Accra Metropolitan Assembly

Second Urban Environmental Sanitation Project

DESIGN REPORT

REHABILITATION, CLOSURE, BID EVALUATION, CONSTRUCTION SUPERVISION AND CONTRACT MANAGEMENT OF THE OBLOGO No. 1 AND MALLAM SCC 2 DUMPSITES IN ACCRA

WASTECARE

CONSULTANT (LUKMAN Y. SALIFU)
WASTECARE ASSOCIATES
P. O. Box LG 486, Legon – Accra
Tel: 233-30-2786072
FAX: 233-30-2786072
Website: www.wcghana.com
E-mail: info@wcghana.com

CLIENT
ACCRA METROPOLITAN ASSEMBLY
UESP II
P.O. Box 385
ACCRA - GHANA

JANUARY 2012

ACCRA METROPOLITAN ASSEMBLY

REHABILITATION AND CLOSURE OF OBLOGO No. 1 AND MALLAM (2) SCC REFUSE DISPOSAL SITES

DRAFT FINAL DESIGN REPORT

TABLE OF CONTENTS

List of Figures

List of Tables

List of Plates

1. INTRODUCTION

1.1 PROJECT BACKGROUND

1. The Accra metropolitan area has faced serious challenges for locating and developing engineered landfills for over two decades. Rapid urbanization of the Accra has led to the contiguous growth of the city and its adjoining areas which makes the location of solid waste disposal facilities difficult. The City Authority in a bid to overcome the problem of open-dumping operations at un-approved sites acquired land in …at Kwabenya for the development of an engineered landfill site. As typical of residents' opposition to the sitting of disposal facilities within their backyards, the Kwabenya Landfill development project has remained on the drawing board despite the sinking of close to $2 million dollars in preparatory works including macadam roads to the proposed site.
2. While the city authority (Accra Metropolitan Assembly, AMA) was anxiously pursuing and anticipating resolution of challenges surrounding development of the new landfill site, it has to frantically locate land for disposal operations in order to continuously deal with the increasing waste flows to protect public health and assuage residents complaints of uncollected refuse especially from low-income communities that depend on communal container systems.
3. AMA therefore resorted to controlled open-dumping operations at a number of sites. The sitting of such refuse dumps, often, do not follow any planning considerations and lead to foul smells and flies in the rainy season, continuous smoke from smoldering fires, and a pollution of nearby water bodies. These malodorous effects and adverse impacts contribute to the vehement complaints of communities near such disposal sites and often the entrenched resistance of residents near locations proposed for treatment and disposal sites of any kind – the "NIMBY" effect.
4. The Mallam SCC dumpsite was opened in October 2001. The site is an abandoned quarry operated in the late 1970's and 80's by the now defunct State Construction Corporation (SCC) hence the name. It served as a temporary relief site to the older Mallam No.1 dump site which had operated as the main disposal site for the Accra metropolis from July 1991 to September 2001. The Mallam SCC site covers an area of approximately 0.65 hectares and is approximately 15 kilometres from the Central Business District (CBD) of Accra. Currently, no waste is dumped at the Mallam SCC dumpsite although there is some residual capacity to be filled due to settlement and subsidence of the waste-fill as decomposition is taking place. However, the rapid generation of leachate during the early stage of methanogenesis requires urgent remedy.
5. The Oblogo No.1 dumpsite was opened in the year January 2002 and was until November 2008 the main waste disposal site for the Accra Metropolis. The Oblogo site covers an area of approximately 3.2 acres and is approximately 17 kilometers from the CBD area of Accra. The daily tonnage of waste received at the Mallam SCC and Oblogo disposal sites was approximately 500.and 1,500 tonnes respectively, including industrial waste.
6. The Mallam No.1 and 2 dumpsites was until the end of …… the main waste disposal site for the Accra Metropolis. The Mallam No.1 covers an approximate area of 10.8 acres while the Mallam No.2 covers an approximate area of 10.6 acres.

7. In July 2011, at the peak of the rainy season the flow of leachate from the two sites above increased substantially and attracted the attention of Ghana's legislature. The Parliamentary Committee on Environment and Social Services visited both sites in early August (see Photo Plate No. …) and expressed grave concerns about the situation.

8. The AMA in mid-August engaged the services of a consultant to study options for rehabilitation and closure of the dump sites including putting in place an effective after-care management particularly for the management of leachate.

9. The Consultant's team visited the four (4) dump sites within the general area – Oblogo No.1 and 2, Mallam SCC and Mallam No.1 and 2 in mid-August - as part of reconnaissance and characterization. The visit was undertaken with the AMA-Waste Management Department (Landfill Operations Manager and Environmental …).

10. The initial, site visits and characterisations, leachate sampling and topographical surveys, review of existing reports and discussions with AMA-WMD staff fed into the preparation of an Inception Report submitted to AMA. This detailed design report presents further work based on comments on the Inception Report received from the AMA, further desk reviews of reports, technical evaluation of the site conditions and field visits.

11. The design and accompanying reports reflect the Consultants appreciation of the ToRs and AMAs desire to urgently implement remedial actions to the issue of leachate and other adverse impacts at the Oblogo No.1 and Mallam SCC sites.

1.2 Objectives of Assignment

12. From the ToRs and discussions with AMA the objectives of the assignment comprise the following:
    i. Review the existing state of the Mallam SCC dumpsite and prepare all necessary documentations for its rehabilitation and decommissioning,
    ii. Review the existing situation of the Oblogo No.1 dumpsite and prepare all necessary documentations for its closure, rehabilitation and decommissioning;
    iii. Review the existing situation of the Mallam No.1&2 dumpsite and prepare all necessary documentations for its closure, rehabilitation and decommissioning; and
    iv. Supervise the rehabilitation of the two dumpsites.

13. While the ToRs was silent on what standards to apply to meet prevailing regulations, the Consultant developed the designs and rehabilitation plans to meet minimum measures for closure, decommissioning and safe after-care management according to Ghana Landfill Guidelines (2002).

1.3 Scope of Assignment

14. The scope of the Consultant's assignment as presented in the TORs is reproduced below. The Consultant's services are limited to the Oblogo No.1, Mallam SCC and Mallam No.1 & 2 dumpsites.

15. The services shall be carried out in two Phases. Phase I will cover objectives (i) and (ii) with Phase II covering objective (iii):

Phase I

16. The services to be provided under this phase include:

Mallam SCC Dumpsite

a. Determine the sources and quantities of cover material for the rehabilitation and capping of the Mallam SCC dumpsite.
b. Determine whether there is leachate contamination of the groundwater and /or surface water and propose methods of eliminating or reducing the effect of leachate on the surface and ground water after closure of the dumpsite.
c. Prepare a decommissioning, aftercare and after use plan for the Mallam dumpsite.
d. Determine the cost of capping, decommissioning and providing aftercare for the dumpsite.
e. Prepare all necessary drawings and bid documents for the rehabilitation of the dumpsite.

Oblogo No. 1 Dumpsite

a. Determine the sources and quantities of cover material for the rehabilitation and capping of the Oblogo No. 1dumpsite.
b. Determine the leachate quantities generated from the dumpsite and provide for its collection and treatment.
c. Investigate the existing condition of the groundwater and surface water bodies in the vicinity of the dumpsite (baseline data) and determine whether these waters have been contaminated by the presence of the dumpsite.
d. Prepare a decommissioning plan, an aftercare and after use plan for the dumpsite.
e. Determine the cost of capping, decommissioning and providing aftercare for the dumpsite.
f. Prepare all necessary drawings and bid documents for the rehabilitation of the dumpsite.

Mallam No. 1 & 2 Dumpsite

g. Determine the sources and quantities of cover material for the rehabilitation and capping of the Mallam No. 1&2 dumpsite.
h. Determine the leachate quantities generated from the Mallam No.1 dumpsite and provide for its collection and treatment.
i. Investigate the existing condition of the groundwater and surface water bodies in the vicinity of the dumpsite (baseline data) and determine whether these waters have been contaminated by the presence of the dumpsite.
j. Prepare a decommissioning plan, an aftercare and after use plan for the dumpsite.
k. Determine the cost of capping, decommissioning and providing aftercare for the dumpsite.

Prepare all necessary drawings and bid documents for the rehabilitation of the dumpsite.

Phase II

17. The services to be provided under this Phase are as follows:

Evaluation of Bids and Preparation of Contract Documents

18. The consultant shall prepare an evaluation report for bids received. On confirmation of contract award, the consultant shall prepare the necessary contract documents.

Supervision of Construction

19. The consultant shall execute continuous supervision of all works including the monitoring of work progress and adherence to specified work standards (quality control).

20. Specifically, these services will include, inter alia:

    a. Providing Contractors with the necessary data points and bench marks for setting out the works; and subsequently checking and approving the detailed setting out;
    b. Checking and approving the contractors' work plans and implementation for the most efficient and expeditious methods of carry out works;
    c. Issuing all necessary instruction to contractors and continuously supervising the work to ensure that they are carried out in accordance with the contract documents;
    d. Carrying out during the execution of the works; inspection of all working areas in installations;
    e. Checking and approving materials used and examining contracts' installations, accommodation, construction equipment and laboratories to ensure that these conform to agreed specifications and proposals;
    f. Checking and approving all working drawings prepared by contractors;
    g. Checking contractors' work measurements and certifying payment claims;
    h. Negotiating with contractors any contractually permissible changes in price or rate for which the need may arise and making recommendations on these to the client;
    i. Informing the client of any problem which arise or might arise in connection with civil work contracts and making recommendations for their solution;
    j. Evaluating all claims during the contract periods for additional for additional payments and time extensions submitted by contractors, and making recommendations on these to the client and;
    k. Assisting the client in any dispute during contract periods that may arise with contracts and giving all the elements on which the judgments are based.

Post Contract Services

During this phase, the Consultant shall perform the following:

a. Inspection of works prior to the expiry of the Contractor's 6 months maintenance period, preparation of a final deficiency list, if required, supervision of remedial works and recommendation to AMA as to the date of the Final Inspection of Works;
b. Carry out final inspection of the works together with representatives of the Accra Metropolitan Assembly, the Ministry of Local Government and Rural Development and the Contractor;
c. Preparation and issuance of Final Acceptance Certificate;
d. Preparation of Final Payment Certificate.

21. The main outputs of the two phases of the assignment as described in the ToRs correspond to typical works contracts of design and construction supervision.

Rehabilitation and closure of disposal sites (even not engineered as for the current case) goes beyond the usually applied defect liability period of 6 months.

22. Therefore, in order to afford value-for-money (VFM) to the client the rehabilitation, closure and aftercare management of the sites will correspond to "Improved Dumping (Mechanical)" or "Service Level 2" as stipulated in the Ghana Landfill Guidelines.

1.4 Available Information and Data on Oblogo No. 1, Mallam SCC And Mallam No.1 & 2 Sites

23. Due to the un-planned start-up of operations at the disposal sites there are no reports of site characterization prior to placement of refuse. Limited information on the Oblogo No1. Site comprising a topographical sheet of the Oblogo No.1 site prepared for site planning was made available by the AMA-WMD.

24. There are no records of initial trial-pitting to furnish information on the underlying rock and groundwater levels. The Consultant as part of initial field investigations carried out a topographical survey and a spot-heights map produced (Figure 1). Laboratory analysis of leachate samples collected from the two sites was also carried out. Rainfall data for the general Accra area from the Ghana Meteorological Agency (GMA) was used and summarised in Table 1.1.

25. In order to meet the requirements of the ToRs and also provide the AMA with a road-map that will lead to fast-track implementation of the rehabilitation and closure of the landfill, this report combines outputs of the initial site characterization, preliminary conceptual and detailed designs to meet Ghana Landfill Guidelines.

26. The rehabilitation, closure and after-care plan makes allowance for leachate monitoring of key parameters including ingress of leachate into groundwater by sinking of observation wells. The intent is to streamline the procedures for closure and after-care by following simple procedures that yet conform to the Ghana Landfill Guidelines, 2002(GLG, 2002)

2. DESCRIPTION OF THE SITES

2.1 LOCATION, SIZE AND ACCESS

27. The Mallam SCC and Oblogo No.1 disposal sites are both located in the Ga South District of the Greater Accra Region.

2.1.1 MALLAM SCC DISPOSAL SITE

28. The site, an abandoned quarry pit of the then State Construction Company (SCC) Limited covering an estimated area of 1.6 hectares (3.84 acres).

29. The site is located within in the high residential area in the heart of Malaam SCC near Mallam. It can be assessed by the partly tarred road that turns left about 400m from the main junction of the Malaam-Gbawe road. The same road runs in front on the huge Mallam dumpsite to the Mallam SCC site.

30. Untreated leachate from the site flows through rain created gullies along the front face and base of the refuse heap and continues through the roadside concrete U drains leading to a nearby stream outfall located northwest of the site. The outfall continues and runs across the main Malam-Cape coast highway to a final discharge point located southwards in a marshy area.

Plate 2-1: View of Oblogo-no.1 dumpsite

Plate 2-2: Collection well for leachate flowing fron-Oblogo No.1 dumpsite

Plate 2-4: closer shot of oblogo no.1 dumpsite showing high composition of polythene

Plate 2-3: growth of vegetation, oblogo no.1 dumpsite

2.1.2 OBLOGO NO.1 DISPOSAL SITE

31. The Oblogo No.1 disposal site covers an estimate area of 5.31 hectares (13.12 acres) and was in operation as the main dumpsite of the Accra Metropolis and peri-urban settlements for about 6 years (January 2002-November 2008).

32. The site is located about one (1) kilometre north of the Ga-South Municipal Assembly block near Weija Junction. It is assessed by the second branch road on the right of the Weija Junction-Oblogo main road. The road that leads to the site is un-tarred and run in front of the Oblogo No.2 refuse dumpsite.

33. The site was initially a quarry pit of the Ghana Stone Quarry Limited. Information gathered revealed that some initial work on closure/capping was started (from the western end of the site) by PW Construction Limited but was however abandoned due to lack of funds.

34. Dumping at a section of the northern portion of the site had to be restricted due to the presence of ECG pylons. Leachate from the refuse heap gradually seeps into an existing reinforced concrete sump built as part of the initial attempt to close the site.

35. From site observations, there was an initial plan to sink a submersible pump to re-circulate the leachate. Since this objective was not easily met, the sump has been broken at a point close to the base of the sump to let out leachate; hence the collected leachate flows out through adjoining earth gullies and the main roadside drains and culverts into the Densu River which is the final outfall.

Plate 2-6: view of mallam (2) scc dumpsite

Plate 2-5: flow of leachate from mallam (2) scc dumpsite

2.1.3 MALLAM NO.1& 2 DISPOSAL SITE

36. The Mallam No. 1 & 2 disposal site covers a total estimated area of 8.7 hectares (21.4 acres) with Mallam No.1 covering 4.3 hectares (10.6 acres) and Mallam No.2 covering 4.4 hectares (10.8 acres) and was in operation as the main dumpsite of the Accra Metropolis and peri-urban settlements for about a decade (July 1991-September 2001).

37. The site which spans a length of about one (1) kilometre is locate a few meters off the Mallam Junction-Gbawe Road. The road that leads to the site is un-tarred and run in front of the refuse dumpsite.

38. Untreated leachate from Mallam No.1 site flows through rain created gullies along the front face and base of the refuse heap and continues through the roadside concrete U drains leading to a nearby stream outfall located northwest of the site. The outfall continues and runs across the main Malam-Cape coast highway to a final discharge point located southwards in a marshy area.

39. The site reconnaissance visit revealed the springing up of illegal structures at the peripherals in some cases blocking assess to the site.

Plate 2-7: View of section of Mallam No.1 dumpsite showing leachate flow in the driest season of the year.

