

Environmental Impact Assessment

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Number: 51077-003
August 2023

Maldives: Greater Malé Waste-to-Energy Project – Waste to Energy Plant (Part D)

Appendices

Prepared by the Ministry of Environment, Climate Change and Technology for the Ministry of Finance and the Asian Development Bank. This is an updated version of the draft originally posted in July 2020 available on <https://www.adb.org/projects/documents/mld-51077-003-eia-2>.

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>35	6
	430

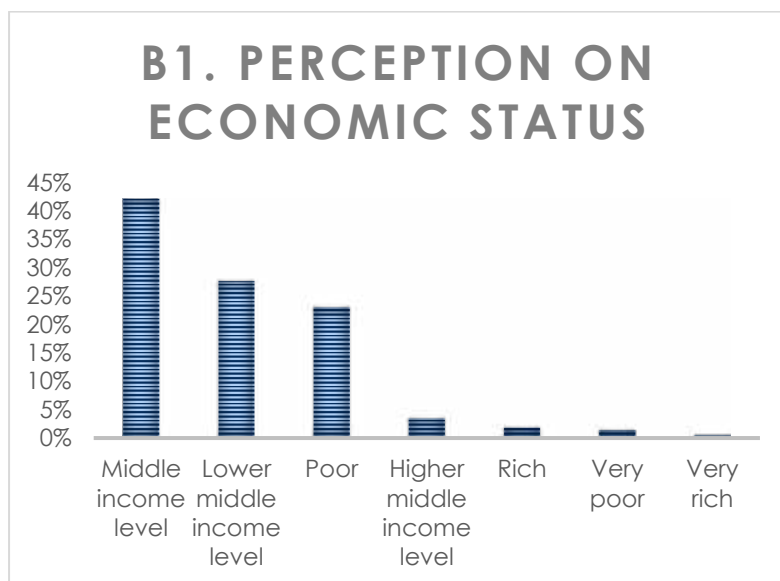
A17. Do you have a work permit?



Don't want to answer	15	4%
No	78	18%
Yes	337	78%

B. INCOME, EXPENDITURE AND SAVINGS

B1. Perception on Economic status

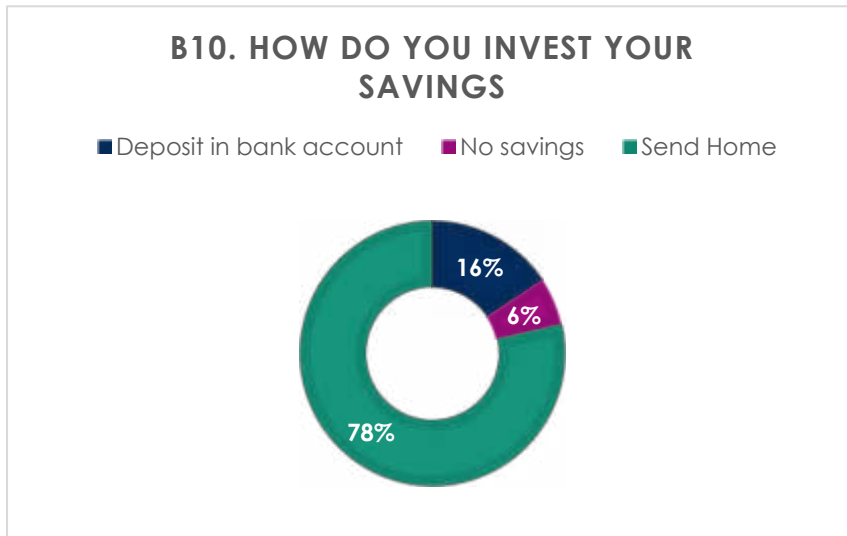


Middle income level	183	42%
Lower middle income level	120	28%
Poor	100	23%
Higher middle income level	15	3%
Rich	8	2%
Very poor	6	1%
Very rich	2	0%

B2/B3/B4/B4/B6/B7/B8. Estimated monthly expenditure

Expenditure (MVR)	Number of people who spent on:						
	B2. Food & Drinks	B3. House Rent	B4. House Maintenance	B5. Healthcare	B6. Electricity	B7. Water	B8. Communication
0-499	253	395	404	396	402	403	149
500-999	40	1	7	14	9	13	205
1000-1499	47	3	3	10	5	2	45
1500-1999	36	3	2	1	3	1	14
2000-2499	15	1	3	4	5	6	11
2500-2999	1	1	2	0	1	0	0
3000-3499	13	2	2	1	0	1	2
3500-3999	2	1	1	0	0	2	0
4000-4499	5	1	1	0	1	1	2
Above 5000	18	22	5	4	4	1	2

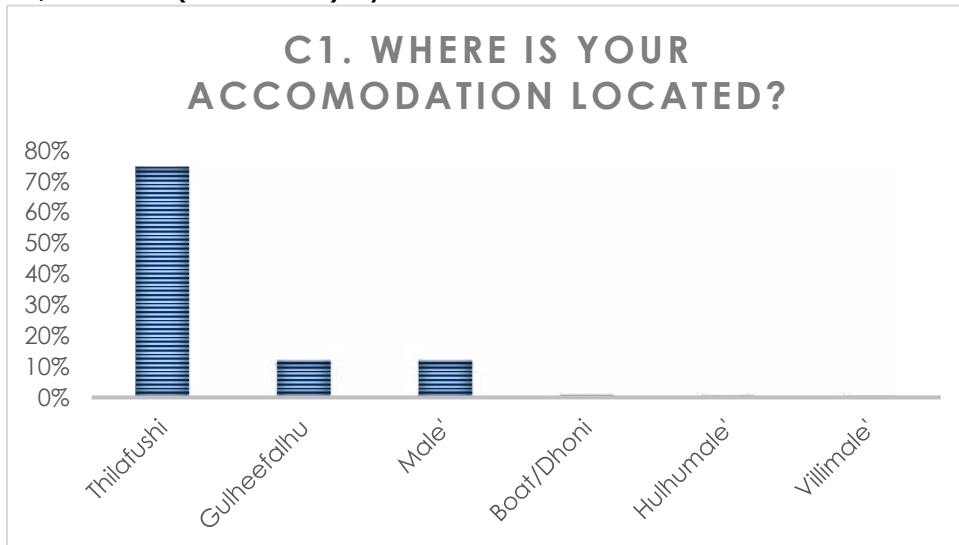
B10. How do you invest your savings?



Deposit in bank account	68	16%
No savings	25	6%
Send Home	341	78%

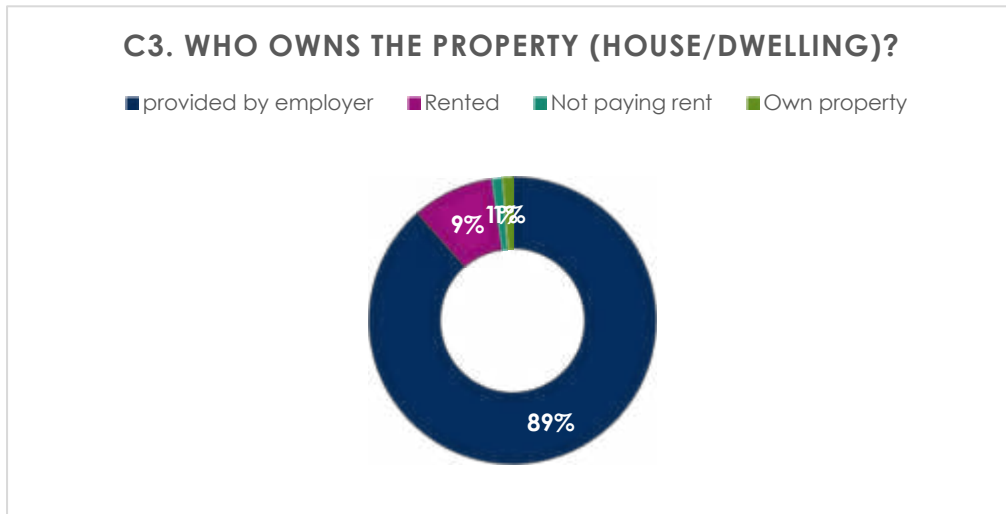
C. HOUSING, INFRASTRUCTURE AND BASIC SERVICES

C1/C2. Where (which island) is your accommodation located?



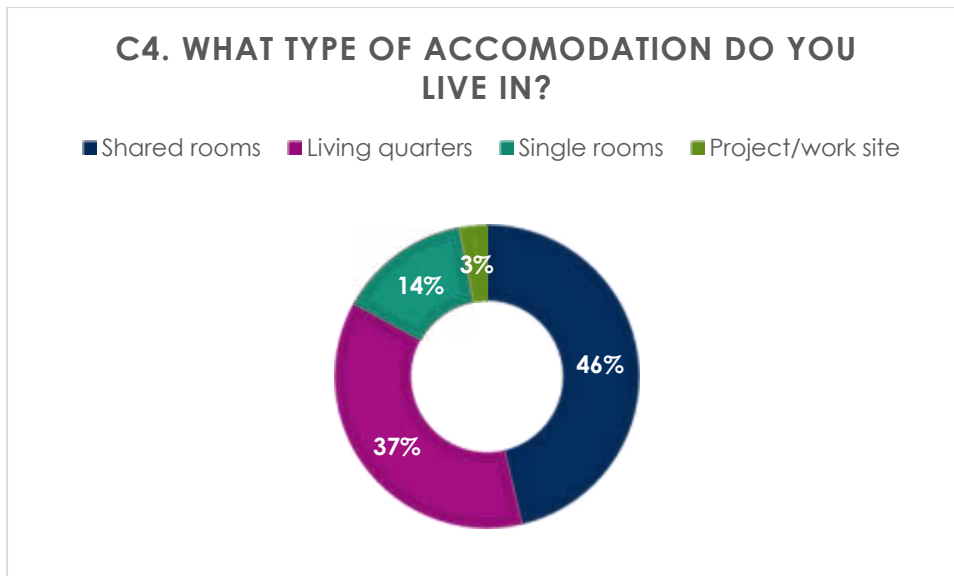
Thilafushi	320	74%
Gulheefalhu	52	12%
Male'	52	12%
Boat/Dhoni	3	1%
Hulhumale'	2	0.47%
Villimale'	1	0.23%

C3. Who owns the property (House/dwelling)?



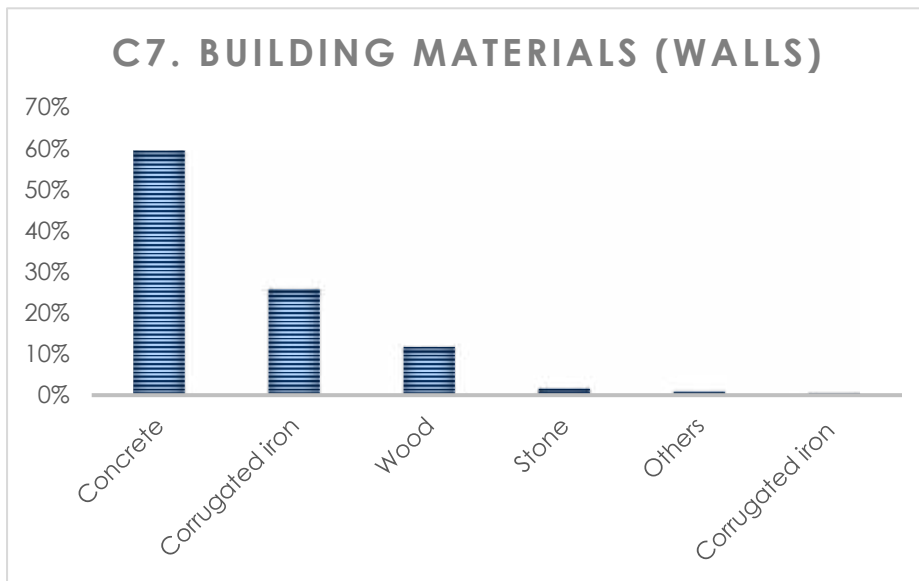
provided by employer	384	88%
Rented	40	9%
Not paying rent	5	1%
Own property	5	1%

C4. What type of accommodation do you live in?



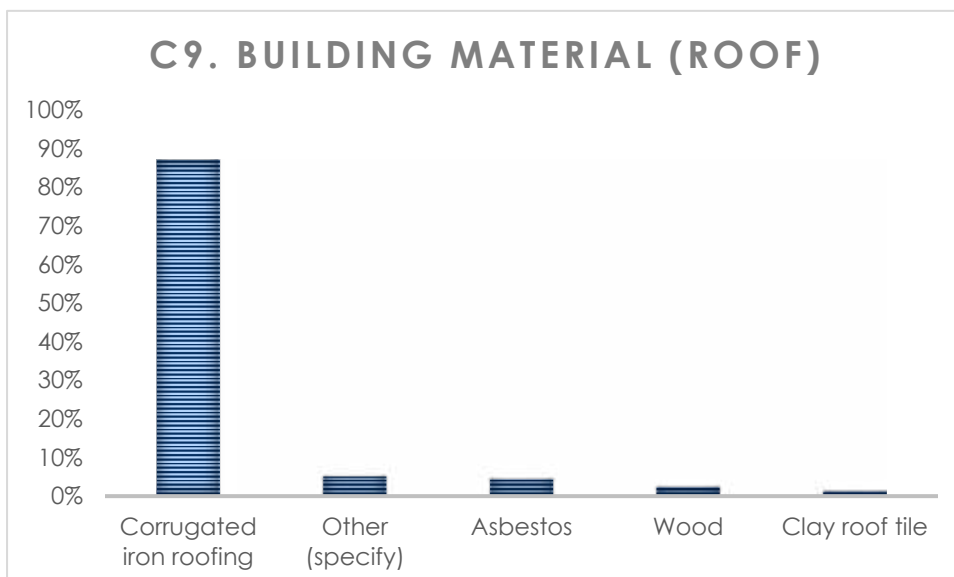
Shared rooms	201	46%
Living quarters	159	37%
Single rooms	61	14%
Project/work site	13	3%

C7/C8. Building material (Walls)



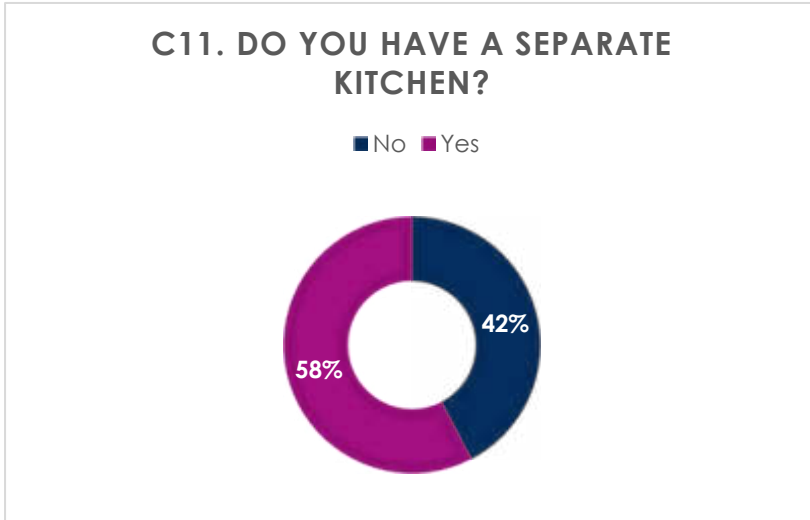
Concrete	258	60%
Corrugated iron	108	25%
Wood	51	12%
Stone	7	2%
Others	4	1%
Corrugated iron	2	0%

C9/C10. Building material (Roof)



Corrugated iron roofing	378	87%
Other (specify)	22	5%
Asbestos	19	4%
Wood	10	2%
Clay roof tile	5	1%

C11. Do you have a Separate kitchen?



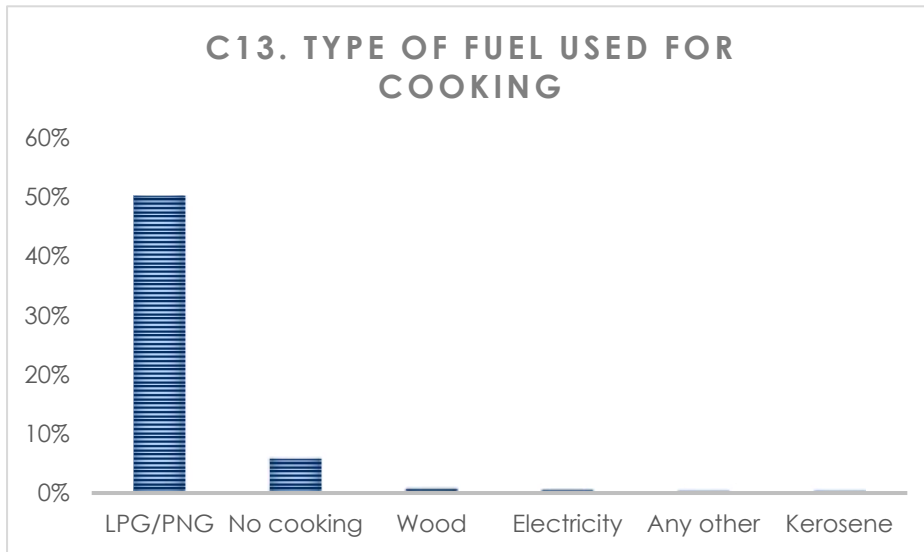
No	184	42%
Yes	250	58%

C12. If yes, do you prepare your own food?



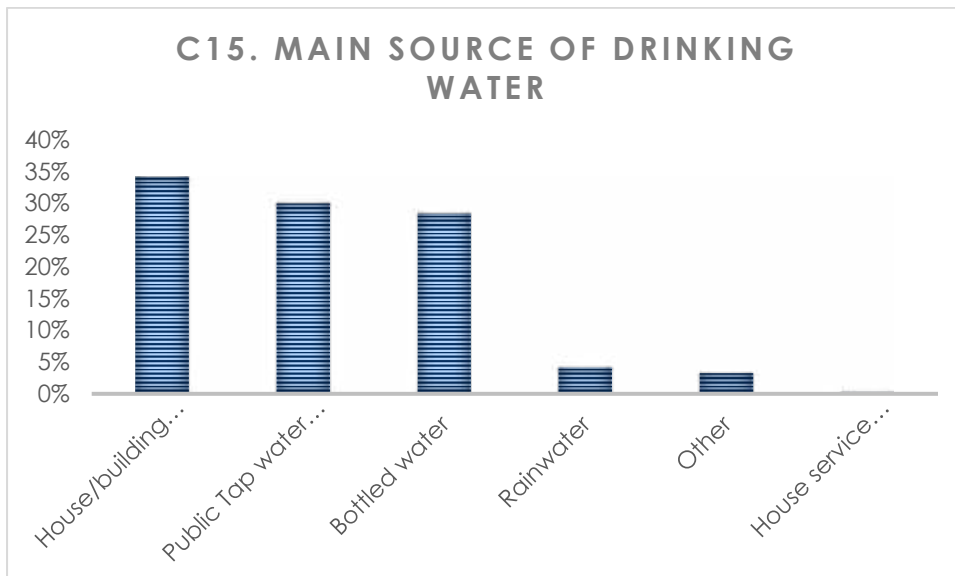
No	106	42%
Yes	144	58%

C13/C14. What type of fuel is used for cooking?



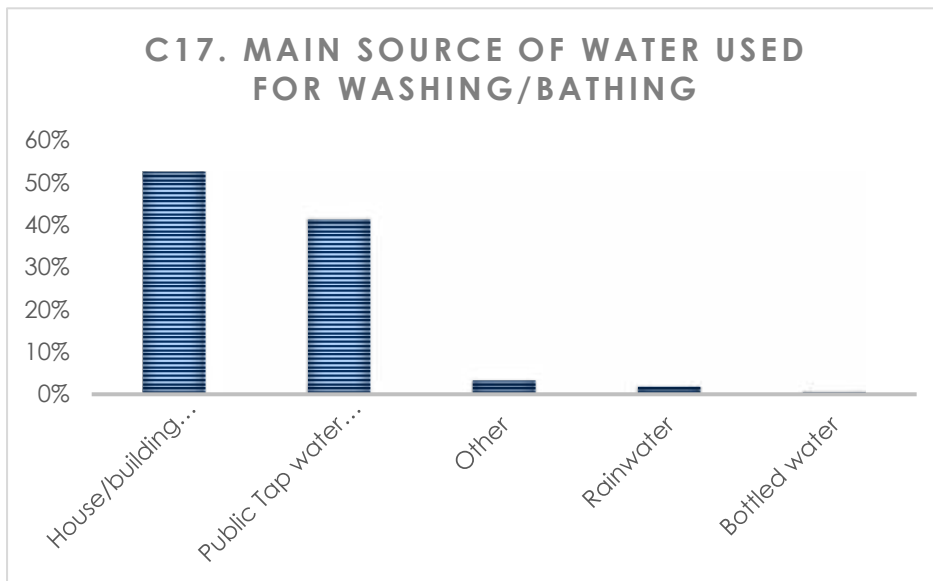
LPG/PNG	218	50%
No cooking	25	6%
Wood	3	1%
Electricity	2	0%
Any other	1	0%
Kerosene	1	0%

C15/C16. Main source of drinking water



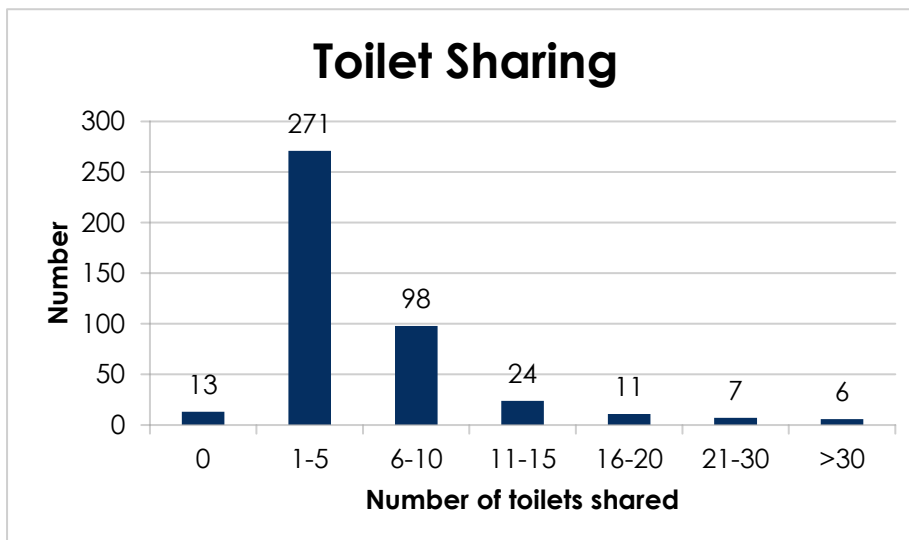
House/building service Connection	148	34%
Public Tap water from treated source	130	30%
Bottled water	123	28%
Rainwater	18	4%
Other	14	3%
House service Connection	1	0%

C17/C18. Main source of water used for washing/ bathing



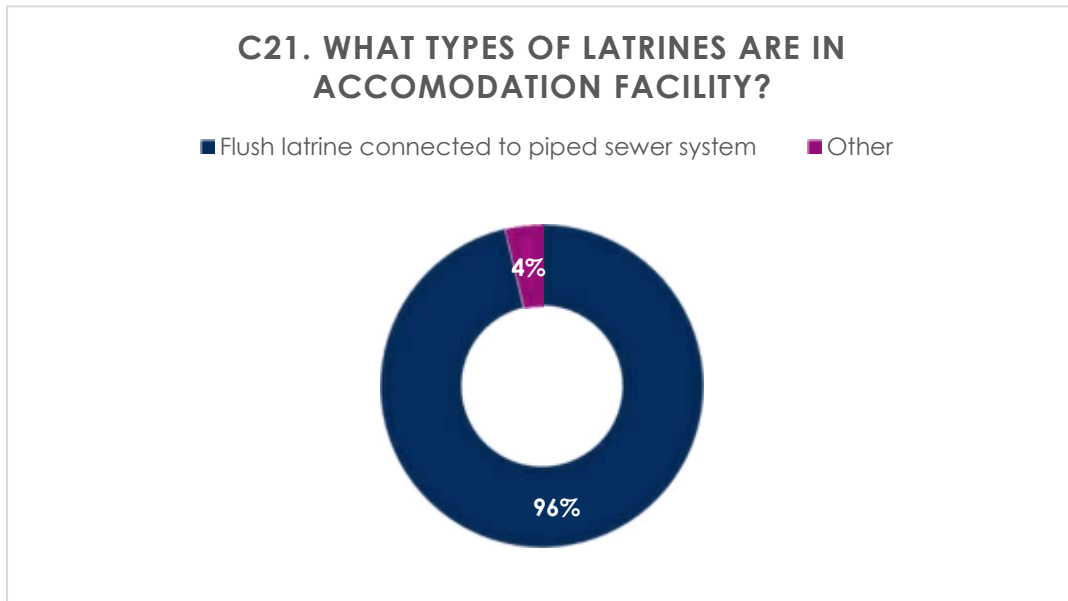
House/building service Connection	228	53%
Public Tap water from treated source	179	41%
Other	14	3%
Rainwater	8	2%
Bottled water	2	0%

C20. Number of toilets shared



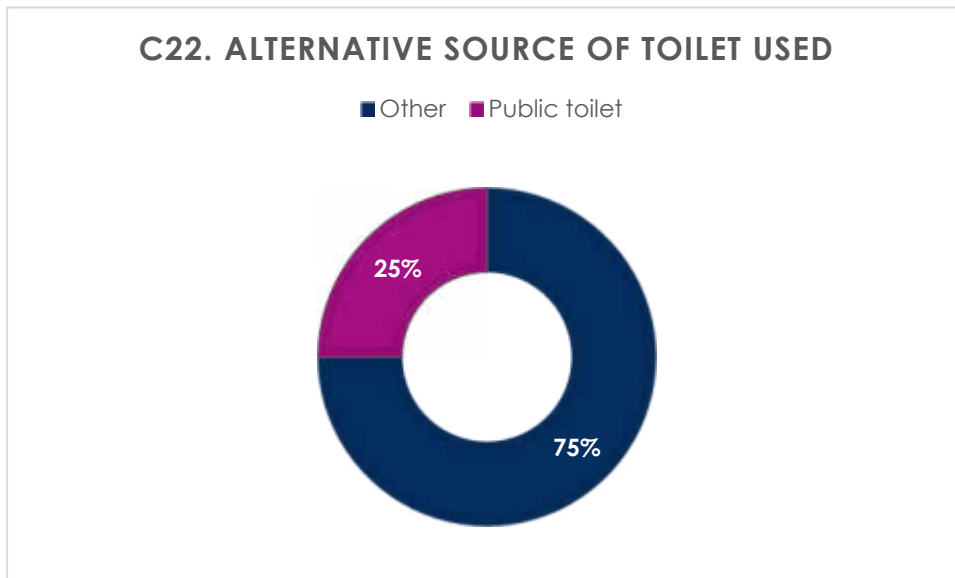
Number of toilets shared	Count
0	13
1-5	271
6-10	98
11-15	24
16-20	11
21-30	7
>30	6
	430

C21. What Types of Latrines are in the accommodation facility?



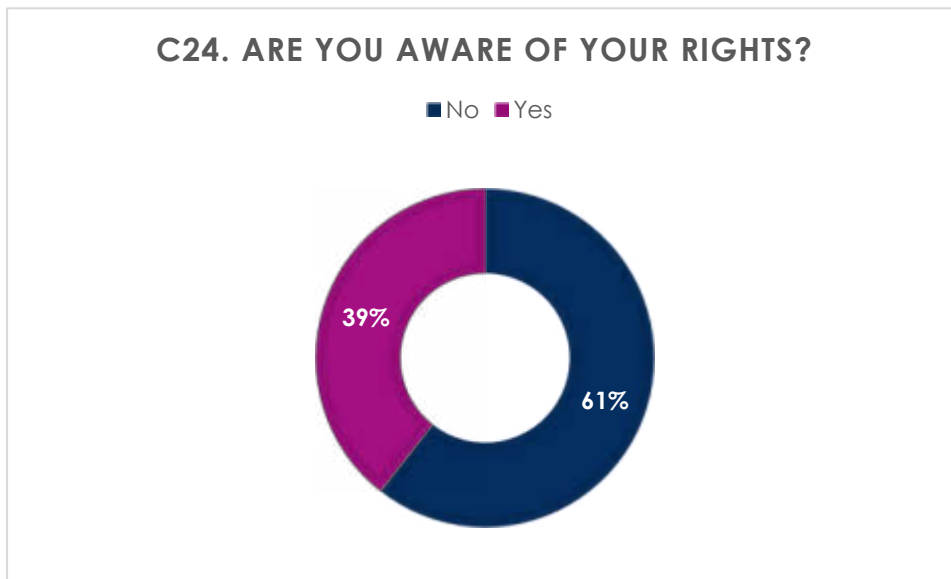
Flush latrine connected to piped sewer system	414	96%
Other	16	4%

C22/C23. Alternate source of toilet used



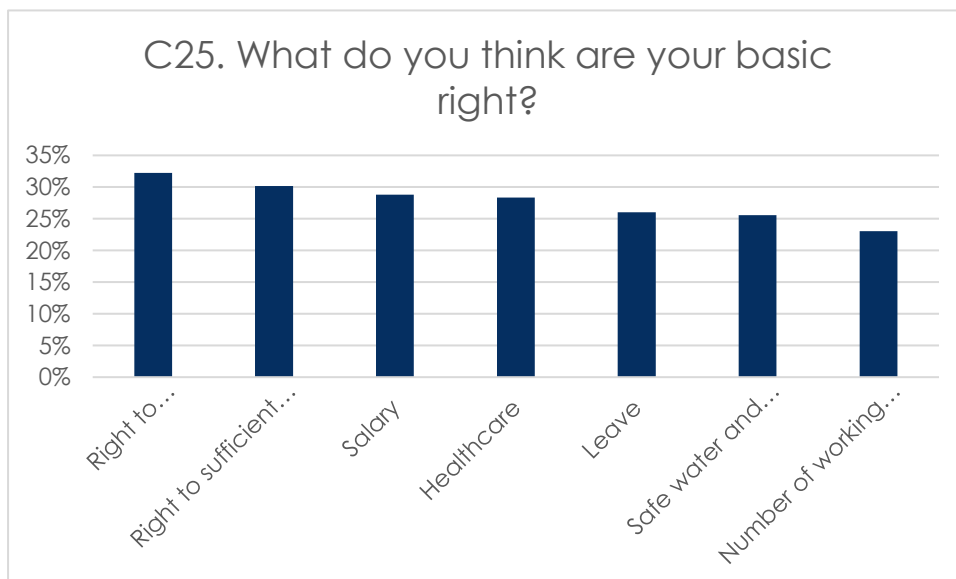
Other	15	83%
Public toilet	3	17%

C24. Are you aware of your rights?



No	263	61%
Yes	167	39%

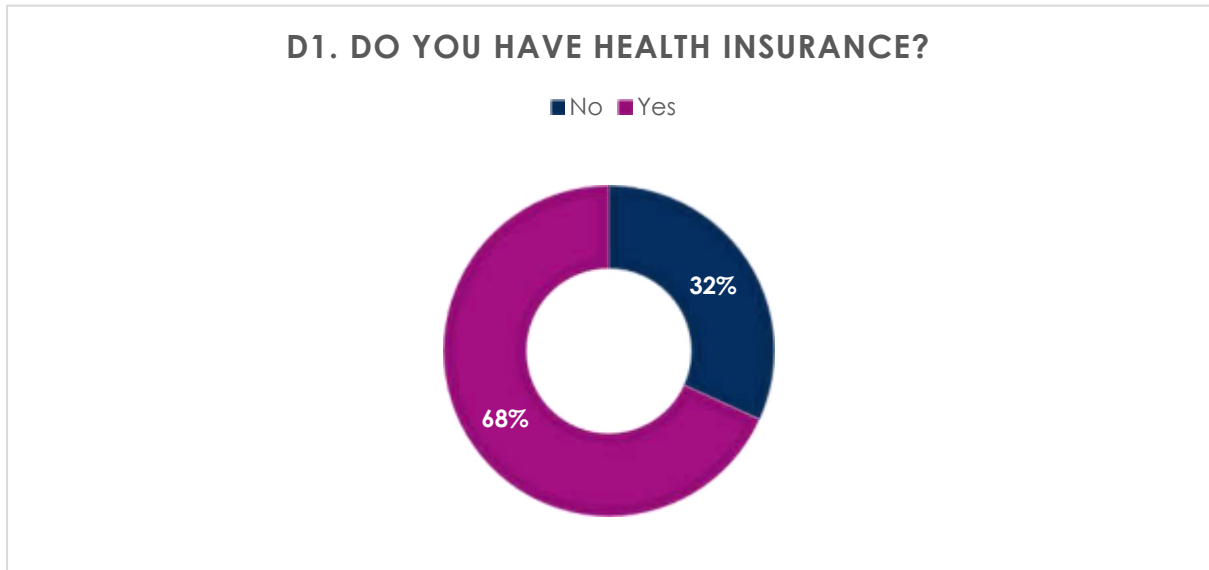
C25. What do you think are your basic rights?



Right to accommodation	140	32%
Right to sufficient foods/meals	131	30%
Salary	125	29%
Healthcare	123	28%
Leave	113	26%
Safe water and sanitation	111	26%
Number of working hours	100	23%

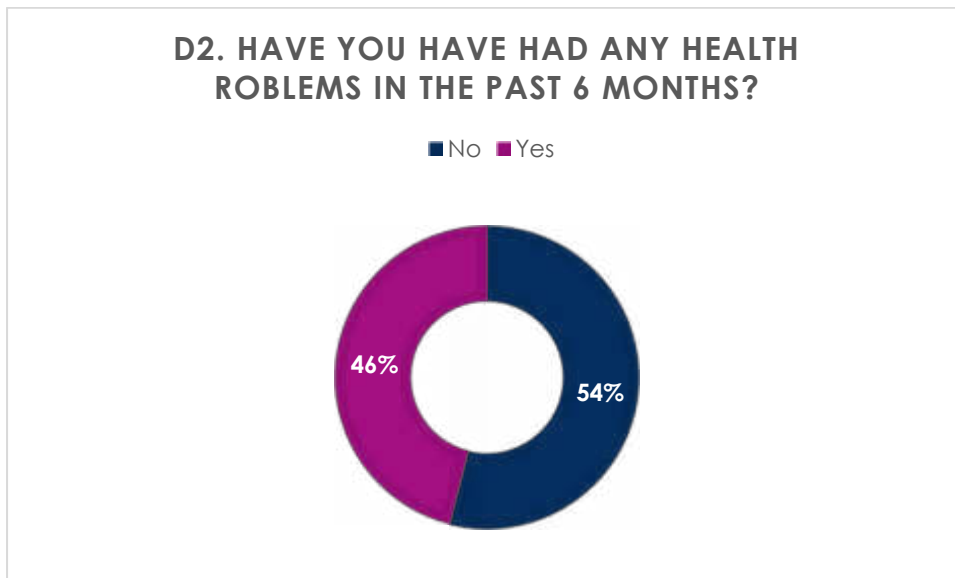
D. HEALTH CONDITION AND HEALTH CARE SERVICES

D1. Do you have health insurance?



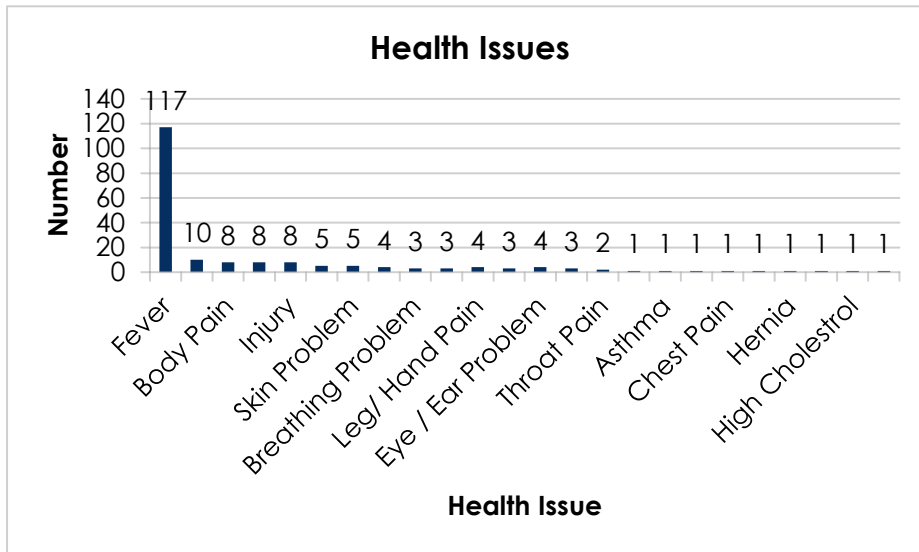
No	138	32%
Yes	296	68%

D2. Have you have had any health problems in the past 6 months?



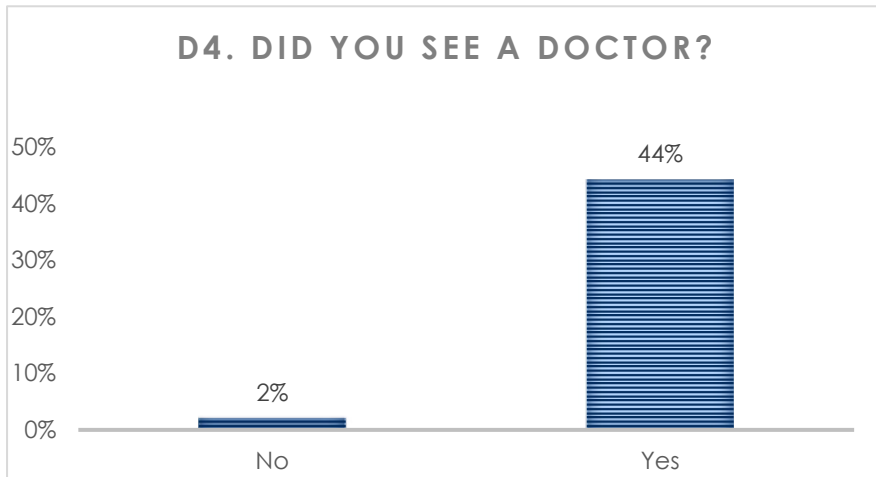
No	234	54%
Yes	200	46%

D3. Health Issues



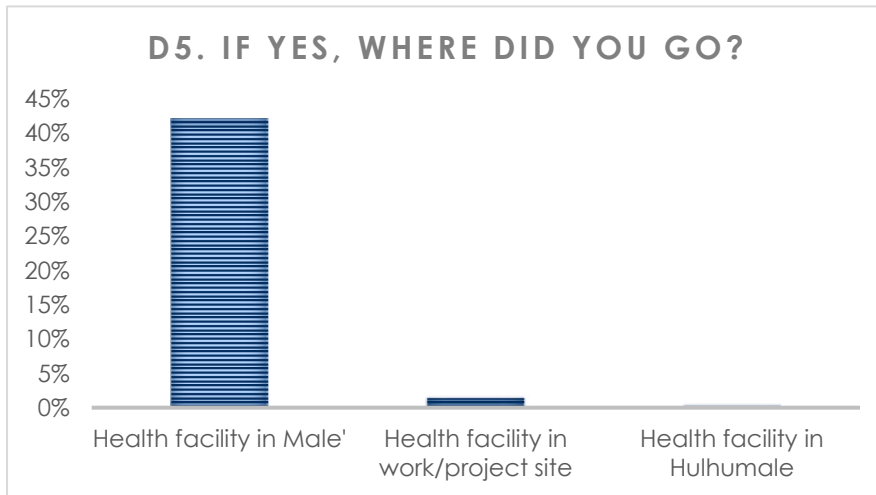
Health Issue	Count
Fever	117
Fever & Cold	10
Body Pain	8
Cold	8
Injury	8
Chikungunya	5
Skin Problem	5
Dengue	4
Breathing Problem	3
Headache	3
Leg/ Hand Pain	4
Tooth Pain	3
Eye / Ear Problem	4
Stomach Pain	3
Throat Pain	2
Allergy	1
Asthma	1
Back Pain	1
Chest Pain	1
Diabetics	1
Hernia	1
High Blood Pressure	1
High Cholestrol	1
Other	1
	196

D4. Did you see a doctor?



No	9	2%
Yes	192	44%

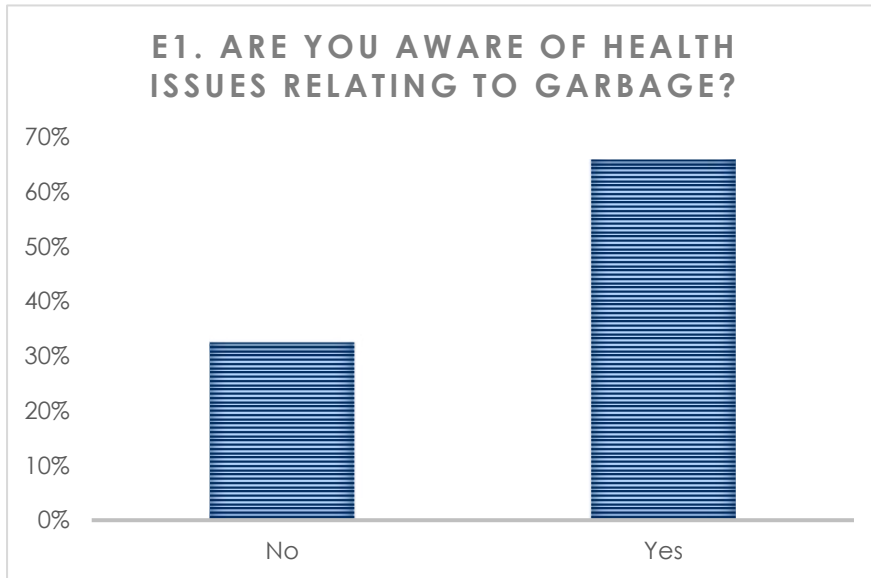
D5. If yes, where did you go?



Health facility in Male'	183	42%
Health facility in work/project site	6	1%
Health facility in Hulhumale	1	0%

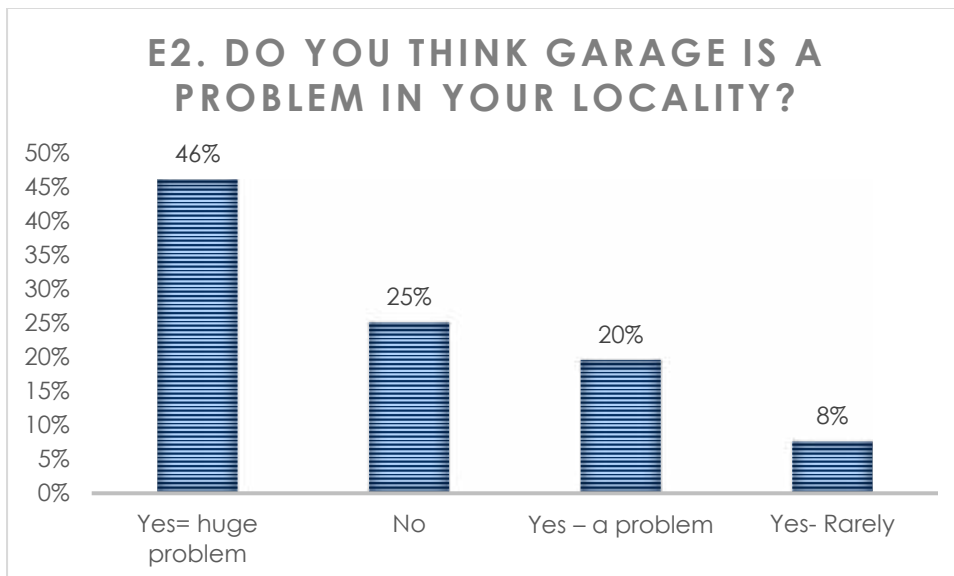
E. SOLID WASTE MANAGEMENT

E1. Are you aware of any health issues relating to garbage/ waste management?



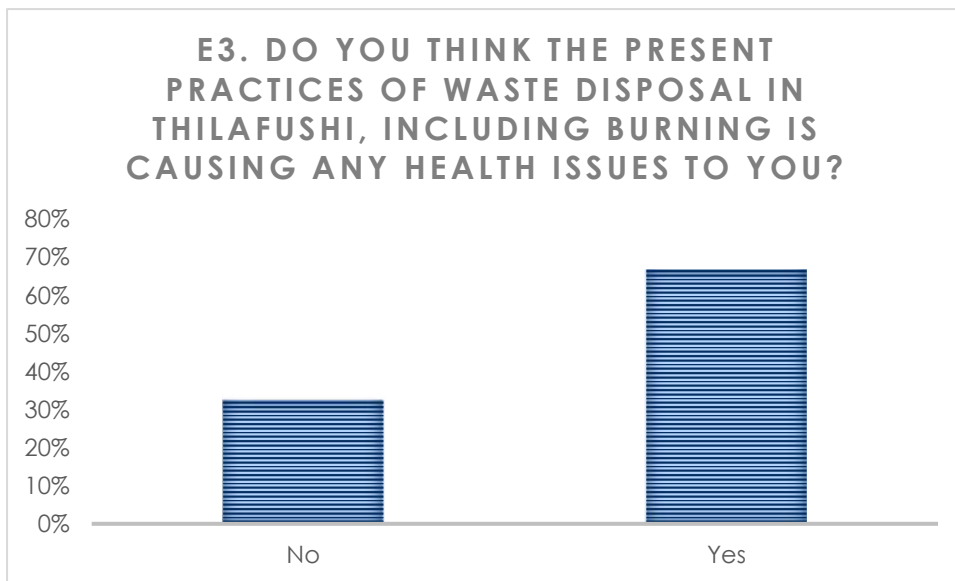
No	141	32%
Yes	286	66%
(blank)	7	2%

E2. Do you think garbage is a problem in your locality?



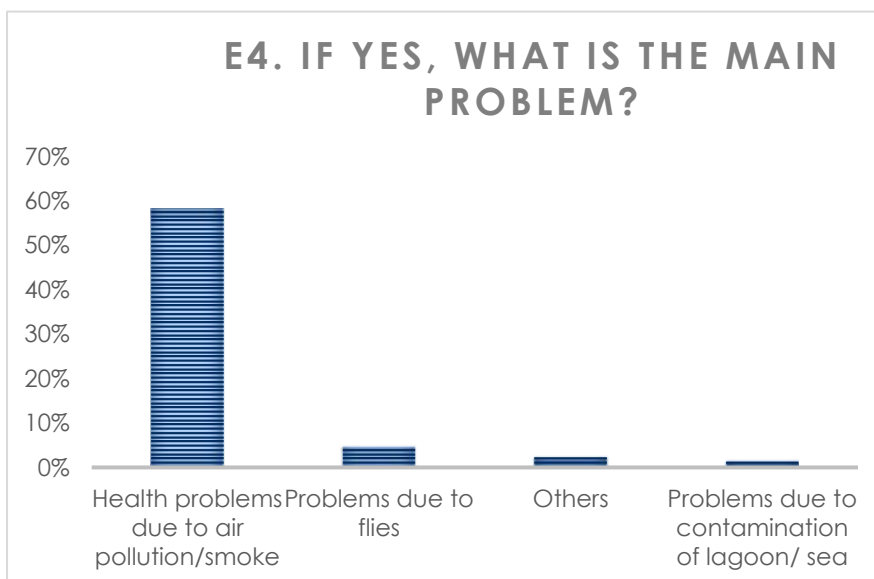
Yes= huge problem	200	46%
No	109	25%
Yes - a problem	85	20%
Yes- Rarely	33	8%
(blank)	7	2%

E3. Do you think the present practices of waste disposal in Thilafushi, including burning is causing any health issues to you?



No	141	32%
Yes	290	67%
(blank)	3	1%

E4/E5. If yes, what are the problems?



