

PART 1 - GENERAL

1.1 SECTION
INCLUDES

- .1 Materials and installation of the 0.75 m thick compacted clay liner and the electrical conductivity sensor system in the containment mound, and the 0.5 m thick compacted clay liner in the drainage works, and stormwater management and equalization ponds.

1.2 MEASUREMENT AND
PAYMENT

- .1 Compacted clay liner will be measured for payment in cubic metres of material installed.
 - .1 Compacted Clay Liner for Mound.
 - .2 Compacted Clay Liner for Equalization Pond, Stormwater Ponds and Roadside Ditches.
- .2 The material and installation of electrical conductivity sensors will be measured for payment per sensor nest. There are to be 10 nests each consisting of 4-electrodes. Price is to include cable and calibration; eight nests are to be installed, two nests to be retained on site for possible later installation as directed by the Departmental Representative.
- .3 The material and installation of electrical conductivity measuring system measured for payment as a Lot Price item. Price shall include components to made and record readings of the sensors, memory module, power source, weatherproof case, software and all materials and procedures required for the proper measurements of all the sensor nests. Price is to include training of Departmental Representative monitoring staff, As Built drawings, equipment manuals, and equipment warranty. The warranty period of the electrical conductivity measuring system shall be five years.

1.3 RELATED
SECTIONS

- .1 Section 31 22 13:General Earthwork and Rough Grading.
- .2 Section 31 23 33.01: Containment Mound Final Cover and Berm
- .3 Section 31 32 19.02: High Density Polyethylene (HDPE) Geomembrane.

1.4 REFERENCES

- .1 ASTM International (ASTM)
 - .1 ASTM D422-63(2007), Standard Method for Particle-Size Analysis of Soils.
 - .2 ASTM D698-12, Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,000 ft-lbf/ft³ (600 kN m/m³)).
 - .3 ASTM D2216-10, Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.
 - .4 ASTM D4318-10, Standard Test Methods for Liquid Limit, Plastic Limit and Plasticity Index of Soils.
 - .5 ASTM D4643-08, Standard Test Method for Determination of Water (Moisture) Content of Soil by Microwave Oven Heating.
 - .6 ASTM D5084-10, Standard Test Methods for measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.
 - .7 ASTM D6391-11, Standard Test Method for Field Measurement of Hydraulic Conductivity Limits of Porous Materials Using Two Stages of Infiltration from a Borehole.
 - .8 ASTM D6938-10, Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).
 - .9 ASTM D7100-11, Standard Test Method for Hydraulic Conductivity Compatibility Testing of Soils with Aqueous Solutions.
- .2 Trautwein, S.J. and Boutwell, G.P. 1994. In situ hydraulic conductivity tests for compacted soil liners and caps. In Hydraulic conductivity and waste containment transport in soils. ASTM STP 1142. Edited by D.E. Daniel and S.J. Trautwein. American Society for Testing and Materials, Philadelphia, pp. 184-226.

1.5 SUBMITTALS

- .1 Provide submittals in accordance with Section 01 33 00.
- .2 At least 16 weeks prior to the Installation of the Compacted Clay Liner (CCL) the Contractor shall submit for review and acceptance by the Departmental Representative:
 - .1 Source(s) of the Clay Liner Material (CLM) including but not limited to location, geological and geotechnical descriptions and mineralogy of the CLM.

1.5 SUBMITTALS
(Cont'd)

- .2 (Cont'd)
- .2 Preliminary field and lab test results confirming that the proposed CLM complies with the requirements of the Specifications. Lab tests are to be from an accredited and pre-approved Laboratory.
- .3 Samples of the CLM to be delivered to the Departmental Representative. Provision of samples will be at the frequency stipulated by the Departmental Representative and based on the characteristics of the source. As well, the Departmental Representative reserves the right to visit and inspect the source area as required.
- .4 Proposed work plan which details the schedule of the investigation and testing of the CCL.
- .5 The Departmental Representative is to review the above submittal within 20 days prior to the installation of CCL.
- .6 Should the above Submittals fail to meet the requirements, the Contractor is to re-submit until satisfactory results are achieved. Contractor to perform this at Contractor's own cost.
- .3 The Departmental Representative shall review above submittal within 20 days.
- .4 Should the above submittal fail to meet requirements, the Contractor is to revise and resubmit until satisfactory results are achieved. Contractor shall perform this at Contractor's own cost.

