take into account the materials to be drilled, depth to groundwater, total depth of the hole, adequate soil sampling, and other such factors that affect the selection of the drilling method. If any fluids are necessary in drilling or installation, then clean, treated water shall be used. Other fluids shall be approved in writing by ESSO before use. Chemical analysis of the water used shall be provided to ESSO with the monitoring well report.

The diameter of the boring shall be at least 100 mm (4 in.) larger than the diameter of the casing. When the boring is in hard rock, a smaller annulus may be submitted to ESSO for approval.

During drilling of the monitoring well, a log of the boring shall be made by a qualified geologist or engineer.

#5.15.2 Casing

The well casing shall be: 50 to 100 mm (2 to 4 in.) in diameter, NSF-certified PVC schedule 40 or 80 pipe, flush-thread, screw joint (no glue or solvents); polytetrafluoroethylene (PTFE, such as Teflon) tape or O-rings in the joints; no collar couplings. The top of the casing shall be at least 600 mm (2 ft.) above ground level. Where high levels of volatile organic compounds (VOC's) or corrosive compounds are anticipated, stainless steel or PTFE casing and screen may be used, subject to approval by ESSO. 100 mm (4 in.) diameter casing is recommended because it allows larger volume samples to be obtained and provides easier access for development, pumps, and repairs. The casing shall be cleaned and packaged at the place of manufacture; the packaging shall include a PVC wrapping on each section of casing to keep it from being contaminated prior to installation. The casing shall be free of ink, labels, or other markings. The casing (and screen) shall be centered in the hole to allow installation of a good filter pack and annular seal, using appropriately placed centralizers. The top of the casing shall be protected by a threaded or slip-on top cap or by a sealing cap or screw-plug seal inserted into the top of the casing. The cap shall be vented to prevent buildup of methane or other gases.

5.15.3 Well Screen

The screen shall be compatible with the casing and shall be of the same material. The screen shall not involve the use of any glues or solvents for construction. A wire-wound screen is recommended to provide maximum inflow area. Field-cut slots are not permitted for well screen. Filter cloth shall not be used. A blank-pipe sediment trap, typically 300 to 600 mm (1 to 2 ft.) shall be installed below the screen. A bottom cap shall be placed on the bottom of the sediment trap. The sediment trap shall not extend through the lower confining layer of the water-bearing zone being treated. Screen sterilization methods are the same as those for casing. Selection of the size of the screen opening shall be performed by a person experienced with such work and shall include consideration of the distribution of particle sizes both in the water-bearing zone and in the filter pack surrounding the screen. The screen opening shall not be larger than the smallest fraction of the filter pack.

5.15.4 Filter Pack

The filter pack, placed between the screen and the well bore, shall consist of pre-packaged, inert, clean, silica sand or glass beads; it shall extend from 300mm to 1200mm (1 ft. to 4 ft.) above the top of the screen. Open stockpile sources of sand or gravel are not permitted. The filter pack usually has a 30% finer grain size that is about 4 to 10 times larger than the 30% finer grain size of the water-bearing zone; the filter pack shall have

a uniformity coefficient less than 2.5. The filter pack shall be placed with a tremie pipe to ensure that the material completely surrounds the screen and casing without bridging. The tremie pipe shall be cleaned prior to installing the first well and before each subsequent well.

5.15.5 Seals

The annular seal shall be placed on top of the filter pack and shall be at least 600 mm (2 ft.) thick. It shall be placed in the zone of saturation to maintain hydration. The seal shall be composed of, in order of preference, coarse-grain sodium bentonite, coarse-grit sodium bentonite, or bentonite grout. Special care shall be taken to ensure that fine material or grout does not plug the underlying filter pack. Placement of a few inches of pre-packaged clean fire sand on top of the filter pack shall be used to prevent migration of the annular seal material into the filter pack. The seal shall be placed on top of the filter pack with a clean tremie pipe to ensure good distribution and shall be tamped with a clean rod to determine that the seal is thick enough. The bentonite shall be hydrated with clean water prior to any further activities on the well and left to stand until hydration is complete (8 to 12 hours, depending on the grain size of the bentonite). If a bentonite-grout (without cement) casing seal is used in the well bore, then it may replace the annular seal.

