GUIDELINES FOR HAZARDOUS WASTE LANDFILL SITE SELECTION AND ENVIRONMENTAL IMPACT ASSESSMENT IN HYPER-DRY AREAS

REGIONAL CENTER FOR TRAINING AND TECHNOLOGY TRANSFER FOR THE ARAB STATES IN EGYPT (BCRC-EGYPT)

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Prepared by

REGIONAL CENTER FOR TRAINING AND TECHNOLOGY TRANSFER FOR THE ARAB STATES IN EGYPT (BCRC-EGYPT)

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Editorial Note

The present document was compiled jointly by Dr. **Ashraf M. El Mhagraby** in collaboration of the Project Team; **Dr. Said Dahroug and Geologist Ahmed Farouk**.

Prof. Dr. **Mortada Murad El Aref** reviewed the technical contents of the document.

Participants (Annex-1) of the Expert Group Meetings contributed much to the ideas developed in the present document.

Foreword

The Cairo-BCRC as the implementing agent of the project "Preparation of a set of tools for the selection, design and operation of hazardous waste landfills in hyper-dry areas" funded under the Strategic Plan of the Basel Convention with the financial and technical support from the Secretariat of the Basel Convention; has the honor to release as an output of the project, a set of three guidelines entitled:

- Guidelines for hazardous waste landfill site selection and EIA in hyper-dry areas.
- Guidelines for hazardous waste landfill site design in hyper-dry areas, and
- Guidelines for hazardous waste landfill site operation, monitoring and aftercare in hyper-dry areas.

These guidelines have been prepared with the overall objective of promoting principles and practices for environmentally sound management of hazardous waste in the Arab Countries. They address the specific, but widespread problem of hazardous waste and the need for their containment and disposal. They offer guidance on site-selection, EIA, design, operation, and monitoring of hazardous waste landfills in hyper-dry areas. They also warn against improvised disposal methods that may cause severe environmental and health problems, as the cost of mitigating the effects of irresponsible disposal can be many times higher than the cost of safe and environmentally sound disposal as recommended in these guidelines.

The guidelines are published in Arabic and English with easy to use indexing and/or relevant decision support charts. The guidelines are designed to be used by those who are engaged in careers that address hazardous wastes, such as landfill designers, engineers from the chemical and process industries, waste treatment system managers and designers, and public officials interested in waste management planning. They are also of interest to government departments responsible for hazardous waste management and chemical pollution control. The guidelines should be regarded as a further instrument to enhance implementation by the local agencies and municipalities, even though; the guidelines should not be used as a substitute for consultation with professional and competent advisors.

The technical information and recommendations presented in these guidelines have the status of "**Final**" which means it has been reviewed by a panel of experts nominated by BCRC-Cairo as well as by the Experts of the Arab Countries participated in the project and the Secretariat of the Basel Convention. Even though, these guidelines will be updated regularly with the intention to revise or to issue addenda when important new disposal methods and technologies become available to be used safely and cost-effectively in Arab Countries. I am pleased to release these documents which now supersede the draft version.

Prof. Dr. M.M. El Aref
Director BCRC-Egypt

PREFACE

Hazardous waste management policies and strategies in many countries of the Arab region is still underdevelopment. Most of the countries focus in dealing with hazardous wastes on the land disposal option. Few consider cleaner technology alternatives. When it comes to institutions and regulating bodies for the implementation of immediate actions or policy directives, one finds that the problem of financing prevails. Many donors provide assistance towards developing policies and strategies, capacity building training and occasionally towards pilot projects implementing hazardous waste management components including basic infrastructures.

The problem of implementing efficient and/or successful waste management policies and strategies in the Arab region is noted to belong to three main issues

1- Lack of financial resources.
2- Lack of the know-how and technical resources.
3- Political well against awareness/ and priority actions.

The problem of financial resources varies from one country to another. For example, sophisticated technology and industrial plants that comply with the international environmental standards can be found in some of the Gulf States of the Arab region for their good economic status. In countries with economic problems like many countries in the region, the problem for allocating proper funds for implementing environmental protection policies (including sound management of hazardous wastes) and cleaner production alternatives is still outstanding.

Technology is always a refulgent word that attracts the attention of decision makers especially in developing countries. Many decision makers encourage and give incentives to investors to import technology under the temptation of improved quality and quantity seeking economic development. However, assessment of cleanliness of technology exported is still a challenging issue in developing countries. Failure of technology and associated accidents recorded in the past two decades in developed and developing countries have inflected serious environmental impacts. As a result, big tolls and occasionally total losses have been noted. Technology and know-how link all the times to financial and technical resources. They also, very often; link to monopolization.

Even countries (capitals) of the region that have the financial resources should deal with industrial technologies very carefully because of the lack of local technical resources and expertise for maintenance. Fears emanate from the fact that the operation and maintenance cost of technology, in the absence of the know-how, can be highly exaggerated; and can stress budgets that in some cases closing or suspending business and lose the investment.

Having understood the different variables that impede the enthusiastic shift towards technology and towards sound management of hazardous wastes, the BCRC-Egypt decided to compromise the situation regarding hazardous waste management via addressing the option of waste disposal by landfilling. The center encourages waste disposal option as a short and intermediate term policy which is thought to be popular in the region under the above mentioned circumstances.

Considering the conditions of the region and current undefined practices in dealing with different types of wastes, the BCRC-Egypt decided to consider the landfill option only to be used after every effort has been made to minimize, reduce, mitigate or eliminate the hazards posed by such wastes. The Center encourages waste disposal option as a short and intermediate term policy.

The need to develop the guidelines for the landfill disposal option as a short term policy is expressed by several member countries in the region as stated in the feasibility study conducted by the Basel convention (1996) for the establishment of the region BCRC. The Guidelines are outputs of a project awarded by the SBC to the center. The project tackles the problem of lacking technical guidelines proper for the region economic and geographic conditions.

Acknowledging the geographic, demographic, geomorphic and meteorological conditions of the region the project concentrated on developing standards for the landfill option in hyper- dry areas as the main natural characteristic of the region. The project concept has been prepared and presented for finance to the Open-Ended Technical Working Group of the Basel Convention in late 2002. The project was approved in late 2003 and started implementation at the beginning of March 2004.

The project aimed at developing Guidelines for the landfill option in hyper- dry areas including:

- Guidelines for site selection and EIA of landfills
- Guidelines for landfill design
- Guidelines for landfill operation, monitoring and aftercare

These guidelines are prepared and approved in three expert group meetings held sequentially over 14 months of the 18 month project total duration. These meetings contributed a lot to the capacity building and information share among countries of the region which participated in the meetings. Also, they helped in raising the awareness regarding hazardous waste management.

The present guidelines represent one out of three documents published by the project. The standards appeared in the guidelines are the result of a continuous work by the project staff since the start of the project, the heated discussions during the expert group meetings held in connection with the project; and finally, the scrutiny revision of renowned consultants. The document was meant to be comprehensive but still simple, that can be used both by technicians and non technicians; and also for training purposes. It is worth noted here that this document and the other guidelines published by the project will remain open files for update and improvements as information and knowledge increased, and the BCRC-Egypt will appreciate receiving feedback from users of these guidelines so that future editions can be more useful.

The document is divided into independent sections to facilitate quick and concentrated reading. These sections take the reader from basic concepts to approaches and to the technical issues. All documents contain for further readings and for easy reference a bibliography of the subject.

Said Dahroug
Project Manager

INTRODUCTION

The present document provides the guidelines for the site-selection and EIA minimum requirements for hazardous waste disposal by landfilling in hyper- dry regions. These guidelines have been developed and elaborated within the context of the “site selection, design and operating hazardous waste landfills in hyper dry areas" project awarded for implementation to the Cairo BCRC by the SBC. The approach used for the development of the present guidelines based a lengthy process that comprised review, documentation, discussion expert group meetings and finally expert elaboration and finalization. The guidelines are presented when a common consensus on ‘minimum requirements’ and/or good practice is finely reached during formal Expert Group Meeting (Annex 1 list the experts participated in the group meetings and contributed to the development of this and other guidelines documents).

