



Republic of Namibia  
Ministry of Environment & Tourism

MUDUMU LANDSCAPE  
**SEMI-CONTROLLED LANDFILL SITE**  
SIMPLIFIED WASTE DISPOSAL SITE DESIGN





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<b>PROJECT LOCATION</b>	Mayuni Conservancy, Kongola, Caprivi Region, Namibia
<b>PROJECT TITLE</b>	The Mudumu Landscape Semi-Controlled Landfill Site Design
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# CONTENTS

<b>CHAPTER 1</b>	<b>INTRODUCTION</b>	<b>4</b>
	1.1. LANDFILL SITE DESIGN RATIONALE	4
	1.2. THE RECEIVING ENVIRONMENT	5
	1.3. LANDFILL SITE DESIGN CONSIDERATIONS AND OBJECTIVES	6
<b>CHAPTER 2</b>	<b>SITE DEVELOPMENT AND INFRASTRUCTURE</b>	<b>7</b>
	2.1. SITE LAYOUT AND PREPARATION	7
	2.2. ACCESS AND TRAFFIC CONTROL	8
	2.3. EMPLACEMENT CELLS	8
	2.4. LEACHATE COLLECTION	9
	2.5. CIVIC WASTE FACILITIES AND SERVICES	9
<b>CHAPTER 3</b>	<b>DAILY OPERATIONS AND MANAGEMENT</b>	<b>10</b>
	3.1. MANPOWER AND KEY PERFORMANCE AREAS	10
	3.2. ACCESS CONTROL AND MAINTENANCE	11
	3.2. EMPLACEMENT, COVERING AND MAINTENANCE	11
	3.3. REUSE AND RECYCLING	12
	3.4. RECORDKEEPING, MONITORING AND REPORTING	13
<b>CHAPTER 4</b>	<b>REFERENCES</b>	<b>13</b>
<b>CHAPTER 5</b>	<b>APPENDIXES: TECHNICAL DRAWINGS</b>	<b>15</b>

1.1.





## 1.1 Landfill Site Design Rationale

There are many potential environmental problems associated with the land filling of waste. These problems are often long-term and include possible contamination of the groundwater and surface water regimes, the generation of odour, noise and visual nuisances. A good design of a landfill site will prevent, or reduce as far as possible, negative effects on the environment, as well as the risks to human health arising from the land filling of waste.

The design process was thus mainly consistent with the need to protect the environment and human health, and not much on any conclusion reached on findings of an environmental assessment; or environmental monitoring results; or risk assessment or on the geology and hydrogeology of the site investigations. However, the designers adopted methods, standards and operational systems based on current waste management practices and best available management techniques guided by prevailing circumstances in the Mudumu Landscape. The fundamental objective behind the design and the waste management plan was that of sustainability. It was therefore implicit that landfill development and operation (which are intrinsically linked) is reflected in the design approach.

This report outlines the design objectives and considerations that need to be taken into account in the design of a landfill. Management systems for the control of leachate and groundwater as well as the operations and maintenance are discussed.

In the past, many of the problem associated with landfills occurred as a result of non - planned facilities and poor management. It is thus imperative that issues outlined in this report are considered in full in the development of the landfill to ensure that the long-term environmental risks posed by landfills are minimized through effective containment, operations, control, monitoring and evaluation.

## **1.2 The Receiving Environment**

Based on a site visit and topdesk studies the area is best described as being mainly flat and around 900 - 1000m above sea-level (Mendelsohn and Roberts). The area is covered by thick deposits of Kalahari sands with very little of the underlying geology exposed. In general, these extensive Kalahari sands are the main features which shape the area. No floodplains could be observed at the area.

The landscape falls into the tree and shrub savanna biome encompassing North-Eastern Kalahari Woodlands, Riverine Woodlands, Caprivi Mopane Woodland and Caprivi Floodplains (VERSACON/IECN 2009). Of the five main land types in the Mudumu landscape, two distinguished ones found in the area allocated for the waste disposal site are the Mopane woodlands and the Kalahari woodlands on sandy plains.

