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MINISTRY OF LOCAL GOVERNMENT AND RURAL DEVELOPMENT (MLGRD)

GA SOUTH MUNICIPAL ASSEMBLY

GHANA NETHERLANDS WATER, SANITATION AND HYGYIENE (WASH) PROJECT.

CONSULTANCY SERVICES FOR TECHNICAL ASSISTANCE FOR THE DESIGN, PROCUREMENT OF WORKS, CONSTRUCTION SUPERVISION AND CONTRACT MANAGEMENT FOR THE REHABILITATION, CLOSURE, AND AFTER-CARE MANAGEMENT FOR THE SABA REFUSE DISPOSAL SITE IN WEIJA, ACCRA

FINAL DETAIL DESIGN REPORT

WASTECARE

CONSULTANT
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

Ga South Municipal Assembly
Ghana Netherlands WASH Project
PMB 2
Weija
Tel: 233- 28-9532910/28-9532911
E-mail: gsmaweija@gmail.com

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1. INTRODUCTION

1.1 Project Background

1. The Ministry of Local Government and Rural Development (MLGRD) and the Embassy of the Kingdom of Netherlands (EKN) in Accra, Ghana are collaborating to implement the planned Ghana Netherlands WASH Programme in five (5) Assemblies: Cape Coast Metropolitan, KEEA (Elmina), Ga West, Ga Central, and Ga South Municipal.

2. As part of formulating procedures and ensuring familiarization of the five selected Assemblies in processes of the proposed WASH Project, the EKN is funding a number of project preparatory activities. These preparatory activities include the identification of feasible quick impact projects by the selected Assemblies. These projects are expected to be completed within a 6-month period ending June, 2013 and provide the respective Assemblies with some "gains" in improving aspects of municipal services.

3. The Ga South (Weija) Municipal Assembly (GSMA) has identified the rehabilitation and closure (capping) of the Saba refuse disposal site as one such quick "gains" project.

4. The Saba dumpsite was opened in 12th December, 2009 as a waste disposal site for the whole of Accra Metropolis by a private operator Zoomlion (Ghana) Limited in collaboration with the GSMA. The site was closed in 14th June, 2012. The site covers an area of approximately 3.9 hectares (9.64 acres) and is approximately 20 kilometers from the city centre of Accra. The daily tonnage of waste received at the Saba disposal site was approximately 1,200 tonnes including industrial waste

5. The GSMA in early-January 2013 engaged the services of a consultant to study options for rehabilitation and closure of the dump site including putting in place an effective after-care management particularly for the management of leachate.

6. The Consultant's team visited the dump site within the general area – Saba refuse dumpsite in Late-January 2013 as part of reconnaissance and characterization.

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

8. The design and accompanying reports reflect the Consultants appreciation of the ToRs and GSMA's desire to urgently implement remedial actions to the issue of leachate and other adverse impacts at the saba dumpsite.

1.2 Objectives of Assignment

9. From the ToRs and discussions with GSMA the objectives of the assignment comprise the following:
   i. Review the existing situation of the Saba refuse disposal site and prepare all necessary documentations including design for the various materials for capping, appurtenances and ancillaries;
   ii. Providing technical assistance for management of the process for procurement of works for its rehabilitation, closure and decommissioning; and

iii. Supervise the works for rehabilitation and closure (capping) of the refuse dumpsite.

10. 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

11. The scope of the Consultant's assignment as presented in the TORs is reproduced below. The Consultant's services are limited to the Saba dumpsite.

12. 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

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

Saba Dumpsite

a. Determine the sources and quantities of cover material for the rehabilitation and capping of the Saba 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 Saba 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.

Phase II

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

Evaluation of Bids and Preparation of Contract Documents

15. 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

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

17. 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 GSMA as to the date of the Final Inspection of Works;
b. Carry out final inspection of the works together with representatives of the Ga South Municipal 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.

18. 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 the disposal site (even not engineered as for the current case) goes beyond the usually applied defect liability period of 6 months.

19. 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 Saba site

20. 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 Saba Site

comprising a topographical sheet of the prepared for during initial site planning was made available by the GSMA-WMD.

21. 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 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.

22. In order to meet the requirements of the ToRs and also provide the GSMA 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.

23. 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

24. The Saba disposal site is located in the Ga South Municipal Assembly of the Greater Accra Region.

2.1.1 SABA DUMPSITE

25. The site, an abandoned quarry pit covering an estimated area of 3.9 hectares.

26. The site is located on the crest of a hill northeast to the main town of weija. It can be assessed by an untarred hilly road that turns right about 350m from the weija road which is about 2.3km from the main weija junction off the main Mallam-Kasoa Road. The same weija road runs in front of an adjoining road leading to the huge recently covered oblogo dumpsite.

27. Untreated leachate flows through crevices in the rock mass into a sump southeast of the site and also seeps from the placed refuse and flows through rain created gullies along the front face and base of the refuse heap and through nearby residential properties, The leachate flows onward through roadside concrete drains and diverts through a culvert leading to a nearby stream outfall known as the Lower Densu. The leachate contaminated stream flows through to the salt pan of Panbros Limited

Plate 2-1: View of Saba dumpsite

Plate 2-2: leachate collection on site

Plate 2-4: Close-up shot of Saba dumpsite showing high composition of polythene

Plate 2-3: Flow of leachate from dumpsite into a u-drain

2.2 OWNERSHIP

28. According to available information furnished by GSMA-WMD the land has been released to GSMA for disposal operations based on agreement with the owners of the land and the Accra metropolitan Assembly.

29. A clear conveyance notice of status of ownership of the site(s) and hence leave of entry and continued operation is important so as 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 ENGINEERING STUDIES

30. 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

31. 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.

32. 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.

33. 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.

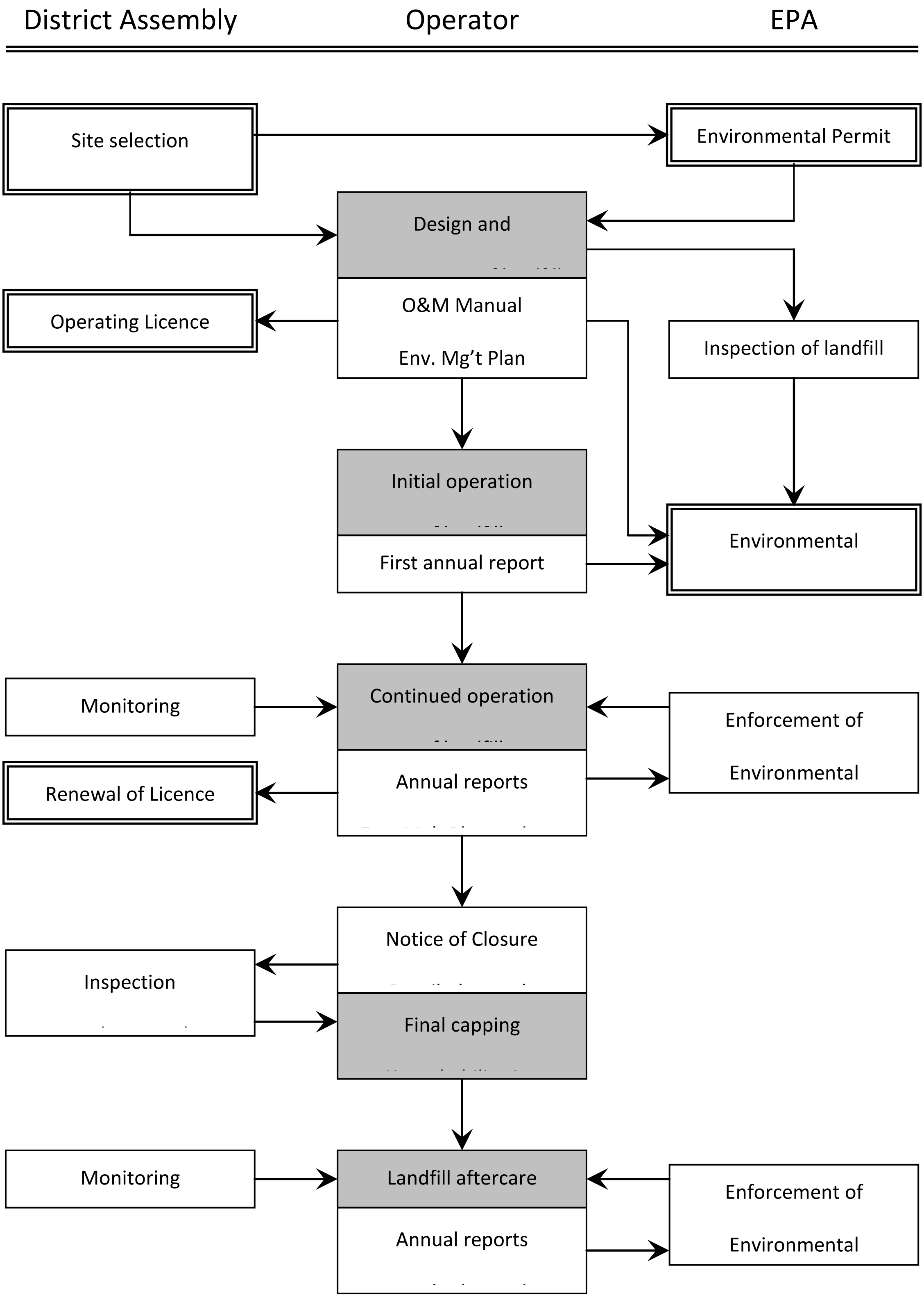
34. The specific studies carried out leading to the preparation of this design report to meet requirements of the TORs and regulatory framework is discussed under the following sections.

3.1.1 List of Landfill Types and Facilities Required

35. In considering the engineering design standards applicable to the rehabilitation, closure and after-care management of the Saba Dumpsite, the Ghana Landfill Guidelines is relied upon. Where appropriate, comparison and/or adoption of other standards is resorted to for completeness.

36. 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

37. 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.

38. **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.

39. The poor operation and maintenance of the dump site 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 the assemblies.

40. **Water Pollution:** refuse placement at the disposal site 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.

41. **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 Saba dump site to the Densu River at Weija where treatment of the drinking water takes place is of great concern.

42. 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 this site spreading to the surrounding residences.

43. The Saba disposal site was operated as a temporary site 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.

44. Minimal scavenging was observed while dumping operations at Saba dumpsite has ceased. The main concern as pointed in earlier sections is for the appropriate management of leachate and run-off from the sites.

45. 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).

46. 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

47. The proposed site is characteristic of the general area stretching from 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.

48. Topographical surveys were carried out on the site to establish the dumpsite boundaries and spot heights picked along 5m intervals grid lines. From the survey, the Saba dumpsite cover approximately 3.9 hectares (9.64 acres)

49. 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.