The guidelines were designed to be a decision support tool to providing the opportunity to use local conditions to relax strict standards that may relief from the more costly, "stricter" construction requirements that would limit developing landfills in developing countries. This is done without compromising human health or the environment.

The guidelines presented herein were designed taking into consideration the Basel Convention, World Bank, US EPA, and RCRA adopted Guidelines for waste disposal by landfilling and many other published reports (see bibliography) with the adjustment required for hazardous wastes. The philosophy behind was to adopt the criteria, regions, to establish compatible methodology involving workable minimum made especially to fit to the site-specific conditions in hyper- dry regions.

It is expected that these guidelines will be used for selecting a hazardous waste landfill in one of the Arab country (Yemen Federation indicated their interest in the expert group meeting).

The state- of- the art construction of hazardous waste landfills (in engineering sense) is very often costly and needs a lot of financial and technical inputs. The present guidelines are tailored to address issues beyond state of the art construction of landfills but still provides for acceptable performance. Special emphasis will be given to the possible exemption of some requirements in the site selection, designing, operation, and monitoring to utilize the hyper-dry conditions of our region, and to fit with financial capabilities of the developing Arab States. The project will always consider the following basic and general objectives of landfill site selection:

- To ensure that the site is developed in environmentally acceptable manner, and that it provides for simple, cost-effective design which in turn provides for good operation.
- To ensure that, because it is environmentally acceptable, it is also accepted by the public and affected parties.

The present document is divided into two main sections; the first is concerned with site selection and the second is concerned with environmental impact assessment (EIA). The first section includes introduction to landfill classification according to waste class, and to leachate management needs; approaches to site selection and site suitability requirements for land filling of hazardous waste in hyper- dry regions.

The second section is devoted to discussing EIA. EIA as an integral part of the overall landfill planning process has become one of the most effective tools we have for incorporating environmental consequences into decision-making. It assists, but does not control project planning and implementation; ensuring that environmental considerations are incorporated into decision-making, along with technical and economic factors. In order to achieve the desired goals, an EIA must begin as soon as a project is conceived, before irrevocable decisions are made.

The objectives of doing EIA are to prevent or minimize potentially adverse environmental impacts and to enhance the overall performance of the Hazardous Waste Landfill (HWLF) projects. The EIA process allows environmental issues to be addressed in a timely and cost-effective way during the project design, preparation and implementation. EIA can therefore help reduce overall HWLF projects costs, assist in completing these projects on schedule, and help design projects which are acceptable to stakeholders.

INTRODUCTION TO LANDFILL CLASSIFICATION

The landfill classification should reflect the nature of landfill use, operation procedures and the landfill objectives. In order to elaborate this fact a recall of the specific objectives of landfill classification is needed. This can summarized as follows:

- To consider waste disposal situations and needs in terms of combinations of waste type, size of waste stream and potential for significant leach ate generation.
- To develop landfill classes which reflect the spectrum of waste disposal needs.
- To use the landfill classes as the basis for setting graded Minimum Requirements for the cost-effective selection, investigation, design, operation and closure of landfills.

Based on the above objectives, landfills can fall into classes according to:

- Type of waste involved
- Size of the waste stream, and
- Potential for significant leach ate generation

2.1 WASTE CLASS

Landfills are grouped into landfills suitable for general waste (G), such as domestic refuse; and landfills for hazardous waste (H). Hazardous wastes can then be classified into groups according to hazard rating;

Hazard Rating 1: Extreme Hazard
Hazard Rating 2: High Hazard
Hazard Rating 3: Moderate Hazard
Hazard Rating 4: Low Hazard

The hazard ratings imply different handling, treatment and disposal requirements. Hazardous waste landfills can therefore be divided into two types according to the hazard rating of the waste that they are designed to deal with. **H:H** landfills that can accept all hazard ratings of waste, while **H:h** landfills can only accept hazard ratings 3 and 4 and general wastes.

2.2 THE POTENTIAL FOR SIGNIFICANT LEACHATE GENERATION AND THE NEED FOR LEACHATE MANAGEMENT

All hazardous waste landfills are assumed to require leachate management system especially when co-disposal of liquid and solid hazardous wastes is allowed. In arid and hyper- dry regions, landfills still have the capacity to generate sporadic leachate during wet weather conditions. Sporadic leachate generation must always be minimized and controlled by proper drainage system. It is only necessary, however, to install leachate management system (under liners, drains and removal systems) when leachate generation could impact adversely on the environment.

The Climatic Water Balance (B), a simple parameter, can be used to quickly assess the potential for leachate generation. It is calculated using only the two climatic components of the full water balance, namely Rainfall (R) and Evaporation (E).

The Climatic Water Balance is defined by the simple equation: **B =R - E**

Where:

- B is the Climatic Water Balance in mm of water,
- R is the rainfall in mm of water,
- E is the evaporation from a soil surface in mm of water.

The value of ***B*** is calculated for the wet season of the wettest year on record**,** ***B*** is then recalculated for successively drier years, because the wettest year on record may only be so on account of unseasonable rainfall, i.e. the wettest wet season does not always occur in the wettest year. This calculation is repeated until it is established whether:

***B* is positive for** *less* **than one year in five, for the years for which data is available.** If so:

- There should be **no significant leachate generation** on account of the climate.
- **The site is classified *B*⁻.**
- If the Minimum Requirements for the sitting, design and operation are met and only dry waste is disposed of, **no leach ate management system** should be necessary.

or, *B* is positive for *more* **than one year in five, for the years for which data is available.** If so:

- There should be **significant leachate generation.**
- The site is classified $\boldsymbol{B}^{+}$.
- As such leachate requires management, **leachate management systems** are a Minimum Requirement.

It is possible that factors other than rainfall and evaporation can affect the water balance of a landfill site. These include the moisture content of the incoming waste and the ingress of either ground or surface water into the waste body, on account of poor sitting, poor drainage design or maintenance.

These factors may affect the water balance to the extent that a site which is classified as $\boldsymbol{B}^{-}$, using the Climatic Water Balance, does, in fact, generate significant leachate, it is therefore very important to use ***site water balance*** (which accounts for factors other than rain fall and evaporation, e.g. liquid waste) rather than climatic water balance to assess leachate generation potential.

The Arab region is characterized by an arid climate in general. The average rainfall does not exceed 40 mm/year. Some desert areas receive no more than 15 mm/year like Bayou and Upper Egypt areas and southern Libya and Eastern part of the Arab peninsula. Exceptions from these areas are costal and mountainous areas close to shorelines. The following Table 1 shows the area of the arid zones in the Arab States.

Aridity Zone	**Humid**	**Moist Sub-Humid**	**Dry Sub-Humid**	**Semi-Arid**	**Arid**	**Hyper-Arid**	**Total**
Area	0.347	156	214.6	1,363.3	3,833.8	5,655.3	11,223.4
%	0.0	1.4%	1.9%	12.1%	34.2%	50.4%	100%

Table 1: Area (x 10^3 km^2) per aridity zone for the Arab States Region.

Enormous varieties of conditions do exist in the hyper- dry areas of the Arab Region. Climatically, they range from the hyper-arid deserts of Saudi Arabia to sub-humid foothills of Lebanon; physiographically, from the sand dunes of northern Sudan to Mediterranean coasts of north Africa; economically, from local orchards and herding communities of the Sudan to high-tech export marketing in Emirates; and socially, from rural children of Somalia and farmers in the Egypt to revolutionary urban life in the Gulf Region to name a few.

2.3 LANDFILL CLASSES

The format for the Landfill Classification System presented hereafter (after RSA, 1998) is based on the two parameters discussed in this section, i.e. waste type, and site water balance.