A casing seal shall be placed on top of the annular seal to prevent fluids and contaminants from entering the borehole from the surface. The casing seal shall consist of a commercial bentonite grout or a cement-bentonite mixture. Drilling spoil, cutting, or other native materials are not permitted for use as a casing seal. Quick-setting cements are not permitted for use because contaminants may leach from them into the groundwater. The top of the casing seal shall be between 1500 mm and 600 mm (5 ft. and 2 ft.) from the surface.

5.15.6 Concrete Pad

Concrete, with a compressive strength of 25 Mpa (3625 psi), shall be placed from the top of the casing seal (600 to 1500 mm (2 to 5 ft.) below the surface) continuously to the top of the ground to form a pad at the surface. This formed surface pad shall be at least 150 mm (6 in.) thick and not less than 1200 mm (4 ft.) square or 1500 mm (5 ft.) in diameter. The pad shall contain sufficient reinforcing steel to ensure its structural integrity in the event that soil support is lost. The top of the pad shall slope away from the well bore to the edges to prevent ponding of water around the casing or collar.

5.15.7 Protective Collar

A steel protective pipe collar shall be placed around the casing "stickup" to protect it from damage and unwanted entry. The collar shall be set at least 300 mm (1 ft.) into the surface pad during its construction and should extend at least 75 mm (3 in.) above the top of the well casing (and top cap, if present). The top of the collar shall have a lockable hinged top flap or cover. A sturdy lock shall be installed, maintained in working order, and kept locked when the well is not being bailed/purged or sampled. The well number or other designation shall be marked permanently on the collar; including the total depth of the well and its elevation on the collar.

#5.15.8 Protective Barrier

Where monitoring wells are likely to be damaged by moving equipment or are located in heavily traveled areas, a protective barrier shall be installed. A typical barrier is three or four 150 mm (6 in.) to 300 mm (12 in.) diameter pipes set in concrete just off the protective pad. The pipes can be joined by pipes welded between them, but consideration must be given to well access for sampling and other activities. Separation of such a pipe barrier from the pad means that the barrier can be damaged without risk to the pad and well. Other types of barriers may be approved by ESSO.

#5.15.9 Unusual Conditions

Where monitoring wells are installed in unusual conditions, all aspects of the installation shall be submitted to ESSO in writing in advance for their consideration. Such aspects include, for example, the use of cellar-type enclosures for the top-well equipment or multiple completions in a single hole.

5.15.10 Well Development

After a monitoring well is installed, it shall be developed to remove artifacts of drilling (clay films, bentonite pellets in the casing, etc.) and to open the water-bearing zone for a maximum flow into the well. Development should continue until all of the water used or affected during drilling activities has been removed and field measurements of pH, specific conductance, and temperature have stabilized. Failure to develop a well properly may mean that it is not properly monitoring the water-bearing zone or may not yield adequate water for sampling even though the water-bearing zone is prolific.

5.15.11 Location and Elevation

Upon completion of a monitoring well, the location of the well and all appropriate elevations associated with the top-well equipment shall be surveyed. The elevation shall be surveyed to the nearest 0.003 m (0.01 ft.)

above mean sea level (with year of the sea-level datum shown). The point on the well casing for which the elevation was determined shall be permanently marked on the casing. The location shall be given in terms of the latitude and longitude at least to the nearest tenth of the second or shall be accurately located with respect to the landfill grid system.

5.15.12 Reporting

Monitoring well installation and construction details shall be completed and submitted to ESSO within 30 days of well completion. A copy of the detailed geologic log of the boring, any particle size or other sample data from the well, and a site map drawn to scale showing the location of all monitoring wells shall be submitted to ESSO.

*5.15.13 Damaged Wells

Any monitoring well that is damaged to the extent that it is no longer suitable for sampling shall be reported to ESSO who shall make a determination about whether to repair or replace the well.