50. Figures 3.2 below shows topographical maps of Saba dump site.

3.3 Solid Waste Volumes and Characteristics

51. There is limited data on the volumes and characteristics of placed waste at the dumpsite. 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 Ga South Municipal Assembly

COMPOSITE OF MUNICIPAL WASTE BY MAIN MATERIAL GROUPS			
Organic	*55%*	*Inorganic*	*45%*
Paper	*15*	*Metal*	*5%*
food materials	*24*	*Glass*	*10%*
Animal waste	*5*	*Plastics*	*30%*
Wood	*4*		
Textile	*7*		
Total	*55%*		
Density	*o.47t/m3*		
Moisture Content	*40%*		

Source: Waste Management Department of GSMA (2012)

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

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Table 3-3: average tonnage of waste generated and collected in weija

GA SOUTH (WEIJA) MUNICIPAL ASSEMBLY WASTE MANAGEMENT DEPARTMENT WASTE GENERATION AND COLLECTION PROJECT POPULATION OF 2012 - 320,000 (BASED ON POPULATION CENSUS 2000)		
		METRIC TONS
1	*Estimated total waste generated per day -*	*172.8*
	Estimated total waste generated per week -	*1209.6*
	Estimated total waste generated per month -	*4838.4*
	Estimated total waste generated per year	*251596.8*
2	*Estimated total waste collected per day*	*103.68*
	Estimated waste collected per week	*725.76*
	Estimated waste collected per month	*2903.04*
	Estimated waste collected per year -	*34836.48*

Source: GSMA Waste Management Department

3.4 Existing Water Usage

52. Saba is the name of the settlement around the Saba refuse dumpsite. Residential properties are within 20 m of from the boundary of the fill material.

53. The inhabitants of saba rely on pipe-borne water from the Weija dam. Access to water coverage is generally above 90%. There are reports of isolated boreholes and wells located within the communities but exact locations were not ascertained due to time constraints.

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

3.5 Fauna and flora

55. 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

56. The nearest residential development to the site as described above is the Saba community. There are existing Electricity Poles belonging to the Volta River Authority and dumpsite lights running in an south-western direction across the site, about 2m from the southern edge of the site.

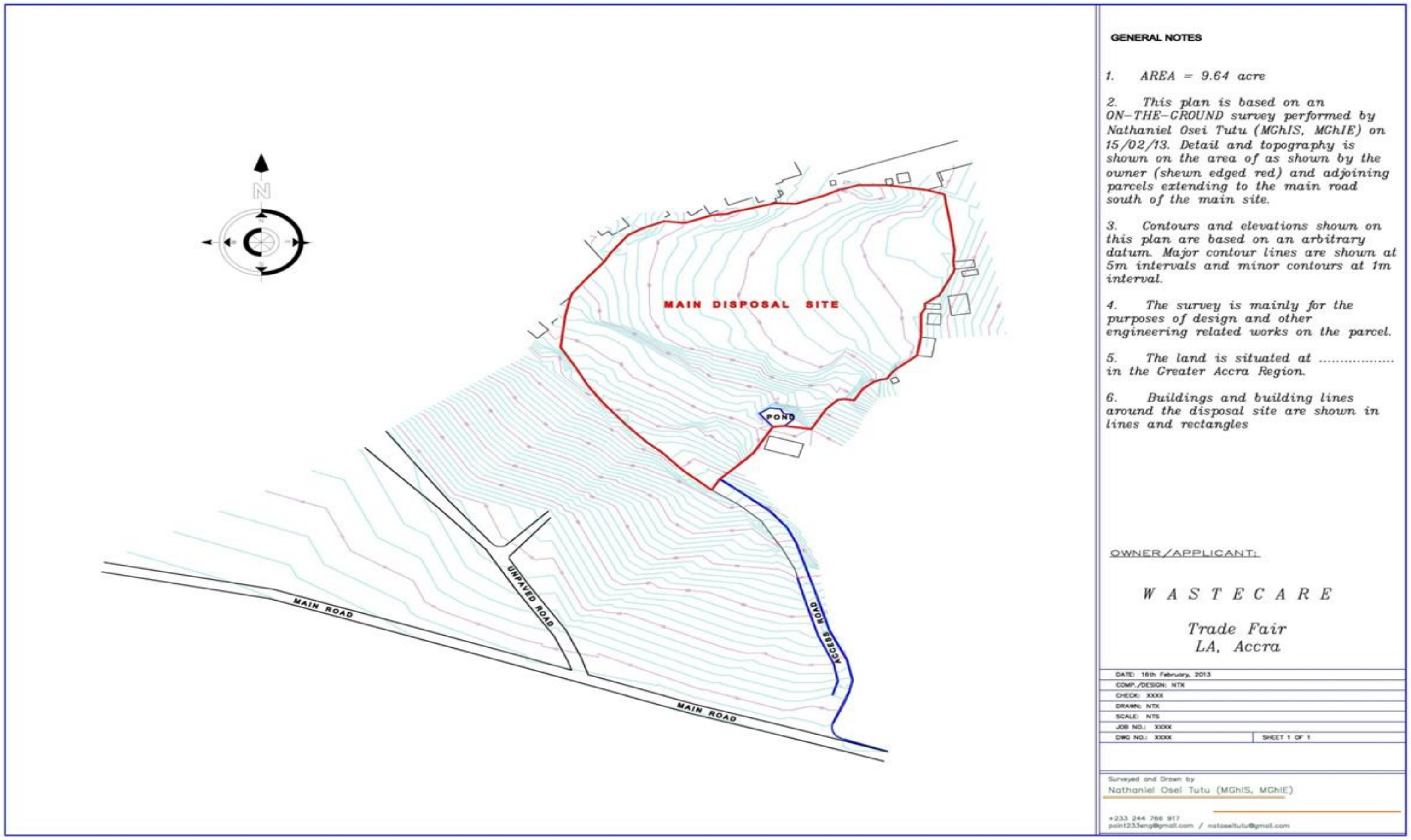

Figure 3-2: Topographic Map of Saba Refuse dumpsite

3.7 CLIMATE

57. The dumpsite is located in the Ga South/Weija Municipality. The Municipality is adjoined to Accra Metropolitan Assembly (AMA). The district lies in the coastal climatic zone of Ghana and has 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.

58. 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: average rainfall and temperature data for Ga South Municipal Assembly (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		

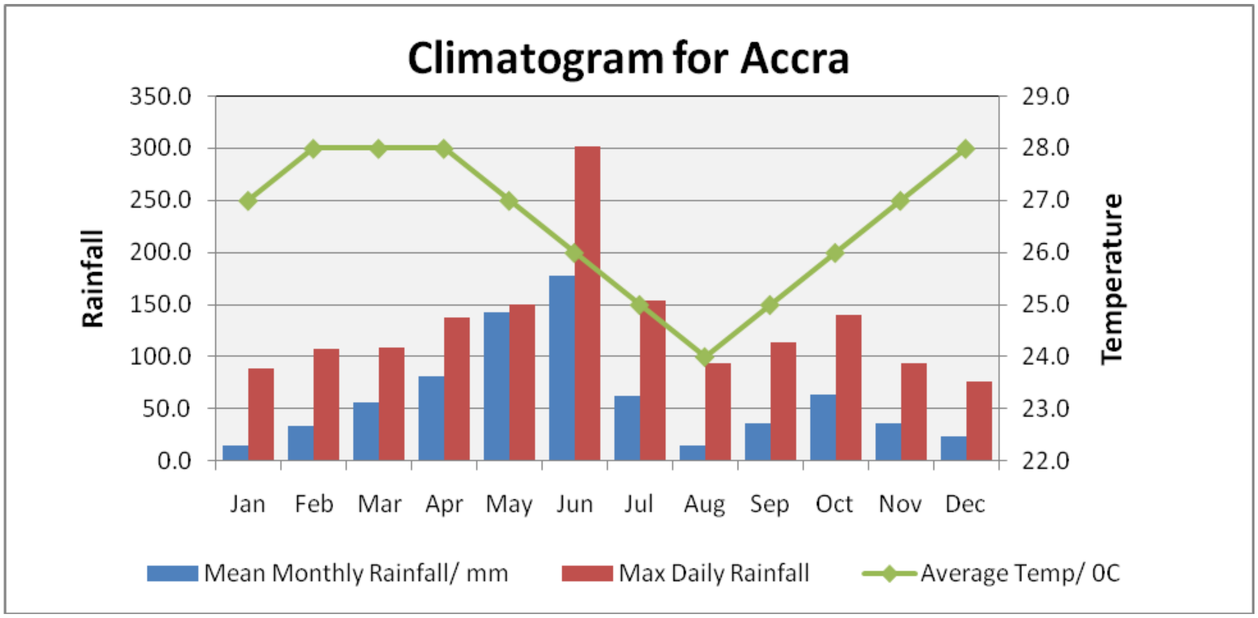

Figure 3-3: composite graph for average rainfall and temperature

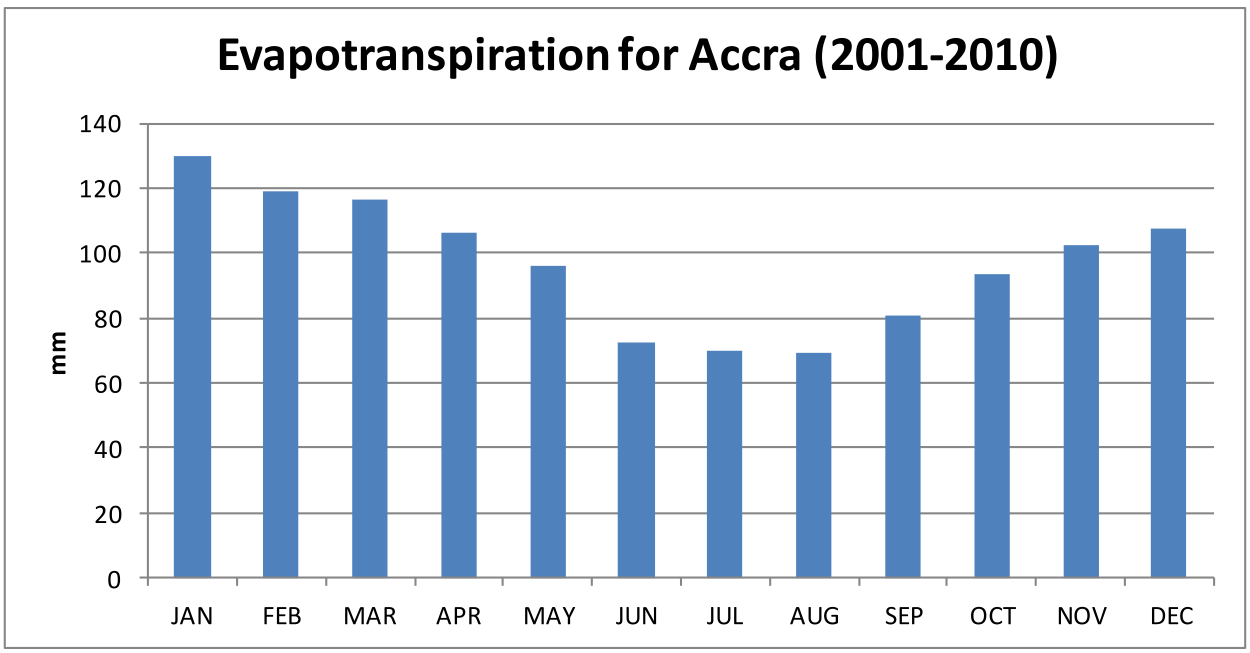

Figure 3-4: mean monthly evapotranspiration for Accra (2001-2010)

Source: Ghana Meteorological Agency

59. 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

60. 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.

