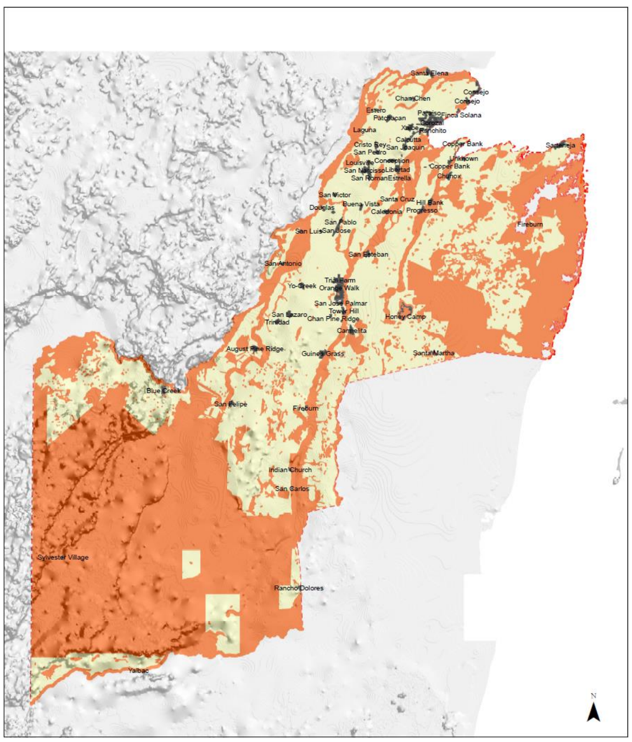
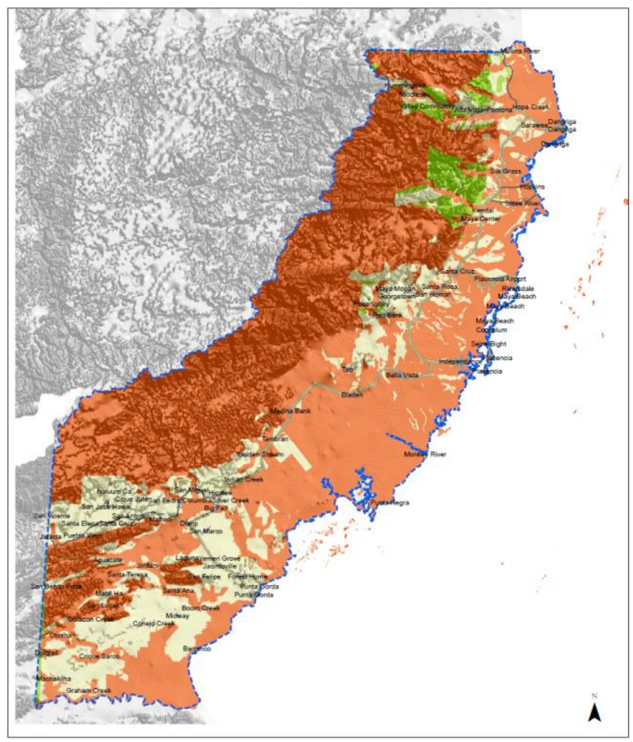
GOVERNMENT OF BELIZE

MINISTRY OF NATURAL RESOURCES AND AGRICOLTURE

Belize Solid Waste Management Agency

Solid Waste Master Plan for Emerging Tourism Areas





ENVIRONMENTAL ASSESSMENT

DRAFT

JANUARY, 2016

DATA SHEET

Project Name:	**Consultancy Services to Prepare a Solid Waste Master Plan for Emerging Tourism Areas**
Project ID:	**TC # BL-T1067**
Form of Contract:	**Lump-Sum**

Consultant

Name: HYDEA SpA
Address: Via del Rosso Fiorentino 2G, 50142 Florence, Italy
Tel: +39 055 719491
Fax: +39 055 7135233
Email: mail@hydea.it
Website: www.hydea.it
Managing Director: Paolo Giustiniani, tel. +39 055719491, mail@hydea.it
Contact Person: Dimitri Abbado, tel. +39 0557194929, d.abbado@hydea.it

<u>Work Team</u>

	Key Experts	
A	Project Manager/SWM Engineering Specialist	Michele Lambertini
B	Procurement Specialist	Fabio Berardi
C	Financial and Institutional Specialist	Jeroen Ijgosse
D	Social Specialist	Jeroen Ijgosse
EI	International Environmental (EIA) Specialist	Sara Monti
EN	National Environmental (EIA) Specialist	Evaristo Avella
F	Landfill and Transfer Station Design Specialist	Stan Ebelewicz
G	Waste Characterization Specialist/HQ PM	Dimitri Abbado
H	Hydrogeologist	Michele Lambertini
	Non Key Expert	
I	Constructed Wetland Specialist	Riccardo Bresciani
J	Hydraulic Engineer	Simone Carotti
K	Civil Engineer	Federico Raspanti
L	Landscape Expert	Luciano Luciani
M	Civil/Structural Engineer	Omar Mitchell
N	Local supports	To be nominated

Contracting Authority:

Name: Solid Waste Management Authority, Ministry of Natural Resources and Agriculture
Address: Market Square, Belmopan, Belize, C.A.
Director: Mr. Gilroy Lewis
Fax: +501 8021527
E-mail: sw.director@mnra.gov.bz

LIST OF ACRONYMS AND ABBREVIATIONS

BATNEEC	Best Available Techniques Not Entailing Excessive Costs
BoQ	Bill of quantities
CAPEX	Capital expenditures
C&D	Construction and Demolition
CF	Compost Facility
CO	Construction and Operation
CQA	Construction Quality Assurance
DBO	Design, Build, and Operate
DFS	Draft Feasibility Study
DOC	Drop Off Centre
DoE	Department of Environment
ESIA	Environmental & Social Impact Assessment
ESMP	Environmental and Social Management Plan
EA	Environmental Analysis
ECP	Environmental Compliance Plan
EF	Emission Factor
EHS	Ealth and Safety
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EU	European Union
FS	Feasibility Study
GHG	Greenhouse Gas
GOB	Government of Belize
GNP	Gross National Product
GWP	Global Warming Potential
HDPE	High-density polyethylene
IDB	Inter-American Development Bank
LFG	Landfill Gas
LEL	Lower Explosive Limit
MASW	Multi-channels Analysis Surface Waves
MRF	Materials Recycling Facility
MSW	Municipal Solid Waste
MNRA	Ministry of Natural Resources and Agriculture
MSWM	Municipal Solid Waste Management
NSR	Noise Sensitive Receivers
OPEX	Operational expenditures
PCB	Polychlorinated Biphenyl
PIU	Project Implementation Unit
PM	Project Manager
POP	Persistent Organic Pollutant

PVC	Poly Vinyl Cloride
RCV	Refuse Collection Vehicle
RFP	Request for Proposals
RORO	Roll-On-Roll Off
SBI	Statistical Institute of Belize
SIPF	Social Inclusion Plan Framework
SW	Solid Waste
SWM	Solid Waste Management
SWaMA	Solid Waste Management Authority
SWMP	Solid Waste Management Project
QA/QC	Quality Assurance and Quality Control
TEQ	Toxic Equivalency
ToR	Terms of Reference
TS	Transfer Station
UEL	Upper Explosive Limit
UK	United Kingdom
WASA	Water and Sewerage Authority
WB	World Bank
WTE	Waste-to-Energy

TABLE OF CONTENTS

NB

Through all the document the unit measures are always referred to the Metric System unless otherwise explicitly specified. The symbols Mg (mega-gram) and ton (metric tonne) are equivalently used to express the same metric tonne.

Unless explicitly specified any reference to dollar ($) refers to Belize Dollars (BZ$ or BZD).

Decimal separator is expressed by a dot (.) and thousand separator is expressed by a comma (,).

LIST OF FIGURES

List of Tables

1 BACKGROUND

Belize suffered an urgent need for improved waste management due to lack of proper infrastructure for waste treatment and disposal. A number of dumpsites have severely deteriorated the environment for several years. This prompted the Government of Belize to apply for a loan from the **Inter-American Development Bank (IDB)** and the **OPEC Fund for International Development (OFID)** for the implementation of the **Solid Waste Management Project (SWMP).** As listed in the draft National SWM Policy major results are:

- Closure of a large dump site close to Belize City (Mile 3)
- Closure of an open dump site close to San Ignacio
- Design, constructions and bringing into operation of a new regional sanitary landfill facility, including access road, to serve the Western Corridor (Mile 24)
- Design, constructions and bringing into operation of two new transfer-loading stations to serve Belize City and San Ignacio / Santa Elena

Further Project components yet to be completed are:

- Closure of open dump sites in San Pedro and Caye Caulker
- Construction and bringing into operation of two new transfer-loading stations to serve San Pedro and Caye Caulker
- Closure of a dumpsite and construction of transfer station along the Burrell Boom – Hattieville Road

The SWMP has addressed solid waste management needs in the central regions of Belize (Cayo and Belize Districts) and the Northern Islands of Ambergris and Caye Caulker. The GOB has now identified the need to expand solid waste management to the other regions in Belize, especially those that are to become key tourism destinations, both in the Country's Northern Corridor (Orange Walk and Corozal Districts) and in the Southern Corridor (Stann Creek and Toledo Districts).

HYDEA SpA (The Consultant) has been awarded the contract for the execution of the **Consultancy Services to Prepare a Solid Waste Master Plan for Emerging Tourism Areas**.

This report was prepared by the Consultant in response to the Terms of Reference of the Consultancy Contract to provide the necessary information needed to describe the environmental and social aspects related to the proposed Solid Waste Management Plan for the two Corridors.

A. EXECUTIVE SUMMARY

2 INTRODUCTION

The present draft document refers the status of the activities carried out for the preparation of the Solid Waste Master Plan for Emerging Tourism Areas (hereinafter referred as the Plan or the Master Plan) and the outcomes of such activities.

Along the process analyses have been made to assess the present situation of the solid waste generation and management in the Northern and Southern Corridors, different alternatives have been compared to give appropriate solution to the matter and the expected impacts of the proposed solutions have been evaluated.

Finally a conceptual design for the solid waste management in the two Corridors has been proposed, as a result of the previous activities.

Hereinafter the more relevant aspects of the different studies and assessments carried out are summarized and reported as briefly described in the following sections.

The document is subdivided in Chapters numbered from A to I and is completed by three (3) appendices. The present Chapter A provides a general outlook of the content of the following chapters.

3 PROJECT DESCRIPTION – CHAPTER B

The section provides an outlook of the proposed system for the solid waste management of the Northern and Southern Corridors of Belize.

A description of the relevant characteristics of the two study areas is initially given. A specific geographical and social structure of the Corridors is proposed to better represent different situations with regard to the current and future waste management strategies.

Based on the proposed structure the expected Municipal Solid Waste generation pattern is estimated for a twenty-five (25) years period, assumed as the duration of the Plan.

The boundaries and conditions assumed at the base of the following assessments and proposals are then presented.

Finally the proposed system of waste management facilities is described.

4 PRELIMINARY ASSESSMENT OF THE INSTITUTIONAL AND LEGAL FRAMEWORK – CHAPTER C

This Chapter provides a summary of the relevant laws and regulations with regard to the waste management and related aspects.
An overview of the Belize applicable Acts and regulations is given followed by the relevant IDB policies and Operational Procedures.
Finally a description of the other regulations to which reference is made for the preparation of the present Plan is reported.

5 ENVIRONMENTAL AND SOCIAL CONDITIONS – CHAPTER D

The Chapter presents a brief description of the present environmental and social conditions that will be impacted by the implementation of the Plan.
In particular, information on the present situation of the sites selected for the location of the Waste Transfer Stations is provided together with a description of the dumpsites the remediation of which is foreseen by the Plan.
A section is then included to describe the characteristics of the population expected to be affected by the project.

6 ENVIRONMENTAL AND SOCIAL IMPACTS – CHAPTER E

The initial sections of Chapter E deal with the assessment of the expected environmental impacts of the Plan. The methodology adopted for the assessment is initially described followed by the assessments related to the different phases of the foreseen waste management system as proposed by the Plan:

- Collection
- Transportation
- Transfer and disposal
- Closure of existing dumpsites

The assessment of the social impacts is then presented.

7 ANALYSIS OF ALTERNATIVES – CHAPTER F

The different alternatives preliminary assessed for the definition of the project are described in Chapter F.
The analysis to determine the most adequate waste management system was extended to:

- Alternative technologies
- Alternative systems: Regional, National, Local
- Alternative locations of the chosen facilities.

Finally other additional criteria considered when weighing the different alternatives are presented.

8 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN – CHAPTER G

The Chapter proposes the necessary requirements for the management of the proposed facilities and activities to ensure the respect of the environmental and social limits and constraints.
The different facilities and the different phases of their implementation (construction, operation, after closure) are considered.

9 PUBLIC PARTICIPATION / CONSULTATION – CHAPTER H

A description of the public consultation process followed so far in the preparation of the Plan is provided in the present Chapter.

10 BIBLIOGRAPHY – CHAPTER I

Finally a list of the main reference documents used for the preparation of the Plan is presented in this Chapter.

11 APPENDICES – CHAPTER J

The document is then completed by three appendices:

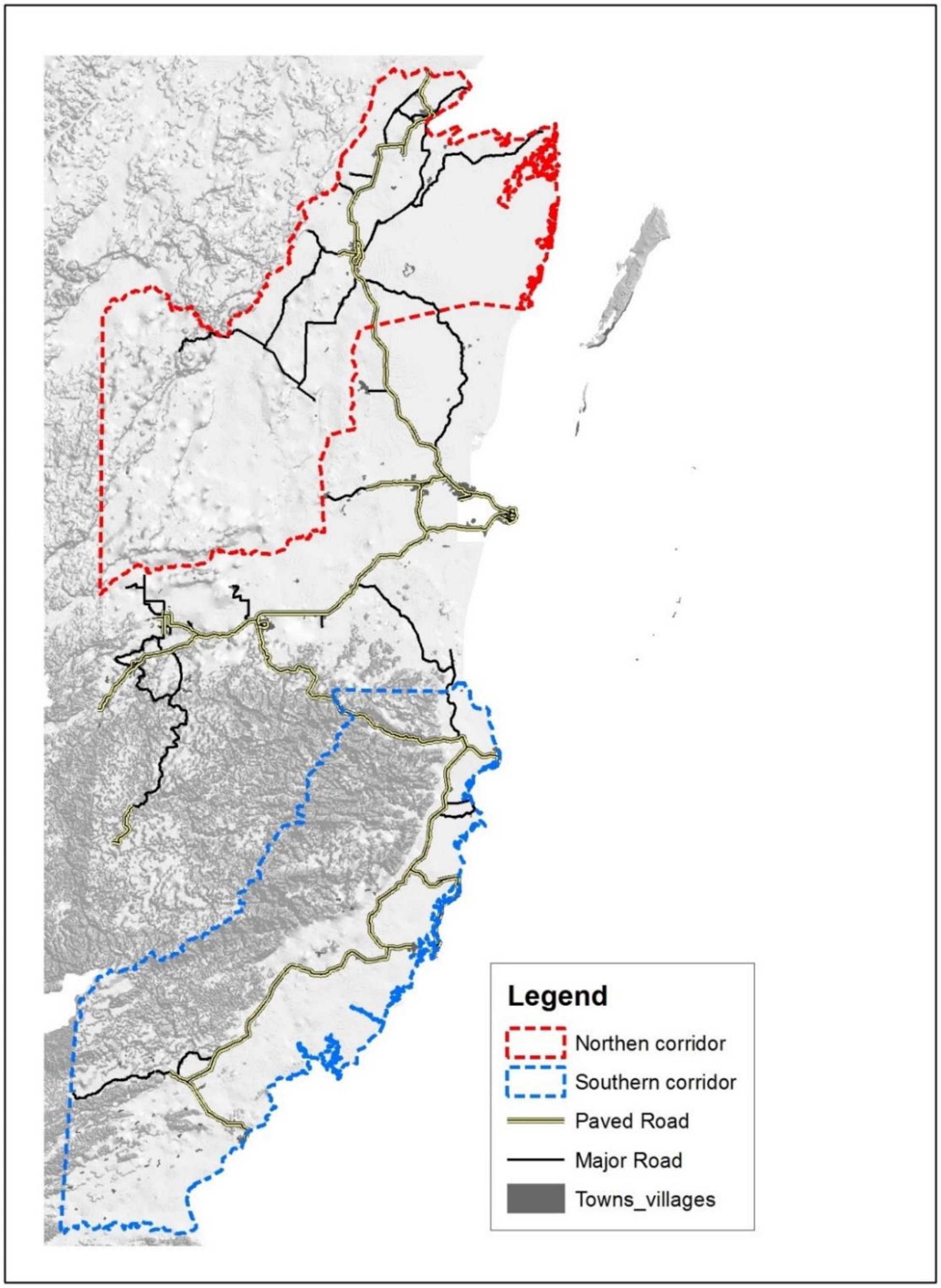
- Appendix 1: List of the authors of the EA;
- Appendix 2: TOR for the preparation of the EIA
- Appendix 3: Complete record of public consultation activities.

B. PROJECT DESCRIPTION

12 THE STUDY AREA

The study areas for this consultancy are the districts of Orange Walk and Corozal in Northern Belize (Northern Corridor) and Stann Creek and Toledo in Southern Belize (Southern Corridor). The map below shows the location of these corridors in Belize.

Figure 1 - Location of Project Sites



In the aim to represent the possible population dynamics and, consequently, to determine the waste management related issues and choices, it was noticed that it would have been necessary to classify the urban centres according to slightly different criteria rather than by their official municipal status only (Towns and Villages).

It was first observed, in fact, that the major Towns are generally surrounded by a number of villages that, although administrative wise independent from the nearby Town, appear to be strictly related to the Town under a social and economic point of view. To the point that the two realities seems to be interdependent in many ways (residents of the villages having their working activities in the Town and the Town providing the business and institutional activities for the villagers also).

To describe such a circumstance it was then decided to deal with the complex of the Towns and the surrounding villages (determined as those that are within a 10 km radius from the Town) as Agglomerates for the purpose of the present Plan.

This assumption is also in line with the ongoing discussion within the Ministry of Local Government, as per the information received (interview with the Director of Local Government), on the possible expansion of the present Towns rather than on the establishment of new ones.

A second assumption was made subdividing the villages in two categories herein defined as Rural and Urban Villages respectively. Such assumption derives from the observation that many villages show a social and economic pattern more similar to that of a Town (even if at a smaller scale) while others have a prevalent rural economy. The adopted criteria in this case was to classify as “Urban” Villages all the villages with a number of inhabitants higher than 1,000 and also the villages with a lower population but located along a Highway. Mennonites villages have been classified as rural independently from the number of inhabitants due to their specific rural economy.

In 2015, an estimated 25% of the total population of the four districts resides in the four district Capital towns of the study area (see Table 1). By including the villages within a radius of 10 km of these towns and those around the villages of Independence and Palencia, 43% of the district population would be concentrated in and around these six population centres. The remaining 57% of inhabitants live in the other (rural) parts of the four districts.

Table 1 Estimated population in the four districts of the project area (2015)

Location	**Corozal District**	**Orange Walk District**	**Stann Creek District**	**Toledo District**	**Total**	**%**
District Capital Town	11,753	14,588	10,281	5,870	42,493	25%
Village within 10 km of District Capital	9,391	9,860	739	1,337	21,328	12%
Total Main Agglomerate	***21,144***	***24,448***	***11,020***	***7,208***	***63,820***	**37%**
Other agglomerates	-	-	9.685	-	9.685	6%
Population living outside agglomerates	25,004	25,327	30,541	27,850	99,037	57%
Total District	**46,148**	**49,776**	**41,561**	**35,058**	**172,542**	**100%**

Notes:
1. Population projections calculated based on SIB census data from 2010.
2. Independence and Placencia

The proposed waste management system is structured around six transfer stations (see Table 2) located in these main six population centres found in the two corridors, denominated as *agglomerates*. Each transfer station serves as a central point for receiving the collected waste[1] from the adjacent town (or village as is the case of Independence and Palencia) and the villages within a 10 km radius from that population centre.

Table 2: Description of the proposed Transfer Stations

District	Locality	Brief description of Location
Corozal District	Corozal Town	Along the Chan Chen Road 3 km off the Town limits (present location of the Slaughterhouse). National Land
Orange Walk District	Orange Walk District	2.5 km from the Northern Highway south of Orange Walk Town, present location of the Orange Walk Dumpsite. The parcel is owned by ASR-BSI that expressed interest to hand it over to the Government for the purpose.
Stann Creek District	Dangriga	Along the Southern Highway 1 km south of the Hummingbird Highway junction. Adjacent to the present Dangriga Dumpsite. Land is Crown Land and available for the project.
Stann Creek District	Placencia	Presently foreseen at the Placencia Dumpsite location. A more suitable site closer to the peninsula is currently being sought.
Stann Creek District	Independence	Along the Southern Highway 1 km south of the Independence Road junction. Present location of the Independence Dumpsite. The site laid on a marginal part of the Mango Creek Forest Reserve now de-reserved.
Toledo District	Punta Gorda	Along the Barranco Road, 16 km off the Punta Gorda Town limits. Land owned by SWaMA.

The remaining 65-75% live in the rural areas in almost 200 villages located either along one of the highways that trisects Belize from North to South, or spread-out over the hinterlands of the districts. To attend the populations in these districts the construction of 69 *drop-off centres (DOC)* is foreseen (see Table 3), where the inhabitants of the villages (and of adjacent villages) can bring their solid waste at their own costs. At the drop-off centre the waste is deposited into at least three roll on – roll off containers as follows: organic material, recyclables and residual fraction. In those (mainly larger) villages where there is no composting done at home an additional composting facility (CF) will be located at the site of the drop-off centre (*DOC_CF)* where the organic fraction is composted. Once the roll-off container of residual fraction is full it will be collected and the waste transported to the nearest transfer station.

Table 3: Number of Drop_Off Centres + Composting Facilities (DOC_CF) and Only Drop_Off Centre per district

District	DOC_CF	DOC	Total
Corozal	13	5	18
Orange Walk	10	4	14
Stann Creek	11	5	16
Toledo	9	12	21
Total	**43**	**26**	**69**

[1] The actual collection of the waste generated in the urban areas (and the associated costs) does not form part of the scope of the consultancy.

The conceptual design of each transfer station considers the option that recyclers can have access to the collected waste that is received from the *agglomerates* and the DOC´s and DOC_CFs, so as to recover recyclables prior to the waste being uploaded into a trash trailer for transportation to the sanitary landfill for final disposal.

The final destination of the collected solid waste will be Mile 24 Landfill in the Western Corridor. The expansion of this landfill to accommodate for the waste of the Northern and Southern Corridors as well is foreseen by the Plan.

Currently the collected waste in the corridors is either dumped at the authorized open dumps found in the towns and in Independence and Placencia or at the outskirts of the villages in the rural areas.
The dumpsites (see Table 4) located in these six populations centres will be remediated.

Table 4: Location of dumpsites that will be remediated

District	Location of dumpsite	Brief description of dumpsites to be remediated
Corozal District	Consejo Road	15 acres of flood prone area. About 15,000 cubic meters of waste piles irregularly deposited on the ground. Private land.
Orange Walk District	Chan Pine Ridge	40 acres irregularly covered by about 15,000 cubic meters of waste piles deposited on top of the ground. Land owned by ASR/BSI
Stann Creek District	Dangriga	6 acres parcel entirely covered by excavated trenches backfilled with waste. Land is Crown Land.
Stann Creek District	Placencia	The official dumpsite is a 6 acres area where the waste is deposited in excavated trenches. Waste piles are also present along the access road and in two nearby areas. The land is private property.
Stann Creek District	Independence	Waste is deposited in excavated trenches spread over a 4 acres area. The land was part of the Mango Creek Forest Reserve now de-reserved.
Toledo District	Punta Gorda	Waste is deposited in a single mass about 8 acres wide in a low lying area. More waste piles are present along the access road. The land is private property.

In the following sub-sections a more detailed description of how the study area has been subdivided for the aim of the Plan is briefly presented and discussed. All the following activities for the preparation of the Plan, such as the population and waste generation assessments, have been based on the proposed classification of the different centres.

12.1 **Agglomerates**

The here proposed Agglomerates (see following Table 5) include all the major Towns of the Districts and the surrounding villages within a 10 km radius. An additional Agglomerate is also proposed in the Stann Creek District including Independence village and villages along the Placencia Peninsula.

With the exception of the Toledo District, where the most of the population is spread through a number of villages, it can be noticed that the proposed Agglomerates encompass approximately the 50% of the respective total District population.

Table 5 – Considered urban Agglomerates, population and estimated total waste generation at year 2015

Town / Village	Estimated population in year 2015	Estimated total waste generation in year 2015 (Mg)
Corozal District – Agglomerate 1		
Corozal Town	11,753	4,381.56
Xaibe	1,799	670.84
San Joaquín	1,679	626.12
Ranchito	1,531	570.75
San Andrés	1,198	446.80
Paraiso	1,150	428.91
Calcutta	967	360.34
San Antonio	591	220.21
Altamira	240	89.45
Carolina	235	87.74
Total Agglomerate	*21,144*	*7,882.72*
Total District (1)	*46,148*	*17,286.81*
% Agglomerate on District	*45.82%*	*45.60%*
(1) The waste generation datum does not include waste generated by the Free Zone		
Orange Walk District – Agglomerate 1		
Orange Walk Town	14,588	5,438.37
Trial Farm	4,537	1,691.53
Carmelita	1,568	584.74
Yo Creek	1,504	560.54
San José Palmar	1,442	537.53
Chan Pine Ridge	475	176.93
Tower Hill	335	124.96
Total Agglomerate	*24,448*	*9,114.60*
Total District	*49,776*	*17,626.06*
% Agglomerate on District	*49.12%*	*51.71%*
Stann Creek District - Agglomerate 1		
Dangriga	10,281	3,833.03
Sarawina	563	209.82
Long Bank	176	65.54
Total Agglomerate	*11,020*	*4,108.38*
Total District	*41,561*	*16,750.84*
% Agglomerate on District	*26.52%*	*24.53%*

Stann Creek District - Agglomerate 2		
Independence	5,321	1,983.78
Placencia	2,324	866.36
Maya Beach	304	113.18
Seine Bight	1,737	647.42
Total Agglomerate	*9,685*	*3,610.74*
Total District	*41,561*	*16,750.84*
% Agglomerate on District	*23.30%*	*21.56%*
Toledo District – Agglomerate 1		
Punta Gorda Town	5,870	2,188.54
Elridge	564	210.22
Forest Home	525	195.91
Cattle Landing	248	92.43
Total Agglomerate	*7,208*	*2,687.11*
Total District	*35,058*	*11,845.98*
% Agglomerate on District	*20.56%*	*22.68%*

12.2 Urban villages

The Urban Villages identified in accordance with the above mentioned criteria are listed in the following Table 6.

Table 6 - Considered Urban Villages, population and estimated total waste generation at year 2015

Village	Estimated population in year 2015	Estimated total waste generation in year 2015 (Mg)
Corozal District		
Libertad	1,764	657.82
Caledonia	1,538	573.44
Patchakán	1,510	562.79
Sarteneja	2,004	747.11
San Narciso	2,661	992.05
Chunox	1,511	563.20
Progreso	1,491	555.83
Concepción	1,381	514.87
San Victor	1,057	394.03
San Román	971	362.09
Louisville	967	360.45
Santa Clara	947	353.07
Buena Vista	544	202.75
Total urban villages	*18,346*	*6,839.49*
Total District (1)	*46,148*	*17,286.81*
% urban villages on District	*39.75%*	*39.56%*
(1) The waste generation datum does not include waste generated by the Free Zone		
Orange Walk District		

San José	3,175	1,183.82
San Pablo	1,253	466.99
August Pine Ridge	1,990	742.06
San Estevan	1,843	687.05
San Felipe	1,663	620.04
Guinea Grass	3,570	1,331.08
San Lázaro	1,166	434.73
Total urban villages	*14,661*	*5,465.77*
Total District	*49,776*	*17,626.06*
% urban villages on District	*29.45%*	*31.01%*
Stann Creek District		
Pomona	2,219	827.08
Hopkins	2,065	769.71
Red Bank	1,540	574.18
Hope Creek	1,447	539.28
Silk Grass	1,400	522.06
Cow Pen	1,336	498.16
San Román	1,146	427.40
Santa Cruz	993	370.03
South Stann Creek	880	327.96
Valley Community	804	299.76
Riversdale	727	271.07
Santa Rosa	695	259.12
Steadfast	617	229.96
Hummingbird Community	598	222.79
San Juan	560	208.92
Maya Centre	495	184.54
Alta Vista	473	176.41
Middlesex	283	105.66
Kendall	151	56.41
Total urban villages	*18,429*	*6,870.50*
Total District	*41,561*	*16,750.84*
% urban villages on District	*44.25%*	*41.02%*
Toledo District		
Bella Vista	4,477	1,669.15
San Pedro Columbia	2,174	810.31
San Antonio	1,537	572.88
Trio	1,147	427.75
Big Falls	1,078	402.06
Indian Creek	920	343.06
Bladen	595	221.73
San Isidro	479	178.43
Hicattee Southern Highway	463	172.72

Golden Stream	445	166.06
Jacinto/Westmoreland	430	160.35
Yemery Grove	338	126.09
Swasey	328	122.28
Medina Bank	302	112.77
Dump	253	94.21
Total urban villages	*14,967*	*5,579.84*
Total District	*35,058*	*11,845.98*
% urban villages on District	*42.69%*	*47.10%*

12.3 Rural villages

The Rural Villages identified in accordance with the above mentioned criteria are listed in the following Table 7.

Table 7 - Considered Rural Villages, population and estimated total waste generation at year 2015

Village	Estimated population in year 2015	Estimated total waste generation in year 2015 (Mg)
Corozal District		
Little Belize	3,013	781.43
Cristo Rey	988	256.25
Chan Chen	813	210.84
San Pedro	590	153.04
Copper Bank	534	138.59
Consejo	398	103.21
Other Corozal (1)	322	83.45
Total rural villages	*6,658*	*1,726.82*
Total District (2)	*46,148*	*17,286.81*
% rural villages on District	*14.43%*	*10.00%*
(1) The term Other followed by the District name refers to villages not listed in the Census 2010 (2) The waste generation datum does not include waste generated by the Free Zone		
Orange Walk District		
Shipyard	3,657	948.51
Indian Creek	988	256.34
Blue Creek	445	115.41
Santa Marta	657	170.42
Trinidad	623	161.63
Douglas	570	147.74
San Román	479	124.20
San Lorenzo	442	114.56
San Antonio	440	113.99
San Juan	350	90.74

Indian Church	292	75.71
Santa Cruz	283	73.44
San Luis	281	72.88
Tres Leguas	173	44.80
Cuatro Leguas	168	43.67
San Carlos	151	39.13
Other Orange Walk	668	173.26
Total rural villages	*10,666*	*2,766.43*
Total District	*49,776*	*17,626.06*
% rural villages on District	*21.43%*	*15.70%*
Stann Creek District		
Maya Mopan	648	168.06
Georgetown	485	125.78
Sittee River	450	116.74
Mullins River	241	62.49
Other Stann Creek	603	156.36
Total rural villages	*2,427*	*629.42*
Total District	*41,561*	*16,750.84*
% rural villages on District	*5.83%*	*3.76%*
Toledo District		
Pine Hill	223	57.73
San José	922	239.09
Jalacté	835	216.56
San Benito	590	152.92
San Miguel	583	151.23
Silver Creek	517	134.05
Dolores	499	129.54
San Vicente	479	124.19
Pueblo Viejo	470	121.94
Santa Cruz	419	108.70
Santa Teresa	402	104.20
Aguacate	401	103.92
Blue Creek	397	103.07
San Felipe	383	99.41
Crique Sarco	356	92.37
Santa Ana	315	81.67
Sunday Wood	309	80.26
Otoxha	284	73.78
Laguna	279	72.38
San Pablo	271	70.40
Mango Walk	265	68.71
Midway	261	67.59
Crique Jute	242	62.80

Conejo	228	59.14
Mabilha	223	57.73
Santa Elena	217	56.32
Monkey River	213	55.20
Corazón	204	52.94
Barranco	170	44.21
Mafredi	162	41.96
Other Toledo	1,763	457.35
Total rural villages	*12,883*	*3,341.39*
Total District	*35,058*	*11,845.98*
% rural villages on District	*36.75%*	*28.21%*

13 WASTE GENERATION ASSESSMENT AND PROJECTION

The waste generation in the two corridors has been estimated for the planning activity based on the aggregated category of the Municipal Solid Waste (MSW) that includes:

- Household waste (domestic)
- Commercial waste (business)
- Institutional waste
- Industrial waste
- Green waste (yard waste)
- Road sweeping
- Green or black bags from Health facilities (waste similar in nature to household waste)

For the purpose of the Plan different population growth indexes and waste generation rates have been estimated and used for the following categories of settlements to better represent and weigh the actual differences across the Corridors:

a. Agglomerates: including Towns and the surrounding villages within a radius of 10 km. from the main Town, that mostly depends on the nearby town businesses and institutions;
b. Urban villages: detached and independent villages with a marked urban structure; this category includes villages the economy of which is mostly based on tourism; this includes those villages with a population of more than 1,000 inhabitants and those villages (also those with a population less than 1,000 inhabitants) located along one of the three highways that cross the country from north to south.
c. Rural villages: generally small villages (with the exception of the Mennonites settlements) which economy is mostly based on agriculture and the urban structure of which is simplified. This includes all those villages with a population less than 1,000 inhabitants with the exception of those located along the three highways.

The initial waste generation rate has been determined based on its relation with the GDP calculated for countries of the Latin America and the Caribbean and adjusted in accordance to previous waste generation studies carried out in the Western Corridor.

Different rates have been used to assess the waste generation from Agglomerates and Urban Villages on one side and Rural Villages on the other. Finally a specific and separate estimate has been carried out to determine the expected waste generation from the tourism sector.

The estimates carried out for the considered 25 years period based on the estimated population and waste generation rates growth are summarized in the following tables.

Table 8: Projected total waste generation for 2015, 2027 and 2040 for Corozal District.

	2015		2027		2040	
Corozal District	**tonne/year**	**tonne/day**	**tonne/year**	**tonne/day**	**tonne/year**	**tonne/day**
Agglomerate 1	7,883	21.60	12,227	33.50	19,703	53.98
Urban villages	5,931	16.25	8,375	22.95	12,192	33.40
Rural villages	2,381	6.52	3,493	9.57	5,315	14.56
Free Zone	4,000	10.96	8,000	21.92	12,000	32.88
Corozal Tourism	838	2.30	1,646	4.51	2,104	5.77
TOTAL MSW	**21,032**	**57.62**	**33,741**	**92.44**	**51,315**	**140.59**

Table 9: Projected total waste generation for 2015, 2027 and 2040 for Orange Walk District.

	2015		2027		2040	
Orange Walk District	**tonne/yr**	**tonne/day**	**tonne/yr**	**tonne/day**	**tonne/yr**	**tonne/day**
Agglomerate 1	9,115	24.97	11,920	32.66	15,967	43.74
Urban Villages	5,466	14.97	7,903	21.65	11,801	32.33
Rural Villages	2,766	7.58	3,694	10.12	5,078	13.91
Tourism	279	0.77	549	1.50	701	1.92
TOTAL MSW	**17,626**	**48.29**	**24,066**	**65.93**	**33,546**	**91.91**

Table 10: Projected total waste generation for 2015, 2027 and 2040 for Stann Creek District.

	2015		2027		2040	
Stann Creek District	**tonne/yr**	**tonne/day**	**tonne/yr**	**tonne/day**	**tonne/yr**	**tonne/day**
Agglomerate 1	4,108	11.26	5,469	14.98	7,468	20.46
Agglomerate 2	3,611	9.89	8,003	21.93	18,982	52.01
Urban villages	6,871	18.82	14,062	38.52	30,596	83.82
Rural villages	629	1.72	720	1.97	838	2.30
Tourism	1,532	4.20	4,927	13.50	7,635	20.92
TOTAL MSW	**16,751**	**45.89**	**33,181**	**90.91**	**65,520**	**179.51**

Table 11: Projected total waste generation for 2015, 2027 and 2040 for Toledo District.

	2015		2027		2040	
Toledo District	**tonne/yr**	**tonne/day**	**tonne/yr**	**tonne/day**	**tonne/yr**	**tonne/day**
Agglomerate 1	2,687	7.36	3,781	10.36	5,483	15.02
Urban Villages	5,152	14.12	10,425	28.56	22,404	61.38
Rural Villages	3,595	9.85	4,722	12.94	6,375	17.46
Tourism	238	0.65	737	2.02	1,092	2.99
TOTAL MSW	**11,671**	**31.98**	**19,665**	**53.88**	**35,353**	**96.86**

With regard to the above reported estimated quantities it has to be noticed that they can be reasonably be assumed as a conservative estimate (overestimation). The chosen generation rates, in fact, are in line with those used to determine the waste generation scenario in the Western Corridor where, after three years of operation of the system, the actual quantities seem to suggest noticeable lower generation rates (in the range of 30-40% less than the projections estimates).

14 WASTE COLLECTION EFFICIENCY ASSUMPTIONS AND CONDITIONS

A further necessary step to plan the waste management scenario for the present project was to estimate the quantities and type of waste that are expected to enter the planned system. Based on the so far reported evidences and considerations the following assumptions have been made with regard to the expected efficiency of the planned system.

All the assumptions are also based on a 2 year preparation period (2016-2017) during which the construction of the facilities will take place and, in parallel, the institutional framework strengthening actions, including homogenisation of the local practices and regulations, shall be implemented to satisfy the conditions listed hereafter.

Table 12 – Waste entering the system, assumptions and conditions

ASSUMPTIONS	CONDITIONS
Agglomerates	
1. 100% collection efficiency in Towns and Villages already served by a Municipal Collection service 2. 30% collection efficiency in villages served by private collectors for the first 5 years 3. 15% collection efficiency in villages without collection (assumed as the voluntary willingness to self-deliver waste to the facilities) for the first 5	a. The garbage fee systems are homogenized in the two Corridors and not based on delivered quantities (including businesses) b. Private collectors are allowed to deliver the waste to Transfer Stations / Landfill at no cost c. In the 5 year interim period either the municipal collection is extended to Villages or DOCs built

years 4. 100% collection in all the villages after 5 years	
Urban Villages	
5. 60% collection the year after the establishment of the DOC gradually increasing to 100% in the following 5 years	a. No or only nominal gate fee at the DOC is applied for the 5 years interim period b. The DOCs are regularly attended by trained personnel c. Village Council is involved in the process and in charge of the control. Fines can be applied by the VC and Health Inspector d. Gradual implementation of recyclables collection is condition for future garbage fee policies
Rural Villages	
6. 100% of the non-organic waste is collected since the establishment of the DOCs	a. No or only nominal gate fee at the DOC is applied for at least a 5 years interim period b. The DOCs are regularly attended by trained personnel c. Village Council is involved in the process and in charge of the control. Fines can be applied by the VC and Health Inspector d. Gradual implementation of recyclables collection is condition for future garbage fee policies e. Yard burning of non-compostable organic materials is tolerated
Tourism	
7. 50% of the generated waste is collected and delivered to nearby Transfer Stations / Landfills	a. About 80% of the tourism generated waste is deemed to be compostable organic (food waste and yard waste). Not to overburden the inadequate public collection system and considering that a relevant percentage of the tourism is concentrated on resorts and large sub-divisions, specific diversion policies and regulations shall be developed to establish or encourage composting practices by operators of

	tourist establishments. The present Plan will include proposals in this sense.
Free Zone	
8. Only 5% of the generated waste (corresponding to the MSW generated in the Free Zone) is considered to directly enter the system at the Corozal Transfer Station / Landfill	a. 95% of waste generated by the Free Zone is estimated to be Commercial Waste (mostly packaging waste). The high generated quantities, comparable to the quantities of MSW generated by Corozal Town; the composition of such waste, almost totally recyclables materials; the peculiar institutional status of the Free Zone; the proximity to the Mexican recycling market; these are all factors that suggest the establishment of a specific policy to encourage the diversion at source of the recyclables materials from the main stream of the MSW of the rest of the District.

Table 13 – Recycling performances, assumptions and conditions

ASSUMPTIONS	CONDITIONS
Agglomerates	
1. 4% of the recyclable fraction recovered at the Transfer Stations 2. No further improvements are envisaged 3. 15% of the recyclables collected re-enter the system after conditioning processes by Recycling Companies. These quantities are considered for the final disposal but not for the transport system	a. Informal Recyclers are allowed and encouraged to operate at the Transfer Stations b. A substantial change (and strengthening) of the collection system would be necessary to implement effective recycling. The conditions of such change are only marginally included in the scope of the present study. These can include special garbage fee policies for businesses and the establishment of DOCs in Towns and Agglomerates to support the collection system. While such measures are proposed and discussed within the present study, their possible results are not here taken into account as a conservative assumption.

<table>
<tr><th colspan="2"><u>Urban Villages</u></th></tr>
<tr><td>4. 40% of the recyclable fraction gradually increasing to 70% in 5 years separated at the DOCs
5. 15% of the recyclables collected re-enter the system after conditioning processes by Recycling Companies. These quantities are considered for the final disposal but not for the transport system.</td><td>a. The DOCs are regularly attended by trained personnel
b. The private recycling sector is involved through formal agreements or contracts including the collection of low valuable fractions and the possibility to deliver the residual waste from sorting to landfills
c. The whole system is managed and controlled by a central agency</td></tr>
<tr><th colspan="2"><u>Rural Villages</u></th></tr>
<tr><td>6. Same as per Urban Villages</td><td>a. Same as per Urban Villages</td></tr>
<tr><th colspan="2"><u>Tourism</u></th></tr>
<tr><td>7. 50% of the generated waste (as per Table 12 assumption #7) is deemed to be delivered directly to the nearby Transfer Station and as such being subject to the same separation process and performances as per the assumptions from #1 to #3 on the present Table.</td><td>a. A specific gate fee and specific disciplinary shall be established for waste generated by tourism facilities of specific categories (e.g. resorts, sub-divisions) to encourage source separation of recyclables. While suggestion on this sense are included in the present Plan the positive effects of such measures are not here considered (conservative assumption).</td></tr>
<tr><th colspan="2"><u>Free Zone</u></th></tr>
<tr><td>8. 5% of the generated waste (as per assumption #8 in Table 12) is deemed to be residual waste (no recyclables available).
9. 95% of the waste generated by Free Zone is assumed to be diverted for recycling not directly entering the system (see condition n. in Table 12)
10. 15% of the recyclables collected re-enter the system after conditioning processes by Recycling Companies. These quantities are considered for the final disposal but not for the transport system</td><td>a. See Condition n. in Table 12.</td></tr>
</table>

Table 14 – Diversion of Biodegradable organic waste

ASSUMPTIONS	CONDITIONS
Agglomerates	
1. No composting is envisaged in Agglomerates for the duration of the Plan	i. Composting is conditioned by an efficient source separation of biodegradable organic waste. A substantial change (and strengthening) of the collection system is thus necessary to implement composting. The conditions of such change are only marginally included in the scope of the present study. It can be reasonably assumed that around 90% of the biodegradable waste from business (restaurants, hotels, markets) can be easily separated at source through a combination of technical, organizational and regulatory tools. These can include special garbage fee policies for businesses. While such tools are proposed and discussed within the present study, their possible results are not here taken into account as a conservative assumption.
Urban Villages	
2. 50% of the biodegradable organic fraction gradually increasing to 70% in 5 years separated at the composting facility	i. Composting facilities are regularly attended by trained personnel ii. Compost not utilised or sold locally is marketed by a central agency iii. The whole system is managed and controlled by a central agency
Rural Villages	
3. No biodegradable organic waste is considered to enter the system	i. Biodegradable organic waste is used for animal feeding, mulching and yard composting
Tourism	
4. No composting is envisaged by the planned system.	i. 50% of the waste generated by tourism and not entering the system (as per Table 12 assumption #7) is deemed to be biodegradable organic

	waste. Not to overburden the inadequate public collection system and considering that a relevant percentage of the tourism is concentrated on resorts and large sub-divisions, specific diversion policies and regulations shall be developed to establish or encourage composting practices by tourist operators. The present Plan will include proposals in this sense.
Free Zone	
5. No composting is envisaged by the planned system	i. See Condition n. in Table 12.

15 WASTE MANAGEMENT FACILITIES (CONCEPTUAL DESIGN)

15.1 Drop Off Centres

While the design of the waste collection phase is not included in the scope of the present Master Plan, it was evident that it should have nevertheless been considered to some extent to allow the inclusion in the system of the majority of the population, living in the villages.
Already established public waste collection systems, in fact, are only existing in the four District Towns and in the Independence and Placencia villages.
Most of the population of the two Corridors is spread in a considerable number of villages. Long driving distances from one another, not always practicable roads and very low population on each centre are the main characteristics of these villages with regard to scope of the present work.
In the first instance it was then discarded the option of a common collection system based on communal bins and collection trucks. Such a system, in fact, appears to be inefficient and expensive given the described characteristics of the territory and the population to be served.

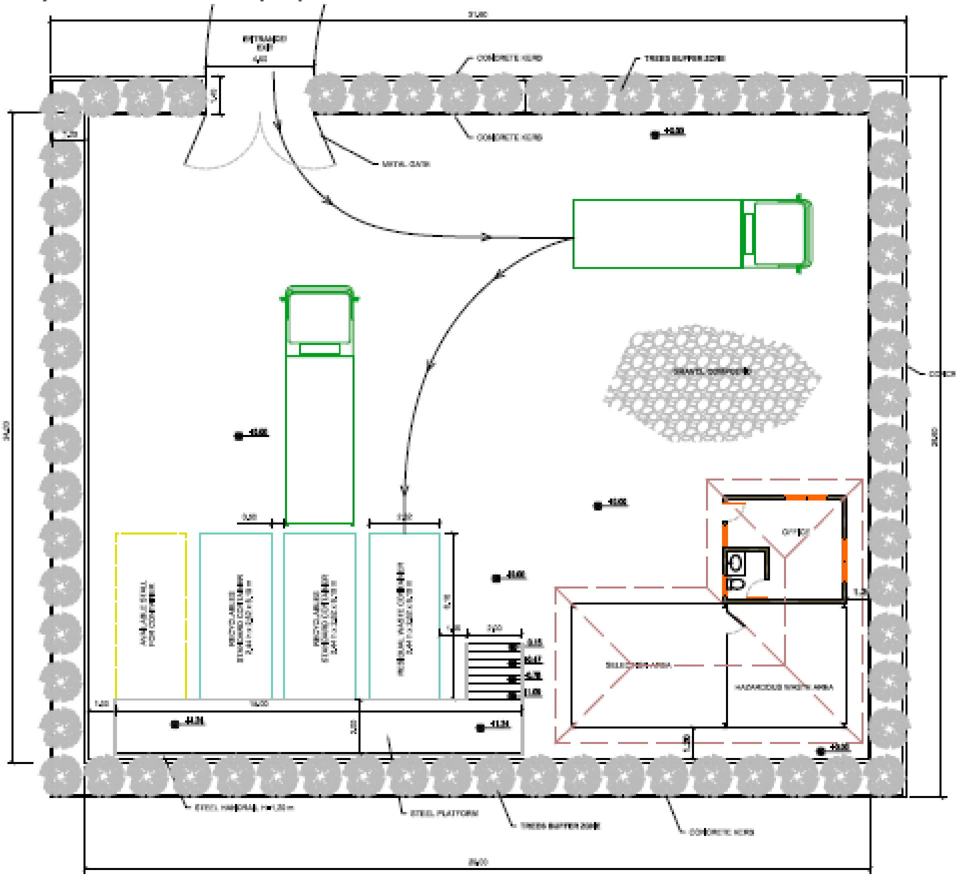
A system based on Drop-Off Centres was then chosen to better serve the rural areas of the Corridors for the aim of the Master Plan. Combined solutions can be evaluated at a more advanced stage of the planning.

Drop-Off Centre (DOC, otherwise also called Civic Amenity Site) is a simple and widely used facility that falls under the Waste Collection system. Such facility can be used both as an integration to more traditional collection systems and/or a stand-alone solution depending on local conditions (social, economic and operational).
Under a technical and operational point of view the DOC is a simple and low impact facility that can be located in a wide variety of different urban situations.

The proposed DOC consists of the following main features:

- Fenced area (concrete kerbs and vegetation screen) served by an access road or directly adjacent to an existing one, approximately 600 m^2 in size;
- Gate for access control;
- Shelter for personnel and hazardous waste enclosure;
- Paved area for hosting waste containers;
- Stormwater drains
- Steel platform for waste delivery into the containers

Figure 2 – Draft Layout scheme of the proposed DOC



The operation of the DOC can be summarized as follows:

- One permanent operator for waste acceptance, separation and storage, and housekeeping. No particular skills are required for the operator, experience as a recycler is an asset;
- The waste delivered by households, businesses and institutions should be sorted from the source and each different fraction stored in the respective container. Users shall be assisted by the operator and progressively instructed to deliver the waste already sorted in accordance with the chosen type of separation.

- Recyclables can be stored together in one container or divided in more specific containers depending on the logistic of the upstream system.
- At least one container is dedicated to non-recyclable or residual materials to be disposed of.
- Once one of the container is full the operator asks for emptying in accordance with the upstream logistic depending on the type of waste.
- Organic fraction is either not delivered (rural villages) or delivered separately for the compost section.

Under the more general point of view of the whole Integrated Waste Management System the use of DOCs offers many organisational advantages:

- Reduced need of house to house collection. Citizens are expected to deliver the waste on their own to the DOC.
- Improved efficiency of the collection: containers can be removed only when full rather than on a prescheduled timeline basis.
- Limited need of initial investment (less and less specific trucks, less communal containers) and low operation costs not only in comparison with an equivalent house to house collection
- Maximisation of the source separation of different fractions
- Constant and direct (personal) interaction with the generators offers an easier and more effective way to modify behaviours.
- Extreme flexibility to changes in the generation patterns and easy adaptability to new waste management treatment and disposal strategies.

In the case of the majority of the Villages of the two Corridors the advantages offered by the use of DOCs appear to be particularly appropriate.
Presently, there are various waste management practices at village level (burning and dumping being the most common practices) and all of them constitute a time and energy consuming activity for both households and businesses. No regular collection is in place at village level a part from a negligible minority of cases.
At the same time the size of the majority of the villages (number of inhabitants and businesses) is such that a traditional collection system is not locally affordable.
Besides the cost of such a system, should it be connected to the wider regional integrated system rather than to a local dumpsite, would be even greater (long distances, secondary roads not in adequate conditions and not always practicable during the rainy season).
Under such circumstances it appears that the DOC is not only the more advantageous logistical solution but also that the acceptance of such method can be reasonably expected to be high.

The proposed DOC also provides room for parking a small collection vehicle in case a local collection system would be considered feasible and affordable.

15.1.1 Location of the DOCs

To take into account the waste quantities generated by the Urban Villages and to estimate the related costs for the collection and transfer the system herein considered is based on the adoption of Drop-off centres and local composting.

The following Table 15 shows the proposed location of the DOCs and Composting Facilities (CF) and related served urban villages.

Table 15 – Proposed location of Drop-off centres and Composting Facilities in urban villages

#	Location of DOCs and CF	Served villages
		Corozal District (#13)
1	Libertad	Libertad, Estrella, San Fransisco
1	Caledonia	Caledonia
1	Patchàkan	Patchàkan, Estero, Xcanluum
1	Sarteneja	Sarteneja
2	San Narciso	San Narciso
1	San Roman	San Roman, Santa Clara
1	Louisville	Louisville
1	Conception	Conception
1	Chunox	Chunox
1	Progreso	Progreso, Hill Bank
1	San Victor	San Victor, San Juan Nuevo
1	Buena Vista	Buena Vista
		Orange Walk District (#10)
1	San Jose	San Jose
1	San Pablo	San Pablo, Douglas, San Juan
1	August Pine Ridge	August Pine Ridge
1	San Estevan	San Estevan
1	San Felipe	San Felipe
2	Guinea Grass	Guinea Grass
1	San Lazaro	San Lazaro, Trinidad
1	Blue Creek	Blue Creek, Tres Leguas, Quatro Leguas
1	Yo Creek	Yo Creek, Santa Cruz, San Antonio, San Lorenzo
		Stann Creek District (#11)
1	Pomona	Pomona, Quarry Hill
1	Altavista	Altavista, Cow Creek
2	Hopkins	Hopkins, Sittee River
1	Red Bank	Red Bank, San Pablo (Toledo)
1	Hope Creek	Hope Creek, Melinda
1	Silk Grass	Silk Grass
1	Cow Pen	Cow Pen, San Juan
1	San Roman	San Roman, Santa Rosa

1	Santa Cruz	Santa Cruz, South Stann Creek
1	Valley Community	Valley Community, Middlesex, Steadfast
	Toledo District (#9)	
2	Bella Vista	Bella Vista, San Isidro, Swasey
1	Trio	Trio
2	San Pedro Columbia	San Pedro Columbia, San Miguel
1	San Antonio	San Antonio, Crique Jute, Mafredi
1	Big Falls	Big Falls, Hicattee, Silver Creek, Pine Hill
1	Indian Creek	Indian Creek, Golden Stream
1	Jacintoville	Jacintoville, Yemery Grove

As a general criteria for the purposes of the present Study, it has been assumed that a DOC could serve approximately 2,000 inhabitants, as such in larger villages two DOCs have been foreseen.
The following Table 16 shows the proposed location of the DOCs and related served rural villages.

Table 16 - Proposed location of Drop-off centres in rural villages

#	Location of DOCs	Served villages
	Corozal District (#5)	
1	Little Belize	Little Belize
1	Cristo Rey	Cristo Rey, San Pedro, Yo Chen
1	Chan Chen	Chan Chen, Santa Rosa
1	Copper Bank	Copper Bank, Saltillo
1	Consejo	Consejo, Consejo Shores
	Orange Walk District (#4)	
1	Sheepyard	Sheepyard
1	Indian Creek	Indian Creek
1	Indian Church	Indian Church, San Carlos
1	Santa Martha	Santa Martha
	Stann Creek District (#5)	
1	Riversdale	Riversdale, Sagitun
1	Hummingbird Community	Hummingbird Community, St. Margret (Cayo)
1	Maya Centre	Maya Centre, Kendall
1	Maya Mopan	Maya Mopan, Georgetown
1	Mullins	Mullins
	Toledo District (#12)	
1	Bladen	Bladen
1	Medina Bank	Medina Bank, Tambran
1	Dump	Dump, San Marcos, Laguna
1	Jalacte	Jalacte, San Vicente, Pueblo Viejo
1	Santa Cruz	Santa Cruz, San Jose, Santa Elena
1	San Benito Poite	San Benito Poite

1	Dolores	Dolores, Hicattee, Otoxha, Corazon Creek
1	Santa Teresa	Santa Teresa, Mabilha, San Lucas, Jordan
1	Blue Creek	Blue Creek, Aguacate
1	Santa Ana	Santa Ana, San Felipe, Midway, Barranco
1	Sunday Wood	Sunday Wood, Conejo, Crique Sarco, Graham Creek
1	Mango Walk	Mango Walk, Monkey River, Esperanza

15.2 Transfer Stations

The choice of the type of the transfer facility was guided by two major constraints:

- Homogeneity with the existing system in the Western Corridor to facilitate the management of the whole national system (technology, procurement processes, operation and control procedures)
- Use of the transfer station also as a sorting facility both for management (waste separation) and social (inclusion of recyclers) purposes.

Under such circumstances alternative systems based on different technologies and/or management concepts were discarded since the beginning. The proposed technology, specifically designed for the Master Plan, is then based on the existing transfer facilities with minor adjustments to improve the expected performances deriving from the lessons learned from the present Western Corridor system.

The transfer facility is then designed to offer the following performances:

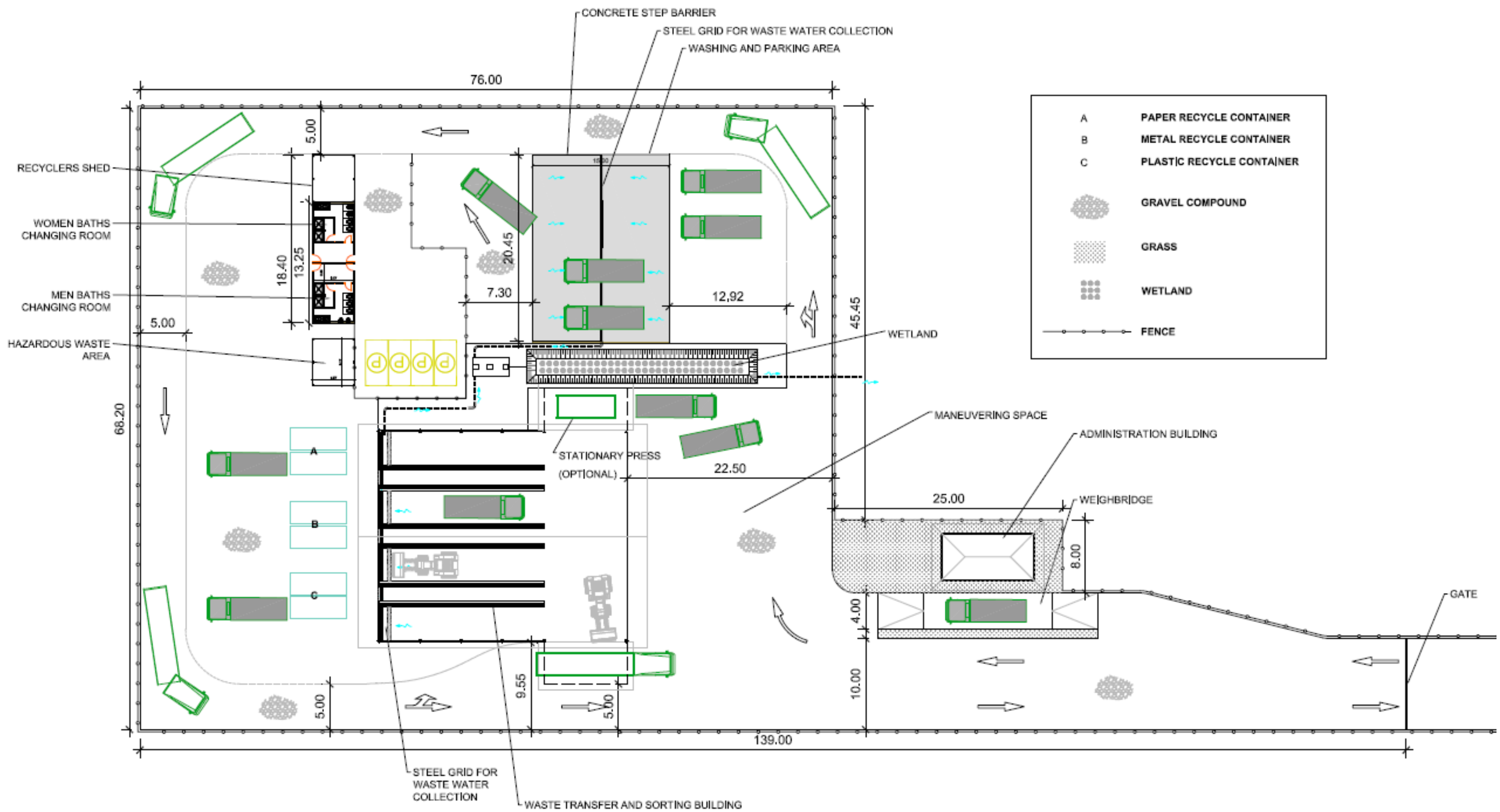
- storage capacity of waste sufficient to cater with emergencies in the transport lasting for 4 days;
- operational capacity in normal conditions for single day 2 times the projected maximum amount of estimated daily input, to cater with emergencies and daily fluctuations in the collection system.
- improved efficiency in waste sorting activities allowing more accessibility to materials and longer times for sorting;
- improved safety with strict separation from the working areas for machines and trucks and working areas for the recyclers.

Description of the operation, normal conditions:

i. weighing of collection trucks and data registration;
ii. collection trucks reverse in the service area and enter the building approaching the available offloading line (Chamber in the drawing) and offload;
iii. the wheel loader spread the waste in a 40 cm thick layer along the line;
iv. operation a. and b. are repeated until the line is full (each line can host form 2 to 5 loads depending on the size of the load;
v. recyclers are allowed to access the completed line and sort the materials (the line will be available for sorting for not less than one hour in peak times);
vi. sorted materials are placed in wheel barrows placed in the adjacent recycling line and removed using the exit at the back of the building to be stored in the respective container;
vii. collection trucks offload in the next available lines in sequence;

viii. after completion of the sorting in the first line the recyclers move to the next available line and the wheel loader removes the residual waste loading it into the transport hauler;
ix. the cycle is repeated.

Figure 3 – Draft layout scheme of the Transfer Station



The building is proposed in two different sizes depending on the projected waste amounts expected for the area:

- four offloading lines (Chambers): Corozal, Orange Walk;
- two offloading lines to be upgraded to four at the 10th year: Independence;
- two offloading lines: Dangriga, Punta Gorda.

The concept of the building is such that it can also be easily adapted to future evolutions of the system and, specifically, of the diversion of the waste at source. In that case the sorting activity will reasonably shift from “positive sorting”, meaning the sorting of the valuable from the undifferentiated mass of waste, to “negative”, sorting of impurities from mainly homogeneous waste fractions.

At that time the conditions for the operation will be characterised by:

- two main waste streams: mixed (non-sortable) waste and source separated (to be refined)
- quicker sorting process: the negative sorting of impurity is a faster process than the positive sorting.

The separation between the different lines is foreseen to be built using pre-casted concrete step barriers bolted to the floor. The sorting building will then be easily adapted to such changed situation by simply removing or rearranging one or more line separation walls should the new conditions request a different configuration of the volumes.

Two truck full length loading sections are foreseen to grant a higher operational flexibility. While the first loading section can be used for loading open trucks a stationary press can be installed in the second one for container loading. This feature offers the possibility of different operational options:

1. use of section 1 as the main one: loading section 2 can be used for:
    a. additional trailer to allow a better management of the towing vehicles
    b. loading of different waste fractions in case of “negative” sorting directly on trucks or
    c. loading of waste in containers through a stationary press
2. use of section 2 as the main one through the installation of a stationary press, section 1 can then be used for:
    a. loading of open trucks in case of malfunctioning/maintenance of the press
    b. loading of different waste fractions.

15.3 Composting

Separation of the organic fraction is the key element of an Integrated Waste Management System. The organic fraction is in fact responsible for methane emissions of in landfills and dumpsites and for the generation of most of the pollutants in leachate. On the other hand, the organic fraction, if properly separated and treated, is a source of renewable resources: compost and energy.

The presence of organic waste is also negatively affecting the technical possibilities to more effectively recover the remaining materials from the commingled waste stream.

The goal of separating the organic fraction at source from the rest of the waste streams shall then be a priority for an Integrated Waste Management Plan.

It has nevertheless to be noted that such goal can only be achieved through an appropriate collection system. While a wide variety of different technical solutions can be in fact proposed for the treatment of the organic biodegradable fraction they all depends on the quality and quantity of the organic waste that the collection system can ensure.

For this reason, and taking into account that the organic waste in Rural Villages is already diverted to other uses, the present Plan only foresees the implementation of composting in Urban Villages.

15.3.1 Composting in Urban Villages

In Urban Villages with population up to 2,000 inhabitants the generation of biodegradable organic waste is estimated to range from 180 to 600 kg per day approximately (70 to 200 tonne/year).
As a conservative assumption it has been assumed that all the organic waste generated is delivered to the DOC to be composted.
Assuming the mentioned range of daily quantities and an initial average density of 0.4 tonne/m^3 the volume to be treated daily ranges between 0.45 ÷ 1.5 m^3 per day.
Finally, considering that the time requested for the full development of the processes in conditions of natural aeration is 90 days, the total volume to accommodate in a single facility ranges between 40 ÷ 135 m^3.

Under such circumstances, very limited total quantities, and considering the need of limiting the investment costs and simplify the operational procedures, the chosen solution is to adopt a simple modular system based on the use of Big Bags.

The Big Bags shall be the type in woven Polypropylene (PP) with opening both on top and bottom side, 1 m^3 capacity (90 x 90 x 120 cm or similar).

The plastic bag is permeable to air but impervious to water penetration. Air circulation is then improved by the insertion of a PVC perforated pipe throughout the bag opening.

The biodegradable waste delivered will be deposited inside of a Big Bag, placed on a pallet, with the addition, if necessary, of wood chipping as a structuring material. Once a bag is full it will be moved to the storage area through a manual pallet carrier.

The bag is then left in the storage area for the time necessary (generally 90 days). The process can be controlled measuring the temperature and, in case, adding moisture.

Figure 4 – Big Bag woven Polypropylene opening on both top and bottom side

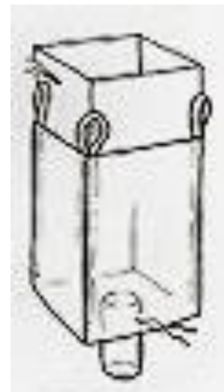


Figure 5 – Rough terrain pallet carrier

According to such system and taking into account the figures provided above, a maximum area of 135 m2 is required for the storage of the bags. Such area can be doubled to consider the need of storing a minimum amount of compost, wood chippings and to cater for service areas.

The compost facility, on the whole, will consist in an additional approximately 300 m^2 wide fenced area to be added to the DOC as described in Annex 4 of the "Conceptual Design" document.

For the operation of the facility it is required a further operator, part time, and the following materials:

- Wheel barrow and shovels
- Mesh screen
- Thermometer stick
- 200 woven PP Big Bags (90 x 90 x120 cm or similar)
- 150 perforated PVS pipes Ø 100 (4”) 150 cm length
- 150 pallets

15.4 Remediation of existing Dumpsites

The present operation methodology of the dumpsites is the same all over the two corridors and applied to any kind of dumpsite (towns, villages, formal, informal).
The only noticeable difference consists in the fact that some of the formal dumpsites (Dangriga, Placencia and Independence) are operated with the trench method; trenches between 10 m and 20 m long and 2 m or 3 m deep are excavated for the disposal of the garbage and roughly covered with soil when full.
It was also noticed, on the other hand, that the waste is only partially dumped directly into the trench by the trucks. Generally, to allow the sorting of the waste by the informal recyclers and by the same personnel in charge of the dumpsite, the waste is deposited at the border of the trench and only subsequently pushed into the trench. It can be therefore said that the methodology described hereafter also applies to these particular dumpsites.

Operation methodology:

i. The waste is dumped onto the bare ground by the trucks or privates in piles. In most of the cases the piles are deposited randomly, wherever space is available and easily reachable.
ii. Piles are sorted by informal recyclers and valuable materials selected.
iii. The waste is put on fire. The whole variety of cases has been noticed with regard to the origin of the waste fires that can be ignited alternatively by:
    - Dumpsite personnel
    - Informal recyclers
    - Privates delivering the waste
    - Self-ignition

    The burning of waste is seen both as a method to reduce the nuisance caused by the putrefaction of the organic waste and the related proliferation of pests and as a way to reduce the volume. The burning is also a way to prevent the removal of the light materials by the wind and the consequent littering of wider areas. In some cases the waste is deliberately put on fire by the dumpsite personnel in favourable wind conditions to prevent the nuisance generated by the spontaneous fires that could occur when nearby inhabited areas are downwind to the dumpsite.
iv. The burned waste piles are periodically pushed aside trough mechanical equipment (hired for the purpose) to free the space for further dumping or, in cases mentioned

above, to fill the trenches. Piles and waste deposits in general are extremely shallow (from 0.5 m to 4 m at most)

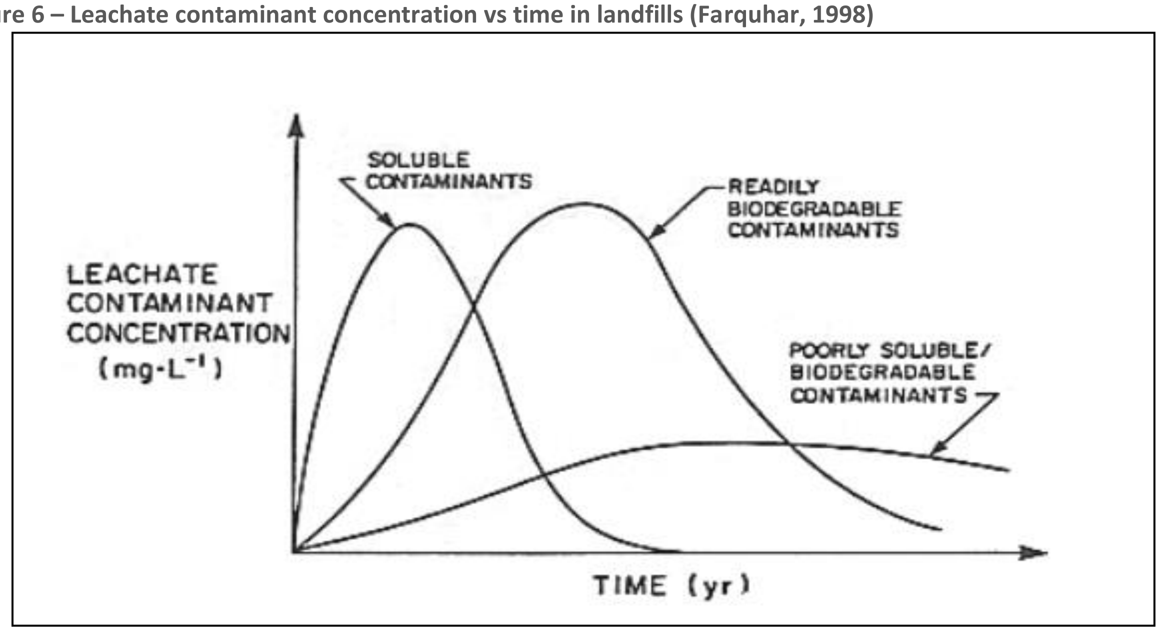
v. Only in the cases of dumpsites operated according to the trench method a rough soil cover is used and even in this case only when the trench is full.

vi. Spontaneous vegetation soon cover the abandoned waste piles.

The above described operational and depositional conditions determine the following evident consequences:

a. The unconfined disposal of the waste maximise both the degradation processes and the easy and fast removal of the contaminants.
b. The easily degradable organic fraction is almost entirely degraded as result of a combination of processes: aerobic degradation due to long exposure of the waste enhanced by generally high temperatures; animal feeding and biological activity; burning; washout.
c. Chemical pollutants are quickly removed and released in the environment either by combustion and flushing do to the intense rain.
d. The remaining waste, after burning and long exposure to weathering, is mostly inorganic (metal cans, glass, melted plastic, bulk waste) with the main exception of partially combusted timber and wood.
e. The residual polluting potential of the waste is then a minor fraction of the original content (see Figure 6 below).
f. The residual biodegradation potential is also extremely low.

Figure 6 – Leachate contaminant concentration vs time in landfills (Farquhar, 1998)

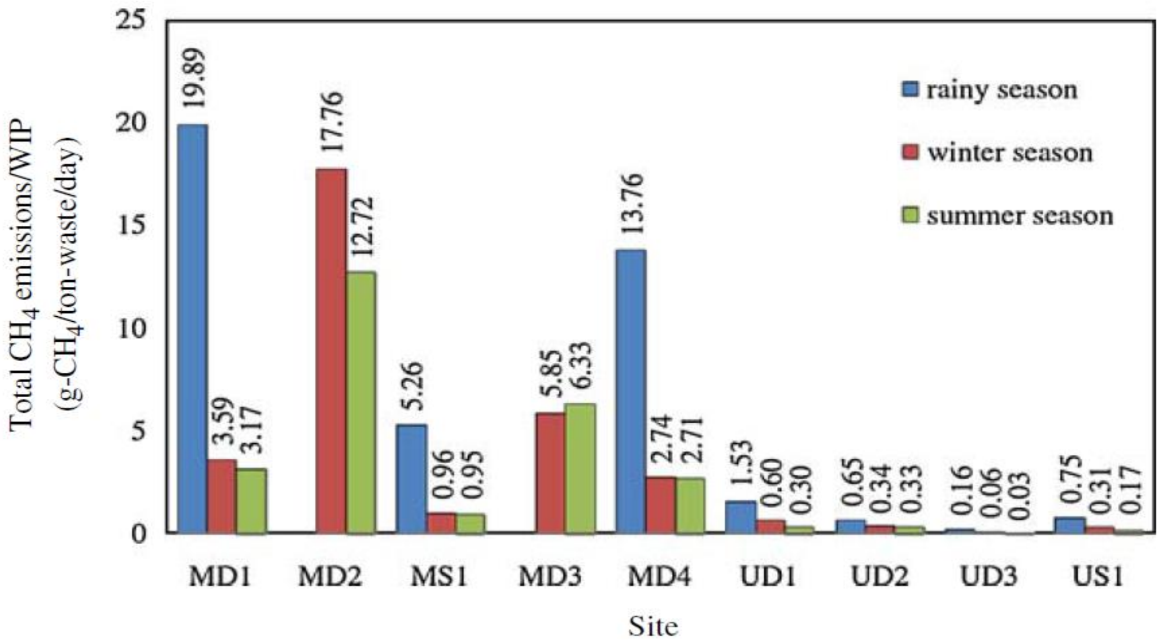


The described situation is common and typical of tropical open dumpsites as also reported by the relevant literature. The figure below, in particular, focuses on the landfill gas emissions from different disposal facilities according to the following codes:

MD managed deep landfill

MS managed shallow landfill
UD uncontrolled deep dumpsite
US uncontrolled shallow dumpsite
1, 2, … reference No. of the studied site

Figure 7 – Emissions of methane per ton of waste in place (WIP) per day from different disposal sites in Malaysia (Wang-Yao, Towprayoon et al., 2010 in A.Kubin, 2012)



Both the leaching and the gas emission potentials of the examined dumpsites are then expected to be a minor residual fraction of the original ones. Most of the pollutants release occur in fact in a short timespan after the deposition.

According to the operation methodology described above and also considering the acceleration of the processes due to the intense tropical climatic conditions the remaining contaminants will be mainly constitute by a residual fraction of readily biodegradable contaminants (mostly from the more recent deposits less than one year old) and by the poorly soluble/biodegradable contaminants not removed/degraded by the weathering and other physical and biological processes.

The following conceptual remediation designs are proposed in accordance with the considerations and guidelines above.

15.4.1 Corozal and Orange Walk

The two dumpsites, in Corozal and Orange Walk, have many similarities:

- The waste is deposited above the ground in a large area without a specific plan;
- Almost untouched portions are present and available on site
- Both sites are flat
- The ground is composed by permeable limestone sand

- The volume of waste is in both cases estimated between 10,000 m^3 and 15,000 m^3

In both cases is thus both possible and advisable to gather the waste in a reduced area on site specifically prepared so to offer an increased level of protection against leaching.

The proposed solution consists of the following main features:

i. Clearing and preparation of an area of approximately 6,600 m^2 (55 m x 120 m) according to the following design:
    a. Peripheral earth bund 1 m elevation above the ground level along the whole perimeter of the cell to prevent flooding (particularly necessary in Corozal dumpsite) and ingression of stormwater
    b. Bottom floor graded with a slope along the short side (55 m), 2% slope
ii. 3 m thick waste deposit on the entire prepared area except for,
iii. 5 meter wide phytoremediation pond along the 120 m lower side
iv. 0.6 m thick soil cover + 0.3 m thick top soil cover
v. Grass seeding and bush planting on the whole surface

15.4.2 Dangriga, Placencia and Independence

Dumpsites in Dangriga, Placencia and Independence have two main traits in common:

- The waste is mainly deposited in trenches
- Trenches are excavated to a depth of around 3 m in soil with a significant clay component (mainly Dangriga and Independence, to a lower extent Independence)

The Dangriga site is spread over a quite large area (approximately 20,000 m^2) and some waste is also deposited above the ground level making the topography of the area irregular.
Considering that there is no more space available to dig new trenches and, on the other hand, that the adjacent site, meant to be used as new dumpsite by the Town Council, is a potentially suitable location for the herein proposed Transfer Station, the remedial design takes into account that the waste collected in the next two years will be deposited on top of the already completed trenches already covered with soil.

In accordance to such assumption the final shape of the site will be approximately that of a large dome with a maximum height around 2 m above the ground.
The proposed remediation design is then simplified with respect to the one proposed for the dumpsites on the Northern Corridor and is based on the following features:

i. Reshaping of the top surface to improve runoff avoiding stagnant water and levelling the surface to host the soil cover
ii. 0.6 m soil cover with the same clayish soil present in the area + 0.3 m of top soil
iii. Stormwater drainage system
iv. Landscaping

A main difference of the Placencia dumpsite with respect to the others is that a significant volume of waste is also deposited above the ground in two further secondary sites and, to a

greater extent, along the access road. On the other hand the formal dumpsite lies in a more restricted area compared with those of Dangriga and Independence.
As in the previous case the remediation design for the Placencia dumpsite foresees a final dome shape where, in this case, the volume above the ground level is due to the waste gathered in the two secondary sites and along the access road. The remaining features of the remediation design are the same as per the Dangriga dumpsite described above.

In the case of the Independence dumpsite the waste is entirely deposited inside the excavated trenches and the remediation design is mainly characterised by the placing of the soil cover and the landscaping in order to reduce the infiltration of rain water.

15.4.3 Punta Gorda

Punta Gorda dumpsite is the only one among those here included that has been developed in a depression. The waste has been deposited in a low lying area progressively filled. Due probably to a large extent to the considerably higher rainfalls occurring in this area the extent of the waste burning practice seems to be lower even if largely evident.
As a result of this a higher fraction of organic waste remains unburned and the general conditions of the site appears worse than in the other cases (odour and proliferation of pests). Besides, the site covers the largest area among those analysed for the aim of the present Study and, differently from Dangriga dumpsite (of a comparable extension), doesn't show evidence of any type of cover.

In spite of this difference the same type of remediation technique proposed above, mainly relying on the final capping (both soil and vegetation) for the reduction of the infiltration of rain water and the oxidisation of the residual methane emissions (negligible in the other sites), is considered as the most viable solution.

The construction of the final cover shall be preceded by the disposal of the considerable amount of waste dumped along the access road and the reshaping of the final top surface so to improve the runoff.

15.5 **Mile 24 Landfill**

An extremely positive element considered when assessing the possible Waste Management Scenarios, was the high quality of the present transfer and disposal system in the Western Corridor. Specifically, the landfill at Mile 24 appears to be built and operated in accordance with adequate international standards.
If problems can be highlighted in this case they are related to the inadequate (for the optimization of an engineered landfill) input of waste due to the lack of the implementation of a well-developed collection system. The performances of the landfill are therefore are necessarily lower than those achievable in landfills of bigger size and higher daily and annual waste inputs.
Both the infrastructural system and the management (SWaMA) system are nevertheless to be considered as a solid base on which the system for the two remaining Corridors can and shall be built upon.

The present Plan therefore consider the construction of a further cell at Mile 24 to cater for the waste to be transferred from the Northern and Southern Corridors in addition to that already coming from the Western Corridor.

A development plan for the whole site will be prepared during the next phase of this work and is not currently available. A technical and environmental audit was nevertheless carried out to ascertain the adequacy of the site and the existing facilities. Such document is available and can be consulted on the matter.

C. PRELIMINARY ASSESSMENT OF THE INSTITUTIONAL AND LEGAL FRAMEWORK

Solid waste management in Belize is not regulated by a specific and general act encompassing the different related aspects and identifying explicit responsibilities of the different actors involved at different levels.

The legal framework for the waste management activities is then defined by a number of regulations included in different Acts as summarised in the following Table 17.

Table 17 – List of waste management related regulations

Agency	Solid Waste Management Authority
Legislation	**Solid Waste Management Authority Act (Chapter 224) Revised Edition 2000**
Highlights	Established the SWMA, and the Board of Directors to govern the affairs of the SWMA. The SWMA is body corporate with perpetual succession and a common seal and with power as such to enter into contracts, to hold property, to sue and be sued in its corporate name and to do all things necessary for the purposes of the Act.
Agency	Department of the Environment
Legislation	**Environmental Protection Act (Chapter 328) Revised Edition 2000**
Highlights	Established the DOE with powers to control pollution (liquid and solid waste); control dumping of solid waste; regulate the movement of hazardous waste.
Agency	Department of The Environment/ Customs Department
Legislation	***Environmental Tax Act Chapter 64:01 Revised Edition 2003***
Highlights	This Law applied an environmental tax (initially at 1%) of the value of certain imported goods. The act is enforced by the Customs Department under the Customs and Excise Duties Act. The funds were originally destined (as per the act) for solid waste management program, garbage disposal and institutional strengthening of the DOE. (See section 7 of the Act)
Agency	Department of The Environment
Legislation	***Environmental Impact Assessment (Amendment Regulations, 2007)***
Highlights	Regulates development through application of the EIA process. The vetting of EIAs is done by the National Environmental Appraisal Committee (NEAC) whose membership is listed in the EIA Regulations
Agency	Department of The Environment
Legislation	***Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, "Chapter 238 Pollution Regulations"***
Highlights	Controls pollution by establishing emission standards for various industries; the act also allows for the control of dumping of waste at sea

Agency	Department of The Environment
Legislation	***Environmental Protection (effluent limitations) Regulations, 1995, and the Environmental Protection Act Chapter 328 Revised Edition 2003***
Highlights	This regulation sets standards for effluent disposal, including from waste treatment facilities.
Agency	Department of The Environment
Legislation	***Hazardous Waste Regulations 2009***
Highlights	Regulates the location of hazardous waste treatment centres; collection and transportation of hazardous waste, and classification of hazardous waste; and the prohibition of disposal and treatment of hazardous waste in poorly planned sites
Agency	Department of The Environment
Legislation	***Summary Jurisdiction (Offences) Act Chapter 98 Littering Offences Violation Tickets Regulation***
Highlights	Authorizes persons to issue Littering Offences Violation Tickets (Fine of $100.00 individuals and $500.00 Corporate Body).
Agency	Department of The Environment & Customs Department
Legislation	***Customs Regulations Prohibited and Restricted Goods Consolidation (Amendment) Order 2006***
Highlights	This act amends the Customs and Excise Act so that the Department of The Environment, Through the Customs Department can regulate the importation of used tires, and lead acid batteries and the export of scrap metals through the use of a license issued by the DOE
Agency	Ministry of Health and Public Health Department
Legislation	**Public Health Act (Chapter 40) Revised Edition 2000.**
Highlights	This act addresses general public health issues but also authorizes the Public Health Officers to regulate nuisances, including refuse in premises.
Agency	All Town Councils
Legislation	**Town Council Act Chapter 87 Revised Edition 2000**
Highlights	Establishes Town Councils as body corporate with perpetual succession and a common seal. The Council shall have capacity to acquire, hold and dispose of real and personal property and to sue and be sued in all courts of law. The Council shall consist of a Mayor and six other members duly elected in accordance with this Act and regulations made thereunder.

Agency	All Village Councils
Legislation	**Village Councils Act Chapter 88 Revised Edition 2000**
Highlights	This Act empowers The Minister responsible for the Ministry under which Village Councils fall to fix and declare any area of Belize not comprised within any city or town to be a village for the purpose of the Act, provided that at least two hundred persons who would be qualified to vote for village councils under this Act live in such an area.

In the following section a more detailed description of the above listed laws is given with specific focus on the waste related aspects.

16 WASTE MANAGEMENT RELATED REGULATORY ACTS

Solid Waste Management Authority Act (Chapter 224) Revised Edition 2000. The Solid Waste Management Authority Act established the Solid Waste Management Authority and a Board of Directors of the Solid Waste Management Authority (SWaMA). The SWaMA is a body corporate with perpetual succession and a common seal and with power as such to enter into contracts, to hold property, to sue and be sued in its corporate name and to do all things necessary for the purposes of the Act. The SWaMA and the Board is charged with the responsibility to deal with all matters pertaining to and conducive to the management of solid waste management. Its functions include the designation of “service areas”, (with the approval of local authorities), to arrange for the collection and disposal of solid waste within a service area, (through contractual services or otherwise), and to enact and implement policy and guidelines conducive to adequate solid waste management throughout the Country.

The Environmental Protection Act, Chapter 328, Revised Edition 2000, relates to the preservation, protection and improvement of the environment, the rational use of our natural resources, and the control of pollution. The DOE is empowered by this Act. A number of regulations including the Environmental Impact Assessment (Amendment) 2007 have been passed under this act. The proposed project for which this EIA is being prepared, falls under “Schedule I” of the EIA Regulations, thus requiring the full EIA to be prepared as part of the approval process.

Environmental Tax Act Chapter 64:01 Revised Edition 2003. This Law applied an environmental tax (initially at 1%) of the value of certain imported goods. The act is enforced by the Customs Department under the Customs and Excise Duties Act. The funds were originally destined (as per the act) for the following functions as specified in Section 7 of the act. The proceeds of the tax shall be placed into a special fund and shall be used –

a) to develop a national solid waste management program;
b) to defray the cost of the disposal of refuse generated by the use of goods referred to in section 3 to assist in the collection and disposal of garbage throughout Belize;
c) to clean up rivers and canals and other internal waterways;
d) for the preservation and enhancement of the environment; and
e) for strengthening the institutional capacity of the Department of the Environment.

It should be noted that at the time of the passing of this act, which was during the preparation of the initial solid waste management program; the Solid Waste Authority was non-existent; and the DOE was seen at the time the lead agency in solid waste management.

Environmental Impact Assessment (Amendment Regulations, 2007). This regulation is the primary legislation under which the EIA process is administered. All projects of industrial scale fall under Schedule I, for which a full EIA must be prepared. Sanitary landfills and waste storage facilities fall within schedule I of the Act, no mention to other and different waste management related facilities and/or activities is included.

Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, "Chapter 238 Pollution Regulations".

Air emissions are regulated under the Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, "Chapter 238 Pollution Regulations". This legislation prevents the emission and deposition of a contaminant from domestic, commercial, agricultural, recreational, industrial or any other source, without the issuance of a permit with conditions to do so. This permit is issued by the Department of the Environment. The law also regulates the discharge standards via emission standards. Emissions are in the form of particulate matter, sulphur dioxide, nitrogen oxides, and water pollutants.

The Pollution Regulations do not specify standards for emissions that are specific to landfill or disposal sites. However, it does regulate the approval of a site to be used for treatment and final disposal of solid and liquid wastes. Regulation 6 (1) prohibits the direct emissions in general of contaminants from any industry. The emission of these contaminants require permitting and licensing requirements; through a process of authorization and reporting.

Regulation 32 also prohibits the pollution of water from leaching of effluent. Regulation 33 specifies that the Department may issue the permit for the use of a site for waste disposal providing certain conditions including the quality of service, standards and limitations are established via the provision of a report. Regulation 35 also allows the Department to approve a site prior to use for waste management and disposal. The subsequent Regulation 36 defines "waste" and "waste management systems", which, at the time of enactment of these laws, was meant to be the operation of a sanitary landfill for solid waste management.

The law also regulates the discharge of air contaminants by establishing generic emission standards as summarized in Table 18.

Table 18 - Concentration of Permitted Air Contaminants as Required by the Pollution Regulations, 1995

Concentration of Air Contaminants				
	Concentrations in micrograms per cubic meter			
	SPM	SO2	CO	NOx
A. Industrial and Mixed use	500	120	5000	120
B. Residential & Rural	200	80	2000	80
C. Sensitive	100	30	1000	30

The Pollutions Regulations also specify standards for noise levels (see Table 19).

Table 19: Noise Levels Required by the Belize Laws. Source: Environmental Protection Act Chapter 328

	Noise Level According to the dB (A) Scale (as defined by the International Electronics Commission).										
		Structure A		Structure B		Structure C		Structure D		Structure E	
	Duration of Noise	D	N	D	N	D	N	D	N	D	N
1	More than 9 hrs	60		60		70		70		85	
2	More than 3 hrs, less than 9 hrs	70		70		75		75		90	
3	More than 30 min	75		75		80		80		100	
4	More than 30 min		45		45		45		45		90
5	More than 15 min and less than 1 hr	70		70		90		90		105	
6	More than 10 min and less than 30 min		45		50		50		50		90
7	More than 5 min and less than 15 min	70		85		100		90		90	
8	More than 2 min and less than 5 min	90		95		100		100		95	
9	Less than 10 min		50		70		70		70		80
10	Less than 2 min	100		100		105		100		110	
	Noise from infrequent (less than 4 times per week) explosions	109		109		114		114		114	

Revised Edition 2003 of the Substantive Laws of Belize, "Chapter 238 Pollution Regulations.
Structure A: any building used as a hospital, convalescent home, old age home, or school.
Structure B: any residential building.
Structure C: any building in an area that is used for residential and one or more of the following purposes: commerce, small scale production, entertainment.
Structure D: any residential apartment in an area that is used for the purposes of industry, commerce or small scale production.
Structure E: any building used for the purposes of industry, commerce, or small scale production in an area used for the purposes of industry, commerce, or small scale production.

The Environmental Protection (effluent limitations) Regulations, 1995: Statutory instrument no. 94 of 1995 and its subsequent amendment of 2009 are key regulatory frameworks governing the discharge of effluents from industrial activities.
The Effluent Limitations Regulations came into effect in 1996. These regulations were enacted to control and monitor discharges of effluent into any inland waters or the marine environment of Belize. These Regulations prohibited the discharges of effluent from new and altered point sources, and established a licensing system for discharging effluents under specific conditions.

This meant that through the licensing system, industries would have to improve their treatment of effluents before discharging into the environment. The Effluent Limitations Regulations also established the requirement for the treatment of effluent, as well as limitations or standards for physical and chemical parameters to be monitored for various industries.

The Environmental Protection (Effluent Limitations) (Amendment) Regulations 2009 (S.I. 102 of 2009) were amended to primarily include provisions for the treatment of domestic wastewater and the categorization of Class I and II Waters that differentiate waters with unique ecological characteristics that are sensitive to impacts of domestic wastewater from those that are less sensitive to the impact of domestic effluent. This amendment also made improvements for effluent standards for both industrial and domestic effluent. This legislation came into effect on August 8th 2009.

As per this legislation "Industrial Effluent" means any liquid water or waste water discharged from any industrial or commercial premises. Each water type (Class I or II) has its limitations as per domestic discharge of effluents. Any person discharging domestic effluent into any of the above classes (I or II), is required to treat this domestic water as per the standards set in Schedule III, which defines the standards for discharge into both Class I and Class II waters.

The requirements for a license to discharge effluents are met by the applicant filling in the form as specified in Schedule Five (Regulation 14 (2) (Form A) of the Effluent Limitations Regulations, 1995, and a license is issued as per (Form B) of the same Regulation 14 (2).

While these regulations do not specify effluent discharge limitations from the operation of solid waste facilities; it does have provisions for the reporting requirements for the operation of such facilities. Regulation 15 (1) specifically details that reporting of the operational status of such facilities shall be submitted to the Department of the Environment; including facilities used for solid waste disposal.

The requirements for a license to discharge effluents are met by the applicant filling in the form as specified in Schedule Five (Regulation 14 (2) (Form A) of the Effluent Limitations Regulations, 1995, and a license is issued as per (Form B) of the same Regulation 14 (2).

Table 20 - Summary of Main Parameters and Effluent Standards for "Other" Industries as per Effluent Limitations Regulations, 1995.

Parameter	**Limitation/Standard**
Temperature	33˚C
Color (LU)	7
pH	6 to 9
DO	5 mg/l
BOD at 20˚C	
COD	100 mg/l
TSS	50 mg/l
TDS	2000 mg/l
Chloride (as cl)	600 mg/l
Sulphate (as SO4)	500 mg/l
Nitrate (as NO)	3 mg/l
Phosphate	5 mg/l
Calcium	200 mg/l
Magnesium	200 mg/l
Total Coliform	0 to 10 MPN/100 ml
Fecal Coliform	0 MPN/100 ml
Fluoride	5 mg/l
Total organic carbon	200 mg/l
Oil and Grease	10
Metals	**Limitation/Standard**
Arsenic	1
Barium	5mg/l
Tin	10 mg/l
Iron	20 mg/l
Beryllium	0.5 mg/l
Manganese	5 mg/l
Boron	5 mg/l
Copper	1 mg/l
Lead	0.1 mg/l
Mercury	0.05 mg/l

Other metals and compounds are also listed in the schedule of limitations.

Table 21 - Required Standards for Discharge of Treated Effluent into Class I and II Waters. ***Source: The Environmental Protection (Effluent Limitations) (Amendment) Regulations 2009 (S.I. 102 of 2009)***

Schedule III (Discharge into Class I Waters)		**Schedule III (Discharge into Class II Waters)**	
Parameter	Effluent Limitation	Parameter	Effluent Limitation
TSS	30 mg/L	TSS	150 mg/L
BOD 5	30 mg/L	BOD 5	150 mg/L
pH	5-10 ph Units	pH	5-10 ph Units
Fats, oil and grease	15 mg/L	Fats, oil and grease	50 mg/L
Faecal coliform	200 mpn/100 ml	Faecal coliform	Not applicable
E. coli (freshwater)	126/100 ml	E. coli (freshwater)	
Enterococci (saline water)	35/100 ml	*Enterococci* (saline water)	

Hazardous Waste Regulations, S.I. 100 of 2009. This regulation controls the transportation, storage and disposal of hazardous waste in liquid and solid waste forms. The law defines hazardous waste as any material that is "toxic, corrosive, flammable, reactive, explosive, infectious or pathogenic that may pose a threat to the environment and human health...". The regulation further specifies a list of hazardous materials in Schedule I to the Regulations, and Schedule II as well as those listed in the Basel Convention on the Transboundary Movement of Hazardous Waste.
This regulation also defines a hazardous waste treatment facility as one authorized by the Department (of the Environment) for the collection, storage, treatment or disposal of hazardous wastes. The regulation also specifies that hazardous waste does not include domestic waste. It also specifies that no liquid hazardous waste shall be disposed of in a landfill (Regulation 15). However, Regulation 16 does allow for the use of a landfill that is suitably designed for the disposal of "solid" hazardous waste.

Public Health Act (Chapter 40) Revised Edition 2000. The *Public Health Act* empowers the *Director of Health Services* to make an inquiry into any matters in connection to public health, and makes regulations for sanitation and prevention of nuisances from dirty properties or premises. The *Director of Health Services* and *Public Health Officers* may enter any premise within a reasonable time to inspect any premises within a Town or Village in order to ensure that health and sanitation of premises and property do not become a nuisance. The act also authorizes the *Town or Village Councils*, as well as any member of the Police Department to assist *Public Health Officers* in the inspection process. This also applies to nuisances caused by overgrown bushes in properties, and the keeping of excess refuse. Any dwelling with refuse or overgrown bushes may be declared a nuisance, for which it has to be cleaned in order to prevent vermin or infectious diseases. This law also authorizes health officers to inspect premises in order to ensure that the property is kept in a sanitary manner.

Town Council Act Chapter 87 Revised Edition 2000

The ***Town Council Act Chapter 87 Revised Edition 2000*** establishes Town Councils as body corporate with perpetual succession and a common seal. The Council shall have capacity to acquire, hold and dispose of real and personal property and to sue and be sued in all courts of law. The Council shall consist of a Mayor and six other members duly elected in accordance with this Act and regulations made thereunder. Town Councils have wide powers to manage the affairs of the towns, and operate within declared town limits. They can make subsidiary laws or by laws for the good governance of the towns.

Towns Property Tax Act Chapter 65 Revised Edition 2000. This act empowers City and Town Councils to charge for property tax of properties within town limits.

Village Councils Act Chapter 88 Revised Edition 2000.
The Village Councils Act Chapter 88 Revised Edition 2000, empowers The Minister responsible for the Ministry under which Village Councils fall to fix and declare any area of Belize not comprised within any city or town to be a village for the purpose of the Act, provided that at least two hundred persons who would be qualified to vote for village councils under this Act live in such an area.

Section 5 (2) of the Act states that every council shall:

(a) be a corporate body bearing the name of "The Village Council of" followed by the name of the village in respect of which it is constituted;
(b) have perpetual succession and a common seal;
(c) be vested with power to sue and be sued in such name;
(d) have capacity to hold lands for the purposes of this Act; and
(e) subject to section 10 of this Act, hold office for three years.

Summary Jurisdiction Offences Act (Chapter 98) Revised Edition 2003.
This Act is a Consolidation of Chapter 98 Summary Jurisdiction (Littering Offences Violation Tickets) Regulations. This law Authorizes officials such as policemen, Justices of the Peace, Town and City Administrators, or those authorized by city or town councils to issue violation tickets for littering offences. The fee charged is $100.00 Belize Dollars for a person and $500.00 for a body corporate. The ticket should be paid at the treasury or sub-treasury in every district.