#5.15.14 Plugging and Abandonment

Any monitoring well that is no longer used shall be properly plugged and abandoned. No abandonment shall take place without prior authorization in writing by ESSO. Procedures for abandonment shall be as given in CCS 11-10-1.

6.0 OPERATING PROCEDURES

The landfill operation performed by Contractor, shall consist of placing, spreading and compacting solid waste materials approved for landfill disposal in Contractor's Waste Management Plan in landfill cell trenches in uniform layers separated by layers of cover material. After construction activities have been completed, the landfill cells used during the pre-operations phase will be capped and closed. The landfill site will remain open and will continue to serve as the disposal area for solid wastes generated by the fixed facilities personnel during operations.

6.1 Health and Safety

The disposal site shall be operated in such a manner as to protect the health and safety of personnel associated with the operation. The Contractor shall instruct personnel as to standard procedures for maintaining safety in accordance with GPS-008 and Section 22 of the Coordination Procedures. In addition, the following measures shall be implemented:

a. Personal safety devices and gear shall be provided by the Contractor to facility personnel.

b. Safety and warning devices shall be provided on all equipment used to spread and compact waste or cover material.

c. The Contractor shall take appropriate steps to prevent and control on site populations of disease vectors using proper compaction and daily cover procedures, and the use of other approved methods as needed.

d. Litter and other windblown material shall be collected on a regular basis and returned to the active disposal area or working face as necessary to minimize unhealthy, unsafe, or unsightly conditions.

e. The working surfaces of all equipment that come in contact with wastes shall be washed down on a regular basis. Wastewaters shall not be allowed to accumulate on site without proper treatment to prevent the creation of odors or an attraction to disease vectors.

f. The Contractor shall make provisions to extinguish any fires in wastes being delivered to the site or which occur at the working face or within equipment or personnel facilities.

6.2 Placement of Solid Waste Material

Waste materials shall be trucked to the landfill and placed in the appropriate landfill cell trenches (based on waste type). The waste shall be compacted on slopes less than 3:1 (H:V) in lifts of 600mm (2 ft.) or less by three to five passes of tracked equipment. Solid waste handling equipment shall on any operating day be capable of performing the following functions:

a. Spreading the waste materials in an uncompacted layer with a maximum thickness of 600mm while confining it to the smallest practicable area,

b. Compacting the spread waste material to the smallest practicable volume, and

c. Placing, spreading and compacting the cover material over a waste layer by the end of the day's operation.

6.3 Daily and Intermediate Cover

Soil cover shall be placed to control insects, rodents, scavenging by birds, blowing litter, flies, odors and to provide better access to the working face. The intent is to ensure that deposition of waste will not adversely affect the environment or public health.

A soil cover (minimum 150 mm (6 in.) thickness) shall be placed and compacted daily. Acceptable cover material shall meet the criteria given in Table 2.

An intermediate soil cover (minimum 300 mm (12 in.) thickness) shall be placed and compacted on areas which will not receive additional wastes for longer periods.

The cover material for each layer of waste shall be spread and compacted in accordance with Table 3.

TABLE 3
Depth of Cover Material

TYPE OF COVER [Period of Site Inactivity (P)]	DAILY [P < 1 week]	INTERMEDIATE [week < P < 1 year]	FINAL [P > 1 year]
Compacted Thickness	150 mm	300 mm	600 mm

6.4 Leachate Collection and Disposal

The leachate sumps shall be monitored by Contractor for level of accumulated liquid and leachate quality. Sumps shall be monitored on a regular basis to ensure that overflowing does not occur. The leachate quality shall be monitored semi-annually. The leachate shall be extracted from the sumps and disposed of by the Contractor in its sewage treatment plant. If necessary, Contractor shall adjust leachate pH and treat to remove heavy metals and excess salts that would not be compatible with the sewage treatment design parameters and effluent quality before sending the leachate to its sewage treatment system.

The leachate collection system must be properly maintained on an annual basis (or more often, as necessary). The leachate lines shall be cleaned out by the Contractor and the sump pump inspected once a year.