61. The Weija township is located within the Togo series lithological group as shown in Figure 3-5.

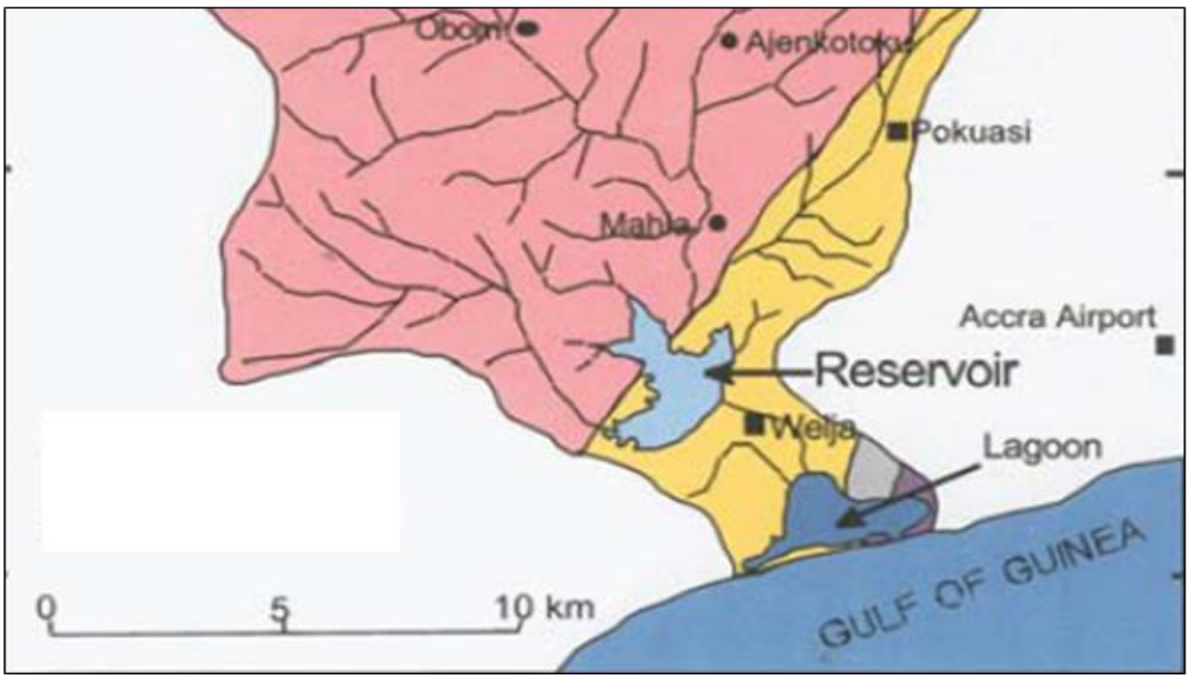

Figure 3-5: Hydro geological Map of Ga South Municipal Assembly

62. The Togo series is characterized by both arenaceous and argillaceous overburdens. The arenaceous overburden has very low attenuation capacity and high infiltration rates. The argillaceous overburden has good attenuation capacity and low infiltration rate. There is occurrence of groundwater at shallow depths. Consequently, groundwater vulnerability for the Saba site can be categorized as very high.

63. The Weija township is situated in an area that has very low intensity of erosion. It is also outside the potential high and medium rockfall zones.

3.9 Leachate Flows and Quality

64. The Saba dumpsite does 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 3.6, especially in the presence of highly-permeable sub-strata. Leachate from this dumpsite through adjoining earth gullies and the main roadside drains/culverts into the tributaries of the Densu River downstream of the Weija reservoir.

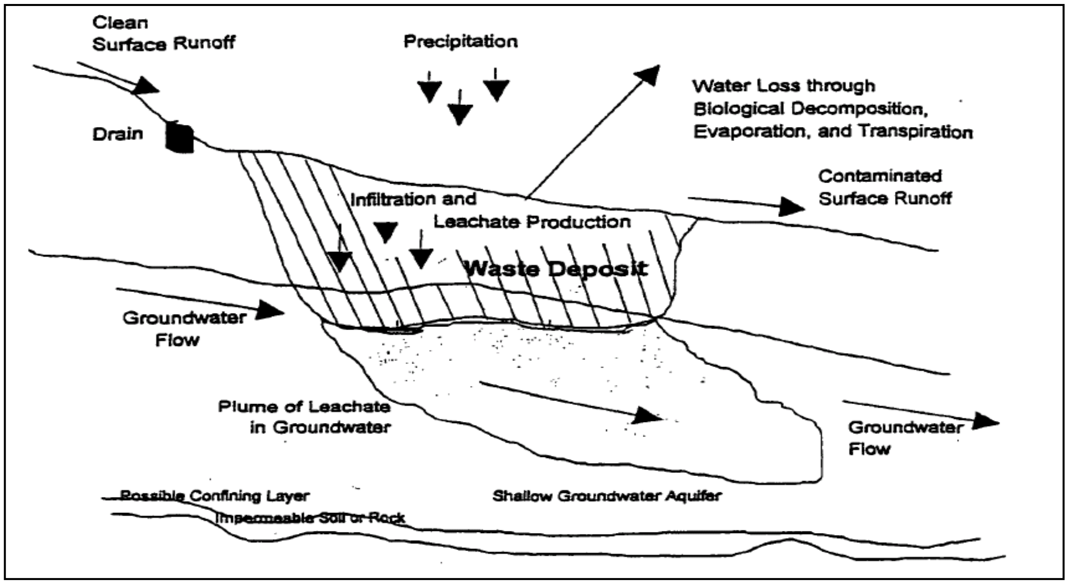

Figure 3-6: Uncontrolled Leachate Flows from Un-Engineered Dumpsites

65. 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.

66. 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).

67. 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.

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

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 ***Waste Care***

Postal Code+

City ***Accra***

Lab Code

Site Name

Analysis start date 11/02/13

Analysis stop date 19/02/13

Sample ID	pH (pH Units)	Turb (NTU)	BOD (mg/l)	COD (mg/l)	Col (mg/l)	TSS (mg/l)	PO_4 (mg/l)	NO_3-N	NH_4-N (mg/l)	Oil/Grease (mg/l)	Pb (mg/l)	Fe (mg/l)	Zn (mg/l)	FC/100ml (mg/l)
S1	7.62	49.4	378	14308	7500	550	9.62	2.33	62.1	64.0	0.081	19.5	0.480	60000
S2	7.11	443	758	3937	2500	7370	6.89	1.13	130	14.0	<0.005	4.78	0.039	90000
S3	7.19	40.1	173	246	37.5	42.0	3.60	0.226	8.39	6993	<0.005	0.305	0.015	3000
EPA Guideline Value	**6.00-9.00**	**75.0**	**50.0**	**250**	**75**	**50.0**	**2.00**	**50.0**	**1.00**	**10.0**	**0.100**	**5.00**	-	**10**

Approved by:

for: [signature]

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

CSIR WATER RESEARCH INSTITUTE
P. O. BOX M32, ACCRA
P. O. BOX 38, ACHIMOTA

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

Sample S1 was the leachate directly taken from the dumpsite .

Sample S2 was taken from the downstream of the lower Densu River around its contact zone with the leachate

Sample S3 was taken from the upstream of the lower Densu River around its contact zone with the leachate

3.10 HYDROLOGY

69. The Weija township is located within the catchment of the Lower Densu Basin in the Ga South Municipality. The main surface water resources in this area include Weija Reservoir, the Densu Delta lagoon and tributaries of the Densu river as shown in Figure 3.4. The Weija Reservoir is a major source of potable water supply for the Accra metropolis whereas the lagoon is categorized as a Ramsar wetland.

70. The Saba dumpsite is located downstream of the Weija reservoir.

71. 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 and the construction of a sump for recirculation of leachate can be considered as some of the measures that can be used to minimize the potential risk of polluting the nearby river.

72. 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

73. 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 Ga South Municipal 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.

74. 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 Saba dumpsite. More specifically, the design presented is aimed at minimizing the potential for pollution from leachate of ground water and surface water bodies.

75. The layout and details of the design proposed for the site is shown in the drawings included with this detailed design report.

4.2 PRELIMINARY DESIGN CONSIDERATIONS

76. 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.

77. 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

78. 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.

79. 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.

80. 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.

81. 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.

82. 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.

83. 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 ESTIMATING LEACHATE VOLUME

84. The leachate quantity for the Saba site was calculated using water balance method. A water balance for a landfill is generally indicated to include the following components:

Leachate = Precipitation + Moisture Content of Incoming Wastes +Inflows of Ground and Surface Water – Runoff – Evapotranspiration – Field Capacity of Waste.

85. For capped site as those under consideration the drainage design and operation assume that no inflows of ground and surface water into the zone of leachate generation and where re-circulation will occur; leachate volume for the dumpsite is thereby estimated based on the water balance.

86. In order to properly size and design the leachate collection, transmission, and treatment systems, estimates of maximum monthly, minimum average daily, maximum average daily,

and peak daily flows are often required. The water balance aids in predicting these flow rates, and can be used throughout the life of the landfill, with appropriate modifications, to determine treatment modifications which may be required.

4.4.2 ESTIMATION USING THE HELP MODEL

87. The Hydrological Evaluation of Landfill Performance (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.

88. 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.

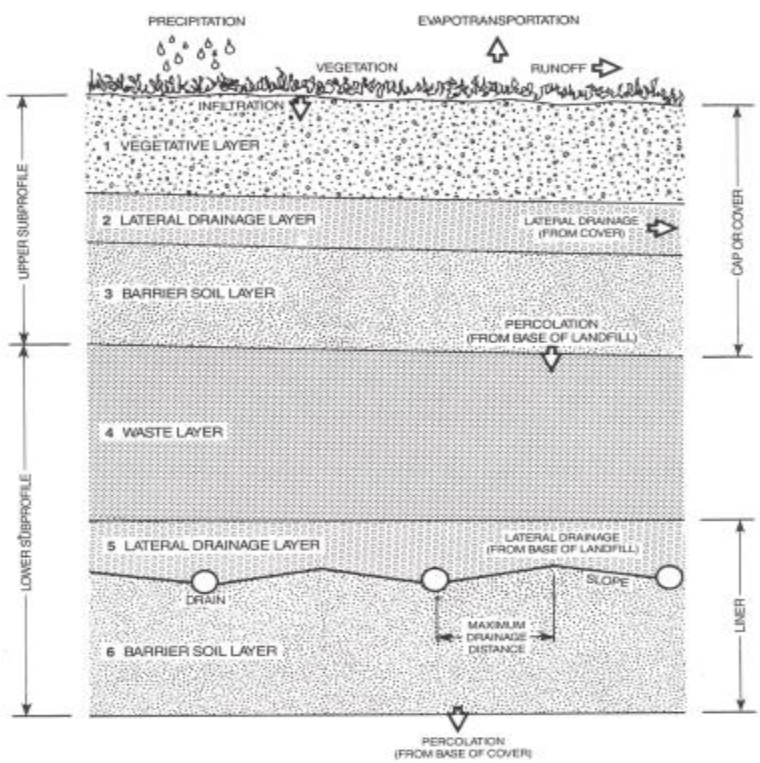

Figure 4-1: Capped Landfill Profile Modeled by Help

89. 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.