The Landfill Classification System provides ten different classes of landfill. These are **G:C:B$^-$, G:C:B$^+$, G:S:B$^-$, G:S:B$^+$, G:M:B$^-$, G:M:B$^+$, G:L:B$^-$, G:L:B$^+$, H:h** and **H:H.** Out of the ten landfill classes, eight cater for general waste and two cater for hazardous waste. The symbols C, S, M and L refer to the site size (normally applied for general waste landfills), and are explained in Table 2.

Landfill Size Class		**Maximum Rate of Deposition (MRD) (Tones per day)**
Communal	C	<25
Small	S	>25 - <150
Medium	M	>150 - < 500
Large	L	>500

Table 2: General waste landfill classes.

The maximum rate of deposition (MRD) describes by weight (expressed in T/day, for a 260 day year) the projected maximum rate of waste deposition during the expected life of a landfill.

APPROACH TO SITE SELECTION

Essential considerations in the landfill site selection are the size and the general location of the required site with respect to waste generation facilities;

- **Size of the site.** When the site is classified, the size of the waste stream and hence the Maximum Rate of Deposition is calculated. This calculation gives a good indication of the physical size of landfill and hence the area of land required.
- **General site location.** This is determined by the waste generation area(s) to be served. It is economically sound practice to establish the proposed facility as close to the generation area(s) as possible, with a view to minimizing transport costs and exposure potential. Thus, the initial area of investigation is defined by the economic radius, which will vary depending on the existing or proposed mode of waste transport. Since the location of the site relative to the waste generation area(s) is an economic consideration rather than an environmental minimum requirement, it is not addressed further.

The further phases involved in the approach to site selection are as follows:

- The elimination of all areas with associated fatal flaws.
- The identification of candidate sites based on the site selection criteria.
- The ranking of candidate sites.
- The carrying out of a feasibility study on the best option(s).

Advancement in space and remote sensing technologies as well as geographical information systems (GIS) provides an efficient and dynamic tool for earth observation and monitoring through studying satellite images and data manipulation.

Geographical information system (GIS) is a digital database management system that stores, retrieves, analyzes, and displays collected information according to the specifications of the user or the analyst. In the GIS, the planner initially specifies all conceivable requirements and consequently, software can define sites that fulfill all the requirements, this saves a lot of costly fieldwork.

The combination of the GIS and Remote sensing systems provide multi-spectral, multi-temporal and multi-scales (spatial resolution), which can be adopted according to the degree of details needed. This technique plays an important role in regional screening for landfill sites. Radar imagery is an active remote sensing system that is capable of penetrating dry soils. Utilizing this technique for investigating subsoil drainage network and structures is critical for the site selection. Laser mapping is very sensitive to the topography and design of landfills drainage networks.

THE SITE SELECTION AND ENVIRONMENTAL IMPACT ASSESSMENT

4.1 SITE SELECTION CRITERIA

Locating a landfill requires minimum or zero impact to environment components; water resources, air, soil, wildlife, as well as to lifeline utilities like transportation, social and economic factors. A Feasibility Study, involving a preliminary environmental impact assessment and geohydrological investigation, must be carried out on each candidate site. This will determine whether the potential impact of the site is environmentally and socially acceptable. Twenty exclusionary criteria to be used to determine the suitability of potential sites for the new land disposal facility are summarized below (Annex 2 summarizes the matrix for siting criteria).

4.1.1 Economic and Social Criteria

Distance and Capacity

The selected site should provide sufficient capacity to meet current and projected needs for hazardous waste disposal in the area being serviced for a minimum of ten years. This length of time justifies the investments made in the site (such as acquisition, studies, access roads and equipment).

The site should be located reasonably close to the centre of hazardous waste generation or to the transfer station. Typically, the maximum recommended distance is 50km, as a radius from the waste generation node. An alternative, and perhaps preferable, suggestion is that average length of time required to reach the site should be considered, rather than the distance. This takes into account variables as well as distance, such as traffic and quality of roads. The maximum length of time for a single journey should be of the order of 30-45 minutes for typical collection vehicles (i.e. vehicles with capacities of about 5 tones). An exception to this is for transport vehicles of large capacity such as transfer trailers; in this case, one-way trips of up to 2 hours may be economically feasible, although this will depend on local circumstances.

Infrastructure

Out of all the infrastructures required at a landfill site, the approach road and the power supply are the most important. All the sites should be therefore, evaluated as to the availability of road and power supply.

Property Boundary

There should be no residential development, either existing or planned, within at least 500 meters of the disposal site's boundary. The fill should also have a buffer of unused land. The buffer zone between the discharged solid and/or hazardous waste landfill and the property boundary should be at least 50 meters of which the 15 meters closest to the property boundary must be reserved for natural or landscaped screening (perms or vegetative screens). Depending on adjacent land use and environmental factors, buffer zones of less than 50 meters but not less than 15 meters may be approved by local administrative authorities. The distance between the discharged solid or the hazardous waste landfill and the nearest residence, water supply well, water supply intake, hotel, restaurant, food processing facility, school, or public parks is to be a minimum of 500 meters. Lesser separation distances may be approved where justified. For those landfills designed to collect and recover methane gas generated, the issue of potential on-site or off-site users of the energy should be addressed.

Distance from Airports

The objective of this criterion is to minimize the potential of random bird strikes upon aircraft during departure and landing at airports, unless bird control measures are acceptable and approved by the site manager. The details of the criterion are as follows:

- Property within a radius of 3 kilometers from the end of any runway used by turbine-powered aircraft shall be excluded from the facility sitting process.
- Property within a radius of 1.5 kilometers from the end of any runway used by only piston-powered aircraft shall be excluded from the facility sitting process.
- Property within a distance of 9.5 kilometers from a public airport property boundary shall be excluded from the facility sitting process.

Distance to Primary Highways

The objective of this criterion is to minimize the visual impacts associated with a landfill from adjacent highways. Usually, the distance depends greatly on topography of the area and the access roads to the site.

Distance to Public Parks and Recreation Areas

The objective of this criterion is to minimize the visual impacts associated with a landfill from public parks and recreation areas. Usually the distance depends greatly on topography of the area and the access roads to the site. The landfill should not be in areas immediately upwind of Public Parks and Recreation Areas in the prevailing wind direction(s).

Local Zoning and Land-use

The objective of this criterion is to minimize the potential for the landfill to be located in areas that are incompatible with surrounding land use. The less the economic importance of the site the more suitability of the site for landfill development. Wasteland or saline areas are excellent sites while sites with extensive vegetation and plantation are considered bad sites from existing land-use consideration.

Distance to Cities and Towns

The objective of this criterion is to minimize the potential for the landfill to be located near or within populated areas. Acceptable distance should not be less than 3 km.

Abandoned mines, wells and old quarries for land filling hazardous wastes

In most states of the Arab Regions, many oil wells are in the third or depleted phase of the exploitation, while a lot of quarries and mines are abandoned that could and should put into efficiency for waste disposal management, particularly for land filling hazardous wastes. There are many wells into which the waste streams could be injected under a very small injection pressure.

The question raised is how to effectively use this old quarries and abandoned mines and wells for waste management in the frame of an environmental strategy. For this reason the following objectives has to be compiled:

- Study of actual and perspective situation of the waste, which could be, managed using old quarries and abandoned mines and wells.
- Compile studies to present the existing situation of abandoned mines and old quarries, selecting the most suitable ones, based on different craters.
- Analyze the best opportunity, i.e. which optimally realizes the management of abandoned mines according to the waste quantities, qualities, etc. their constraints, logistics etc.
- Development of a pilot optimal project for the mines selected.
- Compile study to present the existing situation of abandoned wells from exploration and exploitation of oil and gas fields, selecting the most suitable ones according to the craters determined.
- Define and determine the different technical, financial, logistical etc. requirements of various technological waste disposal procedures, which industrially are going to be implemented in abandoned mines and old quarries.
- Compile knowledge on the processes and phenomena for the different old quarries and abandoned mines as relate to geology, litho logy, stratigraphy, geophysics', hydrology, hydrogeology, rock mechanics, drilling, test analysis, reservoir engineering, mine design, mineral technologies, and mineral economics.

