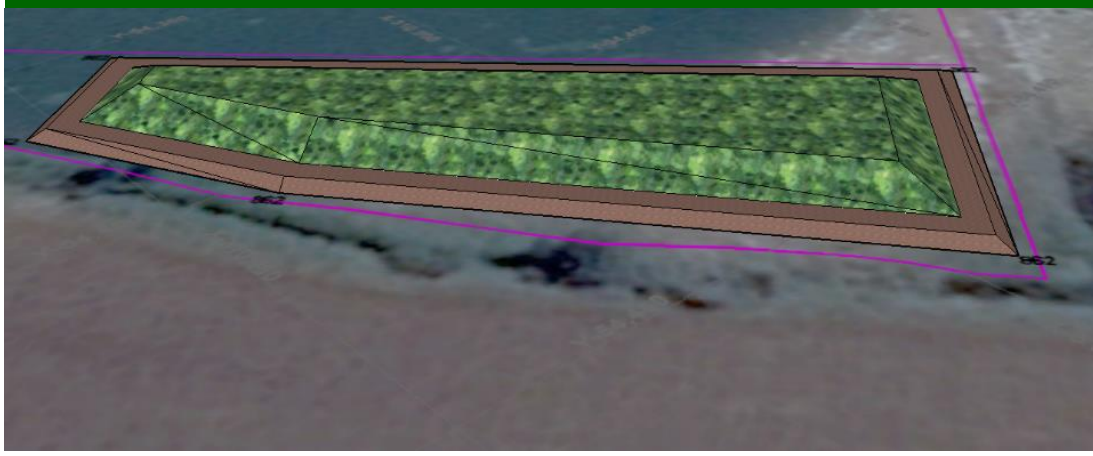
Engineering Design Report
Mansoura Dump Site Remediation



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WHERE HOPE FINDS A WAY

ENGINEERING DESIGN REPORT
MANSOURA DUMP SITE REMEDIATION

Table of Contents

Appendix

Drawings

ENGINEERING DESIGN REPORT MANSOURA DUMP SITE REMEDIATION

INTRODUCTION

A topographic survey was conducted on the Mansoura dump site on October 24, 2018 (one year ago). The topographic survey, in conjunction with trial pits excavated through the waste allowed the estimation of the waste volume in the dump site at the time. The dump site was found to cover an area of about 5,265 m^2. Based on 18 trial pits excavated, waste thickness varied between 20 and 120 cm. The volume of waste in the Mansoura dump site was estimated at 7,000 m^3 using the slice method where the area of each 0.5m to 1m contour line was measured in Autocad and the trapezoidal volume between each slice was calculated.

Figure 1: Mansoura topographic map

Assuming that 3.2 tons of waste were received daily for one year since the topographic survey was conducted and assuming a density of 0.8 Ton/m^3 in the dump site, the additional volume of waste deposited since the last topographic survey is estimated to be in the order of 1,460 m^3, leading to about 8,500 m^3 of waste at the time of closure. This value is an estimate as it does not take into consideration any increase in daily waste deposited if any, any burning of the waste on-site over the past year or different waste densities.

The remediation of the site as discussed between ANERA, the MoE and the Mansoura Municipality will consist in excavating the waste, stockpiling it temporarily, installing a base liner system, placing the waste over the liner, capping the waste and providing topsoil for light vegetation growth. Based on the relatively limited volume of waste present on-site, a removal of the waste to an engineered landfill would have resulted in zero residual impact on-site.