90. Two scenarios were considered in determining the leachate volumes for the capped landfill based on normal and extreme rainfall patterns respectively.

4.4.3 Scenario 1: Leachate Generation for Normal Rainfall Pattern

91. The average monthly rainfall values and temperatures recorded at the Accra Airport synoptic station is used for this simulation. The coordinates for this location are latitude 05.60N and longitude 0.16 W. The climatic data is presented in Table 4-2. Surface runoff will be neglected.

Table 4-2: Climatic data for weija

Month	Rainfall		Temperature (deg ^oC)
	Mean Monthly (mm)	Max Daily (mm)	
January	15	89	27
February	33	107	28
March	56	109	28
April	81	137	28
May	142	150	27
June	178	302	26
July	62	154	25
August	15	94	24
September	36	114	25
October	64	140	26
November	36	94	27
December	23	76	28

92. The simulation results for various soil moisture capacities i.e. 25mm, 50mm and 100mm are shown in Table 4-3. It is observed the infiltration rates through the cover would be negligible even during the wet seasons of the year when a maximum soil moisture capacity of 100mm which is representative of a typical grassed landfill cover is used for simulation. The range of between 7 and 32 mm can be expected for other moisture capacities between 25 and 100 mm.

Table 4-3: Scenario 1 Leachate Percolation Rates

	Soil Moisture Capacity		
Month	**100mm**	**50mm**	**25mm**
Jan	0	0	0
Feb	0	0	0
Mar	0	0	0
Apr	0	0	0
May	0	0	0
Jun	0	7	32
Jul	0	0	0
Aug	0	0	0
Sep	0	0	0
Oct	0	0	0
Nov	0	0	0
Dec	0	0	0

4.4.5 SCENARIO 2: LEACHATE GENERATION FOR EXTREME RAINFALL PATTERN

93. A hypothetical extreme rainfall using historical maximum daily rainfall values recorded for each month was simulated. Surface runoff was included using the runoff coefficient of 0.15 which is representative for grassed landfills with a mild slope of 2-7%.

94. The simulation results are presented in Table 4-4. It is observed the infiltration rates through the cover would be negligible even during the wet seasons of the year when a maximum soil moisture capacity of 100mm which is representative of a typical grassed landfill cover is used for simulation. The leachate rates will range between 10 and 118 mm.

Table 4-4: Scenario 2 Leachate Percolation Rates

	Soil Moisture Capacity		
Month	**100mm**	**50mm**	**25mm**
Jan	0	0	0
Feb	0	0	0
Mar	0	0	0
Apr	0	0	0
May	0	0	0
Jun	56	94	118
Jul	10	10	10
Aug	0	0	0

Sep	0	0	0
Oct	0	0	0
Nov	0	0	0
Dec	0	0	0

4.4.7 LEACHATE VOLUMES FOR SABA DUMPSITE

95. The land surface area for the Saba dumpsite is 39000 m^2. The estimated daily maximum volumes are presented in Table 4-5.

Table 4-5: Maximum Daily Leachate volumes for Saba Dumpsite

Month	Maximum Daily Leachate Volume (m^3/day)	
	Normal Rainfall	**Extreme Rainfall**
Jan	3.8	694.2
Feb	9.2	834.6
Mar	14.1	850.2
Apr	21.1	1068.6
May	35.7	1170
Jun	46.3	2355.6
Jul	15.6	1201.2
Aug	3.8	733.2
Sep	9.4	889.2
Oct	16.1	1092
Nov	9.4	733.2
Dec	5.8	592.8

4.5 LEACHATE COLLECTION AND RE-CIRCULATION SYSTEM

96. 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.

97. The primary criterion for design of the leachate system is that all leachate be collected and removed from the landfill at a rate suffcient 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.

98. 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.

99. 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).

100. 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.

101. 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.

102. For the Saba dumpsite, where dumping operation has proceeded without embankments and leachate collection facilities, the challenge is to determine and ensure that the leachate being generated substantially flows to a collection point and thence treated and disposed of without adverse impacts.

103. The above characteristics of this site reduce the aforementioned challenges to one of adequate treatment and disposal of the leachate from the collection points (sumps). This is the main remedial design consideration provided by the consultant - the WasteCare Sub-surface Irrigation of Re-circulated Leachate (WC-SIRL) system.

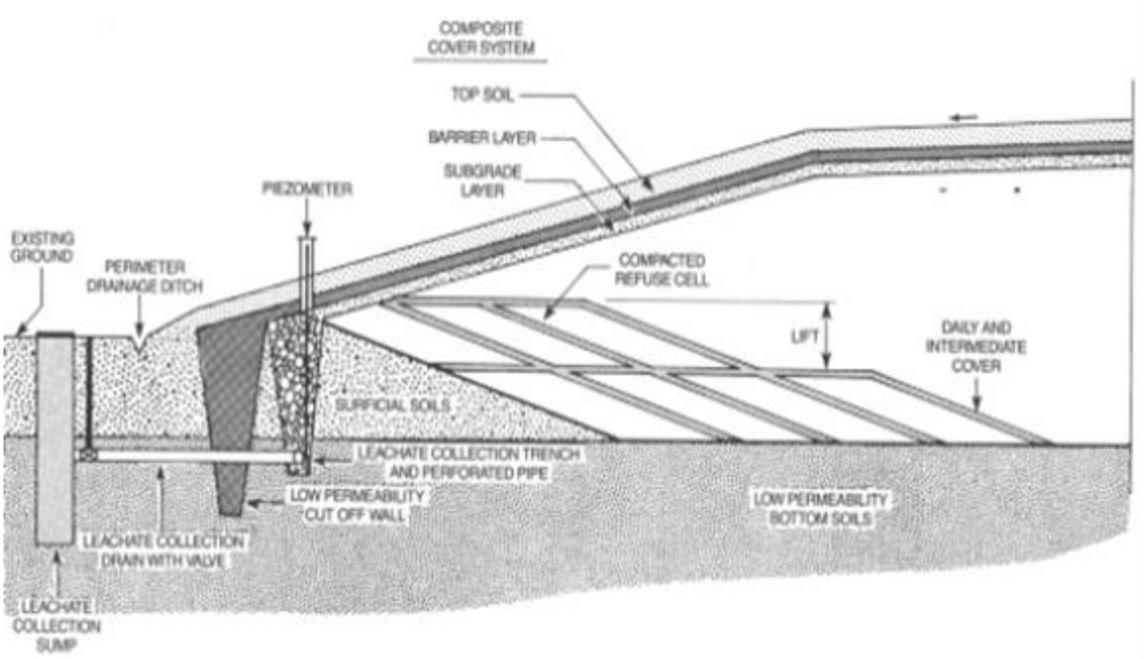

Figure 4-2: Generic Leachate Collection System for an unlined Landfill (in operation)

104. 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.

105. 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.

106. 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.

107. 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.

108. 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.

109. 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 (or HDPE) pipes.

110. 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

111. 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.

112. 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.

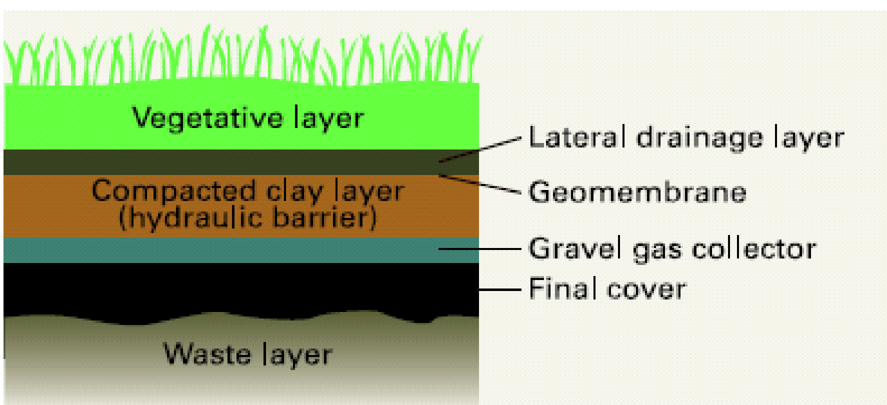

Figure 4-3: Schematic of Landfill Final Cover

113. 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

114. 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

115. 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

116. 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 4-6: 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)	100	1.7×10^{-5}
Barrier soil layer	Compacted Clay	150	1.0×10^{-7}

4.6.3 ESTIMATING THE VOLUMES OF FINAL COVER MATERIALS

117. 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

118. The volumes of the natural soil materials required at the Saba project site which has a land surface area of 3.9 hectares with 3.3 hectares being the rehabilitated area for the final cover design profile is shown in Table 4-5

Table 4-7: Cover Material Volumes for Cover Design Profile

Material	Volume (m^3)
Loam	3300
Laterite	3300
Compacted Clay	4950

4.6.4 FINAL CAPPING SYSTEM LAYOUT AND BOUNDARIES

119. The provision of the capping system will result in the reduction of the land surface area occupied by the dumpsite 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.

120. Figures 4-4 and 4-5 show the existing and proposed post–rehabilitation layout for the Saba dumpsite. The new land surface area will be … hectares and a minimum buffer zone of 10 m to the nearest building.