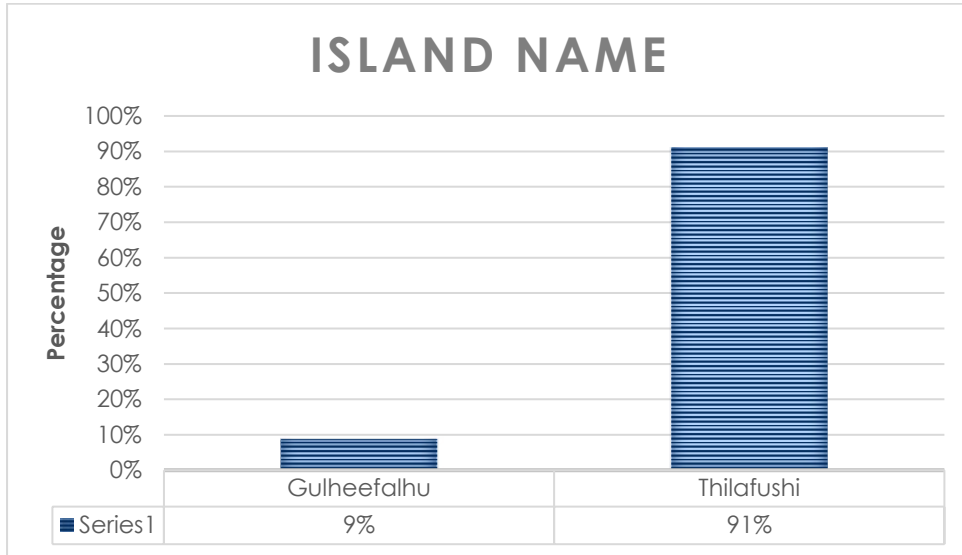
Health problems due to air pollution/smoke	253	58%
Problems due to flies	20	5%
Others	10	2%
Problems due to contamination of lagoon/ sea	6	1%
(blank)	145	33%

APPENDIX E: Graphical representation of data obtained from company survey

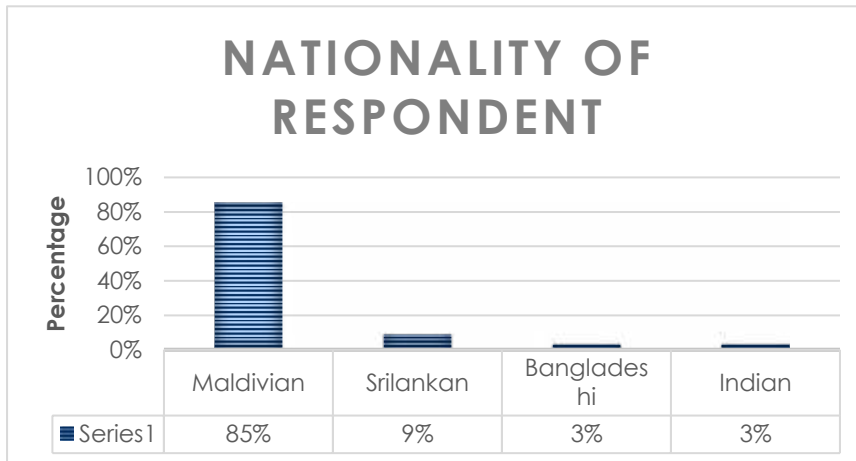
DATA AND GRAPHS – COMPANY SURVEY

A. GENERAL INFORMATION

A2. Island Name



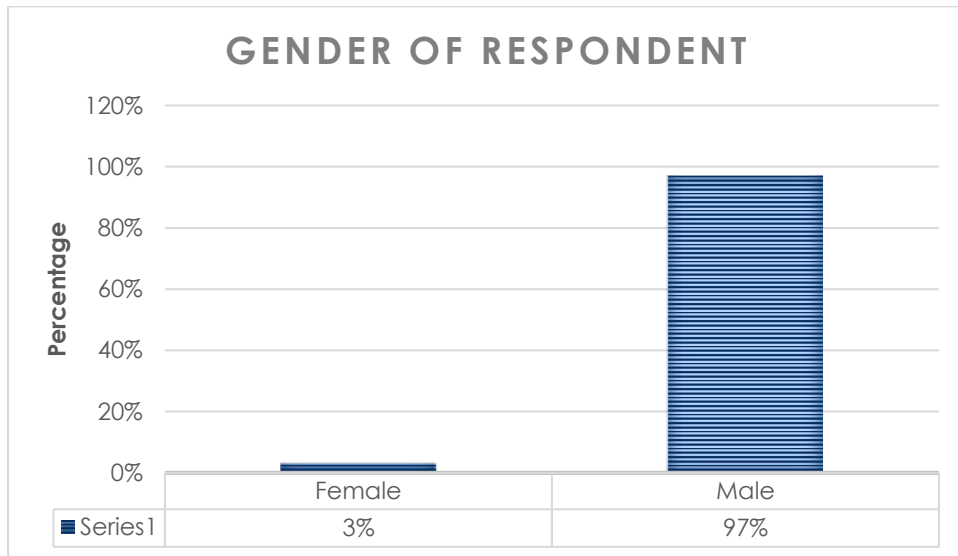
A3 & A4 Nationality (of respondent)



A5. Name of Respondent

(Data not to be disclosed)

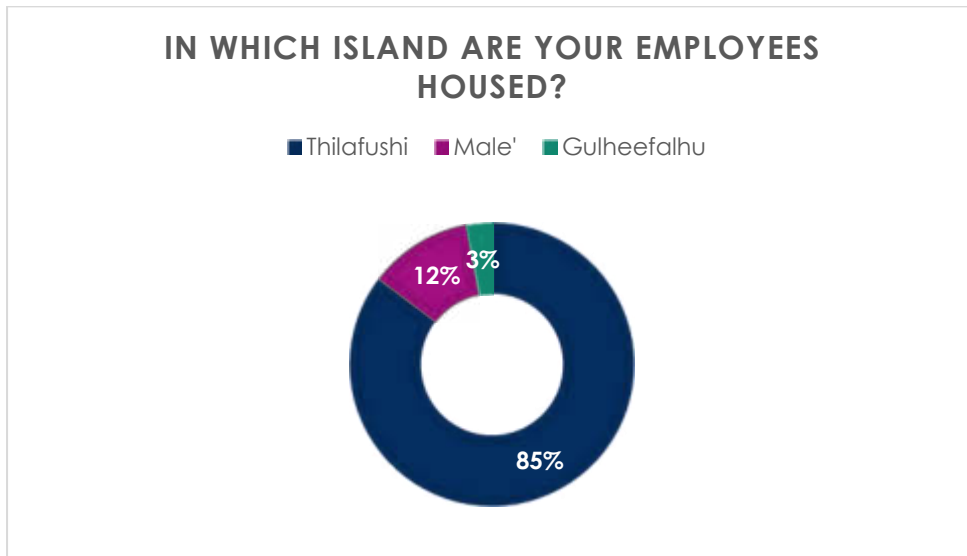
A6. Gender (of respondent)



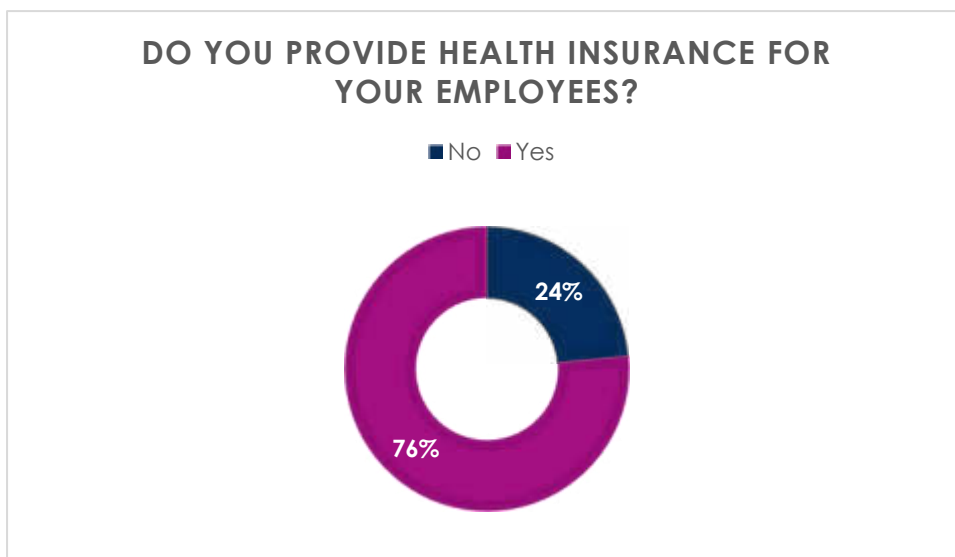
A7, A8 and A9. Company Name, Key Activities and Total Number of Employees

#	A2. Island Name	A7. Company Name	A8. What are the key Activities conducted by the company?	A9. Number of employees?	Gender
1	Thilafushi	Villa Hakatha	Delivery, gas, cement petrol and diesel	130	men
2	Thilafushi	Villa Hakatha F n B	Food and Beverage services, restaurant services	24	men
3	Thilafushi	Batch construction PVT LTD	Warehouse, storing metal, wood and electrical supplies	15	men
4	Thilafushi	Wheel pvt ltd	Leasing tugboats, excavators etc., Repairing and maintenance of vehicles and vessels, Taking projects such as land reclamation	10	men
5	Thilafushi	Mtcc	Warehouse and slipway, boat building and boat repair	180	men
6	Thilafushi	IZ	Workshop	No information	
7	Thilafushi	Eve garment	All works allowed in Thilafushi	No information	
8	Thilafushi	Leo trading	In Thilafushi they have mechanical and technical staff as the main work done there is the maintenance of assets such as landing craft, excavators etc.	47	men
9	Thilafushi	Sony hardware	Warehouse, storing and packaging	200	men
10	Thilafushi	Lafarge Maldives	Cement Factory	No information	
11	Thilafushi	MALDIVE GAS	LPG filling	29	men
12	Thilafushi	WAMCO	Solid waste management services, conduct clean up programs	150	men
13	Thilafushi	Mpl thilafushi	Boat building and boat repair, vehicle garage	35	men
14	Thilafushi	Dhamas	warehouse and workshop, vehicle repair and garage, warehouse	No information	
15	Thilafushi	Nalahiya trahiya trading pvt ltd	Warehouse for constuction materials	200	men
16	Thilafushi	Maldives Structural Product MSP	manufacturing roofing products, corrugated iron sheets	15	men
17	Thilafushi	Raaje logistics pvt ltd	Logistics Work, Transportaion sea and land	33	men
18	Thilafushi	Leo Trade	Logistics work	33	men
19	Thilafushi	Sunfront	Repairing boats and logistics	25	men
20	Thilafushi	Static company (aqua reef)	Water plant and electrical work	19	men
21	Thilafushi	The Hawks	Oil supplier; boatyard for loading, unloading and repair; port harbour; workshop,	120	men
22	Thilafushi	Metco	Garage	5	men
23	Thilafushi	Thilafalhu cafe	Tea shop	7	men
24	Thilafushi	Heavy Force	Repair n maintenance of heavy vehicles, Precast Yard.	35	men
25	Thilafushi	Antrac (maldives petroleum	Heavy vehicles are rented out, sell diesel oil, have 3 landing crafts	28	men
26	Thilafushi	Gulf craft	Boat building n repair	130	1 woman
27	Thilafushi	Maldives police services	Serve and protect	25	men
28	Thilafushi	Best dives pvt ltd	Boat yard, engine repair	12	men
29	Thilafushi	Build Maldives Company	Ship Repair and maintenance	24	men
30	Gulheefalhu	Stelco	Provide electricity	6	men
31	Gulheefalhu	GMIZ	Manage all services related to tenants including municipal services such as road maintenance, land lease, and conflict resolution. Tree plantation to make the island green	35	men
32	Gulheefalhu	Litus	Storage and workshop	15	men
33	Thilafushi	Apollo	Loading and unloading cargo	230	men
34	Thilafushi	GMIZ	Tenants related all municipal service including road works; Conflict resolution; land leasing and monitoring	155	men

A10. In which island are your employees housed?



A11. Do you provide health insurance for your employees?

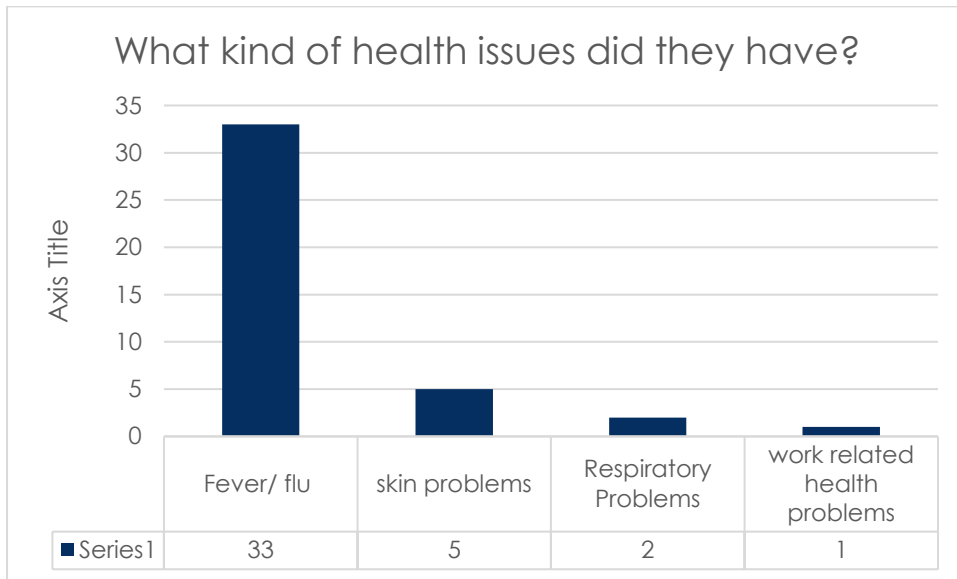


Note: Maldivian Nationals have access to the Government Health Insurance Scheme – Aasandha.

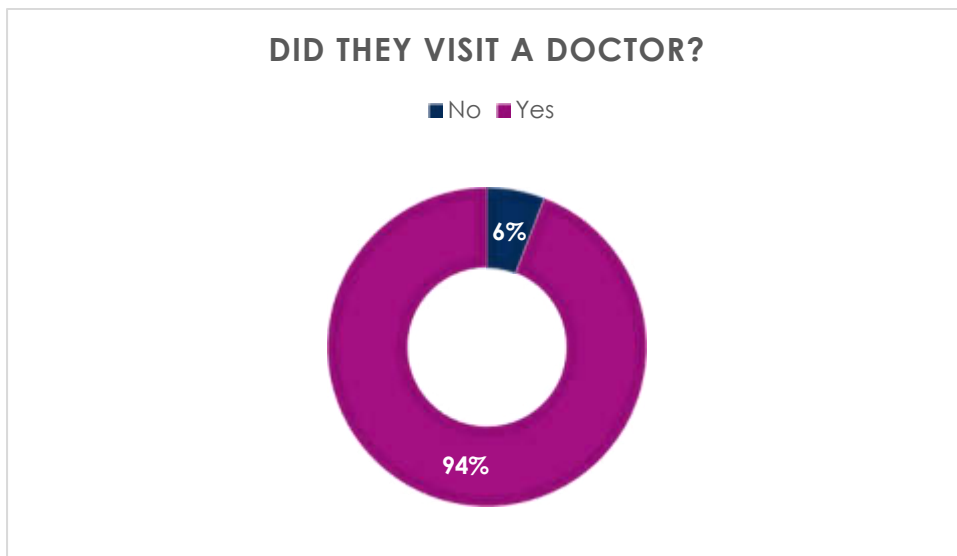
A12. How many of your employees have reported sick in the past year?

	A2. Island Name	A7. Company Name	A9. Total number of employees?	A12. How many of your employees have reported sick in the past year?
1	Thilafushi	Villa Hakatha	130	60
2	Thilafushi	Villa Hakatha F n B	24	10
3	Thilafushi	Batch construction PVT LTD	15	1
4	Thilafushi	Wheel pvt ltd	10	25
5	Thilafushi	Mtcc	180	6
6	Thilafushi	IZ	no information provided	2
7	Thilafushi	Eve garment	no information provided	20
8	Thilafushi	Leo trading	47	10
9	Thilafushi	Sony hardware	200	60
10	Thilafushi	Lafarge Maldives	no information provided	2
11	Thilafushi	MALDIVE GAS	29	3
12	Thilafushi	WAMCO	150	25
13	Thilafushi	Mpl thilafushi	35	3
14	Thilafushi	Dhamas	no information provided	11
15	Thilafushi	Nalahiya trahiya trading pvt ltd	200	4
16	Thilafushi	Maldives Structural Product MSP	15	5
17	Thilafushi	Raajje logistics pvt ltd	33	5
18	Thilafushi	Leo Trade	33	25
19	Thilafushi	Sunfront	25	25
20	Thilafushi	Static company (aqua reef)	19	16
21	Thilafushi	The Hawks	120	36
22	Thilafushi	Metco	5	25
23	Thilafushi	Thilafalhu cafe	7	5
24	Thilafushi	Heavy Force	35	10
25	Thilafushi	Antrac (maldives petroleum	28	4
26	Thilafushi	Gulf craft	130	80
27	Thilafushi	Maldives police services	25	24
28	Thilafushi	Best dives pvt ltd	12	4
29	Thilafushi	Build Maldives Company	24	20
30	Gulheefalhu	Stelco	6	6
31	Gulheefalhu	GMIZ	35	10
32	Gulheefalhu	Litus	15	2
33	Thilafushi	Apollo	230	90
34	Thilafushi	GMIZ	155	60

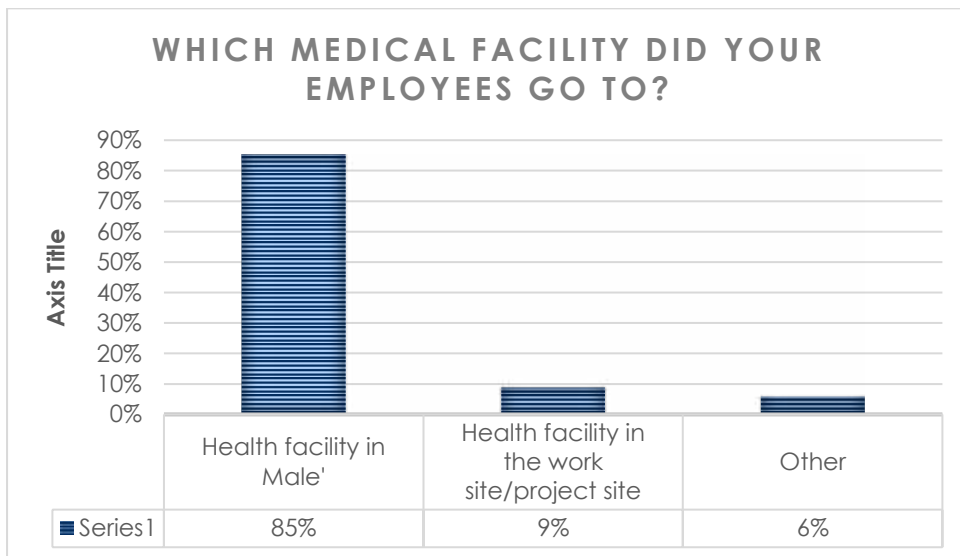
A13. What kind of health issues did they have? (please provide a list if you have one)



A14. Did they visit a doctor?



A15. If yes to A14, Where did they go?



A16. What is the average annual cost for healthcare services for your employees? (in MVR)

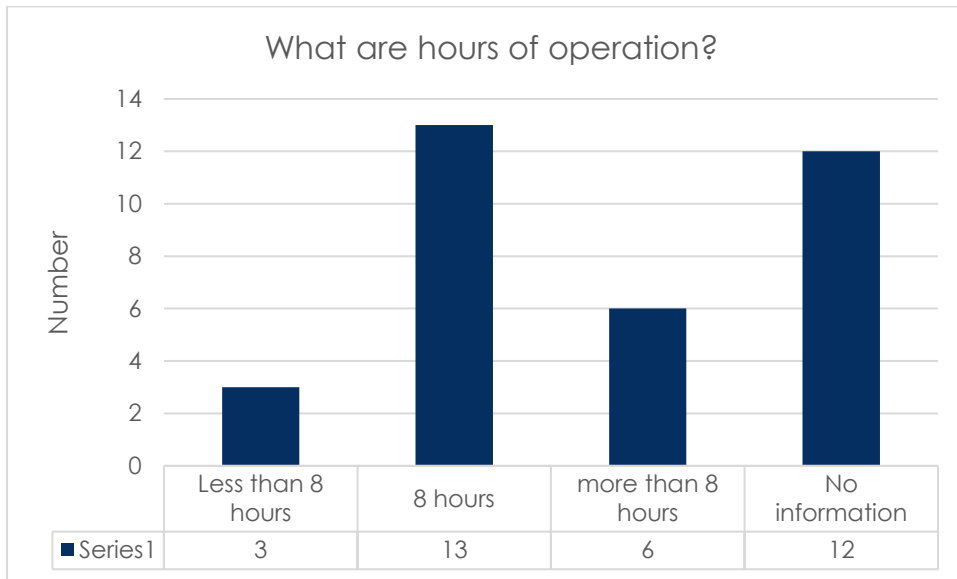
This information was provided by 8 companies.

	Island Name	Company Name	Annual cost for healthcare
1	Thilafushi	Wheel pvt ltd	45000
2	Thilafushi	Leo trading	300000 to 400000
3	Thilafushi	Sony hardware	400000
4	Thilafushi	MALDIVE GAS	66700
5	Thilafushi	Nalahiya trahiya trading pvt ltd	8400
6	Thilafushi	Maldives Structural Product MSP	8250
7	Thilafushi	Heavy Force	350000
8	Thilafushi	Antrac (maldives petroleum	28000 (company pays MVR1000 per person) employee pays MVR1000 (annually)

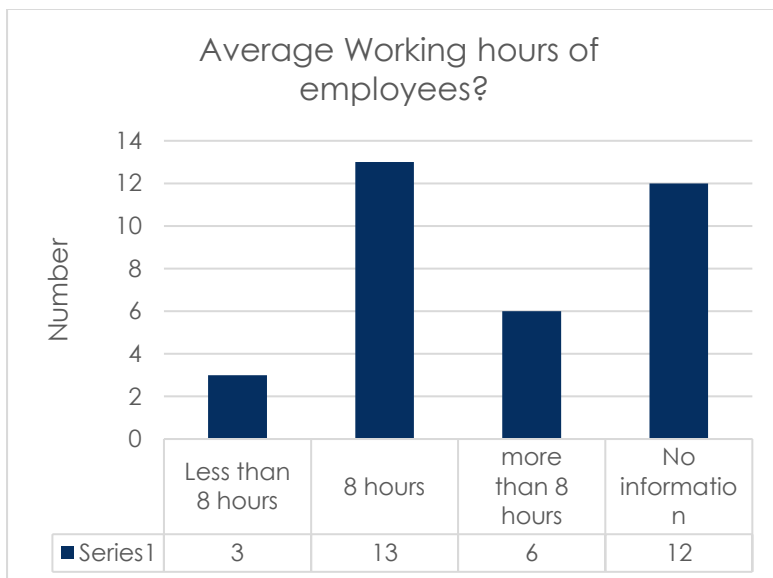
A17. What are the range of salaries of your employees?

None of the companies provided this information

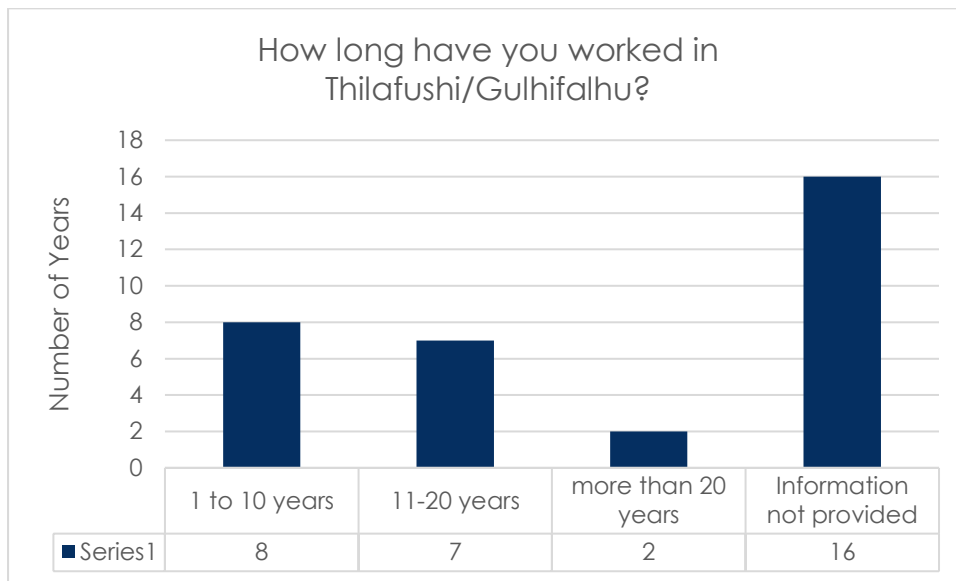
A18. What are the hours of operation?



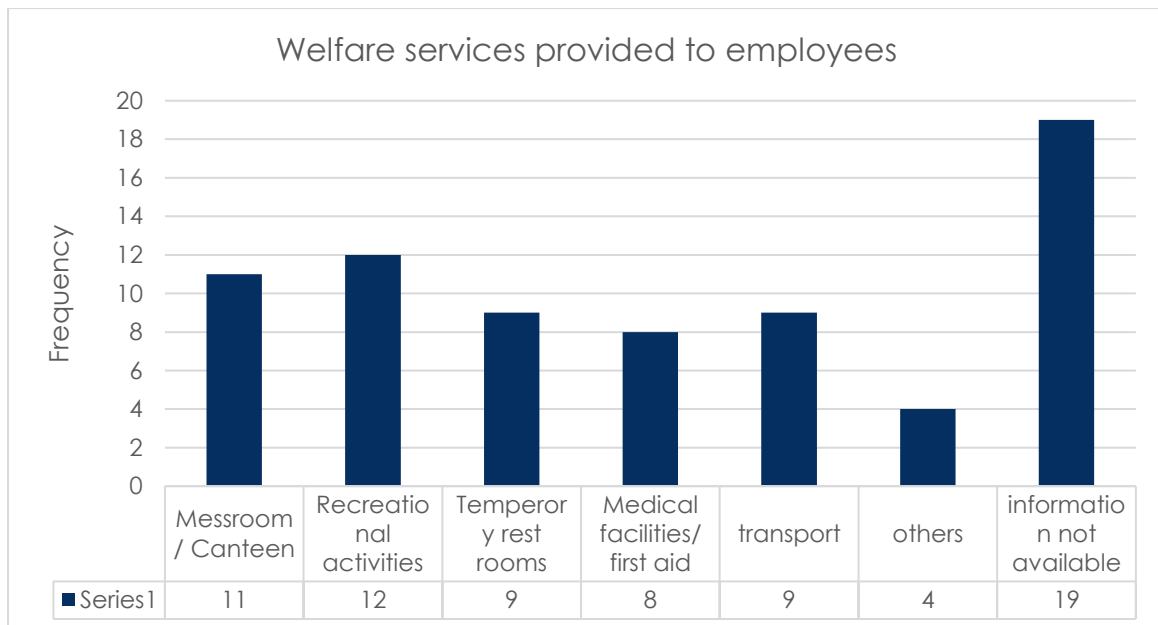
A19. What are the average working hours of your employees?



A20. When did you start operations in Thilafushi/ Gulhifalhu?



A21. Specify the types of employee welfare facilities provided by your company



A22. Do you provide your employees with life insurance?

None of the companies provide life insurance to their employees

A23. Do you provide your employees with disability insurance?

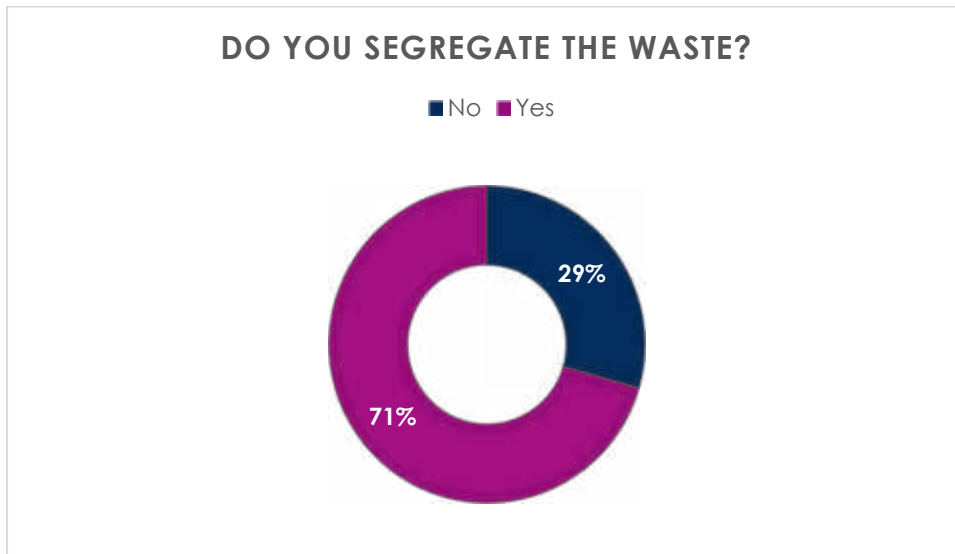
None of the companies provide disability insurance to their employees

A24. What are the company's main assets? Can you provide details?

Only two companies provided details

F. SOLID WASTE MANAGEMENT

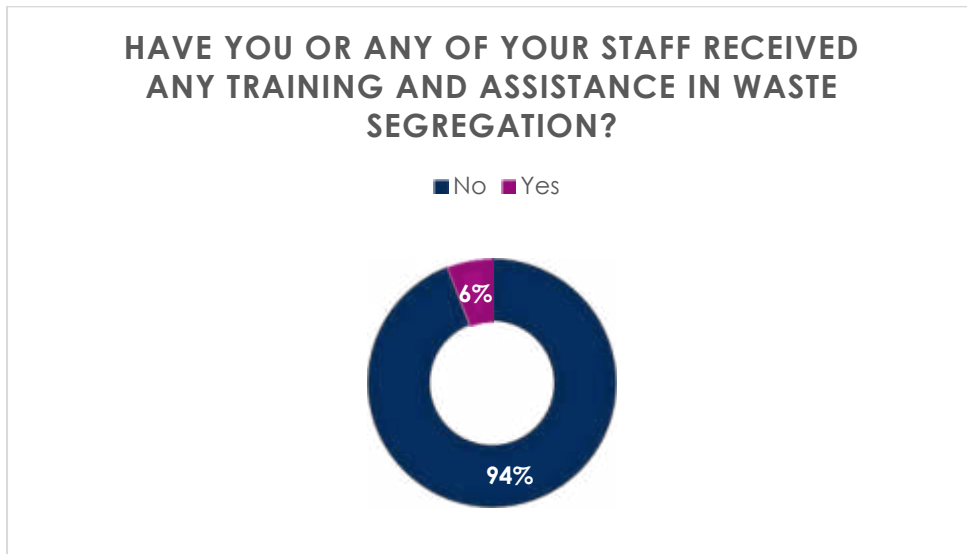
B1. Do you segregate the waste?



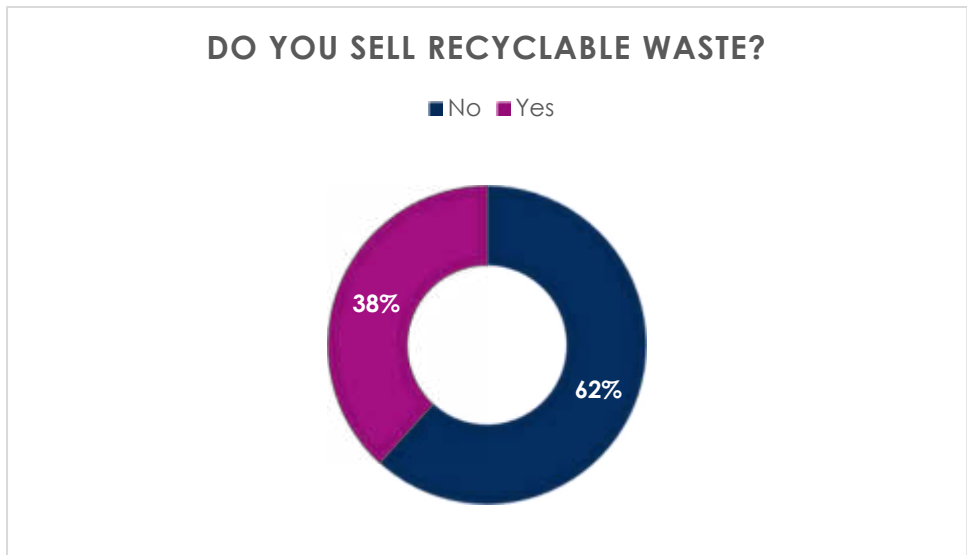
B2 and B3 How do you segregate waste?



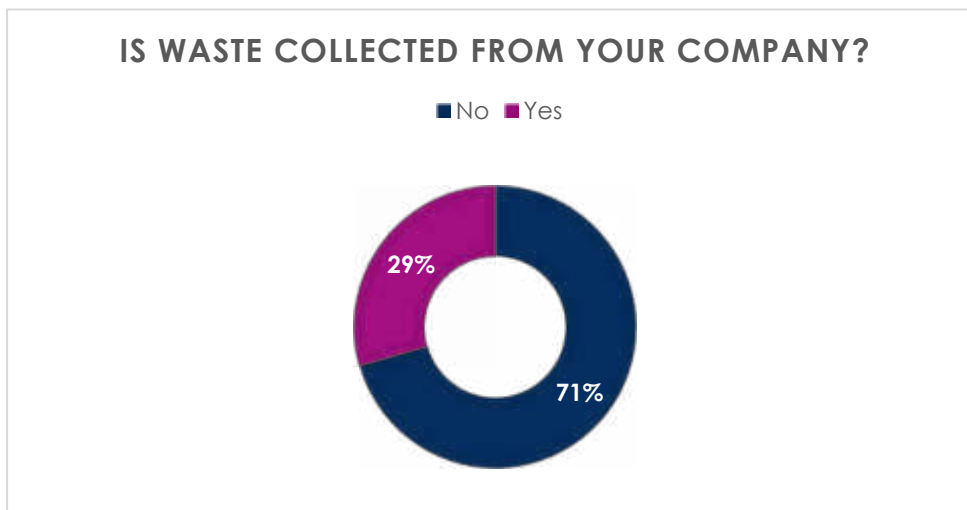
B4. Have you received any training and assistance in waste segregation?



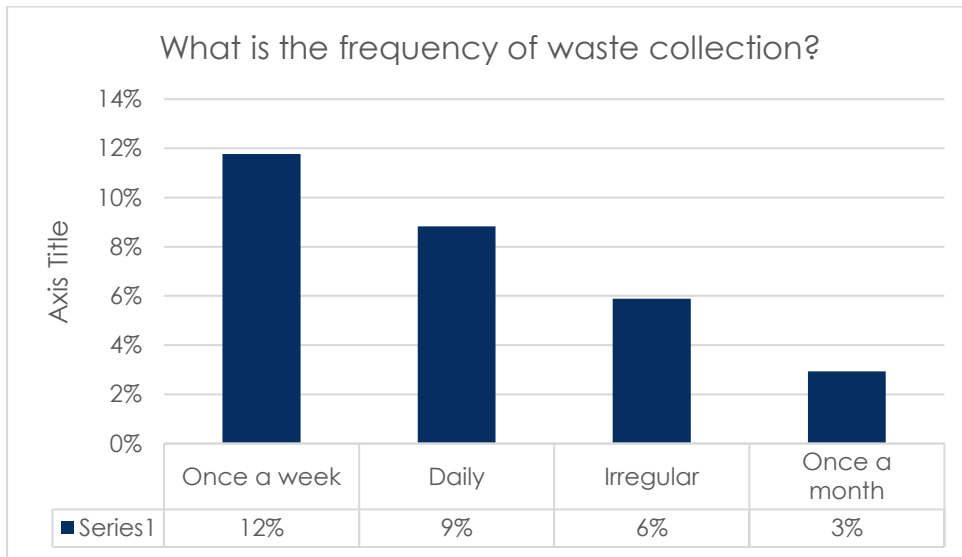
B6. Do you sell recyclable waste?



B7. Is waste collection door to door/ from the company premises?



B8. If yes to B7, what is the frequency of waste collection?



B9 and B10. Who is responsible for waste collection?



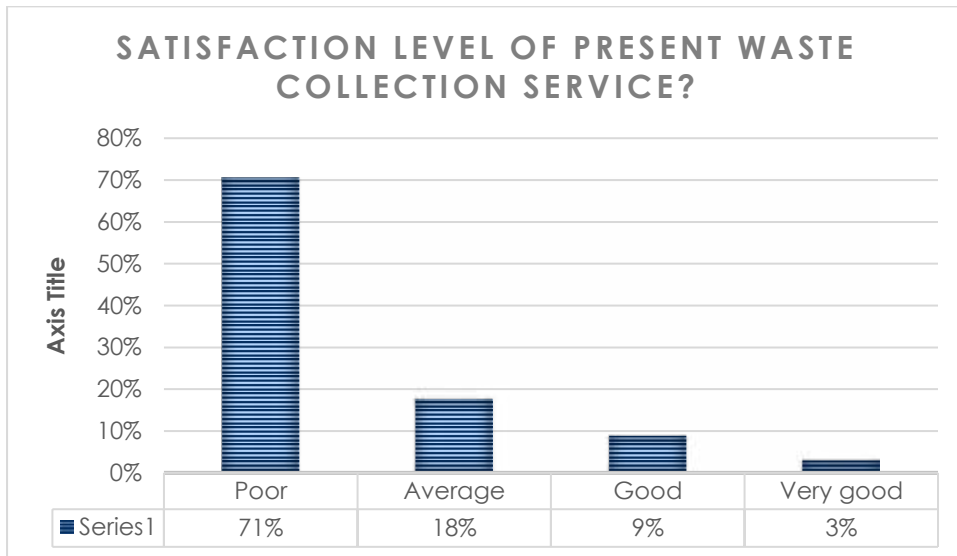
B11. Do you pay for waste collection/ disposal service?



B12. How much do you pay for monthly waste collection (in MVR)

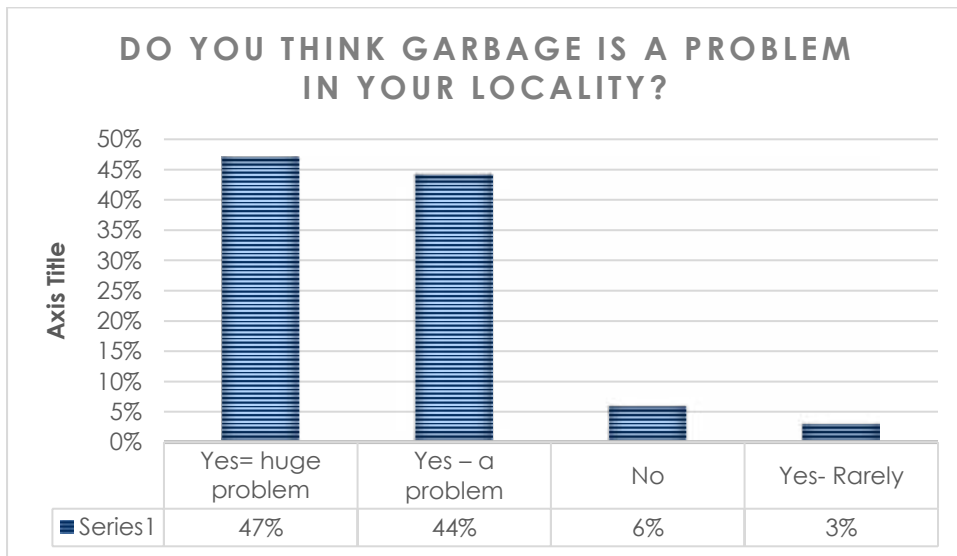
Amount in MVR	Sum of Count
(blank)	1
0-499	14
500-999	2
1000-1499	1
1500-1999	4
2000-2499	5
2500-2999	2
4000-4499	1
6000-6499	1
7000-7499	1
14000-14499	1
19000-19499	1
19500-20000	1
	35

B13. Satisfaction level of present waste collection/ management service?



B14. Do you feel the present monthly charge for waste collection is:

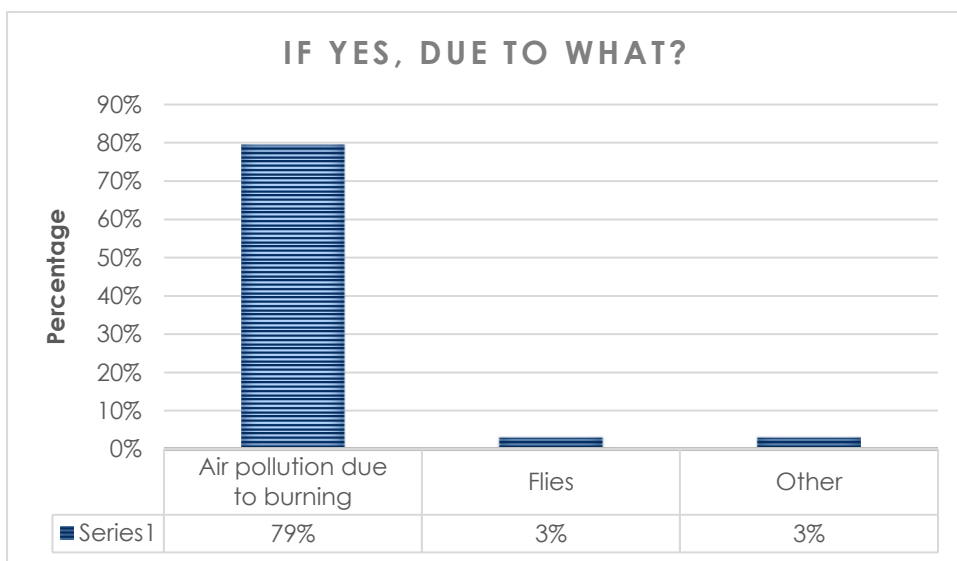
B15. Do you think garbage is a problem in your locality?



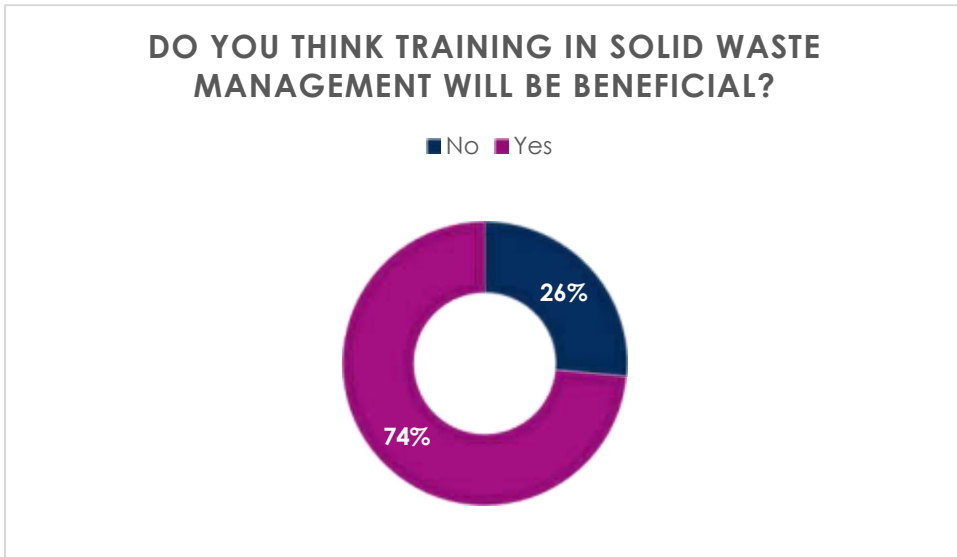
B16 and B17. Do you and your employees face health problems/ issues due to the present practices of waste disposal in Thilafushi, including burning?



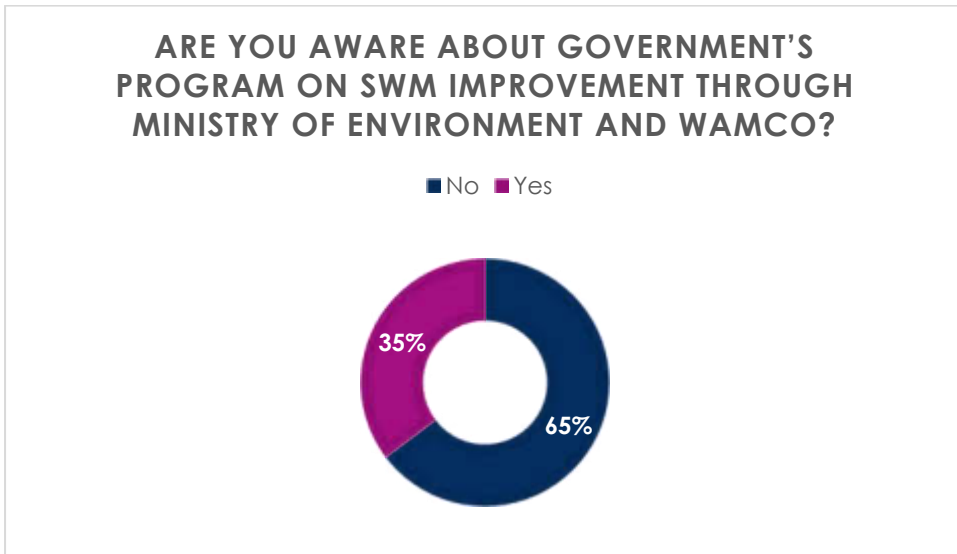
If yes to B16, due to what?



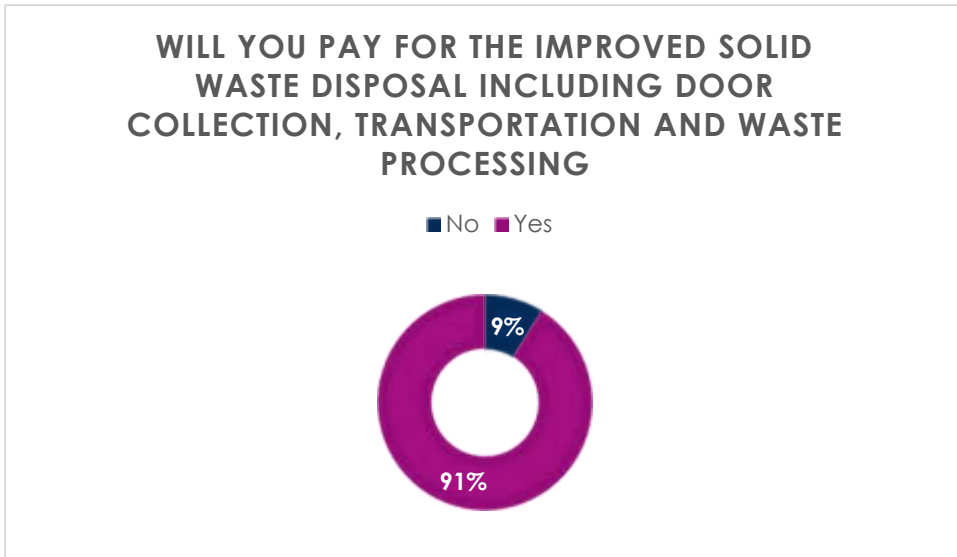
B18. Do you think community level trainings in solid waste management will be beneficial?



B19. Are you aware about Government's program on SWM improvement through Ministry of environment and WAMCO?



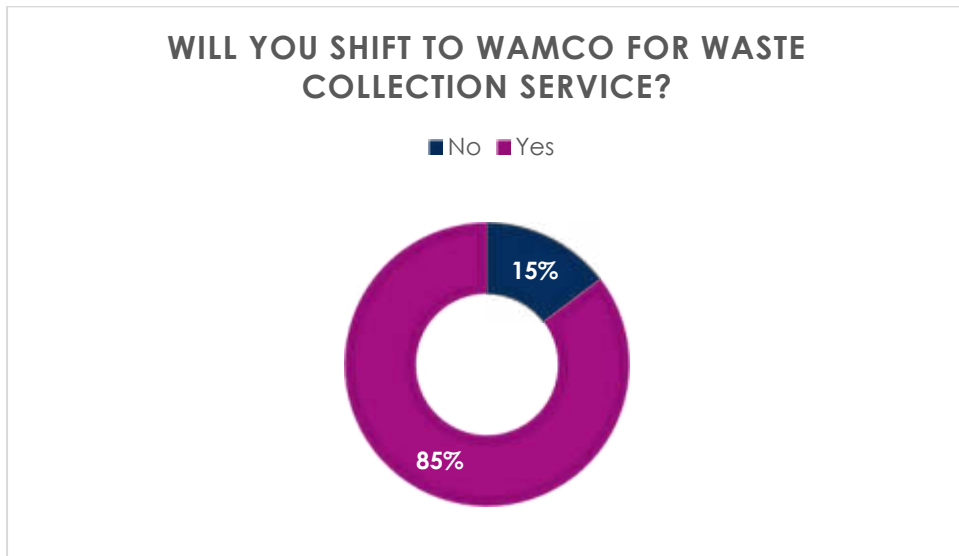
B20. Will you pay for improved solid waste disposal including door collection, transportation and waste processing?



B21. If yes to B20, how much would you be willing to pay for improved waste collection and waste management services?

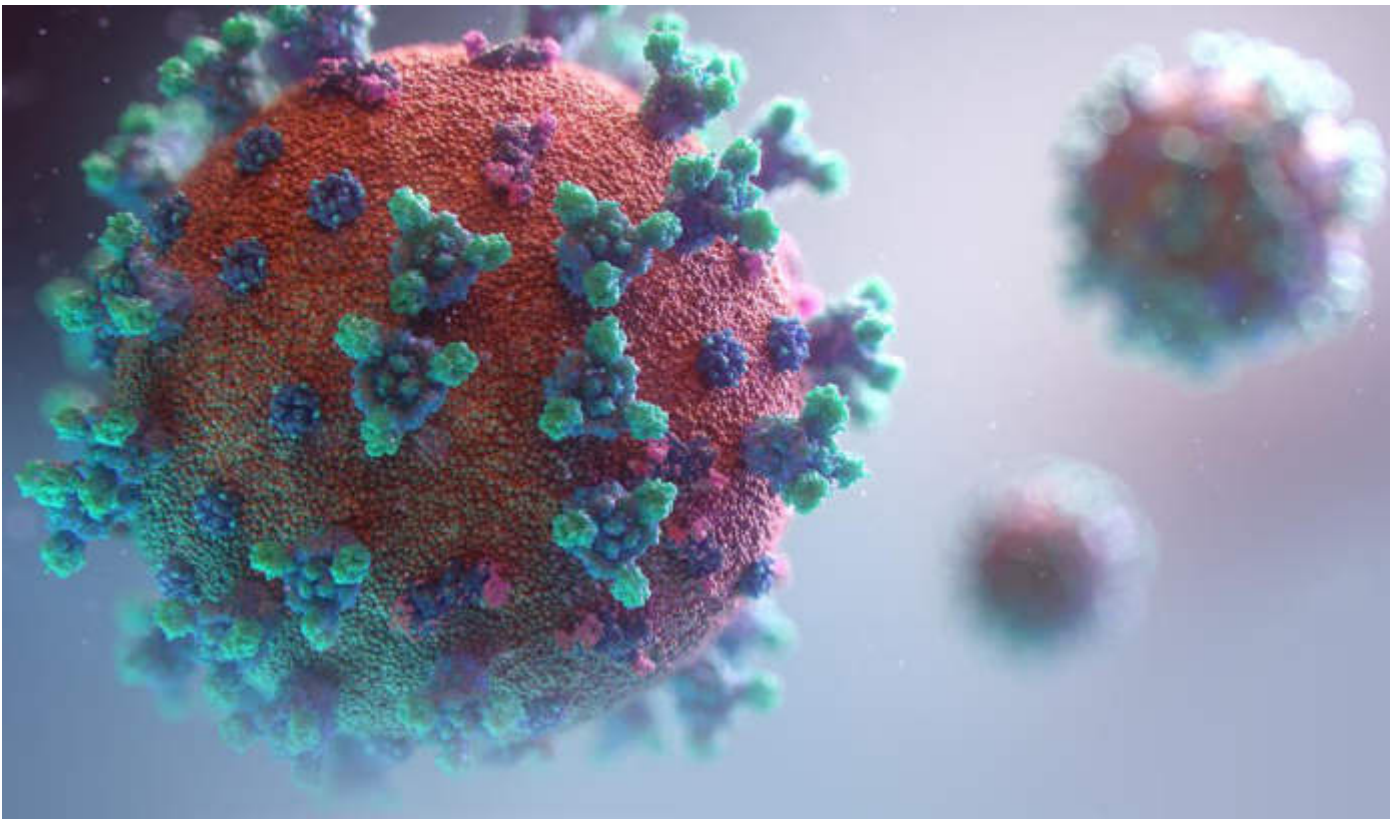
Amount in MVR	Sum of Count
<0 or (blank)	19
0-499	3
500-999	3
1000-1499	4
1500-1999	1
2000-2499	2
5000-5499	2
39500-40000	1
Grand Total	35

B22 and B23. Will you shift to WAMCO for waste collection service?



B24. What are the socio-economic problems face by your employees? Any other suggestions/ comments?

	Island Name	Company Name	What are the socio-economic problems faced by your employees? Any other suggestions or comments?
1	Thilafushi	Villa Hakatha	No comments
2	Thilafushi	Villa Hakatha F n B	Conduct surveys annually to assess
3	Thilafushi	Batch construction PVT LTD	Health issues
4	Thilafushi	Wheel pvt ltd	No comments
5	Thilafushi	Mtcc	No comments
6	Thilafushi	IZ	No water and electricity
7	Thilafushi	Eve garment	No comments
8	Thilafushi	Leo trading	No comments
9	Thilafushi	Sony hardware	Yes. Food services are not so good, no regulations on road safety, parking
10	Thilafushi	Lafarge Maldives	No comments
11	Thilafushi	MALDIVE GAS	No comments
12	Thilafushi	WAMCO	No comments
13	Thilafushi	Mpl thilafushi	Heard about possible other issues. But no choice. Need to work here
14	Thilafushi	Dhamas	Infrastructure, roads, no lights at night. No security fo vehicles, parking space, abandoned vehicles, rule of law and order.
15	Thilafushi	Nalahiya trahiya trading pvt ltd	Health services only recently established, road conditions
16	Thilafushi	Maldives Structural Product MSP	Ferry schedule regularly; taxi services; garbage per tonne of the lorry
17	Thilafushi	Raajje logistics pvt ltd	Waste disposal while transferring loads
18	Thilafushi	Leo Trade	Smoke l inhalation is their main problem, no proper sewage, poor road conditions during rainy season
19	Thilafushi	Sunfront	Waste disposal into the sea can be quite problematic as difficult for boats to come near the jetty for loading n unloading goods
20	Thilafushi	Static company (aqua reef)	Mainly smoke inhalation is their main concern
21	Thilafushi	The Hawks	Fighting;Illegal ppl; drinking; Banking problem; emergency ferry/boat system;;emergency med
22	Thilafushi	Metco	No comments
23	Thilafushi	Thilafalhu cafe	No comments
24	Thilafushi	Heavy Force	Smoke, roads, emergency transport
25	Thilafushi	Antrac (maldives petroleum	No electricity no water or sewage system at the present moment, the road conditions are bad, staff live in newly reclaimed land area and no electricity from main grid is not available, company provides generators and water is carried to site for staff to use. Smoke from burning waste is the main issue.
26	Thilafushi	Gulf craft	Waste gets washed from the ocean into our facility. Seasonal problems are there, during one season flies would be a hazard. During some days smoke is so thick the person standing next to you is not visible.
27	Thilafushi	Maldives police services	Nil
28	Thilafushi	Best dives ptv ltd	Nil
29	Thilafushi	Build Maldives Company	No infrastructure, road lights, road building not provided
30	Gulheefalhu	Stelco	Ferry timing a d the transportation is quite difficult
31	Gulheefalhu	GMIZ	Wamco to pick garbage twice monthly
32	Gulheefalhu	Litus	No comments
33	Thilafushi	Apollo	Waste management is a hazard! The governemnt should solve it as soon as possible
34	Thilafushi	GMIZ	Waste management is a hazard; WAMCO should not charge government for waste management as they have been allocated a plot of land; maybe a nominal fee; drug and prostitution was a problem but not that we have Police and they are patrolling 24/7 problems are minimised; should be given risk allowance for people working here



HEALTH & SAFETY PLAN

Standard Operating Procedure on COVID19

for Greater Male' Environmental Improvement and Waste Management Project

Prepared By:

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Greater Male' Environmental Improvement and Waste Management Project.
Ministry of Environment.
Republic of Maldives.