A variety of soils also seems to appear in the area ranging from sandy soils, clay-loam soils to pure sands. In between is a variety of intermediate soils consisting of different proportions of sand, clay and organic material. These intermediate soils are often the best suited for the establishment of a landfill site because they retain water to some extent and thus minimizing underground water pollutions.

Similarly to Katima Mulilo, a highly variable rainfall averaging around 700mm is anticipated for this area. Highest temperatures occur from September to October when average daily maximum temperatures vary between around 32°C and 35°C. Average daily minimum temperatures vary between around 20°C in summer and about 5°C in winter. Frost is unusual. About 2.5m of water evaporates in an average year which is over four times the normal precipitation.

It is also anticipated that this area is a relatively significant habitat of a variety of biodiversity because of the Caprivi Region's species richness. The environmental assessment impact study will however provide more impact related information on elephants' corridors, wildlife types and populations and as well as other mammal and bird species presence and behaviors within the area designated for the landfill site.

## **1.3 Landfill Site Design Considerations and Objectives**

The designers considered a number of environmental media that may be significantly impacted through the life of the landfill. The chosen design will have a major influence on the operation, restoration and aftercare of the facility. The main aspects that were considered in the design are briefly discussed below.

### **Nature and quantities of waste**

The waste types accepted at the landfill dictated the control measures required. The landfill will be accepting non-hazardous biodegradable whereas hazardous waste, tyres, oil and grease are only accepted for storage purposes.

### **Protection of soil and water**

A liner is provided for the protection of soil, groundwater and surface water. The liner system consists of a natural clay layer combined with a geotextile liner that meets permeability and thickness requirements.

### **Leachate management**

An efficient leachate collection system has been provided to ensure that leachate accumulation at the base of the landfill is kept to a minimum. The leachate system consists of a leachate collection layer with a pipe to convey the leachate to a sump.

### **Environmental nuisances**

Distance provision has been incorporated in the positioning of the site to minimize and control nuisances arising from the construction, operation, closure and aftercare phases of the landfill. Nuisances that may arise from land filling include: noise, odours, dust, litter, birds, vermin and fires.

### **Stability**

Consideration was given to the stability of the liner system and the waste emplacement to ensure stability against sliding.

### **Visual appearances and landscape**

Consideration was given to the visual appearance of the overall landform impacts during operation and land filling on the surrounding landforms by keeping the civic facilities to a minimum.

### **Operational and restoration requirements**

The designers considered the manner of site development and the necessary site infrastructural requirements during landfill operation and restoration. Landfill sites will not be developed on a phase basis, but site infrastructure such as waste emplacement cell, site services and security fencing will be constructed at once.