16.1 Solid waste related specific regulations

Type of Waste or Requirement	Solid Waste
Legislation (Act, etc.)	Solid Waste Management Authority Act (Chapter 224) Revised Edition 2000
Clauses	Part I, Clause 2
Summary of Provisions	"solid waste" includes garbage and refuse but shall not include derelict vehicles, construction waste material, limbs of trees, soil, lumber, packaging materials and chemical by-products "garbage" includes waste food, vegetables, fruits, meats and other putrescible matter

	"refuse" includes waste paper, bottles, cans, boxes, yard clippings and trash
Type of Waste or Requirement	Solid Waste
Legislation (Act, etc.)	Solid Waste Management Authority Act (Chapter 224) Revised Edition 2000
Clauses	Part 1 (2), Section 14 (1) and (2) - Solid Waste collection
Summary of Provisions	The Solid Waste Management Authority is empowered to make arrangements for the collection of solid waste (either via contractual arrangement with a person or corporate body)
Type of Waste or Requirement	Construction Waste
Legislation (Act, etc.)	Solid Waste Management Authority Act (Chapter 224) Revised Edition 2000
Clauses	Section 14 (5) - Contractors obligated to remove construction waste
Summary of Provisions	It shall be the responsibility of contractors to remove and dispose of all construction waste material resulting from new construction or other works on or at any premises.
Type of Waste or Requirement	Declaration of Service Areas
Legislation (Act, etc.)	Solid Waste Management Authority Act (Chapter 224) Revised Edition 2000
Clauses	Part 1 (2) - Declared Service Areas
Summary of Provisions	Persons (except large commercial areas) residing within service areas obligated to use collection service "service area" means such area of the country as may from time to time be declared by the Authority with the approval of the Minister to be provided with solid waste collection service pursuant to this Act
Type of Waste or Requirement	Littering Offence
Legislation (Act, etc.)	Summary Jurisdiction Offences Act (Chapter 98) Revised Edition 2003
Clauses	Section (4) - Authorizes officials to issue violation tickets for littering
Summary of Provisions	An authorised officer may, if he sees a person committing a littering offence, issue him with a violation ticket either at the same time the offence is committed or within forty-eight hours thereafter
Type of Waste or	Pass By Laws for Solid Waste Management

Requirement	
Legislation (Act, etc.)	Town Council Act Chapter 87 Revised Edition 2000
Clauses	Part. VIII Section 30 (b), Part X Section 49 (1)
Summary of Provisions	The Act authorizes the Town Councils to manage garbage; and this can be done through the enactment of bylaws relevant to waste control; including the setting of tariffs for this service According to Section 30 (b) every Council shall have the obligation to coordinate, control, manage or regulate the timely and efficient collection and removal of all garbage material from all residential or commercial areas in its town. Section 49 (1) Every Council may from time to time make by-laws on all matters connected with the rule and good order of its town and for the proper carrying out of the objects and purposes of this Act.
Type of Waste or Requirement	Regulations governing disposal of solid waste and liquid waste
Legislation (Act, etc.)	Effluent Limitations Regulations (S.I. 94 of 1995) & Effluent Limitations Amendment Regulations (S.I. 102 of 2009)
Clauses	Part. V Regulation 15
Summary of Provisions	This regulations allows for the reporting requirements of any facility being operated for the disposal of liquid or solid waste. Regulation 15 (1): The Department may by notice in writing require the owner or operator of any sewage treatment plant, industrial waste treatment facility or any facility for the disposal of solid waste or any other facility for controlling pollution, to submit to the Department at such intervals as the Chief Environmental Officer may specify in the notice, information relating to all or any of the following: (a) the performance of the facility; (b) the quality of the effluent discharged; (c) the area affected by the discharge of effluents; (d) the steps being taken to abate or control pollution; and such owner or operator as aforesaid shall comply with the requirements of the notice.
Type of Waste or Requirement	Waste from street
Legislation (Act, etc.)	Village Councils Act Chapter 88 Revised Edition 2000
Clauses	Part IV Section 23
Summary of Provisions	23 (1) A council may from time to time make by-laws for the rule and good government of its village generally, and in particular in

	respect of all or any of the following matters: … (i) for the cleanliness of streets and other public places; (j) for the cleaning of unkept and overgrown yards within the limits of a village and for recovering the costs of doing same from the owners; (k) (i) for the sanitation of the village in general; (ii) for drainage and sewage; (iii) for scavenging and the removal and disposal of excreta; …
Type of Waste or Requirement	Waste definition and Ministry and Department duties on waste management
Legislation (Act, etc.)	Environmental Protection Act Chapter 328 Revised Edition 2003 and Environmental Protection (Amendment) Act, 2009.
Clauses	Part I Section 2, Part II section 4, Part III Sections 7
Summary of Provisions	Part I Section 2 (1) "waste" includes any matter prescribed to be waste, and any matter, whether liquid, solid, gaseous or radio active, which is discharged, emitted, or deposited in the environment in such a volume, composition or manner as to cause an alteration of the environment. Part II section 4 The powers, duties and functions of the Department shall be to: … *(d)* control the volume, types, constituents and effects of wastes, discharges, emissions, deposits or other sources of emission and substances which are of danger or a potential danger to the quality of the environment; … *(i)* maintain a register of all wastes, discharges, emissions, deposits or other sources of emission or substances which are of danger or potential danger to the environment; … Part III Section 7 (1) The Minister may, after consultation with the Department, make regulations for … *(1)* preserving and protecting the barrier reef and prohibiting the dumping of wastes in the marine environment; *(m)* controlling and minimizing the transboundary movement of toxic and hazardous wastes; and

	…
Type of Waste or Requirement	Waste final treatment plants
Legislation (Act, etc.)	Environmental Protection Act Chapter 328 Revised Edition 2003 and Environmental Protection (Amendment) Act, 2009.
Clauses	Part III Sections 8, 11, Part. VIII Section 45, Part XV Section 72
Summary of Provisions	Part III Section 8 … (2) Every person, installation, factory or plant emitting air pollutants is required to maintain and submit to the Department, records of the type, composition and quantity of pollutants emitted. (3) The Department, where necessary, may instruct the person, installation, factory or plant to make changes with regard to structure, method of operation or manner of disposing of air pollutants. Section 11 (1) No person shall emit, import, discharge, deposit, dispose of or dump any waste that might directly or indirectly pollute water resources or damage or destroy marine life. (2) Any person who contravenes subsection (1) commits an offence and shall be liable on summary conviction to a fine not less than five thousand dollars and not exceeding twenty-five thousand dollars or to imprisonment for a period not exceeding two years or to both such fine and period of imprisonment, and to a further fine not exceeding one thousand dollars a day for every day that the offence is continued after a notice by the duly designated officer requiring him to cease the act specified therein has been served upon him. Part. VIII Section 45 (1) The Minister may make regulations for the better carrying out of the provisions of this Act (2) Without prejudice to the generality of subsection (1), regulations made by the Minister may provide for- … *(i)* the importation, collection, storage, recycling, recovery or disposal of substances which may be hazardous to the environment *(n)* the discharge of wastes generally, and fees payable in

	relation thereto; *(p)* prohibition or regulation of the open-burning of refuse or other combustible matter; … (r) the issuance of permits to construct and operate landfills … (t) the licensing of processing of recyclables; (u) the licensing of other solid waste processing facilities; Part XV Section 72 (1) No person shall construct, operate or manage a landfill or hazardous waste disposal facility without a permit from the Department. (2) A deep well injection site/facility for the purpose of disposal of hazardous wastes shall be considered as a hazardous waste disposal facility. (3) No person shall construct, operate or manage an incinerator or co-generation facility that utilizes refuse derived fuel as its source of fuel without a permit from the Department. (4) The Department may issue a permit subject to conditions including a requirement for a performance bond or guarantee
Type of Waste or Requirement	Dumping
Legislation (Act, etc.)	Environmental Protection Act Chapter 328 Revised Edition 2003 and Environmental Protection (Amendment) Act, 2009.
Clauses	Part IV Sections 12, 13, 14
Summary of Provisions	Part IV Section 12. In this Part “dumping” means the deliberate disposal at sea from ships, aircraft, tankers, floating craft or other marine vessels, or other man-made structures, and includes disposal by incineration or other thermal degradation of any substance, but does not include: *(a)* any disposal that is incidental to or derived from the normal operations of a ship, aircraft, tanker, floating craft or other marine vessel or other man-made structure or of any equipment on a ship, aircraft, tanker, floating craft or other marine vessel or other man-made structure other than the disposal of substances from a ship, aircraft, tanker, floating craft or other marine vessels or other man-made structures operated for the purpose of disposing of such substances at sea; and *(b)* any discharge that is incidental to or derived from the exploration for, exploitation of, and associated offshore

	processing of sea-bed mineral resources; "master" includes every person having command or charge of a ship but does not include a pilot; "sea" means *(a)* the territorial sea of Belize; *(b)* the internal waters of Belize; *(c)* any fishing zone or reserve prescribed under the Fisheries Act; and *(d)* the exclusive economic zone of Belize "ship" includes any description of vessel, boat or craft used or capable of being used solely or partly for marine navigation without regard to its method or lack of propulsion. Section 13. (1) No person shall dump or dispose of or deposit any garbage, refuse, toxic substances or hazardous wastes in any place that may directly or indirectly damage or destroy flora or fauna, or pollute water resources or the environment. (2) Any person who contravenes subsection (1) commits an offence and shall be liable on summary conviction to a fine not exceeding twenty-five thousand dollars or to imprisonment for a term not less than six months and not exceeding five years, or to both such fine and imprisonment. Section 14 (1) Subject to subsection (2), no person shall dump any garbage, refuse, or chemical substances from any aircraft, ship, tanker, floating craft or other marine vessel into the harbours or sea of Belize.
Type of Waste or Requirement	Establishment of Solid Treatment and Disposal Waste Sites
Legislation (Act, etc.)	Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, "Chapter 238 Pollution Regulations" and Pollution (Amendment) Regulations, 2009.
Clauses	Part. IV Section 13, Part X Sections 33, 34, 35, 36.
Summary of Provisions	Part. IV Section 13. (1) The Department may permit the use of disposal sites where burning may be carried out for the purpose of disposing of solid waste and combustible material at such times and under such conditions as it determines. (2) The site, for the purpose of sub-regulation (1), shall be authorized on the basis of the environmental and atmospheric conditions of the area.

	Part. X Section 33. (1) The Department may issue, in respect of a person operating a site for elimination or storage of waste or a solid waste treatment plant and disposal system directions it considers appropriate respecting: *(a)* the quality of the service; *(b)* the reports to be submitted; *(c)* the terms and conditions upon which the operation shall be carried on; and *(d)* the standards to be attained and the code of practice to be followed. (2) Where an operator fails to comply with a direction under subregulation (1) the Department may: *(a)* cancel or suspend the permit issued in respect of that operator; or *(b)* execute any work, at the expense of the operator, that may be necessary to cause the operator to comply with the established standards. Section 34. (1) No person shall, without the written permission of the Department, construct any building on a site that was formerly used for the elimination of waste. (2) No person shall, without the prior written permission of the Department, sell or offer for sale any building on a site that was formerly used for the elimination of waste. Section 35. No person shall deposit waste in a place other than on a site approved by the Department for the elimination or storage of waste or for the operation of a waste treatment plant or a waste management system. Section 36. For the purposes of Regulations 32 to 35: (a) "waste" includes solid or liquid residue from industrial, commercial or agricultural activities, rubbish, household garbage, used lubricants, demolition debris, pathological waste material, bodies of animals, motor vehicle wrecks, chemical and radioactive material, and empty containers; (b) "waste management system" means a combination of technical and administrative operations for the removal, collection, transport, storage, treatment and final disposal of waste.
Type of Waste or	Land pollution

Requirement	
Legislation (Act, etc.)	Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, "Chapter 238 Pollution Regulations" and Pollution (Amendment) Regulations, 2009.
Clauses	Part X Sections 31, 32.
Summary of Provisions	Part. X Section 31 … (2) Without in any way limiting the generality of subregulation (1) a person shall be deemed to have polluted land in contravention of that subregulation if: … *(b)* that person establishes on any land *(i)* a refuse dump; *(ii)* a garbage tip; *(iii)* a soil and rock disposal site; *(iv)* any other site for the disposal of or as a repository for solid or liquid waste: without the written permission of the Department. Section 32. No person shall cause any seepage or leaching contamination of the adjacent soil, ground water or surface water.
Type of Waste or Requirement	Control of Importation and Exportation of Scrap Metal, Lead Acid Batteries and Used Tires
Legislation (Act, etc.)	Customs Regulations Prohibited and Restricted Goods Consolidation Amendment Order 2006
Clauses	Section 2
Summary of Provisions	Prohibits the exportation of scrap metal without an approved License from the DOE, and also prohibits the importation of used tires and lead acid batteries without a license.
Type of Waste or Requirement	Hazardous Waste Management
Legislation (Act, etc.)	Hazardous Waste Regulations, Statutory Instrument 100 of 2009
Clauses	Part I Regulation 2, Part II Regulation 6, Part III Regulations 10, 11, Part V Regulations 14, Part VI Regulations 15, 16, 17, Part VIII Regulation 23
Summary of Provisions	Part I Regulation 2 …

	"hazardous waste" means any material or substance characterized as being toxic, corrosive, flammable, reactive, explosive, infectious, or pathogenic that may pose a threat to the environment and human health, and includes any waste that are: a) Listed in table 1 of the Schedule; or b) Defined by criteria specified in Table 2 of the Schedule; or c) Listed in Annex 1 of the Basel Convention on the Transboundary Movement of hazardous Waste; "hazardous waste management facility" means a facility for the collection, storage, treatment, or disposal of hazardous wastes which is authorized ore permitted to operate for this purpose by the Department. … "treatment" includes, in relation to waste, any thermal, physical, chemical or biological processes that change the characteristics of waste in order to reduce its volume or hazardous nature or facilitates its handling, disposal or recovery. Part II Regulation 6 No person shall establish, construct or operate any hazardous waste management facility: a) In a 100 year floodplain unless the hazardous waste management facility is designed, constructed, operated and maintained to prevent washout of any hazardous waste by a 100 year flood; b) Within 100 meters of any land which is subject to slope failure; c) Within a wetland area or an area immediately adjacent to a wetland so that natural drainage from the secure landfill would flow directly into the wetland area; d) In a recharge area of an unconfined area; e) Within a minimum of one and half (1 ½) mile radius of any human settlement including a village, town, city, farm, resort or hotel; f) Within 300 meter of any non-intermittent watercourse or any other permanent water body. Part III Regulation 10 (1) A person who stores a hazardous waste shall it in a manner

	satisfactory to the Chief Environmental Officer, and in an amount and in a manner such that it will not cause an adverse effect to the environment so that: a) any leakage is contained and prevented from entering into the remainder of the storage site and places beyond, including sewers and the ground underneath the site; b) a secondary containment system is provided as a minimum for liquid hazardous waste; c) the hazardous waste is adequately labeled, stating the identity of the contained hazardous waste; d) incompatible hazardous wastes are stored in such a manner that there will be no contact even in the event of a release; e) routine inspections of the facility are performed; f) the place where the hazardous waste is stored: i. is secured from public entry; ii. is prominently identified as a hazardous waste storage site; iii. is equipped with suitable equipment to handle emergency situations; iv. is provided with operators trained to respond to emergency situations specific to the waste and other substances stored, v. has no opening in the secondary containment system that provides a direct connection to any place beyond the containment system; vi. provides no access for surface water to enter the secondary containment system. (2) For the purpose of this Regulation, adequate labeling includes the identity, quantity, data generated and warning placard indicating the hazard associated with the waste. Regulation 11 (1) All hazardous waste storage facilities shall be sited, designed, operated, and constructed as approved by the Chief Environmental Officer. (2) no person shall store hazardous waste on site unless such storage is approved of by the Chief Environmental Officer. Part V Regulation 14 All the facilities for the treatment or final disposal of hazardous waste shall be sited, designed, constructed and operated as approved by the Chief Environmental Officer

	Part VI Regulation 15 No liquid hazardous waste shall be disposed of in a landfill. Regulation 16 (1) The Chief Environmental Officer shall not approve the disposal of solid hazardous wastes, not otherwise prohibited from disposal in a landfill, unless the landfill is provided with at least: a) two liners of which at least one is a synthetic liner; b) a leachate collection and removal system; c) a groundwater monitoring system; and d) a leak detection system between the two liners. … Regulation 17 All hazardous waste management facilities shall be sited, designed, operated, constructed and closed in accordance with such guidelines as may be approved by the Chief Environmental Officer. Part VIII Regulation 23 (1) any person generating hazardous waste is responsible for classifying each hazardous waste in a manner approved in writing by the Chief Environmental Officer. (2) waste streams shall be individually classified at their source and shall not be analyzed following mixing or dilution with other waste streams. (3) Any person generating a hazardous waste shall keep adequate records of the dates, types and amounts of hazardous waste generated and the date and location where such waste are shipped for disposal.

16.2 Social related applicable Belizean Laws

Although the current legal framework in Belize does not promote recycling, the Solid Waste Management Policy and Strategy and updated the National Solid Waste Management Plan developed in 2015 does include the development of "3Rs" targets and strategies. As such it would be important to include in these documents incentives that support the development of a recycler's network throughout the country.

Specifically:

- ***Income restoration***. Belizean law has no provision for compensating lost income.
- ***Informality***. Informal income activities are not explicitly recognized under Belizean law.

- ***Procedural requirements***. There is no specific reference in Belizean law to 'involuntary resettlement', even with regard to land or physical property. There is no requirement to prepare a formal Resettlement Plan nor to undertake any of the component activities of a Plan, such as a census, socio-economic survey, monitoring or reporting.
- ***Consultation and grievance redress.*** There is no specific legislation in Belize on grievance redress.
- ***Disclosure***. There is no specific legislation in Belize on disclosure of documents.

17 IDB POLICIES AND DIRECTIVES

The effects on the environment of the provisions of the Scenario 1 are hereinafter assessed following the suggestions of the IDB Polices and Directives listed below:

- *IDB Environmental and Safety Compliance Policy Directive B1 "Bank Policies";*
- *IDB Environmental and Safety Compliance Policy Directive B2 "Country Laws and Regulation";*
- *IDB Environmental and Safety Compliance Policy Directive B3 "Screening and Classification";*
- *IDB Environmental and Safety Compliance Policy Directive B5 "Environmental Assessment Requirements";*
- *IDB Environmental and Safety Compliance Policy Directive B6 "Consultations";*
- *IDB Environmental and Safety Compliance Policy Directive B7 "Supervision and Compliance"*
- *IDB Environmental and Safety Compliance Policy Directive B9 "Natural Habitats and Cultural Sites";*
- *IDB Environmental and Safety Compliance Policy Directive B10 "Hazardous materials";*
- *IDB Environmental and Safety Compliance Policy Directive B11 "Pollution Prevention and Abatement";*
- *Public Information and Disclosure Policy (OP-102);*
- *Disaster Risk Management Policy (OP-*704);
- *Gender Equality in Development Policy (OP-*761);
- *Indigenous Peoples Policy (OP-*765),
- *Resettlement Policy (OP-*710).

IDB Environmental and Safety Compliance Policy Directive B1 "Bank Policies
According to this Policy the Bank will only finance operations and activities that comply with the directives of the Environmental and Safety Policy. Therefore the provisions of the Master Plan and the related environmental assessment shall follow the Directives listed above and hereinafter discussed.

IDB Environmental and Safety Compliance Policy Directive B2 "Country Laws and Regulation
According to this Policy the Bank will require the borrower for the operations to ensure that they are designed and carried out in compliance with environmental laws and regulations of the country where the operations are being implemented.

The compliance of the Master Plan provisions with the Belizean laws and Regulation is discussed in the present section

IDB Environmental and Safety Compliance Policy Directive B3 "Screening and Classification".
According to this Policy Directive all the operations financed by the Bank have to be screened and classified according to their potential environmental impacts in the aim to select the appropriate environmental assessment.

Safeguard categorization is determined according to the following considerations:

- *Category A:* An operation will be classified as Category "A" when it is likely to cause significant negative environmental and associated social and cultural impacts whether direct, indirect, regional or cumulative. This concept applies also to the operation's associated facility. Negative impacts are considered significant when: (i) they extend over a large geographic area; (ii) they are permanent or occur for an extended period of time; and (iii) they are of high intensity and/or high magnitude. An absolute definition of significant impact is not possible, as the significance of an activity may vary with the setting. The determination of whether a project may have a significant impact on the environment requires professional knowledge and judgment. This should be based, to the extent feasible, on scientific data and local information. Generally, an environmental/social professional with training and/or experience in environmental assessment should make this determination;
- *Category B:* Operations that are likely to cause mostly local and short-term negative environmental and associated social and cultural impacts and for which effective mitigation measures are readily available will be classified as "B." The magnitude/intensity of Category B projects are moderate in terms of direct, indirect, regional and cumulative impacts and standard procedures, know-how, and skills for the design of the mitigation measures are readily available and implementable.
- *Category C:* Operations that are likely to cause minimal or no negative environmental and associated social and cultural impacts will be classified as Category C. For the most part, these are operations that do not involve works or result in physical modification of the environment. Operations that are clearly designed to produce positive environmental outcomes, unless they include physical works, are considered to be Category C operations.

The Scenario 1 provisions may be classified in the *Category B.*

IDB Environmental and Safety Compliance Policy Directive B5 "Environmental Assessment Requirements".
According to this Policy Directive the Preparation of Environmental Assessments (EA) and associated management plans and their implementation are the responsibility of the borrower. The Bank will require compliance with specified standards for Environmental Impact Assessments (EIAs), Strategic Environmental Assessments (SEAs), Environmental and Social Management Plan (ESMP), and environmental analyses, as defined in this Policy and detailed in the Guidelines.

Category B operations will normally require an environmental analysis, according to, and focusing on, the specific issues identified in the screening process. This analysis will be complemented by a set of provisions to avoid, mitigate or compensate for specific environmental, social, health and safety impacts, which are reported in the ESMP. For those operations where potentially significant associated negative social or cultural impacts are identified, a Socio-cultural Analysis might be required to address such impacts.

The EA could include:

i. a description of the proposed investment plan;
ii. an evaluation of the legal and regulatory framework applicable to the investment plan;
iii. an assessment of the potential environmental and social impacts and risk of the proposed operations, works or activities;
iv. a proposed management plan, including mitigation and monitoring programs to address significant impacts and risks.

The *Environmental Audit* is included among the EA Processes foreseen by this Policy Directive. According to the definition the Environmental audit identifies past or present environmental and social impacts and risks associated with existing or past economic activities and prescribes the means to correct them, when necessary.
An environmental audit focuses on two elements:

i. compliance of existing facilities, activities and operations with the applicable environmental and associated social, and occupational health and safety in-country laws and regulations, and with Bank requirements; and
ii. the nature and extent of existing environmental impacts, including soil, water and groundwater, air and any facility contamination, as well as any relevant impact to the natural environment and resources and its consequences to affected communities as a result of past or existing activities.

An audit at Mile 24 Landfill is carried out in order to assess the adequacy of the infrastructure.

IDB Environmental and Safety Compliance Policy Directive B6 "Consultations"
According to this Policy Directive, as part of the environmental assessment process, Category "A" and "B" operations will require consultations with affected parties and consideration of their views.

Since the present master plan provisions have been classified in *Category B*, this Directive requires at least one consultation with affected parties, preferably when the impact assessment is being reviewed, in order to inform, gather comments, and adjust the assessment and the corresponding environmental and social management plan. Consultations should provide, at a minimum, information to affected parties and a dialogue regarding the project scope and proposed mitigation measures.

Two public consultations, one per each Corridor, have been made as reported in Section H.
IDB Environmental and Safety Compliance Policy Directive B7 “Supervision and Compliance”.
According to this Policy Directive the Bank will monitor the borrower’s compliance with all safeguard requirements stipulated in the loan agreement. The ESMP, included in the present EA, provides the safeguard, mitigation and monitoring measures for being incorporated in the loan agreement.

IDB Environmental and Safety Compliance Policy Directive B9 “Natural Habitats and Cultural Sites”.
According to this Policy Directive the Bank will not support operations that, in its opinion, significantly convert or degrade critical natural habitats or that damage critical cultural sites.

For the purposes of this Policy:
• *Critical natural habitats* are: (i) existing protected areas, areas officially proposed by governments for protection or sites that maintain conditions that are vital for the viability of the aforementioned areas; and (ii) unprotected areas of known high conservation value. Existing protected areas may include reserves that meet the criteria of the IUCN Protected Area Management Categories I through VI; World Heritage Sites, areas protected under the RAMSAR Convention on Wetlands; core areas of World Biosphere Reserves; areas in the UN List of National Parks and Protected Areas.
Areas of known high conservation value are sites that, in the Bank’s opinion, may be:
(i) highly suitable for biodiversity conservation;
(ii) crucial for critically endangered, endangered, vulnerable or near threatened species listed as such in the IUCN Red List of Endangered Species; and (iii) critical for the viability of migratory routes of migratory species

• *Cultural sites* are any natural or manmade areas, structures, natural features and/or objects valued by a people or associated people to be of spiritual, historical, and or archaeological significance. Material remains may be prominent, but will often be minimal or absent.
• *Critical cultural sites* include but are not restricted to those protected (or officially proposed by governments for protection) such as World Heritage Sites and National Monuments, and areas initially recognized as protected by traditional local communities (e.g., sacred groves).
• *Damage,* in the context of a critical cultural site, means spoiling, compromising or impairing the condition or quality of a critical cultural site to the point that it will reduce its spiritual, historical or archaeological value.

The sites proposed for the facilities (TSs and DOCs) location:
i. are not included in Critical Natural Habitats as defined above;
ii. do not affect any Cultural Site (as above defined) already known.

Moreover, the ESMP provide a procedure in the aim to avoid any damage to any archaeological finds that may occur during the construction work.

IDB Environmental and Safety Compliance Policy Directive B10 “Hazardous materials”

According to this Policy Bank-financed operations should avoid adverse impacts to the environment and human health and safety occurring from the production, procurement, use, and disposal of hazardous material, including organic and inorganic toxic substances, pesticides and persistent organic pollutants (POPs).

As per the Master Plan provisions, no hazardous materials will be used, as far as possible, in the construction of the facilities (TSs and DOCs) envisaged.
Moreover, the ESMP provides directives for processing the hazardous waste, potentially collected at the TSs and DOCs, avoiding any risk for the health of the workers and for the environment.

IDB Environmental and Safety Compliance Policy Directive B11 "Pollution Prevention and Abatement"
According to this Policy Directive the Bank-financed operations will include as appropriate, measures to prevent, reduce or eliminate pollution emanating from their activities.
The Bank will require clients to follow source-specific emission and discharge standards recognized by multilateral development banks. Taking into account local conditions and national legislation and regulations, the environmental assessment report or environmental and social management report will justify the standards selected for the particular operation.
In the present EA all the standards selected are justified as per Section 18.

Public Information and Disclosure Policy (OP-102)
The information and the outcomes of the evaluations conducted in the present EA, meet the IDB's needs of divulging to third parties of the activities financed by the Bank. In particular all the social and environmental effects and related mitigation measures will be made known by means of publishing the present EA.

Disaster Risk Management Policy (OP-704)
According to the objectives of this Policy, the present EA assesses the effectiveness of the Plan provisions in terms of:

i. mitigation of the risks emanating from natural disasters, and;
ii. disaster preparedness

In the aim to reduce the risks emanating from natural disasters as hurricanes, floods and fires in the screening of the sites for the location of the facilities (DOCs and TSs) priority is given to the areas with a low susceptibility to these risks.

17.1 Social related applicable IDB Policy

In the event a loan agreement would be signed by the Government of Belize (GOB) and IDB, the IDB policy OP-710, on Involuntary Resettlement would apply to the Project financed by the loan. OP-710, on Involuntary Resettlement (1998), applies to all situations in which people are physically displaced or lose their source of livelihood (fisheries, agricultural land, employment, business outlets, etc.) as a result of land acquisition. The policy applies, for example, in situations in which people lose agricultural land or small businesses, whether or not their housing is not affected. The basic considerations of the Policy also apply where people are temporarily displaced.

The key principles of the Policy are:

- Avoid or minimize the need for resettlement. This requires that serious consideration be given to alternatives, such as the relocation of a dam axle or lower reservoir levels in the case of hydropower projects, or a narrower right-of-way and/or re-routing through less populated areas in the case of highway projects. This principle should, however, balance considerations of safety for people living in the vicinity of the project.
- Ensure that the affected population can achieve an equivalent or improved standard of living within a reasonable time. The affected population should be given access to land, natural resources, housing and infrastructure of a level at least equivalent to that which they previously enjoyed, allowing them to recover or improve their income levels within a reasonable period. They should be provided with an acceptable level of services, including potable water, drainage, sanitation and community infrastructure, regardless of their previous conditions.
- Fully compensate all transitional losses. These include all legal costs, transport costs and loss of income resulting from displacement.
- Minimize the disruption of social networks and economic opportunities. As far as possible the affected population should be encouraged to maintain their social networks. This can be achieved through close consultation, by resettling the affected population as a PRI Environmental and Social Guidance December 2001 1 Private Sector Department Inter-American Development Bank group, as near as possible to their original location, and by timing the move to coincide with the most appropriate times in the school year and/or agricultural cycle.
- The project should provide opportunities for development. Wherever possible, the affected population should be the first to benefit from the opportunities provided by the project. This can be achieved by giving them preference in employment, and if necessary training, and by offering opportunities for self-employment. Examples would include service contracts for local labour, or the provision of parking and basic facilities for roadside vendors affected by highway projects.
- Vulnerable Groups. It is particularly important to ensure that vulnerable groups are adequately protected. They include poor ethnic minorities, such as indigenous peoples, landless rural poor, and small farmers or squatters who lack full legal title to the land they use or occupy. The Bank will only support resettlement of traditional land-based indigenous peoples if it can be shown that resettlement will result in direct benefits to them. This requires that their customary rights must be recognized and fully compensated, they must be offered a suitable land-for-land option, and they must give their informed consent to the resettlement proposals. Special attention should be given to those sectors of the population that are at risk of impoverishment or that may have special difficulty adjusting to the disruption caused by displacement. They include the elderly, the physically handicapped and female heads of household. In addition, the compensation and rehabilitation measures should ensure that the rights of partners living in common-law unions and their children are protected if the couple separate or if one of the partners dies.

Key requirements of the Policy include:

Preparation of a Plan. When displacement is unavoidable, a Resettlement Plan must be prepared to ensure that the affected people receive fair and adequate compensation and rehabilitation.

Dimension. When the number of people to be resettled is very small, the affected group is not vulnerable, or the institutional setting and the marketplace offer reasonable opportunities for the replacement of assets or income, and intangible factors are not significant, a resettlement plan as such may not need to be prepared, and relocation addressed instead prior to the project through mutually agreed contractual covenants.

Compensation. Appropriate compensation and rehabilitation options must provide a fair replacement value for assets lost, and the necessary means to restore subsistence and income, to reconstruct social networks and compensate for transitional hardships.

Livelihoods. OP-710 may be (and is, in the context of current global good practice) broadly interpreted to cover both physical and economic displacement, including impacts on income and means of livelihood. Specifically, livelihoods should be restored to the pre-resettlement standard.

Consultation. Preparation of a resettlement plan should include consultations, carried out in a timely and socio-culturally appropriate manner, with a representative cross-section of the displaced and host communities, to begin in the design phase and continue throughout the execution and monitoring of the plan.

Indigenous Communities. Indigenous communities may only be affected where: (1) resettlement will result in direct benefits to the affected community relative to their prior situation; (2) customary rights are fully recognized and fairly compensated; (3) compensation options include land-based resettlement; and (4) affected persons have given their informed consent to the resettlement and compensation measures.

Vulnerability. Care should be taken to identify the most vulnerable subgroups and ensure that their interests are adequately represented in this process.

Monitoring and Evaluation. The resettlement component must be covered in the progress reports on the overall project. Monitoring and evaluation requirements and their timing must be specified in the resettlement plan and loan agreement.

Adherence to highest standard. Many solid waste projects are designated Environmental Assessment (EA) category "A", which implies the highest environmental and/or social impacts, and thus requires the undertaking of a Social Assessment of any relevant livelihoods activities and adherence to the highest possible standards of impact management and mitigation under the Policy.

In cases in which Belizean law and practice differ from IDB policy, special Project-specific arrangements have been developed under this plan to ensure compliance with the higher standard. IDB Specialists will provide technical assistance and monitoring as necessary to ensure that the project fully complies with the requirements of both Belizean Law and IDB policy.

17.2 Gap Analysis

Nothing in Belizean Law contradicts the requirements of the IDB Policy; the latter merely specifies in greater detail points on which national Law is either mute or implicitly aligned with the Bank OP.

With specific regard to the Environmental Impact Assessment (EIA) requirements, the Belize Environmental Protection Act (EPA), Chapter 328, Revised Edition (2003), showing the Subsidiary Laws as of 31 October, 2003, states in Schedule I (Regulation 7) that a full Environmental Impact Assessment (EIA) shall be completed for any project, program or activity that includes an "installation designed solely for the permanent storage or final disposal of any waste*."* In "Screening of Undertakings" (18:1), the Act states that:

> During the course of an environmental impact assessment, the developer shall provide an opportunity for meetings between the developer and interested members of the public, especially within or immediately adjacent to the geographical area of the proposed undertaking, in order … to provide information concerning the proposed undertaking to the *people whose environment may be affected by the undertaking…*

In accordance with the DOE, however, it is understood that this last condition applies only to the construction of new sanitary landfills and not to the closing of open dump sites or the construction of transfer stations.

17.3 Proposed Gap filling Measures

Project activities include construction of several transfer stations to receive collected solid waste that is currently disposed of at the dumpsites where informal recyclers recover recyclable materials for sale to intermediaries. The redirection of this waste to new locations will result in a significant if not total reduction in the amount of recyclable materials arriving at current dumpsites, and thus a serious impact on the income generating activities of those recovering those materials. Under OP-710, this qualifies as *´loss of access to means of production´.* Furthermore, with the remediation of open dumps after the transfer stations have become operational, not only will new materials stop arriving at the dumpsites, but access to the materials already there will be limited, resulting in still further losses in access to the means of production.

Remediation of open dumpsites may further result in the removal of dwellings of persons currently living on those sites and reallocation of those persons to similar or improved conditions with access to similar or improved income-generating opportunities.

Table 22: Comparison of Belizean Law and IDB Policy

Issue	Belizean Law	IDB Policy (OP-710)	Recommended Measures
Economic Displacement (loss of access to income and means of livelihood)	Belizean Law has no provision for compensating lost income	Impoverishment Risk Analysis: When the baseline information indicates that a significant number of the persons to be resettled belong to marginal or low-income groups, special consideration will be given to the risks of impoverishment to which they may be exposed as a result of resettlement, which includes: - loss of access to means of production - loss of employment	Provide income generating opportunities: i. Same type of activity which would not require additional training ii. Similar type of activity which would require additional training and capacity building iii. Other type of activity with same level of labor skills
Physical Displacement	There is no specific reference in Belizean Law to 'involuntary resettlement', even with regard to land or physical property. There is no requirement to prepare a formal Resettlement Plan nor to undertake any of the component activities of a Plan, such as a census, socio-economic survey, monitoring or reporting.	When the number of people to be resettled is very small, a resettlement plan as such may not need to be prepared. In such cases it may be possible to address relocation prior to project advancement through mutually agreed contractual covenants	Prepare relocation plan in consultation with affected persons in accordance with mutually agreed contractual covenants

Timeliness. A preliminary resettlement plan must be prepared as part of the Environmental Assessment (EA). It must undergo a process of meaningful consultation with the affected population, and must be available as part of the EA, prior to the Analysis Mission. It must include sufficient information to be evaluated along with other project components. At a minimum, it must include:

- evidence that appropriate measures have been taken to prevent new settlements in the area subject to resettlement;
- a tentative cut-off date for compensation eligibility;
- an estimate of the number of people to be resettled based on sufficiently reliable data;
- a definition of the various options to be made available under the compensation and rehabilitation package;
- an estimate of the number of people who will be eligible for each option;
- a preliminary budget and schedule of execution;
- a diagnosis of the viability of the regulatory and institutional framework, identifying issues to be resolved; and

- evidence of consultation with the affected populations. The plan will be summarized in the Environmental and Social Impact Report (ESIR).

18 OTHER REGULATIONS

According to the advice provided by *IDB Environmental and Safety Compliance Policy Directive B11*, in the cases in which the national laws do not provide specific standards for emissions in air or discharge in surface water, the reference is made to other regulations.

In the following the regulations adopted are listed:

- *"Environmental, Health and Safety Guidelines for Waste Management Facilities (International Finance Corporation – World Bank Group);*
- *Guidance on the assessment of odour for planning* - Institute of Air Quality Management (UK). (2014)

Environmental, Health and Safety Guidelines for Waste Management Facilities (International Finance Corporation – World Bank Group).

The Environmental, Health and Safety (EHS) Guidelines are technical reference documents with industry-specific (Waste management) examples of Good International Industry Practice. The EHS Guidelines contain the performance levels and measures that are generally considered to be achievable in new facilities by existing technology at reasonable costs.
The reference is made to the discharge standards foreseen for the effluent of the leachate treatment (Table 4 of the document), in particular for the parameter Ammonia.
As requested by the mentioned IDB Policy Directive B11, this standard is recognised by a multilateral development bank, namely the World Bank.

Guidance on the assessment of odour for planning - Institute of Air Quality Management (UK) (2014).
In the assessment of the impacts due to the odour diffusion from the landfills reference is made to this guidance, because is aimed specifically for assessing odour impacts for planning purposes.
The planning system has the task of guiding development to the most appropriate locations: ideally, significant sources of odour should be separated from odour-sensitive users of the surrounding land (sensitive receptors); failing this, it may be possible to employ control and mitigation measures to make a proposed development acceptable from a land-use perspective.
New proposals for landfill construction may require an odour impact assessment as part of the Environmental Assessment, to evaluate if the odour diffusion may cause significant impacts on the amenities at the receptors around the sites proposed for the facilities location.

This guidance proposes to assess this impact on the basis of the receptor sensitivity (see Figure 8) and the odour exposure level C_{98} (98^{th} percentile of hourly average) as shown in Figure 9.

Figure 8 – receptor sensitivity - *Guidance on the assessment of odour for planning* - Institute of Air Quality Management (UK) (2014)

For the sensitivity of people to odour, the IAQM recommends that the Air Quality Practitioner uses professional judgement to identify where on the spectrum between high and low sensitivity a receptor lies, taking into account the following general principles:

High sensitivity receptor	Surrounding land where: • users can reasonably expect enjoyment of a high level of amenity; and • people would reasonably be expected to be present here continuously, or at least regularly for extended periods, as part of the normal pattern of use of the land. Examples may include residential dwellings, hospitals, schools/education and tourist/cultural.
Medium sensitivity receptor	Surrounding land where: • users would expect to enjoy a reasonable level of amenity, but wouldn't reasonably expect to enjoy the same level of amenity as in their home; or • people wouldn't reasonably be expected to be present here continuously or regularly for extended periods as part of the normal pattern of use of the land. Examples may include places of work, commercial/retail premises and playing/recreation fields.
Low sensitivity receptor	Surrounding land where: • the enjoyment of amenity would not reasonably be expected; or • there is transient exposure, where the people would reasonably be expected to be present only for limited periods of time as part of the normal pattern of use of the land. Examples may include industrial use, farms, footpaths and roads.

Figure 9 – Odour impact assessment - *Guidance on the assessment of odour for planning* - Institute of Air Quality Management (UK) (2014)

Odour Exposure Level C_{98}, ou_E/m^3	Receptor Sensitivity		
	Low	Medium	High
≥10	Moderate	Substantial	Substantial
5-<10	Moderate	Moderate	Substantial
3-<5	Slight	Moderate	Moderate
1.5-<3	Negligible	Slight	Moderate
0.5-<1.5	Negligible	Negligible	Slight
<0.5	Negligible	Negligible	Negligible

When compiling this Table, it has been assumed, on a conservative basis that the odour in question is at the offensive end of the spectrum. For odours that are less unpleasant, the level of odour exposure required to elicit the same effect may be somewhat higher, requiring professional judgement to be applied . It also should be noted that the Table applies equally to cases where there are increases and decreases in odour exposure as a result of this development , in which case the appropriate terms "adverse" or "beneficial"should be added to the descriptors.

D. ENVIROMENTAL AND SOCIAL CONDITIONS

19 TRANSFER STATIONS

A preliminary evaluation of the selected sites for the Transfer Stations has been carried out based on the available information to select the most suitable ones among those so far identified. The following Sections describe this site selection activity and the adopted criteria.
The evaluation is based on the following rating:

Table 23 - rating

Rating	Description
1	Non suitable: the aspect is not suitable for the proposed facility.
2	Difficult: the aspect is not suitable but substantial mitigation measures can be adopted to reduce the impact or substantial additional infrastructures are needed.
3	Adaptable: the aspect is not completely suitable but mitigation measures can be adopted to avoid the impact and/or commonly required additional infrastructures are needed.
4	Adequate: the aspect is favourable but minor mitigation measures and/or minor additional infrastructures are needed.
5	Suitable: the aspect is such that possible impacts are very unlikely or extremely low and temporary, no additional infrastructures or mitigation measures are necessary.

The evaluation has been mainly based on the following characteristics as per the available information, including the information gathered from the official sources used in the landfill site screening (see section 31), and site visit:

- Physical: topography, hydrography
- Technical: infrastructures, position with respect to waste generation areas
- Geological, hydrogeological and geotechnical
- Proximity to human settlements, use of soil

19.1 Northern Corridor

19.1.1 Corozal area

The initial search for a suitable location for a Transfer Station in the Corozal area didn't provide fruitful results. The attention was in fact initially concentrated on the area that, under an operational and logistical point of view, appeared to be as the most desirable. According to such criteria the optimal location for the transfer station should be:

- South to Corozal: to shorten the distance from the majority of the major waste generation centres of the area and, at the same time, from a landfill located in the south (either Mile 24 or a regional landfill alternative to Consejo)

- At a distance not greater than 8÷9 km from Corozal Town not to stress the municipal collection system
- Adjacent to a major road
- Preferably already in the property of the Government, the Town Council or other public agency

This criteria proved to be very difficult to be matched and the research so far hasn’t been successful. More recently Corozal Town Council suggested the area of the existent slaughterhouse as a possible location for the Transfer Station. The area is located along the Cahn Chen Road 3 km north to Corozal Town and 3 km south to the Northern Highway. In the first instance the area appears to be suitable and available. Additional data are being gathered on the site.

19.1.2 Orange Walk area

#	Criteria	Description (mitigation measures and additional infrastructures)	Rating
1	Topography	The site offers both a plain and wide area for the establishment of the main facilities and a lower area at the back ideal for the phytoremediation pond and the stormwater drainage.	5
2	Geology	The foundation soil is firm and no special foundations appear to be necessary in the first instance. The geological unit is Late Tertiary.	5
3	Land Use (site)	The area corresponds to the present formal dumpsite used by the Orange Walk Town Council. The location of the Transfer Station in such area can be synergic with the remediation of the dumpsite and its post-closure control and maintenance program.	5
4	Land Use (adjacent)	The areas in the immediate surrounding are to a large extent covered by sugar cane fields, a significant area at the south is covered by natural vegetation. The ecosystem that occurs in the site is Lowland broad-leaved dry forest	5
5	Potential risks	No risk of flooding is reasonably foreseeable, the site belongs to the “No susceptibility/non forested” class. The site is “High risk” fire risk class. The interference with the traffic related to the nearby Sugar Mill has to be considered	4
6	Distance from settlements	The site is located 5 km south to Orange Walk and 4 km east to the Northern Highway. The position of the site appears particularly favourable with respect to the location of the major villages of the District position.	5
7	Distance from roads	The site is adjacent to a secondary road, adequate for heavy traffic, and only 4 km distant from the Northern Highway.	5
8	Infrastructure	No water supply is present, groundwater wells shall be	3

		drilled on purpose. The closest power line is located 4 km West along the Northern Highway.	
9	Property and Surface	The site is owned by ASR-BSI. The Company representatives have expressed their availability to handover the site to the Government for the purposes of the Plan. The overall surface of the parcel is sufficient to host all the foreseen facilities also considering the remediation of the dumpsite.	4
10	Position within the SW basin	The site is in a favourable location with regard to the minimization of the transport distances from the collection centres. The location is also favourable in case of a landfill located along the San Estevan Road and with respect to the possible transfer of the waste to Mile 24 Landfill. The less favourable position with respect to a possible location of a landfill in the north is almost entirely compensated by the closest position to the District waste generation centroid.	5
11	Other information	-	

Given the extremely favourable and unique (synergies with the dumpsite remediation) conditions of the site no further researches have been made at this stage for alternative sites in the area.

19.2 Southern Corridor

19.2.1 Dangriga area

#	Criteria	Description (mitigation measures and additional infrastructures)	Rating
1	Topography	The site offers a both plain and wide area for the establishment of the main facilities.	5
2	Geology	The foundation soil is firm and no special foundations appear to be necessary in the first instance. The geological unit is Quaternary.	5
3	Land Use (site)	The area is adjacent to the present Dangriga dumpsite. It is almost free of vegetation and some minor excavation activity is evident.	5
4	Land Use (adjacent)	The area is adjacent to the present dumpsite to be remediated. Fairly disturbed pine forest with bushes in the immediate surroundings. Orange plantation in front of the area (other side of the highway). The ecosystem that occurs in the site is Lowland broad-leaved dry forest	5
5	Potential risks	No risk of flooding is reasonably foreseeable, the site belongs to the “No susceptibility/non forested” class. The site is “Moderate risk” fire risk class. No other	5

		specific risks connected to the location.	
6	Distance from settlements	The site is located some 8 km driving distance west to Dangriga. The closest urban settlement is the village of Sarawina, 3 km eastwards.	5
7	Distance from roads	The site is adjacent to the Southern Highway.	5
8	Infrastructure	No water supply is present, groundwater wells shall be drilled on purpose. The closest power line is located along the adjacent highway.	4
9	Property and Surface	The site, about 16 hectares on the whole is owned by the Dangriga Town Council.	5
10	Position within the SW basin	The site is in a favourable location with regard to the driving distances from Dangriga and the main villages in the area both north and south to the site (only 11 km from the Hopkins road junction).	5
11	Other information	-	

19.2.2 Independence area

#	Criteria	Description (mitigation measures and additional infrastructures)	Rating
1	Topography	The site offers a both plain and wide area for the establishment of the main facilities.	5
2	Geology	The foundation soil is firm and no special foundations appear to be necessary in the first instance. The geological unit is Quaternary.	5
3	Land Use (site)	The area corresponds to the present Independence dumpsite. The areas surrounding the waste pits are still vegetated (highly degraded pine forest).	5
4	Land Use (adjacent)	Degraded pine forest. The area is part of the Mango Creek 4 Forest Reserve. The ecosystem that occurs in the site is Lowland broad-leaved dry forest.	4
5	Potential risks	No risk of flooding is reasonably foreseeable. The risk of fire is higher due to the vulnerability of the pine forest, the site belongs to the “No susceptibility/non forested” class. The site is “High risk” fire risk class.	4
6	Distance from settlements	The site is located about 7 km driving distance form Independence (at west) and from Bella Vista (East), the two major and most populated centres of the area. At the opposite no settlements are located in the immediate vicinity of the site.	5
7	Distance from	The site is adjacent to the Southern Highway.	5

	roads		
8	Infrastructure	No water supply is present, groundwater wells shall be drilled on purpose. The closest power line is located along the adjacent highway.	4
9	Property and Surface	The site was part of the Mango Creek 4 Forest Reserve now de-reserved. Crown Land.	3
10	Position within the SW basin	The site is in a favourable location with regard to the driving distances from major centres of the area.	5
11	Other information	It has been reported by the Forest Department that the Mango Creek 4 Forest Reserve, inside of which the site was located, no longer exists, thus the area has been de-reserved.	

19.2.3 Placencia area

A simplified transfer facility is foreseen to serve the Placencia Peninsula. The ideal location of such facility would be along the peninsula in the Seine Bight area to be the closest as possible to the waste collection centroid in the peninsula.
Due to the intense use of soil for residential and touristic uses and the consequent high costs of the land no sites have been identified so far. Further investigations are ongoing on the matter.
Alternatively the present location of the dumpsite can be used.

19.2.4 Punta Gorda area

Three different sites have been visited in the Punta Gorda area as possible location for the preliminary assessment of the Transfer Station siting:

i. A parcel of land along the San Felipe Road owned by the SWaMA
ii. A private lot along the Southern Highway 1 km west to Eldridgeville
iii. A parcel in proximity of the Machaca Forest Station owned by the Punta Gorda Town Council

The latter site has been investigated since it was earlier proposed by the Punta Gorda Town Council as a possible location for the new dumpsite. It is nevertheless not here included since the site is adjacent to a touristic resort and served by the same access road.

San Felipe Road site

#	Criteria	Description (mitigation measures and additional infrastructures)	Rating
1	Topography	The site offers a both plain and wide area for the establishment of the main facilities.	5
2	Geology	The foundation soil is firm and no special foundations appear to be necessary in the first instance. The geological unit is Undif Cretaceous.	5
3	Land Use	The area is covered by broadleaf forest. The ecosystem	3

	(site)	that occurs in the site is Lowland broad-leaved wet forest.	
4	Land Use (adjacent)	Mainly broadleaf forest except for the northern boundary where a timber yard is located.	5
5	Potential risks	No risk of flooding is reasonably foreseeable, the site belongs to the “No susceptibility/ forested” class. The site is “Medium risk” fire risk class.	5
6	Distance from settlements	The site is located about 16 km driving distance form Punta Gorda. San Felipe village is located 1.7 km west to the site.	5
7	Distance from roads	The site is 2.6 km distant from the Southern Highway along the Barranco Road. The last 600 m road segment has to be improved.	4
8	Infrastructure	No water supply is present, groundwater wells shall be drilled on purpose. The closest power line is located 700 m far along the Barranco Road.	4
9	Property and Surface	The site is already property of the SWaMA. The area is about 16 hectares. The area is such that, in future, it can host further facilities such as the composting.	5
10	Position within the SW basin	The site is 16 km driving distance far from Punta Gorda.	4
11	Other information	The site was previously proposed as a possible location for the new dumpsite but, as such, strongly opposed from the local population. Opposition can also be expected in the case of the proposed Transfer Station.	

20 DUMPSITES

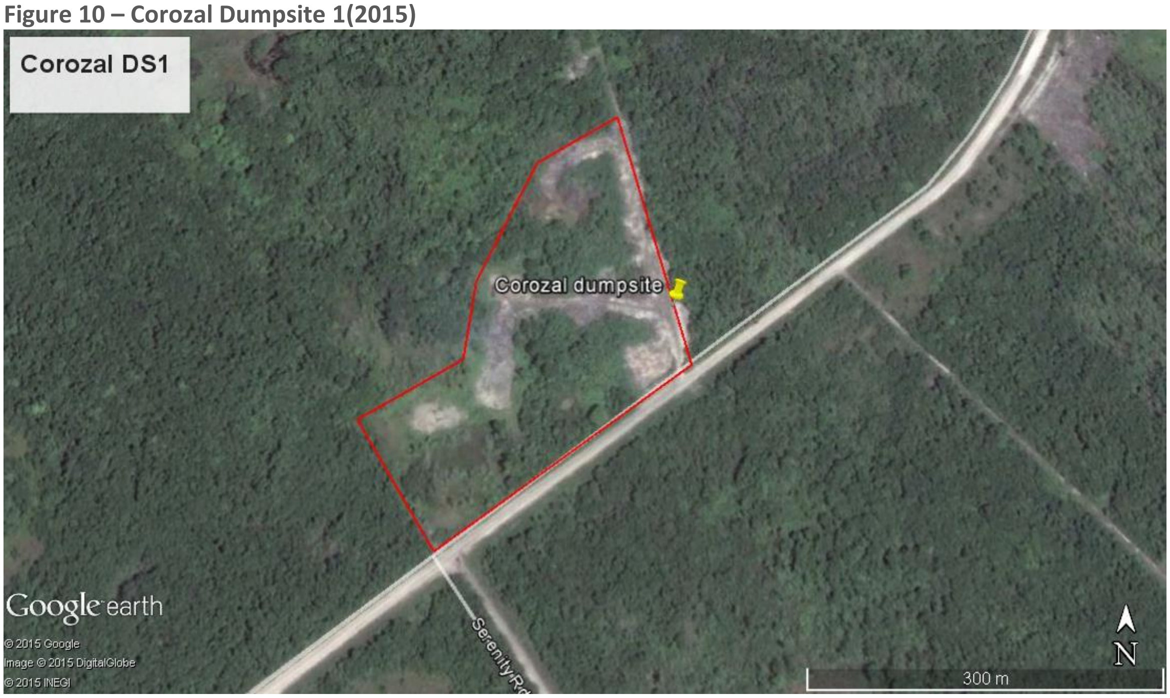
The current disposal system is very homogeneous all over the two Corridors with only minor and non-substantial differences.
The waste is disposed of either directly on the ground (Corozal, Free Zone, Orange Walk, Punta Gorda) or in trenches 3-4 meters deep excavated for disposal purposes (Dangriga, Placencia, Independence).
In all the cases the waste is burned to reduce the volume and the nuisance due to the putrefaction of organic materials. Care is only taken, in some cases, in putting the waste on fire when the prevalent wind is not in direction of inhabited areas.
Dumpsites are located at a relatively short distance from the served centres. This allows the collection trucks to reduce the time for the transport and maximize the time given to the collection.
Pests are common and numerous at each dumpsite.

20.1 Corozal dumpsite

In the Corozal area, three active dumpsites have been identified. The main one is identified here as Corozal Dump 1 and it is used by the Corozal Town Council during most part of the year (dry season) since early ’90. Also waste from Consejo and other nearby settlements is delivered to the dumpsite by private individuals.

The total area of the site as per the figure below is approximately 6 ha and the waste covers about one fourth of it (15,000 m^2). The total quantity of waste is estimated to be in the range of 10,000 to 15,000 cubic meters.
There are two distinct open (no gate) accesses to the site, a watchman is on site 5 days a week. The site is about 5 km from the Corozal Town NE limit along the Consejo Road. No gate fee is paid.

Figure 10 – Corozal Dumpsite 1(2015)



At each dumpsite the waste is simply deposited on the ground, no trenches are excavated.

The environmental information gathered of the site are summarized in Table 24.

Table 24 – Corozal dumpsite characteristics

Location UTM coordinates GPS coordinates	 16 357779.86 2039134.19 8 (elevation, m) 18°26'8.33" N 88°20'50.88" W
Topography	The site is characterized by a plain area and no surface water bodies are present. Approximately, the overall extension of the area (Figure 10) is 6 ha.
Geology	Late Tertiary - The geology of the entire Northern Corridor is

	mainly of carbonate nature and highly permeable. The site is not an exception.
Land Use/Ecosystem	Lowland broad-leaved dry forest – The forest within the site and in the immediate surrounding area is highly disturbed.
Natural Hazards	Fire: High risk, Flood susceptibility: No susceptibility/non forested
Natural Reserves or Parks	The area is not part of a protected area and it does not border protected areas or natural parks
Human settlements	The main human settlement neighbouring the dumpsite is Consejo and is far from the site about 3.5 km.
Archaeological, cultural and historical resources	None known
Property	Private property

20.2 Orange Walk dumpsite

The Orange Walk dumpsite is some 5.2 km from the southern limit of Orange Walk Town along main roads and 2.5 km straight line from the nearest inhabited area (Chan Pine Ridge Village).

The total area of the site, as per the Figure 11 below, is 7.2 ha, of which 2 ha are apparently covered by waste which volume can be estimated in the range from 12,000 to 15,000 cubic meters.

The site is owned by the ASR-BSI Group (Belize Sugar Industries Limited) that expressed interest in the remediation and/or conversion of the site for the purposes of the SWMP II.

The dumpsite is not controlled and the access is open. No gate fee is applied.

Access road to Orange Walk dumpsite

Orange Walk dumpsite

Figure 11 – Orange Walk Dumpsite (2015)

The information gathered from the official sources described in the previous sections are summarized in Table 25.

Table 25 – Orange Walk dumpsite characteristics

Location UTM coordinates GPS coordinates	 16 330261.61 1996790.35 28 (elevation, m) 18° 3'3.84" N 88°36'15.99" W
Topography	The site is characterized by a wide plain area and a smaller lower area. No surface water bodies are present. Approximately, the overall extension of the area (Figure 14) is 7.2 ha.
Geology	Late Tertiary - The geology of the entire Northern Corridor is mainly of carbonate nature and highly permeable. The site is not an exception.
Land Use/Ecosystem	Lowland broad-leaved dry forest – The areas surrounding the dumpsite are mostly used for the cultivation of sugar cane
Natural Hazards	Fire: High risk, Flood susceptibility: No susceptibility/non forested
Natural Reserves or Parks	The area is not part of a protected area and it does not border protected areas or natural parks
Human settlements	The site is approximately 2.7 km on a straight line from Chan Pine Ridge, that is the closest main human settlement
Archaeological, cultural and historical resources	None
Property	Private property, ASR-BSI Company

20.3 **Dangriga dumpsite**

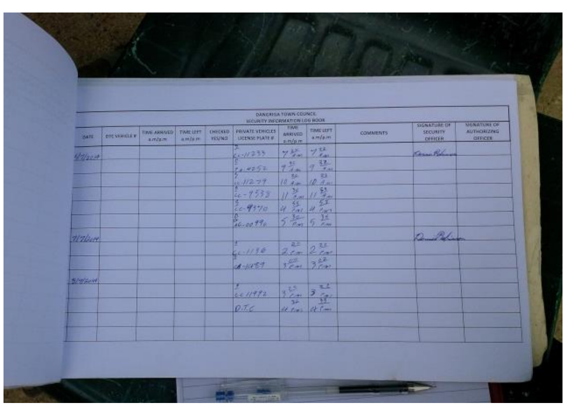
The dumpsite of Dangriga is located along the Southern Highway, 1.15 km south of the junction with the Hummingbird Highway, 7.6 km from the western limit of Dangriga.

The total area as per the figure below is 2.5 ha entirely covered by waste. The waste has been deposited in excavated trenches around 2-3 m deep, the total waste deposited can be estimated in the range from 12,000 to 15,000 cubic meters.

Figure 12 – Dangriga Dumpsite

The access to the dumpsite is controlled by a gate and a watchman is attending the site. The site has a site register but unfortunately it appears not to be well kept (only few loads per day are actually recorded and often not even those from the Town Council).

The site is immediately adjacent to a creek but not prone to flooding. The nearest inhabited settlement is Sarawina, 2.44 km West of the site. The site is Crown Land.



Security log book Dangriga dumpsite

Excavated trench at Dangriga dumpsite

The information gathered from the official sources described in the previous sections are summarized in Table 26.

Table 26 – Dangriga dumpsite characteristics

Location UTM coordinates GPS coordinates	 16 361562.29 1877182.33 20 (elevation, m) 16°58'20.93" N 88°18'3.85"W
Topography	The site is characterized by a plain area and no surface water bodies are present. Approximately, the overall extension of the area (Figure 12) is 2.5 ha.
Geology	Quaternary - Alluvial clay and limestone
Land Use/Ecosystem	Lowland broad-leaved dry forest – Fairly disturbed pine forest with bushes in the immediate surroundings. Orange plantation in front of the area (other side of the highway)
Natural Hazards	Fire: Moderate risk, Flood susceptibility: No susceptibility/non forested, the site borders an high risk area
Natural Reserves or Parks	The area is not part of a protected area and it does not border protected areas or natural parks
Human settlements	The nearest human settlement is along the Hummingbird Highway at a distance of about 1,400 m from the dumpsite
Archaeological, cultural and historical resources	None
Property	Crown Land

20.4 Independence dumpsite

Independence dumpsite is located along the Southern Highway, 1.1 km south of the junction of the Southern Highway with the Independence Road and 6.4 km from the western limit of Independence Village.

The extension of the area used for the disposal of the waste is approximately 2.4 ha as per the figure below.

The access is controlled by a watchman and a barrier is in place at the entrance but no access fee is applied.

The waste is deposited according to the trench method in trenches about 3-4 meter deep. The total estimated waste deposited is between 8,000 and 10,000 cubic meters.

Figure 13 – Independence dumpsite

The information gathered from the official sources described in the previous sections are summarized in
Table 27.

Table 27 – Independence dumpsite characteristics

Location UTM coordinates GPS coordinates	 16 342156.41 1827630.65 28 (elevation, m) 16°31'24.50" N 88°28'47.38" W
Topography	The site is characterized by a plain area and no surface water bodies are present. Approximately, the overall extension of the area is 2.4 ha.
Geology	Quaternary - Alluvial clay and limestone
Land Use/Ecosystem	Lowland broad-leaved dry forest – Degraded pine forest in the immediate surroundings.
Natural Hazards	Fire: High risk, Flood susceptibility: No susceptibility/non forested, the site borders an high susceptibility area
Natural Reserves or Parks	According to the information gathered from the official maps used the area is part of the forest reserve Mango Creek 4, but it has been reported by the Forest Department that the Mango Creek 4 forest reserve no longer exist, thus this area has been already de-reserved.
Human settlements	The nearest human settlement is Bella Vista and is located about 4,000 m far from the dumpsite
Archaeological, cultural and historical resources	None

Property	Crown Land

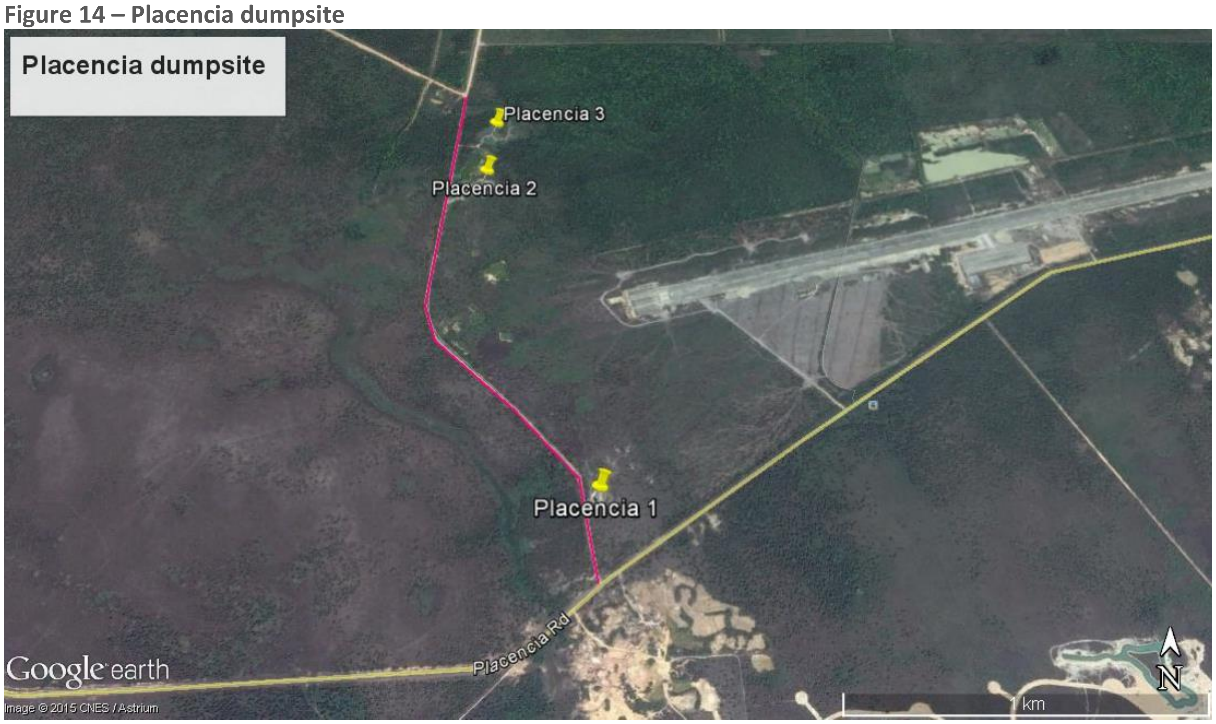
Waste trench – Independence Dumpsite

Informal Recyclers at Independence Dumpsite

20.5 Placencia dumpsite

Placencia dumpsite is the more complex among those examined so far. The site is actually composed of three different areas as per the figure below.

Figure 14 – Placencia dumpsite



The area identified in the figure as Placencia 2 is the main dumpsite, the waste is deposited in excavated trenches. All the trenches are partially filled with water with the exception of the newly excavated one. A major pond (0.5 ha surface) lies between the area 2 and the area 3.
Area 3 appears to be a secondary (less extensive) site were the waste is deposited directly onto the ground. Area 1 is a larger area where the waste is deposited in piles on the ground, piles and C&D (construction and demolition) waste (mainly tree trunks) represents the prevalent type of waste in this area.

Finally waste is also dumped all along the access road (2.1 km long) in almost continuous piles mainly by private sector (businesses and C&D).
The three areas lie between 550 m and 600 m from an adjacent major airport under construction.
The dumpsite is guarded by a watchman employed by the Placencia Sanitation Company.

Waste trench – Placencia Dumpsite (area 2). The adjacent trenches are full of trapped water, waste is floating on the surface

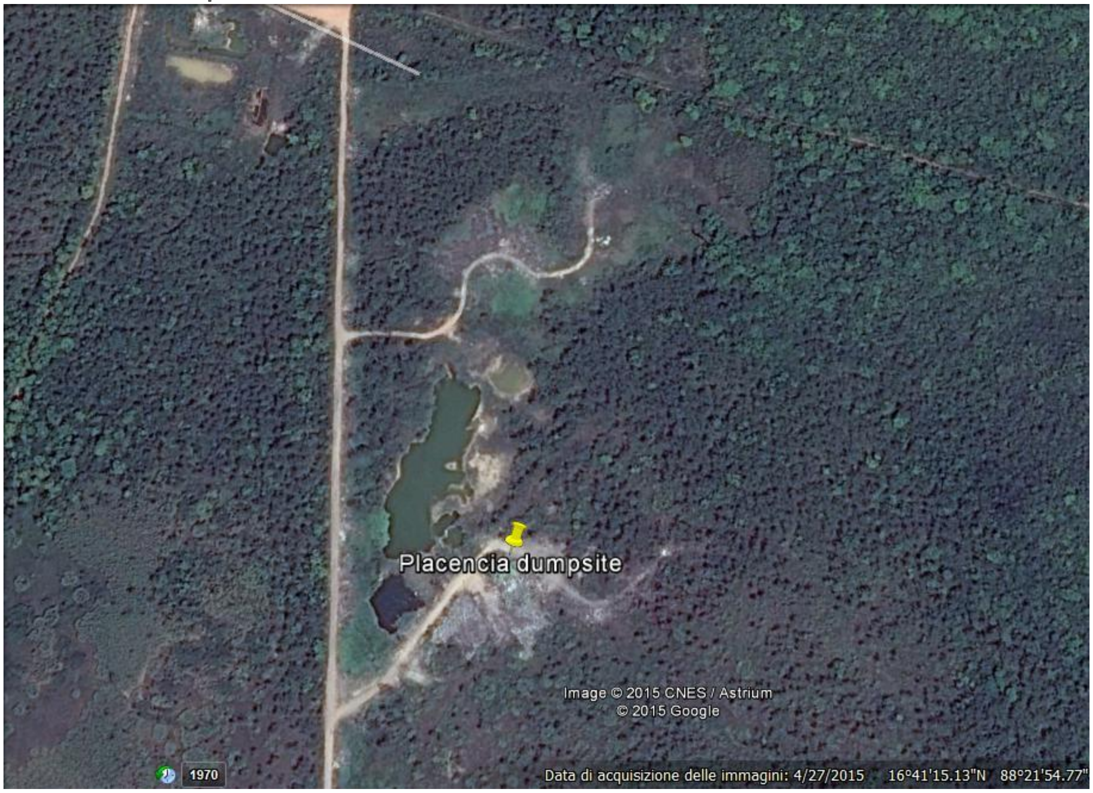
Waste piles along the Placencia dumpsite access road

The remediation design foresees to accumulate all the waste in an area that includes Placencia 2 and Placencia 3, which the following information is referred to (Table 28).

Table 28 – Placencia dumpsite characteristics

Location UTM coordinates GPS coordinates	 16 354389.3 1845601.1 17 (elevation, m) 16°41'11.94" N 88°21'58.96" W
Topography	The site is characterized by a plain area and A creek, which discharges into the Placencia Lagoon, is almost parallel to the access road, 200 m west of it. There are some ponds due to the excavations made for the waste disposing of. Approximately, the overall extension of the area is 40 ha.
Geology	Quaternary - Alluvial clay and limestone
Land Use/Ecosystem	Lowland savannah – Pine Savannah with dominant species Pinus Caribbae.
Natural Hazards	Fire: High risk, Flood susceptibility: Low susceptibility, the site borders a moderate susceptibility area
Natural Reserves or Parks	The area is not part of a protected area and it does not border protected areas or natural parks
Human settlements	There are no human settlements within a distance of 5,000 m from the dumpsite
Archaeological, cultural and historical resources	None
Property	Private property

Figure 15 – Placencia dumpsite



20.6 Punta Gorda dumpsite

The Punta Gorda dumpsite is located north of the Town, 7 km from its northern limit along the main roads and 1.7 km from the nearest inhabited area. 2.5 km is the distance from the Southern Highway.

The site is some 2 ha wide as per the figure below and it lies inside of a low lying area with no water drainage.

An approximate amount of 12,000 m^3 of waste is deposited in the visible part of the dumpsite while a further amount of 4,000 m^3 is estimated to have been dumped along the access road (last kilometre).

Due to the local topography it is likely that the total volume of the waste is actually considerably higher, this aspect will be further investigated in the following phase of the study.

The dumpsite is not controlled and the access is open. A dozer is occasionally hired by the Town Council to free the road from the waste piles. Due to the wetter climate of the region, the burning of the waste is not as effective as in the other dumpsites and the presence of pests is particularly high.

Figure 16 – Punta Gorda dumpsite

The Punta Gorda dumpsite is 1 km from the Rio Grande River and 2 km from the sea.
The information gathered from the official sources described in the previous sections are summarized in Table 29.

Table 29 – Punta Gorda dumpsite characteristics

Location UTM coordinates GPS coordinates	 16 307793.05 1785652.84 13(elevation, m) 16° 8'29.99" N 88°47'53.65" W
Topography	The site is characterized by an area with a gentle slope toward the access road. The current topography of the site, probably, is due to the waste disposed of in the site. No surface water bodies are present in the site. Approximately, the overall extension of the area is 2 ha.
Geology	Undif Cretaceous
Land Use/Ecosystem	Lowland broad-leaved dry forest
Natural Hazards	Fire: High risk, Flood susceptibility: No susceptibility/Non forested and No susceptibility/forested, the site borders a high susceptibility area
Natural Reserves or Parks	The area is not part of a protected area and it does not border protected areas or natural parks
Human settlements	The main human settlement closest to the dumpsite is Toledo and it is about 2,000 m far from the dumpsite
Archaeological, cultural and historical resources	None
Property	Private property and, partially, unknown

Punta Gorda dumpsite

Waste along the Punta Gorda dumpsite access road

21 DROP OFF CENTRES (DOC)

The siting of DOCs is not part of the present Study. DOCs should be located adjacent or within the limits of each Village or between two or more close villages. The site selection process shall necessarily be implemented in conjunction with local Village Councils and taking into account the specific local conditions including access from main roads and interference with traffic. General siting process is provided in the ESMP:

22 SOCIAL CONDITIONS

22.1 Project affected population

During the months of April-October 2015 the consultant team visited[2] the dump sites in the four district capital towns and villages of Independence, Placencia and San Antonio (Toledo District) with the purpose of verifying the presence of informal recyclers on these sites and consult with those present on their current activities and how the operations of a transfer station in their town or village would affect their livelihood. This chapter provides an overview of the findings from the visits to each of the dump sites.

A distinction will be made on the type of affected population found on the dump sites, primarily:

1. Recyclers working at the dumpsites ***permanently***
2. Recyclers working at the dumpsites ***temporarily***
3. A third category could be watchmen that perform recycling activities and receive payment from the municipality

loan[2] Although all dump sites (except San Antonio) were visited on at least two occasions by the team, the main interviews and conducting of the initial recyclers census was done during the month of October 2015 by the local consultant. It should be noted that not all those recyclers present at the dump sites were willing to complete the Recyclers Census form, even though they participated in providing general information in the group discussion.

Each category would be eligible for a different type of compensation.

Detailed consultation reports of visits to each dump site are available in the project files.

22.2 Context

There is no national recycler's organisation in Belize. Except for the recycler's formally active at the Mile 3 Transfer Station, all other recyclers operated in an informal manner and mainly on an individual basis although some form of *loosely structured organization* can be found on some dump sites.

The recovered materials fall into two main categories, a) plastic and glass beverage bottles that are mainly commercialized locally for further processing before exportation and b) metals that are sold to buyers from Mexico and Guatemala who come to the dumpsites at different intervals to buy the accumulated quantities.

At most of the dump sites there are 1-2 *vendors* present, who have some form of vehicle (mostly a pick-up). They sell the recovered materials to the middle men and the buyers that come from Mexico and/or Guatemala.

The next section gives an overview of the recycling activities found at the different dump sites in the four districts.

22.3 Results of Initial Census Socioeconomic Baseline Survey

22.3.1 Corozal District

In the Corozal District, three locations were visited where the presence of (informal) recyclers was observed, namely the dump site at Corozal Town, the recycler's family that operates from a site near Paraiso Village and the dump site near the Free Zone in the north of Corozal District near the Border with Mexico.

Dump site at Corozal Town

The dump site is located 5 kilometres outside of Corozal Town on the road to Consejo, and receives primarily the waste collected in Corozal Town by the sanitation department. There is no official gate or weigh bridge at the dump site, but there is a watchman responsible for coordinating the disposal of the waste for which he receives a monthly salary from the Corozal Town Council. There are 9 permanent adult persons recovering recyclables at the dump site and an additional 10 to 15 who work at irregular intervals, but were not considered by the main group of recyclers as permanent recyclers.

This core group of nine recyclers is formed by 3 couples (husband + wife) and three single male adults, primarily of origin mestizo. Six of them are between 41-55 years old, while the other 3 are 19, 25 and 34 years of age. It should be noted that the husband of one of the couples is the watchman (foreman) of the dumpsite.

All recyclers live within a 6 miles' radius of the dump site (either in Corozal Town or Xaibe), and save one person (who recently started) all have been active at least 3 years sorting and recovering recyclable materials for a living, with 4 of them for more than 10 years. No recycler lives at the dump site and no (permanent) structures were found at the dumpsite, nor has their presence been reported in the past.

Most of the group work together during week days from 7 to 17:00 sorting the recyclables and recovering primarily: metals (aluminium, copper, bronze, cans, and iron), glass bottles (local rum bottles) and some hdpe plastic containers. The glass bottles (soft drink and rum) are sold to local companies including Cuello Distillery (Orange Walk) and Bowen and Bowen (Belize City), whilst the aluminium and other metals are sold to Mexican traders.

The reported average monthly income ranges from BZD$600-900, which is the sole source of income; with the exception of the foreman who receives a salary from the local authorities.

Main points of concern (of the current work practices) raised include:

- There is only limited time to sort because waste is burnt to control pests;
- Lack of shelter, inclement weather conditions, rain and sunlight;
- Transportation and availability of water;
- Sanitary facilities are required, including a shower.

Group members indicated that they would lose their only source of income if the dump site were to be closed. All recyclers are aware of the recycling facilities at the transfer station at Mile 3, and all indicated that they would be interested to work at a similar type of facility if it were close by. The main reason cited being the need for a source of income.

When the new transfer station at Corozal Town becomes operational, the waste collected from Corozal Town will no longer be disposed of at the dump site, but go directly to the transfer station. As such, a total of 8 persons, who work permanently at the dump site, would be affected by the closing of the dump site at Corozal Town, as they would lose their primary source of income. It should be noted that this does not include the Foreman who has a salary from the Town Council. The 10-15 persons, who work temporarily at the dump site and, frequent the dump site at irregular intervals to supplement their income are not included in this total. Furthermore, as no evidence of permanent dwellings was reported, there would be no need to activate *resettlement activities.*

Figure 17: Recyclers organizing their recovered material at the Corozal Town dump site.

Recycling activities at Paraiso Village

In Paraiso Village, three members of the family (parents and son) actively recover recyclables for commercialization. Previously, the family sorted waste disposed of at the Consejo Village dumpsite, but frequent burning prevented them from recovering enough materials. Consequently, they approached a private land owner to lease of a small portion of his land (located 1 mile from Paraiso Village), where they could receive waste for sorting. The private waste collection company, , which provides collection services in 9 villages around Corozal Town, uses this land to dispose of its waste, which is based on a mutually agreed verbal contract with the family. The family sorts the recyclable materials found in the disposed waste, primarily (scrap metals, paper, cardboard and plastic), which is sold to the Mexican traders and to the soft drink company in Belize City who pays for soft drink bottles for re-use and disposal. This economic activity is the sole source of income for this family of three recyclers.

The new transfer station in Corozal is designed to receive also the waste collected from the villages around Corozal Town, either through direct collection, or through the operation of the Drop Off Centres proposed to serve these villages. Consequently, waste currently collected by private waste collection company would be diverted from the land where the Chable family is currently recovering recyclables to the new transfer station and as such, leaving the recyclers family without a source of income.

Dump site near the Free Zone

This dump site is located near the Free Zone, in the north of Corozal District, close to the Mexican Border, and receives waste from both the commercial activities in the Free Zone and the Casino. There is no gate control or presence of a watchman or employee of a nearby local authority.

During the visit only 1 recycler was encountered, however there was evidence of more extensive recycling and sorting activity. According to the recycler present[3], the site is frequented by 11 *temporary* recyclers who work three (3) days per week between Mondays to Fridays from 6:00 a.m. to 4:00 p.m. The frequency depends primarily, on when the casino disposes more waste, which would be normally after weekends or festivities. During the Christmas festivities the site is visited daily, because there is a higher production of waste. The recyclers reportedly come from Corozal Town, and the villages of Chan Chen, Paraiso and Xaibe.

Bottles and broken glass are the main materials that are recovered. The bottles are broken, sorted per colour and stored in bags, after which they are sold to a Guatemalan recycler who comes every few weeks, and loads a large truck to take the glass to Guatemala for recycling.

When there are limited materials available at the site, the recyclers[4] also frequent the dumpsite at Consejo to supplement their income.

Figure 18: Storage containers with a high content of potentially recyclable materials in the Free Zone in north Corozal.

[3] A complete report of visit is available in the project files.

[4] To avoid double counting these recyclers have only been considered to the Free Zone dump site.

Because the dump site does not receive any waste from Corozal Town and surrounding villages, the operation of the new transfer station in Corozal Town would not necessarily affect the quantity of waste (and as such recyclables) that would be available at the Free Zone dump site. Furthermore, this dumpsite is not included in the list of the proposed dumpsites to be remediated.

At the same time, it should be noted the following assumption is made for the Master Plan concerning the *waste entering the system, assumptions and conditions* for the Corozal Free Zone (CFZ):

ASSUMPTIONS	**CONDITIONS**
Free Zone	
9. Only 5% of the generated waste (corresponding to the MSW generated in the Free Zone) is considered to directly enter the system at the Corozal Transfer Station / Landfill	d. 95% of waste generated by the Free Zone is estimated to be Commercial Waste (mostly packaging waste); the high quantities generated are comparable to the quantities of MSW generated by Corozal Town; the composition of the waste, is almost totally recyclables materials; the peculiar institutional status of the Free Zone; the proximity to the Mexican recycling market; these are all factors that suggest the **establishment of a specific** policy to encourage diversion at source of the recyclable materials from the main stream of the MSW of the rest of the District.

It is recommended that the development of a specific policy for the Free Zone should take into consideration the dump site at the Free Zone and those informal recyclers operating at this dumpsite.

22.3.2 Orange Walk District

In the Orange Walk District the main presence of informal recyclers is found on the dump site, 10 km outside of Orange Walk Town.

The dump site is being controlled by the watchman, who works for the Town Council and his job is to charge a fee for disposal and to burn the garbage. He interacts with recyclers daily and also actively participates in the recycling activities. There is no gate or weighbridge, and the access road is open to anyone.

There are two main groups of recyclers active on the dump site. A group of 20 *permanent recyclers*, who recover materials from Monday to Friday (from 5:00 a.m. to about 2:00 p.m); they do not work on weekends nor on holidays. During the visit in October, 15 of them were present at the time of the interview[5]. The second group, 10 women, come occasionally to the

[5] Only three (including the watchman) completed the Recyclers Census form. The full report is available in the project files.

dump site to collect clothes and other items. These *temporary recyclers* were not present during the visit and the *permanent* group of recyclers do not mingle with them and vice versa. Other than that, they are Belizeans, little else is known about them.

The numbers present of the *permanent group* of recyclers change slightly depending on the season, but it is mostly due to weather. During the rainy season some of them stay away, but they work consistently throughout the year. The group is composed of 18 men and 2 women, ranging in age from 20 to 65 years, all of them are Belizean of Hispanic/Mayan decent. They speak Spanish, English (albeit broken) and Creole, the local language. They come from Orange Walk Town, and the adjoining villages of San Jose Palmar, Guinea Grass, Yo Creek, and Chan Pine Ridge.

One of the woman on site is a buyer but she refused to be interviewed. The group appears to have a coherent structure, although they claim that they act independently and each one sorts his own materials. However, they display *"cooperation"* in the sense that they all share the same recycling area, and mingle with each other a lot. They are friendly to each other, show each other a lot of respect, and they seem to have little or no internal conflicts within the work site.

The main materials which they recover include aluminium, plastic bottles, glass bottles, copper and bronze. They sell the recovered materials to *"middle men"*, who buy at a price and sell to the soft drink and rum industries at a higher price, and to the Mexican recyclers. They refused to give information on this. There was one male and his female companion present on site who did this as a trade.

The recyclers´ income averages between BZD $ 500 – 600 per month, with the watchman making BZD 800 since it complements his salary from the municipality.

Main points of concern (of the current work practices) raised include:

- There is no water on site and it is difficult to find food to buy of food
- The entire site is unsanitary
- Lack of shelter

Each of group members that were interviewed indicated that they would lose their only source of income if the dump site were to be closed. All recyclers are aware of the recycling facilities at the transfer station at Mile 3, and all indicated that they would be interested to work at a similar type of facility if it were close by. The main reason cited being the need for a source of income.

Most recyclers live in houses, albeit in poor conditions, but have potable water and electricity.
On the dump site there was a make-shift shelter from inclement weather and sun (see Figure 19). However, no evidence of permanent dwellings was reported, and as such there would be no need to activate *resettlement activities.*

Figure 19: Make-shift shelter at Orange Walk Town dump used by recyclers to protect from inclement weather and sun.

When the new transfer station at Orange Walk Town becomes operational, the waste collected from Orange Walk Town will no longer be disposed of at the dump site, but go directly to the transfer station. As such in total 20 persons would be affected by the closing of the dump site at Orange Walk Town, as they would lose their primary source of income. It should be noted that this does not include the watchman (who has a salary from the Town Council).

As for the issue of resettlement, as no evidence of permanent dwellings was reported, there would not be any need to activate *resettlement activities.*.

22.3.3 Stann Creek District

In the Stann Creek District, three locations were visited where the presence of (informal) recyclers was observed, namely the dump site at Dangriga in the north of the district, and the dump sites of the villages of Placencia and Independence in the south of the district.

Dangriga dump site
The Dangriga dump site is situated on the Southern Highway, 10 km away from Dangriga, the district capital of Stann Creek District. There is an improvised gate at the entrance manned by a watchman, who is paid by the Town Council and who also performs recycling activities. The dump site receives primarily the waste collected from Dangriga Town and there is no weighbridge at the dump site.

During the visit[6] there were only two persons present, one male Guatemalan recycler who operates permanently at the site and a Belizean man[7] who recovers materials on a temporary basis.

Reportedly, the dump site is also frequented by two other groups of recyclers, although neither of them are active on a permanent Monday to Friday basis on the dump site. The first group of 10 recyclers (half Belizean and half of other Central American nationalities) visit the site twice a week and work from about 7:00 a.m. to about 2:00 p.m, sorting recyclables for commercialization. Their number fluctuates and their presence intensifies during the tourist season, which, according to them, is from December to May. According to those interviewed, this group is not well defined nor well organized. While they sort waste twice a week, some appear one week and some another, but the numbers in terms of consistency remains the same, which is normally at least five of them present, but on that day only two were present.

Figure 20: Entrance to the Dangriga dump site

The main materials recovered are local soft drink, beer, and rum bottles which are sold locally. The availability of these materials fluctuates according to the tourist seasons and in part explains the temporary presence of the recyclers on the site. The *permanent* recycler present

[6] The site was also visited on a number of other occasions during 2015 for activities related to the EA, and no permanent presence of recyclers was observed.
[7] He did not want to fill out the census form nor have his name registered, although he was willing to provide general information.

recycled other material including copper, aluminium, iron and bronze. These materials are sold primarily to Guatemala middlemen, including *Southern Metal Recyclers* described below. No plastics and papers are recovered, because they are not bought by the Guatemalan middlemen.

The second group, considered as *temporary recyclers*, are Guatemalan women (between 5 and 10) who pass by the dumpsites of Dangriga and Placencia at irregular intervals to collect clothes and shoes for commercialization.

The main problem reported is that not enough material reaches the site because there is too much illegal dumping. According to the interviewee, this is caused by the fee being charged at the gate since January 2015. The general public is unaware that a fee is charged, and when they arrive at the dump site, and they need an official receipt from the Town Council, they need to go back to Dangriga for one and most of them end up dumping on the highways and roads.

The interviewed recycler indicated that he would lose his only source of income if the dump site were to be closed. He is aware of the recycling facilities at the transfer station at Mile 3, and indicated that he would be interested to work at a similar type of facility if it were close by. The main reason cited being the need to earn a living.

If waste collected from Dangriga would be brought directly to the newly planned transfer station at Dangriga this would affect primarily the one recycler who is working permanently at the dumpsite, as he would lose his main source of income. The watchman has a salary paid by the Dangriga Town Council, and is not included in this total. The two other groups of recyclers would frequent the dump on a temporary basis are not included in this total, nor is the owner of *Southern Metal Recyclers* who collects materials from the dump site.

With regards to needs from *resettlement activities*, although both the watchman and the *permanent* recycler live on site in a *make shift shelter* they both report to have a residence close to the dump site.
Finally, as no evidence of permanent dwellings was reported, there would not be any need to activate *resettlement activities.*

Placencia dump site
The Placencia dump site is located just off the Placencia Road, relatively distant (29 miles) from Placencia at the tip of the peninsula. The site, is located on privately owned land, and receives waste primarily from the villages located along the peninsula (Placencia, Seine Bight and Maya Beach).

Recycling activities at the dumpsite are heavily dependent on the season, with a marked increase during the tourist high season along the peninsula. During most of the year there is only one *permanent* male recycler who is permanently present at the dump site. He reported[8] during the visit that he lives in a shelter on site, but his family live in a small concrete house in Cow Pen (25 km away from the dump).

[8] Full report of visit is included in the project files.

In the period December – March a group of *temporary recyclers (so-called international recyclers)* are also active at the dump site. The group is composed of four families, in the case of two families the couple work on site, whilst the other families on occasions would bring their children as well. The group members come primarily from Guatemala and Honduras, although reportedly, some might be from Belize as well. It is not clear if they work during the low season and if so where, although the watchman and *permanent* recycler suppose it would be at the banana plantations during the banana season.

There is no official gate or weighbridge at the dump site. There is a watchman, paid by the village council of Placencia, who lives on site and coordinates where the collection vehicles can dispose their waste. The relationship between him and those recycling at the site is ambivalent, he appears to grant the recyclers *permission* to enter the site, and seems to work along with the persons active on site. He claims the "families" work for him, but the one person on site says he works for himself.

The main recyclable materials recovered by the permanent recycler at the site are: local products, soft drink plastic and beer bottles and some rum bottles, which are all sold locally in Placencia. He reportedly earns approximately BZD $500.00 to $600.00 monthly.

During the high tourist season, when the *international recyclers* are present, metals are also recovered and there appears to be an agreement that the permanent recycler *stores* any metals he recovers during the time they are not on site. The metals are sold to Guatemalan middlemen.

The main problem reported is the lack of recyclable materials at the site, because of the seasonal fluctuation and poor (perceived) collection services in the peninsula.

Figure 21: Overview of materials recovered (left) and many more not recovered (right) at Placencia dump site

Entrance to Placencia dump site

The permanent recycler stated that he would lose his only source of income if the dump site were to be closed. He had heard of the recycling facilities at the transfer station at Mile 3, and indicated that he would be interested to work at a similar type of facility if it were close by. The main reason cited being the need to earn a living.

In principal 1 person would be affected directly if waste collected from Placencia would be brought to any of the newly planned transfer stations in the Stann Creek District as well as by the closing of the Placencia dump site, as they would lose their primary source of income. It should be noted that this does not include the watchman who has a salary from the Village Council. The 6-8 members of the *international recyclers* who frequent the dump site only during the period December to March are not included in this total.

With regards to needs from *resettlement activities*, although both the watchman and the *permanent* recycler live on site in a *make shift shelter* they both report to have a residence close to the dump site.

Independence dump site

The dump site at Independence is located 9 km away from Independence on the Southern Highway, and was visited three times during the period April - October 2015. No *permanent* recyclers were found during the visit in October 2015, although evidence was found of recyclable materials accumulated from a period of 3-4 weeks. During the visit in April, three

young women were present at the site who recovered primarily beverage bottles, but no census was conducted at that time.
There is a watchman[9] at the gate, but he was not present during the last visit.

Figure 22: Recovery of recyclable materials by women during visit to Independence dumpsite in April 2015

Entrance to Independence dump site

Other recycling activities in Stann Creek District

Two other activities involving recycling were identified during the visits to the dump sites in the southern districts.

[9] The watchman does not recycle at the dump site.

First of all, the presence of *temporary recyclers,* a so-called *international* group of (8-10 persons) primarily Guatemalans and Hondurans, who visit the different dump sites[10] on an irregular basis to collect clothes and shoes etc. that they can probably use or sell.

The second is a Belizean registered company called ***Southern Metal Recycling*** [11]that operates from a property the owner bought at the junction of Red Bank and Southern Highway. The owner is a Guatemalan nationalized Belizean, who collects and transports metals to Guatemala for recycling. Although he mainly deals in scrap metals from old cars, he does buy metals recovered at the dump sites in the south. He owns two trucks and a tow head. The trucks are used to collect the waste metals and batteries. These are stored on site for placing in large container truck for transportation to Escuintla, Guatemala, a 20-hour drive from Red Bank. A portion of the highway connecting Belize and Guatemala from « The Dump » or the Big Falls Junction is not yet paved. This prohibits large vehicles from using this road; therefore, he goes via the Western Border. His trip is 20 hours, and completion of the Belize/Guatemala southern road would cut his trip by three to four hours.

He transports 60 tons of mostly metals once every 20 days to Guatemala. He has 4 full time employees (two drivers and two helpers) and sometimes hires another when needed. He also has his daughter who helps to run the business.

Table 30: Prices paid by Southern Metal Recycling

Material	**Price (BZ$)**
Aluminium	$0.50 to $0.60 ($0.60 for solid aluminium) / lb
Plastic Bottles (Soft Drink)	*
Copper	Not being recycled at this time
Bronze	
Glass Bottles (Soft Drink)	Local products that the company does not recycle
Glass Bottles (Beer)	
Glass Bottles (Rum)	
Glass Bottles (Smirnoff)	
Iron	$0.07/Lb
Metals from cans	$0.07/lb
Metals from zinc roofing	$0.03/lb
Batteries	Based on size, from $8.00 to $15.00 each
HDPE**	** no one recycling these at the moment
Cardboard/paper**	Claims that Caribbean Paper was recycling paper and cardboard but sending to El Salvador

22.3.4 Toledo District

In Toledo District the dumpsites at Punta Gorda and San Antonio were visited and consultations were held with local authority representatives in both localities.

[10] Their presence was mentioned at both the Dangriga and Placencia dump sites by the recyclers present, although none were actually interviewed.
[11] See project files for complete interview.

In Punta Gorda, the dump site authorised by the municipality receives waste from the town and from 5-10 villages[12] in the Toledo District. There was no permanent presence of recyclers observed at the dump site, nor evidence of recyclable materials been sorted and stored separately. According to the municipal authorities (itinerant) buyers come from Guatemala at irregular intervals to recover materials from the dump site.

Figure 23: Dump site at Punta Gorda, Toledo district

The dump site of San Antonio is located on the outskirts of the village. Here also, no evidence of recyclers was noticed nor of materials being recovered. This was confirmed by the *Alcalde* of the village.

Figure 24: State of open dump in San Antonio village (April 2015).

Presence of potentially recyclable materials that are not recovered by (informal) recyclers

[12] Including: Jacinto Ville, Yemeri Grove, San Felipe, Santa Ana, Eldridge Ville and Forest Home.

Dump site 6 km outside of San Antonio village with no clear evidence of presence of recyclers

As such, no informal recyclers would be affected by the proposed activities of the Master Plan foreseen for Punta Gorda Town.

22.4 Analysis

Based on the descriptions presented in the previous section, a comprehensive analysis is given in this section of the recycling activities encountered in the nine dump sites that were visited.

An overview of the activity of informal recyclers is given in Table 31. Four main characteristics can be noted regarding the recycling activities observed at the different locations:

- **Permanent (daily) presence**[13] of a total of 33 informal recyclers can be observed at 5 dumpsites, with a clear distinction between the northern corridor districts (31 recyclers) and the southern corridor districts (2 recyclers); these would receive the highest priority in terms of compensation for possible loss of income.
- **Temporary presence** of an additional 60-68 informal recyclers was found in 6 of the dumpsites, with a varying degree of irregular presence; these would be considered as a medium priority in terms of compensation for possible loss of income, with the following order of priority:

Table 31: Overview of activity of informal recyclers at dumpsites in northern and southern corridors.

#	Location of dumpsite	Persons active at dumpsite	Type of	Presence of

[13] From Monday to Friday at least 6 hours per day.

		Permanently[1]		Temporary	materials recovered	buyers of recyclable materials
		Performing ´technical´ operations	Recovering recyclable materials	Recovering recyclable materials		
1.	Corozal Town, Corozal District	Watchman[2]	8 persons	10-15 persons[3]	Metals, plastic, broken glass, glass bottles per unit, batteries	Buyers from Mexico (weekly) and Guatemala (monthly) come to dumpsites to buy different materials
2.	Consejo / Paraiso (Villages) Corozal District	None	3 persons			
3.	Corozal Free Zone Dump site	None	0	11 persons[4]		
4.	Orange Walk Town, Orange Walk District	Watchman	20 persons	10 persons[5]		
5.	Dangriga, Stann Creek District	Watchman	1 person	20 persons[6]		
6.	Placencia (Village), Stann Creek District	Watchman	1 person	6-8 persons[7]		
7.	Independence (Village), Stann Creek District	Watchman	0	3-4 persons		
8.	Punta Gorda, Toledo District	None	No permanent presence of recyclers, reportedly buyers come from Guatemala at irregular intervals to recover materials from the dump site			
9.	San Antonio (Village), Toledo District	None	None found		None	None
Total		**5**	**33**	**60-68**		

Notes:

1. Monday to Friday on a full time basis during the day.
2. The watchman also performs sorting activities, as an additional income source to the salary received from the municipality.
3. Include 1 underage girl.
4. Reportedly three times a week on a regular basis.
5. Women who come at irregular intervals to collect clothing for commercialization.
6. 10 persons reportedly twice a week (7:00 am -14:00 pm) on a regular basis; 10 others come at irregular intervals to collect clothing for commercialization.
7. Seasonal recyclers, some are reportedly from Guatemala and Honduras

Source: Field visits to the different dumpsite during period April – September 2015

- ***Part-time*** (2 or 3 days a week) but regular presence at the dump site, such as the case of Corozal Free Zone Dump site (11 persons) and Dangriga dump site in Stann Creek district (10 persons).
- ***Seasonal variance*** with increased presence during high tourism season (Dec-May), such as the case of Placencia (6-8 persons)
- ***Material bounded variance***, as is the case of groups of women who visit the dump sites to collect (only) clothing and shoes for commercialization or own use; such as the reported group of 10 women in Orange Walk and 10 women who visit the Dangriga and Placencia dump sites.

- **Active participation in recycling activities** of the watchman at five dump sites. The watchman is paid by the local authority responsible for the dump site, and coordinates the disposal by the waste collection trucks, but also actively recycles as a supplement to his municipal salary. This category would receive the lowest priority as it would be the responsibility of the municipality to attend to the issue of possible loss of income.

- **No presence of recycler**, although buyers would come directly to the dump site to recover materials at irregular intervals as is the case of Punta Gorda dump site. The buyers would not be considered as possible beneficiaries of the Social Inclusion Plan.

In summary, an estimated total of 100 recyclers were reported as being active at the different dump sites, although only one third (33 recyclers) are permanently involved and depend solely on the recovery of materials as their source of income. Of the two-third that are temporary in their presence, 40-48 recyclers could be considered to have some direct relation to the dump sites for providing a principal source of income, whilst the link to the dump sites of the final group of 20 or so persons who recover clothing and shoes, could be seen as insignificant.

The *permanent* recyclers are predominantly male, of Mestizo/Hispanic ethnicity, varying in age between 19-65 years and with (at most) a primary school education completed. Of the *female permanent* recyclers all of these work together with their partner / husband. Table 32 provides an overview of the *permanent recyclers.*

Table 32: Characteristics of recyclers working permanently at the dump sites

Location of dumpsite	Number of Males	Number of females	Age range years	Ethnicity	Highest level of education completed
Corozal Town, Corozal District	5	3	19-55 (male) 23-45 (female)	Mestizo	Primary school
Consejo / Paraiso (Villages) Corozal District	2	1		Mestizo	Primary school
Corozal Free Zone Dump site	0	0			
Orange Walk Town, Orange Walk District	18	2		Mestizo	Primary school
Dangriga, Stann Creek District	1	0	32	Hispanic/Mestizo	Primary school
Placencia (Village), Stann Creek District	1		43	Creole Belizean	Primary school
Independence (Village), Stann Creek District	0	0			
Punta Gorda, Toledo District	None	None			
San Antonio (Village), Toledo District	None	None			
Total	**27**	**6**			
Note: The watchmen contracted by the respective town and villages councils are not included.					

Of those recyclers that are permanently active at the dump sites, those that completed the *recyclers census form* all indicated that they have no additional income source other than the income obtained through the commercialization of the recovered materials. The range of monthly income reported was between BZD $400 – 900, which in most cases was reported as being sufficient to meet the needs of the recyclers.

Table 33: Range of monthly income (BZD $) from commercialization of recyclables reported by recyclers.

Location of dumpsite	# of recyclers[1] who would lose their income with the operation of the transfer station and closing of the dumpsite	Range of monthly income[2] (BZD $)	# who indicated that ´working at the site give them enough money to meet their needs`
Corozal Town, Corozal District	8	600-900	4/8
Consejo / Paraiso (Villages) Corozal District	3	Not available	Not available
Corozal Free Zone dump site	0	700-800[3]	1/1
Orange Walk Town, Orange Walk District	20[4]	500-600	2/2
Dangriga, Stann Creek District	1[4]	400-500	1/1
Placencia (Village), Stann Creek District	1	500-600	1/1
Independence (Village), Stann Creek District	0	No temporary recyclers interviewed	
Punta Gorda, Toledo District	0	No evidence of recyclers	
San Antonio (Village), Toledo District	0		
Total	**33**	**$400-900**	

Notes:
1. Includes only recyclers working permanently on each dump site
2. The wage of the watchmen contracted by the respective town and villages councils is not included.
3. Wage of interviewed recycler onsite that works there irregularly.
4. Not all were willing to complete the Recyclers Census form.

The table below shows an overview of the need to activate resettlement activities due to remediation of dump sites.

Table 34: Overview of need to activate *resettlement activities* due to remediation of dump sites

Location of dumpsite	Number of non-permanent dwellings on site	Need to activate *resettlement activities*
Corozal Town, Corozal District	None	No
Consejo / Paraiso (Villages) Corozal District	None	No
Corozal Free Zone dump site	None	No
Orange Walk Town, Orange Walk District	2 make shift shacks	No
Dangriga, Stann Creek District	None	No
Placencia (Village), Stann Creek District	2 make shift shacks	No
Independence (Village), Stann Creek District	None	No
Punta Gorda, Toledo District	None	No
San Antonio (Village), Toledo District	None	No

Note: The watchmen contracted by the respective town and villages councils are not included.

E. ENVIRONMENTAL AND SOCIAL IMPACTS

In the present section is conducted the assessment of the potential environmental impacts, positive or negative, due to the project. The project provisions being considered are divided as follows:

- dumpsites remediation;
- new SWM system implementation.

Since the waste produced in the two Corridors shall be disposed of at Mile 24 landfill, the outcomes of the audit for the Mile 24 landfill are also reported.