From the managerial point of view the issue of abandoned wells, mines, and old quarries as alternative waste disposal sites is a multidimensional problem, which encompasses many components such as political, legal, engineering, economical, financial, social, and environmental. Of course each component represents a specific question that could and should be treated in detail.

The selection of wells and mines as alternative waste disposal site should be based on and in accordance with sustainable waste management strategies. Classification of wastes according to theirs properties and characteristics is a prime factor in the determination of technological procedures and technical tools that will effectively grantee the success of the respective selection of a particular abandoned well, mine, or quarry.

For example let’s consider the injection of the waste streams containing oils-water, hydrocarbons, water mixtures, emulsions into the wells. It is indispensable to know: the layer geology, rock properties and the contained fluids, energy characteristics and their mechanisms, well equipment, surface installations, infrastructure and logistic (transportation and injection system), log and well test analysis, and fluids flow and their solutions.

4.1.2 Environmental Criteria

Hydrology/Hydrogeology

Hydrology and hydrogeology deal with ground and surface water movements and use. Several other variables including water content, water potential, humidity, temperature and how tightly the water is held by the soil matrix; must be evaluated to define rates and directions of water movement specifically under situations other than saturation. The importance of vapor flow as a potential transport mechanism and as a contaminant release pathway should be considered in any water balance modeling/assessment during the process of evaluating a proposed waste site in hyper-dry region.

The general hydrologic conditions at and near the waste-burial site in arid and hyper-dry regions with low average annual precipitation and high average annual evapo-transpiration would prevent water from percolating downward more than 25-75 cm below land surface unless through open fractures. This assumption, however, is not valid during extreme rain events where deeper percolation can occur.

The Zone of Continuous Saturation

In case of aquifers used locally as major sources of water supply, the hydrogeologic evaluation may be carried out in phases. In the first phase of the evaluation, all available information, both published and unpublished, about the facility and surrounding area should be identified and evaluated. A report on this phase should be prepared, to include maps and photos of the site in addition to the following information about the site:

- Soils
- Topography
- Groundwater level
- Vegetation
- Climate
- Seismic conditions, including the location of faults near the site

Report should also include (where possible)

- Geologic columns
- Cross-sections
- Direction of groundwater flow
- Inventory of all active and abandoned wells within 2 km of the site .

In the second phase of the hydrogeologic evaluation, the properties and distribution of the earthen materials underlying the site should be described, as well as the groundwater conditions beneath the site. At least two soil borings should be performed per hectare, to define the site's soil and bedrock conditions (Geophysical techniques can also be used for the same purposes), with additional borings performed where necessary. The soils and bedrock should be described and classified, and the permeability of the soils of the site determined.

Groundwater

The following suggestions are made relating to groundwater :

- The ten-year high level of the groundwater should be at least 5 meters below the base of the fill or of any planned excavation
- The existing soils should have relatively low permeability, i.e. 10^{-6} cm/sec or lower
- The site should not be within or near the ten-year groundwater recharge area for current or future water supply development
- No type of porous rock formations (such as carbonate or limestone) should be part of the uppermost geologic layer, as these types of rocks would not be barriers to gas or leachate migration
- The site should not be located within a flood plain that may be subject to 50-year floods (that is, major floods occurring once every 50 years or so). If the site is located within a 100-year flood plain, it should allow for a financially feasible design that would eliminate washout .

Groundwater Flow Gradient

The groundwater gradient gives the idea of the rate and direction of flow of the groundwater. The greater the gradient, the greater is the flow rate. For a suitable site, the hydraulic gradient should be as low as possible. If there is any contamination due to the failure of the liner system, the impact at the downstream is minimal

Groundwater Flow Direction

As the wastes will be disposed in the landfill permanently, they can pose a threat to the groundwater in case of failure of the protection system. So it is necessary to locate the site in such a way that in case of such event, the impact is the least. The sites have to be evaluated as per the distance of downstream communities.

Groundwater quality

Groundwater quality may not directly influence the evaluation of the waste disposal site. If the groundwater is non-potable or cannot be used for any useful purpose, then the site has the advantage over the others. If the ground water quality does not conform to the drinking water quality standards, and that water treatment option is not valid, the site is to be considered as excellent in this context.

Containment Boundary

The first step in setting groundwater performance standards is to establish a containment boundary. The boundary should surround the area where the waste is going to be deposited. The compliance boundary should be no further than 50 m from the boundary of the waste.

A surface water compliance boundary should be defined if it is demonstrated that the pollutants entering the groundwater may contaminate the surface water.

Rainfall and Storm water Infiltration

Evaluation of the potential for groundwater pollution and surface water pollution to occur due to rain/storm water infiltration must be done using plausible Worst-Case Situations. If rain/storm water infiltration is possible based on the vadose and saturated zones hydraulic characteristics, the following parameters must be determined:

- The groundwater hydrology, water quality characteristics and the Existing and potential groundwater use in the area that could be impacted by storm water infiltration.
- Physical characteristics of aquifer
- Groundwater flow direction and velocity (mean and maximum)
- Permeability of Vadose Zone and Saturated Zone
- Homogeneous character of Vadose and Saturated Zones
- Sand/Gravel lenses - low permeability layers
- Cracks in clay layers
- Age of groundwater, to evaluate time associated with groundwater recharge
- Depth to the Water Table
- Variability of Water Table depth

Permeability

The permeability of the subsoil of a landfill site has an important role to play in the development of landfill as it acts like a barrier to leachate. In an ideal condition, the permeability of the soil should be about 1×10^{-7} cm/sec. In hyper- dry regions where the volume of water infiltration is minimized due to evaporation, and in case the runoff water diversion measures are considered, and the aquifer is at depths greater than 30 m; the permeability of the substratum can be relaxed to 10^{-6}cm/sec. This also can be further relaxed depending on the site conditions.

Distance to lakes or ponds

The objective of this criterion is to minimize the potential that surface water runoff from a landfill will impact a perennial lake or pond with contaminated runoff, sediment load, and/or waste. Property within 200 meters around ponds, marshes and swamps or around any perennial lakes that are either naturally occurring or contain non-industrial use water shall be excluded from the facility sitting process.

Distance to rivers or streams

The objective of this criterion is to minimize the potential that surface water runoff from a landfill will impact a perennial river or stream with contaminated runoff, sediment load, and/or waste. Property within an offset of 500 meters from the waterline of any perennial river or stream (both sides) shall be excluded from the facility sitting process. The following minimum distances are recommended: 1000 meters from flowing bodies of water less than 3 meters wide, 3000 meters from flowing bodies of water greater than or equal to 3 meters wide.

Wetlands

The objective of this criterion is to minimize the potential for impacts to wetlands habitat or species, water quality, or degradation of the wetlands associated with a hazardous landfill. Any property that is designated a wetland by National or local authorities shall be excluded from the facility sitting process. Hazardous waste should not be placed into environmentally important wetlands with significant biodiversity.

Coastal Features

The landfill boundary should be at least 100 meters from a marine shoreline. This distance can be increased according to land tenure near coastal areas.

Site drainage

Sites providing natural minimization of run-off should be considered better than other sites. However, design can minimize run on – run off water through the use of adequate methods of diversion and collection, and other methods of control which imply increase in cost of construction and operation.

Biodiversity

The site should be selected so that no known living or breeding areas of environmentally endangered or rare species are present within the site boundaries; neither should the perimeter of a site be located within 1000 meters of protected areas.

Distance to Industrial Process Water

The objective of this criterion is to minimize the potential that surface water runoff from a landfill will impact process water or storm water pond with contaminated runoff, sediment load and/or waste. Property within a radius of 100 meters around any process water or storm water management pond shall be excluded from the facility sitting process.

Floodplains

The objective of this criterion is to minimize the potential that storm water flows associated with the100-year flood event will (1) disturb and erode the landfill cover, (2) disturb and wash out in-place waste, or (3) impact environmental monitoring systems. Also, the objective is to minimize the potential that the landfill will restrict the flows associated with the 100-year flood event or reduce the water storage capacity of the floodplain. Property located within 100-year floodplains shall be excluded from the facility sitting process.