In order to complete the agreed upon remedial activities with minimal disruption to nearby sites, the following sequence will be implemented:

- Excavation and stockpile of a portion of the waste from Zone A to Zone B
- Excavation of soil in Zone A to reach suitable subgrade level
- Placement and compaction of engineering fill for the base and the perimeter berm for Zone A
- Deployment of synthetic base liner system in Zone A
- Moving the waste from Zone B over the newly lined area overfilling temporarily the area to contain all the waste
- Re-diminishing of Zone B in view of actual quantities to be put in the engineered Cell; i.e. if the waste quantities are less than estimated, zone B will be shortened or otherwise extended to accommodate the entire waste quantities
- Earthworks and basal liner system for Zone B
- Moving back a portion of the waste from Zone A to Zone B
- Capping system
- Topsoil and revegetation
- Fencing
- Monitoring and aftercare

Access to various parts of the site should be provided in order to allow for all site activities to be conducted. This may be a challenge as the site is relatively small and narrow. The following is a schematic of the way the site will be remediated.

The project will include aftercare and environmental monitoring for a period of time.

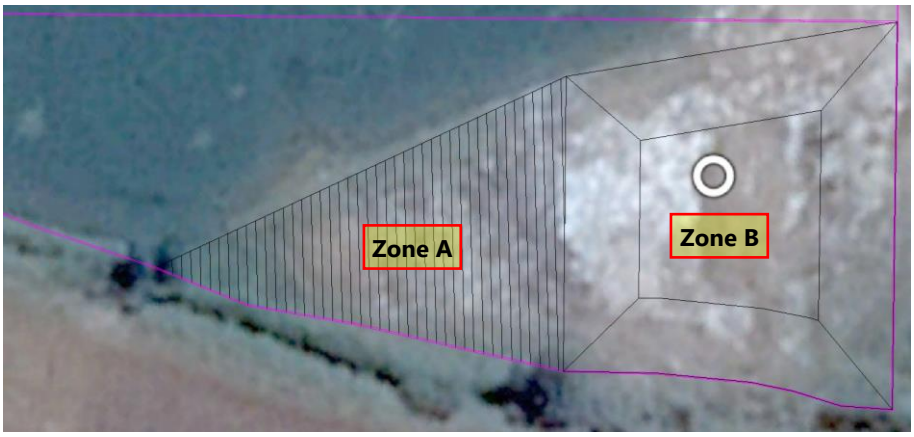

Figure 2: Excavation of western portion of the waste (Zone A) and stockpile over existing waste in the east (Zone B)

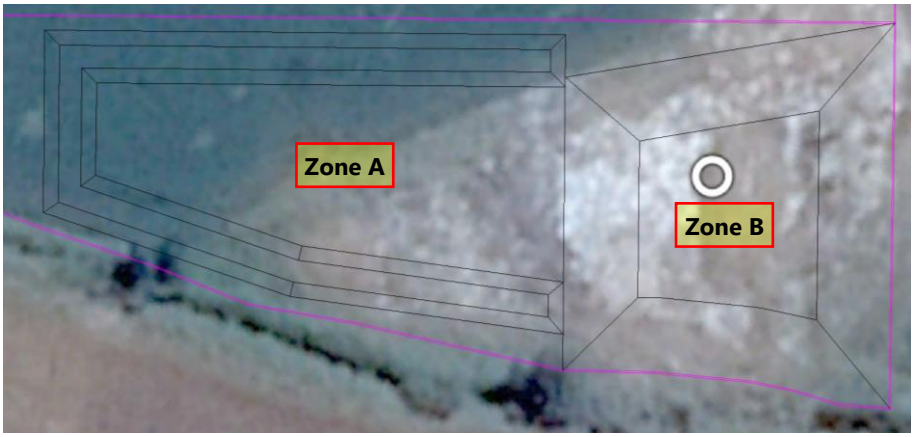

Figure 3: Construction of the outer berm and installation of the basal liner in Zone A