23 METHODOLOGY

General criteria can be used to assess the significance of environmental impacts. In the present EA the impacts assessment methodology proposed by the *"Resource and Guidance Manual for Environmental Impact Assessments – Desalination"* UNEP is adopted as hereinafter described.
The following general criteria are taken into account in examining potentially significant adverse effects:

- nature of impacts (direct/indirect, positive/negative, cumulative, transboundary);
- time-span (short/medium/long-term, permanent/temporary, frequent/seldom);
- extent (geographical area, size of affected population/habitat/species);
- magnitude (severe, reversible/ irreversible);
- probability (high/medium/low probability);
- possibility to mitigate, avoid or offset significant adverse impacts.

The following assessments are based on a so-called "ecological risk assessment" approach. The objective of this approach is to systematically identify and evaluate the relationships between *stressors* as caused by anthropogenic activity (*exposure analysis*), and subsequent impacts on *receptors* (*effects analysis*).
Stressors can be all single characteristics of a project or activity that lead to an ecological effect.
Stressors can be of chemical, physical, or biological nature, such as for example the release of a chemical, the mechanical impact from construction, or the introduction of an alien species.
The *receptors* are the different environmental features, usually operationally defined by an ecological entity (e.g. a single species) and its indicators (e.g. population size, biodiversity).

23.1 Exposure analysis

The objective of the *exposure analysis* is to describe the exposure of receptors in terms of intensity, space, and time. To this end, exposure pathways are established, including the stressor source, the spatial and temporal distribution of stressors in the environment, and the extent and pattern of contact or co-occurrence with receptors.
The ecological effects analysis then investigates the relationship between stressor *levels* and resulting responses.

In essence, the ecological risk assessment approach is based on an analysis of how exposure to stressors is likely to occur and on an analysis of the significance of the associated impacts. The result is a list of stressor-response relationships, often also termed cause-effect relationships.
As ecosystems are diverse and complex systems, these relationships are often interrelated and have a netlike rather than a linear structure, as one stressor may lead to multiple exposures and may also cause secondary (indirect) effects.
The establishment of single cause-effect relationships should therefore be understood as a simplified conceptual model which is used to systematically predict and investigate the key relationships between stressors and receptors.
The cause-effect relationships are typically summarized in a *risk matrix*, in which the rows represent the various stressors (or causes) of a proposed project and the columns represent the various environmental receptors. In the fields where rows and columns intersect, the potential environmental risks are listed. The risk matrix provides the basis for *risk characterization*. The stressors and receptors provide the system boundaries for EA studies.

23.2 **Stressors**

Stressor sources of a solid waste management system can be subdivided into the following key elements:

- waste collection;
- waste transportation;
- waste disposal and treatment plants including associated facilities (roads, leachate treatment plants,…) in terms of:
    - construction;
    - operation;
    - decommissioning;
    - after care.

23.3 **Receptors**

An environmental assessment should address the effects of a project on fauna, flora, soil, water, air, climate and landscape, including all direct and indirect effects and the interactions between single factors. Based on this definition the following categories are used for describing the potential impacts of the present projects on the environment:

- Landscape and natural scenery;
- Archaeological, cultural and historical resources;
- Air quality and climate;
- Soils;
- Ground and surface water quality;
- Flora and fauna.

If the project effects cause impacts on human settlements, these impacts should be assessed evaluating the compliance to specific quality standards prescribed by the national laws or by other international regulations assumed as reference.

24 ENVIRONMENTAL IMPACT ASSESSMENT CRITERIA

The potential stressor sources identified are rated in terms of intensity, space, and time.
Space and *time* refer to the spatial and temporal distribution of the stressor sources. Whether or not an exposure occurs also depends on the spatial and temporal distribution of the receptors in the environment.

The probability criterion gives a rough estimate of the likelihood of exposure, taking the likelihood of stressor occurrence (e.g. of a chemical spill) as well as receptor occurrence (e.g. presence of a mobile species) into account.

A three-stage grading system is used for each criterion (e.g. severe, notable and negligible) for the intensity of impacts, see

Table 35.
The ratings for intensity, space and time are formally integrated into a single rating for priority/significance (Figure 25**Error! Reference source not found.**). The probability criterion is not formally integrated into this system but used as an indicator. When a result between two ratings is obtained, the next higher rating is usually selected as a precautionary approach.

Impacts of typically *high priority* for project and site-specific EIA studies are those which fulfil the following criteria:

- Severe alterations of natural properties, functions or processes, which are of
  - long-term duration and far range, or
  - long-term duration and mid-range, or
  - medium-term duration and far range.
- Notable alterations of natural properties, functions or processes, which are of long-term duration and far-range.

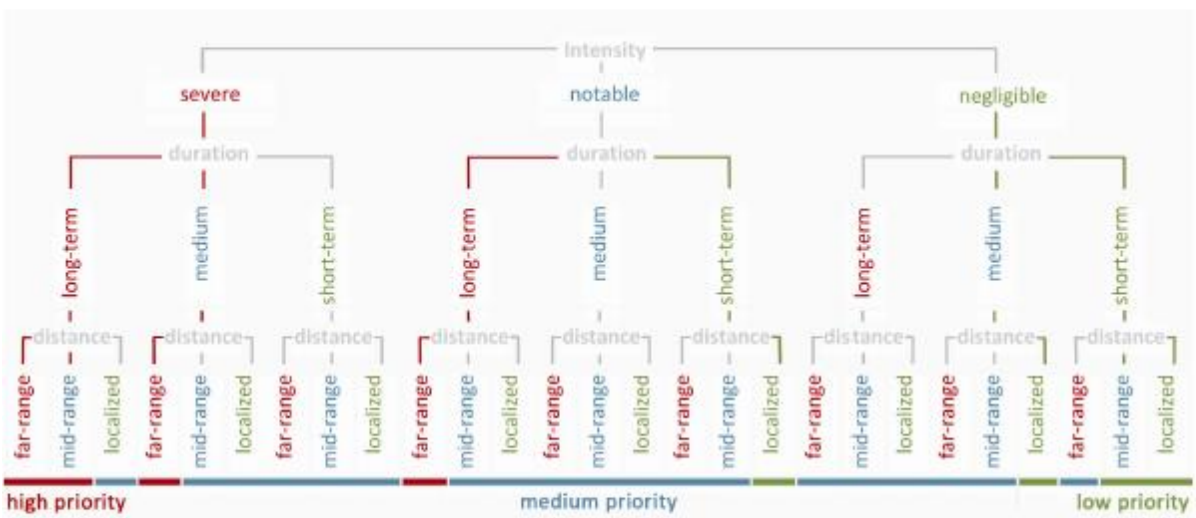
Impacts of typically *low priority* for project and site-specific EIA studies are those which fulfil the following criteria:

- Negligible alterations of natural properties, functions or processes of
  - short-term duration and localized, or
  - short-term duration and mid-range, or
  - medium-term duration and localized range.
- Notable alterations of natural properties, functions or processes, which are of short-term duration and localized range.

Table 35 - Significance ratings for evaluation criteria – "*Resource and Guidance Manual for Environmental Impact Assessment – Desalination*" (UNEP) (2008), modified

Impact rating		Description	Significance
Intensity	severe	severe alteration of natural properties, functions, processes	high
	notable	notable alteration of natural properties, functions, processes	medium
	negligible	negligible alteration of natural properties, functions, processes	low
Duration	long-term	continuously or regularly (once per day) over project life, permanent or irreversible effects (including aftermath effects)	high
	medium-term	several years (<15 after activities end) of duration, reversible, good frequency periodic events	medium
	short-term	equal to activities duration, reversible, low frequency periodic events	low
Spatial extent	far-range	effects beyond project site and nearby areas, beyond 1,000 m distance from origin.	high
	mid-range	effects beyond project site and nearby areas, within 1,000 m from origin	medium
	localized	punctual, within the area of the project site; within 100 m from origin	low
Probability	definite/likely	high probable (>80%) or definite	high
	possible	fair chance of occurring	medium
	unlikely	little or no chance of occurring (<20%)	low

Figure 25 – Decision hierarchy used to identify high (red bottom line) and low priority impacts (green) – "*Resource and Guidance Manual for Environmental Impact Assessment – Desalination*" (UNEP) (2008),



All the evaluations carried out hereafter are referred only to the potential environmental impacts related to the activities/projects of the present Master Plan, that aren't being set in the current SWM system, in order to assess only the effects of the actions planned in this study.
At this aim, for each stressor, the potential impacts that can affect the receptors, as listed above, are identified, firstly, and then assessed to determine their significance and to plan the mitigation measures.

24.1 Waste collection

The present Master Plan does not foresee a waste collection system in Agglomerates different from the one currently being set, therefore this stressor will not been further considered.
Instead in the villages the collection will be made through the implementation of a system of DOCs. The impacts due to construction and operation of these facilities are rated in the Section 25.2

24.2 Waste transportation

The potential environmental impacts due to the transportation of the waste from DOCs to TSs and then to Mile 24 will be identified and rated.

The potential environmental impact related to the stressor "Waste transportation" identified for each receptor are listed in Table 36.

Table 36 – Waste transportation – Possible impacts identification

Waste Transportation	Landscape and natural scenery
Waste transportation	None
Waste Transportation	**Archaeological, cultural and historical resources**
Waste transportation	None
Waste Transportation	**Air quality and climate**
Waste transportation	Emissions of air pollutants and greenhouse gases from the vehicles used for the transportation
Waste Transportation	**Soils**
Waste transportation	Accidental spillage or leakage of fuel may cause soil contamination
Waste Transportation	**Ground and surface water quality**
Waste transportation	Accidental spillage or leakage of fuel may cause surface water contamination
Waste Transportation	**Flora and fauna**
Waste transportation	Potential indirect impacts related to the deterioration of the quality of air, of soil or of ground and surface water

24.3 Waste transfer and disposal plants

24.3.1 Drop Off Centres

According to the adopted methodology for the identification and evaluation of the impacts, the following plant life-cycle phases are considered:

- construction;
- operation;
- decommissioning.

No after-care phase is considered for this type of plant since its effects cease at the closure of the facility. Besides, in terms of environmental impacts, it is considered that the construction and decommissioning phases are equivalent and so these phases are assessed together.

In Table 37 the potential impacts identified for the present stressor are listed.

Table 37 – DOC – Possible impacts identification

Drop off centre	Landscape and natural scenery
All phases	alteration of the landscape
Drop off centre	**Archaeological, cultural and historical resources**
All phases	damage of the site
Drop off centre	**Air quality and climate**
Construction/Decommissioning	Emissions of air pollutants and greenhouse gases from the vehicles used for the construction
	Increasing of noise levels in the area surrounding the plant
Operation	Emissions of air pollutants and greenhouse gases from the vehicles used for waste handling
	Emissions of odour from the waste during the composting and from the wastewater treatment
	Increasing of noise levels in the area surrounding the plant
Drop off centre	**Soils**
Construction/Decommissioning	Accidental spillage or leakage of fuel from vehicles may cause soil contamination
Operation	Accidental spillage or leakage of fuel from vehicles may cause soil contamination
	Accidental leakage from the sections for the hazardous waste collection may cause soil contamination
Drop off centre	**Ground and surface water quality**
Construction/Decommissioning	Accidental spillage or leakage of fuel may cause surface water contamination
Operation	Accidental spillage or leakage of fuel may cause surface water contamination
	Accidental leakage from the sections for the hazardous waste collection may cause waters contamination
Drop off centre	**Flora and fauna**
Construction/Decommissioning	potential indirect impacts related to the deterioration of the quality of air, of soil or of ground and surface water
Operation	potential indirect impacts related to the deterioration of the quality of air, of soil or of ground and surface water

24.3.2 Transfer Stations

According to the adopted methodology for the identification and evaluation of the impacts, the following plant life-cycle phases are considered:

- construction;
- operation;
- decommissioning.

Similarly to the DOC no after-care phase is considered for this type of plant since its effects cease at the closure of the facility. Also in this case, in terms of environmental impacts, it is considered that the construction and decommissioning phases are equivalent and so these phases are assessed together.

In Table 38 below the potential impacts identified for the present stressor are listed.

Table 38 – TS – Possible impacts identification

Transfer station	Landscape and natural scenery
All phases	alteration of the landscape
Transfer station	**Archaeological, cultural and historical resources**
All phases	damage of the site
Transfer station	**Air quality and climate**
Construction/Decommissioning	Emissions of air pollutants and greenhouse gases from the vehicles used for the construction
	Increasing of noise levels in the area surrounding the plant
Operation	Emissions of air pollutants and greenhouse gases from the vehicles used the waste handling
	Emissions of odour from the waste handling operations and from the leachate treatment facility (phytoremediation)
	Increasing of noise levels in the area surrounding the plant
Transfer station	**Soils**
Construction/Decommissioning	Accidental spillage or leakage of fuel from vehicles may cause soil contamination
Operation	Accidental spillage or leakage of fuel from vehicles may cause soil contamination
	Accidental leakage from the sections for the hazardous waste collection may cause soil contamination
Transfer station	**Ground and surface water quality**
Construction/Decommissioning	Accidental spillage or leakage of fuel may cause surface water contamination
Operation	Accidental spillage or leakage of fuel may cause surface water contamination
	Accidental leakage from the sections for the hazardous waste collection may cause waters contamination
	Accidental failure of the leachate treatment system can affect the surface water quality
Transfer station	**Flora and fauna**
All the phases	potential indirect impacts related to the deterioration of the

	quality of air, of soil or of ground and surface water
All the phases	loss or damage of vegetation and habitat for wildlife

25 POTENTIAL ENVIRONMENTAL IMPACT ASSESSMENT

25.1 Waste transportation

In the present section, on the basis of the criterion adopted, the potential environmental impacts on each receptor are rated. The results of this assessment are summarized in Table 52.

25.1.1 Air quality and climate

25.1.1.1 Emissions of air pollutants and greenhouse gases from the vehicles used for the transportation

The "intensity" of this impact is assessed following the guidelines provided by the IDB's guidance "Greenhouse Gas Assessment Emissions Methodology" (Milena Breisinger, August 2012).

According to this guideline the CO_2, CH_4 and N_2O emissions associated with the transportation of waste are estimated by means of the computation of fuel emissions from mobile sources, based on the type of vehicles and total miles travelled.

The emissions computation is prior to the assessment of the annual carbon footprint (in terms of CO_2e) of this activity using the following formula:

$$CO_2e = \frac{\sum_i \left(D_{tot}(mile/yr) \times gCO_2EF_i + (D_{tot}(mile/yr) \times gCH_4EF_i \times 25\right) + \left(D_{tot}(mile/yr) \times gNO_2EF_i \times 298\right)}{1000000}$$

where:

D_{tot} is the total distance travelled by vehicle type

EF_i is the emission factor (see Table 39)

Table 39 – Default emission factors per vehicle type (Source: *Greenhouse Gas Assessment Emissions Methodology* – Milena Breisinger – IDB)

Default EF per vehicle type			
CO_2 Emissions	g CO_2/mile	gCH_4/mile	g N_2O/mile
Motorcycle	57.7875208	0.0672	0.0069
New small gas/electric hybrid	62.1992563	N/A	N/A
Gasoline light duty automobile	144.088212	0.0704	0.0647
LPG light duty automobile	165.284737	0.037	0.067
Diesel light duty automobile	144.779487	0.0005	0.001
Gasoline vans & pick-up truck	196.151351	0.0813	0.1035
Gasoline light truck	248.548476	N/A	N/A
Diesel light truck	232.392825	0.0011	0.0017
Gasoline heavy truck	574.146981	0.3246	0.1142
Diesel heavy truck	540.592937	0.0051	0.0048
Diesel bus	642.877670	N/A	N/A

The following assumptions are made for the computation:

- Vehicle type used for the waste transportation: Diesel heavy truck.
- Trucks loads:
    - trucks used for the transportation from DOCs to TSs: 15 Mg;
    - trucks used for the transportation from DOCs and TSs to landfill: 21 Mg.

The total distance travelled is referred to the transportation of the "residual" waste stream, as estimated in the DFS, to the Mile 24 Sanitary landfill, as per the Scenario 1 expectations.

The pollutants emissions so calculated and for each district (CZ: Corozal district, OW: Orange Walk district, SC: Stann Creek, TO: Toledo) are shown in tables from Table 41**Error! Reference source not found.** to Table 50.

In the following Table 40 the maximum total values of CO_2eq emissions are shown and also the maximum emission factor per Mg of waste managed is estimated.

Table 40 - Total CO_2eq (Mg/y)

Corridor	CO_2eq in 2040 (Mg/y)	Total GHG emissions (Mg)	GHG emission per Mg of waste (CO_{2eq} /Mg_{waste})
Northern	**211.15**	**3,373.81**	**0.0040**
Southern	**348.28**	**4,480.83**	**0.0064**

Table 41 – Northern Corridor: Total distance travelled (miles per year) to Mile 24

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
CZ	78,025.36	83,762.35	86,116.75	96,063.40	102,650.19	139,076.44	143,881.06	148,856.46	154,008.63	159,343.76	164,868.27	170,588.77	176,512.13	182,645.43	188,996.00	195,571.42	202,379.54	209,428.47	216,726.59	224,282.57	232,105.40	240,204.33	248,588.97
OW	56,003.87	58,812.06	59,784.27	64,824.72	68,040.54	92,502.63	94,803.86	97,164.96	99,587.42	102,072.76	104,622.54	107,238.36	109,921.86	112,674.73	115,498.66	118,395.44	121,366.85	124,414.74	127,541.01	130,747.59	134,036.46	137,409.66	140,869.25
TOT	**134,029.23**	**142,574.41**	**145,901.02**	**160,888.12**	**170,690.73**	**231,579.07**	**238,684.92**	**246,021.42**	**253,596.05**	**261,416.52**	**269,490.81**	**277,827.14**	**286,434.00**	**295,320.15**	**304,494.66**	**313,966.86**	**323,746.39**	**333,843.21**	**344,267.60**	**355,030.17**	**366,141.86**	**377,613.99**	**389,458.22**

Table 42 - Northern Corridor: total CO_2 (Mg/y)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
CZ	42.18	45.28	46.55	51.93	55.49	75.18	77.78	80.47	83.26	86.14	89.13	92.22	95.42	98.74	102.17	105.72	109.40	113.22	117.16	121.25	125.47	129.85	134.39
OW	30.28	31.79	32.32	35.04	36.78	50.01	51.25	52.53	53.84	55.18	56.56	57.97	59.42	60.91	62.44	64.00	65.61	67.26	68.95	70.68	72.46	74.28	76.15
TOT	**72.46**	**77.07**	**78.87**	**86.97**	**92.27**	**125.19**	**129.03**	**133.00**	**137.09**	**141.32**	**145.68**	**150.19**	**154.84**	**159.65**	**164.61**	**169.73**	**175.02**	**180.47**	**186.11**	**191.93**	**197.93**	**204.14**	**210.54**

Table 43 - Northern Corridor: total CH_4 (g/y)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
CZ	397.93	427.19	439.20	489.92	523.52	709.29	733.79	759.17	785.44	812.65	840.83	870.00	900.21	931.49	963.88	997.41	1,032.14	1,068.09	1,105.31	1,143.84	1,183.74	1,225.04	1,267.80
OW	285.62	299.94	304.90	330.61	347.01	471.76	483.50	495.54	507.90	520.57	533.57	546.92	560.60	574.64	589.04	603.82	618.97	634.52	650.46	666.81	683.59	700.79	718.43
TOT	**683.55**	**727.13**	**744.10**	**820.53**	**870.52**	**1,181.05**	**1,217.29**	**1,254.71**	**1,293.34**	**1,333.22**	**1,374.40**	**1,416.92**	**1,460.81**	**1,506.13**	**1,552.92**	**1,601.23**	**1,651.11**	**1,702.60**	**1,755.76**	**1,810.65**	**1,867.32**	**1,925.83**	**1,986.24**

Table 44 - Northern Corridor: total NO_2 (g/y)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
CZ	374.52	402.06	413.36	461.10	492.72	667.57	690.63	714.51	739.24	764.85	791.37	818.83	847.26	876.70	907.18	938.74	971.42	1,005.26	1,040.29	1,076.56	1,114.11	1,152.98	1,193.23
OW	268.82	282.30	286.96	311.16	326.59	444.01	455.06	466.39	478.02	489.95	502.19	514.74	527.62	540.84	554.39	568.30	582.56	597.19	612.20	627.59	643.38	659.57	676.17
TOT	**643.34**	**684.36**	**700.32**	**772.26**	**819.32**	**1,111.58**	**1,145.69**	**1,180.90**	**1,217.26**	**1,254.80**	**1,293.56**	**1,333.57**	**1,374.88**	**1,417.54**	**1,461.57**	**1,507.04**	**1,553.98**	**1,602.45**	**1,652.48**	**1,704.14**	**1,757.48**	**1,812.55**	**1,869.40**

Table 45 - Northern Corridor: total CO_2e (Mg/y)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
CZ	42.30	45.41	46.69	52.08	55.65	75.40	78.01	80.70	83.50	86.39	89.38	92.48	95.70	99.02	102.46	106.03	109.72	113.54	117.50	121.59	125.84	130.23	134.77
OW	30.36	31.89	32.41	35.14	36.89	50.15	51.40	52.68	53.99	55.34	56.72	58.14	59.59	61.09	62.62	64.19	65.80	67.45	69.15	70.88	72.67	74.50	76.37
TOT	**72.66**	**77.30**	**79.10**	**87.23**	**92.54**	**125.55**	**129.40**	**133.38**	**137.49**	**141.73**	**146.10**	**150.62**	**155.29**	**160.11**	**165.08**	**170.22**	**175.52**	**180.99**	**186.64**	**192.48**	**198.50**	**204.72**	**211.15**

Table 46 - Southern Corridor: Total distance travelled (miles per year) to Mile 24

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
SC	264.24	72,176.75	75,786.72	103,631.47	112,728.90	130,071.69	145,343.27	157,650.15	170,956.86	180,409.71	190,445.07	201,100.40	212,415.61	224,433.19	237,198.45	250,759.62	265,168.11	280,478.68	296,749.67	314,043.24	332,425.62	351,967.36	372,743.63
TO	874.15	42,312.51	43,508.36	86,498.52	94,391.86	102,679.86	118,342.88	128,928.59	140,508.28	146,968.70	153,766.01	160,918.95	168,447.36	176,372.19	184,715.64	193,501.15	202,753.55	212,499.08	222,765.53	233,582.25	244,980.34	256,992.66	269,654.02
TOT	**1,138.39**	**114,489.26**	**119,295.08**	**190,129.99**	**207,120.76**	**232,751.55**	**263,686.15**	**286,578.74**	**311,465.13**	**327,378.40**	**344,211.08**	**362,019.35**	**380,862.96**	**400,805.39**	**421,914.08**	**444,260.77**	**467,921.66**	**492,977.76**	**519,515.20**	**547,625.50**	**577,405.96**	**608,960.03**	**642,397.65**

Table 47 - Southern Corridor: total CO_2 (Mg/y)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
SC	0.14	39.02	40.97	56.02	60.94	70.32	78.57	85.22	92.42	97.53	102.95	108.71	114.83	121.33	128.23	135.56	143.35	151.62	160.42	169.77	179.71	190.27	201.50
TO	0.47	22.87	23.52	46.76	51.03	55.51	63.98	69.70	75.96	79.45	83.12	86.99	91.06	95.35	99.86	104.61	109.61	114.88	120.43	126.27	132.43	138.93	145.77
TOT	**0.62**	**61.89**	**64.49**	**102.78**	**111.97**	**125.82**	**142.55**	**154.92**	**168.38**	**176.98**	**186.08**	**195.71**	**205.89**	**216.67**	**228.08**	**240.16**	**252.96**	**266.50**	**280.85**	**296.04**	**312.14**	**329.20**	**347.28**

Table 48 - Southern Corridor: total CH_4 (g/y)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
SC	1.35	368.10	386.51	528.52	574.92	663.37	741.25	804.02	871.88	920.09	971.27	1,025.61	1,083.32	1,144.61	1,209.71	1,278.87	1,352.36	1,430.44	1,513.42	1,601.62	1,695.37	1,795.03	1,900.99
TO	4.46	215.79	221.89	441.14	481.40	523.67	603.55	657.54	716.59	749.54	784.21	820.69	859.08	899.50	942.05	986.86	1,034.04	1,083.75	1,136.10	1,191.27	1,249.40	1,310.66	1,375.24
TOT	**5.81**	**583.90**	**608.40**	**969.66**	**1,056.32**	**1,187.03**	**1,344.80**	**1,461.55**	**1,588.47**	**1,669.63**	**1,755.48**	**1,846.30**	**1,942.40**	**2,044.11**	**2,151.76**	**2,265.73**	**2,386.40**	**2,514.19**	**2,649.53**	**2,792.89**	**2,944.77**	**3,105.70**	**3,276.23**

Table 49 - Southern Corridor: total NO_2 (g/y)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
SC	1.27	346.45	363.78	497.43	541.10	624.34	697.65	756.72	820.59	865.97	914.14	965.28	1,019.59	1,077.28	1,138.55	1,203.65	1,272.81	1,346.30	1,424.40	1,507.41	1,595.64	1,689.44	1,789.17
TO	4.20	203.10	208.84	415.19	453.08	492.86	568.05	618.86	674.44	705.45	738.08	772.41	808.55	846.59	886.64	928.81	973.22	1,020.00	1,069.27	1,121.19	1,175.91	1,233.56	1,294.34
TOT	**5.46**	**549.55**	**572.62**	**912.62**	**994.18**	**1,117.21**	**1,265.69**	**1,375.58**	**1,495.03**	**1,571.42**	**1,652.21**	**1,737.69**	**1,828.14**	**1,923.87**	**2,025.19**	**2,132.45**	**2,246.02**	**2,366.29**	**2,493.67**	**2,628.60**	**2,771.55**	**2,923.01**	**3,083.51**

Table 50 - Southern Corridor: total CO_2e (Mg/y)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
SC	0.14	39.13	41.09	56.18	61.12	70.52	78.80	85.47	92.68	97.81	103.25	109.03	115.16	121.68	128.60	135.95	143.76	152.06	160.88	170.26	180.22	190.82	202.08
TO	0.47	22.94	23.59	46.90	51.17	55.67	64.16	69.90	76.18	79.68	83.36	87.24	91.32	95.62	100.14	104.91	109.92	115.21	120.77	126.64	132.82	139.33	146.19
TOT	**0.62**	**62.07**	**64.68**	**103.08**	**112.29**	**126.19**	**142.96**	**155.37**	**168.86**	**177.49**	**186.61**	**196.27**	**206.49**	**217.30**	**228.74**	**240.86**	**253.68**	**267.27**	**281.66**	**296.90**	**313.04**	**330.15**	**348.28**

According to the information provided by the “Third national greenhouse gas inventory”, the total amount of CH_4 emissions from the source “Solid Waste Disposal on Land” is 2.65 Gg for the year 2009. Considering, as per IDB “Greenhouse Gas Assessment Emissions Methodology”, a Global Warming Potential (GMP) for the CH_4 equal to 25, the total GHG emissions from this source are 66.25 Gg, namely 66,250 Mg.

Table 51 – Total GHG emissions for year 2009 (Gg) – Source: *“Third national greenhouse gas inventory”* (Caribbean Community Climate Change Centre) (2015)

GHG Source and Sink Category	CO_2 Emission	CO_2 Removal	CH_4	N_2O	NO_X	CO	NMVOC	SO_2	Total
Energy	**445.0355**	**0.0000**	**0.2974**	**0.0408**	**0.0004**	**0.0004**	**0.0004**	**0.0000**	**445.3748**
A. Fuel Combustion	445.0355	0.0000	0.2974	0.0408	0.0004	0.0004	0.0004	0.0000	**445.3748**
Energy Industry	32.9595		0.2755	0.0368	0.0004	0.0004	0.0004	0.0000	33.2730
Manufacturing/Construction Industr	70.3469		0.0056	0.0009	0.0000	0.0000	0.0000	0.0000	70.3534
Transport	247.0243		0.0104	0.0021	0.0000	0.0000	0.0000	0.0000	247.0368
Other	94.7048		0.0058	0.0010	0.0000	0.0000	0.0000	0.0000	94.7116
Industrial Processes	**2.3550**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0757**	**0.0000**	**2.4307**
Mineral Products	2.3550						0.0000		2.3550
Other Production							0.0757		0.0757
Agriculture	**0.0000**	**0.0000**	**5.7774**	**1.5612**	**0.0260**	**0.5008**	**0.0000**	**0.0000**	**7.8654**
Enteric Fermentation			4.8896						4.8896
Manure Management			0.1815	0.9300					1.1115
Rice Cultivation			0.6825						0.6825
Agricultural Soils				0.6305					0.6305
Savannah Burning									0.0000
Agric. Residue Burning			0.0238	0.0007	0.0260	0.5008			0.5514
Land-Use Change & Forestry	**12065.8324**	**-8778.1520**	**39.5735**	**0.3887**	**9.8333**	**346.2682**	**0.0000**	**0.0000**	**12461.8961**
Changes in Woody Biomass Stocks		-8576.4853							-8576.4853
Forest and Grassland Conversion	12324.1113		39.5735	0.3887	9.8333	346.2682			12720.1749
Abandonment of Managed Land		-201.6667							-201.6667
CO2 Emissions/Removals from Soil	-258.2788								-258.2788
Waste	**0.0000**	**0.0000**	**3.5700**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**3.5700**
Solid Waste Disposal on Land			2.6500						2.6500
Wastewater Handling			0.9200						0.9200
Industrial Waste Water			83.9800	0.02					
Total Emissions	**12513.2229**	**-8778.1520**	**49.2183**	**1.9907**	**9.8597**	**346.7694**	**0.0761**	**0.0000**	**12921.1370**
Total Net CO2 Emissions	**3735.0709**								

Under such circumstances and assuming, as conservative hypothesis, that:

- total GHG emissions value from waste transportation will be constant for the next years, considering that the foreseen increase in waste production will be counterbalanced by the improvement in the efficiency of the SWM;
- the waste generation in Northern and Southern Corridors is about 50% of the overall national waste production for the duration of the plan, and
- taking into account the worst condition, namely the maximum emission value referred to the year 2040 (559.43 Mg);

the total amount of CO_2eq emissions from the waste transportation, is about 0.85% of the overall emission of the waste sector at the national level, and about 1.70% of the emissions, if referred to the Northern and Southern corridors only (the 50% of the overall waste produced at national level).

Therefore, in general terms, the intensity of this impact can be assessed as “negligible”.

The duration of this impact is equal to the duration of the transportation activity, so, according to the evaluation criteria adopted, is "short term". The effects of GHG emissions are wide-ranging due to the extension of the waste transportation pattern, so the spatial extent of the impact can be assumed as "far-range". Finally, the probability of the impact is assumed as "definite".

Therefore the *Emissions of air pollutants and greenhouse gases from the vehicles used for the transportation* is classified as a medium priority impact.

25.1.2 Soil, ground and surface water quality

25.1.2.1 Accidental spillage or leakage of fuel may cause soil or ground/surface water contamination

The potential impacts on the receptors "Soil" and "Ground and surface water quality**"** are assessed together. The soil or water contamination can be caused by accidental spillage or leakage of fuel from the vehicles utilized for the waste transportation.
Taking into account:

- the modest amount of fuel contained in the tank of the vehicles;
- the possibility of confining the spillage/leakage and thus mitigating the liquid diffusion;

The intensity of this impact can be assumed as "negligible", the duration of the impact "short term" and the spatial extent "localized". About the probability, it is worth outline that the spillages or leakages are accidental, so the probability of the impact can be assumed as "unlikely".

Therefore the potential impact *Accidental spillage or leakage of fuel may cause soil or ground/surface water contamination* has a low priority.

25.1.3 Flora and fauna

25.1.3.1 Potential indirect impacts related to the deterioration of the quality of air, of soil or of ground and surface water

As above underlined, the present environmental impacts assessment is referred to a preliminary stage of the SWM system planning, so the assessment itself is at a preliminary level. In particular, in this phase, the sensitivity of the animal and vegetal species possibly affected by the impacts, due to waste transportation, has not been determined. Therefore the priority of these indirect impacts is assessed without considering the specific sensitivity of the different receptor species, but following the evaluations already conducted about the impacts on the quality of soil, surface and ground water and air.

So, in general terms, *the potential indirect impacts related to the deterioration of the quality of air, of soil or of ground and surface water* have a low priority.

Table 52 – Waste transportation impacts assessment

Waste Transportation	Landscape and natural scenery	Intensity	Duration	Spatial extent	Probability	Priority
Waste transportation	None	-	-	-	-	
Waste Transportation	**Archaeological, cultural and historical resources**					
Waste transportation	None	-	-	-	-	
Waste Transportation	**Air quality and climate**					
Waste transportation	Emissions of air pollutants and greenhouse gases from the vehicles used for the transportation	negligible	short term	far range	definite	**medium**
Waste Transportation	**Soils**					
Waste transportation	Accidental spillage or leakage of fuel may cause soil contamination	negligible	short-term	localized	unlikely	**low**
Waste Transportation	**Ground and surface water quality**					
Waste transportation	Accidental spillage or leakage of fuel may cause surface water contamination	negligible	short-term	localized	unlikely	**low**
Waste Transportation	**Flora and fauna**					
Waste transportation	potential indirect impacts related to the deterioration of the quality of air, of soil or of ground and surface water	negligible	short-term	localized	unlikely	**low**

25.2 **Drop Off Centres**

In the present section, on the basis of the criterion adopted, for each receptor, the potential environmental impacts are rated. The results of this assessment are shown in Table 53**Error! Reference source not found.**.

25.2.1 Landscape and natural scenery

25.2.1.1 Alteration of the landscape.

DOCs are foreseen to be built in urban areas or in the immediate nearby. Moreover DOC is a small size plant, without significant buildings, and, according to the conceptual design, at the perimeter of the plant is foreseen a vegetated screen in order to mitigate this impact. Therefore the intensity of this impact can be assessed as “negligible” and the duration of the impact is “short-term”, in accordance with the established criteria (its duration is equal to the duration of the plant). The spatial extent of this impact is “mid-range”, since the alteration of the landscape is noticeable from a distance of plant beyond 100 m. The probability of the impact is definite.

Therefore the impact *Alteration of the landscape* has a low priority.

25.2.2 Archaeological, cultural and historical resources

25.2.2.1 Damage of the site

All the DOCs shall be built at an adequate distance from possible archaeological or historical sites, already known, in the aim to not damage historical interest monuments. The highest probability of occurrences of finds is during the excavation works and, as per the conceptual design of the DOC, significant excavation works will not be reasonably foreseeable. Taking into account the high historical and cultural value of finds, the intensity of this impact can be rated as “severe”, the duration of the impact can be assumed as “medium” and the spatial extent “localized”. The probability of the impact can be assessed as “possible”.

Therefore the impact *Damage of the site* has a medium priority.

The intensity and the duration of this impact may be lowered through the implementation of an operating procedure aimed to avoid the damage to the archaeological findings.
The ESMP attached to the present report foresees a procedure according to which if during the construction works they were any archaeological finds, the works would be immediately stopped and, following the suggestions provided by the competent authority, the finds would be properly managed.
The ESMP envisages that the Contractor, before the commencement of the construction works, shall establish and submit to SWaMA a procedure to be adopted in case of archaeological finds. The procedure shall include:

a. Information and training of the personnel involved in the construction works;
b. Name and contacts numbers of people to be informed in case of archaeological finds;

c. Instruction on how to preserve the finds and secure the site until inspection by relevant authorities.

The implementation of this operational procedure may mitigate the intensity of the impact to a "notable" class and the duration of the impact to a "short-term" one.

Therefore the priority of the impact *Damage of the site* is deemed to be mitigated to low class.

25.2.3 Air quality and climate

25.2.3.1 Emissions of air pollutants and greenhouse gases from the vehicles used for the construction

Taking into account the general layout of the plant, it can be foreseen that the number of work vehicles used at the same time for the construction will be limited to two or three units. Moreover the duration of the construction works will be limited to 2 or 3 months.
Therefore the intensity of these impacts can be assumed as "negligible", the duration "short-term", the spatial extent "mid-range" and the probability "definite".

Therefore the impact *Emissions of air pollutants and greenhouse gases from the vehicles used for the construction* has a low priority.

25.2.3.2 Increasing of noise levels in the area surrounding the plant.

Considering the construction conditions described above and the typical noise emissions of work vehicles, the intensity of these impacts can be assumed as "notable", the duration "short-term", the spatial extent "mid-range" and the probability "definite".

Therefore the impact *Increasing of noise levels in the area surrounding the plant* has a medium priority.

25.2.3.3 Emissions of air pollutants and greenhouse gases from the vehicles used for waste handling and increasing of noise levels in the area surrounding the plant.

No vehicles are used for the waste handling. Considering the low quantities of waste collected in each centre, the number of trips estimated from each DOC to TS or Landfill is very low.
So the intensity of both these impacts can be assumed as "negligible", the duration "short-term", the spatial extent "localized" and the probability "definite".

Therefore the impact *Emissions of air pollutants and greenhouse gases from the vehicles used for waste handling and increasing of noise levels in the area surrounding the plant* has a low priority.

25.2.3.4 Emissions of odours from the waste during the composting and from the wastewater treatment

Waste composting can cause the emission of odour nuisance, if the process is not properly managed, so the intensity of this impact can be assumed as “notable”, the duration “short-term”, the spatial extent “mid-range” and the probability “possible”.

Therefore the impact *Emissions of odours from the waste during the composting and from the wastewater treatment* has a medium priority.

The ESMP attached at the present report provides an operating procedure aimed to prevent odour nuisance due to the composting activities. So, through the implementation of this procedure the intensity of this impact may be lowered to a “negligible” class and the probability to an “unlikely” class.

Therefore the intensity of the impact *Emissions of odours from the waste during the composting and from the wastewater treatment* is deemed to be mitigated to a low class.

25.2.4 Soil, ground and surface water quality

25.2.4.1 Accidental spillage or leakage of fuel may cause soil or ground/surface water contamination

The impacts on the receptors “Soil” and “Ground and surface water quality**”** are assessed together in the two considered phases. The soil or water contamination can be caused by accidental spillage or leakage of fuel from the vehicles utilized for the construction of the plant and the waste handling.
Taking into account:

- the modest amount of fuel contained in the tank of the vehicles, and;
- the possibility of bordering the spillage/leakage, mitigating the liquid diffusion;

The intensity of this impact can be assumed as “negligible”, the duration of the impact “short term” and the spatial extent “localized”. About the probability, it is worth outline that the spillages or leakages are accidental, so the probability of the impact can be assumed as “unlikely”.

Therefore the impact *Accidental spillage or leakage of fuel may cause soil or ground/surface water contamination* has a low priority.

25.2.4.2 Accidental leakage from the section for the hazardous waste collection may cause soil, ground and surface water contamination.

The impacts on the receptors “Soil” and “Ground and surface water quality**”** are assessed together. The soil or water contamination can be caused by accidental leakage from the section of the plant utilized for the collection of hazardous waste.
Taking into account:

- the modest amount of hazardous waste stored at the same time in the plant, and;
- the possibility of confining the leakage, mitigating the liquid diffusion;

The intensity of this impact can be assumed as “negligible”, the duration of the impact “short term” and the spatial extent “localized”. About the probability, it is worth outline that the spillages or leakages are accidental, so the probability of the impact can be assumed as “unlikely”.

Therefore the impact *Accidental leakage from the section for the hazardous waste collection may cause soil, ground and surface water contamination* has a low priority.

25.2.5 Flora and fauna

25.2.5.1 Potential indirect impacts related to the deterioration of the quality of air, of soil or of ground and surface water

As above underlined, the present environmental impacts assessment is referred to a preliminary stage of the SWM system planning, so the assessment itself is at a preliminary level. In particular, in this phase, the sensitivity of the animal and vegetal species possibly affected by the impacts, has not been determined. Therefore the priority of these indirect impacts is assessed without considering the specific sensitivity of the different receptor species, but in accordance to the evaluations already conducted about the impacts on the quality of soil, surface and ground water and air.

So, in general terms, *the potential indirect impacts related to the deterioration of the quality of air, of soil or of ground and surface water* have a low priority*.*

It is worth to recall that the DOCs will be located within urban areas or in the immediate surroundings, and, that pretty much all the impacts related to the operation of this facility have a “localized” extension. Therefore is deemed to be reasonably foreseeable that the impacts so far identified and assessed will be “limited” within compromised areas (such as urban areas), therefore they will slightly affect the flora and the fauna.

Table 53 – Drop off centre – Potential impacts assessment

Drop off centre	Landscape and natural scenery	Intensity	Duration	Spatial extent	Probability	Priority
Construction/Decommissioning	alteration of the landscape	negligible	short-term	mid-range	definite	**low**
Operation	alteration of the landscape	negligible	short-term	mid-range	definite	**low**
Drop off centre	**Archaeological, cultural and historical resources**					
Construction/Decommissioning	damage of the site	notable	short-term	localized	possible	**low**
Drop off centre	**Air quality and climate**					
Construction/Decommissioning	Emissions of air pollutants and greenhouse gases from the vehicles used for the construction	negligible	short-term	mid-range	definite	**low**
	Increasing of noise levels in the area surrounding the plant	notable	short-term	mid-range	definite	**medium**
Operation	Emissions of air pollutants and greenhouse gases from the vehicles used for the waste handling	negligible	short-term	localized	definite	**low**
	Emissions of odour from the waste during the composting and from the wastewater treatment	negligible	short-term	mid-range	unlikely	**low**
	Increasing of noise levels in the area surrounding the plant	negligible	short-term	localized	definite	**low**
Drop off centre	**Soils**					
Construction/Decommissioning	Accidental spillage or leakage of fuel from vehicles may cause soil contamination	negligible	short-term	localized	unlikely	**low**
Operation	Accidental spillage or leakage of fuel	negligible	short-	localized	unlikely	**low**

	from vehicles may cause soil contamination		term			
	Accidental leakage from the sections for the hazardous waste collection may cause soil contamination	negligible	short-term	localized	unlikely	**low**
Drop off centre	**Ground and surface water quality**					
Construction/Decommissioning	Accidental spillage or leakage of fuel may cause surface water contamination	negligible	short-term	localized	unlikely	**low**
Operation	Accidental spillage or leakage of fuel may cause surface water contamination	negligible	short-term	localized	unlikely	**low**
	Accidental leakage from the sections for the hazardous waste collection may cause waters contamination	negligible	short-term	localized	unlikely	**low**
Drop off centre	**Flora and fauna**					
Construction/Decommissioning	potential indirect impacts related to the deterioration of the quality of air, of soil or of ground and surface water	negligible	short-term	mid-range	definite	**low**
Operation	potential indirect impacts related to the deterioration of the quality of air, of soil or of ground and surface water	negligible	short-term	mid-range	definite	**low**

25.3 **Transfer Stations**

The SWM system foreseen by the present Master Plan is based on the construction of six TSs. Four sites for their location have been identified (see Section 19) and listed below:

- Northern Corridor: Orange Walk;
- Southern Corridor: Independence, Dangriga, Punta Gorda.

The site selection process for the location of the TS respectively in the areas close to Corozal and Placencia is still ongoing.

Three of the four sites identified coincide with the sites of the current dumpsites (Orange Walk, Independence) or are located in the nearby (Dangriga) and the fourth one is a vegetation cleared area adjacent to a timber yard (Punta Gorda).

The site screening process has been prevalently focused on sites already compromised that have been interested by activities with significant impacts (dump, borrow pit). The first assessed option, therefore, has been the possibility to locate the TSs in the current dumpsites. In the cases of Punta Gorda, Placencia and Corozal the location of the dumpsite is nevertheless not such to satisfy the necessary criteria for accommodating the TS.
In these cases the screening process continued focusing on sites already affected by previous activities.

The adopted criteria were then to prevent possible impacts in the first instance by avoiding sites with a high environmental value and high sensitivity to the impacts due the construction and operation of the TS.
Besides, since most of the sites proposed have already been interested by excavation works, the probability of archaeological finds is significantly reduced.

In the following sections the assessment of the potential environmental impacts due to the construction and operation of the TSs in the different proposed locations is discussed.

25.3.1 Orange Walk

On the basis of the adopted criteria the potential environmental impacts are rated for each receptor.

25.3.1.1 Landscape and natural scenery

25.3.1.1.1 Alteration of the landscape.

Taking into account the general layout of a TS and the likelihood to improve the structure with additional services, it can be envisaged that at least one structure of appreciable size shall be built. Therefore the intensity of this impact can be assessed as “notable”. The duration of the impact is “short-term”, because is equal to the duration of the plant. The spatial extent of this impact is “mid-range”, because the alteration of the landscape is noticeable from a distance greater than 100 m. The probability of the impact is definite.

Therefore the potential impact *Alteration of the landscape* has a medium priority.

25.3.1.2 Archaeological, cultural and historical resources

25.3.1.2.1 Damage of the site

All the TSs shall be built at an adequate distance from possible archaeological or historical sites, already known, in the aim to not damage historical interest monuments.
Taking into account the high historical and cultural value of finds, the intensity of this impact can be rated as “severe”, the duration of the impact can be assumed as “medium” and the spatial extent “localized”. Considering that the site has been since long used as dump the probability that archaeological finds might occur during the construction works is very low, so the probability of the impact can be assessed as “unlikely”.

Therefore the potential impact *Damage of the site* has a medium priority.

The intensity and the duration of this impact may be lowered through the implementation of an operating procedure aimed to avoid the damage to the archaeological findings.
The ESMP attached to the present report foresees a procedure according to which if during the construction works they were any archaeological finds, the works would be immediately stopped and, following the suggestions provided by the competent authority, the finds would be properly managed.
The ESMP envisages the Contractor, before the commencement of the construction works, shall establish and submit to SWaMA a procedure to be adopted in case of archaeological finds. The procedure shall include:

a. Information and training of the personnel involved in the construction works;
b. Name and contacts numbers of people to be informed in case of archaeological finds;
c. Instruction on how to preserve the finds and secure the site until inspection by relevant authorities.

The implementation of this operational procedure may mitigate the intensity of the impact to a “notable” class and the duration of the impact to a “short-term” one.

Therefore the priority of the potential impact *Damage of the site* is deemed to be mitigated to low class.

25.3.1.3 Air quality and climate

25.3.1.3.1 Emissions of air pollutants and greenhouse gases from the vehicles used for the construction

Taking into account the general layout of the plant, it can be foreseen that the number of operating machines used at the same time for the construction will be limited to two or three units. Moreover the duration of the building works will be limited to 6 or 8 months.
Therefore the intensity of these impacts can be assumed as “negligible”, the duration “short-term”, the spatial extent “mid-range” and the probability “definite”.

Therefore the potential impact *Emissions of air pollutants and greenhouse gases from the vehicles used for the construction* has a low priority.

25.3.1.3.2 Increasing of noise levels in the area surrounding the plant.

Considering the above described construction conditions and the typical noise emissions of operating machines, the intensity of these impacts can be assumed as “notable”, the duration “short-term”, the spatial extent “mid-range” and the probability “definite”.

Therefore the potential impact *Increasing of noise levels in the area surrounding the plant* has a medium priority.

25.3.1.3.3 Emissions of air pollutants and greenhouse gases from the vehicles used for the waste handling and increasing of noise levels in the area surrounding the plant.

According to the assumptions of this Plan, only one machine is used for waste handling and the number of trips of the vehicles that unload or upload the waste is low.
So the intensity of these impacts can be assumed as “negligible”, the duration “short-term”, the spatial extent “localized” and the probability “definite”.

Therefore the potential impacts *Emissions of air pollutants and greenhouse gases from the vehicles used for waste handling and increasing of noise levels in the area surrounding the plant* have a low priority.

25.3.1.3.4 Emissions of odour from the waste handling operations and from the wastewater treatment

Waste handling and waste water treatment can cause the emission of odour, if the processes are not properly managed.
So the intensity of this impact can be assumed as “notable”, the duration “medium”, the spatial extent “mid-range” and the probability “possible”.

Therefore the potential impact *Emissions of odour from the waste during the handling and from the wastewater treatment* has a medium priority.

The ESMP attached at the present report provides an operating procedure aimed to prevent odour nuisance due to the waste processing and wastewater treatment. So, through the implementation of this procedure the intensity of this impact may be lowered to a “negligible” class, the duration to a “short term” class and the probability to an “unlikely” class.

Therefore the intensity of the impact *Emissions of odours from the waste during the handling and from the wastewater treatment* is deemed to be mitigated to a low class.

Besides the ESMP foresees an Odour Monitoring Program that will include a survey of the sensitive receptors in the vicinity of the TS.

25.3.1.4 Soil, ground and surface water quality

25.3.1.4.1 Accidental spillage or leakage of fuel may cause soil or ground/surface water contamination

The impacts on the receptors "Soil" and "Ground and surface water quality**"** are assessed together. The soil or water contamination can be caused by accidental spillage or leakage of fuel from the vehicles utilized for the construction of the plant and the waste handling.
Taking into account:

- the modest amount of fuel contained in the tank of the vehicles;
- the possibility of confining the spillage/leakage, mitigating the liquid diffusion;

The intensity of this impact can be assumed as "negligible", the duration of the impact "short term" and the spatial extent "localized". About the probability, it is worth outline that the spillages or leakages are accidental, so the probability of the impact can be assumed as "unlikely".

Therefore the potential impact *Accidental spillage or leakage of fuel may cause soil or ground/surface water contamination* has a low priority.

25.3.1.4.2 Accidental leakage from the section for the hazardous waste collection may cause soil, ground and surface water contamination.

The impacts on the receptors "Soil" and "Ground and surface water quality**"** are assessed together. The soil or water contamination can be caused by accidental leakage from the section of the plant utilized for the collection of hazardous waste.
Taking into account:

- the modest amount of hazardous waste stored at the same time in the plant, and;
- the possibility of confining the leakage, mitigating the liquid diffusion;

The intensity of this impact can be assumed as "negligible", the duration of the impact "short term" and the spatial extent "localized". About the probability, it is worth outline that the spillages or leakages are accidental, so the probability of the impact can be assumed as "unlikely".

Therefore the potential impact *Accidental leakage from the section for the hazardous waste collection may cause soil, ground and surface water contamination* has a low priority.

25.3.1.5 Flora and fauna

25.3.1.5.1 Potential indirect impacts related to the deterioration of the quality of air, of soil or of ground and surface water

The environmental conditions of the site and of the area surrounding have been affected by the current activity of dumping.
The harmful emissions on air and ground water related to the current activity have strongly affected the quality of this natural elements. The current impacts on this receptors, in fact, are more significant than the ones assessed for the TS so far. The impacts related to the current activity have compromised the natural habitats (flora and fauna).

Therefore the priority of these indirect impacts is assessed without considering the specific sensitivity of the different receptor species, but following the evaluations already conducted about the impacts on the quality of soil, surface and ground water and air.

So, in general terms, *the potential indirect impacts related to the deterioration of the quality of air, of soil or of ground and surface water* have a low priority.

25.3.1.6 Loss or damage of vegetation and habitat for wildlife

The environmental conditions of the site and of the area surrounding have been affected by the current activity of dumping. Therefore no sensitive habitats for wildlife are expected to be present in the site of the dump and in the nearby. The remediation of the dumpsite will encourage the partial restoration of habitats for wildlife and the construction and operation of a TSs will be strategic in the aim:

i. to guarantee the maintenance of the remediated dump and, thus, the efficacy of all the mitigation actions put in place, and;
ii. to avoid that illegal dumping practices will take place in the site once remediated.

Therefore, taking into account all these aspects, it can be assumed that **the presence of a TS in this site will not determine a negative impact on the natural habitat.**

The outcomes of the impacts rating show that almost all the expected impacts have a low priority, especially in the “operation” phase that has the longest duration.

Moreover it has to be highlighted that the maximum spatial extent of all the rated impacts is “mid-range” (effects of the impacts can affect within a distance of 1,000 m from the origin). No human settlements are present within a 2,000 m distance from the site.

Taking into account all these aspects it can be assumed that the construction and operation of a TS in this site is sustainable in environmental terms.

25.3.2 Dangriga

25.3.2.1 Landscape and natural scenery

25.3.2.1.1 Alteration of the landscape.

Taking into account the general layout of a TS and the likelihood to improve the structure with additional services, it can be envisaged that at least one structure of appreciable size shall be built. Therefore the intensity of this impact can be assessed as “notable” and the duration of the impact is “short-term”, because it is equal to the duration of the plant. The spatial extent of this impact is “mid-range”, because the alteration of the landscape is noticeable from a distance greater than 100 m. The probability of the impact is definite.

Therefore the potential impact *Alteration of the landscape* has a medium priority.

25.3.2.2 Archaeological, cultural and historical resources

25.3.2.2.1 Damage of the site

All the TSs shall be built at an adequate distance from possible archaeological or historical sites, already known, in the aim to not damage historical interest monuments. Taking into account the high historical and cultural value of finds, the intensity of this impact can be rated as “severe”, the duration of the impact can be assumed as “medium” and the spatial extent “localized”. Considering that the site has been already interested by excavation works, the probability that archaeological finds might occur during the construction works is very low, so the probability of the impact can be assessed as “unlikely”.

Therefore the potential impact *Damage of the site* has a medium priority.

Taking into account the high historical and cultural value of finds, the intensity of this impact can be rated as “notable”, but considering the timely interruption of the works the duration of the impact can be assumed as “short-term” and the spatial extent localized. The probability of the impact can be assessed as “possible”.

Therefore the potential impact *Damage of the site* has a low priority.

The intensity and the duration of this impact may be lowered through the implementation of an operating procedure aimed to avoid the damage to the archaeological findings.
The ESMP attached to the present report foresees a procedure according to which if during the construction works they were any archaeological finds, the works would be immediately stopped and, following the suggestions provided by the competent authority, the finds would be properly managed.
The ESMP envisages that the Contractor, before the commencement of the construction works, shall establish and submit to SWaMA a procedure to be adopted in case of archaeological finds. The procedure shall include:

a. Information and training of the personnel involved in the construction works;
b. Name and contacts numbers of people to be informed in case of archaeological finds;
c. Instruction on how to preserve the finds and secure the site until inspection by relevant authorities.

The implementation of this operational procedure may mitigate the intensity of the impact to a “notable” class and the duration of the impact to a “short-term” one.

Therefore the priority of the potential impact *Damage of the site* is deemed to be mitigated to low class.

25.3.2.3 Air quality and climate

25.3.2.3.1 Emissions of air pollutants and greenhouse gases from the vehicles used for the construction

Taking into account the general layout of the plant, it can be foreseen that the number of operating machines used at the same time for the construction will be limited to two or three units. Moreover the duration of the building works will be limited to 6 or 8 months.
Therefore the intensity of these impacts can be assumed as “negligible”, the duration “short-term”, the spatial extent “mid-range” and the probability “definite”.

Therefore the potential impact *Emissions of air pollutants and greenhouse gases from the vehicles used for the construction* has a low priority.

25.3.2.3.2 Increasing of noise levels in the area surrounding the plant.

Considering the construction conditions described above and the typical noise emissions of operating machines, the intensity of these impacts can be assumed as “notable”, the duration “short-term”, the spatial extent “mid-range” and the probability “definite”.

Therefore the potential impact *Increasing of noise levels in the area surrounding the plant* has a medium priority.

25.3.2.3.3 Emissions of air pollutants and greenhouse gases from the vehicles used for the waste handling and increasing of noise levels in the area surrounding the plant.

According to the assumptions of this Plan, only one vehicle is used for waste handling.
So the intensity of these impacts can be assumed as “negligible”, the duration “short-term”, the spatial extent “localized” and the probability “definite”.

Therefore the potential impacts *Emissions of air pollutants and greenhouse gases from the vehicles used for waste handling and increasing of noise levels in the area surrounding the plant* have a low priority.

25.3.2.3.4 Emissions of odour from the waste handling operations and from the wastewater treatment

Waste handling and wastewater treatment can cause the emission of odour, if the processes are not properly managed.
So the intensity of this impact can be assumed as “notable”, the duration “medium”, the spatial extent “mid-range” and the probability “possible”.

Therefore the potential impact *Emissions of odour from the waste during the handling and from the wastewater treatment* has a medium priority.

The ESMP attached at the present report provides an operating procedure aimed to prevent odour nuisance due to the waste processing and wastewater treatment. So, through the implementation of this procedure the intensity of this impact may be lowered to a “negligible” class, the duration to a “short term” class and the probability to an “unlikely” class.

Therefore the intensity of the impact *Emissions of odours from the waste during the handling and from the wastewater treatment* is deemed to be mitigated to a low class.

Moreover the ESMP foresees an Odour Monitoring Program that will include a survey of the sensitive receptors in the vicinity of the TS.

25.3.2.4 Soil, ground and surface water quality

25.3.2.4.1 Accidental spillage or leakage of fuel may cause soil or ground/surface water contamination

The impacts on the receptors "Soil" and "Ground and surface water quality**"** are assessed together. The soil or water contamination can be caused by accidental spillage or leakage of fuel from the vehicles utilized for the construction of the plant and the waste handling.
Taking into account:

- the modest amount of fuel contained in the tank of the vehicles;
- the possibility of confining the spillage/leakage, mitigating the liquid diffusion;

The intensity of this impact can be assumed as "negligible", the duration of the impact "short term" and the spatial extent "localized". About the probability, it is worth outline that the spillages or leakages are accidental, so the probability of the impact can be assumed as "unlikely".

Therefore the potential impact *Accidental spillage or leakage of fuel may cause soil or ground/surface water contamination* has a low priority.

25.3.2.4.2 Accidental leakage from the section for the hazardous waste collection may cause soil, ground and surface water contamination.

The impacts on the receptors "Soil" and "Ground and surface water quality**"** are assessed together. The soil or water contamination can be caused by accidental leakage from the section of the plant utilized for the collection of hazardous waste.
Taking into account:

- the modest amount of hazardous waste stored at the same time in the plant, and;
- the possibility of confining the leakage, mitigating the liquid diffusion;

The intensity of this impact can be assumed as "negligible", the duration of the impact "short term" and the spatial extent "localized". About the probability, it is worth outline that the spillages or leakages are accidental, so the probability of the impact can be assumed as "unlikely".

Therefore the potential impact *Accidental leakage from the section for the hazardous waste collection may cause soil, ground and surface water contamination* has a low priority.

25.3.2.5 Flora and fauna

25.3.2.5.1 Potential indirect impacts related to the deterioration of the quality of air, of soil or of ground and surface water

The site is adjacent to the present Dangriga dumpsite. It is almost completely free of vegetation and some minor excavation activity is evident. The current and previous activities done in this area and in the nearby have already affected the natural environment. Therefore no sensitive habitats for wildlife are present in the site of the dump and in the nearby excavated area.

Therefore the priority of these indirect impacts is assessed without considering the specific sensitivity of the different receptor species, but following the evaluations already conducted about the impacts on the quality of soil, surface and ground water and air.

So, in general terms, *the potential indirect impacts related to the deterioration of the quality of air, of soil or of ground and surface water* have a low priority*.*

25.3.2.5.2 Loss or damage of vegetation and habitat for wildlife

The site is adjacent to the present Dangriga dumpsite. It is almost free of vegetation and some minor excavation activity is evident. The current and previous activities done in this area and in the nearby have already affected the environment. Therefore no sensitive habitats for wildlife are present in the site of the dump and in the nearby excavated area.
The construction and operation of a TS will not cause a loss of vegetation.
Moreover the remediation of the adjacent dumpsite will encourage the restoration of habitats for wildlife and the construction and operation of this TS will be strategic in the aim:

i. to guarantee the maintenance of the remediated dump and, thus, the efficacy of all the mitigation actions put in place, and;
ii. to avoid that illegal dumping practices will take place in the site once remediated.

Therefore, taking into account all these aspects, it can be assumed that **the presence of a TS in this site will not have a negative impact on the natural habitat.**

The outcomes of the impacts rating show that almost all the impacts have a low priority, especially in the “operation” phase that has the longest duration.

Moreover it has to be highlighted that all the rated impacts have the maximum spatial extent defined as “mid-range” (the effects of the impacts can affect within a distance of 1,000 m from the origin). No human settlements are present in the area surrounding the site within a 1,000 m distance from the site.

Taking into account all these aspects it can be assumed that the construction and operation of a TS in this site is sustainable in environmental terms.

25.3.3 Independence

25.3.3.1 Landscape and natural scenery

25.3.3.1.1 Alteration of the landscape.

Taking into account the general layout of a TS and the likelihood to improve the structure with additional services, it can be envisaged that at least one structure of appreciable size shall be built. Therefore the intensity of this impact can be assessed as “notable” and the duration of the impact is “short-term”, because is equal to the duration of the plant. The spatial extent of this impact is “mid-range”, because the alteration of the landscape is noticeable from a distance greater than 100 m. The probability of the impact is definite.

Therefore the potential impact *Alteration of the landscape* has a medium priority.

25.3.3.2 Archaeological, cultural and historical resources

25.3.3.2.1 Damage of the site

All the TSs shall be built at an adequate distance from possible archaeological or historical sites, already known, in the aim to not damage historical interest monuments.
Taking into account the high historical and cultural value of finds, the intensity of this impact can be rated as “severe”, the duration of the impact can be assumed as “medium” and the spatial extent “localized”. Considering that the site has been used as a dump since long the probability that archaeological finds might occur during the construction works is very low, so the probability of the impact can be assessed as “unlikely”.

Therefore the potential impact *Damage of the site* has a medium priority.

The intensity and the duration of this impact may be lowered through the implementation of an operating procedure aimed to avoid the damage to the archaeological findings.
The ESMP attached to the present report foresees a procedure according to which if during the construction works they were any archaeological finds, the works would be immediately stopped and, following the suggestions provided by the competent authority, the finds would be properly managed.
The ESMP envisages the Contractor, before the commencement of the construction works, shall establish and submit to SWaMA a procedure to be adopted in case of archaeological finds. The procedure shall include:

a. Information and training of the personnel involved in the construction works;
b. Name and contacts numbers of people to be informed in case of archaeological finds;
c. Instruction on how to preserve the finds and secure the site until inspection by relevant authorities.

The implementation of this operational procedure may mitigate the intensity of the impact to a “notable” class and the duration of the impact to a “short-term” one.

Therefore the priority of the potential impact *Damage of the site* is deemed to be mitigated to low class.

25.3.3.3 Air quality and climate

25.3.3.3.1 Emissions of air pollutants and greenhouse gases from the vehicles used for the construction

Taking into account the general layout of the plant, it can be foreseen that the number of operating machines used at the same time for the construction will be limited to two or three units. Moreover the duration of the building works will be limited to 6 or 8 months.
Therefore the intensity of these impacts can be assumed as “negligible”, the duration “short-term”, the spatial extent “mid-range” and the probability “definite”.

Therefore the potential impact *Emissions of air pollutants and greenhouse gases from the vehicles used for the construction* has a low priority.

25.3.3.3.2 Increasing of noise levels in the area surrounding the plant.

Considering the construction conditions described above and the typical noise emissions of operating machines, the intensity of these impacts can be assumed as “notable”, the duration “short-term”, the spatial extent “mid-range” and the probability “definite”.

Therefore the potential impact *Increasing of noise levels in the area surrounding the plant* has a medium priority.

25.3.3.3.3 Emissions of air pollutants and greenhouse gases from the vehicles used for the waste handling and increasing of noise levels in the area surrounding the plant.

According to the assumptions of this Plan, only one machine is used for waste handling.
So the intensity of these impacts can be assumed as “negligible”, the duration “short-term”, the spatial extent “localized” and the probability “definite”.

Therefore the potential impacts *Emissions of air pollutants and greenhouse gases from the vehicles used for waste handling and increasing of noise levels in the area surrounding the plant* have a low priority.

25.3.3.3.4 Emissions of odour from the waste handling operations and from the wastewater treatment

Waste handling and wastewater treatment can cause the emission of odour, if the processes are not properly managed.
So the intensity of this impact can be assumed as “notable”, the duration “medium”, the spatial extent “mid-range” and the probability “possible”.

Therefore the potential impact *Emissions of odour from the waste during the handling and from the wastewater treatment* has a medium priority.

The ESMP attached at the present report provides an operating procedure aimed to prevent odour nuisance due to the waste processing and wastewater treatment. So, through the implementation of this procedure the intensity of this impact may be lowered to a “negligible” class, the duration to a “short term” class and the probability to an “unlikely” class.

Therefore the intensity of the impact *Emissions of odours from the waste during the handling and from the wastewater treatment* is deemed to be mitigated to a low class.

Moreover the ESMP foresees an Odour Monitoring Program that will include a survey of the sensitive receptors in the vicinity of the TS.

25.3.3.4 Soil, ground and surface water quality

25.3.3.4.1 Accidental spillage or leakage of fuel may cause soil or ground/surface water contamination

The impacts on the receptors "Soil" and "Ground and surface water quality**"** are assessed together. The soil or water contamination can be caused by accidental spillage or leakage of fuel from the vehicles utilized for the construction of the plant and the waste handling.
Taking into account:

- the modest amount of fuel contained in the tank of the vehicles;
- the possibility of confining the spillage/leakage, mitigating the liquid diffusion;

The intensity of this impact can be assumed as "negligible", the duration of the impact "short term" and the spatial extent "localized". About the probability, it is worth outline that the spillages or leakages are accidental, so the probability of the impact can be assumed as "unlikely".

Therefore the potential impact *Accidental spillage or leakage of fuel may cause soil or ground/surface water contamination* has a low priority.

25.3.3.4.2 Accidental leakage from the section for the hazardous waste collection may cause soil, ground and surface water contamination.

The impacts on the receptors "Soil" and "Ground and surface water quality**"** are assessed together. The soil or water contamination can be caused by accidental leakage from the section of the plant utilized for the collection of hazardous waste.
Taking into account:

- the modest amount of hazardous waste stored at the same time in the plant, and;
- the possibility of confining the leakage, mitigating the liquid diffusion;

The intensity of this impact can be assumed as "negligible", the duration of the impact "short term" and the spatial extent "localized". About the probability, it is worth outline that the spillages or leakages are accidental, so the probability of the impact can be assumed as "unlikely".

Therefore the potential impact *Accidental leakage from the section for the hazardous waste collection may cause soil, ground and surface water contamination* has a low priority.

25.3.3.5 Flora and fauna

25.3.3.5.1 Potential indirect impacts related to the deterioration of the quality of air, of soil or of ground and surface water

The environmental conditions of the site and of the area surrounding have been affected by the current activity of dumping.

The harmful emissions on air and ground water related to the current activity have strongly affected the quality of this natural elements. The current impacts on this receptors, in fact, are more significant than the ones assessed for the TS so far. The impacts related to the current activity have compromised the natural habitats (flora and fauna).
Therefore the priority of these indirect impacts is assessed without considering the specific sensitivity of the different receptor species, but following the evaluations already conducted about the impacts on the quality of soil, surface and ground water and air.

So, in general terms, *the potential indirect impacts related to the deterioration of the quality of air, of soil or of ground and surface water* have a low priority.

25.3.3.5.2 Loss or damage of vegetation and habitat for wildlife

The environmental conditions of the site and of the area surrounding have been affected by the current activity of dumping. Therefore no sensitive habitats for wildlife are present in the site of the dump and in the nearby.
As reported by the Forest Department, the Mango Creek Forest Reserve (4), in which the site was included, no longer exists and the area has been de-reserved.
The remediation of the dumpsite will encourage the restoration of habitats for wildlife and the construction and operation of a TS will be strategic in the aim:

i. to guarantee the maintenance of the remediated dump and, thus, the efficacy of all the mitigation actions put in place, and;
ii. to avoid that illegal dumping practices will take place in the site once remediated.

Therefore, taking into account all these aspects, it can be assumed that **the presence of a TS in this site will not have a negative impact on the restoration of the natural habitat, due to the remediation actions.**

The outcomes of the impacts rating show that almost all the impacts have a low priority, especially in the “operation” phase that has the longest duration.

Moreover it has to be highlighted that all the impacts rated have the maximum spatial extent defined as “mid-range” (the effects of the impacts can affect within a distance of 1,000 m from the origin). No human settlements are present in the area surrounding the site within a 1,000 m distance from the site.

Taking into account all these aspects it can be assumed that the construction and operation of a TSs in this site is sustainable in environmental terms.

25.3.4 Punta Gorda

25.3.4.1 Landscape and natural scenery

25.3.4.1.1 Alteration of the landscape.

Taking into account the general layout of a TS and the likelihood to improve the structure with additional services, it can be envisaged that at least one structure of appreciable size shall be built. Therefore the intensity of this impact can be assessed as "notable" and the duration of the impact is "short-term", because is equal to the duration of the plant. The spatial extent of this impact is "mid-range", because the alteration of the landscape is noticeable from a distance of plant beyond 100 m. The probability of the impact is definite.

Therefore the potential impact *Alteration of the landscape* has a medium priority.

25.3.4.2 Archaeological, cultural and historical resources

25.3.4.2.1 Damage of the site

All the TSs shall be built at an adequate distance from possible archaeological or historical sites, already known, in the aim to not damage historical interest monuments.
Taking into account the high historical and cultural value of finds, the intensity of this impact can be rated as "severe", the duration of the impact can be assumed as "medium" and the spatial extent "localized". The probability of the impact can be assessed as "possible".

Therefore the potential impact *Damage of the site* has a medium priority.

The intensity and the duration of this impact may be lowered through the implementation of an operating procedure aimed to avoid the damage to the archaeological findings.
The ESMP attached to the present report foresees a procedure according to which if during the construction works they were any archaeological finds, the works would be immediately stopped and, following the suggestions provided by the competent authority, the finds would be properly managed.
The ESMP envisages the Contractor, before the commencement of the construction works, shall establish and submit to SWaMA a procedure to be adopted in case of archaeological finds. The procedure shall include:

a. Information and training of the personnel involved in the construction works;
b. Name and contacts numbers of people to be informed in case of archaeological finds;
c. Instruction on how to preserve the finds and secure the site until inspection by relevant authorities.

The implementation of this operational procedure may mitigate the intensity of the impact to a "notable" class and the duration of the impact to a "short-term" one.

Therefore the priority of the potential impact *Damage of the site* is deemed to be mitigated to low class.

25.3.4.3 Air quality and climate

25.3.4.3.1 Emissions of air pollutants and greenhouse gases from the vehicles used for the construction

Taking into account the general layout of the plant, it can be foreseen that the number of operating machines used at the same time for the construction will be limited to two or three units. Moreover the duration of the building works will be limited to 6 or 8 months.

Therefore the intensity of these impacts can be assumed as “negligible”, the duration “short-term”, the spatial extent “mid-range” and the probability “definite”.

Therefore the potential impact *Emissions of air pollutants and greenhouse gases from the vehicles used for the construction* has a low priority.

25.3.4.3.2 Increasing of noise levels in the area surrounding the plant.

Considering the construction conditions described above and the typical noise emissions of operating machines, the intensity of these impacts can be assumed as “notable”, the duration “short-term”, the spatial extent “mid-range” and the probability “definite”.

Therefore the potential impact *Increasing of noise levels in the area surrounding the plant* has a medium priority.

25.3.4.3.3 Emissions of air pollutants and greenhouse gases from the vehicles used for the waste handling and increasing of noise levels in the area surrounding the plant.

According to the assumptions of this Plan, only one machine is used for waste handling.
So the intensity of these impacts can be assumed as “negligible”, the duration “short-term”, the spatial extent “localized” and the probability “definite”.

Therefore the potential impacts *Emissions of air pollutants and greenhouse gases from the vehicles used for waste handling and increasing of noise levels in the area surrounding the plant* have a low priority.

25.3.4.3.4 Emissions of odour from the waste handling operations and from the wastewater treatment

Waste handling and wastewater treatment can cause the emission of odour, if the processes are not properly managed.
So the intensity of this impact can be assumed as “notable”, the duration “medium”, the spatial extent “mid-range” and the probability “possible”.

Therefore the potential impact *Emissions of odour from the waste during the handling and from the wastewater treatment* has a medium priority.

The ESMP attached at the present report provides an operating procedure aimed to prevent odour nuisance due to the waste processing and wastewater treatment. So, through the implementation of this procedure the intensity of this impact may be lowered to a “negligible” class, the duration to a “short term” class and the probability to an “unlikely” class.

Therefore the intensity of the impact *Emissions of odours from the waste during the handling and from the wastewater treatment* is deemed to be mitigated to a low class.

Moreover the ESMP foresees an Odour Monitoring Program that will include a survey of the sensitive receptors in the vicinity of the transfer station and will outline all operational controls, monitoring, measurement and corrective actions, and communication and management reviews required to achieve the objective of managing odour associated with the handling of putrescible waste at the facility in order to prevent or mitigate any odour impacts on the nearby sensitive receptors

25.3.4.4 Soil, ground and surface water quality

25.3.4.4.1 Accidental spillage or leakage of fuel may cause soil or ground/surface water contamination

The impacts on the receptors "Soil" and "Ground and surface water quality**"** are assessed together. The soil or water contamination can be caused by accidental spillage or leakage of fuel from the vehicles utilized for the construction of the plant and the waste handling.
Taking into account:

- the modest amount of fuel contained in the tank of the vehicles;
- the possibility of confining the spillage/leakage, mitigating the liquid diffusion;

The intensity of this impact can be assumed as "negligible", the duration of the impact "short term" and the spatial extent "localized". About the probability, it is worth outline that the spillages or leakages are accidental, so the probability of the impact can be assumed as "unlikely".

Therefore the potential impact *Accidental spillage or leakage of fuel may cause soil or ground/surface water contamination* has a low priority.

25.3.4.4.2 Accidental leakage from the section for the hazardous waste collection may cause soil, ground and surface water contamination.

The impacts on the receptors "Soil" and "Ground and surface water quality**"** are assessed together. The soil or water contamination can be caused by accidental leakage from the section of the plant utilized for the collection of hazardous waste.
Taking into account:

- the modest amount of hazardous waste stored at the same time in the plant, and;
- the possibility of confining the leakage, mitigating the liquid diffusion;

The intensity of this impact can be assumed as "negligible", the duration of the impact "short term" and the spatial extent "localized". About the probability, it is worth outline that the spillages or leakages are accidental, so the probability of the impact can be assumed as "unlikely".

Therefore the potential impact *Accidental leakage from the section for the hazardous waste collection may cause soil, ground and surface water contamination* has a low priority.

25.3.4.5 Flora and fauna

25.3.4.5.1 Potential indirect impacts related to the deterioration of the quality of air, of soil or of ground and surface water

The site is adjacent to an existing lumber yard and represents the marginal portion of a native broadleaf forest. The construction of the TS will determine the deforestation of a further portion of about 3.5 acres in continuity with the lumber yard.
The present environmental impact assessment is based on a conceptual design, so the assessment itself is at a preliminary level. In particular, in this phase, the sensitivity of the animal and vegetal species possibly affected by the impacts has not yet been determined.
Also taking into account the marginality of the site with respect to the adjacent forest a conservative assumption can be made and the priority of these indirect impacts is assessed without considering the specific sensitivity of the different receptor species, but increasing the class of priority of the impacts on the quality of soil, surface and ground water and air so far determined.

So, in general terms, *the potential indirect impacts related to the deterioration of the quality of air, of soil or of ground and surface water* have a medium priority.

25.3.4.5.2 Loss or damage of vegetation and habitat for wildlife

The site is the marginal portion of a broadleaf forest and adjacent to an active timber yard.
Since no filed surveys on the animal and vegetal species have been made, a conservative assumption can be made and the intensity of the potential impact can be assessed as “severe”, the duration “short term”, and the spatial extent “localized”. The probability can be assume as “definite”.

So, in general terms, *the potential impact related to the loss or damage of vegetation and habitat for wildlife* have a medium priority.

The outcomes of the impacts rating show that almost all the impacts have a low priority, especially in the “operation” phase that has the longest duration.

Moreover it has to be highlighted that all the impacts rated have the maximum spatial extent defined as “mid-range”, (the effects of the impacts can affect within a distance of 1,000 m from the origin). No human settlements are present in the area surrounding the site within a 1,000 m distance from the site.

Taking into account all these aspects it can be assumed, in the first instance, that the construction and operation of a TS in this site will be sustainable in environmental terms.
Further assessments on the flora and fauna will be carried out to confirm the assumption.
In the following Table 54 a comparison between the priority and probability classes of each impact, as rated in the different sites, is shown.

Table 54 – TSs - Potential impacts assessment comparison

All sites	Landscape and natural scenery	Probability	Priority
All phases	alteration of the landscape	**definite**	**medium**
Orange Walk, Dangriga Independence	**Archaeological, cultural and historical resources**		
Construction	damage of the site	**unlikely**	**low**
Punta Gorda	**Archaeological, cultural and historical resources**		
Construction	damage of the site	**possible**	**low**
All sites	**Air quality and climate**		
Construction/Decommissioning	Emissions of air pollutants and greenhouse gases from the vehicles used for the construction	**definite**	**low**
	Increasing of noise levels in the area surrounding the plant	**definite**	**medium**
Operation	Emissions of air pollutants and greenhouse gases from the vehicles used for waste handling	**definite**	**low**
	Emissions of odour from the waste handling operations and from the leachate treatment	**unlikely**	**low**
	Increasing of noise levels in the area surrounding the plant	**definite**	**low**
All sites	**Soils**		
Construction/Decommissioning	Accidental spillage or leakage of fuel from vehicles may cause soil contamination	**unlikely**	**low**
Operation	Accidental spillage or leakage of fuel from vehicles may cause soil contamination	**unlikely**	**low**
	Accidental leakage from the sections for the hazardous waste collection may cause soil contamination	**unlikely**	**low**
All sites	**Ground and surface water quality**		
Construction/Decommissioning	Accidental spillage or leakage of fuel may cause surface water contamination	**unlikely**	**low**
Operation	Accidental spillage or leakage of fuel may cause surface water contamination	**unlikely**	**low**
	Accidental leakage from the sections for the hazardous waste collection may cause waters contamination	**unlikely**	**low**
Orange Walk, Dangriga Independence	**Flora and fauna**		
All the phases	potential indirect impacts related to the deterioration of the quality of air, of soil or of ground and surface water	**-**	**low**
All the phases	loss or damage of vegetation and habitat for wildlife	**-**	**-**
Punta Gorda	**Flora and fauna**		
All the phases	potential indirect impacts related to the deterioration of the quality of air, of soil or of ground and surface water	**-**	**medium**
All the phases	loss or damage of vegetation and habitat for wildlife	**definite**	**medium**

25.4 Dumpsites remediation

The assessment of the environmental effects of the dumpsites remediation can be carried out through the evaluation of the efficacy of the remediation in terms of reduction of harmful emissions on air and water compared to the current situation.

25.4.1 Current situation

In the aim to assess the environmental effects of the remediation of each dumpsite it is needed to evaluate the major environmental concerns due to the operation of the current dumps.

The waste collected in the main towns and in the villages, served by a Municipal waste collection, is dumped in local dumpsites. The dumping operation methodology is described in Section 15.4.

The waste is dumped onto the bare ground in shallow piles, which are sorted by informal recyclers, and then the residual waste is put on fire. The piles, and waste deposits in general, are so shallow that anaerobic biodegradation processes cannot take place, and the easily degradable organic fraction is almost entirely degraded as result of a combination of processes: aerobic degradation due to long exposure of the waste enhanced by generally high temperatures; animal feeding and biological activity; burning; washout.

The waste disposal is totally unconfined so the risk of leakage and groundwater contamination is extremely high.

Considering the biodegradation conditions described above, a low production of methane can be expected. The main impact on the air is due to waste open burning. It is known, in fact, that waste open burning is primary a source of GHG emissions and of very harmful pollutants such as particulate and dioxins and furans.

The latter, moreover, can also affect the quality of the leachate, because the combustion residues contain dioxins and furans as well and the washout, due to intense rains, of ashes can cause the transfer of these substances also to the water.

A general assessment of the quality of the emissions from dumps can be carried out on the basis of monitoring data gathered in similar sites and on the basis of data from literature.

25.4.1.1 Leachate

In the “Environmental Assessment and Landfill Gas Management for Mile 3, San Pedro and Caye Caulker Open Dumps, Belize – Draft Final Report” IDB (August 2008) data are listed concerning the leachate quality (see Table 55) that can be useful for the assessment of the quality of the leachate in the dumps of the Northern and Southern Corridor. At first it is important to note that the quality of leachate is subjected to wide variations within the dump itself, because the quality is related to the characteristics (age, hazardousness…) of the waste disposed of in the area surrounding the monitoring point. Besides, as already mentioned in Section 15.4, the quality of the leachate varies very quickly over time, because of different factors:

- The unconfined disposal of the waste maximises both the degradation processes and the easy and fast removal of the contaminants;
- The easily degradable organic fraction is almost entirely degraded as result of a combination of processes: aerobic degradation due to long exposure of the waste enhanced by generally high temperatures; animal feeding and biological activity; burning; washout.
- Chemical pollutants are quickly removed and released into the environment either by combustion and flushing do to the intense rain.

Table 55 - *"Environmental Assessment and Landfill Gas Management for Mile 3, San Pedro and Caye Caulker Open Dumps, Belize – Draft Final Report"* IDB (August 2008)

Parameter	unit	Caye Caulker	Mile 3	San Pedro
Arsenic	mg/l	nd	nd	nd
Barium	mg/l	0.4409	0.3232	0.5875
Cadmium	mg/l	nd	nd	0.0453
TOC	mg/l	320.60	164.1	1,069.6
Chloride	**mg/l**	**11,432**	**1,020**	**3,425**
Coliform bacteria (fecal)	**NMP/100ml**	**9,300**	**nd**	**>24,000**
Chromium	mg/l	nd	nd	nd
BOD_5	**mg/l**	**89.1**	**nd**	**286.1**
COD	**mg/l**	**880**	**320**	**10,900**
Iron	mg/l	5.027	5.241	37.76
Fat and oils	**mg/l**	**2.8**	**nd**	**29,862.80**
Manganese	mg/l	0.1935	0.41	0.7858
Mercury	mg/l	0.0002	nd	0.0068
Nitrate	mg/l	0.3024	0.2874	0.4885
Nitrite	mg/l	0.1154	0.245	0.1966
Ammonia nitrogen	**mg/l**	**0.4001**	**91.2394**	**56.0193**
Lead	mg/l	0.4374	0.0359	0.9856
Selenium	mg/l	nd	nd	nd
TDS (total dissolved solids)	mg/l	21,382	3,201	8,483
Sulfate	mg/l	104.14	173.14	1,142.08
Zinc	mg/l	0.6040	0.0145	4.98

From the data of the above table some major aspects can be highlighted:

- there are substantial differences between the quality of the leachate in the three sites;
- the leachate of Caye Caulker dump is characterised by low values of BOD_5, COD and Ammonia nitrogen and high values of chloride and Coliform bacteria that can also depend on the intrusion of salted external water. The presence of external water can explain the low values of the parameters since a high dilution factor of the leachate can be assumed;
- the leachate of the San Pedro dump is characterised by high values of BOD_5, COD, fecal coliform bacteria and fat and oil, and a low Ammonia nitrogen concentration;
- the leachate of Mile 3 dump is characterised by low values of BOD_5, COD, fecal coliform bacteria and Ammonia nitrogen.

The available data show that the leachate of a dump can be very harmful and, in the absence of adequate natural or artificial barriers able to prevent leakages, can affect the quality of surface and ground water, so reducing the chance to exploit available drinking water supplies in the area surrounding the dump. The worsening of the quality of these waters can also cause a negative impact on the flora and fauna in the area surrounding the dump.

As already mentioned, other pollutants related to the waste combustion, can be found, in very low concentrations, in leachate.

To focus on dioxin emissions from open waste burning reference is made to *"Update of Dioxin Emission Factors for Forest Fires, Grassland and Moor Fires, Open Burning of Agricultural Residues, Open Burning of Domestic Waste, Landfills and Dump Fires" Pat Costner - International POPs Elimination Network (15 November 2006).* This study, on the basis of the results of experimental data, provides dioxin emissions factors for releases to air, to land and to residues from the combustion of different fuels. These factors are listed in Table 56.

Table 56 – Dioxin emission factors with strongest scientific support to date – Source: "*Update of Dioxin Emission Factors for Forest Fires, Grassland and Moor Fires, Open Burning of Agricultural Residues, Open Burning of Domestic Waste, Landfills and Dump Fires*" Pat Costner - International POPs Elimination Network (15 November 2006).

	Emission factor for releases to air	**Emission factor for releases to land**	**Emission factor for releases to residues**
ng TEQ/kg			
Forest fires, grassland and moor fires	0,125-0,5	0,02-0,05	
Agricultural residues, open burning	0,5-0,8	0,02-0,05	
Domestic waste open burning			
No PVC content, 0%	4,4-14		0,3
Moderate PVC content, 0,2% or less	17-79		0,3-343
High PVC content, 1,0%-7,5%	200-5.000		343-892
Landfill/open dump fires	23-46		120-170

The emission factors for releases to air are, in almost all the cases, bigger than the factors for releases to land or residues with the notable exception of open dump fires. In this case the emission factor for releases to residues is considerably higher. The pollutants present in combustion ashes can then affect the quality of the water leaching through the residues. Organic compounds, such as dioxins, are very dangerous for the health of the operators and of the informal recyclers that operate at the dump.

It's very difficult to carry out an accurate evaluation of the impacts on water quality related to the presence of these pollutants, because no analytical data are available, but taking into account the hazardousness and the persistence of these substances this possible impact has to be considered.

25.4.1.2 Releases to air

The operation of a dump can cause the emission into air of:

- nuisance odour;
- greenhouse gases;
- other pollutants such as dioxins or furans.

As already mentioned, the waste biodegradation in dumps is mainly aerobic and the most of the putrescible waste, residual from sorting, is put on fire. This operation methodology reduces the emissions of nuisance odour and of methane from waste biodegradation, therefore the main hazardous emissions into air are caused by waste open burning.
So in the present section is carried out an assessment of the pollutant emissions caused by waste open burning, focusing on greenhouse gases and dioxin.

In the aim to rate the GHG emission per Mg of waste burnt (CO_{2eq}/Mg_{waste}), reference is made to the IDB's guidance "*Greenhouse Gas Assessment Emissions Methodology*" and to "*2006 IPPC Guidelines for National Greenhouse Gas Inventories, Vol.5, Chapter 5 Incineration and open burning of waste".*
The greenhouse gases emitted in waste burning are CH_4, NO_2 and CO_2. CH_4 and NO_2 emission factors for "Open burning of waste" are shown in Figure 26, while the CO_2 emission factor is calculated following the suggestions provided by the mentioned IPPC Guidelines (see Table 57).

Figure 26 – EFs for Incineration of Municipal Solid Waste - "Greenhouse Gas Assessment Emissions Methodology" Milena Breisinger (August 2012) - IDB

IPCC Default CH_4 and N_2O Factors for Incineration of Municipal Solid Waste		
Type of Incineration technology	**CH_4 EF (kg/ton waste)**	**N_2O EF (kg/ton waste)**
Continuous incineration - Stoker	0.0002	0.050
Continuous incineration - Fluidized Bed	0	0.050
Semi-continuous incineration - Stoker	0.006	0.050
Semi-continuous incineration - Fluidized Bed	0.188	0.050
Batch type incineration - Stoker	0.060	0.060
Batch type incineration - Fluidized Bed	0.237	0.060
Open Burning of Waste	6.50	0.150

The CO_2 emission factor depends on the waste composition, and in particular on the amount of fossil carbon in the waste. Plastics represent the waste fraction with the highest fossil carbon fraction.

Table 57 – Excel spreadsheet on CO_2 emission factor calculations "*2006 IPPC Guidelines for National Greenhouse Gas Inventories, Vol.5, Chapter 5 Incineration and open burning of waste*"

Sector		**Waste**						
Category		**Open Burning of Waste**						
Category Code		**4C2**						
Sheet		**1 of 1 Estimation of CO_2 emissions from Open Burning of Waste**						
STEP 1			**STEP 2**					
Type of Waste		F	G	H	I	J	K	L
		Total Amount of Waste open-burned (Wet Weight) (Gg Waste)	Dry Matter Content [1] dm (fraction)	Fraction of Carbon in Dry Matter [2] CF (fraction)	Fraction of Fossil Carbon in Total Carbon [3] FCF (fraction)	Oxidation Factor OF (fraction)	Conversion Factor 44/12	Fossil CO_2 Emissions (Gg CO_2)
		$F = A \times B \times C \times D \times E \times 10^{-6}$ [4]						$L = F \times G \times H \times I \times J \times K$
Municipal Solid Waste (MSW) [5,6]		This comes from previous table						
Composition [5,6]	Plastics							
	Textiles							
	Rubber							
	Nappies							
	etc							
	add as needed							
Other (specify)								
							Total	

1 For default data and relevant equations on the dry matter content in MSW and other types of waste, see Section 5.3.3 in Chapter 5.

2 For default data and relevant equations on the fraction of carbon, see Section 5.4.1.1 in Chapter 5.

3 For default data and relevant equations on the fraction of fossil carbon, see Section 5.4.1.2 in Chapter 5.

4 The amount MSW can be calculated in the previous sheet "Estimation of Total Amount of Waste Open-burned". See also Equation 5.7.

5 Users may either enter all MSW incinerated in the MSW row or the amount of waste by composition by adding the appropriate rows.

6 All relevant fractions of fossil C should be included. For consistency with the CH_4 and N_2O sheets, the total amount open-burned should be reported here. However, the fossil CO_2 emissions from MSW should be reported either for total MSW or its components.

Taking into account the waste composition assumed in the present Master Plan and shown in Table 58, the emission factor for 1 Mg of waste burnt is calculated with the assumptions listed in Table 59 and considering just the following waste fractions, which contain fossil carbon:

- other organic;
- plastics;
- paper/cardboard.

Table 58 – waste composition

Fraction	Percentage (%)
Organic biodegradable	33
Other organic	14
Glass	8
Metals	5
Plastics	19
Paper/Cardboard	16
Household hazardous waste	2
Rest categories	3

Table 59 – assumptions

Fraction	Percentage (%)	Total Carbon content in % of dry weight[14]	Fossil carbon fraction in % of total carbon[15]	Oxidation factor in % of carbon input[16]
Organic biodegradable	33	50	20	58
Plastics	19	75	100	58
Paper/Cardboard	16	46	1	58

The result of the CO_2 emission factor assessment is shown in

[14] Source: "*2006 IPPC Guidelines for National Greenhouse Gas Inventories, Vol.5, Chapter 2 Waste Generation, Composition and Management Data, Table 2.4*

[15] Source: "*2006 IPPC Guidelines for National Greenhouse Gas Inventories, Vol.5, Chapter 2 Waste Generation, Composition and Management Data, Table 2.4*

[16] Source: "*2006 IPPC Guidelines for National Greenhouse Gas Inventories, Vol.5 Chapter 5 Incineration and open burning of waste, Table 5.2*

Table 60.

Table 60 – calculation

Fraction	%	Dry Matter Content [1] 1Mg waste	Fraction of Carbon in Dry Matter	Fraction of Fossil Carbon in Total Carbon	Oxidation Factor	Conversion Factor	Fossil CO_2 Emissions Mg
Other organic	14.00%	0.1400	0.0700	0.0140	0.0081	3.6667	0.0298
Plastics	19.00%	0.1900	0.1425	0.1425	0.0827	3.6667	0.3031
Paper/Cardboard	16.00%	0.1600	0.0736	0.0007	0.0004	3.6667	0.0016
						TOT Mg/Mg$_{waste}$	**0.3344**

The total GHG emission factor of CO_{2eq} per 1 Mg of waste burnt is calculated as the sum of the emission factors of the three gas taken into account (see Table 61).

Table 61 – total emission factor

Gas	EF (kg/Mg$_{waste}$)	GWP	EF(kgCO_{2eq}/Mg$_{waste}$)
CH_4	6.50	25	162.5
NO_2	0.150	298	44.70
CO_2	334.40	1	334.40
TOT			541.60
TOT (MgCO_{2eq}/Mg$_{waste}$)			**0.5416**

All the evaluations made so far are valid also for the domestic waste burning. It's known, in fact, that in all the villages, where there is not a waste collection system presently in place, the organic waste is often used for feeding the animals, while the residual fractions are burnt.
Therefore in the aim to assess the global impact caused by waste burning, the domestic waste burning has to be considered.

The temperature of combustion in waste open burning is low and causes the emission of very harmful pollutants such as dioxins and furans. Furans result from the combustion of PCB (Polychlorinated biphenyl), but considering the assumed waste composition, a very low presence of PCB is deemed to be foreseeable and, consequently, the furans presence in emissions can be assumed as negligible.
Dioxins, instead, are the result of the combustion chlorinated substances, such as PVC (polyvinyl chloride), that are present in the considered waste. So in order to assess Dioxin emission from waste combustion reference is made again to *"Update of Dioxin Emission Factors for Forest Fires, Grassland and Moor Fires, Open Burning of Agricultural Residues, Open Burning of Domestic Waste, Landfills and Dump Fires" Pat Costner - International POPs Elimination Network (15 November 2006)*, Table 56.

So, summarizing the emission factors considered, every Mg of burnt waste can emit:

- 0.5416 Mg CO_{2eq};
- 0.023-0.046 (average value 0.0345) ng TEQ

A current global impact on air caused by waste combustion can be assessed on the basis of provided data on the total waste production in the two Corridors and the current disposal methods.

Data provided by the SIB Census 2010 (Table 62) are useful to identify the disposal technology used currently in the two Corridors.

Table 62 – Households by major administrative area and method of garbage disposal, Belize 2010 Source: Census 2010 (Table HC3.3) modified

# households	total	take to dumpsite		burn		municipal collection		private collection		other		not reported	
Corozal	9258	2166	23.40%	3375	36.45%	2625	28.35%	802	8.66%	242	2.61%	48	0.52%
Orange Walk	10452	2226	21.30%	4122	39.44%	3446	32.97%	256	2.45%	356	3.41%	46	0.44%
Stann Creek	9074	931	10.26%	2017	22.23%	4100	45.18%	1345	14.82%	649	7.15%	32	0.35%
Toledo	6358	777	12.22%	3380	53.16%	1414	22.24%	386	6.07%	569	8.95%	12	0.19%
Total	**35142**	**6100**	**17.36%**	**12894**	**36.69%**	**11585**	**32.97%**	**2789**	**7.94%**	**1816**	**5.17%**	**138**	**0.39%**

On the basis of the data on the current disposal methodology it can be assumed that, presently, at least the 95% of the generated waste is burnt, in dumps or in the villages without a waste collection system.
Taking into account the amount of waste produced in each district of the two corridors in 2015 and listed in Table 63, the waste quantity actually burnt can be estimated as **63,726 Mg**.

Table 63 – waste production

District	Waste amount (Mg)
Corozal	21,032
Orange Walk	17,626
Stann Creek	16,751
Toledo	11,671
TOT	**67,080**

The corresponding emissions are shown in Table 64

Table 64 – amount emitted

Pollutant	Amount emitted
GHG	**34,514.00 $MgCO_{2eq}$**
Dioxins	**2,918.55 ng TEQ**

25.4.2 Environmental outcomes of the remediation

The environmental assessment of the present prevalent disposal methodology outlies the hazardousness of the emissions from dumps and the high related risks of air and waters (surface and ground water) contamination.

The conceptual solutions for the remediation of the examined dumpsites envisaged by the Master Plan are mainly aimed to the reduction of the emissions of leachate and air pollutants.

The efficacy of the remediation actions, are, hereinafter, assessed in terms of reduction of harmful emissions.

Leachate

The provisions of the project lead to achieve the drop of the leachate production through to the minimization of the infiltration of rainwater and through the prevention of flooding. The present Plan foresees different solutions for the management of this aspect, according to the different waste dumping methodologies adopted.

Taking into account the evaluations on the leachate quality carried out in the Sections 15.4 and 25.4.1.1 it can be assumed that the remaining contaminants in leachate will be mainly constituted by a residual fraction of readily biodegradable contaminants (mostly from the more recent deposits less than one year old) and by the poorly soluble/biodegradable contaminants not removed/degraded by the weathering and other physical and biological processes.

Thus considering the quality characteristics of the leachate and the drop of its production, the provisions of the project can be expected to lead to a substantial reduction of the risk of soil and ground water contamination.

Since a residual emission of leachate can be expected, the potential related residual impact to groundwater shall be monitored through the monitoring of the quality of the groundwater in the areas nearby the remediated dumps, as explained in the ESMP.

An additional mitigation measure is also foreseen by the remediation design of the dumpsites operated according to the area method (Corozal, Orange Walk and Punta Gorda). In these cases a solution is proposed to collect a share of the leaching waters still draining through the waste, and to treat it in phytoremediation trenches, before the discharge into superficial water bodies.

Air pollutants

The project provisions are expected to lead to the removal of any sources of harmful emissions into air. According to the evaluations conducted about the actual emissions of air pollutants in the Sections 15.4 and 25.4.1.2 the oxidation capacity of the top cover envisaged by the Plan is estimated to be sufficient to oxidize the residual methane generation. Moreover the closure of the dumpsite and the consequential adoption of landfilling technologies will lead to avoid the waste open burning and the related impacts on air and water.

Therefore no residual emissions into air are estimated.

The outcomes of the evaluations so far carried out can then be summarized as follows. The remediation actions envisaged by the plan lead to:

- drastic reduction of the risk of soil and groundwater contamination due to leachate leakages, and monitoring of the residual impact to groundwater;
- removal of any sources of harmful emissions into air through the top covering of the dump and the cessation of waste open burning.

26 MILE 24 LANDFILL

Since all the waste produced in Northern and Southern Corridors will be disposed of at Mile 24 landfill, an environmental audit has been carried out in order to verify the compliance of management actions with the directives provided by the Compliance Plan and to make a preliminary assessment of the adequacy of Mile 24 Landfill for the disposal of the waste from the Northern and Southern Corridors.
Hereinafter the conclusions and recommendations of the audit are reported.

According to the outcomes of the auditing activities carried out at the Mile 24 Landfill the following conclusions can be summarized:

- The landfill is constructed and operated in accordance to high quality standards
- No environmental or social issues has been reported and are noticeable so far
- The operation of the landfill is substantially compliant with the ECP
- Major non compliances are related to the delay in the submission of contingency plans
- A general lack of established operational and control procedures is nevertheless noticeable. This aspect can, if not adequately considered, lead to future possible non-compliances (especially with regard to the leachate management).

General recommendations:

- Establishment and implementation of an adequate management and control system based on recognised quality standards (ISO 14001 is recommended)
- In specific a more accurate record keeping and reporting of the activities is needed to fully comply with the ECP requirements
- Keep an inspection register on site
- review of some of the ECP requirements that appears to be obsolete, redundant or replaced in fact by alternative and equivalent solutions
- include the effluents (gas and water) from the HDPE pipe laid underneath the cells in the monitoring plan.