Plate 2-8: Structures springing up on main Mallam dumpsite

2.2 OWNERSHIP

40. The Mallam SCC site is originally Government acquired site for quarrying activities managed by the defunct State Construction Corporation (SCC). The Oblogo No.1 Site has been used as a disposal point since 2002 and also formed part of an old quarry.

41. According to available information furnished by AMA-WMD the land has been released to AMA for disposal operations based on agreement with the owners of the land and Chief of Oblogo.

42. The status of ownership of the sites and leave of entry and continued operation is important so as to take steps to avoid any un-official entry unto the site after rehabilitation and closure which can affect effective after-care and thence pose potential future risks from incompatible use of the site.

3. PRELIMINARY ANALYSES, FIELD INVESTIGATIONS AND AND ENGINEERING STUDIES

43. This section of the report lists the various studies and desk reviews including geotechnical, geophysical and geo-hydrological investigation, potential environmental impact assessments and the probable mitigation measures that ought to be considered for engineering designs will conform to applicable guidelines and regulations.

3.1 DESCRIPTION OF SPECIFIC STUDIES AND ANALYSES

44. The final closure plan, which would require EPA endorsement, addresses final cover design (including grading, permeability, drainage, filtering, vegetative support and vegetative cover), a leachate collection and re-circulation system, final landfill contours, landscaping, stormwater control, groundwater and surface water monitoring system, as well as site security. These items when sufficiently provided for will fulfill the Phase-1 requirements of the current assignment.

45. Since landfills typically settle from approximately 10%-30% of their original thickness, and landfill leachate and methane gas will possibly continue to be generated by a closed landfill for several years, the post-closure regulatory requirements often include monitoring and maintaining the capped landfill for a period of between 10 - 30 years. This period can be shortened when the installed remedial system (as in this case) can be demonstrated to safeguard public health and the environment within the first 5 years of installation.

46. Due to the lack of information prior to the commencement of placement of refuse at the sites and limited ex-post site investigations, the aftercare management of the site should be given careful consideration. A minimum of 7 years of initial close monitoring is recommended for the 2 sites under consideration.

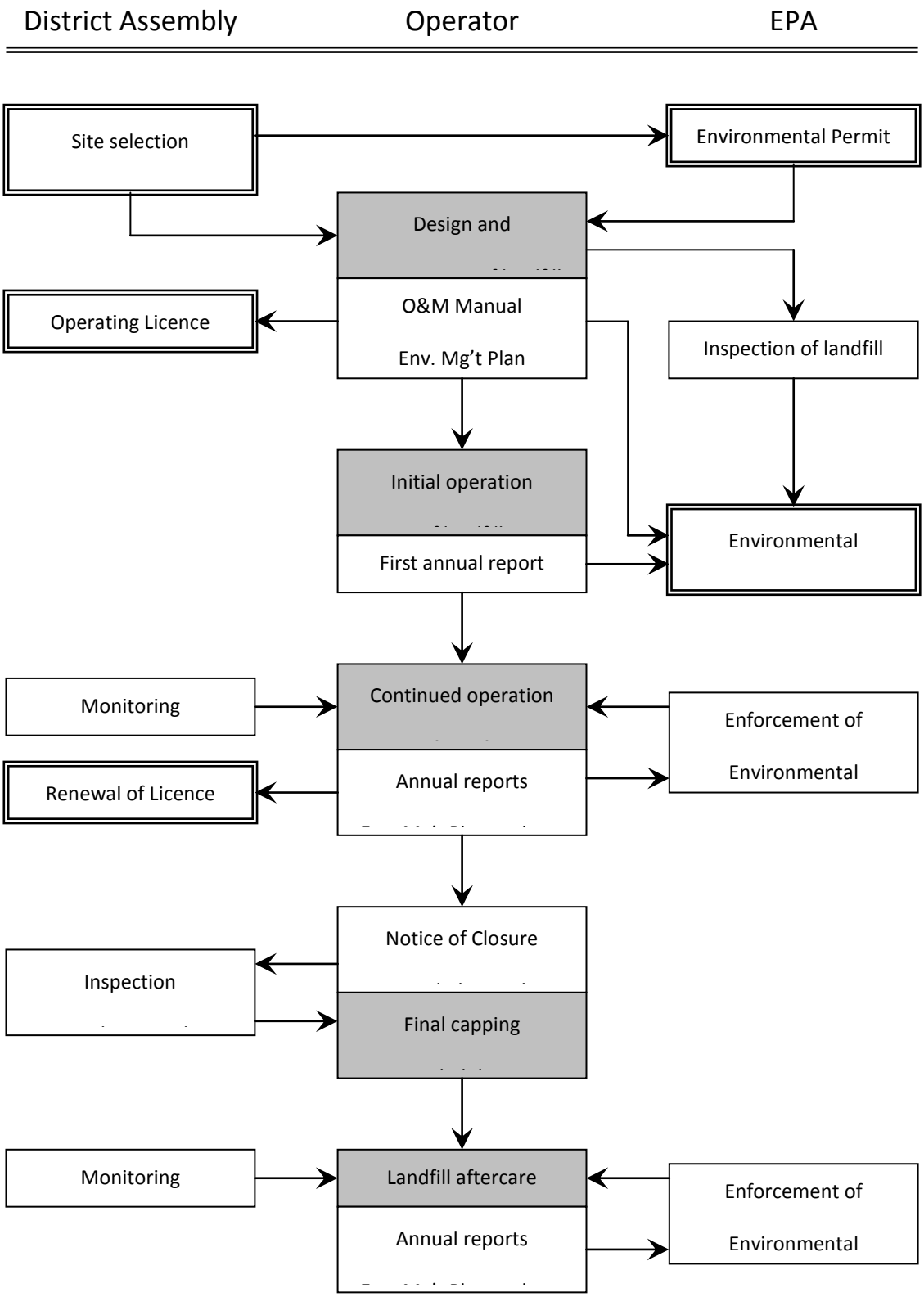
47. The specific studies carried out leading to the preparation of this design report to meet requirements of the TORs and regulatory framework is discussed under the following sections.

3.1.1 LIST OF LANDFILL TYPES AND FACILITIES REQUIRED

48. In considering the engineering design standards applicable to the rehabilitation, closure and after-care management of the Mallam SCC and Oblogo No.1 sites, the Ghana Landfill Guidelines is relied upon. Where appropriate, comparison and/or adoption of other standards is resorted to for completeness.

49. The generic framework for regulating landfill development in Ghana is presented in Figure 3.1. To ensure that the rehabilitation, closure and after-care management conforms to existing regulations and currently applied operational guidelines the EPA was consulted at each important stage of the process of closure.

Figure 3-1: Regulatory framework for landfills, ghana landfill guidelines 2002



3.1.2 ENVIRONMENTAL ASSESSMENT OF IMPACT OF PLACED WASTE

50. The unsightly nature and smell of poorly managed placed waste constitute a major source of discomfort to nearby residents. Pollution of water resources potentially increases the technical difficulty and cost of providing water supplies and also has serious potential health impact, with attendant social and economic costs.

51. **Aesthetics of the Environment:** as a result of lack of routine covering of the dump sites there is adverse aesthetic impact from windblown litter, especially due to the high content of thin-film plastics and the presence of rodents and flies. The flow of leachate within the built environment increases unsightliness and also poses grave danger to human-beings and domestic animals.

52. The poor operation and maintenance of the dump sites also depreciate the value of landed property within the vicinity: – vermin, scavenging birds, mal-odour and leachate combine to reduce amenity values. . These visual impairments are the main reasons that spur residents to oppose any proposals for the development of new disposal sites by city authorities.

53. **Water Pollution:** refuse placement at the disposal sites within the built environment constitutes high potential for the spread of diseases through various transmission routes while leachate flows which peak offs during rains can lead to contamination of ground and surface water.

54. **Human Health and Social Effects**: the prevalence of parasites has been attributed to unsanitary conditions in and around the dumping grounds with consequences beyond the immediate vicinities. Common infectious diseases like malaria, intestinal worms, and upper respiratory infections are among the most common health problems reported at out-patient facilities in and around Accra. The nearness of the Oblogo dump sites to the Densu River at Weija where treatment of the drinking water takes place is of great concern.

55. Local high temperatures also facilitate high decomposition rates and degradation of organic components of the waste to produce leachate and landfill gases. This is the main source of mal-odours emanating from these sites spreading to the surrounding residences.

56. The Mallam SCC and Oblogo No.1 disposal sites were operated as temporary sites and poses minimum of resettlement impact. The remedial actions proposed for rehabilitation, closure and after-care management will be validated with a quick social survey to be conducted to document inputs and concerns of residents of nearby communities.

57. Minimal scavenging was observed at the Mallam SCC while dumping operations at Oblogo No.1 have ceased with initial covering of placed was carried out. The main concern as pointed in earlier sections is for the appropriate management of leachate and run-off from the sites.

58. An Environmental Impact Statement will be compiled for the sites according to requirements of the Ghana Landfill Guidelines (2002) for Improved Dumping

(Mechanised) operations consistent with Environmental Assessment Regulations, 1999 (L.I. 1652).

59. Potential environmental impacts expected to be encountered will be catered for according to the closure an after-care operations appropriate for an Improved-Dumping (Mechanised) category. The potential impacts can be effectively remedied if the key impact-issues of groundwater, surface water, litter nuisance, odours, birds and other vermin are adequately managed (Section 3.3, GLG 2002).

3.2 TOPOGRAPHY AND DRAINAGE

60. The proposed sites are characteristic of the general area stretching from Gbawe-Macarthy Hill-Weija area made up of undulating hilly terrain broken with gentle slopes with low-lying land in-between (ridges) that results in rapid run-off of rain. The presence of rocky outcrop influenced the sitting of many stone quarries within the area.

61. Topographical surveys were carried out on the sites to establish the dumpsites boundaries and spot heights picked along 50m intervals grid lines. From the survey, the Oblogo No.1 and Mallam SCC dumpsites cover approximately 5.31 hectares (13.12 acres) and 1.6 hectares (3.84) acres, respectively.

62. Results of the field topographical surveys aided the determination of quantity of fill materials required for capping and site drainage requirements for storm-water conveyance away from the fill when capping works are completed.

63. Figures 2.3 and 2.4 below shows topographical maps of Oblogo No. 1 and Mallam SCC No.2 dump sites respectively.

3.3 SOLID WASTE VOLUMES AND CHARACTERISTICS

64. There is limited data on the volumes and characteristics of placed waste at the two dumpsites. Review of relevant literature suggests that Municipal Solid Waste (MSW) streams in Accra at point of disposal are high in putrescible organic content. Waste from domestic sources include, food waste, garden waste, sweepings, ash, packaging materials, textiles and electric and electronic waste. Waste from industrial sources include metals, wood, textiles, plastic; food waste from slaughter houses, cocoa processing factories, fruit processing and grain mills. The central business districts generate waste with high food and plastic contents while waste from schools and offices have high paper and plastic contents. These wastes are classified with their composition in the Table 3-1 and 3-2.

Table 3-1: Waste type and composition in the accra metropolis

Waste type	Organic	Paper	Textile	Plastic	Glass	Metal	Inert	Others
Proportion	65%	6%	1.7%	3.5%	3%	2.5%	17.1%	1.2%

Source: Waste Management Department of AMA (1999)

Table 3-2: Average Composition of Waste stream, GAMA (Baseline surveys)

Waste type	Organic	Paper/ Cardboard	Textile	Plastic/ Rubber	Glass	Metal	Inert/ Residues	Miscellaneous
Proportion	60%	8%	4%	8%	4%	3%	11%	4%

Source: National Environmental Sanitation Strategy and Action Plan (NESSAP), MLGRD 2010

.

Table 3-3: average daily tonnage of waste generated and collected in accra (1998-2009)

Year	Average tonnage generated/day	Average tonnage collected/day
1998	750	450 - 600
1999	960	600 - 800
2000	1650	1200 - 1500
2001	1700	1300 - 1500
2002	1720	1300 - 1500
2003	1800	1300 - 1500
2004	1799	1163
2005	1799	1402
2006	1799	1752
2007	1999	1656
2008	1999	1802
2009	2000	1750

Source: AMA Waste Management Department

65. The AMA-WMD estimates that approximately 2000 metric tonnes of waste is routinely collected from premises and locations within AMA's boundary and transported to various disposal sites within the larger Greater Accra Metropolitan Area (GAMA) since the city authority does not own any functional site within its jurisdictional area. Figure 2.5 gives a snap-shot of the main sources of generation of refuse from AMA area and the destination for final disposal.

3.4 EXISTING WATER USAGE

66. The nearest settlements within the vicinity of the Mallam SCC site include…The nearest houses are within 30m of the fill-slopes at the site. Oblogo is the name of the settlement around the Oblogo No.1 site. Residential properties are within 75 m of from the boundary of the fill material.

67. The inhabitants of Mallam and Oblogo rely on pipe-borne water from the Weija dam. Access to water coverage is generally above 85%. There are reports of isolated boreholes and wells located within the communities but exact locations were not ascertained due to time constraints.

68. For supply of water to the two sites for after-care operations extension of pipe-borne water from the adjoining areas can be resorted to.

3.5 FAUNA AND FLORA

69. During the site visits no specific fauna native to the area were observed. The site has few rodents and birds. At this preliminary stage of characterisation, it is concluded that no unique plant growth or plant communities of ecological sensitivity occur on the site.

3.6 EXISTING LAND USE, SETTLEMENT AND INFRASTRUCTURE

70. The nearest residential development to the sites as described above are the Mallam and Oblogo communities. There are High-Tension 161 KVA pylons belonging to the Volta River Authority running in an east-westerly direction across the site, about 10 m from the northern edge of the site.