National Historic and Landmarks Preservation

The objective of this criterion is to minimize the threat posed by a landfill to irreplaceable historic or archeological sites listed pursuant to the National Historic Preservation and to natural landmarks (protected areas) designated by the Environmental Affairs Agencies in the concerned Arab States. The details of this criterion are as follows:

- Property containing historic or archeological sites listed pursuant to the National Historic Preservation shall be excluded from the facility sitting process.
- Property containing protected areas designated by Environmental Affairs Agencies shall be excluded from the facility sitting process.

Endangered Species

The objective of this criterion is to minimize the threat posed by a landfill to (1) cause destruction or adverse modification to critical habitat of an endangered or threatened species, (2) jeopardize the continued existence of endangered or threatened species or (3) contribute to the taking of endangered or threatened species. Property containing critical habitat of an endangered or threatened species listed pursuant to acts by local Environmental Affairs Agencies shall be excluded from the facility sitting process where the landfill may cause destruction or adverse modification to critical habitat of an endangered or threatened species, jeopardize the continued existence of endangered or threatened species, or contribute to the taking of endangered or threatened species.

Winter Range / Breeding Grounds

The objective of this criterion is to minimize the potential for impacts associated with a landfill to critical winter ranges for big game or grouse breeding grounds. Property containing big game critical winter ranges or grouse breeding grounds established by concerned departments in the Arab States shall be excluded from the facility sitting process.

4.1.3 Public Acceptance Criteria

Public acceptance criteria relate to such issues as the possible adverse impact on public health, quality of life, and local land and property values. They also relate to potential public resistance to the development of a landfill site. Failure to meet the public acceptance criteria may constitute a Fatal Flaw. The following are important considerations:

- The displacement of local inhabitants. This will usually arouse public resistance.

- Exposed sites with high visibility. These are less desirable than secluded or naturally screened sites.
- The sensitivity of the environment through which the access road(s) passes. The shorter the distance to the site through residential areas, the more acceptable the site.
- Prevailing wind directions. New landfills must be sited downwind of residential areas.
- The distance to the nearest residential area or any other land-use which is incompatible with landfilling.

The greater the distance from incompatible land-uses, the lower the risk of nuisance problems and hence resistance to the facility.

To protect the public from any adverse effects of a waste disposal operation, adequate buffer zones must be provided around landfills as indicated in above cited sections. Buffer zones are ‘set back distances’ or separations between the registered site boundary and residential developments. They may vary in width, depending on the classification of the landfill, the Site Specific Factors affecting the environmental impact, and the requirements of the Concerned Department and the IAPs. In general, no development may take place within a proclaimed buffer zone.

4.1.4 Geology and Geomorphology implications

The investigator must observe the surface geology, topography, slope, erosion patterns (wind derived and water derived), streams and other water bodies, and surface micro-relief.

- ***Slope Percent:*** Natural slope of a site is important from the drainage consideration. But, land with higher slopes may pose difficulty in the construction and may need leveling up. To prevent water logging, the site should not be concave i.e. there should not be any depression. Therefore, following scales have been developed for evaluating the slope percent of the sites:
- ***Topography:*** In general the site topography is to be convex in relation to the surrounding so that the rain-water is drained away from the site naturally. So, a site with convex topography can be regarded as excellent and that with concave topography is regarded as bad.
- ***Subsidence:*** Area with unstable soil such as filled up area still under the process of consolidation may not be suitable for construction of the landfill due to chances of uneven settlement, which may rupture the liner system. A fairly settled soil can be considered as an excellent site whereas a site filled up with borrowed soil can be considered as a bad or poor site from the subsidence point of view.

Subsurface Geology

- ***Lithology:*** If the nature of the subsurface strata underlying the landfill is heterogeneous, it is difficult or even impossible to properly monitor the groundwater parameters.
- ***Depth to bedrock:*** Higher the depth to bedrock better will be the site from construction of landfill point of view. A depth between 10 to 15 meters ranking the sites as 'excellent' from depth to bed rock consideration
- ***Seismic Condition:*** Seismic conditions should be considered in the site evaluation to know the seismic intensity at various identified sites. The

seismic intensity should be as low as possible so that there is no danger involved due to any earthquake.

Fault Areas

The objective of this criterion is to minimize the potential that ground movements associated with active faults will damage the landfill containment system and compromise its performance. Property that is located within an offset of 100 m (both sides) from faults that have experienced displacement in Holocene time shall be excluded from the facility sitting process. Landfills should not be located where there is significant risk of seismic activity as mentioned.

Karst Terrains

Karst terrains mean areas where karst topography, with its characteristic surface and subterranean features, developed as the result of dissolution of limestone, dolomite, or other soluble rock. Characteristic physiographic features present in karst terrains include, but are not limited to, sinkholes, sinking streams, caves, large springs, and blind valleys. Other rocks such as dolomite or gypsum also may be subject to solution effects.

Additional information on karst conditions can come from remote sensing techniques, such as aerial photograph interpretation. Surface mapping of karst features can help to provide an understanding of structural patterns and relationships in karst terrains. An understanding of local carbonate geology and stratigraphy can aid in the interpretation of both remote sensing and geophysical techniques.

Areas Susceptible to Mass Movement

Are those areas of influence (i.e., areas characterized as having an active or substantial possibility of mass movement) where the movement of earth material at, beneath, or adjacent to the landfill unit, because of natural or man-induced events, results in the down slope transport of soil and rock material by means of gravitational influence. Areas of mass movement include, but are not limited to, landslides, debris slides and flows, solifluction, block sliding, and rock fall.

Avalanche Areas

The objective of this criterion is to minimize the potential that areas associated with avalanches (steep slope and accidental heavy rainfall) will damage the landfill containment system and compromise its performance. Since there are only limited data on avalanche prone areas, for the purpose of this evaluation, steep topography shall be used as a surrogate for avalanche prone areas.

Soils

Waste facilities should not be located on poorly drained or very poorly drained soils, such as those common to wetlands, nor should they be sited on excessively well-drained soils. Upon excavation to the base of the future landfill, a minimum of two, 2meter deep test pits should be dug per hectare of the site, and the soils tested and photographed to confirm their suitability for supporting the facility.

Sand Dune Movement

The proposed site must be away from the general track of sand dunes swarms. The prevailing as well as predicted sand dune movement directions must be determined and should be considered as exempted or exclusionary sites for land filling. Stationary (consolidated) sand dunes may serve as a potential cost effective source for intermittent (daily) cover activities.

4.2 ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

Once a candidate landfill site has been selected for development location criteria, further detailed investigation and reporting are required before starting site development. The assessment of the potential environmental impacts of a landfill usually takes place in parallel with the detailed site investigation. The objectives of the assessment of potential environmental impacts are:

- To identify the various ways in which an existing, proposed or closed landfill will affect its receiving environment
- To ensure that the identified impacts can be eliminated or mitigated (minimized) by means of proper design and operation combined with ongoing monitoring.

There are two stages in assessing the potential impact of a landfill on the environment. These are the Environmental Impact Assessment and the Assessment of the Environmental Consequences of Failure.

- **Environmental Impact Assessment.** This makes use of accepted methodology to assess the potential impacts of a site on the environment. Since the environment includes the social environment, the Environmental Impact Assessment (EIA) must include wide consultation with all stakeholders including the local communities.
- **Assessment of the Environmental Consequences of Failure.** This assesses the consequences of the escape of contaminants from a landfill site in the event of design failure.

Most EIA methods depend on, or have as their starting point, a checklist of considerations that should form part of the design process. This checklist may be used to identify interactions between site characteristics, design and operation, and their potential impacts on the environment.