1.5 SUBMITTALS
(Cont'd)

- .5 At least 16 weeks prior to installation of compacted clay liner, submit to Departmental Representative preliminary information of the proposed source(s) of clay. The information shall include, as a minimum, location, geological and geotechnical descriptions of the source(s), mineralogy of the clay and preliminary assessment with respect to clay leachate compatibility, preliminary field and laboratory test results to demonstrate that the soil complies with the requirements of the Specifications. The leachate quality shall be based on the upper range values in Table 1 - Expected Range In Leachate Quality For The Mound, attached to this section. The data shall also include testing results of natural moisture contents, grain size analysis (with hydrometer), Atterberg Limits, standard Proctor tests, shear strength, hydraulic conductivity tests, and compacted dry density-moisture content-hydraulic conductivity relationship.
- .6 Within four weeks after the acceptance of the preliminary information by the Departmental Representative and at least eight weeks before the installation of the compacted clay liner, submit to Departmental Representative additional details of the proposed source(s) of clay for the compacted clay liner. The information shall include, as a minimum, clay leachate compatibility testing as required, additional field investigation results necessary to define the limit and amount of the source and its variability, and necessary field and laboratory test results to demonstrate that the soil complies with the requirements of the Specifications. The leachate quality shall be based on the upper range values in Table 1 - Expected Range In Leachate Quality For The Mound, attached to this section. The data provided shall also clearly identify the degree of compaction in term of minimum compacted dry densities and the range of corresponding moisture content that are wet of the optimum water content which the compacted clay will achieve the design hydraulic conductivity.

1.5 SUBMITTALS
(Cont'd)

- .7 At least eight weeks prior to installation of the compacted clay liner, submit to the Departmental Representative, for review and approval, a work plan of the construction and testing of a test pad to demonstrate that the proposed soil, equipment and construction method will produce a compacted clay liner that meets the requirements of the Specifications.
- .8 Within 8 weeks after prior to installation of the compacted clay liner submit a Survey Control Plan outlining:
 - .1 Associated procedures for field verification and documentation of installation of compacted clay liner.
 - .2 Provide proof of licensure for Surveyors completing work.
 - .3 Schedule for all related surveying activities.
 - .4 Drawings showing survey control points.
 - .5 Survey equipment specifications.
- .9 Within two weeks after the acceptance of the test pad work plan by the Departmental Representative, complete the test pad and associated testing and submit the results to Departmental Representative to demonstrate that the proposed clay liner material and construction method meet the requirements of the Specifications.
- .10 At least three weeks prior to installation of the compacted clay liner, submit to the Departmental Representative a Construction Quality Control Plan.
- .11 Retain Clay Liner Material (CLM) samples collected and/or tested by the Contractor and submit when requested by the Departmental Representative.
- .12 At least eight(8) weeks prior to installation of the compacted clay liner, submit to the Departmental Representative for acceptance the details of the electrical conductivity measuring system including but not limited to the soil resistivity meter and associated data logger and software, and details of access for measurements of the sensor.

1.5 SUBMITTALS
(Cont'd)

- .13 Within one (1) week after complete As Built installation of the system in each cell, record drawings shall be submitted to the Departmental Representative identifying the location of the installed sensors, cables and access points for measurement with unique identification for each sensor (a set of 4 equally spaced electrodes) and access point.