Further recommendations related to the adequacy of Mile 24 Landfill for the disposal of the waste from the Northern and Southern Corridors:

- an additional cell of at least 5 hectares extension should be built not later than 4 years from now
- the operational permanent equipment and disposal procedures shall be reviewed to cater for a doubled waste input.
- The use of a light landfill compactor (28 tonne) would be recommended together with the adoption of offloading procedures that allows a quicker offloading of an increased number or trucks simultaneously.
- It is recommended that the soil excavated for the preparation of the future cells would be stockpiled and used for the final cover of the same cells. At the same time the selection and use of alternative intermediate cover is highly recommended

In the next phase of the project a development plan for the landfill site will be prepared. The plan will determine the conditions for the construction and operation of the additional cells taking into account the present recommendations.

27 SOCIAL IMPACTS

27.1 Introduction

The implementation of new transfer stations in the northern and southern corridor will result in the ceasing of recyclables going to the dump sites located in this corridor. As discussed before, this will directly affect the access to a source of income and lead to loss of income for those working on the dump sites either on a permanent or on a temporary basis. The initial consultations done at the dump sites indicate that at least 33 persons who operate permanently on these sites will be affected, and in potential up to 100 persons of those operating on a temporary basis are included. These do not include the watchmen[17] who work at the dumpsites as they are employed by the local authorities responsible for the dump site and it is assumed the authorities will furnish alternative employment in case it is needed.

This part of the Social Inclusion Plan Framework examines the compensation entitlements and the options for mitigating these negatives impacts and potential loss of income. As indicated in Table 65, the recommended measures should focus (where possible) on providing (alternative) income generating opportunities that are:

a) Same type of activity which would not require additional training
b) Similar type of activity which would require additional training and capacity building
c) Other type of activity with same level of labour skills

Table 65: Compensation entitlements matrix.

	Category	Eligibility Criteria	Impacts	Mitigation/Compensation Options
1.	Loss of access to means of production	1) having worked at one of the affected sites before the Cut-off Date (as verified by inclusion in the Baseline Census)	Loss of income for recyclers due to reduction in (or elimination of) access to recyclable materials at the dumpsite	• Income-generating opportunities at transfer stations constructed in the same municipality • Income-generating opportunities at Drop Off Centres constructed in the same District • Income-generating opportunities in activities that require a similar skill level (construction industry, harvesting, domestic cleaning and housekeeping services, restaurant and housekeeping services in the tourism and hotel sector, etc.)
2.	'involuntary resettlement'	1) having a *dwelling* at one of the affected sites before the cut-off data (as verified by inclusion in the baseline census)	Loss of dwelling because of remediation of dump site and in certain cases also due to the construction of the	• Dwelling of similar conditions with access to basic necessities (drinking water, electricity, sanitary facilities) within a reasonable traveling distance from future income generating activity

[17] Those watchmen that are performing recycling activities they will be included within the affected population, but not as the one with highest priority of compensation since they won't lose most of their income.

			new transfer station on the current dumpsite location	

In the next section an overview of the employment opportunities that will be generated as a result of the proposed activities in the Solid Waste Master Plan will be set out and assessed to what extent these could incorporate those working at the dump sites currently.

27.2 Relation employment generation and the Solid Waste Master Plan

The implementation of the activities foreseen in the *Solid Waste Master Plan for Emerging Tourism Areas* will not only strive to improve the living conditions, health of the inhabitants and their surrounding environment in the two corridors, but it will also directly and indirectly result in the generation of new employment opportunities.

Direct opportunities will arise during the construction phase and operation phase of the different components of the Master Plan, whilst indirect employment opportunities in the areas of communication, training, supervision, education and awareness raising can be identified.

Personnel of varying skill levels will be required to operate the different solid waste management facilities foreseen in the Master Plan and the logistical activities to transport the different solid waste streams between the facilities. Potentially, there exist the possibility that a number of these employment opportunities could be filled by some of those currently working at the dump sites that will be closed, and result in a loss of income for those recyclers.

This paragraph will present, per component of the proposed solid waste management system, the number of labourers required for operation in accordance with their competency level. The number of persons required during the construction of the transfer stations and drop-off centres will not be estimated.

27.2.1 Transfer stations

A work crew of four persons (see table below) is proposed for the operation of each of the five transfer stations.

Table 66: Proposed personnel required for operating the transfer station (number and function)

Number of employees	PERSONNEL	Skill level	Monthly wage (USD)
1	Foreman	Medium	800,00
1	Machine operator	Low	500,00
2	Unskilled labourer		400,00

This means that when the five transfer stations become operational, potentially 21 vacancies will be created, 8 in the Northern Corridor districts and 13 in the Southern Corridor districts. As for the equipment used at the transfer stations, it is supposed that the maintenance and repair activities of the equipment will be outsourced and as such are not included as *directly* generated employment, but rather *indirectly* generated.

Table 67: Potential number of jobs created for operating the transfer stations (2019-2040)

Location of Transfer Station	Skilled labourers			Unskilled labourers	Total employment opportunities
	High skill level	Medium skill level	Low skill level		
Transfer Station Corozal Town, Corozal District	0	1	3	2	6
Transfer Station Orange Walk Town, Orange Walk District	0	1	3	2	6
Transfer Station Dangriga, Stann Creek District	0	1	3	2	6
Transfer Station Independence, Stann Creek District	0	1	3	2	6
Transfer Station Punta Gorda, Toledo District	0	1	3	2	6
Number of jobs created	**0**	**5**	**15**	**10**	**30**

In addition, the design of the transfer station will allow recyclers to extract and recover recyclable materials from the waste that is brought to the transfer station. It is estimated that 8-10 recyclers will be able to operate during the interval that the waste is deposited and loaded into the trash trailer. A total of 40-50 income earning opportunities will be created through this mechanism.

27.2.2 Drop-off Centres and composting facilities

It is proposed that one person can operate each drop-off centre (DOC), and in the case of a combined drop-off centre and composting facility (CF), one additional person will be required on a part time basis (see table below). Both would be low-level skilled personnel.

Table 68: Proposed personnel required for operating the drop-off centres and composting facilities (number and function)

	Item	Skill level	Monthly wage
#	**PERSONNEL**		**USD**
1	Operator	Low	500.00
0,25	Assistant for composting activities	Low	400.00

Table 69 shows that potentially 80 job opportunities could be created in villages spread out over the four districts to operate the 69 DOCs.

Table 69: Potential number of jobs created for operating the drop-off centres and composting facilities (2021-2040).

District	Number of centres	Skilled labourers			Unskilled labourers	Total employment opportunities
		High skill level	Medium skill level	Low skill level		
Drop off Centre + Composting Facility						
Corozal District	13	0	0	17	0	17
Orange Walk District	10	0	0	13	0	13
Stann Creek District	11	0	0	13	0	13
Toledo District	9	0	0	11	0	11
Number of vacancies created DOC+CF	**43**	**0**	**0**	**54**	**0**	**54**
Drop off Centres Only						
Corozal District	5	0	0	5	0	5
Orange Walk District	4	0	0	4	0	4
Stann Creek District	5	0	0	5	0	5
Toledo District	12	0	0	12	0	12
Number of vacancies created DOC only	**26**	**0**	**0**	**26**	**0**	**26**
Total number of jobs created for both	**69**	**0**	**0**	**80**	**0**	**80**

Furthermore, there exists the possibility that the operator of the DOCs could also provide a collection service to the village(s) served by the DOC. In case this activity cannot be combined with the daily operation of the DOC, an additional person might need to be contracted which could serve 3-4 DOC´s, creating an additional 15-20 job opportunities.

In those villages[18] where a composting facility is foreseen, the application of the produced compost could lead to the strengthening of current economic (agricultural) activities and possibly to the creation of new job opportunities.
In addition, the logistics and commercialization of the recyclable materials delivered to the DOCs (both with and without CF), will enhance current economic activities in this sector and potentially lead to new income generating opportunities.

27.2.3 Transportation from Drop-off centres to Transfer Stations

In the Drop-off centres, the incoming waste stream will be dropped off into three roll off containers, namely a) the recyclable fraction, b) the compostable fraction[19] and c) the residual fraction that will be transported to the nearest transfer station from where it will be sent to the Mile 24 sanitary landfill for disposal.
The transportation of the residual fraction will be done with a Roll-off Truck (for transporting a 20 m^3 Container) with a trailer hooked onto it (that will also transport a 20 m^3 Container). A driver and a helper will operate each truck and trailer combination.

[18] ANNEX 2 includes a list of the DOC and DOC + CF proposed per district.
[19] In case of the rural villages where there is no composting facility but only a DOC, this fraction is assumed to be treated at household level and will not reach the DOC.

Table 70: Proposed personnel required for operating the roll-off truck for transport from DOC to transfer stations (number and function)

	Item	Skill level	Monthly wage
#	**PERSONNEL**		**USD**
1	Driver	Low	500,00
1	Helper	Low	400,00

During the planning period (2015-2040) the amount of waste generated is projected to grow, and as such also the quantity of the residual fraction that will require transport from the drop-off centres to the transfer stations. To accommodate for this increase in demand it is estimated that 11 roll-off trucks will be operating in the four districts by 2040 (see Table 71 for start-up year for each truck with crew per district).

Table 71: Number of roll-off trucks needed to serve each transfer station for planning period (2021-2040)

Transfer Station served by Roll-off trucks and trailer combination	Number	1st year of operation	Driver	Helper
Transfer Station Corozal Town	Roll-off truck 1	2021	1	1
Transfer Station Corozal Town	Roll-off truck 2	2029	1	1
Transfer Station Orange Walk Town	**Roll-off truck 1**	**2021**	**1**	**1**
Transfer Station Orange Walk Town	**Roll-off truck 2**	**2029**	**1**	**1**
Transfer Station Dangriga	Roll-off truck 1	2021	1	1
Transfer Station Dangriga	Roll-off truck 2	2035	1	1
Transfer Station Independence	**Roll-off truck 1**	**2021**	**1**	**1**
Transfer Station Independence	**Roll-off truck 2**	**2030**	**1**	**1**
Transfer Station Punta Gorda	Roll-off truck 1	2021	1	1
Transfer Station Punta Gorda	Roll-off truck 2	2025	1	1
Transfer Station Punta Gorda	Roll-off truck 3	2038	1	1
Total	**11**		**11**	**11**

In 2021, when the DOC are expected to be fully operationally, 10 persons will be needed to operate the five trucks. This number will grow to 22 by 2040, when the 11 trucks should be operational. The maintenance and repair activities of the trucks and trailers are assumed to be outsourced and as such are not included as *directly* generated employment, but rather *indirectly* generated.

Table 72: Potential number of jobs created for operating the roll-off trucks transferring waste to the transfer stations.

Transfer Station served by Roll-off trucks	Skilled labourers			Unskilled labourers	Total employment opportunities
	High skill level	Medium skill level	Low skill level		
Transfer Station Corozal Town	0	0	4	0	4
Transfer Station Orange Walk Town	0	0	4	0	4
Transfer Station Dangriga	0	0	4	0	4
Transfer Station Independence	0	0	4	0	4
Transfer Station Punta Gorda	0	0	6	0	6
Number of jobs created	**0**	**0**	**22**	**0**	**22**

27.2.4 Summary of total potential employment opportunities created

The following table provides a summary of the potential direct employment opportunities[20] that are estimated to arise during the implementation of the Solid Waste Management Plan during the period 2019-2040. In total 133 direct employment opportunities could be created in the two corridors, 10 unskilled and 118 requiring low skill levels.

Table 73: Minimum number of potential jobs created for all components for the solid waste management system (2017-2040)

Component of solid waste management system	Skilled labourers			Unskilled labourers	Total employment opportunities
	High skill level	Medium skill level	Low skill level		
Transfer Stations	0	5	15	10	**30**
Drop-off centres and composting facilities	0	0	80	0	**80**
Transportation from DOC to Transfer Stations	0	0	22	0	**22**
Number of jobs created	**0**	**5**	**117**	**10**	**132**

In addition, potential direct job opportunities will be created:

- At the five transfer stations for those 40-50 persons that will recover (and commercialize) recyclable materials from the incoming waste stream. The conceptual design of the transfer station foresees that 8-10 persons can recover recyclables at designated areas on the tipping floor.

27.3 Matching affected recyclers with potential employment opportunities

An initial assessment indicates that 172-182 employment opportunities could be created as a result of the activities from the solid waste master plan, that potentially require skill levels available within the recycler group or attainable with training and capacity building.

The next section assesses the geographical distribution per district of those opportunities.

27.3.1 Corozal District

In the Corozal District, a total of 41 employment opportunities related to the activities of the solid waste management plan could be created (see Table 74). This would in principle, accommodate for the number of 37 persons identified that would be affected by the implementation of the transfer station for Corozal Town and the closing of the Corozal dump site.

[20] The employment opportunities generated at the landfill in Mile 24 and those required for transporting the waste from the transfer stations to the landfill at Mile 24 are not included.

In the event that only those permanently active at the Corozal Town dump site are considered, then the 10 opportunities at the sorting facility at the transfer station in Corozal Town would suffice, with the option to accommodate also a number of those that work on a temporary basis.

Table 74: Comparison of the number of recyclers who would lose their source of income versus number of employment opportunities created in Corozal District by the Solid Waste Management Plan

Location	Persons active at dumpsite recovering recyclable materials		
	Permanent basis	Temporary basis	Total
Corozal Town, Corozal District	8	15	23
Consejo / Paraiso (Villages) Corozal District	3	0	3
Corozal Free Zone Dump site	0	11	11
Total	**11**	**26**	**37**
Activity with employment opportunity	**Low skill level**	**Unskilled labourers**	**Total**
Transfer station Corozal			
Opportunities to recover (and commercialize) recyclable materials from the incoming waste stream		10	10
Operation of Transfer station	3	2	5
Operation of Drop off Centre + Composting Facility (13 in total)	17	0	17
Operation of Drop off Centre (5 in total)	5	0	5
Transportation from DOC to Transfer Stations	4	0	4
Total	**29**	**12**	**41**

27.3.2 Orange Walk District

In the Orange Walk District, a total of 36 employment opportunities related to the activities of the solid waste management plan could be created (see Table 75). This would in principle, accommodate for the number of 30 persons identified who would be affected by the implementation of the transfer station for Orange Walk Town and the closing of the Orange Walk Town dump site.

In case, only those permanently active at the Orange Walk Town dump site are considered, then the 10 opportunities at the sorting facility at the transfer station would need to be complemented by a number of opportunities in the operation of the transfer station and also in the operation of the DOC´s and DOC+CF within a range of 20-30 km from Orange Walk.

Table 75: Comparison of the number of recyclers who would lose their source of income versus number of employment opportunities created in Orange Walk District by the Solid Waste Management Plan

Location	Persons active at dumpsite recovering recyclable materials		
	Permanent basis	Temporary basis	Total
Orange Walk Town	20	10	30
Total	**20**	**10**	**30**

Activity with employment opportunity	Low skill level	Unskilled labourers	Total
Transfer station Orange Walk			
Opportunities to recover (and commercialize) recycle materials from the incoming waste stream		10	10
Operation of Transfer station	3	2	5
Operation of Drop off Centre + Composting Facility (10 in total)	13	0	13
Operation of Drop off Centre (4 in total)	4	0	4
Transportation from DOC to Transfer Stations	4	0	4
Total	**24**	**12**	**36**

27.3.3 Stann Creek District

In the Stann Creek District, a total of 52 employment opportunities related to the activities of the solid waste management plan could be created (see Table 76). This would in principle, accommodate for the number of 33 persons identified that would be affected by the implementation of the transfer stations at Dangriga, Placencia and Independence and the closing of the dump sites in these three areas.

In the event that only those permanently active at the dump sites are considered, then the 20 opportunities at the sorting facilities at the transfer stations in Dangriga and Independence would suffice, with the option to accommodate also a number of those that work on a temporary basis in the different dump sites.

Table 76: Comparison of the number of recyclers who would lose their source of income versus number of employment opportunities created in Stann Creek District by the Solid Waste Management Plan

Location	Persons active at dumpsite recovering recyclable materials		
	Permanent basis	Temporary basis	Total
Dangriga Dump site	1	20	21
Placencia Dump site	1	8	9
Independence dump site	0	3	3
Total	**2**	**31**	**33**

Activity with employment opportunity	Low skill level	Unskilled labourers	Total
Transfer station Dangriga			
Opportunities to recover (and commercialize) recycle materials from the incoming waste stream		10	10
Operation of Transfer station	3	2	5
Transfer station Independence			
Opportunities to recover (and commercialize) recycle materials from the incoming waste stream		10	10
Operation of Transfer station	3	2	5
Operation of Drop off Centre + Composting Facility (11 in total)	13	0	13
Operation of Drop off Centre (5 in total)	5	0	5
Transportation from DOC to Transfer Stations	4	0	4
Total	**28**	**24**	**52**

27.3.4 Toledo District

In the Toledo District a total of 44 employment opportunities related to the activities of the solid waste management plan could be created (see Table 77). Since no affected recyclers were identified at the Punta Gorda dump site, the vacant positions could be filled by those from other districts in case the necessity would arise. This would probably entail a permanent resettlement to Punta Gorda considering the distances from Punta Gorda to Orange Walk and Corozal Town.

Table 77: Comparison of the number of recyclers who would lose their source of income versus number of employment opportunities created in Toledo District by the Solid Waste Management Plan

Location	Persons active at dumpsite recovering recyclable materials		
	Permanent basis	Temporary basis	Total
Punta Gorda	0	0	0
Total	**0**	**0**	**0**
Activity with employment opportunity	**Low skill level**	**Unskilled labourers**	**Total**
Transfer station Punta Gorda			
Opportunities to recover (and commercialize) recycle materials from the incoming waste stream		10	10
Operation of Transfer station	3	2	5
Operation of Drop off Centre + Composting Facility (9 in total)	11	0	11
Operation of Drop off Centre (12 in total)	12	0	12
Transportation from DOC to Transfer Stations	6	0	6
Total	**32**	**12**	**44**

27.4 Activities of SIPF

The timetable below provides the general framework of the activities for the forthcoming seven years until the proposed system is fully operational and the facilities are receiving and processing the collected waste. The activities in blue indicate the integration of the SIPF in general terms.

Figure 27: General framework of activities for implementation of SWM and integration of SIPF.

Activity	Corridor	2016	2017	2018	2019	2020	2021	2022
Loan procedures + Tendering	NC+SC							
Consultation processes recyclers	NC+SC							
Training + capacity and organisation building recyclers	NC+SC							
Transfer stations construction	NC+SC							
Landfills + Transfer stations operational to receive waste from Agglomerates	NC+SC							
Recyclers integrated in operation of TS´s	NC+SC							
Construction of DOC_CFs and DOCs	NC+SC							
Complementary system (DOCs+transportation) operational to receive waste from urban and rural villages	NC+SC							
Recyclers integrated in operation of DOC´s	NC+SC							
Estimated status of dumpsites	NC+SC	receiving waste	receiving waste	receiving less waste	receiving no waste	closed / remediation		
Estimated status of income of recyclers	NC+SC	No loss of income			Possible loss of income	No loss of income		
Institutional strengthening SWaMA								

The activities fall into four main phases:

- **Phase 1:** Consultation processes with the recyclers at the dump sites
- **Phase 2:** Training + capacity and organisation building recyclers
- **Phase 3:** Recyclers integrated in operation of TS´s
- **Phase 4:** Recyclers integrated in operation of DOC´s

27.4.1 Phase 1: Consultation processes with the recyclers at the dump sites

Phase 1 is expected to run in parallel to the loan procedures and tendering for the design and construction of the transfer stations. This phase should focus on the consultation process with all the recyclers present at the different dump sites, where the cut-off date for eligibility should strive to be prior to commencement of construction of the transfer stations. During this phase it is essential:

- To define which dump sites are included in the SIPF and for which an individual SIP needs to be prepared.
- To define those recyclers affected in dumpsites that will not be closed, but that will be affected by the construction of the Transfer Stations, as is the case for Paraiso Village,
- To define the eligibility criteria of the recyclers to be included in the SIPF and as such would be entitled to compensation and be beneficiaries of mitigation measures.
- To establish a list of recyclers who are eligible for compensation and would be beneficiaries of mitigation measures.
- To define which recyclers would work at which transfer stations and/or DOCs.
- To define the minimum qualifications and skills required for the different functions in the transfer stations and DOCs.

- To conduct a training needs assessment of the recyclers for them to be able take on the (operational) functions in the TS´s and DOC´s.
- To prepare a training program to train the recyclers for them to be able take on the (operational) functions in the TS´s and DOC´s
- To define the operational and financial model for the recyclers to operate within the TS´s and /or DOC´s.
- Strengthen SWaMA with at least one social officer that would be responsible to accompany the implementation of the SIPF and the site specific SIPs and take a lead role in their implementation.

During this phase it is assumed that the dump sites remain open and continue to receive waste and as such no loss of income is foreseen for the recyclers.

27.4.2 Phase 2: Training + capacity and organisation building for recyclers

This second phase will take place whilst the transfer stations are being constructed in the different districts. This phase should focus on preparing the different recyclers groups that will start to work within each transfer station.

Principal activities during this phase include:

- Training of recyclers so that they can a) operate in the sorting facility at the transfer stations or b) other functions within the transfer station.
- Process of definition of organisation model of recyclers and legal registration of chosen model.
- Capacity and organisation building of the recyclers groups as per the organisational and financial model.
- Development of monitoring and evaluation procedures and indicators for the implementation of the SIP.
- Develop model agreements /contracts between SWaMA, the operators of the Transfer Stations and the recycler groups on how the sorting activity is financed.

This phase is expected to last 2 years and the recyclers groups should be prepared in accordance with the construction schedule of the different TSs.

During this phase it is assumed that the dump sites remain open and continue to receive waste and as such no loss of income is foreseen for the recyclers.

27.4.3 Phase 3: Recyclers integrated in operation of TS´s

This phase will focus on:

- Accompanying the process of the integration of the recyclers into the transfer stations operations.

- Training and capacity building for those recyclers that will be integrated in the operation of the DOC´s.
- Process of definition of organisation model of recyclers and legal registration of chosen model.
- Capacity and organisation building of the recyclers groups for the DOC´s in definition of organisational and financial model.

During this phase, in those municipalities where the transfer stations become operational, the dump sites cease to receive waste and it is expected that the recyclers groups will start to function in each of the transfer stations.

27.4.4 Phase 4: Recyclers integrated in operation of DOC´s

This phase will focus on:

- Continuation of the monitoring of the process of the integration of the recyclers into the transfer stations operations
- Accompanying the process of the integration of the recyclers in the DOC´s

It is assumed that by this stage all dumps will be closed and remediated and that all recyclers will have been integrated into one of the other facilities of the new system or are gainfully employed elsewhere.

27.5 Estimated Budget

The table below provides an estimate of the costs associated with the implementation of the SIPF whereby the assumption is made that:

- All the affected population will be compensated on different levels according to how they are classified. It will depend on the eligibility criteria and on the definition of different types of compensation for each case and on the prioritization that needs to be established during the initial phase of the SIPF.
- The definition of options that will be offered exclusively or in combination, and considerations of phasing periods will be clearly described according to recyclers that work permanently vs temporarily
- Some of those recyclers active on a temporary basis on the dump sites will not work at the transfer stations and could be integrated in the future DOC´s when they will be constructed.

Table 78: Estimated budget for implementation of SIP from 20XX to 20XX.

Quantity	Item	Estimated Cost (US$)
1. Consultation process		
5	Consultation meetings Corozal (accommodation, food)	5 000
3	Consultation meetings Orange Walk	3 000
3	Consultation meetings Dangriga	3 000
3	Consultation meetings Placencia	3 000
3	Consultation meetings Independence	3 000
1	Consultation meetings Punta Gorda	1 000
	Total	**16 000**

2. Training needs assessment and training program development		
1	Training needs assessment for all districts	10 000
1	Training program development for all districts	10 000
	Total	**20 000**
3. Training and capacity building		
1	100 hours training and capacity building Corozal	10 000
1	100 hours training and capacity building Orange Walk	10 000
1	100 hours training and capacity building Dangriga	10 000
1	100 hours training and capacity building Placencia	10 000
1	100 hours training and capacity building Independence	10 000
1	100 hours training and capacity building Punta Gorda	10 000
	Total	**60 000**
4. Organization definition and registration		
1	Organization definition recyclers´ group and registration Corozal	10 000
1	Organization definition recyclers´ group and registration Orange Walk	10 000
1	Organization definition recyclers´ group and registration	10 000
1	Organization definition recyclers´ group and registration Placencia	10 000
1	Organization definition recyclers´ group and registration Independence	10 000
1	Organization definition recyclers´ group and registration Punta Gorda	10 000
	Total	**60 000**
Total		**156 000**

In addition, the budget would need to include the hiring of a Social specialist by SWaMA for the period from 2016 till at least one year after all the Transfer Stations have become operational and recyclers have started working at them.

A 10% discretionary budget will remain unallocated, for any additional items to be identified during implementation.

27.6 Institutional Arrangements and Capacity

The three main stakeholder groups initially to be involved in the implementation of this Social Inclusion Plan are SWAMA, the eligible recyclers at the different dump sites (whether represented by an organization or not), and the Operators of the new transfer stations where the recyclers will operate, and possibly the umbrella organisation responsible for the operation of Drop Off Centres in each district. Additional stakeholder groups to consider include the Town Council of the local municipalities (in which the facilities are located), intermediaries who purchase the recyclable materials, the operational staff at the transfer stations and relevant staff at the IDB (Country Office or HQ).

Belize Solid Waste Management Authority (SwaMA). SWaMA would be responsible for overseeing Safeguards compliance in this project, including livelihoods restoration of affected recyclers and any resettlement-related issued. SWaMA has very high capacity but no dedicated Specialist for Safeguards or social issues. We have recommended the hiring of a dedicated consultant, the drafting of TORs and a hiring process to begin. Coordination between SWaMA and the other actors should include:

- Regular meetings
- Division of tasks regarding monitoring activities

Recyclers. The recyclers per dump site will be responsible for setting up and operating their own organization to operate at each of the transfer stations with support from SWaMA, the operator of the respective Transfer station and other actors, including the Cooperatives Department.

Operators of transfer stations: The operators of the transfer stations would be responsible for overseeing, implementing and also monitoring the operations at the new facilities where recyclers would potentially be working at.

Belize Recycling LTD and/or other recycling entities. Belize Recycling is the main buyer of recyclables from Mile 3 and San Ignacio, and would play an important role as well in purchasing of materials recovered in the transfer stations and DOCs. Southern Metal recycling also could play an important role in this respect. It should be assessed whether they would need a signed agreement with SWaMA and the TS operators. These contractual arrangements between SWaMA and the operator of the new facility to sanction:

- Agreements on payment of recyclers
- Working conditions of recyclers
- Additional compensation (if relevant)

Inter-American Development Bank (IDB). IDB is responsible for Supervision of all Safeguards-related work, including implementation of this SIP.

Capacity assessment of SWaMA and the TS operators should include:

- Training activities
- Consultations events (with the eligible recyclers)
- Monitoring and Evaluation activities

F. ANALYSIS OF ALTERNATIVES

28 INTRODUCTION

In order to determine the most suitable choices for the Municipal Solid Waste management in the two considered Regions, Northern and Southern Corridors, different alternatives have been preliminarily investigated.
The initial and most relevant choice was the decision on the actual extent of the analysis for the Master Plan to be carried out. While the implementation of a waste collection system is out of the scope of the Master Plan it was noticed that not considering this crucial aspect would have been a highly limiting factor. Such approach, in fact, would have limited the extent of the study to a minority of the population of the two Corridors (between the 35% and 40% approximately) that is presently served by an already established collection system.
A Master Plan based on these reduced boundaries could have then led to choices suitable for such extent but not necessarily ideal at a larger scale. This not only because of the large amount of the population living outside those boundaries but especially when taking into account the substantially different characteristics of the urban settlements not included in the initial list.
A solution was then proposed and agreed with SWaMA for the definition of a basic waste collection system applicable to villages (based on Drop Off Centres) that could have allowed their inclusion in the following analysis and proposals.
The following studies and assessments have then been based on the whole extension of the two Corridors including all the urban and rural settlements.

The following areas have been considered during the process:

- Alternative technologies
- Alternative systems (regionally based vs. national scenario)
- Alternative locations of the facilities (site screening)

In the present document, according to the directives provided by the TOR approved by the DoE, the systematic comparison of these alternatives is reported, in the aim to provide evidence of the process that led to the final choice of what has been considered as the most suitable scenario to fulfil the needs of the two Corridors in terms of solid waste management.

The assessment of the suitability of each scenario is made taking into account:

- environmental factors (potential environmental impacts, natural hazard, climate change);
- social factors (social impacts);
- capital and operating costs (reliability, suitability under local conditions, and institutional, training requirements).

The waste management scenario that is finally proposed by the Master Plan has been identified on the basis of the outcomes of the comparisons hereinafter reported.

All the laws and regulations to which reference is made in the present document are discussed in the "Environmental Assessment" document, and all the guidelines and studies mentioned in the present document are listed in the paragraph "Bibliography" of the "Environmental Assessment" document.

29 ALTERNATIVE TECHNOLOGIES

Once the waste generation and characterisation study, documented by the Inception Report, provided the necessary base information, different technologies for the different stages of the management system (collection, transport, treatment, and disposal) have been compared to compose a suitable set of technologies.

29.1 **Collection**

While the design of a waste collection phase is not included in the scope of the present Master Plan, it was evident that it should have nevertheless been considered to some extent to allow the inclusion in the system of the majority of the population, living in the villages.
Already established public waste collection systems, in fact, are only existing in the four District Towns and in the Independence and Placencia villages.
Most of the population of the two Corridors is spread in a considerable number of villages. Long driving distances from one another, not always practicable roads and very low population on each centre are the main characteristics of these villages with regard to scope of the present work.
In the first instance it was then discarded the option of a common collection system based on communal bins and collection trucks. Such a system, in fact, appears to be inefficient and expensive given the described characteristics of the territory and the population to be served.

A system based on Drop-Off Centres was then chosen to better serve the rural areas of the Corridors for the aim of the Master Plan. Combined solutions can be evaluated at a more advanced stage of the planning.

Drop-Off Centre (DOC, otherwise also called Civic Amenity Site) is a simple and widely used facility that falls under the Waste Collection system. Such facility can be used both as an integration to more traditional collection systems and/or a stand-alone solution depending on local conditions (social, economic and operational).
Under a technical and operational point of view the DOC is a simple and low impact facility that can be located in a wide variety of different urban situations.

The proposed DOC consists of the following main features:

a. Fenced area (concrete kerbs and vegetation screen) served by an access road or directly adjacent to an existing one, approximately 600 m^2 in size;
b. Gate for access control;
c. Shelter for personnel and hazardous waste enclosure;
d. Paved area for hosting waste containers;
e. Stormwater drains

f. Steel platform for waste delivery into the containers

The operation of the DOC can be summarized as follows:

a. One permanent operator for waste acceptance, separation and storage, and housekeeping. No particular skills are required for the operator, experience as a recycler is an asset;
b. The waste delivered by households, businesses and institutions should be sorted from the source and each different fraction stored in the respective container. Users shall be assisted by the operator and progressively instructed to deliver the waste already sorted in accordance with the chosen type of separation.
c. Recyclables can be stored together in one container or divided in more specific containers depending on the logistic of the upstream system.
d. At least one container is dedicated to non-recyclable or residual materials to be disposed of.
e. Once one of the container is full the operator asks for emptying in accordance with the upstream logistic depending on the type of waste.
f. Organic fraction is either not delivered (rural villages) or delivered separately for the compost section (see next paragraph).

Under the more general point of view of the whole Integrated Waste Management System the use of DOCs offers many organisational advantages:

- Reduced need of house to house collection. Citizens are expected to deliver the waste on their own to the DOC.
- Improved efficiency of the collection: containers can be removed only when full rather than on a prescheduled timeline basis.
- Limited need of initial investment (less and less specific trucks, less communal containers) and low operation costs not only in comparison with an equivalent house to house collection
- Maximisation of the source separation of different fractions
- Constant and direct (personal) interaction with the generators offers an easier and more effective way to modify behaviours.
- Extreme flexibility to changes in the generation patterns and easy adaptability to new waste management treatment and disposal strategies.

In the case of the majority of the Villages of the two Corridors the advantages offered by the use of DOC appear to be particularly appropriate.

Presently, there are various waste management practices at village level (burning and dumping being the most common practices) and all of them constitute a time and energy consuming activity for both households and businesses. No regular collection is in place at village level a part from a negligible minority of cases.

At the same time the size of the majority of the villages (number of inhabitants and businesses) is such that a traditional collection system is not locally affordable.

Besides the cost of such a system, should it be connected to the wider regional integrated system rather than to a local dumpsite, would be even greater (long distances, secondary roads not in adequate conditions and not always practicable during the rainy season).
Under such circumstances it appears that the DOC is not only the more advantageous logistical solution but also that the acceptance of such method can be reasonably expected to be high.

The proposed DOC also provides room for parking a small collection vehicle in case a local collection system would be considered feasible and affordable.

29.2 Transfer Stations

The choice of the transfer facility was guided by two major constraints:

- Homogeneity with the existing system in the Western Corridor to facilitate the management of the whole national system (technology, procurement processes, operation and control procedures)
- Use of the transfer station also as a sorting facility both for management (waste separation) and social (inclusion of recyclers) purposes.

Under such circumstances alternative systems based on different technologies and/or management concepts were discarded from the beginning. The proposed technology, specifically designed for the Master Plan, is then based on the existing transfer facilities with minor adjustments to improve the expected performances deriving from the lessons learned from the present Western Corridor system.

The transfer facility is then designed to offer the following performances:

- storage capacity of waste sufficient to cater for emergencies in the transport lasting for 4 days;
- operational capacity in normal conditions for single day 2 times the projected maximum amount of estimated daily input, to cater for emergencies and daily fluctuations in the collection system.
- improved efficiency in waste sorting activities allowing more accessibility to materials and longer times for sorting;
- improved safety with strict separation of the working areas for machines and trucks and working areas for the recyclers.

Description of the operation, normal conditions:

i. weighing of collection trucks and data registration;
ii. collection trucks reverse in the service area and enter the building approaching the available offloading line (Chamber in the drawing) and offload;
iii. the wheel loader spread the waste in a 40 cm thick layer along the line;
iv. operation (i.) and (ii.) are repeated until the line is full (each line can host from 2 to 5 loads depending on the size of the load;
v. recyclers are allowed to access the completed line and sort the materials (the line will be available for sorting for not less than one hour in peak times);

vi. sorted materials are placed in wheel barrows placed in the adjacent recycling line and removed using the exit at the back of the building to be stored in the respective container;
vii. collection trucks offload in the next available lines in sequence;
viii. after completion of the sorting in the first line the recyclers move to the next available line and the wheel loader removes the residual waste loading it into the transport hauler;
ix. the cycle is repeated.

The building is proposed in two different sizes depending on the projected waste amounts expected for the area:

- four offloading lines (Chambers): Corozal, Orange Walk;
- two offloading lines to be upgraded to four at the 10th year: Independence;
- two offloading lines: Dangriga, Punta Gorda.

The concept of the building is such that it can also be easily adapted to future evolutions of the system and, specifically, of the diversion of the waste at source. In that case the sorting activity will reasonably shift from “positive sorting”, meaning the sorting of the valuable from the undifferentiated mass of waste, to “negative”, sorting of impurities from mainly homogeneous waste fractions.
At that time the conditions for the operation will be characterised by:

- two main waste streams: mixed (non-sortable) waste and source separated (to be refined)
- quicker sorting process: the negative sorting of impurity is a faster process than the positive sorting.

The separation between the different lines is foreseen to be built using pre-casted concrete step barriers bolted to the floor. The sorting building will then be easily adapted to such changed situation by simply removing or rearranging one or more line separation walls should the new conditions request a different configuration of the volumes.
Two truck full length loading sections are foreseen to grant a higher operational flexibility. While the first loading section can be used for loading open trucks a stationary press can be installed in the second one for container loading. This feature offers the possibility of different operational options:

3. use of section 1 as the main one: loading section 2 can be used for:
    a. additional trailer to allow a better management of the towing vehicles
    b. loading of different waste fractions in case of “negative” sorting directly on trucks or
    c. loading of waste in containers through a stationary press
4. use of section 2 as the main one through the installation of a stationary press, section 1 can then be used for:
    a. loading of open trucks in case of malfunctioning/maintenance of the press
    b. loading of different waste fractions.

29.3 **Waste treatment**

Municipal waste can be sub-divided in two main components depending on the type of treatment:

- Wet waste (organic)
- Dry waste (inorganic).

The different and many types of treatment can also be sub-divided in three main categories:

- Mechanical: e.g. compaction, shredding, separation, sorting
- Biological: e.g. composting, anaerobic digestion;
- Thermal: e.g. incineration, gasification.

Mechanical treatments are mainly aimed to allow or facilitate the following processes: transport, treatment and disposal. They are herein seen as part of the main treatment processes and not considered by themselves.

In the following both the man biological and thermal treatment options are discussed with specific focus on the aim of the present Master Plan.

29.3.1 Biological treatment

Separation of the organic fraction is the important element of an Integrated Waste Management System. The organic fraction is in fact responsible for methane emissions in landfills and dumpsites and for the release of most of the pollutants in leachate. On the other hand, the organic fraction, if properly separated and treated, is a source of renewable resources: compost and energy.
The presence of organic waste also negatively affects the technical possibilities to more effectively recover the remaining materials from the commingled waste stream.

The goal of separating the organic fraction at source from the rest of the waste streams shall then be a priority for an Integrated Waste Management Plan.

It has nevertheless be noted that such goal can only be achieved through an appropriate collection system. While a wide variety of different technical solutions can be in fact proposed for the treatment of the organic biodegradable fraction they all depends on the quality and quantity of the organic waste that the collection system can ensure.

The present Plan is nevertheless focused on the establishment of a functional final disposal system and such proposal shall necessarily consider and be consistent with the present collection situation.
On the other hand, it is our advice that the aspect shall be here included providing proposals for its future implementation consistent with the present Plan and, to the extent possible, already including such solutions that are not conflicting with the existent collection system.

In the following paragraph 29.3.1.1 technical options are presented as suitable to be adopted in the following cases:

i. *Agglomerates*: the municipal collection system is already in place in all the Towns and two villages (Placencia and Independence). In the majority of the cases the conditions of the system in place are very critical both under a technical and an economic point of view. It cannot be expected neither to replace nor to sufficiently improve such systems to cater for additional tasks such as the separate collection of waste in the short – medium term. In few villages an “on demand” private collection system is in place serving a great minority of households, it is not likely that such system can evolve as such as to include separate collection of organics.
ii. *Large generators of organic waste*: in the case of already existing large generators of biodegradable organic waste such as touristic facilities, markets, agro-food industries agreements can be proposed for the establishment of separate collection and treatment either at a national level (Associations) or at a local level (single generators). In case of new operators of the abovementioned sectors whose projects are subject to EIA the aspect should be considered in the evaluation of the project.

The subsequent paragraph 15.3.1 presents the proposal, included in the present Plan, to cater for the organic waste in all those villages with a population above 1,000 inhabitants (here referred to as Urban Villages) where also the DOC system is proposed.

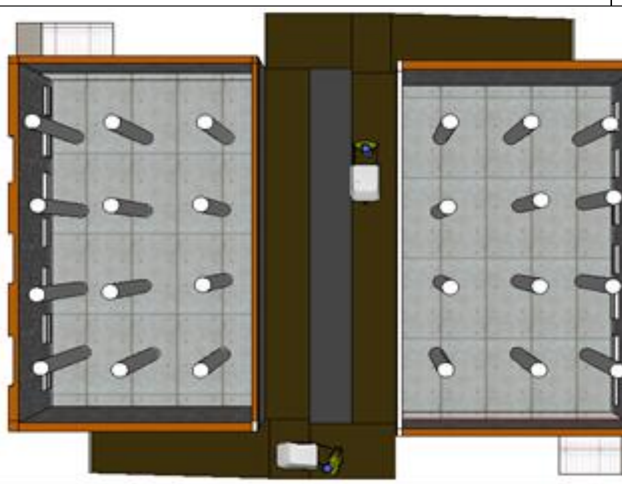
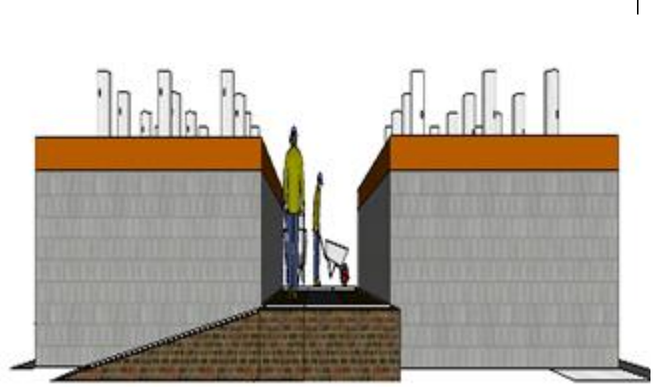
29.3.1.1 Agglomerates and large generators

Technical and economical effective solutions to cater for source separated biodegradable waste are various and applicable to different generated quantities and quality.

Low quantities (less than 500 kg per day) with presence of yard waste
The solution proposed in the following section for Urban Villages can be adopted.

Medium low quantities (between 500 kg and 1 tonne per day) with presence of yard waste
The construction of a small compost facility with static aeration as in the following example can become economically suitable. The following Figure 28 shows an example of an effective and low cost solution of a static aeration composting plant as adopted by the Republic of El Salvador.

Figure 28 – Local community composting plant, El Salvador

	
Composting facility, each building host four chambers	*Static aeration chamber*
	
Plan view of chambers	*Perspective view*
Source: Manual de operación para los proyectos de compostaje y reciclaje de desechos sólidos municipales, República de El Salvador - Ministerio de Medio Ambiente y Recursos Naturales	

Medium high quantities (more than 1 tonne and up to 10 tonnes per day) and presence of yard waste

Larger areas are needed when, due to the quantities, it becomes inconvenient to build enclosed facilities. The forced aeration in enclosed facilities could be a technically feasible solution but with very high energy consumption and complex operation. Given the availability of a sufficiently wide area the following solutions are suggested as the most cost effective (approximately 1 hectare is needed to treat 10 tonnes per day - 3,700 tonne/year without forced aeration).

Figure 29 – Plastic membrane biotunnel composting

Source: www.ceamse.gov.ar/reciclaje/compostaje/

Figure 30 – Static windrow composting

with forced aeration	With natural aeration
Source: www.waste-management-world.com	

High quantities (between 10 and 60 tonnes per day) and no yard waste

The tendency to combine the treatment of the organic biodegradable fraction with the waste water treatment has already been explored and successfully implemented in many cases with a variety of different technical and organisational solutions. This option allows, among other advantages, to optimise the needed investment and to achieve better performances in both processes.

Whenever such an option could be possibly implemented it should be thoroughly considered in future. The simplest and most cost effective solution in such case can be the shredding of the organic fraction and its injection in the sludge digester.

Alternatively the press-extrusion of the organic fraction of the MSW is also possible. The process allows the separation of a semi-liquid phase easily digestible even in small plants from the solid phase (fibres and impurities such as plastic) to be landfilled (see Figure 31).

Figure 31 – Press-extrusion of organic fraction of MSW

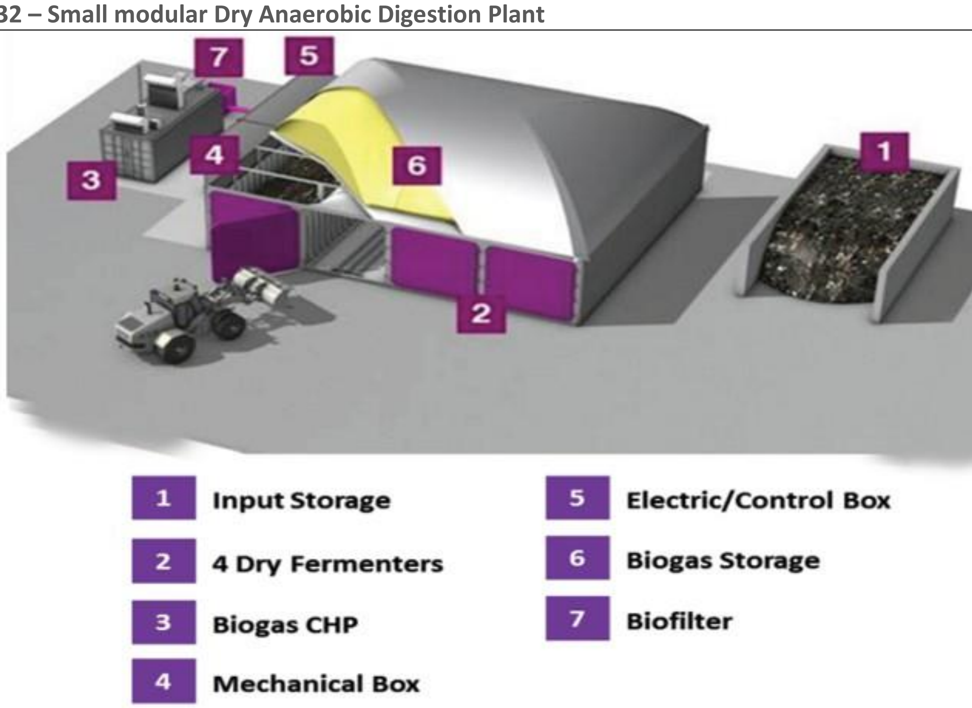
Organic bag from source separated collection	*After primary shredding*	*Organic pulp after press-extrusion*

Press-extrusion device

Source: www.vmpresstechnologies.com

An alternative and increasingly adopted solution for organic waste, especially with higher impurity content, is also the Dry Anaerobic Digestion.

Figure 32 – Small modular Dry Anaerobic Digestion Plant



Source: www.waste-management-world.com

While composting is a very simple, low tech and low cost solution that can be adopted at the present stage of the waste management system in Belize, anaerobic digestion should only be considered as a feasible and mostly desirable solution only when a fully developed Waste Management Agency is in place and the capability of the collection system to cater for separate collection of the organic fraction is well established.

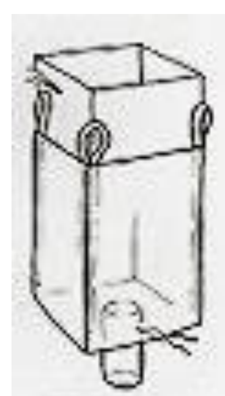
29.3.1.2 Urban Villages

In Urban Villages with population up to 2,000 inhabitants the generation of biodegradable organic waste is estimated to range from 180 to 600 kg per day approximately (70 to 200 tonne/year).
As a conservative assumption it has been assumed that all the organic waste generated is delivered to the DOC to be composted.
Assuming the mentioned range of daily quantities and an initial average density of 0.4 tonne/m^3 the volume to be treated ranges between 0.45 - 1.5 m^3 per day.
Finally, considering that the time requested for the full development of the processes in conditions of natural aeration is 90 days, the total volume to accommodate in a single facility ranges between 40 - 135 m^3.

Under such circumstances, very limited total quantities, and considering the need of limiting the investment costs and simplify the operational procedures, the chosen solution is to adopt a simple modular system based on the use of Big Bags.

The Big Bags shall be of the woven Polypropylene (PP) type with opening both on top and bottom side, 1 m^3 capacity (90 x 90 x 120 cm or similar).

Figure 33 – Big Bag woven Polypropylene opening on both top and bottom side



The plastic bag is permeable to air but impervious to water penetration. Air circulation is then improved by the insertion of a PVC perforated pipe throughout the bag opening.
The biodegradable waste delivered will be deposited inside of a Big Bag, placed on a pallet, with the addition, if necessary, of wood chipping as a structuring material. Once a bag is full it will be moved to the storage area through a manual pallet carrier.

Figure 34 – Rough terrain pallet carrier

The bag is then left in the storage area for the time necessary (generally 90 days). The process can be controlled measuring the temperature and the addition of moisture as required.

According to such system and taking into account the figures provided above, a maximum area of 135 m2 is required for the storage of the bags. Such area can be doubled to consider the need of storing a minimum amount of compost, wood chippings and to cater for service areas.

The compost facility, on the whole, will consist in an additional approximately 300 m^2 wide fenced area to be added to the DOC as described in Annex 4 of the "Conceptual Design" document.

For the operation of the facility another operator will be required on a part time basis, as well as the following materials:

- Wheel barrow and shovels
- Mesh screen
- Thermometer stick
- 200 woven PP Big Bags (90 x 90 x120 cm or similar)
- 150 perforated PVS pipes Ø 100 (4") 150 cm length
- 150 pallets

29.3.1.3 Marketing of compost

Provided that the compost from the biodegradable component of the MSW respects adequate quality standards for the marketing it can be used to any different purposes:

- Agriculture: to limit the use of chemical fertilizers and restore the organic content of the soil. This use is not very common (more expensive than conventional methods) and requires very high quality standards
- Degraded land restoration: for the recovery of compromised lands improving their stability and reducing soil erosion
- Green public and private areas maintenance: a more common use, directly by the municipalities or by private entities mainly in the tourism sector
- Flower and pot plants growing sector: one of the most common uses at a large scale
- Gardening: a very common small scale use both for pot plants and gardens.

In spite of the usefulness of compost in a wide variety of applications it is not advisable, at a general planning level, to consider any possible revenue from the sale of compost.
The actual marketability of compost can only be determined at a local level when designing a specific facility. In many cases in fact not only the compost is sold at a very low price, if not for free, but it can also be difficultly marketed if produced in large amounts.

An important phase of the design work for the specific foreseen central facility (Town level) is the preliminary search for uses of the compost to be produced. This can be done by involving the tourism sector as well as identifying lands to be restored. The use of compost for gardening at household level can also be promoted.

29.3.2 Conventional Thermal treatments

SW incineration, together with other more complex thermal treatments (pyrolysis), is a solid waste treatment technology that has successfully been implemented in many developed countries, because it offers a number of advantages such as:

- this technology guarantees the most efficient way of reducing the volume of the waste and thus the demand for landfilling;
- with proper air pollution control system, as the case may be, the plants can be situated close to urban areas, reducing the needs for transportation;
- if the energy of the waste is recovered for power and/or heat or steam production, SW can act as a substitute for fossil fuel.

Accurate evaluations of the SWM system have to be carried out in order to:

- determine if this technology could be suitable in the areas being considered, and;
- plan a successful implementation of SW incineration facilities

In the assessment of the suitability of the incineration technology for the treatment of the waste produced in Northern and Southern Corridors, the reference is made to *"ISWA Guidelines: waste to Energy in Low and Middle Income Countries"* prepared by the Working Group on Energy Recovery of ISWA (International Solid Waste Association), August 2013.

The guidelines mentioned above aim to assist decision makers in the planning and implementation of Municipal Solid Waste (MSW) incineration facilities in low and middle income countries. The guidelines illustrate some of the key factors and criteria necessary for a successful implementation of an MSW incineration facility.
According to the suggestions provided, incineration should generally only be considered as an option for the waste treatment if all the key factors listed in Table 79 are complied with.
In Table 79, we have evaluated the compliance of the SWM system being planned in the present Master Plan with the key factors suggested.

Table 79 – compliance with the key factors

Key factor	Compliance
<u>A mature and well operated waste management system already exists</u>. Implementing an MSW incineration facility in a poorly developed waste management system and without proper planning can lead to environmental and economic failure. The key risks are varying waste amounts delivered, too low calorific value, poor financial support, inappropriate choice of technology and inadequate institutional framework.	The performances of the actual SWM system do not meet the standards needed to allow the implementation of this technology and even considering the improvements foreseen in the short and medium terms by the present Master Plan, the SWM system shall not have the required characteristics.
<u>MSW is already being disposed in controlled and well-operated landfills</u>. When investigating the viability of MSW incineration it is important that regulations and enforcement exist such that non-recyclables are disposed of at landfills. Having an established system where all non-recyclables are actually disposed of at controlled locations makes the transition to MSW incineration more realistic as the waste sector can be assumed to provide a reliable supply of waste to a new facility.	The performances of the actual SWM system do not meet the standards needed to allow the implementation of this technology and even considering the improvements foreseen in the short and medium terms by the present master plan, the SWM system shall not have the required characteristics.
<u>The supply of combustible MSW should at least amount to 100,000 tonne / year. (Can be smaller in isolated areas</u>)	The overall amount of the waste currently produced in Northern and Southern Corridors is lower than the minimum quantity needed. Even considering the increment in production as done in the present Master Plan, taking onto account that the diversion and recovering of the recyclable waste shall be a priority in the medium term, the overall amount of waste that could be treated with

	this technology would be too low (in the range of 20,000 t/year in each of the two Corridors)
<u>The lower calorific value must be, on average, at least 7 MJ/kg and never fall below 6 MJ/kg</u>	The waste being considered in the present planning process is characterised by a high fraction of organic matter and, considering the high amount of rain that falls, especially in the rainy season, it has to be expected that the waste should have a high humidity. All this elements affect the lower calorific value causing it to drop.
<u>The community is able and willing to pay for the increased treatment cost for example via management charges, tipping fees, tax based subsidies or high electricity feed-in tariffs</u>	The capital investments and operating costs of this type of plants are very high (investment costs are typically US$ 1000-1500/tonne and operational costs US$ 110-230/tonne), and the increment of the treatment cost will not be sustainable for the community.
<u>Skilled staff can be hired and maintained.</u> Skilled staff is required for the operation and maintenance of the furnace, boiler, turbine/generator and the flue gas cleaning system. Moreover the spare parts of the plants have to be acquired in foreign countries.	The maintenance of this type of conventional plants could be an issue because of the lack of skilled staff and the difficulty in acquiring spare parts and chemicals needed for the process.

Four small incinerators for medical waste have been built in the country, just one of them is currently operating, and the lack of the possibility of guaranteeing a good maintenance service prevent the others from being properly operated.

29.4 **Landfilling**

While the landfilling appears to be the only applicable final disposal system for the aim of the Master Plan, it is necessary to assess the most suitable landfill concept amongst the more commonly used.

In this regard the following main concepts can be mentioned:

- Traditional Landfill: the waste is disposed of according to commonly accepted practices but without aiming to enhance specific processes. Generally the result is that the waste is subject to a combination of aerobic and anaerobic processes depending on the characteristics of the landfill (waste input, thickness of the layers, …);
- Semi-Aerobic Landfill: the construction and operation of this type of landfill are aimed to enhance aerobic degradation processes of the waste through natural ventilation;
- Aerobic Landfill: same as the semi-aerobic one but the degradation processes are through forced aeration of the waste mass;
- Anaerobic Bioreactor Landfill: the construction and operation are aimed to enhance the anaerobic degradation of the waste. Landfill gas is collected and flared or used for energy recovery;

- Flushing Reactor Landfill: less common than the previous ones, is based on a forced and significant water circulation aimed to wash out the pollutants.

A first screening of the different available techniques is sufficient to exclude the following concepts as unsuitable for the aim of the Master Plan:

- Aerobic Landfill: more technology based in comparison to the semi-aerobic. It is used when the waste input rate is too high with respect to the available space. In the case of the current Master Plan, the waste inputs are very low and sufficient surface area is available to adopt the simpler and less expensive semi-aerobic landfill with comparable results;
- Anaerobic Reactor Landfill: needs high waste input rates and high depth of the waste mass with a quick burying of the waste under the new layers. It is not the case for this Master Plan due to the very low waste inputs and flat disposal areas.
- Flushing Reactor Landfill: it requires a lot of energy consumption, large and constant availability of water and adequate waste water treatment plants downstream. Such conditions are not satisfied in the case of the Master Plan.

The assessment of the possible alternatives is then reduced to the comparison of the Traditional Landfill and the Semi-Aerobic Landfill. The construction of a regional landfill is the key point of Scenario 2 as assessed in Section 0. Considering that the projected annual and final amounts of waste to be landfilled both in Northern and Southern Corridors are very similar, the proposed conceptual design for the regional landfill is the same in the two cases.

The major concern with regard to the construction of a landfill in both Regions, under an environmental and social point of view, is related to the potential impact of the waste disposal on groundwater.

The geology of Belize, particularly in the Northern Region, is mainly characterised by highly permeable soils and abundance of groundwater resources.

It is undoubtedly true that, at a regional level, the replacement of the dispersed system of dumpsites with a central controlled landfill certainly offers a significant improvement in the protection of groundwater.

On the other hand, at a local level, the landfill still constitutes an environmental threat. The lack of adequate geological formations that could have offered a natural geological barrier shall then be mitigated by decreasing the potential risk related to the landfill emissions.

This aim can be achieved through three different intervention strategies:

1. Reduce the hazardousness of the waste to be deposited (e.g. divert the organic waste to specific treatments for recovery or safe disposal; diversion of hazardous waste; pre-treat the waste, etc.). This strategy should become a priority in the implementation of a developed collection system but it doesn’t appear to be attainable in the short-medium term.
2. Improve the performance of the waste disposal through techniques that can reduce the type and harming potential of the emissions (e.g. through the pre-treatment of waste or by using a reactor landfill either aerobic or anaerobic).
3. Improve the Design of the artificial-constructed barriers.

In keeping with points 2 and 3 above, the proposed type of landfill is the semi-aerobic bioreactor (Fukuoka Method). This method is particularly suitable in cases where the annual input of waste is not extremely high (in the range of 20,000-30,000 tonne/year) and/or there is sufficient availability of space.
This condition appears to be well satisfied looking at the projected annual quantities estimated for the first half of the whole implementation period (around 12 years).
In the second half of the implementation period the annual waste input will increase to levels that are still compatible with a semi-aerobic landfill provided that the construction of the last landfill cell, as proposed in the Conceptual Design, will be anticipated with respect to a traditional landfill, so providing the necessary space to operate the landfill in accordance with the chosen model.

The principles and operational method of the semi-aerobic bioreactor landfill are summarized as follows:

- Construction of a modified leachate drainage system that works as a natural venting system at the same time.
- The system is taking advantage of the natural air circulation mainly enhanced by the high temperatures generated inside of the waste mass by the biodegradation processes. (The high ambient temperatures of tropical countries, on the other hand, do not cause a drastic drop of the inside temperatures that could cause the stoppage of the processes).
- The operation shall be only slightly modified with respect to a traditional landfill. The waste shall be spread daily in thin layers (generally 2 or 3 meters) without excessive compaction (maximum initial densities around 0.7 tonne/m^3 are typical).
- The ventilation system shall be constructed during the deposition of the waste (venting wells, horizontal trenches). Horizontal trenches can be constructed using bulky and/or permeable waste available on site (tires, plastic components, hardly degradable wood – e.g. coconut shells, wood chippings, pallets).
- The filling stages shall proceed horizontally rather than vertically, one temporary layer of waste approximately 4-5 meters thick shall be left unburden for at least 9 months or one year to allow aerobic processes to reach completion.
- The leachate head shall be constantly kept at the minimum.

Advantages and performances of the semi-aerobic reactor landfill:

- The process is very low technology and does not require energy, totally relying on natural processes.
- The process requires less energy for the compaction of the waste (less fuel consumption and machine depreciation – wear and tear)
- To operate a semi-aerobic landfill is not substantially different from operating a traditional landfill and does not require additional or specific equipment.
- If correctly operated only a negligible fraction of the waste will degrade anaerobically:
    i. Largely reduced odorous emissions;
    ii. No need for landfill gas extraction and combustion system.

- The pollutant content of the leachate, after a short initial period, will drop to values significantly lower than those typical of a traditional landfill. The leachate can also be partially recirculated during extended dry periods to enhance the degradation processes also reducing the total quantity at the final discharge.
- The landfill is constantly drained, no leachate head is left above the bottom liner. The risk of leakage and groundwater contamination is then virtually equal to zero.
- The largest majority of the degradation processes (and consequent emissions) occurs during the active life. The post-closure care of the landfill and the residual risk of environmental impacts after the closure are significantly reduced together with related costs.
- The volume reduction due to the degradation processes also occurs to the largest extent during the active life of the landfill. This results in an increased active life of the site.

A more detailed comparison of the environmental performances of the two types of landfills is given in section 30.1.2.2

30 ALTERNATIVE SYSTEMS – WASTE MANAGEMENT SCENARIOS

Having chosen the more suitable types of facilities for the aim of the Master Plan, different alternative waste management systems have been assessed and compared under their expected environmental and financial performance based on the location of the landfill as per the following:

<u>Scenario 1 - National landfill scenario</u>
Separation at source, recycling and local treatment of waste (composting) options are maximised and only the residual waste is transported to Mile 24 Landfill site from the considered Region. An adequate number and type of transfer stations is included.

<u>Scenario 2 – Regional landfill scenario</u>
One centralised Regional Landfill for each Region is proposed (two different locations within the Region are assessed). An adequate number and type of transfer stations is included.

<u>Scenario 3 – Small Landfill scenario</u>
A system of improved local dumpsites is evaluated, at different locations from the current dumpsites. The scenario, based on environmental performance only, is meant to represent the "do nothing" scenario.

30.1 Environmental aspects

In order to carry out the abovementioned comparison, the environmental performance of the following key elements of a SWM system shall be evaluated:

- waste collection;
- waste transportation;
- waste final disposal.

The provisions of Scenario 3 concern only the final disposal of the waste, therefore they shall be taken into account only in carrying out the environmental assessment of the waste final treatment methodologies.
The same waste collection system is foreseen in scenarios 1 and 2, therefore this key element can be overlooked in the comparative environmental assessment.

30.1.1 Waste transportation

The major environmental impact due to waste transportation is air pollution. The emissions from vehicles used in waste transportation might worsen the quality of the air, so, with a view to rate this impact in each scenario, the greenhouse gases (GHG) emitted shall be evaluated, for each year in the design period.

The following components of the overall waste transportation shall be considered:

- Scenario 1: Transportation from DOCs to TSs and then to Mile 24;

- Scenario 2: Transportation from DOCs to TSs or Regional Landfill and from TSs to Regional Landfill.

The GHG emissions are assessed following the methodology explained in section 25.1

The total distance travelled is referred to the transportation of the "residual" waste stream, as estimated in the DFS, to the Mile 24 Sanitary landfill, as per the Scenario 1 expectations, or to the regional landfill, as per the Scenario 2 expectations.

Northern Corridor

The pollutants emissions calculated for each scenario and for each district (CZ: Corozal District, OW: Orange Walk District) are shown in the following tables (Table 80 to Table 94).

In Scenario 2 the evaluations are conducted considering the possibility to locate the regional landfill in Consejo (Scenario 2a) or in San Estevan (Scenario 2b).

Table 80 - Scenario 1: Total distance travelled (miles per year) to Mile 24

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
CZ	78,025.36	83,762.35	86,116.75	96,063.40	102,650.19	139,076.44	143,881.06	148,856.46	154,008.63	159,343.76	164,868.27	170,588.77	176,512.13	182,645.43	188,996.00	195,571.42	202,379.54	209,428.47	216,726.59	224,282.57	232,105.40	240,204.33	248,588.97
OW	56,003.87	58,812.06	59,784.27	64,824.72	68,040.54	92,502.63	94,803.86	97,164.96	99,587.42	102,072.76	104,622.54	107,238.36	109,921.86	112,674.73	115,498.66	118,395.44	121,366.85	124,414.74	127,541.01	130,747.59	134,036.46	137,409.66	140,869.25
TOT	**134,029.23**	**142,574.41**	**145,901.02**	**160,888.12**	**170,690.73**	**231,579.07**	**238,684.92**	**246,021.42**	**253,596.05**	**261,416.52**	**269,490.81**	**277,827.14**	**286,434.00**	**295,320.15**	**304,494.66**	**313,966.86**	**323,746.39**	**333,843.21**	**344,267.60**	**355,030.17**	**366,141.86**	**377,613.99**	**389,458.22**

Table 81 - Scenario 1: total CO_2 (Mg/y)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
CZ	42.18	45.28	46.55	51.93	55.49	75.18	77.78	80.47	83.26	86.14	89.13	92.22	95.42	98.74	102.17	105.72	109.40	113.22	117.16	121.25	125.47	129.85	134.39
OW	30.28	31.79	32.32	35.04	36.78	50.01	51.25	52.53	53.84	55.18	56.56	57.97	59.42	60.91	62.44	64.00	65.61	67.26	68.95	70.68	72.46	74.28	76.15
TOT	**72.46**	**77.07**	**78.87**	**86.97**	**92.27**	**125.19**	**129.03**	**133.00**	**137.09**	**141.32**	**145.68**	**150.19**	**154.84**	**159.65**	**164.61**	**169.73**	**175.02**	**180.47**	**186.11**	**191.93**	**197.93**	**204.14**	**210.54**

Table 82 - Scenario 1: total CH_4 (g/y)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
CZ	397.93	427.19	439.20	489.92	523.52	709.29	733.79	759.17	785.44	812.65	840.83	870.00	900.21	931.49	963.88	997.41	1,032.14	1,068.09	1,105.31	1,143.84	1,183.74	1,225.04	1,267.80
OW	285.62	299.94	304.90	330.61	347.01	471.76	483.50	495.54	507.90	520.57	533.57	546.92	560.60	574.64	589.04	603.82	618.97	634.52	650.46	666.81	683.59	700.79	718.43
TOT	**683.55**	**727.13**	**744.10**	**820.53**	**870.52**	**1,181.05**	**1,217.29**	**1,254.71**	**1,293.34**	**1,333.22**	**1,374.40**	**1,416.92**	**1,460.81**	**1,506.13**	**1,552.92**	**1,601.23**	**1,651.11**	**1,702.60**	**1,755.76**	**1,810.65**	**1,867.32**	**1,925.83**	**1,986.24**

Table 83 - Scenario 1: total NO_2 (g/y)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
CZ	374.52	402.06	413.36	461.10	492.72	667.57	690.63	714.51	739.24	764.85	791.37	818.83	847.26	876.70	907.18	938.74	971.42	1,005.26	1,040.29	1,076.56	1,114.11	1,152.98	1,193.23
OW	268.82	282.30	286.96	311.16	326.59	444.01	455.06	466.39	478.02	489.95	502.19	514.74	527.62	540.84	554.39	568.30	582.56	597.19	612.20	627.59	643.38	659.57	676.17
TOT	**643.34**	**684.36**	**700.32**	**772.26**	**819.32**	**1,111.58**	**1,145.69**	**1,180.90**	**1,217.26**	**1,254.80**	**1,293.56**	**1,333.57**	**1,374.88**	**1,417.54**	**1,461.57**	**1,507.04**	**1,553.98**	**1,602.45**	**1,652.48**	**1,704.14**	**1,757.48**	**1,812.55**	**1,869.40**

Table 84 - Scenario 1: total CO_2e (Mg/y)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
CZ	42.30	45.41	46.69	52.08	55.65	75.40	78.01	80.70	83.50	86.39	89.38	92.48	95.70	99.02	102.46	106.03	109.72	113.54	117.50	121.59	125.84	130.23	134.77
OW	30.36	31.89	32.41	35.14	36.89	50.15	51.40	52.68	53.99	55.34	56.72	58.14	59.59	61.09	62.62	64.19	65.80	67.45	69.15	70.88	72.67	74.50	76.37
TOT	**72.66**	**77.30**	**79.10**	**87.23**	**92.54**	**125.55**	**129.40**	**133.38**	**137.49**	**141.73**	**146.10**	**150.62**	**155.29**	**160.11**	**165.08**	**170.22**	**175.52**	**180.99**	**186.64**	**192.48**	**198.50**	**204.72**	**211.15**

Table 85 - Scenario 2a: Total distance travelled (miles per year) to Consejo landfill

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
CZ	13,102.40	14,497.62	14,839.25	17,502.85	19,118.93	24,040.17	24,821.74	25,629.62	26,464.68	27,327.83	28,219.99	29,142.13	30,095.24	31,080.34	32,098.49	33,150.79	34,238.36	35,362.36	36,524.01	37,724.53	38,965.22	40,247.39	41,572.41
OW	34,704.73	36,543.42	37,113.97	40,486.38	42,598.34	57,409.67	58,852.04	60,332.33	61,851.49	63,410.51	65,010.39	66,652.16	68,336.86	70,065.59	71,839.44	73,659.56	75,527.08	77,443.22	79,409.18	81,426.22	83,495.60	85,618.65	87,796.70
TOT	**47,807.14**	**51,041.04**	**51,953.21**	**57,989.22**	**61,717.27**	**81,449.84**	**83,673.78**	**85,961.95**	**88,316.17**	**90,738.34**	**93,230.38**	**95,794.28**	**98,432.10**	**101,145.93**	**103,937.93**	**106,810.34**	**109,765.44**	**112,805.58**	**115,933.19**	**119,150.75**	**122,460.82**	**125,866.04**	**129,369.12**

Table 86 - Scenario 2a: total CO_2 (Mg/y)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
CZ	7.08	7.84	8.02	9.46	10.34	13.00	13.42	13.86	14.31	14.77	15.26	15.75	16.27	16.80	17.35	17.92	18.51	19.12	19.74	20.39	21.06	21.76	22.47
OW	18.76	19.76	20.06	21.89	23.03	31.04	31.81	32.62	33.44	34.28	35.14	36.03	36.94	37.88	38.84	39.82	40.83	41.87	42.93	44.02	45.14	46.28	47.46
TOT	**25.84**	**27.59**	**28.09**	**31.35**	**33.36**	**44.03**	**45.23**	**46.47**	**47.74**	**49.05**	**50.40**	**51.79**	**53.21**	**54.68**	**56.19**	**57.74**	**59.34**	**60.98**	**62.67**	**64.41**	**66.20**	**68.04**	**69.94**

Table 87 - Scenario 2a: total CH_4 (g/y)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
CZ	66.82	73.94	75.68	89.26	97.51	122.60	126.59	130.71	134.97	139.37	143.92	148.62	153.49	158.51	163.70	169.07	174.62	180.35	186.27	192.40	198.72	205.26	212.02
OW	176.99	186.37	189.28	206.48	217.25	292.79	300.15	307.69	315.44	323.39	331.55	339.93	348.52	357.33	366.38	375.66	385.19	394.96	404.99	415.27	425.83	436.66	447.76
TOT	**243.82**	**260.31**	**264.96**	**295.75**	**314.76**	**415.39**	**426.74**	**438.41**	**450.41**	**462.77**	**475.47**	**488.55**	**502.00**	**515.84**	**530.08**	**544.73**	**559.80**	**575.31**	**591.26**	**607.67**	**624.55**	**641.92**	**659.78**

Table 88 - Scenario 2a: total NO_2 (g/y)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
CZ	62.89	69.59	71.23	84.01	91.77	115.39	119.14	123.02	127.03	131.17	135.46	139.88	144.46	149.19	154.07	159.12	164.34	169.74	175.32	181.08	187.03	193.19	199.55
OW	166.58	175.41	178.15	194.33	204.47	275.57	282.49	289.60	296.89	304.37	312.05	319.93	328.02	336.31	344.83	353.57	362.53	371.73	381.16	390.85	400.78	410.97	421.42
TOT	**229.47**	**245.00**	**249.38**	**278.35**	**296.24**	**390.96**	**401.63**	**412.62**	**423.92**	**435.54**	**447.51**	**459.81**	**472.47**	**485.50**	**498.90**	**512.69**	**526.87**	**541.47**	**556.48**	**571.92**	**587.81**	**604.16**	**620.97**

Table 89 - Scenario 2a: total CO_2e (Mg/y)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
CZ	7,10	7.86	8.05	9.49	10.37	13.03	13.46	13.90	14.35	14.82	15.30	15.80	16.32	16.85	17.40	17.97	18.56	19.17	19.80	20.45	21.13	21.82	22.54
OW	18.82	19.81	20.12	21.95	23.09	31.12	31.91	32.71	33.53	34.38	35.25	36.14	37.05	37.99	38.95	39.93	40.95	41.99	43.05	44.15	45.27	46.42	47.60
TOT	**25.92**	**27.67**	**28.17**	**31.44**	**33.46**	**44.16**	**45.36**	**46.60**	**47.88**	**49.19**	**50.54**	**51.93**	**53.37**	**54.84**	**56.35**	**57.91**	**59.51**	**61.16**	**62.85**	**64.60**	**66.39**	**68.24**	**70.14**

Table 90 - Scenario 2b: Total distance travelled (miles per year) to San Estevan landfill

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
CZ	32,665.60	35,369.12	36,317.25	41,175.45	44,289.35	58,703.98	60,697.81	62,761.49	64,897.42	67,108.11	69,396.13	71,764.16	74,214.95	76,751.35	79,376.32	82,092.90	84,904.24	87,813.60	90,824.34	93,939.95	97,164.03	100,500.29	103,952.59
OW	8,224.36	8,807.34	8,875.23	10,066.93	10,746.40	13,632.49	13,998.63	14,375.04	14,762.02	15,159.85	15,568.83	15,989.25	16,421.43	16,865.70	17,322.37	17,791.79	18,274.30	18,770.26	19,280.02	19,803.97	20,342.49	20,895.96	21,464.81
TOT	**40,889.96**	**44,176.45**	**45,192.48**	**51,242.38**	**55,035.76**	**72,336.47**	**74,696.44**	**77,136.53**	**79,659.44**	**82,267.96**	**84,964.96**	**87,753.41**	**90,636.38**	**93,617.05**	**96,698.69**	**99,884.69**	**103,178.54**	**106,583.85**	**110,104.36**	**113,743.92**	**117,506.52**	**121,396.26**	**125,417.39**

Table 91 - Scenario 2b: total CO_2 (Mg/y)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
CZ	17.66	19.12	19.63	22.26	23.94	31.73	32.81	33.93	35.08	36.28	37.52	38.80	40.12	41.49	42.91	44.38	45.90	47.47	49.10	50.78	52.53	54.33	56.20
OW	4.45	4.76	4.80	5.44	5.81	7.37	7.57	7.77	7.98	8.20	8.42	8.64	8.88	9.12	9.36	9.62	9.88	10.15	10.42	10.71	11.00	11.30	11.60
TOT	**22.10**	**23.88**	**24.43**	**27.70**	**29.75**	**39.10**	**40.38**	**41.70**	**43.06**	**44.47**	**45.93**	**47.44**	**49.00**	**50.61**	**52.27**	**54.00**	**55.78**	**57.62**	**59.52**	**61.49**	**63.52**	**65.63**	**67.80**

Table 92 - Scenario 2b: total CH4 (g/y)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
CZ	166.59	180.38	185.22	209.99	225.88	299.39	309.56	320.08	330.98	342.25	353.92	366.00	378.50	391.43	404.82	418.67	433.01	447.85	463.20	479.09	495.54	512.55	530.16
OW	41.94	44.92	45.26	51.34	54.81	69.53	71.39	73.31	75.29	77.32	79.40	81.55	83.75	86.02	88.34	90.74	93.20	95.73	98.33	101.00	103.75	106.57	109.47
TOT	**208.54**	**225.30**	**230.48**	**261.34**	**280.68**	**368.92**	**380.95**	**393.40**	**406.26**	**419.57**	**433.32**	**447.54**	**462.25**	**477.45**	**493.16**	**509.41**	**526.21**	**543.58**	**561.53**	**580.09**	**599.28**	**619.12**	**639.63**

Table 93 - Scenario 2b: total NO_2 (g/y)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
CZ	156.79	169.77	174.32	197.64	212.59	281.78	291.35	301.26	311.51	322.12	333.10	344.47	356.23	368.41	381.01	394.05	407.54	421.51	435.96	450.91	466.39	482.40	498.97
OW	39.48	42.28	42.60	48.32	51.58	65.44	67.19	69.00	70.86	72.77	74.73	76.75	78.82	80.96	83.15	85.40	87.72	90.10	92.54	95.06	97.64	100.30	103.03
TOT	**196.27**	**212.05**	**216.92**	**245.96**	**264.17**	**347.22**	**358.54**	**370.26**	**382.37**	**394.89**	**407.83**	**421.22**	**435.05**	**449.36**	**464.15**	**479.45**	**495.26**	**511.60**	**528.50**	**545.97**	**564.03**	**582.70**	**602.00**

Table 94 - Scenario 2b: total CO_2e (Mg/y)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
CZ	17.71	19.18	19.69	22.32	24.01	31.83	32.91	34.03	35.18	36.38	37.62	38.91	40.24	41.61	43.03	44.51	46.03	47.61	49.24	50.93	52.68	54.49	56.36
OW	4.46	4.77	4.81	5.46	5.83	7.39	7.59	7.79	8.00	8.22	8.44	8.67	8.90	9.14	9.39	9.65	9.91	10.18	10.45	10.74	11.03	11.33	11.64
TOT	**22.17**	**23.95**	**24.50**	**27.78**	**29.84**	**39.22**	**40.50**	**41.82**	**43.19**	**44.60**	**46.06**	**47.58**	**49.14**	**50.75**	**52.43**	**54.15**	**55.94**	**57.78**	**59.69**	**61.67**	**63.71**	**65.82**	**68.00**

With the purpose of comparing the environmental performance of the three scenarios in terms of greenhouse gas emission, the total CO_2e emissions are shown in Figure 35, and the maximum values per each scenario are listed in Table 95.

Figure 35 – Total CO_2e emissions per scenario

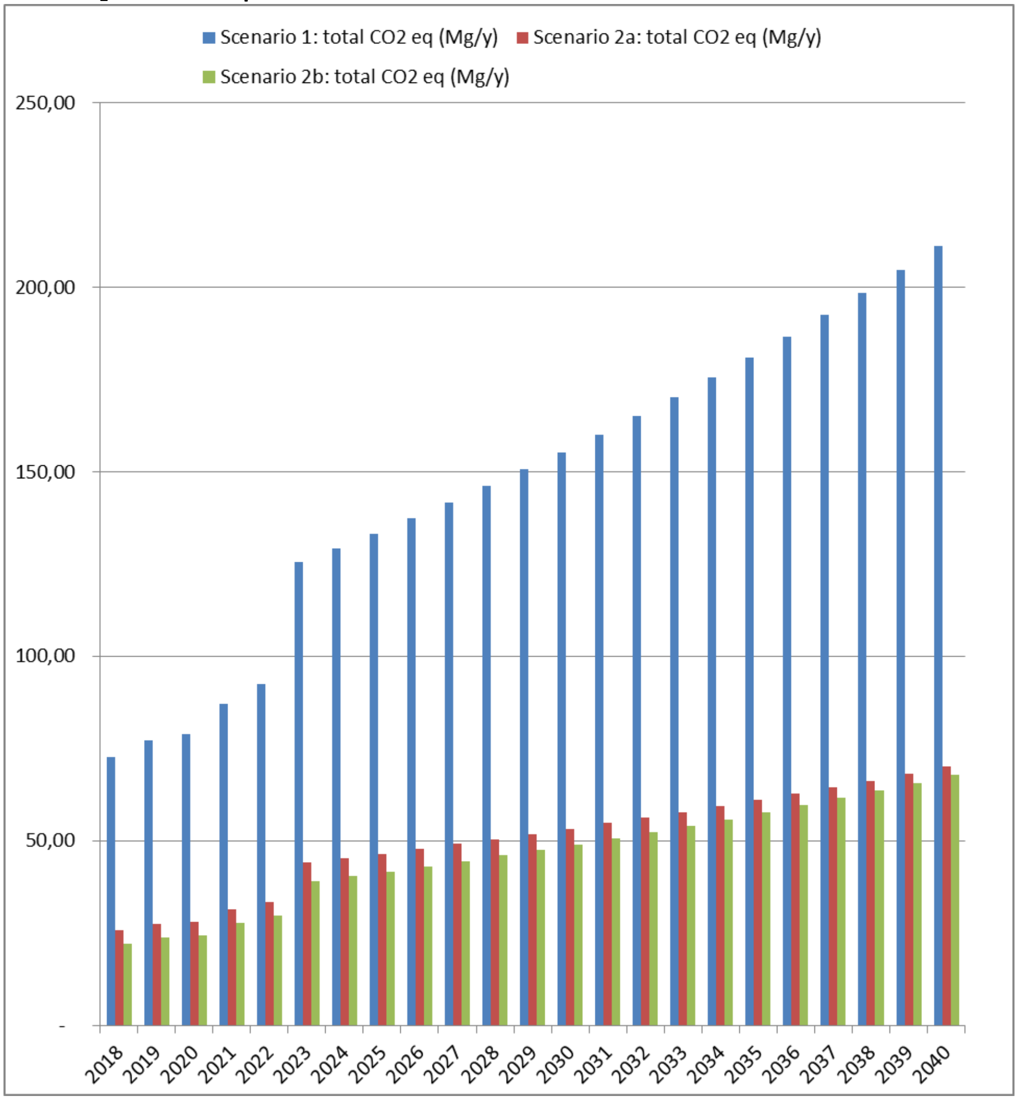


Table 95 - Total CO_2eq (Mg/y)

Scenario	CO_2eq in 2040 (Mg/y)	Total GHG emissions (Mg)	GHG emission per Mg of waste (CO_{2eq} /Mg_{waste})
1	**211.15**	**3,373.81**	**0.0040**
2a	**70.14**	**1,157.68**	**0.0014**
2b	**68.00**	**1,070.27**	**0.0013**

While Scenario 1 is obviously the worst one in terms of carbon footprint, the two remaining scenarios are very similar to each other and almost three times lower than Scenario 1.

Southern Corridor

The pollutants emissions calculated for each scenario and for each district (SC: Stann Creek District, TO: Toledo District) are shown in the following tables (Table 98 to Table 107)

With the purpose of comparing the environmental performance of the two scenarios in terms of greenhouse gas emission, the total CO2e emissions are shown in Figure 36, and the maximum values per each scenario are listed in Table 96.

Figure 36 – Total CO_2e emissions per scenario

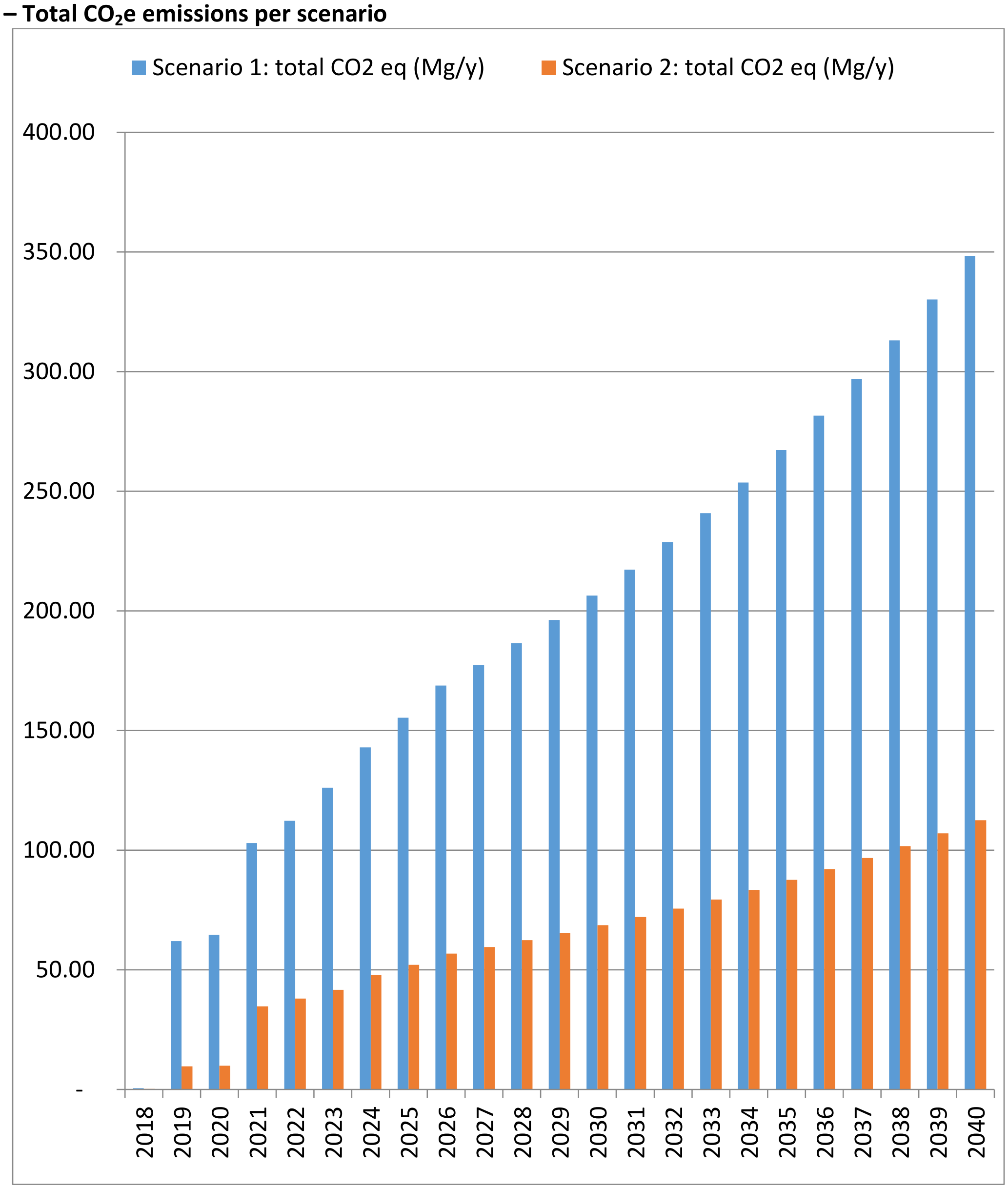


Table 96 - Total CO_2eq (Mg/y)

Scenario	CO_2eq in 2040 (Mg/y)	Total GHG emissions (Mg)	GHG emission per Mg of waste (CO_{2eq} /Mg_{waste})
1	**348.28**	**4,480.83**	**0.0064**
2	**112.59**	**1,456.07**	**0.0021**

The GHG emissions estimated in Scenario 1 are three times those estimated in Scenario 2. According to the information gathered from the "Third national greenhouse gas inventory", the total amount of CH_4 emissions from the source "Solid Waste Disposal on Land" is 2.65 Gg for the year 2009. Considering, as per IDB "Greenhouse Gas Assessment Emissions Methodology", a Global Warming Potential (GWP) for the CH_4 equal to 25, the total GHG emissions from this source are 66.25 Gg, namely 66,250 Mg.

Table 97 – Total GHG emissions for year 2009 (Gg) – Source: *"Third national greenhouse gas inventory"* (Caribbean Community Climate Change Centre - 2015)

GHG Source and Sink Category	CO_2 Emission	CO_2 Removal	CH_4	N_2O	NO_X	CO	NMVOC	SO_2	Total
Energy	**445.0355**	**0.0000**	**0.2974**	**0.0408**	**0.0004**	**0.0004**	**0.0004**	**0.0000**	**445.3748**
A. Fuel Combustion	445.0355	0.0000	0.2974	0.0408	0.0004	0.0004	0.0004	0.0000	445.3748
Energy Industry	32.9595		0.2755	0.0368	0.0004	0.0004	0.0004	0.0000	33.2730
Manufacturing/Construction Industr	70.3469		0.0056	0.0009	0.0000	0.0000	0.0000	0.0000	70.3534
Transport	247.0243		0.0104	0.0021	0.0000	0.0000	0.0000	0.0000	247.0368
Other	94.7048		0.0058	0.0010	0.0000	0.0000	0.0000	0.0000	94.7116
Industrial Processes	**2.3550**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0757**	**0.0000**	**2.4307**
Mineral Products	2.3550						0.0000		2.3550
Other Production							0.0757		0.0757
Agriculture	**0.0000**	**0.0000**	**5.7774**	**1.5612**	**0.0260**	**0.5008**	**0.0000**	**0.0000**	**7.8654**
Enteric Fermentation			4.8896						4.8896
Manure Management			0.1815	0.9300					1.1115
Rice Cultivation			0.6825						0.6825
Agricultural Soils				0.6305					0.6305
Savannah Burning									0.0000
Agric. Residue Burning			0.0238	0.0007	0.0260	0.5008			0.5514
Land-Use Change & Forestry	**12065.8324**	**-8778.1520**	**39.5735**	**0.3887**	**9.8333**	**346.2682**	**0.0000**	**0.0000**	**12461.8961**
Changes in Woody Biomass Stocks		-8576.4853							-8576.4853
Forest and Grassland Conversion	12324.1113		39.5735	0.3887	9.8333	346.2682			12720.1749
Abandonment of Managed Land		-201.6667							-201.6667
CO2 Emissions/Removals from Soil	-258.2788								-258.2788
Waste	**0.0000**	**0.0000**	**3.5700**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**3.5700**
Solid Waste Disposal on Land			2.6500						2.6500
Wastewater Handling			0.9200						0.9200
Industrial Waste Water			83.9800	0.02					
Total Emissions	**12513.2229**	**-8778.1520**	**49.2183**	**1.9907**	**9.8597**	**346.7694**	**0.0761**	**0.0000**	**12921.1370**
Total Net CO2 Emissions	**3735.0709**								

However, the assessment of the intensity of this impact has been conducted and compared to a baseline value from the "Third National Greenhouse Inventory" (Caribbean Community Climate Change Centre - 2015).

Assuming, as conservative hypothesis, that:

- total GHG emissions value from this source will be constant for the next years, considering that the foreseen increase in waste production will be counterbalanced by the improvement in the efficacy of the SWM;
- the waste production in the Northern and Southern Corridors will be about 50% of the overall national waste production for the duration of the planning horizon, and
- taking into account the worst condition, namely the maximum emission value referred to Scenario 1 in the year 2040 (559.43 Mg);

the total amount of emissions from the waste transportation considered, is about 0.85% of the overall emission of the waste sector at the national level, and about 1.70% of the emissions, if referred to the Northern and Southern corridors only (the 50% of the overall waste produced at national level).

The outcomes of these evaluations can be summarized as follows:

- the GHG emissions are larger in Scenario 1 than in Scenario 2, the figures assessed in Scenario 1 are almost three times those assessed in Scenario 2;
- considering the emissions evaluated in Scenario 1, though, the total amount due to waste transportation is about the 0.85% of the overall amount emitted, at national level, by the source “waste”, and 1.70% of the overall amount attributable to Northern and Southern Corridors. Therefore the total amount of GHG emitted in the most conservative condition (Scenario 1) is negligible compared to the overall amount of the Waste Sector.

Table 98 - Scenario 1: Total distance travelled (miles per year) to Mile 24

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
SC	264.24	72,176.75	75,786.72	103,631.47	112,728.90	130,071.69	145,343.27	157,650.15	170,956.86	180,409.71	190,445.07	201,100.40	212,415.61	224,433.19	237,198.45	250,759.62	265,168.11	280,478.68	296,749.67	314,043.24	332,425.62	351,967.36	372,743.63
TO	874.15	42,312.51	43,508.36	86,498.52	94,391.86	102,679.86	118,342.88	128,928.59	140,508.28	146,968.70	153,766.01	160,918.95	168,447.36	176,372.19	184,715.64	193,501.15	202,753.55	212,499.08	222,765.53	233,582.25	244,980.34	256,992.66	269,654.02
TOT	**1,138.39**	**114,489.26**	**119,295.08**	**190,129.99**	**207,120.76**	**232,751.55**	**263,686.15**	**286,578.74**	**311,465.13**	**327,378.40**	**344,211.08**	**362,019.35**	**380,862.96**	**400,805.39**	**421,914.08**	**444,260.77**	**467,921.66**	**492,977.76**	**519,515.20**	**547,625.50**	**577,405.96**	**608,960.03**	**642,397.65**

Table 99 - Scenario 1: total CO_2 (Mg/y)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
SC	0.14	39.02	40.97	56.02	60.94	70.32	78.57	85.22	92.42	97.53	102.95	108.71	114.83	121.33	128.23	135.56	143.35	151.62	160.42	169.77	179.71	190.27	201.50
TO	0.47	22.87	23.52	46.76	51.03	55.51	63.98	69.70	75.96	79.45	83.12	86.99	91.06	95.35	99.86	104.61	109.61	114.88	120.43	126.27	132.43	138.93	145.77
TOT	**0.62**	**61.89**	**64.49**	**102.78**	**111.97**	**125.82**	**142.55**	**154.92**	**168.38**	**176.98**	**186.08**	**195.71**	**205.89**	**216.67**	**228.08**	**240.16**	**252.96**	**266.50**	**280.85**	**296.04**	**312.14**	**329.20**	**347.28**

Table 100 - Scenario 1: total CH_4 (g/y)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
SC	1.35	368.10	386.51	528.52	574.92	663.37	741.25	804.02	871.88	920.09	971.27	1,025.61	1,083.32	1,144.61	1,209.71	1,278.87	1,352.36	1,430.44	1,513.42	1,601.62	1,695.37	1,795.03	1,900.99
TO	4.46	215.79	221.89	441.14	481.40	523.67	603.55	657.54	716.59	749.54	784.21	820.69	859.08	899.50	942.05	986.86	1,034.04	1,083.75	1,136.10	1,191.27	1,249.40	1,310.66	1,375.24
TOT	**5.81**	**583.90**	**608.40**	**969.66**	**1,056.32**	**1,187.03**	**1,344.80**	**1,461.55**	**1,588.47**	**1,669.63**	**1,755.48**	**1,846.30**	**1,942.40**	**2,044.11**	**2,151.76**	**2,265.73**	**2,386.40**	**2,514.19**	**2,649.53**	**2,792.89**	**2,944.77**	**3,105.70**	**3,276.23**

Table 101 - Scenario 1: total NO_2 (g/y)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
SC	1.27	346.45	363.78	497.43	541.10	624.34	697.65	756.72	820.59	865.97	914.14	965.28	1,019.59	1,077.28	1,138.55	1,203.65	1,272.81	1,346.30	1,424.40	1,507.41	1,595.64	1,689.44	1,789.17
TO	4.20	203.10	208.84	415.19	453.08	492.86	568.05	618.86	674.44	705.45	738.08	772.41	808.55	846.59	886.64	928.81	973.22	1,020.00	1,069.27	1,121.19	1,175.91	1,233.56	1,294.34
TOT	**5.46**	**549.55**	**572.62**	**912.62**	**994.18**	**1,117.21**	**1,265.69**	**1,375.58**	**1,495.03**	**1,571.42**	**1,652.21**	**1,737.69**	**1,828.14**	**1,923.87**	**2,025.19**	**2,132.45**	**2,246.02**	**2,366.29**	**2,493.67**	**2,628.60**	**2,771.55**	**2,923.01**	**3,083.51**

Table 102 - Scenario 1: total CO_2e (Mg/y)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
SC	0.14	39.13	41.09	56.18	61.12	70.52	78.80	85.47	92.68	97.81	103.25	109.03	115.16	121.68	128.60	135.95	143.76	152.06	160.88	170.26	180.22	190.82	202.08
TO	0.47	22.94	23.59	46.90	51.17	55.67	64.16	69.90	76.18	79.68	83.36	87.24	91.32	95.62	100.14	104.91	109.92	115.21	120.77	126.64	132.82	139.33	146.19
TOT	**0.62**	**62.07**	**64.68**	**103.08**	**112.29**	**126.19**	**142.96**	**155.37**	**168.86**	**177.49**	**186.61**	**196.27**	**206.49**	**217.30**	**228.74**	**240.86**	**253.68**	**267.27**	**281.66**	**296.90**	**313.04**	**330.15**	**348.28**

Table 103 - Scenario 2: Total distance travelled (miles per year)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
SC	101.83	101.83	101.83	26,033.29	28,518.29	31,941.12	36,292.74	39,601.17	43,189.77	45,385.16	47,708.66	50,168.20	52,772.21	55,529.68	58,450.14	61,543.76	64,821.32	68,294.32	71,974.97	75,876.28	80,012.05	84,397.01	89,046.78
TO	427.70	17,875.42	18,378.94	38,101.32	41,544.33	45,021.34	51,918.17	56,548.24	61,618.08	64,465.00	67,461.11	70,614.76	73,934.74	77,430.38	81,111.55	84,988.67	89,072.77	93,375.52	97,909.29	102,687.13	107,722.87	113,031.13	118,627.38
TOT	**529.52**	**17,977.25**	**18,480.77**	**64,134.61**	**70,062.63**	**76,962.46**	**88,210.91**	**96,149.41**	**104,807.85**	**109,850.16**	**115,169.77**	**120,782.95**	**126,706.95**	**132,960.06**	**139,561.69**	**146,532.42**	**153,894.09**	**161,669.85**	**169,884.27**	**178,563.41**	**187,734.92**	**197,428.13**	**207,674.16**

Table 104 - Scenario 2: total CO_2 (Mg/y)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
SC	0.06	0.06	0.06	14.07	15.42	17.27	19.62	21.41	23.35	24.53	25.79	27.12	28.53	30.02	31.60	33.27	35.04	36.92	38.91	41.02	43.25	45.62	48.14
TO	0.23	9.66	9.94	20.60	22.46	24.34	28.07	30.57	33.31	34.85	36.47	38.17	39.97	41.86	43.85	45.94	48.15	50.48	52.93	55.51	58.23	61.10	64.13
TOT	**0.29**	**9.72**	**9.99**	**34.67**	**37.88**	**41.61**	**47.69**	**51.98**	**56.66**	**59.38**	**62.26**	**65.29**	**68.50**	**71.88**	**75.45**	**79.21**	**83.19**	**87.40**	**91.84**	**96.53**	**101.49**	**106.73**	**112.27**

Table 105 - Scenario 2: total CH_4 (g/y)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
SC	0.52	0.52	0.52	132.77	145.44	162.90	185.09	201.97	220.27	231.46	243.31	255.86	269.14	283.20	298.10	313.87	330.59	348.30	367.07	386.97	408.06	430.42	454.14
TO	2.18	91.16	93.73	194.32	211.88	229.61	264.78	288.40	314.25	328.77	344.05	360.14	377.07	394.89	413.67	433.44	454.27	476.22	499.34	523.70	549.39	576.46	605.00
TOT	**2.70**	**91.68**	**94.25**	**327.09**	**357.32**	**392.51**	**449.88**	**490.36**	**534.52**	**560.24**	**587.37**	**615.99**	**646.21**	**678.10**	**711.76**	**747.32**	**784.86**	**824.52**	**866.41**	**910.67**	**957.45**	**1,006.88**	**1,059.14**

Table 106 - Scenario 2: total NO_2 (g/y)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
SC	0.49	0.49	0.49	124.96	136.89	153.32	174.21	190.09	207.31	217.85	229.00	240.81	253.31	266.54	280.56	295.41	311.14	327.81	345.48	364.21	384.06	405.11	427.42
TO	2.05	85.80	88.22	182.89	199.41	216.10	249.21	271.43	295.77	309.43	323.81	338.95	354.89	371.67	389.34	407.95	427.55	448.20	469.96	492.90	517.07	542.55	569.41
TOT	**2.54**	**86.29**	**88.71**	**307.85**	**336.30**	**369.42**	**423.41**	**461.52**	**503.08**	**527.28**	**552.81**	**579.76**	**608.19**	**638.21**	**669.90**	**703.36**	**738.69**	**776.02**	**815.44**	**857.10**	**901.13**	**947.66**	**996.84**

Table 107 - Scenario 2: total CO_2e (Mg/y)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
SC	0.06	0.06	0.06	14.11	15.46	17.32	19.68	21.47	23.42	24.61	25.87	27.20	28.61	30.11	31.69	33.37	35.14	37.03	39.02	41.14	43.38	45.76	48.28
TO	0.23	9.69	9.96	20.66	22.52	24.41	28.15	30.66	33.41	34.95	36.57	38.28	40.08	41.98	43.97	46.08	48.29	50.62	53.08	55.67	58.40	61.28	64.31
TOT	**0.29**	**9.75**	**10.02**	**34.77**	**37.98**	**41.73**	**47.82**	**52.13**	**56.82**	**59.56**	**62.44**	**65.48**	**68.69**	**72.08**	**75.66**	**79.44**	**83.43**	**87.65**	**92.10**	**96.81**	**101.78**	**107.04**	**112.59**

30.1.2 Final disposal

The waste collected in Towns is presently taken to local dumpsites where, after an initial sorting, is burnt, and the residual ashes are dumped.
The waste produced in villages, where waste collection is not implemented, is instead mainly burnt in the yards or in illegal dumpsites in the outskirts of the village.
One of the main goals of the present Master Plan is then to avoid these harmful habits in final treatment of the waste, through the implementation a SWM system that shall allow the recovery/recycling of waste and shall foresee the final disposal of the residual waste in engineered landfills.
Different landfilling technologies are envisaged in the three scenarios being considered. In Scenario 1 the residual waste from sorting in TSs shall be disposed of in the existing (traditional) Mile 24 landfill. In Scenario 2 the residual waste from sorting in TSs shall be disposed of in newly designed and built regional landfills.
In Scenario 3, no improvements in collection, recovery and recycling of waste are foreseen, so the whole amount of waste collected in the Towns shall be disposed of in local improved dumpsites, and the waste produced in villages, where waste collection is not implemented, shall be still open burnt.