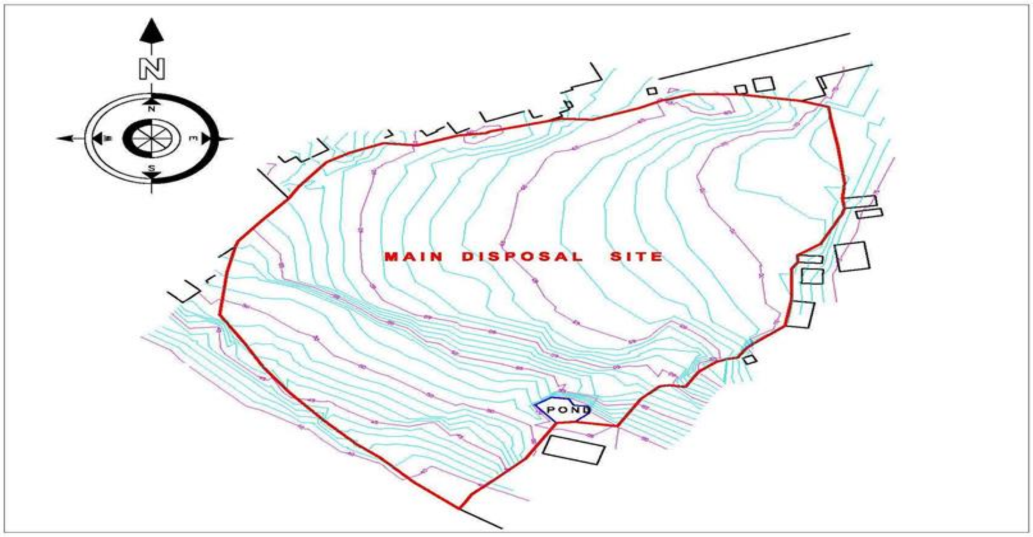

Figure 4-4: Existing Layout of Saba Dumpsite

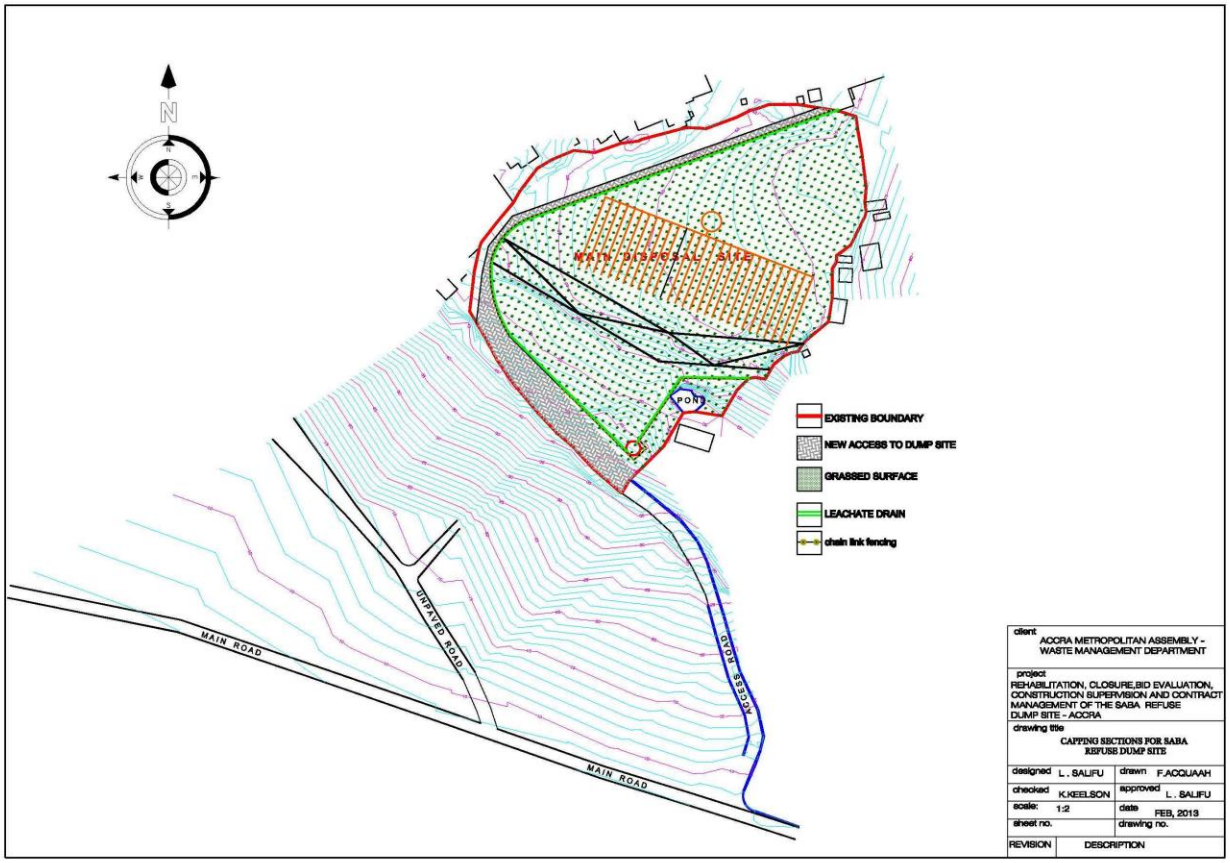

Figure 4-5: Proposed Layout of Rehabilitated Saba Dumpsite

4.6.5 DRAINAGE OF LANDFILL COVERS

121. An integral part of the capping system is the provision of surface water drainage channels round the perimeter of the final landform as illustrated in Figures 4-6 and 4-7 which show the longitudinal and plan views of drainage structures around the perimeter of the final capped form.

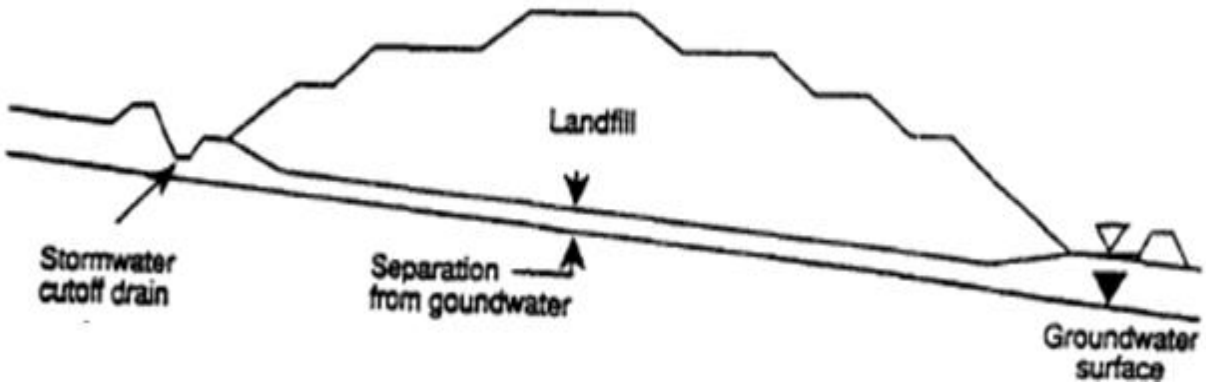

Figure 4-6: Plan view of Capped Landfill and Surface Water Drainage Channels

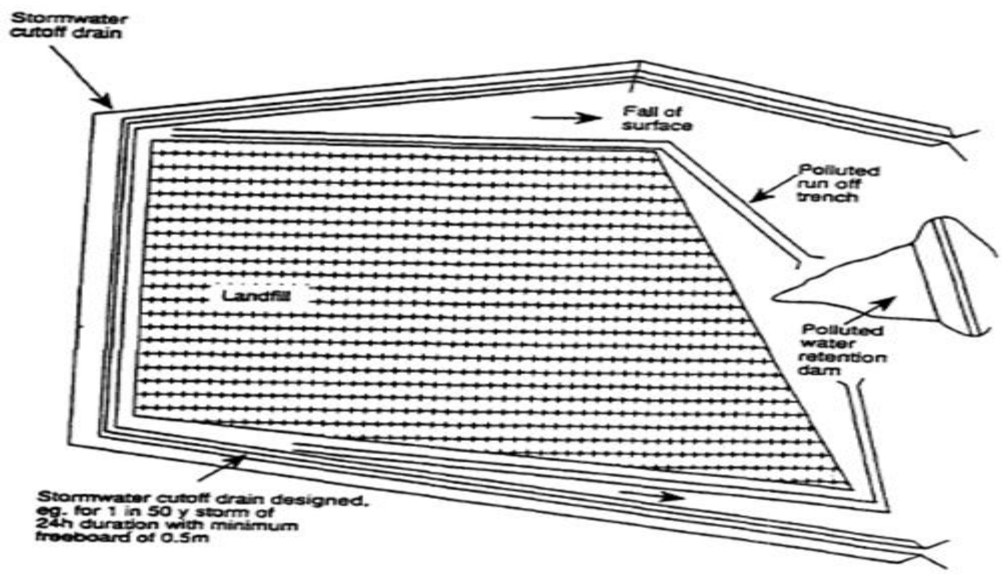

Figure 4-7: Plan view of Capped Landfill and howing shape of peripheral drains

122. The length of the cutoff drains for the two sites which have been determined from the topographical map are shown in Table 4.8

Table 4-8: **Length of perimeter drains at various project sites**

Project Site	**Perimeter Drain Length (m)**
Saba	490

4.7 Constraints and factors affecting design

123. 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:

- 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 provision 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 direction of leachate flows, towards the sumps this case is an indication of the location of lowest point of the disposal site.

4.8 Site Layout

124. Based on the aforementioned constraints and the design considerations the overall layouts for Saba dumpsite have been developed as shown on Figures 4.4 – 4.6. 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.

125. 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.

4.9 Landfill Stability Analysis

126. Two potential landfill infrastructure failure modes were analyzed for the Saba Landfill site. These are:

- Waste slope stability due to shearing of the waste mass as shown in Figure 4.9
- Landfill cover system integrity due to differential settlement of waste and the shearing of the mineral layer as shown in Figure 4.10

127. However the latter was considered as being less critical issue since the damage would tend to be localized i.e. occur at isolated portions of the cover. It is also expected that appropriate compaction procedures would minimize the possibility of the shearing of the cover in the short to medium term.