1.6 QUALITY
ASSURANCE (CLAY)

- .1 Contractor shall conduct a field investigation and laboratory testing program to confirm that the proposed source(s) of clay material for the compacted clay layer meet the requirements of the Specifications. The program shall be executed by firm(s) that are experienced in this type of program and in the design and construction quality assurance of similar compacted clay liner.
- .2 The investigation and testing program of the proposed source of clay shall include determination of the mineralogy and activity of the clay and assessment of its compatibility with the leachate anticipated at the containment mound. The leachate quality shall be based on the upper range values in Table 1 - Expected Range In Leachate Quality For The Mound, attached to this section.
- .1 If the results cannot definitively confirm that there will be no detrimental effect on the clay when exposed to the leachate, leachate compatibility test shall be conducted.
- .2 The test shall include, as a minimum, testing of samples in accordance with ASTM D7100-06 Method 2 using aqueous solution representative of the leachate.
- .3 The measured hydraulic conductivities shall not be more than 1×10^{-9} m/s as determined through testing of samples under an effective confining stress of 35 kPa and hydraulic gradient of 20.
- .4 Test at least four leachate variations based on the anticipated waste type and waste characteristics.
- .5 Use local groundwater if necessary to use water to develop leachate for test.
- .3 A test pad shall be constructed before construction of the actual, full-scale compacted clay liner, in accordance with the following requirements:

1.6 QUALITY
ASSURANCE (CLAY)
(Cont'd)

- .3 (Cont'd)
- .1 The test pad shall be constructed from the same soil material, design specifications, equipment and procedures as are proposed for the full-scale liner.
 - .2 The test pad shall be at least four times the width of the widest piece of equipment to be used.
 - .3 The test pad shall be long enough to allow the equipment to reach normal operating speed before reaching the test area.
 - .4 The complete thickness of the compacted clay liner shall be constructed.
 - .5 The test pad shall be tested as described below for each of the following physical properties in compliance with the work plan provided under paragraph 1.5.7 of this section.
 - .1 Field testing techniques according to ASTM D6391 as modified by Trautwein and Boutwell (1994) shall be used to determine the hydraulic conductivity.
 - .2 Samples shall also be tested in the laboratory for hydraulic conductivity. The laboratory results shall be evaluated to determine if there is a statistical correlation to the field testing results.
 - .3 Other engineering parameters, including but not limited to particle size distribution, plasticity, water content, and in-place density, that are needed to evaluate the full-scale liner shall be determined.
 - .6 Additional test pads shall be constructed for each time the material properties of a new borrow source changes or for each change in equipment or procedures.
- .4 Based on the quality assurance results completed prior to installation of the compacted clay liner and the requirements of the Specifications, the Contractor shall prepare a Construction Quality Control Plan that clearly defines the proper materials, equipment, procedures, testing, and controls that are to be used in the construction of the compacted clay liner. The plan shall as a minimum include the following:
- .1 Type, purpose and operation of construction equipment.
 - .2 Staff and their responsibilities.
 - .3 Monitor and control of quality of the clay at the source and prior to haulage.
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- .5 The Departmental Representative shall prepare in accordance to this Specification a Quality Assurance Plan prior to installation of the compacted clay liner and shall perform and document the construction quality assurance work.
- .6 Contractor shall coordinate with the Departmental Representative the planning, scheduling, execution, reporting, and reviewing of all investigation, testing and field program.

- .1 The Contractor shall allow the Departmental Representative to inspect the installation and testing of the electrical conductivity sensor nests.
- .2 The Contractor shall demonstrate to the Departmental Representative in the field to confirm each installed electrical conductivity sensor nest is working properly both prior to and after covering with material above it.

1.7 QUALITY
ASSURANCE
(ELECTRICAL
CONDUCTIVITY
MEASURING SYSTEM)
(Cont'd)

- .3 Contractor is to repair or replace at his own cost any electrical conductivity sensor nest and the measuring system and associated installation found to be defective.

PART 2 - PRODUCTS

2.1 SOIL FOR LINER

- .1 The soil must be capable of being compacted to construct a compacted clay liner with a maximum hydraulic conductivity of not more than 1×10^{-9} m/s as determined through testing of samples of the as-constructed liner using ASTM D5084-03 under an effective confining stress of 35 kPa and hydraulic gradient of 20 using de-ionized water as the permeant.
- .2 The soil shall also have the following properties:
- .1 The soil shall contain no rock greater than 100 mm in the maximum dimension.
 - .2 Fraction (by dry weight) retained by the 4.75 mm (No. 4) sieve: 20% or less.
 - .3 Fraction (by dry weight) passing the 75 μ m sieve: 50% or greater.
 - .4 Liquid Limit: 30% or greater.
 - .5 Plasticity Index: 15 or greater.
 - .6 Free from frozen lumps, waste, contaminated material, organic matter, and any other deleterious material.
- .3 The soil must be, as specified in this Specification, compatible with the leachate.