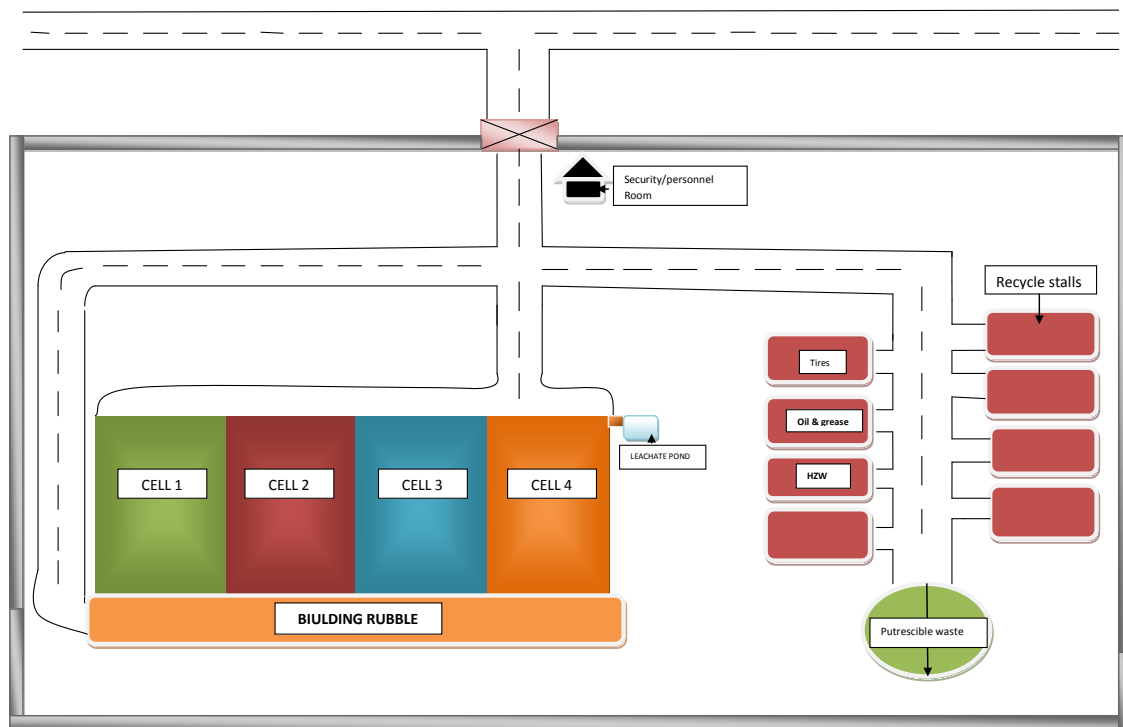
### **Estimated costs of the facility**

The designers kept the cost of the total construction and operation in consideration. The costs of planning, restoration/capping works, landfill aftercare and monitoring were not taken much into consideration.

Based on the above considerations, the primary objective of landfill site design is *to provide effective control measures to prevent or reduce as far as possible negative effects on the environment, in particular the pollution of surface water, groundwater, soil and air, as well as the resulting risks to human health arising from land filling of waste.*

Landfill practice is dynamic in that it will change with both advances in technology and changes in legislation. To incorporate such advances and changes a periodic review of the design should be carried out, as the lifespan of a landfill site from commencement to completion is long compared to other construction projects, where in generally, landfills are constructed on a phased basis. The design lifespan of the site has been determined at a minimum of 15 years, which lifespan can be extended significantly through reuse and recycling activities.

## 2.1 Site Layout and Preparation



**Figure 1:** A diagrammatic drawing of the suggested simplified landfill site layout

The suggested landfill site layout design and plan will enable a practicable operation of the facility and shows clearly the location of the area to be land filled, where to store other waste types, and where recycling activities will take place. Figure 1 below depicts a diagrammatic drawing of the suggested simplified landfill site layout whereas detailed technical design drawings are appendices to this report.

The extent of preparatory works will include the stripping/filling of soil to formation level for the:

- ◇ Lining system for cell construction;
- ◇ Leachate management facilities;
- ◇ Landscaping and screening; and
- ◇ All other site infrastructure.

The existing gravel road located within the proposed area of waste disposal must be utilized as public road leading to the waste disposal site.

The quantity of the excavated soil arising from the development of the emplacement cells will be sufficient and suitable usable material available on site for daily operation and intermediate restoration covering requirements.



Any possible available building rubble will also be a suitable material for such purposes. Apart from clay that can be purchased from the locals, gravel, river sand, geotextile, HDPE pipe, sump construction and all civic waste facilities requirements will be purchased as per the technical drawings details.

The landfill will present a clean and well managed appearance to the public. Provision of a buffer zone with other tree planting is recommended to lessen the environmental impact. The proposed end use of the site after completion should be determined through the environmental impact assessment. However, this final landform should fit in with the surrounding environment.