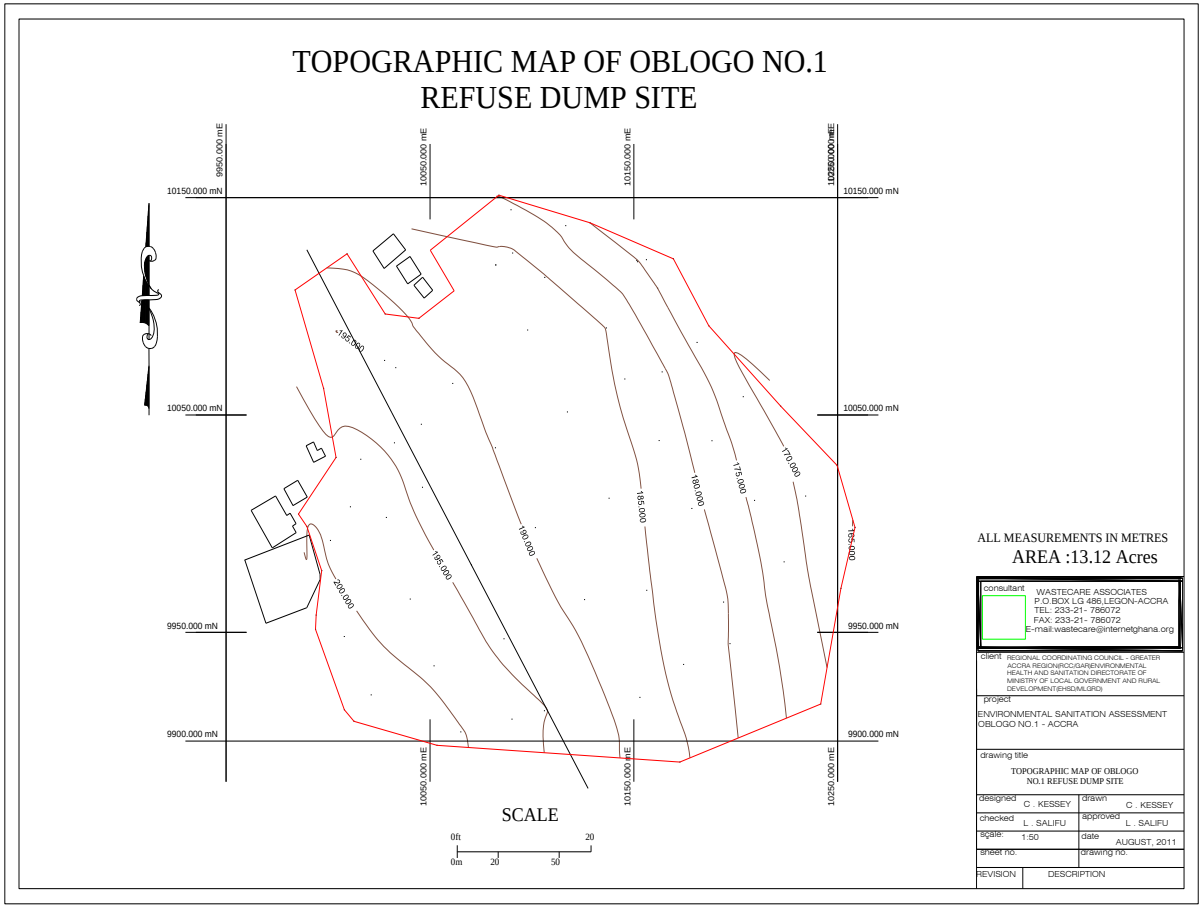


Figure 3-2: Topographic Map of Oblogo No1 Refuse dumpsite

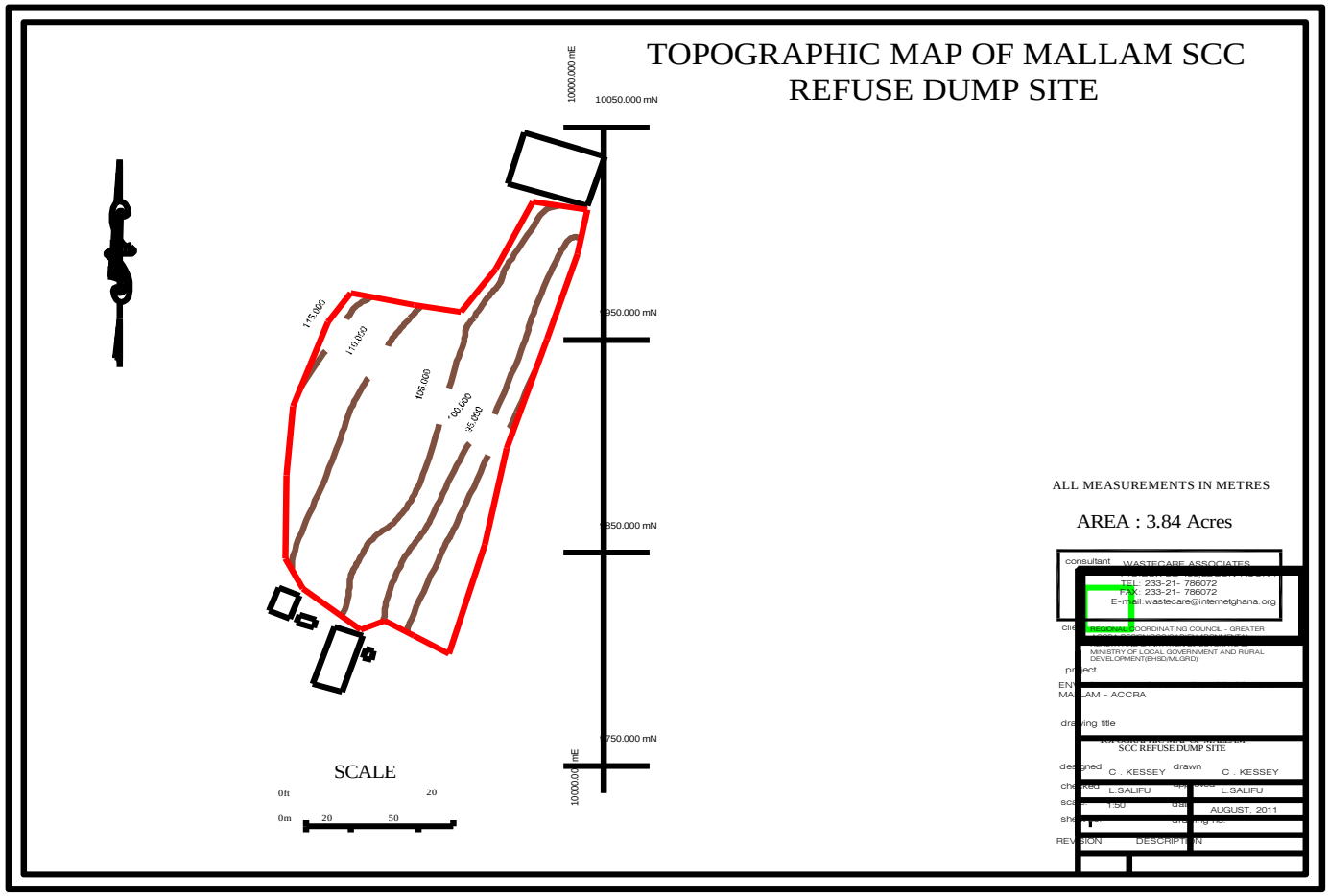


Figure 3-3: Topographic Map of Mallam SCC Refuse dumpsite

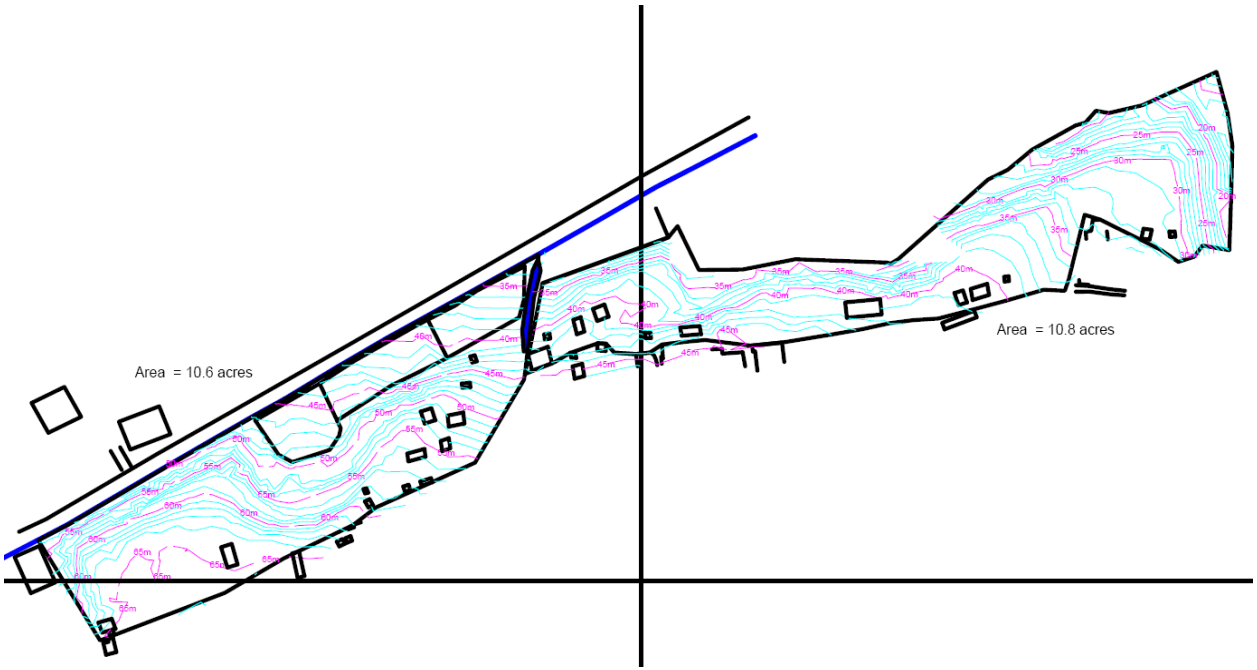


Figure 3-4: Topographic Map of Mallam No.1 & 2 Refuse dumpsite

3.7 CLIMATE

71. Both dumpsites (i.e. Mallam SCC and Oblogo No.1) are located in the Ga South/Weija Municipality. The Municipality is adjoined to Accra Metropolitan Assembly (AMA). Both districts lie in the coastal climatic zone of Ghana and thus have similar climatic conditions. The zone has two rainy seasons with an average annual rainfall of 730-740 mm. The first is between May-July and the second August - October. Rainfall is usually convectional in nature with the highest occurring in June.

72. Monthly temperature ranges from approximately 24°C- 28°C with annual average of 27°C. Humidity is generally high varying from 65% in the mid-afternoon to 95% at night.

Table 3-4: averate rainfall and temperature data for accra metropolis (and its environs)

MONTH	Mean Monthly Rainfall/ mm	Max Daily Rainfall	Average Temp/ ^{0}C
JANUARY	15.0	89.0	27.0
FEBRUARY	33.0	107.0	28.0
MARCH	56.0	109.0	28.0
APRIL	81.0	137.0	28.0
MAY	142.0	150.0	27.0
JUNE	178.0	302.0	26.0
JULY	62.0	154.0	25.0
AUGUST	15.0	94.0	24.0
SEPTEMBER	36.0	114.0	25.0
OCTOBER	64.0	140.0	26.0
NOVEMBER	36.0	94.0	27.0
DECEMBER	23.0	76.0	28.0
YEARLY AVERAGE	61.8	130.5	26.6
TOTAL	741.0		

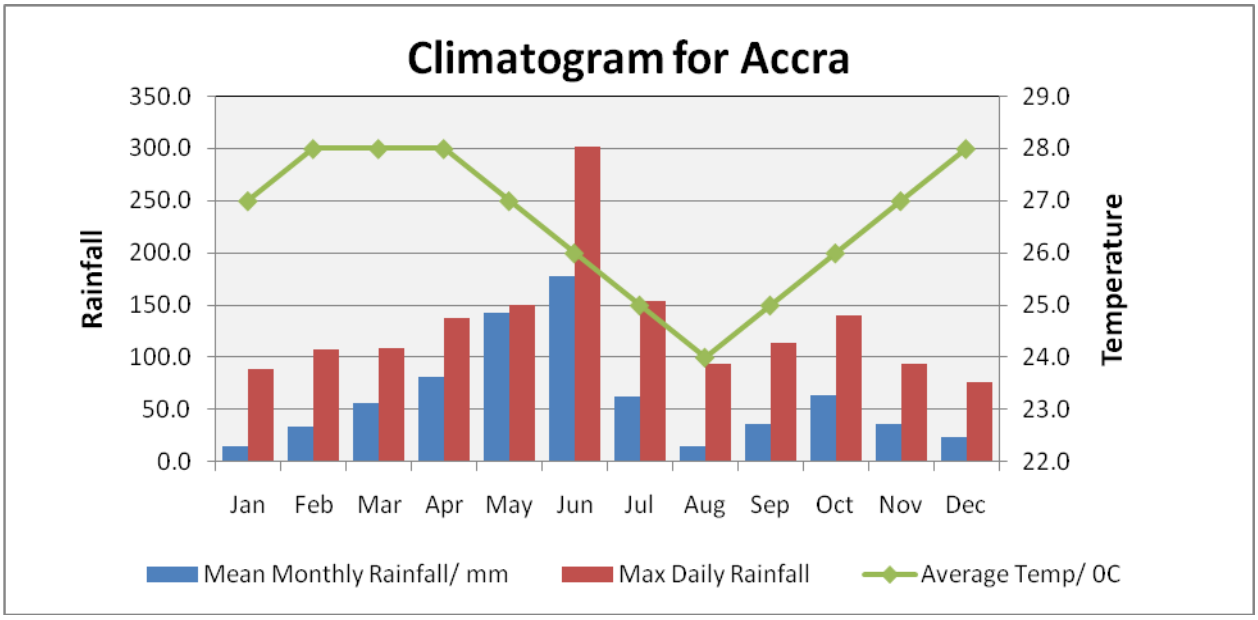


Figure 3-5: composite graph for average rainfall and temperature

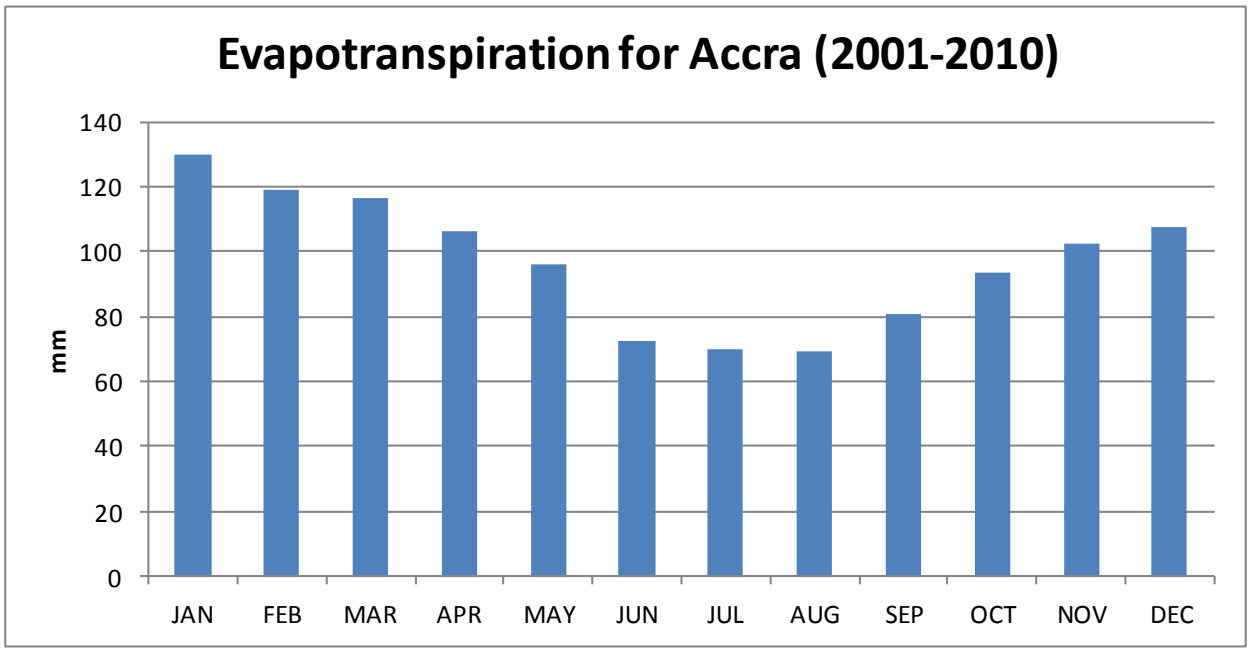


Figure 3-6: mean monthly evapotranspiration for accra (2001-2010)
Source: Ghana Meteorological Agency

73. As shown in the above Evapotranspiration graph, Accra is a net dry area. The moderate-to-low rainfall pattern has been considered in the design adopted for the capping of the sites

and the proposed sub-surface drainage of leachate to be recirculated and any cut-off barriers to be installed.

3.8 GEOTECHNICAL AND GEOLOGICAL STUDIES

74. The remediation of existing dumpsites is always hampered by specific challenges of lack of adequate background and baseline information on parameters such as geotechnical properties of soil materials which will aid the assessment of permeability and properties of sub-soils and hence the infiltration of leachate into the ground.