2.2 WATER

- .1 Only uncontaminated water shall be used for moisture adjustment.

2.3 ELECTRICAL
CONDUCTIVITY
SENSORS AND CABLE

- .1 Each sensor will consist of 4 equally spaced stainless steel electrodes. Each electrode is to be 13 mm diameter by 35 mm length and is to have a polyethylene coated copper wire lead. The electrodes and cables shall be compatible with the soil resistivity meter approved by the Departmental Representative. The system shall be capable of measuring soil resistivity by using a soil resistivity meter to apply a known current to two outer electrodes while measuring the resulting voltage potential across the inner electrodes of each horizontal array of four electrodes.
- .2 Cable must have sufficient length for accurate measurement being made with access point(s) at the perimeter of the mound perimeter.

2.4 ELECTRICAL
CONDUCTIVITY
MEASURING SYSTEM

- .1 The soil resistivity meter shall be capable of applying a known current to the outer electrodes while measuring the voltage potential across the two inner electrodes. The meter shall be able to measure resistance from 0.01 to 100,000 ohm with an accuracy of within +/- 10%.
- .2 At the sensors access locations, all cables shall be protected in weather-proof enclosure(s) and connection to each cable shall be clearly and uniquely identified to the approval of the Departmental Representative. The connection between the soil resistivity meter and the sensor nest shall be arranged to allow easy and correct measurements to be made and recorded. The arrangement shall prevent the risk of making wrong connection of the respective cables to the meter.
- .3 The meter shall have internal memory and/or be connected to a data logger that can store in memory applied current and measured voltage potential along with at least the following sampling information: date, time, and sensor ID or location. The system shall also display the readings as measured. These instruments shall be suitable for outdoor and winter operations.

2.4 ELECTRICAL
CONDUCTIVITY
MEASURING SYSTEM
(Cont'd)

- .4 The measurement and recording system shall include software that allows date and time to be automatically recorded when measurements are made. The system shall also allow the stored data be transferred to a PC or computer for analysis and the conversion of the measured data to soil conductivity unit in milliSeimens per metre (mS/m).

PART 3 EXECUTION

3.1 GENERAL

- .1 The installation of the compacted clay liner shall be carried out in accordance with the Specifications, Construction Quality Control Plan and Construction Quality Assurance Plan. This Part 3 Execution shows only the minimum requirements in the installation of the compacted clay liner and is to be supplemented with others according to the characteristics of the clay source and based on the results of the test pad.

3.2 EQUIPMENT

- .1 The Contractor shall provide earthmoving equipment necessary for construction of the compacted clay liner and shall include as a minimum the following:
- .1 Tractor with agricultural disc or equivalent as approved by the Departmental Representative, for conditioning the soil prior to compaction.
 - .2 Water tank trucks equipped with spray bars and hose to wet the soil as needed, and capable of producing a fine and even water spray.
 - .3 Sheepsfoot/padfoot compactor with a minimum foot length of 200 mm. In general, the compactor shall have a mass of not less than 20,000 kg. The Contractor shall also provide light weight sheepsfoot/padfoot compactors for compacting soil in confined conditions and where heavy equipment is not suitable as agreed by the Departmental Representative.
 - .4 Other equipment necessary for the supply and installation of the compacted clay liner.

3.3 SUPPLY AND
STOCKPILING

- .1 The Contractor shall supply and haul only suitable materials from the accepted source of clay.
- .2 This stockpile shall be routinely graded and sealed to minimize infiltration to control the water content of the soil and erosion.
- .3 The Contractor shall also manage a spoils stockpile for materials that are unsuitable for the Work.
- .4 The Contractor to remove and dispose of stockpiled spoils off site at Contractor's own expense.