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1 PROJECT BACKGROUND

The Greater Male' Environmental Improvement and Waste Management Project (GMEIWMP) is a multi-donor funded project which aims to establish a sustainable and integrated solid waste management system in the Greater Male' region (Zone 3: AA, ADh, K, and V, Atoll islands) including collection, transfer, treatment using advanced waste to energy (WTE) technology, disposal, recycling, dumpsite closure and remediation, public awareness in reduce-reuse-recycle (3R) and strengthen institutional capacities for service delivery and environmental monitoring. The project will create a cleaner environment, contribute to reductions in the cost of electricity, reduce greenhouse gas emissions, and improve climate change resilience and disaster risk management.

The recent outbreak of COVID19 poses risks to the implementation of the project in several aspects. Both indoor and outdoor related activities of the project are at risk. Outdoor activities include components of this project which involves civil works and surveys. Indoor activities include works related to project management and administration. All project activities need to be implemented in such a way that the health and safety of all project personnel are ensured.

2 INTRODUCTION

This document is not intended to substitute any formalized procedures currently in place for all project personnel, including the Project Management Staff, Project Implementation Staff, Contractors, Sub-contractors, Managers, Supervisors, and workers. Where this guideline does not meet or exceed the standards put forth, all Project Personnel shall abide by the most stringent procedure available.

The instructions given in this Health and Safety Plan must be followed by all Project Personnel as mentioned above, including all personnel at the PMU/PIU Offices, Contractor's Field Offices, Construction Sites and worker camps.

The Contractor must assign a COVID-19 Officer at the Contractor's worksite who is appointed by Contractor and agreed by PMU. The COVID-19 Officer must submit a written report to the Client's Representative (Social and Environmental Safeguard Specialist of the PMU) weekly. The COVID-19 Officer shall verify that the Contractor and all subcontractors are in full compliance with this H&S Plan and other guidelines and instructions given by the Health Protection Agency (HPA) and must submit a written report weekly to the Social and Environmental Safeguard Specialist of the PMU. The COVID-19 officer should be present on site at all times.

Any issue of non-compliance with these guidelines/plans shall be a basis for the suspension of work. The Contractor will be required to submit a corrective action plan detailing each issue of non-conformance and a plan to rectify the issue(s). The Contractor will not be allowed to resume work until the plan is approved by the Client. Any additional issues of non-conformance may be subject to action against the Contractor's as health & safety/safeguard clauses of the contract.

Construction sites operating during the Covid-19 pandemic need to ensure they are protecting their WORKFORCE and minimising the risk of spread of infection.

The health and safety conditions of any construction activity must not be compromised at this time. If an activity cannot be undertaken safely due to a lack of suitably qualified personnel being available or social distancing being implemented, it should not take place.

This H&S Plan must be made available at all the Project related areas including PMU/PIU Offices, Contractor's Field Offices, Construction Sites and workers camps. The salient features must be displayed through signages at the appropriate locations throughout work sites and stretches for wider dissemination and awareness.

This document is intended to introduce consistent measures on sites of all sizes in line with the HPA and Government's recommendations regarding COVID19. The Contractor and all other relevant project personnel must comply with this H&S Plan and shall follow and abide by the guidelines and instructions given by the Health Protection Agency (HPA) relating to COVID-19.

If a worksite is not consistently implementing the measures set out, it may be required to shut down.

3 OBJECTIVES OF THE PLAN

The overall objectives of this Health and Safety Plan is to:

- Control and prevent disease transmission among all project personnel. (workers/staff)
- Protect those who are at high risk for complications. (those with underlying health problems)
- Maintain construction operations as efficiently and safely as possible.
- Ensure the overall protection of health and safety of all project personnel. (workers/staff)

4 CLEANING AND DISINFECTION OF OFFICES PRIOR TO RESUMPTION OF WORK

All project activities were on hold due to the lockdown enforced by the government of Maldives to reduce the spread of COVID19. However, when the lock down is lifted and permission is given to resume work, it is important to have a plan to ensure that the COVID19 disease infection rate does not rise again.

Some scientific studies have reported that a number of people infected with COVID-19 are “silent spreaders,” that is, either asymptomatic or pre-symptomatic, exhibiting no signs of fever, cough, or laboured breathing. All project personnel must assume that some workers are likely to come to work while infectious. Enforcing physical distancing, establishing administrative controls to minimize worker contact, and mandating the use of personal protective equipment (PPE) are all part of pandemic response. However, keeping indoor work areas clean and hygienic plays a critical part in infection control too.

Before the offices are opened and works are resumed, it is crucial that these offices and work areas are cleaned and disinfected. More information on Cleaning and Disinfecting can be found on Section 8 which can be applied to cleaning and disinfecting of offices prior to resumption of work.

While cleaning and disinfecting before work resumption, more emphasis should be given to high traffic areas in the workplace like reception area, lobby, rest rooms and meeting rooms.

However, the use of foggers or wide area spraying of disinfectants is generally discouraged and should not be a substitute for directly applying the disinfectant onto a surface. HPA approved liquid disinfectant products are recommended to clean contaminated surfaces.

All personnel involved with the cleaning and disinfecting must wear appropriate PPE to avoid contamination and chemical exposure.

5 PREPARATION OF OFFICES PRIOR TO RESUMPTION OF WORK

All project personnel should continually monitor international (World Health Organization), and national (Health Protection Agency) guidelines for changes in recommendations, cleaning strategies, and other best management practices. For example, general guidelines regarding best practices for specific industries, worker hygiene, cleaning and disinfection, physical distancing, and employee wellness should be reviewed and addressed.

Aspects to reopening an office that should be emphasized during the pandemic include, workplace configuration, (conference rooms, lobby and common areas, kitchens, ventilation)

and enhanced cleaning practices. All of these aspects, regardless of workplace sector or size, should be considered to ensure both worker safety and comfort when returning to work.

Prior to re-occupancy, perform a detailed review of the configuration of your workspaces:

- Consider eliminating reception seating areas and requesting that guests phone ahead or install a plastic partition at the reception area.
- Review floorplans and remove or reconfigure seats, furniture and workstations as needed to preserve recommended physical distancing in accordance with guidelines.
- Reconfigure workstations so that employees do not face each other or establish partitions if facing each other cannot be avoided.
- Consider using signage to aware and inform the employees about good practices.
- Employees should be encouraged to use virtual meeting tools, including phone and virtual teleconference, in lieu of in-person meetings, whenever possible.
- If in-person meetings are essential, consider limiting meetings to 10 people or less depending on local, state, and federal guidelines.

During the reopening process, employers should also consider how they will prepare their workforce. Aspects such as communication, training, and employee comfort are important to have in mind during development of the reopening plan to address employee.

- Communicate to employees what is being done to mitigate the spread of COVID-19 (e.g., disinfection routine, health policies for staff, and health & safety measures in place).
- Employers should notify employees of new workplace policies and changes prior to reopening and upon resuming operations.
- Ensure all protective measures and supplies are available prior to occupancy (e.g., demarcate floors that have access to the public, rearrange office lay-out to increase distance between employees, provide adequate hand washing/hand sanitizer supplies, etc.).
- Prior to reopening, consider flexible work schedules, work from home options, and shift rotations as per advice from the relevant government agencies, to reduce the density of employees in common areas such as screening areas, break rooms, and locker rooms.

6 CONTROL AND PREVENTION

Measures for protecting workers from exposure to, and infection with, SARS-CoV-2, the virus that causes Coronavirus Disease 2019 (COVID-19), depend on the type of work being performed, contamination of the work environment, and exposure risk, including potential for interaction with people with suspected or confirmed COVID-19. Contractors should adapt infection control strategies based on this H&S Plan and other relevant guidelines and standards put in place by HPA, using appropriate combinations of engineering and administrative controls, safe work practices, and personal protective equipment (PPE) to prevent worker exposures.

6.1 Screening

- After the lockdown is lifted and permission is given to continue physical works at sites, an initial screening must be conducted for all workers, supervisors and managers, in advance of arriving to the job site. This initial screening would be conducted **one time** only. If the visitor answers “yes” to any of the following questions, he/she should stay home as they are of high risk for severe illness from COVID19 (See Appendix I)
- The Contractor shall Identify workers who may be at increased susceptibility for COVID19 infection or complications from COVID-19 as mentioned above and consider adjusting their work responsibilities or locations to minimize exposure. Other flexibilities, if feasible, can help prevent potential exposures among workers who have underlying medical/health conditions as stated in Appendix I.
- The Contractor shall also carry out **daily** health screening (See Appendix E) of workers using contactless temperature checks prior to site entrance, during working hours and after site works to identify persons showing signs of being unwell with the COVID-19 symptoms.
- Contractor must keep records of both Initial Screening and Daily Health Screening which takes place at the site.

6.2 Risk Assessment

Worker risk of occupational exposure to COVID19 may depend in part on the industry type and the need for contact within 6 feet of people known to be, or suspected of being, infected with COVID19. Other factors, such as conditions of workers' labour quarters, work environment, their activities outside of work (including travel to COVID-19-affected areas), and individual health conditions, may also affect workers' risk of getting COVID-19 and/or developing complications from the illness.

The risk exposure levels can be divided into 4 parts: very high, high, medium, and lower risk, as shown in the occupational risk pyramid, below. The four exposure risk levels represent the probable distribution of risk. Most workers related to this project will likely fall in the lower exposure risk (caution) or medium exposure risk levels.



Occupational Risk Pyramid

The Contractor must assess potential risks before the commencement of physical works at the site. While assessing potential risks, employers should consider if and when their workers may encounter someone infected with COVID-19 in the course of their duties. Employers should also determine if workers could be exposed to environments (e.g., work sites) or materials (e.g., laboratory samples, waste) contaminated with the virus.

Depending on the work setting, employers may also rely on the identification of sick individuals who have signs, symptoms, and/or a history of travel to COVID-19-affected areas or HPA quarantined locations, to help identify exposure risks for workers and implement appropriate control measures. It is also possible that someone may have been in close contact (within about 6 feet) with someone with COVID-19 in their community and, thus, may have had exposure.

6.3 Workplace Mapping

In the event of an employee being confirmed as having COVID-19, those who are potentially affected need to be quickly identified.

Employers should implement processes to record the schedule and work locations for employees (including contractors), that enables tracing of those who have come into contact with the confirmed case.

The record should include:

- Day and time work was undertaken
- Members of teams that worked together
- Specific work area on the construction site
- Any breaks taken, including time and location.

Movement between sites, or areas within large sites, should be minimised as much as possible. Where attending multiple sites is necessary movement between sites should be recorded in the workplace mapping.

The Contractor must also ensure that all staff, workers and other relevant personnel have installed the “**Trace Ekee**” app, developed and recommended by Government of Maldives for contact tracing of COVID-19 patients.

6.4 Physical Distancing and Occupancy Limits

Before initiating or resuming work at the site, the Contractor must ensure that the workers practice physical distancing of 6 feet wherever possible. Contractors should also consider each work task and whether there is a safe alternative way to undertake the work with an increased distance between employees.

- Mark safe distances in work, transit and break areas (eg 6ft safe distance floor and wall markers).
- Consider different shift patterns to minimise the number of employees onsite (eg AM/PM shifts).
- Stagger start times, breaks and finish times to avoid congestion in high traffic areas and minimise employees coming into contact with each other as they move around the site.
- Plan for how physical distancing will be maintained during inclement weather (eg use of lunch or crib rooms and amenities).
- Install temporary physical barriers (eg fences, screens) between work areas, where appropriate. (See 3.5 Engineering Controls for more information)



Where it is not possible to undertake work tasks and maintain physical distancing, other control measures need to be implemented. For example:

- Minimise the number of person to person interactions that need to be completed within 6 feet.
- Minimise the number of individuals involved in activities that need to occur within 6 feet of each other.
- Provide personal protective equipment (PPE) (eg gloves, masks, glasses).

More information about the safe use of PPE is given in section 3.7 PPE and Appendix J

Where essential work activities need to be undertaken in restricted spaces (eg lift shafts, personnel hoists, lifts), the number of employees working in the space should be minimised.

6.5 Engineering Controls

Engineering controls involve isolating employees from work-related hazards. In workplaces where they are appropriate, these types of controls reduce exposure to hazards without relying on worker behaviour and can be the most cost-effective solution to implement. Some Engineering Controls the Contractor can implement for COVID-19 include:

- Installing high-efficiency air filters.
- Increasing ventilation rates in the work environment.
- Installing physical barriers, such as clear plastic sneeze guards.

In the indoor construction environment, when work is determined to be essential or emergency work, and a person (e.g., coworker, visitor, resident, subcontractor) suspected of having or known to have COVID-19 is present at the worksite in close proximity to where workers would be working:

- Use closed doors and walls, whenever feasible, as physical barriers to separate workers from any individuals experiencing signs and/or symptoms consistent with COVID-19.
- Consider erecting plastic sheeting barriers when workers need to occupy specific areas of an indoor work site where they are in close contact (less than 6 feet) with someone suspected of having or known to have COVID-19.
- During the COVID-19 pandemic, periodically reassess engineering controls, as well as work practices and administrative controls (See Section 3.6 Administrative Controls and Rules) to identify any changes that can be made to decrease the need for face coverings and other personal protective equipment (PPE) ordinarily used for work activities that involve exposure to hazardous substances. This can help conserve PPE that is in short supply or needs to be diverted to activities associated with higher COVID19 exposure risks.

In addition, the Contractor must train construction workers on:

- The signs and symptoms of COVID-19 and an explanation of how the disease is potentially spread, including the fact that infected people can spread the virus even if they do not have symptoms.
- All policies and procedures that are applicable to the employee's duties as they relate to potential exposures to SARS-CoV-2. It is helpful to provide employees with a written copy of those standard operating procedures.
- Information on appropriate social distancing and hygiene practices.

6.6 Administrative Controls and Rules

Administrative controls require action by the worker or employer. Typically, administrative controls are changes in work policy or procedures to reduce or minimize exposure to a COVID19. Contractor must ensure that these Administrative Controls are implemented at the work site:

- Encouraging sick workers to stay at home.
- Minimizing contact among workers, clients, and customers by replacing face-to-face meetings with virtual communications and implementing telework if feasible.
- Establishing alternating days or extra shifts that reduce the total number of employees in a facility at a given time, allowing them to maintain distance from one another while maintaining a full onsite work week.
- Follow HPA guidelines for preventing the spread of COVID-19 infection and discontinue nonessential travel to locations with ongoing COVID-19 outbreaks.
- Developing emergency communications plans, including a forum for answering workers' concerns and internet-based communications, if feasible.
- Providing workers with up-to-date education and training on COVID-19 risk factors and protective behaviours (e.g., cough etiquette and care of PPE).
- Training workers who need to use protective clothing and equipment how to put it on, use/wear it, and take it off correctly, including in the context of their current and potential duties. Training material should be easy to understand and available in the appropriate language and literacy level for all workers. (See Appendix J)

6.7 Personal Protective Equipment (PPE)

Contractors must provide information, instruction and training on the safe use, decontamination, maintenance, and disposal of any PPE provided. Any PPE provided needs to be practical for the work environment (eg allowing the necessary visibility and mobility) and properly decontaminated or disposed off at the end of every shift.

Contractor should also monitor and encourage correct use of PPE, for example by providing information on posters and digital screens about:

- Washing or sanitising hands before putting PPE on, and putting face protection on before gloves. (See Appendix F and J)
- Removing gloves before face protection, washing or sanitising hands after removing PPE and decontaminating or disposing off used PPE safely. (use of enclosed bins for the disposal used PPE) (See Appendix F and J)

More information on Hand Hygiene and Face Coverings can be found in Appendices F and J respectively.

6.8 Wash Stations

All site-specific projects with outside construction sites MUST install Wash Stations.

- All worksites should have access to toilet and hand washing facility with soap.
- Providing hand cleaning facilities at entrances and exits. This should be soap and water wherever possible or hand sanitiser if water is not available
- All onsite workers must help to maintain and keep stations clean
- Ensure that the handwashing soap is refilled regularly.
- Enclosed dustbins must be placed next to the hand wash station for discarding of used tissues/towels with regular removal and disposal facility (end of each day)

7 WORK-SITE PROTECTIVE PRACTICES

7.1 General Safety Rules

- At the start of each shift, confirm with all employees that they are healthy and inform all workers of reusable and disposable PPE.
- Outside person should be strictly prohibited at worksite
- All construction workers will be required to wear cut-resistant gloves or the equivalent.
- Use of eye protection (reusable safety goggles/face shields) is recommended. The supply of eye protection equipment to the workers is considered as a standard part of PPE during construction works.
- In work conditions where required social distancing is impossible to achieve, such employees shall be supplied with standard face mask, gloves, and eye protection.
- The Contractor will divide workers/staff into two (2) groups where possible so that projects can continue working effectively in the event that one of the divided teams is required to quarantine.
- All employees shall drive to work site in a single occupant vehicle. Employees are encouraged to minimize ride-sharing. While in vehicle, employees must ensure adequate ventilation and consider the use of face coverings.
- When entering a machine or vehicle which you are not sure you were the last person to enter, make sure that you wipe down the interior and door handles with disinfectant (see Appendix G for dilution of disinfectant) prior to entry. Adequate quantity of the disinfectant shall be provided by the Contractor at all such site-specific locations.
- Workers should maintain separation of 6' from each other.

- Multi person activities will be limited where feasible (two persons lifting activities)
- Gathering places on the site such as sheds and/or break areas will be eliminated, and instead small break areas will be used with seating limited to ensure social distancing.
- Contact the cleaning person of the worksite and ensure proper COVID-19 sanitation processes. Increase cleaning/disinfection visits to at least 2 times a day. Cleaning person(s) to be provided with gloves, gown and face mask for each cycle of cleaning. The Contractor shall make available adequate supply of PPE and chemicals while the threat of COVID-19 continues.
- Clean all high contact surfaces a minimum of twice a day in order to minimize the spread of germs in areas that people touch frequently. This includes but is not limited to desks, laptops and vehicles
- Maintain your good health by getting adequate sleep; eating a balanced, healthy diet, avoid alcohol; and consume plenty of fluids.
- Continuation of works in construction project with workers available on site and no workers to be brought in from outside
- The site offices shall have adequate ventilation. The air conditioning or ventilation systems installed at the site offices would have high-efficiency air filters to reduce the risk of infection. The frequency of air changes may be increased for areas where close personal proximity cannot be fully prevented such as control rooms, elevators, waiting rooms, etc.
- Employees should limit the use of co-workers' tools and equipment. To the extent tools must be shared, the Contractor will provide alcohol-based wipes to clean tools before and after use. When cleaning tools and equipment, consult manufacturing recommendations for proper cleaning techniques and restrictions.
- All in-person meetings will be limited. To the extent possible, meetings will be conducted by telephone.
- Employees are encouraged to use engineering and work practice controls to minimize dust. Such controls include the use of water delivery and dust collection systems, as well as limiting exposure time.
- All staff, workers, supervisors, managers and visitors must wear a face cover at the site at all times. (See Appendix J)
- In lieu of using a common source of drinking water, such as a cooler, employees should use individual water bottles. Use of tobacco products (chewing tobacco, smoking), vaping, etc., should be avoided.
- The Contractor must keep records of locations workers had visited and lived immediately before and during construction.

7.2 Site Visitors

- The number of visitors to the job site, including the trailer or office, will be limited to only those necessary for the work.
- All visitors will be screened using the 'Visitor and Employee Health Screening Checklist' in advance of arriving on the job site. If the visitor answers "yes" to any questions in the checklist, he/she should not be permitted to access the jobsite. (See Appendix E)
- Contractor may determine that taking visitor temperatures at worksites is appropriate and restricting access based upon temperature readings. As an alternative to taking temperatures at the worksite, Contractor may request visitors take their own temperatures prior to coming to the worksite. (See Appendix A for more information.)
- Site deliveries will be permitted but should be properly coordinated with the minimal contact. Delivery personnel should remain in their vehicles if at all possible. Use where possible, cashless transactions and avoid hand contact.
- Site Visitors must wear face coverings at all times within the site as specified in Appendix J.

8 CLEANING AND DISINFECTING

Cleaning means physically removing germs, dirt and organic matter from surfaces. Cleaning alone does not kill germs, but by reducing the numbers of germs on surfaces, cleaning helps to reduce the risk of spreading infection.

Disinfection means using chemicals to kill germs on surfaces. This process does not necessarily clean dirty surfaces or remove germs, but by killing germs that remain on surfaces after cleaning, disinfection further reduces the risk of spreading infection. Cleaning before disinfection is very important as organic matter and dirt can reduce the ability of disinfectants to kill germs.

Transmission or spread of coronavirus occurs much more commonly through direct contact with respiratory droplets than through contaminated objects and surfaces. The risk of catching coronavirus when cleaning is substantially lower.

8.1 Use of Disinfectants

Where possible, use a disinfectant for which the manufacturer claims antiviral activity (meaning it can kill viruses). Chlorine-based (bleach) disinfectants are one product that is commonly used. Other options include common household disinfectants or alcohol solutions with at least 70% alcohol (for example, methylated spirits). Follow the manufacturer's instructions for appropriate dilution and use. Appendix G provides dilution instructions when using bleach solutions

The Contractor will ensure that any disinfection shall be conducted using one of the following:

- Common HPA-approved disinfectant; (COVID-19 Quick Reference Guidelines*)
- Alcohol solution with at least 60% alcohol; or
- Diluted Sodium Hypochlorite as per HPA recommendation* (See Appendix G)

* <https://covid19.health.gov.mv/wp-content/uploads/2020/05/COVID-19-QR-SOPs-v9-first-revision.pdf>

The Contractor must maintain Safety Data Sheets of all disinfectants used on site. Cleaning person(s) to be provided with gloves, gown and face mask for each cycle of cleaning.

8.2 Routine Cleaning and Disinfection

Workplaces should routinely (at least daily) clean frequently touched surfaces. Also, clean surfaces and fittings when visibly soiled and immediately after any spillage. Where available, a disinfectant may be used following thorough cleaning

Each worksite should have enhanced cleaning and disinfection procedures that are posted and shared including sheds, gates, equipment, vehicles, etc. and shall be posted at all entry points to the sites, and throughout the project site. These include common areas and high touch points like:

- Taps and washing facilities
- Toilet flush and seats
- Door handles and push plates
- Handrails on staircases and corridors
- Lift and hoist controls
- Machinery and equipment controls
- Food preparation and eating surfaces
- Telephone equipment / mobiles
- Keyboards, photocopiers and other office equipment
- tabletops, light switches, desks, toilets, taps, remotes, cupboard handles etc
- other equipment and materials relevant to construction and building sites

The Contractor must ensure regular housekeeping practices, which includes cleaning and disinfecting frequently used tools and equipment, and other elements of the work environment, where possible. Employees should regularly do the same in their assigned work areas.

- Jobsite trailers and break/lunchroom areas must be cleaned at least once per day. Employees performing cleaning will be issued proper personal protective equipment (“PPE”), such as nitrile, latex, or vinyl gloves and gowns, as recommended by the HPA.
- Any trash collected from the jobsite must be changed frequently by someone wearing nitrile, latex, or vinyl gloves.
- Any portable jobsite toilets should be cleaned by the leasing contractor at least twice per week and disinfected on the inside. The Contractor will ensure that hand sanitizer dispensers are always filled. Frequently touched items (i.e., door pulls and toilet seats) will be disinfected frequently.

- Vehicles and equipment/tools should be cleaned at least once per day and before change in operator or rider.

Gloves are recommended when cleaning and disinfecting. Use of eye protection, masks and gowns is not required when undertaking routine cleaning. Always follow the manufacturer's advice regarding use of PPE when using disinfectants. Re-usable PPE should be thoroughly cleaned after use and not shared between workers.

9 JOB SITE EXPOSURE SITUATIONS

In the event of a suspected case of COVID19, the workers must inform their supervisors and the supervisors/contractor must assist the worker to contact the HPA at their toll free number **1676**. HPA will provide further instructions and inform if testing is required. If tested positive for COVID-19 HPA will contact the individual to identify the close contacts and the causal contacts. If the employee has attended their workplace while they were infectious and had close contact with other employees, HPA will contact the Contractor. Further information is provided below.

9.1 Employees Exhibiting COVID-19 Symptoms

If an employee/worker exhibits COVID-19 symptoms (See Appendix C), the employee must immediately contact HPA at 1676 and follow their instructions and must remain at home until he or she is symptom free for 72 hours (3 full days) without the use of fever-reducing or other symptom-altering medicines (e.g., Panadol, cough suppressants). The Contractor will similarly require an employee that reports to work with symptoms to return home until they are symptom free for 72 hour (3 full days). To the extent practical, employees are required to obtain a doctor's note clearing them to return to work. The Contractor must ensure that the employee/worker is compensated for the duration which he/she was out of work due to this.

9.2 Employee Tests Positive for COVID-19

An employee/worker that tests positive for COVID-19 needs to follow the instructions given by HPA and needs to be directed to self-quarantine away from work. Employees that test positive can only return back to work once HPA confirms that the individual is tested negative and fully recovered from COVID19. Employees that test positive and have been hospitalized may return to work when directed to do so by their medical care provider. The Contractor will require employees to provide documentation clearing their return to work. The Contractor must ensure that the employee/worker is compensated for the duration which he/she was out of work due to COVID19.

9.3 Employee Has Close Contact with a COVID-19 Positive Individual

Employees that have come into close contact with a confirmed-positive COVID-19 individual (co-worker or otherwise), will need to inform HPA at 1676 and follow their instructions. If the employee is not tested for COVID19, the employee must be directed to self-quarantine for 14 days from the last date of close contact with the carrier. Close contact is defined as six (6) feet for a prolonged period of time.

If the Contractor learns that an employee has tested positive, the Contractor will conduct an investigation into co-workers that may have had close contact with the confirmed-positive employee in the prior 14 days and direct those individuals that have had close contact with the confirmed-positive to self-quarantine for 14 days from the last date of close contact with the carrier. If an employee learns that he or she has come into close contact with a confirmed-positive individual outside of the workplace, he/she must alert a manager or supervisor of the close contact.

The Contractor must ensure that the employee/worker is compensated for the duration which he/she was out of work due to COVID19.

10 TRAINING AND AWARENESS

Contractor to ensure all workers get training on the requirements of this H&S Plan before start of any construction activity. During construction period frequent visual and verbal reminders to workers can improve compliance with hand hygiene practices and thus reduce rates of infection. Posters should be displayed at work site and labour camps regarding Hand Hygiene and Face Coverings. (See Appendix F and J)

The Contractor must also ensure all staff, workers and other relevant personnel have installed the “**Trace Ekee**” app, developed and recommended by Government of Maldives for contact tracing of COVID-19 patients.

A copy of this H&S Plan along with all appendices should be kept at the work site and labour camp at all times.

11 IMPORTANT CONTACTS

Contractor must provide an emergency contact number of a supervisor or a medical personnel at work site and labour camp for reporting COVID-19 symptoms.

Contact the Health Protection Agency (HPA) at the 24/7 toll free number **1676** for all queries including:

- Case Reporting
- General Inquiries

For Medical Emergencies, contact **102** and if assistance is required to transfer the patient to the ambulance, please contact Fire and Rescue number **118**

Contact Incident Command Posts (ICP) operated by City Council below for support services for households/quarters under monitoring and urgent support service requests from any other household/quarters.

- Thilafushi ICP - 9300924
- Vilimale ICP - 9300917
- Hulhumale ICP - 9300918
- Male' ICP - 9300904, 9300908

Contact any number below for Psychosocial Support Services:

- 3337892
- 7897892
- 7567030

A table of important contacts are listed in Appendix D. Online doctor consultation services by medical facilities are provided on Appendix H.

12 CONFIDENTIALITY

Except for circumstances in which the Contractor is legally required to report workplace occurrences of communicable disease, the confidentiality of all medical conditions will be maintained in accordance with applicable laws of Maldives and to the extent practical under the circumstances. When it is required, the number of persons who will be informed of an employee's condition will be kept at the minimum needed not only to comply with legally-required reporting, but also to assure proper care of the employee and to detect situations where the potential for transmission may increase. A sample notice to employees is attached to this Plan (Appendix B).

The Contractor reserves the right to inform other employees that a co-worker (without disclosing the person's name) has been diagnosed with COVID-19 if the other employees might have been exposed to the disease so the employees may take measures to protect their own health.

APPENDIX A – Temperature Screening Guidance

General Considerations¹

- Certain local jurisdictions have recommended or required employers to conduct temperature screenings of employees as they enter the worksite. Any applicable federal, state, or local requirements on employee temperature screenings should be consulted prior to performing them.
- Temperature screenings must be conducted consistently, professionally, and with proper training for those conducting the checks. Such checks must be uniformly and non-discriminatorily conducted on all employees (as well as contractors, vendors, customers, and/or visitors, if they will also be screened).
- Any information obtained from temperature screenings should be stored securely with access limited to those with a business need to know. It is essential to have proper documentation in the event that an individual needs to be excluded from the worksite based on the results of their temperature screening. If excluding individuals from a worksite based upon temperature, a set temperature should be established, based upon public health recommendations. Many employers have set the temperature required for exclusion at 100.4 degrees Fahrenheit or above.
- Wage protocols and procedures to account for any potential time spent waiting in line to be screened must also be considered. This is particularly important at worksites where there may be numerous workers reporting to their shift at the same time and only one or two individuals conducting the temperature screenings. Any existing Collective Bargaining Agreements should also be considered.

Screening

- The temperature screening can be conducted by the employer, at the worksite, when the employee arrives to report for their shift.
- Recommended type of temperature screeners:
 - *Infrared thermometers.* Infrared thermometers are the most practicable and safe option for conducting screening at work. However, the individual conducting such temperature screening must still be provided with appropriate protective gear. If the infrared thermometer does not allow the individual conducting the screening to stand at least six feet from the employee being screened, the following protective gear is recommended:

¹ Temperature screening involves numerous, difficult legal issues. This Appendix does not represent a comprehensive discussion of all of those issues. It is intended to provide some basic guidance to contractors who might be performing screening. Contractors should consult with legal counsel before implementing a screening program.

- The individual conducting the screening should wear a face covering and gloves. If at all possible, the employee being screened should wear a face covering as well during the check.
- If the employee is not wearing a face covering, the individual conducting the screening should wear a gown and eye protection in addition to a face covering and gloves.

If the individual conducting the screening is able to stand six feet or more from the employee being screened, no additional protective gear is necessary, though a face mask and gloves are recommended.

APPENDIX B – Employee Notification

DATE: [DATE]

TO: [CLOSE CONTACT EMPLOYEE]

FROM:[COMPANY REP]

We have been informed by one of our [employees/customer/vendor/etc] working at [SITE] that he/she has a confirmed case of COVID-19, commonly known as “Coronavirus,” based on test results obtained on [DATE]. Per company policy, this [employee/customer/vendor/etc] has been directed to self-quarantine until permitted to return to work.

We are alerting you to this development because, based on the Company’s investigation, we believe that you may have come into contact with the confirmed-positive case, on or about [DATE]. As a critical infrastructure employee, [INSERT COMPANY NAME] will permit you to work provided you remain asymptomatic. In addition, we are implementing the following practices:

- Measuring temperature of employees before they enter the worksite;
- Regularly monitoring asymptomatic employees;
- Ensuring employees maintain social distancing as work duties permit; and
- Routinely disinfecting workspaces.

You are also required to wear a face covering at all times while at the worksite for at least 14 days. Please inform [COMPANY CONTACT] if any of the following occur to you during the next 14 days: you experience flu-like symptoms, including fever, cough, sneezing, or sore throat; or you test positive for COVID-19.

We also want to take this opportunity to remind you that one of our core values as a company is respect for and among our employees [or customers]. We will treat information regarding the identity of employees [or customers] with suspected or confirmed cases of COVID-19 as confidential to the extent practicable and will comply with applicable laws regarding the handling of such information. Further, per Company policy, we will not tolerate harassment of, or discrimination or retaliation against, employees [or anyone].

Please contact [COMPANY CONTACT AWARE OF APPROPRIATE PROTOCOLS] at [PHONE NUMBER] if you have any questions or concerns.

For more information about COVID-19, please visit the HPA website at: <https://covid19.health.gov.mv/>

APPENDIX C – Information Related to COVID19

What is COVID-19?

The novel coronavirus, COVID-19 is one of seven types of known human coronaviruses. COVID-19, like the MERS and SARS coronaviruses, likely evolved from a virus previously found in animals. The remaining known coronaviruses cause a significant percentage of colds in adults and children, and these are not a serious threat for otherwise healthy adults. Patients with confirmed COVID-19 infection have reportedly had mild to severe respiratory illness with symptoms such as fever, cough, and shortness of breath.

According to the Health Protection Agency of Maldives (HPA), the virus can cause mild to severe respiratory illness. The outbreak began in Wuhan, Hubei Province, PRC, and has spread to a growing number of other countries—including the Maldives.

How is COVID-19 Spread?

COVID-19, like other viruses, can spread between people. Infected people can spread COVID-19 through their respiratory secretions, especially when they cough or sneeze. According to the HPA, spread from person-to-person is most likely among close contacts (about 6 feet). Person-to-person spread is thought to occur mainly via respiratory droplets produced when an infected person coughs or sneezes, like how influenza and other respiratory pathogens spread. These droplets can land in the mouths or noses of people who are nearby or possibly be inhaled into the lungs. It is currently unclear if a person can get COVID-19 by touching a surface or object that has the virus on it and then touching their own mouth, nose, or possibly their eyes.

In assessing potential hazards, employers should consider whether their workers may encounter someone infected with COVID-19 in the course of their duties. Employers should also determine if workers could be exposed to environments (e.g., worksites) or materials (e.g., laboratory samples, waste) contaminated with the virus.

Depending on the work setting, employers may also rely on identification of sick individuals who have signs, symptoms, and/or a history of travel to COVID-19-affected areas that indicate potential infection with the virus, in order to help identify exposure risks for workers and implement appropriate control measures.

There is much more to learn about the transmissibility, severity, and other features associated with COVID-19, and investigations are ongoing.

APPENDIX D – Important Contacts

Medical Emergencies	102
Fire and Rescue	118
Health Protection Agency (HPA) For all queries including: <ul style="list-style-type: none"> • Case Reporting • General Inquiries 	1676
Contact Incident Command Posts (ICP) Operated by City Council below for support services for households/quarters under monitoring and urgent support service requests from any other household/quarters.	Thilafushi ICP - 9300924 Vilimale ICP - 9300917 Hulhumale ICP - 9300918 Male' ICP - 9300904, 9300908
Psychosocial Support Services	3337892 7897892 7567030
Greater Male Industrial Zone Limited (GMIZL)	3307513 6642505
Project Management Unit	Safeguard Specialist: 7785277

APPENDIX E – Daily Health Screening Checklist

Greater Male Environmental Improvement and Waste Management Project (GMEIWMP)

CONDUCT HEALTH SCREENING EACH TIME EMPLOYEES OR VISITORS ENTER THE SITE.

You may also opt to conduct temperature screening if it can be done with proper social distancing, protection, and hygiene protocols. However, temperature screening is not required.

If a worker or visitor answers “Yes” to any of the screening questions or has a measured temperature above 100.4°F, they should be advised to go home, stay away from other people, and contact their health care provider.

Visitor and Employee Health Screening Checklist

Have you had any of the following symptoms since your last day at work or the last time you were here that you cannot attribute to another health condition?

Please answer “Yes” or “No” to each question. Do you have:

- Fever (100.4°F or higher), or feeling feverish?
- Chills?
- A new cough?
- Shortness of breath?
- A new sore throat?
- New muscle aches?
- New headache?
- New loss of smell or taste?

How to Handwash?

WASH HANDS WHEN VISIBLY SOILED! OTHERWISE, USE HANDRUB



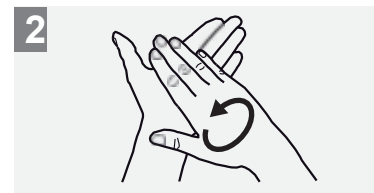
Duration of the entire procedure: 40-60 seconds



0 Wet hands with water;



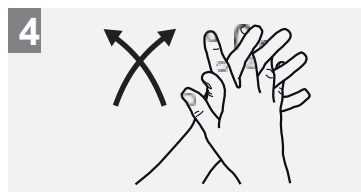
1 Apply enough soap to cover all hand surfaces;



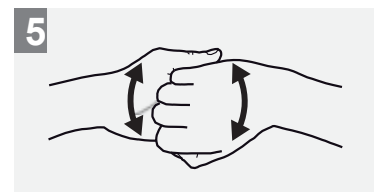
2 Rub hands palm to palm;



3 Right palm over left dorsum with interlaced fingers and vice versa;



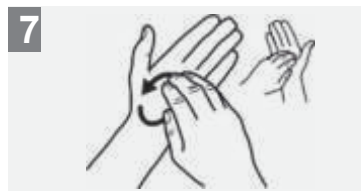
4 Palm to palm with fingers interlaced;



5 Backs of fingers to opposing palms with fingers interlocked;



6 Rotational rubbing of left thumb clasped in right palm and vice versa;



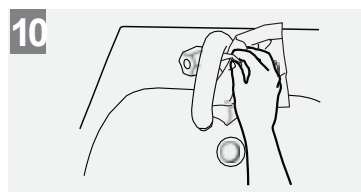
7 Rotational rubbing, backwards and forwards with clasped fingers of right hand in left palm and vice versa;



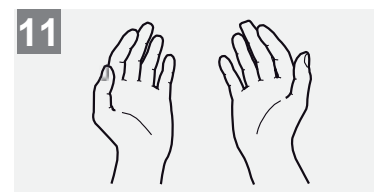
8 Rinse hands with water;



9 Dry hands thoroughly with a single use towel;



10 Use towel to turn off faucet;



11 Your hands are now safe.



World Health Organization

Patient Safety
A World Alliance for Safer Health Care

SAVE LIVES
Clean Your Hands

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May 2009

How to Handrub?

RUB HANDS FOR HAND HYGIENE! WASH HANDS WHEN VISIBLY SOILED

🕒 Duration of the entire procedure: 20-30 seconds



Apply a palmful of the product in a cupped hand, covering all surfaces;



Rub hands palm to palm;



Right palm over left dorsum with interlaced fingers and vice versa;



Palm to palm with fingers interlaced;



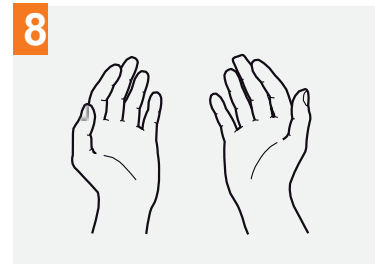
Backs of fingers to opposing palms with fingers interlocked;



Rotational rubbing of left thumb clasped in right palm and vice versa;



Rotational rubbing, backwards and forwards with clasped fingers of right hand in left palm and vice versa;



Once dry, your hands are safe.



World Health Organization

Patient Safety

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SAVE LIVES

Clean Your Hands

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May 2009

APPENDIX G – Dilution of Disinfectant

Household bleach comes in a variety of strengths. The concentration of active ingredient — hypochlorous acid — can be found on the product label. The recommended concentration of Sodium Hypochlorite (bleach) is **0.1% (1000ppm)** for non-healthcare settings.

Recipes to achieve a 1000 ppm (0.1%) bleach solution

Original strength of bleach		Disinfectant recipe		Volume in standard 10L bucket
%	Parts per million	Parts of bleach	Parts of water	
1	10,000	1	9	1000 mL
2	20,000	1	19	500 mL
3	30,000	1	29	333 mL
4	40,000	1	39	250 mL
5	50,000	1	49	200 mL

<https://www.who.int/publications-detail/cleaning-and-disinfection-of-environmental-surfaces-in-the-context-of-covid-19>

APPENDIX H – Online Doctor Consultation Services

ONLINE CONSULTATION			
PROVIDER NAME	CONTACT NUMBER	PROVIDER TYPE	ATOLL / ISLAND
ADK Hospital	1440 / 3313553	Hospital	K. Male'
Senahiya Hospital	7969897	Hospital	K. Male'
Medica Hospital	9748013	Hospital	K. Male'
Eye Care Hospital	7201026	Hospital	K. Male'
Primax Medi-Care	3330511	Clinic	K. Male'
Eye Care Clinic	7201026	Clinic	K. Male'
Family Care Clinic & Scan Center	7468046	Clinic	K. Male'
Uro Medical Care	7776689	Clinic	K. Male'
Central Clinic	7893464	Clinic	K. Male'
Advance Medical Clinic	7947778	Clinic	K. Male'
Central Medical Center	7987781	Clinic	K. Male'
Mednova Medical Centre	7999736	Clinic	K. Male'
Kulunu Medical Center	9939797	Clinic	K. Male'
Eve Clinic	3300788 / 7900788	Clinic	K. Male'
First Care Medical Center	3329449 / 7969449	Clinic	K. Male'
Institute of Mental Well-Being	7897892 / 7226667	Clinic	K. Male'
Image Center	9477293 / 9477294 / 9477311	Clinic	K. Male'
Eye Care Clinic Hulhumale' Branch	7201026	Clinic	K Hulhumale'

Unique Dental	7909017	Clinic	K.Hulhumale'
Care Trust Multi Specialty Clinic	7969001	Clinic	K.Hulhumale'
Pro Care Clinic and Dental Center	9977758 / 9969920 / 9504051	Clinic	ADH Mahibadhoo
Dr Jihad's Dental and Medical Center	7779794	Clinic	K. Male
Imperial Medical Center	9471414	Clinic	K. Male
Maldicare	7705353 / 3331590	Clinic	K. Male
Faruvaa Clinic	7950535	Clinic	K. Male
Master Dental Care Center	9410090 / 9410096	Clinic	K. Male
Master Dental Care Centro	9410090 / 9410096	Clinic	K. Hulhumale'

APPENDIX I – Initial Health Screening Checklist

Greater Male Environmental Improvement and Waste Management Project (GMEIWMP)

CONDUCT THIS HEALTH SCREENING BEFORE THE WORK INITIATE AT THE SITE

If a worker or visitor answers “Yes” to any of the screening questions, they should be advised to stay home as they are of high risk for severe illness from COVID19.

Employee Initial Health Screening Checklist

Please answer “Yes” or “No” to each question. Do you have:

- Are you 60 years and older?
- Have you been confirmed positive for COVID-19?
- Are you currently experiencing, or recently experienced, any acute respiratory illness symptoms such as fever, cough, or shortness of breath?
- Have you been in close contact with any persons who have been confirmed positive for COVID-19 and are also exhibiting acute respiratory illness symptoms?
- Have you been in close contact with any persons who have travelled and are also exhibiting acute respiratory illness symptoms?
- Do you have any of the underlying medical conditions:
 - Severe Asthma or chronic respiratory Disease
 - Cardiovascular Disease
 - Cancer
 - Diabetes
 - Cardiovascular Disease
 - Chronic Liver Disease
 - Chronic Kidney Disease
 - Any other underlying medical condition, please specify:

APPENDIX J – Face Coverings

While construction work could generally be considered “low risk” for viral transmission, some construction tasks or activities may involve working with others in proximity closer than six feet, including sitting in the same vehicle, and therefore might be considered as “medium risk”.

Due to this, it is important to implement a face covering policy for certain work activities for the foreseeable future, including those situations where (1) it is mandated by the government rule, or (2) employees must work in proximity of six (6) feet from other employees. A face covering is a cloth, bandana, or other type of material that covers a person’s nose and mouth. Disposable surgical masks are recommended, however if not available, cloth face coverings can be used. The five criteria for “cloth face coverings” is given below:

- fit snugly but comfortably against the side of the face;
- be secured with ties or ear loops;
- include multiple layers of fabric;
- allow for breathing without restriction; and
- be able to be laundered and machine-dried without damage or change to shape.

If disposable surgical masks are being used by workers, make sure the mask is disposed off safely in an enclosed bin and wash hands after. Use of a face covering is not a substitute for other workplace preventative techniques that are outlined in this Plan.

Wear your Face Covering Correctly

- Wash your hands before putting on your face covering
- Put it over your nose and mouth and secure it under your chin
- Try to fit it snugly against the sides of your face
- Make sure you can breathe easily

Use the Face Covering to Protect Others:

- Wear a face covering to help protect others in case you’re infected but don’t have symptoms
- Keep the covering on your face the entire time you’re in public
- Don’t put the covering around your neck or up on your forehead
- Don’t touch the face covering, and, if you do, wash your hands

Take Off Your Cloth Face Covering Carefully, When You’re Home

- Untie the strings behind your head or stretch the ear loops
- Handle only by the ear loops or ties
- Fold outside corners together
- Place covering in the washing machine (learn more about how to wash cloth face coverings)
- Be careful not to touch your eyes, nose, and mouth when removing and wash hands immediately after removing.



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How to put on, use, take off and dispose of a mask

1



Before putting on a mask, wash hands with alcohol-based hand rub or soap and water

2



Cover mouth and nose with mask and make sure there are no gaps between your face and the mask

Avoid touching the mask while using it; if you do, clean your hands with alcohol-based hand rub or soap and water

3



Replace the mask with a new one as soon as it is damp and do not re-use single-use masks

4



To remove the mask: remove it from behind (do not touch the front of mask); discard immediately in a closed bin; wash hands with alcohol-based hand rub or soap and water

CORONAVIRUS DISEASE 2019 (COVID-19)

Your cloth face covering protects them.
Their cloth face covering protects you.



===== END =====



**Wash your
hands.**



**Stay home
when sick.**



**Cover your
cough.**

Republic of Maldives

Ministry of Environment and Energy

Consultancy Services for Feasibility Study for an Integrated Solid Waste Management System for Zone III (including Greater Male') and Preparation of Engineering Design of the Regional Waste Management Facility at Thilafushi



Saafu Raaje Zone III Integrated Waste Management System

Environmental and Social Impact Assessment for the Regional Solid Waste Management Facility (RSWMF) Thilafushi

Chapter on Air quality (2nd revision of 18.09.2019)

Date:	18/09/2019
Prepared by:	Ahmed Jameel
Checked by:	Chakir Kasdarli

Revision History

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01	Completion of section 7.4 and 9	12/09/2019	AJ
02	Revised version after ADB comments of 16.09.2019	18/09/2019	AJ



Disclaimer:

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List of units, abbreviations and acronyms

Abbreviations and acronyms	
ADB	Asian Development Bank
ADM	Air dispersion modelling
AQMA	Air Quality Management Area
AQO	Air Quality Objective
As	arsenic
Cd	cadmium;
CO	carbon monoxide
Cr	chromium
CrVI	chromium VI
Cu	copper
DBO	Design-Build-Operate
GOM	Government of Maldives
GM	Greater Male'
EAL	Environmental Assessment Level
ELV	Emissions Limit Value
EU	European Union
HCl	hydrogen chloride
HF	hydrogen fluoride
Hg	mercury
HSE	Health, Safety, Environment
IED	Industrial Emissions Directive
IFC	International Finance Corporation
IWM	Integrated waste management
MOE	Ministry of Environment
MSL	Mean Sea Level
MSW	Municipal Solid waste
NH ₃	ammonia
Ni	nickel
NO ₂	nitrogen dioxide

NO _x	nitrogen oxides
Pb	lead
PM ₁₀	fine airborne particulate matter with an aerodynamic diameter of less than 10 micrometers
PM _{2.5}	fine airborne particulate matter with an aerodynamic diameter of less than 2.5 micrometers
RSWMF	Regional Solid Waste Management Facility
Sb	antimony
SBD	Standard Bidding documents
SO ₂	sulphur dioxide
SWM	Solid Waste Management
TA Luft	First General Administrative Regulation Pertaining the Federal Immission Control Act (Technical Instructions on Air Quality Control in the following document as " <i>TA Luft</i> ")
TOC	Total Organic Carbon
TPD	Tonnes Per Day
V	vanadium
VDI	Verein Deutscher Ingenieure (German Engineer Association)
VOCs	Volatile Organic Compounds;
WHO	World Health Organisation
WTE	Waste to Energy
Units	
µm	micrometre: 1 µm = 0.001 mm
mm	millimetre: 1 mm = 0.001 m
m	metre: 1 m = 0.001 km
km	kilometre
m ²	square metre
ha	hectare: 1 ha = 10,000 m ²
l	litre: 1 l = 0.001 m ³
m ³	cubic metre
ng	nanogram: 1 ng = 0.001 µg
µg	microgram: 1 µg = 0.001 mg
mg	milligram: 1 mg = 0.001 g

g	gram: 1 g = 0.001 kg
kg	kilogram: 1 kg = 0.001 Mg (t)
Mg	megagram (same as t: tonne)
s	second
h	hour
d	day (calendar day)
a	year
°C	degrees Celsius
K	Kelvin
Pa	pascal: 1 Pa = 0.01 mbar (millibar)
kPa	kilopascal: 1 kPa = 1,000 Pa
MPa	megapascal: 1 MPa = 1,000,000 Pa
kJ	kilojoule
kWh	kilowatt hour: 1 kWh = 3,600 kJ
MW	megawatt
OU	odour unit
OU/m ³	odorous substances concentration
LU	livestock unit (1 livestock unit equals an animal live weight of 500 kg)

Glossary

<p>Immissions</p>	<p>Immissions shall be air pollutants affecting humans, animals, plants, soil, water, the atmosphere, cultural assets and any other property.</p> <p>Immissions shall be indicated as follows:</p> <ul style="list-style-type: none"> a) Mass concentration, as mass of air pollutant per unit volume of polluted air; for gaseous substances, mass concentrations are to be referenced to 293.15 K and 101.3 kPa. b) Deposition, as mass of pollutant per unit area of ground per unit time. <p>Synonym of immission : Ambient air quality</p>
<p>Immission Indicators,</p>	<p>Immission indicators describe the initial load, the additional load or the total load of the respective air pollutant. The initial load shall describe the pre-existing load of a pollutant. The additional load shall characterise the concentrations, which can be expected to be caused (for planned installations) or which are actually caused (for existing installations) by the planned project. With respect to planned installations, the indicator for the total load shall be calculated on the basis of the initial load plus the additional load indicators. With respect to existing installations, this indicator equals the initial load.</p>
<p>Assessment Points,</p>	<p>Assessment points shall be those points in the vicinity of an installation for which immission indicators, indicative of the total load, are determined.</p>
<p>Grid Points</p>	<p>Grid points shall be those points in the vicinity of an installation for which the additional load is calculated (immission projection).</p>
<p>Immission Values also known as immission rate or ambient air values</p>	<p>The annual immission value shall be the concentration or deposition value of a substance averaged over one year.</p> <p>The daily immission value shall be the concentration value of a substance averaged over one calendar day, taking into account the respective frequency limit for excess values (number of days) over one year.</p> <p>The hourly immission value shall be the concentration value of a substance, averaged over a whole hour (e.g., from 8 a.m. to 9 a.m.), taking into account the respective frequency limit for excess values (number of hours) over one year.</p>
<p>Waste Gas Volume and Waste Gas Volumetric Flow Rate</p>	<p>Waste gases shall be carrier gases with solid, liquid or gaseous emissions. any data regarding the waste gas volume and the waste gas volumetric flow rate are referenced to standard conditions (273.15 K and 101.3 kPa) after subtraction of the water vapour content unless explicitly indicated otherwise</p>
<p>Emissions</p>	<p>Emissions shall be air pollutants originating from an installation.</p> <p>Emissions shall be indicated as follows:</p> <ul style="list-style-type: none"> a) mass of substances or groups of substances emitted as related to the volume (mass concentration) <ul style="list-style-type: none"> aa) of waste gas under standard conditions (273.15 K and 101.3 kPa) after subtraction of the water vapour content, bb) of waste gas (wet) under standard conditions (273.15 K and 101.3 kPa) before subtraction of the water vapour content, b) mass of substances or groups of substances emitted per unit time as a mass flow (emitted mass flow); the mass flow is the total emission occurring in one hour of normal operation of an installation under operating conditions which are most unfavourable to the maintenance of air quality;

	<ul style="list-style-type: none"> c) quantity of fibres emitted (fibre dust concentration), as related to the volume of waste gas under standard conditions (273.15 K and 101.3 kPa) after subtraction of the water vapour content; d) ratio of the mass of emitted substances or groups of substances to the mass of products generated or processed or to stocking density (emission factor); the mass ratio shall take into account the total emissions from the installation occurring over one day of normal operation of such installation under operating conditions most unfavourable to the maintenance of air quality; e) amount of Odour Units of odorous substances emitted, as related to the volume (odorous substances concentration) of waste gas at 293.15 K and 101.3 kPa before subtraction of the water vapour content; the odorous substances concentration is the olfactometrically-measured ratio of volume flows when diluting a waste gas sample with neutral air down to the odour threshold, indicated as a multiple to the odour threshold.
Emission Ratio	The emission ratio shall be the ratio of the mass of an air pollutant emitted in waste gas to the mass of supplied fuels or input materials; it shall be provided as a percentage.
Emission Reduction Ratio	The emission reduction ratio shall be the ratio of the mass of an air pollutant emitted in waste gas to its mass supplied in crude gas; it shall be provided as a percentage. The odour reduction ratio is an emission reduction ratio.
Emission Standards and Emission Limits	<p>Emission standards shall provide the basis for emission limits. The emission limits shall be established in the letter of permit or in a subsequent order as</p> <ul style="list-style-type: none"> a) permissible fibre dust, odorous substances or mass concentrations of air pollutants in waste gas provided that <ul style="list-style-type: none"> aa) any daily mean values do not exceed the established concentration level and bb) any half-hourly mean values do not exceed twice the established concentration level, b) permissible mass flows, as related to one hour of operation, c) permissible mass ratios, as related to one day (daily mean values), d) permissible emission ratios, as related to one day (daily mean values), e) permissible emission reduction ratios, as related to one day (daily mean values), or f) any other requirements to provide precaution against harmful effects of air pollutants on the environment.