## 2.2 Access and Traffic Control

The landfill design has incorporated security provisions which include the following:

**Fencing:** Perimeter fencing should be provided around the entire site. The fencing should be to an adequate standard (chain link, palisade) and sufficient height (approximately 2.3m) to prevent unauthorized access.

**Gates:** An access gate should be provided at the reception area. It may be necessary to provide another two gates at points around the site for access and emergencies. All gates should be to a standard similar to that of the specification for the security fencing. The gates must be secured with suitable locks.

**Signage:** Signage will provide direction to customers and the public to the entrances of the landfill. A 6m width two-way public access and internal roads should be provided and maintained through regular grading for all-weather conditions. Traffic signs within the landfill site should include stop signs and directional signs to reception, car park, emplacement cells and civic waste area etc. In addition to traffic signs provision should be made for the inclusion of a site sign at the site entrance. This should specify relevant details such as "non-authorized entrance", opening hours, types of waste accepted, landfill site operators' name and contact numbers, etc.

## 2.3 Emplacement Cells

Two emplacement cell types are recommended for logistical and practical emplacement, compaction and covering of waste namely:

- ◇ A trench landfill for putrescible waste, which is usually located in an area of flat land where the soil has been excavated and waste is deposited into the void. The stockpiled soil is then used to cover the waste.
- ◇ A ramp landfill for municipal solid waste, which is usually where a low bank is present, or has been created, and waste is deposited along one end. Soil excavated from the front of the face of the ramp is used to cover the waste.

The ramp/emplacement cells should be **clay-lined - inclined slope** linked to a simplified leachate drainage control system. The five cells sizes are based on a combination of factors availability of funds, site space, vehicular maneuvering and etc. Cells are separated by intercell bunds for soil stability purposes. Minimizing the cell size facilitates the landfilling operation through reducing leachate generation; minimizing the area of exposed waste thereby reducing cover requirements, and assisting in the control of windblown litter. For each cell the designers estimated void space volume, development sequence and active lifespan at a minimum of 15 years, which lifespan can be extended significantly through reuse and recycling activities.

## 2.4 Leachate Collection

Leachate produced in a landfill is a liquid which has percolated through the waste, picking up suspended and soluble materials that originate from or are products of the degradation of the waste. The leachate management system was designed considering the following objectives and or reasons:

- ◇ To reduce the potential for seepage out of the landfill through the base either by exploiting weaknesses in the liner or by flow through its matrix;
- ◇ To prevent liquid levels rising to such an extent that they can spill over and cause uncontrolled pollution to any water source and soil;
- ◇ To minimize the interaction between the leachate and the liner, and
- ◇ To ensure the stability of the waste.

## 2.5 Civic Waste Facilities and Services

Site principal infrastructure elements considered during the design are access and traffic control; site services such as water and power supply and *civic waste facilities* only in order to minimize development costs. Those that were considered unnecessary are site accommodation and compounds; lighting, weighbridges, wheel cleaners, security/telemetry, telephone/fax, fire water and wastewater (removal/treatment).

Other civic waste facilities that will provide householders and commercial operators with a convenient centre to drop off recyclables and other wastes will consist of a variety of containers designed for specific wastes and dedicated areas. The entrance and drive-in area should be graded. All collection containers should be placed on a paved surface where possible. Bunding or containers should be considered for areas earmarked for hazardous waste such as waste oils; out of date medicines; veterinary products; household detergents; paints and solvents; primary batteries; pesticide and herbicides, and similar materials. Civic waste facilities should be manned and supervised closely at all times that they are open to the public. A sealed drainage system can be constructed to collect liquids emanating from these areas. Such collected liquid should then be diverted to the leachate sump. Areas designed for storage or handling of putrescible wastes and construction/demolition wastes should comprise of a hard standing surface. Civic waste facilities should be landscaped so that they are aesthetically pleasing.