3.4 SUBGRADE
PREPARATION

- .1 The surface of the subgrade shall be graded to lines, grades, and tolerances shown on the Drawings. The subgrade surface shall be flat, smooth and free of ruts, standing water, excessive moisture, snow or ice. Clay liner materials shall not be placed on frozen subgrade.
- .2 The top of subgrade will be proof-rolled prior to commencing the liner construction. Any soft areas shall be replaced as directed by the Departmental Representative.
- .3 The Departmental Representative shall inspect and accept the subgrade conditions prior to placement of the clay liner materials.
- .4 The Contractor shall carry out a topographic survey during excavation to confirm that the subgrade for the base of the compacted clay liner is the Upper Till unit. Survey information (e.g. elevation and coordinates of excavated base) shall be provided to the Departmental Representative.

3.5 SOIL
CONDITIONING,
PLACEMENT AND
COMPACTION

- .1 Conditioning Prior to Compaction:
 - .1 Prior to compaction, soil clods shall be broken into smaller segments using mechanical equipment (e.g. agricultural disc) such that no clod is bigger than 100 mm.

3.5 SOIL
CONDITIONING,
PLACEMENT AND
COMPACTION
(Cont'd)

- .1 (Cont'd)
- .2 Prior to compaction, the moisture content of the soils shall be adjusted to within the range as determined from prior laboratory testing and Test Pad construction. If the soil materials have water contents which are above the specified range, the Contractor shall have the materials spread out and allowed to dry prior to placement. If the materials have water contents which are below the specified range, the Contractor shall add water using self-propelled equipment which has the capability of mechanically spraying water to evenly distribute water.
- .3 In the event that water must be added to the soils, the soils shall be mixed by mechanical means to provide a uniform distribution of water content throughout the lift being worked.
- .4 Prior to compaction of each lift, the Contractor shall provide labour and/or machinery, as appropriate, to locate and remove all unsuitable materials from the soil.
- .5 Any cobbles, boulders or objects larger than or equal to 100 mm, as measured in any dimension, shall be removed from the soils.
- .2 Lift Thickness: maximum compacted lift thickness shall be 150 mm. Subject to confirmation by the test pad, slightly additional lift thickness as determined may occasionally be permitted in anticipation of adverse rainstorm and if agreed by the Departmental Representative.
- .3 Compaction: Each lift shall be passed at least five times by the sheepfoot compactor and more as needed to achieve the required compacted properties. For compactors with front and rear drums, a "pass" is defined as a traversal by both drums. The compactor shall work in an orderly manner and ensure each pass overlaps with previous passes. If field and test pad results are sufficient to demonstrate that with less than five passes remolding of the clay is sufficient to remove all voids and form a uniform mass, the minimum passes may be reduced to four or three if agreed by the Departmental Representative. In any case, the clay shall meet all requirements specified and more than the minimum number of passes shall be carried out as needed.

3.5 SOIL
CONDITIONING,
PLACEMENT AND
COMPACTION
(Cont'd)

- .4 Hydraulic Conductivity: the in-place compacted clay shall achieve a saturated hydraulic conductivity as listed below:
 - .1 Undisturbed samples from completed areas of the liner shall be collected by the Departmental Representative with assistance of the Contractor. The samples shall be tested at a laboratory engaged by the Departmental Representative to measure the hydraulic conductivity according to ASTM D5084 under an effective confining stress of 35 kPa and hydraulic gradient of 20 using de-ionized water as the permeant.
 - .2 All laboratory permeability test results shall be 1×10^{-9} m/s or less.
 - .3 If any of the tests fail, the area shall be repaired out to the limits defined by passing hydraulic conductivity tests. The Contractor will be responsible for payment of charges associated with resampling and retesting of the liner soil material resulting from non-passing tests.
 - .5 Uniformity: the compacted clay liner is intended to be constructed as a uniform, homogeneous monolith of soil with the specified hydraulic conductivity, density, and moisture content. The compacted soil distribution and gradation throughout the clay liner shall be free from lenses, pockets, streaks, layers, or material differing substantially in texture, moisture content, dry density, or gradation from surrounding material. The soil shall be free of organic debris, frozen material, rubbish, construction debris, and other deleterious material. Any liner soil containing unsuitable material shall be removed and discarded.
 - .6 Moisture Conditioning: The Contractor shall ensure that each compacted lift is within specified range of moisture content.
 - .7 The Contractor shall sufficiently scarify the lift surface prior to placement of the overlying lift to encourage good bonding between lifts.
 - .8 The Contractor shall place lifts of the liner soil to form a continuous monolithic material. All soil shall be compacted with a compactor not less than 20,000 kg. The compactor feet shall be sufficiently long to break clods and knead (bond) new lifts into previously placed lifts.
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3.5 SOIL
CONDITIONING,
PLACEMENT AND
COMPACTION
(Cont'd)