Consultation/Comments & answers matrix

Following the ADB mission held in Male' between the 04-08.08.2019 the following questions and comments have been addressed to the consultant:

N°	ADB experts Comments	Answer/Reference after 1st draft comments	Comments of ADB expert team (Ricardo) from 16.09.2019	Consultant's answers
AQ1	Need for robust baseline data to inform air quality modelling and to confirm airshed status	(new comments)	Update: Further air quality monitoring is reported as being currently in progress ('Air quality and air dispersion modelling report 190828' page 41), which is welcomed. The measurements made during this period should be analysed and assessed against the relevant limit values to determine background conditions and whether the location should be treated as a degraded airshed.	Please see updated Chapter 7.4. It could not be clearly determined whether the location should be treated as a degraded airshed or not. The site is clearly influenced by the adjacent dumpsite and its open burning. (see Chapter 7.4)
AQ2	Impact of the proposed facility on air quality	(new comments)	Update: AQ2 comments remain valid. The new report 'Air quality and air dispersion modelling report 190828' is unfinished, but does not refer to the EHS requirement for the contribution from a facility to account for less than 25% of the air quality standard/guideline. When baseline air quality data are available, the assessment results should be reinterpreted in the light of these requirements.	Please see Chapter 8.4. It is obvious that new facilities emissions are far below the EHS requirements. The main problematic is the ambient baseline condition which is mainly influenced by the dumpsite and which contributes to a temporary degraded airshed.
AQ3	Required assessment of average emission limit values for heavy metals	(new comments)	Update: these substances are now all listed in Table 6 (p44). These substances have been considered in the assessment, at least at the preliminary screening stage. The assessment states (p51) that "In the calculation, the heavy metal nickel was considered representative of the group of heavy metals and their components: antimony, chromium, copper, manganese, vanadium, tin, lead, cobalt, nickel". The reason for limiting the assessment to nickel is not explained. The assessment for all substances listed above should be clearly set out. The new report also states that: 'For ammonia and hydrogen chloride (5.2.4 Class III TA Luft), for carbon	For the calculation at the assessment point the emission value for Nickel was considered as 0,5 mg/m ³ which is the emission threshold value for all heavy metals (Antimony, chromium, copper, mangan, vanadium, tin, lead, cobalt and nickel) which means we are considering a worst case.



N°	ADB experts Comments	Answer/Reference after 1st draft comments	Comments of ADB expert team (Ricardo) from 16.09.2019	Consultant's answers
			<p>monoxide, for organic substances (expressed as total C) as well as dioxins and furans no minor mass flow are set in the regulations therefore there is no need to undertake a detailed dispersion modelling for these parameters either.' These substances should in principle be included in the assessment. It is likely that no significant impacts would be identified for ammonia or hydrogen chloride. However, emissions of dioxins and furans should be modelled and, as a screening approach, evaluated against the WHO guideline of Air concentrations of 0.3 pgTEQ/m³ which is used to identify local emission sources that need to be identified and controlled</p>	
AQ4	Confirmation of stack height	(new comments)	<p>The revised assessment confirms the proposed stack height of 50 metres, which would be adjacent to a building of height 43 metres. This appears to be relatively low for a facility of this nature. AQ4 remains valid.</p>	<p>This comment is wrong. The building height is 30 m (and not 43 m). There is no reference in the report that the building is 43 m high. The statement relatively low is not clear enough. If ADB experts has another formula how to calculate the stack height than please do it and provide us with a clear height</p>
AQ5	Reliability of model results	(new comments)	<p>The new report 'Air quality and air dispersion modelling report 190828' states: 'The results have been checked again and are considered as right and robust. The model used is a state of the art, accepted model by the German Ministry of Environment. It reaches it best performances in flat environment and poor database which is the case in the Maldives. The comparison with plants in the UK which has provenly different ambient and environmental conditions could not be considered as appropriate.' The consultant is correct: the situation in the Maldives is different to the UK, and different dispersion characteristics would be expected. However, our experience is based on the use of ADMS</p>	<p>The Consultant is unable to run another model as the one presented in this report. As far as there is no mandatory requirement to use AERMOD or ADMS in the national ToR as well in the EHS guidelines, the consultant estimate to use an internationally recognized ADM. Rationale for using this model has been presented.</p>

N°	ADB experts Comments	Answer/Reference after 1st draft comments	Comments of ADB expert team (Ricardo) from 16.09.2019	Consultant's answers
			<p>and AERMOD for modelling assessments worldwide, not just in the UK. This comment remains valid.</p> <p>In the context of assessing mercury, the report states “[As] pre-pollution with air pollutants at the site is not known (baseline), so it is assumed that the calculated values represent the total load.” This seems to imply that the assessment has been carried out by assuming that there is no baseline contribution due to mercury. This is not a conservative approach to the assessment, and the assessment should take account of baseline levels of air pollutants.</p>	<p>This text has been changed. The additional represents the “process contribution” from the WtE. Considering this source as a single standing source, the results from the calculations shows that increase of pollutants in the atmosphere is far below the requirements of IFC. The combination of process contribution and baseline unfortunately not (for the parameter PM, SO₂, NO₂). This is mainly related to the influence of the dumpsite.</p>
AQ6	Calculation of emission mass flows for nitrogen oxides (nitrogen monoxide and nitrogen dioxide), specified as nitrogen dioxide	(new comments)	Further clarification has been provided which indicates that there may be a further factor of 90% involved in calculating nitrogen dioxide concentrations. This is not clearly explained, and does not account for the discrepancy, but the difference is small and not likely to significantly affect the study conclusions.	OK
AQ7	Responses provided to questions from ADB Experts			
1	Air quality assessment to be undertaken following international good practice, for which ADB would usually refer to IFC EHS Guidelines. Since German approach has been utilized and ADB is not familiar with this, it needs to be demonstrated how this is consistent with international good practice, notably in stack height calculation, scoping out potential air quality impacts, and in terms of the dispersion model used, the EIA should also include the justification for using the German approach	See Chapter 4 “Methodology”	The report explains the background to the German method, but does not relate this to the IFC EHS methodology which is specified for use in the ADB Safeguard Policy Statement (2009). See AQ1 and AQ2 above.	<p>It is not very clear for the consultant, what the ADB experts wants more. Concerning AQ1 and AQ2 we completed the report accordingly. The German approach does not differs from other approaches which is :</p> <ul style="list-style-type: none"> • Considering Regulatory requirements (in this case due to non availability of Maldivian regulation, we used German regulations and International standards



N°	ADB experts Comments	Answer/Reference after 1st draft comments	Comments of ADB expert team (Ricardo) from 16.09.2019	Consultant's answers
				<ul style="list-style-type: none"> • Significance of the source (detailed description of WtE facility was provided in the document) • Location of the emitting facility relative to other sources (Macro, Meso and Microlocation presented) • Location of sensitive receptors (done) • Existing ambient air quality, and potential for degradation of the airshed from a proposed project (The airshed is already temporary degraded due to the dumpsite and is tending to be better after the dumpsite closure) • Technical feasibility and cost effectiveness of the available options for prevention, control, and release of emissions (part of the complete EIA)
2	<p>in any case, as ADB is used to seeing assessments undertaken against terminology of IFC EHS Guidelines, the results of German approach should be presented in that context in EIA and avoid using German specific terminologies.</p>	<p>Whether it was possibly terminology has been harmonized additional glossary was presented on page 1-2</p>	<p>The glossary is useful, but terminology has not been harmonized. E.g. sections 8.1.2 and 8.2.1.2 use the German terminology throughout.</p>	<p>Terminology has been harmonized. Whether it was not possible to use another terminology the glossary can be used.</p>
3	<p>Specifically German approach ambient air quality standards are based on WHO interim targets, rather than the WHO</p>	<p>For baseline assessment table 1.1.1 of IFC HSE guidelines (WHO guidelines was used) for emission values German</p>	<p>The WHO guidelines or EU standards should be used throughout the assessment (not just for baseline assessment) rather than using the approach based on</p>	<p>The German standards are mainly similar to EU standards, for certain parameters even more stringent.</p>



N°	ADB experts Comments	Answer/Reference after 1st draft comments	Comments of ADB expert team (Ricardo) from 16.09.2019	Consultant's answers
	guidelines; the EIA is to also discuss results in context of latter.	standards have been used which are more stringent than EU IED standards presented in the IFC EHS sector guidelines for MSW treatment facilities (see Chapter 4 "methodology")	German standards. See also AQ2 Reference to emission standards is not relevant	
4	The status of the airshed does need to be reported, for this baseline ambient air quality monitoring at Thilafushi is required	Thilafushi Island airshed is actually highly influenced by the uncontrolled burning of the illegal dumpsite. Once the dumpsite fires have been stopped (latest with the operation of the WtE), there is no further emission source like the dumpsite. The fires and smokes are temporary and with actual baseline air monitoring no significant pollution has been detected. If there was a similar source (after extinguishing the fires on Thilafushi) the concerns about the degraded airshed would be reasonable. Actually on Thilafushi the dispersion of any potential pollutant that yet may be produced is unrestricted.	Report is incomplete. The issue of open burning can be addressed when considering the results of baseline air quality monitoring. The report could explain why baseline levels are considered likely to be negligible: this would need to take account of existing industrial and other activity in the local area.	Based on the updated baseline chapter and its results we did an assessment of the airshed. Baseline monitoring have been done on 4 locations at 3 different periods: <ul style="list-style-type: none"> • June 2018 • March 2019 • August 2019 Covering main parameters as per ToR with a monitoring and recording frequency which able to develop baseline parameters comparable to WHO guidelines for ambient air quality. See chapter 7.4



N°	ADB experts Comments	Answer/Reference after 1st draft comments	Comments of ADB expert team (Ricardo) from 16.09.2019	Consultant's answers
5	Monitoring should include NO ₂ , SO ₂ , PM ₁₀ and PM _{2.5} as well as all parameters listed in national TOR including CH ₄ , CO, Cd, Pb, Hg, HC which do not yet appear to have been monitored (or it needs to be explained why the cannot be, but if mercury has more than negligible impact it should have baseline).			NO ₂ , SO ₂ ; PM ₁₀ ; PM _{2.5} done at all survey points. CH ₄ , CO done at selected survey points. Pb, Cd, Hg and HC could not be done due to the non-availability of adequate equipment. Additional paramaters done : CO ₂ , H ₂ S See Chapter 7.4
6	Monitoring should enable the ambient air quality to be clearly established by reference to WHO guidelines: 1 hour averages for NO ₂ , 10 minute and 24 averages for SO ₂ , and 24 hour averages for PM ₁₀ and PM _{2.5} . Monitoring program should be done over a period of two weeks, i.e. not just a one off and undertaken in different seasons (second season can be added to EIA at later date) to reflect changes in wind direction etc.	Done see page 42.	Report incomplete	Done see Chapter 4 methodology and Chapter 7.4 Baseline
7	The ambient air quality data already collected needs to be adequately presented with averaging period, units etc.They also need to be compared to the WHO guidelines to determine if the airshed is degraded.	Done see page p 42	Report incomplete	Done see Chapter 7.4 Baseline
9	The assessment to include consideration of all the parameters in the EU IED even if it is just to scope out they have a negligible impact	Done	All pollutants now included. Assessment of metals needs to be further explained; assessment of dioxins & furans is required. See AQ3.	



N°	ADB experts Comments	Answer/Reference after 1st draft comments	Comments of ADB expert team (Ricardo) from 16.09.2019	Consultant's answers
10	<p>Under German approach, mercury is reported to have more than a negligible impact. It needs to be clarified why in terms of input data used, ideally to support that WtE is clean technology preferable if mercury levels were negligible. It may raise concerns why mercury is flagged, as perhaps it relates to burning of unsegregated hazardous waste?</p>	<p>The 17th ordinance for the implementation of the Federal Immission control Act (Ordinance on Incineration Plants for municipal waste and similar combustible substances) has defined an maximum emission value of 0,03 mg/m³. This value is monitored and controlled at the stack To respect this value active carbon is used in the flue gas cleaning in order to deposit the mercury. The problematic with mercury is that it is difficult to identify the source in the waste. Therefore it is a venture that the mercury is provided by hazardous waste. With the maximum flue gas volume flow and maximum allowed mercury concentration we have a mass flow which is over the threshold value. Therefore an air dispersion model is needed (made with Astral200). This was made an the expert (sub-contractor) came to the conclusion that there is</p>	<p>Provided issues with the air quality assessment can be addressed (AQ1, AQ2, AQ4, AQ5), the evaluation of mercury is acceptable.</p>	<p>OK</p>



N°	ADB experts Comments	Answer/Reference after 1st draft comments	Comments of ADB expert team (Ricardo) from 16.09.2019	Consultant's answers
		no critical additional pollution		
11	Consultant has modelled the parameters in Table 10, whilst not required under German legislation it is important to ADB the EIA clearly demonstrates the air quality impacts of the WtE plant on a spatial basis and, given what is currently degraded airshed, that maximum project contribution impact is not significant. Thus dispersion plots for all the modelled parameters should be provided,	Done	The assessment does not clearly demonstrate the air quality impacts of all pollutants: see comments AQ1 to AQ6 above. Dispersion plots were provided for some parameters: these are a mix of airborne concentration and deposition plots.	Please precise what ADB experts understand under "clearly". The assessment is saying that parameters below minor mass flow have a negligible impact, for those over the minor mass flow an ADM has to be conducted to see "the dispersion effect" of this parameter and consequently its impact. Dispersion plots have been provided upon request of the ADB expert after on site mission. Most of the plots show clearly that the impacts are low at the receiving sensitive points
12	Also confirm the maximum ground level concentration (additional load in German terms) that the model has predicted. Note the maximum ground level concentration may not be at the same location as ANP1 receptor point included in the model by consultant. The dispersion modelling is required by the national TOR.	Ambiant air quality baseline measures have not been done actually for Mercury. ADB is right that maximum ground level concentration may not be at the same location as ANP 1. On the ANP1 we have factories with people working 8-10 h permanently exposed to hazards. On our experts opinion it makes less sense to undertake an extensive Mercury baseline survey: Actually Mercury is released in a diffuse form	This comment refers to model outputs, not to ambient air quality measurements. The consultant's response does not address the question.	We confirm these figures as it was mentioned in the report received from our sub-consultant. If ADB experts identified a mistake then please advice then we could check with the data set. But a first cross check does not show any discrepancies



N°	ADB experts Comments	Answer/Reference after 1st draft comments	Comments of ADB expert team (Ricardo) from 16.09.2019	Consultant's answers
		<p>from the old dumpsite on fire. This releasing will be stopped as soon as the dumpsite is closed and rehabilitated.</p> <p>Mercury baseline surveys are complex and costly because of the surveying of vaporous gaz and of particle-bound mercury. In order to meet the requirements of ADB it is necessary to have a narrow mesh of measurement points. Also the analytics is very expensive.</p>		
13	<p>Confirm the basis for 8,000 hours operation, as 8,200 hours availability is also mentioned. Is it possible it could operate for more hours? Though WtE plant will not operate all the time, dispersion modelling is usually done for 8,760 hours since it is not known exactly which days of the year (under what met conditions) will be operational or not.</p>	<p>We confirm that ADM was made on the communicated operation hours of 8,000 hrs. There are mandatory yearly revisions imposed to the contractor so it is not expected that it could be operated longer</p>	<p>The response addresses the question, and confirms that the assessment is not conservative in respect of operating hours. This should be taken into account when interpreting the results.</p>	<p>The WtE facility needs mandatory yearly revision and maintenance time where the facility is shut down or working partially. These are mandatory requirements to the DBO contractor. So it is almost impossible that the WtE facility will operate at all thime and therefore a realistic operation time of 8,000 is considered as realistic for the conclusion of the outcome of this report</p>
14	<p>The consultant needs to check the results of the model, as per our technical advisor the emissions of NO₂, SO₂ and PM₁₀ appear to be relatively low for a WtE plant of this scale. At the minute the impacts are not significant, but this raises a concern they have been underestimated. Need to confirm the</p>	<p>The results have been checked again and are considered as right and robust. The model used is a state of the art, accepted model by the German Ministry of Environment. It reaches</p>	<p>The consultant is correct: the situation in the Maldives is different to the UK, and different dispersion characteristics would be expected. Our experience is based on the use of ADMS and AERMOD for modelling assessments worldwide, not just in the UK. Our comment AQ5 remains valid.</p>	<p>There are more than 140 models developed and accepted only in Europe.</p> <p>As per National ToR and also as per IFC performance standard it is not mandatory to use a specific ADMS or AERMOD. As a German consultants we have used Austal 2000 which is the</p>



N°	ADB experts Comments	Answer/Reference after 1st draft comments	Comments of ADB expert team (Ricardo) from 16.09.2019	Consultant's answers
	<p>model inputs are appropriate and were correctly inputted and why model concentrations can be considered as robust. This issue may relate to either input data or the type of model used which does not follow same principles as more frequently used ADMS or AERMOD.</p>	<p>it best performances in flat environment and poor database which is the case in the Maldives. The comparison with plants in the UK which has provenly different ambient and environmental conditions could not be considered as appropriate</p>		<p>official reference model of the German Regulation on Air Quality Control, listed as an accepted model by the European Environment agency and the 11th International Conference on Harmonization within Atmospheric Dispersion Modeling for Regulatory Purposes, held in Cambridge, England.</p> <p>The model is considered as robust and has been runned two times. The model running (including additional parameters) costs 8,000 EUR. The consultant cannot afford to use a second model for consistency check anymore. If ADB experts are not convinced about the results we suggest to engage a special consultant for consistency check with AERMOD or other ADM model</p>

AIR QUALITY REPORT WtE THILAFUSHI

1 Introduction

The ambient air quality status of Maldives is currently unknown due to the lack of monitoring data. It is generally considered good as the sea breezes flush the air masses over the small the islands. However rapid urbanization and economic growth in the recent years has shown noticeable changes in the air quality, particularly in the Male' region. Aside from the increased land and sea vessels, diesel power generation, and construction, open burning in Thilafushi is also a significant source of air pollution in the region.

The proposed WtE Facility will treat approximately 500 TPD of municipal waste (Household waste and similar to Household waste) based on the estimated throughput at design point, generating as a "by-product", electricity. This air quality report for the proposed facility was carried out as follows:

- a) Outline review of the policy context for air quality.
- b) Assessment of baseline air quality
- c) Identification of potentially sensitive locations
- d) Calculation of the minimum stack height
- e) Identification of potential parameters which needs a more detailed dispersion modelling
- f) Evaluation of forecast levels of released substances against relevant standards, guidelines, critical levels and critical loads
- g) Dispersion modelling study of emissions to forecast air concentrations and deposition rates at potentially sensitive locations
- h) Conclusions

The main focus of the air quality assessment was the evaluation of modelled levels against relevant standards and guidelines. Levels of relevant substances were forecast at sensitive receptors to enable an assessment of the effects on air quality with regard to human health risks and environment to be evaluated.

As the Maldives did not have a wide range of air quality survey network, therefore baseline assessment have been done through temporary field measures.

The proposed development is forecast to have no significant effects on air quality during abnormal operating conditions or due to road traffic emissions, and no significant cumulative effects are forecast to occur. No amenity issues such as odours or dusts would be expected to arise outside the site boundary, and emissions to air from the proposed facility are forecast to have no significant effects on the local environment.

The proposed facility will have no significant adverse effects on air quality. Consequently, it was concluded that no further mitigation is necessary, other than the extensive mitigation and control measures already built into the proposed facility.

2 Scope of work

2.1 ToR for air modelling consultant

For this special purposes of establishing a detailed and reliable air quality report (as part of a complete EIA), Water solutions and Kocks Consult GmbH hired The Engineer Company Ulbricht GmbH from Germany a specialised consultant in the field of environmental consultancy, permitting procedures and noise abatement.

The scope of work was to undertake:

- the stack height calculation
- The calculation and assessment of air pollutants emission

According First General Administrative Regulation Pertaining the Federal Immission Control Act (Technical Instructions on Air Quality Control – TA Luft).

For the purpose of this work Water Solutions and Kocks Consult GmbH have submitted the following documentation to the consultant

[1] The emission values according Industrial Emissions Directive (IED) (2010/75/ EU, 2010) and 17th Ordinance for the implementation of the Federal Immission control Act (Ordinance on Incineration Plants for municipal waste and similar combustible substances (the more stringent had to be used, dioxins and furans according IED)

[2] The data set for Thilafushi from the National Maldives meteorological service

[3] The dimensioning parameter for WtE, particularly the flue gas cleaning

3 Policy and Guidance

3.1 National legislation

The proposed SWM project will be governed by the laws of the Government of Maldives and the implementing regulations promulgated in accordance with such laws. As summarized below, the legal and regulatory framework for the protection and preservation of the environment of the Maldives with respect to solid waste management is currently evolving to conform to international standards within the unique context of the Maldivian natural environment. In light of the development of a comprehensive national solid waste management program including establishment of facilities to provide state of the art solid waste disposal, recycling and resource recovery, it is expected that certain existing proposed laws, draft regulations and temporary guidelines concerning solid waste management will be significantly revised and promulgated in binding final form during the course of the project. To the extent that Maldivian laws and regulations become final they shall be binding upon the project proponents superseding analogous standards referenced herein.

At present, Maldives does not have a national air quality policy or a national ambient air quality standard. However there are legislations and programmes to prevent air pollution such as Environmental Protection and Preservation Act (4/93), Draft Waste Incineration Guideline, Concrete Batch Plant Guideline and the Vehicular Emission Standard (MEE, 2017).

[The Environmental Protection and Preservation Act \(eppa\) 1993](#)

The Environmental Protection and Preservation Act (EPPA) of the Maldives (Law No. 4/93) is an umbrella law that provides statutory powers regarding environmental regulation and enforcement.

The relevant components of the EPP Act 1993 are:

Environmental Guidance

Article (2) The concerned government authorities shall provide the necessary guidelines and advise on environmental protection in accordance with the prevailing conditions and needs of the country. All concerned parties shall take due considerations of the guidelines provided by the government authorities.

Environmental Protection and Conservation

Article (3) The Ministry of Environment shall be responsible for formulating policies, rules and regulations for protection and conservation of the environment in areas that do not already have a designated government authority already carrying out such functions.

Protected Areas and Natural Reserves

Article (4) The Environment Ministry shall be responsible for identifying and registering protected areas and natural reserves and drawing up of rules and regulations for their protection and preservation.

Environmental Impact Assessment

Article (5) (a) An EIA shall be submitted to the Environment Ministry before implementing any developing project that may have a potential impact on the environment.

The EIA process in the Maldives is coordinated by the Environment Protection Agency (EPA) in consultation with relevant government agencies and National Commission for the Protection of the Environment (NCPE). The first step in environmental assessment process involves screening of the project to be classified as one that requires an Initial Environmental Examination (IEE) or one that requires a full Environmental Impact Assessment (EIA). Based on this decision, the Ministry then decides the scope of the EIA which is discussed with the proponent and the EIA consultants in a “scoping meeting”. The consultants then undertake the EIA starting with baseline studies, impact prediction and finally reporting the findings with impact mitigation and monitoring plan. The EIA report is reviewed by EPA following which an EIA Decision Note is given to the proponent who will have to implement the Decision Note accordingly. As a condition of approval, appropriate environmental monitoring may be required and the proponent will have to report monitoring data at required intervals to the Ministry.

Environmental Impact Assessment regulation, 2007

The Environment Ministry issued the EIA Regulation in May 2007, which guides the process of undertaking the Environmental Impact Assessment in the Maldives. This Regulation provides a comprehensive outline of the EIA process, including the application to undertake an EIA, details on the contents, format of the IEE/EIA report, the roles and responsibilities of the consultants and the proponents as well as minimum requirements for consultants undertaking the EIA.

The objective of the Maldivian Environmental Impact Regulations, 2007 is to serve as a decision making tool for stakeholders in assessing the potential significant environmental impacts of a development proposal at the same time providing required guidance in obtaining environmental approval for such projects in the form of Environmental Decision Statement.

The Table of Contents for Initial Environmental Examination or EIA as specified in Schedule E of the EIA Regulations requires the proponent to furnish a detailed description of the natural, economic and human environment. This includes

- description of site characteristics including soil type, relief, landforms, present land use and drainage system
- type of flora and fauna, rare or endangered species, sensitive habitats of ecological importance including wetlands and mangroves
- marine environment including rocky bottom, coral reefs and sea grass beds
- beach systems; composition; stability; current; tide and wave dynamics
- description of surrounding infrastructure including utilities
- socio-economic characteristics including demographic profile, economic activities, housing and utilities, employment statistics and available skills, labour availability, unique cultural characteristics
- other attributes of the locality e.g. amenities and recreational values

The proposed WtE and landfill project is categorized under “Schedule D” list of projects requiring an EIA study.

Post EIA monitoring, auditing and evaluation

The EIA Regulations 2007 provides a guideline of the environmental monitoring programme that should be included in EIA reports as monitoring is a crucial aspect of the EIA process.

Accordingly, the monitoring programme shall outline the objectives of monitoring, the specific information to be collected, the data collection program and managing the monitoring programme. Managing the monitoring programme requires assigning institutional responsibility, enforcement capability, requirements for reporting and ensuring that adequate resources are provided in terms of funds, skilled staff and the like.

Solid waste management regulation

The main objective of the regulation is to implement the National Solid Waste Management Policy and through that protect the environment by;

- minimizing the impact of waste on the environment including, in particular, the impact of waste so far as it directly affects human health;
- Establishing an integrated framework for minimizing and managing waste in a sustainable manner; and putting in place uniform measures to seek to reduce the amount of waste that is generated, and where waste is generated, to ensure that waste is reused, recycled and recovered in an environmentally sound manner before being safely treated and disposed.

The regulation also takes note in detail accounts of the following fields in its enactment.

Waste management measures - Waste Management Standards, Plans, Protocols of declaration of priority wastes, Extended producer responsibilities, Prohibition of unauthorized disposal of waste, Littering, Container standards for collection of waste in public places, Waste Collection standards in sea vessels, Waste collection facilities standards in ports, Protocols in Reduction, re-use recycling and recovery of waste, Waste Management activities list and Protocols of restrictions on provision of waste management services.

Waste Management Licenses – Basic requirements for licensing, key standards, the validity period of the license, transfer protocols of a license, protocols for surrendering a license, license fees and governance of a license register.

Transportation of Waste - Duties of personnel transporting the waste, protocols of exporting and transboundary transfer of hazardous wastes, protocols of transportation of waste from one island to another, duties of receivers of waste and accidentals protocols at sea

Monitoring, Inspection, Auditing and Enforcement - Duty to furnish information, duty to reporting, Notice from the Administering Authority requiring a review of activities carried out under a license, Revocation of a license, Defrayal of Administering Authority costs, Register of fines and administrative actions, Inspectors, Establishment of national waste information system, National Waste Management Status Reports.

Clause 18 of this regulation restricts provision of waste management services without obtaining a licence for the following activities:

- Operate a waste management facility
- Operate waste collection and transportation services
- Waste recycling services
- Operation of landfills

Waste management policy

Former MHTE (Now MoE) has published a National Solid Waste Management Policy for the Maldives. The aim of the waste management policy is to formulate



and implement guidelines and means for solid waste management in order to maintain a healthy environment. The developer shall follow any guidelines /regulations on waste management that the government may introduce.

Waste management during construction and operation of the proposed project will be guided by the relevant laws, regulations and policies related to waste in Maldives.

Review of the Maldivian regulatory framework during the course of the baseline monitoring exercise revealed that there exists limited regulations/standards which are appropriate to the present study and can be referred for compliance to the environmental components being monitored. Hence an attempt has been made in accordance with IFC PS requirements to identify the internationally recognized standards viz. WHO which has been referred to review conformance with the baseline values of the various environmental parameters being monitored. The list of such international standards has been provided below.

[WHO air quality guidelines, 2005](#)

the WHO Air quality guidelines as revised in 2005 (Refer Annex 3.7) represent the most widely agreed and up- to-date assessment of health effects of air pollution, recommending standards for air pollutants viz. PM10, PM2.5, SO₂, NO_x and Ozone at which the public health risks are significantly reduced. Necessary efforts has therefore been made by the proponent to compare the baseline air pollutant values monitored with the WHO air quality standards to establish any possible deterioration in ambient air quality and subsequent impact on worker health due to emissions that are resulting from open burning of solid wastes. Significant improvement in ambient air quality, if any due to implementation of the proposed waste management facility will also be verified based on the WHO standards.

[Male' declaration on control and prevention of air pollution and its likely transboundary effects for South Asia](#)

The objectives of Male' Declaration includes:

Assessing and analyzing the origin and causes, nature, extent and effects of local and regional air pollution,

Developing and/or adopting strategies to prevent and minimize air pollution

Setting up monitoring arrangements beginning with the study of sulphur and nitrogen and volatile organic compounds emissions, concentrations and deposition.

The proposed project will minimize the air pollution caused by the existing waste management practices of open burning of mixed waste in Thilafushi.

3.2 European legislation

The Industrial Emissions Directive (IED) (2010/ 75/ EU, 2010) brings together seven existing directives, including the Waste Incineration Directive, into one piece of legislation. The IED outlines total emission limit values (ELVs) for a number of pollutants typically emitted during waste incineration. These are NO_x, CO, total dust, HCl, HF, SO₂, organic substances, trace metals, and dioxins and furans. The design and operation of all new waste incinerations facilities must ensure compliance with the ELVs.

3.3 German legislation (as basis for the ADM)

First General Administrative Regulation Pertaining the Federal Immission Control Act (Technical Instructions on Air Quality Control – TA Luft) published in the Joint Ministerial Gazette from 30 July 2002 (English translation)

At the national level in Germany, the Act on the Prevention of Harmful Effects on the Environment Caused by Air Pollution, Noise, Vibration and Similar Phenomena (Federal Immission Control Act - BImSchG) is at the core of the body of statutory instruments that makes up immission control legislation. It has in the meantime received significant reinforcement in the form of numerous statutory instruments and two significant administrative provisions – Technical Instructions on Air Quality Control (TA Luft) and Technical Instructions on Noise Abatement (TA Lärm). The TA Luft is a comprehensive air pollution control regulation that includes:

- A discussion of the scope of the TA Luft application, which is to review applications for licenses to construct and operate new industrial facilities (or altered existing facilities) and to determine whether the proposed new or altered facilities will comply with the requirements of the TA Luft and the requirements of other air pollutant emission regulations promulgated under the Federal Pollution Control Act.
- Air pollutant emission limits for dust, sulfur dioxide, nitrogen oxides, hydrofluoric acid and other gaseous inorganic fluorine compounds, arsenic and inorganic arsenic compounds, lead and inorganic lead compounds, cadmium and inorganic cadmium compounds, nickel and inorganic nickel compounds, mercury and inorganic mercury compounds, thallium and inorganic thallium compounds, ammonia from farming and livestock breeding operations, inorganic gases and particulates, organic substances and others.
- Emission limits may also be set for hazardous, toxic, carcinogenic or mutagenic substances as part of the TA Luft review procedures.
- Other limits or requirements related to stack heights (for flue gases or other process vents) and for storing, loading or working with liquid or solid substances.
- Various requirements for sampling measuring and monitoring emissions.
- Listing of the industries subject to the requirements of the TA Luft, such as mining, electric power generation, glass and ceramics, steel, aluminum and other metals, chemical plants, oil refining, plastics, food, and others.

Annex 3 is devoted to guidelines on: how the atmospheric dispersion modeling required during the TA Luft review is to be performed, and the acceptable type of dispersion model to be used. In essence, the modeling must be in accordance with the VDI Guidelines 3782 Parts 1 and 2, 3783 Part 8, 3784 Part 2, and 3945 Part 3.

17th Ordinance for the implementation of the Federal Immission control Act (Ordinance on Incineration Plants for municipal waste and similar combustible substances)

The 17th Ordinance for the implementation sets the regulatory framework for the special case of the municipal waste incinerators based on the general requirement of the Federal immission control Act and the TA Luft. The Air emissions standards which have been set as the basis for the project (DBO) are *similar to the EU-IED and in some cases more stringent*

VDI (German Engineer Association) Guideline 3945 part 3 “Environmental meteorology/Atmospheric dispersion models –Particle model” of September 2000

The Commission on Air Pollution Prevention of the VDI and DIN – Standards Committee, which includes experts from science, industry and administration, acting independently, establish VDI guidelines and DIN standards in the field of environmental protection. These describe the state of the art in science and technology in the Federal Republic of Germany and serve as a decision-making aid in the preparatory stages of legislation and the application of legal regulations and ordinances. KRdL’s working results are also considered as the common German point of view in the establishment of technical rules at the European level by CEN (the European Committee for Standardization) and at the international level by ISO (the International Organization for Standardization). This guideline describes a numerical model for simulating the dispersion and calculating the concentrations of trace species in the atmosphere. Data required for the model include the mean wind field, turbulence parameters, emission data and, depending on the specific case, further application-specific input data.

3.4 Guidance note

Latest IFC General EHS Guideline, page 3-17 “Air emission and ambient air quality”

The Environmental, Health, and Safety (EHS) Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP). These General EHS Guidelines are designed to be used together with the relevant Industry Sector EHS Guidelines which provide guidance to users on EHS issues in specific industry sectors. 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. Page 3-17 applies to facilities or projects that generate emissions to air at any stage of the project life-cycle. It complements the industry-specific emissions guidance presented in the Industry Sector Environmental, Health, and Safety (EHS) Guidelines by providing information about common techniques for emissions management that may be applied to a range of industry sectors. This guideline provides an approach to the management of significant sources of emissions, including specific guidance for assessment and monitoring of impacts. It is also intended to provide additional information on approaches to emissions management in projects located in areas of poor air quality, where it may be necessary to establish project-specific emissions standards.

Latest IFC EHS Guideline for Waste management facilities page 8-10 and 29-30

The proposed WtE will involve a state of the art management of MSW generated from the Zone III waste catchment area (GM and other atolls and resorts) through waste incineration and sanitary landfill disposal of residual waste and is likely to be driven by IFC Sector EHS Guidelines on Waste Management Facilities. The guideline outlines significant EHS issues associated with waste management facilities during operations and decommissioning phases along with recommendations for mitigating the identified impacts. The applicability of these guidelines with respect to specific waste management operation including the current waste management practices has been discussed in details below.

Presently waste received at the Thilafushi is dumped in an uncontrolled manner with intentionally or non-intentionally burning leading to emission of pollutants (VOCs, dioxins & furans, particulate matter, acid fumes, SO_x, NO_x, etc.) which are expected to result in the deterioration of ambient air quality and occupational health. Hence in line with IFC Sectoral EHS requirements the ambient air quality needs to be periodically monitored by the proponent to check conformance with WHO Ambient Air Quality Guidelines, 2005.

Air pollutant emissions are also envisaged during the operation of waste incineration to be commissioned as an integral part of the proposed Thilafushi WtE. Carbon dioxide, Sulfure dioxide, particulate matter etc. have been identified as the key air pollutants that are likely to be released by waste incineration. High temperature maintained within the combustion furnace of the plant generally limits/restricts the formation of toxic substances viz. dioxins/furans, NO_x, SO_x and CO. Hence in accordance to the provision of the IFC EHS Guidelines it is necessary to undertake periodic monitoring of such emissions to review the performance of these proposed waste management systems against national & internationally recognized standards. However in absence of specific standards catering to emissions from Incineration plants in Maldives, project will be designed and operated in accordance with the substantive provisions of the following guidelines: "Air Emission Standards for MSW Incinerators in the EU & US" (Refer Appendix 4.1) and respective EU and German legislation. These regulations establish the minimum standards that must be met by facilities; specifically, emission levels for various pollutant materials: organics (dioxins, furans), metals (cadmium, lead and mercury), particulate matter (opacity), acid gases (hydrogen chloride, sulfur dioxide, nitrogen dioxide) and fugitive gas emissions.

IFC Performance standard

This section specifies the environmental monitoring requirements and assesses the compliance to the applicable national and international EHS guidelines/standards with respect to the current waste management practices and proposed Thilafushi RWMF as defined under relevant provisions of the applicable IFC Performance Standards.

PS3: pollution prevention & abatement

PS3 identifies the contribution of industrial activity and urbanization towards increased levels of pollution to air, water, and land that may threaten people and the environment at the local, regional, and global level. This performance standard therefore aims towards avoidance and minimization of the adverse impacts on human health and environment by addressing the pollution from project activities.

Paragraph 9 of the PS requires the proponent to undertake periodic monitoring of pollutants appropriate to the nature and scale of the potential impacts to demonstrate compliance with applicable national regulations and evaluate project environmental performance to determine corrective actions, if any. For project involving pollutant emissions Paragraph 26 and 27 of the PS requires the proponent to evaluate whether the existing background ambient levels are in compliance with the relevant national or internationally recognized ambient quality guidelines and/or standards so that adequate control measures can be put in place to prevent significant deterioration of environment quality and demonstrate continual improvement.

As the proposed Thilafushi Waste Management Project will involve emissions of air pollutants (CO₂, CO, NO_x, SO_x, PM, VOCs, dioxins/furans, etc.) and noise from operation of the plant and vehicles involved in waste handling and



transportation, generation of leachate landfill facilities there may exist potential risks on ambient environment, occupational and community health from such operations if not properly managed. Hence it is imperative that a monitoring framework is developed and implemented during the project operations stage to periodically assess and evaluate the performance of key HSE indicators to regularly check conformance with applicable national and international standards/guidelines (*WHO Ambient Air Quality Standards*, IFC Waste Management Facility EHS Guidelines, etc.) for necessary corrective action, if any.

Further in line with provisions of PS1, primary monitoring has been undertaken for physical components (ambient air) to establish the baseline environment and check for any possible deterioration in ambient environment.

4 Methodology

This air quality report was carried out in accordance with the TA Luft and established good practice for air quality modelling and assessment. The study considered emissions from the WtE stack and the Diesel Genset controlled under the 17th Ordinance of the German Federal Immission Control act and the Industrial Emissions Directive (2010/75/EU). In summary, the substances to be assessed are set out in the table below. For the sake of clarity a comparison table with Table 1 of the IFC HES sector guideline for MSW facilities (standard guideline for ADB) has been developed. The values in blue are the values used for this project.

Table 1 Air emission standards for MSW Incinerators in the EU and US as per IFC EHS sector guideline Waste management Facilities page 29			17. Ordinance for the Implementation of the Federal Immission Control Act (Germany)
Parameter	EU	USA ^a	
Total Suspended particulates (PM ₁₀)	10 mg/m ³ [24 hr average]	20 mg/dscm	5 mg/m ³ [24 hr average] 20 mg/m ³ [0,5 hr average]
Total Carbon (C)			10 mg/m ³ [24 hr average] 20 mg/m ³ [0,5 hr average]
Sulfur Dioxide (SO ₂)	50 mg/m ³ [24 hr average]	30 ppmv (or 80% reduction)	50 mg/m ³ [24 hr average] 200 mg/m ³ [0,5 hr average]
Oxides of Nitrogen (NO _x)	200-400 mg/m ³ [24 hr average]	150 ppmv [24 hr average]	150 mg/m ³ [24 hr average] 400 mg/m ³ [0,5 hr average]
Opacity	n/a	10%	n/a
Hydrochlorid Acid (HCl)	10 mg/m ³	25 ppmv (or 95% reduction)	10 mg/m ³ [24 hr average] 60 mg/m ³ [0,5 hr average]
Dioxins and furans	0,1 ng TEQ/m ³ [6-8 hr average]	13 ng/dscm (total mass)	n/a
Cadmium*	0,05-0,1 mg/m ³ [0,5-8 hr average]	0,010 mg/dscm	n/a
Carbon Monoxide (CO)	50-150 mg/m ³	50-150 ppmv ^c	50 mg/m ³ [24 hr average] 100 mg/m ³ [0,5 hr average]

Table 1 Air emission standards for MSW Incinerators in the EU and US as per IFC EHS sector guideline Waste management Facilities page 29			17. Ordinance for the Implementation of the Federal Immission Control Act (Germany)
Parameter	EU	USA ^a	
Lead (Pb)*	See total metals below	0,140 mg/dscm	n/a
Mercury (Hg)	0,05-0,1 mg/m ³ [0,5-8 hr average]	0,050 mg/dscm (or 85% reduction) ^b	0,03 mg/m ³ [24 hr average] 0,05 mg/m ³ [0,5 hr average]
Total metals*	0,5-1 mg/m ³ [0,5-8 hr average]	n/a	n/a
Hydrogen Fluoride (HF)	1 mg/m ³	n/a	1 mg/m ³ [24 hr average] 4 mg/m ³ [0,5 hr average]
Ammonia (NH ₃)	n/a	n/a	10 mg/m ³ [24 hr average] 15 mg/m ³ [0,5 hr average]

^a All values corrected to 7% oxygen ^b Whichever is less stringent

*Actually as there were no requirements for heavy metals (including lead) and cadmium this was not considered. The Consultant has contacted his sub-contractor due undertake additional assessment of these pollutants

It could be seen that values considered in this report for PM₁₀, NO_x, Mercury (Hg) are more stringent than EU-IED values. Additional parameters like Ammonia (NH₃), Total Carbon (C) (*in the TA luft but not in the IED*) and dioxin and furans (*in the IED but not in the TA Luft*) have been considered.

4.1 Ambient air quality/Existing conditions

Actually the Maldives does not have an Air quality monitoring surveying network. Therefore ambient air quality has been assessed through a temporary field survey.

Baseline Air quality monitoring was conducted at four locations: 3 locations at Thilafushi (AQ1, AQ2, and AQ3) and one location at Villingili (AQ4) by Water Solutions. In 2018, air quality monitoring was carried out at AQ3 at Thilafushi from 20th to 26th June 2018. In 2019, air quality monitoring was carried out at AQ4 at Villingili from 3rd to 9th March 2019, at AQ1 from 19th to 25th March 2015. Additional air quality monitoring was carried at AQ2 from 20th to 25th August 2019 and at AQ3 from 25th to 31st August 2019.

One station was selected in the downwind direction of the WtE stack emission plume while another station was placed at the cross wind direction of the plume. One station was selected in the cross wind direction of the smoke plume from the existing dump site at Thilafushi. The additional station at Vilingili was selected as a control site.

The instrument used for taking air quality for baseline is the Aeroqual series 500 monitors and sensors. Aeroqual is a portable monitor suited for surveying common indoor and outdoor pollutants compatible with over 30 different sensors. The Series 500 can be deployed for short term fixed monitoring by

adding an optional outdoor enclosure. The Aeroqual Series 500 is also highlighted as the leading instrument for measuring ozone, nitrogen dioxide and carbon monoxide by the United States Environmental Protection Agency (US EPA).



Figure 1: Air Quality monitoring station with two Aeroqual Series 500 monitors

Predominant wind direction is an important criteria in selection of the air quality sampling stations as gaseous and particulate emissions from the project activities have a greater chance of dispersal along the predominant wind direction and affect the downwind human habitations. The monitoring network for ambient air quality was developed based on the following key criteria;

- Regional meteorology (primarily wind speed and direction)
- Important receptor locations (e.g. nearby inhabitation);
- Proposed project activities
- Logistics for operating the air monitoring equipment

The predominant wind directions in Maldives are dependent on the NE and SW monsoons. The wind directions for all seasons recorded at the National Meteorological Centre, Maldives reveal that apart from the winter months (when winds primarily blow from NW-NE), winds predominantly blow from the west.

The ambient air quality monitoring locations are shown in and rationale for selection of the locations is presented in [Table 1](#).

Table 1: Locations for ambient air quality monitoring

Station Name	Station Coordinates	Monitoring rationale
<i>Thilafushi</i> Downwind (AQ1)	4°10'56.6 N 73°26'53.3 E	This downwind station with respect to the proposed facility has been selected to establish the baseline that could be compared with the monitoring to be undertaken during the construction and operational phases of the project to detect actual project imprints to the air quality of the nearest receptor.
<i>Thilafushi</i> crosswind (AQ2)	4°10'57.3 N 73°25'59.4 E	The cross wind station with respect to the proposed facility has been selected to establish the general baseline of the island, for comparison with the downwind station at the time of project activities

Station Name	Station Coordinates	Monitoring rationale
<i>Thilafushi crosswind (AQ3)</i>	4°11'07.6 N 73°26'37.4 E	The cross wind station with respect to the existing dumpsite at the Thilhafushi has been selected to establish the general baseline of the island
<i>Viligili Island (AQ4)</i>	4°10'26.4 N 73°28'59.9 E	The cross wind station with respect to Thilhafushi has been selected as a control site and to detect project imprints to air quality of the nearest receptor due to trans-island transportation of pollutants

The exact location of the ambient air stations were selected by WS/Kocks on site personnel to ensure the stations experience free air flow and are established at height between 1.5-5 meters and comply with the rationale of the monitoring program.

Selection of the sampling stations was based on the general climatological data obtained from the National Meteorological Center, Maldives. Also, data for the predominant wind directions for the sampling period was obtained from the National Meteorological Centre Maldives. As the direction of flow of exhaust air will be affected with changing wind directions, predominant exhaust air directions were noted down several times during the sampling program.

Because of the location of the island, strong gusts and variations of wind directions were noted which have the potential to influence the dispersion and in turn affect the air sampling. As a result it was thought pertinent to systematically record wind direction and strong gust.

Summary of the parameters measured:

Station	Parameters	Date	Frequency of recording
AQ 1	PM ₁₀	19.03.2019-20.03.2019	Minutely (24 hrs)
	PM _{2,5}	19.03.2019-20.03.2019	Minutely (24 hrs)
	NO ₂	20.03.2019-21.03.2019	Minutely (24 hrs)
	CO	22.03.2019-23.03.2019	Minutely (24 hrs)
	CH ₄	21.03.2019-22.03.2019	Minutely (24 hrs)
	CO ₂	19.03.2019-20.03.2019	Minutely (24 hrs)
	H ₂ S	20.03.2019-21.03.2019	Minutely (24 hrs)
	SO ₂	22.03.2019-23.03.2019	Minutely (24 hrs)
	VOC	21.03.2019-22.03.2019	Minutely (24 hrs)
AQ2	CO ₂	25.08.2019-26.08.2019	Every 15 min (24 hrs)
	CO	26.08.2019-27.08.2019	Every 15 min (24 hrs)
	NO ₂	27.08.2019-29.08.2019	Every 15 min (24 hrs)
	PM _{2,5}	25.08.2019-26.08.2019	Every 15 min (24 hrs)
	PM ₁₀	25.08.2019-26.08.2019	Every 15 min (24 hrs)



Station	Parameters	Date	Frequency of recording
AQ 3	PM ₁₀	20.06.2018-24.06.2018	Every 10 min (96 hrs)
	PM _{2,5}	20.06.2018-24.06.2018	Every 10 min (96 hrs)
	SO ₂	20.06.2018-24.06.2018	Every 10 min (96 hrs)
	CO ₂	25.08.2019-26.08.2019	Every 15 min (24 hrs)
	CO	26.08.2019-27.08.2019	Every 15 min (24 hrs)
	NO ₂	28.08.2019-29.08.2019	Every 15 min (24 hrs)
	PM ₁₀	25.08.2019-26.08.2019	Every 15 min (24 hrs)
	PM _{2,5}	25.08.2019-26.08.2019	Every 15 min (24 hrs)
AQ 4	SO ₂	06.03.2019-10.03.2019	Minutely (96 hrs)
	NO ₂	06.03.2019-10.03.2019	Minutely (96 hrs)
	PM ₁₀	06.03.2019-10.03.2019	Minutely (96 hrs)
	Pm _{2,5}	06.03.2019-10.03.2019	Minutely (96 hrs)
	CH ₄	06.03.2019-10.03.2019	Minutely (96 hrs)
	CO	06.03.2019-10.03.2019	Minutely (96 hrs)



Figure 2: Location of Ambient air quality monitoring station (Source Google earth)

4.2 Air dispersion modelling (ADM)

4.2.1 Rationale

The dispersion modelling for the pollutants was carried out using the dispersion model AUSTAL2000. The computer program AUSTAL2000 is a reference implementation developed on behalf of the *German Federal Environmental Agency*. (Available as a free download at <https://www.umweltbundesamt.de/themen/luft/regelungen-strategien/ausbreitungsmodelle-fuer-anlagenbezogene/austal2000n-download>)

AUSTAL2000 is a steady-state dispersion model that is designed for long-term sources and continuous buoyant plumes. AUSTAL2000 is also capable of using multiple point, area, volume, and line sources. This model includes dry deposition algorithms and considers the conversion of nitric oxide (NO) to nitrogen dioxide (NO₂). It is also able to make predictions about the frequency of odour nuisance.

It also available in English version as it is used by *other EU-member states*

The program system AUSTAL2000 calculates the spread of pollutants and odours in the atmosphere. It is an extended implementation of Annex 3 of the German regulation TA Luft (Technical Instruction on Air Quality Control) demands for dispersion calculations a Lagrangian particle model in compliance with the German guideline VDI 3945 Part 3. The modelling work was carried out by Ulbricht Consulting (Germany). The dispersion modelling report is attached as an Annex to this report.

Steady-state Gaussian plume models assess pollutant concentrations and/or deposition fluxes from a variety of sources associated with an industrial source complex. *Unlike the Gaussian models* commonly used, this flexible modelling procedure used in AUSTAL2000 *provides realistic results even when buildings and uneven terrain influence flue gas dispersion*. The model calculates the contribution of specified air pollutants from a given point source to the background concentrations present in the ambient air at ground level in the area surrounding the source.

4.2.2 Comparaison AUSTAL2000 vs AERMOD¹

Unlike the Gaussian dispersion model AERMOD, AUSTAL2000 is a Lagrangian dispersion model that simulates the dispersion of air pollutants by utilizing a random walk process. According to Sawford² a Lagrangian simulation *has greater potential for application* as it mimics the behaviour of particles. The direction and velocity of dispersion are estimated by wind field vectors. Additionally, the vector of the turbulent velocity is randomly varied for every particle by using a Markov process. The random element varies with the intensity of turbulence. The concentration is determined by counting the particles in a given volume³

¹ Christian Langner & Otto Klemm (2011) A Comparison of Model Performance between AERMOD and AUSTAL2000, Journal of the Air & Waste Management Association, 61:6,640-646, DOI: 10.3155/1047-3289.61.6.640

² Sawford, B.L. Lagrangian Statistical Simulation of Concentration Mean and Fluctuation Fields; J. Climate Appl. Meteorol. 1985, 24, 1152-1166.

³ Guideline 3945, Part 1. Environmental Meteorology—Atmospheric Dispersion Models—Particle Model; Verein Deutscher Ingenieure: Düsseldorf, Germany, 2000.