# CHAPTER 3

# DAILY OPERATIONS AND MANAGEMENT

## 3.1 Manpower and Key Performance Areas

The minimum manpower recommended for a well-managed site is:

**Landfill Site Supervisor (LSS)** - The LSS will be coordinating and supervising the overall landfill site operations; accounting and reporting to the ML Committee, and ensuring the implementation and adherence to recommendations.

*It is recommended that the operation of the landfill site be outsourced to a competent Solid Waste Service Provider (SWSP) such as Rent-A-Drum or a local group/company/SME. Such SWSP should be supervised by the LS.*

**Security Guard(s)** - The security guard(s) will be controlling legal and illegal access to the landfill site; assisting in the prevention (and where possible regulating) waste burning, and assisting in the recording of waste types and quantities entering and leaving the landfill site.

*It is recommended that the security guard services be outsourced to a security company or to become the responsibility of the SWSP.*

**Traffic Controller** - The traffic controller will be keeping record of types and quantities of waste entering and leaving the landfill site and complementing the records of the waste removal contractors and recyclers, and directing and guiding vehicles to respective disposal areas and cells.

*It is instead recommended that two (2) security guards be appointed to rotate the security guard's and traffic controller's duties on a daily or weekly basis.*

**Manual Laborers** - The laborers will manually be covering the previous day non-recycled waste each morning; daily cleaning and inspecting the conditions of the landfill site fence and reporting defects to the LSS or SWSP; preventing (and where possible regulating) waste burning, and performing any other manual laborer tasks as required by the LSS.

*It is recommended that at least 3-4 laborers be appointed instead of landfill site equipment operators. Some roles can be combined on this small landfill. It is thus advisable to rather appoint five (5-6) laborers who should rotationally perform the security guard's, traffic controller's and laborers' tasks. It is thus recommended for the ML Committee to rather go into partnership with a competent SWSP or local SME to render all the above required services with the ML Committee only performing inspections and ensuring compliance.*

## 3.2 Access Control and Maintenance

Access will be controlled to minimize unauthorized human and animal presence, and vehicular traffic as well as unauthorized and illegal dumping within the landfill by:

- ◇ Preventing unauthorized entrance.
- ◇ Visually inspecting and recording types and quantities of waste loads.
- ◇ Directing vehicles to respective emplacement and offloading areas.
- ◇ Inspecting perimeter fence and gates for damage. Reporting and or making repairs if necessary.

- ◇ Inspecting access roads, entrance areas and perimeter fence for loose trash, and weekly clean-ups as necessary.
- ◇ Inspecting site access road for damage from vehicle traffic, erosion, or excessive mud accumulation. Maintaining entrance and internal roads as needed.

### 3.3 Emplacement, Covering and Maintenance

Operations at the working face will be conducted in a manner that allows the prompt and efficient emplacement and or offloading of waste through measures such as:

- ◇ Vehicles transporting solid waste arriving at the waste disposal working face will be directed to an unloading area by on-site personnel and or signage.
- ◇ The approach to the unloading area will be wide enough to safely offload at least two vehicles side-by-side.
- ◇ Two emplacements cells will be utilized daily – one for offloading and collection of recyclables while the second cell is being maintained for proper placement, covering and compaction.
- ◇ Waste should be disposed off and covered in thin bands up to 6.0m which should be build up into a layer about 1.5m deep. This reduces the likelihood of instability and settlement problems in future.
- ◇ Compacted waste should be covered with excavated soil or similar inert material (alternatives such as construction and demolition material may be used) to deter flies and other insects from breeding in waste; to reduce the attraction of birds to wastes; to suppress odors and dust as well as reducing wind-blown waste and improving the surface for waste vehicles.
- ◇ Inspection of all site signs for damage, general location, and accuracy of posted information and correcting thereof on date of discovery.
- ◇ Inspecting for proper placement, thickness, slope, settlement, erosion, and compaction. Correcting problems as needed.