75. The general geology of the Oblogo and Mallam dump sites as shown in Figure 3-4 consists of two lithological groups namely:
    - Togo quartzite, orthoquartzite and phyllite
    - Recent unconsolidated sand, red continental deposits and slightly consolidated conglomerates

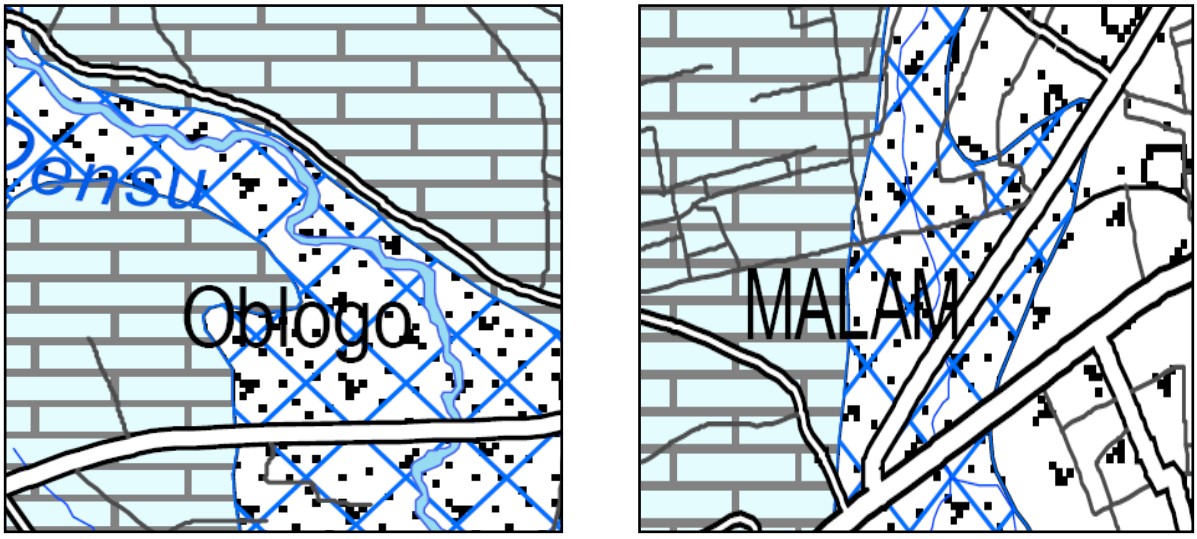


Figure 3-7: Hydro geological Map of Dumpsites

76. Both locations are situated within zones with shallow groundwater levels making these water resources very highly vulnerable to pollution hazards. The overburden in these areas consists of either argillaceous or arenous materials. This includes less permeable clay materials and highly permeable sand and rock intrusions.

77. While the location of the Mallam SCC site is wholly within an area underlain by impermeable clay, the Oblogo No.1 site is underlain in places by soil and rock intrusions. The likelihood of groundwater contamination at the Mallam SCC site is therefore minimal, whereas that at Oblogo No.1 is unknown and will require precaution. The proposed solution to leachate collection and treatment will therefore be critical for the Oblogo No.1 site as far as percolation to ground water is concerned.

78. Nevertheless the initial preparation of the site for leachate recirculation does not preclude the collection of substantial quantity of the leachate to the sump located at the downstream portion of the site. The proposed environmentally responsive solution will therefore be to collect and treat this flow of leachate along the lines of Best Available Technology Not Entailing Excessive Costs (BATNEEC).

3.9 LEACHATE FLOWS AND QUALITY

79. The Oblogo No.1 and Mallam SCC dumpsites do not have any installed bottom and side liners. This lack of impermeable barriers can lead to uncontrolled flow of leachate to the underlying soil and potentially contaminate ground and/or surface water in the down slope areas as illustrated in Figure 3.2, especially in the presence of highly-permeable sub-strata.

80. Regarding the Oblogo No. 1 dumpsite, there was an initial plan to collect and re-circulate leachate to be generated. Preparatory work carried out included the laying of leachate collection pipes which convey leachate to a sump. The leachate re-circulation system was not completed and so leachate currently flows from the sump through adjoining earth gullies and the main roadside drains/culverts into the Densu River which acts as the final outfall.

81. For the Mallam SCC dumpsite, untreated leachate from the site flows through rain created gullies along the working (front) face and base of the refuse heap and continues through roadside concrete U drains which then leads to a nearby stream outfall located northwest of the site. Flows from the outfall continues and runs across the main Mallam-Cape coast highway to a final discharge point located southwards in a marshy area.

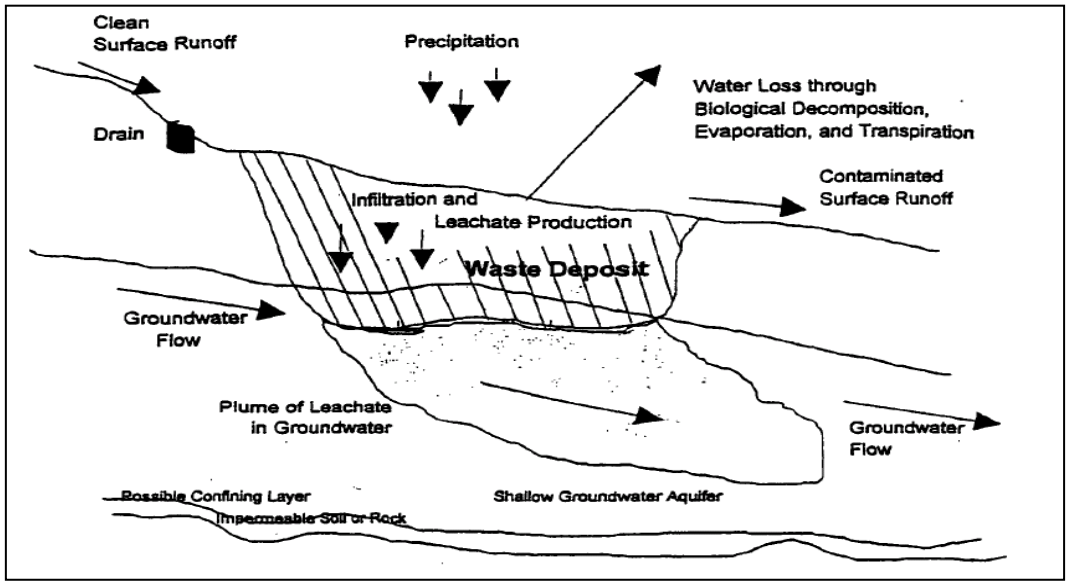


Figure 3-8: Uncontrolled Leachate Flows from Un-Engineered Dumpsites

82. The character and nature of the flow of leachate at both sites is indicative of the presence of impermeable soils underlying the refuse fill which influences flow in a predominant direction.

83. In order to gauge the worse-case for the production of leachate from the site is estimated based on peak flows that can occur during the rainy season. As part of investigation studies samples of leachate as collected from the dumpsites and analysed to determine concentrations of pollutants. The analysis showed very high concentrations of organics and nutrients (nitrogen and phosphorus).

84. The organic pollutants exert oxygen demand on receiving water bodies. This oxygen depletion kills aquatic life. On the other hand, the high nutrient concentrations cause eutrophication. The design adopted for handling leachate is based on gradual reduction and final curtailment of leachate flows to the receiving surface water to maintain the biodiversity of the receiving ecosystem.

85. Table 3-5 shows results of laboratory analysis carried out on leachate samples.

Table 3-5: Results of Laboratory analysis carried out on leachate sample

Analysis Results

Water Research Institute, Environmental Chemistry Division
CSIR Premises, Airport Res. Area
P. O. Box M. 32
Accra, Ghana
Phone: (+233-21) 775351/52 Fax: (+233-21) 777170 E-mail: info@ csir-water.com

Sample ID ***Company Name Waste Care***
Contact Name
Postal Code+ ***City Accra***
Lab Code ***Site Name***
Analysis start date 11/08/11 **Analysis stop date 17/08/11**

Sample ID	PH (pH Units)	Colour Hz	Turb. NTU	BOD mg/l	COD mg/l	TSS mg/l	NO_2-N mg/l	PO_4 mg/l	NH4-N mg/l	Fe mg/l	Lead mg/l	Zn m/l	FC cfu/100ml	Oil/Grease
M1	7.97	4000	>1000	168	4000	740	<0.005	16.1	19.9	11.9	0.014	0.549	0	24.0
M2	7.27	52.5	36.0	5.20	33.7	23.0	0.288	0.279	2.12	0.219	0.027	0.014	162×10^2	16.0
M3	7.50	35.0	37.0	2.00	45.0	23.0	0.263	0.395	3.40	0.223	0.031	0.011	192×10^2	20.0
01	8.00	2100	14.2	72.0	1237	45.0	0.212	6.59	11.4	8.05	<0.005	0.146	61×10^2	14.0
02	7.02	75.0	28.4	18.0	70.7	27.0	0.121	0.303	6.19	0.686	0.021	0.018	15×10^2	23.0
03	7.11	52.5	25.8	15.0	67.5	31.0	0.218	0.285	6.16	0.462	<0.005	0.017	12×10^2	25.0
WHO Guideline	**6.00 – 9.00**	**200.0**	**75.0**	**50.0**	**250.0**	**50.0**	-	**2.00**	**1.00**	-	-	-	**10.0**	**10.0**

Approved by:

Dr. Osmund D. Ansa-Asare, Head (ECD)

CSIR WATER RESEARCH INSTITUTE
P. O: BOX M 32, ACCRA
P: O: BOX 38 ACHIMOTA

3.10 HYDROLOGY

86. The other stream or rivulet within the area is the Balle receives leachate from Mallam SCC, and then flows southwards through Pambros and finds its way into the Densu peninsula. River Densu also receives the leachate from Oblogo No. 1 and this river serves the Weija Dam.

87. The Weija river from which water is abstracted and piped to serve mainly the West of Accra is a major perennial surface water body within the area. Indeed the danger posed by potential leachate contamination from the Oblogo No.1 site constitute the single most significant risk that has to be overcome.

88. While the Ghana Landfill Guidelines does not stipulate the provision of leachate drainage for Improved Dumping (mechanized) sites, the provision of leachate collection pipes, as originally envisaged for the Oblogo No.1 site and the construction of a sump for recirculation of leachate were to overcome the potential risk of polluting the nearby river.

89. Further studies of water census data (quality, yield, depth and usage) within a radius of 2.5 km around the site will be carried out to collect data on surface and ground water occurrences to aid monitoring and evaluation during the period of after-care management.

4. FACILITIES DESIGN

4.1 INTRODUCTION

90. The draft detailed design presented in this document is intended to meet the objectives and scope of work specified in the ToRs. Subsequently it will aid the Accra Metropolitan Assembly to secure approval of the Environmental Protection agency (EPA) prior to finalizing the design for implementation of rehabilitation and closure and thereafter the proposed after-care management processes.

91. The general objective of the design is to provide a cost effective, sustainable, environmentally acceptable procedure for the rehabilitation, closure and aftercare management of the Oblogo No.1 and Mallam SCC dump sites. More specifically, the design presented is aimed at minimizing the potential for pollution from leachate of ground water and surface water bodies.

92. The layout and details of the design proposed for the the two sites are shown in the drawings included with this detailed design report.

4.2 PRELIMINARY DESIGN CONSIDERATIONS

93. The considerations for the rehabilitation, closure and after-care management plan be accordance with Ghana Landfill Guidelines. The preliminary design considerations given attention is therefore consistent with Improved Dumping (Mechanised) operations as indicated in Table 4-1 (see sections not shaded).

Table 4-1: Design Parameters for Rehabilitation, Closure and after-care Management (adapted from GLG 2002)

Site Drainage	• Provide perimeter drainage ditches. Design of drainage should be in accordance with local rainfall, existing topography and soil conditions. Perimeter drains are to be earth drains with trapezoidal sections and top width of at least 1.5 m with base slopes <10%. • Where water table is high, perforated pipes or old tyres laid in rock-filled, clay covered trenches at the lower perimeter of the site are to be provided for groundwater drainage.
Access Roads	• Access roads should allow two-way traffic. • Permanent access roads should be 6m wide with single surface dressing and 1m shoulder on each side. • If access roads are not surface-dressed, a wheel-washing facility must be provided. • All temporary access roads constructed on fill should be provided with a firm base and should be covered with suitable material to allow adequate traction, particularly during the wet season. Selected earth fill or 3"x3" hardwood boards may be used for the base of temporary roads. Sawdust may be used for improved tyre traction.

Site Facilities	• Provide site office close to the entrance. • Site office should be furnished and should include a toilet, washing area, changing room, etc. • Office space area should be at least 20 m^2 • A room shall be provided for eating, fitted with a washbasin and adequately protected from litter, dust and vermin. • A store room shall be provided for hand tools, chemicals, etc. • A simple facility affording protection from sun and rain shall be provided for the use of scavengers.
Entrance	• Should allow two-way traffic and should be at least 8m wide. • Location of entrance should be along the main access road with minimum or no traffic conflict. • Provide adequate notice board close to entrance. • Notice board should provide the following information *inter alia*: Name of Landfill, Responsible Authority, Contact Address, Operational Hours, Acceptable Types of Waste, Dumping Fees, etc. • Plant trees and landscape entrance area to present a pleasing aspect.
Fence	• Provide fence 1.8 m high in chain link or barbed wire (placed @ 30 cm spacing). Fence is to allow containment of blown litter. • Vertical supports for fencing are to be provided in either concrete, metal , wood or plastic at 2.5 – 3.0 m spacing. • Fast-growing trees or shrubs should be planted outside the perimeter fence.
Leachate Management	• Provide adequate facilities for leachate collection. Collected leachate should be allowed to infiltrate into the ground media. • Provide 0.6 x 1.2-1.5m deep main channels to link collector channels at the lower perimeter of fill. All channels should have 2% slopes. All channels should be gravel filled. • The main channel is to be gravel filled up to 60% depth and provided with baffles at 10m intervals to pond leachate and allow infiltration. All baffles should have 0.3-0.5m freeboard above them. • Excess leachate is to be channeled to 2 no. basins each 0.8-1.0m deep for storage, infiltration and evaporation. Basins should cover an area of 10 m^2 per 1T/day capacity.
Hazardous Waste Disposal Cells	• Special cells are to be designated for disposal of hazardous waste within the fill. • The cells are to be cordoned off with no access to scavengers. • Each cell should be adequate for disposal of hazardous waste for several months.
Landfill Equipment (ID Mechanical)	• 31 HP tractor(s) (each tractor can be used to manage up to 20T of waste per day) with the following relevant accessories per tractor for ID (Mechanical): ➢ Front blades for pushing and leveling; ➢ Buckets for excavation; ➢ Sheep footed heavy drums (rollers) for compaction; • Gloves, boots, overalls, etc. and annual medical check-ups for staff.

94. The above parameters provided in GLG 2002 serve as a basis for the proposed design and supplemented with adaptable design criteria from other sources, such as those of the USEPA, to meet the minimum operational standards for rehabilitation, closure and after-care management.

4.3 APPROPRIATE TECHNOLOGY AND ENVIRONMENTAL ACCEPTABILITY

95. To meet the objectives of rehabilitation, closure and appropriate after-care the technology identified and to be implemented would be seen as appropriate to the conditions under consideration. It would represent a significant improvement on the status quo, yet be sustainable in the local environment.

96. The approach adopted in this assignment aims to match the objectives of modern dumpsite closure theory with the realities of the local conditions and standards as those specified in the GLG 2002. Therefore, high technology systems and equipment requiring sophisticated operation and maintenance are to be avoided. These include sophisticated pumping systems, mechanized leachate treatment systems and geo-membrane liners.

97. An important aspect of the proposed approach is its cost effectiveness and affordability both in terms of development and operating costs. The construction of the proposed leachate re-circulation system will accommodate labour intensive construction so as to provide maximum opportunity for the employment of local people. The design also utilizes locally available materials wherever possible.