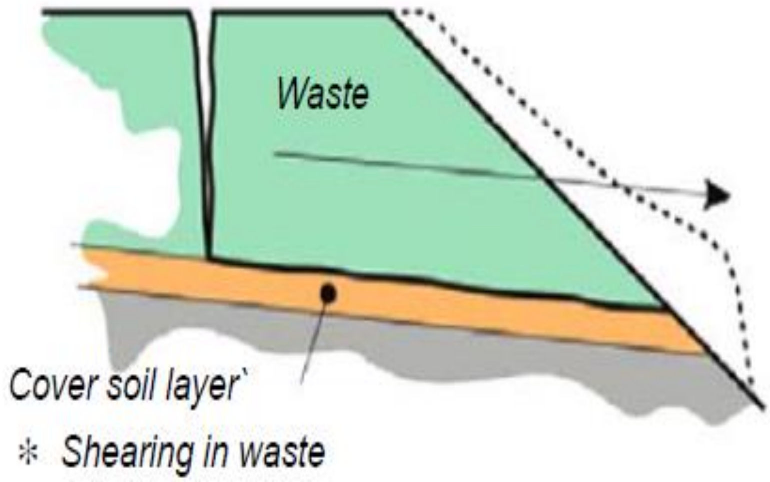

Figure 4-8 Waste slope stability

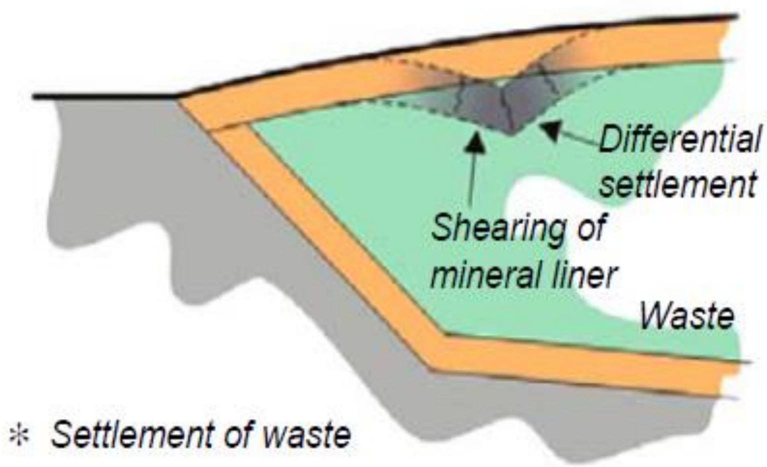

Figure 4-9 Landfill cover system integrity

4.9.1 Waste Slope Analysis

The objective of the waste slope stability analysis was to determine a recommended range of value for the safe slope angle (**i°**) and the height of slope (H) as illustrated in Figure 4.11 below. The mechanical properties of the waste mass used for the preliminary are presented in Table 4.10. These values are based on estimates provided in the South African landfill manual (DWAF, 1998). It was assumed that waste characteristics for Ghana and South Africa are to a large extent similar compared to those of the industrialized countries like Britain and United States.

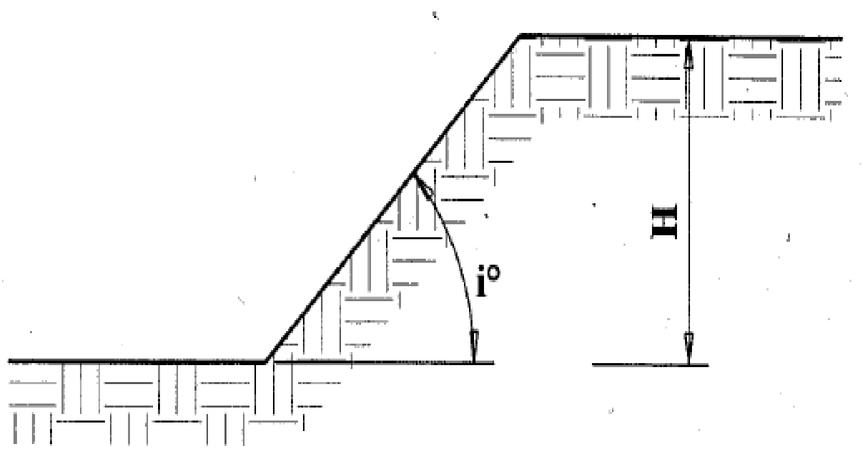

Figure 4-10: Schematic diagram of safe slope angle (i°) and the height of slope (H)

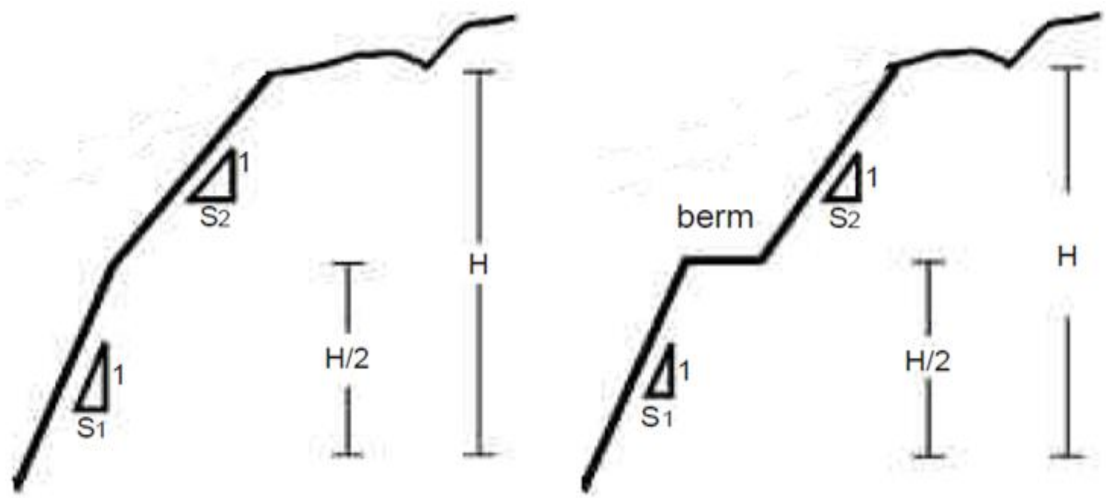

Figure 4-11: Compound slopes and intermediate berms

It is recommended the slope angle should not exceed 30° i.e. 1.7:1 and the maximum slope height should not exceed 60 meters. A range of maximum slope heights and corresponding safe slope angles which would provide a factor safety value of 1.25 as per the South African landfill manual (DWAF, 1998) is presented in Table 4.13. The construction of compound slopes or compound slopes with intermediate berms i.e. terracing shown in the figure 4.11 can be considered. Compaction should be done in thinner layers i.e. about 1.0 m in order to achieve better compaction. The maximum layer thickness should not exceed 2m.

Table 4-9: Mechanical properties of waste materials (DWAF, 1998)

Parameter	Value
Cohesion	25 kPa
Angle of shearing resistance	15^o
Unit mass of waste	10 KN/m^3

Table 4-10: Recommended values for waste slopes heights and angles (DWAF, 1998)

Safe slope angle (^{o})	Max Height of slope (m)
30	33
26	40
25	44
23	50
21	60

Computer Simulation of Recommended Waste Slope Angles and Heights

Based on results from computer simulation of recommended waste slope angles and heights employing angle of slope of maximum slope angle of 30^o and a slope height of 33 meters achieves a factor of safety of 1.52 and so this is recommended for the freshly placed refuse at Saba disposal site

5. FACILITIES AND INFRASTRUCTURE

5.1 Fencing

128. The entire perimeter of the site 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.

129. 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

130. 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

131. 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

132. A trapezoidal stone-pitched open drain is to be constructed around the western, eastern and southern sections of the Saba site to join the existing concrete road-side drain abutting the southeastern face of the site.

5.3 Closure and end-use

133. 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

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

135. 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.

136. Based on the surrounding topography, the maximum height of the landfill will be about 5m above the original natural ground level of the Saba Site. The upper surface of the capped site is to have general slopes of at least 1:5 to promote rapid drainage of the surface.

137. It is recommended that the sites be returned to the local community as a recreational 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.

138. 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. The 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.

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

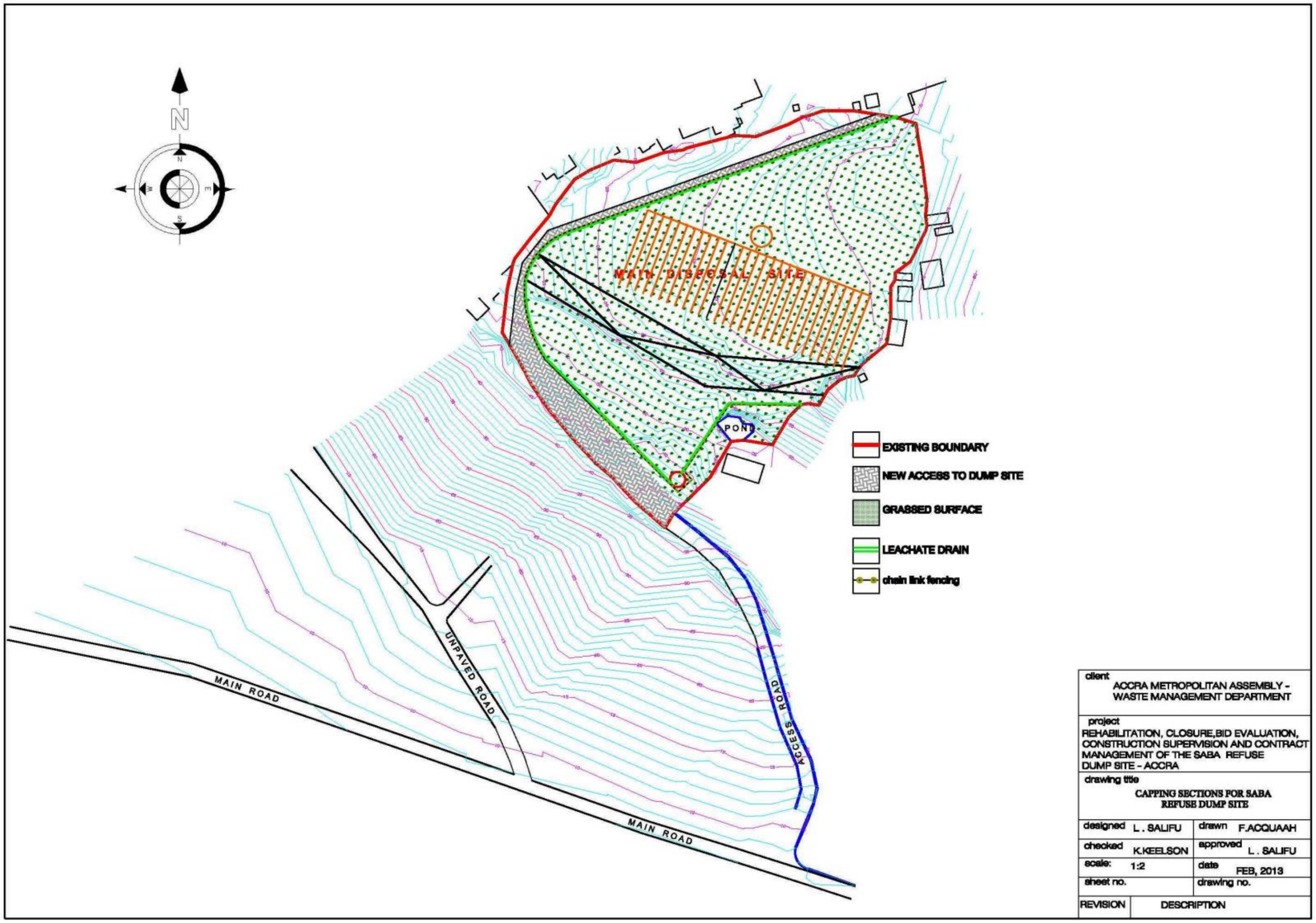

Figure 5-1: Plan view of Saba Dumpsite showing final shape with peripheral drains