6.5 Groundwater Monitoring

The groundwater monitoring program shall include consistent sampling and analysis procedures that are designed to ensure monitoring results that provide an accurate representation of groundwater quality at the background and downgradient wells.

The Contractor shall notify ESSO promptly (within 1 day) in writing of changes in site construction or operation or changes in adjacent property that affect or are likely to affect the direction and rate of groundwater flow and the potential for detecting groundwater contamination from the solid waste landfill that may require the installation of additional monitoring wells or sampling points.

#6.5.1 Groundwater Sampling and Analysis Plan

Contractor shall submit a groundwater sampling and analysis plan (GWSAP) to ESSO for review and approval prior to commencement of sampling and shall maintain a current copy in the operating record. The GWSAP shall:

a. include procedures and techniques for sample collection, sample preservation and shipment, analytical procedures, chain-of-custody controls, quality assurance, and quality control;

b. provide for measurement of groundwater elevations at each sampling point prior to bailing or purging. Measurement at an event shall be

accomplished over a period of time short enough to avoid temporal variations in water levels. Sampling at each event shall proceed from the point with the highest water-level elevation to those with successively lower elevations unless contamination is known to be present, in which case wells not likely to be contaminated shall be sampled prior to those that are known to be contaminated unless an alternative procedure is approved by ESSO; and

c. include sampling and analytical methods that are appropriate for groundwater sampling and that accurately measure hazardous constituents and other monitoring parameters in groundwater samples. The number of samples to be collected to establish groundwater quality data shall be consistent with the appropriate statistical procedures for determination of evidence of contamination.

6.5.2 Groundwater Sampling and Analysis

Groundwater samples shall not be field-filtered prior to laboratory analysis.

The sampling procedures shall be protective of human health and the environment and appropriate for generation of statistically significant data.

Contractor shall establish background groundwater quality in hydraulically upgradient wells or in background wells for each of the monitoring parameters or constituents required in the ground monitoring program for a solid waste landfill. Downgradient groundwater data shall not be adjusted by subtracting background groundwater data.

The Contractor shall determine within 7 calendar days after completing sampling and analysis whether or not there is evidence of a statistically significant change from background values for each constituent required in the groundwater monitoring program for the solid waste landfill. In determining if there is evidence of a statistically significant change from background, the Contractor shall compare the groundwater quality of each tested constituent at each monitoring well or other sampling points to the background value of that constituent.

*6.5.3 Constituents to be Monitored

Compounds that groundwater samples shall be tested for include those listed in Table 4, at a minimum. ESSO may delete any of the constituents listed in Table 4 if it can be documented that the removed constituents are not reasonably expected to be in or derived from the waste contained in the landfill. Contractor may also petition ESSO for removal of constituents from the list if it believes these conditions are met.

Parameters shall be tested using methods in Standard Methods for the Examination of Water and Wastewater (Mary Ann H. Franson, editor,

American Public Health Association, 1995). Test results shall be certified by Contractor and the records of said tests kept as per Section 30 of the Coordination Procedure.

ESSO may establish an alternative list of inorganic indicator constituents in lieu of some or all of the heavy metals if the alternative constituents provide a reliable indication of inorganic releases from the solid waste landfill to the groundwater.

ESSO may also add inorganic or organic constituents to those to be tested if they are reasonably expected to be in or derived from the waste contained in the unit or if they are likely to provide a useful indication of releases from the solid waste landfill to the groundwater.

TABLE 4
Sample Analysis Parameters

	INORGANIC CONSTITUENTS	CAS RN[1,2]
1	Antimony	(Total)
2	Arsenic	(Total)
3	Barium	(Total)
4	Beryllium	(Total)
5	Cadmium	(Total)
6	Chromium	(Total)
7	Cobalt	(Total)
8	Copper	(Total)
9	Lead	(Total)
10	Mercury	(Total)
11	Nickel	(Total)
12	Selenium	(Total)
13	Silver	(Total)
14	Thallium	(Total)
15	Vanadium	(Total)
16	Zinc	(Total)
	ORGANIC CONSTITUENTS[3]	
17	Acetone	67-64-1
18	Acrylonitrile	107-13-1
19	Benzene	71-43-2
20	Bromochloromethane	74-97-5
21	Bromodichloromethane	75-27-4
22	Bromoform (tribromomethane)	75-25-2
23	Carbon disulfide	75-15-0
24	Carbon tetrachloride	56-23-5
25	Chlorobenzene	108-90-7
26	Chloroethane (ethyl chloride)	75-00-3