98. An approach that utilizes locally sustainable and affordable technology will logically lead to less stringent designs than those prescribed by, for instance, the USEPA. Such design standards will only be acceptable; however, if it can be shown that they can limit the projected contaminant release from the dumpsites to a level that will not have an adverse impact on the receiving environment.

99. A design aiming potentially at zero impact could be unaffordable in this case and the related sophisticated technology required for leachate treatment could be beyond the capacity of the Accra Metropolitan Assembly.

100. As indicated in the ToRs and discussed in previous sections of this report, the single important contaminant of grave concern is leachate. The rehabilitation of the two dump sites will be incomplete if after capping leachate flows uncontrolled within nearby communities and into streams as before. The core aspect of the process of rehabilitation, closure and after-care therefore focuses on leachate management as stipulated in the ToRs.

4.4 LEACAHATE QUANTITY

4.4.1 POST-CLOSURE LEACHATE ESTIMATION PROCEDURE

101. Post-closure leachate generation potential can be estimated using the Hydrologic Evaluation of Landfill Performance Model (HELP). The HELP model is a computer model developed to assist landfill designers and regulators in evaluating cover systems, bottom liners and leachate collection systems. Figure 4-1 illustrates the profile of a typical lined landfill and processes that are simulated by the HELP model. The HELP model has two main uses. During the conceptual planning and evaluation stage, the model can be used to evaluate a large number of different designs for both the bottom liner and leachate collection system and the final cover system.

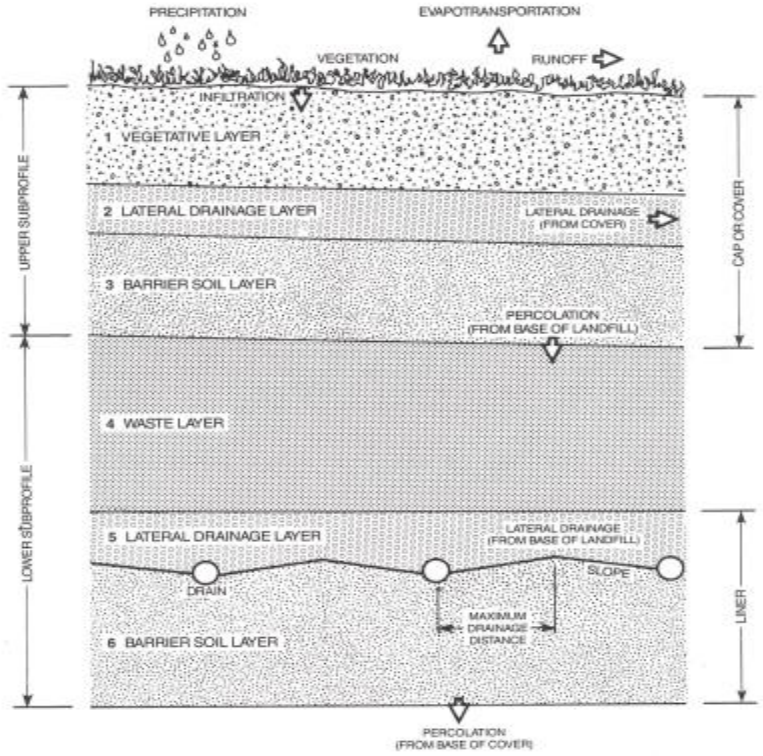


Figure 4-1: Capped Landfill Profile Modeled by Help

102. The input data types required for the HELP model include climatologic, vegetative cover, soil characteristics, landfill design site data. The output results for the HELP model includes daily volumes, monthly totals, annual averages, annual totals, amount of leachate collected and the percolation rates through the bottom of the landfill.

103. The HELP model relies on calibration field verification if predictably accurate results are to be provided. The problem encountered often (as for this current assignment) in modeling solid waste disposal sites is that the measured data (percolation, runoff, evapotranspiration, etc.) are not available and therefore calibration and verification are not possible. Thus, the model results contain an unknown amount of uncertainty. However, the HELP model is the most powerful and readily available model for evaluating leachate management and therefore the model of choice for this case.

4.4.2 HELP MODEL SET-UP

104. The components for the HELP Model are presented in Table 4-2.

Table 4-2: HELP Model setup for landfill cover profile

Material	Type of Layer	HELP Model Classification	Thickness (mm)
Loam	Vertical Percolation	8	100
Lateritic Clayey Soil	Vertical Percolation	15	75
Compacted Clay	Barrier Soil Liner	16	150

4.4.3 HELP MODEL RESULTS

105. The peak daily and annual landfill cover leakage volumes at the various project sites are presented in tables 4-3.

Table 4-3: Landfill cover leakage volumes for various project sites

Project Site	Peak Daily Volume (m^3)	Annual Volume (m^3)
Mallam Main	16.28	3080
Mallam SCC	2.95	566
Oblogo No.1	9.92	1878

4.5 LEACHATE COLLECTION AND RE-CIRCULATION SYSTEM

106. For the current assignment which is for **rehabilitation, closure and after-care management of a closed dump site**, the emphasis is on the collection of leachate where biological degradation is taking place and there is therefore need for treatment and subsequent disposal of leachate.

107. The primary criterion for design of the leachate system is that all leachate be collected and removed from the landfill at a rate sufficient to prevent a hydraulic head greater than a specified value e.g. 300 mm from occurring at any point over the lining system. The system is designed to remove the accumulation of storm water resulting from a specified design storm e.g. a 25-year, 24-hour storm, within a specific time frame e.g. 72 hours.

108. Other design criteria include the following:

- The system for leachate conveyance must be designed to minimize clogging;
- System must be designed to handle the runoff from a 25-year, 24-hour storm;

- Sumps, liquid removal and attenuation systems must be of sufficient size to prevent back up into the drainage layer;
- System components that come into contact with waste must be chemically resistant to that waste; and
- System components must have sufficient durability to resist collapse as settlement occurs in the fill.

109. The leachate pumping (or recirculation) system consist of

- low-flow pumps for regular pumping of leachate to attenuation tanks in the case of leachate re-circulation;
- sumps should be designed to have overflow weirs that can be controlled to divert storm-water overflow in the event of large storms (25-year/24-hour criteria).

110. Selection of a low-flow pump is based on the average leachate flow from the landfill. The pump is sized for slightly more flow capacity thus allowing for a margin of safety.

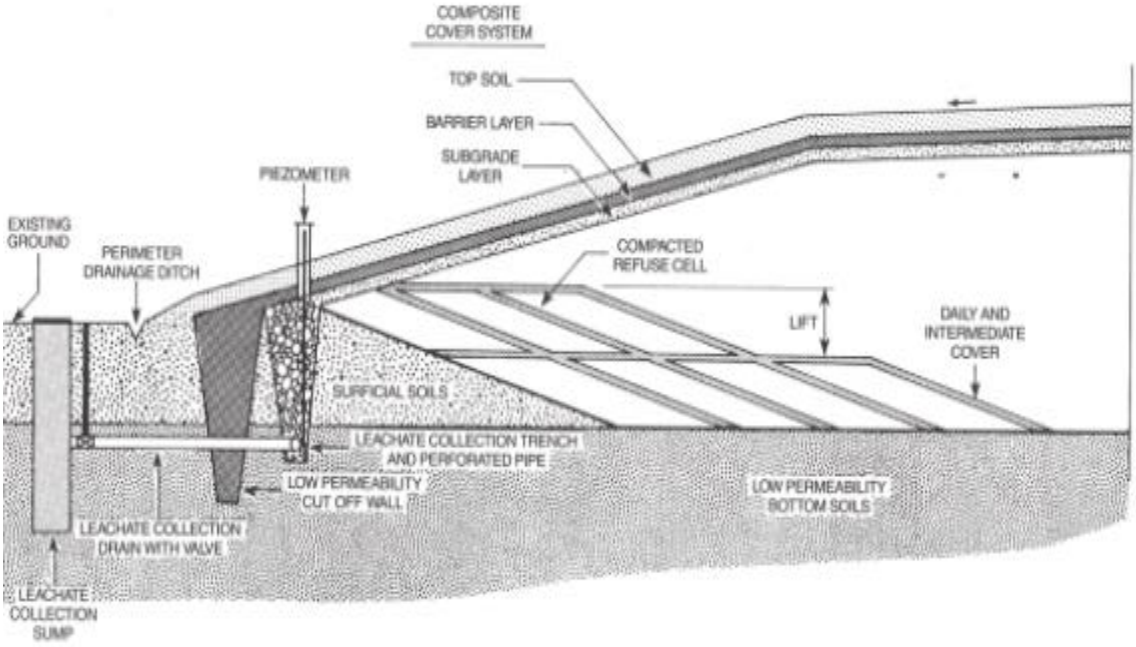


Figure 4-2: Generic Leachate Collection System for an unlined Landfill (inoperation)

111. The generic consideration for the development of a new improved (mechanized) dumping operation will be for the construction of embankments to ensure adequate control of

leachate flows through the proper installation of a leachate collection system and final installation of a cover system.

112. For the Oblogo No.1, Mallam SCC and Mallam No.1 dumpsites, where dumping operation have proceeded without embankments and leachtae collection facilities, the challenge is to determine and ensure that the leachate being generated substantially flows to a collection point (i.e the sump in the case of the Onlogo No1. Site, for example) and thence treated and disposed of without adverse impacts.

113. As described in previous sections, the topography and geology of the Mallam SCC site potentially precludes sub-soil infiltration of leachate and influences gravity flow towards the lowest points of the site which can be engineered to serve as a point.

114. The above characteristics of the two sites reduce the aforementioned challenge to one of adequate treatment and disposal of the leachate from the collection points (sumps) – to be constructed for the Mallam SCC and Mallam No.1 sites and relying on the already existing sump for the Oblogo No.1 site. This the major design input proffered by the consultant and referred to as the WasteCare Sub-surface Irrigation of Re-circulated Leachate (WC-SIRL) system.

115. The WasteCare SIRL system has three main components. These include:

- A recirculation system (sump and pump) for re-introduction of leachate contained within the landfill enclosure;
- A composite lining system with an acceptable liner (barrier) performance;
- Storage and attenuation of re-circulated leachate for controlled dispersion into placed waste-fill and;
- Sub-surface irrigation into land or solid waste-fill of re-circulated leachate.

116. Leachate recirculation is a disposal technique whereby landfill leachate is recirculated through the deposited refuse to allow for dispersion and treatment through natural stabilization processes of the placed refuse.

117. Leachate recirculation in a landfill results in more rapid stabilization of the organic fraction of the deposited refuse because of the accelerated growth of an anaerobic biological population. Typical leachate application rates of 0.31-0.62 m^3/m of trench length per day at 14 to 23 m^3/hr have been reported. The by-products from a properly operated leachate recirculation landfill are the recirculated leachate and gases emitted during anaerobic digestion. During the leachate recirculation landfill process, the moisture content of the solid waste is increased from 25-30 to 65-70% so that anaerobic microbial activity can be maximized.

118. The sub-surface irrigation of leachate is a modification of normal drain fields used for treatment of sewage and a process of land treatment of leachate suitable for locations where

high rainfall leads to the production of large volumes of dilute leachate. It is widely practiced in many parts of the world such as the USA and Britain.

119. The critical element in this instance is for the gradual treatment and volume reduction in the continuously re-circulated to occur over time. The loss of leachate volume is through evapotranspiration by vascular plants described as phytoremediation of leachate.

120. In the WC-SIRL system a sump serves as storage of the pre-treated leachate and an above ground HDPE tank serves as further storage and attenuation system to allow for controlled drip irrigation through perforated PVC pipes.

121. As part of after-care management procedures a flow meter or a calibrated pump hour meter may be installed to record effluent flow volume going to the dispersion sites.

4.6 DESIGN OF FINAL COVERS

4.6.1. CONCEPTUAL DESIGN

122. The Ghana Landfill Guidelines does not specify the configuration of the final cover as such the design specification for the two dumpsites will be based on international best practices.

123. A primary aim of the final cover or cap as shown in Figure 4-3 is to isolate the wastes from the environment, and restrict the infiltration of rainwater and other surface water into the wastes below the cap. The configuration of the capping system i.e. the types and thickness of the various layers will depend on site specific conditions and the final intended use of the site.

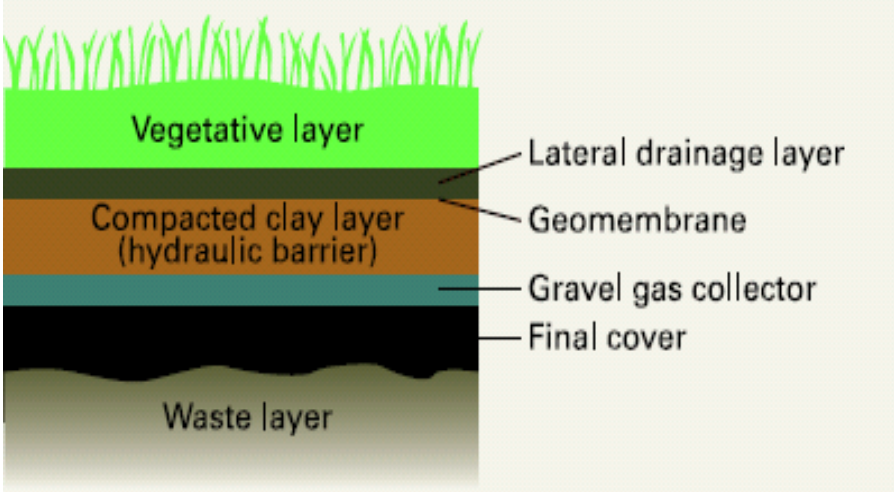


Figure 4-3: Schematic of Landfill Final Cover

124. The components of a typical landfill capping system may include topsoil, subsoil, drainage layer, barrier (infiltration) layer, gas drainage layer and filter layers. The primary function of the topsoil is to enable the planned after use to be achieved. The topsoil should be uniform and have an adequate slope minimum to prevent surface water ponding and to promote surface water run off. The topsoil should also be thick enough to:

- accommodate root systems

- provide water holding capacity to attenuate moisture from rainfall and to sustain vegetation through dry periods
- allow for long term erosion losses

125. Drainage layers are used below the topsoil/subsoil and above the barrier layer to:
    - minimise the head of water on the underlying barrier layer, which reduces percolation of water through the capping system
    - provide drainage of the overlying topsoil and subsoil, which increases the water storage capacity of these layers and helps to minimize erosion by reducing the time during which the surface and protection layer materials remain saturated with water
    - increase slope stability by reducing pore water pressure in the overlying soil materials

126. The principal functions of the barrier layer are to control leachate generation through minimizing infiltration of water; and control movement of landfill gas.

4.6.2 FINAL COVER DESIGN SPECIFICATIONS

127. Section 7.6 of the Ghana Landfill Guidelines requires that final covers for improved mechanical and manual dumping. It however, does not specify the type of natural or synthetic materials that may be used. As such, the design specifications were also based on specification provided in the World Bank Technical Publication 416 for solid waste landfills in Middle and Low Income countries. The final cover design profile which consists of natural soil material is shown in Tables 4-4.

Table 4-4: Final cover design profile 1

Component	Material	Thickness (mm)	Conductivity (cm/s)
Topsoil /Vegetative cover layer	Loam	100	3.7×10^{-4}
Subsoil (protection layer)	Laterite (Clayey)	75	1.7×10^{-5}
Barrier soil layer	Compacted Clay	150	1.0×10^{-7}

128. The final cover design adopted for the Oblogo No.1, Mallam SCC and Mallam No.1 and No.2 sites is derived from a combination of specifications provided in the Ireland EPA Landfill Site Design Manual for non-hazardous biodegradable landfill capping systems shown in Figure 4-4 and that of World Bank Technical Publication No. 416 (Rushbrook and Pugh, 1999) for solid waste landfills in Middle and Low Income countries.