30.1.2.1 Mile 24 Landfill (Scenario 1)

The adequacy of Mile 24 Landfill site to host additional waste from one or both the Northern and Southern Corridors is the precondition for the assessment of Scenario 1.
To determine the suitability of this choice, the Mile 24 Landfill has been subject to an Environmental Audit with the aim of ascertaining the adequacy of the infrastructures and the operational system and the compliance of the operation to the present Environmental Compliance Plan.

According to the outcomes of the auditing activities carried out at the Mile 24 Landfill the following conclusions can be summarized:

- The landfill is constructed and operated in accordance to international quality standards;
- No environmental or social issues have been reported and are noticeable so far;
- The operation of the landfill is substantially compliant with the ECP;
- Major non compliances are related to the delay in the submission of contingency plans;
- A general lack of established operational and control procedures is nevertheless noticeable. This aspect can, if not adequately considered, lead to future possible non-compliances (especially with regard to leachate management).

General recommendations:

- Establishment and implementation of an adequate management and control system based on recognized quality standards (ISO 14001 is recommended);Specifically, a more accurate record keeping and reporting of the activities is needed to fully comply with the ECP requirements;
- Keep an inspection register on site;

- Review some of the ECP requirements that appears to be obsolete, redundant or replaced in fact by alternative and equivalent solutions;
- Include the effluents (gas and water) from the HDPE leachate pipe laid underneath the cells in the monitoring plan.

Further recommendations related to the adequacy of Mile 24 Landfill for the disposal of the waste from the Northern and Southern Corridors:

- an additional cell of at least 5 hectares extension (same extension of the already completed cells) should be built no later than 4 years from now;
- the operational permanent equipment and disposal procedures shall be reviewed to cater for doubling of the waste input.
- The use of a light landfill compactor (28 tonne) would be recommended together with the adoption of offloading procedures that allows a quicker offloading of an increased number of trucks simultaneously.
- It is recommended that the soil excavated for the preparation of the future cells would be stockpiled and used for the final cover of the same cells. At the same time the selection and use of alternative intermediate cover is highly recommended.

The general adequacy of the site has been preliminarily ascertained at this stage and for the purpose of the alternatives assessment, a development plan for the site shall nevertheless be prepared in a second phase in accordance with the final Scenario selected.

30.1.2.2 Landfilling technologies comparison (Scenario 2)

The major environmental impacts, related to landfill construction and operation are caused by landfill emissions, such as leachate and LFG.

In this section, attention is then focused in carrying out a preliminary assessment of the quantity and quality of landfill emissions: leachate and LFG, with the main purpose of comparing the environmental performance of two different types of landfill: traditional anaerobic landfill and semi-aerobic landfill.

In order to prevent, as far as possible, adverse effects on the environment due to landfill construction and operation, it is necessary to choose the landfilling technology that can guarantee the lowest harmful emissions, in terms of quantity and hazardousness, and the most effective emissions control, in terms of collection and treatment.

The hazardousness of landfill emissions is strongly related to:

- the hazardousness of the waste disposed;
- the biodegradation processes that involve the organic fraction of the waste disposed.

As envisaged by the present Master Plan, the hazardous waste has to be diverted to specific treatment, and a share of the organic fraction of the waste has to be separated, collected and treated in composting plants, reducing, therefore, the harmful potential of the landfill emissions.

In regards to waste degradation, it has to be considered that different biodegradation processes develop in semi-aerobic and anaerobic conditions.
Waste biodegradation in semi-aerobic landfills can be enhanced more than in traditional anaerobic landfills, and is mainly gasification dominated by CO_2 production.

Figure 37 shows that about 80% of organic contaminants in waste is converted into gases (mainly as carbon dioxide and nitrogen) in semi-aerobic landfill, while about 60% is converted into leachate in anaerobic landfill after four years.

Moreover, comparing the cumulative amount of generated gases and leaching contaminants in anaerobic and semi-aerobic conditions, during the first 48 months after waste disposal, it has to be noticed that the total amount of pollutants discharged from the semi-aerobic landfill (66.3 kg) is greater than the amount from anaerobic landfills (53.2 kg). So the biodegradation process, in semi-aerobic conditions, is more enhanced than under anaerobic conditions, and, consequently, the waste stabilization is faster.

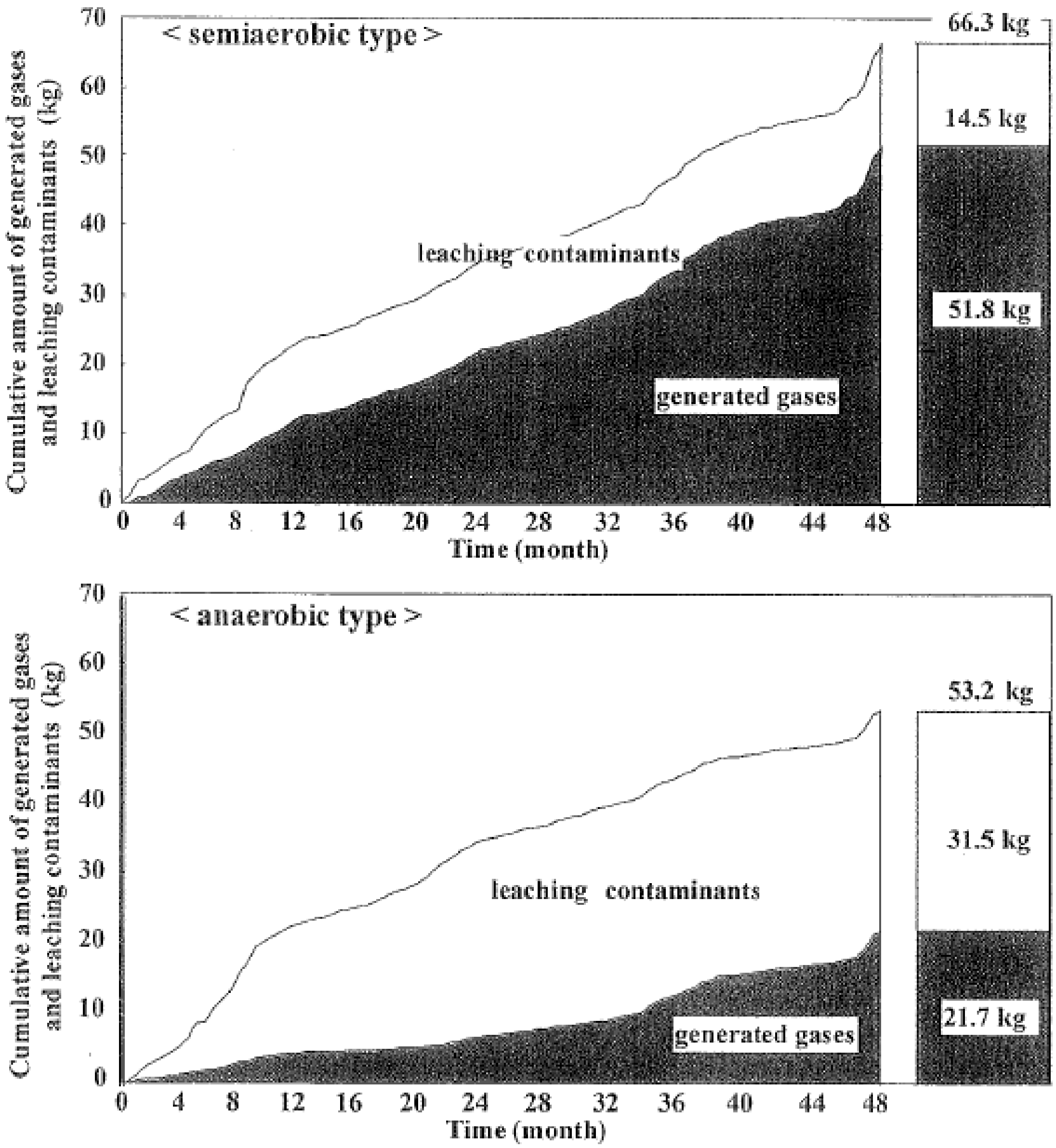
30.1.2.2.1 Leachate

The difference between the biodegradation processes that develop in semi-aerobic and anaerobic conditions affect the quality of the leachate produced in such conditions.
As per *"The Biogeochemistry of Contaminant Groundwater Plumes Arising from Waste Disposal Facilities"* - PL Bjerg, H-J Albrechtsen, P Kjeldsen, and TH Christensen, , Lyngby, IM Cozzarelli, (2014) the landfill leachate may be characterized as a water-based solution of four groups of pollutants (Christensen et al., 1994):

- Dissolved organic matter, expressed as chemical oxygen demand (COD) or total organic carbon (TOC), including methane, volatile fatty acids (in particular in the acid phase of the waste stabilization, Christensen and Kjeldsen, 1989), and more refractory compounds, for example, fulvic-like and humic-like compounds.
- Inorganic macrocomponents: calcium (Ca_2^+), magnesium (Mg_2^+), sodium (Na^+), potassium (K^+), ammonium ($NH4^+Z$), iron (Fe^{2+}), manganese (Mn^{2+}), chloride (Cl^-), sulfate (SO_4^{2-}), and hydrogen carbonate (HCO_3^-).
- Heavy metals: cadmium (Cd^{2+}), chromium (Cr^{3+}), copper (Cu^{2+}), lead (Pb^{2+}), nickel (Ni^{2+}), and zinc (Zn^{2+}).
- Xenobiotic organic compounds (XOCs) originating from household or industrial chemicals and present in relatively low concentrations in the leachate (usually less than 1 mg/l of individual compounds). These compounds include, among others, a variety of aromatic hydrocarbons, phenols, chlorinated aliphatic hydrocarbons, and pesticides.

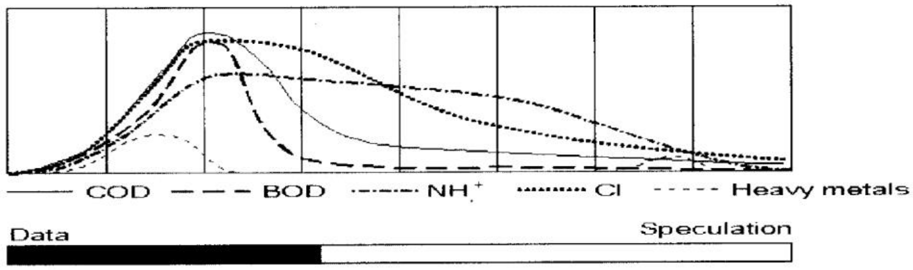
Other compounds may be found in leachate from landfills, for example, borate, sulphide, arsenate, selenate, barium, lithium, mercury, and cobalt. In general, however, these compounds are not measured very often, and when measured, they are usually found in very low concentrations and are considered only of secondary importance.
Leachate composition varies significantly among landfills, depending on waste composition, waste age and **landfilling technology**.

Figure 37 – Comparison of cumulative amount of generated gases and leaching contaminants from anaerobic and semi-aerobic conditions (*"Biodegradation process of Municipal Solid Waste by Semi-Aerobic Landfill Type" Yasushi Matsufuji, Ayako Tanaka, Masataka Hanashima – Department of Civil Engineering, Faculty of Engineering, Fukuoka University, Japan) (2008)*



The general trends in leachate quality development in anaerobic conditions are shown in Figure 38. It has to be noticed that BOD_5, COD and NH_4 are the main components, present in highest concentrations, so their concentration values and trends deeply influence the leachate quality, such as its hazardousness.

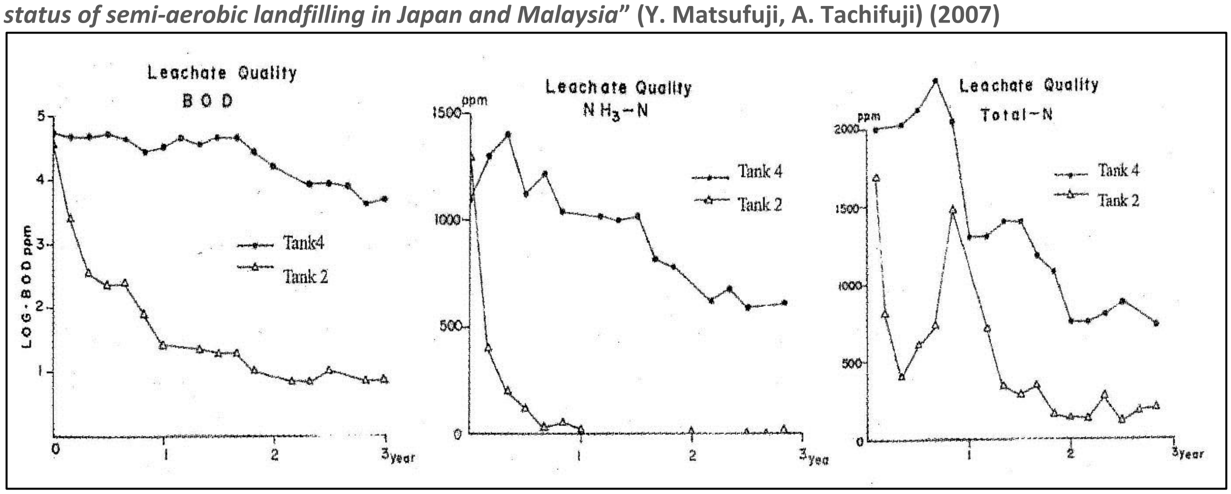
Figure 38 – General trends in leachate quality development *"Present and Long-Term Composition of MSW Landfill Leachate: A Review"* Peter Kjeldsen, Morton A. Barlaz, Alix P. Rooker, Anders Baun, Anna Ledin and Thomas H. Christensen - Critical Reviews in Environmental Science and Technology, 32(4):297-336 (2002)



Therefore, hereinafter, the quality of leachate produced in anaerobic or semi-aerobic landfill is assessed on the basis of the patterns of BOD_5, COD and NH_4.

The influence of aeration on biodegradation processes and, consequently, on leachate quality is evaluated in "*The history and status of semi-aerobic landfilling in Japan and Malaysia*" (Y. Matsufuji, A. Tachifuji). The results of the experiment conducted for this study are shown in Figure 39. Considering a 3 years long period after waste disposal, the BOD_5 and NH_3^- trends are compared in the two different conditions. The BOD_5 concentration values are comparable in anaerobic and aerobic conditions just for a short period after disposal in aerobic conditions, in fact, its concentration strongly and rapidly decreases to very low values.

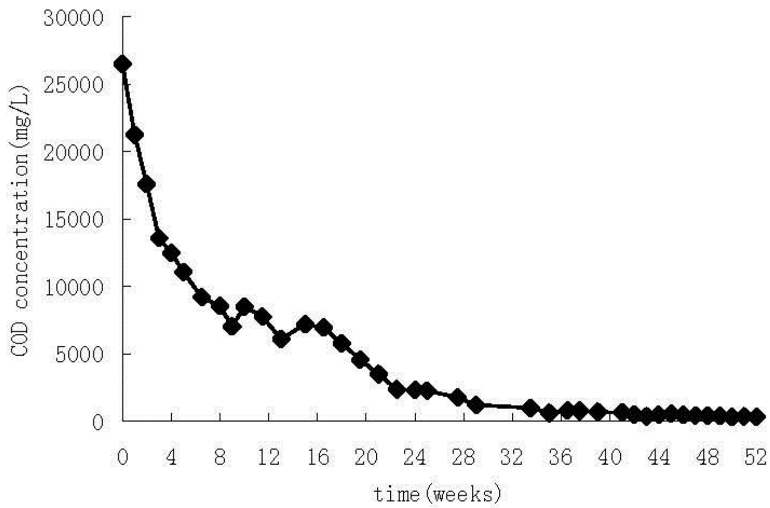
Figure 39 – Trends in leachate in aerobic conditions (tank 2) and anaerobic conditions (tank 4) - *The history and status of semi-aerobic landfilling in Japan and Malaysia*" (Y. Matsufuji, A. Tachifuji) (2007)



A significant reduction of the NH_3^- concentrations is also shown and is due to nitrification processes that occurs while the leachate passes through the aerated waste mass.

In particular the evolution of leachate quality in a semi-aerobic landfill has been studied in "*Influence of Landfill Structure on Leachate Characteristics"* - Q.F. Huang, Q. Wang, Y. Yang, L. Dong Chinese Research Academy of Environmental Sciences, Beijing, China (2005).
In this paper are shown the results of experiments conducted in an in situ, simulated, semi-aerobic landfill in order to study the development of waste stabilization processes.

Figure 40 – Trend of COD concentration in leachate - ***Influence Of Landfill Structure On Leachate Characteristics"-*** **Q.F. Huang, Q. Wang, Y. Yang, L. Dong Chinese Research Academy of Environmental Sciences, Beijing, China (2005).**



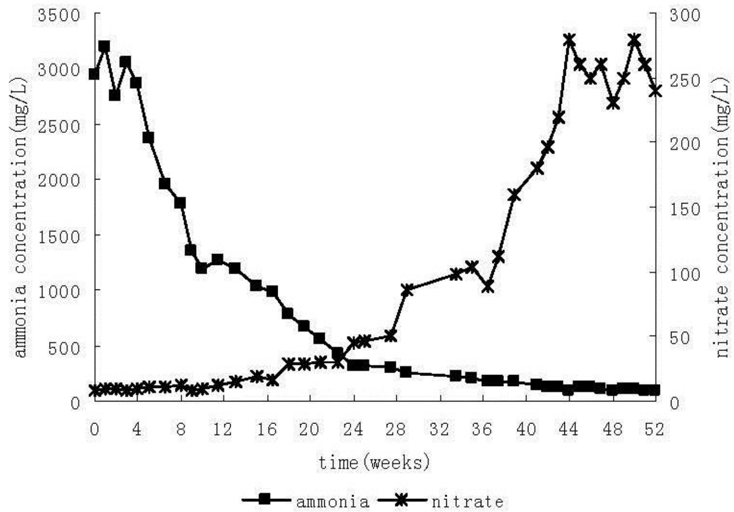
The trend of COD concentration in leachate is shown in Figure 40. As already remarked for BOD_5 concentration trend, the concentration values decrease rapidly, just after 24 weeks from waste disposal, the COD concentrations measured are 10 times less the previous ones.

Ammonia nitrogen in leachate, mostly comes from the biodegradation of organic nitrogen compounds. One remarkable character of leachate is high ammonia concentration, which restrains microorganism activity and slows waste biodegradation.

Ammonia concentration in leachate fluctuates during the first four weeks after waste disposal, and then presents a stable descending trend (see Figure 41). As a consequence of unavailable oxygen in anaerobic landfill, the likelihood of an ammonia transformation into nitrogen is very low. Indeed in semi-aerobic landfill, the simultaneous development of aerobic and semi-aerobic conditions allows nitrification and denitrification processes. Therefore, in semi-aerobic landfill, ammonia can be converted into gaseous nitrogen, through nitrification and denitrification processes, and the ammonia concentration in leachate is so reduced.

Moreover Ammonia –nitrogen has been identified in several studies (i.e., heyer, 2003; Krümpelbeck, 2001) as one of the main parameters that determines the predicted time for the duration of leachate treatment, in the course of landfill aftercare. In anaerobic conditions, in fact, the ammonia concentrations in leachate remains high after landfill closure, longer than it would under semi-aerobic conditions.

Figure 41 – Trend of ammonia and nitrate concentration in leachate - *Influence Of Landfill Structure On Leachate Characteristics"-* Q.F. Huang, Q. Wang, Y. Yang, L. Dong Chinese Research Academy of Environmental Sciences, Beijing, China (2005).



The leachate quality characterisation, conducted on the basis of the concentration values and trends of the pollutants related to organic matter, points out that the leachate produced in semi-aerobic landfill is less harmful. So its treatment is easier, and less expensive, than the treatment needed by the leachate produced in anaerobic conditions. Moreover, the pollutants concentrations in semi-aerobic landfill leachate decrease rapidly, so the duration of the needed treatment is lower than that necessary for anaerobic landfill leachate and, in general terms, the duration (and related costs) of the landfill aftercare phase is lower.

Leachate treatment

The leachate treatment method proposed in semi-aerobic landfill is widely applied in many tropical countries and is the multi-stage treatment in different leachate ponds. Whereby the collected leachate is first treated anaerobically, then aerobically (aerated pond, or in many cases a facultative pond to reduce the technological footprint of the system), followed by a maturation pond or a constructed wetland, as polishing stage, from which the treated leachate is finally discharged into the receiving watercourse.

This treatment method is quite inexpensive and simple to operate, considering that no regulation is needed and the degradation is based on natural processes, without the need of any energy input. The high hydraulic retention times make the system quite flexible and adaptable to the significant seasonal and daily oscillation of hydraulic and organic loads at the inflow, guaranteeing an appreciable "buffer" effect on the leachate before the final discharge.

Compared to other more technological options (as physical and chemical treatment, or enhanced biological treatment as MBR) the effectiveness is limited; but due to the low level of skills in sanitation technology and the difficulty to ensure an appropriate operation and management of high engineered sanitation system in Belize, the pond treatment could be a low cost and low maintenance viable option. Moreover, the presence of a Constructed Wetland (free water surface type) as a polishing stage can improve significantly the overall contaminant

removal; this kind of technology, is in fact, very effective in tropical climates, where wastewater temperature is relatively constant throughout the year and the warm climate promotes a more rapid biological degradation of organic matter by aerobic and anaerobic bacteria. During drier periods, when leachate flow is reduced and the concentrations of the pollutants increase, the constructed wetland can ensure high removal rates thanks to the longer retention time.
The presence of the wetland can improve also the landscaping of the system, permitting a better integration of the anaerobic and facultative ponds.

This technology has been chosen for various reasons:

- it permits a substantial reduction of overall project cost (investment & operation cost);
- treatment ponds are very efficient in tropical and warm climates and widely diffused in developing countries;
- CW enables an efficient treatment (carbon removal, enhanced nitrogen & phosphorus removal, improved pathogen removal) and a significant buffer action;
- operation is easy and affordable for the local community and can be transferred to unskilled labour after adequate training;
- the overall treatment is flexible enough to cater for different conditions of hydraulic and organic loads and it is adaptable both to the initial scenario when the landfill is uncovered and in operation, and after, when the landfill will be closed and covered;
- implementation can be done using locally available materials;
- the operation and management of the system do not need skilled labour and spare parts;
- by-products of the process are low: only sludge produced in the anaerobic and settling zone.

This envisaged treatment technology is currently used at Mile 24 landfill, where the quality of the leachate entering the system and the quality of the water leaving are monitored in order to verify the removal efficiency of the treatment itself.
In Table 108 the removal efficiency values calculated on monitoring data are listed, and in the figures below, the removal efficiency trends are shown.
BOD_5, COD and ammonia nitrogen concentrations are strongly reduced by this treatment, the maximum values of efficiency in removal are reached for ammonium nitrogen, that is, among these, the pollutant more harmful and persistent.
The efficiency of the constructed wetland as polishing stage is outlined by the high removal values referred to Total and Fecal coliforms, moreover this technology is deemed to be suitable also in terms of water sanitisation.
It has to be noticed that the removal performances of this technology are not constant in time, but subject to fluctuations. This is a characteristic of this type of treatment plant, that, using the purifying action of plants and microorganisms, needs more time to react to input changes, such as changes in leachate quality or weather conditions, than more engineered technologies. However, the average values of removal efficiency, for the considered parameters, are high and can guarantee the achievement of the quality standards required for the water discharged.

Table 108 – Removal efficiency values (Mile 24 monitoring data)

Parameter	Aug.13	Sep.13	Oct.13	Nov.13	Dec.13	Jan.14	Feb.14	Mar.14	May.14	Jun.14	Jul.14	Aug.14	Oct.14	Nov.14	Dec.14	March.15	min	max	average
BOD- RE%	96.09	95.88	99.21	78.33	87.12	73.19	76.12	86.21	33.76	43.90	77.46	79.39	88.20	94.92	92.84	63.50	33.76	99.21	**79.13**
COD- RE%	94.40	75.74	97.78	66.15	68.99	53.55	75.26	68.15	40.29	0.59	0.67	55.56	82.02	86.98	84.22	25.25	0.59	97.78	**60.97**
T,Coli-RE%	99.00	100.00	99.99	90.00	99.82	100.00	99.85	100.00	46.51	40.00	99.88	99.69	96.09	99.13	99.38	90.00	40.00	100.00	**91.21**
F.Coli-RE%	100.00	100.00	99.99	90.00	99.90	100.00	99.85	100.00	46.51	40.00	99.88	99.69	96.09	99.13	99.38	90.00	40.00	100.00	**91.28**
Cond. -RE%	88.54	87.08	90.03	34.19	25.52	21.58	82.39	80.58	74.75	72.83	60.76	59.57	85.77	88.03	89.72	79.40	21.58	90.03	**70.05**
AN -RE%	98.69	98.50	96.65	56.42	70.00	70.34	99.79	99.10	95.97	99.75	99.70	99.69	99.87	99.90	99.86	99.75	56.42	99.90	**92.75**

Figure 42 – BOD and COD removal efficiency

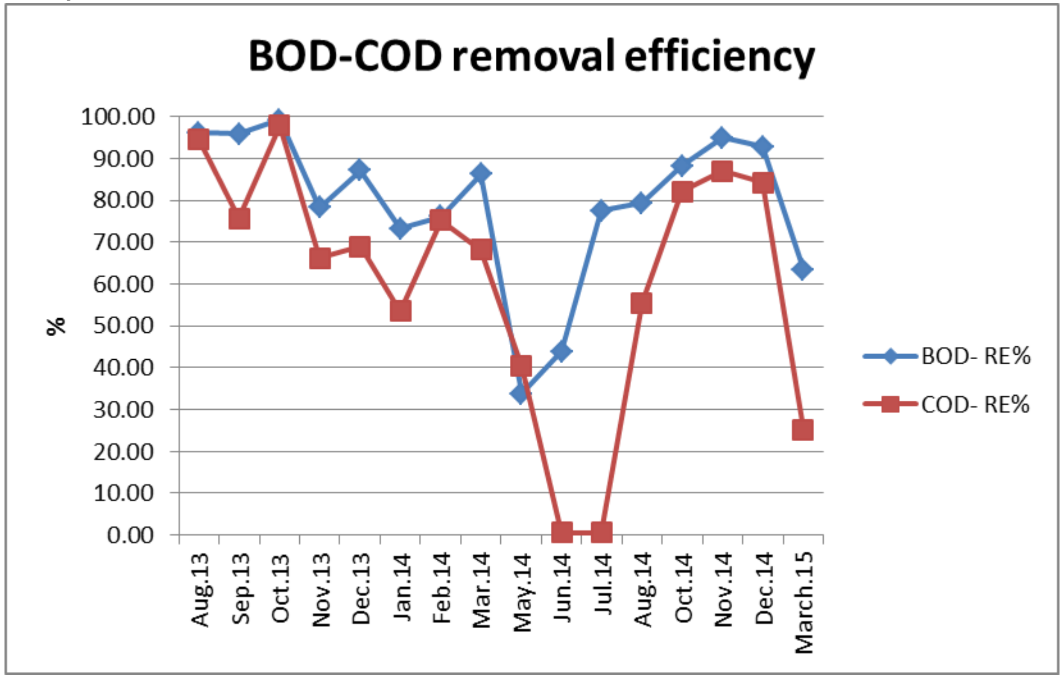


Figure 43 – Total and Fecal coliforms removal efficiency

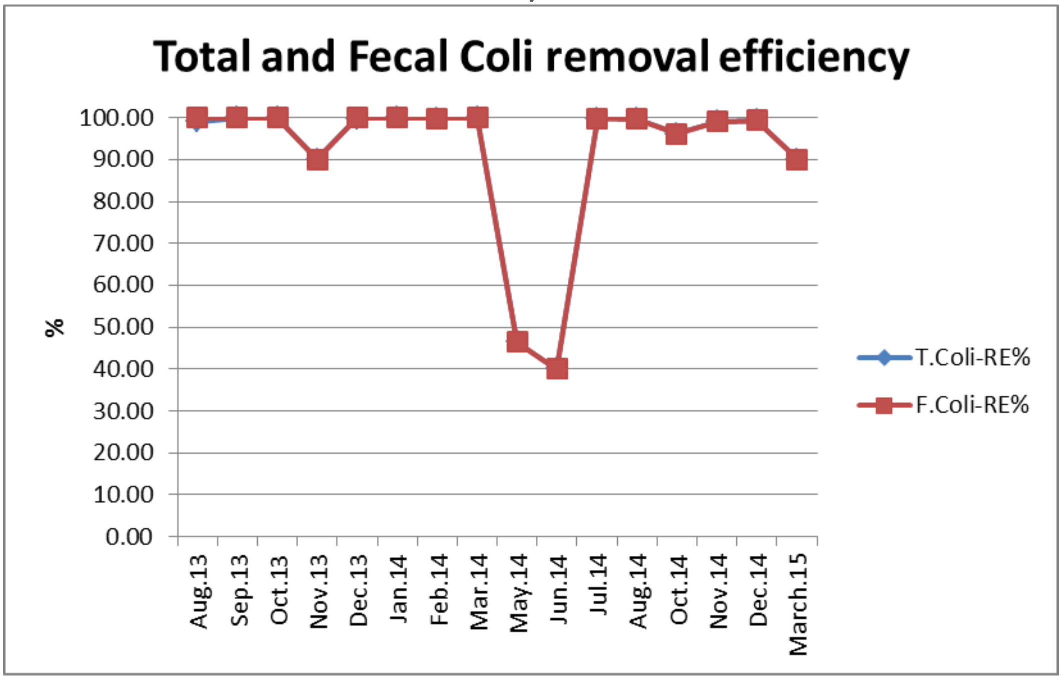


Figure 44 – Conductivity and Ammonia nitrogen removal efficiency

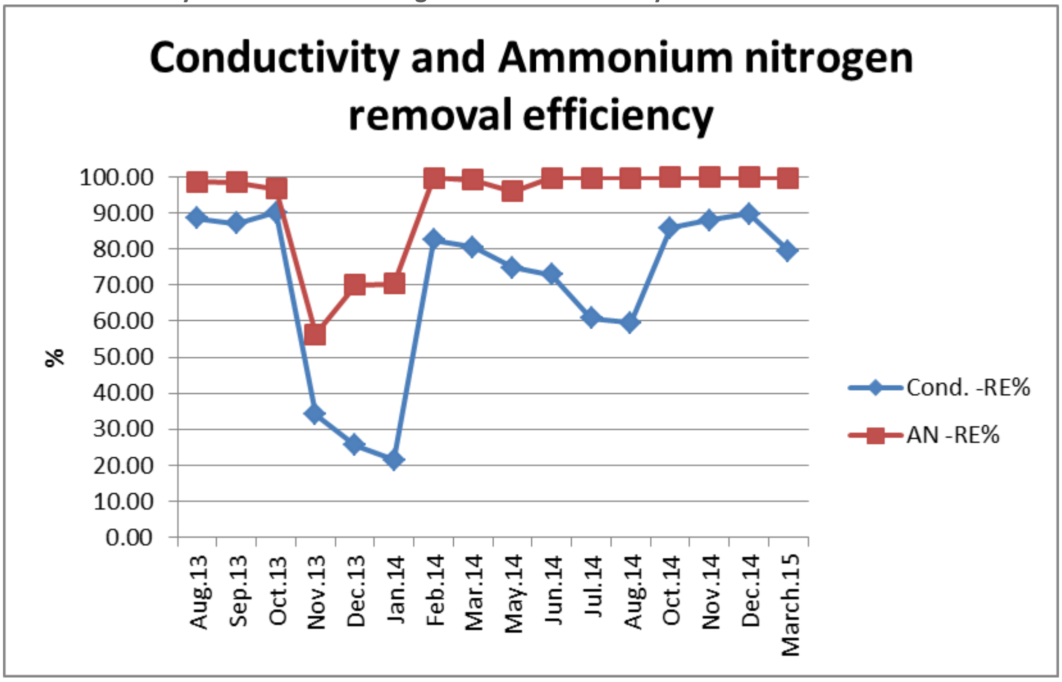


Table 109 – quality of leachate effluent at Mile 24 landfill

Parameter	Aug.13	Sep.13	Oct.13	Nov.13	Dec.13	Jan.14	Feb.14	Mar.14	May.14	Jun.14	Jul.14	Aug.14	Oct.14	Nov.14	Dec.14	Mar.15	Max.	Min.	Ave.	Effluent standards	Units
Total Coliforms	2400	3	23	24000	430	3	700	3	2300	90	3	750	90	40	150	40	24000.000	3.000	1939.063		MPN/100mL
Fecal Coliforms	3	3	23	24000	230	3	700	3	2300	90	3	750	90	40	150	40	24000.000	3.000	1776.750	200[21]	MPN/100mL
pH	8.96	8.8	7.64	7.39	8.44	8.45	8.97	8.81	9.31	9.53	9.14	8.98	7.22	7.15	8.97	9.06	9.530	7.150	8.551	6-9	
Temperature	28.6	33.9	29.7	26.2	26.4	29.3	31.9	29	35.8	34.8	32.3	30.3	25.8	26.4	30.6	35.8	35.800	25.800	30.425	33	oC
Conductivity	172.370	235.700	398.000	1029.670	964.000	756.000	894.670	1074.000	972.000	856.000	930.000	911.000	650.000	586.670	547.000	861.000	1074.000	172.370	739.880		µS/cm
Chloride	10.520	16.410	32.810	74.890	7.870	91.450	394.010	160.450	148.650	144.870	92.170	138.690	83.110	86.600	70.560	129.280	394.010	7.870	105.146	600	mg/L
Total Hardness	57.360	66.120	91.390	229.290	224.980	108.530	100.030	141.370	91.490	69.070	75.140	88.800	61.550	59.840	79.170	2.000	229.290	2.000	96.633		mg/L
Color *	5.000	5.000	5.000	5.000	25.000	5.000	15.000	15.000	15.000	5.000	5.500	15.000	5.000	5.000	5.000	50.000	50.000	5.000	11.594	7	Pt-Co
Dissolved Oxygen *	8.480	7.470	6.260	1.100	10.210	6.810	12.920	8.480	4.690	3.730	2.060	9.320	8.140	4.840	8.160	3.170	12.920	1.100	6.615	5	mg/L
Biochemical Demand of Oxygen5	19.750	8.700	15.450	79.920	45.870	15.400	73.710	9.560	32.370	17.470	5.820	19.580	10.880	3.470	11.440	22.390	79.920	3.470	24.486	30[22]	mg/L
Chemical Demand of Oxygen	36.000	82.000	76.210	214.660	182.470	73.270	285.060	166.480	252.390	267.190	239.520	190.220	82.800	103.700	93.040	284.630	285.060	36.000	164.353	100	mg/L
Total Suspended Solids	13.000	19.000	22.000	65.720	173.310	16.000	81.660	35.000	90.020	81.850	62.150	52.130	19.980	20.080	20.080	100.100	173.310	13.000	54.505	30[23]	mg/L
Total Dissolved Solids	113.080	170.210	236.050	565.340	491.630	440.090	529.770	703.070	651.130	602.290	636.010	636.040	392.520	412.740	362.530	609.880	703.070	113.080	472.024	2000	mg/L
Nitrates	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.110	0.100	0.100	0.100	0.100	0.100	0.110	0.100	0.101	3	mg/L
Fats and Oils	3.980	3.980	3.980	3.980	3.980	3.980	5.940	3.980	3.980	3.980	3.980	3.980	3.980	3.980	3.980	5.180	5.940	3.980	4.178	10	mg/L
Ammonia Nitrogen	0.300	0.300	3.950	18.590	14.050	7.960	0.300	2.810	6.260	0.300	0.300	0.300	0.300	0.300	0.300	0.320	18.590	0.300	3.540	4.9[24]	mg/L
Total Phosphorus	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	5	mg/L
Arsenic	N.D.	N.D.	N.D.	0.021	0.013	0.010	N.D.	0.015	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.021	0.001	0.006	1	mg/L
Boron	0.027	0.045	0.068	0.130	0.209	0.136	0.116	0.368	0.420	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.420	0.027	0.139	5	mg/L
Cadmium	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.1	mg/L
Copper	0.005	0.010	N.D.	N.D.	0.001	0.004	N.D.	0.006	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.001	0.033	1	mg/L
Hexavalent Chromium	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	1	mg/L
Phenol				0.044	0.132	0.017	0.011	0.020	0.010	0.010	0.010	0.010			0.010	0.010	0.132	0.010	0.026		
Iron	0.959	1.680	1.843	12.970	14.530	1.523	4.016	3.073	0.337	0.359	0.275	0.414	0.188	0.162	0.166	0.260	14.530	0.162	2.672	20	mg/L
Manganese	0.137	0.558	1.244	1.500	0.974	0.158	0.243	0.247	0.050	0.050	0.050	0.050	0.050	12.590	0.050	0.050	12.590	0.050	1.125	5	mg/L
Mercury	0.000	0.000	0.000	N.D.	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.005	0.001	0.001	0.001	0.001	0.005	0.000	0.001	0.05	mg/L
Nickel	N.D.	N.D.	0.008	N.D.	0.008	0.009	0.011	0.015	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.008	0.065	1	mg/L
Lead	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.1	mg/L
Sodium	8.036	22.510	25.000	58.000	79.600	62.100	87.800	69.500	58.912	94.130	133.320	92.851	58.840	69.867	49.700	91.530	133.320	8.036	66.356		mg/L
Zinc	N.D.	0.006	0.012	0.026	0.019	0.010	0.032	0.021	0.050	0.050	0.050	0.050	0.050	0.053	0.050	0.050	0.053	0.006	0.035	1	mg/L

[21] Required standards for discharge of treated effluents into Class I waters. *The Environmental protection (Effluent limitations) (Amendment) Regulation 2009*
[22] Required standards for discharge of treated effluents into Class I waters. *The Environmental protection (Effluent limitations) (Amendment) Regulation 2009*
[23] Required standards for discharge of treated effluents into Class I waters. *The Environmental protection (Effluent limitations) (Amendment) Regulation 2009*
[24] Environmental, Health and Safety Guidelines for Waste Management Facilities (IFC) Table 4

In Table 109 the data on the quality of the effluent from leachate treatment gathered by the Mile 24 environmental monitoring activities are listed. Every set of data, of each parameter, is compared with the related threshold value shown in the column "Effluent standards". As quality standards of reference, they have used the most conservative values out of those provided by "*Summary of Main Parameters and Effluent Standards for "Other" Industries*" as per Effluents Limitations Regulations (1995) and them provided by "*Required standards for discharge of treated effluents into Class I waters*" as per The Environmental Protection (Effluent limitations) (Amendment) Regulation 2009. Since no Ammonia threshold value is given in the latter Regulations, just for this parameter, the reference is made to *"Environmental, Health and Safety Guidelines for Waste Management Facilities (IFC) Table 4".*

The quality standards so considered are different from the leachate effluents standards required at Mile 24 landfill. The set of standards here considered has been created with the sole aim of comparing the effluent pollutants concentrations with the most restrictive threshold values suggested by Belizean legislation or by other international regulations.

The figures in "red cells" exceed the related threshold values.

The most critical parameters are BOD_5, COD, TSS and Ammonia Nitrogen. As already mentioned, these parameters mainly define the quality and the hazardousness of a leachate, and the concentrations in leachate from semi-aerobic landfill of BOD_5, COD and Ammonia Nitrogen are, at least, 50% of those ones from anaerobic landfill, such as Mile 24.

Therefore, if in the Mile 24 case, the effluent concentration values of the most critical parameters exceeded the related threshold value in more than 50% of the total surveys, in a semi-aerobic landfill it can be assumed that, considering the same efficiency of the leachate treatment, the total exceedances would drop to 25% of the total surveys.

30.1.2.2.2 Landfill Gas (LFG)

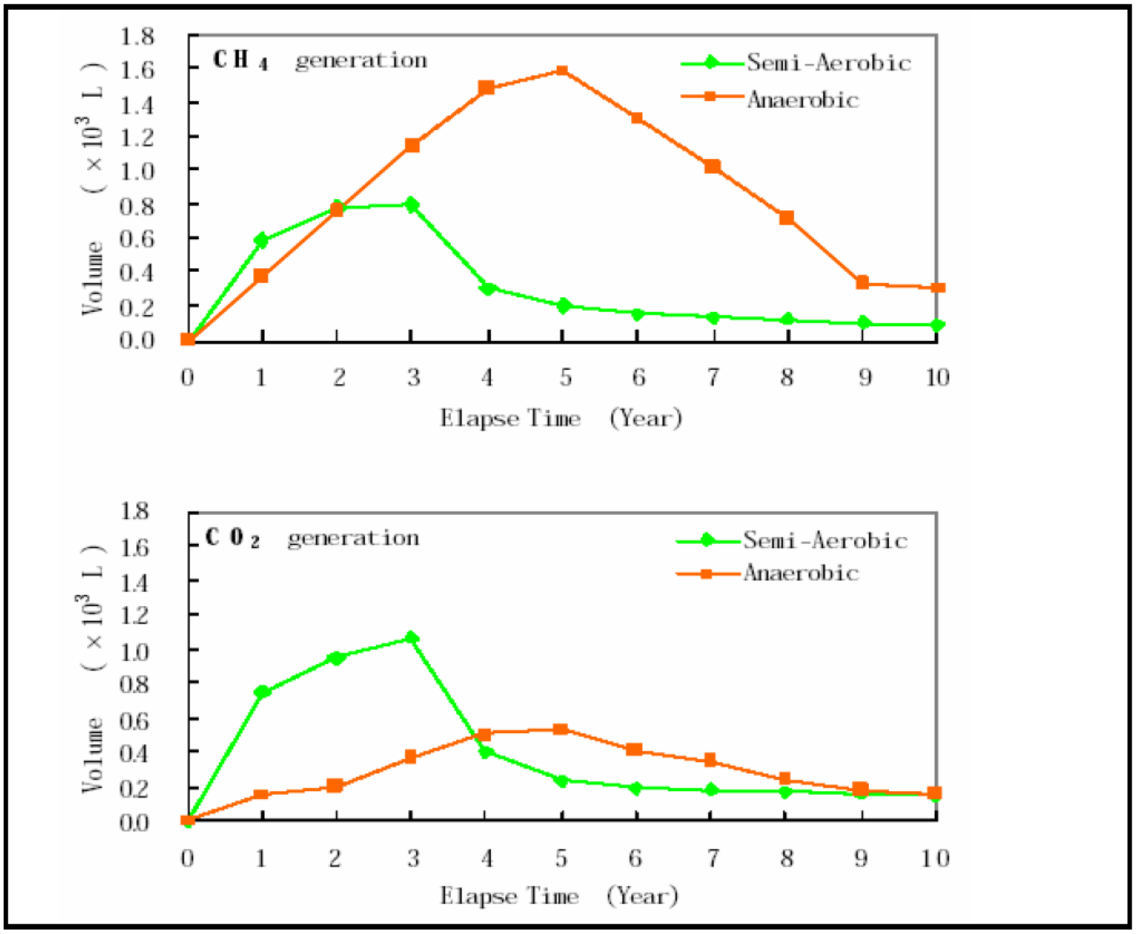
The biodegradation of the organic fraction of waste produces a landfill gas composed, mainly, of methane and carbon dioxide. Methane is a harmful gas and is a, so called, "greenhouse" gas, because it can impact the global temperature, contributing to warming Earth.

Moreover, methane accumulation in waste mass can cause fires, which are dangerous for the safety of the operators, and are responsible for the emission of very harmful gas into air, such as dioxins and furans.

Therefore, with the aim of reducing the possibility of accidents and the impact on air quality, a landfilling technology that guarantees the lowest methane production has to be chosen.

As already mentioned, the landfill gas produced in semi-aerobic landfill is mainly characterised by the abundant presence of carbon dioxide. In Figure 45, a comparison of methane and carbon dioxide emissions from anaerobic and semi-aerobic landfills is shown.

Figure 45 – Comparison of methane and carbon dioxide emissions from anaerobic and semi-aerobic conditions (*Meeting the challenge – Landfill in Samoa Ellen Blake, Bruce Chapman Program Manager- Pacific Futures – SPREP)*



The CH_4 generation trends shown in Figure 45 point out two main aspects:

1. The total amount of CH_4 generated in semi-aerobic landfill is lower than that generated in the anaerobic landfill, in particular the CH_4 concentration in LFG from semi-aerobic landfill is about 50% of that from the anaerobic landfill;
2. In semi-aerobic landfill, the LFG production reaches a peak at the closure of the plant, then decreases very rapidly. In anaerobic landfill also, the LFG production peak is reached at the closure of the landfill, but is lower, and the production decline, during the aftercare phase, is slow, so the LFG production is significant for several years after the end of waste disposal or placement.

So the semi-aerobic landfilling technology is deemed to be more suitable for the purpose of reducing all the impacts related to LFG emissions.

This topic, the LFG production in anaerobic and semi-aerobic landfill, is hereinafter more extensively discussed, through the assessment of the quantities of gas produced by the disposal of the waste as envisaged, for the duration of the design period, in Northern Corridor.

This production assessment is made using LandGEM software by EPA. LandGEM is based on a first-order decomposition rate equation for quantifying emissions from the decomposition of landfilled waste in MSW landfills. The software provides a relatively simple approach to estimating landfill gas emissions. Model defaults are based on empirical data from U.S. landfills (EPA, 2005). Landfill gas is assumed, by this model, to be roughly half methane and half carbon dioxide with additional, relatively low, concentrations of other air pollutants.

Calculation assumption

Table 110 – Calculation assumptions

Waste design capacity (Mg)	1,000,000
Waste acceptance rates (Mg)	Annual amount of waste to landfilling, as per DFS predictions
Semi-aerobic	
Methane generation rate, k ($year^{-1}$)	0.7 (Bioreactor)
Potential Methane Generation Capacity, L_0, (m^3/Mg)	170 (CAA – Conventional)
Methane Content (% by volume)	50%
Anaerobic	
Methane generation rate, k ($year^{-1}$)	0.04 (Inventory - Conventional)
Potential Methane Generation Capacity, L_0, (m^3/Mg)	170 (CAA – Conventional)
Methane Content (% by volume)	50%

The value of the Potential Methane Generation Capacity, L_0, considered, enables the estimation of the maximum rate of CH_4 production.

Since Landgem provides an annual Methane production, assuming the Methane content equals 50% of the total LFG, in the case of semi-aerobic landfill, the values provided by this software have been reduced to 25% of the total amount of the total LFG. According to IDB suggestion ("Greenhouse Gas Assessment Emissions Methodology" Milena Breisinger - August 2012), the CH_4 emissions of a semi-aerobic landfill are half the CH_4 emissions of an anaerobic one.

Table 111 – Total CH_4 emissions

Landfill type	CH_4 (Mg)
Anaerobic	112,836
Semi-aerobic	58,716

The values of the overall emissions so estimated are shown in Table 111. The following figures show the production trends as a function of time, for the two different landfill types.

Figure 46 – Semi-aerobic landfill – LFG production

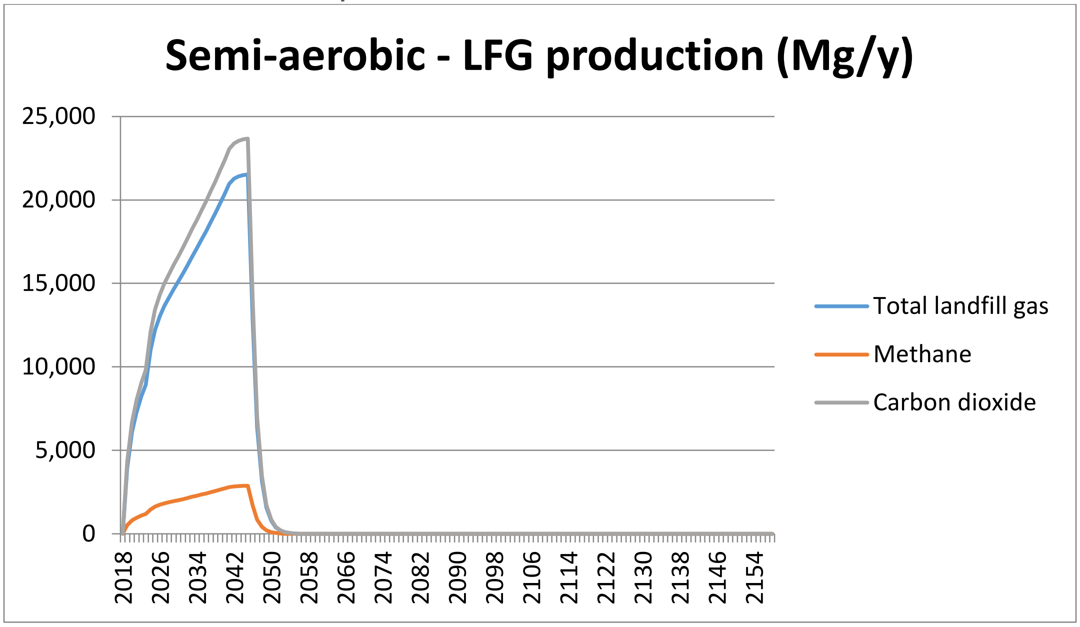
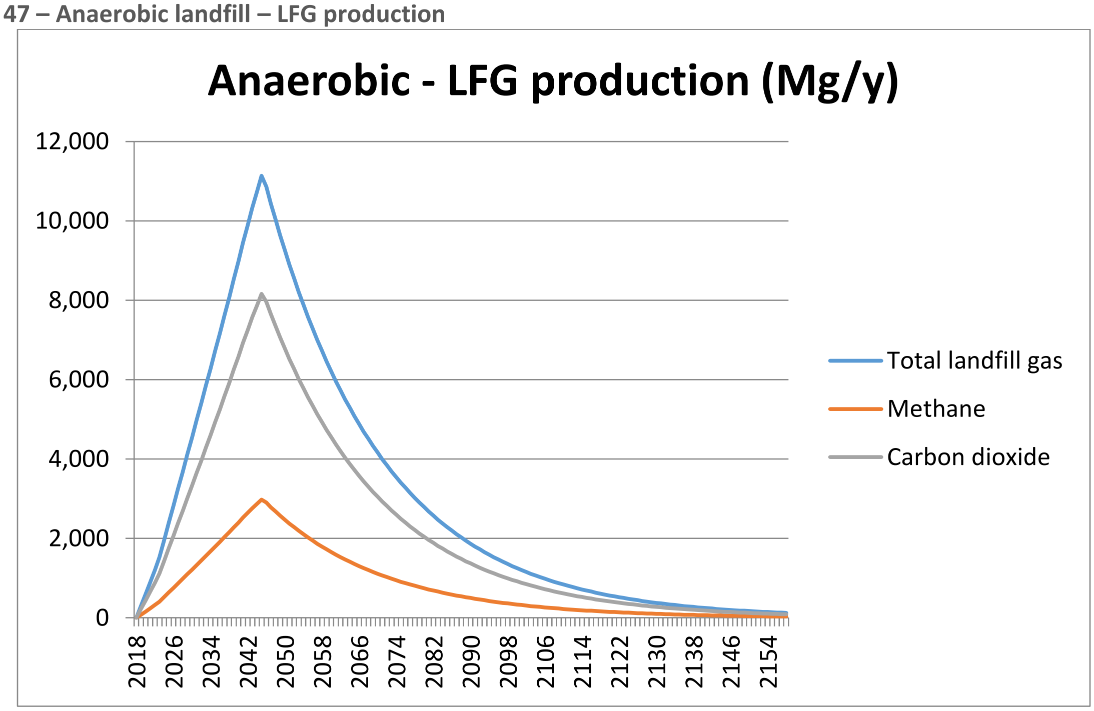


Figure 47 – Anaerobic landfill – LFG production



As already observed, in the semi-aerobic landfill the biodegradation processes are enhanced and are mainly gasification dominated. The maximum annual rate of LFG in semi-aerobic landfill, in fact, is 21,527.233 Mg, while in an anaerobic landfill is 11,137.26 Mg. But in a semi-aerobic landfill, the LFG production is rapidly reduced in a few years after landfill closure, while in an anaerobic one, it decreases more slowly.

In regards to Methane, the maximum annual rate is 2,875.078 Mg in semi-aerobic and 2,974.88 Mg in anaerobic, so the maximum values are comparable, but the semi-aerobic overall production is half the anaerobic one.

Therefore, summarizing the results of the estimation of LFG emissions, it can be observed that the emissions from semi-aerobic landfill are less harmful, due to the lower methane content, and are mainly generated during the operation phase of the landfill.

In order to compare the GHG emissions of the landfill types being considered, a GHG emission factor has been calculated for each Mg of waste disposed of in:

- semi-aerobic landfill;
- anaerobic landfill;

The results of the estimation are shown in Table 112.

Table 112 – GHG emission factor

Landfill type	Waste disposed of (Mg)	CH_4 (Mg)	GHG (CO_{2eq} Mg/y)	GHG emission per Mg of waste ($MgCO_{2eq}$ /Mg_{waste})
Anaerobic	1,000,000	112,836	2,820,911	2.82
Semi-aerobic	1,000,000	58,716	1,467,888	1.47

Therefore the lower GHG emission factor per Mg of waste disposed of is related to semi-aerobic landfill.

Considering Scenarios 1 and 2 and the annual average of waste taken to landfill in the duration of the plan, the annual amount of GHG emissions is calculated (see Table 113)

Table 113 – GHG emissions amount

Corridor	Annual average amount of waste to landfill (Mg)	GHG annual emissions from anaerobic landfill ($MgCO_{2eq}$)	GHG annual emissions from semi-aerobic landfill ($MgCO_{2eq}$)
Northern	34,525.23	97,361.15	50,752.09
Southern	35,789.27	100,925.74	52,610.23
TOT	70,314.50	**198,286.89**	**103,362.32**

30.1.2.2.3 Landfilling technologies- Conclusions and recommendations

As already mentioned, in order to prevent, as far as possible, the effects on the environment of landfill construction and operation, it is recommended to choose the landfilling technology that can guarantee the lowest harmful emissions (leachate and LFG), in terms of quantity and hazardousness, and the most effective emissions control, in terms of collection and treatment.
The leachate quality characterisation, conducted on the basis of the concentration values and trends of the pollutants related to organic matter, points out that the leachate produced in semi-aerobic landfill is less harmful. So its treatment is easier, and less expensive, than the

treatment needed by the leachate produced in anaerobic conditions. Moreover, the pollutants concentrations in semi-aerobic landfill leachate decrease rapidly, so the duration of the needed treatment is lower than that for anaerobic landfill leachate and, in general terms, the duration (and related costs) of the landfill aftercare phase is lower.
The outcomes of the estimation of LFG emissions point out that the emissions from semi-aerobic landfill are less harmful, due to the lower methane content, and generated mainly during the operation phase of the landfill.
Therefore the semi-aerobic landfilling technology is deemed to be more effective in terms of reduction of emissions and related environmental impacts. As such, this type of landfill is considered in Scenario 2 in the following analysis (conceptual design and financial assessment).

30.1.2.3 Small Landfill (Scenario 3)

Scenario 3 corresponds, in the aim of the present Study, to the "do nothing" scenario and it is evaluated for environmental purposes only. It is not a reasonable technical option in fact, in the medium-long term perspective, to rely on a local system of dumpsites (even at an improved level of environmental performance) to resolve the strategic need of an efficient and adequate waste management system (technically, economically and environmentally).
And this is particularly self-evident when looking at the rapidly increasing importance of the aspect in the near future as shown by the waste generation projections for the two corridors in comparison with the present situation of waste management at a local level.

The following figures can provide a better picture of this aspect.

Table 114 – Expected waste generation growth in the four Districts compared with the estimated generation in year 2015, which is assumed as 100

District	2020	2025	2030	2035	2040
Corozal	115	152	173	215	243
Orange Walk	114	130	148	168	190
Stann Creek	130	175	240	304	391
Toledo	124	155	197	246	310
Average	*121*	*153*	*190*	*233*	*284*

A 20% average growth in the generation of waste is expected in the next 5 years increasing to a 53% in the following 5 year period to finally reach the doubling of the quantities in the year 2030.
In the Southern Corridor in particular the evolution is expected to be even larger and faster (30%, 75% and 140% increase respectively in the Stann Creek District) due to the expected greater influence of the tourism factor.

The inadequacy of the "do nothing" scenario is also reinforced and made more evident by the economic and social relevance of the planned tourism increase in the two Corridors and considering that the lack of adequate infrastructures (including waste management) is a limiting factor for the attainability of the planned goals.

Major obstacles to the implementation of a local landfill system are:

a. *Increase in investment and operational costs*. The investment cost for a local landfill is not proportionally lower to that of a regional landfill based on the estimated waste inputs. The total unit cost per tonne, as estimated by the NSWM Strategy[25] ranges from 18.8 USD/tonne for a regional landfill to 25.5 USD/tonne (Dangriga) and to an even higher 29.5 USD/tonne for a smaller local landfill in Punta Gorda. It is easy to estimate the economic result of a system based on two local landfills in the south with respect to a regional landfill located in the Placencia area:
    i. 29.5 USD/tonne – 18.8 USD/tonne = 10.7 USD/tonne (major unit cost of a local landfill in Punta Gorda with respect to a Regional Landfill)
    ii. 25.5 USD/tonne – 18.8 USD/tonne = 6.7 USD/tonne (major unit cost of a local landfill in Dangriga with respect to a Regional Landfill)
    iii. 10 USD/tonne, cost for transfer the waste from Punta Gorda to the Regional Landfill as a conservative assumption
    iv. Assuming the major cost in i. in Punta Gorda equal to the alternative transfer cost in iii. as a conservative assumption, the increase of the total cost of a local landfill system based on two landfills with respect to a regional landfill can be estimated as:
    the major unit cost of a local landfill in Dangriga (as per ii.) multiplied by the total tonnes disposed of in the Dangriga local landfill, that is:
    6.7 USD/tonne x 10,891 tonne/year (year 2018 estimated data for the Stann Creek District as per the present Study) = 72,970 USD/year

b. *Only partial relief to environmental impacts and insufficient response to the waste management goals*. A local landfill system should necessarily focus on major centres and areas with expected higher waste annual generation. This would leave unsolved the disposal problems of the majority of the centres in both regions. A response to this aspect would make necessary the implementation of a wide waste collection and transfer system not dissimilar to that proposed for the two previous Scenarios. The minor saving that could be obtained would be largely overshadowed by the higher costs of the landfills with respect to transfer facilities.

c. *Greater social and economic impacts*. A local landfill is, for its same definition, located close to the beneficiary communities is not different from the present dumpsites. The reduced choice for the location of a landfill in restricted areas will lead to the use of otherwise valuable lands and to a higher proximity with highly populated and/or touristic areas. It is not surprising that attempts in this regard, made in the recent past by the Punta Gorda Town Council, have already been strongly opposed by the local communities leading to the failure of the projects. The inevitable process to push the sites far from the inhabited centres will lead back to the proposal of a regional landfill.

On the other hand it is recognised that the need of an accurate planning of the resources for the implementation of the waste management strategy needs necessarily to prioritise the

[25] Belize Waste Flows and Cost Model 26-2-15 v2 excel spreadsheet attached to Belize NSWM Strategy & Plan – Draft Final Report v1 25 June 2015

investments and to also look at interim solutions to ease the pressure and gradually drive to the completion of the programs.
In this sense and with this aim in mind, the following proposals for the upgrading of the existent rural system are presented and can be possibly considered to the extent needed.

30.1.2.3.1 Temporary upgrade of waste management in rural villages

Main problems caused by the present waste management at village level are:

- Air pollution due to combustion of waste
- Diffuse littering in the outskirts of the villages
- Water pollution

Separation of biodegradable organic matter appears to be an indispensable habit to be developed through promotion of yard composting in order to avoid the burning of the yard waste and to divert the biodegradable organics from being dumped where it is the main cause of environmental problems and generation of nuisances.

In accordance with the waste generation estimates as per the present Study the almost totality of the villages in the two Corridors generates between 10 tonne/year and 400 tonne/year of residual waste (no biodegradable organic) which correspond, considering a 0.2 tonne/m^3 density, to a volume range between 60 m^3 and 2000 m^3 per year.

The proposed solution is the identification and preparation of a communal area in the outskirts of the village in accordance to the proposed remediation design for the Corozal and Orange Walk dumpsites (see Conceptual Design document) possibly with the addition of a simple bottom lining system as described below. The phytoremediation trench at the base of the lower side should be planted with plants resistant to dry periods and with high water consumption during the wet season (e.g. hibiscus).

A 50 m by 20 m area (1,000 m^2) can cater for a 1 year waste generation of 200 tonnes deposited in a 1 m thick layer at a cost of approximately 5,000 USD depending on the area. The bottom lining can be built through a 30 cm clay layer, if locally available. Alternatively an HDPE 0.75 mm sheet can be used. The preparation of the site, consisting mainly in earthmoving, can also be done with local available resources.

31 ALTERNATIVE LOCATION – LANDFILL SITE SCREENING

The screening process to determine the most suitable locations for the proposed landfills in Scenario 2 is designed and phased as per the following description.
The selection process is phased as follow:

- <u>Phase 1: Exclusion criteria</u>
  Based on data collection and analysis, a Negative Map is developed representing areas not available. This Phase was implemented during the Inception Report activities.

- Phase 2: Evaluation criteria
  Based on distances from the centroid of waste collection areas, preliminary transport cost analysis, waste streams projections and site availability, from 4 to 6 sites per Region are selected.
- Phase 3: Site evaluation
  Physical, technical, geological, hydrogeological and geotechnical data have been collected and compared. Social aspects, such as the proximity to human settlements and infrastructures will also be considered. From 2 to 3 sites are subjected to environmental assessment and a comparative site rating provided.
- Phase 4: Site Investigation
  The final chosen site will be fully investigated to collect all the necessary data to develop the preliminary design of the landfill.

31.1 Exclusion criteria

To carry out the preliminary site screening the information made available by different Government Departments as described in the following have been used.

The information on the different available aspects has been divided in three categories:
A the aspect is not compatible with the location of a landfill
B the aspect shall be further investigated according to its actual local conditions
C the aspect is consistent with the location of a landfill

31.1.1 Geology

The information on the geology has been kindly provided by the Geology and Petroleum Department under the Ministry of Energy, Science & Technology and Public Utilities.

The geology map provided is reportedly based on the information gathered by the Department and continuously updated based on the most recent geological surveys progressively carried out nationwide for different purposes.

As per the information received by the personnel of the Department, the reliability of the map becomes more uncertain at the boundaries between different geological units and as such needs in any case to be confirmed through specific investigations.

The geological units identified nationwide are as per the Legend of the Geological Map of Belize as shown below. For each unit, the respective exclusion category adopted for the aim of the present Study is specified.

Table 115 - Geological Map Legend

Geological Unit		**Exclusion criteria**
Q	Quaternary Alluvium and Modern Reef	(A) The unit only appears to emerge in a small area in the Cayo District. It is excluded due to its carbonate and conglomerate nature.
Lt	Late Tertiary Red Bank and Orange Walk Groups Clay, gypsum, sand, chert, marl, limestone	(B) This unit includes lithotypes of very different nature mainly sedimentary. Needs specific and local information.
O	Oligocene Iguana Creek Fm Carbonate – chert conglomerate	(B) The unit is preliminarily not excluded, although mainly of carbonate nature since dolomite can offer acceptable local conditions.
Et	Early Tertiary El Cayo Group-Doubloon Bank Fm (limestone, marl, gypsum, chert nodules)	(A) The unit is excluded due to the carbonate nature of all the lithotypes included.
K/UK	Undif. Cretaceous Barton Creek Fm(BC)/Campur Fm Limestone, dolomite Coban Fm (dolomite)	(B) This unit includes lithotypes of very different nature mainly sedimentary. Needs specific and local information.
Bf	Late Paleocene – Recent Belize Formation (offshore) Reef and mud carbonates	(A) The unit is preliminarily excluded due to the carbonate nature of all the lithotypes included.
T	Late Cretaceous . Early Tertiary Toledo Fm (Sepur Fm Eq) Sandstones, conglomerates, limestones, mudstones	(B) Metamorphic and sedimentary rocks, to be further locally investigated.
Kt	Cretaceous – Early Tertiary La Cumbre megabreccias Carbonates	(A) The unit only appears to emerge in a small area in the Cayo District. It is excluded due to its carbonate and conglomerate nature.
J	Jurassic Margaret Creek/Todos Santos Fm Shales, sandstones	(B) This unit includes lithotypes of very different nature mainly sedimentary. Needs specific and local information.

Geological Unit		**Exclusion criteria**
Gr	Late Silurian or Late Triassic Plutons Mountain Pine Ridge pluton (diorite-granodiorite, granodiorite, quartz monzonite, granite and muscovite granite) Hummingbird – Mullins River pluton (two-mica granite, granodiorite and quartz monzonite) Cocksomb-Sapote pluton and stock (porphyritic biotite granite)	B) Plutonic rocks, to be further locally investigated.
Pz	Shales, argillites, slates, schists, phyllites (sandstones)	(C) Metamorphic rocks, among the other lithotypes appears to offer more favorable conditions.
Pzq	Quartzsites, sandstones, conglomerates	(B) Sedimentary rocks of favorable nature, to be further investigated with regard to hydrogeological local conditions.
Pzl	Crinoidal limestones	(A) The unit is preliminarily excluded due to the carbonate nature of the lithotype included.
Pzv	"Bladen Member" Volcanic rocks: lavas and pyroclastics, rhyolitic to andesitic volcaniclastics	(B) Volcanic rocks, to be further investigated with respect to local conditions
Pzc	Schists, slates w. contact metamorphism minerals	(C) Metamorphic rocks, among the other lithotypes appears to offer more favorable conditions.

31.1.2 Ecosystems

The information on the ecosystems was sourced from the Biodiversity & Environmental Resource Data System (BERDS) (www.biodiversity.bz).

The following ecosystems, as per BERDS terminology, have been classified as non-available for the location of landfills:

- Mangrove and littoral forest
- Wetland
- Coral Reef
- Seagrass
- Water
- Urban

The remaining ecosystems have been preliminarily classified as available. Even if the preliminary siting activity will focus mainly and in the measure possible, on compromised sites, further and specific investigations will be carried out on the aspect at a local level in the following phases.

31.1.3 Protected areas

The information on the protected areas is sourced from the BERDS (www.biodiversity.bz).
All the protected areas have been classified as non-available for the location of landfills.

31.1.4 Fire risk

The information on the fire risk it is sourced from the BERDS(www.biodiversity.bz).
The fire risk classification is only added with the aim of providing further information to be used in the following phases of the siting process.

31.1.5 Flood susceptibility

The information on the flood susceptibility is sourced from the Belize National Emergency Management Organization (NEMO).
According to NEMO's classification the national territory of Belize has been divided in the following classes:

1. No-susceptibility, non-forested
2. No-susceptibility, forested
3. Low susceptibility
4. Moderate susceptibility
5. High susceptibility
6. Water bodies

For the aim of the present study classes 1 and 2 have been classified as suitable for the location of landfills. Class 3 (moderate susceptibility) has been considered to be further and locally investigated if necessary. The remaining classes are here excluded for the purpose of the siting of landfills.
A buffer zone 150m wide on both sides of the main water bodies (main rivers, lakes, lagoons) has also been here excluded.

31.2 Preliminary Site selection

Based on the available information and the results of the Waste Generation Assessment a first selection of possible sites for the location of the required facilities and the assessment of currently operated major dumpsites was carried out.

The following sites/areas were preliminarily visited in the Northern Corridor (see Figure 48):

1. Consejo L: previously proposed site for the location of a new local landfill in the Corozal District potentially available for the location of the new Regional Landfill;
2. San Pablo L: possible suitable area for the location of a new Regional Landfill;
3. San Estevan L: possible suitable area for the location of a new Regional Landfill;

4. Orange Walk L: possible suitable area for the location of a new Regional Landfill.

The following sites/areas were preliminarily visited in the Southern Corridor (see Figure 49):

1. Dangriga L: possible location of a new local/regional Landfill
2. Hopkins L: possible location of a new local/regional Landfill
3. Santa Cruz L: possible suitable area for the location of a new Regional Landfill
4. San Juan L: possible suitable area for the location of a new Regional Landfill
5. San Felipe L: previously proposed site for the location of a new local landfill for the Punta Gorda area, potentially available for the location of the new local/Regional Landfill

31.3 Additional sites and information

During the selection process other sites have been brought to the attention of the Consultant and will be considered in the following phases of the Study.

At the same time, additional information was collected that can modify the rating or even the actual suitability of the sites already selected.

Specifically, the following additional information was gathered after the initial selection phase that are worth considering in the following Study.

31.3.1 San Juan landfill site

According to additional data gathered after the preliminary site screening the San Juan proposed landfill site is apparently located on the recharging area of a major regional aquifer.
If confirmed, such circumstance will inevitably lead to the exclusion of the site. More detailed data is being sought.

31.4 Preliminary site evaluation

A preliminary evaluation of the above listed sites has been carried out based on the available information to select the most suitable ones among those so far identified. The following paragraphs describe this site selection activity and the adopted criteria.
The evaluation is based on the following rating:

1. Non suitable: the aspect is not suitable for the proposed facility.
2. Difficult: the aspect is not suitable, but substantial mitigation measures can be adopted to reduce the impacts or substantial additional infrastructure is needed.
3. Adaptable: the aspect is not completely suitable, but mitigation measures can be adopted to avoid the impacts and/or commonly required additional infrastructure is needed.
4. Adequate: the aspect is favourable, but minor mitigation measures and/or minor additional infrastructure is needed.
5. Suitable: the aspect is such that possible impacts are very unlikely or extremely low and temporary, no additional infrastructure or mitigation measures are necessary.

Figure 48 – Preliminary Siting inspection, Northern Corridor (no scale)

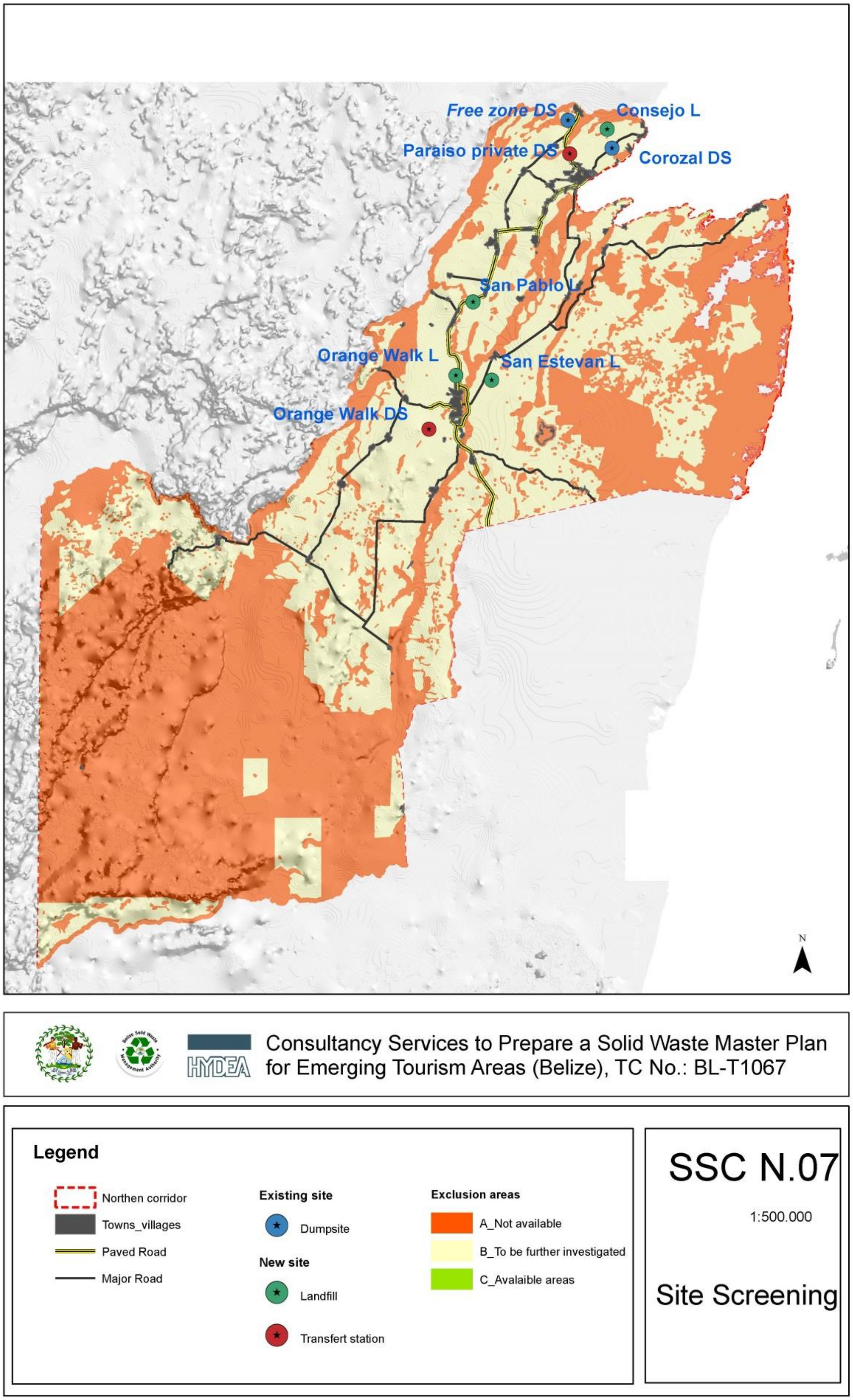
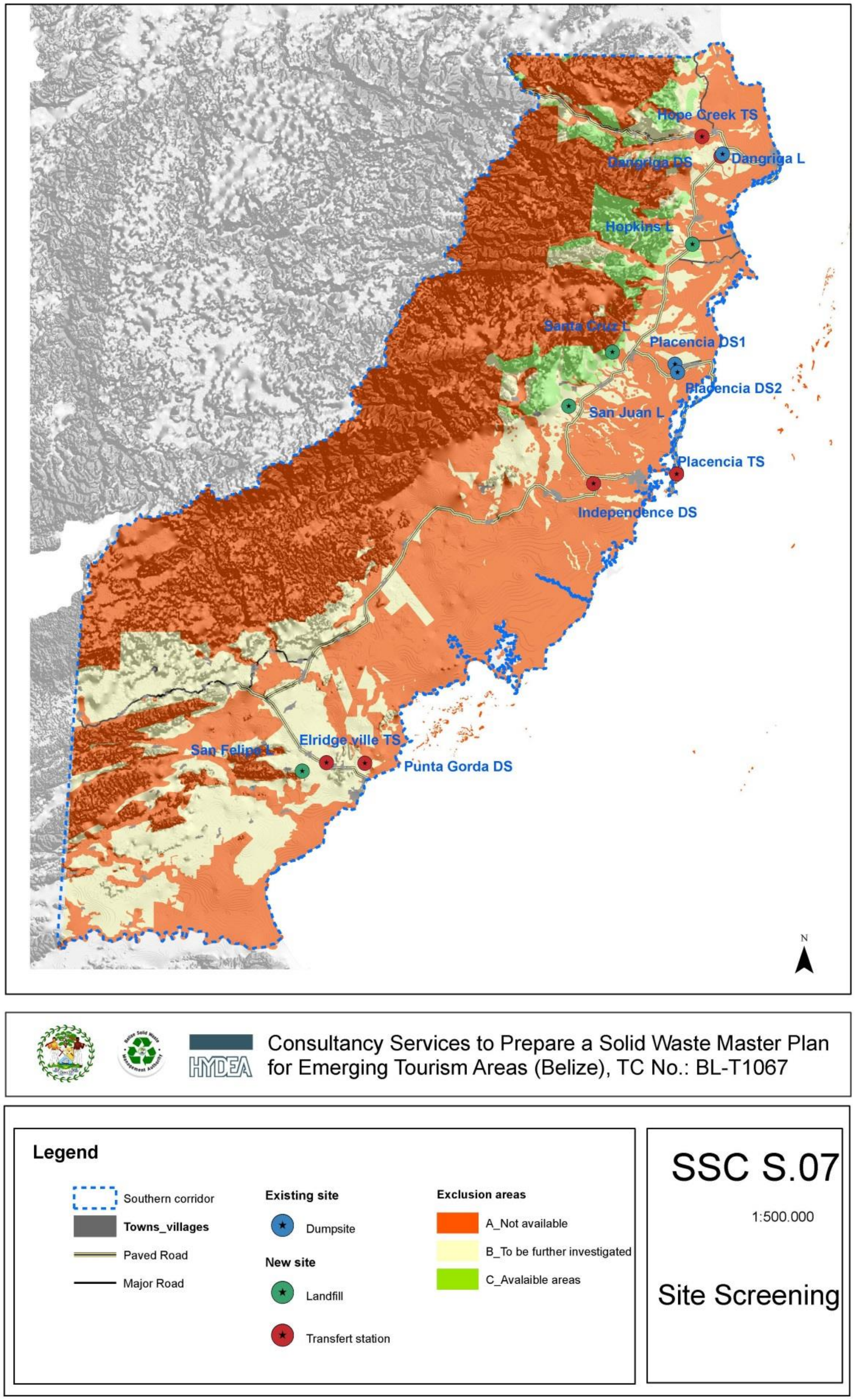


Figure 49 – Preliminary Siting inspection, Southern Corridor (no scale)



The selection carried out corresponds to the activity, “Phase 3: Site evaluation”. The evaluation has been mainly based on the following characteristics as per the available information and site visits:

- Physical: topography, hydrography
- Technical: infrastructure, location with respect to waste generation areas
- Geological, hydrogeological and geotechnical
- Proximity to human settlements, land use

31.5 Northern Corridor

The options for the location of a landfill in the Northern Corridor are highly limited by many different factors:

- Available infrastructure: to avoid non sustainable costs for the construction of additional and specific infrastructure and excessive transportation costs, the landfill shall be located not too far away from existing all weather roads and power lines (from 2 to 5 km). In the Northern Corridor, this is limiting the options almost only to a narrow area along the Northern Highway between Orange Walk Town and Corozal Town.
- Density of urban settlements: the same area served by the necessary infrastructure is also densely covered by numerous villages.
- Geology: the geology of almost the entire region is characterized by carbonate soils with frequent and diffuse karst activities. Such geological characteristics would lead, under a strictly technical point of view, to the exclusion of any possible location for a landfill based on internationally accepted criteria. The lack of alternatives may make it necessary to reconsider this criterion.
- Hydrogeology and hydrology: due to the abovementioned geology, the drainage capacity of the soil is very high. Diffuse presence of phreatic water bodies and, on the other hand, absence of a well developed and permanent surface water drainage system are the results of such condition. Only major rivers are present in the area. While the diffuse presence of phreatic water and the high drainage capacity of the soil is a condition for an increased risk of diffusion of contaminants, the absence of a permanent superficial drainage is a limiting factor for the adequate discharge of the treated wastewater generated by the landfill.
- Use of soil: with the exception of an extended unpopulated area in the south of the Orange Walk District and the similarly extended and unpopulated eastern area of the two Districts, the largest part of the territory is dedicated to the cultivation of sugar cane. Residual portions, more and more threatened, are covered by fragmented natural forests. Disturbed lands (of both low economic and ecologic value) are generally represented by marginal, temporarily abandoned parcels, intercluded by one or the other of the two mentioned systems.
- Finally, the topography of the region is prevalently flat with only minor gradients. This is not a favourable condition for the location of a landfill, since it requires increased earthworks and, on the other hand, causes a higher visual impact of the landfill.

If the combination of all the above mentioned aspects largely reduces the options for the location of a landfill, the geological and hydrological constraints pose serious challenges to the design, construction and operation of it.
The following sections shall be read bearing in mind the above general considerations.

31.5.1.1 Consejo Landfill site (rating as per section 5.4)

#	Criteria	Description (mitigation measures and additional infrastructures)	Rating
1	Topography	The site has a gentle slope with a total difference in elevation of a few metres. This characteristic allows less earthworks for the construction of the base of the landfill. It also offers good conditions for the design of the stormwater drainage system and the leachate treatment system.	5
2	Hydrology	There is no natural hydrology drainage channel. The high permeability of the soil in the area does not favour the establishment of a natural drainage system. This factor is highly limiting with regards to the final discharge of the treated leachate. The design and operation of the landfill and, mainly, the design of the leachate treatment system shall then require the consideration of other viable alternatives (e.g. evaporation ponds, equalisation basins, etc.). The cost increase and the need of additional available areas have to be necessarily considered.	2
3	Geology	The geology of the entire Northern Corridor is mainly of carbonate nature and highly permeable. The site is not an exception. The bottom lining of the landfill shall then be overdesigned to reduce the risk of leakage.	2
4	Land Use (site)	Most of the area of the proposed site is presently vegetated (broad leaf forest). If, on the one hand, this factor implies the removal of such natural vegetation, on the other hand it offers a natural buffer area limiting visual and noise impacts. The natural mitigation of such impacts offered by the site counterbalances the measures to be taken for compensating the removal of natural vegetation.	3
5	Land Use (adjacent)	The areas in the immediate surroundings of the site within a 2.5km distance are covered by natural vegetation (between 60% and 70%) with the remaining land used for agriculture (sugar cane and papaya).	5
6	Potential risks	No risk of flooding is reasonably foreseeable. The risk of fire is potentially increased due to the proximity of the sugar cane fields all around the site and especially on the	3

		SE side (upwind to main wind direction). The increase of the risk is connected to the customary practice of burning the cane fields before harvesting.	
7	Distance from settlements	The location of the site appears to be favourable with regards to the distance from human settlements. The nearest centres are located upwind and at a minimum distance of 3 km. The closest centre downwind is the village of Santa Elena (4.6 km). No isolated houses are closer than 3 km from the site.	5
8	Distance from roads	The site is adjacent to a large all weather road. Two main routes can presently be used to reach the site. From the Consejo road 2.5 km south to the site or through the Paraiso Village (9.7 km). In both cases, the traffic directed to and coming from the landfill should cross inhabited areas (Corozal Town in the first case and Paraiso Village in the second). To avoid such occurrence, as it appears necessary, a third access can be created along an existent road connected with the Chan Chen Road 3 km south to the Philip Goldson Highway. A 700 m long connection would be built for the purpose.	3
9	Distance from airstrips	The site is located 10 km from the Corozal airstrip (to the SW) but is only 5.5 km South of the major airport of Chetumal (Mexico). The relevance of this aspect shall be further investigated. It is preliminarily noticed that the orientation of the airstrip is such that landing and taking off routes would not intersect the site.	X
10	Infrastructure	No water supply is present, groundwater wells shall be drilled on purpose. The closest power line is located 2.5 km South along the Consejo road.	3
11	Property and Surface area	The site is private property. SWaMA has approached the Ministry to acquire a portion of the site (parcel 1281). Considering what was mentioned with regards to leachate treatment (#2), it appears that purchasing of parcel 1282 as well as a total area of approximately 39 hectares will be necessary.	3
12	Position within the SW basin	The Solid Waste generation in the Northern Corridor is almost equally divided in two main sub-basins centred respectively in the Corozal Town area in the North and in Orange Walk Town in the South. The location of the landfill within the entire basin is consequently indifferent, since an increase in the logistic costs related to one of the two sub-basins will correspond to a similar decrease of the costs related to the other sub-basin.	5
13	Other	The site was recently considered (year 2011) for the	

	information	location of a local landfill. No opposition have been reported to the project, which was anyway temporarily abandoned.	

The site is not discarded at this stage. Its final eligibility is nevertheless conditioned by further investigations. Main negative aspects are the lack of a receptor water body for the discharge of the treated leachate and the proximity to the Chetumal airport which relevance shall be further assessed.
Main positive aspects are the favourable topography, the distance from inhabited centres and the fact that SWAMA has made some progress in acquiring the site.

31.5.1.2 Free Zone Landfill site (rating as per section 5.4)

#	Criteria	Description (mitigation measures and additional infrastructures)	Rating
1	Topography	The site is gently sloping toward the NW with a total difference in elevation of a few metres. This characteristic allows less earthmoving for the construction of the base of the landfill. It also offers good conditions for the design of the stormwater drainage system and the leachate treatment system.	5
2	Hydrology	A minor natural drainage channel is located about 1.5 km NW of the site, 700 m downstream the channel discharges into the Rio Hondo (international border with Mexico). Also in this case, the final discharge of the leachate appears to require additional infrastructure. The construction of a 1.5 km pipeline appears to be the most viable solution. The cost increase has to be necessarily considered.	2
3	Geology	The geology of the entire Northern Corridor is mainly of carbonate nature and highly permeable. The site is not an exception. The bottom lining of the landfill shall then be overdesigned to reduce the risk of leakage.	2
4	Land use (site)	1/5 of the area (≈7 hectares) is covered by the present dumpsite used by the Corozal Free Zone; 8 hectares are covered by sugar cane fields; 5 hectares are covered by former and abandoned sugar cane fields; the remaining part of the site (about the half of the total area) is covered by highly disturbed natural vegetation. The impact generated by the location of the landfill would be less than in the case of the Consejo site and would allow the remediation of the present dumpsite.	4
5	Land Use (adjacent)	The areas in the immediate surroundings of the site, within a 2.5 km distance are covered by natural	5

		disturbed vegetation (around 60%) with the remaining land used for agriculture (sugar cane fields).	
6	Potential risks	No risk of flooding is reasonably foreseeable. The risk of fire is potentially increased by the proximity of the sugar cane fields around the site and especially on the SE side (upwind to main wind direction). The increase of the risk is connected to the customary practice of burning the cane fields before harvesting.	3
7	Distance from settlements	The nearest urban centre is Santa Elena (1.4 km NE) while the nearest houses are 1 km distant (South to the site) along the Northern Highway. The nearest centre beyond the Mexican border is Huay Pix (4.5 km NW) but isolated houses are also present at a minimum distance of 2.8 km NW of the site. While the Belizean centres are closer, the Mexican ones are also to be considered since they are located upwind of the site.	3
8	Distance from roads	The site is only 1 km away from the Northern Highway to which it is connected through an unpaved but adequate access road.	5
9	Distance from airstrips	The site is located 10 km from the Corozal airstrip (to the SE) and 8.2 km SW of the major airport of Chetumal (Mexico). The relevance of the aspect shall be further investigated involving the Mexican aviation authority.	X
10	Infrastructure	No water supply is present, groundwater wells shall be drilled on purpose. The closest power line is located 1 km SE along the Philip Goldson Highway.	4
11	Property and Surface area	The site is private property. Parcels from #99 to #104 should be purchased for a total of approximately 38 hectares.	2
12	Position within the SW basin	The Solid Waste generation in the Northern Corridor is almost equally divided in two main sub-basins centred respectively in the Corozal Town area in the North and in Orange Walk Town to the South. The location of the landfill within the entire basin is consequently indifferent since an increase in the logistic costs related to one of the two sub-basins will correspond to a similar decrease of the costs related to the other sub-basin.	5
13	Other information	The site is presently partially covered by the Corozal Free Zone dumpsite.	

The site is not discarded at this stage. Its final eligibility is nevertheless conditioned by further investigations. Main negative aspects are the distance to a receptor water body for the discharge of the treated leachate, the proximity to the Chetumal airport, which relevance shall be further assessed, and the presence and proximity of numerous inhabited centres.

Main positive aspects are the favourable topography and the proximity to the George Price Highway and power grid.

31.5.1.3 San Pablo Landfill site (rating as per section 5.4)

#	Criteria	Description (mitigation measures and additional infrastructures)	Rating
1	Topography	The area is almost flat. More substantial earthworks are necessary to create the necessary gradients for leachate collection and treatment. The visual impact as well would be accentuated.	2
2	Hydrology	No natural drainage basin is present in the proximity of the site as in most parts of the Corridor. The New River is 6 km SE of the site. Also in this case, the final discharge of the leachate appears to require additional infrastructure. The cost increase has to be necessarily considered.	2
3	Geology	The geology of the entire Northern Corridor is mainly of carbonate nature and highly permeable. The site is not an exception. The bottom lining of the landfill shall then be overdesigned to reduce the risk of leakage.	2
4	Land use (site)	A mix of disturbed vegetation and sugar cane fields characterise the entire area with the prevalence of the latter. A higher cost of the land can be expected.	3
5	Use of soil (adjacent)	The areas in the surrounding of the site within a 2.5 km distance are covered by sugar cane fields (around 60%) and disturbed vegetation for the rest. A more intense agricultural use of the land with respect to the previous sites is here considered as a negative aspect due to economic and social impacts.	3
6	Potential risks	No risk of flooding. The risk of fire is potentially increased by the proximity of the sugar cane fields all around the site. The increase of the risk is connected to the customary practice of burning the cane fields before harvesting.	3
7	Distance from settlements	The area is 1.6 km NE of San Pablo Village, 3.2 km East of Nuevo San Juan, 2.2 km South of Buena Vista	3
8	Distance from roads	The site is only 0.5 km away from the Philip Goldson Highway to which it is connected through an unpaved access road.	5
9	Distance from airstrips	The site is located 10 km from the nearest airstrip (to the NE).	5
10	Infrastructure	No water supply is present, groundwater wells shall be drilled on purpose. The closest power line is located 0.5	5

		km away, along the Philip Goldson Highway.	
11	Property and Surface area	The site is private property and sub-divided in many small parcels with different owners. This aspect is here considered as particularly negative since it is likely to generate more complex procedures and cost increase.	2
12	Position within the SW basin	The Solid Waste generation in the Northern Corridor is almost equally divided in two main sub-basins centred respectively in the Corozal Town area to the North and in Orange Walk Town to the South. The location of the landfill within the entire basin is consequently indifferent, since an increase in the logistic costs related to one of the two sub-basins will correspond to a similar decrease of the costs related to the other sub-basin.	5
13	Other information		

The site is discarded due to the sum of many and relevant negative aspects such as:

- the fragmentation of the property,
- the proximity to inhabited centres,
- the high concentration of agricultural activities in the surroundings,
- the unfavourable topography,
- the lack of receptors for the discharge of the treated leachate.

31.5.1.4 Orange Walk North Landfill site (rating as per section 5.4)

#	**Criteria**	**Description (mitigation measures and additional infrastructures)**	**Rating**
1	Topography	The area is almost flat. More substantial earthworks are necessary to create the necessary gradients for the leachate collection and treatment.	2
2	Hydrology	No natural drainage basin is present in the proximity of the site as in the most part of the Corridor. Also in this case, the final discharge of the leachate appears to require additional infrastructure. The cost increase has to be necessarily considered.	2
3	Geology	The geology of the entire Northern Corridor is mainly of carbonate nature and highly permeable. The site is not an exception. The bottom lining of the landfill shall then be overdesigned to reduce the risk of leakage.	2
4	Land Use (site)	A mix of disturbed vegetation and sugar cane fields characterise the entire area with the prevalence of the former.	4
5	Land Use (adjacent)	The areas in the surrounding of the site within a 2.5 km distance are covered by sugar cane fields (around 50%)	4

		and disturbed vegetation for the rest. A less intense agricultural use of the land with respect to the previous sites is here considered as a positive aspect due to lower economic and social impacts.	
6	Potential risks	No risk of flooding. The risk of fire is potentially increased by the proximity of the sugar cane fields around the site. The increase of the risk is connected to the common practice of burning the cane fields before harvesting.	3
7	Distance from settlements	The area is 2 km N of Orange Walk Town, 7 km south of San Pablo, 6 km east of San Estevan. The closest receptor is a Recycling facility 500 m east, isolated houses are present to the NE and SE at a distance between 1 and 2 km.	4
8	Distance from roads	The site is only 1 km away from the Philip Goldson Highway to which it is connected through an unpaved access road to be adapted.	5
9	Distance from airstrips	The site is located 9 km from the nearest airstrip (to the South).	5
10	Infrastructure	No water supply is present, groundwater wells shall be drilled on purpose. The closest power line is located 1 km away along the Northern Highway.	5
11	Property and Surface area	The site is private property and sub-divided in medium size parcels with different owners. This aspect is here considered as negative since it is likely to generate more complex procedures and cost increase.	3
12	Position within the SW basin	The Solid Waste generation in the Northern Corridor is almost equally divided in two main sub-basins centred respectively in the Corozal Town area in the North and in Orange Walk Town in the South. The location of the landfill within the entire basin is consequently indifferent since an increase in the logistic costs related to one of the two sub-basins will correspond to a similar decrease of the costs related to the other sub-basin.	5
13	Other information	Reportedly the area was previously investigated for the location of an alternative local landfill. The project was abandoned due to its proximity to Orange Walk Town that is expected to expand toward the area in future.	

The site is discarded due to its proximity to Orange Walk Town. The North of this area can be nevertheless further investigated in case other sites should result ineligible after further analysis.

31.5.1.5 San Estevan Landfill site

#	Criteria	Description (mitigation measures and additional infrastructures)	Rating
1	Topography	The site is generally flat only slightly sloping toward the low lying area to the East. Due to the large extension of the area, more detailed investigations can offer a better assessment of the aspect and identify the more suitable portion.	3
2	Hydrology	There is no natural drainage basin. The high permeability of the soil in the area does not favour the establishment of a natural drainage system. This factor is highly limiting with regard to the final discharge of treated leachate. The design and operation of the landfill and, mainly, the design of the leachate treatment system shall then require the consideration of other viable alternatives (e.g. evaporation ponds, equalisation basins, etc.). The cost increase and the need of additional available areas have to be necessarily considered.	2
3	Geology	The geology of the entire Northern Corridor is mainly of carbonate nature and highly permeable. The site is not an exception. The bottom lining of the landfill shall then be overdesigned to reduce the risk of leakage.	2
4	Land Use (site)	The area is covered by broad leaf forest and is located at the border of a wider forested corridor. If, on the one hand, this aspect implies the marginal damaging of such natural system, on the other hand it offers a natural buffer area limiting visual and noise impacts. The natural mitigation of such impacts offered by the site counterbalances the measures to be taken for the removal of natural vegetation.	3
5	Land Use (adjacent)	The areas in the immediate surrounding of the forested area, within a 2.5 km distance, are to a large extent, covered by sugar cane fields. A significant portion is nevertheless covered by forests and natural vegetation systems.	5
6	Potential risks	No risk of flooding is reasonably foreseeable. The risk of fire is potentially increased by the proximity of the sugar cane fields all around the site. The increase of the risk is connected to the customary practice of burning the cane fields before harvesting.	3
7	Distance from settlements	The site is located 3 km South of San Estevan and 4.5 km NE of Orange Walk. A Junior College is located 3.5 km South of the site. One isolated house is located 1.5 km	4

		West of the site.	
8	Distance from roads	The site is approximately 900 m away from the San Estevan Road. No access road is present.	4
9	Distance from airstrips	No airstrips are present within a distance of 10 km of the site.	5
10	Infrastructure	No water supply is present, groundwater wells shall be drilled on purpose. The closest power line is located 1 km West along the San Estevan Road.	3
11	Property and Surface	The site is National Land.	5
12	Position within the SW basin	The Solid Waste generation in the Northern Corridor is almost equally divided in two main sub-basins centred respectively in the Corozal Town area to the North and in Orange Walk Town to the South. The location of the landfill within the entire basin is consequently indifferent, since an increase in the logistic costs related to one of the two sub-basins will correspond to a similar decrease of the costs related to the other sub-basin.	5
13	Other information	-	

The site is not discarded at this stage. Its final eligibility is nevertheless conditioned by further investigations. Main negative aspects are the absence of a receptor water body for the discharge of the treated leachate and the topography not particularly favourable (to be further investigated).

Main positive aspects:

- the proximity to the San Estevan Road and power grid,
- the fact that the site is National Land,
- the absence of airstrips within a distance of 10 km,
- the distance from nearby inhabited areas
- the distance from the coast (more than 40 km).

31.6 Southern Corridor

The main features of the southern region with regard to the location of a landfill site can be summarized as follows:

- Geology: presence of more suitable soils in comparison to the northern corridor. Clayey impervious layers are present in significant portions of the corridor.
- Flood susceptibility: the areas on the western side of the southern highway appear to offer very limited possibilities for the location of a landfill due to the wide presence of flood prone areas and wetlands.
- Land use: the flat areas encompassed by the highway on the west and the foothills on the east are generally covered by plantations (banana, orange). Most of the urban settlements lie along the Highway and along the coast. While the touristic facilities are increasingly spreading mainly along the coast, where several touristic sub-divisions are

planned or under construction, also the internal parts of the region are of touristic interest for tours and leisure activities.

- Protected areas: around 50% of the entire southern corridor is covered by protected areas that mainly lie on the western mountainous portion of the region.
- Hydrogeology: the areas between the foothills of the Maya Mountains and approximately, the highway are identified by some studies as the recharging area of the main regional aquifer[26] and therefore, unsuitable for the location of a landfill.
- Climate: the average annual rainfall rapidly increases from north to south (from around 2000 mm in the Stann Creek District to more than 4000 mm in the Toledo District).
- Hydrology: a well-developed hydrology pattern characterizes the southern corridor.

In comparison to the Northern Corridor, the Southern Corridor therefore appears to offer, from a technical point of view, more opportunities for the location of a landfill.
Such opportunities are nevertheless severely limited by social, economic and environmental factors. Only a narrow strip of land along the foothills in fact remains as potentially available, limited by the protected areas on the east and the recharging area of the aquifer covered by plantations on the west.
Ideally, the location of the regional landfill should also overcome the following constraints:

- Be located between Dangriga and Independence to intercept most of the waste generation areas (present and planned) in order to minimise transportation costs.
- Be located along the highway, not too far from it, to minimise the investment costs (access road construction). This limits the search to areas where the highway is nearer to the foothills.
- Be located as far north as possible to take advantage of lower precipitation (less leachate production, less road and general maintenance, lower risk of accidents related to bad or extreme weather conditions).