Burning of waste should be avoided by all means and thus concentrating on covering which is an essential element of landfilling operations. The daily and intermediate covering assists in the control of nuisances such as windblown litter, odour, vermin, flies and birds. Daily soil cover of about 150mm should be spread over deposited waste at the end of every working day. Daily cover should ideally be permeable to allow water to pass through thereby preventing ponding/perched water buildup. Intermediate soil cover of minimum 300mm should be used for a period of time prior to restoration or prior to further disposal of waste. Intermediate cover should significantly reduce rainfall infiltration.

### 3.4 Reuse and Recycling

Once again, waste burning should not be permitted. Fires can cause hollows in the waste, encouraging instability, and they could ignite pockets of landfill gas, causing explosions. If not quickly extinguished, fires can become deep seated and smolder for many years. It is thus recommended to reuse or recycle waste accordingly.

**Marketable recyclables:** “*Rent-A-Drum*” (a well-known Namibian based waste management company) and “*Scrap & Skins*” as well as conservancies indicated eagerness and interest to trade in **office paper, cartons, plastic, plastic bottles, newspaper and magazines, iron, glass bottles and tins**. It is thus recommended for the ML Committee to enter into a Public Private Partnership agreement with Rent-A-Drum (and or other recycling companies) and unemployed individuals or groups of waste pickers to provide informal collection services in search for the recovery of such recyclables at source and at the waste disposal site as a job creation venture. The unemployed waste pickers should be organized into specialized groups with a permit to operate at the landfill. They can sell their bottles, plastics, cardboard, and paper to Rent-A-Drum (at their recycling stalls - at the landfill site and or other allocated areas). The extent to which these transactions occur will depend on the availability of marketable recyclables.

**Special waste** such as **tyres** can be recycled as retreads, for use on carts, to make shoes, flower pots, gardening, road



demarcation, playground equipment, animal feeding troughs and for a number of other domestic, farming, agricultural and industrial articles. **Construction and Demolition Debris (CDD)** should be recycled as covering material during landfilling, and for the filling of low-lying areas subjected to regular flooding. **Wood, nails, bricks, and other materials of direct use** can also be reclaimed from CDD for use in a number of minor construction projects. The rate of recycling of CDD, especially bricks and wood (for the manufacturing of furniture and as firewood), has already been established country-wide. Similarly to the marketable recyclables, unemployed community members should be organized into tyres and CDD specialized groups with permission to operate at the landfill as job creation ventures. **Used oil and grease** can be recycled as an industrial lubricant or fuel through the establishment of a deposit system to increase the rate of oil recycling. It is suggested to identify companies, within the Caprivi Region (instead of Wesco Group, a factory for the regeneration of used oil operating in Walvis Bay) that are collecting used oil for refining and reuse purposes. Again the establishment of PPP with such companies will promote the recycling of used oil across and within the entire landscape. Worthwhile for consideration is to provide waste pickers with rag-pulling equipment to shred, clean, and reknit these **fabrics and textiles** as all-purpose utility cloths for resale. This is equally applicable to **repairable waste items** such as electrical equipment, utensils, bicycles, radios and many other items.

### 3.5 Recordkeeping, Monitoring and Reporting

It should be noted that quantities of waste being generated in any setup such as the Mudumu Landscape (and more specifically in Kongola) is expected to grow. It is thus important to measure daily and seasonal waste streams data variations as well as the generation rate of waste at varying points in the chain through representative surveys of households and at any transfer, recycling and disposal sites. This will enable the landscape's solid waste management services to cope with all situations and to feed data into the evaluation of management options.

Records of waste deliveries to the site should be kept, showing who delivered the waste, what type, how much and when delivered. These records are particularly important in deciding on charging waste generators for waste services and such records will equally be vital for any future waste management ventures.