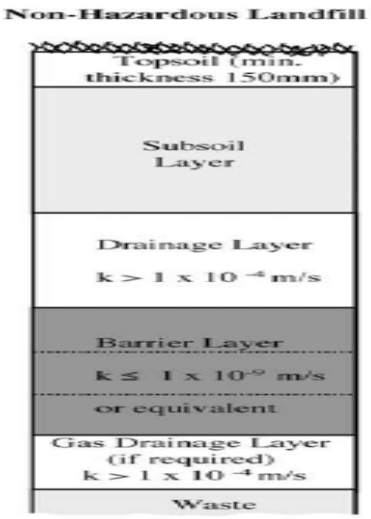


Figure 4-4: Ireland EPA Landfill Capping System for Non-hazardous Biodegradable Landfill

4.6.3 ESTIMATING THE VOLUMES OF FINAL COVER MATERIALS

129. The minimum volume of material for each component is determined as shown below

$$V_L = St_L$$

Where V_L is the volume of the layer material
S is the land surface area of the dumpsite
t_L is the thickness of the layer

130. The volumes of the natural soil materials required at the various project sites for the alternative final cover design profile is shown in Table 4-5.

Table 4-5: Cover Material Volumes for Cover Design Profile

Material	Volumes (m^3)		
	Mallam Main	Mallam SCC	Oblogo No. 1
Loam	8,700	1,600	5,300
Laterite	6,525	1,200	3,975
Compacted Clay	13,050	2,400	7,980

4.6.4 FINAL CAPPING SYSTEM LAYOUT AND BOUNDARIES

131. The provision of the capping system will result in the reduction of the land surface area occupied by the dumpsites originally since the wastes will have to be compacted to achieve the required domed landform with adequate slopes to enhance run-off. This will also ensure that there is an adequate buffer zone around the capped dumpsite for the installation of perimeter drains.

132. Figures 4-5 and 4-6 show the existing and proposed post–rehabilitation layouts for the Mallam SCC site. The new land surface area will be 0.48 hectares and a minimum buffer zone of 10 m to the nearest building.

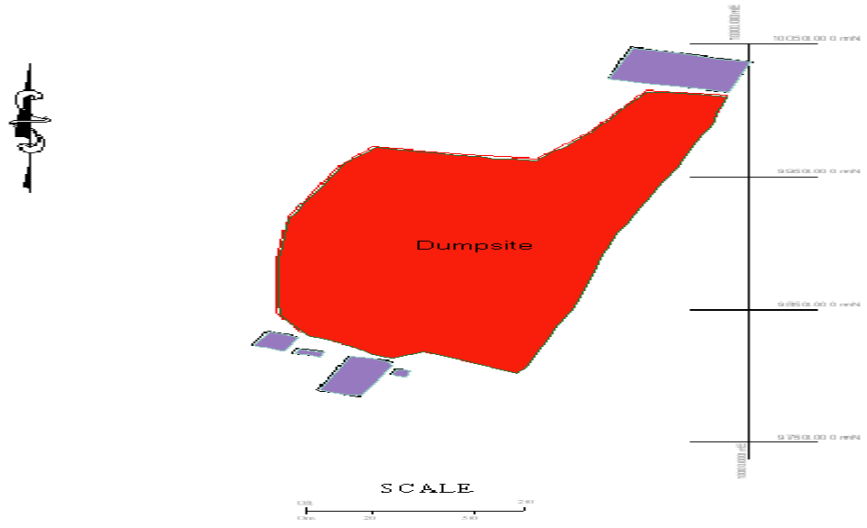


Figure 4-5: Existing Layout of Mallam SCC Dumpsite

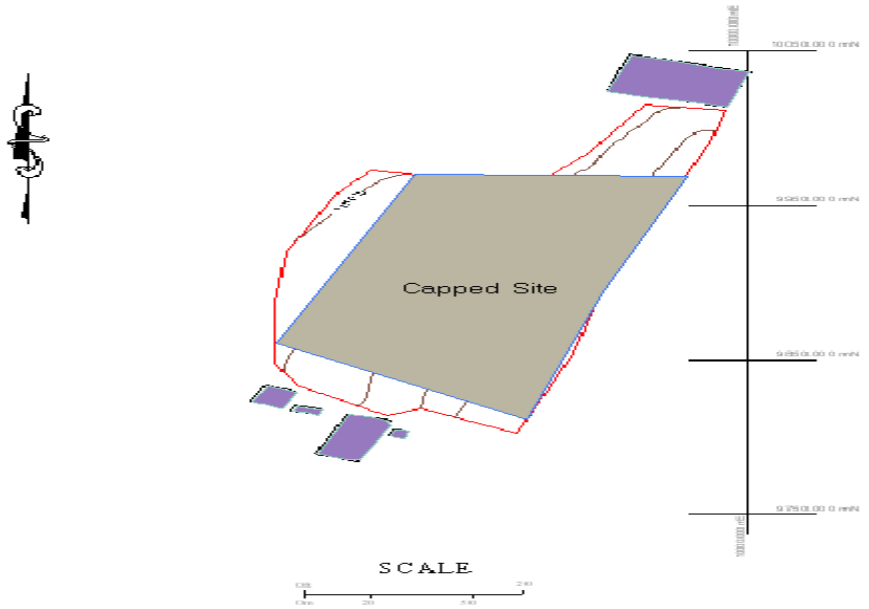


Figure 4-6: Proposed Layout of Rehabilitated Mallam SCC Dumpsite

133. Figures 4-7 and 4-8 show the existing and proposed post–rehabilitation layouts for the Oblogo No.1 dumpsite. The new land surface area will be 3.03 hectares and a minimum buffer zone of 10 m to the nearest building.

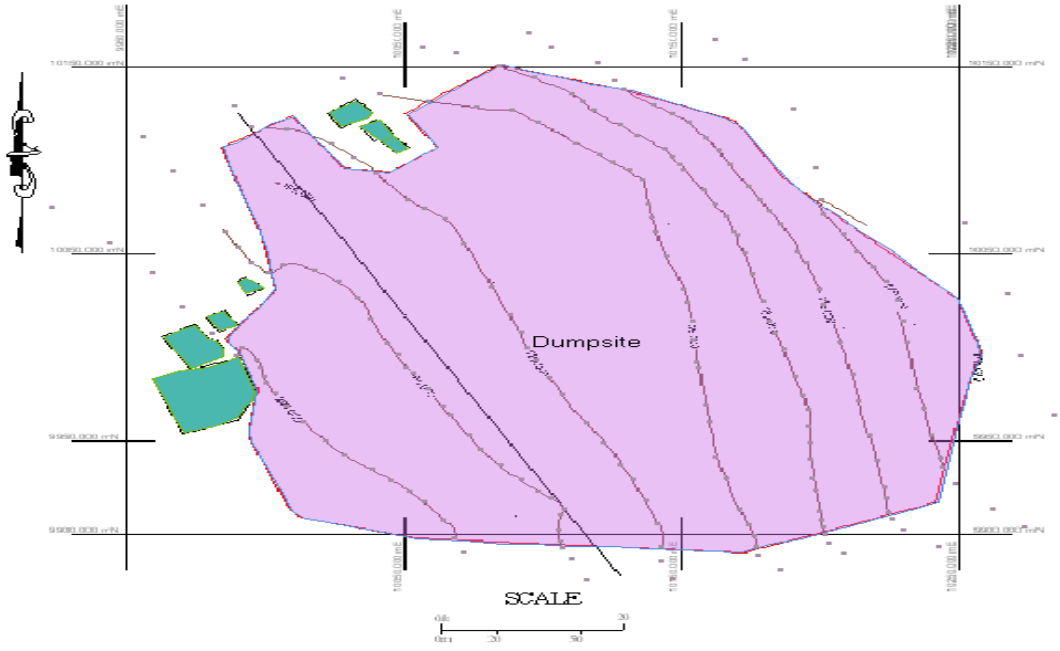


Figure 4-7: Existing Layout of Oblogo No.1 Dumpsite

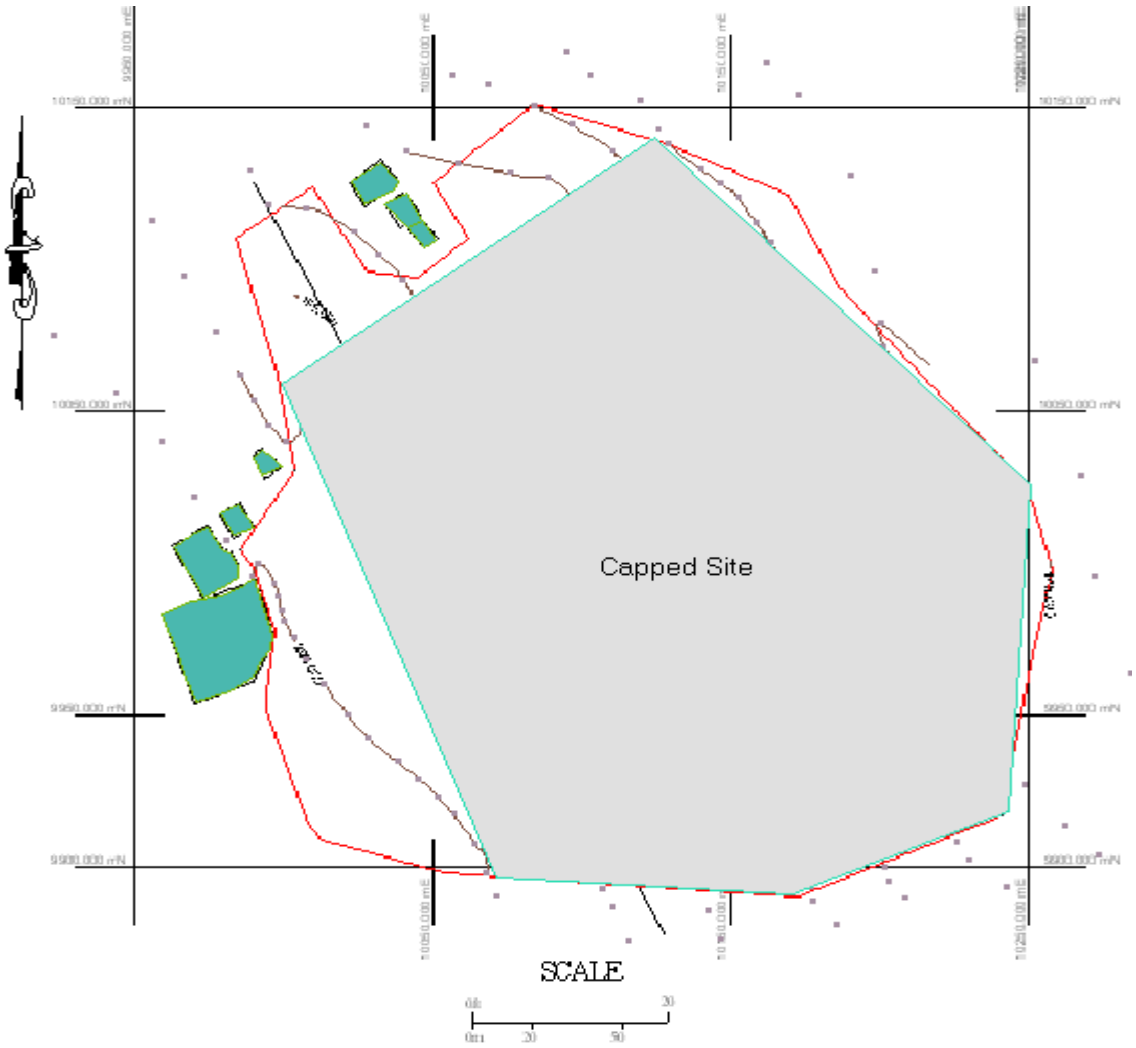


Figure 4-8: Proposed Layout of Rehabilitated Oblogo No.1 Dumpsite

134. Figures 4-9 and 4-10 show the existing and proposed post–rehabilitation layouts for the Mallam No.1 & No.2 dumpsites. The new land surface area will be …. hectares and a minimum buffer zone of 10 m to the nearest building.