In order to identify interactions, use is often made of a two dimensional environmental impact identification matrix (see *table 2).*

These matrices usually list the project results along the horizontal axis and the possible impacts on various aspects of the environment on the vertical axis. In order to be effective, the matrices normally have to be large and complex. A simple example is provided in *table 1.*

Actions and impacts would include those linked to the following phases of the project:

- Site preparation and construction
- Operation
- Closure and rehabilitation
- After-use.

The actions and impacts that make up the axes of the matrix must be selected by a qualified team with multi disciplinary representation. The matrix must also be scored by the team, each rating being the result of rational discussion and consensus.

Once the EIA has been scored, the interpretation of the results must be documented in a report. The report must describe how each adverse impact and its implications will be monitored, mitigated or, preferably, eliminated, by the design, operation and monitoring of the landfill. This report is referred to as `The Environmental Impact Assessment Report'. The following details the minimum requirements for environmental impact assessment reporting that gives a glimpse on the nature of conducting EIA study.

4.2.1 INTRODUCTION

EIA Procedures

Before final approving an EIA and start the procedure for licensing the landfill site; an Environmental Impact Assessment procedure should include as a minimum the following steps

- Scoping report (including public and expert consultation as appropriate).
- Description of project and alternatives.
- Baseline data collection of preferred site.
- Prediction and analysis of impacts against baseline information.
- Mitigation.
- Consultation on Draft EIA with public and other stakeholders.
- Mitigation.
- Final EIA published.
- Monitoring and reporting impacts.

Public participation is regarded as a very important feature of modern EIA. Generally speaking the opportunities for public consultation and participation should be through out the EIA process. However as a minimum participation should be carried out during scoping and on the draft EIA report

Methodology

The methodology for conducting an EIA should be clearly explained with highlights on the week points of the different approaches and measurement methods, uncertainties and limitations imposed.

4.2.2 PROJECT DESCRIPTION

Site Location, Area, and Boundaries

- The assessment of the different sites should contain the same level of detail, unless a site is discarded because a landfill simply cannot fit in that particular site. However, when discarding a site it must be clearly stated why the site should not be considered further.
- The size of each area proposed for the landfill must be given.
- The boundaries for all properties or parcels within project construction and access limits should be surveyed.

Waste Characteristics and Quantities

- Waste streams
- Other wastes having clearly identified constituents (i.e. mercury, lead etc.)
- Waste inventories and statistics and their projections on further capacity requirements.

Acceptable Waste

- List of waste types to be accepted together with a list of banned waste types.
- Hazardous versus non-hazardous wastes.
- Co-disposal of wastes.

Landfill Capacity

- Present and future waste generation.
- Service lifetime of the landfill.

Landfill Construction Phase (s)

- Site Layout showing all proposed structures.
- Activities Time Schedule
- Leveling and Excavation works.
- Access Roads.
- Cell Construction Details
- Type of liner and placement method (Bottom and side slope liner).
- Construction of the treatment, recycling and leachate collection facilities.
- Surface water collection system.
- Gates, Boundary Fencing, Administrative Building, Garage, Maintenance area, and Scale house
- Power Supply and Distribution Network
- Water Supply System
- Wastewater Treatment Facility
- Fire Control.
- Labor and safety

Landfill Operation Phase

- Land use map showing vehicle traffic routes.
- Unloading of waste and Compaction.
- Filling Operation Plan.
- Staff.
- Equipment Specification and Maintenance Schedule
- Cover Material Management Plan.
- Daily and Intermediate Cover.
- Leachate Treatment
- Security.
- On-site fuel storage
- Dust Control.
- Gas Collection System
- Vehicle Washing
- Fire Control.
- Vector Control
- Safety/HSE (Industrial Hygiene)

Landfill Closure Phase

- Final Cover Specifications
- Landfill closure Plan (including closure schedule).
- Monitoring Facilities.
- Final Contours.

Post Closure and Decommissioning Phase

- Future Land use
- Aesthetic Aspects
- Monitoring

4.2.3 LEGISLATIVE AND REGULATORY CONSIDERATIONS

National Laws

- Local environmental regulations.
- Landfill standards provided in the local legislation.

- Statements of opinion for considered sites from surrounding municipalities, local authorities and professional organizations dealing with environment protection.

International and National Laws and Conventions

- Adoption of the framework of the Basel (BC), Rotterdam (RC), and Stockholm Conventions (SC).
- Evaluating/regulating new and existing chemicals (RC & SC)
- Waste management (BC & SC)
- Hazard communication (BC, RC, SC)
- Alternatives (SC)
- Environmental releases (SC)

Regulatory Bodies

- Local Environmental Affairs Agencies
- Implementing Agencies
- Authorities Assisting Agencies

4.2.4 ENVIRONMENTAL SETTING

Description of the Physical Environment

- Geology and Geomorphology
- Site Topography
- Floods and Earthquake Hazards
- Soil Characteristics
- Climatic Conditions
- Hydrogeology and Hydrology

Description of the Biological Environment

- Marine Biological Life (if close to the sea)
- Terrestrial Life (Flora and Fauna)

Description of the Socio-Cultural Environment

- Population and Neighboring Communities
- Local People and Current Activities
- Archaeology and Sensitive areas
- Minorities and Gender

Description of Economy

- Employment and Income
- Economic Setting

Description of Health Aspects

- Community health profile
- Sanitation

4.2.5 POTENTIAL ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

Environmental Categories Affected

- Physical Environment

Land, Surface water and Groundwater Quality, Air Quality, Noise levels, Visual Intrusion

- Biological Environment

Marine Life and ecology (if close to coastal area), and Terrestrial Life and ecology

- Social Environment

Public Health, Poverty and Cultural Heritage, Traffic, Impacts on Communities.

- Economic Activity

Employment, Costs, Other Economic Activity

- Aesthetic Value

Criteria Involved in Impact Assessment

- Reversible or irreversible impacts
- Direct or indirect impacts
- Local or regional impacts
- Short-term or long-term impacts
- Synergistic or cumulative

Grading of Impacts

The assessment of the significance of environmental effects can be represented as grades ranging from –2 to +2. The (+) sign to refer to beneficial impact, while the (-) sign refers to adverse effects, whereas –1/+1 would mean important adverse effect could become important beneficial effect if mitigation measures were implemented.

The grading system is described as follows:

- High Beneficial +2
- Low beneficial +1
- Insignificant 0
- Low adverse -1
- High Adverse -2

It is also possible to use a colour coding system, where: red is seem as a high adverse impact; orange low adverse; white insignificant; yellow low beneficial and green high beneficial.

Also a Question mark (?) can be used to denote where the impact is uncertain

Proposed Activities Causing Environmental Impacts

During Construction Phase

The following are the possible impacts that should be evaluated during the construction phase

- loss of ecosystem or its integrity
- erosion of soil
- disruption and /or alteration of nutrient cycle
- disturbance due to noise and vibration
- water quality deterioration
- Air/dust pollution.

During Operation Phase

The following are possible impacts that should be considered during the landfilling operation

- uptake of contaminated water by plants/people
- food chain (consumption of contaminated food/prey)
- bioaccumulation
- water, air and noise pollution
- Invasion of foreign species to the area.

After Closure Phase

Most of the possible impacts of the operation phase are valid for the after closure phase.

The following Table 3 can be used as a prelim and quick check list for impact assessment.

Table 3: EIA scooping martix for waste disposal by landfilling.

Activity	**Environmental Attributes**												
	Physical Environment					**Biological Environment**		**Social Environment**					
	Land	**Water**	**Air**	**Noise**	**Visual**	**Terrestrial**	**Marine**	**Public Health**	**Community**	**Poverty**	**Traffic**	**Aesthetic**	**Economic**
1. Construction Activities													
Land Occupation													
Excavation Works													
Material Transportation													
Material Storage													
Waste Disposal													
Workforce													
2. Operation Activities													
Filling Activities													
Equipments Movements													
Leachate Collection													
Gas Collection													
Treatment Facility													
Fuel Storage													
Workforce													

Daily cover													
3. Closuring Activities													
Placement of Final Cover													
Fencing													
Buffering													
4. Post Closure Activities													
Monitoring													
Rehabilitation works													

Residual Impacts

Residual impacts are unforeseen impacts that occur due to inefficient/imperfect mitigation measure (failure of a measure). This can be covered under emergency and contingency plans if impacts exceed certain levels.