- .9 Placement Method on Slope: liner soil shall be placed on slopes in lifts parallel to the slope.
- .10 Tie-in Areas: Where new liner soil is tied-in to liner soil already placed, any areas of the existing soil which are soft, cracked, desiccated, or otherwise unsuitable shall be removed until acceptable material is exposed to the satisfaction of the Departmental Representative. The edge of the existing soil shall be trimmed in a stepwise fashion such that a step at least 1 m wide in the horizontal direction is cut into each existing lift. Where new soil shall be placed, the surface of the existing soil shall be scarified and moisture conditioned as described in this section. New soil shall be placed in accordance with the requirements of this section and shall be thoroughly kneaded into the existing soil to form a monolithic mass free of seams or other discontinuities.

3.6 SURVEYS

- .1 Surveys shall be performed to provide existing conditions and to layout the Work. Ongoing surveys will also be completed to verify and document the limits and extents of Work.
- .2 The Contractor shall furnish and/or provide all labour, tools, materials, equipment and services to survey and document the progress of Work. The Contractor shall be responsible for layout of any survey controls, grid coordinate location, lines, grades and elevations necessary for proper construction, documentation and testing of the Work. Survey activities shall include, but not be limited to:
 - .1 Verify existing conditions with pre-construction surveys and bring any discrepancies with the base plan to Departmental Representative's attention.
 - .2 Permit the Departmental Representative time to do any grading redesign necessary should discrepancies exist.
 - .3 Perform post excavation, re-graded base of excavation, interim surveys and backfill surveys to ensure limits and extents are attained.

3.6 SURVEYS
(Cont'd)

- .3 The Contractor is responsible for survey control for construction and documentation. The Contractor shall safeguard all survey point and benchmarks. If any of these points are destroyed, the replacement costs shall be borne by the Contractor. The Contractor shall assume the entire expense for rectifying work improperly constructed due to failure to maintain and protect such established survey points and benchmarks.
- .4 Total Station/GPS Surveys shall be conducted as required by an Ontario licensed land surveyor. Survey data shall include:
 - .1 Provision of survey data x,y,z (easting, northing, elevation) format. Each data file shall include a descriptive header including but not limited to: software and equipment information, horizontal and vertical datum, units, survey type, alignment and stations surveyed.
 - .2 Provision of all Construction and Record Drawings as required.
 - .3 Furnishing the Departmental Representative with copies of all field notes, computations, any records relating to the layout of work or survey and any software required to interpret the data and records.
 - .4 Conversion of all data into a format that is acceptable to the Departmental Representative.
 - .5 Complete post construction surveys following completion of Work.
 - .6 Accuracy: Minimum accuracy of +/- 30 mm in vertical measurements and +/- 300 mm in horizontal measurements.
 - .7 The Contractor shall retain the services of an appropriately licensed Surveyor necessary for the proper construction and documentation of the Work. All survey-related work products shall be sealed and signed by an appropriately licensed Surveyor.
 - .8 For all surveys, the Contractor shall use and report data in the coordinate system and datum referenced on the Construction Drawings.

3.7 SURFACE
FINISHING

- .1 The surface of the compacted clay liner shall be trimmed to the design grades as shown on the drawings. The surface of the soil shall be rolled with a smooth-drum roller to form a smooth surface to within the tolerance of plus 20 mm and minus 0 mm. The visual final surface shall be cleared of any stones or objects which any dimensions is larger than or equal to 10 mm. The installation of the geomembrane on top of the completed and accepted clay liner shall be completed as soon as practicable.