27	Chlorform (trichloromethane)	67-66-3
28	Dibromochloromethane (chlorodibromomethane)	124-48-1
29	1,2-Dibromo-3-chloropropane (DBCP)	96-12-8
30	1,2-Dibromoethane (ethylene dibromide, EDB)	106-93-4
31	o-Dichlorobenzene (1,2-dichlorobenzene)	95-50-1
32	p-Dichlorobenzene (1,4-dichlorobenzene)	106-46-7
33	trans-1,4-Dichloro-2-butene	110-57-6
34	1,1-Dichloroethane (ethylidene chloride)	75-34-3
35	1,2-Dichloroethane (ethylene dichloride)	107-06-2
36	1,1-Dichloroethylene (1,1-dichloroethene, vinylidene chloride)	75-35-4
37	cis-1,2-Dichloroethylene (cis-1,2-dichloroethene)	156-59-2
38	trans-1,2-Dichloroethylene (trans1,2-dichloroethene	156-60-5
39	1,2-Dichloropropane (Propylene dichloride)	78-87-5
40	cis-1,3-Dichloropropane	10061-01-5
41	trans-1,3-Dichloropropene	10061-02-6
42	Ethylbenzene	100-41-4
43	2-Hexanone (methyl butyl ketone)	591-78-6
44	Methyl bromide (bromomethane)	74-83-9
45	Methyl chloride (chloromethane)	74-87-3
46	Methylene bromide (dibromomethane)	74-95-3
47	Methylene chloride (dichloromethane)	75-09-2
48	Methyl ethyl ketone (MEK, 2-butanone)	78-93-3
49	Methyl iodide (iodomethane)	74-88-4
50	4-Methyl-2-pentanone (methyl isobutyl ketone)	108-10-1
51	Styrene	100-42-5
52	1,1,1,2-Tetrachloroethane	630-20-6
53	1,1,2,2-Tetrachloroethane	79-34-5
54	Tetrachloroethylene (tetrachloroethene, perchloroethylene)	127-18-4
55	Toluene	108-88-3
56	1,1,1-Trichloroethane (methychloroform)	71-55-6
57	1,1,2-Trichloroethane	79-00-5
58	Trichloroethylene (trichloroethene)	79-01-6
59	Trichlorofluoromethane (CFC-11)	75-69-4
60	1,2,3-Trichloropropane	96-18-4
61	Vinyl acetate	108-05-4
62	Vinyl chloride	75-01-4
63	Xylenes	1330-20-7

1. The Chemical Abstracts Service registry number (CAS RN).

2. Where "Total" is entered, all species in the groundwater that contain the element are included.
3. Common names of the volatile organic compounds are those widely used in government regulation, scientific publications and commerce; synonyms exist for many of them.

6.5.4 Monitoring Frequency

The monitoring frequency for all constituents shall be annually during the active life of the facility and the closure period.
A minimum of four statistically independent samples from each background and each downgradient well shall be collected and analyzed for the constituents. The independence of the four samples shall be achieved by bailing or purging at least three well volumes (or to dryness, if less) from each well before each of the four samples is collected.

ESSO may specify an appropriate alternative frequency for repeated sampling and analysis of the constituents. The alternative frequency shall be no less than annual and shall be based on factors such as lithology and hydraulic conductivity of the aquifer and unsaturated zone, groundwater flow rates, minimum distance of travel from waste to monitoring wells, and resource value of the uppermost aquifer.

#6.5.5 Changes in Groundwater Quality

Not later than 60 days after each sampling event, Contractor shall notify ESSO in writing if there has been a statistically significant change from background of any tested constituent at any monitoring well.