4.2.6 ALTERNATIVES

There are three types of alternatives that are available:

1. Alternative environmentally sound disposal methods for hazardous waste (e.g. landfill versus incineration or reuse and recycling)
2. Alternative sites for landfill
3. Alternative designs for landfill

Alternative Waste Disposal Methods to Landfill

- Identification and Analysis of Alternatives
- Outlines of alternatives
- Reasons for rejection
- Thoroughly assess "No Action" alternative, and the Environmental Consequences of Failure.

Alternative Sites

- Brief description of other sites
- Exclusionary Criteria and Elimination of Areas with Fatal Flaws (site ranking)
- Maps showing candidate areas and exclusionary areas

Alternative Designs

- Considerations Beyond Ideal Design
- Natural containment and/or natural attenuation of leachate
- Cost effectiveness and financial resources Conservation
- Design models consistent with climatic conditions e.g. hyper- dry regions.

4.2.7 MONITORING PROGRAMMS

During Construction

- Surface and groundwater quality
- Air Quality
- Noise Levels

<u>During Operation</u>

- Surface and Groundwater quality
- Air Quality
- Noise Levels
- Health Conditions/ Occupational Health

<u>After Closure</u>

- Groundwater Monitoring
- Air Quality Monitoring
- Land use
- Health Conditions/Occupational Health

The parameters to be analyzed in the samples taken must be derived from the expected composition of the leachate and the groundwater quality in the area.

In selecting the parameters for analysis account should be made to mobility in the groundwater zone.

Parameters could include indicator parameters in order to ensure an early recognition of change in water and/or air quality.

4.2.8 ENVIRONMENTAL MANAGEMENT SYSTEMS

An environmental management system should be in place especially during landfill operation it should address mitigation measures to contain environmental impacts and shall reflect the resources and mechanisms for implementation.

<u>During Construction</u>

- Construction and Excavation Waste Management Plan
- Equipment Maintenance Management Plan

<u>During Operation</u>

- Environmental Management System
- Water Conservation Program
- Energy Conservation Program

<u>After Closure</u>

- Long term Monitoring plan
- Rehabilitation plan

4.2.9 CONTINGENCY AND DISASTER MANAGEMENT PLAN

<u>Risk Assessment</u>

- Estimation of each risk's probability and impact, and identification of feasible risk reduction measures and fallback options to arrive at a consolidated register of risks (usually database)
- Quantitative analysis of expected cost of risks to aid budget contingency management, including probabilistic modeling
- Quantitative analysis of expected delays to the project programme to identify critical programme risks and associated critical paths, including probabilistic modeling

<u>Risk Management</u>

- Production of an appropriate risk management plan, including a focused programme of actions.

- Periodic risk monitoring, review and reporting, including progress monitoring of actions.
- Provision of technical support to oversee or implement the risk management plan.

Emergency Response

- Emergency Planning for an effective immediate response to identified major risk areas.
- Crisis Management planning to minimize business interruption and enable normal business to be resumed as quickly as possible.

4.3 RANKING OF CANDIDATE LANDFILL SITES

When several candidate sites are initially proposed, the above criteria are used for technically evaluating and comparing these sites, to determine their acceptability.

In the early stages, when there are many candidate sites, a 'coarse screening' is carried out to eliminate the unsuitable sites and identify the top ranking sites. This exercise would initially be undertaken by specialists. The following Table 4 proposes one form of site ranking matrix for rapid assessment.

Candidate site	**Economic Criteria**				**Environmental Criteria**					**Public Acceptance Criteria**				**Total Score**
Site 1	Distance	Size	Access	etc.	Ground water	Surface water	Soil depth	Setting	etc	Distance	Visibility	Wind	etc	
Site 2														
Site 3														
……..														
……..														
Site n														

Table 4: Candidate landfill site ranking matrix

The results are expected to be presented to the licensing authorities in a report, the *Candidate Landfill Site Report*.

Please note that adding up individual impact score and comparing options against a total score from another option can be extremely misleading. For example, if one option performs fairly well against most of the criteria except one where it performs very badly (e.g. ground water contamination has a highly adverse impact) then its overall score may not be too bad thus masking the high adverse score on a critical aspect of the environment. Consequently, it is now generally more common in good practice EIA to use colors or symbols, to indicate the significance of impacts and which also discourage adding scores.

4.4 PUBLIC PARTICIPATION

As mentioned above public participation within the EIA process is very important. There are a number of methods that can be used such as

1) Informing the public of the project through the media
2) Supplying EIA document for members of the public to comment on together with an address for correspondence
3) Providing a workshop or face to face meeting with project developers, the appropriate government officials and the concerned members of the public.

Principles of good practice of public participation are:

1) Ensure that the public are informed of when and how consultation will be carried out
2) Provide EIA information in a timely fashion to the public
3) Ensure that the meetings or consultation period are at reasonable times so that the public can be easily involved
4) Provide feedback to the public on how there concerns were incorporated into the EIA

4.5 STRATEGIC ENVIRONMENTAL ASSESSMENT

The success of project level environmental Impact Assessment has led to the extension of the principles of environmental Impact Assessment to plans and programmes and occasionally national or regional policies.

For example a national waste management policy may be subject to a strategic environmental assessment (SEA). Generally speaking this assessment will require less technical information as less is known about the types of disposal technologies, which will not be eventually used, in what proportion, nor where facilities will be sited. However, the assessment will provide information on what are the environmental consequences of choosing different approaches or technologies at the national level, where the resources should be spent most appropriately (e.g. on waste reduction recycling or environmentally sound disposal as well as the different disposal technologies). At the plan, programe or strategy level more information on the location of activities and the focus of resources is known through the SEA of the policy (i.e. landfill will be the most important disposal technique). Consequently, a more technical approach to assessment can be used. Finally the plan programme or strategy assessment provides information for the project level assessment, which has been described in detail in these guidelines.

SEA much like EIA includes the following stages

4) Screening
5) Scoping
6) Impact identification
7) Evaluation using an Impact matrix
8) A Report and non technical summary
9) Monitoring

4.6 THE FEASIBILITY STUDY AND REPORT

Before subjecting the top ranking candidate landfill sites to a more detailed investigation, a feasibility study report may be mandatory. The feasibility study should be a minimum requirement for both H:h and H:H sites. Its aim is to confirm that the site has no fatal flaws. To do this, any critical factors must be identified and addressed to the satisfaction of the licensing department.

4.7 DOCUMENTATION

All pertinent information that was collected as part of the EIA process, as well as the manner in which it was assessed and the judgments used in selecting the preferred alternatives must be described in an EIA document. The language of the EIA document must be clear and concise. The information presented should be balanced, relevant, and succinct. Detailed technical data should be generally confined to appendices or referenced to reports. As the EIA document is used for decision-making, it should focus on clarifying issues which are important to project decisions, such as trade-offs, evaluation criteria, evaluation and selection process, irreversible impacts, etc. An EIA document should typically include:

- Introduction, the introduction should include information about
  - ⇒ Hazardous waste projection in the Arab Countries.
  - ⇒ The need of guidelines for site selection, design, operation, closure, and monitoring of HWLF be designed specifically for hyper- dry regions particularly the Arab States region.
  - ⇒ The approach taken to carry out the EIA and how far it can differ somewhat, depending on the requirements and practices of the different international funding organizations; a country's legislative framework; and the type of HWLF.
  - ⇒ The different EIA tools and methods that will be utilized at the different stages of the EIA such as checklists and matrices.
  - ⇒ The alternatives to the project, and the alternative methods of carrying out the project.
  - ⇒ The need to consider cost effective alternatives.
  - ⇒ Possible exemption or relaxation of international regulations.
  - ⇒ Arguments that encourage performance based designs over engineered designs.