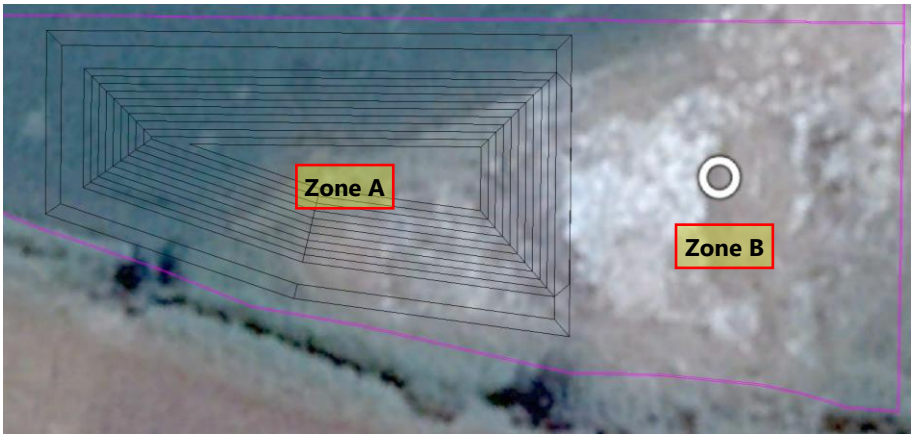

Figure 4: Placement of all the waste temporarily over the lined Zone A

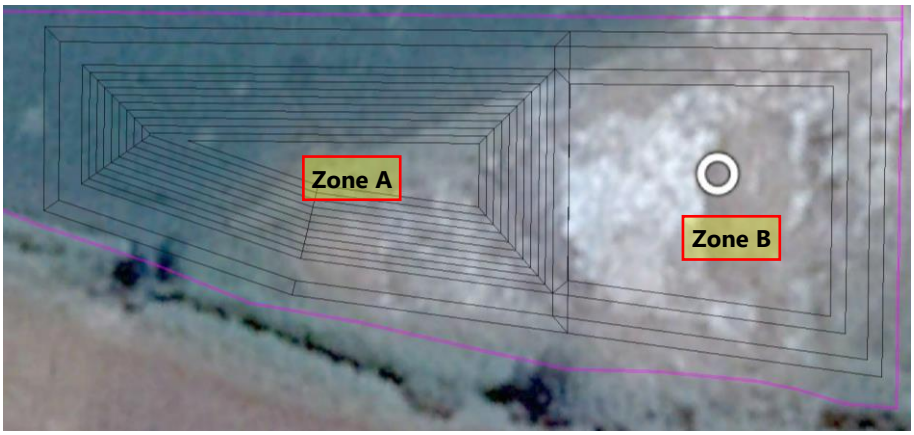

Figure 5: Construction of the outer berm and installation of the basal liner in Zone B

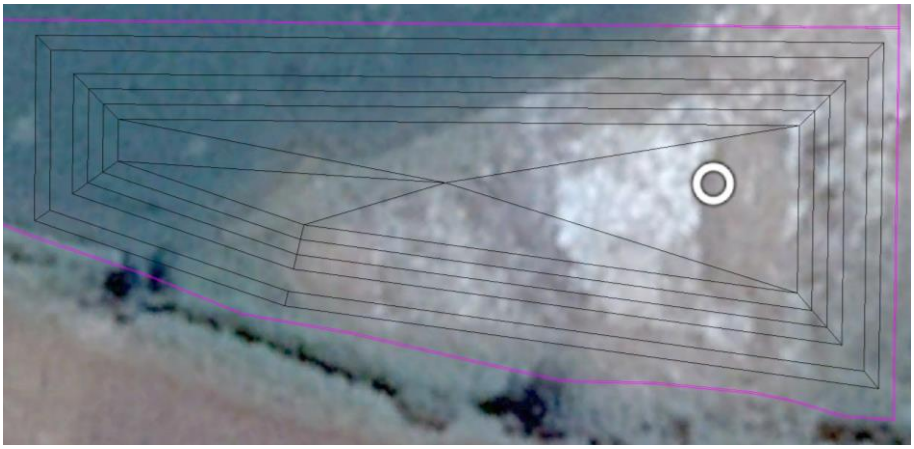

Figure 6: Moving back to Zone B the overfill placed in Zone A and capping the entire site

1 DESIGN AND SPECIFICATIONS

1.1 GEOMETRY

The berm surrounding the Zone A cell s bound by the following coordinate points:

X	Y
-310,889	-54,,407
-310,937	-54,355
-310,954	-54,372
-310,940	-54,404
-310,918	-54,434

The berm surrounding the Zone A cell is bound by the following coordinate points:

X	Y
-310,889	-54,,407
-310,860	-54,437
310,894	-54,468
-310,918	-54,434

A perimeter dike will be built around the cell. The height of this dike will be 1m. Assuming a clean subgrade is found at elevation 862m above sea level (ASL), then the top of the dike will be at 863m. The side slopes of the dike will be approximately 2H to 1V. The crest of the dike will be 3m wide in order to receive the base liner and cap liner anchor trench.

Excavated waste will be placed and compacted at a slope of 2:1 to reach a top plateau at 3m above the perimeter dike level or 866m with a surface water management dome of 1m culminating at 867m. Actual levels will depend on actual volumes of waste.

1.2 ENGINEERING FILL

Engineering fill may be require to adjust the level of the base of the landfill if it is found to be more than 1m below the road level leading to the site, in case the subgrade is found to be below groundwater level or of poor structural conditions. Engineering fill will also be used for the perimeter dike.

Engineering fill will have a minimum of 25 percent by weigh passing No. 200 sieve and will be free from organic matter, or other deleterious substances as determined by the Engineer. The fill material will not contain rocks or lumps over 15 cm in largest dimensions and not more than 10 percent larger than 5 cm. The fill will be placed in 25 cm thick loose lifts and compacted to 95 percent Standard Proctor maximum dry density (ASTM 698). The finished surface shall be smooth and free from sharp objects, roots, stone, and any other unsuitable or foreign material. The subgrade material upon which the liner will be installed will consist of a minimum 15 cm layer of engineering fill material compacted to 95 percent of Standard Proctor maximum dry density.

A small temporary berm will have to be constructed around the waste stockpiled in Zone B in order to prevent the migration of leachate outside the stockpiles area and to prevent the ingress of clean surface water within the waste stockpile.

Prior to installing the liner system and after removal of the waste, the subgrade area will be inspected in order to ensure that it is clear of vegetation, roots, rubbish, and any other matter that could either interfere with proper placement and compaction of fill materials, hinder proper subgrade preparation, or provide inadequate support for the foundation of the cell.

Viable topsoil outside the existing footprint of the dump site (but within the limit of the area to be landfilled) will be stripped and stockpiled.

1.3 GRADES AND ELEVATIONS

The final levels of the perimeter dike and base of the landfill will depend on the nature of the subgrade encountered after removal of the waste and the need to place layers of engineering fill. The general geometry of the landfill site will remain the same even if the actual levels may vary a bit because of required site adjustments. The base of the cell will be sloped to a low point where the leachate extraction system will be installed. Base slope shall be in the order of 1 to 2%.

As part of the Quality Assurance and Quality Control (QA/QC), the subbase elevations will have to be approved by the Engineer prior to liner deployment.

1.4 LINER SYSTEM

The liner system will comprise from bottom to top:

- A regulating engineering fill layer.
- A 350 g/m^2 geotextile layer to protect the HDPE geomembrane
- A 2mm HDPE geomembrane.
- A geocomposite drainage geonet with two geotextile heat laminated.
- A first layer of waste with minimal protruding waste.

1.4.1 GEOTEXTILE

The geotextile material proposed for use would be manufactured from polypropylene or polyethylene fibers chemically resistant to the landfill environment.

A non-woven geotextile of 350 g/m^2 will be placed above the prepared subgrade. The purpose of this geotextile is to protect the HDPE geomembrane from any protrusion in the subgrade. The lower geotextile layer would be installed on a smooth compacted subgrade surface that would be made free from roots, stones, standing water, or desiccation cracks.

If the drainage net is supplied without geotextile, then the geotextiles to be used below or above the drainage net shall conform to the specifications of the geotextile presented in this section.