The above described constraints have so far limited the number of suitable sites identified to only one. Further investigations are ongoing.

31.6.1.1 Santa Cruz Landfill site

#	Criteria	Description (mitigation measures and additional infrastructures)	Rating
1	Topography	The site lies on a low lying hill crest and slopes on each side, prevalently merging toward west. The topography is gently sloping. On the one hand, a more careful design is needed to limit the earthworks, on the other hand, this characteristic offers good conditions for the design of the stormwater drainage system and the leachate treatment system.	5
2	Hydrology	A natural permanent creek (Silver Creek) is adjacent to	5

[26] Assessment of Groundwater Resources in the Southern Coastal Water Province of Belize. Referred to as Savannah Groundwater Province – GEOMEDIA Ltd, September 2014

		the site on its southern boundary.	
3	Geology	The site lies on the Santa Rosa Group area characterized by metamorphic rocks and also including argillite. This latter impervious lithology seems to be prevalent on the site.	5
4	Land Use (site)	The area is a former quarry surrounded by primary growth forest and shrubs. Most of the area is cleared and degraded due to the quarry activities.	5
5	Land Use (adjacent)	The areas in the immediate surroundings of the site are covered by natural vegetation (mainly on the east and south sides). The areas on the west side, beyond a natural vegetation screen (500 m wide on average) are mainly covered by orange plantations.	5
6	Potential risks	No risk of flooding is reasonably foreseeable. Since the recharging area of the regional aquifer is downstream of the site, the risk of groundwater contamination connected to potential failure of the leachate treatment system shall be considered within the disaster management plan.	4
7	Distance from settlements	The location of the site appears to be favourable with regard to the distance from human settlements. The nearest centre is the Santa Cruz Village, located some 2.5 km eastward (upwind). No other settlements or isolated households have been noticed in the surroundings.	5
8	Distance from roads	The site is served by an unpaved 2.2 km long access road since it was used as a quarry. The road shall nevertheless be upgraded.	4
9	Distance from airstrips	The site is located 10 km from the Placencia airstrip (to the SE), under construction and more than 20 km from existent airstrips in the south (Placencia, Independence).	5
10	Infrastructure	No water supply is present, groundwater wells shall be drilled on purpose. The closest power line is located 2.5 km South along the highway.	3
11	Property and Surface area	The site is private property. The parcel of interest (about 20 hectares) is the property of one, Shadine J. Zabaneh. Two adjacent parcels can be of partial interest as well in case of future expansion.	4
12	Position within the SW basin	The position within the Solid Waste generation basin is favourable and close to the waste generation centroid of the southern corridor.	5
13	Other information		

The site appears to be optimal in the first instance under almost all the considered aspects.

31.6.1.2 San Juan Landfill site

The site, previously investigated, was later discarded since it lies on top of what some studies report to be the recharging area of the regional aquifer. Such circumstance will in fact determine a rating of 1 (unsuitable) for the site.

31.6.1.3 Hopkins Landfill site

The site, previously investigated due to its reported availability, was found non optimal under many different points of view. It has been then later discarded since it lies on top of what some studies report to be the recharging area of the regional aquifer. Such circumstance will in fact determine a rating of 1 (unsuitable) for the site.

31.7 Landfill siting conclusion and recommendations

31.7.1 Northern Corridor

The whole region is not geologically favourable for the location of a regional landfill due to the presence of soils of carbonate composition and karst activity. Besides *"the northern coast of Belize is exposed to more frequent and more intense storms than the southern part. For example, tropical storm events are expected to occur in Punta Gorda on average every 6 years, while in Ambergris Cay they typically occur twice as often, every 3 years"* (Caribbean Disaster Mitigation Project (CDMP), OAS, 1995).

Notwithstanding the geological constraints, both the Consejo and the San Estevan sites can be considered as the primary locations of the landfill.
The San Estevan site appears to be to some extent preferable for the following main reasons:

- National Land: no additional costs for land acquisition
- Possibility to create a wide, already forested, buffer zone
- Proximity to a main road and power grid
- Greater distance from the coast (lower likelihood of it being hit by tropical storms)

The Free Zone site can also be still considered as a possible alternative in case the other two sites are discarded.

31.7.2 Southern Corridor

Among the Southern Corridor suitable soils for the siting of a landfill can only be found in a narrow belt at the foothills of the Maya Mountains.
The plain coastal areas, in fact, are for the most part subject to possible flooding. Besides, this same areas are of ecological (wetlands) and touristic interest.
Moving toward west the extensive recharging area of the regional (Savannah) aquifer with permeable soils advices against the location of potentially water polluting activities. Such area is also the most densely covered by villages.

The Santa Cruz site only has then been judged as eligible between those investigated so far. It appears to be favourable based on the site screening criteria. It has nevertheless to be noticed that, while the soil underlying the site appears to be adequate, the site itself is located immediately upstream to the reported recharging area of the Savannah aquifer.

31.8 Assessment of the main potential environmental impacts of landfills

The methodology adopted for the identification and evaluation of the potential environmental impacts is explained in sections 23 and 24

In the present section, evaluations are carried out in order to assess and compare the environmental impacts due to the construction and operation of a semi-aerobic landfill in the different locations that have emerged from the site screening process and listed below:

- Northern Corridor: Consejo and San Estevan;
- Southern Corridor: Santa Cruz.

This EA is referred to a preliminary level of SWM system planning and the evaluation hereafter presented are not made on the basis of data collected by specific field survey, but on the basis of data available in literature or gathered from similar plans.

In Table 116 the possible impacts due to a semi-aerobic landfill are listed.

Table 116 – Landfill impacts identification

Landfill	**Landscape and natural scenery**
All the phases	Alteration of the landscape
Landfill	**Archaeological, cultural and historical resources**
All phases	Damage to the site
Landfill	**Air quality and climate**
All the phases	Emissions and diffusion of air pollutants and greenhouse gases
	Increasing of noise levels in the area surrounding the landfill
Operation	Emissions and diffusion of odour from the waste handling operations and from the leachate treatment
Landfill	**Soils**
All the phases	Accidental spillage or leakage of fuel from vehicles/storage tank may cause soil contamination
Operation, Closure, After care	Accidental leakage of leachate can seep through the soil and ground water contaminating soil
Landfill	**Ground and surface water quality**
All the phases	Accidental spillage or leakage of fuel from vehicles/storage tank may cause surface water contamination
Operation, Closure, After-care	Accidental leakage of leachate can seep through the soil and ground water contaminating soil and waters (Ground and Surface)
	Accidental failure of the leachate treatment system can affect the surface water quality

Landfill	Flora and fauna
All the phases	potential indirect impacts related to the deterioration of the quality of air, of soil or of ground and surface water

In the present section, an assessment of the possible environmental impacts listed in Table 116 is conducted following the methodology described above.
The evaluation is carried out per each proposed site for the landfill location.

31.8.1 Consejo

31.8.1.1 Landscape and natural scenery

31.8.1.1.1 Alteration of the landscape.

With the aim of rating the intensity of this impact, the following aspects have to be considered:

- the general layout of the semi-aerobic landfill, as proposed by the Master Plan, foresees a significant plant extension, including all the ponds necessary for leachate and stormwater treatment and all the facilities (administrative buildings, scale house, …) and a maximum height of the final landfill of about 20 m;
- the morphology of the site is flat and the site remains visible from a distance and from almost any angle of view, though, as shown in Figure 50, the main human settlements and roads are at a considerable distance from the site (see Table 117).

Figure 50 - Receptors

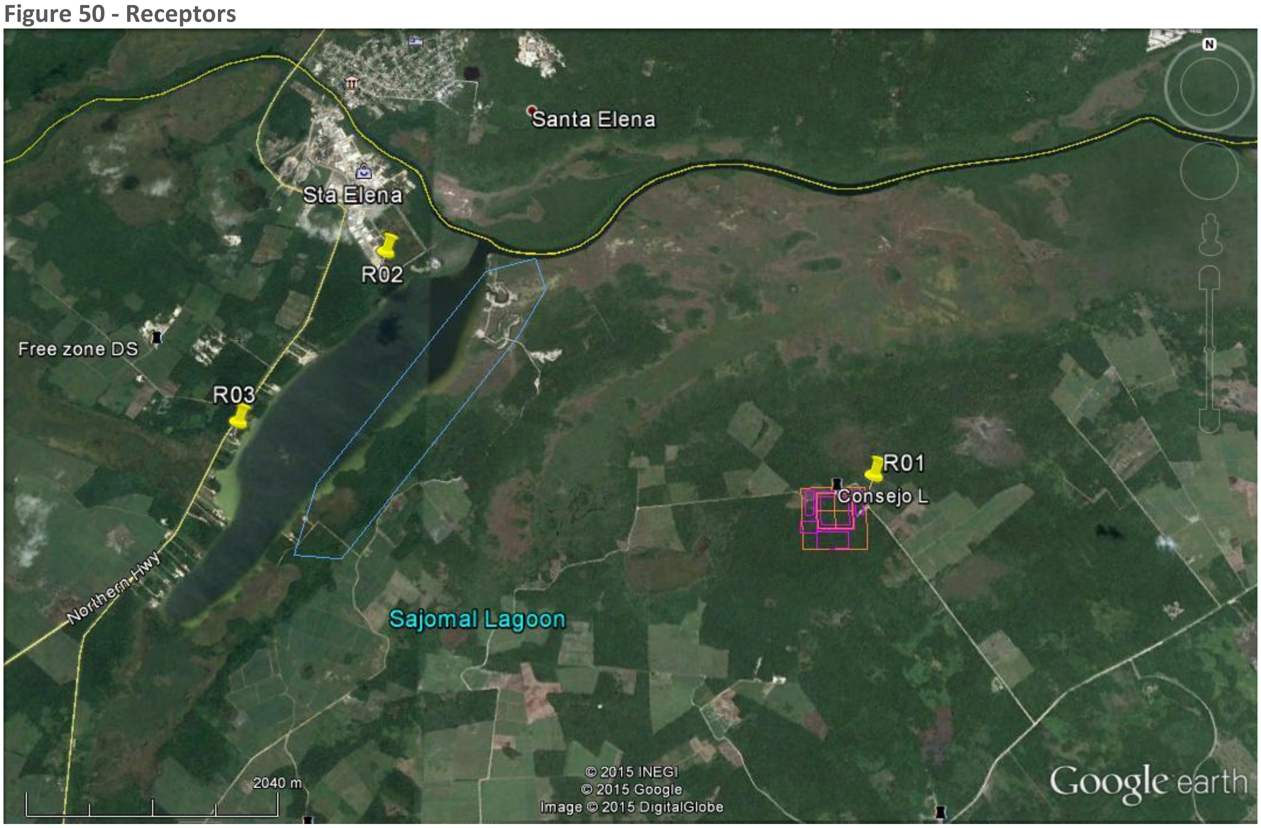


Table 117 – Receptors

Receptor	UTM 16 coordinates	Distance (m)	Description
R01	357236(x); 2041582 (y)	140	outlying house (residential/rural)
R02	353008(x); 2043608 (y)	4,300	Santa Elena
R03	351787(x); 2042088 (y)	5,000	outlying group of houses (residential/rural)

Therefore the intensity of this impact can be assessed as “severe” and the duration of the impact is “long-term”. The spatial extension of this impact is “far-range”, because the alteration of the landscape is noticeable from a distance of beyond 1,000 m. The probability of the impact is definite.

Therefore the potential impact *Alteration of the landscape* has a high priority.

31.8.1.2 Archaeological, cultural and historical resources

31.8.1.2.1 Damage to the site

The proposed site is at an adequate distance from known archaeological and historical sites. If during the construction works (excavation works mainly) any archaeological finds are made, the works would be immediately stopped and, according to the directives provided by the competent authority, the finds would be properly managed.
Taking into account the high historical and cultural value of finds and considering the significant amount of bulk material handled during excavation, the intensity of this impact can be rated as “severe”. The timely interruption of the works makes the duration of the impact “short-term” and the spatial extent “localized”. The probability of the impact can be assessed as “possible”.

Therefore the potential impact *Damage to the site* has a medium priority.

31.8.1.3 Air quality and climate

In order to assess the priority of this impact, in the present paragraph the emissions of air pollutants are assessed and site specific simulations of their diffusion are conducted.
The simulation of the diffusion of all these pollutants in air, enables the evaluation of the concentration of these substances at the identified receptors and to compare it with the threshold value permitted by the Laws of Belize.

31.8.1.3.1 Emissions and diffusion of air pollutants

Considering the life-cycle of a landfill, it can be assumed that the main work done in this plant is bulk material (soil or waste) handled by earthmoving machines. Therefore, at this preliminary analysis level, the pollutants taken into account are PM_{10}, NOx and CO, characteristic of the work vehicles and bulk material emissions.

The phases of the life-cycle of the landfill, characterized by the most relevant air pollutants emitted, are construction and operations. Therefore, the estimation of the emission and diffusion of contaminants are assessed in these two critical phases, particularly, during the final filling of the operational phase of the landfill, where the annual amount of waste treated is maximum. This includes waste handling, daily capping and spreading.

The diffusion of pollutants in air is simulated using the CALPUFF Modelling System. The CALPUFF Modelling System includes three main components: CALMET, CALPUFF and CALPOST and a large set of pre-processing programs designed to interface the model to standard, routinely-available meteorological and geophysical datasets. In the simplest terms, CALMET is a meteorological model that develops hourly wind and temperature fields on a three-dimensional gridded modelling domain. Associated two-dimensional fields such as mixing height, surface characteristics and dispersion properties are also included in the file produced by CALMET. CALPUFF is a transport and dispersion model that advects “puff” of material emitted from modelled sources, simulating dispersion and transformation process along the way. In doing so, it typically uses the field generated by CALMET. Temporal and spatial variations in the meteorological fields selected are explicitly incorporated in the resulting distribution of puffs throughout a simulation period. The primary output files from CALPUFF contain either hourly concentrations or hourly deposition fluxes evaluated at selected receptors location. CALPOST is used to process these files, producing tabulations that summarize the results of the simulation. When performing visibility-related modelling, CALPOST uses concentrations from CALPUFF to compute extinction coefficients and related measures of visibility, reporting these for selected averaging times and locations.

Site specific meteorological data are used for this assessment. The data are processed by the MM5 (Mesoscale Model Five of Pennsylvania State University). The PSU/NCAR mesoscale model (known as MM5) is a limited-area, non-hydrostatic, terrain-following sigma-coordinate model designed to simulate or predict mesoscale atmospheric circulation. The model is supported by several pre- and post-processing programs, which are referred to collectively as the MM5 modelling system.

These data were used for the reconstruction of the 3D fields by CALMET processor.
The sources characterisation is made for phases of construction and operation of the landfill and is suitable for all the sites. However, the diffusion of pollutants is modelled at each site, so taking into account the specific topographical and meteorological conditions.

Sources characterisation
Assumption for the estimations:
The construction of the landfill shall be made cell by cell, as shown in Drawings A.06 and A.07, so in this section the construction of the first cell, including the related leachate treatment lagoons and stormwater sedimentation pond are considered.
The emissions include those from vehicles and the particulate matter from excavation and embankment construction and are estimated using the methods reported in the notes.

Table 118 – Assumptions for the estimations

	Construction	Operation
Handled material volume (m^3) clay and soil	91,379	45.2 (daily capping)
Annual working days	310	
Emission factor PM_{10} (kg/Mg) [27]	0.015	
Daily PM_{10} emissions (g/s)	0.049	0.013
Work vehicles number - construction	6	4
Daily work time (h)	8	
Emission factor PM_{10} (g/kg vehicle)[28]	1.71	
Daily PM_{10} emissions (g/s)	0.223	0.149
Emission factor NO_x (g/kg vehicle)[29]	11.73	
Daily NO_x emissions (g/s)	1.530	1.021
Emission factor CO (g/kg vehicle)[30]	9.18	
Daily CO emissions (g/s)	1.200	0.800

All the evaluations are referred to the condition characterized by the most relevant air pollutants emitted, considering the maximum number of work vehicles working at the same time for 8 hours/day.

In the modelling process, the sources are considered as area sources isolated from diffuse dust emissions, with a constant emission factor and the emissive flux is evaluated taking into account a scheduling of 10 hours, as the daily work time.

Receptors

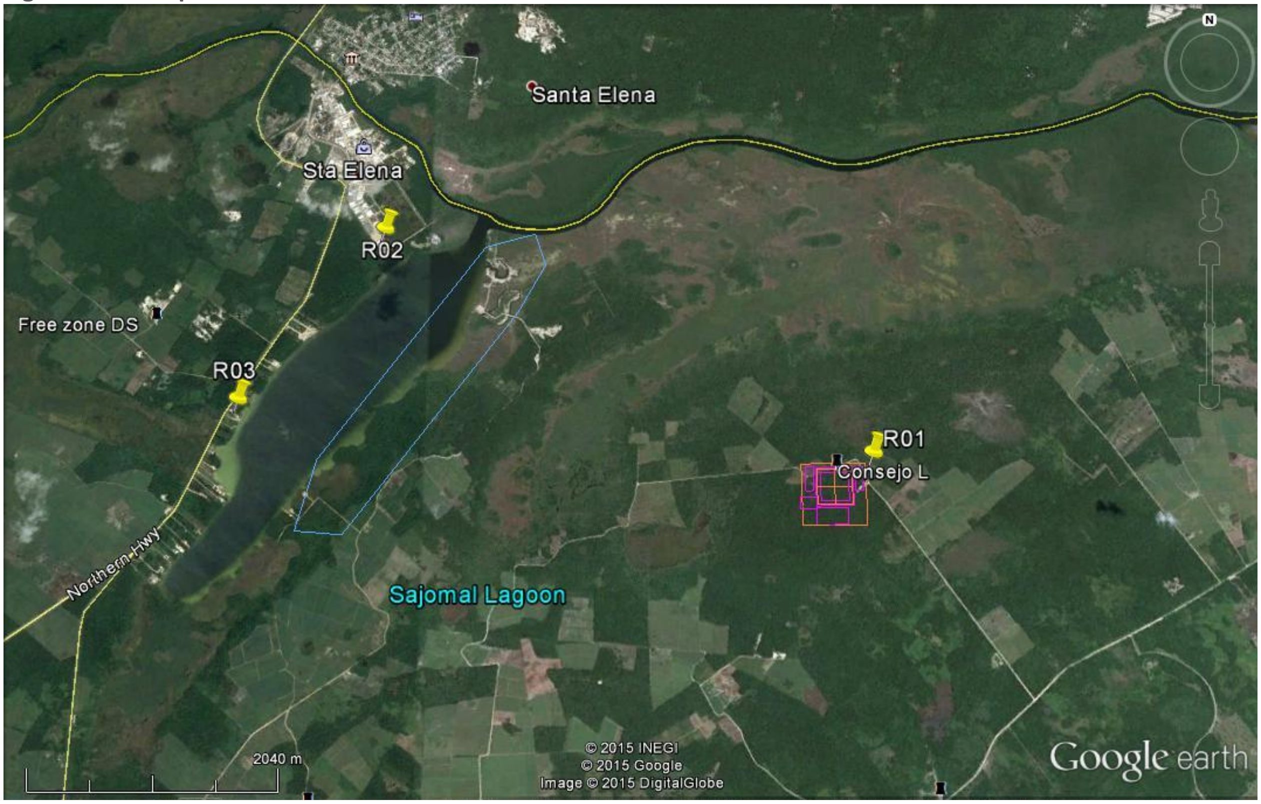
The list of the receptors considered is shown in Table 119 and a general plan in Figure 51.

Table 119 – Receptors

Receptor	UTM 16 coordinates	Distance (m)	Description
R01	357236(x); 2041582 (y)	140	outlying house (residential/rural)
R02	353008(x); 2043608 (y)	4,300	Santa Elena
R03	351787(x); 2042088 (y)	5,000	outlying group of houses (residential/rural)

[27] This value is calculated following the guidelines provided by AP42, chapter 13.2.4 (EPA)
[28] This value is calculated following the guidelines provided by Emission inventory guideline (CORINAIR)
[29] This value is calculated following the guidelines provided by Emission inventory guideline (CORINAIR)
[30] This value is calculated following the guidelines provided by Emission inventory guideline (CORINAIR)

Figure 51 - Receptors



Construction phase

In the following table the main source characteristics used in the diffusion modelling are listed:

Table 120 – Source characteristics

geographical coordinates (UTM 16) (m)	356656 (x); 2041607 (y) 357203 (x); 2041609 (y) 357203 (x); 2041088 (y) 356655 (x); 2041088 (y)
source surface (sqm)	285,505
height of point of emission (m)	1

Modelling results

Table 121 – Modelling results

Receptor	Estimated PM_{10} conc (µg/cm)	PM_{10} Concentration limit[31] (µg/cm),	Estimated NOx conc (µg/cm)	NOx Concentration limit[32] (µg/cm)	Estimated CO conc (µg/cm)	CO Concentration limit[33] (µg/cm)
R01	6.74	200	0.71	80	0.59	2,000
R02	0.37		0.09		0.09	
R03	0.14		0.06		0.06	

The results of the modelling are compared to the Concentrations of Permitted Air Contaminant as per the "Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, Chapter 238 Pollution Regulation", Regulation 6, First Schedule, as shown in

Table 121. **All the evaluated concentrations, PM_{10} , NO_x and CO are below the allowed specific limits.**

The spatial distributions of the diffusion of the pollutants are shown in Figure 52, Figure 53 and Figure 54.

[31] As per "Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, Chapter 238 Pollution Regulation", Regulation 6, First Schedule

[32] As per "Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, Chapter 238 Pollution Regulation", Regulation 6, First Schedule

[33] As per "Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, Chapter 238 Pollution Regulation", Regulation 6, First Schedule

Figure 52 – Spatial distribution of PM_{10} diffusion (µg/cm)

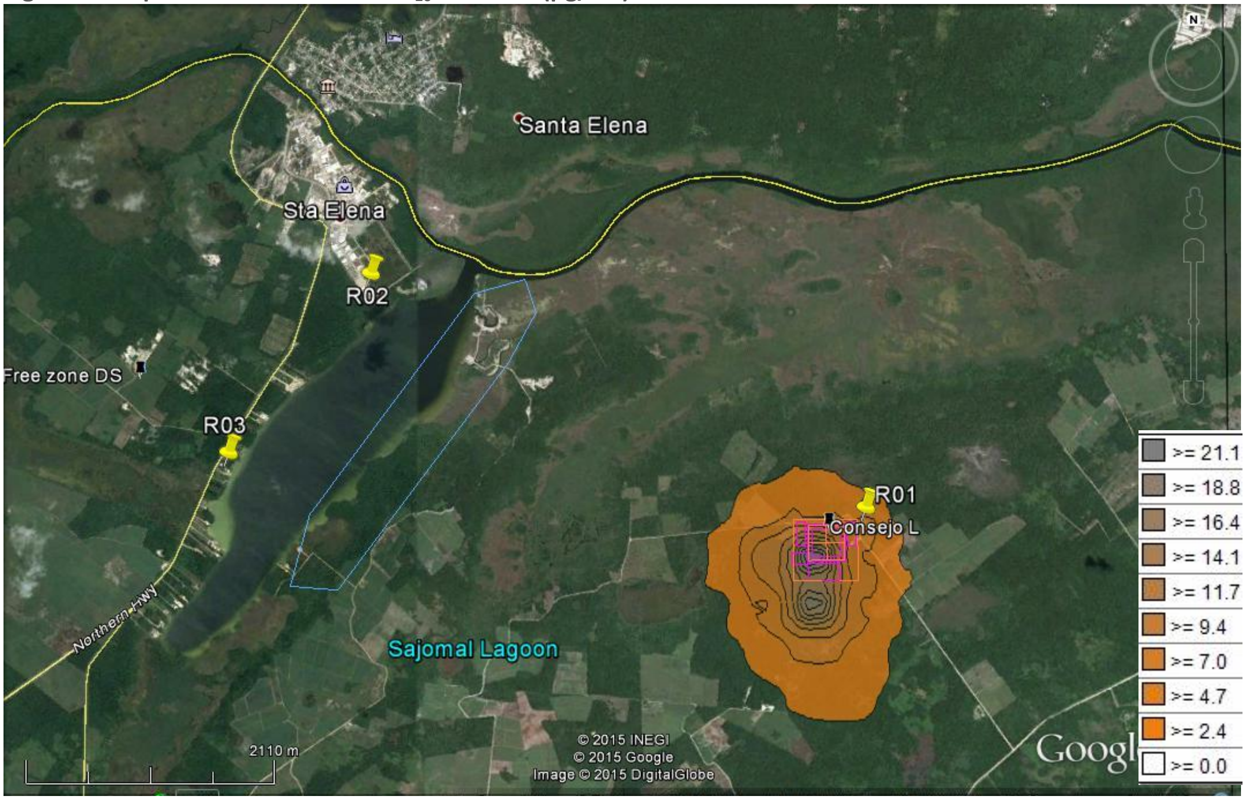


Figure 53 – Spatial distribution of NOx diffusion (µg/cm)

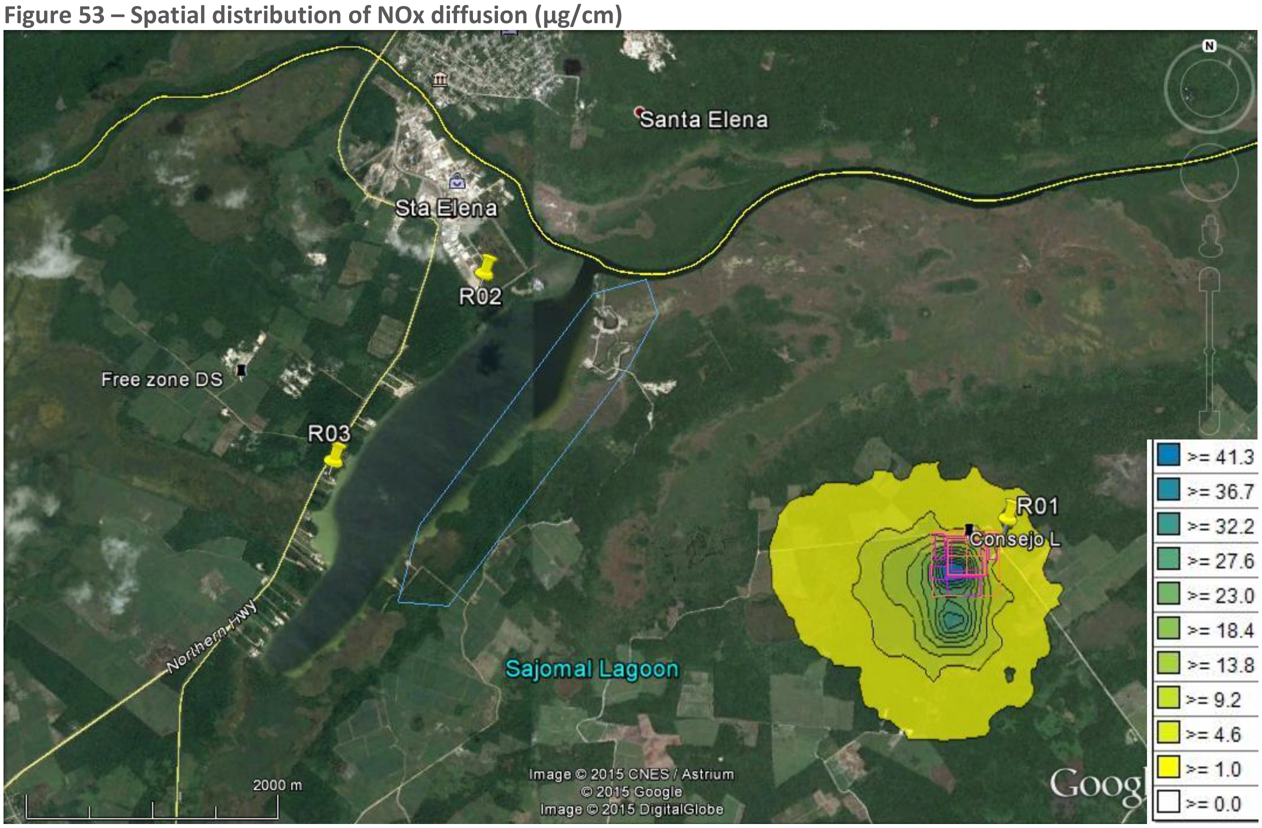
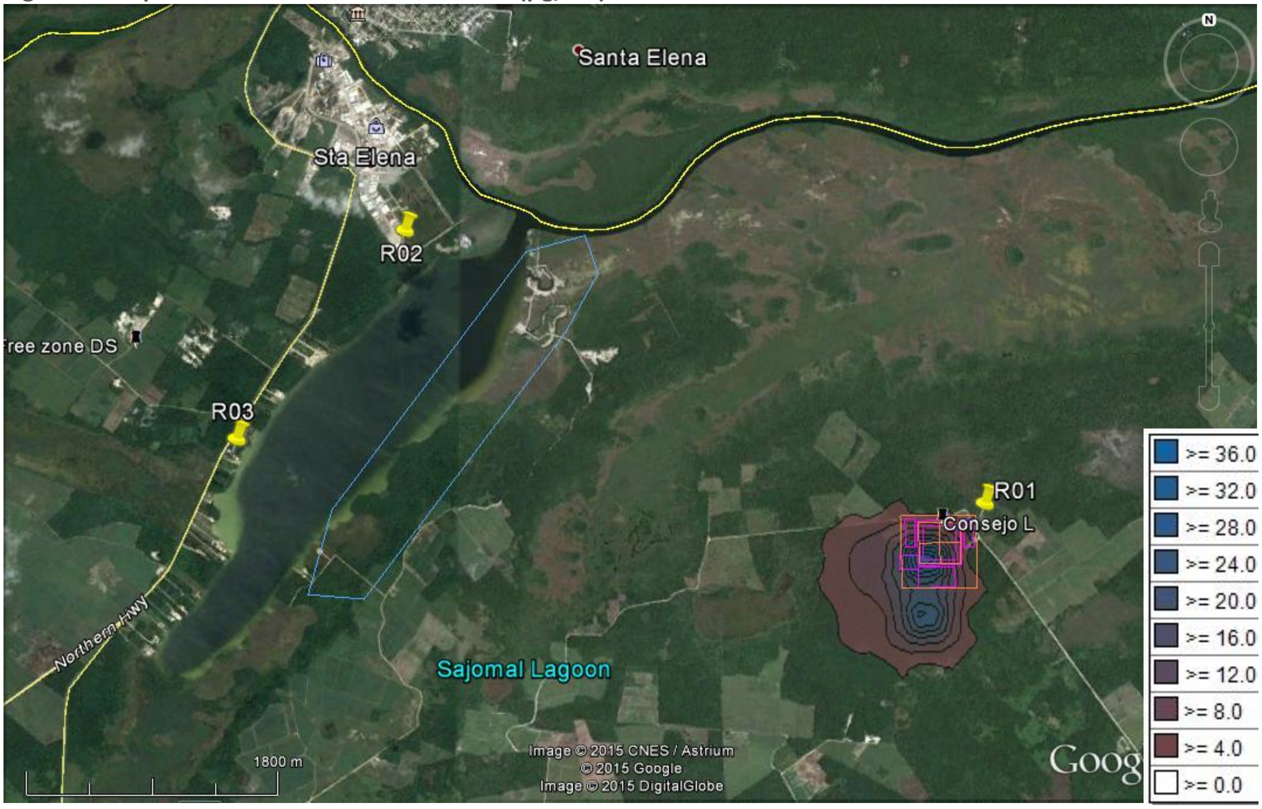


Figure 54 – Spatial distribution of CO diffusion (µg/cm)



<u>Operation phase</u>

In the following table the main source characteristics used in the diffusion modelling are listed:

Table 122 – Source characteristics

geographical coordinates (UTM 16) (m)	356786 (x); 2041559(y) 356937 (x); 2041563 (y) 356936 (x); 2041410 (y) 356786 (x); 2041411 (y)
source surface (sqm)	22,500
height of point of emission (m)	9

<u>Modelling results</u>

Table 123 – Modelling results

<u>Receptor</u>	<u>Estimated PM_{10} conc (µg/cm)</u>	<u>PM_{10} Concentration limit[34], (µg/cm),</u>	<u>Estimated NOx conc (µg/cm)</u>	<u>NOx Concentration limit[35] (µg/cm)</u>	<u>Estimated CO conc (µg/cm)</u>	<u>CO Concentration limit[36] (µg/cm)</u>

[34] As per "Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, Chapter 238 Pollution Regulation", Regulation 6, First Schedule

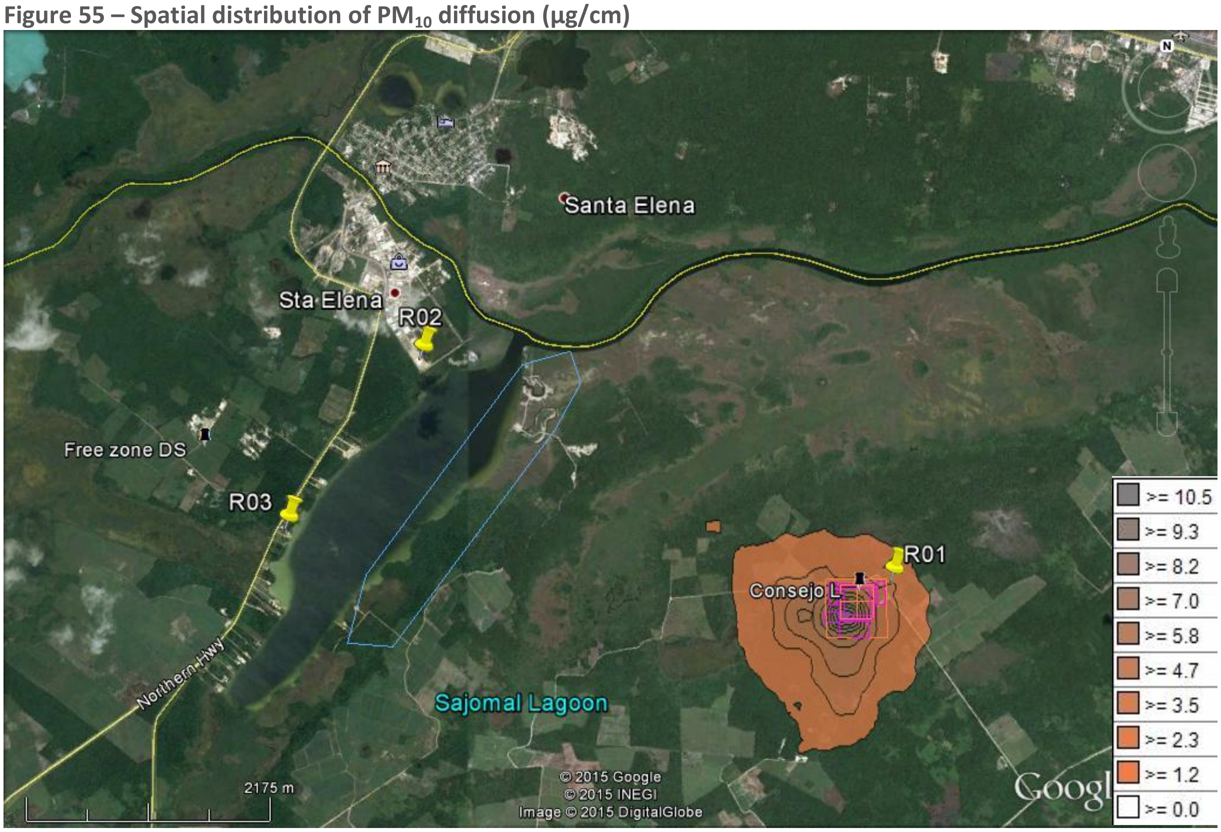
[35] As per "Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, Chapter 238 Pollution Regulation", Regulation 6, First Schedule

R01	2.57	200	0.20	80	0.16	2,000
R02	0.13		0.04		0.03	
R03	0.04		0.03		0.02	

The results of the modelling are compared to the Concentrations of Permitted Air Contaminant as per the “Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, Chapter 238 Pollution Regulation”, Regulation 6, First Schedule, as shown in Table 123. **All the evaluated concentrations, PM_{10}, NO_x and CO are below the allowed specific limits.**

The spatial distributions of the diffusion of pollutants are shown in Figure 55, Figure 56 and Figure 57 – Spatial distribution of CO diffusion (µg/cm).

Figure 55 – Spatial distribution of PM_{10} diffusion (µg/cm)



[36] As per “Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, Chapter 238 Pollution Regulation”, Regulation 6, First Schedule

Figure 56 – Spatial distribution of NOx diffusion (µg/cm)

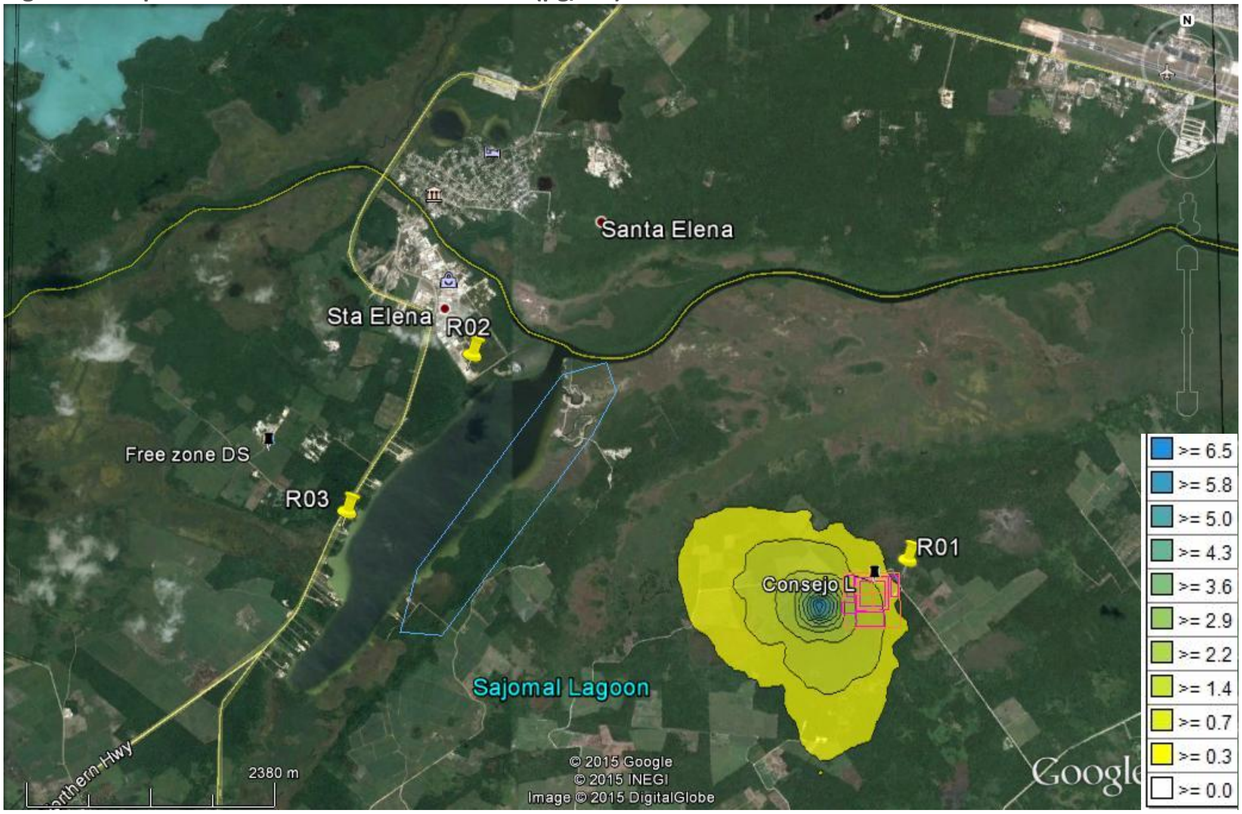
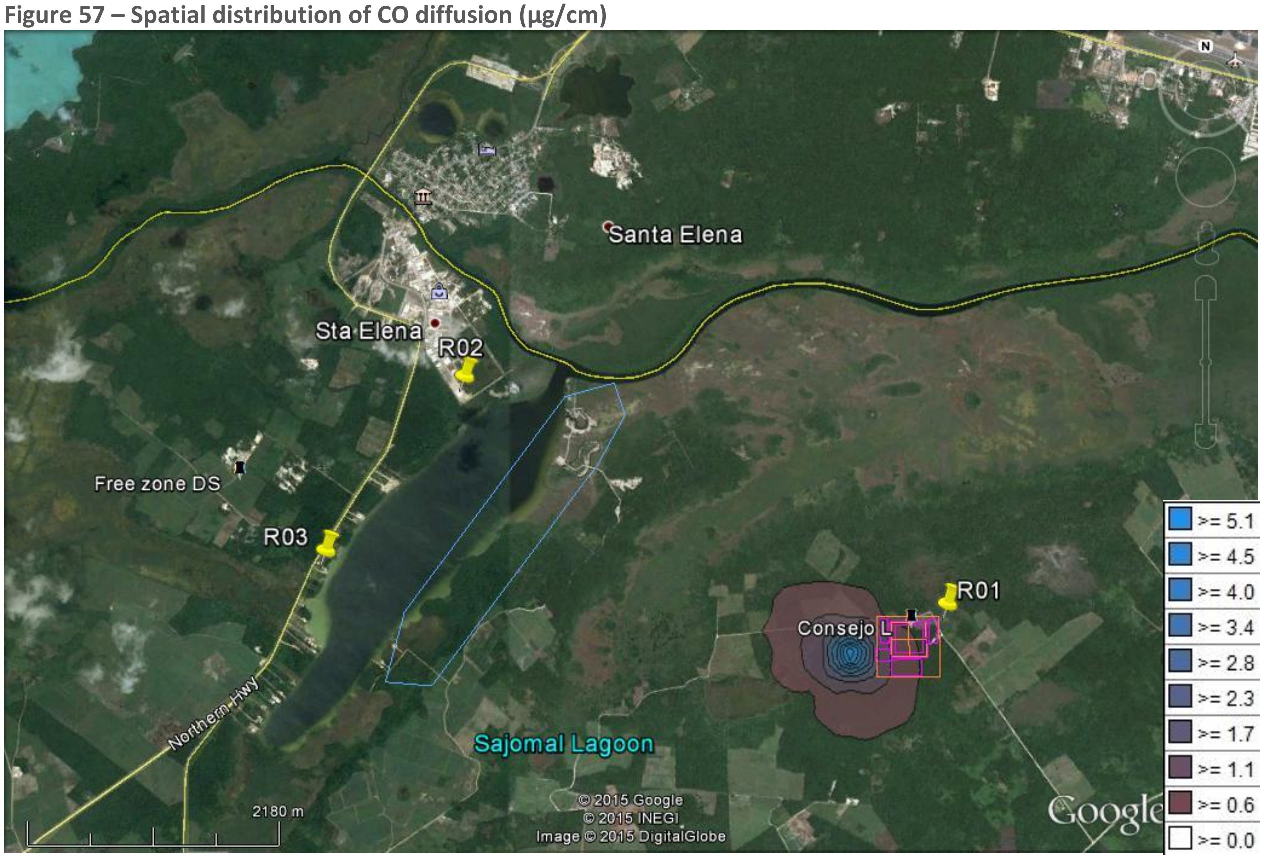


Figure 57 – Spatial distribution of CO diffusion (µg/cm)



31.8.1.3.1.1 *Diffusion of methane*

A further evaluation is carried out with the aim of evaluating the diffusion of methane, because it is the pollutant that most characterizes the emissions from waste decomposition.
A modelling of CH_4 diffusion in air is made hereafter at each proposed site, considering one of the final filling phases of the landfill, when the annual amount of waste treated as well as the amount of CH_4 produced is at a maximum.
In the modelling process, the source is considered as area source isolated from diffuse dust emissions, with a constant emission factor in the overall duration of the day.

In the following table the main source characteristics used in the diffusion modelling are listed:

Table 124 – Source characteristics

geographical coordinates (UTM 16) (m)	356815 (x); 2041532 (y) 357057 (x); 2041530 (y) 357056 (x); 2041290 (y) 356814 (x); 2041290 (y)
source surface (m^2)	57,600
height of point of emission (m)	9
emission factor (g/s)	91.17

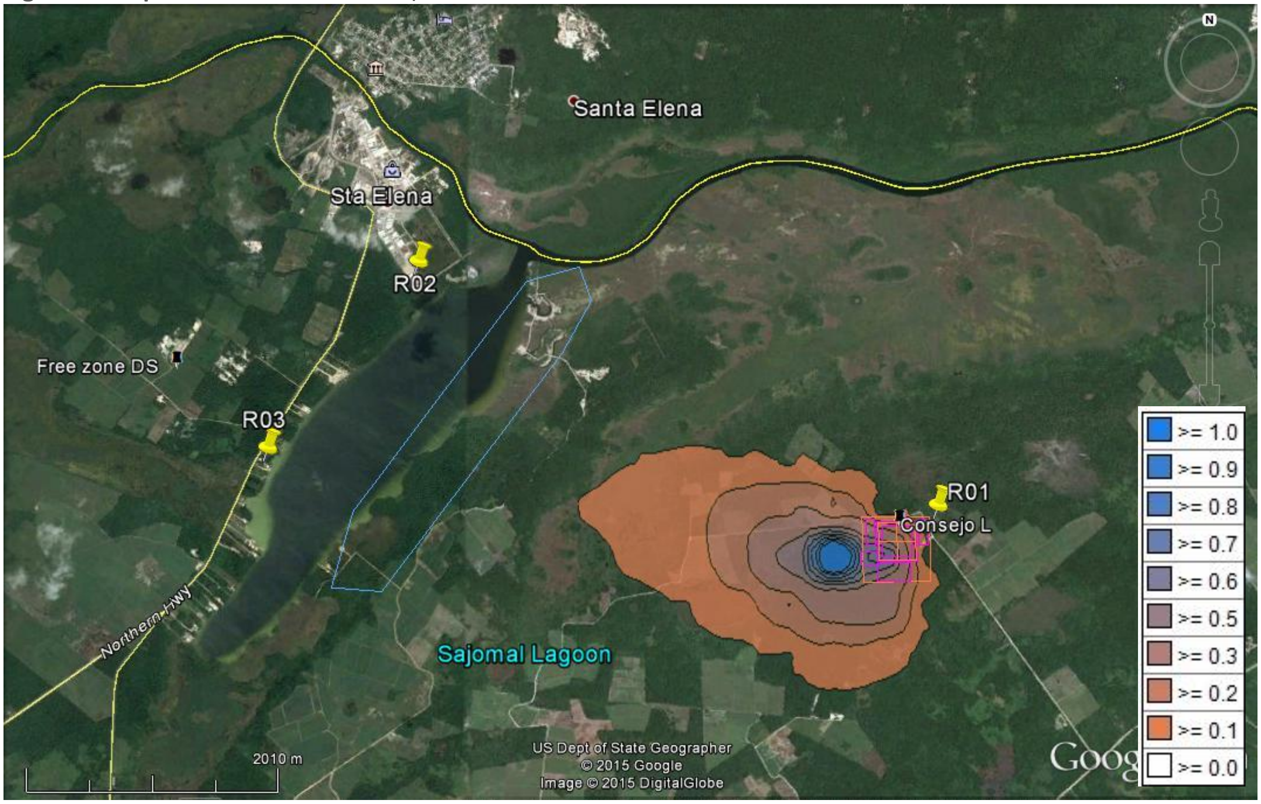
The receptors considered are showed in the previous paragraph, in the following table the modelling results are shown.

Table 125 – Modelling results

Receptor	Estimated CH4 concentration (mg/m^3)
R01	0.024
R02	0.023
R03	0.026

The spatial distributions of the diffusion of pollutants are shown in Figure 58.

Figure 58 – Spatial distribution of CH_4 diffusion



31.8.1.3.2 Emission of odour nuisance

Among the human activities that may generate problems related to unpleasant odour emissions, landfills represent one of the major causes of complaints.

The first step of this impact rating is the estimation of the emission of nuisance odour from the landfill during the operation phase, considering one of the final filling phases, when the annual amount of waste treated is maximum. In the choice of the odour emission factors for the emission evaluation, reference is made to the study ***"Odour emission factors for assessment and prediction of Italian MSW landfills odour impact"*** written by Selena Sironia, Laura Capellia, Paolo Centola, Renato Del Rosso, Massimiliano Il Grande (2005).

In this study, the database of odour concentration values collected during one year period of monitoring of seven different and dimensionally representative MSW Italian landfills was examined. Based on these data, it has been possible to derive some general principles regarding the impact of odour from these landfills and thereby to obtain the ''odour emission factors'' (OEFs) relevant to these sites.

The SOER (Specific Odour Emission Rate, ou_E/m^2) calculated for the different emitting surfaces of a landfill are listed in the Table 126.

Table 126 – SOER values from different emitting surfaces

Emitting surface	SOER (specific odour emission rate) ou_E/m^2
Freshly tipped waste (freshly tipped, still uncovered waste)	59
Active landfill parcel (waste temporarily and	8

permanently capped)	
Exhausted parcel	4

Assumption for the emission estimation

Table 127 – Assumptions

SOER (specific odour emission rate) ou_E/m^2 s Freshly tipped waste	59
SOER (specific odour emission rate) ou_E/m^2 s Active landfill parcell	8
daily waste surface exposed to the atmosphere (m^2)	262
active surface (m^2)	57,374
total OER (ou_E/s)	**8.2**

The second step of the impact rating is the modelling of the diffusion of odour in air, simulated using the CALPUFF Modelling System.
In the following table the main source characteristics used in the diffusion modelling are listed:

Table 128 – Source characteristics

geographical coordinates (UTM 16) (m)	356815 (x); 2041532 (y) 357057 (x); 2041530 (y) 357056 (x); 2041290 (y) 356814 (x); 2041290 (y)
source surface (m^2)	57,600
height of point of emission (m)	9
emission factor (ou_E/s)	8.2

The receptors considered are showed in the previous paragraph, in the following table the modelling results are shown.

Table 129 – Modelling results

Receptor	C_{98} (98 percentile of hourly average) OU_E/m^3
R01	0.000011
R02	1.80
R03	1.83

With the aim of assessing the potential impact in each receptor, considering that there are no National Regulations in Belize regarding emission of odors, reference is made to ***Guidance on the assessment of odour for planning -*** Institute of Air Quality Management (UK). This guidance proposes to assess this impact on the basis of the receptor sensitivity (see Figure 59) and the odour exposure level C_{98} (98^{th} percentile of hourly average) as shown in
Figure 60.

Figure 59 – Receptor sensitivity - *Guidance on the assessment of odour for planning* - Institute of Air Quality Management (UK)

For the sensitivity of people to odour, the IAQM recommends that the Air Quality Practitioner uses professional judgement to identify where on the spectrum between high and low sensitivity a receptor lies, taking into account the following general principles:

High sensitivity receptor	Surrounding land where: • users can reasonably expect enjoyment of a high level of amenity; and • people would reasonably be expected to be present here continuously, or at least regularly for extended periods, as part of the normal pattern of use of the land. Examples may include residential dwellings, hospitals, schools/education and tourist/cultural.
Medium sensitivity receptor	Surrounding land where: • users would expect to enjoy a reasonable level of amenity, but wouldn't reasonably expect to enjoy the same level of amenity as in their home; or • people wouldn't reasonably be expected to be present here continuously or regularly for extended periods as part of the normal pattern of use of the land. Examples may include places of work, commercial/retail premises and playing/recreation fields.
Low sensitivity receptor	Surrounding land where: • the enjoyment of amenity would not reasonably be expected; or • there is transient exposure, where the people would reasonably be expected to be present only for limited periods of time as part of the normal pattern of use of the land. Examples may include industrial use, farms, footpaths and roads.

Figure 60 – Odour impact assessment - *Guidance on the assessment of odour for planning* - Institute of Air Quality Management (UK)

Odour Exposure Level C_{98}, ou_E/m^3	Receptor Sensitivity		
	Low	Medium	High
≥10	Moderate	Substantial	Substantial
5-<10	Moderate	Moderate	Substantial
3-<5	Slight	Moderate	Moderate
1.5-<3	Negligible	Slight	Moderate
0.5-<1.5	Negligible	Negligible	Slight
<0.5	Negligible	Negligible	Negligible

When compiling this Table, it has been assumed, on a conservative basis that the odour in question is at the offensive end of the spectrum. For odours that are less unpleasant, the level of odour exposure required to elicit the same effect may be somewhat higher, requiring professional judgement to be applied . It also should be noted that the Table applies equally to cases where there are increases and decreases in odour exposure as a result of this development , in which case the appropriate terms "adverse" or "beneficial"should be added to the descriptors.

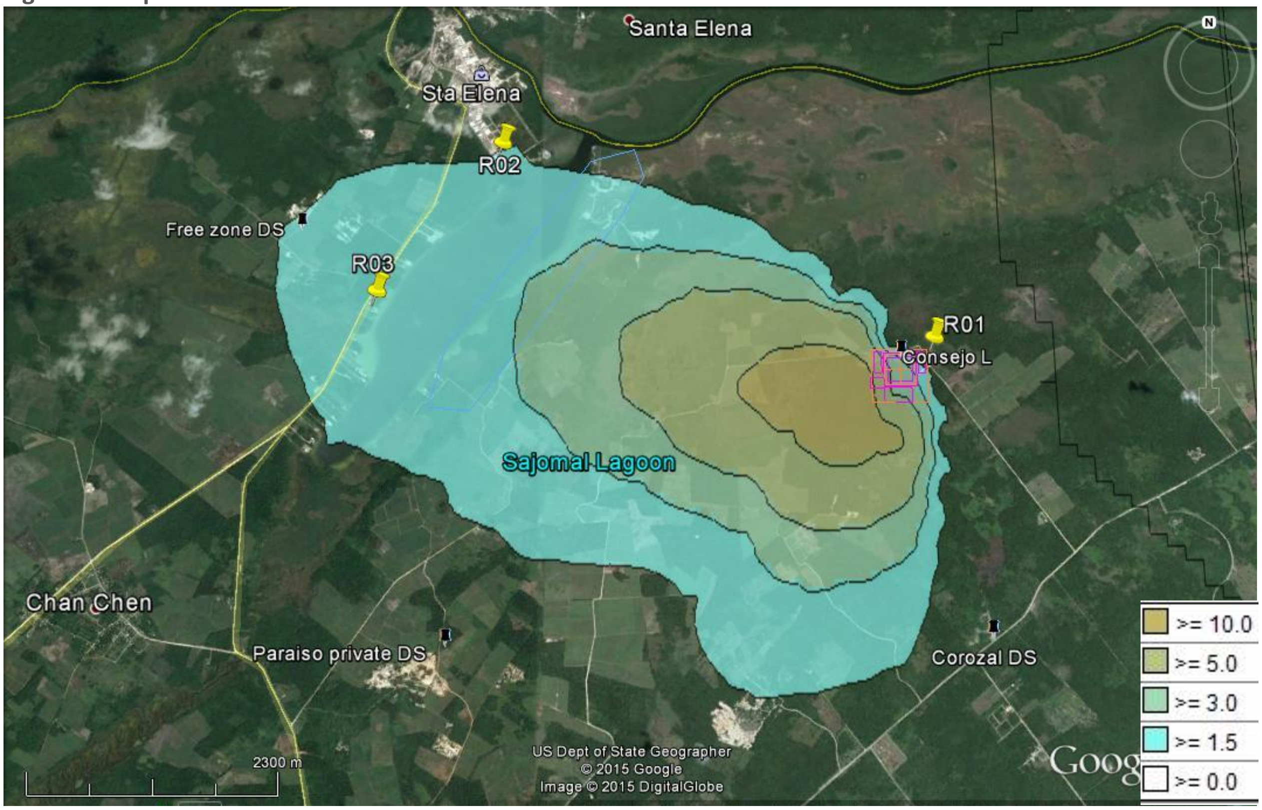
The assessment results are shown in Table 130.

Table 130 – Assessment results

Receptor	Sensitivity	C_{98} (98th percentile of hourly average) ou_E/m^3	priority
R01	low	0.000011	Negligible
R02	medium	1.80	Slight
R03	low	1.83	Negligible

The spatial distributions of the odour exposure level C_{98} diffusion are shown in Figure 61.

Figure 61 – Spatial distribution of odour diffusion



According to "*Odour Guidance for Local Authorities"* by DEFRA UK (2010) the following guideline values, as per the UK Environment Agency, *Draft 2009, H4 - Odour Management* , may help to provide some context for discussion about exposure to odours:

- 1 ou_E/m^3 is the point of detection;
- 5 ou_E/m^3 is a faint odour; and
- 10 ou_E/m^3 is a distinct odour.

However, it is important to consider that these values are based on laboratory measurements and in the general environment; other factors affect our sense of odour perception, such as:

- the population is continuously exposed to a wide range of "background" odours at a range of different concentrations, and usually people are unaware of there being any background odours at all due to normal "habituation". Individuals can also develop a "tolerance" to background and other specific odours. In an odour laboratory the determination of detection threshold is undertaken by comparison with non-odorous air, and in carefully controlled, odour-free conditions. Normal background odours such as those from traffic, vegetation, grass mowings etc., can provide background odour concentrations from 5 to 60 ouE m-3 or more;
- the recognition threshold, that is the concentration at which a person might be able to recognise or describe a specific odour may be about three odour units per cubic metre,

although it might be less for offensive substances or higher if the receptor is less familiar with the odour or distracted by other stimuli; and

- an odour which fluctuates rapidly in concentration is often more noticeable than a steady odour at a low concentration.

31.8.1.3.3 Noise levels in the area surrounding the plant

The priority of the potential noise impact in the areas surrounding the proposed landfill sites, is rated by comparing the noise levels at the identified receptors with the threshold values admitted by the Laws of Belize.
The sound pressure level at the receptor nearest to the landfill is estimated using the “free field” law of noise propagation. The noise propagation is assessed in the phases of construction and operation, considering, as conservative assumption, that all the work vehicles work at the same time.

In a free field, the intensity and sound pressure at a given point, at a distance d2 (in meters) from the source, is expressed by the following equation:

$$dB2 = dB1 - 20 * \mathrm{Log}\,(d2/d1)$$

where
dB1 = sound pressure level at source (dBA)
d1 = distance of reference
dB2 = sound pressure level at receptor (dBA)
d2 = distance between the source and the receptor

Table 131 – Sound pressure estimation

Receptor	Source	Source sound pressure level [dBA]	Distance of reference [m]	Distance between source and receptor [m]	Attenuation [dB]	Sound pressure at receptor [dBA]	Total sound pressure at receptor [dBA]
R01	CONSTRUCTION						
	S1	80	16	140	19.4	61.2	**74.4**
	S2	85	16	140	19.4	66.2	
	S3	85	16	140	19.4	66.2	
	S4	88	16	140	19.4	69.2	
	S5	88	16	140	19.4	69.2	
	S6	80	16	140	19.4	61.2	
	OPERATION						
	S3	85	16	140	19.4	66.2	**73.4**
	S4	88	16	140	19.4	69.2	
	S5	88	16	140	19.4	69.2	
	S6	80	16	140	19.4	61.2	

The values of the sound pressure calculated at the receptor are compared with the noise level limits as per "*Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, Chapter 238 Pollution Regulation*", Regulation 42, Second Schedule. It has to be noticed that, as per Second Schedule definitions, the receptor considered is a "Structure B" and the duration of noise is "more than 3 hours, and less than 9 hours".

Table 132 – Noise pressure levels comparison

Phase	Noise pressure at the receptor (dBA)	Noise level as per pollution regulation
Construction	74.4	70
Operation	73.4	70

In every phase considered the noise pressure levels at the considered receptor is greater than the allowed limit.
The aspect shall then be considered by the design and mitigated through the necessary and available measures such as physical barriers (embankments, artificial barriers and vegetation screens).

31.8.1.4 Soil, ground and surface water quality

31.8.1.4.1 Accidental spillage or leakage of fuel may cause soil or ground/surface water contamination

The potential impacts on the receptors "Soil" and "Ground and surface water quality**"** are assessed together. The soil or water contamination can be caused by accidental spillage or leakage of fuel from the vehicles utilized for the construction of the plant and the waste handling or from the fuel storage tank.

Taking into account:

- the modest amount of fuel contained in the tank of the vehicles;
- the fuel storage tank shall have an impermeable containment structure for collecting the fuel in the event of a spill;
- the possibility of confining the spillage/leakage, mitigating the diffusion of liquid;

The intensity of this impact can be assumed as "negligible", the duration of the impact "short term" and the spatial extent "localized". In regards to the probability, it is worth noting that the spillages or leakages would be accidental, so the probability of the impact can be assumed as "unlikely".

Therefore the potential impact of "*Accidental spillage or leakage of fuel may cause soil or ground/surface water contamination"* has a low priority.

31.8.1.4.2 Accidental leakage of leachate can seep through the soil and ground water.

The potential impacts on the receptors "Soil" and "Ground and surface water quality**"** are assessed together. The soil or water contamination can be caused by accidental leakage from the bottom of the landfill or from the leachate treatment lagoons.

The geology of almost the entire region (Northern Corridor) is of carbonate nature and karst activity is not uncommon. According to internationally recognised standards these soils should be excluded when planning the siting of a landfill. Due to the abovementioned geology, the drainage capacity of the soil is very high.

Diffuse presence of phreatic water bodies and, on the other hand, absence of a developed and permanent superficial drainage system are the results of such condition. The diffuse presence of phreatic water and the high drainage capacity of the soil are conditions for an increased risk of diffusion of contaminants.

Taking into account all these aspects, the intensity of this impact can be assumed as "severe". The duration of the impact depends on the source of the leachate leakage, a spillage from the bottom of the landfill, in fact, can have a duration assessed as "long term". The spatial extent can be assumed as "far-range".

The probability of this impact, considering the artificial barriers foreseen in order to reduce the likelihood of leachate leakage, is "unlikely".

Therefore the potential impact of "*Accidental leakage of leachate can seep through the soil and ground water"* has a high priority.

31.8.1.4.3 Accidental failure of leachate treatment can affect the surface water quality

An accidental failure of the leachate treatment could cause the discharge of effluent containing pollutants in concentrations exceeding the threshold values allowed by the laws and so compromising the quality of the surface water of the watercourse where the effluent is discharged into.

Taking into account the possible high sensitivity of the surface water, the intensity of this impact can be assumed as “notable”. The duration of the impact “short term”. The spatial extent can be assumed as “mid-range”.
The probability of this impact, considering the monitoring of effluent quality that shall be conducted and the possibility to recirculate the effluent, is “unlikely”.

Therefore the potential impact of “*Accidental failure of leachate treatment can affect the surface water quality”* has a medium priority.

31.8.1.5 Flora and fauna

31.8.1.5.1 Potential indirect impacts related to the deterioration of the quality of air, of soil or of ground and surface water

As above underlined, the present environmental impact assessment is referred to a preliminary stage of the SWM system, so the assessment itself is at a preliminary level. In particular, in this phase, the sensitivity of the flora and fauna to the impacts due to waste transportation, has not been determined. Therefore the priority of these indirect impacts is assessed without considering the specific sensitivity of the different receptor species, but following the evaluations already conducted on the impacts on the quality of soil, surface and ground water and air.

So, in general terms, *the potential indirect impacts related to the deterioration of the quality of air, of soil or of ground and surface water* have a high priority.

The results of the assessments are summarized in Table 133.

Table 133 – Consejo site - Potential impacts assessment

Landfill	**Landscape and natural scenery**	**Intensity**	**Duration**	**Spatial extent**	**Probability**	**Priority**
All the phases	Alteration of the landscape	severe	long-term	far-range	definite	**high**
Landfill	**Archaeological, cultural and historical resources**					
All phases	Damage to the site	severe	short-term	localized	possible	**medium**
Landfill	**Air quality and climate**					
All the phases	Emissions and diffusion of air pollutants and greenhouse gases					
	Increasing of noise levels in the area surrounding the landfill					
Operation	Emissions and diffusion of odour from the waste handling operations and from the leachate treatment					
Landfill	**Soils**					
All the phases	Accidental spillage or leakage of fuel from vehicles/storage tank may cause soil contamination	negligible	short-term	localized	unlikely	**low**
Operation, Closure, After care	Accidental leakage of leachate can seep through the soil and ground water contaminating soil	severe	long-term	far-range	unlikely	**high**
Landfill	**Ground and surface water quality**					
All the phases	Accidental spillage or leakage of fuel from vehicles/storage tank may cause surface water contamination	negligible	short-term	localized	unlikely	**low**
Operation, Closure, After-care	Accidental leakage of leachate can seep through the soil and ground water contaminating soil and waters (Ground and Surface)	severe	long-term	far-range	unlikely	**high**
	Accidental failure of the leachate treatment system can affect the surface water quality	notable	short-term	mid-range	unlikely	**medium**
Landfill	**Flora and fauna**					
All the phases	Potential indirect impacts related to the deterioration of the quality of air, of soil or of ground and surface water	severe	long-term	mid-range	unlikely	**high**

31.8.2 San Estevan

31.8.2.1 Landscape and natural scenery

31.8.2.1.1 Alteration of the landscape.

With the aim of rating the intensity of this impact, the following aspects have to be considered:

- the general layout of the semi-aerobic landfill, as proposed by the Master Plan, foresees a significant t extension in area, including all the ponds necessary for leachate and stormwater treatment and all the facilities (administrative buildings, scale house, …), and a maximum height of the final landfill of about 20 m;
- the morphology of the site is flat and the site remains visible from a distance and from almost any angle of view, though, as shown in Figure 62 also in this case the main human settlements and roads are at a considerable distance from the site (see Table 134).

Figure 62 - Receptors

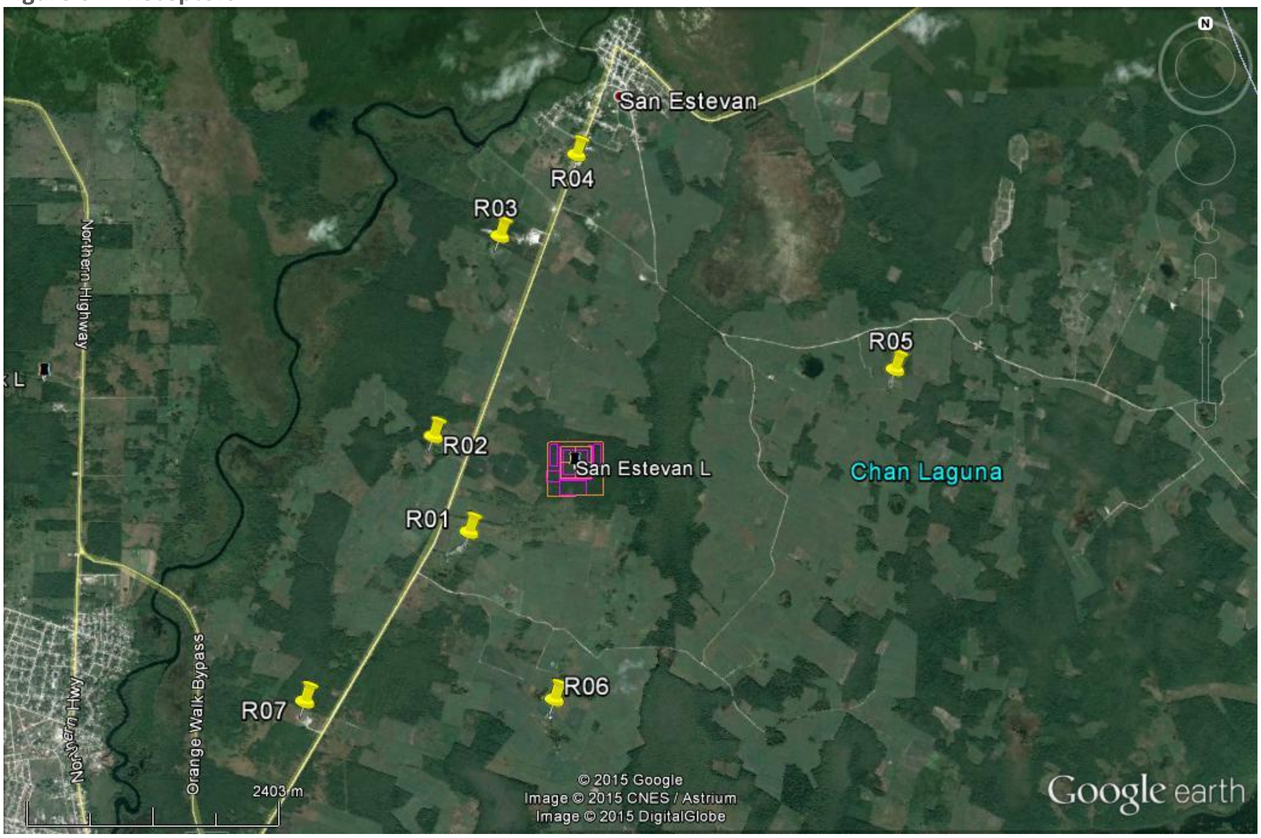


Table 134 – Receptors

Receptor	UTM 16 coordinates		Distance (m)	Description
R01	338529 (x)	2003026 (y)	1,140	outlying group of houses (residential/rural)
R02	338177 (x)	2003956 (y)	1,280	outlying house (residential/rural)
R03	338828 (x)	2005934 (y)	2,050	outlying house (residential/rural)
R04	339593 (x)	2006748 (y)	2,700	San Estevan

R05	342724 (x)	2004576 (y)	3,000	outlying house (residential/rural)
R06	339356 (x)	2001424 (y)	2,260	outlying house (residential/rural)
R07	336950 (x)	2001424 (y)	3,400	Muffles Jr College - school (sensitive)

Therefore the intensity of this impact can be assessed as "severe" and the duration of the impact is "long-term". The spatial extension of this impact is "far-range", because the alteration of the landscape is noticeable from a distance of beyond 1,000 m. The probability of the impact is definite.

Therefore the potential impact *Alteration of the landscape* has a high priority.

31.8.2.2 Archaeological, cultural and historical resources

31.8.2.2.1 Damage to the site

The site proposed is at an adequate distance from known archaeological and historical sites. If during the construction works (excavation works mainly) any archaeological finds are made, the works would be immediately stopped and, according to the directives provided by the competent authority, the finds would be properly managed.
Taking into account the high historical and cultural value of finds, and considering the significant amount of bulk material handled during excavation, the intensity of this impact can be rated as "severe". The timely interruption of the works makes the duration of the impact "short-term" and the spatial extent "localized". The probability of the impact can be assessed as "possible".

Therefore the potential impact *Damage to the site* has a medium priority.

31.8.2.3 Air quality and climate

In the present section the assessments of the potential impacts into air are carried out, following the methodologies and assumptions described in section 31.8.1.3.1.

31.8.2.3.1 Emissions and diffusion of air pollutants

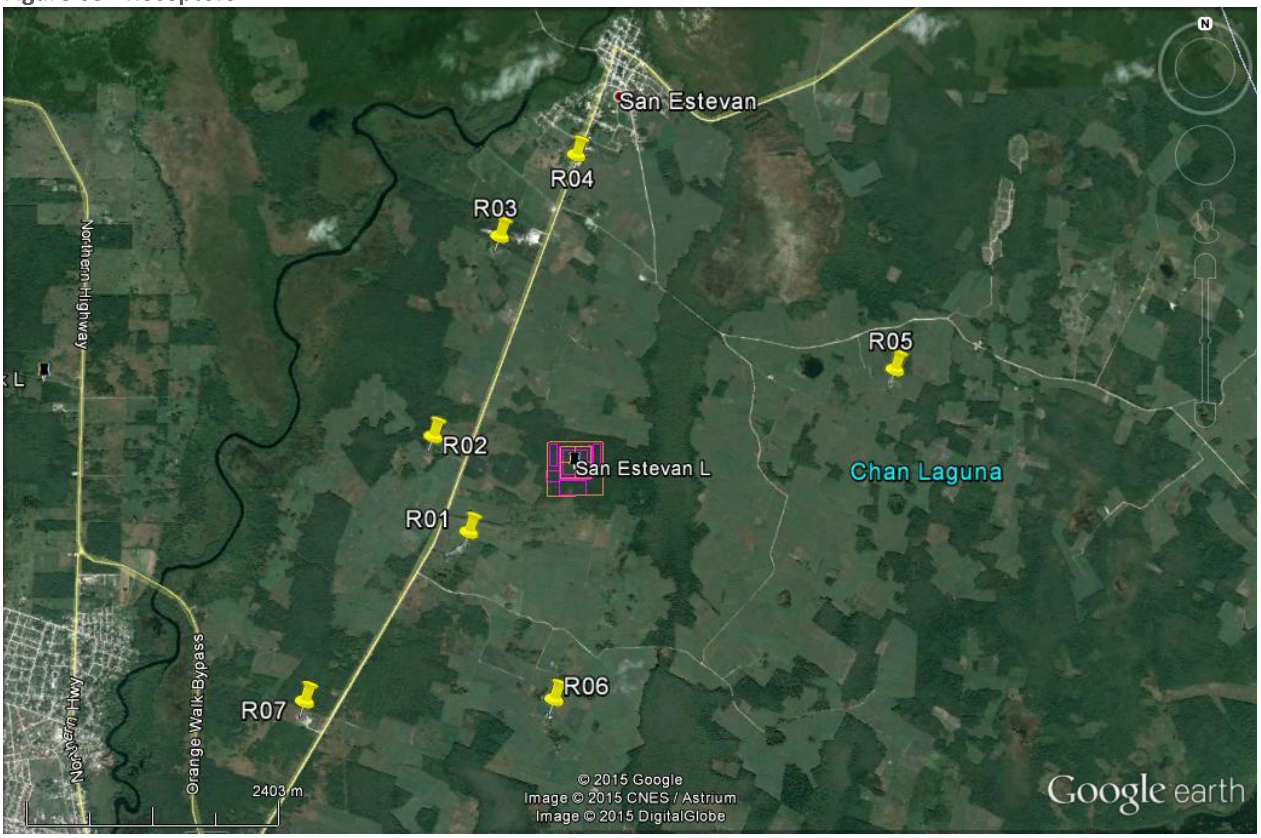
The receptors being considered are listed in **Table 135** and shown in Figure 63.

Table 135 – Receptors

Receptor	UTM 16 coordinates		Distance (m)	Description
R01	338529 (x)	2003026 (y)	1,140	outlying group of houses (residential/rural)
R02	338177 (x)	2003956 (y)	1,280	outlying house (residential/rural)
R03	338828 (x)	2005934 (y)	2,050	outlying house (residential/rural)
R04	339593 (x)	2006748 (y)	2,700	San Estevan
R05	342724 (x)	2004576 (y)	3,000	outlying house

			(residential/rural)
R06	339356 (x) 2001424 (y)	2,260	outlying house (residential/rural)
R07	336950 (x) 2001424 (y)	3,400	Muffles Jr College - school (sensitive)

Figure 63 - Receptors



Construction phase

In the following table the main source characteristics used in the diffusion modelling are listed:

Table 136 – Source characteristics

geographical coordinates (UTM 16) (m)	339341 (x); 2004042 (y) 339887 (x); 2004046 (y) 339887 (x); 2003524 (y) 339340 (x); 2003521 (y)
source surface (m^2)	285,505
height of point of emission (m)	1

Modelling results

Table 137 – Modelling results

Receptor	Estimated PM_{10} conc ($\mu g/m^3$)	PM_{10} Concentration limit[37] ($\mu g/m^3$),	Estimated NOx conc (µg/cm)	NOx Concentration limit[38] ($\mu g/m^3$)	Estimated CO conc (µg/cm)	CO Concentration limit[39] ($\mu g/m^3$)
R01	2.85	200	0.69	80	0.64	2,000
R02	1.26		1.30		1.18	
R03	0.52		0.06		0.07	
R04	0.24		0.01		0.02	
R05	0.10		0.00		0.00	
R06	1.39		0.48		0.44	
R07	0.24	100	0.06	30	0.06	1,000

The results of the modelling are compared to the Concentrations of Permitted Air Contaminant as per the "Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, Chapter 238 Pollution Regulation", Regulation 6, First Schedule, as shown in Table 137. **All the evaluated concentrations, PM_{10} , NO_x and CO are below the allowed specific limits.**

The spatial distributions of the pollutants diffusion are shown in Figure 64, Figure 65 and Figure 34.

[37] As per "Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, Chapter 238 Pollution Regulation", Regulation 6, First Schedule

[38] As per "Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, Chapter 238 Pollution Regulation", Regulation 6, First Schedule

[39] As per "Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, Chapter 238 Pollution Regulation", Regulation 6, First Schedule

Figure 64 – Spatial distribution of PM_{10} diffusion (µg/cm)

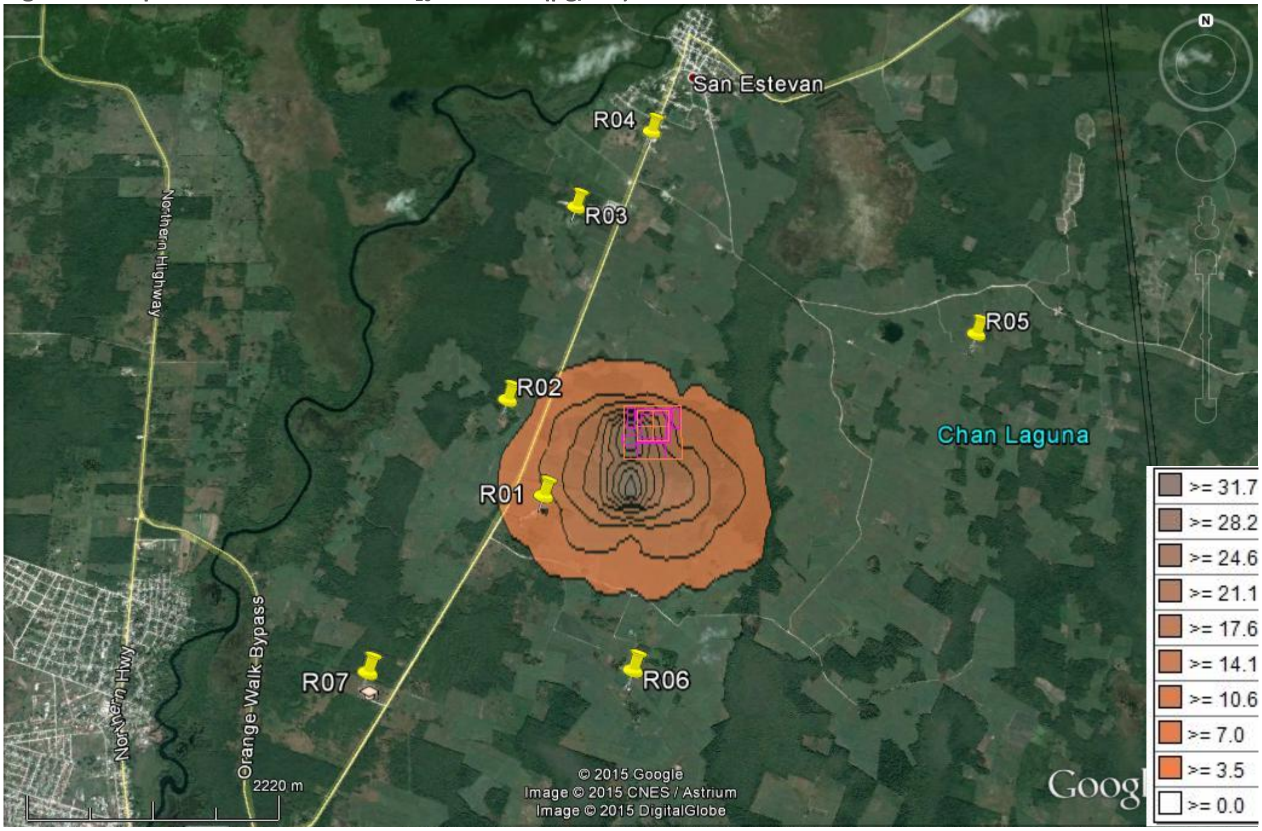


Figure 65 – Spatial distribution of NOx diffusion (µg/cm)

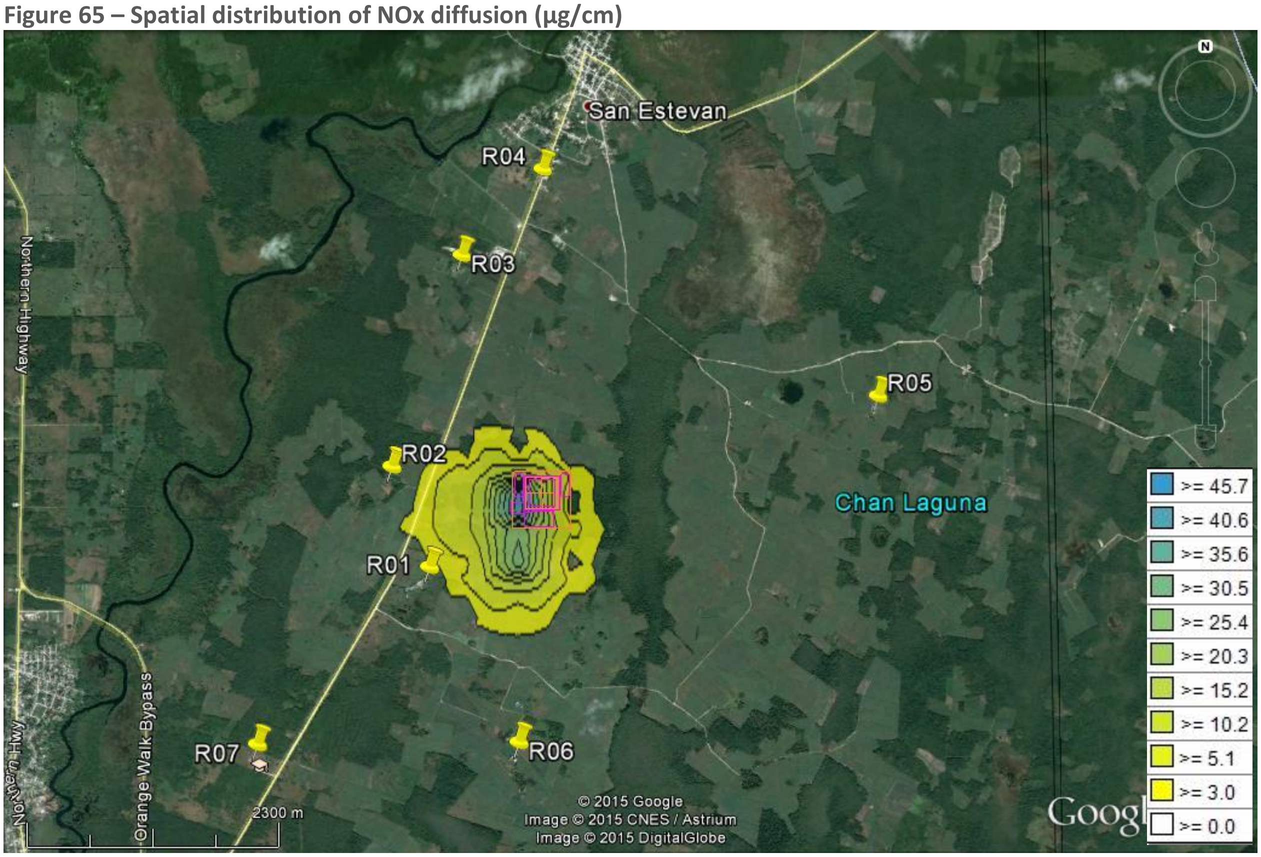
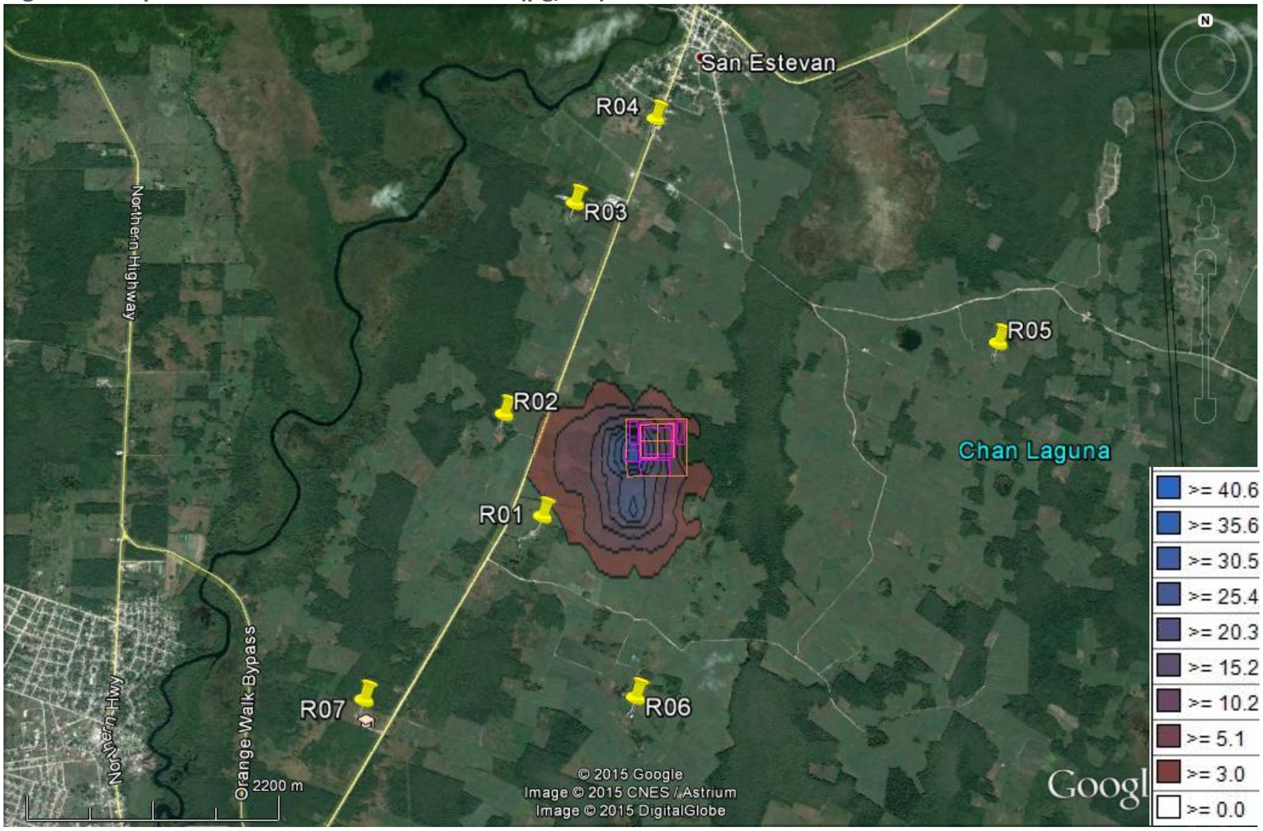


Figure 66 – Spatial distribution of CO diffusion (µg/cm)



Operation phase

In the following table the main source characteristics used in the diffusion modelling are listed:

Table 138 – Source characteristics

geographical coordinates (UTM 16) (m)	339471 (x); 2003995 (y) 339622 (x); 2003997 (y) 339620 (x); 2003846 (y) 339471 (x); 2003846 (y)
source surface (m^2)	22,500
height of point of emission (m)	9

Modelling results

Table 139 – Modelling results

<table>
<tr><th>Receptor</th><th>Estimated PM_{10} conc ($\mu g/m^3$)</th><th>PM_{10} Concentration limit[40] ($\mu g/m^3$),</th><th>Estimated NOx conc (µg/cm)</th><th>NOx Concentration limit[41] ($\mu g/m^3$)</th><th>Estimated CO conc (µg/cm)</th><th>CO Concentration limit[42] ($\mu g/m^3$)</th></tr>
<tr><td>R01</td><td>0.38</td><td rowspan="6">200</td><td>0.21</td><td rowspan="6">80</td><td>0.16</td><td rowspan="6">2,000</td></tr>
<tr><td>R02</td><td>0.53</td><td>0.47</td><td>0.36</td></tr>
<tr><td>R03</td><td>0.17</td><td>0.03</td><td>0.02</td></tr>
<tr><td>R04</td><td>0.10</td><td>0.01</td><td>0.01</td></tr>
<tr><td>R05</td><td>0.03</td><td>0.00</td><td>0.00</td></tr>
<tr><td>R06</td><td>0.55</td><td>0.19</td><td>0.14</td></tr>
<tr><td>R07</td><td>0.12</td><td>100</td><td>0.03</td><td>30</td><td>0.02</td><td>1,000</td></tr>
</table>

The results of the modelling are compared to the Concentrations of Permitted Air Contaminant as per the "Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, Chapter 238 Pollution Regulation", Regulation 6, First Schedule, as shown in Table 121. **All the evaluated concentrations, PM_{10} , NO_x and CO are below the allowed specific limits.**

The spatial distributions of the pollutants diffusion are shown in Figure 67, Figure 68 and Figure 69.

[40] As per "Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, Chapter 238 Pollution Regulation", Regulation 6, First Schedule

[41] As per "Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, Chapter 238 Pollution Regulation", Regulation 6, First Schedule

[42] As per "Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, Chapter 238 Pollution Regulation", Regulation 6, First Schedule

Figure 67 – Spatial distribution of PM_{10} diffusion (µg/cm)

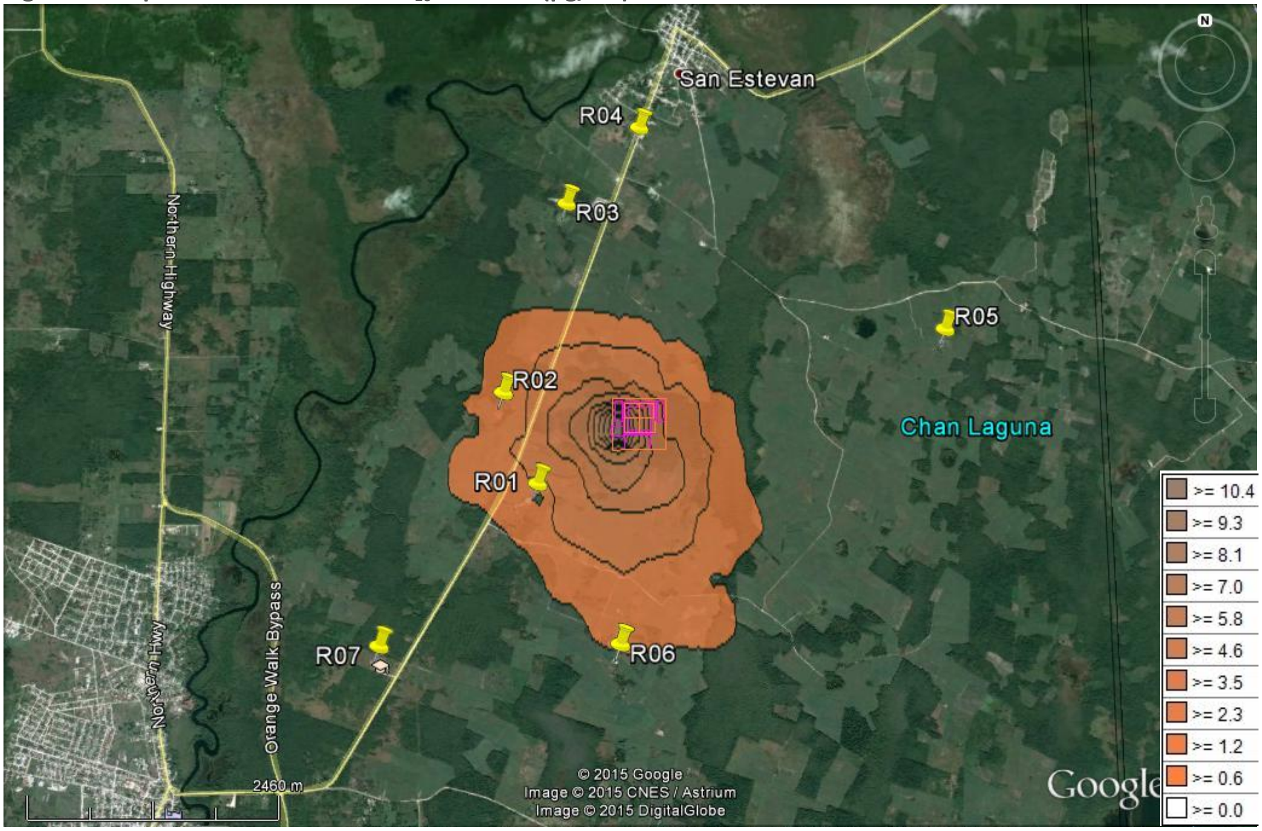


Figure 68 – Spatial distribution of NOx diffusion (µg/cm)

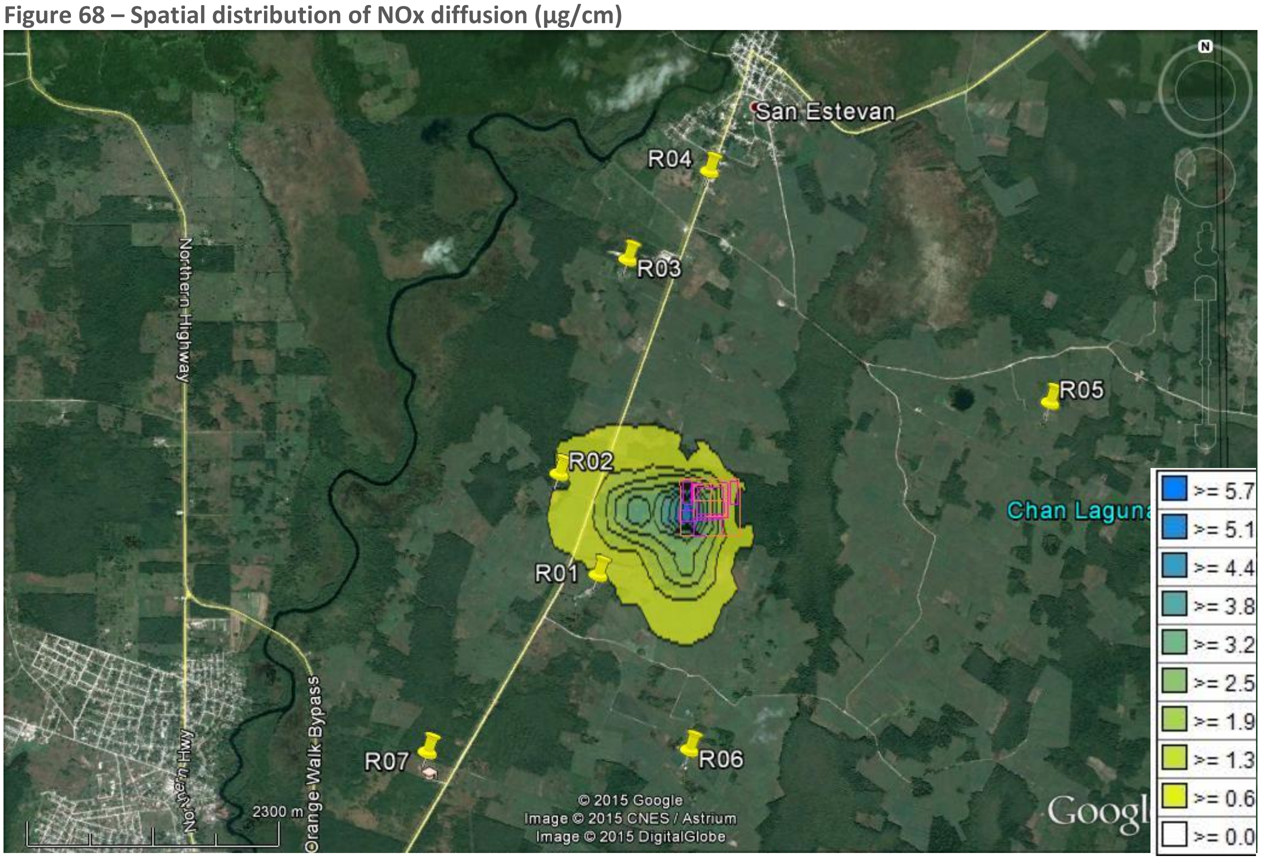
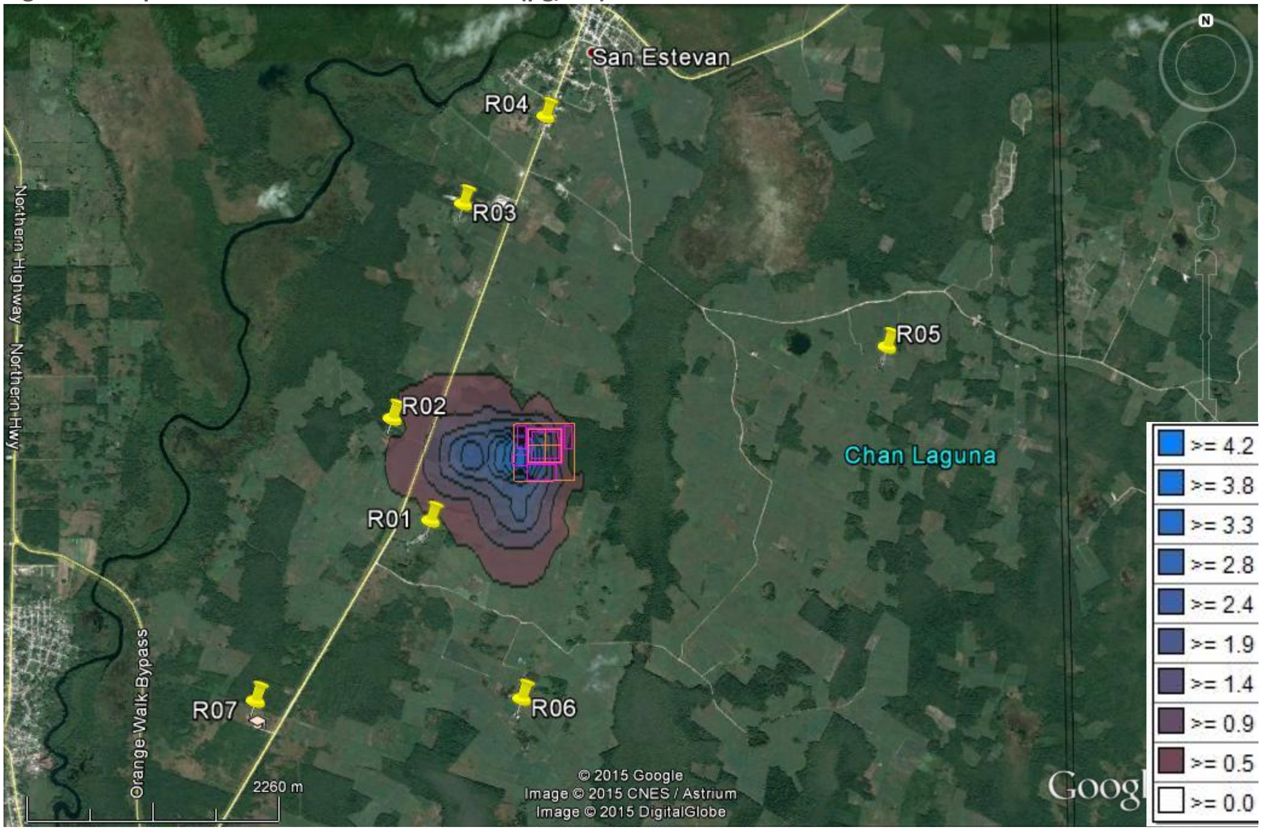


Figure 69 – Spatial distribution of CO diffusion (µg/cm)



31.8.2.3.1.1 *Diffusion of methane*

In the following table the main source characteristics used in the diffusion modelling are listed:

Table 140 – Source characteristics

geographical coordinates (UTM 16) (m)	339502 (x); 2003962 (y) 339741 (x); 2003963 (y) 339741 (x); 2003726 (y) 339500 (x); 2003726 (y)
source surface (m^2)	57,600
height of point of emission (m)	9
emission factor (g/s)	91.17

The receptors considered are showed in the previous paragraph, in the following table the modelling results are shown.