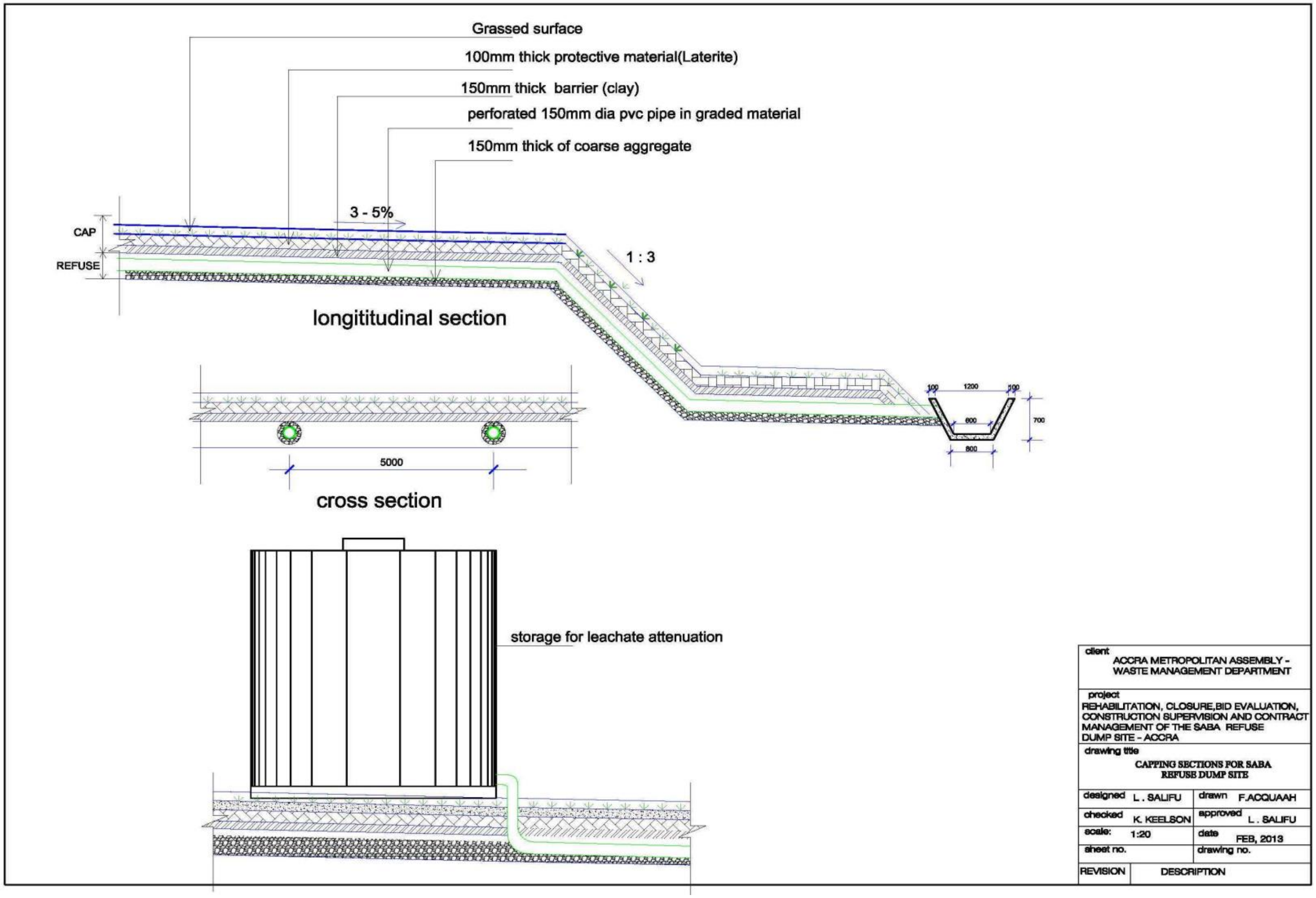

Figure 5-2: Vertical cross section of Saba Dumpsite showing 3 multi-layer capping system.

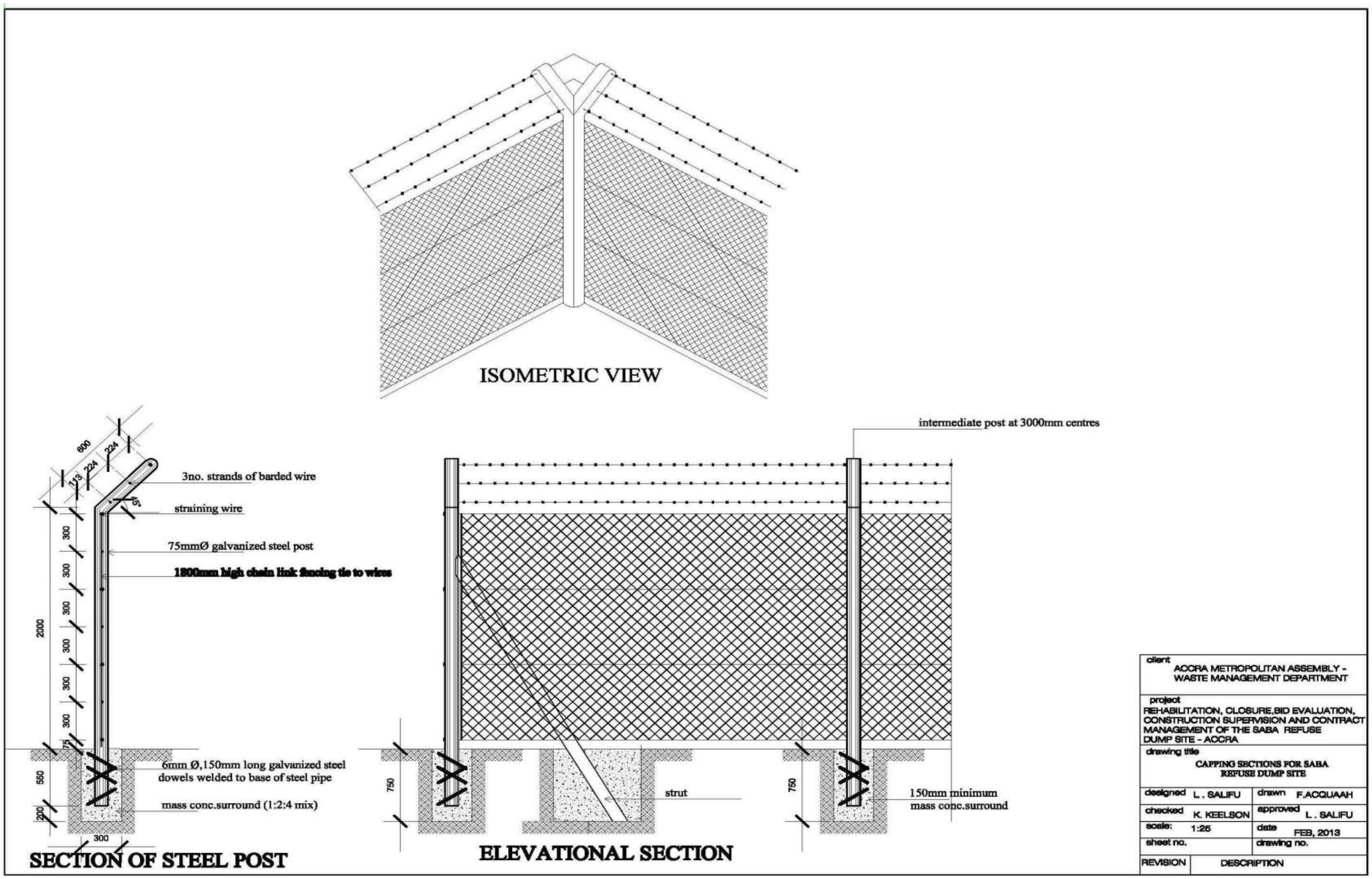

Figure 5-3: chainlink fencing of Saba Dumpsite

6. COSTING

6.1 INTRODUCTION

140. 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

141. 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.

8. RECOMMENDATIONS

142. Based on the discussions of the above designs proposed and the conclusions reached it is recommended that the Ga South Municipal 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.

143. Furthermore it is recommended that the implementation of the Rehabilitation and Closure be implemented by one contractor with the requisite equipment and skill to bid for the lot. This recommendation is made in the light of the urgency and time limitation for executing the project within 16 working weeks (4 months) including week-end work-hours.

144. 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

9. ANNEXES

9.1 LEACAHATE QUANTITY

9.1.1 POST-CLOSURE LEACHATE ESTIMATION PROCEDURE

145. 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 9-1 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.

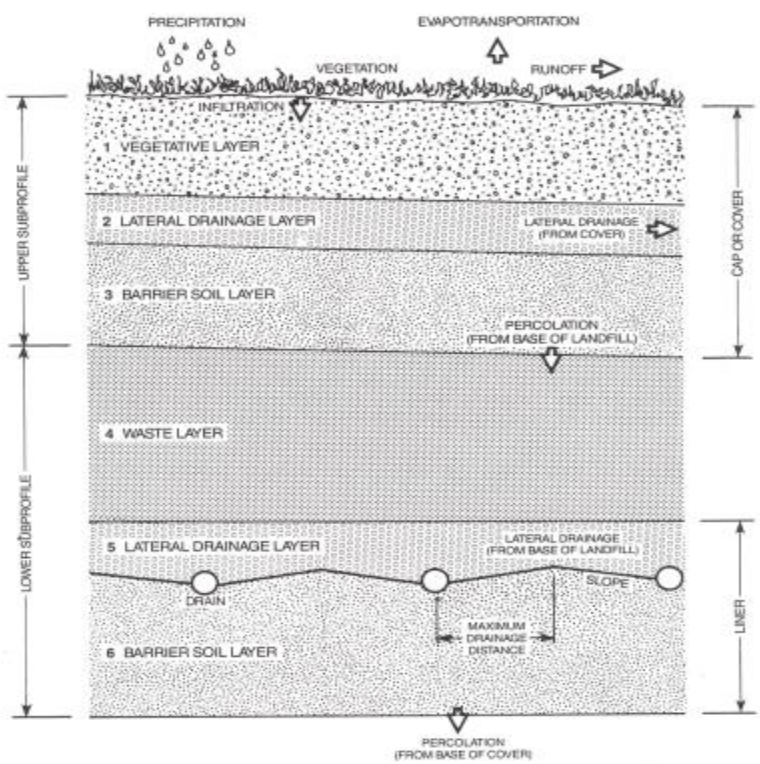

Figure 9-1: Capped Landfill Profile Modeled by Help

146. 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.

147. 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

148. The components for the HELP Model are presented in Table 9-1.

Table 9-1: 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

149. The computer simulation results for the landfill cover are presented in tables 9-2.

Table 9-2: Landfill cover simulation results

Parameter	Value	Unit
Peak Daily Percolation	7.30	m^3
Annual Average Percolation	1381.5	m^3
Maximum hydraulic head	175	mm
Average hydraulic head	59.65	mm

9.2 LEACHATE COLLECTION AND RE-CIRCULATION SYSTEM

150. 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.

151. 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.

152. 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.

153. 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).