Prior to installment of geotextile material, a method statement should be issued detailing installation procedures, including the method of holding it in place and joining adjacent rolls. In general and in accordance with accepted good practice, the rolls would be arranged so that whenever practicable, the seams are aligned parallel to the line of maximum slopes (i.e. normal to contours). All geotextile overlaps should be of 150mm between adjacent panels. Adjacent geotextile rolls shall be welded using low temperature devices.

All geotextile products shall be subject to approval based on independent conformance testing provided by the manufacturer. The monitoring program should include inspection of all geotextile Quality Control Certificates provided by the Manufacturer.

Delivery and handling of material should be conducted in accordance with manufacturer's recommendations. At a minimum, the material shall be stored on a flat surface free from stones and debris.

Upon delivery, the manufacturer or supplier shall provide the following information for each material delivered to site:

- Product name and grade designation;
- Name and address of supplier;
- Batch or code number and delivery date;
- Composition and type of major material constituents;
- Method of manufacturing;

The specification values for the geotextile are included in the following table.

Table 1: Geotextile specifications

PROPOSED SPECIFICATIONS	PROPOSED VALUE
Mass per Unit Area	350 g/m^2
Minimum Thickness under 2kPa	3.6 mm
Minimum Thickness under 200kPa	2.3 mm
Minimum CBR Puncture Resistance	715 N
Maximum CBR Puncture Displacement	60 mm
Maximum Cone Drop Perforation Hole Diameter	6 mm
Minimum Tensile Strength MD & TD	15 kN/m

1.4.2 HDPE GEOMEMBRANE

The High Density Polyethylene (HDPE) shall be 2mm thick. The HDPE should be produced from new resins and contain no plasticisers or additives with the exception of carbon black content.

Prior to the commencement of geomembrane installation, a drawing sketch would be issued showing the proposed panel layout and direction of deployment. The HDPE seaming would be aligned using the same criteria as that of the geotextile, with the seams aligned parallel to the line of maximum slope. Welding activities would incorporate fusion or extrusion welding techniques using approved equipment at specified speed and temperatures.

All geomembrane products shall be subject to approval based on independent conformance testing provided by the manufacturer. The monitoring program should include inspection of all geomembrane Quality Control Certificates provided by the Manufacturer.

Delivery and handling of material should be conducted in accordance with manufacturer's recommendations. At a minimum, the material shall be stored on a flat surface free from stones and debris. Upon delivery, the manufacturer or supplier shall provide the following information for each material delivered to site:

- Product name, type, length, and thickness;
- Name and address of supplier;
- Batch or code number and delivery date;
- Composition and type of major material constituents;
- Date and method of manufacturing;

The liner installer shall have extensive experience of installing specified type of material. All trial and field seaming shall conform to the methods detailed in the EPA Technical Guidance Document 'The Fabrication of Polyethylene FML Field Seams' (EPA/530/SW-89/069). Sampling and testing program shall include non-destructive, qualitative, and quantitative tests; details of which should form part of the final design stages.

Table 2: HDPE Geomembrane Specifications

PROPOSED SPECIFICATIONS	PROPOSED VALUE
Thickness *– (mm)*	2.0mm +/- 10%
Carbon Black Content – (%)	>2.0% by mass
Carbon Black Dispersion	A1, A2, or B1
Density – (Kg/m^3)	$940Kg/m^3$ +/- 1%
Tensile Properties (testing in Longitudinal & Transverse Directions)	
Stress @ yield – (N/mm^2)	> $14N/mm^2$
Stress @ break – (N/mm^2)	> $14N/mm^2$
Elongation @ yield – (%)	> 13%
Elongation @ break – (%)	> 100%
Puncture Resistance *– (N)*	210N
Melt Flow Index – (g/10min)	0.1 – 1.0g/10 min
NCTL ESCR – (Hours)	> 200 hrs.
Oxidative Induction Time - (Minutes)	> 100 min

1.4.3 DRAINAGE NET

The drainage net will ensure flow of leachate at the base of the landfill cell. It will be used as a gas collection layer under the cap and as a surface water diversion media reducing the head on the cap liner.