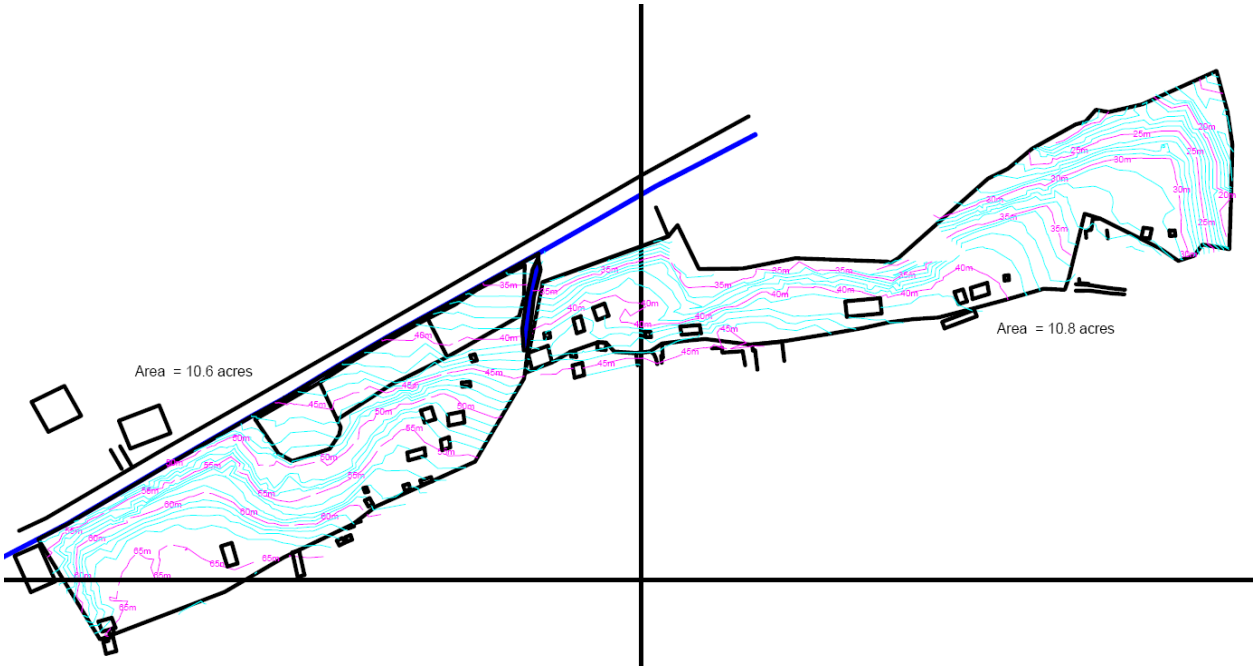


Figure 4-9: Existing Layout of Mallam No.1 and No.2 Dumpsites

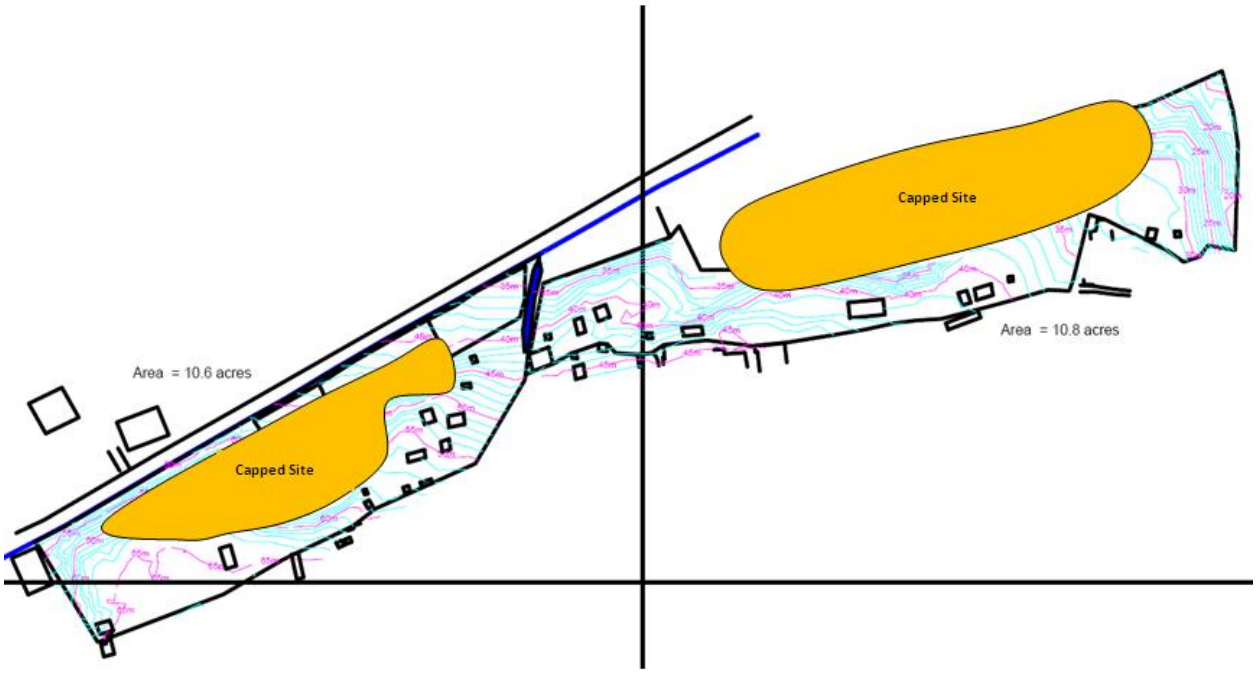


Figure 4-10: Proposed Layout of Rehabilitated Mallam Main Dumpsite

4.7 DESIGN OF SURFACE WATER DRAINAGE CHANNELS

135. The drainage systems for closed disposal site are intended to manage the following surfacewater flow components:
    - Uncontaminated upslope run-off
    - Uncontaminated run-off from the capped site

136. Generally, the uncontaminated upslope run-off is diverted around the site into a natural drainage course. Surface run-off from the capped sites is also considered to be un-contaminated and channeled to perimeter drainage channels. Figures 4-11 and 4-12 show the longitudinal and plan views of drainage channels constructed around the perimeter of the final capped form.

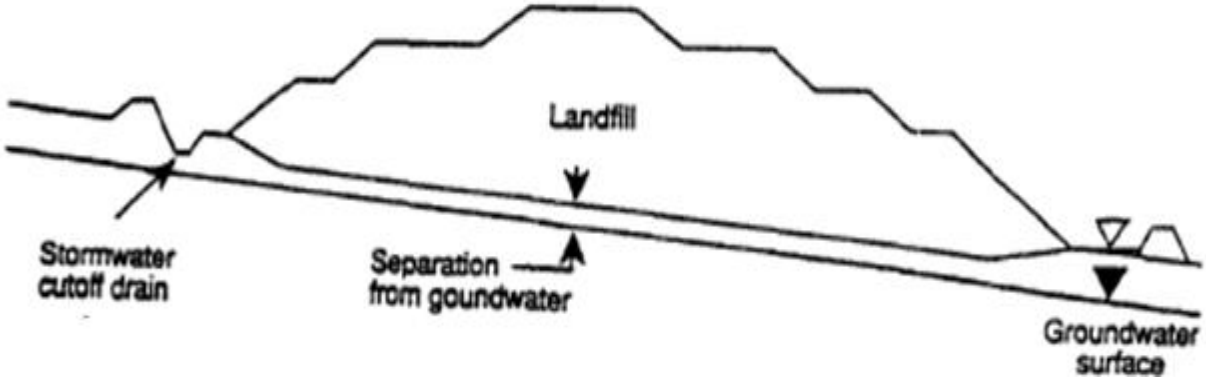


Figure 4-11: Plan view of Capped Landfill and Surface Water Drainage Channels

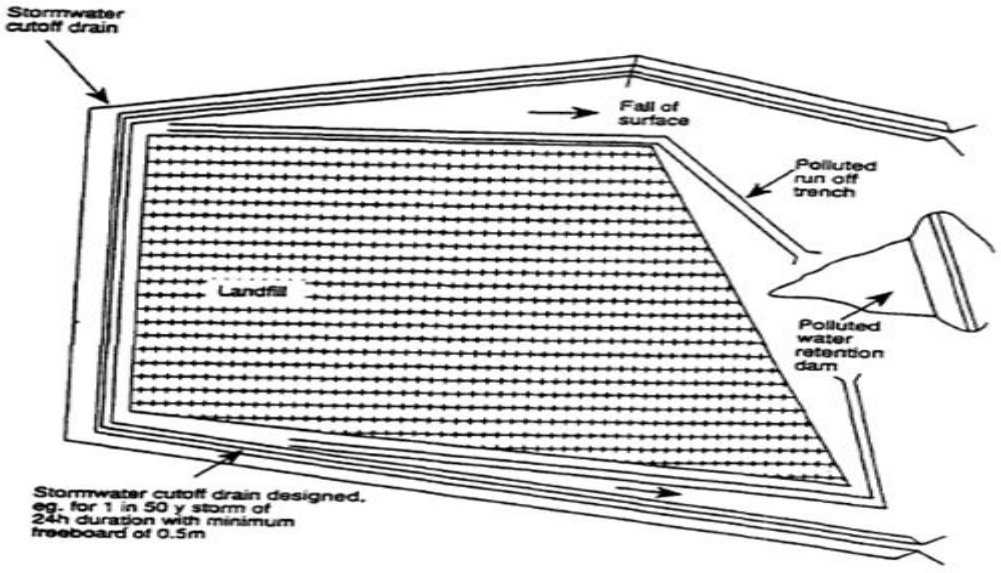


Figure 4-12: Plan view of Capped Landfill and Surface Water Drainage Channels

4.7.1 HYDROLOGIC ANALYSIS

137. The Ghana Landfill Guidelines does not provide any specific hydrologic analysis procedures for improved mechanical dumping as such reference was made to other technical publications and international best practices. The peak runoff for the three project sites was determined using the EPA SWMM software. EPA SWMM is a dynamic rainfall-runoff simulation model used for single event or long-term continuous simulation of runoff quantity and quality from primarily urban areas. The use of the computer models in peak flow estimation makes it possible to assess the effect of different storm profiles and subcatchment characteristics. A 24-hour design storm with a return period of 25 years which corresponds to 176 mm was used in the computations. The choice of that storm duration and return period was premised on the need to ensure a compromise between cost implications and the risk of failure. Five scenarios based on different 24-hour storm profiles were modeled namely; block rain, SCS Type l, SCS Type 1A, SCS Type ll, and SCS Type lll distributions. The block rainfall profile has a constant rainfall depth or intensity whereas the other profiles have varying rainfall depths with respect to time. Table 4-6 presents a comparison of the 25-yr peak discharges from the various design storm profile scenarios for the Mallam Main, Mallam SCC and Oblogo No. 1 dumpsite. It is observed that the highest and lowest peak discharges at both dumpsites are obtained for the Type ll design storm and block rain profile respectively.

Table 4-6: EPA SWMM simulation results for peak runoff

Storm Profile	25-yr Peak Runoff (m^3/s)			
	Oblogo No.1	Mallam Main A	Mallam Main B	Mallam SCC
Block Rain	0.100	0.0828	0.0835	0.030
SCS Type l	0.513	0.456	0.462	0.175
SCS Type lA	0.267	0.234	0.237	0.090
SCS Type ll	1.026	0.914	0.926	0.351
SCS Type lll	0.753	0.642	0.653	0.242

4.7.2 HYDRAULIC DESIGN OF PERIMETER DRAINS

138. The permissible tractive force or shear force approach for the design of stable channels was adopted in sizing the perimeter drains. The tractive force approach requires that the shear stresses on the channel bed and banks do not exceed the allowable amounts for the given channel boundary. The hydraulic analysis was done using the FHWA Hydraulic Toolbox software. This computer program makes it possible for the hydraulic engineer to optimize

various design parameters such as channel geometry, geometry, bottom slopes, lining type, freeboard and permissible shear stress. Table 4-7 presents the hydraulic analysis i.e. results namely design flows, velocities and shear stresses. Table 4-8 presents the channel cross-section dimensions for the Mallam Main, Mallam SCC and Oblogo No.1 drains. The length of perimeter drains at each project site as determined from the topographical maps is also presented in Table 4-9.

Table 4-7: Hydraulic analysis results for respective sites

Design Parameter	Oblogo No.1	Mallam Main A	Mallam Main B	Mallam SCC
Discharge (m^3/s)	1.025	0.914	0.926	0.351
Flow depth (m)	0.454	0.429	0.432	0.247
Average velocity (m/s)	1.763	1.712	1.718	1.463
Max shear stress (N/m^2)	133.45	126.22	127.01	72.68
Avg shear stress (N/m^2)	76.43	73.10	73.47	47.32

Table 4-8: Channel cross-section dimensions

Design Parameter	Oblogo No.1	Mallam Main	Mallam SCC
Base width (m)	0.600	0.600	0.600
Depth (m)	0.900	0.900	0.900
Right side slope (H:V)	1.5	1.5	1.5
Left side slope (H:V)	1.5	1.5	1.5

Table 4-9: Length of perimeter drains at various project sites

Design Parameter	Perimeter drain Length (m)
Mallam Main	860
Mallam SCC	190
Oblogo No.1	480

4.7 CONSTRAINTS AND FACTORS AFFECTING DESIGN

139. Based on the Terms of reference, the need for proper handling of leachate as well as the conditions at the already existing disposal sites, the design is influenced by a number of factors. These include:

- There is a limited total budget of US$ 300,000 (US$150,000 per site, per lot) for implementing rehabilitation and closure as well as for immediate facilities for after-care management for the two sites. In order to manage the works effectively the funds should be pooled and contractors allowed to bid for more than one lot.
- The WC-SIRL system is proposed based on appropriate technology for the local situation and conditions. Maximum use of local materials and gravity flow systems, reworked soil liners etc is to be relied upon.
- The design is based on the proviso that there is no significant ground water flow contributing to leachate generation. The lack of information on groundwater recharge levels or the presence of a perched water table is a critical constraint. It is assumed that the flow of leachate towards the sump, in the case of Oblogo No.1 is an indication of the location of lowest point of the disposal site.
- The presence of constructed Volta River Authority (VRA) pylons (power line) across the northern portion of the Oblogo No1. site means the final height of the finished landform should conform to regulations.

4.8 SITE LAYOUT

140. Based on the aforementioned constraints and the design considerations the overall layouts for Oblogo No1. and Mallam SCC dump sites have been developed as shown on Figures 4.10 – 4. 14. . The arrangement of facilities has been determined according to the topography, drainage requirements, and access to the site, and buffer requirements of adjoining residential properties.

141. The details and descriptions of the various facilities to be constructed or installed for the closure and after-care management of the sites are discussed in the following sections.

5. FACILITIES AND INFRASTRUCTURE

5.1 FENCING

142. The entire perimeter of the site(s) is to be fenced with a 1.5 m high security fence to prevent unauthorized access to the site. I addition the area for the sumps and tanks are to be fenced to safe-guard equipment and machinery, if any.

143. The fencing is to consist of galvanized chain-linked mesh secure to straining wires on 100mm x 100mm precast concrete (or recycled plastic) posts at 3m centres. The top of the fence is to have a 3 strand barbed wire security overhang.

5.2 STORM DRAINAGE AND SURFACE WATER MANAGEMENT

144. The drainage systems normally associated with a closed disposal site addresses three components:

- Uncontaminated upslope run-off
- Uncontaminated run-off from the capped site
- Contaminated leachate generated within the landfill

145. Generally, the uncontaminated upslope run-off is diverted around the site into a natural drainage course. Surface run-off from the capped sites is also considered to be un-contaminated and channeled to peripheral drains

146. A trapezoidal stone-pitched open drain is to be constructed around the eastern and southern sections of the Oblogo No.1 site while the Mallam SCC site will rely on the existing concrete road-side drain abutting the northern face of the site.

5.3 CLOSURE AND END-USE

147. The objectives of the end-use design of closed disposal sites are as follows:

- To creation an aesthetically acceptable landform with gentle slopes (not exceeding 1:3) that, as far as possible, blends in with the surrounding terrain.
- To maximize the beneficial use of the generated open-space by local communities.

5.3.1 FINAL LANDFORM AND END-USE

148. The proposed final shape of the landfill has been determined according to topography, drainage and possible end-use requirements.

149. The completed and capped site is to be shaped to final contour levels as shown on drawings on the following pages. Selected sections through the sub-surface irrigation are also shown.

150. Based on the surrounding topography, the maximum height of the landfill will be about 5m above the original natural ground level of the Oblogo Site. The upper surface of the

capped site is to have general slopes of at least 1:50 to promote rapid drainage of the surface.

151. It is recommended that the sites be returned to the local community as a park. The end-use of the site should be discussed with all stakeholders as part of the ongoing public participation programme to ensure that the rehabilitated site is acceptable to them.

152. Revegetation of the sites will commence as soon as capping commences. Indigenous trees and shrubs are to be planted around the site for screening purposes, as well as in any areas where the substrate will support tree growth. Over the rest of the site, grass is to be established using indigenous grass types. For the Oblogo No.1 site vegetation will be planted to create a "the rising green wall effect" by progressively grading the vegetation to follow the slopes of the site.