Like AERMOD, AUSTAL2000 is capable of calculating terrain and contains its own algorithm to assess the effects of building downwash⁴. AUSTAL2000 does not differentiate between rural or urban areas. AUSTAL2000 requires *less meteorological* information than AERMOD: z0, wind measurement height, wind direction, wind speed, and the stability classes according to Klug–Manier. The Klug–Manier classes represent the German standard stability classification for the atmosphere, similar to the Pasquill stability classes⁵ in the United States. All of these meteorological data come from ground-based measurements and no information from upper air soundings is utilized. The wind measurement height and z0 are provided in the input file. If z0 is not provided by the user, AUSTAL2000 will calculate it using an internal database of roughness lengths and the coordinates of the area. AUSTAL2000 uses the register of roughness lengths and the integrated wind field component TALdia, which creates wind field libraries for complex terrain and for cases with buildings.

AERMOD generally predicted concentrations closer to the field observations. AERMOD and AUSTAL2000 performed considerably better when they included the emitting power plant building, indicating that the downwash effect near a source is an important factor. Both models performed acceptable for a non-buoyant volume source. AUSTAL2000 had difficulties in stable conditions, resulting in severe underpredictions. This analysis indicates that AERMOD is the stronger model compared with AUSTAL2000 in cases with complex and urban terrain.

Generally speaking, the analysis indicates that AERMOD is the stronger model compared with AUSTAL2000 in complex and urban terrain. *In cases with simple terrain*, both models lead to acceptable results. Given the specific conditions and scope of the investigation, a model user has to evaluate whether he/she can get the meteorological data required to operate AERMOD. *For cases of poor meteorological data coverage, AUSTAL2000 could be an alternative*

4.2.3 Comparaison AUSTAL2000 vs CALPUFF⁶

Given the same quality of meteorological data, the performance of AUSTAL is similar to that of CALPUFF when using the Kincaid data set. The AUSTAL predictions tend to be conservative, usually overestimating the Kincaid GLC by roughly a factor two. AUSTAL performance is strongly affected by the choice of “quality factor” parameter, which controls the stochastic variability through the number of particles released. AUSTAL also tends to underestimate the wind speed at elevated levels, but AUSTAL predictions *are greatly improved when wind data at an elevated level* (close to the elevated source) is provided. AUSTAL predictions are improved when the thermal properties of exhausted gas from a power plant are described by the *VDI thermal flux equation*.

4.2.4 Conclusion

The computer program AUSTAL2000 is a reference implementation developed on behalf of the German Federal Environmental Agency. It is also used by other EU-state members and is a state of the art model following international good practice. AUSTAL2000 is a Lagrangian dispersion model that simulates the

⁴ AUSTAL2000—Program Documentation of Version 2.4; Janicke Consulting: Dunum, Germany, 2009.

⁵ Pasquill, F. The Estimation of the Dispersion of Windborne Material; Meteor. Mag. 1961, 90, 33-49

⁶ Ka-Hing Yau, Robert W. Macdonald & Jesse L. Thé (2011), inter-comparison of the austrial2000 and calpuff dispersion models against the kincaid data set, 9th Int. Conf. on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes

dispersion of air pollutants by utilizing a random walk process, with a particular strong performance in simple terrain and with poor meteorological data coverage. The model requires less meteorological information than similar models (AERMOD, etc.) which, given the circumstances and the environment in Maldives, makes it probably more suitable to generate a reliable output.

4.2.5 Grid

The stack height of has been set for the ADM to min 46 m (Worst case/see stack height calculation). Therefore the ADM area has a radius of at least 2,300 m (50 times the stack height). The grid for the calculation of concentration and deposition shall be selected in accordance with Chapter 7 (2) of Annex 3 of the Technical Instruction "Air" so that the location and contribution of the maximum emission can be determined with sufficient certainty. This is usually the case when the horizontal mesh size does not exceed the stack height. At source distances greater than 10 times the height of the stack, the horizontal mesh size can be selected proportionally larger. The calculations and assessments were carried out in an area of 3.2 x 2.6 km and a grid with mesh sizes of 5 to 20 m.

4.2.6 Potential sensitive locations/Assessment points

In the examination area, two assessment points were determined for the calculations. The location of these points can be found in Annex 3. BUP 1 (west) is the point with the maximum load. ANP 1 (East) has been considered for additional mercury load dispersion calculation. These points are also nearby the baseline ambient air survey points.

4.2.7 Level of uncertainty

The resulting statistical uncertainty (in %) was taken into account in the evaluation. The calculation was performed with the quality level "2". To assess the emissions, the calculated value is increased by the statistical uncertainty.

4.2.8 Meteorology

4.2.8.1 Rainfall, Temperature, atmospheric pressure

The rainfall over the Maldives varies during the two monsoon periods with more rainfall during the southwest monsoon. These seasonal characteristics can be seen from [Figure 3](#), which shows the mean monthly rainfall observed for central atolls.

The average annual rainfall for the archipelago is 2,124 mm. There are regional variations in average annual rainfall: southern atolls receive approximately 2,280 mm, and northern atolls receive approximately 1,790 mm annually (MEE, 2015). Mean monthly rainfall also varies substantially throughout the year with the dry season getting considerably less rainfall. This pattern is less prominent in the southern half, however. The proportions of flood and drought years are relatively small throughout the archipelago, and the southern half is less prone to drought (UNDP, 2006).

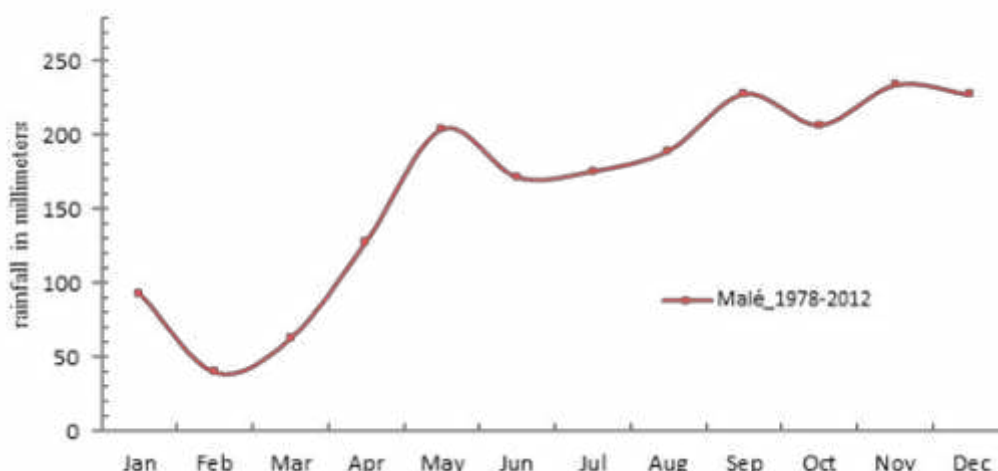


Figure 3: Long term average rainfall for the central atolls (Source: Maldives Meteorological Service, 2016)

For the ADM the following meteorological data have been acquired and used

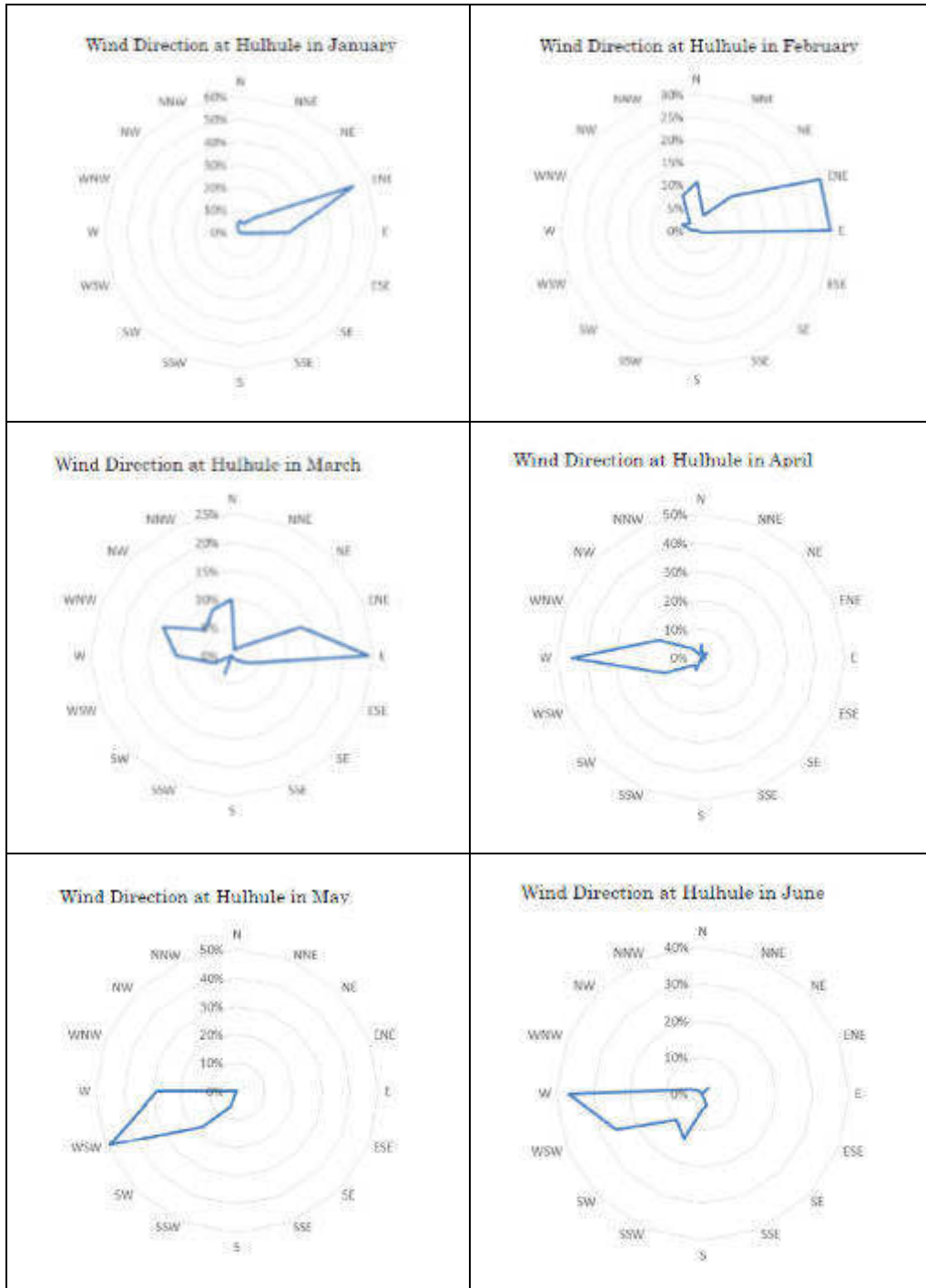
Rainfall data set (daily)	Source : Maldives Meteorological service Location : Weather station Hulhule' (Airport) at 10 km East of Thilafushi Data set: from 08.1974-12.2017
Temperature data set (daily)	Source : Maldives Meteorological service Location : Weather station Hulhule' (Airport) at 10 km East of Thilafushi Data set: from 01.-12.2017
Atmospheric pressure data set (daily)	Source : Maldives Meteorological service Location : Weather station Hulhule' (Airport) at 10 km East of Thilafushi Data set: from 01.-12.2017

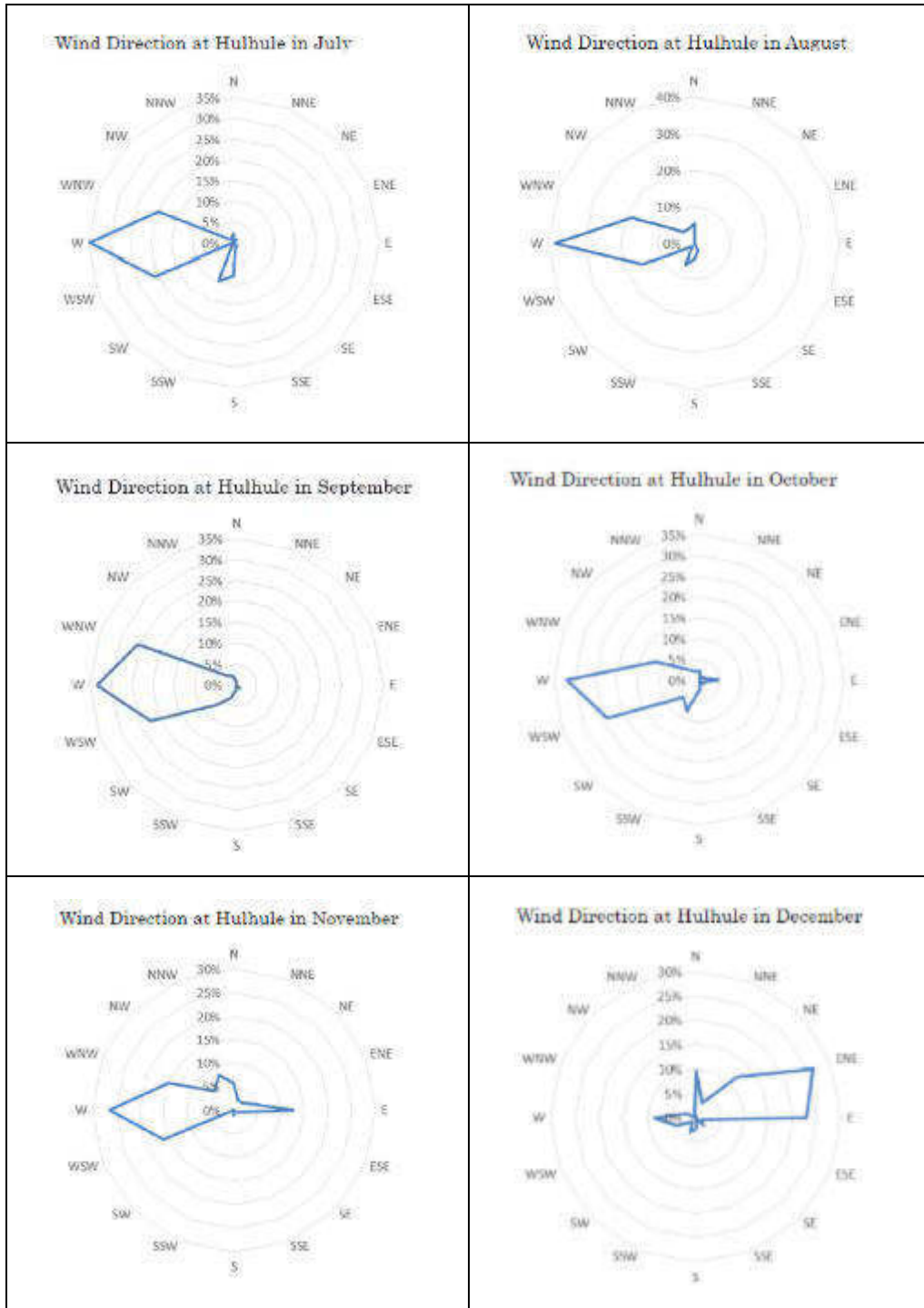
The data set have been provided in Excel format and have been computed for the purpose of the model in AKterm format.

4.2.8.2 Wind

The prevailing wind over the Maldives represents typical Asian monsoonal characteristics. It follows the traditional definition of monsoon as seasonal reversal of wind direction by more than 120° between the months January and July. Looking at annual variations, westerly winds are predominant throughout the country, varying between west-southwest and west-northwest [Figure 4](#).

The southwest monsoon, with winds predominantly between SW and NW, lasts from May to October. In May and June, winds are mainly from WSW to WNW, and in July to October, winds between W and NW predominate. The northeast monsoon, with winds predominantly from NE to E, lasts from December to February. During March and April, winds are variable. During November, winds are primarily from the west, becoming variable and can occasionally exceed 30 knots from the NE sector. However, yearly wind speed in the northeast and southwest monsoons are observed to be between 9-13 knots.





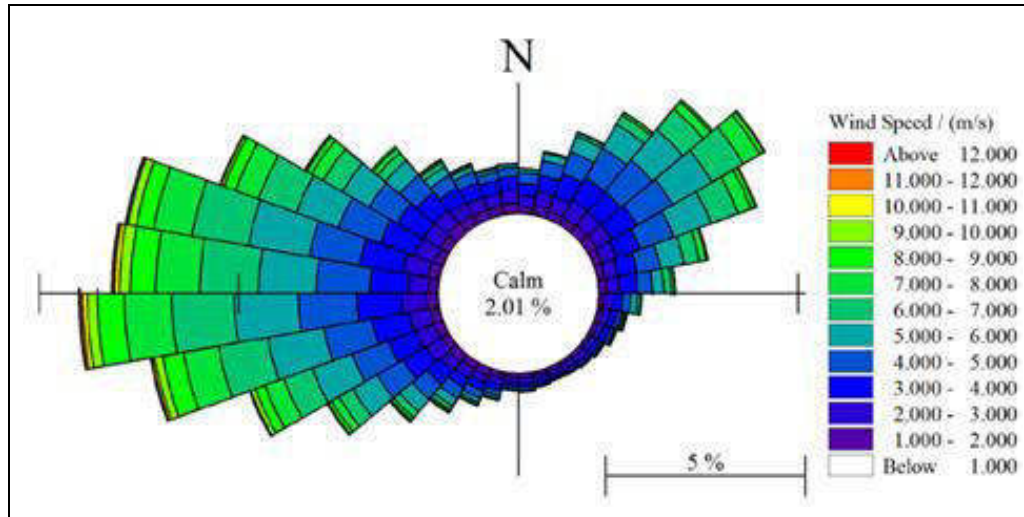


Figure 4: Spatial distribution of wind speed and directions from 1986-2016 (Source: LHI, 2018)

Figure 5 illustrates clearly wind the distribution pattern in terms of direction and frequency. The length of the “slices” represents the percentage of occurrence while the colour code illustrates wind speed. Furthermore, Table 15 shows the occurrence of wind by values in different directions and various speeds. According to the analysis, two dominant wind directions can be observed; i.e. West and North-East. The wind from the South-East quadrant is negligible. Significantly, calm conditions are rare, occurring 2.01% of the time.

Dir (Deg N) Speed (m/s)	0 - 10	10 - 20	20 - 30	30 - 40	40 - 50	50 - 60	60 - 70	70 - 80	80 - 90	90 - 100	100 - 110	110 - 120	120 - 130	130 - 140	140 - 150	150 - 160	160 - 170	170 - 180	180 - 190	190 - 200	200 - 210	210 - 220	220 - 230	230 - 240	240 - 250	250 - 260	260 - 270	270 - 280	280 - 290	290 - 300	300 - 310	310 - 320	320 - 330	330 - 340	340 - 350	350 - 360	Total		
0 - 1	0.03	0.06	0.06	0.05	0.06	0.07	0.06	0.04	0.09	0.03	0.03	0.05	0.04	0.06	0.05	0.04	0.05	0.08	0.03	0.06	0.07	0.06	0.06	0.06	0.07	0.08	0.11	0.03	0.06	0.07	0.08	0.06	0.07	0.06	0.06	0.03	2.07		
1 - 2	0.17	0.24	0.20	0.21	0.24	0.26	0.21	0.19	0.20	0.14	0.14	0.14	0.10	0.12	0.10	0.10	0.11	0.12	0.11	0.16	0.19	0.18	0.24	0.21	0.23	0.24	0.30	0.23	0.30	0.23	0.27	0.29	0.27	0.24	0.23	0.18	7.07		
2 - 3	0.29	0.38	0.43	0.48	0.44	0.45	0.43	0.35	0.34	0.23	0.19	0.16	0.15	0.14	0.13	0.11	0.11	0.13	0.12	0.17	0.19	0.28	0.32	0.40	0.51	0.53	0.64	0.53	0.64	0.54	0.48	0.45	0.39	0.34	0.31	0.29	12.16		
3 - 4	0.31	0.40	0.57	0.67	0.67	0.72	0.60	0.49	0.42	0.24	0.19	0.16	0.13	0.10	0.09	0.09	0.09	0.08	0.08	0.16	0.22	0.27	0.44	0.65	0.73	0.98	1.10	0.95	1.13	0.92	0.77	0.58	0.41	0.38	0.35	0.26	16.39		
4 - 5	0.26	0.38	0.58	0.86	1.03	1.05	0.90	0.61	0.37	0.20	0.18	0.08	0.07	0.03	0.04	0.04	0.05	0.09	0.08	0.13	0.20	0.31	0.48	0.75	0.97	1.28	1.48	1.36	1.31	1.11	0.82	0.55	0.38	0.29	0.21	0.19	18.62		
5 - 6	0.10	0.19	0.42	0.68	0.89	1.13	1.00	0.58	0.30	0.16	0.06	0.05	0.03	0.03	0.03	0.01	0.04	0.05	0.04	0.07	0.11	0.21	0.41	0.70	1.07	1.40	1.63	1.45	1.51	1.15	0.75	0.48	0.23	0.14	0.08	0.08	17.39		
6 - 7	0.02	0.04	0.09	0.28	0.69	0.90	0.72	0.39	0.19	0.06	0.05	0.03	0.02	0.01	0.00	0.01	0.02	0.01	0.03	0.04	0.06	0.11	0.20	0.40	0.76	1.24	1.56	1.49	1.43	0.96	0.57	0.25	0.12	0.07	0.03	0.02	12.89		
7 - 8	0.00	0.01	0.03	0.08	0.23	0.47	0.35	0.18	0.08	0.03	0.03	0.02	0.01	0.01				0.01	0.02	0.02	0.02	0.06	0.09	0.21	0.50	0.90	1.18	1.07	0.96	0.62	0.33	0.15	0.05	0.03	0.00	0.01	7.78		
8 - 9		0.00	0.03	0.02	0.05	0.12	0.11	0.04	0.01	0.01	0.02	0.00						0.01	0.00	0.01	0.02	0.02	0.04	0.09	0.25	0.52	0.65	0.62	0.43	0.30	0.14	0.04	0.03	0.02			3.60		
9 - 10				0.02	0.04	0.05	0.03	0.00	0.00	0.00	0.00										0.00	0.01	0.01	0.02	0.12	0.21	0.24	0.28	0.21	0.08	0.04	0.01	0.00				1.39		
10 - 11					0.00	0.01																0.01	0.00	0.01	0.03	0.06	0.13	0.12	0.06	0.02	0.02	0.00						0.47	
11 - 12																									0.01	0.02	0.08	0.04	0.02	0.01	0.00	0.01							0.18
12 - 13																								0.01	0.01	0.04	0.01	0.01	0.01	0.00									0.09
13 - 14																							0.00			0.01	0.01												0.02
14 - 15																										0.00													0.00
15 - 16																											0.00												0.00
Total	1.18	1.70	2.42	3.33	4.41	5.22	4.42	2.86	2.00	1.12	0.81	0.69	0.54	0.51	0.44	0.41	0.47	0.56	0.51	0.81	1.08	1.53	2.28	3.60	5.26	7.42	9.13	8.22	6.09	6.03	4.27	2.89	1.95	1.56	1.26	1.06	100		

Figure 5: Directional Distribution of Wind Statistics (% Occurrence for Wind Speed vs. Wind Direction)

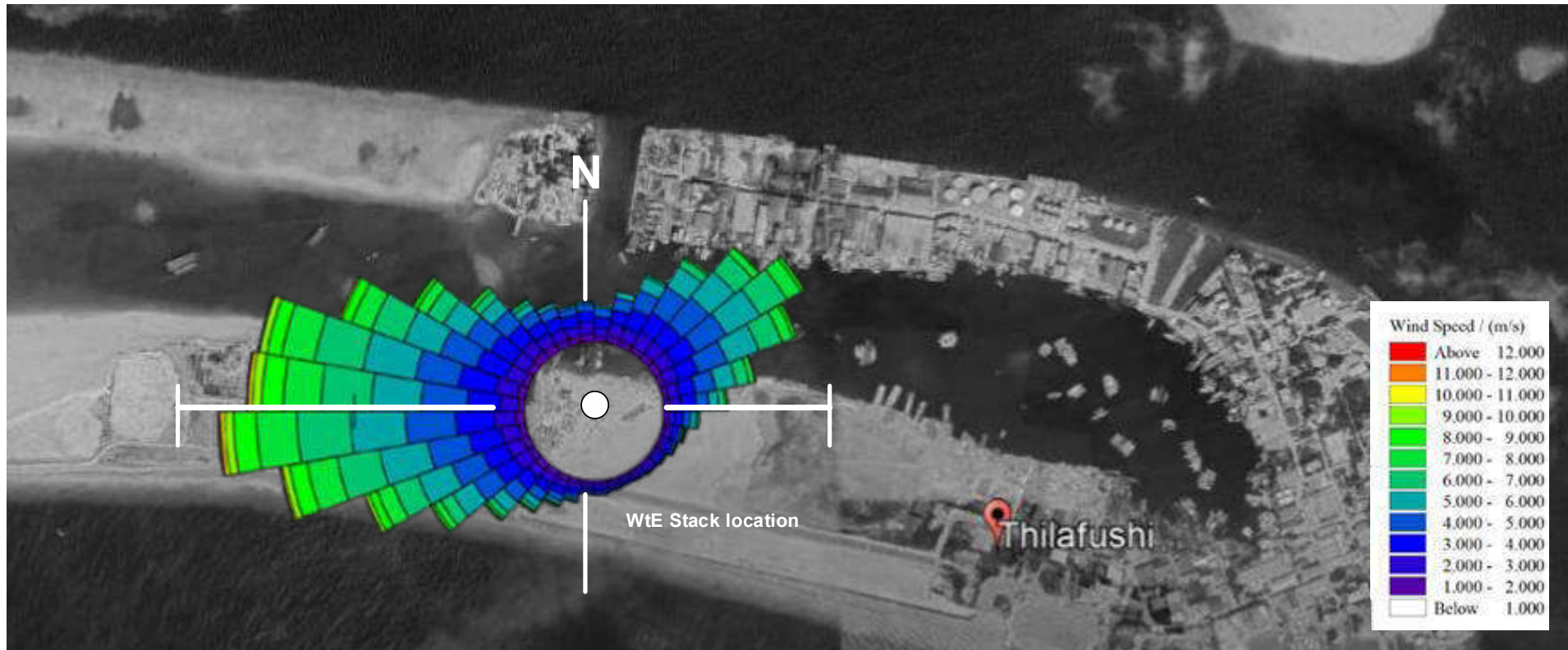


Figure 6: average Wind rose over project location



Besides the annual monsoonal wind variations, there are occasional tropical storms in the central region of the Maldives which increases wind speeds up to 110 km/h, precipitation to 30 to 40 cm over a 24 hour period and storm surges up to 3 m in the open ocean (UNDP, 2006).

For the ADM the following hourly wind data set have been acquired and used

Wind data set (hourly)	Source : Maldives Meteorological service Location : Weather station Hulhule' (Airport) at 10 km East of Thilafushi Data set: from 01.-12.2017 (24 hrs/day) Wind measurement height z_0 : 11,5 m over ground level
Dispersion class time series	The wind direction distribution and the wind speeds were modelled with a dispersion class time series for the year 2017 ⁷ .

The data set have been provided in Excel format and have been computed for the purpose of the model in AKterm format.

4.2.9 Topography

All islands of the Maldives are very low lying; more than 80% of the land area is less than 1 m above mean high tide level (MEEW, 2005). Combined with the small size of the islands, this means that accelerated sea level rise will have devastating effects on the islands and threatens the very existence of all the islands of the Maldives.

The proposed site for the establishment of the WtE was reclaimed in 2018. 15 hectares of land was reclaimed from the shallow lagoon which was located on either side of the link road that was constructed at Thilafushi. The materials for the reclamation was borrowed from North Male' Atoll with a radius of 10 km from Thilafushi using a Trailing Suction Hopper Dredger (TSHD). The dredger borrowed the material for the reclamation from borrow sites were within a depth range of 40-50m. The material from the dredger was discharged to the reclamation area via a floating pipe line which ran from the sea floor to the reclamation area, which was bunded with sand bunds, from southern side of the reclamation area.

The site has been reclaimed to a height of +1.5 m from MSL from an average depth of -1.5 m above the sea floor. The sand grains are angular to sub-angular in shape with gravel size varies from 20 – 30 mm in diameter and fairly uniformly graded. It can be described as loosely packed, silty, coral sand with pieces of corals and shells. Since the area had been recently reclaimed, the site does not have humus topsoil which is found on typical tropical islands. The soils have very high permeability for water. Much of the rainfall occurs as intense storms but no signs of erosion is observed, confirming high infiltration capacity.

The entire Island and the project location are mainly on the main level over MSL and don't present any substantial elevation (only the actual dumpsite is culminating at approx. 15 m over MSL). The following figure present the actual site configuration

⁷ Wind data provided by Maldives Meteorological Services



Figure 7: areal picture of reclaimed area for WtE Facility

Ground roughness	The ground roughness of the terrain is described by an average roughness length z_0 . It is determined according to the land use classes of the CORINE Cadastre. The roughness length was chosen within the calculation to be $z_0 = 0.2$. This value should be considered as representative for the area of calculation.
Terrain and slope	It is a flat terrain. In the computing area, no gradients of more than 1:20 or even more than 1: 5 occur.

4.2.10 Building effects

Influence of buildings have been also considered in the model. The following building dimension and location (stack and Diesel genset) have been considered for the WtE facility.

WtE dimensions: Approx. Length x width x height [m]: 100 x 70 x 30

Surrounded buildings location have been considered according land use plan, topographical survey and google earth maps. The height of the buildings have been considered to maximum 10 m.

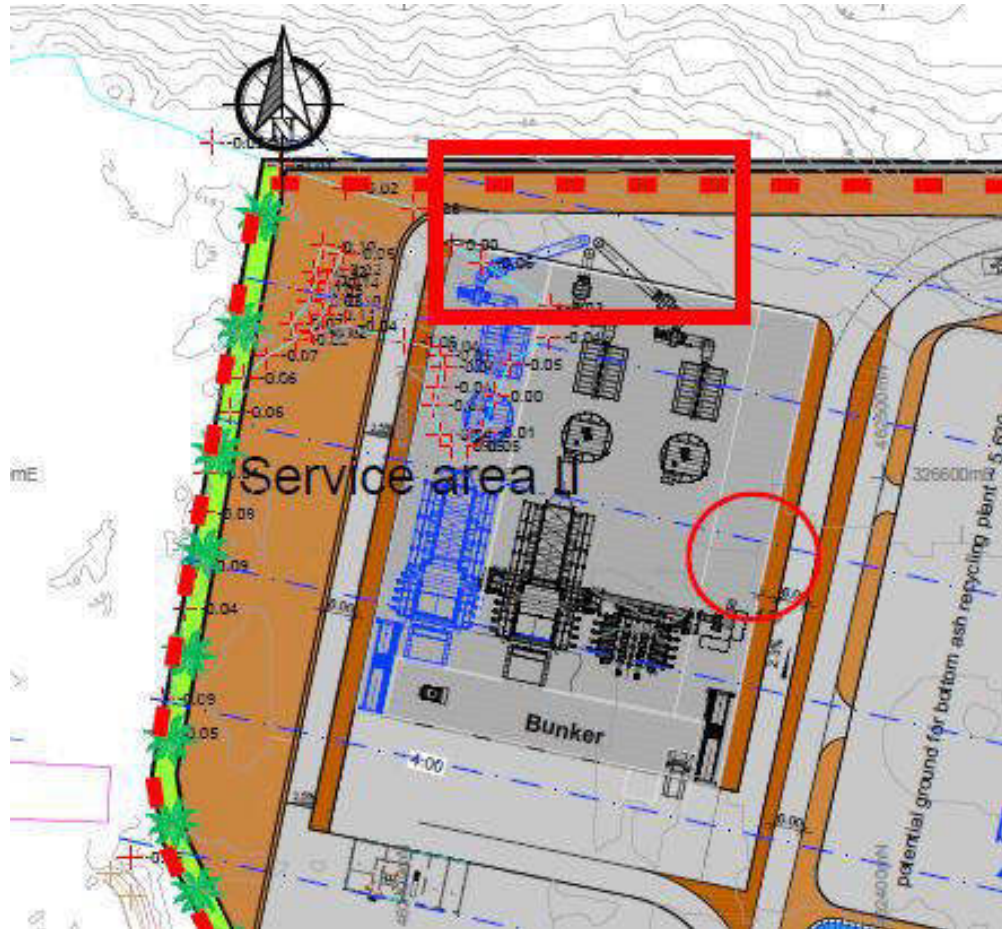


Figure 8: tentative Location of the WtE, the stack (square) and the genset (circle)

4.2.11 Emissions

The following parameter have been provided to the consultant for the ADM

Location of the stack	4.183004 N; 73.437155 E	
Number of stacks	2	
Stack height above ground level	46 m for ADM (Stack height will be fixed to 50 m for DBO)	
Distance between stacks	7 m (to be considered as 1 single source)	
Equivalent diameter	2.12 m	
Operation hrs WtE/Stack	8,000 hrs/year	
Flue gas volume flow	Stack 1	Stack 2
	57,856 m ³ /h	57,856 m ³ /h
Flue gas temperature	180°C	
Location of Genset	4.182394 N; 73.437370 E	
Number of Genset	1	

Distance between Genset and stack	Approx. 150 m
Operation hours Genset	760 h/year (only emergency/Island mode)
Flue gas volume flow Genset	12.470 Nm ³
Emissions (based on 11% O ₂ in the flue gas)	
Total dust	5 mg/Nm ³
PM ₁₀	0,5 mg/Nm ³
Total carbon	10 mg/Nm ³
HCl	10 mg/Nm ³
Hf	1 mg/Nm ³
SO ₂	50 mg/Nm ³
NO _x	150 mg/Nm ³
Hg	0,03 mg/Nm ³
CO	50 mg/Nm ³
NH ₃	10 mg/Nm ³
Dioxin/furan	0,1 ng/Nm ³

5 Assessment criteria

5.1 Criteria to protect human health

The Technical Instruction provides Immision rate/ambient air concentration values for the concentration of substances above which risks to human health are expected (paragraph 4.2) or they cause considerable nuisance or considerable disadvantages (Section 4.3). significant drawbacks, in particular protection of vegetation and ecosystems (Section 4.4) and harmful environmental effects by pollutant depositions (section 4.5) as well as irrelevant additional burdens, the compliance of which, according to Number 4.1 the TA Luft, can eliminate the determination of the total load, if the threshold are not respected

The following tables show the Immision rate/ambient air concentration values specified in the TA Luft as well as the irrelevant additional loads for the WtE plant relevant pollutants.

Table 2: Immission rate/ambient air concentration values and irrelevant values according Nr. 4.2 of the TA Luft

Substance/group of substances	Immision rate/ambient air concentration values	Average period	Allowed exceeding frequency per year	Irrelevant additional load
Protection of human health - Emission values according N° 4.2 TA Luft				
Aerosol (PM ₁₀)	40 µg/m ³	year	-	1.2 µg/m ³
	50 µg/m ³	24 hours	35	-
Sulfur dioxide (SO ₂)	50 µg/m ³	year	-	1.5 µg/m ³
	125 µg/m ³	24 hrs	3	-
	350 µg/m ³	1 hr	24	-
Nitrogen dioxide (NO _x)	40 µg/m ³	year	- 18	1.2 µg/m ³
	200 µg/m ³	1 hr	-	-

5.2 Criteria to protect ecological sites

Table 3: Immission rate/ambient air concentration values and irrelevant values according Nr. 4.3 - 4.5 of the TA Luft

Substance	Ambient air quality value	Averaging period	Irrelevant additional load
Protection against considerable nuisance or major drawbacks due to dust precipitation - Ambient air quality values according to number 4.3 TA Luft			
Dust precipitation (non-hazardous dust)	0.35 g / (m ² · d)	year	0.0105 g / (m ² · d)
Protection against nuisances, in particular protection of vegetation and ecosystems - Ambient air quality values according to 4.4 TA Luft			
Ammonia	Whether the protection against nuisances and drawbacks by damage of sensitive plants (eg nurseries, crop plants) and ecosystems by the effect of ammonia is guaranteed, is to be examined according to number 4.8 TA Luft.		
Protection against harmful environmental effects through pollutant deposition - Ambient air quality values according to number 4.5 TA Luft or protection against considerable disadvantages according to number 4.4 TA Luft			
Mercury and its inorganic compounds, expressed as mercury	1 µg / (m ² · d)	year	0.05 µg / (m ² · d)
Hydrogen fluoride and gaseous inorganic fluorine compounds, indicated as fluorine	0.4 µg / m ³	year	0.04 µg / m ³
Arsenic and its inorganic compounds, expressed as arsenic	4 µg / (m ² · d)	year	0.2 µg / (m ² · d)

Substance	Ambient air quality value	Averaging period	Irrelevant additional load
Lead and its inorganic compounds, indicated as lead	100 µg / (m ² · d)	year	5 µg / (m ² · d)
Cadmium and its inorganic compounds, expressed as cadmium	2 µg / (m ² · d)	year	0.1 µg / (m ² · d)
Nickel and its inorganic compounds, expressed as nickel	15 µg / (m ² · d)	year	0.75 µg / (m ² · d)
Thallium and its inorganic compounds, reported as thallium	2 µg / (m ² · d)	year	0.1 µg / (m ² · d)

6 Determination of significance of effects

According to the TA Luft calculated emission loads were assessed against the relevant critical loads fixed in the regulation. Only for the loads which are over the critical load (minimum mass flow) an detailed air dispersion model is required. For the purpose of the determination of the significance of effects and the need of a detailed ADM the following parameters have been considered:

- Total suspended material/dust expressed as PM10
- Sulphur oxide and dioxide expressed as Sulphur dioxide (SO₂)
- Nitrogen oxide (NO_x)
- Ammonia (NH₃)
- And mercury (Hg).

In the present case, the emissions are calculated with the calculation program for all relevant pollutants, insofar as emission values are specified for these substances in the TA Luft

For the other relevant pollutants: total C, carbon monoxide (CO), hydrogen chloride, dioxins and furans, no emission values are specified in the TA Luft.

7 Baseline conditions

7.1 Project location (Macrolocation)

The development of the proposed project takes place at Thilafushi. Thilafushi is located in North Male' atoll, 9.5km from Male'. In terms of geographic coordinates, it is located at 04° 11' 00" N and 73° 26' 44" E. The nearest inhabited island is Villingili, approximately 7.1 km east of Thilafushi. The reef system is approximately 4.65 km long, 0.94 km wide (width of ring reef, including the lagoon area). A newly reclaimed Industrial Island (Gulhi Fahlu) is approximately at 650 m from the eastern tip of the Thilafushi and the nearest resort (Centar Ras Fushi) at more than 3,2 km on the North-West of the Island.

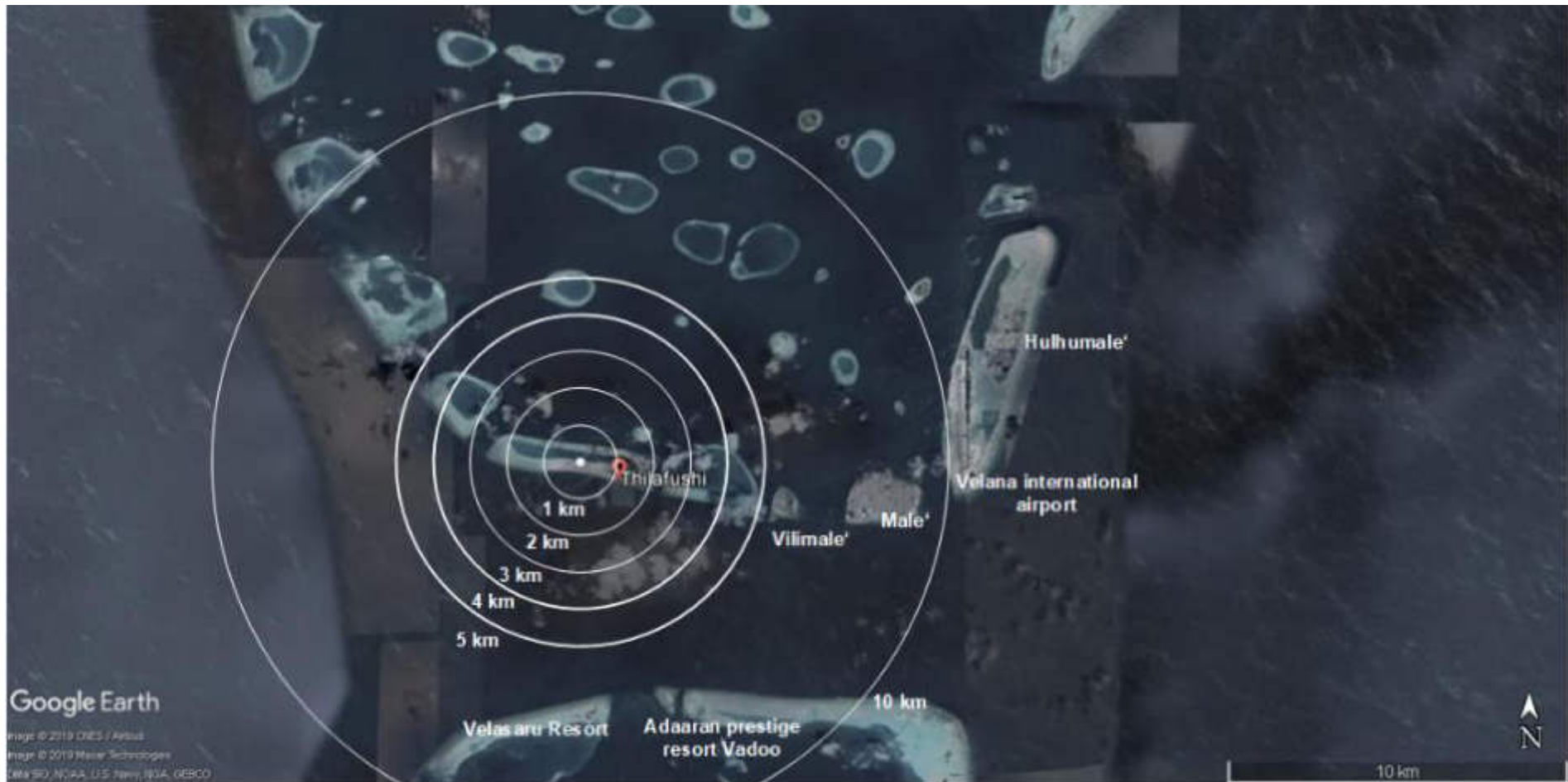


Figure 9: Project location (macro-location) [Source Google Earth]



Figure 10: Project location (Meso-location, distances from tentative stack location of the WtE) [Source google Earth]



Thilafushi Island has been developed as a solid waste land fill since December 1992. The island was initially developed as a sand bank using dredged material from the Thilafushi Reef. Since then, land has been reclaimed by placing solid waste in dredged holes on the reef flat and later topping it up with fresh lagoon sand. The island referred to as Thilafushi-1 was and is being reclaimed using this method.

A second island, zoned as Thilafushi-2, was reclaimed from lagoon sand to meet the demand. Subsequently a third island, Thilafushi-3, was initiated to reclaim 167 Ha of land from the remaining reef areas of Thilafushi.

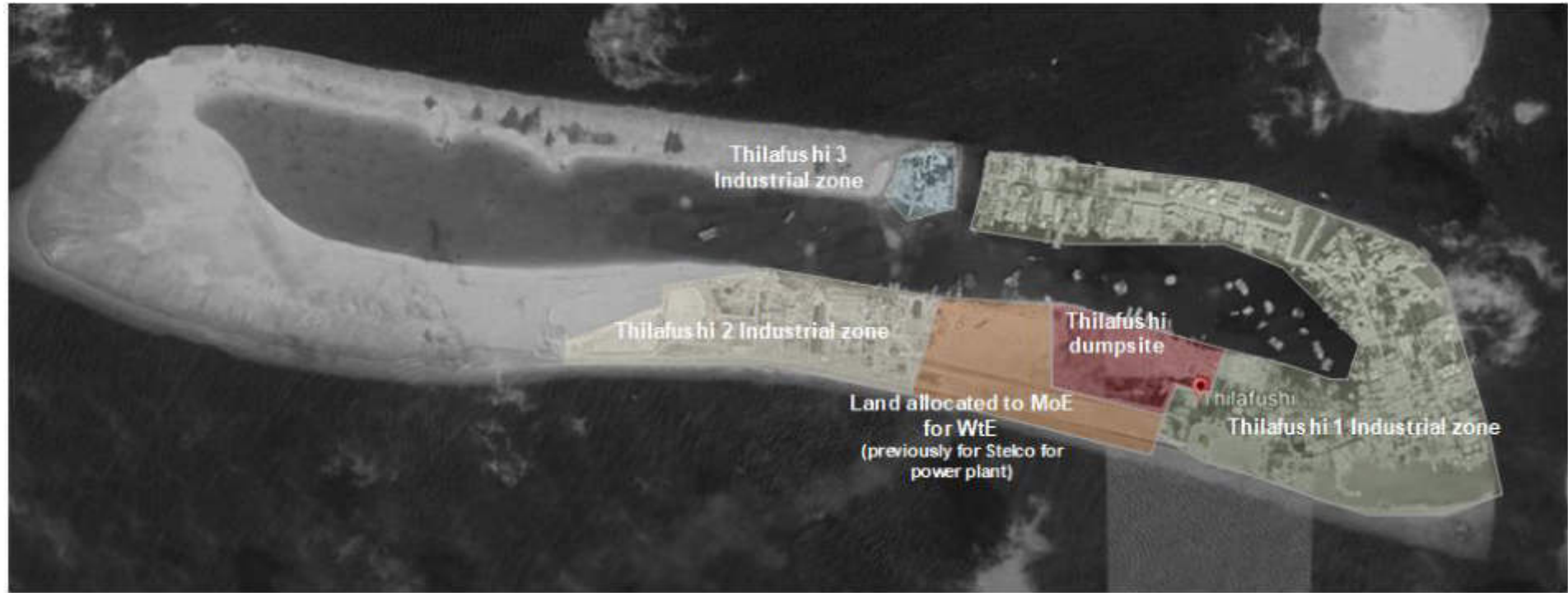


Figure 11: land use plan [developed by given land use plan and Google Earth Image]

Name	Thilafushi Island
History	1992 lagoon became dumpsite by filling with waste and sand. Development of the site by land reclamation through waste and sand dumping
Coordinates	4°11'N 73°26'E
Dimensions	Length : approx. 3.50 km Width: approx. 0.20 km
Vocation	Industrial Island
Population	Registered people (workers) Approx. 2,052 workers 2,048 male, 04 female, no children, 69 % Foreigners (international migrants) Approx. 1,500 residents (one base camp) Others relocated in Guli Fahlu
Borders/Boundaries	Island surrounded by seawater
Nearest Island	Guli Fahlu at 2,081 km from WtE stack (650 m from edge of Thilafushi), Industrial Island and workers camp
Nearest Resort or inhabited Island	Centar Ras fushi resort at 3,20 km (from WtE stack)
Vegetation	Basic vegetation, after landscaping measure, no rare or endangered species, no high vegetation
Tourism	None
Industry	Boat building Cement conditioning Construction companies' base/storage sites Methane gas bottling Storage of goods Water bottling Small industry (RO plants, etc.)
Facilities	Customs Small police and fire station Ferry station

Table 4: Summary of Thilafushi project location (macro-location)

7.2 Project location (Microlocation)

The coordinates of the project location are 4°10'54.49"N 73°26'24.38"E. The establishment of RWMF for Zone 3 at Thilafushi requires 15 hectares which have been reclaimed from the adjacent shallow lagoon. Figure 12 illustrates the location of the project.



Figure 12: Project location (micro-location)

Name	Waste to Energy facility Thilafushi
Description of the components	Waste acceptance area with weighbridge Waste bunker with crane Waste incineration (grate technology) with 3 combustion chambers Boiler Flue gas cleaning and stack Residual waste treatment : bottom ash treatment plant Residual waste disposal: residual waste (fly ash conditioned in big bags) state of the art landfill Buildings and facilities (admin, storage, maintenance, water supply, sewerage, electricity, firewater, stormwater, etc..)
Coordinates	North West: 4°10'58.73"N, 73°26'11.51"E North East: 4°10'58.87"N, 73°26'22.20"E South West: 4°10'50.71"N, 73°26'9.74"E South East: 4°10'48.09"N, 73°26'20.87"E
Borders/boundaries	North: Lagoon East: Old dumpsite West: New reclaimed industrial area South: Open sea
Contract	Design-Build Operate Contract for 20 years
Actual stage	Preliminary design and Tender documents for DBO contractor
Project site	Newly reclaimed area (no waste) with compacted coarse sand North side (lagoon) closed by a concrete quay wall with a height of 1,5 m over MSL South side is closed by a coastal shore protection of rock boulders and a separation liner of a geotextile with an average height of 2,0 over MSL
Vegetation	No vegetation actually, landscaping measures foresee in the DBO
Activity	None (WtE later stage)
Ambient air quality	No activities/negligible
Surface water	Lagoon seawater on the north of the site Open seawater at the Southside
Groundwater	Brackish seawater (after land reclamation)

Table 5: Summary of project location (Micro-location WtE plant)

7.3 Component of the WtE facility

The WtE facility shall be designed and built as a conventional state-of-the-art grate type incinerator of two lines of 250 Mg/d each (total of 500 Mg/d), that shall consist of the following main set of process units and plant components:

- a) Waste reception, storage and feeding consisting of a weigh bridge incl. guard house, tipping hall and waste bunker, a shredder and waste cranes;
- b) Thermal treatment consisting of combustion system; boiler and heat recovery system and boiler feed water and make-up water system;
- c) Air pollution control system and ID fan and stack and continuous emission monitoring system (CEMS)
- d) Turbine with generator and condenser, cooling water pre-treatment system and cooling water pumps,
- e) Other balance of plant components incl. fuel and chemicals supply and storage; fire-fighting water supply system; waste water treatment plant for sewerage, water supply system;
- f) Bottom ash treatment plant incl. bottom ash bunker and conveying system;
- g) Residue sanitary landfill and leachate collection, management and treatment system;
- h) Electric system incl. connection to public network

All process units and the balance of plant components are to be equipped with the necessary electrical and control components, with valves, fittings, piping, utility mains etc. and shall be combined to a fully functional system that is fit for purpose and that is operated and controlled by a DCS which shall facilitate monitoring and recording of operational data.

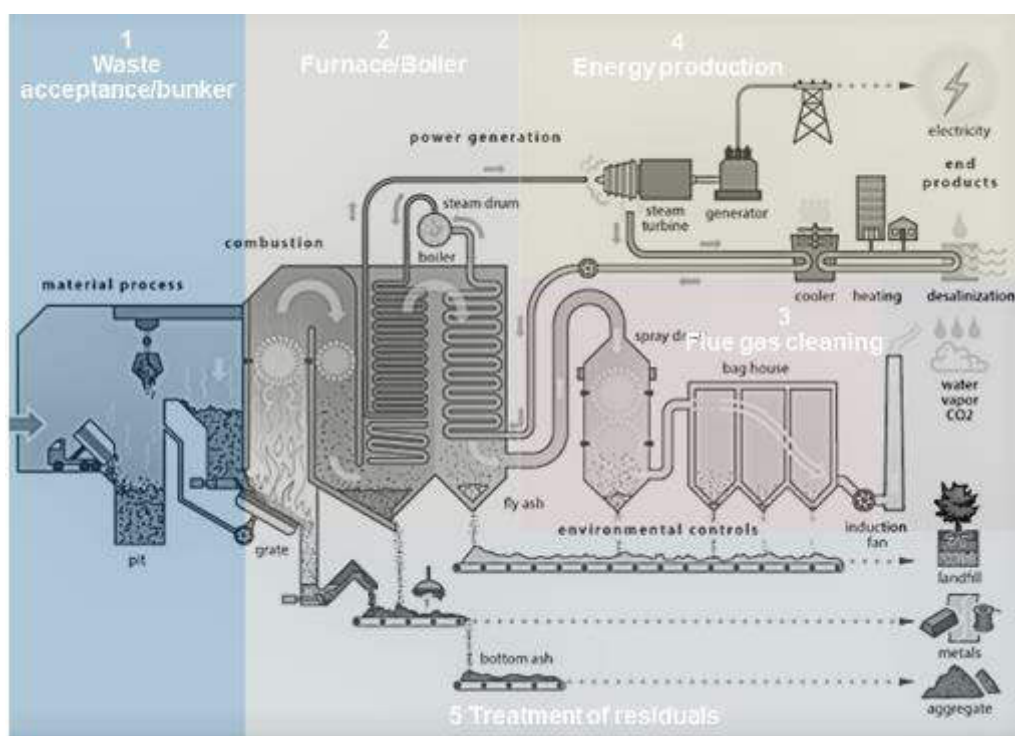


Figure 13: schematic layout of the WtE Facility

These process units are accommodated by the following buildings, housings and civil constructions:

- a) Waste reception/guard house
- b) Tipping hall
- c) Waste bunker
- d) Machinery hall and steam turbine housing
- e) Housing for the bottom ash processing plant
- f) Administration block incl. control room and visitors' center
- g) Workshop

h) Housing of the leachate treatment plant

The WtE facility shall be designed and built to allow the extension of the plant by a third line of 250 Mg/d (to reach a total of 750 Mg/d)

To operate the facility the following infrastructure needs also to be realised:

- Water supply, electricity supply (emergency Genset), sewerage system
- Roads, carriageways and sidewalks
- Cooling water inlet and outlet structure
- Storm water drainage system
- Landscaping
- Fencing

All infrastructural elements shall be incorporated into the buildings and process units to allow an easy operation and maintenance of all facilities.