The drainage net as part of the base liner system shall be covered by a geotextile layer meeting the same specifications as the ones presented in Section 2.4.1.

Overlap of drainage nets shall also be 15cm. Ties to connect adjacent drainage nets shall be made of plastic and not metal.

All drainage net products shall be subject to approval based on independent conformance testing provided by the manufacturer. The monitoring program should include inspection of all drainage net Quality Control Certificates provided by the Manufacturer.

Delivery and handling of material should be conducted in accordance with manufacturer's recommendations. At a minimum, the material shall be stored on a flat surface free from stones and debris.

Table 3: Drainage Net Specifications

PROPOSED SPECIFICATIONS	PROPOSED VALUE
Geo-composite	
Thickness under 2kPa	4.5mm
In-plane Flow Capacity Under 20kPa with (i=1)	0,62 l/m.s MD
Tensile Strength)	18 kN/m MD
	16 kN/m TD
Mass per Unit Area	640 g/m2
Filter Geotextile both sides	120 g/m2
CBR Puncture Resistance	1,4 kN
Opening Size O_{80}	90 µm

1.5 FINAL COVER

Final cover at the landfill has been designed to minimize the ingress of rainfall into the landfill after closure. Provision of gas extraction is incorporated in the cap design as well as diversion of surface water runoff. In addition, a soil cover is also provided in order to enhance vegetation growth and improve the visual aspect of the landfill and to control erosion. Final vegetation should be native to the locality where possible and not have the potential to interfere with any cover system.

The final cover has been designed with reasonable slopes to drain surface water while not causing erosion issues. The length of the cap is limited and should therefore not cause major concerns in terms of erosion.

Parts of the cap could be progressively installed if final levels are reached. Any area that has been filled to the required maximum filling height will receive the permanent capping material. This would allow completed areas to be capped quickly, thus minimizing the potential for water infiltration and subsequent leachate generation.

The final capping system would comprise from bottom to top:

- A regulating layer of waste with minimal protrusion. Compaction shall be applied before installing the system
- A gas collection layer consisting of a drainage net transferring the landfill gas to the nearest gas well. A geocomposite drainage geonet with two geotextile heat laminated.
- A 1mm VFPE geomembrane.

- A surface water drainage layer. A geocomposite drainage geonet with two geotextile heat laminated.
- 500mm of topsoil.

The specifications of the geotextiles and the drainage net used as part of the cap shall be the same as the ones presented for the base liner to be installed with the same controls and CQA procedures as described for the basal lining system.

1.5.1 VFPE GEOMEMBRANE

The Very Flexible Polyethylene (VFPE) shall be 1 mm thick. The VFPE should be produced from new resins and contain no plasticisers or additives with the exception of carbon black content.

Prior to the commencement of geomembrane installation, a drawing sketch would be issued showing the proposed panel layout and direction of deployment. The VPPE seaming would be aligned using the same criteria as that of the geotextile, with the seams aligned parallel to the line of maximum slope. Welding activities would incorporate fusion or extrusion welding techniques using approved equipment at specified speed and temperatures.

All geomembrane products shall be subject to approval based on independent conformance testing provided by the manufacturer. The monitoring program should include inspection of all geomembrane Quality Control Certificates provided by the Manufacturer.

Delivery and handling of material should be conducted in accordance with manufacturer's recommendations. At a minimum, the material shall be stored on a flat surface free from stones and debris. Upon delivery, the manufacturer or supplier shall provide the following information for each material delivered to site:

- Product name, type, length, and thickness;
- Name and address of supplier;
- Batch or code number and delivery date;
- Composition and type of major material constituents;
- Date and method of manufacturing;

The cap liner installer shall have extensive experience of installing specified type of material. All trial and field seaming shall conform to the methods detailed in the EPA Technical Guidance Document 'The Fabrication of Polyethylene FML Field Seams' (EPA/530/SW-89/069). Sampling and testing program shall include non-destructive, qualitative, and quantitative tests; details of which should form part of the final design stages.