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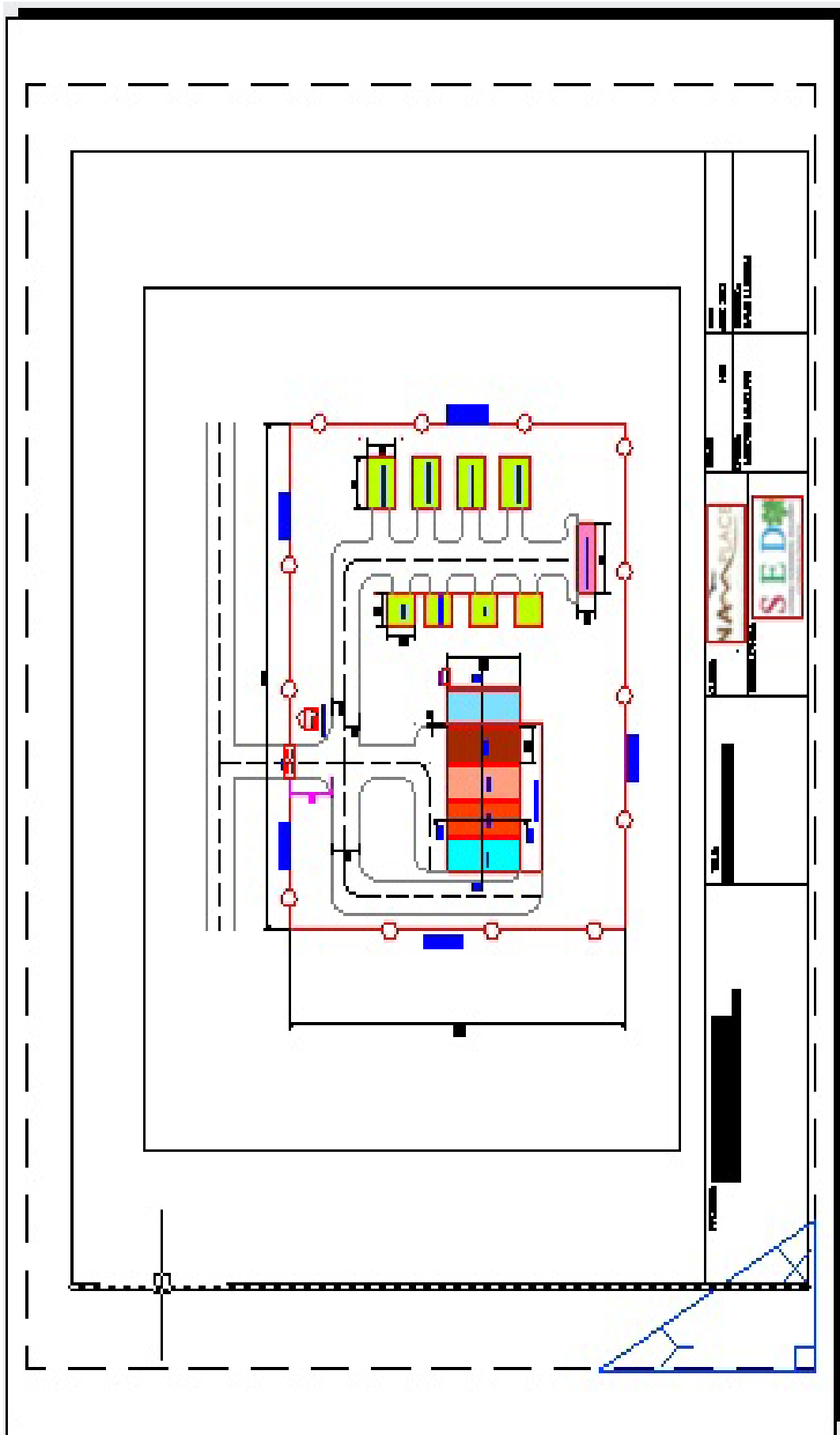
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