The residual waste from the waste incineration is bottom ash, slag and the residues from flue ash. Bottom ash and slag is a valuable fraction which may potentially be used for many purposes: as covering material for landfill, as a ballast layer or reinforcement layer in road construction or as a filler/aggregate for construction blocks. A bottom ash processing plant is also part of the facility

The residues from the flue gas cleaning (fly ash) are hazardous and need to be dumped in a controlled way on a sanitary landfill after being conditioned safely in sealed big bag.

7.3.1 Stack height

The stack height has been established through the use of modelling services engaged for the EIA. The assessment was done with reference to standards applied for air quality control in Germany, as set out in an instruction document with legal standing in Germany, TA Luft. The stack height required to comply with the technical instruction was determined, following which predictions of concentrations of pollutants in the emissions from the WtE were predicted, and dispersion modelling undertaken for those exceeding a designated minimum level.

Determination of the requisite stack height was undertaken using a nomogram and calculation steps provided in the German TA Luft. The input values for this process are the inside diameter of the stack, the temperature of the waste gas at the mouth of the stack, the volume of flow of the waste gas in standard conditions after subtraction of the water vapour content, and the rate of emission mass flow of the air pollutants from the plant. In determining these parameters, a feed of 500 tons of household waste per day was assumed. The final stack height is determined based on the dimensions of adjoining buildings.

A stack height of minimum 45.7m would have sufficient dilution of the exhaust gases and an undisturbed transport with the free air flow is ensured.

With a view to alleviate the potential air quality impacts at critical air sensitive receivers (ASRs) but at the same time to minimize potential visual impact associated with a tall stack, 50m is selected as the stack height for the RWMF at Thilafushi. It has considered the air quality benefit and visual impact due to a relatively tall stack in a small island geographic setting. The cleaned and cooled gases from the gas cleaning system are discharged into a stack. The gases are discharged by means of an induced drafted fan.

7.3.2 Cooling system

The heat energy of the exhaust air from the furnace is transmitted to water, converting the water to high pressure steam. The high pressure steam is used to rotate a steam turbine and generate electricity. After the electricity generation process, steam pressure is reduced and the steam is further cooled down by a cooling system. The proposed cooling system uses a seawater cooled condenser and involves exchange of the heat of the low pressure steam to sea water, which is then discharged to the sea from south side of Thilafushi.

7.3.3 Bottom ash treatment

The DBO-Contractor shall be responsible for designing and building the bottom ash processing plant including bottom ash storage to satisfy the requirements of the envisaged bottom ash reuse. Subject to the design considerations of the DBO Contractor an intermediate bottom ash storage shall be provided. The floor of the bottom ash storage hall shall allow run-off from the wet bottom ash via a drainage system. The drained run-off from the bottom ash storage area shall be forwarded after either mechanical or gravity cleaning to buffer tanks prior to the leachate treatment system. The intermediate bottom ash storage area shall be sized to accommodate short term stoppages in the conveying system (e.g. the overhead cranes and belt conveyors).

Table 6: Design parameters for Bottom ash treatment plant

Bottom ash Handling System (design parameter)	
Ash content in SW (dry ash/wet)	Max. 35%
Water content in bottom ash downstream extractor	Max. 15%
Capacity	Min. 160% of the maximum bottom ash flow
Boiler & Fly ash transport system	
Boiler hopper ash and air pollution control system fly ash shall be collected from each boiler, economizer, and air pollution control system hopper with drag conveyors, screw conveyors, or a pneumatic conveying system to conditioning the fly ash into big bags. After conditioning the fly ash shall be deposited into the landfill cell. Provisions will be made to prevent dusting during transfer to a disposal truck. The big bags shall be fully enclosed and dustproof and located in the residue building before transport	
Boiler ash and fly ash drag conveyors, screw conveyors, or pneumatic system shall be completely dust-tight to prevent leakage of fly ash.	

7.3.4 Residual waste landfill

The DBO Contractor's shall design the residual waste landfill complying with the following criteria:

- The landfill arrangement shall be designed to maximise the useable landfill volume of the Site;
- The landfill cell arrangements shall be designed to allow for the progressive closure of individual landfill cells on completion and thereby to minimise the amount of leachate requiring treatment over the lifetime of the landfill;

- The design shall allow for the development of individual cells in a coherent and logical sequence and in a manner which ensures the stability of all working faces and of the waste mound as a whole.
- The design shall incorporate appropriate back-up systems in the event of failure of any component of the environmental control and management systems;
- The landfill concept shall be designed to minimise the lateral and vertical extent of the working face and thereby the amount of deposited waste that is exposed to the environment;
- The design shall ensure that waste can be deposited in a manner that prevents damage to the engineered barrier or liner, the leachate control system, and the collection and transfer system.
- The landfill design shall incorporate an internal access corridor to allow for safe traffic movement and to accommodate site services and monitoring devices;
- Measures shall be provided for controlling unauthorised access to the landfill including, as appropriate, the provision of ditches, berms, planting and fencing;
- Slopes shall be graded to ensure long term slope stability. Graded slopes shall be a maximum of 25%;
- Soil erosion and dust generation shall be minimised;
- All landfill construction materials shall be free of organic matter and debris;
- Measures shall be provided to monitor and manage groundwater beneath and adjacent to the landfill area;

The Contractor's design shall include surface water and storm water collection and diversion systems in order to protect the landfill area and minimise the generation of leachate. Sedimentation ponds shall be established to contain polluted drainage and runoff containing soil and sediment.

The Contractor's design shall include an engineered barrier to prevent leachate contamination of surface water and groundwater. The barrier shall comply with the following:

- The hydraulic conductivity of the barrier shall be no greater than the equivalent of 1×10^{-9} metres per second.
- The level of the engineered barrier shall be no deeper than 1.5 metres above mean sea level and in accordance with the applicable environmental standards;

All components of the leachate collection, extraction, transfer and treatment system shall be capable of being maintained in a clean condition to ensure effective operation. Concentrate shall be re-injected in the flue gas treatment process of the WtE. The Contractor shall design and build or organise a system for the safe collection, transport and re-injection of the LTP concentrate.

7.3.5 Electricity generation

The heat produced during the incineration process will be recovered and used for electricity generation. The electricity generated from the incineration process will be used to support the normal operation of the facilities within the RWMF. Surplus energy will be exported to other users via the existing electricity grids maintained by the State Electric Company (STELCO). The supply of process steam and electrical energy for the side shall take place via combined heat and power.

7.3.6 Layout arrangement

The RWMF has been designed to provide long term environmentally sustainable solution for waste management in Zone 3 of the Maldives. Limitations and scarcity of land and the requirement to protect the fragile ecosystem have also been considered during the design of RWMF. With a view to minimize the land use and the associated environmental impacts, the preferred location for the RWMF was the area around the old dumpsite of Thilafushi. This has the advantage to reduce environmental risks on another location and islands, and to conduct the dumpsite rehabilitation in parallel. The vocation of Thilafushi as an industrial island plays also in favour of a site location of the facility on this island.

The layout for the RWMF is considered appropriate, taking into consideration the functional need for operation of the RWMF, reasonable flexibility in design for the DBO contractor and allowance of suitable size of land for provision for the future. The design of the RWMF has been done considering factors such as waste composition, quantity reaching RWMF, applicability in the local condition and regulatory compliance.

7.4 Ambient Air quality/Baseline survey

Air quality monitoring for baseline was conducted by Water Solutions at Thilafushi (and Villingili). Three locations were selected at Thilafushi and one location at Villingili for baseline Air quality monitoring in 2018 and 2019 (see chapter methodology). The Principal objective of the ambient air quality monitoring is to assess background environment status and to check the conformity to the applicable standards of ambient air quality. Despite rapid increase in sources of air pollutants and associated diseases there is no national standard for air quality or regulations to control air emission in the Maldives (MEE, 2017). In the absence of any National Ambient Air Quality Standards, the WHO guidelines were considered to assess the air quality.



Figure 14: View around AQ4 (Villingil) on 3rd March 2019

On each sampling day, 1 set of 24-hour average samples were collected continuously. PM_{10} , $PM_{2.5}$, Sulphur dioxide (SO_2) and Oxides of nitrogen (NO_2) were measured by sampling continuously during the sampling period.



Figure 15: Air quality monitoring at location AQ1 on 19rd March 2019

As per ToR additional survey for the parameter CH₄, VOC, CO₂, CO, H₂S has been undertaken at selected locations (see Methodology).



Figure 16: Air quality monitoring at location AQ3 on 20th August 2019



Figure 17: View around AQ2 (Thilhafushi) on 25th August 2019

7.4.1 Air Quality baseline survey AQ 1 (Thilafushi workers camp)

Weather/climate	Clouds	Wind direction	Wind speed	Dumpsite
Sunny 33°C	No	North-East	Low-moderate	Open burning


Parameter	Date	$\mu\text{g}/\text{m}^3$	WHO ambient air quality guideline (as per Table 1.1.1 of IFC EHS guidelines) in $\mu\text{g}/\text{m}^3$
PM ₁₀	19.03.-20.03.2019	26,5 [24 hr]	50 [24 hr]
PM _{2,5}	19.03.-20.03.2019	26,9 [24 hr]	25 [24 hr]
SO ₂	22.03.-23.03.2019	214 [24 hr]	20 [24 hr]
		866 [10 min max]	500 [10 min]

NO ₂	19.03.-20.03.2019	67,5 [1 hr max.]	200 [hr]
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Additional parameters according ToR

Parameter	Date	µg/m ³	WHO ambient air quality guideline (as per Table 1.1.1 of IFC EHS guidelines) in µg/m ³
CH ₄	19.03.-20.03.2019	11.745 [24 hr]	N/a
CO	19.03.-20.03.2019	126 [24 hr]	N/a
VOC	21.03.2019	4.889 [24 hr]	N/a

7.4.2 Air Quality baseline survey AQ 2 (Thilafushi 2, new reclaimed area)

Weather/climate	Clouds	Wind direction	Wind speed	Dumpsite
Sunny 32°C	yes	North-East	moderate	Open burning
				

Parameter	Date	µg/m ³	WHO ambient air quality guideline (as per Table 1.1.1 of IFC EHS guidelines) in µg/m ³
PM ₁₀	25.08.-26.08.2019	538,93 [24 hr]	50 [24 hr]
PM _{2,5}	25.08.-26.08.2019	387,45 [24 hr]	25 [24 hr]
SO ₂	-	N/a	20 [24 hr]
		N/a	500 [10 min]
NO ₂	28.08.-29.08.2019	72,8 [1 hr max]	200 [hr]

7.4.3 Air Quality baseline survey AQ 3 (Thilafushi 3, Opposite of dumpsite)

Weather/climate	Clouds	Wind direction	Wind speed	Dumpsite
Sunny 31°C	yes	North-East	Moderate-high	Open burning
Weather/climate	Clouds	Wind direction	Wind speed	Dumpsite
Sunny 33°C	yes	West	moderate	Open burning

Parameter	Date	$\mu\text{g}/\text{m}^3$	WHO ambient air quality guideline (as per Table 1.1.1 of IFC EHS guidelines) in $\mu\text{g}/\text{m}^3$
PM ₁₀	20.06.-21.06.2018	359,7 [24 hr]	50 [24 hr]
	21.06-22.06.2018	96,50 [24 hr]	
	22.06-23.06.2018	86,29 [24 hr]	
	23.06-24.06.2018	291,47 [24 hr]	
	25.08.-26.08.2019	88,46 [24 hr]	
PM _{2,5}	20.06.-21.06.2018	233,33 [24 hr]	25 [24 hr]
	21.06-22.06.2018	61,38 [24 hr]	
	22.06-23.06.2018	51,38 [24 hr]	
	23.06-24.06.2018	184,70 [24 hr]	
	25.08.-26.08.2019	42,81 [24 hr]	
SO ₂	22.06-24.06.2018	291 24 [hr]	20 [24 hr]
		970 [10 min max]	500 [10 min]
NO ₂	28.08.-29.08.2019	72,8 [1 hr max]	200 [hr]

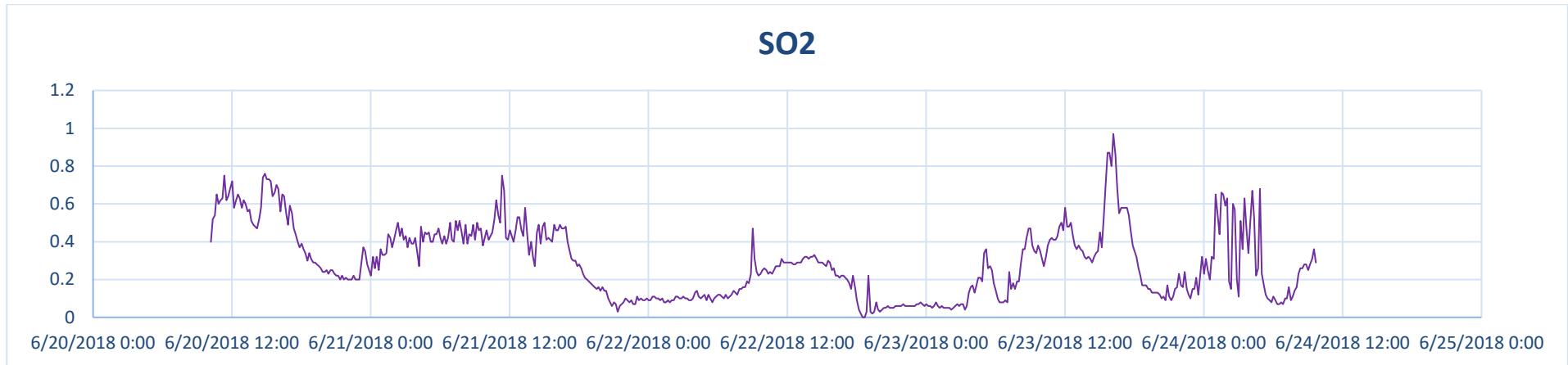


Figure 18: graphical presentation of survey results for SO₂ at AQ3 (PPT)

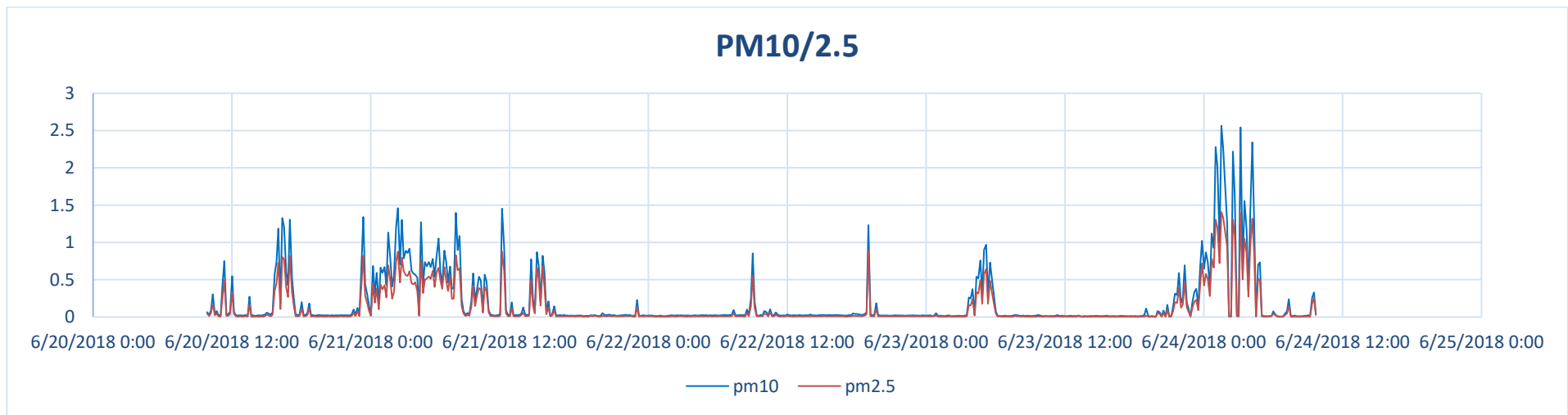


Figure 19: graphical presentation of survey results for PM_{2.5} and PM₁₀ at AQ3 (PPT)

7.4.4 Air Quality baseline survey AQ 4 (Vilingili)

Parameter	Date	$\mu\text{g}/\text{m}^3$	WHO ambient air quality guideline (as per Table 1.1.1 of IFC EHS guidelines) in $\mu\text{g}/\text{m}^3$
PM ₁₀	06.03.-08.03.2019	22,7 [24 hr]	50 [24 hr]
PM _{2,5}	06.03.-08.03.2019	22,7 [24 hr]	25 [24 hr]
SO ₂	06.03.-08.03.2019	7,6 [24 hr]	20 [24 hr]
		190 [10 min max]	500 [10 min]
NO ₂	06.03.-08.03.2019	87 [1 hr]	200 [hr]

Additional parameters according ToR

Parameter	Date	$\mu\text{g}/\text{m}^3$	WHO ambient air quality guideline (as per Table 1.1.1 of IFC EHS guidelines) in $\mu\text{g}/\text{m}^3$
CH ₄	06.03.-08.03.2019	0,175 [24 hr]	N/a
CO	06.03.-08.03.2019	124 [24 hr]	N/a

7.4.5 Interpretations of the results

The ambient air quality results obtained from the monitoring undertaken at Thilafushi indicate that only some parameters were within the WHO guidelines for ambient air quality.

As it could be seen one main influencing factor is the dumpsite at Thilafushi and its illegal burning

Particular matters usually varies between 27-540 $\mu\text{g}/\text{m}^3$ (daily average) with a min around 4 $\mu\text{g}/\text{m}^3$ and a maximum peak reaching more than 2.000 $\mu\text{g}/\text{m}^3$.

NO₂ (hourly maximum) are below WHO guidelines at all places

SO₂ is in the rage of 214-290 $\mu\text{g}/\text{m}^3$ (24 hr average) and 800-866 $\mu\text{g}/\text{m}^3$ and over the WHO values.

It must be noted that at each period of surveying the dumpsite was burning and that unfortunetaly the wind direction and the wind speed (velocity) were during the survey period exactly in the direction of the survey points. It can be seen that when the velocity is low (AQ 1 end of March 2019) or the wind direction is not in the direction of the survey point (AQ3 August 2019) the parameters are closer to the WHO guidelines.

For Vilingili as the main inhabited islands close to Thilafushi all the parameters are below the WHO guidelines.

8 Identification and assessment on potential effects

8.1 General emission

The following maximum mass concentrations should be achieved by the flue gas cleaning.

Table 7: Maximum mass concentration

Substance	Mass concentration [1]
Total dust, including particulate matter (No 5.2.1 TA Luft)	5 mg /m ³
Fluorine and its compounds, indicated as hydrogen fluoride (5.2.4 Class II TA Luft)	1 mg /m ³
gaseous inorganic chlorine compounds, indicated as hydrogen chloride (5.2.4 class III TA Luft)	10 mg/m ³
Ammonia (5.2.4 class III TA Luft)	10 mg/m ³
Sulphur oxides (sulphur dioxide and sulphur trioxide), expressed as sulphur dioxide (5.2.4 Class IV TA Luft)	50 mg/m ³
Nitrogen oxides (nitrogen monoxide and nitrogen dioxide), expressed as nitrogen dioxide (5.2.4 (2), 2nd sentence TA Luft)	150 mg/m ³
Carbon monoxide (5.2.4 para. 2 sentence 1 TA Luft)	50 mg/m ³
organic substances (expressed as total C) (TA Luft 5.4.10.20)	10 mg/m ³
Mercury and its compounds, reported as Hg (No 5.2.2 Class I TA Luft)	0.03 mg/m ³
Dioxins and furans	0.1 ng/m ³
Sum of heavy metals and their components: antimony, chromium, copper, manganese, vanadium, tin, lead, cobalt, nickel (5.2.2 TA Luft class II and III)	as total 0.5 mg/m ³
Thallium and its compounds (5.2.2 TA Luft class I) cadmium	as total of 0.05 mg/m ³
Arsenic/cadmium and its compounds (expressed as As and Cd), benzo (a) pyrene, water-soluble cobalt compounds (expressed as Co), chromium (VI) compounds (expressed as Cr) (5.2.7.1.1 TA Luft Class I)	as total 0.05 mg / m ³

8.1.1 Emission mass flow

Table 8: Emission mass flow (for R = 115 713 m³/h, T = 180 °C, Ø = 2.12 m)

Substance	Masses concentration	Mass flow Q in kg/h	Factor S	Q/S in kg/h **
Total dust, including particulate matter (No 5.2.1 TA Luft)	5 mg/m ³	0.579	0.08	7.2
Fluorine and its compounds, indicated as hydrogen fluoride (5.2.4 Class II TA Luft)	1 mg/m ³	0.116	0.0018	64.3

Substance	Masses concentration	Mass flow Q in kg/h	Factor S	Q/S in kg/h **
Gaseous inorganic chlorine compounds, indicated as hydrogen chloride (5.2.4 class III TA Luft)	10 mg/m ³	1,157	0.1	11.6
Ammonia (5.2.4 class III TA Luft)	10 mg/m ³	1,157	-	-
Sulphur oxides (sulphur dioxide and sulphur trioxide), expressed as sulphur dioxide (5.2.4 Class IV TA Luft)	50 mg/m ³	5,786	0.14	41.3
Nitrogen oxides (nitrogen monoxide and nitrogen dioxide), expressed as nitrogen dioxide (5.2.4 (2), 2nd sentence TA Luft)	150 mg/m ³	11,108 *	0.1	111.08 *
Carbon monoxide (5.2.4 para. 2 sentence 1 TA Luft)	50 mg/m ³	5,786	7.5	0.77
Organic substances (expressed as total C) (TA Luft 5.4.10.20)	10 mg/m ³	1,157	0.1	11.6
Mercury and its compounds, reported as Hg (No 5.2.2 Class I TA Luft)	0.03 mg/m ³	0.00347	0.0013	26.7
Dioxins and furans	0.1 ng/m ³	1.16 x 10 ⁻⁸	-	-
Sum of heavy metals and their components: antimony, chromium, copper, manganese, vanadium, tin, lead, cobalt, nickel (5.2.2 TA Luft class II and III)	0.5 mg / m ³	0.05786	0.05 0.1	1.157 0.579
Thallium and its compounds (5.2.2 TA Luft class I) cadmium	0.05 mg / m ³	0.00579	0.005	1.16
Arsenic / cadmium and its compounds (expressed as As and Cd), benzo (a) pyrene, water-soluble cobalt compounds (expressed as Co), chromium (VI) compounds (expressed as Cr) (5.2.7.1.1 TA Luft Class I)	0.05 mg / m ³	0.00579	0.00005	115.7

* According to point 5.5.3 TA Luft, the emission of nitrogen monoxide is based on a conversion rate of 60% to nitrogen dioxide, and is based on a ratio of NO/NO₂ = 90%/10%, cf. Annex 1.1

8.1.2 Control of the necessity of the dispersion calculation

The determination of the ambient air quality characteristics is not required if the emissions of the air pollutants do not exceed the following minor mass flows:

Table 9: Minor mass flow according 4.6.1.1 TA Luft and WtE mass flow

Pollutants	Minor mass flow	Plant mass flow (Annex 2)
	in kg / h	
Emissions derived from stacks		
Dust (without consideration of dust contents)	1	0.579
Fluorine and its compounds, indicated as hydrogen fluoride (5.2.4 Class II TA Luft)	0.15	0.116
Gaseous inorganic chlorine compounds, indicated as hydrogen chloride (5.2.4 class III TA Luft)	-	1,157
Ammonia (5.2.4 class III TA Luft)	-	1,157
Sulphur oxides (sulphur dioxide and sulphur trioxide), expressed as sulphur dioxide (5.2.4 Class IV TA Luft)	20	5,786
Nitrogen oxides (nitrogen monoxide and nitrogen dioxide), expressed as nitrogen dioxide (5.2.4 (2), 2nd sentence TA Luft)	20	11.108
Carbon monoxide (5.2.4 para. 2 sentence 1 TA Luft)	-	5,786
Organic substances (expressed as total C) (TA Luft 5.4.10.20)	-	1,157
Mercury and its compounds, reported as Hg (No 5.2.2 Class I TA Luft)	0.0025	0.00347
Dioxins and furans	-	1,16x 10 ⁻⁸
Sum of heavy metals and their components: antimony, chromium, copper, manganese, vanadium, tin, lead, cobalt, nickel (5.2.2 TA Luft class II and III)	0.025 lead, nickel (class II)	0.05786
Thallium and its compounds (5.2.2 TA Luft Class I)	0.0025	0.00579
Arsenic / cadmium and its compounds (expressed as As and Cd), benzo (a) pyrene, water-soluble cobalt compounds (expressed as Co), chromium (VI) compounds (expressed as Cr) (5.2.7.1.1 TA Luft Class I)	0.0025	0.00579

For most of substances the values are below the minor mass flows. For mercury as well as heavy metals and their components (referred to thallium and arsenic/cadmium and lead/nickel) the values are over the minor flows, therefore there is a need to perform the **dispersion modelling** for these substances.

For ammonia and hydrogen chloride (5.2.4 Class III TA Luft), for carbon monoxide, for organic substances (expressed as total C) as well as dioxins and furans no minor mass flow are set in the regulations therefore there is no need to undertake a detailed dispersion modelling for these parameters either.

Emergency Gen-set

For the emissions mass flow calculation of the air pollutants of the emergency Gen-set, data of the client have been made available [1].

The following pollutants have to be considered. The exhaust gas volume flow was given as $V_n = 12\,470 \text{ mN}^3/\text{h}$ and the exhaust gas temperature to $T=180^\circ \text{C}$.

Table 10: Minor mass flow according to Section 4.6.1.1 TA Luft - system mass flow

Substance	Minor mass flow	Plant mass flow in kg/h
	in kg / h	
Dust (without consideration of dust contents)	1	0.9976
Nitrogen oxides (nitrogen monoxide and nitrogen dioxide), expressed as nitrogen dioxide (5.2.4 (2), 2nd sentence TA Luft)	20	3.99
Carbon monoxide (5.2.4 (2) sentence 1 TA Luft)	-	3,741
Formaldehyde - HCHO	-	0,748

The minor mass flows have also been not exceeded by the Gen-set emission values, so that no dispersion calculation has to be carried out for these substances.

For carbon monoxide and formaldehyde no minor mass flow has been set in the regulation. For these substances, so that for this substance group also no dispersion calculation is to be carried out.

No indications were found which requires a special case test according to section 4.8 TA Luft.

8.2 Air dispersion modelling for relevant parameter

In order to estimate exposures to airborne pollutants from the incineration and emergency electricity generation, dispersion modelling was carried out. Modelling was done for the pollutants: dust, nitrogen monoxide and nitrogen dioxide), carbon monoxide and formaldehyde from the emergency electricity generation sets. Modelling was done for the pollutants: total dust including fine dust, fluoride and its compound specified as hydrogen fluoride, ammonia, sulphur (sulphur dioxide and sulphur trioxide), specified as sulphur dioxide, nitrogen oxide (nitrogen monoxide and nitrogen dioxide) specified as nitrogen dioxide and mercury and its compound specified as mercury from the waste to energy plant. The study zone was defined as a 5000 m radius of influence from incinerator stack at Thilafushi. The figure below shows the area around the proposed waste to energy plant at Thilafushi Island.

The dispersion modelling for the pollutants was carried out using the dispersion model AUSTAL2000. The computer program AUSTAL2000 is a reference implementation developed on behalf of the German Federal Environmental Agency

The program system AUSTAL2000 calculates the spread of pollutants and odours in the atmosphere. It is an extended implementation of Annex 3 of the German regulation TA Luft (Technical Instruction on Air Quality Control) demands for dispersion calculations a Lagrangian particle model in compliance with the German guideline VDI 3945 Part 3. The modelling work was carried out by Ulbricht Consulting (Germany). The dispersion modelling report is attached as an Annex 1 to this report.

Steady-state Gaussian plume models assess pollutant concentrations and/or deposition fluxes from a variety of sources associated with an industrial source complex. Unlike the Gaussian models commonly used, this flexible modelling procedure used in AUSTAL2000 provides realistic results even when buildings and uneven terrain influence flue gas dispersion. The model calculates the contribution of specified air pollutants from a given point source to the background concentrations present in the ambient air at ground level in the area surrounding the source.

Parameter for additional load, the parameter for the emission year-additional load (IJZ) is the average of all calculated individual contributions at each reference point.

8.2.1.1 *Emission from installations*

The following emission sources have been considered:

Exhaust stack: WtE

The following operation time has been considered: 8,000 h/a

8.2.1.2 *Emissions from guided sources*

For the emissions of the air pollutants of the incinerator WtE data are available from the client [1]. For the incineration plant, the following pollutants have been taken into account in the dispersion calculation. The exhaust gas volume flow was given as $V_n = 115713 \text{ m}^3/\text{h}$ and the exhaust gas temperature as $T = 180^\circ \text{ C}$.

The air dispersion calculation was made with a stack height of 46,0 m.

In chapter 6 (Employer's requirement) of the DBO a minimum height of 50,0 m has been fixed.

Therefore the calculated emissions are presenting the worst case. With the extension of the stack, the ambient air concentration value will be reduced at the reception point.

Table 11: Emissions Stack WtE

Substance	mg / m ³	Total V _N m ³ /h	flow	Emission mass flow in kg/h
Total dust, including particulate matter	5	115713		0.579
Fluorine and its compounds, indicated as hydrogen fluoride	1			0.1 16
Ammonia	10			1,157
Sulphur oxides (sulphur dioxide and sulphur trioxide), expressed as sulphur dioxide	50			5,786
Nitrogen oxides (nitric oxide and nitrogen dioxide), expressed as nitrogen dioxide	150			11.108
Mercury and its compounds, indicated as Hg	0.03			0.0035
Sum of heavy metals and their components: antimony, chromium, copper, manganese, vanadium, tin, lead, cobalt, nickel (5.2.2 TA Luft class II and III)	0.5 mg / m ³			0.05786
Thallium and its compounds (5.2.2 TA Luft class I)	0.05 mg / m ³			0.00579
Arsenic / cadmium and its compounds (expressed as As and Cd), benzo (a) pyrene, water-soluble cobalt compounds (expressed as Co), chromium (VI) compounds (expressed as Cr) (5.2.7.1.1 TA Luft Class I)	0.05 mg / m ³			0.00579




3.1 Auszug aus der fischen Karte	Firmenname: Ingenieurbüro Ulbricht GmbH		
	Bearbeiter: Dipl. Ing. (FH) Uta Figula		
	QUELLEN: 1	MASSTAB: 1:23.000 0 0,5 km	
	DATUM: 22.05.2019		

Figure 20: Location of the emission points where maximum load was calculated and examined

Computer model

For the calculation the dispersion model AUSTAL2000, version 2.6.11-WI-x, of the company Janicke Consulting was used, which is implemented in the program AustalView TG of the company Argusoft. The program system AUSTAL2000 calculates the spread of pollutants and odours in the atmosphere. It is an extended implementation of Annex 3 of the TA Luft. The model underlying the program is described in guideline VDI 3945 Part 3.

Computational domain

Due to the stack height of 46 m the calculation area has a radius of at least 2300 m (50 times the height). The grid for the calculation of concentration and deposition shall be selected in accordance with Chapter 7 (2) of Annex 3 of the TA Luft so that the location and contribution of the maximum ambient air quality can be determined with sufficient certainty. This is usually the case when the horizontal mesh size does not exceed the stack height. At source distances greater than 10 times the height of the stack, the horizontal mesh size can be selected proportionally larger. The calculations and assessments were carried out in an area of 3.2 x 2.6 km and a grid with mesh sizes of 5 to 20 m.

Ground roughness

The ground roughness of the terrain is described by an average roughness length z_0 . It is in accordance with the land use classes in the CORINE cadastre. The roughness length was chosen to be $z_0 = 0,2$ in the calculation. This value should be considered representative for the area of calculation

Sources

In the calculation program emission source can be differentiated into different source types. Exhaust stacks are defined as point sources.

The source calculated on the basis of the emission behaviour described in Appendix 3, in accordance with Appendix 3, was entered using the parameters described. The parameters and emission data are given in Appendix 3. An emission source plan is also included in Appendix 3.

Pollutants

As per Table 4 in section 6 the dispersion modelling is required for mercury and heavy metals and their components (represented by lead/nickel, thallium and arsenic/cadmium). For all other pollutants, the minor mass flows according to Table 7 of No. 4.6.1.1 of the TA Luft have not been exceeded. For these substances, it can be assumed that harmful environmental effects from the plant cannot be caused.

The following pollutants relevant to the plant could be calculated according to TA Luft: dusts (dust precipitation, PM10), sulphur dioxide, nitrogen oxide, ammonia, mercury, arsenic, cadmium, nickel, lead, thallium. In the present case, for all relevant pollutants, insofar as emission limits are defined for these substances in TA Luft, the air dispersion modelling has been run.

For the other relevant pollutants: total C, carbon monoxide (CO), hydrogen chloride, dioxins and furans, no emission values are specified in the TA Luft.

Dispersion class time series

The wind direction and wind speeds were modelled with a dispersion class time series for the year 2017 [8].

Terrain and slope

It is a flat terrain. In the computing area, no gradients of more than 1:20 or more than 1:5 occur.

Statistics

The resulting statistical uncertainty (in %) was taken into account in the evaluation. The calculation was performed with the quality level "2". To assess the ambient air quality limits, the calculated value have been increased by the statistical uncertainty.

Receiver points

In the examination area two ambient air quality points have been determined for the calculations. The BUP 1 was chosen as the point of presumed highest load due to the shortest distance to the emission source. The ANP 1 (nearby a food place), due to which in comparison with the BUP 1 gives the higher additional load of pollutant deposition, was to be considered in more detail. The location of the ambient air quality points can be found in Annex 3.

Table 12: Ambient air quality points

Ambient air quality points
BU P 1 West
ANP 1 east

8.3 Maximum ground level/Additional load

The following results apply exclusively taking into account the characteristics of the emission sources mentioned in Chapter 7. The dispersion calculation is required for the substances mentioned in chapter 6.1. All other results in Table 10 are presented for information only. As a guide, a comparison is made with the irrelevance values and the ambient air quality values of TA Luft.

The detailed analysis results are given in Appendix 3 and the grid diagram representation of the substances (except for ammonia and suspended particulate PM₁₀) could be found in Annex 4 .

Table 13: Ambient air quality Maximum ground level/additional load (IZ) (including statistical uncertainty)

Ambient air quality points	Irrel. IZ	IW	BUP 1	ANP 1
Substance				
Mercury g/(m ² d)	0.05	1	0,007	1.0
PM _{DEP} g/(m ² d)	0.0105	0.35	0,0001	0,0001
PM ₁₀ µg/m ³	1.2	40	0	0
Hydrofluoric µg/m ³	0.04	0.4	0	0.005
Sulphur dioxide µg/m ³	1.5	50	0	0.2
Nitrogen oxides µg/m ³	1.2	40	0	0.4
Ammonia µg/m ³	-		0	0.04
Lead µg/(m ² d)	5	100	0,2	17,0
Nickel µg/(m ² d)	0.75	15	0,122	17,1
Thallium µg/(m ² d)	0.1	2	0,01	1,7
Cadmium µg/(m ² d)	0.1	2	0.01	1, 7
Arsenic µg/(m ² d)	0.2	4	0.02	1,7

A pre-pollution with air pollutants at the site is not known (baseline), so it is assumed that the calculated values represent the total load.

Evaluation point BUP 1

At assessment point BUP 1, the values are below the “irrelevance thresholds” of TA Luft for the substances.

Analysis point ANP 1

At the ANP 1 analysis point, the air pollutants PM10, dust precipitation, sulphur dioxide, nitrogen oxides, hydrogen fluoride fall below the irrelevance values according to TA Luft.

If an orienting comparison is made with the air quality values of TA Luft, the following can be stated:

- For lead, thallium, cadmium, arsenic, the ambient air quality value of TA Luft is below. For mercury, the ambient air quality value of TA Luft is reached (not exceeded).
- The specified ambient air quality value in the TA Luft for nickel is exceeded. In the calculation, the heavy metal nickel was considered representative of the group of heavy metals and their components: antimony, chromium, copper, manganese, vanadium, tin, lead, cobalt, nickel (5.2.2 TA Luft class II and III).

Taking into account the volumetric flow and the desired mass concentration (corresponding to the emission limit value (class II according to 5.2.2 TA Luft) for the group of heavy metals, the emission mass flow for the group of heavy metals was assigned to the substance nickel. From a technical perspective it is not expected that none of the further elements of the heavy metal group occur in the exhaust gas, so that the exceeding of the ambient air quality value for nickel is likewise not expected.

Ammonia

No ambient air quality value is specified for ammonia. The desired mass concentrations by means of flue gas cleaning are below the values specified in the TA Luft (limit values). A negative impact on the environment is therefore not expected.

Hydrogen chloride, total C, carbon monoxide (CO), dioxins and furans

No ambient air quality values are specified for these substances. The mass concentrations aimed at by means of flue gas cleaning are below the values stated in the TA Luft (limit values). A negative impact is therefore not to be feared.

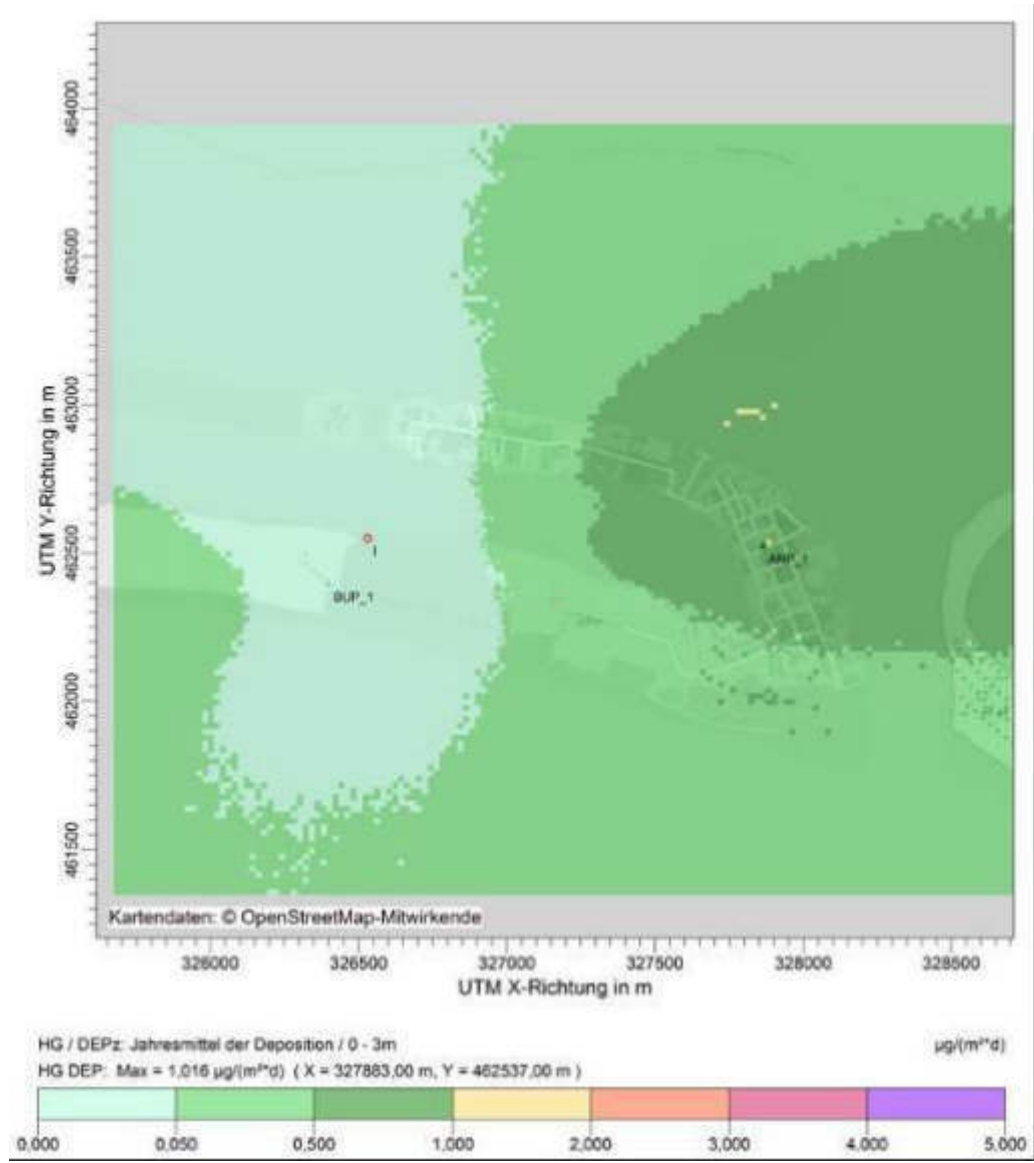


Figure 21: additional load Mercury-Deposit from the dispersion model.

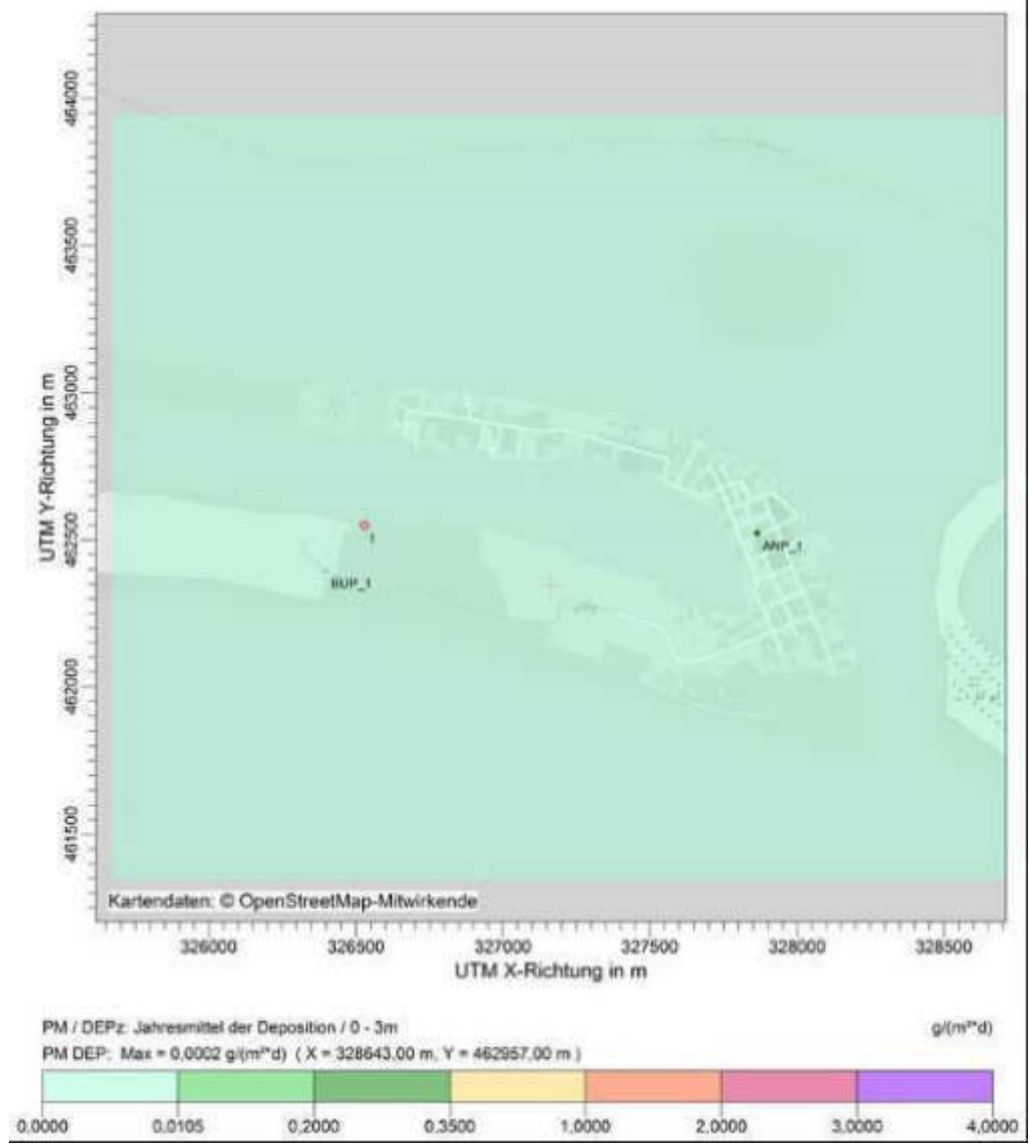


Figure 22: PM-Deposit from the dispersion model.

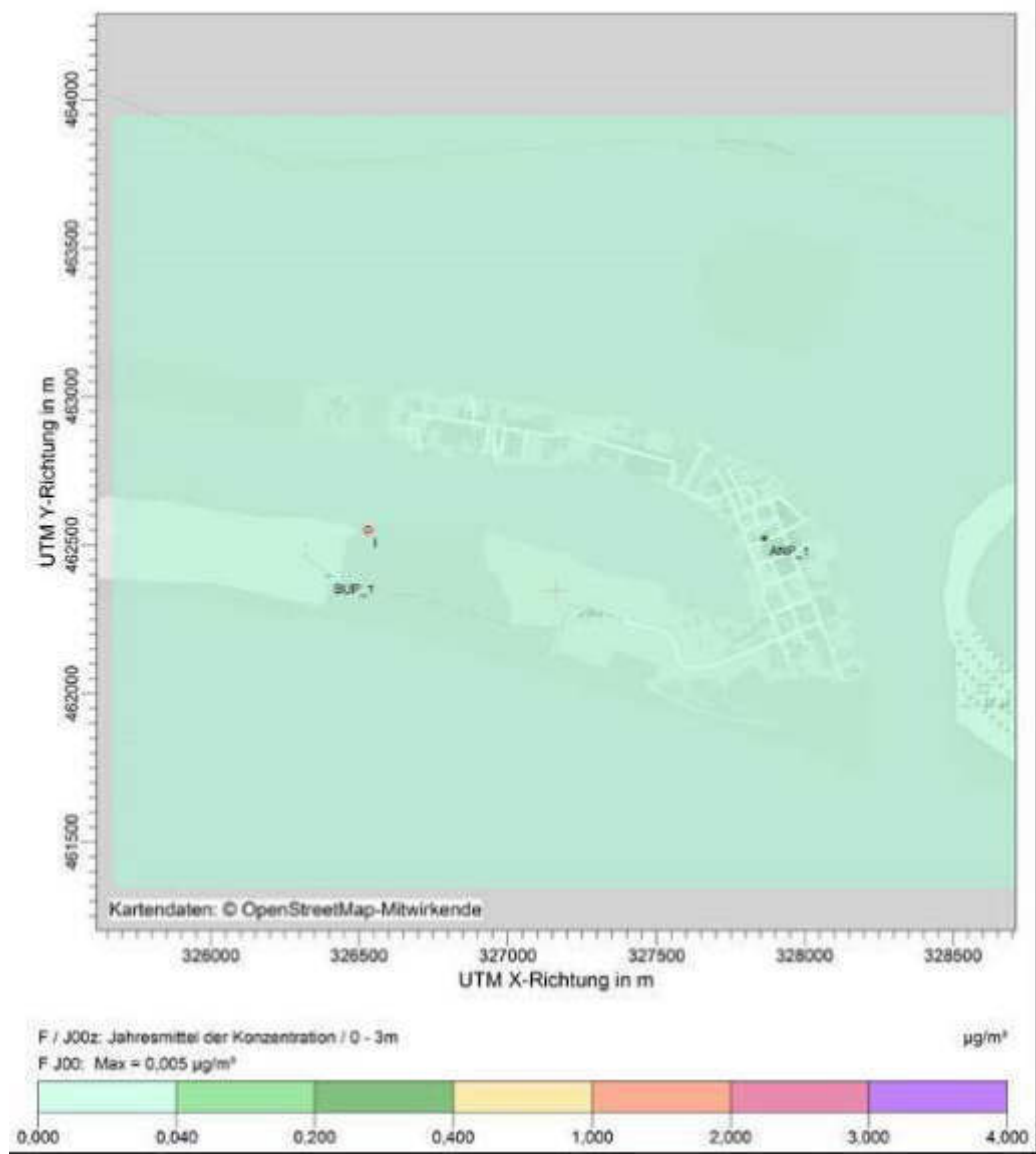


Figure 23: F-Deposit from the dispersion model.

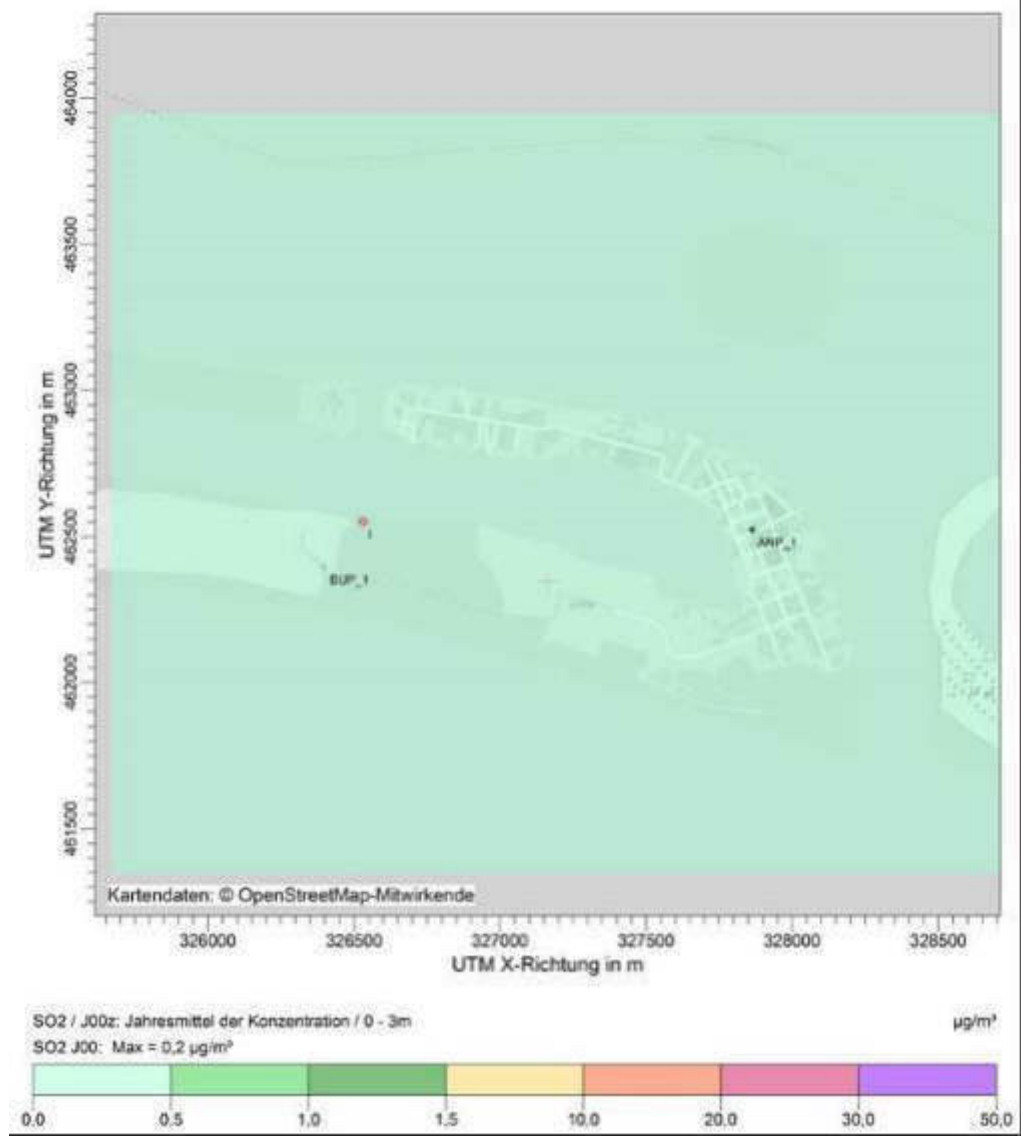


Figure 24: SO₂-Deposit from the dispersion model.