3.8 REPAIR OF CLAY
LINER

- .1 Holes made in the liner by the Departmental Representative to perform test or quality assurance to collect samples for testing shall be repaired by the Contractor with the area over-excavated in a stepwise fashion as necessary so the affected area is repaired in lifts in a stepwise fashion with good bonding between lifts and with the existing liners. All repair lifts shall be completed and tested in accordance with the Specifications. The Departmental Representative shall be present and keep a complete record of such repairs.
- .2 All small holes formed after measurement by the nuclear densitometer for quality assurance purposes shall be filled with granulated bentonite by the individual performing the testing, observed by the Departmental Representative.

3.9 MAINTENANCE

- .1 The Contractor shall carry out procedures to prevent damage and measures to protect the completed work including but not limited to the effect of adverse weather, desiccation, freezing, vehicular traffic, rodents, and differential settlement.

3.10 TESTING AND
INSPECTION

- .1 In the development of the Construction Quality Control Plan, the Contractor shall include as a minimum testing of Percent Fines, Percent Gravel, Liquid and Plastic Limits, and Laboratory Compaction Curve at minimum frequency stated in Table 2 - Compacted Clay Liner Properties, attached to this section.

3.10 TESTING AND
INSPECTION
(Cont'd)

- .2 In the development of the Construction Quality Assurance Plan, the Departmental Representative shall include as a minimum testing of Field Compaction, Water Contents, Laboratory Hydraulic Conductivity, and Field Hydraulic Conductivity at minimum frequency stated in Table 2 - Compacted Clay Liner Properties.
- .3 The Contractor and Departmental Representative shall include additional tests that are appropriate. The Departmental Representative may change the minimum testing frequency according to variability and characteristics of the liner soil.
- .4 Full time inspection of clay liner construction will be carried out by the Departmental Representative. Daily inspections to include as a minimum:
 - .1 Source excavation, loading and hauling.
 - .2 Soil conditioning.
 - .3 Loose and compacted lift thickness.
 - .4 Effects of equipment on the soil surface.
 - .5 Bonding between lifts.
 - .6 Number of passes required for compaction.
 - .7 In-situ density and water content of compacted soil.

3.11 INSTALLATION
OF ELECTRICAL
CONDUCTIVITY
MEASUREMENT SYSTEM

- .1 The electrical conductivity sensors shall be installed after completion of the compacted clay liner at that location.
- .2 A small pit with non-vertical slope shall be excavated to a depth and size that are just sufficient to install the sensors. The Contractor may propose alternative method of installation of the electrodes for approval by the Departmental Representative.
- .3 Each array of four electrodes shall be inserted horizontally into the sidewall of the trench such that the horizontal spacing is 50 mm. Before the installation of the electrodes in the liner, the Contractor shall demonstrate on site for approval by the Departmental Representative a method of insertion of the electrodes that ensure that the electrodes are in the correct position and making good contact with the soil.

3.11 INSTALLATION
OF ELECTRICAL
CONDUCTIVITY
MEASUREMENT SYSTEM
(Cont'd)

- .4 The cable of the sensor wires shall be placed on top of the clay liner without tension and folding. The cable shall be protected before and during the placement of the geomembrane on top without damage to and creation of tension and folding in the cable. The end of the cables at the perimeter of the mound shall be protected using a weatherproof enclosure. All wire leads are to be clearly and uniquely identified.
- .5 The excavated pit for the installation of the sensor shall be repaired in small lifts that is consistent with the compaction equipment used to ensure that each lift is well compacted and remolded and good bonding is achieved between lifts and between the sloping face of the pit and the new lifts. The compacted in-situ density and water content of the repair shall also be checked by the Departmental Representative.
- .6 Work to be completed above the sensors and cabling shall follow methods of construction that will not damage the instrumentation.
- .7 The Contractor shall demonstrate to the Departmental Representative that the system is working properly before and after installation of the work above the sensor system. All repair and associated work shall be made by the Contractor without extra time or cost.
- .8 Operation of the system shall be demonstrated to the Departmental Representative monitoring staff. Training shall be provided to ensure that the staff can use and maintain the system properly.