- Executive Summary, the executive summary should provide a concise discussion of significant findings and recommended actions.

- Policy, legal and administrative framework within which the EIA is prepared.
- Project Need/Justification.
- Description of project and its alternatives in a geographic, ecological, social and temporal context.
- Description of existing environment including a description of relevant physical, biological, resource use and socio-economic conditions prevailing before the project is developed.
- Discussion of potential environmental impacts, both positive and negative, that are likely to result from the proposed project - including an identification of mitigation measures, residual impacts that cannot be mitigated, opportunities for environmental enhancement, and uncertainties associated with impact predictions.
- An analysis of alternatives, which compares design, site, technological and operational options systematically (and quantitatively where possible) in terms of potential environmental impacts, capital and operating costs, appropriateness, and institutional and monitoring requirements.
- Impact management plan including proposals for feasible and cost-effective mitigation measures that may reduce potentially significant adverse environmental impacts to acceptable levels; and compensatory measures where mitigation measures are not possible.

- A summary of the EIA for the general public
- Appendices - including a list of EIA contributors, references and record of inter-agency meetings.

Detailed data and analysis that are important but not critical to the EIAs findings should be provided in a series of support documents to the main EIA report.

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ANNEXES

Annex (1)
Attendance Sheet for Participants of Expert Group Meetings

Email	***Third Expert group meeting 23-26/5/2005***	***Second Expert group meeting 22-25/11/2004***	***First Expert group meeting 5-8/7/2004***	***Name***	***Country***
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Annex (2)

Proposed matrix of screening criteria for site selection of hazardous waste landfills in hyper-hyper- dry regions modified from US EPA 600/2-85/018, 1985

Criterion	**Relative Measurements**							**Relative Value =Grading Importance of Criterion***			
	0	1	2	3	4	5	6	**Real Value**	**Relative value**	**Criterion Grade**	**Estimated value**
	Unacceptable	**Bare Acceptance**	**Below average**	**average**	**Above average**	**Good**	**Ideal**				
Preliminary Studies											
Rainfall (mm/year)	40 <	30 - 40	20 - 30	15 - 20	10 - 15	5 - 10	5>			10	
Distance from Drainage lines (km.)	2>	4-2	6-4	8-6	14-8	25-14	25<			5	
Distance from wells (km.)	2>	4-2	6-4	8-6	14-8	25-14	25<			5	
Distance from active seismic areas (km.)	2>	5-2	8-5	10-8	20-10	30-20	30<			2	
Distance from Urban areas (meters)	500 >	-500 1500	- 1500 2500	-2500 3500	-3500 4500	-4500 8500	8500 <			4	
Distance from airports	1500 >	-1500	-3000	-4500	-5500	-7500	11500 <			4	

(meters)		3000	4500	5500	7500	11500					
Distance from protected areas (meters)	1500 >	-1500 2000	20000 3000 -	-3000 4000	-4000 5000	-5000 10000	10000 <			4	
Distance from historical and archeological areas (meters)	500 >	-500 1500	- 1500 2500	-2500 3500	-3500 4500	-4500 8500	8500 <			4	
Distance from waste generation sources (km.)	30 <	20- 30	15- 20	10 -15	8-10	5-8	3 >			4	
Distance from supply lines (meters)	50 >	100- 50	-100 250	400- 250	- 400 500	- 500 650	650<			2	
Slope (%)	15< 0.5>	10 0.6	8 0.7	5-4 0.9	3 1.1	2 1.2	1.5 1.5			4	
Landform Stability	Unstable						Stable			4	
Flood probability	High						Low			4	
Weathering	High						Low			2	
Groundwater depth (meters)	10>	25 - 10	35-25	70-35	100-70	-100 200	200<			5	
Depth to Bedrock (meters)	10 >	20-10	40-20	65-40	100-65	-100 200	200<			5	
Type of filling media	Pebbles Clay						Fine Sand			4	
Land subsidence(meters)	2<	1.5	1.25	1	0.75	0.25	0			3	

Wind speed and direction	Inapprop riate						Appropriate			2	
Detailed Field Studies											
Distance from faults and joints (meters)	500>	700-	1000-	1500-	2200-	3500-	3500<			3	
Landfilling Media and Subsurface Layers											
Water absorption property (mm/100 gm)	2>	3.5 -	8 -	12.5-	25 -	50 -	50 <			4	
Soil Thickness (meters)	18 >	25-	30-	50-	100-	150-	150 <			4	
Soil Engineering Properties	Bad						Very Good			4	
Permeability (liter/day/m^2)	24< 0.0024	12 - 0.0 1-	8 - 0.05-	2 - 0.1 -	075 - 0.25 -	0.5- 1 -	0.24 -			4	
Effective Porosity	High Low	→					Medium			4	
Geologic Structures	Compl icated	←					Simple			4	
Evaporation Rate (ml/year)	40>	45	50	55	60	75	84<			5	
Hydrologic Complexity	Compl icated						Simple			5	
Control on Water Gradient	Diffic ult						Easy			2	

Ease of monitoring and follow up	Difficult						Easy			3	
Ease of rehabilitation and reforming	Difficult						Easy			3	
Landfilling in Quarries	Limestone Sand Pebbles			→			Granite Clay Rock			3	
Hydraulic Gradient	20 >	14	11	8.5	4.8	2.6	2 <			4	
If the slope is less than 1% and the site is not in the course of flood boundaries of a river or a lake and the other criteria was above average, then the slope criterion could be neglected or replaced with value of 6.	0	1	2	3	4	5	6	Total			

- If total grading is less than 500, then the site may be adequate as sanitary landfill for municipal solid waste only.
- If total grading range between 500 and 650, then the site may be adequate as natural landfill for municipal solid waste.
- If total grading range between 650 and 780, then the site is adequate as sanitary landfill for hazardous waste only.
- If total grading is more than 780, then the site is adequate as natural landfill for hazardous waste.

Note: The highest value is 804 and the lowest value is zero, and before the site utilization final decision, the concerned department has to make sure that other economical, social and political issues are taken into consideration

Criterion	**Relative Measurements**							**Relative Value =Grading Importance of Criterion***			
	0	1	2	3	4	5	6	**Real Value**	**Relative value**	**Criterion Grade**	**Estimated value**
	Unacceptable	**Bare Acceptance**	**Below average**	**average**	**Above average**	**Good**	**Ideal**				
Preliminary Studies											
Rainfall (mm/year)											
Distance from Drainage lines (km.)											
Distance from wells (km.)											
Distance from active seismic areas (km.)											
Distance from Urban areas (meters)											
Distance from airports (meters)											
Distance from protected areas (meters)											
Distance from historical and archeological areas											

(meters)											
Distance from waste generation sources (km.)											
Distance from supply lines (meters)											
Slope (%)											
Landform Stability											
Flood probability											
Weathering											
Groundwater depth (meters)											
Depth to Bedrock (meters)											
Type of filling media											
Land subsidence(meters)											
Wind speed and direction											
Detailed Field Studies											
Distance from faults and joints (meters)											
Landfilling Media and Subsurface Layers											
Water absorption property (mm/100g)											

Soil Thickness (meters)											
Soil Engineering Properties											
Permeability (liter/day/m^2)											
Effective Porosity											
Geologic Structures											
Evaporation Rate (ml/year)											
Hydrologic Complexity											
Control on Water Gradient											
Ease of monitoring and follow up											
Ease of rehabilitation and reforming											
Landfilling in Quarries											
Hydraulic Gradient											
If the slope is less than 1% and the site is not in the course of flood boundaries of a river or a lake and the other criteria was above average, then the slope criterion could be neglected or replaced with value of 6.											

The BCRC-Egypt is presenting these guidelines to assist in the development of sound environmental practices for the disposal of hazardous wastes in the Arab hyper-arid regions. It is needed that those who read these guidelines and would like to contribute to their improvement in future editions to contact BCRC-Egypt at

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