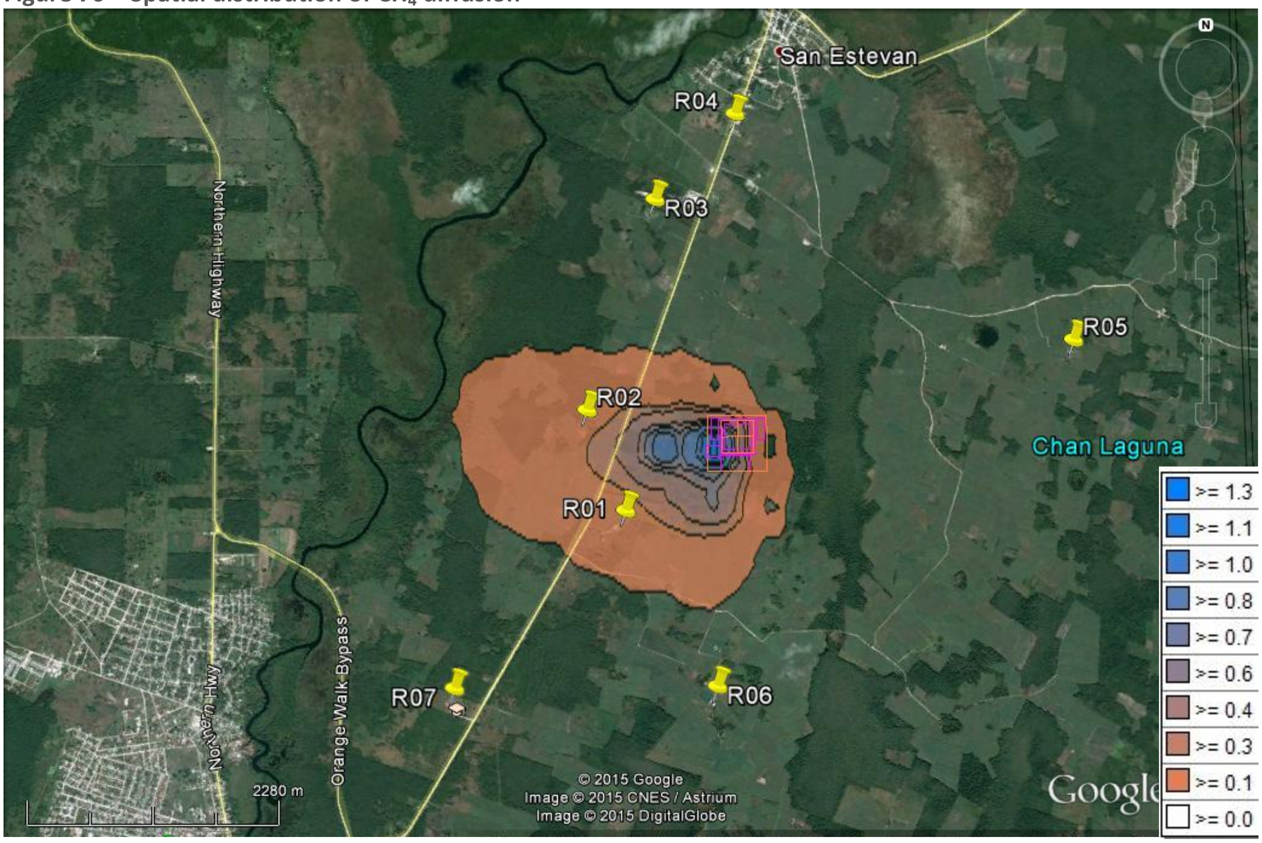
Table 141 – Modelling results

Receptor	Estimated CH4 concentration (mg/m^3)
R01	0.11
R02	0.23
R03	0.01

R04	0.003
R05	0.002
R06	0.04
R07	0.02

The spatial distributions of the pollutants diffusion are shown in Figure 70.

Figure 70 – Spatial distribution of CH_4 diffusion



31.8.2.3.2 Emission of odour nuisance

In the following table the main source characteristics used in the diffusion modelling are listed:

Table 142 – Source characteristics

geographical coordinates (UTM 16) (m)	339502 (x); 2003962 (y) 339741 (x); 2003963 (y) 339741 (x); 2003726 (y) 339500 (x); 2003726 (y)
source surface (m^3)	57,600
height of point of emission (m)	9
emission factor (ou_E/s)	8.2

The receptors considered are showed in the previous paragraph, in the following table the modelling results are shown.

Table 143 – Modelling results

Receptor	C_{98} (98 percentile of hourly average) OU_E/m^3
R01	8.13
R02	13.20
R03	0.37
R04	0.06
R05	0.001
R06	2.89
R07	1.32

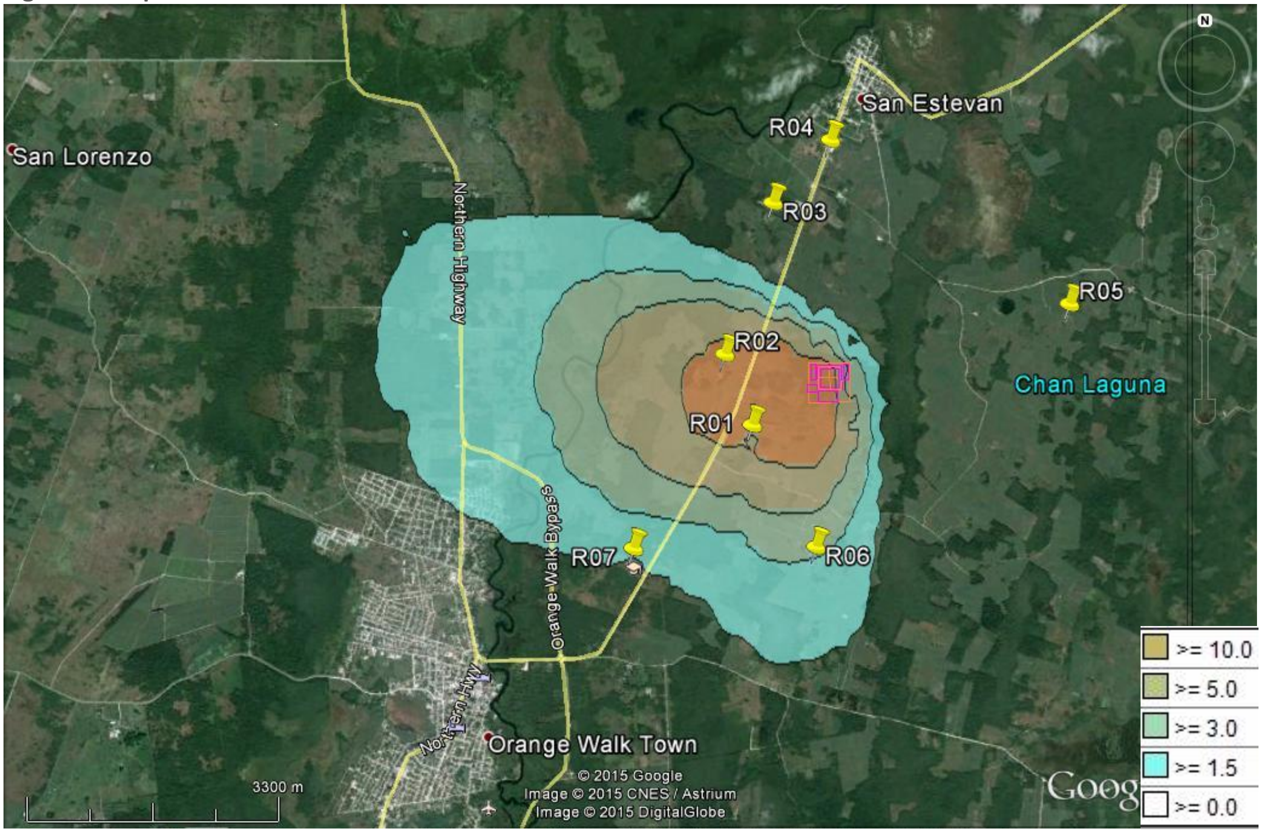
The assessment results are shown in Table 144.

Table 144 – Assessment results

Receptor	Sensitivity	C_{98} (98 percentile of hourly average) OU_E/m^3	priority
R01	low	8.13	Moderate
R02		13.20	Moderate
R03		0.37	Negligible
R04	medium	0.06	Negligible
R05	low	0.001	Negligible
R06		2.89	Negligible
R07	high	1.32	Slight

The spatial distributions of the C_{98} diffusion are shown in Figure 71.

Figure 71 – Spatial distribution of odour diffusion



31.8.2.3.3 Noise levels in the area surrounding the plant

Table 145 – Sound pressure estimation

Receptor	Source	Source sound pressure level [dBA]	Distance of reference [m]	Distance between source and receptor [m]	Attenuation [dB]	Sound pressure at receptor [dBA]	Total sound pressure at receptor [dBA]
R01	CONSTRUCTION						
	S1	80	16	1140	37.1	42.9	**56.2**
	S2	85	16	1140	37.1	47.9	
	S3	85	16	1140	37.1	47.9	
	S4	88	16	1140	37.1	50.9	
	S5	88	16	1140	37.1	50.9	
	S6	80	16	1140	37.1	42.9	
	OPERATION						
	S3	85	16	1140	37.1	47.9	**55.2**
	S4	88	16	1140	37.1	50.9	
	S5	88	16	1140	37.1	50.9	
	S6	80	16	1140	37.1	42.9	

The values of the sound pressure calculated at the receptor are compared with the noise level limits as per "*Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, Chapter 238 Pollution Regulation*", Regulation 42, Second Schedule. It has to be noticed that, as per Second Schedule definitions, the receptor considered is a "Structure B" and the duration of noise is "more than 3 hours, and less than 9 hours".

Table 146 – Noise pressure levels comparison

Phase	Noise pressure at the receptor (dBA)	Noise level as per pollution regulation
Construction	56.2	70
Operation	55.2	70

In every phase considered the noise pressure levels at the considered receptor is lower than the allowed limit.

31.8.2.4 Soil, ground and surface water quality

31.8.2.4.1 Accidental spillage or leakage of fuel may cause soil or ground/surface water contamination

The potential impacts on the receptors "Soil" and "Ground and surface water quality**"** are assessed together. The soil or water contamination can be caused by accidental spillage or leakage of fuel from the vehicles utilized for the construction of the plant and the waste handling or from the fuel storage tank.

Taking into account:

- the modest amount of fuel contained in the tank of the vehicles;
- the fuel storage tank shall have an impermeable containment structure for collecting the fuel in the event of a spill;
- the possibility of confining the spillage/leakage, mitigating the diffusion of liquid;

The intensity of this impact can be assumed as "negligible", the duration of the impact "short term" and the spatial extent "localized". In regards to the probability, it is worth noting that the spillages or leakages would be accidental, so the probability of the impact can be assumed as "unlikely".

Therefore the potential impact of "*Accidental spillage or leakage of fuel may cause soil or ground/surface water contamination*" has a low priority.

31.8.2.4.2 Accidental leakage of leachate can seep through the soil and ground water.

The potential impacts on the receptors "Soil" and "Ground and surface water quality**"** are assessed together. The soil or water contamination can be caused by accidental leakage from the bottom of the landfill or from the leachate treatment lagoons.

The geology of almost the entire region (Northern Corridor) is of carbonate nature and karst activity is not uncommon. According to internationally recognised standards these soils should be excluded when planning the siting of a landfill. Due to the abovementioned geology the drainage capacity of the soil is very high.

Diffuse presence of phreatic water bodies and, on the other hand, absence of a developed and permanent superficial drainage system are the results of such condition. The diffuse presence of phreatic water and the high drainage capacity of the soil are conditions for an increased risk of diffusion of contaminants.
Taking into account all these aspects, the intensity of this impact can be assumed as "severe". The duration of the impact depends on the source of the leachate leakage, a spillage from the bottom of the landfill, in fact, can have a duration assessed as "long term".
The spatial extent can be assumed as "far-range".
The probability of this impact, considering the artificial barriers foreseen in order to reduce the likelihood of leachate leakage, is "unlikely".

Therefore the potential impact of "*Accidental leakage of leachate can seep through the soil and ground water*" has a high priority.

31.8.2.4.3 Accidental failure of leachate treatment can affect the surface water quality

An accidental failure of the leachate treatment could cause the discharge of effluent containing pollutants in concentrations exceeding the threshold values allowed by the laws and so compromising the quality of the surface water of the watercourse where the effluent is discharged into.
Taking into account the possible high sensitivity of the surface water, the intensity of this impact can be assumed as "notable". The duration of the impact "short term".
The spatial extent can be assumed as "mid-range".
The probability of this impact, considering the monitoring of effluent quality that shall be conducted and the possibility to recirculate the effluent, is "unlikely".

Therefore the potential impact of "*Accidental failure of leachate treatment can affect the surface water quality*" has a medium priority.

31.8.2.5 Flora and fauna

31.8.2.5.1 Potential indirect impacts related to the deterioration of the quality of air, of soil or of ground and surface water

As underlined above, the present environmental impacts assessment is referred to a preliminary stage of the SWM system, so the assessment itself is at a preliminary level. In particular, in this phase, the sensitivity of the flora and fauna to the impacts due to waste transportation, has not been determined. Therefore the priority of these indirect impacts is assessed without considering the specific sensitivity of the different receptor species, but following the evaluations already conducted in respect of the impacts on the quality of soil, surface and ground water and air.

So, in general terms, "*the potential indirect impacts related to the deterioration of the quality of air, of soil or of ground and surface water*" have a high priority.
The results of the assessments are summarized in Table 147.

Table 147 – San Estevan site - Potential impacts assessment

Landfill	**Landscape and natural scenery**	**Intensity**	**Duration**	**Spatial extent**	**Probability**	**Priority**
All the phases	Alteration of the landscape	severe	long-term	far-range	definite	**high**
Landfill	**Archaeological, cultural and historical resources**					
All phases	Damage of the site	severe	short-term	localized	possible	**medium**
Landfill	**Air quality and climate**					
All the phases	Emissions and diffusion of air pollutants and greenhouse gases					
	Increasing of noise levels in the area surrounding the landfill					
Operation	Emissions and diffusion of odour from the waste handling operations and from the leachate treatment					
Landfill	**Soils**					
All the phases	Accidental spillage or leakage of fuel from vehicles/storage tank may cause soil contamination	negligible	short-term	localized	unlikely	**low**
Operation, Closure, After care	Accidental leakage of leachate can seep through the soil and ground water contaminating soil	severe	long-term	far-range	unlikely	**high**
Landfill	**Ground and surface water quality**					
All the phases	Accidental spillage or leakage of fuel from vehicles/storage tank may cause surface water contamination	negligible	short-term	localized	unlikely	**low**
Operation, Closure, After-care	Accidental leakage of leachate can seep through the soil and ground water contaminating soil and waters (Ground and Surface)	severe	long-term	far-range	unlikely	**high**
	Accidental failure of the leachate treatment system can affect the surface water quality	notable	short-term	mid-range	unlikely	**medium**
Landfill	**Flora and fauna**					
All the phases	Potential indirect impacts related to the deterioration of the quality of air, of soil or of ground and surface water	severe	long-term	mid-range	unlikely	**high**

31.8.3 Santa Cruz Landfill Site

31.8.3.1 Landscape and natural scenery

31.8.3.1.1 Alteration of the landscape.

With the aim of rating the intensity of this impact, the following aspects have to be considered:

- the general layout of the semi-aerobic landfill, as proposed by the Master Plan, foresees a significant extension in surface area, including all the ponds necessary for leachate and stormwater treatment and all the facilities (administrative buildings, scale house, …), and a maximum height of the final landfill of about 20 m;
- the morphology of the site is hilly and the site remains visible from a distance and from some angle of view, though, as shown in Figure 72 the main human settlements and roads are at a considerable distance from the site (see Table 148).

Figure 72 - Receptors

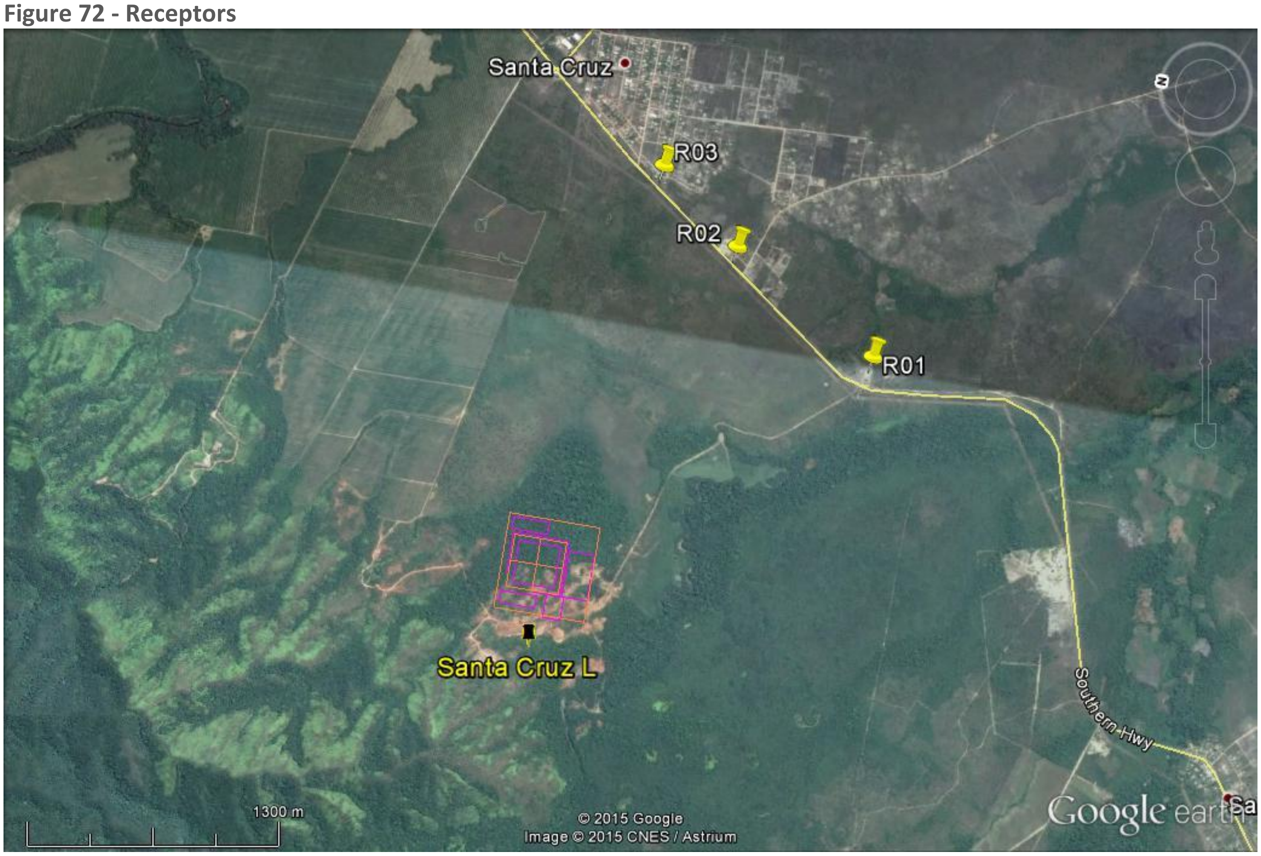


Table 148 – Receptors

Receptor	UTM 16 coordinates		Distance (m)	Description
R01	346719 (x)	1845545 (y)	1,900	outlying house (residential/rural)
R02	347214 (x)	1846415 (y)	1,870	outlying group of houses (residential/rural)
R03	347603 (x)	1846906 (y)	2,100	Santa Cruz

Therefore the intensity of this impact can be assessed as "severe" and the duration of the impact is "long-term". The spatial extension of this impact is "far-range", because the alteration of the landscape is noticeable from a distance beyond 1,000 m. The probability of the impact is definite.

Therefore the potential impact *Alteration of the landscape* has a high priority.

31.8.3.2 Archaeological, cultural and historical resources

31.8.3.2.1 Damage to the site

The proposed site is at an adequate distance from known archaeological and historical sites. If during the construction works (excavation works mainly) any archaeological finds are made, the works would be immediately stopped and, according to the directives provided by the competent authority, the finds would be properly managed.
Taking into account the high historical and cultural value of finds, and considering the significant amount of bulk material handled during excavation, the intensity of this impact can be rated as "severe". The timely interruption of the works makes the duration of the impact "short-term" and the spatial extent "localized". The probability of the impact can be assessed as "possible".

Therefore the potential impact of "*Damage to the site"* has a medium priority.

31.8.3.3 Air quality and climate

In the present section the assessments of the potential impacts on air are performed, following the methodologies and assumptions described in par. 9.3.1.3.

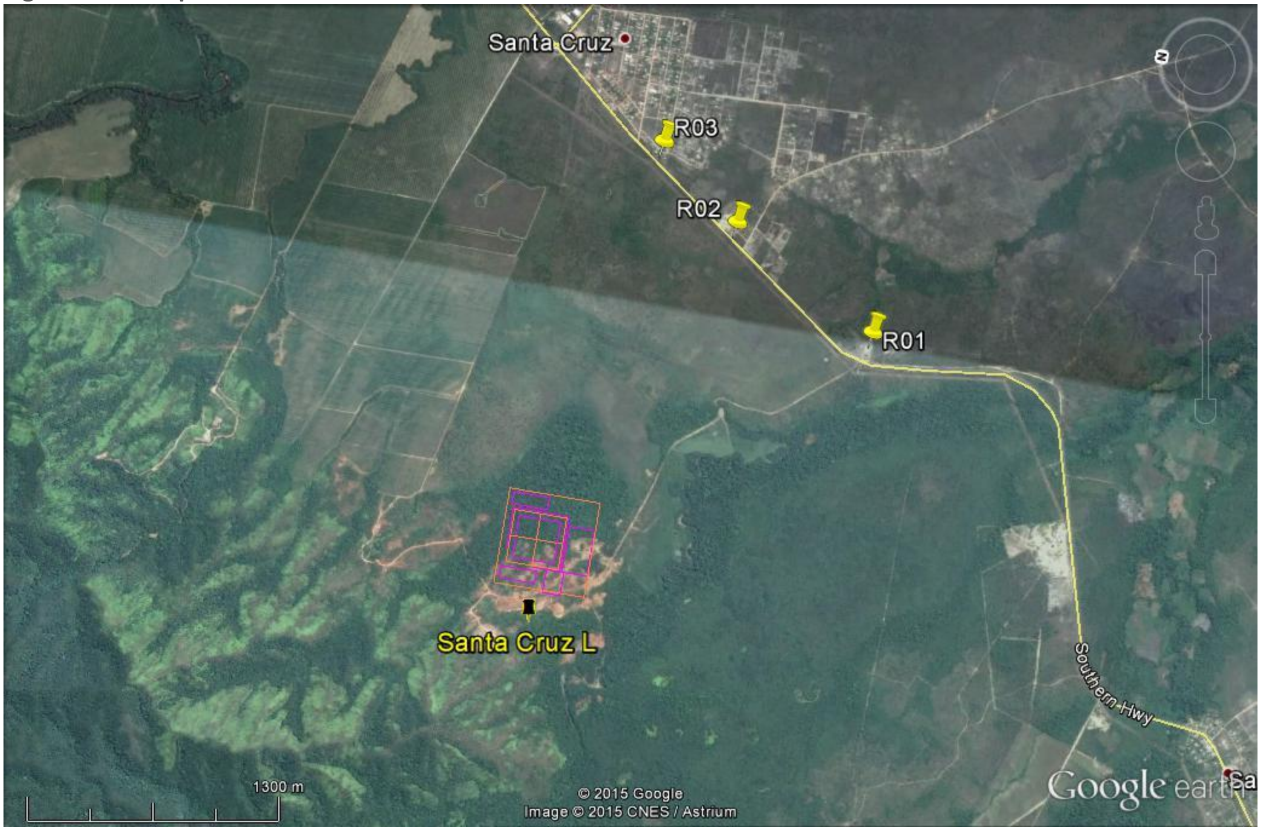
31.8.3.3.1.1 *Emissions and diffusion of air pollutants*

The receptors being considered are listed in Table 149 and shown in Figure 73.

Table 149 – Receptors

Receptor	UTM 16 coordinates		Distance (m)	Description
R01	346719 (x)	1845545 (y)	1,900	outlying house (residential/rural)
R02	347214 (x)	1846415 (y)	1,870	outlying group of houses (residential/rural)
R03	347603 (x)	1846906 (y)	2,100	Santa Cruz

Figure 73 - Receptors



Construction phase

In the following table the main source characteristics used in the diffusion modelling are listed:

Table 150 – Source characteristics

geographical coordinates (UTM 16) (m)	345028 (x)	1847428 (y)
	345576 (x)	1847428 (y)
	345576 (x)	1846906 (y)
	345030 (x)	1846906 (y)
source surface (m^2)	285,505	
height of point of emission (m)	1	

Modelling results

Table 151 – Modelling results

Receptor	Estimated PM_{10} conc ($\mu g/m^3$)	PM_{10} Concentration limit[43] ($\mu g/m^3$),	Estimated NOx conc ($\mu g/m^3$)	NOx Concentration limit[44] ($\mu g/m^3$)	Estimated CO conc (µg/cm)	CO Concentration limit[45] ($\mu g/m^3$)
R01	1.50	200	0.22	80	0.25	2,000
R02	0.63		0.09		0.11	
R03	0.57		0.04		0.05	

The results of the modelling are compared to the Concentrations of Permitted Air Contaminant as per the "Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, Chapter 238 Pollution Regulation", Regulation 6, First Schedule, as shown in Table 137. **All the evaluated concentrations, PM_{10} e NO_x and CO are below the allowed specific limits.**

The spatial distributions of the diffusion of pollutants are shown in Figure 74, Figure 75, Figure 76.

[43] As per "Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, Chapter 238 Pollution Regulation", Regulation 6, First Schedule

[44] As per "Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, Chapter 238 Pollution Regulation", Regulation 6, First Schedule

[45] As per "Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, Chapter 238 Pollution Regulation", Regulation 6, First Schedule

Figure 74 – Spatial distribution of PM_{10} diffusion (µg/cm)

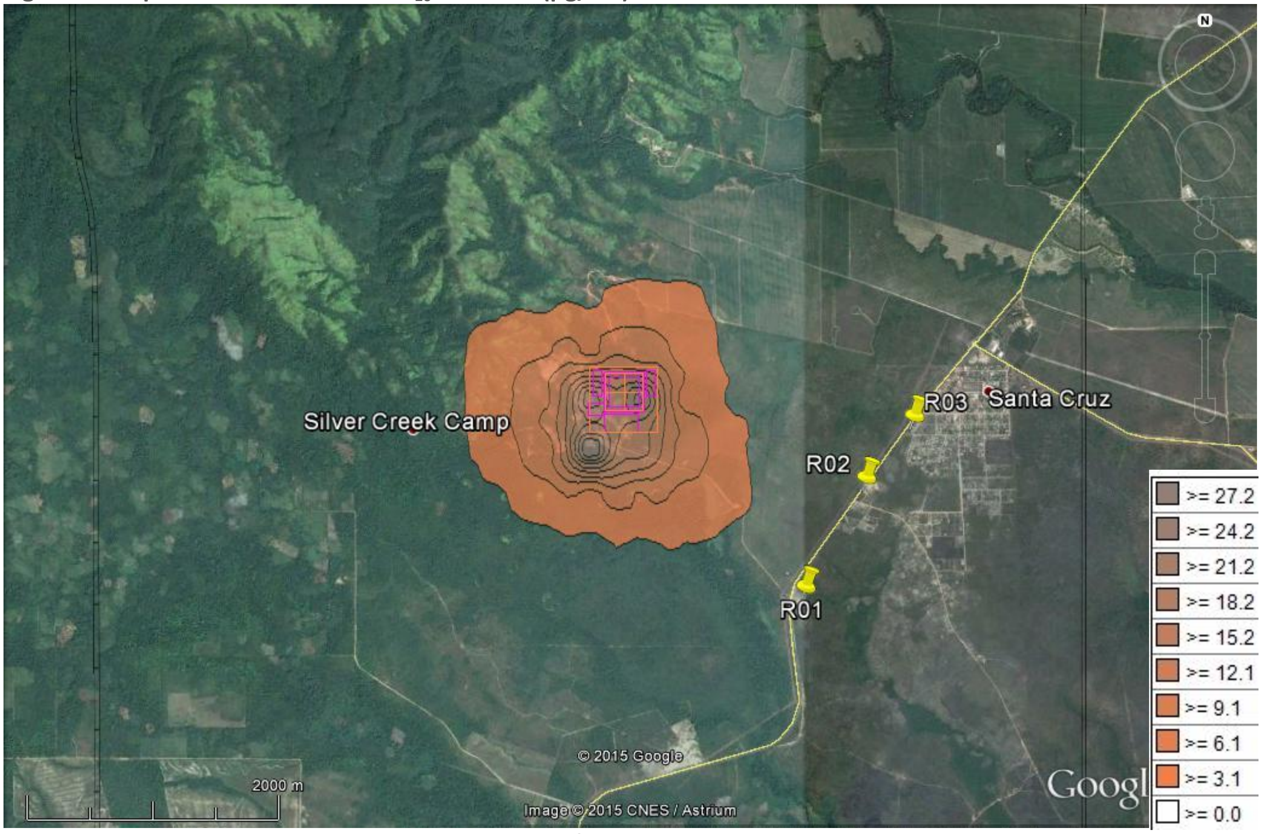


Figure 75 – Spatial distribution of NOx diffusion (µg/cm)

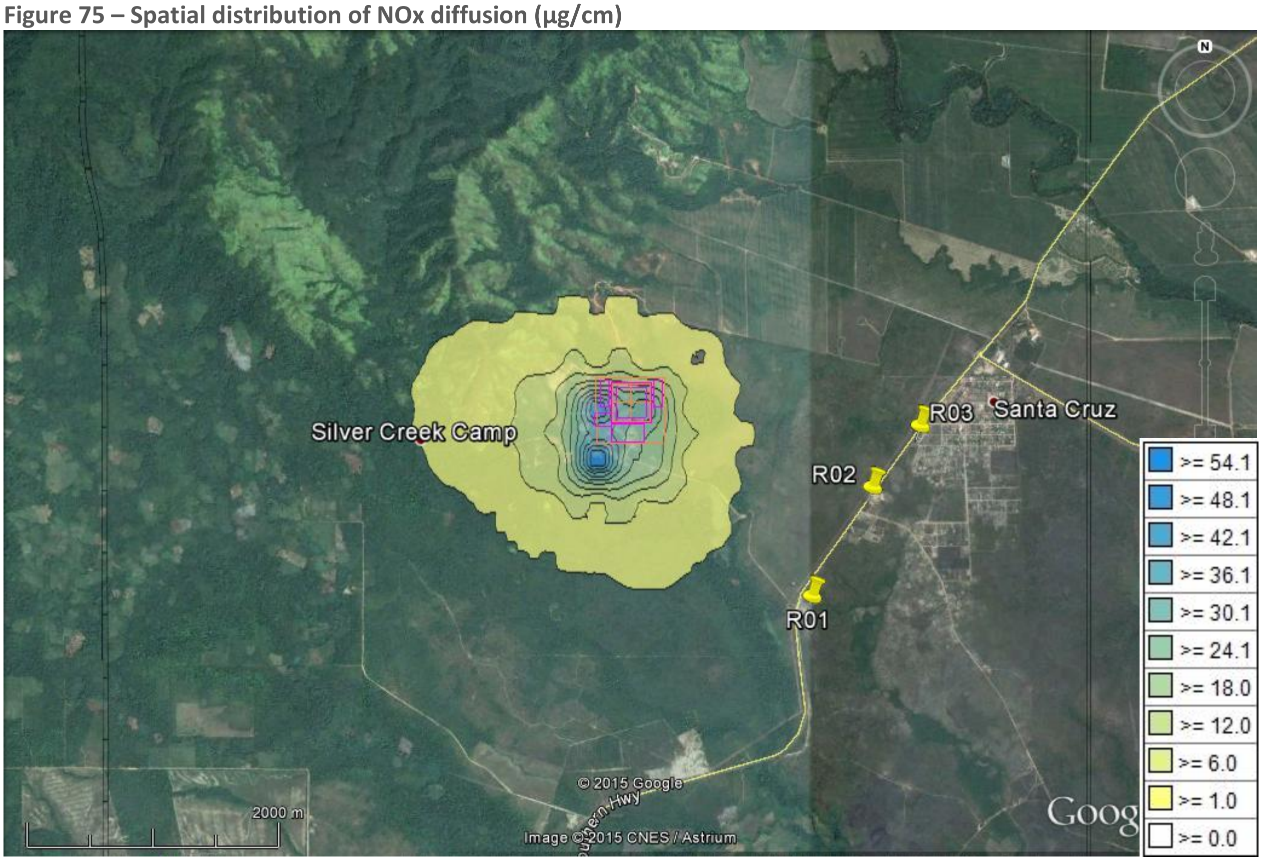
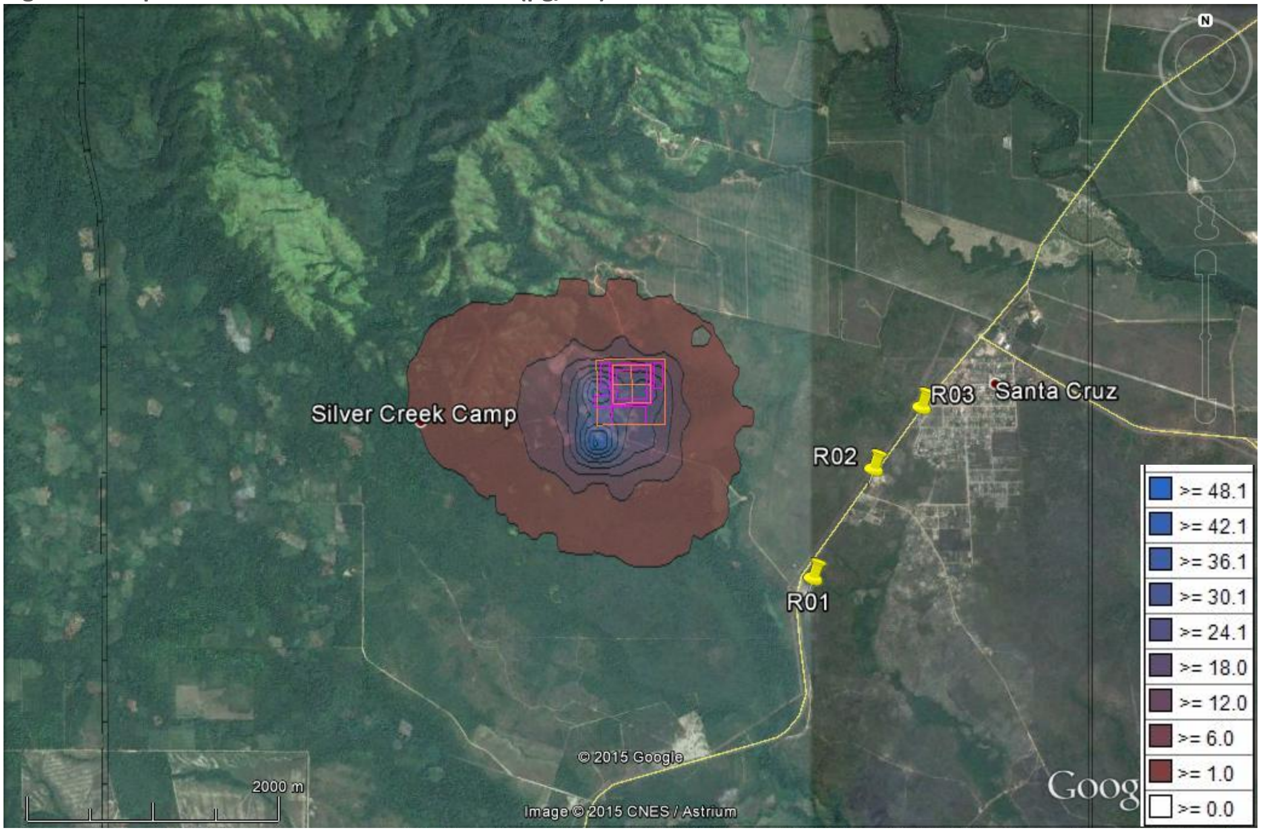


Figure 76 – Spatial distribution of CO diffusion (µg/cm)



Operation phase

In the following table the main source characteristics used in the diffusion modelling are listed:

Table 152 – Source characteristics

geographical coordinates (UTM 16) (m)	345160 (x)	1847379 (x)
	345309 (x)	1847380 (x)
	345310 (x)	1847229 (x)
	345160 (x)	1847230 (x)
source surface (m^2)	22,500	
height of point of emission (m)	9	

Modelling results

Table 153 – Modelling results

Receptor	Estimated PM_{10} conc ($\mu g/m^3$)	PM_{10} Concentration limit[46] ($\mu g/m^3$),	Estimated NOx conc ($\mu g/m^3$)	NOx Concentration limit[47] ($\mu g/m^3$)	Estimated CO conc (µg/cm)	CO Concentration limit[48] ($\mu g/m^3$)

[46] As per "Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, Chapter 238 Pollution Regulation", Regulation 6, First Schedule

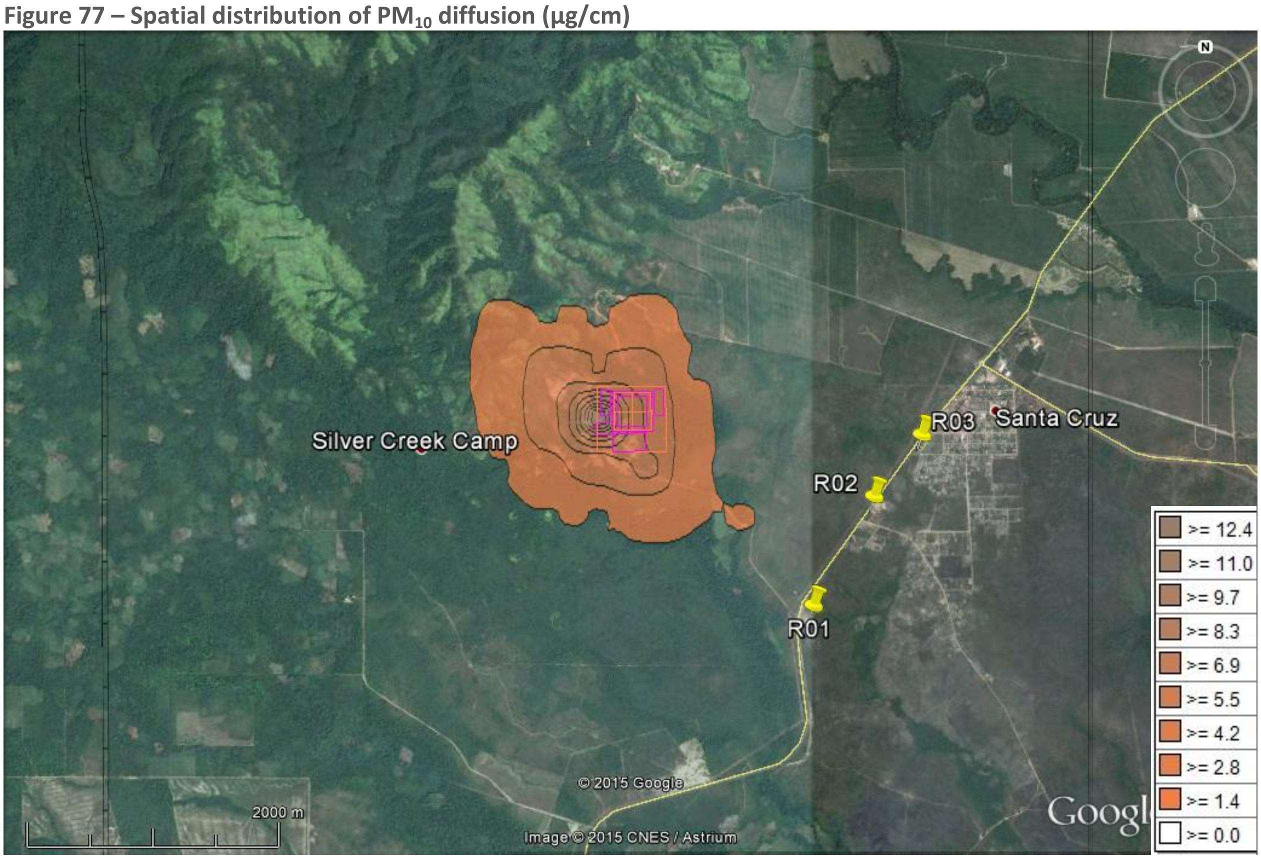
R01	0.72	200	0.10	80	0.09	2,000
R02	0.27		0.05		0.04	
R03	0.12		0.02		0.02	

The results of the modelling are compared to the Concentrations of Permitted Air Contaminant as per the "Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, Chapter 238 Pollution Regulation", Regulation 6, First Schedule, as shown in Table 39.

All the evaluated concentrations, PM_{10} e NO_x and CO are below the allowed specific limits.

The spatial distributions of the pollutants diffusion are shown in Figure 77, Figure 78, Figure 79.

Figure 77 – Spatial distribution of PM_{10} diffusion (μg/cm)



[47] As per "Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, Chapter 238 Pollution Regulation", Regulation 6, First Schedule

[48] As per "Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, Chapter 238 Pollution Regulation", Regulation 6, First Schedule

Figure 78 – Spatial distribution of NOx diffusion (µg/cm)

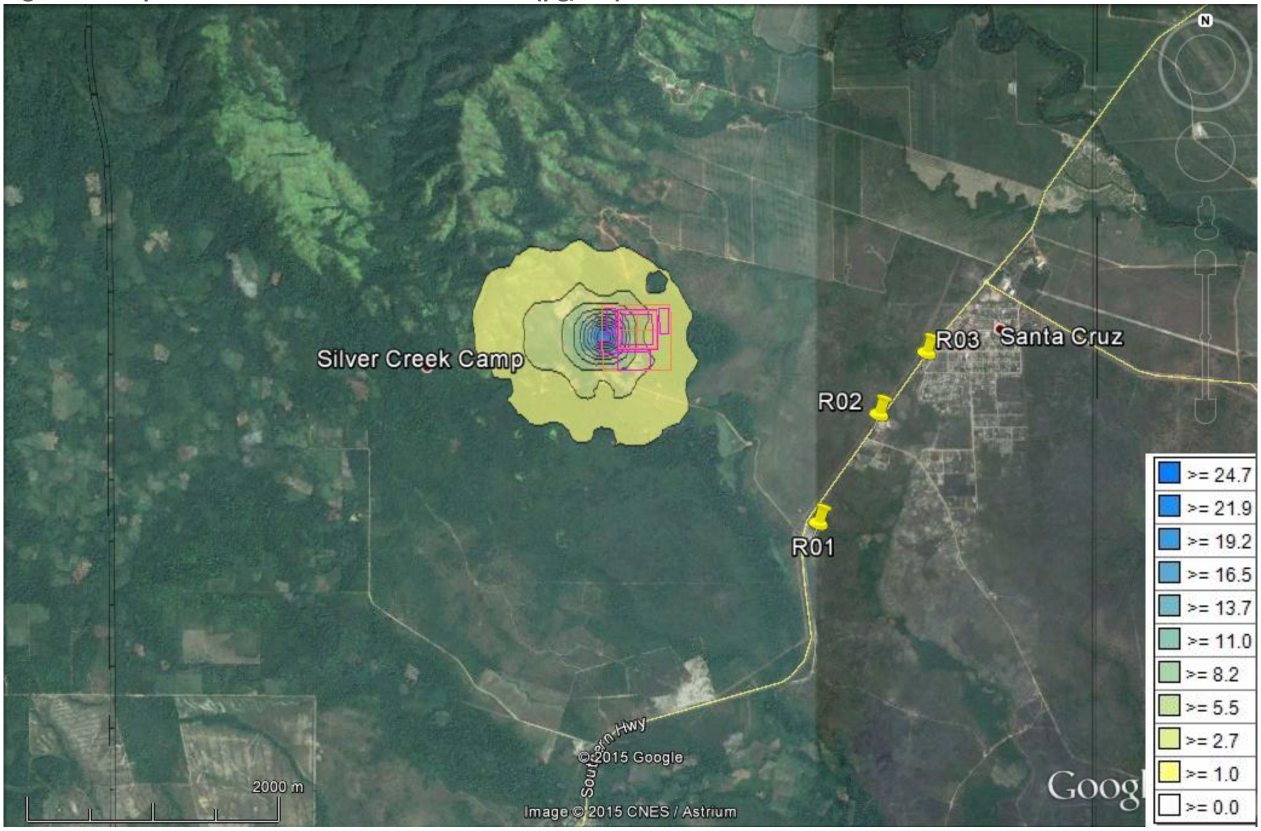
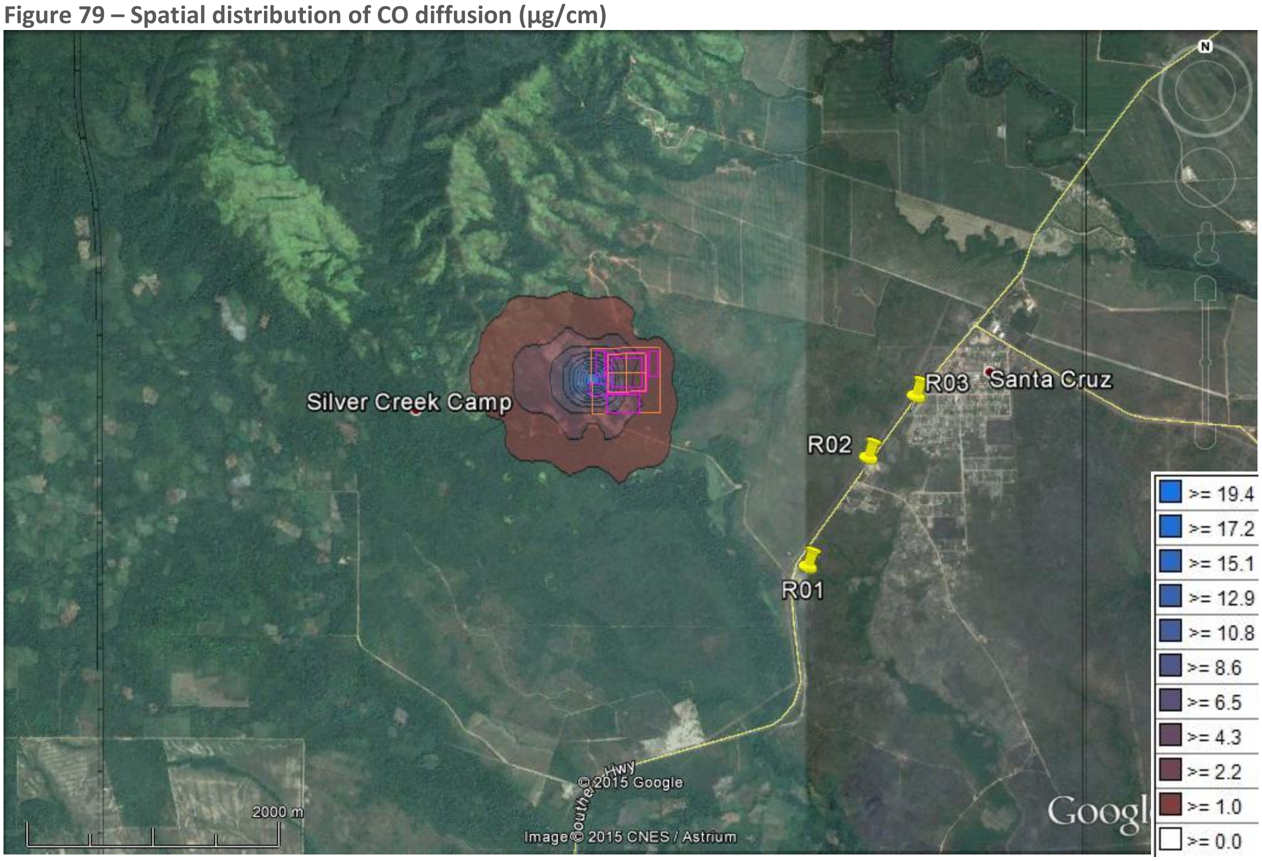


Figure 79 – Spatial distribution of CO diffusion (µg/cm)



In all the sites considered, the pollutants concentrations at the identified receptors do not exceed the threshold values allowed by the related law.
The climate characteristics (wind direction and intensity, humidity …), the site morphology and for the most part, the significant distances of the receptors from the landfill lead to a reduction of this impact below the values allowed by the related law.

31.8.3.3.1.2 *Diffusion of methane*

In the following table the main source characteristics used in the diffusion modelling are listed:

Table 154 – Source characteristics

geographical coordinates (UTM 16) (m)	345189 (x) 1847356 (y) 345433 (x) 1847342 (y) 345424 (x) 1847110 (y) 345188 (x) 1847108 (y)
source surface (m^2)	57,600
height of point of emission (m)	9
emission factor (g/s)	91.17

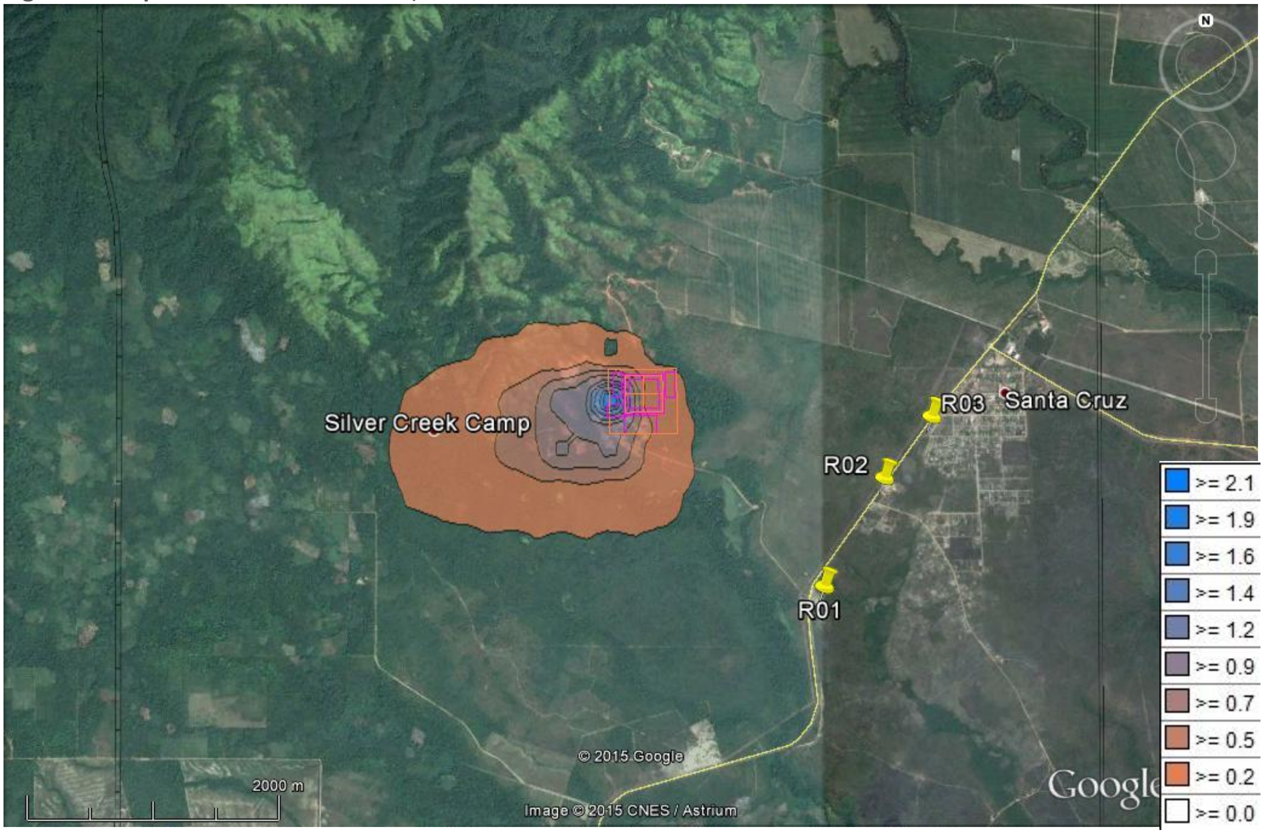
The receptors considered are showed in the previous paragraph, in the following table the modelling results are shown.

Table 155 – Modelling results

Receptor	Estimated CH4 concentration (mg/m^3)
R01	0.03
R02	0.02
R03	0.01

The spatial distributions of the diffusion of pollutants are shown in Figure 80.

Figure 80 – Spatial distribution of CH_4 diffusion



There are not any laws in Belize dealing with the allowed concentration of this pollutant in air, and no different references have been found.

All the evaluations have been made assuming the maximum CH_4 emission value, and for the most part, the concentrations estimated at the receptors are very low.

31.8.3.3.2 Emission of odour nuisance

In the following table the main source characteristics used in the diffusion modelling are listed:

Table 156 – Source characteristics

geographical coordinates (UTM 16) (m)	345189 (x) 1847356 (y) 345433 (x) 1847342 (y) 345424 (x) 1847110 (y) 345188 (x) 1847108 (y)
source surface (m^2)	57,600
height of point of emission (m)	9
emission factor (ou_E/s)	8.2

The receptors considered are showed in the previous paragraph, in the following table the modelling results are shown.

Table 157 – Modelling results

Receptor	C_{98} (98 percentile of hourly average) OU_E/m^3
R01	2.26
R02	0.79
R03	0.39

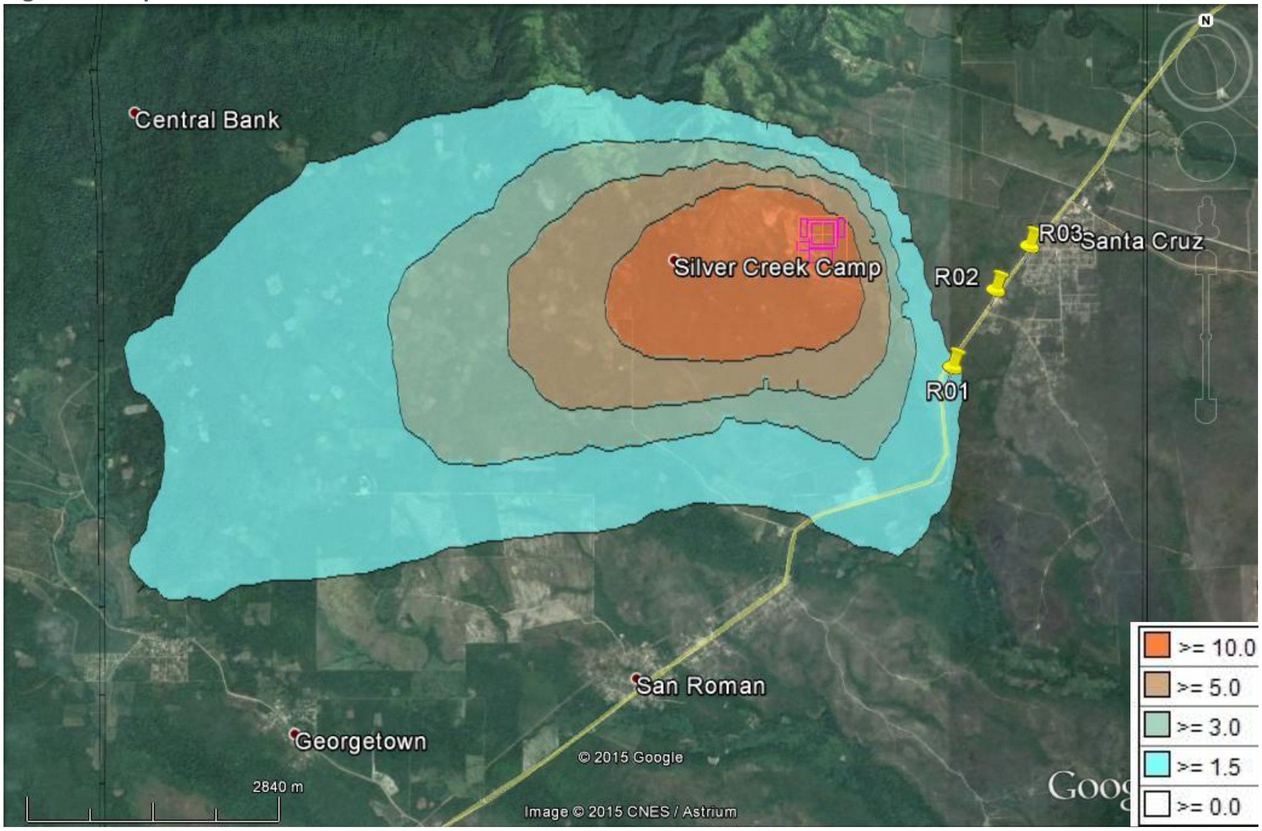
The assessment results are shown in Table 144.

Table 158 – Assessment results

Receptor	Sensitivity	C_{98} (98 percentile of hourly average) OU_E/m^3	priority
R01	low	2.26	Negligible
R02		0.79	Negligible
R03	medium	0.39	Negligible

The spatial distributions of the C_{98} diffusion are shown in Figure 81.

Figure 81 – Spatial distribution of odour diffusion



31.8.3.3.3 Noise levels in the area surrounding the landfill

Table 159 – Sound pressure estimation

Receptor	Source	Source sound pressure level [dBA]	Distance of reference [m]	Distance between source and receptor [m]	Attenuation [dB]	Sound pressure at receptor [dBA]	Total sound pressure at receptor [dBA]
R02	CONSTRUCTION						
	S1	80	16	1870	41.4	38.6	**51.9**
	S2	85	16	1870	41.4	43.6	
	S3	85	16	1870	41.4	43.6	
	S4	88	16	1870	41.4	46.6	
	S5	88	16	1870	41.4	46.6	
	S6	80	16	1870	41.4	38.6	
	OPERATION						
	S3	85	16	1870	41.4	43.6	**50.9**
	S4	88	16	1870	41.4	46.6	
	S5	88	16	1870	41.4	46.6	
	S6	80	16	1870	41.4	38.6	

The values of the sound pressure calculated at the receptor are compared with the noise level limits as per "*Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, Chapter 238 Pollution Regulation*", Regulation 42, Second Schedule. It has to be noticed that, as per Second Schedule definitions, the receptor considered is a "Structure B" and the duration of noise is "more than 3 hours, and less than 9 hours".

Table 160 – Noise pressure levels comparison

Phase	Noise pressure at the receptor (dBA)	Noise level as per pollution regulation
Construction	51.9	70
Operation	50.9	70

In every phase considered the noise pressure levels at the considered receptor is lower than the allowed limit.

31.8.3.4 Soil, ground and surface water quality

31.8.3.4.1 Accidental spillage or leakage of fuel may cause soil or ground/surface water contamination

The potential impacts on the receptors "Soil" and "Ground and surface water quality**"** are assessed together. The soil or water contamination can be caused by accidental spillage or leakage of fuel from the vehicles utilized for the construction of the plant and the waste handling or from the fuel storage tank.

Taking into account:

- the modest amount of fuel contained in the tank of the vehicles;
- the fuel storage tank shall have an impermeable containment structure for collecting the fuel in the event of a spill;
- the possibility of confining the spillage/leakage, mitigating the diffusion of liquid;

The intensity of this impact can be assumed as "negligible", the duration of the impact "short term" and the spatial extent "localized". In regards to the probability, it is worth noting that the spillages or leakages would be accidental, so the probability of the impact can be assumed as "unlikely".

Therefore the potential impact of "*Accidental spillage or leakage of fuel may cause soil or ground/surface water contamination"* has a low priority.

31.8.3.4.2 Accidental leakage of leachate can seep through the soil and ground water.

The potential impacts on the receptors "Soil" and "Ground and surface water quality**"** are assessed together. The soil or water contamination can be caused by accidental leakage from the bottom of the landfill or from the leachate treatment lagoons.

The site lies on the Santa Rosa Group area characterized by the metamorphic rocks and also including argillite. This latter impervious lithology seems to be prevalent on the site. This soil would be suitable for the siting of a landfill, but this area, located between the foothills and

approximately, the highway, is identified by some studies as the recharging area of the main regional aquifer[49] and therefore unsuitable for the location of a landfill.
Taking into account all these aspects, the intensity of this impact can be assumed as "severe". The duration of the impact depends on the source of the leachate leakage, a spillage from the bottom of the landfill, in fact, can have a duration assessed as "long term".
The spatial extent can be assumed as "far-range".
The probability of this impact, considering the artificial barriers foreseen in order to reduce the likelihood of leachate leakage, is "unlikely".

Therefore the potential impact of "*Accidental leakage of leachate can seep through the soil and ground water"* has a high priority.

31.8.3.4.3 Accidental failure of leachate treatment can affect the surface water quality

An accidental failure of the leachate treatment could cause the discharge of effluent containing pollutants in concentrations exceeding the threshold values allowed by the laws and so compromising the quality of the surface water of the watercourse where the effluent is discharged into.
Taking into account the possible high sensitivity of the surface water, the intensity of this impact can be assumed as "notable". The duration of the impact "short term".
The spatial extent can be assumed as "mid-range".
The probability of this impact, considering the monitoring of effluent quality that shall be conducted and the possibility to recirculate the effluent, is "unlikely".

Therefore the potential impact of "*Accidental failure of leachate treatment can affect the surface water quality"* has a medium priority.

31.8.3.5 Flora and fauna

31.8.3.5.1 Potential indirect impacts related to the deterioration of the quality of air, of soil or of ground and surface water

As underlined above, the present environmental impacts assessment is referred to a preliminary stage of the SWM system, so the assessment itself is at a preliminary level. In particular, in this phase, the sensitivity of the flora and fauna to the impacts due to waste transportation, has not been determined. Therefore the priority of these indirect impacts is assessed without considering the specific sensitivity of the different receptor species, but following the evaluations already conducted about the impacts on the quality of soil, surface and ground water and air.

So, in general terms, *the potential indirect impacts related to the deterioration of the quality of air, of soil or of ground and surface water* have a high priority.

The results of the assessments are summarized in Table 133.

---

[49] Assessment of Groundwater Resources in the Southern Coastal Water Province of Belize Referred to as Savannah Groundwater Province – GEOMEDIA Ltd, September 2014

Table 161 – Santa Cruz site - Potential impacts assessment

Landfill	Landscape and natural scenery	Intensity	Duration	Spatial extent	Probability	Priority
All the phases	Alteration of the landscape	severe	long-term	far-range	definite	**high**
Landfill	**Archaeological, cultural and historical resources**					
All phases	Damage to the site	severe	short-term	localized	possible	**medium**
Landfill	**Air quality and climate**					
All the phases	Emissions and diffusion of air pollutants and greenhouse gases					
	Increasing of noise levels in the area surrounding the landfill					
Operation	Emissions and diffusion of odour from the waste handling operations and from the leachate treatment					
Landfill	**Soils**					
All the phases	Accidental spillage or leakage of fuel from vehicles/storage tank may cause soil contamination	negligible	short-term	localized	unlikely	**low**
Operation, Closure, After care	Accidental leakage of leachate can seep through the soil and ground water contaminating soil	severe	long-term	far-range	unlikely	**high**
Landfill	**Ground and surface water quality**					
All the phases	Accidental spillage or leakage of fuel from vehicles/storage tank may cause surface water contamination	negligible	short-term	localized	unlikely	**low**
Operation, Closure, After-care	Accidental leakage of leachate can seep through the soil and ground water contaminating soil and waters (Ground and Surface)	severe	long-term	far-range	unlikely	**high**
	Accidental failure of the leachate treatment system can affect the surface water quality	notable	short-term	mid-range	unlikely	**medium**
Landfill	**Flora and fauna**					
All the phases	Potential indirect impacts related to the deterioration of the quality of air, of soil or of ground and surface water	severe	long-term	mid-range	unlikely	**high**

31.9 Semi aerobic landfills environmental impacts conclusions and recommendations

In the present section evaluations has been carried out in order to assess and compare the environmental impacts due to the construction and operation of a semi-aerobic landfill in the different locations that have come out from the site screening process, and listed below:

- Northern Corridor: Consejo and San Estevan;
- Southern Corridor: Santa Cruz.

The potential impacts assessment has been made in two different steps:

- potential impacts identification;
- rating of the priority of each identified potential impact.

The outcomes of the evaluation conducted indicate that the highest priority potential impacts, in all the sites being considered, are:

- Alteration of the landscape;
- Accidental leakage of leachate can seep through the soil and ground water contaminating soil;
- Accidental leakage of leachate can seep through the soil and ground water contaminating soil and waters (Ground and Surface);
- Potential indirect impacts related to the deterioration of the quality of air, of soil or of ground and surface water.

In all the considered sites the same environmental concerns have been identified, and the outcomes of the assessment point out that none of the sites is totally suitable for a landfill construction/operation. The major environmental issue is due to the likelihood of impairing the quality of soil and water, reducing the chance to exploit available drinking water supplies and compromising the natural habitats in a wide area around the sites.

31.10 Financial aspects

In 2015, an estimated 25% of the total population of the four districts in the study area resides in the four district Capital towns (see Table 162). By including the villages within a radius of 10 km of these towns and those around the villages of Independence and Palencia, 43% of the district population would be concentrated in and around these six population centres. The remaining 57% of inhabitants live in the other (rural) parts of the four districts,

Table 162: Estimated population in the four districts of the project area (2015)

Location	Corozal District	Orange Walk District	Stann Creek District	Toledo District	Total	%
District Capital Town	11,753	14,588	10,281	5,870	42,493	25%
Village within 10 km of District Capital	9,391	9,860	739	1,337	21,328	12%
Total Main Agglomerate	***21,144***	***24,448***	***11,020***	***7,208***	***63,820***	**37%**
Other agglomerates	-	-	9,685	-	9,685	6%
Population living outside agglomerates	25,004	25,327	30,541	27,850	99,037	57%
Total District	**46,148**	**49,776**	**41,561**	**35,058**	**172,542**	**100%**

Notes:
1. Population projections calculated based on SIB census data from 2010.
2. Other agglomerate refers to: Independence and Placencia

The proposed waste management system is structured around six transfer stations (see Table 163) located in these main six population centres found in the two corridors, denominated as so-called *agglomerates*.
Each transfer station serves as a central point for receiving the collected waste[50] from the adjacent town (or village as is the case of Independence and Palencia) and the villages within a 10 km radius from that population centre.

Table 163: Description of the proposed Transfer Stations

District	Locality	Brief description of Location
Corozal District	Corozal Town	Along the Chan Chen Road, 3 km off the Town limits (present location of the Slaughterhouse). National Land
Orange Walk District	Orange Walk District	2.5 km from the Northern Highway south of Orange Walk Town, present location of the Orange Walk Dumpsite. The parcel is owned by ASR-BSI that expressed interest to hand it over to the Government for the purpose.
Stann Creek District	Dangriga	Along the Southern Highway, 1 km south of the Hummingbird Highway junction. Adjacent to the present Dangriga Dumpsite. Land owned by the Dangriga Town Council and available for the project.
Stann Creek District	Placencia	Presently foreseen at the Placencia Dumpsite location. A more suitable site closer to the peninsula is currently being sought.
Stann Creek District	Independence	Along the Southern Highway, 1 km south of the Independence Road junction. Present location of the Independence Dumpsite. The site, formerly a marginal part of the Mango Creek Forest Reserve, has been now de-reserved.
Toledo District	Punta Gorda	Along the Barranco Road, 16 km from Punta Gorda Town limits. Land owned by SWaMA.

The remaining 65-75% live in the rural areas in almost 200 villages located either along one of the highways that trisects Belize from North to South, or spread-out over the hinterlands of the districts. To attend the population in these districts, the construction of 69 *drop-off centres (DOC)* is foreseen (see Table 164), where the inhabitants of the villages (and of adjacent villages) can bring their solid waste at their own costs. At the drop-centre, the waste is deposited into at least three roll-off containers as follows: organic material, recyclables and the residual fraction. In those (mainly larger) villages where there is no composting done at home, an additional composting facility (CF) will be located at the site of the drop-off centre (*DOC_CF)* where the organic fraction is composted. Once the roll-off container of the residual fraction is full, it will be collected and the waste transported to the nearest transfer station.

Table 164: Number of Drop-Off Centres + Composting Facilities (DOC_CF) and Only Drop-Off Centre per District

District	DOC_CF	DOC	Total
Corozal	13	5	18
Orange Walk	10	4	14
Stann Creek	11	5	16
Toledo	9	12	21
Total	**43**	**26**	**69**

[50] The actual collection of the waste generated in the urban areas (and the associated costs) does not form part of the scope of the consultancy.

The conceptual design of each transfer station considers the option that recyclers can have access to the collected waste that is received from the *agglomerates* and the DOC´s and DOC_CFs, so as to recover recyclables prior to the waste being uploaded into a transfer trailer for transportation to the sanitary landfill for final disposal.

The final destination of the collected solid waste will be a sanitary landfill, with the main alternatives being a) making use of the national sanitary landfill located at Mile 24 in the Western Corridor by expanding it with the necessary new cells to accommodate for the waste, and/ or b) constructing a new (regional) sanitary landfill in the northern corridor and /or southern corridor.

Currently the collected waste in the corridors is either dumped at the authorized open dumps found in the towns and in Independence and Placencia or at the outskirts of the villages in the rural areas.
The dumpsites (see Table 165) located in these six populations centres will remediated

Table 165: Location of dumpsites that will be remediated

District	Location of dumpsite	Brief description of dumpsites to be remediated
Corozal District	Consejo Road	15 acres of flood prone area. About 15,000 cubic meters of waste piles irregularly deposited on the ground. Private land.
Orange Walk District	Chan Pine Ridge	40 acres irregularly covered by about 15,000 cubic meters waste piles deposited on top of the ground. Land owned by ASR/BSI
Stann Creek District	Dangriga	6 acres parcel entirely covered by excavated trenches backfilled with waste. Land is the property of the Dangriga Town Council.
Stann Creek District	Placencia	The official dumpsite is a 6 acres area where the waste is deposited in excavated trenches. Waste piles are also present along the access road and in two nearby areas. The land is private owned.
Stann Creek District	Independence	Waste is deposited in excavated trenches spread over a 4 acres area. The land formed part of the Mango Creek Forest Reserve now de-reserved.
Toledo District	Punta Gorda	Waste is deposited in a single mass about 8 acres wide in a low lying area. More waste piles are present along the access road. The land is private owned.

31.10.1 Least cost analysis

As part of the Solid Waste Master Plan for Emerging Tourism Areas, a least cost analysis was conducted based on the conceptual designs of the different facilities for processing the collected solid waste generated in the districts of the northern and southern corridors.

This section will discuss this costs analysis considering different scenarios (see Table 166) for the transfer and disposal of the solid waste generated in the districts, with the primary variable being the destination for final disposal of the collected solid waste from the two districts in each corridor. In both cases, the option of transferring the solid waste to the already operating landfill in Mile 24 (Western Corridor) is compared to transporting the waste to one of two alternatives for a regional landfill located in the respective corridor.

Table 166: Overview of base scenarios compared

Northern Corridor	Southern Corridor
Scenario -1 - Landfill Mile 24	Scenario -1 - Landfill Mile 24
Scenario -2a – Regional Landfill Consejo, Corozal District	Scenario -2a – Regional Landfill Santa Cruz, Stann Creek District
Scenario -2b Regional Landfill San Estevan, Orange Walk District	Scenario -2b - Regional Landfill San Juan, Stann Creek District

The table below shows the four main combinations that are possible when combining the scenarios of the northern and southern corridor.

Corridor	COMBINATION A	COMBINATION B	COMBINATION C	COMBINATION D
Northern Corridor	Transfer to National Landfill Mile 24	Regional Landfill	Regional Landfill	Transfer to National Landfill Mile 24
Southern Corridor	Transfer to National Landfill Mile 24	Regional Landfill	Transfer to National Landfill Mile 24	Regional Landfill

Because the costs for the two different scenarios in each corridor are allmost the same only the regional scenario with the highest costs in each corridor is used for comparison purposes.

Each scenario includes the following costs related to the components of the proposed solid waste management system:

- Costs related to final disposal (either a regional landfill in the Northern or Southern corridor, or using the sanitary landfill currently operational in Mile 24 in the Western Corridor).
- Costs related to the construction and operation of a number of transfer stations (two in the Northern Corridor and three in the Southern Corridor).
- Costs related for each Corridor to the transportation of waste from each of the Transfers station to the specific Landfill.
- Costs related to the construction and operation of a number of Drop-off Centres with Composting Facilities and Drop-off Centres without Composting Facilities in each of the districts in the two corridors.
- Costs related to transporting waste from the Drop-off Centres (with and without Composting Facilities) to the nearest Transfer Station in each district in the two corridors.
- Costs related to the construction and operation of *Transfer System in the Placencia Peninsula* in the Southern Corridor.

The least cost analysis considered a 25-year design period from 2016-2040 to determine the net present value (NPV) of the different combination of scenarios. Table 167 provides a comparison of the NPV[51] of all investment costs (infrastructure + equipment) during 2017-2040 related to:

[51] Discount rate of 12%

- Initial investment costs
- Purchase of new machinery and equipment as result of expansion of the system

Table 167: Comparison of NPV (US$) of all Investments during 25 years period brought back to 2017 value

Corridor	COMBINATION A	COMBINATION B	COMBINATION C	COMBINATION D
	Scenario -1 - Landfill Mile 24	Scenario -2: Two Regional Landfills	SC 2a/bRegional Landfill NC; SC 1 Mile 24 SC	SC 2a/bRegional Landfill SC; SC 1 Mile 24 NC
Northern Corridor	7,845,714	11,120,550	11,120,550	7,845,714
Southern Corridor	9,775,575	12,564,470	9,775,575	12,564,470
Total NC + SC (NPV)	**17,621,289**	**23,685,020**	**20,896,124**	**20,410,184**

Combination A, transporting the generated waste from both the northern corridor districts and southern corridor districts to the Mile 24 sanitary landfill, appears to have the more favourable NPV of the four combinations.

Table 168 compares the NPV for the different combination of scenarios for all investments together with OPEX and CAPEX to 2040. With this comparison Combination A also emerges as having the more favourable NPV.

Table 168: Comparison of NPV (US$) of all Investments + total OPEX + CAPEX during 25 years period brought back to 2017 value

Corridor	COMBINATION A	COMBINATION B	COMBINATION C	COMBINATION D
	Scenario -1 - Landfill Mile 24	Scenario -2: Two Regional Landfill	SC 2a/bRegional Landfill NC; SC 1 Mile 24 SC	SC 2a/bRegional Landfill SC; SC 1 Mile 24 NC
Northern Corridor	17,259,828	20,653,357	20,653,357	17,259,828
Southern Corridor	21,467,079	24,287,690	21,467,079	24,287,690
Total NC + SC (NPV)	**38,726,906**	**44,941,047**	**42,120,436**	**41,547,518**

Based on this comparison the recommended preferred option would be Combination A.

31.10.2 Detailed overview costs of selected preferred option

As discussed above, the selected preferred option would be combination A, in which for both corridors the collected waste is transferred from Transfer Stations and transported to Mile 24 for final disposal in the Sanitary Landfill located there

Table 169 gives an overview of the total initial investment costs for the required infrastructure[52] spread out of the period 2017-2021, differentiated:

- By corridor
- By urban and rural areas

Table 169: Overview of total initial investment costs for infrastructure for period 2017-2021

Cost Item	Initial Invest. Infrastructure	2017	2018	2019	2020	2021
Landfill Mile 24: Construction of additional cell to receive collected waste (urban and rural areas) from both Corridors	**2,517,926**	1,258,963	1,258,963			
Northern Corridor						
Transfer Station for Corozal Town	**852,895**	426,448	426,448			
Transfer Station for Orange Walk Town	**852,895**	426,448	426,448			
Remediation dumpsite Corozal	**331,749**	165,875	165,875			
Remediation dumpsite Orange Walk Town	**331,254**	165,627	165,627			
Southern Corridor						
Transfer Station Dangriga	**719,495**	359,748	359,748			
Transfer Station Independence	**719,495**	359,748	359,748			
Transfer Station Eldridgeville (Toledo District)	**719,495**	359,748	359,748			
Transfer System Placencia	**57,500**	28,750	28,750			
Remediation dumpsite Dangriga	**432,052**	216,026	216,026			
Remediation dumpsite Placencia	**155,127**	77,564	77,564			
Remediation dumpsite Independence	**203,940**	101,970	101,970			
Remediation dumpsite Punta Gorda	**532,950**	266,475	266,475			
Total Investment Infrastructure Urban Areas	**8,426,773**	**4,213,390**	**4,213,390**			
Infrastructure for Rural Areas in both Corridors						
Northern Corridor						
Drop_Off Centres + Composting Facility Corozal (13 Facilities)	**1,167,660**			389,220	389,220	389,220
DOCs + Composting Facility Orange Walk (10 Facilities)	**898,200**			299,400	299,400	299,400
Drop_Off Centres Only Corozal (5 Facilities)	**338,350**			112,783	112,783	112,783
Drop_Off Centres Only Orange Walk (4 Facilities)	**270,680**			90,227	90,227	90,227
Southern Corridor						
DOCs + Composting Facility Stann Creek District (11 Facilities)	**988,020**	-		329,340	329,340	329,340
DOCS + Composting Facility Toledo District (9 Facilities)	**808,380**	-		269,460	269,460	269,460
Drop_Off Centres Only Stann Creek (5 Facilities)	**338,350**	-		112,783	112,783	112,783
Drop_Off Centres Only Toledo (12 Facilities)	**812,040**	-		270,680	270,680	270,680
Total Investment Infrastructure Rural Areas	**5,621,680**			**1,873,893**	**1,873,893**	**1,873,893**
Total Investment Infrastructure Urban and Rural Areas	**14,048,453**	**4,213,390**	**4,213,390**	**1,873,893**	**1,873,893**	**1,873,893**
Total Investment Northern Corridor (Urban and Rural)	**6,302,646**	**1,813,880**	**1,813,880**	**891,630**	**891,630**	**891,630**
Total Investment Southern Corridor (Urban and Rural)	**7,745,807**	**2,399,511**	**2,399,511**	**982,263**	**982,263**	**982,263**

The following two graphs indicated the Annual OPEX (US$) for the Northern Corridor and the Southern Corridor, as well as the Annual CAPEX (US$) expressed in the year the actual replacement investment would need to be made. Figure 82 provides the figures both individually as jointly per Corridor.

Figure 82: OPEX and CAPEX of total waste management system of Northern Corridor of Combination A.

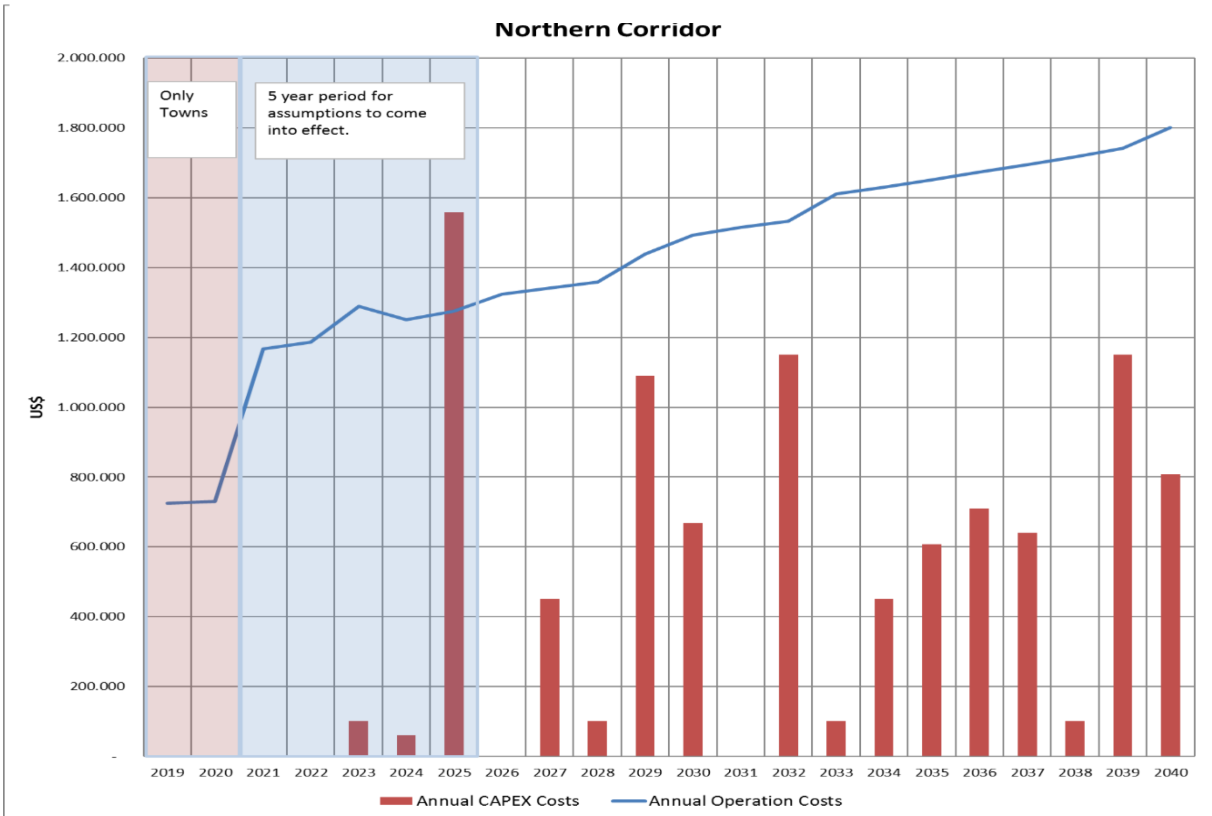


Figure 83: OPEX and CAPEX of total waste management system of Southern Corridor of Combination A.

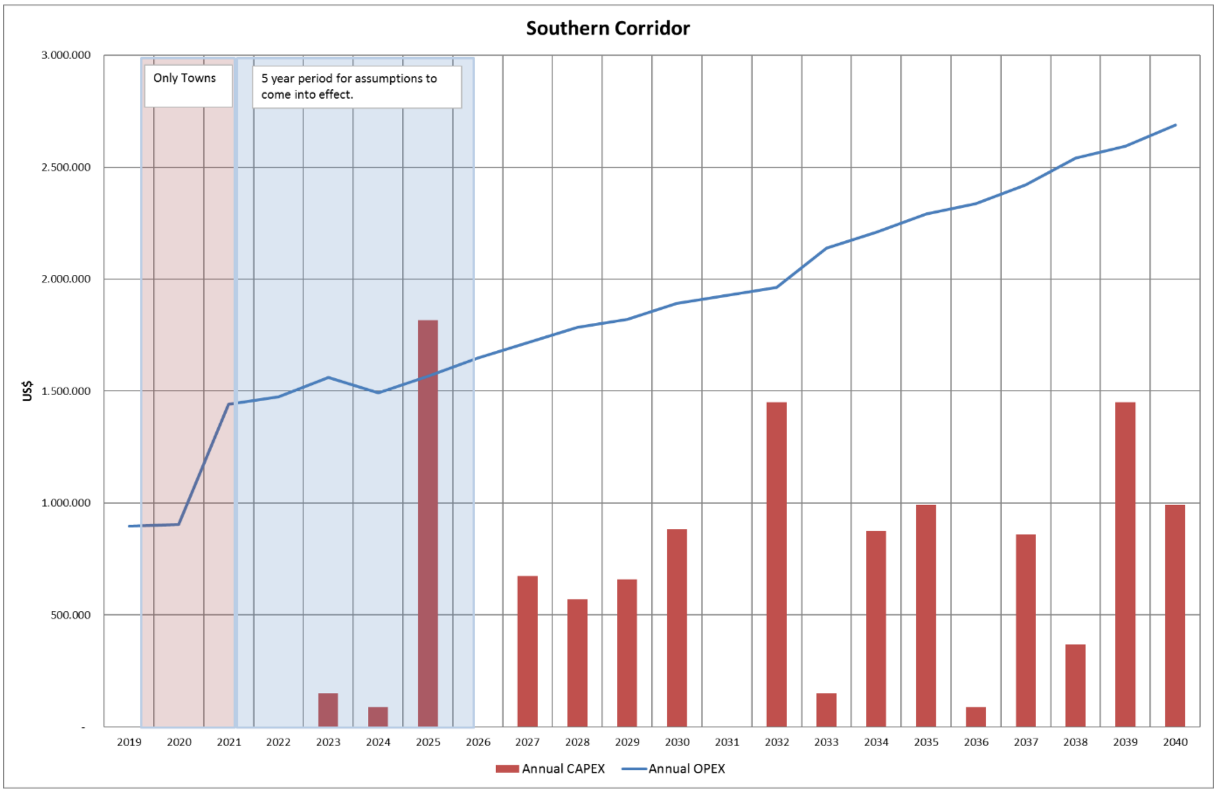
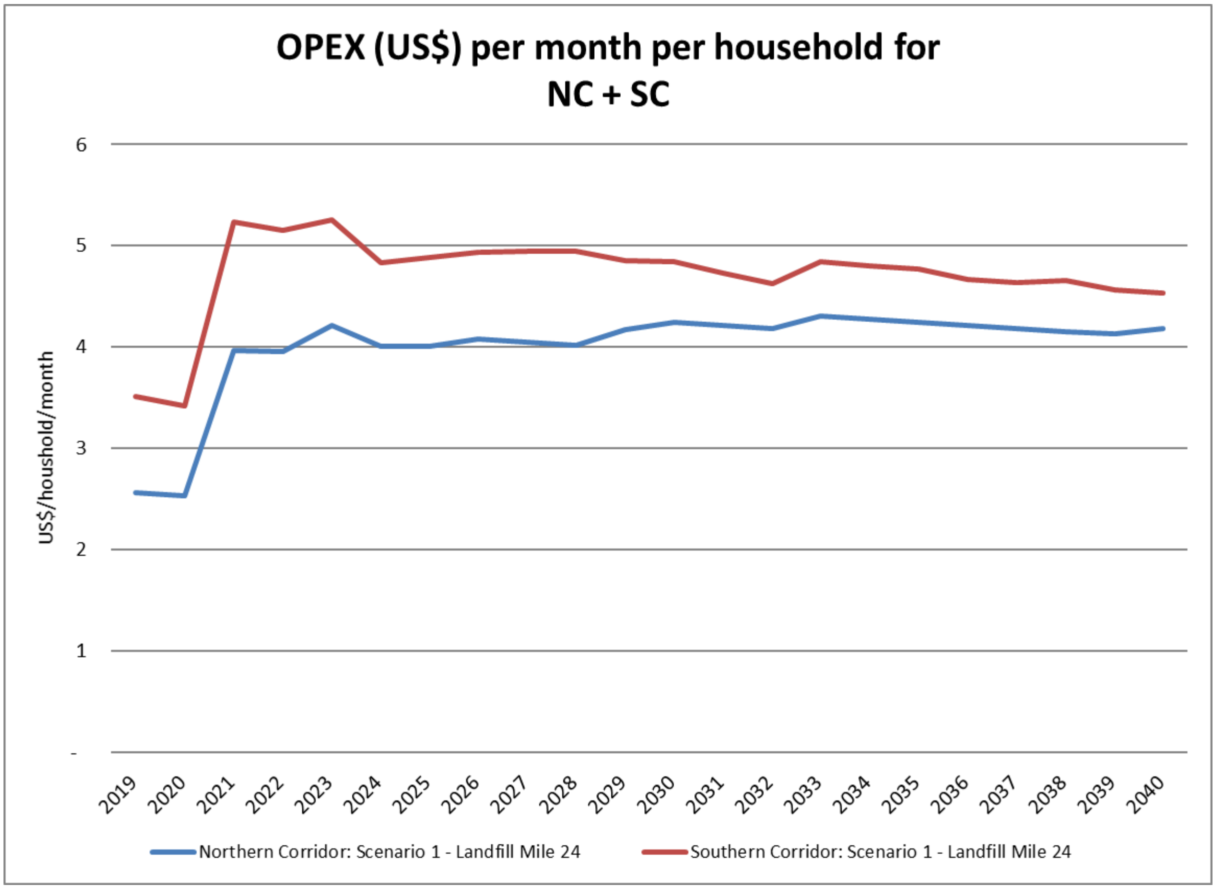


Table 170: OPEX and CAPEX for the Northern Corridor and Southern Corridor individually and jointly.

	Northern Corridor				Southern Corridor				Northern + Southern Corridor		
Year	OPEX	CAPEX	OPEX + CAPEX		OPEX	CAPEX	OPEX + CAPEX		OPEX	CAPEX	OPEX + CAPEX
2019	724,799	-	**724,799**		897,723	-	**897,723**		1,622,522		**1,622,522**
2020	731,033	-	**731,033**		905,613	-	**905,613**		1,636,646		**1,636,646**
2021	1,167,880	-	**1,167,880**		1,441,566	-	**1,441,566**		2,609,446		**2,609,446**
2022	1,187,067	-	**1,187,067**		1,473,487	-	**1,473,487**		2,660,554		**2,660,554**
2023	1,289,709	100,000	**1,389,709**		1,559,919	150,000	**1,709,919**		2,849,628	250,000	**3,099,628**
2024	1,250,575	60,000	**1,310,575**		1,492,184	90,000	**1,582,184**		2,742,759	150,000	**2,892,759**
2025	1,275,831	1,558,000	**2,833,831**		1,566,424	1,817,000	**3,383,424**		2,842,255	3,375,000	**6,217,255**
2026	1,324,461	-	**1,324,461**		1,646,887	-	**1,646,887**		2,971,348		**2,971,348**
2027	1,341,183	450,000	**1,791,183**		1,715,017	675,000	**2,390,017**		3,056,200	1,125,000	**4,181,200**
2028	1,358,454	100,000	**1,458,454**		1,785,304	570,000	**2,355,304**		3,143,758	670,000	**3,813,758**
2029	1,438,454	1,090,000	**2,528,454**		1,821,753	660,000	**2,481,753**		3,260,207	1,750,000	**5,010,207**
2030	1,493,044	668,000	**2,161,044**		1,891,793	882,000	**2,773,793**		3,384,837	1,550,000	**4,934,837**
2031	1,514,605	-	**1,514,605**		1,926,338	-	**1,926,338**		3,440,943		**3,440,943**
2032	1,533,378	1,150,000	**2,683,378**		1,962,878	1,450,000	**3,412,878**		3,496,256	2,600,000	**6,096,256**
2033	1,611,164	100,000	**1,711,164**		2,139,033	150,000	**2,289,033**		3,750,197	250,000	**4,000,197**
2034	1,631,145	450,000	**2,081,145**		2,211,018	875,000	**3,086,018**		3,842,163	1,325,000	**5,167,163**
2035	1,651,760	608,000	**2,259,760**		2,290,472	992,000	**3,282,472**		3,942,232	1,600,000	**5,542,232**
2036	1,673,027	710,000	**2,383,027**		2,336,293	90,000	**2,426,293**		4,009,320	800,000	**4,809,320**
2037	1,694,968	640,000	**2,334,968**		2,420,969	860,000	**3,280,969**		4,115,937	1,500,000	**5,615,937**
2038	1,717,604	100,000	**1,817,604**		2,539,581	370,000	**2,909,581**		4,257,185	470,000	**4,727,185**
2039	1,740,957	1,150,000	**2,890,957**		2,593,978	1,450,000	**4,043,978**		4,334,935	2,600,000	**6,934,935**
2040	1,801,215	808,000	**2,609,215**		2,687,760	992,000	**3,679,760**		4,488,975	1,800,000	**6,288,975**

The costs for households of the OPEX vary between 4 and 5 US$ per month per household, with the Northern Corridor at the lower end (see Figure 84).

Figure 84: OPEX per month per household in US$ for Northern and Southern Corridor

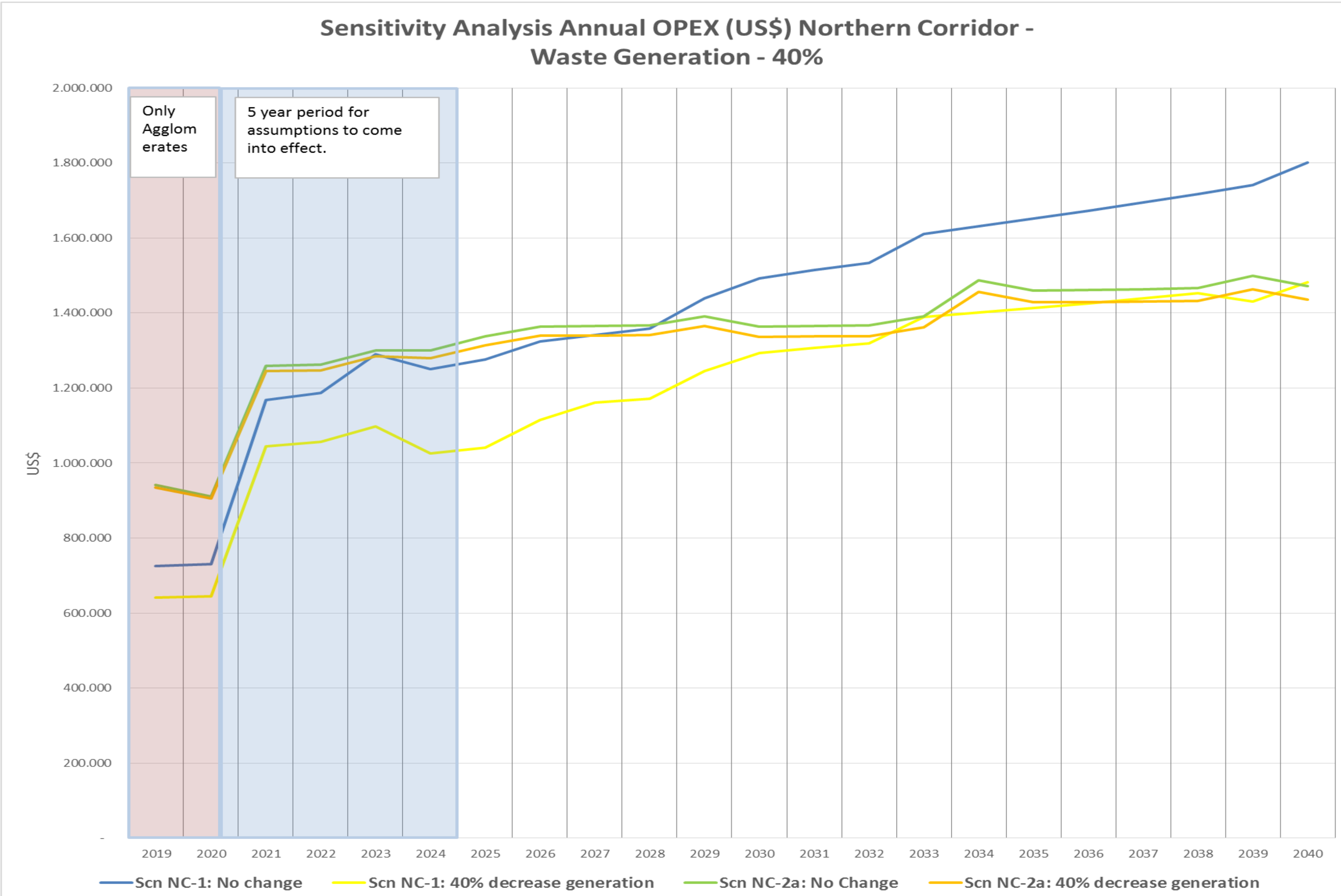


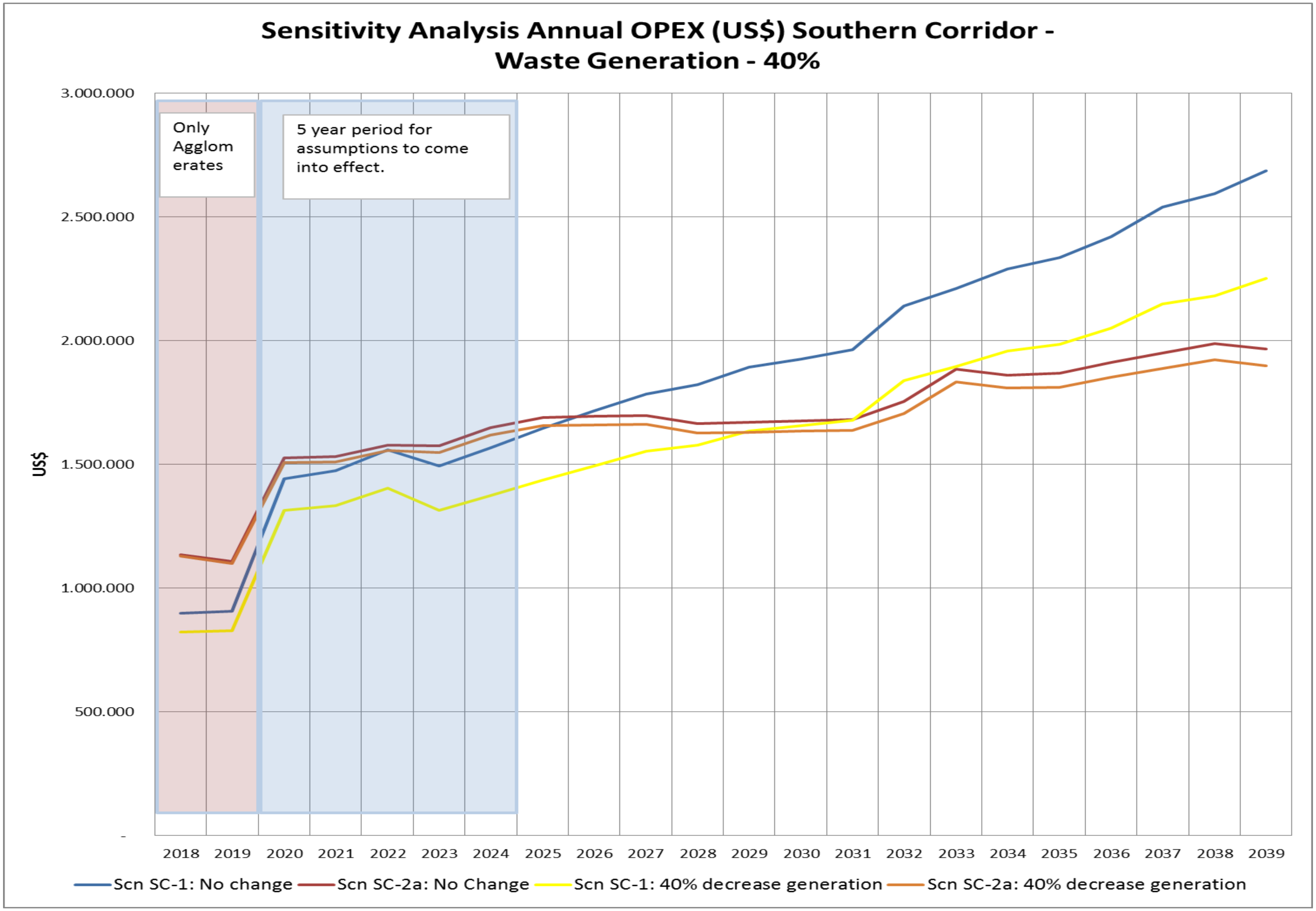
These operating costs do not include the costs related to collection in the Urban Areas and assume that the population using the DOCs will bring the different waste fractions to the nearest DOC at their own cost (also if this is in an adjacent village.).