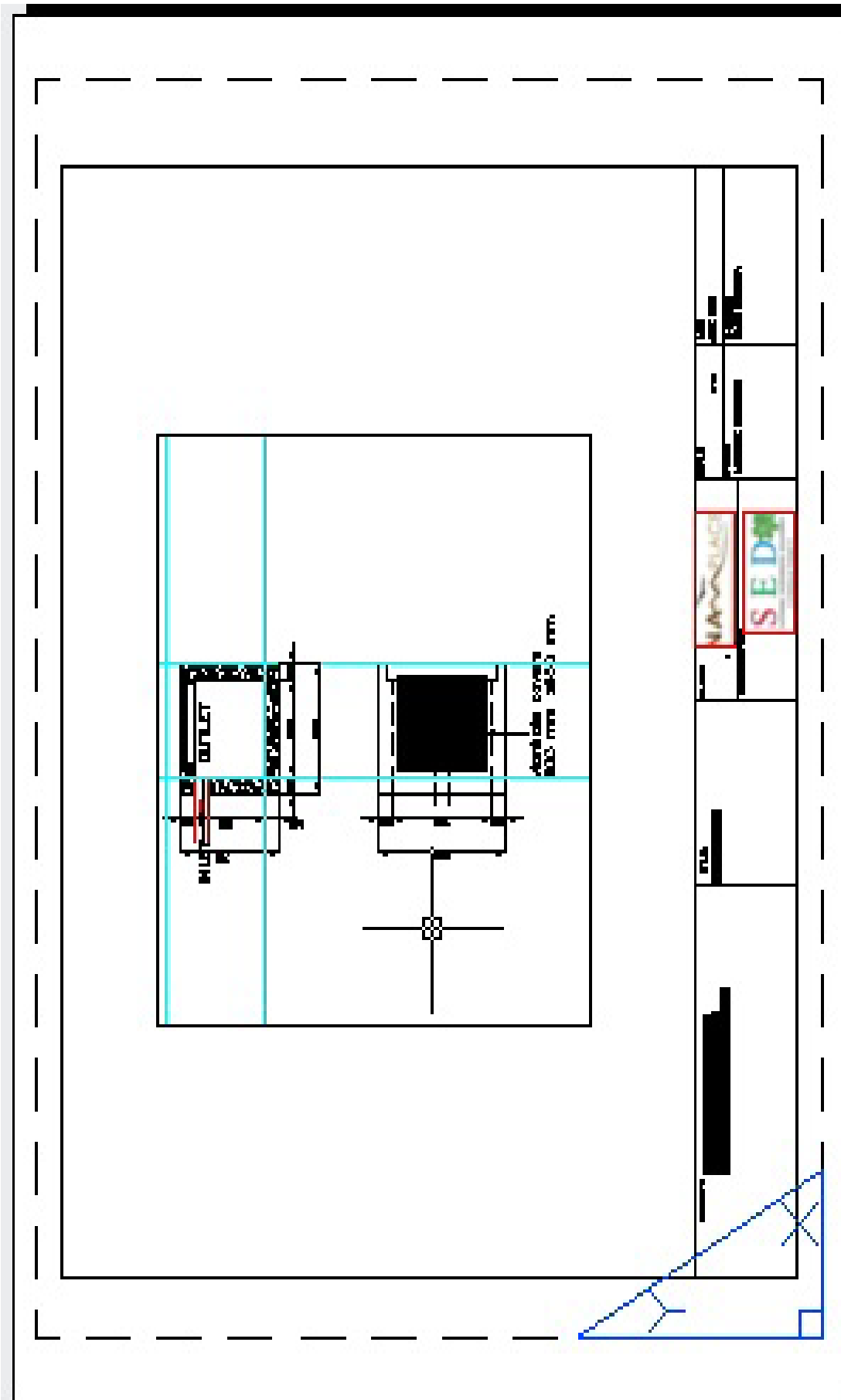
# APPENDIXES: TECHNICAL DRAWINGS















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