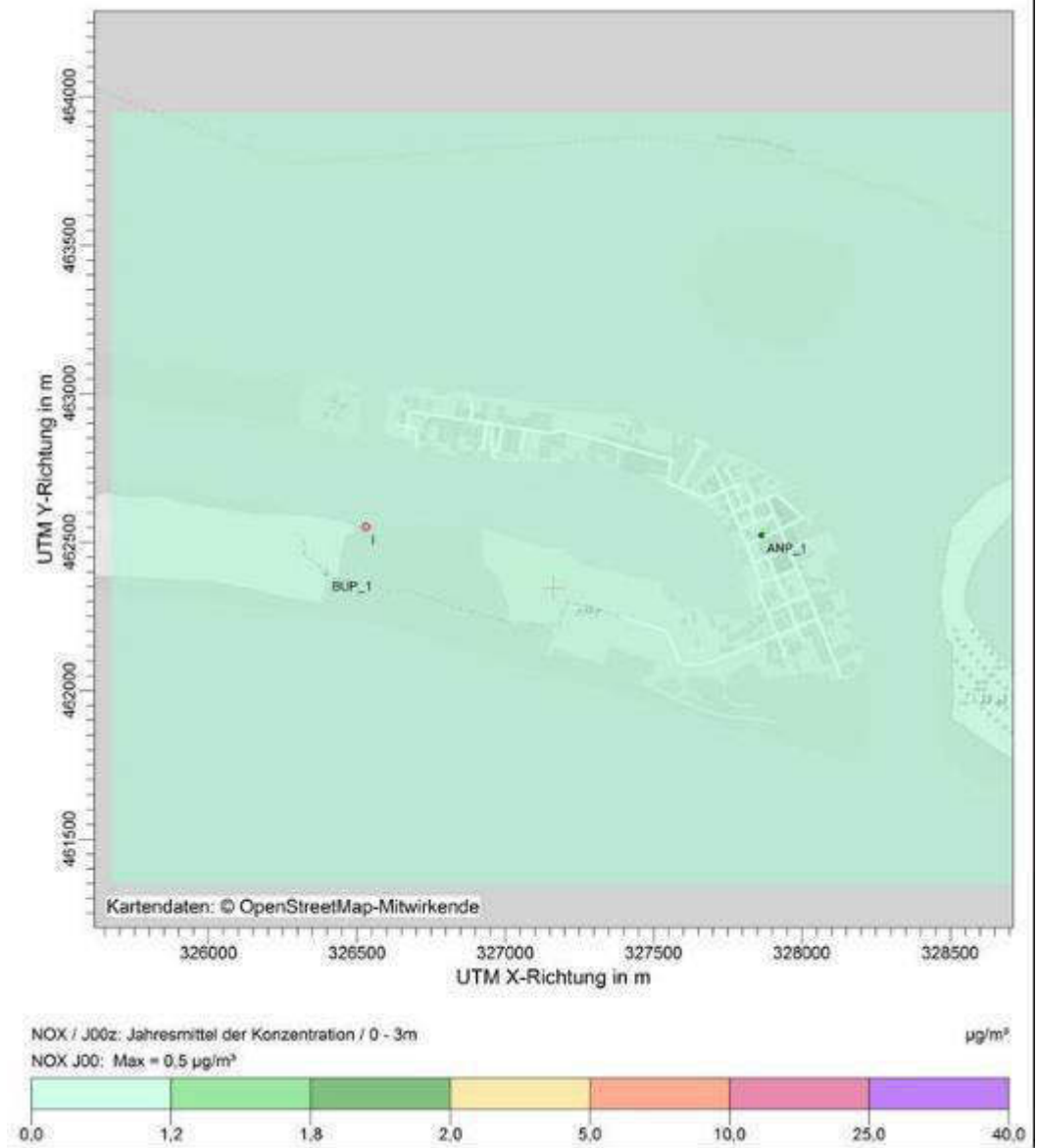


Figure 25: NOx-Deposit from the dispersion model.

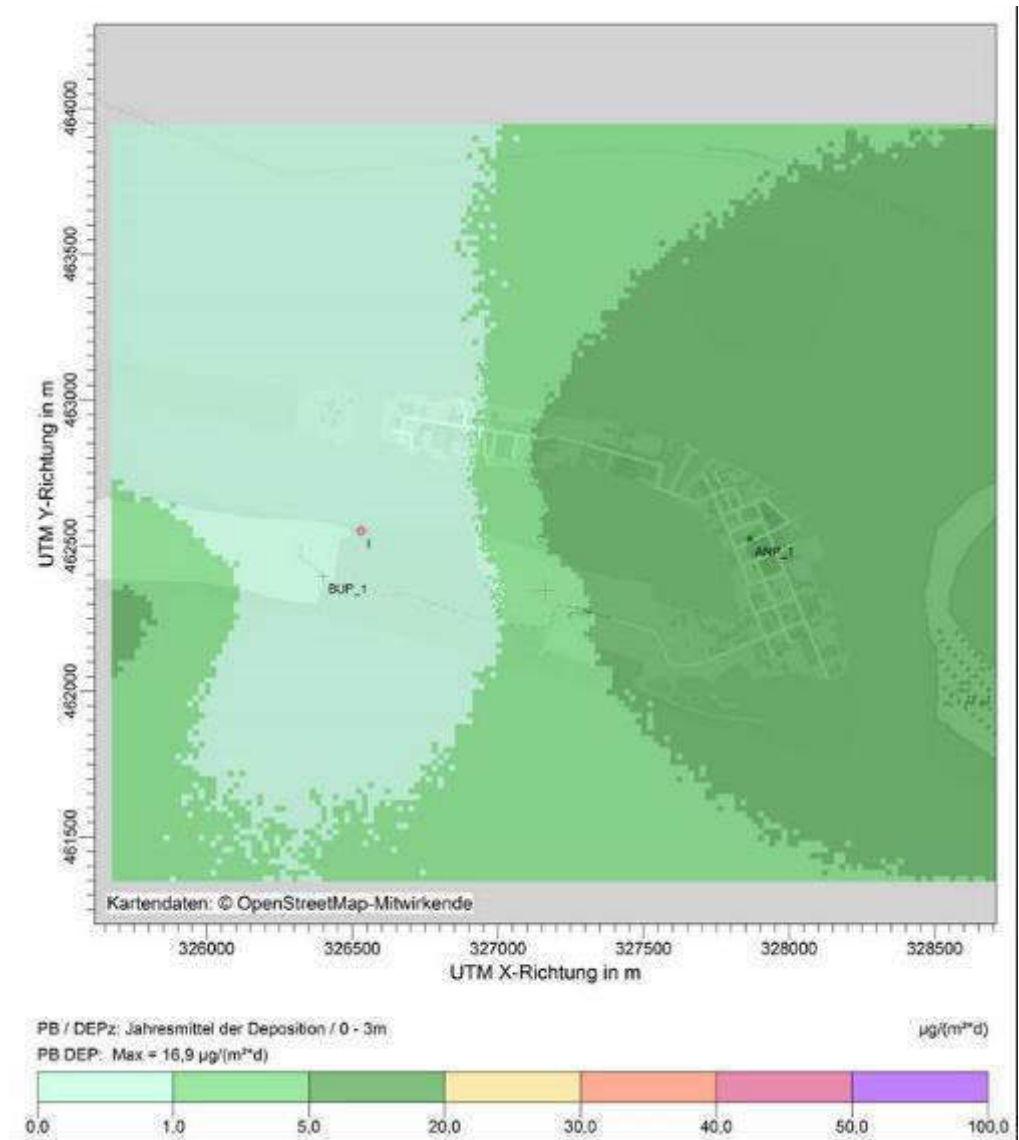


Figure 26: Pb-Deposit from the dispersion model.

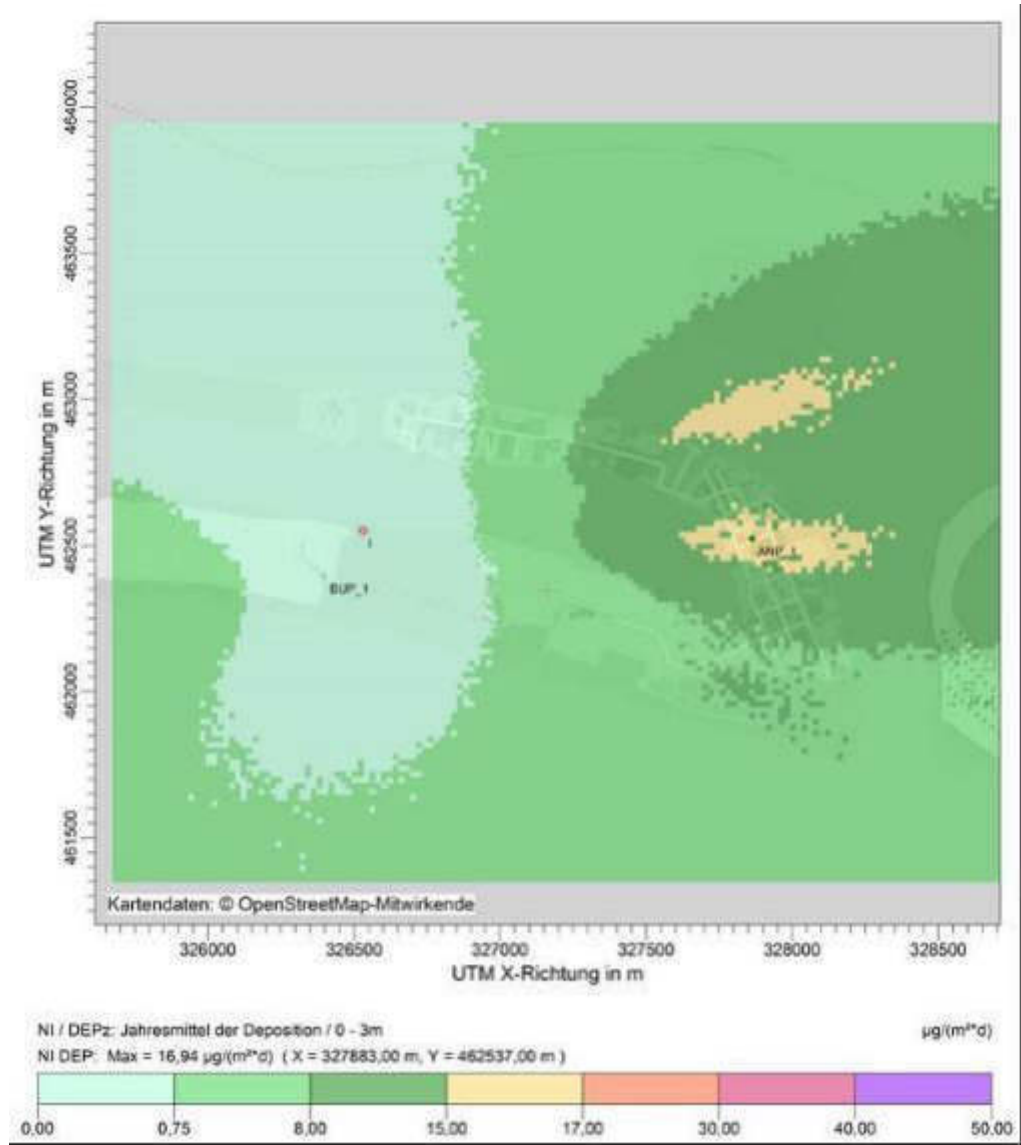


Figure 27: Ni-Deposit from the dispersion model.

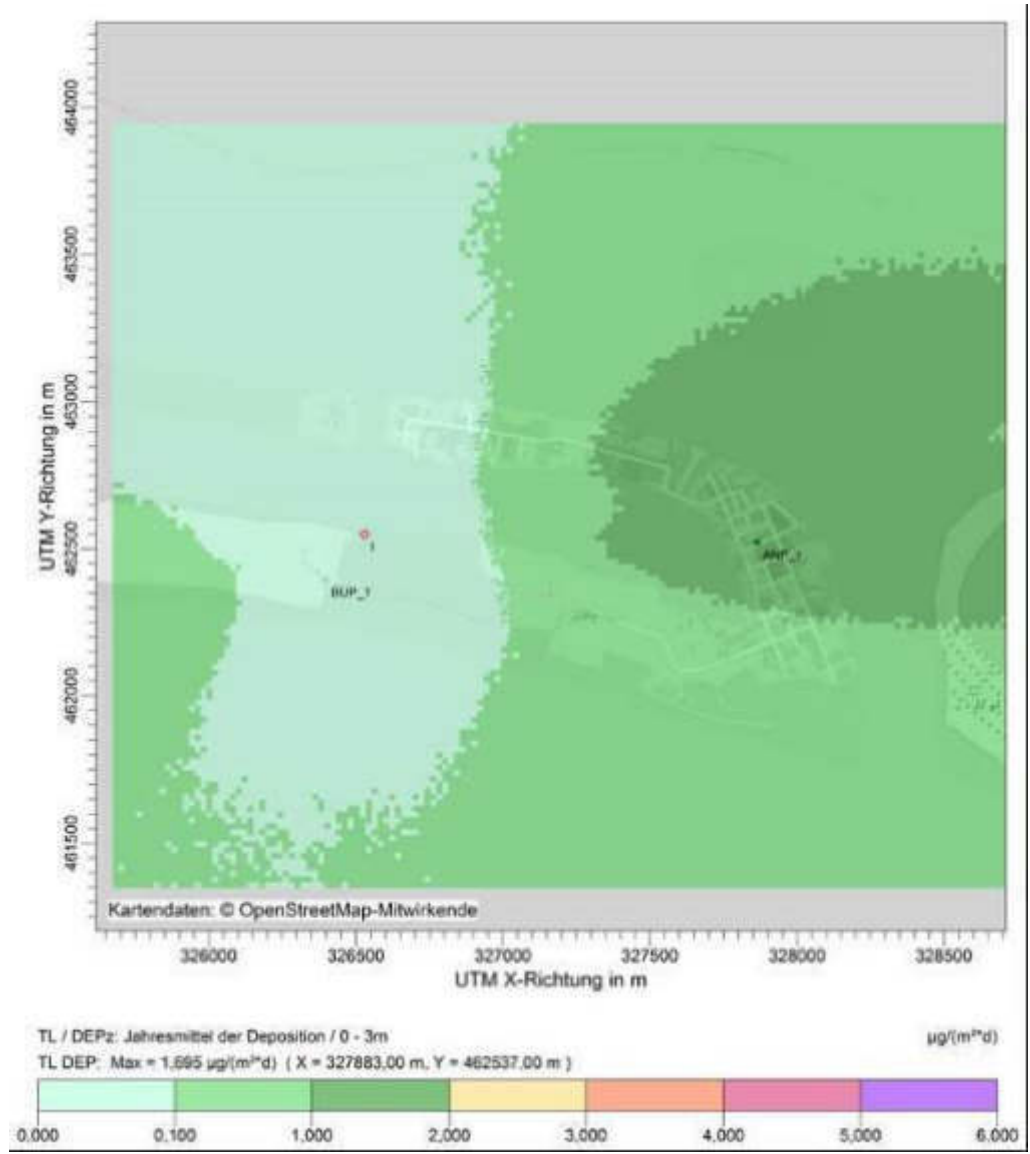


Figure 28: TI-Deposit from the dispersion model.

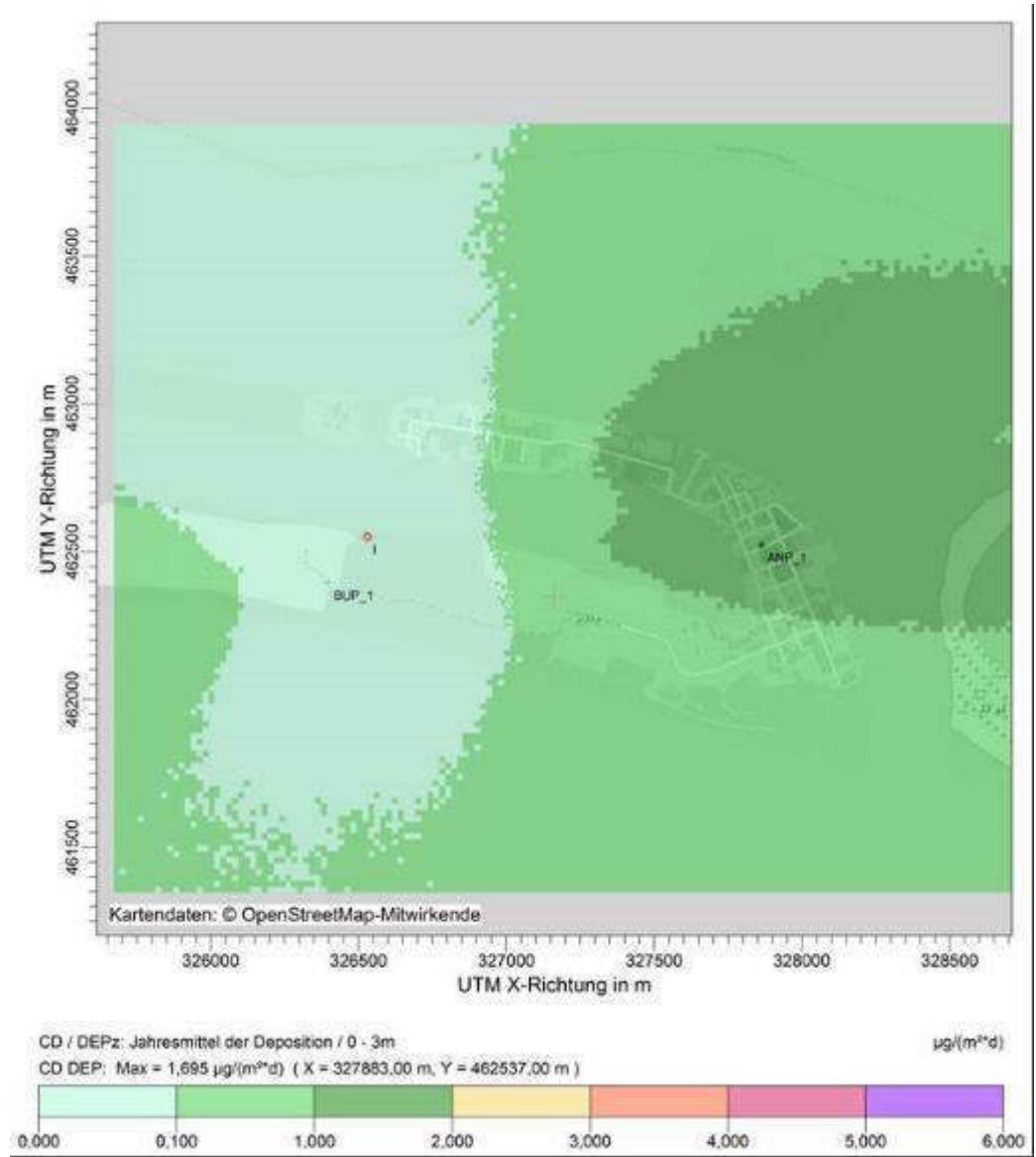


Figure 29: Cd-Deposit from the dispersion model.

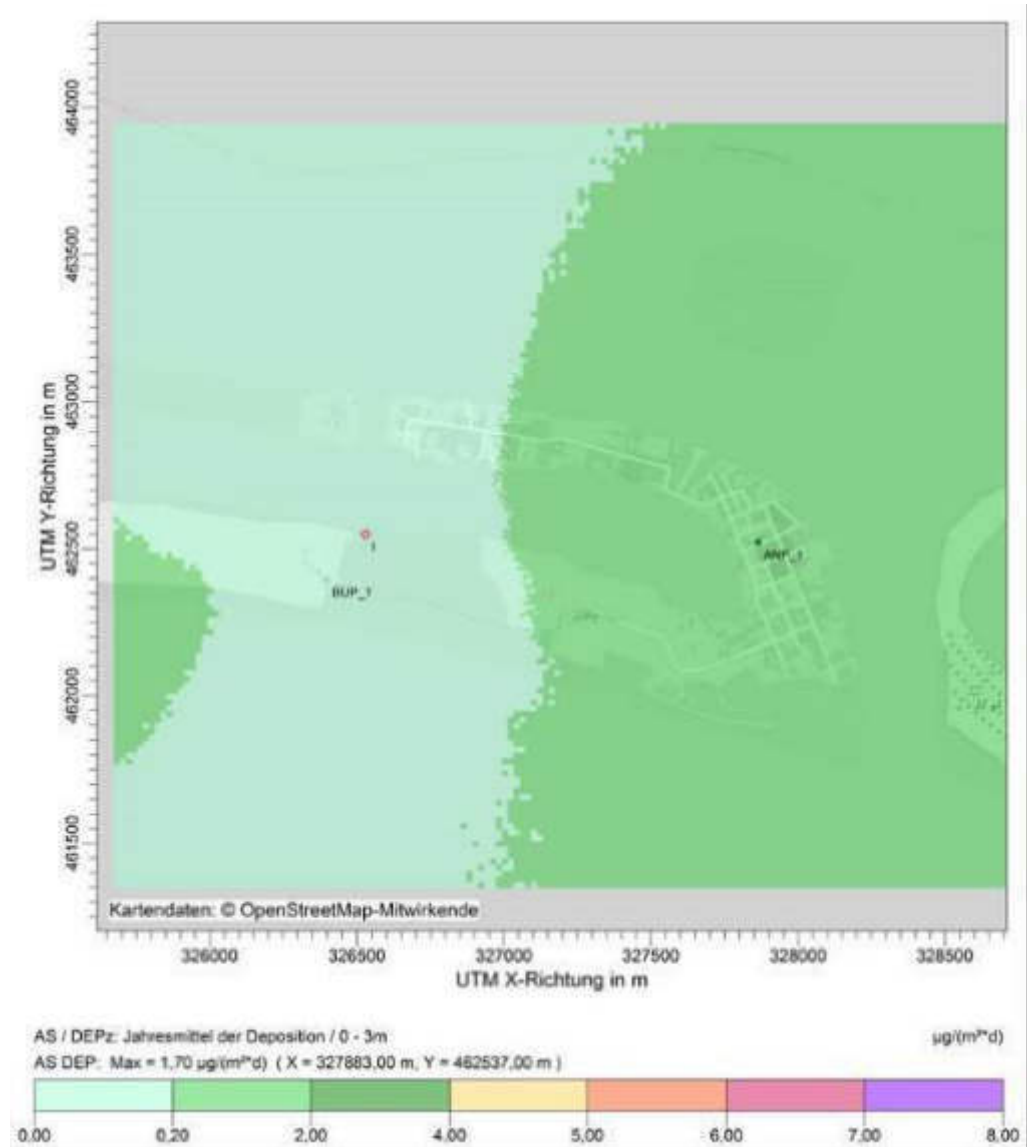


Figure 30: As-Deposit from the dispersion model.

The overall air quality of the project site is expected to increase with time. More significantly when the existing dumpsite is closed. Therefore, a long term, positive, and significant impact is expected with the operation of this project.

8.4 Interpretation of the results with respect to baseline conditions

Considering only the additional from process contribution it is clear that no harmful pollution is to be expected from the installation. Actually the baseline situation is mainly characterized by the dumpsite of Thilafushi which is set to be closed at the start of the operation of the new facility. Therefore the following results needs to be considered with care

Substance	Averaging time	AQ Standard/ Guideline ($\mu\text{g}/\text{m}^3$)	Baseline ($\mu\text{g}/\text{m}^3$)	Process contribution ($\mu\text{g}/\text{m}^3$)	PC/ AQSG	Combined process + baseline ($\mu\text{g}/\text{m}^3$)	Combined/ AQSG
Particulate matter (PM ₁₀)	24 hr average	50	538,94	0,100	0,20%	539,04	1078,08%
Particulate matter (PM ₁₀)	1 year	20		0,000	0,00%		
Particulate matter (PM _{2,5})	24 hr average	25	387,57	0,100	0,40%	387,67	1550,68%
Particulate matter (PM _{2,5})	1 year	10		0,000	0,00%		
Sulfur dioxide SO ₂	24 hr average	20	291,24	0,200	1,00%		
Sulfur dioxide SO ₂	10 minutes	500	970,00	1,333	0,27%	971,33	194,27%
Nitrogen dioxide (NO ₂)	1 year	40		0,000	0,00%		
Nitrogen dioxide (NO ₂)	1 hr	200	72,80	0,017	0,01%	72,82	36,41%

9 Conclusions

The ambient air quality status of Maldives had been unknown due to the lack of air quality monitoring data. The air quality is generally considered good as the sea breezes flush the air masses over the small the islands. However rapid urbanization and economic growth in the recent years has shown noticeable changes in the air quality, particularly in the Male' region. Thilafushi Island is being used to dump huge volume of wastes from the neighbouring inhabited islands (Malé, Villingili and Hulhumalé) and nearby resort islands. Open burning of mixed wastes is being practiced at the island to reduce the volume of the waste. The smoke generated from burning increases the air pollutant load in the local air shed and also affects the air quality of the island.

The air quality at the Thilafushi Island is expected to be polluted i.e. the values for the pollutants such as PM_{2.5}, PM₁₀, SO₂ and NO_x are expected to be higher in the region downwind of Thilafushi as the smoke plume generated from the open burning of waste frequently passes through this region. The numbers of stations and their locations for baseline air quality monitoring was selected to collect ambient air quality data that is representative of the baseline air quality of the Thilafushi Island and its surrounding areas.

Air quality monitoring for baseline was conducted at four locations. One station was selected in the downwind direction of the WtE stack emission plume while another station was placed at the cross wind direction of the plume. One station was selected in the cross wind direction of the smoke plume from the existing dump site at Thilafushi. Additional station was selected at Villingili as a control site.

The ambient air quality results obtained from the monitoring at Villingili undertaken indicate that all parameters were within the WHO guidelines for ambient air quality at station AQ-4 (Villingili Island). The stations at AQ-1 AQ-2 and AQ-3 had all parameters that were beyond the WHO guidelines for ambient air quality. The monitoring results showed that the air quality of Thilfushi which are on downwind wind direction of the existing waste dump site is degraded with the smoke from the dumpsite.

In order to estimate exposures to airborne pollutants from the incineration and emergency electricity generation, air pollutant dispersion modelling was carried out. Modelling was done for the pollutants: total dust including fine dust, fluoride and its compound specified as hydrogen fluoride, ammonia, sulphur (sulphur dioxide and sulphur trioxide), specified as sulphur dioxide, nitrogen oxide (nitrogen monoxide and nitrogen dioxide) specified as nitrogen dioxide and mercury and its compound specified as mercury from the waste to energy plant.

The dispersion modelling for the pollutants was carried out using the dispersion model AUSTAL2000. The computer program AUSTAL2000 is a reference implementation developed on behalf of the German Federal Environmental Agency. AUSTAL2000 is a steady-state dispersion model that is designed for long-term sources and continuous buoyant plumes. Given that poor meteorological data coverage near the proposed project site, the dispersion model AUSTAL2000 was preferred to a popular dispersion model AERMOD, which requires high quality meteorological data to run the AERMOD.

The proposed site for the establishment of the WtE was reclaimed in 2018. The entire Island and the project location are mainly on the main level over MSL and do not present any substantial elevation.

The stack emission dispersion modelling showed, except for mercury as well as heavy metals and their components (referred to thallium and arsenic/cadmium and lead/nickel), maximum mass concentrations was achieved by the flue gas cleaning and will be mass concentration of the emission from the stack. Hence emission characteristics was not required as the emissions of the air pollutants do not exceed the minor mass flows. For mercury as well as other heavy metals and their components the values were over the minor flows, therefore dispersion modelling was carried out for these substances.

Dispersion modelling showed that the level of lead, thallium, cadmium, arsenic, would be below the ambient air quality value and for mercury, level in the the ambient air quality would be reached but not exceeded. It is not expected that heavy metal group occur in the exhaust gas, so that the exceeding of the ambient air quality value for nickel is not expected. The desired mass concentrations by means of flue gas cleaning are below the limit values for ammonia and a negative impact on the environment is therefore not expected. Similar is with hydrogen chloride, total carbon, carbon monoxide, dioxins and furans as desired mass concentrations by means of flue gas cleaning would achieve below the emission value limits.

Based on the predicted concentrations and the post project concentrations of concerned pollutants, it can be inferred that the ambient air quality of the area is unlikely to be affected significantly due to proposed project. The overall air quality of the project site is expected to increase with time. More significantly when the existing dumpsite is closed. Therefore, a long term, positive, and significant impact is expected with the operation of this project.

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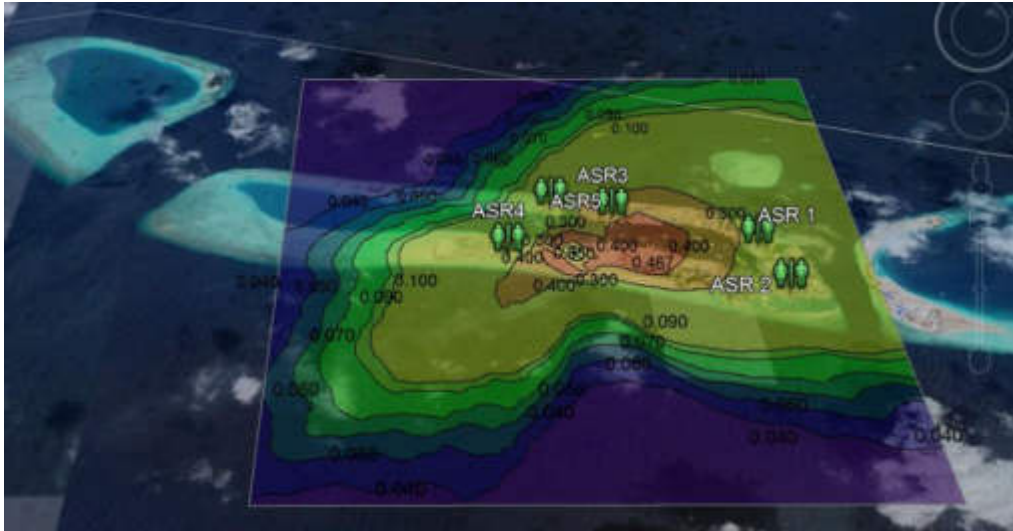
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**DISPERSION MODEL REPORT
AERMOD VALIDATION PROJECT**

2 UNITS X 250 TON/DAY WTE GRATE TYPE INCINERATOR AND
0.8 MW DIESEL GENRATORSET ENGINE



Greater Male' Waste to Energy Project
Environmental Impact Assessment Waste to Energy

Draft as of 11 OCTOBER 2019

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EXECUTIVE SUMMARY

AERMOD validation modeling was conducted in comparison with the Austal2000 German Lagrangian model. In said report, it was highly acknowledged that AERMOD is a “Stronger model” compared to Austal2000 in complex and urban terrain. It was also noted that Austal2000 was used as an alternative only because of the complexity of the meteorological data requirement of AERMOD. For the AERMOD validation run, the meteorological (metdata) provides a strong advantage because it accounts land use data, surface and upper air and its influence mechanical and convective mixing among other Planetary Boundary Layer (PBL) Parameters included met data set.

AERMOD meteorological data utilize surface characteristics in the form of albedo, surface roughness and Bowen ratio, plus standard meteorological observations such as wind speed, wind direction, temperature, and cloud cover. Using the AERMOD metdata processor AERMET, it calculates the PBL parameters such as: friction velocity, Monin-Obukhov length, convective velocity scale, temperature scale, mixing height, and surface heat flux . These parameters are then passed to the Interface within AERMOD where similarity expressions in conjunction with measurements are used to calculate vertical profiles of wind speed, lateral and vertical turbulent fluctuations, potential temperature gradient, and potential temperature. The AERMOD processes the MM5 formatted data to generate *.SFC and *.PFL met data files. See snapshot of the generated *.SFC met data file and *.PFL met data file. Figure below also shows the AERMOD treatment of boundaries parameters.

In the same way as the Austal2000 model, AERMOD validation run has considered the effects of building downwash. Waste to Energy (WTE) dimensions: Approx. Length x width x height [m]: 100 x 70 x 30. Surrounding building location have been considered according to land use plan, topographical survey and Google Earth maps. The height of the buildings has been considered to maximum 10m. This is another strong feature in AERMOD that the aerodynamic turbulence induced by nearby buildings cause a pollutant emitted from an elevated source to be mixed rapidly toward the ground (downwash), resulting in higher ground-level concentrations.

Terrain effects, such as elevations, were also incorporated which have impact on the air dispersion, deposition modeling results and potential risk to human health and the environment. Terrain elevation is the elevation relative to the facility base elevation. Complex Terrain are those elevations defined as anywhere within 50 km from the stack, are above the top of the stack being evaluated in the air modelling analysis. Terrain consideration was determined using SRTM3 terrain data processed by AERMAP terrain processor and has noted that highest elevations in the project area is at 7 meters only above sea level. Nevertheless, this AERMOD validated executed terrain situations using SRTM3 terrain data processed by AERMAP terrain processor where model considers terrain height exceeds stack base elevation, model receptors are also assumed on elevated terrain. Terrain elevations for receptors in the receptor Pathway are also considered.

Output of model run includes: one (1) hour, twenty-four (24) hour, and one (1) year averaging time plot files, isopleths diagrams, and table of worst-case scenarios. Meteorological data used is based on TIER 4 meteorological data, NCAR MM5 (5th-generation Mesoscale Model) prognostic meteorological model was the basis for meteorological background of the areas. Prognostic MM5 meteorological model are specified location and site domain. Once the MM5 preprocessing has been completed, the MM5 output file is converted into a format recognized by the **AERMET model** (meteorological preprocessor for the AERMOD model). The final output is generated by creating a pseudo met-station at the specified site location.

AREA SENSITIVE RECEPTORS (ASRs)

Area Sensitive Receptors (ASRs) include, but are not limited to residential areas, hospitals, schools, daycare facilities, elderly housing and convalescent facilities. These are areas where the occupants are more susceptible to the adverse effects of exposure to air pollutants. Extra monitoring and abatement efforts must be taken when dealing with contaminants and pollutants in close proximity to areas recognized as ASRs. For the WTE project and for the purpose of assessing potential impacts, Thilafushi islands' industrial areas are considered as ASRs as there are identified facilities with workers quarters. ASRs are located in the following area and details are provided in the main text of this report: (1.) ASR1-ENE; (2.) ASR2-SSE; (3.) ASR3-NNE; (4.) ASR4- SSW; (5) ASR5-NNW 474 to 1273 meters upwind and downwind directions from the center of the domain at UTM coordinates Easting 326540 and Northing 462472. This AERMOD Report includes results of the dispersion model showing the highest predicted ground level concentrations (GLC) in the ASRs.

The results and outputs of the models are compared with TA Luft Standards as specified in the Austal2000 Report and applicable United States Environmental Protection Agency (USEPA) standards and World Health Organization (WHO) Air Quality Guidelines.

TOTAL DUST (TD)

Predicted short term (1 hour) for controlled¹ total dust (TD) maximum ground level concentrations is 7.60 ug/m³ located 280 meters ENE from the center of the domain. The 24 hour controlled total dust (TD) maximum ground level concentrations is 3.188 ug/m³ located 608 meters ENE from the center of the domain. Simulated concentrations for maximum ground level concentration for 1 hour total dust (TD) are generally very low. There is no available the Ambient Air Quality Standards for total dust in the Austal2000 Report. For the total dust (TD) deposition, AERMOD results shows 0.00754 g/m² for 1 hour, 0.038505 g/m² for 24 hr, and 0.43394 g/m² for 1 year deposition. Deposition simulations are all below the TALuft precipitation limit of 0.35 g/m²-d. There are no applicable USEPA standards and WHO Air Quality Guideline Values. Reference center of the domain is the location of the Boiler Stack-1 at Universal Transverse Mercator (UTM) coordinates Easting 326540 and Northing 462472.

Summary Maximum Ground Level Concentration using AERMOD

Parameters	Ave.Time	Results	German Standard (TA Luft)		USEPA	WHO Air Quality Guidelines	% of the Applicable Standards
			Conc (ug/Nm ³)	Deposition (g/m ²)	Conc (ug/Nm ³)	Conc (ug/Nm ³)	%
Total Dust	1 hour	7.60628	-	-	-	-	-
Total Dust	24 hour	3.18863	-	-	-	-	-
Total Dust	1 year	0.34134	-	0.35	-	-	-

PARTICULATE MATTER 10 (PM10)

Predicted short term (1 hour) for controlled particulate matter 10 (PM-10) maximum ground level concentrations is 0.102 ug/m³ located 100 meters E from the center of the domain. The 24-hour controlled PM-10 maximum ground level concentrations is 0.02844 ug/m³ located

¹ Controlled emission parameters refer to post-air pollution control devices. For the WtE, each stack will include baghouse and electrostatic precipitators.

100 meters E from the center of the domain. Simulated concentration for maximum ground level concentration for 24 hour PM10 is below the 35 ug/m³ TA Luft standards. There is no available Ambient Air Quality Standards for PM-10 in the Austal2000 report. For the PM-10 deposition, AERMOD results shows 0.00037 g/m² for 1 hour, 0.0007g/m² for 24 hour and 0.025 g/m² for 1 year deposition. There is no TALuft limit for PM10 for 1-hour in the Austal2000 report. Results are below TA Luft and WHO Air Quality Guideline Values. There are no USEPA standards in ug/Nm³ unit, the values used are converted from parts per billion by volume (ppbv). The results show insignificant increase of 0.51% for 1-hour, 0.06% for 24-hour, and 0.01% for 1-year. Reference center of the domain is the location of the Boiler Stack-1 at UTM coordinates Easting 326540 and Northing 462472.

Summary Maximum Ground Level Concentration using AERMOD

Parameters	Ave.Time	Results	German Standard (TA Luft)		USEPA	WHO Air Quality Guidelines	% of the Applicable Standards
			Conc (ug/Nm ³)	Conc (ug/Nm ³)	Deposition (g/m ²)	Conc (ug/Nm ³)	Conc (ug/Nm ³)
PM10	1 hour	0.10288	-	-	-	20	0.51
PM10	24 hour	0.02844	50	-	150	50	0.06
PM10	1 year	0.0025	40	-	50	20	0.01

SULFUR DIOXIDE (SO₂)

Predicted short term (1 hour) for controlled sulfur dioxide (SO₂) maximum ground level concentrations is 10.34 ug/m³ located 100 meters E from the center of the domain. The 24 hour controlled SO₂ maximum ground level concentrations is 2.85 ug/m³ located 100 meters E from the center of the domain. For 1-year averaging time, results of maximum concentration is 0.25302 ug/m³. Results for maximum ground level concentration for 1 hour, 24 hour and 1 year SO₂ are all below the TA Luft standards of 350 ug/m³ for 1 hour, 125 ug/m³ for 24 hr and 50 ug/m³ for 1 year respectively. There are no USEPA standards in ug/Nm³ unit, the values used are converted from parts per billion by volume (ppbv). The results show insignificant increase of 4.88% for 1-hour, 14.29% for 24-hour, and 0.32% for 1-year. Reference center of the domain is the location of the Boiler Stack-1 at UTM coordinates Easting 326540 and Northing 462472.

Summary Maximum Ground Level Concentration using AERMOD

Parameters	Ave.Time	Results	German Standard (TA Luft)		USEPA	WHO Air Quality Guidelines	% of the Applicable Standards
			Conc (ug/Nm ³)	Conc (ug/Nm ³)	Deposition (g/m ²)	Conc (ug/Nm ³)	Conc (ug/Nm ³)
SO2	1 hour	10.33980	350	-	212	-	4.88
SO2	24 hour	2.85793	125	-	365	20	14.29
SO2	1 year	0.25302	50	-	79	-	0.32

NITROGEN OXIDES (NOX)

Predicted short term (1 hour) for controlled NO₂ maximum ground level concentrations is 48.91 ug/m³ located 100 meters E from the center of the domain. The 24 hour controlled NO₂ maximum ground level concentrations is 14.16 ug/m³ located 100 meters E from the center of the domain. For 1 year averaging time, results of maximum NO₂ concentration is 2.1 ug/m³. Simulated concentration for maximum NO₂ ground level concentration for 1 year is below the TA

Luft standards of 40 ug/m3. There are no USEPA standards in parts per billion by volume (ppbv) therefore cannot be converted to ug/Nm3 unit. The results show increase of 24.46% for 1-hour, and 5.25% for 1-year if compared to WHO Air Quality Guidelines. Reference center of the domain is the location of the Boiler Stack-1 at UTM coordinates Easting 326540 and Northing 462472.

Summary Maximum Ground Level Concentration using AERMOD

Parameters	Ave. Time	Results	German Standard (TA Luft)		USEPA	WHO Air Quality Guidelines	% of the Applicable Standards
			Conc (ug/Nm3)	Conc (ug/Nm ³)	Deposition (g/m2)	Conc (ug/Nm ³)	Conc (ug/Nm ³)
NO2(Nox)	1 hour	48.91013	200	-	100 ppb	200	24.46
NO2(Nox)	24 hour	14.16085	-	-	-	-	-
NO2(Nox)	1 year	2.10000	40	-	53 ppb	40	5.25

MERCURY (HG)

Predicted short term (1 hour) for controlled mercury (Hg) maximum ground level concentrations is 0.00643 ug/m3 located 100 meters E from the center of the domain. The 24 hour controlled Hg maximum ground level concentrations is 0.00178 ug/m3 located 100 meters E from the center of the domain. For 1 year averaging time, results of maximum concentration is 0.0057 ug/m3. There are no TA Luft, USEPA standards and WHO Air Quality Guideline Values. The results show insignificant increase of 0.18% for 24-hour and 3.14% for 1-year using TA Luft standards. Reference center of the domain is the location of the Boiler Stack-1 at UTM coordinates Easting 326540 and Northing 462472.

Summary Maximum Ground Level Concentration using AERMOD

Parameters	Ave. Time	Results	German Standard (TA Luft)		USEPA	WHO Air Quality Guidelines	% of the Applicable Standards
			Conc (ug/Nm3)	Conc (ug/Nm ³)	Deposition (g/m2)	Conc (ug/Nm ³)	Conc (ug/Nm ³)
Hg	1 hour	0.00643	-	-	-	-	-
Hg	24 hour	0.00178	-	1	-	-	0.18
Hg	1 year	0.00157	-	0.05	-	-	3.14

AMMONIA (NH₃)

Predicted short term (1 hour) for controlled ammonia (NH₃) maximum ground level concentrations is 2.066 ug/m3 located 100 meters E from the center of the domain. The 24 hour controlled NH₃ maximum ground level concentrations is 0.57123 ug/m3 located 100 meters E from the center of the domain. There are no NH₃ TA Luft standards in the Austal2000 report. There are no USEPA standards and WHO Air Quality Guideline Values. Reference center of the domain is the location of the Boiler Stack-1 at UTM coordinates Easting 326540 and Northing 462472.

Summary Maximum Ground Level Concentration using AERMOD

Parameters	Ave. Time	Results	German Standard (TA Luft)		USEPA	WHO Air Quality Guidelines	% of the Applicable Standards
			Conc (ug/Nm3)	Conc (ug/Nm ³)	Deposition (g/m2)	Conc (ug/Nm ³)	Conc (ug/Nm ³)

NH3	1 hour	2.06667	-	-	-	-	-
NH3	24 hour	0.57123	-	-	-	-	-
NH3	1 year	0.00147	-	-	-	-	-

HYDROGEN CHLORIDE (HCL)

Predicted short term (1 hour) for controlled hydrogen chloride (HCl) maximum ground level concentrations is 2.066 ug/m³ located 100 meters E from the center of the domain. The 24 hour controlled NH₃ maximum ground level concentrations is 0.57123 ug/m³ located 100 meters E from the center of the domain. There are no HCl TA Luft standards in the Austal2000 report. There are no USEPA standards and WHO Air Quality Guideline Values. Reference center of the domain is the location of the Boiler Stack-1 at UTM coordinates Easting 326540 and Northing 462472.

Parameters	Ave. Time	Results	German Standard (TA Luft)		USEPA	WHO Air Quality Guidelines	% of the Applicable Standards
			Conc (ug/Nm ³)	Conc (ug/Nm ³) Deposition (g/m ²)			
HCl	1 hour	2.06667	-	-	-	-	-
HCl	24 hour	0.57123	-	-	-	-	-
HCl	1 year	0.00147	-	-	-	-	-

HYDROGEN FLOURIDE (HF)

Predicted short term (1 hour) for controlled hydrogen fluoride (HF) maximum ground level concentrations is 2.066 ug/m³ located 100 meters E from the center of the domain. The 24 hour controlled HF maximum ground level concentrations is 0.57123 ug/m³ located 100 meters E from the center of the domain. There are no HF TA Luft standards in the Austal2000 report. There are no USEPA standards and WHO Air Quality Guideline Values. Reference center of the domain is the location of the Boiler Stack-1 at UTM coordinates Easting 326540 and Northing 462472.

Parameters	Ave. Time	Results	German Standard (TA Luft)		USEPA	WHO Air Quality Guidelines	% of the Applicable Standards
			Conc (ug/Nm ³)	Conc (ug/Nm ³) Deposition (g/m ²)			
Hf	1 hour	0.20705	-	-	-	-	-
Hf	24 hour	0.05723	-	-	-	-	-
Hf	1 year	0.00015	-	-	-	-	-

DIOXINS AND FURANS (D/F)

Predicted short term (1 hour) for controlled Dioxins and Furans maximum ground level concentrations is 0.0258 ug/m³ located 100 meters E from the center of the domain. The 24 hour controlled Dioxins and Furans maximum ground level concentrations is 0.00569 ug/m³ located 100 meters E from the center of the domain. There are no Dioxins and Furans TA Luft standards in the Austal2000 report. There are no USEPA standards and WHO Air Quality Guideline Values. Reference center of the domain is the location of the Boiler Stack-1 at UTM coordinates Easting 326540 and Northing 462472.

Parameters	Ave.Time	Results	German Standard (TA Luft)		USEPA	WHO Air Quality Guidelines	% of the Applicable Standards
			Conc (ug/Nm ³)	Conc (ug/Nm ³)	Deposition (g/m ²)	Conc (ug/Nm ³)	Conc (ug/Nm ³)
D/F	1 hour	0.02058	-	-	-	-	-
D/F	24 hour	0.00569	-	-	-	-	-
D/F	1 year	0.00002	-	-	-	-	-

SUM OF HEAVY METALS AND THEIR COMPONENTS: ANTIMONY, CHROMIUM, COPPER, MANGANESE, VANADIUM, TIN, LEAD, COBALT, NICKEL (TA LUFT CLASS II AND III)

Predicted short term (1 hour) for the Sum of heavy metals and their components: antimony, chromium, copper, manganese, vanadium, tin, lead, cobalt, nickel (TA Luft class II and III) ground level concentrations is 1.3161 ug/m³ located 316 meters NorthNorthEast (NNE) from the center of the domain. The 24 hour controlled total sum of metals maximum ground level concentrations is 0.4954 ug/m³ located 141 meters NorthWest (NW) from the center of the domain. For 1 year averaging time, results of maximum concentration is 0.0982 ug/m³. Simulated concentrations for maximum ground level concentration for both 1, 24 hours & 1 Year averaging which are generally very low. Results are generally lower than US RSLs for combined 24 hr averaging for Cu, Vn, Cr and Mn of 0.152 ug/m³ and the 3 month NAAQS for Lead of 0.15 ug/m³. There is no available the Ambient Air Quality Standards for said metals in the Austal2000 Report. Reference center of the domain is the location of the Boiler Stack-1 at UTM coordinates Easting 326540 and Northing 462472.

Parameters	Ave.Time	Results	German Standard (TA Luft)		USEPA	WHO Air Quality Guidelines	% of the Applicable Standards
			Conc (ug/Nm ³)	Conc (ug/Nm ³)	Deposition (g/m ²)	Conc (ug/Nm ³)	Conc (ug/Nm ³)
Sum of Metals (Sb) ¹	1 hour	1.31607	-	-	-	-	-
Sum of Metals (Sb) ¹	24 hour	0.49540	-	-	-	-	-
Sum of Metals (Sb) ¹	1 year	0.09818	-	-	-	-	-

¹Sum of metals: Antimony, Chromium, Copper, Manganese, Vanadium, in, Lead, Cobalt, Nickel

ARSENIC / CADMIUM AND ITS COMPOUNDS (EXPRESSED AS As AND Cd), BENZO (A) PYRENE, WATER-SOLUBLE COBALT COMPOUNDS (EXPRESSED AS CO), CHROMIUM (VI) COMPOUNDS (EXPRESSED AS CR) (TA LUFT CLASS I)

Predicted short term (1 hour) for the Sum of heavy metals and their components: Arsenic / cadmium and its compounds (expressed as As and Cd), benzo (a) pyrene, water-soluble cobalt compounds (expressed as Co), chromium (VI) compounds (expressed as Cr) (TA Luft Class I) ground level concentrations is 0.13161 ug/m³ located 316 meters NorthNorthEast (NNE) from the center of the domain. The 24 hour controlled total sum of metals maximum ground level concentrations is 0.049 ug/m³ located 141 meters NorthWest (NW) from the center of the domain. For 1 year averaging time, results of maximum concentration is 0.00982 ug/m³. Simulated

concentrations for maximum ground level concentration for both 1, 24 hours & 1 Year averaging which are generally very low. Results are generally lower than the available ESL for Arsenic of 3 ug/m³ and 0.067 ug/m³ for 1 year. There is no available the Ambient Air Quality Standards for said metals in the Austal2000 Report. Reference center of the domain is the location of the Boiler Stack-1 at UTM coordinates Easting 326540 and Northing 462472.

Parameters	Ave.Time	Results	German Standard (TA Luft)		USEPA	WHO Air Quality Guidelines	% of the Applicable Standards
			Conc (ug/Nm ³)	Conc (ug/Nm ³)	Deposition (g/m ²)	Conc (ug/Nm ³)	Conc (ug/Nm ³)
Sum of Metals (As) ¹	1 hour	0.13161	-	-	-	-	-
Sum of Metals (As) ¹	24 hour	0.04954	-	-	-	-	-
Sum of Metals (As) ¹	1 year	0.00982	-	-	-	-	-

¹Sum of metals: Arsenic / cadmium and its compounds (expressed as As and Cd), benzo (a) pyrene, water-soluble cobalt compounds (expressed as Co), chromium (VI) compounds (expressed as Cr)

THALLIUM AND ITS COMPOUNDS (TA LUFT CLASS I) CADMIUM

Predicted short term (1 hour) for the Sum of heavy metals and their components: Thallium and its compounds (TA Luft class I) cadmium ground level concentrations is 0.13161 ug/m³ located 316 meters NorthNorthEast (NNE) from the center of the domain. The 24 hour controlled total sum of metals maximum ground level concentrations is 0.049 ug/m³ located 141 meters NorthWest (NW) from the center of the domain. For 1 year averaging time, results of maximum concentration is 0.00982 ug/m³. Simulated concentrations for maximum ground level concentration for both 1, 24 hours & 1 Year averaging which are generally very low. There is no available the Ambient Air Quality Standards for said metals in the Austal2000 Report and in the USEPA NAAQS, ESLs and RSLs. Reference center of the domain is the location of the Boiler Stack-1 at UTM coordinates Easting 326540 and Northing 462472.

Parameters	Ave.Time	Results	German Standard (TA Luft)		USEPA	WHO Air Quality Guidelines	% of the Applicable Standards
			Conc (ug/Nm ³)	Conc (ug/Nm ³)	Deposition (g/m ²)	Conc (ug/Nm ³)	Conc (ug/Nm ³)
Sum of Metals (Tl) ¹	1 hour	0.13161	-	-	-		
Sum of Metals (Tl) ¹	24 hour	0.04954	-	-	-		
Sum of Metals (Tl) ¹	1 year	0.00982	-	-	-		

¹Sum of metals: Thallium and its compounds and cadmium

For all the above parameters, controlled emissions have been validated to be in compliance with the TA Luft Standards as provided in the Austal2000 Report and with the USEPA standards and the WHO Air Quality Guidelines.