Table 4: VFPE Geomembrane Specifications

PROPOSED SPECIFICATIONS	PROPOSED VALUE
Thickness – *(mm)*	1.0mm +/- 10%
Carbon Black Content – (%)	2 to 3% by Mass
Carbon Black Dispersion	A1, A2, or B1
Density – (Kg/m^3)	920 Kg/m^3
Tensile Properties (Uniaxial) Strength @ break – (N/mm^2) Elongation @ break – (%)	 > 13 N/mm^2 >300%
Multiaxial Properties Strain – (%) Strength (N/mm^2)	 > 90% > 13 N/mm^2
Puncture Resistance – *(N)*	240 N
Melt Flow Index – (g/10min)	0.1 – 1.1 g/10min
NCTL ESCR – (Hours)	> 400 hrs.

Note: Tensile testing to be performed in Longitudinal & Transverse Directions

1.6 WELLS

HDPE pipes shall be used to extract collected leachate and to collect landfill gas. Pipes shall be 100mm PN16 HDPE perforated pipes.

The leachate pipe will have a 300x300mm HDPE plate affixed at its end in order to prevent puncture of the liner system. An extra geonet layer will be placed at the base of the leachate pipe in order to further dissipate the vertical pressure from the well.

Gas wells will be installed 50cm above the level of the liner they will have a cap at their base. The last meter of the gas well shall not be perforated in order to prevent the ingress of outside air into the well.

All wells shall be surrounded by 50 to 60cm fine gravel to create a depression for gas and leachate collection.

Wells shall be equipped with removable caps at the end. Plywood wooden boxes shall be manufactured to cover the wells properly.

The constructed Cell shall be enclosed with a fence that includes a small gate.

2 BILL OF QUANTITIES

The quantities estimated for the remediation of this project are presented in the following table. These quantities are estimates and are subject to changes based on site conditions encountered at the time of execution of the project. Although quantities are provided, it is recommended to award the project based on a remeasurable contract.

Quantities are net quantities not including overlap for geomembrane, geotextile and drainage nets and do not include areas in anchor trenches.

	Item	Quantities	Unit of Measure
Waste movement			
	Excavate waste from Zone A and stockpile over Zone B Waste	4,000	m^3
	Excavate waste from Zone B and stockpile over the lined area in Zone A	4,000	m^3
	Excavate excess waste from Zone A and place over lined area of Zone B	4,000	m^3
	Excavate waste outside the site and place over the lined areas (Zone A or B)	500	m^3
Earthworks			
	Place and Compact **in stages** base regulating layer (assumed 50 cm thick over entire site)	2,100	m^3
	Build Perimeter Dike **in stages** with engineering fill	1,300	m^3
Base Liner			
	350 g/m^2 geotextile	2,800	m^2
	2mm HDPE geomembrane	2,800	m^2
	Drainage net	2,800	m^2
	350 g/m^2 geotextile	2,800	m^2
Cap			
	350 g/m^2 geotextile	3,000	m^2
	Drainage net	3,000	m^2
	1mm VFPE geomembrane	3,000	m^2
	350 g/m^2 geotextile	3,000	m^2
	Topsoil	900	m^3
Wells			
	Gas wells	10	m

	Leachate well	5	m
Fence			
	Fence with small gate (Dimensions and specs to be set by Contractor before implementation		

3 Contractor Deliverables

3.1 PRE-IMPLEMENTATION

Detailed schedule of implementation with dates and quantities
Material datasheets and specs to be approved by Anera
List of Equipment and staff working in the project

3.2 DURING IMPLEMENTATION

Prepare and fill inspection forms at each phase of the project implementation

3.3 POST-IMPLEMENTATION

Factual Report that includes as-builts drawings, the material data sheets and specs, signed inspections forms and other data that is relevant to the project

Softcopy of all required pertinent deliverables is required.