31.10.3 Sensitivity analysis

To test the sensitivity of the financial model with respect to a variation in the waste sent to final disposal, a 40% decrease of the projected amounts has been estimated. Such a decrease (-40%) well represent both a possible overestimation of the waste generation (of the same order of that registered in the Western Corridor) and a reasonable rate of diversion of the waste at source (e.g. composting, recycling).

Under such circumstances the overall OPEX of Scenario 1 shows a significant decrease with respect to the estimated costs of Scenario 2 for almost the entire 25 years period for both Corridors.


Sensitivity Analysis Annual OPEX (US$) Northern Corridor - Waste Generation - 40%
Only Agglom erates
5 year period for assumptions to come into effect.
US$
2.000.000
1.800.000
1.600.000
1.400.000
1.200.000
1.000.000
800.000
600.000
400.000
200.000
-
2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040
Scn NC-1: No change
Scn NC-1: 40% decrease generation
Scn NC-2a: No Change
Scn NC-2a: 40% decrease generation


Sensitivity Analysis Annual OPEX (US$) Southern Corridor - Waste Generation - 40%
Only Agglom erates
5 year period for assumptions to come into effect.
US$
3.000.000
2.500.000
2.000.000
1.500.000
1.000.000
500.000
-
2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039
Scn SC-1: No change
Scn SC-2a: No Change
Scn SC-1: 40% decrease generation
Scn SC-2a: 40% decrease generation

<u>Major outcomes</u> deriving from the financial analysis can then be summarized as follows:

a. Both OPEX and CAPEX are lower in the case of Scenario 1 (Mile 24 Landfill). The difference in costs of the two scenarios is not such, per se, to be a deciding factor in the long term (25 years) since in the second part of the considered period the costs of Scenario 1 are deemed to be increasingly higher, with respect to Scenario 2, when the whole waste generated is considered.
b. A reduction in the estimated quantities of waste or the increase of the expected and desired waste diversion practices will result in a more significant decrease of OPEX in Scenario 1 over the design period compared with Scenario 2. In the Northern Corridor in particular such condition will lead to lower costs even at the end of the 25 years period.
c. In the medium term (10 years) Scenario 1 appears, to be more cost effective in any case.
d. The investment costs entailed by Scenario 1 are lower than those of Scenario 2.

<u>Recommendations</u>:

- Investments in waste diversion rather than in regional disposal facilities are expected to be more cost effective in the long term.

32 ADDITIONAL ASPECTS

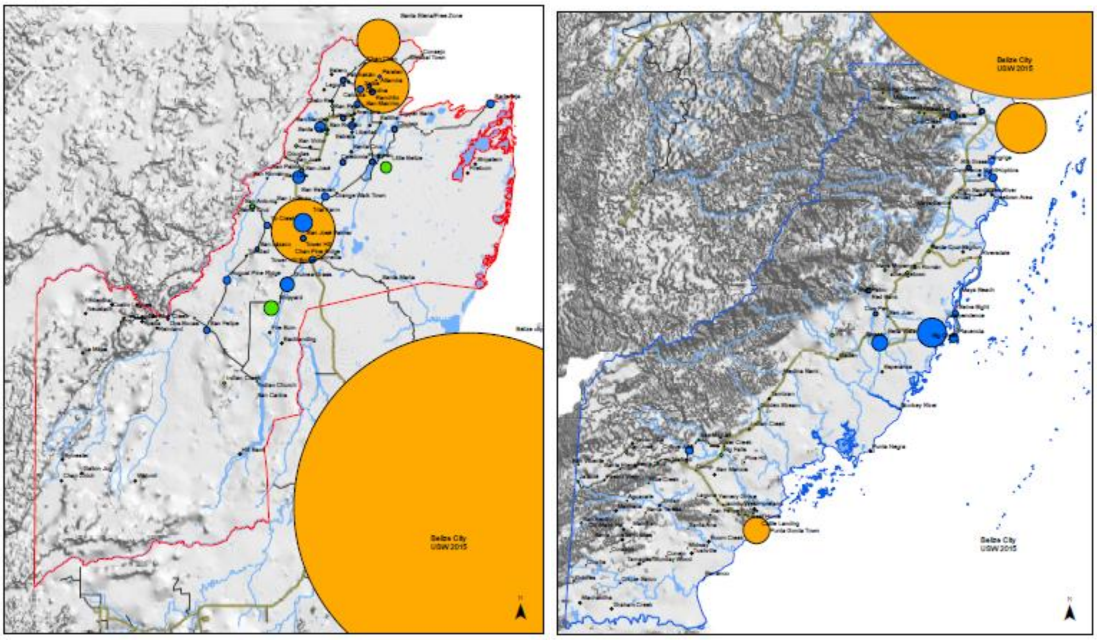
32.1 Waste generation

The waste generation and characterization study has been carried out by cross checking literature data with the results of the field study carried out for the aim of the waste management project in the Western Corridor. Other data proposed by different studies in Corozal and Punta Gorda respectively have been reviewed for the purpose.

Future projections of the waste generation in the two Corridors have been based on the population growth (SIB 2010 Census), tourism increase (BTB Masterplan 2030, 2011) and linking the per capita waste generation rate to the GDP, assumed to constantly grow during the period at a 3% annual rate.

All the estimates have been made under conservative assumptions, that is to say, such as to favour the overestimation of the quantities of waste to be managed.
The overestimation is, in fact, considered to be a conservative assumption taking into account the relatively low quantities expected and considering that the facilities at the base of each scenario (transfer stations and DOCs) have a functional minimum size that cannot be further reduced proportionally to lower waste quantities.

Figure 85 – Schematic representation of estimated waste generation in Northern and Southern Corridor in year 2015 compared with the estimated waste generation in Belize City for the same year



If the uncertainties of the available data (both derived from literature and field studies) are many and significant, the overestimation of the projected data is nevertheless confirmed by the only available certain data provided by the Mile 24 Landfill weighbridge. The actual data registered at Mile 24 landfill show a lower amount of waste generated (in the range of 30% to 40% less than expected) and an almost flat trend-line during the three years period of operation since its opening.

<u>Major outcomes</u> deriving from the waste generation study can then be summarized as follows:

a. Relatively low quantities of waste generated (each Corridor generates approximately 50% of that generated by the Western Corridor)
b. The daily and annual quantities to be landfilled are barely sufficient to justify the construction and operation of an engineered landfill of simplified technology (from 50 to 160 tonne/day)
c. High percentages of putrescible organic and recyclable materials available for diversion
d. In terms of total quantities of waste the present disposal system (Mile 24) can easily and adequately accommodate the waste generated by both Corridors

<u>Recommendations</u>:

- Investment in constant and reliable data collection and analysis can significantly reduce the uncertainties and allow a more thorough and effective planning

32.2 Present SWM System

32.2.1 Waste collection

The waste collection system appears by far to be a major contributor to the inefficiency of the whole system. It suffers from many different problems common across the two Corridors:

- Lack of resources at town level. Old, in some cases also inadequate, collection fleets in poor mechanical conditions is the result.
- Lack of proper organisation at any level. In towns the waste collection organisation is replaced at any change of the Town Administration impeding any planning and consolidation of the professional structure. In villages the collection system is almost absent with the exception of a few villages served by private collectors hired directly by residents.
- Deficiencies in the collection of garbage fees.

A positive note is the presence, here and there, of a self-established and self-sustained system of separate collection and sorting of recyclables materials from the waste.

32.2.2 Management of existing facilities (Western Corridor)

An extremely positive element to be considered is the high quality of the present transfer and disposal system in the Western Corridor. Specifically, the landfill at Mile 24 appears to be built and operated in accordance with high standards.
If problems can be highlighted in this case they are related to the inadequate input of waste due to collection deficiencies. The performance of the landfill therefore, is necessarily lower than those achievable in landfills of bigger size and higher daily and annual waste inputs.
Both the infrastructural system and the management (SWaMA) system are nevertheless to be considered as a solid base on which the system for the two remaining Corridors can and shall be built upon.

32.3 Institutional Framework

The preliminary analysis of the institutional and regulatory frameworks offers different and to some extent contradictory elements.
On the one hand, a well-established and efficient system of agencies (DOE and SWaMA) together with an evident and proven interest in investing to improve the sector, can be noticed.
On the other hand, a substantial review and homogenization of the regulatory framework is imperative.

Waste management regulatory provisions are today dispersed across different Acts and regulations. At the same time such provisions appear to be sometime contradictory in different aspects and, on the other hand, not providing a sufficiently clear and exhaustive regulation scheme.

The lack of an adequate regulatory framework and the overlapping or uncertain attribution of responsibilities determined in many cases by the present provisions can become soon a limiting factor for the development of the waste management sector and the protection of the environment.

33 CONCLUSIONS AND RECOMMENDATIONS

The present document summarizes the major outcomes of the activities carried out so far in order to provide the essential information needed for the analysis of alternative scenarios.
To proceed with the following phases of the planning activity, it is in fact necessary to select, among the various possibilities, the scenario that better satisfies all the desired conditions and at the same time, offers the highest expected performance.

None of the different assessments carried out so far (technical, institutional, financial, social and environmental) appears to be, in itself, a deciding factor in this regard.

Besides, the analysis of many of the aspects considered within the two Corridors, often encourages to direct the attention to a larger (national) scale to find a more appropriate solution for the aspect or set up the necessary conditions for such a solution.

Where a system based on a centralized landfill is chosen, no major differences can be noticed between a scenario based on new regional landfills rather than on the already existing Mile 24 Landfill under an economical and environmental point of view.

On the other hand the preliminary activities carried out to assess the present situation with regard to the institutional framework and the waste collection system highlight priorities that need to be properly addressed to allow future improvements.
The analysis of the present situation also offers many and significant positive elements and consolidated experiences that necessarily have to be taken into account.

In the following paragraphs the outcomes of the different single aspects and analysis are summarized. The scheme and order of the these paragraphs does not necessarily follow the same priority of the activities carried out but rather reflects the importance of the different aspects, as assessed so far and as per our perception, with regard to the decision making process.
It is nevertheless important to stress again that only taking into account all the aspects together and considering their possible and likely interactions, the difference between the scenarios appears to be clearer and to offer a more solid ground on which to base the final decision.

33.1 Strategic goals

The major outcomes of the different aspects, as here above very briefly summarised, can be finally better weighed making reference to the strategic goals for the waste management sector in the near future and in the long term perspective.

The first priority of the system to be pursued is undoubtedly the collection, treatment and disposal of the totality of the waste generated all over the Country (and specifically in the two Regions at hand).

At the same time such goal shall be pursued maximising the diversion of the recoverable fractions at source (separate collection) or along the process (sorting).

An additional need that shall be taken into account as a precondition for the achievement of a fully integrated waste management system is that it requires an adequate capability to manage the complexity of such a system in particular where so many uncertainties are still present.

If these are the necessary priorities to be considered while planning the next investments, all the conclusions so far summarised can be coherently added up to compose a more clear and homogeneous final scenario.

Facts/Needs	*Suggested final scenario*
Mile 24 Landfill: provides adequate standards; underused; better performances achievable with increased waste inputs	Scenario 1
Regional Landfills: Will result in higher investment costs; more uncertain environmental performance; higher operational costs in the medium period (10 years); comparable costs in the long period (25 years)	Scenario 1
Uncertainties in the waste generation: The estimated waste amounts have been assessed under conservative assumptions. In case of lower quantities generated and/or collected costs and performance of the regional landfills will be comparatively worse	Scenario 1
Increase in the diversion of waste: Future investments and actions in diversion will have the same effect of a reduction in the expected generation of waste.	Scenario 1 + investments in diversion of waste rather than in regional final disposal
Maximisation of collection: Need for investment in the strengthening of the collection system both at a town and village level.	Priority to be given to investments in waste collection
Strengthening of the institutional framework: Notwithstanding the solution chosen, the strengthening of the present institutional framework is a priority to manage a more and more complex system and to create the necessary professional background nationwide.	investments in institutional framework

33.2 Environmental aspects

33.2.1 Siting

The hydrogeological conditions of the Northern and Southern Corridors appears, in general, not to be very favourable for the siting of a landfill for different reasons:

- Northern Corridor: the geology of almost the entire region is of carbonate nature and karst activity is not uncommon. According to internationally recognised standards these soils should be excluded when planning the siting of a landfill
- Southern Corridor: suitable soils for the siting of a landfill can only be found in a narrow belt at the foothills of the Maya Mountains. While such soils appears to be adequate, it must be noticed that they lie immediately upstream to an extensive recharging area of the regional (Savannah) aquifer.

Although the construction of a landfill in the two Corridors is technically possible, specific precautionary constructional and operational measures should be considered, that would tend to increase the investment costs.

33.2.2 Expected impacts

Also in this case a comparison of the different scenarios does not appear to provide noticeable deciding elements to discriminate between the proposed scenarios.
While gas emissions and other traffic related aspects are in favour of Scenario 2 (Regional landfills) they are, on the other hand, of no substantial magnitude.
Main environmental aspects related to both scenarios are those generated by the disposal of the waste:

- Gas emissions
- Leachate management

If, under controlled conditions, these aspects can be considered as in favour of Scenario 2 (because of the choice of semi-aerobic landfilling in Scenario 2, justified by the low waste quantities, and, at the opposite, the lower performance of Mile 24 related to low quantities of waste) the balance turns in favour of Mile 24 Landfill when introducing the potential impacts in case of failures or emergency conditions. It has also to be considered that the present low waste inputs at Mile 24 (less than 100 tonnes per day) do not allow the implementation of more advanced operational techniques (e.g. waste compaction and gas extraction and combustion/recovery) that can result in further improvement of the environmental performance of the landfill.

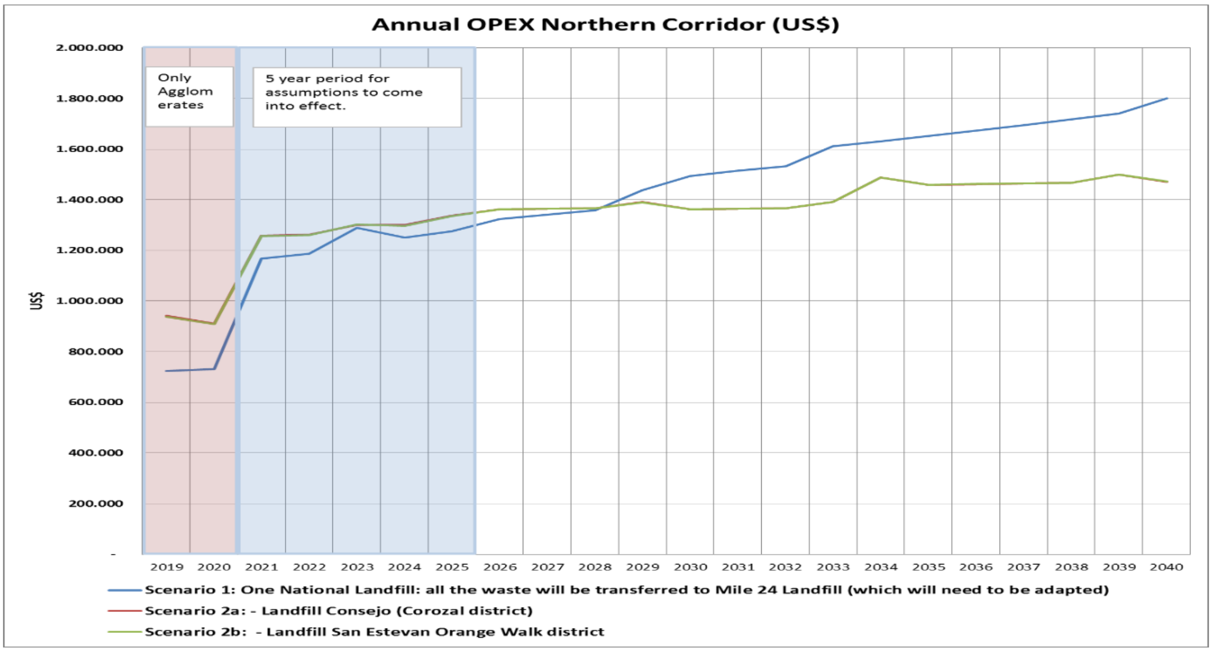
Major outcomes deriving from this aspect:

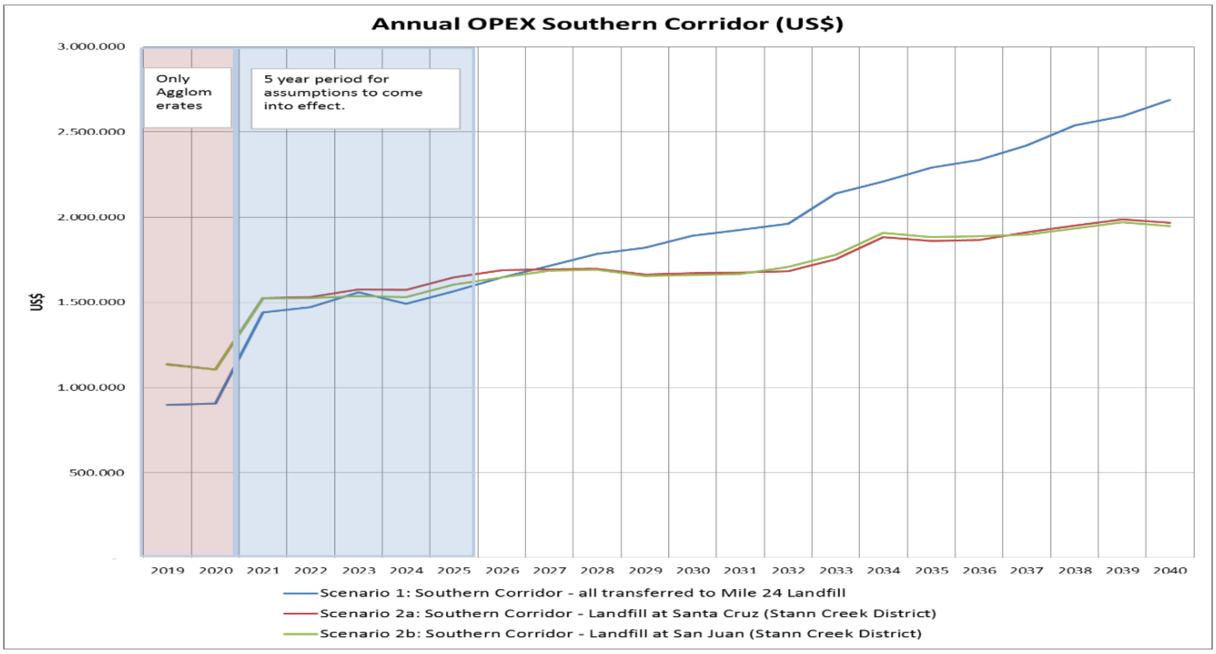
a. Low geological and environmental suitability of the two Corridors for the location of a landfill
b. Potentially high risk of negative impact on groundwater in case of accident for Regional landfills
c. Possible optimization of Mile 24 environmental performance in case of higher waste inputs

33.3 Financial aspects

33.3.1 Comparison of different scenarios

The cost of waste management in both Corridors in Scenario 1 (transfer to Mile 24 Landfill) is expected to be lower than that of Scenario 2 (Regional Landfill) for an initial period of about 10 years. Only after a 10 years period the increase in the amount of waste to be disposed of will gradually determine the raise of the cost of Scenario 1 compared with the Regional Landfill option, assuming that this is not compensated by increases in diversion of waste from landfill.





As per the initial and total investment, Scenario 1 implies a lower cost only requiring the construction of additional landfill cells since the ancillary facilities are already in place and adequate. (All the estimates made do not take into account possible optimisation of operational costs at Mile 24 as a conservative assumption).

COMPARISON of Overall Investment for Infraestucture (with one initial cell in Mile 24) 2017-2040				
Corridor	COMBINATION A Scenario -1 - Landfill Mile 24	COMBINATION B Scenario -2: Two Regional Landfills	COMBINATION C SC 2a/b Regional Landfill NC; SC 1 Mile 24 SC	COMBINATION D SC 2a/b Regional Landfill SC; SC 1 Mile 24 NC
Northern Corridor	11.095.150	14.860.396	14.860.396	11.095.150
Southern Corridor	12.077.345	15.842.591	12.077.345	15.842.591
Total NC + SC	**23.172.496**	**30.702.987**	**26.937.741**	**26.937.741**
Correction for 1 initial cell in Mile 24, in case of combination A	**1.678.618**	**-**	**-**	**-**
Total NC + SC (corrected)	**21.493.878**	**30.702.987**	**26.937.741**	**26.937.741**
Remediation dumpsites NC + SC	**2.066.392**	**2.066.392**	**2.066.392**	**2.066.392**
Total NC+SC (incl. Remediation)	**23.560.270**	**32.769.378**	**29.004.133**	**29.004.133**

33.4 Final recommendations

All the considered aspects so far reported (environmental, financial and others) show a unique preference for a waste management system based on the provisions of Scenario 1.

Mile 24 Landfill not only appears to be an adequate disposal facility for the needs of the entire Country, but would also take advantage of an increased waste input to improve its operational and environmental performance.

In a conservative scenario based on the waste generation and financial estimates carried out, a 10-year period can be foreseen during which the costs of a Regional landfill, both in the Northern and Southern Corridors, are expected to be higher than the transfer of all the waste to Mile 24.

The analysis of the different trend-lines based on more accurate and detailed data will provide a sufficiently reliable base for planning with more reliability, the type, size and location of the necessary treatment or disposal facilities.

At the present stage higher priorities appears to be:

- Creation of a more solid institutional framework. This aspect represents a priority independent of the chosen scenarios. The increasing complexity of the system requires the strengthening of the management agency, the creation of the necessary skills and the adequacy of the regulatory framework.
- Consolidation of the waste collection system in towns through the necessary technical and organisational measures. Creation of a widespread collection system in minor centres (DOCs). Establish the necessary regulatory framework and tools for adequate waste collection and management by private entities in synergy with the public system (industries, touristic sub-divisions).
- Development of all the necessary initiatives for the minimisation of waste generation and maximisation of waste diversion.

Should these goals be achieved within the next 10 years period, as it can be reasonably expected, the need for investments in the final disposal of the waste in the two Corridors can be drastically postponed. More appropriate and adequate facilities can instead be planned to locally treat the waste, further decreasing the waste to be disposed of.

G. ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

34 DEFINITIONS

Customer: the entity (person, private company, institution) generator of the waste delivered to the facility. In case of multiple generators coincides with the collector of the waste.

Contractor: is either the entity contracted by SWaMA for the construction or the operation of the facilities as per the context.

Developer: the entity in charge of the implementation of the Plan and responsible for its compliance with environmental requirements (SWaMA).

Master Plan: the Solid Waste Master Plan for Emerging Tourism Areas (actually the Northern and Southern Corridors of Belize).

Operator: the entity (private contractor or institution) in charge of the operation of the facility thanks to a specific Operation contract with the Developer.

Residual waste: the municipal solid waste that residues after separate collection, sorting or other waste treatment activities and destined to final disposal.

35 INTRODUCTION

The present ESMP deal with the following components of the Master Plan as identified by the previous steps of the work:

- Transfer Stations
- Drop Off Centres
- Transport of the waste
- Mile 24 Landfill
- Closure of old dumpsites

The ESMP takes into account the requirements of the Environmental Compliance Plan (ECP) adopted for the similar facilities built and operated in the Western Corridor as released by the Belize DoE. All the relevant requirements of the ECP are adopted in the present document.

The structure of this EMCP, anyway, is slightly different from that of the ECP since all the common requirements (specifically those for Manuals and Training, Emergency Response and Social Aspects) are here dealt with in separate sections at the end of the document.

With regard to Mile 24 Landfill, only additional or modified requirements are here reported with respect to those already included in the ECP.

Also differently from the ECP, in the present document distinction is made between the Developer (actually SWaMA) as defined in the ECP and the Operator of the facility or activity. If it is true that the responsibility of the implementation of the whole plan is on the SWaMA, it is also true, in fact, that some of the requirements and responsibilities shall be placed upon the Operator. In such cases the responsibility of SWaMA will be the inclusion of such

requirements in the contract documents with the Operators and the subsequent control of compliance.
Wherever in the following a requirement of the present ECP is included it is reported in italic characters. Modifications and additions are instead in plain text.

Finally, the following requirements apply to all the similar facilities included in the Master Plan and wherever located as listed in the respective Section unless differently specified.

36 TRANSFER STATIONS

The construction and operation of the following waste transfer stations is envisaged by the Master Plan:

- Corozal Town
- Orange Walk Town
- Dangriga
- Placencia
- Independence
- Punta Gorda

Transfer Stations will receive the waste from the Agglomerates and Villages as identified by the Master Plan. While the waste from Agglomerates and Independence and Placencia villages will be delivered by the collection trucks, the waste from the villages will be delivered, at least in a first phase, by Roll-on Roll-off trucks serving the foreseen Drop-off Centres established in the villages as per the present Master Plan (see Section 5 for a list of such facilities).

The waste from the above listed transfer stations will be transported to the Mile 24 Landfill for final disposal. Manual sorting of the waste will be carried out at each facility to recover recyclables materials and separate hazardous waste for temporary storage, recover, treatment or final disposal according to its nature and to the availability of specific facilities.

The Transfer Station can also receive, depending on the future evolution of the organization of the whole waste management service, recyclable fractions either selected or mixed (mono-material or multi-material) either for temporary storage and/or pre-conditioning (sorting and bailing).

The following paragraphs provide the necessary minimal requirements for the construction and operation of the facilities.

36.1 Construction

36.1.1 Materials

The use of hazardous construction material shall be avoided to the extent possible.
Before the commencement of the construction the Contractor shall submit for approval a Construction and Demolition Waste Management Plan (C&DWMP).
The C&DWMP shall:

a. Maximise the on-site recycling reuse of the materials, including excavated soil, unless this can be harmful for the environment;
b. Determine the temporary storage needs of the C&D materials during the works and provide measures for the minimization of the nuisances and the avoidance of environmental impacts (e.g. dust generation, groundwater pollution);
c. Determine the necessary transport and disposal measures of the residual C&D waste that have to be disposed of.

36.1.2 Nuisance control

None of the selected sites for the location of the TSs is close to residential areas. Commonly adopted measures for the mitigation of the aspects as follows will be sufficient.

The operating equipment shall be in good mechanic conditions and all the standard noise limiting devices in place good working conditions;
The working time shall be limited to daylight hours of week days, extra hours and work on holidays shall be approved by local authorities;
Dust limiting measures shall be implemented to prevent dust generation from piles, roads and service areas;
No burning of waste or any other materials, including removed trees and vegetation, shall be carried out;
The delivery of the materials has to be planned such as not to create problems to the traffic along the nearby roads, peak times should be avoided.

36.1.3 Archaeological, cultural and historical resources

If during the construction works any archaeological finds occurs, the works shall be immediately halted and the Institute of Archaeology contacted to determine the potential importance and provide the necessary recommendations;
All the findings shall be left in place and the site secured and controlled until the competent authority inspect the site, no findings can be removed or allowed to be removed from the site without the authorisation of the Institute of Archaeology.
The Contractor, before the commencement of the construction works, shall establish and submit to SWaMA a procedure to be adopted in case of archaeological finds. The procedure shall include:

a. Information and training of the personnel involved in the construction works;
b. Name and contacts numbers of people to be informed in case of archaeological finds;
c. Instruction on how to preserve the finds and secure the site until inspection by relevant authorities.

36.2 Operation and maintenance

36.2.1 Security

The site may operate twenty four hours per day, 365 days of the year unless otherwise limited either by municipal by-laws or the operating hours that are identified in the operation contract documents[53]

The Developer will install a sign at the main entrance/exit of the facility on which is legibly displayed the following information:

a. *The name of the facility and the Developer*
b. *A twenty four hour telephone number that can be used to reach the Developer in the event of a complaint or an emergency[54]; and*
c. *The type of waste that is approved for receipt at the facility.*

The Developer will operate and maintain the facility in a secure manner, with access to the facility regulated and perimeter secured by fencing or natural features. During non-operating hours the entrance and exit gates will be locked and the facility shall be secured against access by unauthorised persons.

36.2.2 Approved waste

A. *The acceptable wastes include solid municipal and industrial waste*
B. *Recyclable wastes will be stored in separate receptacles*
C. *Hazardous waste will be received and stored in separate receptacles* together with the hazardous waste recovered from the municipal waste and hazardous waste generated by the operation activities.

All the incoming loads will be visually inspected to ascertain the nature of the waste in comparison with the accepted waste and with what declared by the Customer and to detect possible risks (e.g. fire).

The maximum amount of non-hazardous *waste that may be stored at the facility at any time will not exceed the amount of waste received in* one week[55]

The maximum amount of recyclables materials sorted from the waste that may be stored at the facility at any time will not exceed:

a. Paper and cardboard in bales: 300 m^3 in piles
b. Plastic in bales: 300 m^3 in piles
c. Scrap metals: 40 m^3 in containers
d. Other non-hazardous materials: 20 m^3 in containers or adequate receptacles.

Piles of combustible materials shall be separated by at least a 20 m distance from one another and be away from any source of flames, sparks and electrical devices.

The maximum amount of hazardous waste that maybe stored in the specifically build receptacle at the facility at any time will not exceed the 80% of the maximum capacity of the receptacle for more than 5 days.

In the event that residual waste cannot be transferred from the facility, the Developer will cease accepting any additional waste.

---

[53] Modified from the original "*Design Report*"

[54] See following Section 42

[55] Modified with respect to the "*two months*" of the ECP since the facilities are designed for a storage capacity between 5 and 10 days average daily input.

If, for any reason, the Developer should need to derogate from the above requirements it shall give notice at least one day in advance to the DoE both by email and by telephone. The email shall specify the reasons, the extent and the estimated duration of the derogation and the environmental and safety measures adopted to ensure the same level of protection.

36.2.3 Waste storage

Waste will be stored in accordance with the accepted operational principles and at a minimum the Developer will ensure that:

a. *All activities related to the unloading and storing of incoming waste and residual waste will be conducted indoors at all times;*
b. *All putrescible waste will be removed from the tipping floor at the end of each operating day and the tipping floor cleaned as necessary. Any putrescible waste that is not removed from the sites at the end of the operating day will be stored indoors in a tarped or enclosed container; and*
c. *All containers* and piles *used for the outside storage of non-putrescible processed waste that is destined for recycling markets will be maintained in a leak-proof condition and will be tarped or enclosed unless material is being added or removed.*

36.2.4 Processing

Processing carried out at the facility is limited to the sorting and transfer of Municipal Waste including pre-conditioning of the waste such as compacting and bailing.

36.2.5 Hazardous waste

All incoming loads will be inspected for hazardous materials. If hazardous materials are identified, these will be safely segregated and placed in special hazardous waste receptacles. These will be transported in an approved manner as per the requirements of the Hazardous Regulations, 2009.

36.2.6 Nuisance control

The Developer will operate and maintain the facility such that the dust, odours, vectors, birds, litter, vibration, noise and traffic do not create a nuisance.
If at any time vectors or vermin become a nuisance, the Developer will hire a qualified, licensed pest control professional to design and implement a pest control plan for the site. This plan must be done in consultation with the Forest Department.
If at any time litter become a nuisance, the Developer will develop a litter control plan, which will detail all practical steps that the Developer shall implement to control litter at the facility.
If at any time odours are generated at the transfer station resulting in complaints the Developer will take appropriate remedial actions immediately to eliminate the cause of the problem. Appropriate measures may include the removal of waste from the facility and temporary suspension of all the operations until the problem has been rectified and measures have been undertaken to prevent future occurrence.

The Odour Monitoring Program will include a survey of the sensitive receptors in the vicinity of the transfer station and will outline all operational controls, monitoring, measurement and corrective actions, and communication and management reviews required to achieve the objective of managing odour associated with the handling of putrescible waste at the facility in order to prevent or mitigate any odour impacts on the nearby sensitive receptors.
The Developer will ensure that there is no queuing or parking of trucks that are waiting to enter the site on any roadway that is not a distinct part of this facility.
The Developer will ensure that vehicles leaving the facility do not drag dirt and/or other material that may become a contaminant or a nuisance onto public roads.

36.2.7 Stormwater management

The Developer will ensure that contact between storm-water and received waste, processed waste and residual waste is kept to a minimum.

36.2.8 Reporting and record keeping

36.2.8.1 Record keeping

The Developer will maintain a daily record both *electronically* and[56] *in a log book which include the following information:*

a. *The type, date and time of arrival and source* (generator and carrier) *of all the waste vehicles entering and leaving the facility;*
b. *The date, type and destination of all the residual waste transferred from the facility;*
c. The date, type and destination of all the recyclables materials leaving the facility;
d. [57]A daily operation register including at least the following information:
    i. Personnel on site;
    ii. Maintenance and control activities carried out;
    iii. Inspections received and visitors;
    iv. Complaints received;
    v. *A record of any spills or process upsets at the transfer station, the nature of the spill or process upset and the action taken for the clean-up or correction of the spill or process upset, and for spills, the time that persons were notified of the spill.*

36.2.8.2 Periodic reports[58]

On a monthly basis, the Operator will prepare a written Monthly Report to be submitted to SWAMA and retained on-site. The report will include, at a minimum, the following information:

[56] The ECP specifies "*either … or …*". It is here preferred to suggest the use of both forms of recording data: the log book being non modifiable proof of the recording at the right time and easy to inspect, while the electronic form will be used to prepare statistics and periodic reports.
[57] The ECP also asks for the record of the amount of waste received for the calendar year. This requirement has been herein moved to the "Periodic Report" section.
[58] This section replace the ECP's "Annual Report" section.

a. A summary of the daily amount of waste received and the daily recyclable materials leaving the facility;
b. Accidents and emergencies occurred during the period if any;
c. Maintenance and control activities carried out during the period;
d. Any environmental and operational problem if any that occurred during the period;
e. Any other occurrence worth to be reported.

On an annual basis, the Developer will prepare, send to the DoE *and retain on-site a written annual report for the previous calendar year. The report will include, at a minimum, the following information:*

a. Any environmental and operational problems that are likely to negatively impact the environment, encountered during the operation of the facility and during the facility inspections and any mitigative action taken;
b. A summary of complaints received and the actions taken to mitigate the issue associated with the complaint;
c. A summary of any changes to the Design and Operation Report, the Emergency Response, Spill Reporting and Contingency Plan and/or the site Closure Plan that have been approved since the last annual report;
d. Any recommendations to minimize environmental impacts from the operation of the facility and to improve operations and monitoring programs in this regard.

36.2.9 Inspection

An inspection of the entire facility and all equipment will be conducted daily for the transfer station to ensure that the facility is secure; that all monitoring devices are in good working order; that there are no leachate seeps; and that conditions at the site are not otherwise causing any adverse effects on the environment or any nuisance effect.

Any deficiencies discovered as a result of the inspection will be remedied immediately or otherwise as soon as practicable.

A record of the inspections, including the following information, will be kept in the log book:

a. The name and signature if person that conducted the inspection;
b. The date and time of the inspection;
c. A list of any deficiencies discovered;
d. Any recommendations for remedial action; and
e. The date, time and description of action taken.

36.2.10 Monitoring of performances

36.2.10.1 Operation

The following operation aspects shall be constantly monitored to assess their performances:

a. Quantity and quality of the recycled materials and hazardous waste recovered at the facility;
b. Quantity and quality of source separated waste delivered to the facility for further conditioning.
c. Quantity of incoming waste related to number of incoming collection trucks (average load) distinct for different generation areas and/or collection routes;

d. Average load of residual waste trucks destined to final disposal.

The collected data shall be reported and discussed semi-annually in a specific report including recommendations for the improvement of the performances.

36.2.10.2 Environment

The following aspects shall be monitored at least semi-annually in normal operational conditions of the facility:

a. Noise level at the boundaries of the site in direction of the nearest inhabited areas;
b. Quality of the waste water at the inlet and outlet of the wetland treatment system. The concentration of the following parameters shall at least be determined:
   i. pH
   ii. COD
   iii. BOD
   iv. Ammonia
   v. Coliform bacteria

36.2.11 Mitigation measures

Leachate is the very complex product of the degradation processes of the waste (mainly anaerobic). Such processes generally start a few weeks or months after the disposal of the waste. For this reason, and in accordance to the experience of waste transfer and waste treatment facilities operators, only negligible quantities of waste water of low pollutant content are generated in transfer pits and floors. A waste water treatment pond is envisaged by the design for the treatment of the water originated by the washing of the transfer facility floor and by the vehicles washing facility.

A vegetated barrier should be planted around the perimeter of the site in correspondence of the most visually exposed sections to minimize the visual impact of the facility.

To minimize the dust production and create traps to hinder the spreading of the dust all the residual areas not used for specific operational purposes shall be planted with grass and shrubs.

The site maintenance plan shall include the maintenance of the vegetation of the wetland as well as the vegetated areas and barriers.

37 DROP-OFF CENTRES

37.1 Construction

Drop-off centres are very simple facilities mainly based on a fenced service area, for the location of the removable container, a small shelter for the temporary storage of household hazardous waste and for the personnel and, if such is the case, an additional open area to host the composting big-bags.

In terms of construction then the activities are very limited and of very low duration and impact.

37.1.1 Location

A Drop-Off Centre is commonly located within the urban area since its function is to receive the waste delivered directly by the nearby residents. The nuisance caused by a DOC is extremely limited and, as such, no international regulations have been found with regard to the location and mitigation measures of this type of facility.

The location of the DOC on each village and/or town neighbourhood shall be decided after public consultation with the village residents.
The location of the DOC shall take into account the following criteria:

a. Sufficient proximity to the served residential areas: for easy delivery of waste
b. Proximity to market areas if possible or other suitable public areas frequently attended by residents
c. The access to the DOC from the adjacent public road shall be such to allow safe entrance and exit manoeuvring of the trucks without creating hindrance to the traffic.

37.1.2 Materials

The use of hazardous construction material shall be avoided to the extent possible.
Before the commencement of the construction the Contractor shall submit for approval a Construction and Demolition Waste Management Plan (C&DWMP).
The C&DWMP shall:

a. Maximise the on-site recycling reuse of the materials, including excavated soil, unless this can be harmful for the environment;
b. Determine the temporary storage needs of the C&D materials during the works and provide measures for the minimization of the nuisances and the avoidance of environmental impacts (e.g. dust generation, groundwater pollution);
c. Determine the necessary transport and disposal measures of the residual C&D waste that have to be disposed of.

37.1.3 Nuisance control

As said the intensity of the construction activities is very low in the case of DOCs and most of the activities do not imply the use of heavy machinery.

The operating equipment shall be in good mechanic conditions and all the standard noise limiting devices in place good working conditions;
The working time shall be limited to daylight hours of week days, extra hours and work on holidays shall be approved by local authorities;
Dust limiting measures shall be implemented to prevent dust generation from piles, roads and service areas;
No burning of waste or any other materials, including removed trees and vegetation, shall be carried out;
The transfer of the full containers has to be planned such as not to create problems to the traffic along the nearby roads, peak times should be avoided;

To prevent odour nuisance due to composting activities, where is the case, an operating practise has to be implemented. Bags generating odours shall be emptied, the material aerated, structuring material such as wood chippings added and mixed with the original material and then backfilled and put back in place.

37.1.4 Archaeological, cultural and historical resources

If during the construction works any archaeological finds occurs, the works shall be immediately halted and the Institute of Archaeology contacted to determine the potential importance and provide the necessary recommendations;
All the findings shall be left in place and the site secured and controlled until the competent authority inspect the site, no findings can be removed or allowed to be removed from the site without the authorisation of the Institute of Archaeology.
The Contractor, before the commencement of the construction works, shall establish and submit to SWaMA a procedure to be adopted in case of archaeological finds. The procedure shall include:

d. Information and training of the personnel involved in the construction works;
e. Name and contacts numbers of people to be informed in case of archaeological finds;
f. Instruction on how to preserve the finds and secure the site until inspection by relevant authorities.

37.2 Operation and maintenance

The operation of the DOCs does not imply the use of machineries. The only mechanical operation involved is the periodic replacement of the containers by the transfer truck. The remaining and daily operations are limited to manual sorting of the waste and managing of the composting big-bags where is the case (DOCs in Urban villages).

37.2.1 Security

The site may operate twenty four hours per day, 365 days of the year unless otherwise limited either by municipal by-laws or the operating hours that are identified in the operation contract documents
The Developer will install a sign at the main entrance/exit of the facility on which is legibly displayed the following information:

d. The name of the facility and the Developer
e. A twenty four hour telephone number that can be used to reach the Developer in the event of a complaint or an emergency; and
f. The type of waste that is approved for receipt at the facility.

The Developer will operate and maintain the facility in a secure manner, with access to the facility regulated and perimeter secured by fencing or natural features. During non-operating hours the entrance and exit gates will be locked and the facility shall be secured against access by unauthorised persons.

37.2.2 Approved waste

A. The acceptable wastes include solid municipal waste only
B. Recyclable wastes will be sorted and stored in specific container/s
C. Household hazardous waste will be received and stored in separate receptacles.

All the incoming loads will be visually inspected to ascertain the nature of the waste and to detect possible risks (e.g. fire).
The maximum amount of non-hazardous waste that may be stored at the facility at any time will not exceed the maximum capacity of the specific containers.
The maximum amount of hazardous waste that maybe stored in the specifically build receptacle at the facility at any time will not exceed the 80% of the maximum capacity of the receptacle for more than 5 days.
The organic fraction to be composted cannot exceed the maximum capacity of the composting yard.
In the event that residual waste cannot be transferred from the facility, the Operator will cease accepting any additional waste until the container has been replaced.
If, for any reason, the Developer should need to derogate from the above requirements it shall give notice at least one day in advance to the DoE both by email and by telephone. The email shall specify the reasons, the extent and the estimated duration of the derogation and the environmental and safety measures adopted to ensure the same level of protection.

37.2.3 Processing

Processing carried out at the facility is limited to the sorting and transfer of Municipal Waste, including possible pre-conditioning of the waste such as compacting and bailing.
Composting of the organic fraction through the use of specific big-bags will also take place in DOCs approved for such activity. An operating practice for composting shall be implemented at such DOCs.

37.2.4 Hazardous waste

All incoming loads will be inspected for hazardous materials. If hazardous materials are identified, these will be safely segregated and placed in special hazardous waste receptacles. These will be transported in an approved manner as per the requirements of the Hazardous Regulations, 2009.

37.2.5 Nuisance control

All the containers shall be covered by tarp except for the delivery of the waste. All the organic waste received shall be placed in big-bags at the end of each working day.
The Developer will operate and maintain the facility such that the dust, odours, vectors, birds, litter, vibration, noise and traffic do not create a nuisance.
If at any time vectors or vermin become a nuisance, the Developer will hire a qualified, licensed pest control professional to design and implement a pest control plan for the site. This plan must be done in consultation with the Forest Department.

If at any time litter become a nuisance, the Developer will develop a litter control plan, which will detail all practical steps that the Developer shall implement to control litter at the facility.

If at any time odours are generated at the facility resulting in complaints the Developer will take appropriate remedial actions immediately to eliminate the cause of the problem. Appropriate measures may include the removal of waste from the facility and temporary suspension of all the operations until the problem has been rectified and measures have been undertaken to prevent future occurrence.

The Developer will ensure that vehicles leaving the facility do not drag dirt and/or other material that may become a contaminant or a nuisance onto public roads.

37.2.6 Stormwater management

The Developer will ensure that contact between storm-water and received waste, processed waste and residual waste is kept to a minimum.

37.3 Reporting and record keeping

37.3.1 Record keeping

The Operator will maintain a daily record in a log book which include the following information:

a. Number of private customers delivering their waste; number and names of the business and institutional customers delivering their waste;
b. The date, type and destination of all the residual waste transferred from the facility;
c. The date, type and destination of all the recyclables materials leaving the facility;
d. The number of compost big-bags placed onto the yard, in the case of DOCs with compost yard;
e. A daily operation register including at least the following information:
    i. Personnel on site;
    ii. Maintenance and control activities carried out;
    iii. Inspections received and visitors;
    iv. Complaints received;

37.3.2 Periodic reports

On a monthly basis, the Operator will enter all the data from the pertaining DOCs in an electronic form and prepare a written Monthly Report to be submitted to SWAMA. The report will include, at a minimum, the following information:

a. Complaints, accidents and emergencies occurred during the period if any;
b. Maintenance and control activities carried out during the period;
c. Any environmental and operational problem if any that occurred during the period;
d. Any other occurrence worth to be reported.

37.4 Inspection

An inspection of the entire facility and all equipment will be conducted daily to ensure that the facility is secure and that conditions at the site are not otherwise causing any adverse effects on the environment or any nuisance effect.

Any deficiencies discovered as a result of the inspection will be remedied immediately or otherwise as soon as practicable.

A record of the inspections, including the following information, will be kept in the daily log book:

a. The name and signature if person that conducted the inspection;
b. The date and time of the inspection;
c. A list of any deficiencies discovered;
d. Any recommendations for remedial action; and
e. The date, time and description of action taken.

37.5 Monitoring of performances

37.5.1 Operation

The following operation aspects shall be constantly monitored to assess their performances:

a. Number of private customers with respect to total number of households served;
b. Number of businesses and institutions customers with respect to total businesses and institutions served;
c. Percentage of recycled materials with respect to the total waste delivered;
d. Volume of compost produced (if this is the case);

The collected data shall be reported and discussed semi-annually in a specific report including recommendations for the improvement of the performances.

38 TRANSPORT PHASE

As Transport operations shall be considered the following:

A. Transport of waste from DOCs to TSs;
B. Transport of waste from TSs to Mile 24 Landfill;
C. Transport of recyclable materials from TSs and DOCs to recycling facilities.

Unless differently specified the following requirements apply to all the above mentioned operations.

38.1 Carrying vehicles

The carrying vehicles for the waste shall be appropriate for waste handling and in specific shall have the following minimum characteristics:

a. Containment devices for waste water percolating form the waste;
b. Fixed or removable covering system;
c. Automated offloading device;
d. Appropriately sized to allow for optimum storage and safe transport.

The transport of hazardous waste is subjected to the requirements of the Hazardous Regulations, 2009 and shall be carried out accordingly.

38.2 Transport

Every vehicle used for the collection and transportation of waste will be clearly marked with the company name.

Transport of waste shall not generally be undertaken *before sunrise or within two hours of sunset.*

To the extent possible the transport routes shall avoid densely inhabited areas, town centres and roads in proximity of schools and hospitals.

Unless necessary for limiting nuisance or environmental impacts the transport of waste and recyclables shall be undertaken at the maximum admissible load of the truck or when reached the maximum capacity of the containers.

At the back of each vehicle, trailer and waste container shall be legibly displayed the established telephone number to which address possible complaints from the public.

38.3 Cleaning and maintenance

The carrying vehicles and containers shall be kept in good operational conditions at all times.

The liquid containment devices shall be constantly checked and timely fixed or replaced in case of malfunctioning.

The waste water percolated in the containers and/or in the specific storage devices of the vehicles shall be discharged either at the landfill or at the washing facility of the Transfer Station.

The containers and trailers shall be washed and sanitized at least weekly at the appropriate facilities either at the landfill site or at the Transfer Station or other authorized facility of the Contractor.

The whole vehicle shall be kept in decorous conditions.

39 MILE 24 LANDFILL

The operation of Mile 24 Landfill appears to be substantially compliant both with environmental and operational standards and also with the requirements of the Environmental Compliance Plan (see Mile 24 Landfill Audit Report for details).

Minor non compliances have been noticed in the record keeping and periodic reporting areas. This weak point can become a major issue in the perspective of an increased waste input possibly leading to substantial non compliances due to the insufficient control of the different operational aspects.

General recommendations:

- Establishment and implementation of an adequate management and control system based on recognized environmental quality standards (ISO 14001 is recommended);
- In specific a more accurate record keeping and reporting of the activities is needed to fully comply with the ECP requirements;
- A register of the received inspections by third parties(DoE, SWAMA)should be kept on site;
- Revision of some of the ECP requirements that appears to be obsolete, redundant or replaced in fact by alternative and equivalent solutions

- inclusion of the effluents (gas and water) from the HDPE pipe laid underneath the cells in the monitoring plan.

Further recommendations related to the adequacy of Mile 24 Landfill for the disposal of the waste from the Northern and Southern Corridors:

- an additional cell of at least 5 hectares extension should be built not later than 4 years from the beginning of the implementation of the Master Plan in the Northern and Southern Corridors;
- the operational permanent equipment and disposal procedures shall be reviewed to cater for a doubled waste input;
- The use of a light landfill compactor (28 tonne) would be advisable together with the adoption of offloading procedures that allows a quicker offloading of an increased number or trucks simultaneously.
- It is recommended that the excavated soil from the preparation of the future cells is stockpiled and used for the final cover of the same cells. At the same time the selection and use of alternative intermediate cover is highly recommended.

40 CLOSURE OF DUMPSITES

40.1 Final cover

Within thirty (30) days of the cessation of waste disposal activities at the site, final cover will be applied to the area.

The Developer will ensure that the following materials are applied to the waste fill zone as final cover, from bottom to top:

a. *A minimum of 50 cm of low permeability cover material, with a hydraulic conductivity of $1x10^{-7}$ cm/sec*
b. *A minimum of 15 cm of topsoil or other material approved to sustain plant growth,*
c. *A vegetative cover consisting of vegetation that is suited to local conditions and is capable with minimal care of providing vigorous, plentiful cover not later than its third growing season.*

40.2 Final slopes

The Developer will ensure that the final slopes above grade within the waste fill zone at the time of the site closure do not exceed one unit vertical to four unit horizontal (1:4) and are not less than one unit vertical to 20 units Horizontal (1:20).

40.3 Interim operational guidelines

The operation of the present dumpsites is expected to continue for a period of about 3 years before the full implementation of the Master Plan. Not to compromise or make more expensive the actions foreseen by the Master Plan it is necessary that the dumpsites are operated according to minimum interim requirements.

40.3.1 Corozal and Orange Walk dumpsites

The operation at the Corozal dumpsite in the foreseen interim period before the final remediation should consider the following guidelines:

a. Identify a 6,000 m^2 area for the implementation of the remediation design as per the Preliminary Design and preserve it from dumping of waste
b. Concentrate the dumping of waste in a restricted area without opening new sections

40.3.2 Dangriga dumpsite

Considering that there is no more space available to dig new trenches and, on the other hand, that the adjacent site, meant to be used as new dumpsite by the Town Council, is a potentially suitable location for the herein proposed Transfer Station the waste collected in the next two years shall be deposited on top of the already completed trenches already covered with soil.

40.3.3 Placencia dumpsite

The deposit of waste in the subsidiary areas, mainly the flat area closer to Placencia Road shall be avoided with the exception of Construction and Demolition Waste (mainly tree trunks and minor concrete blocks).
The deposit of the waste can instead proceed in the same current area with the trench method. Soil excavated for the formation of trenches should be stored on site for future use as a final cover material.

40.3.4 Independence dumpsite

The deposit of the waste can proceed with the trench method in the same current area. The opening of new trenches in different areas should be avoided to the extent possible.

40.3.5 Punta Gorda dumpsite

No specific guidelines, the available area is sufficient for the deposit of the waste in the interim period. The widening of the dumping area should be avoided.

40.4 After closure monitoring program

After the closure and remediation of the dumpsites a monitoring program shall be carried out by SWaMA on a monthly basis in accordance to the following recommendations. The frequency of the monitoring activities can be modified after the first year in agreement with the DoE and in accordance with the results of the monitoring activities and the measured performances. A brief monthly report shall be prepared after inspection and made available to the DoE.

40.4.1 General control of the status of the site (monthly)

a. Access and service roads

b. Unauthorized access or modifications to the site
c. Illegal dumping
d. Stability of covers on slopes and differential settlements on top (stagnation of rain water)
e. Establishment of vegetation
f. Drainage system
g. Additional comments

40.4.2 Groundwater

Quarterly, sampling points to be established by the preliminary design, at least one upstream and one downstream to the site.

Static level	m
pH	Standard units
Temperature	°C
Redox potential	mV (SHE)
Dissolved Oxygen	mg/l
Conductivity	µS/cm
COD	mg/l
BOD_5	mg/l
TSS	mg/l
TDS	mg/l
Ammonia	mg/l
TKN	mg/l

41 MANUALS AND TRAINING

41.1 Common recommendations for all the facilities

41.1.1 Training Plan

A training plan will be developed and maintained for all employees that operate transfer vehicles. Only trained personnel with appropriate motor vehicle operation licences may operate the transfer vehicles (trucks). The training plan will require and ensure through proper written records that all persons directly involved with activities relating to the haulage and transport of waste have been trained with respect to:

a. Relevant waste management legislation, regulations and guidelines;
b. Major environmental concerns pertaining to the waste to be transported;
c. Emergency response procedures;

The Developer will maintain a written record of training which includes:

a. Date of training;
b. Name and signature of person who has been trained; and
c. Description of the training provided.

41.1.2 Design and Operation Report

A design and Operations Report will be prepared for approval and retained at the facility. It will be kept up to date and available for inspection.
The Design and Operations Report will contain at a minimum the following *information* specific *for each waste processing site:*

a. As built drawings including electrical and hydraulic diagrams
b. Operation and Maintenance Plan including:
    i. Waste acceptance procedures
    ii. Health and Safety Plan
    iii. Training Plan
    iv. Maintenance Plan
    v. Monitoring and Control Plan
    vi. Emergency Response, Spill Reporting and Contingency Plan
c. Copy of all the permits, certificates and licences

41.1.3 Training

A training plan will be developed and maintained for all the employees that operate the facility. Only trained personnel will operate the site. The training plan will require and ensure through proper written records that all persons directly involved with activities relating to the site have been trained with respect to:

a. Relevant waste management legislation, regulations and guidelines;
b. Major environmental concerns pertaining to the waste to be handled;
c. Occupational health and safety concerns pertaining to the processes and waste to be handled;
d. Emergency response procedures;
e. Specific written procedures for refusal of unacceptable waste loads;

The Developer will maintain a written record of training at the facility which includes:

a. Date of training;
b. The name and signature of persons who have been trained; and
c. Description of the training provided.

The Developer will ensure that trained personnel is/are on duty at all times when the facility is open.

41.1.4 Procedures manual and preventative maintenance

A procedures manual specific to the facility will be prepared prior to the acceptance of any waste at the facility. The procedures manual will contain detailed standard operating procedures relating to all aspects of the handling and processing of waste at the transfer station and will be maintained current at all times and kept on site in a central location tht is accessible to site personnel.

Within ninety (90) days from the beginning of the Operation[59] *of the transfer stations, the Developer will develop and implement a preventative maintenance program for all on-site equipment associated with the handling and processing of waste.*

A control and maintenance program will also be developed and implemented by the Developer for the following:

a. *Wetland and stormwater drainage system*
b. *Fence and gate*
c. *Internal roads and service areas*
d. *Buildings and shelters*
e. *Emergency response equipment and devices*

41.1.5 Emergency response, spill reporting and contingency planning

An Emergency Response, Spill Reporting and Contingency Plan will be prepared for the facility a minimum of thirty (30) days prior to the acceptance of waste at the facility. The Spill Contingency and Emergency Response Plan submitted must be approved by the DoE after consultation with acceptance to the local municipal authority and the local fire services authority and will be implemented prior to any waste being received at the facility.

The Developer will review the Emergency Response, Spill Reporting and Contingency Plan on an annual basis as a minimum, and will ensure that the names and telephone numbers of the persons to be contacted are up-to-date, and that these numbers are prominently displayed and immediately available to all staff and emergency response personnel.

The equipment, materials and personnel requirements outlined in the Emergency Response, Spill Reporting and Contingency Plan are required to be kept on-site and will be immediately available at all times. The equipment will be kept in good state of repair and in a fully operational condition.

All persons involved with the operation of the facility will be fully trained in the use of the Emergency Response, Spill Reporting and Contingency Plan and in the procedures to be employed in the event of an emergency.

The Developer will promptly take all necessary steps to contain and clean up any spills or upsets which result from this operation. All spills and upsets will be recorded in a written log or an electronic file format, as to the nature of the spill or upset, and action taken for cleanup, correction and prevention of future occurrences.

41.1.6 Hurricane Plan

A hurricane preparedness plan shall be developed for each of the facilities and kept updated and adjusted, wherever necessary, prior to beginning of the operation.

The hurricane season in Belize commences officially on June 1st and ends on November 30th. The hurricane preparedness plan will be updated every year if there is no emergency event, and on a case by case basis after each and every storm or hurricane event. This revision will ensure constant improvement in the preparedness plans and actions.

[59] The ECP specified "within ninety days of commissioning …" and that was appropriate considering a DBO contract. In this case the Operator won't necessarily be the same subject of the construction phase. Hence it seems to be more appropriate to refer to the beginning of the Operation phase.

The preparedness plan needs to conform to the Hurricane Orders for each area where the facility is located as produced by the NEMO District Committees.

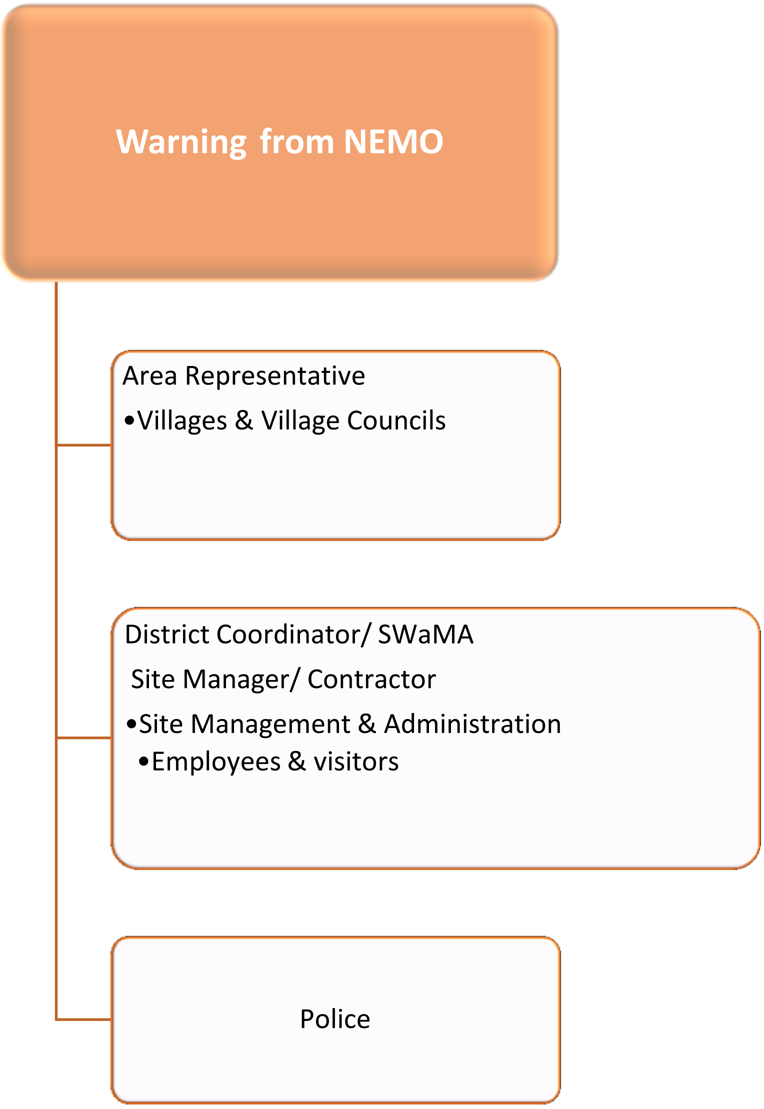


Figure 86 - Generalized Hurricane Alerting Mechanism.

The relationship between the alerting mechanism used by NEMO and the Contractor and SWaMA is shown in Figure 1. The Manager is directly responsible for implementing actions resulting from the hurricane plan.

41.1.6.1 Purpose of Plan

The purpose of this hurricane preparedness plan is to:

(i) Increase awareness to management, employees and visitors of the need for hurricane and tropical storm preparedness;
(ii) To establish the coordinating mechanisms necessary for Management to prepare and implement measures to safeguard property and lives of all concerned during the threat of a storm or hurricane.

The basic responsibilities of management is to ensure that the coordinating mechanism that will ensure maximum safety of property or lives during an incoming storm, is put in place, and to make sure that employees or visitors are familiar with the mechanism.
Management shall be responsible for updating, and implementing this plan in order to ensure its effectiveness.

41.1.6.2 Hurricane Warning System

The contractor or relevant party responsible for each site will follow the official alert system currently in place by the National Emergency Management Organization (NEMO). It will follow the District Emergency Committee's orders and alerting system.
Hurricane Categories and Wind Speeds

- Tropical Depression 38 mph
- Tropical Storm 39-73 mph
- Hurricane Category 1 74-95 mph
- Hurricane Category 2 96-110 mph
- Hurricane Category 3 111-130 mph
- Hurricane Category 4 131-155 mph
- Hurricane Category 5 bove 155 mph

41.1.6.3 Summary of Hurricane Warnings

Warning Flags

The following warning system is adopted from the official hurricane warning system as follows:

- One Red Flag - Preliminary Alert First Phase (storm or hurricane watch)
- One Red Flag with Black Center - Red I Phase (storm or hurricane watch)
- Two Red Flags with Black Centers - Red II (Warning Phase)
- One Green Flag – Green Phase (all clear)

41.1.6.4 Pre-season Preparations

At the beginning of May of each year the Manager will ensure that the disaster management plan is reviewed, and updated, if necessary. Any important or critical updates should be communicated to the owners/principals of the company.

41.1.6.4.1 Pre-season Actions to be taken:

Manager: (i) Communicate the results of the emergency plan updating activities by verbal or written communication to the company who relays to District NEMO and or SWaMA (if necessary), (ii) Ensure that actions required as follow up are done and, (iii) Take actions to ensure the effective implementation of this hurricane preparedness plan.

The Manager will ensure that all relevant equipment and items required for the hurricane season is available. This includes updates of this document, the identification of the sources of hurricane tracking charts etc.

41.1.6.5 Implementation Plan during Threats

41.1.6.5.1 Preliminary Alert - Hurricane Watch

This is the First Phase, and means that a storm or hurricane may threaten within 72 hours. A storm or hurricane is within 21° N 80° W of Belize. At the issue of the Preliminary Phase, the Manager will ensure that post the tracking map and start plotting the course of the hurricane.

He/She will also ensure that all personnel are familiar with the hurricane response plan, and their roles and responsibilities under the plan, and are indeed able to carry them out.

Actions to be taken:

i. Management will ensure that an updated list of employed persons, telephone numbers, and telephone numbers of next of kin are kept in the office.
ii. The management should be prepared to convene and take action if the National Meteorological Service issues a warning, and upon advice of the committee. Stay informed by radio and television of the storm progress, and on all local advisories.
iii. Obtain hurricane tracking chart for management and administration members and relevant personnel,
iv. Ensure that contact is made with all drivers of company vehicles, whether by direct or indirect means to alert them of the phase and to make initial contact.
v. Prepare a checklist (electronically) of items required in the event of an emergency for each head of household.
vi. The Management will identify and categorize items or equipment to be removed as follows: list of equipment to stay, and list of those to be removed to the company's central office, or a similarly designated site.
vii. Advise foreign nationals (if applicable) to shelter immediately and provide them with a list of public shelters in the region. This should be done on the advice of the District NEMO Coordinator. A list of these nationals and telephone numbers or other means of contacts should be kept at all times.

41.1.6.5.2 Hurricane Warning – RED 1 Phase (Watch)

During this phase, a hurricane may threaten within 36 hours. A hurricane or storm is located within 20° N 85° W.

Actions to be taken:

Transfer Stations and Facilities:

These actions to be taken apply to tropical storms and category one hurricanes only:

i. Ensure that all visiting personnel leave immediately, wherever possible.
ii. Inform all personnel to secure all personal property and be prepared to leave upon recommendations of the committee chairperson, in the event that mandatory evacuations are ordered.
iii. The management of the facility will identify employees to report to work after the hurricane or after the Green Phase all clear is given.
iv. Remain in contact via telephone and radio, and Update SWaMA on all actions taken.

41.1.6.5.3 Hurricane Warning – RED 2 Phase

Whenever Phase 2 (Red) is given, this means that a hurricane is likely to strike Belize within 24 hours.

Actions to be taken:

i. Management will advise all employees to secure property and to leave the project site immediately, (if possible),
ii. All employees to be dismissed from active duty at this stage and only required staff will remain at this stage.
iii. The checklist of items required shall then be printed and each head of a household will be provided with a checklist,
iv. The list of employed persons will be printed and provided to management for their perusal,
v. Shelter will be sought (outside of the project site) for employed persons requiring shelter, and as soon as steps 1 and 2 are completed, and wherever, possible, will advise Nemo or Demo.

41.1.6.5.4 Fourth Phase – Green (All Clear)

This is the ALL CLEAR, which will be declared by NEMO after the hurricane has passed and it is safe to return to review the effects of the hurricane.

Actions to be taken:

i. Management will ensure that a survey the project site and all properties is done soon as possible,
ii. The Manager will immediately make a brief report on all damages (supported with photographs), and prepare an estimate of damages, and submit the same to District Committees for their perusal.
iii. Employees will report as previously advised.
iv. Clean-up phase will commence with the assistance of project employees, and others, where possible.

41.1.7 Fire Management Plan for Transfer Stations

The construction of all buildings should be done to meet and exceed the standards of the Belize Building Authority.

At each transfer station, there is need to have a management plan in place in case there is a fire. Therefore, all buildings are to be equipped with fire extinguishers, and an area outside the buildings be designated as a safe area (can be the parking area). The main building should be equipped with an alarm system to be used in the event of any emergency including fire.

41.1.7.1 Fire Prevention and Control

It is important to note that almost all fires are preventable, and control measures can limit the losses if a fire does occur. Fire prevention and control principles include the following:

1. Prevent a fire from starting by using fire-proof construction materials, wherever possible, designing facilities to isolate hazardous areas, controlling operations, using preventive maintenance, and eliminating unsafe practices.
2. Do not overload electrical circuits or use frayed or defective electrical cords.
3. Do not allow any electrical repairs to be made by an unqualified person.
4. Do not use fuels for anything except to run an engine.
5. Use and store gasoline and other fuels only in a safety can, and in a safe area.
6. Provide instruction in the prevention of fires to employees.
7. Mark all exits clearly and ensure that they remain clear.
8. Provide periodic instruction in the location and proper use of fire extinguishers and other fire-fighting equipment.
9. Require all employees to be able to explain how and where to locate fire extinguishers and choose the correct type of fire extinguisher for the type of fire.
10. Properly mount and mark all fire extinguishers, and fire-fighting equipment.
11. Have all extinguishers inspected regularly and records kept of inspection. Regular check should include inspection of hoses, nozzles, seals, gauge pressure, corrosion and dents.
12. Have all extinguishers tested annually and hydrostatically tested every five years.
13. Promptly extinguish the fire before it grows out of control. Most fires start small and can initially be extinguished by a hand-held fire extinguisher or water.
14. Limit the spread of fire. Provide suitable fire barriers and keep the amount of combustibles stored to minimum.

All buildings will be equipped with a fire extinguisher and two (2) (or as deemed necessary) will be strategically located at the main building. Because of the inherent nature of waste processed within the facilities the initial emphasis for fire protection shall be on the prevention of fires. This can be done by the designing of buildings with adequate fire protection features. All permanent staff will be trained in basic fire-fighting and emergency response skills.

Individuals have certain responsibilities for fire protection. Loss of employees' lives, and property, as well as permanent injuries, may be averted through the understanding of fire protection. Therefore, the primary purpose of this fire protection plan is to provide guidelines and procedures to be used in case of a fire, so that all personnel will be fully aware of their responsibilities.

41.1.7.2 Procedures to be used in Case of a Fire

1. Sound the alarm.
2. Evacuate building or area immediately.

3. Block all entrances to building.
4. If an attempt is made to put out the fire, always use appropriate equipment with care.
5. Secure all fuel sources such as vehicles within the compound.
6. After the fire, prepare a detailed report, intended to investigate sources or cause of the fire; route and general incendiary characteristics, procedure and steps used for fire suppression, general safety and health issues (if any), conclusions and recommendations for improvement.

41.2 Specific recommendations for the transport phase

41.2.1 Emergency Response, Spill Reporting and Contingency Plan

An Emergency Response, Spill Reporting and Contingency Plan will include, but not necessarily be limited to:

a. Emergency response procedures to be undertaken in the event of a spill, including specific clean-up methods for:
   i. Roadsides;
   ii. Streams and rivers;
   iii. Lagoons;
   iv. Near-shore waters; and
   v. Harbors.

b. A list of equipment and spill clean-up materials available in case of an emergency;

c. Notification protocol with names and telephone numbers of persons to be contacted, including persons responsible for the waste haulage vehicles and the local municipal authorities.

The Developer will review the Emergency Response, Spill Reporting and Contingency Plan and will update the plan if necessary whenever Modifications are made to the facility.

The Developer will review the Emergency Response, Spill Reporting and Contingency Plan on an annual basis as a minimum, and will ensure that the names and telephone numbers are prominently displayed and immediately available to all the staff and emergency response personnel.

All persons involved with the transportation operations will be fully trained in the use of the Emergency Response, Spill Reporting and Contingency Plan and in the procedures to be employed in the event of an emergency.

The Developer will promptly take all the necessary steps to contain and clean-up any spills or upsets which result from the waste transportation operation. All spills shall be recorded in a written log or an electronic file format, as to the nature of the spill or upset, and action taken for clean-up, correction and prevention of future occurrences.

42 SOCIAL ASPECTS

A Grievance Mechanism shall be established by SWaMA in order to deal with all the reported grievances due to impacts and nuisances caused by the waste management activities and malfunctioning to improve the environmental performances of the Operation Services and provide the public of the right information.

Given the number of different facilities and activities and different Contractors it appears to be advisable that the grievance mechanism is implemented and managed directly by SWaMA at a central level rather than be left under the responsibility of the single Contractors.
This option has also the advantage of providing SWaMA of an indirect but effective control of the performances of the different Contractors and parts of the waste management system.

The need of cooperation of the Contractors to the mechanism can be conveniently included in the Contract requirements. Any complaint received directly by the Contractor's personnel shall be registered at the relevant facility and immediately forwarded to SWaMA Communication Officer.

42.1 Grievance mechanism minimum requirements

The SWaMA shall establish the following contacts:

- Grievance Phone number (Communication Officer)
- Email address (to be regularly checked by the Communication Officer)
- Website page

The contacts shall be made available to the public through:

- advertisement in at least two major newspapers for at least two times
- SWaMA web page.
- Each facility signboard
- Rear of each waste transport truck

Any time the Communication Officer is notified a grievance shall:

- Record it in a properly established Grievance Register including, if available, the contacts of the person that reported the complaint
- Immediately inform by email the relevant SWaMA officer in charge of the supervision of the contract related to the received grievance
- Provide feedback within 24 hours to the person who reported the complaint preferably by email if available specifying action taken in accordance to the provided information

Any time the Contract Supervision Officer is notified a grievance shall:

- Verify, as long as it is feasible, if the referred event still persist
- Identify the possible origin and extension of the aspect generating the event
- Take the necessary action to remove the cause/s of the event if determined by a malfunctioning or non-respect of operating procedures issuing to the Contractor Site Manager a specific Site Instruction/Administrative Order
- Inform the Director of SWaMA in case the problem is originated by some aspect that cannot be dealt with within the Operation Services contractual restraints or not directly connected with the Operation Services performances

A brief summary on the Grievances received during the period including remedial actions and comments shall be included in the Monthly Report of the relevant facility.

42.1.1 Responsibility

It is responsibility of Communication Officer of SWaMA to superintend the activities related to the Grievance Mechanism and to guarantee the necessary information to the public in the adequate forms including the updating of the website page and, in case of general interest or high relevance, the call for Public consultations.

H. PUBLIC PARTICIPATION/CONSULTATION

Two public meetings have been done so far in the aim to explain the Master Plan provisions to the main stakeholders and to get feed-back
The first meeting has been done in Corozal, on August the 12th , 2015 and was addressed to the stakeholders of the Northern Corridor. The second one has been done in Toledo, on October the 6th , 2015 and was addressed to the stakeholders of the Southern Corridor.

The reports of these consultations are attached at the present.

I. BIBLIOGRAPHY

- Government of Belize. *Belize Disaster Management Plan*. July 1997.
- Government of Belize, *National Emergency Management Organization (NEMO). Hurricane Preparedness Bulletin*. Belmopan, Belize, 2005.
- Government of Belize. *National Emergency Management Organization. National Emergency Management Plan*, 2004.
- NEMO, Belize Website HTTP://WWW.NEMO.ORG.BZ/DEO/STANNCREEK.PHP
- Usher, Wayne. *National Climate Change Adaptation Issues in Belize*. Ministry of Economic Development, Belize. September 2000.
- CDMP, *Atlas of Probable Storm Effects in the Caribbean Sea. Caribbean Disaster Mitigation Project (CDMP), Models and data output by Watson Technical Consulting*, Inc. Editing and presentation by Ross Wagenseil, Ph.D. March 2000.
- Yasushi Matsufuji, Ayako Tanaka, Masataka Hanashima, *"Biodegradation process of Municipal Solid Waste by Semi-Aerobic Landfill Type",* Department of Civil Engineering, Faculty of Engineering, Fukoka University, Japan (2008).
- PL Bjerg, H-J Albrechtsen, P Kjeldsen, and TH Christensen, "*The Biogeochemistry of Contaminant Groundwater Plumes Arising from Waste Disposal Facilities"* - Technical University of Denmark, Lyngby, Denmark, IM Cozzarelli, U.S. Geological Survey, Reston, VA, USA (2014).
- Peter Kjeldsen, Morton A. Barlaz, Alix P. Rooker, Anders Baun, Anna Ledin and Thomas H. Christensen *"Present and Long-Term Composition of MSW Landfill Leachate: A Review",* Critical Reviews in Environmental Science and Technology, 32(4):297-336 (2002).
- Y. Matsufuji, A. Tachifuji, *"The history and status of semi-aerobic landfilling in Japan and Malaysia*" (2007).
- Q.F. Huang, Q. Wang, Y. Yang, L. Dong, "*Influence Of Landfill Structure On Leachate Characteristics"* - Chinese Research Academy of Environmental Sciences, Beijing, China (2005).
- IFC,*"Environmental, Health and Safety Guidelines for Waste Management Facilities"*
- Ellen Blake, Bruce Chapman *"Meeting the challenge – Landfill in Samoa"* – SPREP.
- EPA, *"Landfill Gas Emissions Model (LandGEM) Version 3.02 User's Guide"* (2005).
- Milena Breisinger, *"Greenhouse Gas Assessment Emissions Methodology"*, August 2012.
- IDB, "*Safeguard Policy OP-703*".
- IDB, *"Environmental Assessment and Landfill Gas Management for Mile 3, San Pedro and Caye Caulker Open Dumps, Belize – Draft Final Report"* (August 2008).
- Pat Costner, *"Update of Dioxin Emission Factors for Forest Fires, Grassland and Moor Fires, Open Burning of Agricultural Residues, Open Burning of Domestic Waste, Landfills and Dump Fires"* International POPs Elimination Network (15 November 2006).
- IPPC, "*2006 IPPC Guidelines for National Greenhouse Gas Inventories"*.
- SIB, Statistical Institute of Belize *"Census 2010"*.
- UNEP, *"Resource and Guidance Manual for Environmental Impact Assessments – Desalination"* (2008).

- Caribbean Community Climate Change Centre, *“Third national greenhouse gas inventory”*, (2015).
- Scire, Strimaitis, Yamartino *“A user’s guide for the CALPUFF dispersion model”* (2000).
- Selena Sironia, Laura Capellia, Paolo Centola, Renato Del Rosso, Massimiliano Il Grande *“Odour emission factors for assessment and prediction of Italian MSW landfills odour impact”* (2005);
- Institute of Air Quality Management (UK), *“Guidance on the assessment of odour for planning”* (2014).
- DEFRA UK, “*Odour Guidance for Local Authorities”* (2010).
- UK Environment Agency, “*Draft 2009, H4 - Odour Management”*
- ISWA (International Solid Waste Association). *“ISWA Guidelines: Waste to Energy in Low and Middle Income Countries”* (August, 2013).

J. APPENDICES

- Appendix 1: List of the authors of the EA;
- Appendix 2: TOR for the preparation of the EIA
- Appendix 3: Complete record of public consultation activities.

APPENDIX 1 – LIST OF THE AUTHORS

Name	Affiliation	Qualification	Relationship to project sponsor
Sara Monti	HYDEA	International Environmental Specialist	None
Evaristo Avella	HYDEA	National Environmental Specialist	None
Michele Lambertini	HYDEA	SWM Engineering Specialist	None

APPENDIX 2 – TOR FOR THE PREPARATION OF THE EIA

APPENDIX 3 – COMPLETE RECORD OF PUBLIC CONSULTATION ACTIVITIES

NORTHERN CORRIDOR STAKEHOLDERS CONSULTATION MEETING
August 12 2015

OPENING: Mr. Tyronne, SWaMA
Welcome Remarks: Mr. Rafael Castillo, Deputy Mayor, Corozal Town Council
Introduction: Mr. Javier Grau Benaiges, IDB
Presentation: Mr. Gilroy Lewis, SWMA
Presentation: Michele Lambertini and Jeroen Ijgosse, Hydea

QUESTIONS AND ANSWERS PERIOD

The following is a summary of the questions and answers given at the Northern Corridor consultation meeting.

The first question was asked during the presentation of the statistical assumptions and findings. A participant asked whether the villages were analysed based on priority to be given or whether all villages were to be treated equally.
The response was that the determination of village sizes and composition was strictly for technical reasons as to what type of collection system can be applied based on population sizes and local practices.

Question: Since one option was to use the Mile 24 Landfill; what capacity does that landfill currently has in terms of expansion?
Answer: The response was that there is enough capacity for 15 years; after which additional costs will be incurred as a result of the need for construct new cells.

Question: What is the difference in performance between the traditional and anaerobic landfill systems?
Response: The primary difference is the environmental performance in terms of effluent and emissions of gases; whereby traditional landfills (such as the Mile 24 Site).

Question: What size of property are we looking at for the two proposed landfill sites in the north?
Answer: Approximately 100 acres.

Question: Who monitors the environmental parameters at the Mile 24 sites and what parameters are monitored?
Answer: The DOE, along with PASA (the contractor) does monitoring of effluent, using approved standard methods and an approved laboratory in Mexico. The results of effluent and water quality monitoring are submitted to the DOE for revision. The DOE also does its own monitoring.

Question: How would the proposed master plan would be funded?
Answer: A brief discussion was held on some financial mechanisms for cost recovery of but it was stressed that at the second phase this will be looked at in greater detail.

The discussion then continued on the issue of payment for waste services, which seems to come mostly from the tourism sector, and it was pointed out that due to the poverty level, some people will not be able to afford the fees.
The response was given that a willingness to pay survey was also being done and that the poorest quintile of persons will be considered.
Question: What is the purpose of the Environmental Tax? The opinion of the individual was that this would be able to sustain the solid waste program.
Answer: The entire fiscal policy of the Government is being discussed; and the Central Government believes that it should be for the core of the solid waste programs; i.e., to construct and operate the waste sites; but that other service such as collection should be the function of local governments.

It was stated that the operation at Mile 24 is being paid for by the Government from funds generated from the Environmental Tax.
It was also clarified that the future of the environmental tax fund was uncertain because the World Trade Organization was putting pressure on the government to remove the tax due to trade differences. The Government is looking to abolish the tax but it may be replaced by another tax; but this was uncertain at this time.

Comment: A comment was made by participants from the Belize Sugar Industries Limited (BSI); who stated that in terms of the assessment of potential sites for landfill and transfer stations, that the B.S.I. site being used by Orange Walk was included in the assessment but that B.S.I was interested in closing the site. It was also remarked that B.S.I. is keen in addressing the issue of use of the site and was willing to facilitate the process by transferring ownership of the property for use as a transfer station.

Question: Do these landfills provide for the treatment of hazardous waste material?
Answer: At the new sites no cells will be used for hazardous waste treatment because one cell designed for this is already in place at the Mile 24 site; and this is enough to treat/hold hazardous waste. The hazardous waste cell is being improved by including pre-treatment for disposal.

Question: Does the SWMA envision that the project can have an inter-ministerial committee to oversee the proposed new projects; particularly since the new projects will incorporate the village councils, and the village councils have no revenue generation.
Answer: It is hoped that this would facilitate because the new solid waste policy recommended to the Government that an Inter-ministerial committee can act as a steering committee and the DOE can serve as the regulatory agency.

Question: A question was posed to the Cane Farmers Association as to the two proposed sites being considered; whether these sites would affect any future plans for sugar cane production.

The members from the association responded that in terms of expansion, the Industry is presently completing a mapping exercise of its cane fields; and that the industry is looking at vertical expansion instead of horizontal expansion, and that the approximately 100 acres to be used for the new landfill will not impact the industry.

Clarification was done as to the two sites being proposed. A participant was interested in knowing where the two sites were and this was clarified.

A final comment was made that the garbage fee needs to include incentives and disincentives for it to function.

At the end of the meeting, the thanks were given by the consultants and the SWMA.

SOUTHERN CORRIDOR STAKEHOLDERS CONSULTATION MEETING

The Senter Independence Toledo
October 6 2015

QUESTIONS AND ANSWERS PERIOD
OPENING OF MEETING: 9:15 By Tyronne, Facilitator of the Meeting

Welcome Remarks
Mr. Antonio Zabaneh, Chairman of Independence Village

Presentation by Gilroy Lewis, SWMA
Questions based on this presentation

Question: With respect to the transfer stations; it was asked whether these would be constructed, and with respect to the landfills, whether the hazardous waste could be disposed at these facilities.
Answer: The transfer stations will be built at municipalities. With respect to the hazardous waste management it has been explained that there is a cell for hazardous waste treatment at the Western Sanitary Landfill, and this cell has double protection against leachate leakages.

Question: What about scrap metals, old vehicles etc?
Answer: There is also a separate legislation that addresses scrap metals. These are collected for recycling in neighbouring countries. The Department of Environment deals with the recovery of scrap metals, refrigerants and recycling of cylinders.

Question: Is there any collection system for recyclable materials?
Answer: It is done by recycling companies.

Question: How will old dump sites be managed?
Answer: In the proposed solid waste master plan, as in the case of the Western Corridor, there is a proposal for old dump sites to be remediated. There is also the need for legislation for source separation, and this is a work in progress.

A Presentation by Mr. Xavier of IDB on waste separation at the Belize City Transfer station was done.

PRESENTATION: Michele Lambertini, Hydea
Mr. Lambertini of Hydea then presented the management scenarios proposed by the master plan for the solid waste management for southern Belize.

QUESTIONS PRIOR TO PLENARY SESSION:

Question: One concern was raised that the Placencia dump site is too far away and this increases costs for disposal.

Answer: People will continue dumping at the present site since they will not have anyone collecting their waste, because the illegal dumping can be faced through the implementation of a collection system, and this is one of the goals of the master plan. Another issue related is the way they are asked to pay for the service. The way the fees are collected influences waste separation. If the payment of the fees is separated from the waste taking, the population is not encouraged to separate the recyclable fractions of the waste.

A comment was made that there was nothing in the presentation that talked about recycling of materials from households and businesses, a good collection system was explained but no recycling initiatives. Another issue highlighted was the illegal dumping at beaches.
Answer: It was mentioned that the paradigm is to change the system towards resource management. Recycling, re-use etc. And concerning the issue of the illegal dumping at beaches, the answer was that this concern was being faced with the neighbouring countries, such as Honduras and Guatemala.
It was agreed that the disposal site from Placencia is very far and the solution is to find a small area close to Placencia for a transfer site.

Comment: In reference to Placencia, the waste growth is different because of the rise of tourism. Was this considered during project development?
Answer: Waste projections based on the tourism growth were considered, and specific activities for recycling and other initiatives need to be put in place.

Question: Was the Has Harvest Caye tourism project taken into account?
Answer: With respect to Harvest Caye, Environmental approvals from the DOE made provisions for them to manage their own waste; therefore, it has not been factored. They will incinerate waste. Large developments generally are responsible for their own waste management.

QUESTION AND ANSWER PERIOD

Comment/Question: It seems that one of the most important parts of the project is recycling. Are there any plans for recycling and what about the market for recycling products and the plans for it?
Answer: With respect to recycling there are two aspects that must be considered: 1) economics of recycling; and,2) environmental issues that include, reducing pollution, landfill waste etc.
First, the experience with recycling in the country is bleak. Recycling in the Western Corridor has been left to the recycling companies. For us (at SWMA) recycling is geared primarily at the creation of jobs, since there is no cost recovery for SWMA due to the selling of recovered materials. For example, the Belize Recycling Company weighs the waste and pays the recyclers. We may continue with that model. Recyclers recover mostly pet bottles, hdpe plastics, paper, aluminium cans, and glass bottles. These are products that have a market at this time, but the demand in the markets changes. Presently, for example, the price of plastics for recycling is down due to the drop in the price of petroleum.
Furthermore, the recycling centres would not self-sustained as a result of recycling. However, it can lead to a decrease in cost of waste management, which is still an economic benefit. In other words, instead of generating revenue, it can reduce the cost of managing

waste, which is still a positive financial benefit. However, it can't really be seen as a revenue source.

Question: In reference to Placencia, Independence and Punta Gorda, would these dumpsites be closed and the same used for transfer stations?
Anwer: At Independence, yes, for Dangriga, there is another parcel nearby, and not the present one. About Punta Gorda, there is a piece of land owned by SWMA where a dump site was planned, but it was not done. This site may be used.
There would be drop off centres in each population centre. For private tourist subdivisions, there also may be local initiatives for the installation of their own waste management plans.

Question: While the present site, behind San Felipe, is being considered for a transfer station, it was commented that there is a concern with the distance between this site and the municipality.
Another issue raised was that of cost recovery, how is the user fee system to be implemented. Specifically, how do we go from paying nothing to paying something?
Answer: With regards to the distance, yes we agree there is a problem. There would be an increase in cost due to the distance.
Also the fee collection is a critical point in the process. How to implement a fee structure has been a challenge. However, preliminary considerations are being given that at the beginning 70% of the costs will be paid by the Central Government, and 30% by municipality; then possibly reversing this when the system becomes more efficient.
Another possibility being looked at is the implementing a garbage fee through electricity bills or property taxes or other taxes.

Question: It was mentioned that at the moment there is another assessment being done called Willingness to Pay Survey. Based on the outcomes of this survey, decisions can be made. The cost recovery mechanism has to be implemented and charging of fees will be done at some point.
It was commented that in terms of the use of Mile 24 waste disposal site, it would be more feasible if coastal road is upgraded.
Answer: It was mentioned that with respect to this road, the first phase is the construction of bridges which have already began. But this option can be discussed with Ministry of Finance.

Question: A question was asked as to whether there are markets for all the recycling products. Do the waste pickers have to wait to sell their products or is there a salary for them.
Answer: Currently there is market for paper. Belize Recycling Company has invested in a plant near San Estevan. Also aluminium, and plastic bottles do have a local market. Perhaps legislation needs to be created for water plastic bottles too. However, there is no market for cartons, and perhaps pilot projects are needed. One of the problems with the internal market in Belize, is due to the size of the country the quantities being produced are not big enough to sustain a local market.
Transportation is also a cost. However, recycling does result in reduced cost for disposal at the landfill. Therefore, one needs to consider that it is not only the profit to be gained from recycling, but also the savings as a result of diverting the waste to disposal systems.

Question: What is the projected timeline for project implementation?
Answer: First of all the completion of the document being prepared is expected. In terms of budget, there are some final decisions to see if the loan is enough for the project, but in 2016 the loan would be approved. Therefore, construction can start in the months after.

Question: What is the interest rate for this loan?
Answer: It is believed that it is 1% of the loan. It will be similar as that for the Western Corridor, which cost 14 million US dollars; and covered the costs of closures of disposal sites and construction of transfer stations and the Western Sanitary Landfill.

Question: When waste will be transferred from Middlesex to Dangriga, how would it be done? How many trucks would be used?
Answer: The system will work with containers, and depending on the size of the village and volume of waste, it is expected that garbage will be transported at least once a week from villages.

Question: Would this be under management of SWMA?
Answer: Yes, from operation of transfer stations, collection and transportation to the landfills is the responsibility of SWMA. As for local collection, local governments will do this. These are the options being considered

Question: Is there a budget for the cleanup of the Punta Gorda dump?
Answer: Yes, a total of six (6) dump sites shall be remediated. Two (2) in the north and four (4) in the south.

Question: What will be done with this garbage?
Answer: It will not be transported to a landfill. The site remediation was designed considering environmental and cost factors, and the project provisions follow the IDB directives.

Comment: A concern about pollutants at the PG dump was raised.
Answer: Due to the disposal methodology characteristics and to the abundance of rain falls, the pollutant concentrations in the leachate of the open dump, such as the Punta Gorda one, drop very quickly.

Question: What about illegal dumps? There are many of these.
Answer: The master plan has an aim to put in place a management system, remediation and construction of landfills. The remediation of all illegal dump sites is not part of the master plan. However, since the government is addressing the major problems, the local communities have to address these local issues. Perhaps at the village level the clean-up can be corrected and charged of a fee.
The experience in the Western Corridor is that once the program is in place, the illegal dump sites are then addressed. Along with the DOE, some of these are being addressed. For example, on the western corridor, illegal sites are investigated, then the Lands Department is approached in order to identify the owner of land where an illicit dump exists, then the

property owner is notified that the dumping on their property has to be addressed. One such illicit dump was stopped in the Western Corridor.
In addition, coordination with communities and clean up campaigns etc, are also done to address the issues such as local dumping.

CONCLUSION

In the end there were no more questions and a questionnaire for further comments was distributed, and also the use of the SWMA web site and the facebook page were encouraged.
The meeting was concluded by Mr. Tyronne thanking all participants for attending.

Presentation of Solid Waste Master Plan for Emerging Tourism Areas (SWMP II)

Southern Corridor Consultation, Independence Village, 6th Oct 2015

Feedback from Ian Morton, Hickatee Cottages, Punta Gorda

The comments in red are made by Michele Lambertini

I have attached a copy of my report to the BTIA Toledo members for your information.

Unfortunately I was late in arriving and missed the first part of the presentation dealing with 'Transfer Stations'. Please bear this in mind if some of my concerns were addressed in the first part.

The overall message of the presentations was clear and easily understood. However, some parts of the HYDEA presentation were of a technical nature and I would have liked more time to study these aspects. But, the sizes of the slides on the screen were so small that, even with more time, I would not have been able to read the data.

We apologize for the necessarily limited time given to the presentation of the technical data. The main aim of the consultation was, on the other hand, to provide an overall view of the project and outline the major aspects. Should you need more detailed information on the technical aspects please feel free to contact me.

I have the impression that either:

a. I was one of only a few people in the meeting that understood the HYDEA presentation and wanted more time to study the data, or

b. Most people in the meeting already had access to the presentation before the meeting and had already made their opinions known.

I would however like to offer a few points where I have concerns and/or an opinion:

1. I very much like the concept presented at the consultation and feel that this is a great leap forward for Belize in managing its solid waste and that, for a developing nation, this is an achievable goal and an example to other developing nations.
2. The recognition that Toledo and South Stann Creek are not suitable for landfill sites comes as no surprise, and I welcome the proposed transfer station/s concept and practice.
3. The siting of the transfer station in (or near) San Felipe will increase the distance solid waste must be transported, leading to probable increases in costs and "down time" for the men collecting the waste.

   We recognize this problem. This aspect was also discussed during the consultation with the Mayor of Punta Gorda and other Town Counsellors. The strengthening of the collection system in Towns (including Punta Gorda) is in fact one of the aspects to be further discussed.
4. From what I have seen in the UK of transfer stations and the transfer stations here in Belize there is little or no contamination of the local area as the waste is containerized and, presumably, transferred in good time to a landfill site. This may increase the potential for a possible transfer station sited slightly closer to PG Town but still providing the essential easy access from the Southern Highway.

Alternative sites have been visited and considered during the process located along the Highway and closer to the Town. They have been discarded since either too expensive or too close to residential settlement and/or touristic facilities. The siting process can still be reopened in case a more suitable site would be proposed by the Punta Gorda Town Council or private owners.

5. The siting of the transfer station nearer to PG/Southern Highway should encourage residents to use the station as a “drop off” thereby reducing fly tipping, which is a major problem in the area. (However, a reduction in fly-tipping, as well as the significant littering in and around PG Town, is dependent on PG Town Council enforcing the current littering legislation. Were the fine system to be enforced, a litter officer(s) could be a self-financing position and cost the Council no extra money, and even generate some income.)

6. I would have liked more time to study the methods used to assess the volume/weight of solid waste production per family/household, as the figures presented are less than half the amount assessed in a 2009 physical survey carried out by TIDE in Punta Gorda Town. I am extremely concerned at the differences and, if the TIDE assessment is the more accurate, this will have a significant impact on the costings for the project.

   The 2009 TIDE survey has been reviewed and considered during our waste generation study. It actually provides figures that are significantly lower than those assessed by us (HYDEA) for the aim of this project. The misunderstanding is probably generated by the fact that TIDE expresses the generation rate in Kg per inhabitant per WEEK (1.93) where our figures are in Kg per inhabitants per DAY (1.02). TIDE’s figure is then more than 3 times lower if correctly compared. It must be considered, on the other hand, that TIDE’s projections do not apparently include waste generated by commerce, tourists and other Municipal Solid Waste generators. TIDE’s figure was then not considered for conservative reasons.

7. Given the relatively recent changes in importation restrictions I am seeing a huge increase in nonreturnable glassware. If your assessments were made prior to the changes then the family/household production figures should be re-assessed.

   Can you please provide us further details on the restrictions you mention? We will consider the aspect in the future stages of the work.

8. The figures presented for the volume/weight of solid waste production by “tourists” may, or may not, be correct. Unless I am able to see how this figure was arrived at I am unable to make a judgment, but my feeling is that this figure is too high. In my experience, most Toledo tourism businesses do much more than many other businesses to reduce, reuse and recycle and to dispose of their solid waste as conscientiously as possible, reducing the pressure on both the environment and the current waste collection service. Perhaps Toledo is different from other parts of the country?

   The generation rates from tourism come from detailed studies made specifically on tourism sources within the Caribbean. The mentioned good practices are certainly encouraging and go in the direction of what the Plan is suggesting (diversion at source). Again, should your feeling be correct, this in favour of the conservative assumptions made for the aim of the Plan further confirming the proposed solutions.

We would be glad to further discuss with you on the matter to include such good practices in the final version of the work.

9. Assumptions regarding waste reduction and re-use, composting etc may be optimistic: an educational campaign would almost certainly need to be instituted, and possible incentives (or penalties) provided, for it to be successful. Littering seems to have long been an accepted part of life, as you will have seen from the trash in Independence. PG is little better.

   The assumption at the base of the study are actually very low in regard to the recycling and composting in Agglomerates (Towns and surrounding villages). No composting and only 4% recovery of the recyclable fractions are envisaged by the analysis for conservative purposes.

10. So who is to pay for all this? I believe that those who create the waste should pay for the disposal of that waste, but that it should be a fair division and those who produce more should pay more.

    The current "opt-in" payment system in Punta Gorda simply does not work! Whilst some people pay, others who don't pay still have their garbage collected, leading to a downward spiral of 'why bother paying if it's collected anyway'. There are no consequences to non-payment and hence no incentive to pay.

    a. ***Adding a solid waste charge to Land Tax***
    I am led to believe the Lands Department is not wholly effective in collecting land tax that is owed to them. To burden them with not only an additional fee to collect and process, but also to require them to differentiate between land that is lived on and land that is not, and how many houses and families are on any one piece, may be far beyond their current capabilities and resources.

       There seem to be very few avenues available to - or perhaps enforced by - the Lands Department to collect unpaid land taxes, so it does not seem sensible to task them with additional duties.

    b. ***Adding a solid waste charge to customers' water bill***
    This may be more practical than option (a), but will require dealing with a number of different water supply methods: BWS water supply, independent village supply, or communal well. Whilst it may be a less complex process than (a) the level of waste produced will not necessarily correspond to water consumption, especially when considering those households who have additional access to a natural water source and/or collect rainwater.

    c. ***Adding a solid waste charge to customers' electricity bill***
    This may be a more preferable method through one nationwide company, BEL, rather than liaising with the different water providers, and is likely to have a greater reach than does BWS et al. Although not all villages are connected to the power grid it is more likely they will get mains electricity ahead of getting mains water?

       Electricity consumption will likely correspond more closely to the amount of solid waste produced than in (b) e.g. larger families as opposed to couples;

family homes as opposed to offices; shops and restaurants and hotels as opposed to industry.

Both (b) and (c) would have immediate consequences – disconnection - in the event of unpaid bills, and therefore gives more incentive/requirement to pay the relevant charges. However, both options would likely require a 'right of appeal' in some instances (e.g. a water bottling plant may use vast quantities of water, or a freezing plant may use an enormous amount of power, but may produce very little solid waste. Conversely, a food stall may use little or no power or water, but result in ridiculous levels of Styrofoam containers littering the area!)

d. ***Surcharge to Trade Licences and/or Liquor Licences***
Were the current local 'semi-voluntary' payment collection system to continue, then an easy way to ensure business pay their fair share would be to add a solid waste management surcharge to trading licences and/or liquor licences. (I continue to observe businesses engage in regular fly-tipping without consequences.)

Thanks a lot for these comments, the proposal of a cost-recovery mechanism is part of the next stage of the work and your comments are much appreciated in this regard.

Please note that the opinions expressed above are my opinions and not necessarily the opinions of BTIA Toledo who I represented at the consultation.

Ian Morton
Hickatee Cottages
Punta Gorda Town
Tel: 662 4475

OFFICIAL ATTENDEES LIST