154. 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.

155. 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.

156. For the Saba dumpsite, where dumping operation has proceeded without embankments and leachate collection facilities, the challenge is to determine and ensure that the leachate

being generated substantially flows to a collection point and thence treated and disposed of without adverse impacts.

157. The above characteristics of this site reduce the aforementioned challenges to one of adequate treatment and disposal of the leachate from the collection points (sumps). This is the main remedial design consideration provided by the consultant - the WasteCare Sub-surface Irrigation of Re-circulated Leachate (WC-SIRL) system.

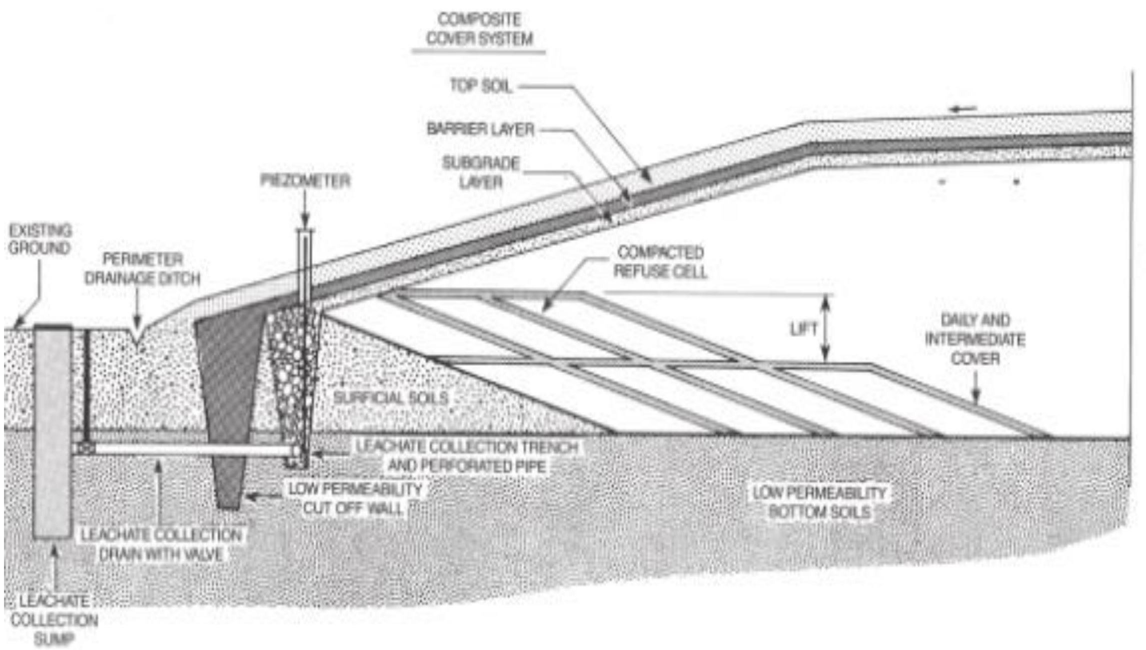

Figure 9-2: Generic Leachate Collection System for an unlined Landfill (in operation)

158. 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.

159. 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.

160. 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.

161. 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.

162. 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.

163. 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 (or HDPE) pipes.

164. 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.

9.3 Design of Surface Water Drainage Channels

165. 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

166. 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 9-3 and 9-4 show the longitudinal and plan views of drainage channels constructed around the perimeter of the final capped form.

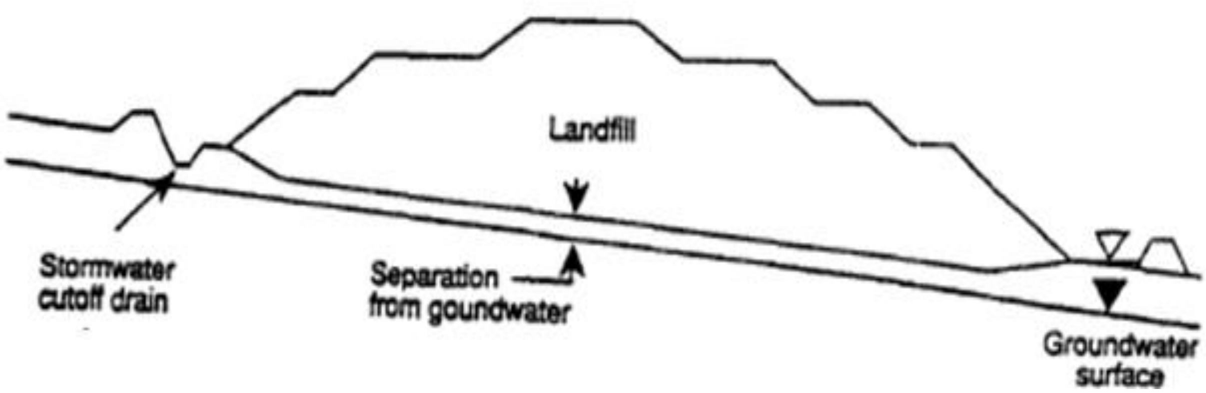

Figure 9-3: Plan view of Capped Landfill and Surface Water Drainage Channels

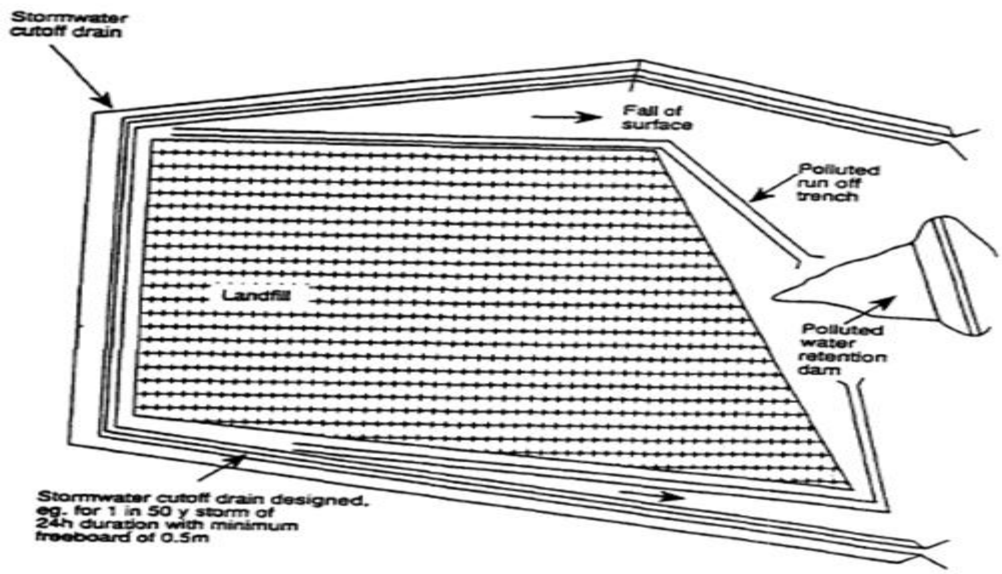

Figure 9-4: Plan view of Capped Landfill and Surface Water Drainage Channels

9.4 Hydrologic Analysis

167. 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.

168. 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.

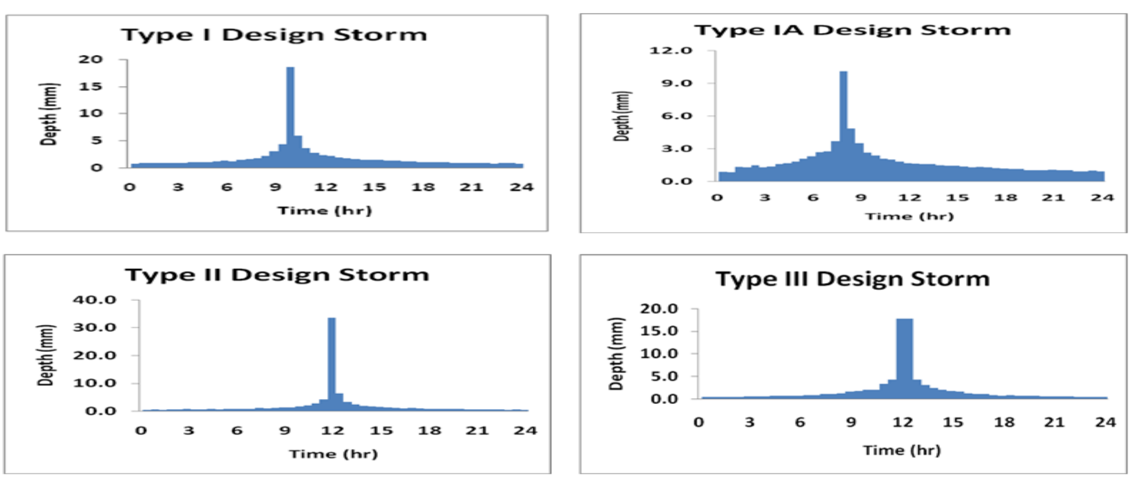

Figure 9-5: 24-hour design storm profiles

169. 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.

170. Five scenarios based on different 24-hour storm profiles were modeled namely; block rain, Type l, Type 1A, Type ll, and Type lll distributions. These storm profiles are shown in Figure 4.13. The block rainfall profile has a constant rainfall depth or intensity whereas the other profiles have varying rainfall depths with respect to time. Table 9-3 presents a comparison of the 25-yr peak discharges from the various design storm profile scenarios for the 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 9-3: EPA SWMM simulation results for peak runoff

Storm Profile	25-yr Peak Runoff (m^3/s)
Block Rain	0.079
Type l	0.293
Type lA	0.165
Type ll	0.580
Type lll	0.482

9.4.1 Hydraulic Design of Perimeter Drains

171. 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. Table 9-4 presents the design parameters that were used to size the perimeter drains. The range of values for these parameters were based on a review of literature on stable channel design and landfill site drainage.

. Table 9-4: Hydraulic design parameters for sizing of drains

Design Parameter	Unit	Value
Bed slope	%	< 10

Side slope	H:V	0.5:1 - 1.5:1
Base width	m	0.6 – 1.0
Lining material	-	Stone pitching
Manning coefficient	-	0.035
Permissible shear stress	N/m^2	95.8
Factor of safety	-	1 - 1.5
Freeboard	mm	150 -300

172. Table 9-5 presents the hydraulic analysis i.e. results namely design flows, velocities and shear stresses. Table 9-6 presents the channel cross-section dimensions for the Saba dumpsite drains.

Table 9-5:Hydraulic analysis simulation results

Design Parameter	Value
Discharge (m^3/s)	0.580
Flow depth (m)	0.320
Average velocity (m/s)	1.67
Max shear stress (N/m^2)	94.18
Avg shear stress (N/m^2)	57.99

Table 9-6 : Channel cross-section dimensions

Design Parameter	Value
Base width (m)	0.600
Depth (m)	0.900
Right side slope (H:V)	1.5
Left side slope (H:V)	1.5