153. After closure of the sites on-going management will be required to maintain the integrity of the capping and vegetation

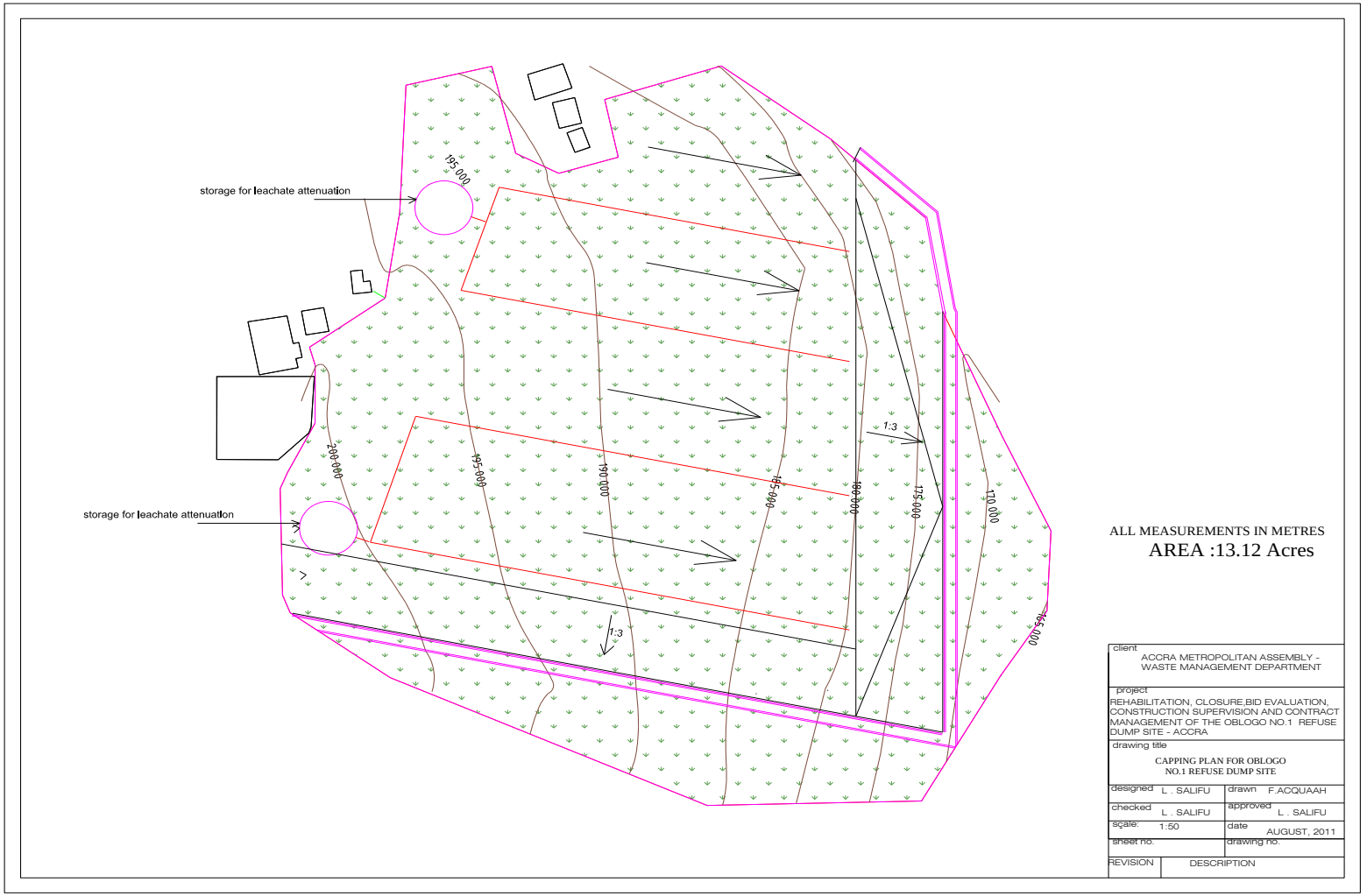


Figure 5-1: Plan view of Oblogo No.1 Dumpsite showing final shape with peripheral drains

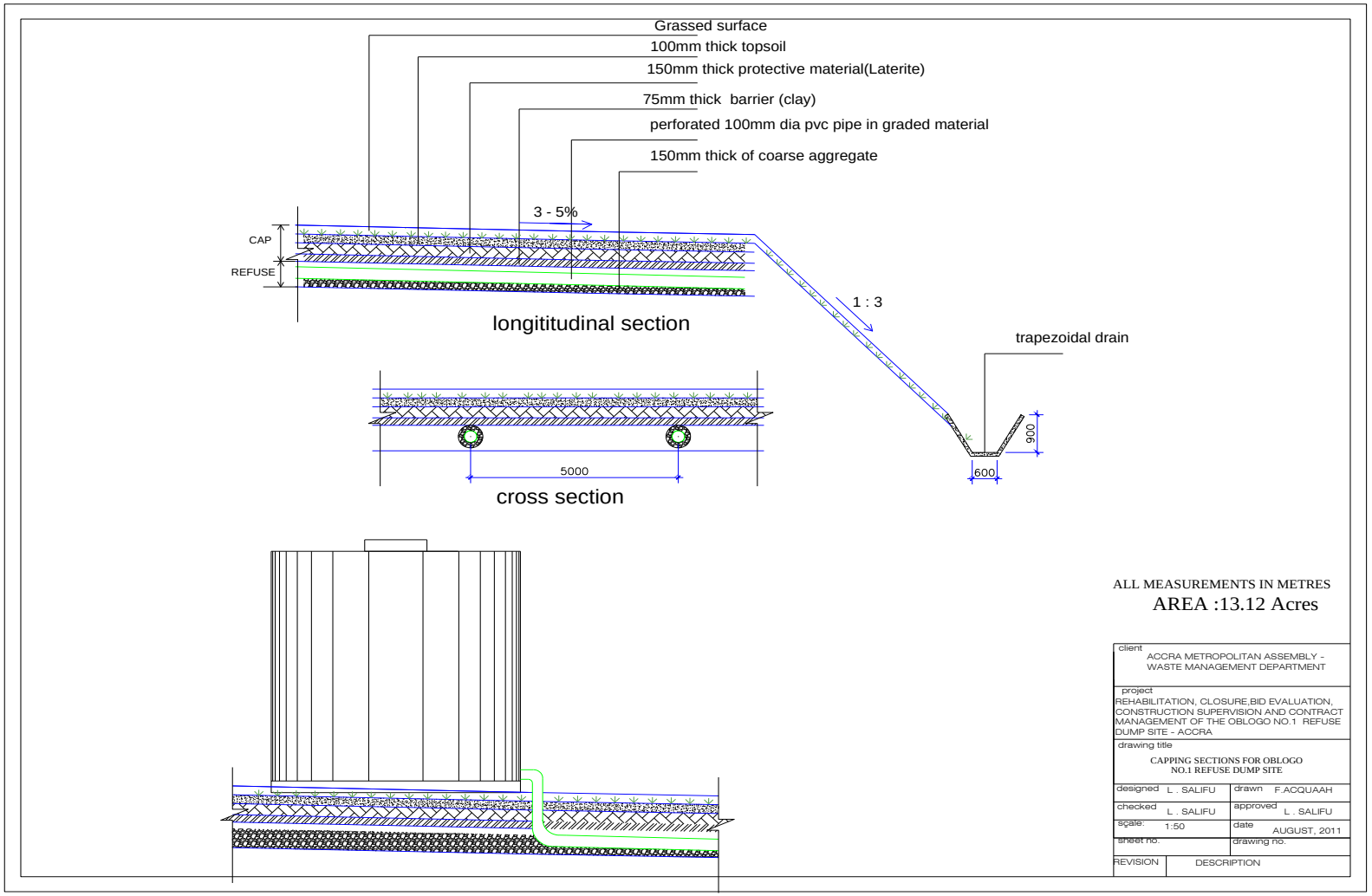


Figure 5-2: Vertical cross section of Oblogo No. 1 Dumpsite showing 4 multi-layer capping system.

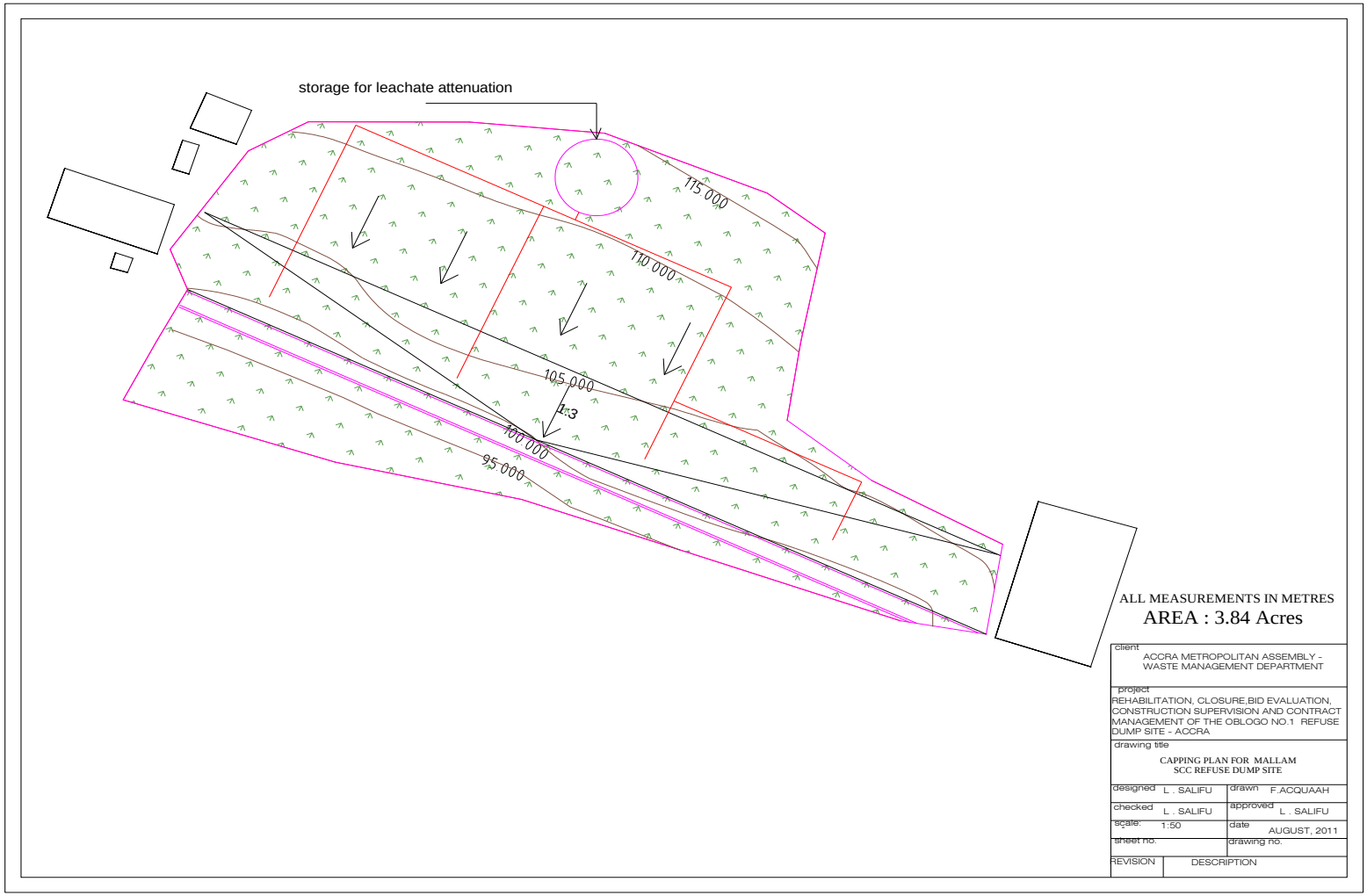


Figure 5-3: Plan view of Mallam SCC Dumpsite showing final shape with peripheral drains

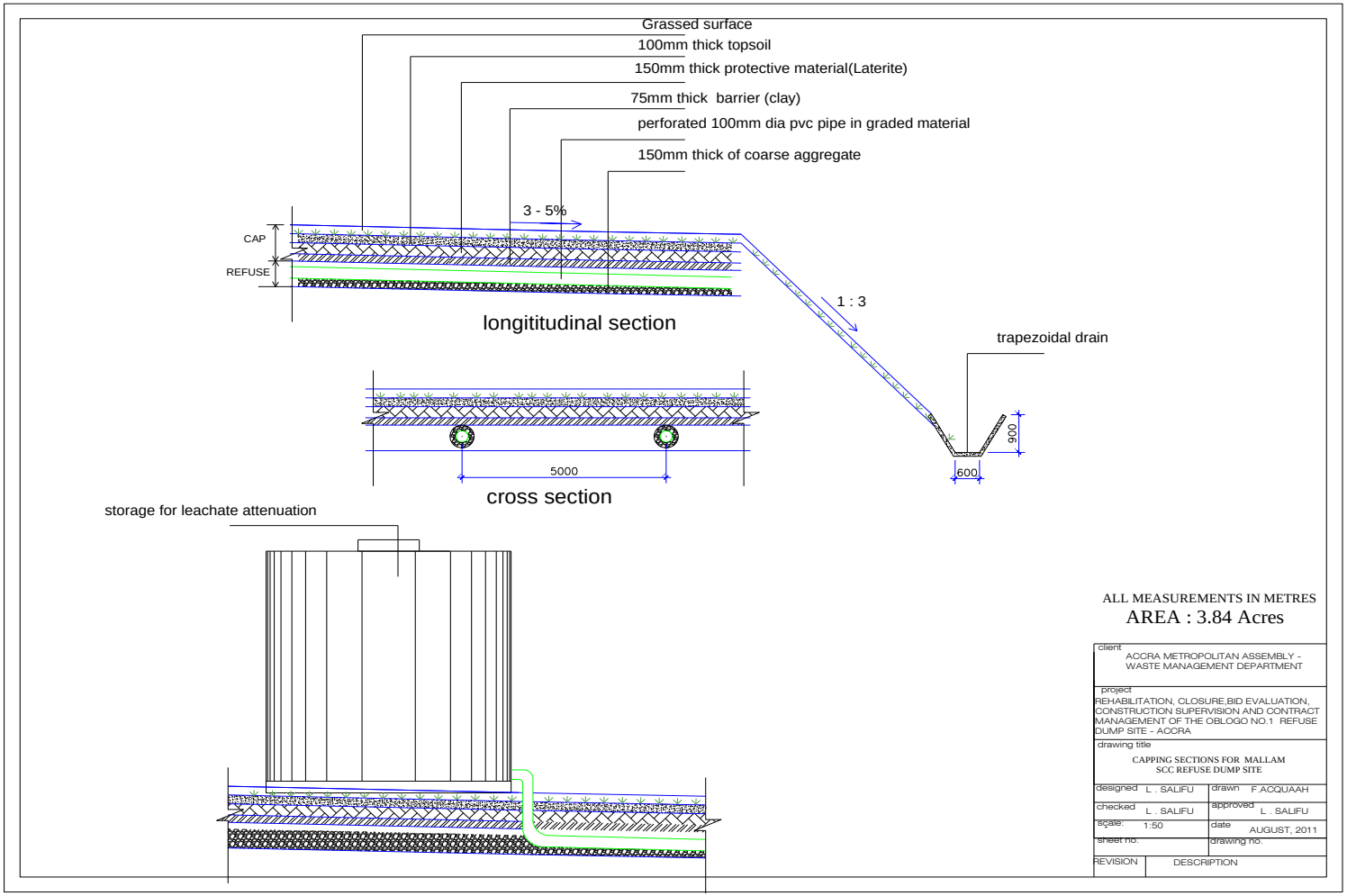


Figure 5-4: Vertical cross section of Mallam SCC Dumpsite showing 4 multi-layer capping system

6. COSTING

6.1 INTRODUCTION

154. The rehabilitation, closure and after-care management costs provided in this report are based on preliminary engineer's estimation of the quantities and current market prices for similar works items and goods on the local market.

7. CONCLUSION

155. Based on the overall objective for the rehabilitation, closure and after-care management as provided in the ToRs for the assignment it is concluded that the detailed design for the proposed facilities as presented in this design report and as shown on the accompanying drawings, meets the stated intention within the constraints stated earlier.

156. The estimated cost for rehabilitation and closure GH₵…(..), or US$...(…), which is within the stated budget of US$300,000.00.

157. Additionally there is an estimated annual after-care (post-closure) operation and maintenance management cost of US$.... The initial 3-year cost amounts to GH₵…This is cost is not inclusive of price contingencies.

8. RECOMMENDATIONS

158. Based on the discussions of the above designs proposed and the conclusions reached it is recommended that the Accra Metropolitan Assembly and the Environmental Protection Agency (EPA) of the Ministry of Environment, Science and Technology (MEST) review/comment on the Draft Detail Design submitted herewith, with a view to approval of the design for subsequent implementation within the shortest possible time.

159. Furthermore it is recommended that the implementation of the Rehabilitation and Closure be implemented in two (2) lots but with the allowance for one contractor with the requisite equipment and skill to bid for the separate lots. This recommendation is made in the light of the urgency and time limitation for executing the project within 10 working weeks (2½ months) including week-end work-hours.

160. It is also recommended that the funds for post-closure (after-care) operation and maintenance management be secured immediately the capping of the site is completed in order to ensure integrity of the installed facility beyond the defects liability period of 6 months

ANNEXES