If a statistically significant change from background of any tested constituent at any monitoring well has occurred, Contractor shall immediately place a notice in the operating record describing the increase.

If a statistically significant change from background of any tested constituent at any monitoring well has occurred and the Contractor has reasonable cause to think that a source other than the solid waste landfill caused the contamination or that the statistically significant change resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality, then the Contractor shall submit a report providing documentation to this effect. The report shall be prepared by a qualified groundwater scientist and submitted to ESSO for review and approval not later than 90 days after the sampling event.

6.6 Records

The Contractor shall maintain disposal records covering at least the following:

a. Major operational problems or difficulties.

b. Qualitative and quantitative evaluations of the environmental impact of the disposal site including results of:
   1. Leachate sampling and analysis;
   2. Ground and surface water quality sampling and analysis upstream and downstream of the site.
   3. Source of daily, intermediate and final cover material.
   4. Waste compaction.
   5. Gas generation and gas control procedures.
   6. Vector control efforts.
   7. Dust and litter control efforts.

c. Quantitative measurements of the solid wastes handled, accomplished through routine or periodic utilization of scales and topographic surveys of the site.

d. Description of amounts and types of solid waste materials received in each landfill cell identified by source of materials, as per the database required by Coordination Procedure Section 30. This database shall be turned over to ESSO at project completion.

e. Location and development of cells used by the Contractor.

#7.0 CLOSURE REQUIREMENTS

7.1 Within 180 days of the last receipt of wastes generated during construction, the Contractor shall complete the installation of a final cover system for the landfill cells used during the pre-operations phase that is designed and constructed to minimize infiltration and erosion. The final cover system shall be composed of no less than 750 mm (2.5 ft.) of soil and consist of an infiltration layer overlain by an erosion layer as follows:

a. The infiltration layer shall consist of a minimum of 450 mm (18 in.) of earthen material with a coefficient of permeability no greater than $1x10^{-5}$ cm/sec ($3.94x10^{-6}$ in/sec) overlain by a synthetic membrane that has a permeability less than or equal to the permeability of the bottom liner system. The minimum thickness of the synthetic membrane shall be 0.5 mm (20 mils), or 1.5 mm (60 mils), in the case of HDPE, in order to ensure proper seaming of the synthetic membrane.

b. The erosion layer shall consist of a minimum of 300 mm (12 in.) of earthen material that is capable of sustaining native plant growth and shall be seeded

or sodded immediately following the application of the final cover in order to minimize erosion.

7.2 The Contractor shall submit to ESSO for approval a written final closure plan that describes the steps necessary to close the landfill cells used during the pre-operations phase. The final closure plan, at a minimum, shall include the following information:

a. a description of the final cover design and methods and procedures to be used to install the cover;

b. an estimate of the largest area of the landfill site ever requiring a final cover at any time during the active life of the landfill;

c. an estimate of the maximum inventory of wastes ever on-site over the active life of the landfill and a summary of the types and amounts of waste contained in each landfill cell;

d. a schedule for completing all activities necessary to satisfy the closure criteria; and

e. a final contour map depicting the proposed final contours, establishing top slopes and side slopes, proposed surface drainage features, and protection of any 100-year flood-plain.

7.3 No later than 45 days prior to the initiation of closure activities for the landfill cells used during the pre-operations phase, the Contractor shall provide written notification to ESSO of the intent to close the cells and place this notice of intent in the operating record.

7.4 Following receipt of the required final closure documents, ESSO shall acknowledge the termination of operation and closure of the cells and evaluate whether they are properly closed. Contractor shall correct any deficiencies identified by ESSO in its evaluation.

#7.5 Quality control testing documentation is as follows:

a. The Contractor is responsible for placing and compacting clay soils for the final cover infiltration layer.

b. The Contractor shall test the 450 mm (18 in.) of compacted material for its coefficient of permeability at a frequency of no less than one test per surface acre of final cover.

c. Permeability data shall be submitted to ESSO for approval.