RESULTS

AERMOD validation of the Austal2000 model results shows slightly higher results than the Austal2000 report but still within TA Luft Standards and USEPA Standards. For the deposition results, Total Dust, SO₂, NO₂ and Hg are confirmed to be way below the 1 year TA Luft precipitation standards. Toxic heavy metal parameters such Ni, Ti, As, Cd, and Pb was excluded in the validation model due to absence of design emission data.

Based on the design emission of the proposed WTE plant, proposed stack height of 50 meters in the Austal2000 report was found to be favorable considering all predicted ground level concentrations in the AERMOD validation model are below the TA Luft and USEPA standards.

RECOMMENDATIONS

It recommended to (i) retain the four (4) ambient monitoring stations used in conducting ambient air quality in Thillafushi island for the EIA study; and (ii) put up additional ambient monitoring stations in ASR 2, ASR 3 and ASR 5 areas due to industrial facilities with workers quarters.

Background ambient air quality was not accounted in the modeling run. However given there are no potential significant sources of air pollution (such as mobile, area, line sources, community and other air-pollutant emitting industries) near the WTE plant, the results of both the Austal2000 and AERMOD models are generally acceptable and can be seen as below TA Luft and USEPA Standards. However, it is highly recommended to conduct a validation run after 1 to 3 months during operations stage using actual CEMS, stack testing, and ambient air monitoring results.

1. BACKGROUND INFORMATION

Atmospheric dispersion modeling is the mathematical simulation of how air pollutants disperse in the ambient atmosphere. The dispersion models are used to estimate the downwind ambient concentration of air pollutants emitted from sources. They can also be used to predict future concentrations under specific scenarios (i.e. changes in emission sources) and are most useful for pollutants that are dispersed over large distances and that may react in the atmosphere. advanced dispersion modeling programs include a pre-processor module for the input of meteorological and other data, and many also include a post-processor module for graphing the output data and/or plotting the area impacted by the air pollutants on maps. The plots of areas impacted may also include isopleths showing areas of minimal to high concentrations that define areas of the highest health risk. The isopleths plots are useful in determining protective actions for the public and responders.

Objectives of This Study²

The objectives of this validation studies are: (i) evaluation of Austal2000 model conducted as part of the EIA study; (ii) compare results with relevant TA Luft and USEPA standards and guidelines; and (iii) identify and forecast levels of relevant pollutants at different area sensitive receptors (ASRs) in Thillafushi to assess effects of air quality with regards to human health, risks and environment.

Component of the WTE Plant³

The WTE plant shall be designed and built as a conventional state-of-the-art grate type incinerator of two lines of 250 Mg/d each (total of 500 Mg/d), that shall consist of the following main set of process units and plant components:

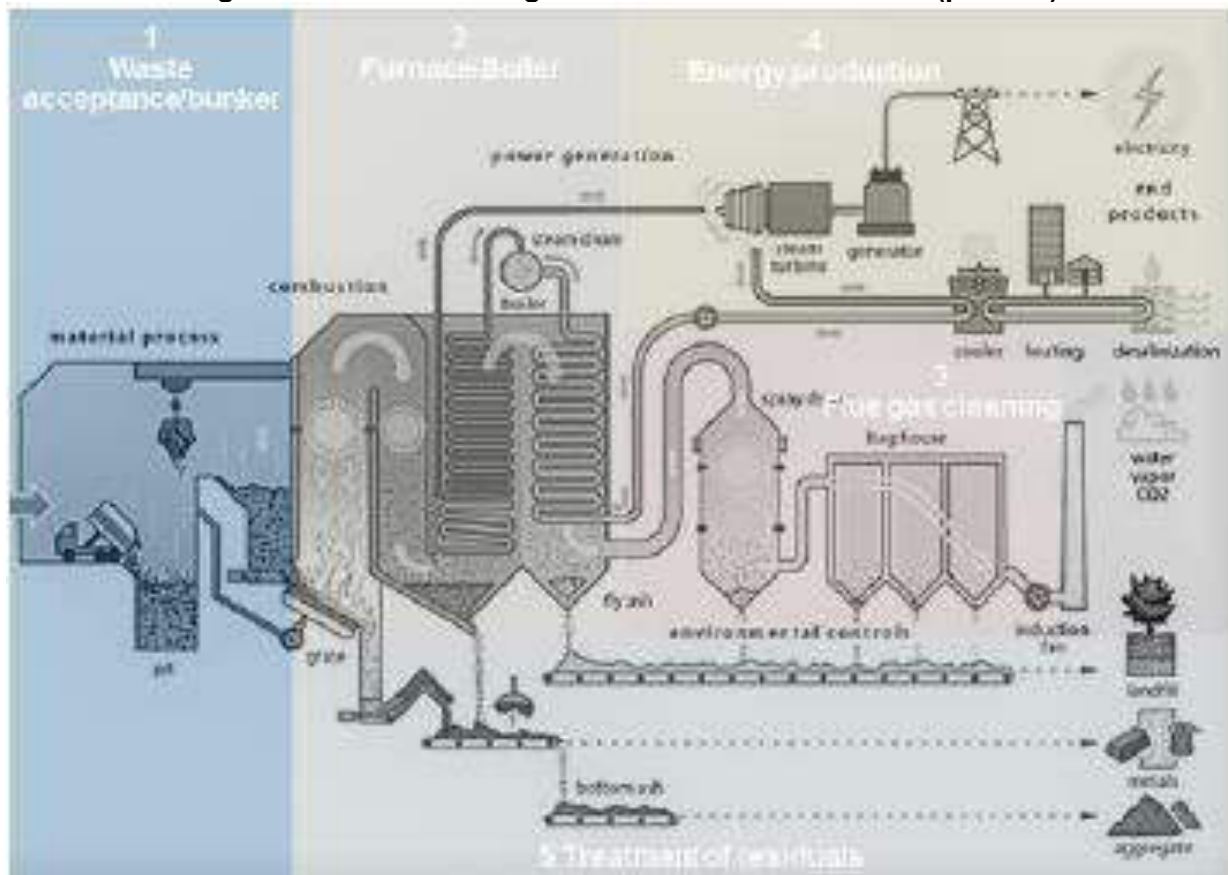
- a) Waste reception, storage and feeding consisting of a weigh bridge incl. guard house, tipping hall and waste bunker, a shredder and waste cranes;
- b) Thermal treatment consisting of combustion system; boiler and heat recovery system and boiler feed water and make-up water system;
- c) Air pollution control (APC) system and ID fan and stack and continuous emission monitoring system (CEMS);
- d) Turbine with generator and condenser, cooling water pre-treatment system and cooling water pumps;
- e) Other balance of plant components incl. fuel and chemicals supply and storage; fire-fighting water supply system; wastewater treatment plant for sewerage, water supply system;
- f) Bottom ash treatment plant incl. bottom ash bunker and conveying system;
- g) Residue sanitary landfill and leachate collection, management and treatment system;
- h) Electric system incl. connection to public network

All process units and the balance of plant components are to be equipped with necessary electrical and control components, with valves, fittings, piping, utility mains etc. and shall be combined to a fully functional system that is fit for purpose and that is operated and controlled by a **DCS** which shall facilitate monitoring and recording of operational data.

² Greater Male' Waste to Energy Project Environmental (EIA) Waste to Energy Facility in Thilafushi

³ Greater Male' Waste to Energy Project Environmental (EIA) Waste to Energy Facility in Thilafushi

Figure 1: Schematic Diagram of the WTE Plant Boiler (per line)



2. The Study Area

The WTE plant will be located on a 27 hectares government-owned land, of which 15 hectares have been reclaimed from shallow lagoon in Thilafushi island. It is on the southern rim of North Malé atoll, and on the eastern line of atolls within the archipelago. Thilafushi is located 9.5 km from Malé. In terms of geographic coordinates, it is located at 04° 11' 00" N and 73° 26' 44" E. The nearest inhabited island is Villingili, approximately 7.1 km east of Thilafushi.

3. Air Pollutants of Concern

Particulate Matter Emissions (PM)

Particulate matter (PM) can vary greatly in size with diameters ranging from less than 1 micrometer to hundreds of micrometers (μm). Fine particulates, having diameters less than $10\mu\text{m}$ (known as PM-10), are of increased concern because a greater potential for inhalation and passage into the pulmonary region exists. Further, acid gases, metals, and toxic organics may preferentially adsorb onto particulates in this size range. Particulate emissions may be categorized as either filterable or condensable. Filterable emissions are generally considered to be the particles that are trapped by the glass fiber filter in the front half of USEPA Reference Method 5 or Method 17. Vapors and particles less than 0.3 microns pass through the filter. Condensable particulate matter is material that is emitted in the vapor state which later condenses

to form homogeneous and/or heterogeneous aerosol particles. The condensable particulate emitted from boilers is primarily inorganic in nature.

The level of PM at the inlet of the APC SYSTEM will vary according the combustor design, air distribution, waste characteristics, and the combustor's operation. Under normal combustion conditions, solid fly ash particulates formed from inorganic, noncombustible constituents in MSW are released into the flue gas. Most of this particulate is captured by the facility's APC system and are not emitted to the atmosphere.

Carbon Monoxide Emissions (CO)

The presence of carbon monoxide (CO) in the exhaust gases of combustion systems results principally from incomplete fuel combustion. High levels of CO indicate that the combustion gases were not held at a sufficiently temperature in the presence of oxygen (O₂) for a long enough time to convert CO to carbon dioxide (CO₂). Several conditions can lead to incomplete combustion, including insufficient oxygen (O₂) availability; poor fuel/air mixing; cold-wall flame quenching; reduced combustion temperature; decreased combustion gas residence time; and load reduction (i.e., reduced combustion intensity).

By controlling the combustion process carefully, CO emissions can be minimized. Thus, if a unit is operated improperly or not well maintained, the resulting concentrations of CO (as well as organic compounds) may increase by several orders of magnitude. Smaller boilers, heaters, and furnaces tend to emit more of these pollutants than larger combustors. This is because smaller units usually have a higher ratio of heat transfer surface area to flame volume than larger combustors have; this leads to reduced flame temperature and combustion intensity and, therefore, lower combustion efficiency.

Since various combustion modifications for NO_x reduction can produce one or more of the mentioned conditions, the possibility of increased CO emissions is a concern for environmental, energy efficiency, and operational reasons.

Nitrogen Oxides Emissions (NO_x)

Oxides of nitrogen (NO_x) formed in combustion processes are due either to thermal fixation of atmospheric nitrogen in the combustion air ("thermal NO_x"), or to the conversion of chemically-bound nitrogen in the fuel ("fuel NO_x"). The term NO_x refers to the composite of nitric oxide (NO) and nitrogen dioxide (NO₂). Test data have shown that for most external fossil fuel combustion systems, over 95 percent of the emitted NO_x is in the form of nitric oxide (NO). Nitrous oxide (N₂O) is not included in NO_x but has recently received increased interest because of atmospheric effects. The formation of thermal NO_x is affected by four factors: (1) peak temperature, (2) fuel nitrogen concentration, (3) oxygen concentration, and (4) time of exposure at peak temperature. The emission trends due to changes in these factors are generally consistent for all types of boilers: an increase in flame temperature, oxygen availability, and/or residence time at high temperatures leads to an increase in NO_x production.

Conversion of nitrogen in the waste occurs at relatively low temperatures (less than 109 °C), while fixation of atmospheric nitrogen occurs at higher temperatures. Because of the relatively low temperatures at which WTE plants operate, 70 to 80% of NO formed is associated with nitrogen in the waste.⁴

⁴ USEPA AP 42- Chapter 2.1 Refuse Combustion

Sulfur Oxides Emissions (SOX)

Sulfur oxides (SOx) emissions are generated during combustion from the oxidation of sulfur contained in the fuel. The emissions of SOx are predominantly in the form of SO₂. Uncontrolled SOx emissions are almost entirely dependent on the sulfur content of the fuel and are not affected by boiler size, burner design, or grade of fuel being fired. On average, more than 95% of the sulfur content in the municipal solid waste is converted to SO₂, about 1% to 5% is further oxidized to sulfur trioxide (SO₃), and 1% to 3% is emitted as sulfate particulate. SO₃ readily reacts with water vapor (both in the atmosphere and in flue gases) to form a sulfuric acid mist.

Metals Emissions and Acid Gases

Metals are present in a variety of municipal solid waste streams are emitted from WTE plant in association with PM (e.g., arsenic [As], Cd, chromium [Cr], and Pb) and as vapors, such as Hg. Due to the variability in municipal solid waste composition, metal concentrations are highly variable and are essentially independent of combustor type. If the vapor pressure of a metal is such that condensation onto particulates in the flue gas is possible, the metal can be effectively removed by the PM control device. Except for mercury (Hg), most metals have sufficiently low vapor pressures which result in almost all of the metals being condensed. Therefore, removal in the PM control device for these metals is generally greater than 98%. Hg, on the other hand, has a high vapor pressure, but the level of carbon in the fly ash appears to affect the level of Hg control. A high level of carbon in the fly ash can enhance Hg adsorption onto particles. Hg can be removed in a typical APC system controlling the operating temperature and by the PM control device.⁵

The chief acid gases of concern from WTE plants are hydrochloric acid (HCl) and sulfuric acid (H₂SO₄) from SO₂. Hydrogen fluoride (HF), hydrogen bromide (HBr), and sulfur trioxide (SO₃) are also generally present, but at much lower concentrations. Concentrations of HCl and H₂SO₄ in flue gases directly relate to the chlorine and sulfur content in the municipal solid waste the availability of alkali materials in combustion-generated fly ash that act as sorbents, and the type of APC system used. Acid gas concentrations are considered to be independent of combustion conditions.

Greenhouse Gases

WTE plants involve generation of climate-relevant emissions such as CO₂ (carbon dioxide) as well as N₂O (nitrous oxide), N₂O, ammonia (NH₃) and organic carbon, measured as total carbon. Methane (CH₄) is not generated in a WTE plant during normal operation. It only arises, in exceptional cases and to a small extent (from waste remaining in the waste bunker), therefore that in quantitative terms CH₄ is not to be regarded as climate relevant.

CO₂ constitutes the chief climate-relevant emission of WTE plant. A WTE plant of 1 Mg of municipal solid waste is associated with the production/release of about 0.7 to 1.2 Mg of CO₂ output. The proportion of carbon of biogenic origin is usually in the range of 33% to 50%. The climate-relevant CO₂ emissions from WTE plants are determined by the proportion of waste whose carbon compounds are assumed to be of fossil origin. The allocation to fossil or biogenic carbon has a crucial influence on the calculated amounts of climate-relevant CO₂ emissions. An energy transformation efficiency equal to or greater than about 25% results in an allowable

⁵ USEPA AP 42- Chapter 2.1 Refuse Combustion

average substituted net energy potential that renders the emission of WTE plants (calculated as CO₂ equivalents) climate-neutral due to the emission credits from the power plant mix.⁶

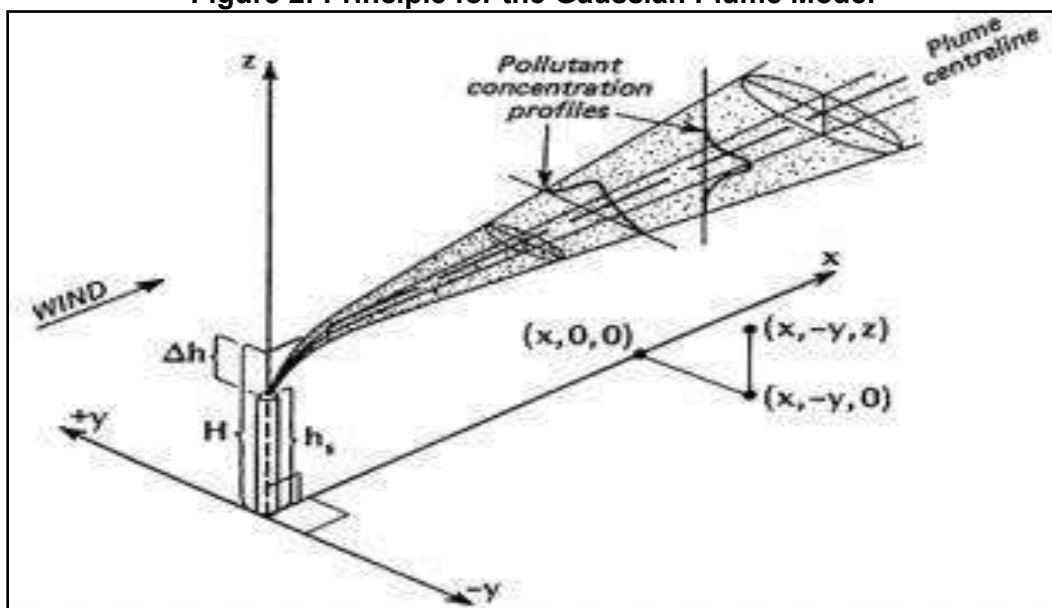
The Air Dispersion Model

Gaussian plume model

Gaussian plume model uses a realistic description of dispersion, where it represents an analytical solution to the diffusion equation for idealized circumstances. The model assumes that the atmospheric turbulence is both stationary and homogeneous. The model is the method of choice for many, especially for the prediction of yearly averaged concentration. It is the most widely used plume model and is the basis for most of the computer models distributed by the USEPA.

In the Gaussian plume dispersion model the concentration of pollution downwind from a source is treated as spreading outward from the centerline of the plume following a normal statistical distribution. The plume spreads in both the horizontal and vertical directions (Figure 2).

Figure 2: Principle for the Gaussian Plume Model



In the model, determining the pollutant concentrations at ground-level beneath an elevated plume involves two main steps:

- (i) first, the height to which the plume rises at a given downwind distance from the plume source is calculated. The calculated plume rise is added to the height of the plume's source point to obtain the so-called "effective stack height"
- (ii) second, the ground-level pollutant concentration beneath the plume at the given downwind distance is predicted using the Gaussian dispersion equation.

The Gaussian dispersion equation can be written as Figure 3:

⁶ Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, paper was written by Mr. Bernt Johnke (Germany) and reviewed by Robert Hoppaus (IPCC/OECD/IEA), Eugene Lee (US), Bill Irving (USEPA), T. Martinsen (IPCC/OECD/IEA), and K. Mareckova (IPCC/OECD/IEA).

Figure 3: Gaussian Dispersion Equation

$$C(x, y, z) = \frac{Q}{2\pi\sigma_y\sigma_z u} \exp\left(-\frac{y^2}{2\sigma_y^2}\right) \times \left\{ \exp\left(-\frac{(z-H)^2}{2\sigma_z^2}\right) + \exp\left(-\frac{(z+H)^2}{2\sigma_z^2}\right) \right\}$$

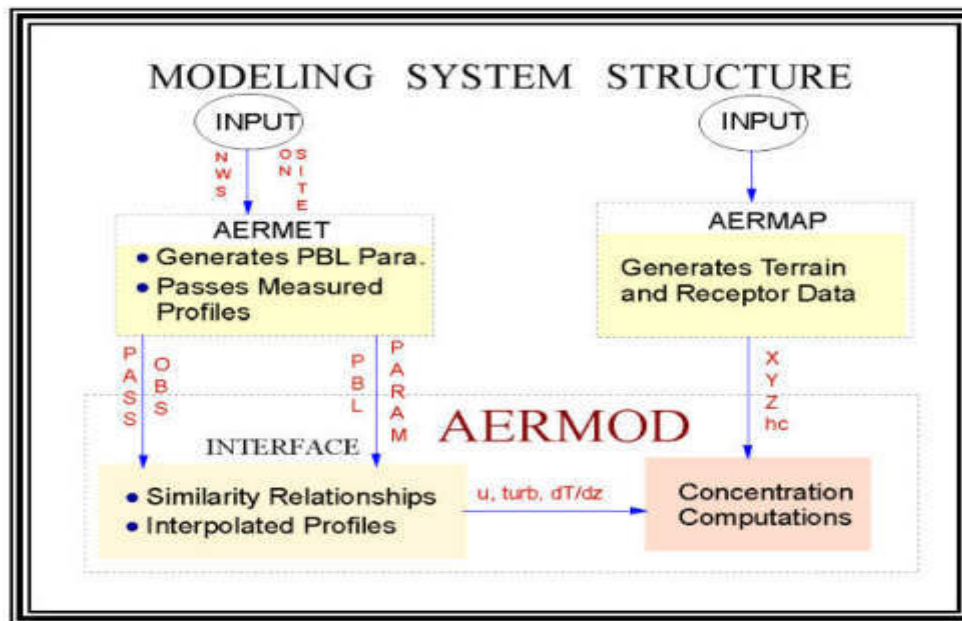
Where	C	=	concentration
	Q	=	emission rate of the pollutant from the source
	u	=	wind speed which defines the direction
	x, y	=	horizontal distance perpendicular to the wind direction
	z	=	vertical direction
	h _s	=	Height of the source
	H	=	effective height of the plume (considering the additional height Δh to which the hot gases rise above the physical height of the source, h _s); i.e., H = h _s + Δh
	σ _y , σ _z	=	parameters of the normal distributions in y and z directions, usually called the dispersion coefficients in y and z directions respectively

AERMOD Modeling System

The American Meteorological Society/Environmental Protection Agency Regulatory Model Improvement Committee (AERMIC) was formed to introduce state-of-the-art modeling concepts into the USEPA's air quality models. Through AERMIC, a modeling system, AERMOD, was introduced that incorporated air dispersion based on planetary boundary layer turbulence structure and scaling concepts, including treatment of both surface and elevated sources, and both simple and complex terrain.

There are two input data processors that are regulatory components of the AERMOD modeling system: AERMET, a meteorological data pre-processor that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, and AERMAP, a terrain data pre-processor that incorporates complex terrain using United States Geological Survey (USGS) Digital Elevation Data.

Figure 4: Data flow in AERMOD Modeling System



AERMOD is a steady-state plume model. In the stable boundary layer (SBL), it assumes the concentration distribution to be Gaussian in both the vertical and horizontal. In the convective boundary layer (CBL), the horizontal distribution is also assumed to be Gaussian, but the vertical distribution is described with a bi-Gaussian probability density function (pdf). This behavior of the concentration distributions in the CBL was demonstrated by Willis and Deardorff (1981) and Briggs (1993). Additionally, in the CBL, AERMOD treats “plume lofting,” whereby a portion of plume mass, released from a buoyant source, rises to and remains near the top of the boundary layer before becoming mixed into the CBL.

AERMOD also tracks any plume mass that penetrates the elevated stable layer, and then allows it to re-enter the boundary layer when and if appropriate. Using a relatively simple approach, AERMOD incorporates current concepts about flow and dispersion in complex terrain. Where appropriate the plume is modeled as either impacting and/or following the terrain. This approach has been designed to be physically realistic and simple to implement while avoiding the need to distinguish among simple, intermediate and complex terrain, as required by other regulatory models. As a result, AERMOD removes the need for defining complex terrain regimes. All terrain is handled in a consistent and continuous manner while considering the dividing streamline concept (Snyder et al. 1985) in stably stratified conditions.

Meteorology in the Study Area - Wind Rose

The prevailing wind over the Maldives represents typical Asian monsoonal characteristics. It follows the traditional definition of monsoon as seasonal reversal of wind direction by more than 120° between the months January and July. Looking at annual variations, westerly winds are predominant throughout the country, varying between west-southwest and west-northwest.⁷

⁷ Consultancy Services for Feasibility Study for an Integrated Solid Waste Management System for Zone III and Prepare Engineering Design of the Regional Waste Management Facility at Thilafushi

The southwest monsoon, with winds predominantly between SW and NW, lasts from May to October. In May and June, winds are mainly from WSW to WNW, and in July to October, winds between W and NW predominate. The northeast monsoon, with winds predominantly from NE to E, lasts from December to February. During March and April, winds are variable. During November, winds are primarily from the west, becoming variable and can occasionally exceed 30 knots from the NE sector. However, yearly wind speed in the northeast and southwest monsoons are observed to be between 9-13 knots.

As part of the recent update to the USEPA Guideline on Air Quality Models (EPA,2017), the use of prognostic data is allowed for regulatory applications of AERMOD where it is cost-prohibitive or not feasible to collect site-specific data and there is no representative weather data or comparable station nearby. EPA developed the Mesoscale Model Interface Program, or MMIF for processing prognostic meteorological data for AERMOD (Environ, 2014).

For the study area, meteorological data was obtained from Lakes Environmental https://www.weblakes.com/services/met_data.html which employs the Weather Research and Forecasting (WRF) model⁸ to compute accurate wind fields and provide modeled meteorological data. The data is obtained by running the Fifth-Generation Penn State/NCAR Mesoscale Model (MM5)⁹ prognostic meteorological model for a specified location and site domain. Once the MM5 pre-processing has been completed, the MM5 output file is converted into a format recognized by the AERMET model. The final output is generated by creating a pseudo met-station at the specified site location.

Below is the frequency distribution and wind rose of Maldives for 2018 based on MM5 AERMET processed prognostic meteorological data.

⁸ Weather Research and Forecasting (WRF) model is a numerical weather prediction (NWP) system designed to serve both atmospheric research and operational forecasting needs. NWP refers to the simulation and prediction of the atmosphere with a computer model, and WRF is a set of software for this. WRF features two dynamical (computational) cores (or solvers), a data assimilation system, and a software architecture allowing for parallel computation and system extensibility. The model serves a wide range of meteorological applications across scales ranging from meters to thousands of kilometres. WRF can produce simulations based on actual atmospheric conditions (i.e., from observations and analyses) or idealized conditions.

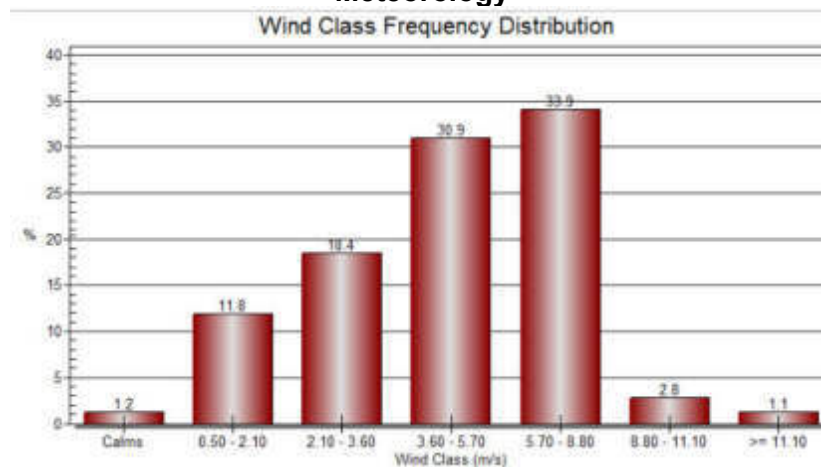
⁹ It is a community model maintained by Penn State University and the National Center for Atmospheric Research. The MM5 is a limited-area, terrain-following sigma coordinate model that is used to replicate or forecast mesoscale and regional scale atmospheric circulation.

Table 1: Wind Direction Frequency Diagram for Maldives, 2018

	Directions / Wind Classes (m/s)	0.50 - 2.10	2.10 - 3.60	3.60 - 5.70	5.70 - 8.80	8.80 - 11.10	>= 11.10	Total
1	346.75 - 11.25	0.00502	0.00400	0.00731	0.00342	0.00000	0.00000	0.01975
2	11.25 - 33.75	0.00662	0.00628	0.01370	0.01199	0.00000	0.00000	0.03858
3	33.75 - 56.25	0.00765	0.01267	0.02500	0.01450	0.00137	0.00000	0.06119
4	56.25 - 78.75	0.00947	0.01267	0.02078	0.00970	0.00000	0.00000	0.05263
5	78.75 - 101.25	0.00811	0.01370	0.01290	0.00571	0.00000	0.00000	0.04041
6	101.25 - 123.75	0.00788	0.00993	0.00422	0.00285	0.00000	0.00011	0.02500
7	123.75 - 146.25	0.00639	0.00868	0.00685	0.00126	0.00000	0.00000	0.02317
8	146.25 - 168.75	0.00377	0.00742	0.01016	0.00354	0.00000	0.00000	0.02489
9	168.75 - 191.25	0.00491	0.00856	0.01587	0.00537	0.00000	0.00000	0.03470
10	191.25 - 213.75	0.00514	0.01438	0.02078	0.01769	0.00000	0.00000	0.05799
11	213.75 - 236.25	0.00913	0.01781	0.03185	0.05342	0.00148	0.00000	0.11370
12	236.25 - 258.75	0.00856	0.01747	0.04075	0.08950	0.01005	0.00616	0.17249
13	258.75 - 281.25	0.01005	0.01564	0.04669	0.06815	0.01107	0.00457	0.15616
14	281.25 - 303.75	0.00902	0.01450	0.02443	0.03779	0.00342	0.00034	0.08950
15	303.75 - 326.25	0.00970	0.01221	0.01975	0.00936	0.00011	0.00000	0.05114
16	326.25 - 348.75	0.00628	0.00788	0.00753	0.00502	0.00000	0.00000	0.02671
	Sub-Total	0.11769	0.18379	0.30856	0.33927	0.02751	0.01119	0.98801
	Calms							0.01199
	Missing/Incomplete							0.00000
	Total							1.00

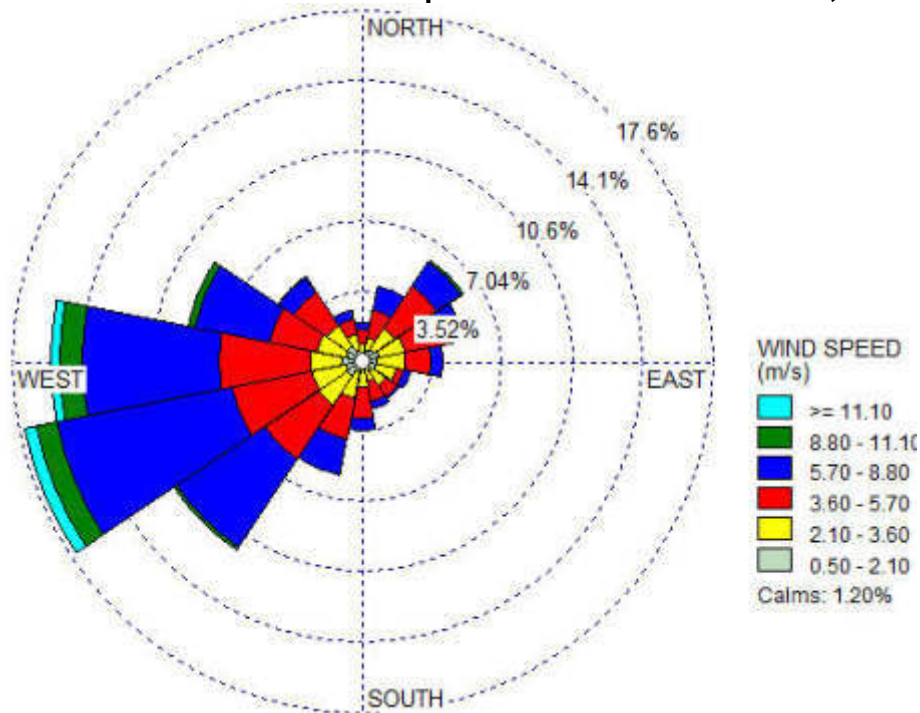
* Reference bearing CW 90°

Figure 5: MM5 Frequency Distribution of Wind Speed and Direction 2018 Maldives Meteorology



Windrose diagram generated using WRPlot view Version 5.8 software which utilizes SCRAM (.DAT) files. Wind direction was oriented in "Blowing from" configuration. Figure 6 presents the annual wind rose diagram at Maldives Synoptic Station.

Figure 6: MM5 Annual Wind Rose Wind Speed and Direction Windrose, 2018 Maldives



Meteorological data such as stability classes and wind speeds, mixing height, cloud cover among other are considered this model run. TIER 3 meteorological data was used.

AERMET meteorological processor (EPA, 2018a) was applied to prepare the meteorological data for the AERMOD model (EPA, 2018b). Values for three surface characteristics: surface roughness length $\{z_0\}$,¹⁰ albedo $\{r\}$,¹¹ and Bowen ratio $\{Bo\}$ ¹² were determined.

¹⁰ The surface roughness length is related to the height of obstacles to the wind flow and is, in principle, the height at which the mean horizontal wind speed is zero based on a logarithmic profile. The surface roughness length influences the surface shear stress and is an important factor in determining the magnitude of mechanical turbulence and the stability of the boundary layer.

¹¹ The albedo is the fraction of total incident solar radiation reflected by the surface back to space without absorption.

¹² The daytime Bowen ratio, an indicator of surface moisture, is the ratio of sensible heat flux to latent heat flux and is used for determining planetary boundary layer parameters for convective conditions driven by the surface sensible heat flux.

Figure 7: MM5 Surface Meteorology (SFC)

File Header Data

Surface File Name: AER_HAZZ2_SAGUR/SFC

Station Latitude: 4.000N Upper Air Station ID: 1 Grids Station ID: NA

Station Longitude: 8.000W Surface Station ID: 1 Version: 14134 CCV0_SUB_TEMP_SUB

Filter: Year: All Month: All Day: All Julian Day: All [Show All]

Date Quality: Data: 73% (hours) 0.21 (%) Missing: 24 (hours) 0.27 (%)

Year	Month	Day	Julian Day	Hour	Sensible Heat Flux (W/m ²)	Surface Friction Velocity (m/s)	Convective Velocity Scale (m/s)	Vertical Potential Temperature Gradient above PBL (K)	Height of Convectively-Generated Boundary Layer - PBL (m)	Height of Mechanically-Generated Boundary Layer - SBL (m)	Monte-Carlo Length (m)	Surface Roughness Length (m)	Brown Rate	Albedo	Wind Speed - Ws (m/s)	Wind Direction - Wd (degrees)	Reference Height for Ws and Wd (m)	Temperature - temp (K)	Reference Height for temp (m)	Precipitation Code
Min	2004	Jan	1	1	-889.0	-9.000	-9.000	-9.000	-889.0	-889.0	-99999.0	1.000	2.00	1.00	0.00	0.0	10.0	295.1	-9.0	0
Max	2004	Dec	31	24	397.6	0.585	2.826	0.005	4000.0	1934.0	8888.0	1.000	2.00	1.00	899.00	899.0	10.0	899.0	2.0	0

Graph

1	2004	Jan	1	1	-889.0	-9.000	-9.000	-9.000	-889.0	-889.0	-99999.0	1.000	2.00	1.00	0.00	0.0	10.0	301.1	2.0	0
2	2004	Jan	1	2	-889.0	-9.000	-9.000	-9.000	-889.0	-889.0	-99999.0	1.000	2.00	1.00	0.00	0.0	10.0	301.1	2.0	0
3	2004	Jan	1	3	-21.5	0.294	-9.000	-9.000	-889.0	302.0	88.0	1.000	2.00	1.00	2.10	144.0	10.0	301.1	2.0	0
4	2004	Jan	1	4	-45.7	0.493	-9.000	-9.000	-889.0	332.0	237.3	1.000	2.00	1.00	3.10	143.0	10.0	301.1	2.0	0
5	2004	Jan	1	5	-36.3	0.504	-9.000	-9.000	-889.0	353.0	318.9	1.000	2.00	1.00	3.10	142.0	10.0	301.1	2.0	0
6	2004	Jan	1	6	-36.3	0.504	-9.000	-9.000	-889.0	353.0	318.9	1.000	2.00	1.00	3.10	142.0	10.0	301.1	2.0	0
7	2004	Jan	1	7	-38.8	0.500	-9.000	-9.000	-889.0	348.0	282.0	1.000	2.00	1.00	3.10	145.0	10.0	301.1	2.0	0
8	2004	Jan	1	8	20.4	0.558	0.388	0.005	50.0	899.0	-397.9	1.000	2.00	0.32	3.10	163.0	10.0	301.1	2.0	0
9	2004	Jan	1	9	126.1	0.587	1.272	0.005	570.0	1070.0	-141.2	1.000	2.00	0.21	3.10	157.0	10.0	301.1	2.0	0
10	2004	Jan	1	10	202.1	0.662	1.676	0.005	840.0	1124.0	-97.9	1.000	2.00	0.19	3.10	161.0	10.0	301.1	2.0	0
11	2004	Jan	1	11	214.2	0.606	1.901	0.005	1067.0	1131.0	-63.0	1.000	2.00	0.17	3.10	164.0	10.0	301.1	2.0	0
12	2004	Jan	1	12	187.8	0.603	1.833	0.005	1324.0	1123.0	-98.0	1.000	2.00	0.16	3.10	170.0	10.0	301.1	2.0	0
13	2004	Jan	1	13	237.2	0.611	2.162	0.005	1541.0	1145.0	-86.0	1.000	2.00	0.16	3.10	163.0	10.0	301.1	2.0	0

Figure 8: MM5 Surface Meteorological Data MM5

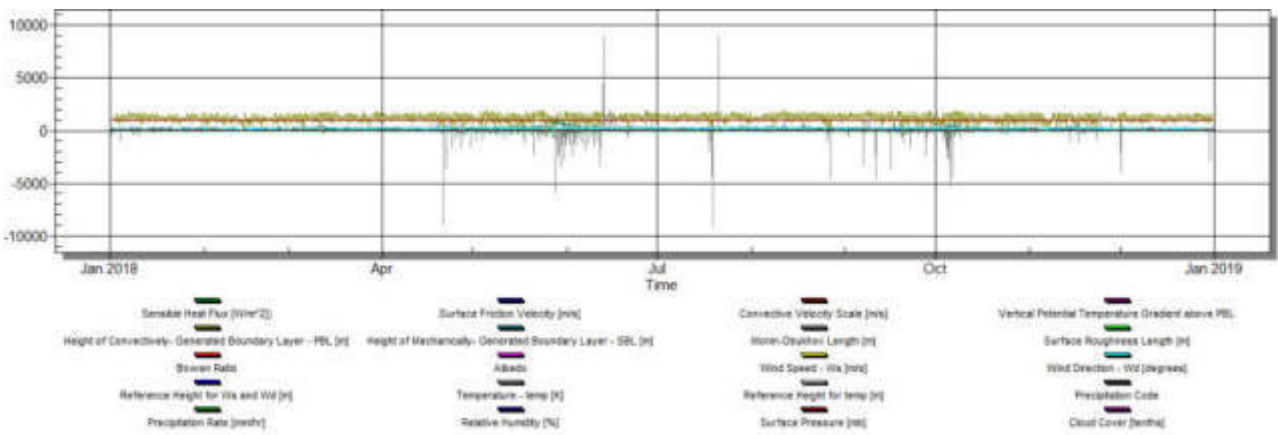


Figure 9: MM5 Profile Meteorology (PFL)

Filter
 Year: All Month: All Day: All

Table Graph

	Year	Month	Day	Hour	Measurement Height [m]	1, if this is the last (highest) level for this hour, or 0 otherwise	Direction the wind is blowing from for the current level [degrees]	Wind Speed for the current level [m/s]	Temperature at the current level [C]	Standard deviation of the wind direction fluctuations [degrees]	Standard deviation of the vertical wind speed fluctuations [m/s]
Min.	2004	Jan	1	1	10.0	1	0.0	0.00	22.0	99.0	99.00
Max.	2004	Dec	31	24	10.0	1	999.0	999.00	99.9	99.0	99.00
Graph					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2004	Jan	1	1	10.0	1	0.0	0.00	28.0	99.0	99.00
2	2004	Jan	1	2	10.0	1	0.0	0.00	28.0	99.0	99.00
3	2004	Jan	1	3	10.0	1	144.0	2.10	28.0	99.0	99.00
4	2004	Jan	1	4	10.0	1	143.0	3.10	28.0	99.0	99.00
5	2004	Jan	1	5	10.0	1	143.0	3.10	28.0	99.0	99.00
6	2004	Jan	1	6	10.0	1	142.0	3.10	28.0	99.0	99.00
7	2004	Jan	1	7	10.0	1	145.0	3.10	28.0	99.0	99.00
8	2004	Jan	1	8	10.0	1	183.0	3.10	28.0	99.0	99.00
9	2004	Jan	1	9	10.0	1	157.0	3.10	28.0	99.0	99.00
10	2004	Jan	1	10	10.0	1	161.0	3.10	28.0	99.0	99.00
11	2004	Jan	1	11	10.0	1	184.0	3.10	28.0	99.0	99.00
12	2004	Jan	1	12	10.0	1	176.0	3.10	28.0	99.0	99.00
13	2004	Jan	1	13	10.0	1	183.0	3.10	28.0	99.0	99.00
14	2004	Jan	1	14	10.0	1	179.0	3.10	28.0	99.0	99.00
15	2004	Jan	1	15	10.0	1	322.0	3.10	28.0	99.0	99.00
16	2004	Jan	1	16	10.0	1	324.0	3.10	28.0	99.0	99.00
17	2004	Jan	1	17	10.0	1	321.0	3.10	28.0	99.0	99.00
18	2004	Jan	1	18	10.0	1	357.0	3.10	28.0	99.0	99.00
19	2004	Jan	1	19	10.0	1	4.0	3.10	28.0	99.0	99.00

Figure 10: MM5 Profile Meteorological Data (PFL)

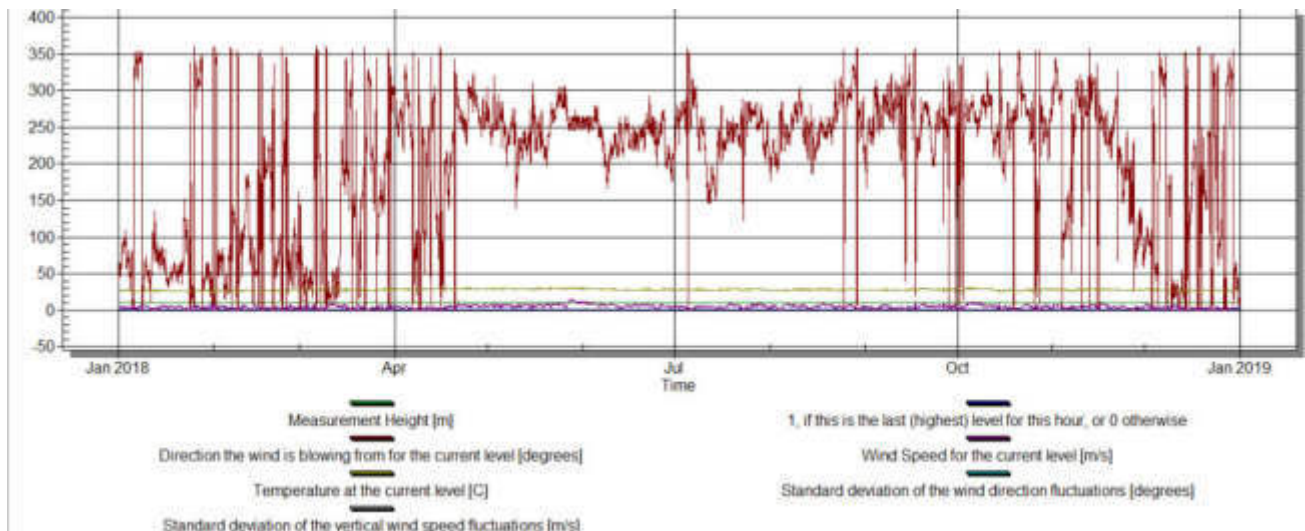
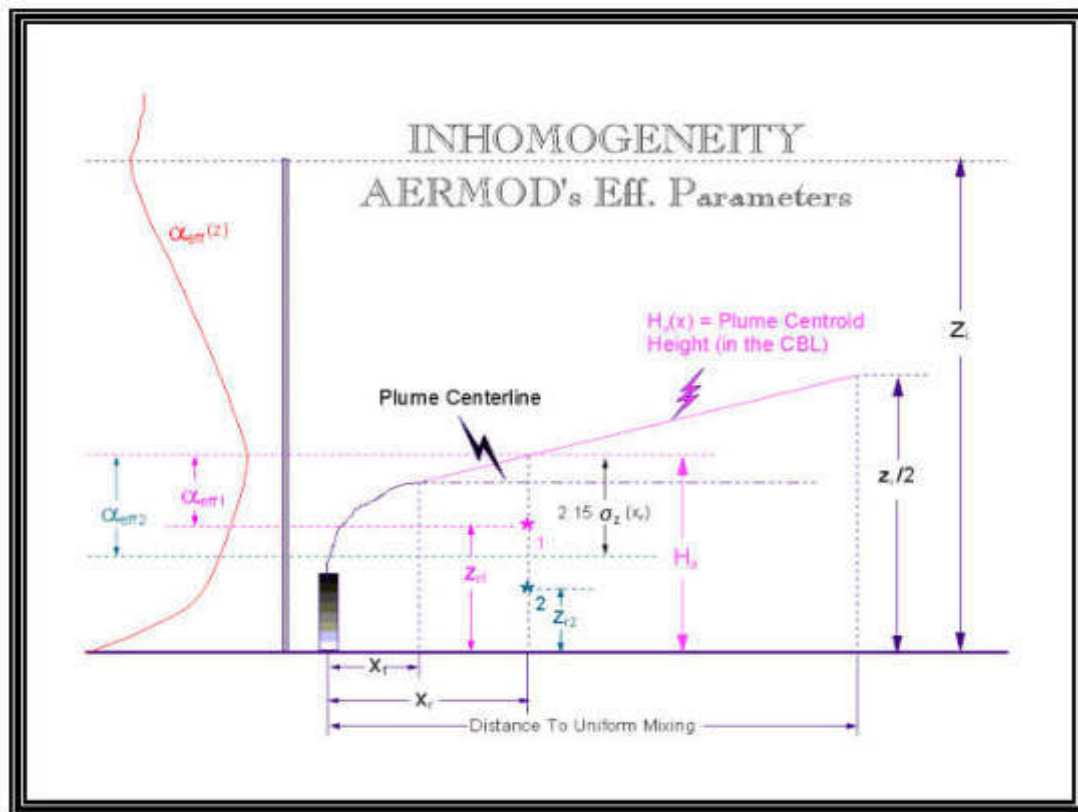


Figure 11: AERMOD Treatment of Boundary Parameters



Model Receptor Grid (Model Domain) and Grid Coordinates

The extent of the grid was chosen to include any regions of sensitive or important receptors such as residential areas and should also be sufficiently large to capture peak downwind pollutant predictions. For sources emitting pollutants close to ground level, the maximum ground-level concentration will be close to the source. However, for stack sources, the maximum ground-level concentration can be some distance away, and the model may have to be run more than once with increasing grid ranges to make sure the peak is captured.

The WTE plan stack 1 (designated as origin) is assigned with coordinates 0,0 m and all site measurements can relate to this benchmark. All facility buildings and sources could then be related spatially to this origin.

Model domain covers 4,000 meters by 4,000 meters with 100 meter grid spacing. This is to cover area sensitive receptors (ASRs) near the WTE plant site and in Thilafushi. Center of the model domain is based on the location of the WTE plant's of 250 TPD boilers (2 units) and 0.8 mW diesel generator set. Figures 12 to 14 show the model domain.

Figure 12: Domain of AERMOD Dispersion Modeling



Figure 13: 4 km X 4 km Model Domain (100 x 100 meters grid)

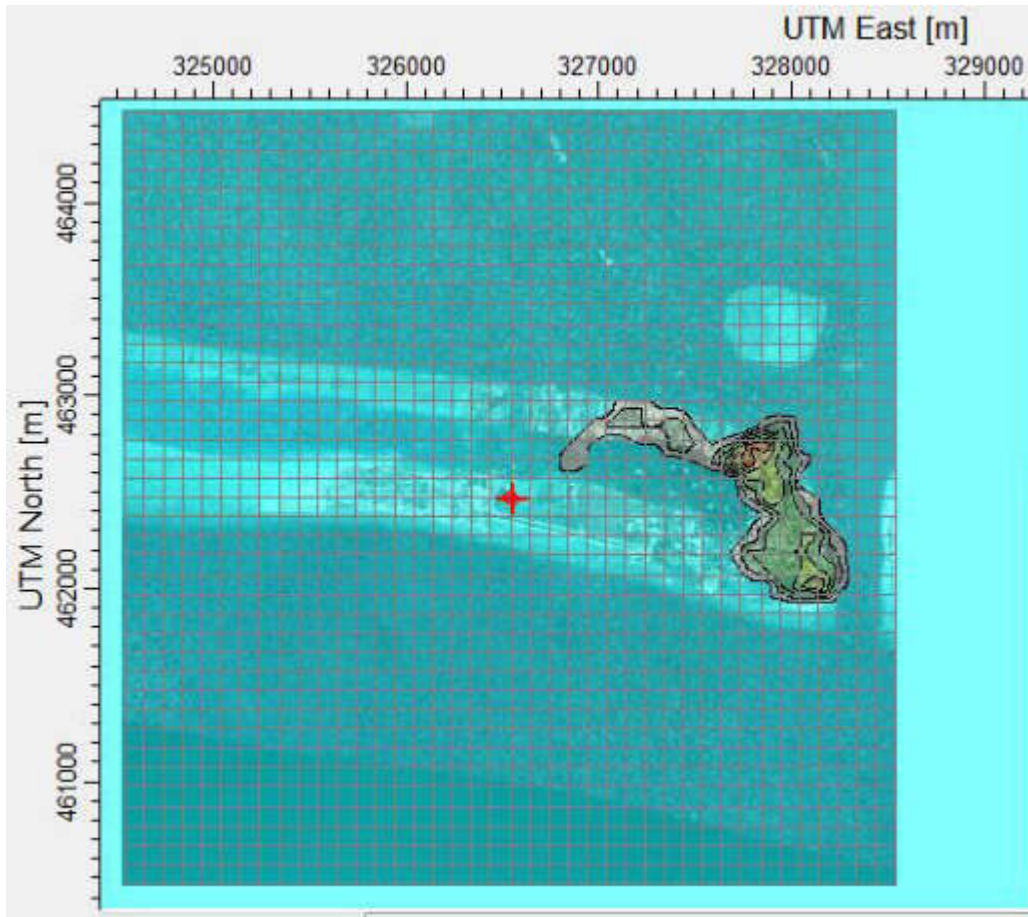
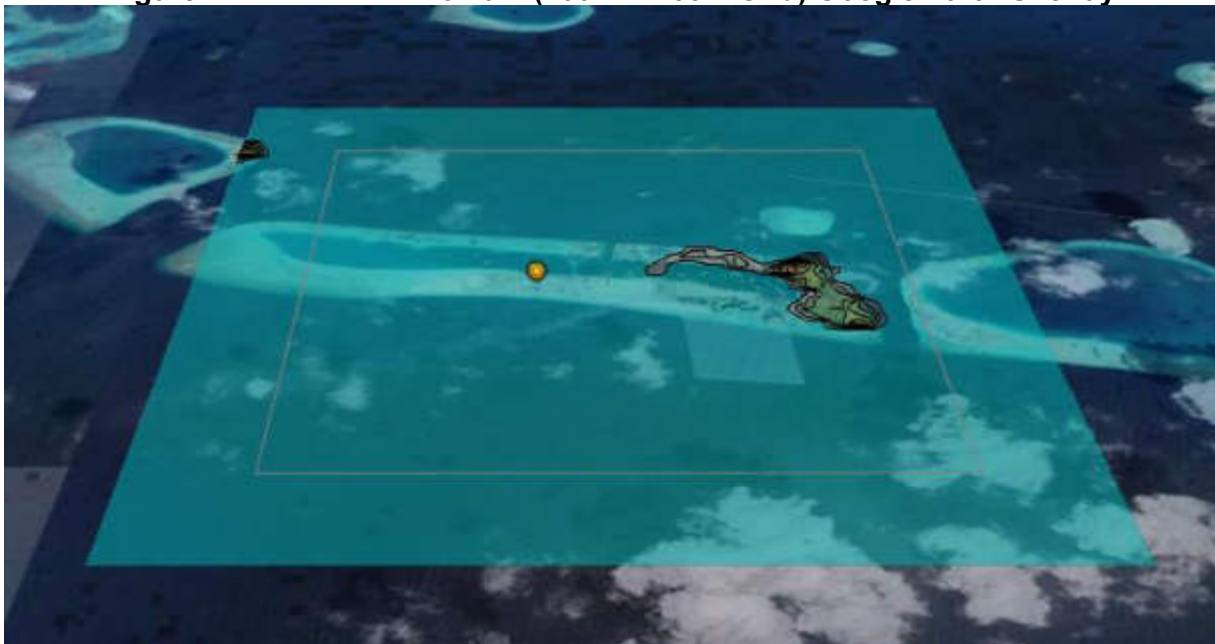


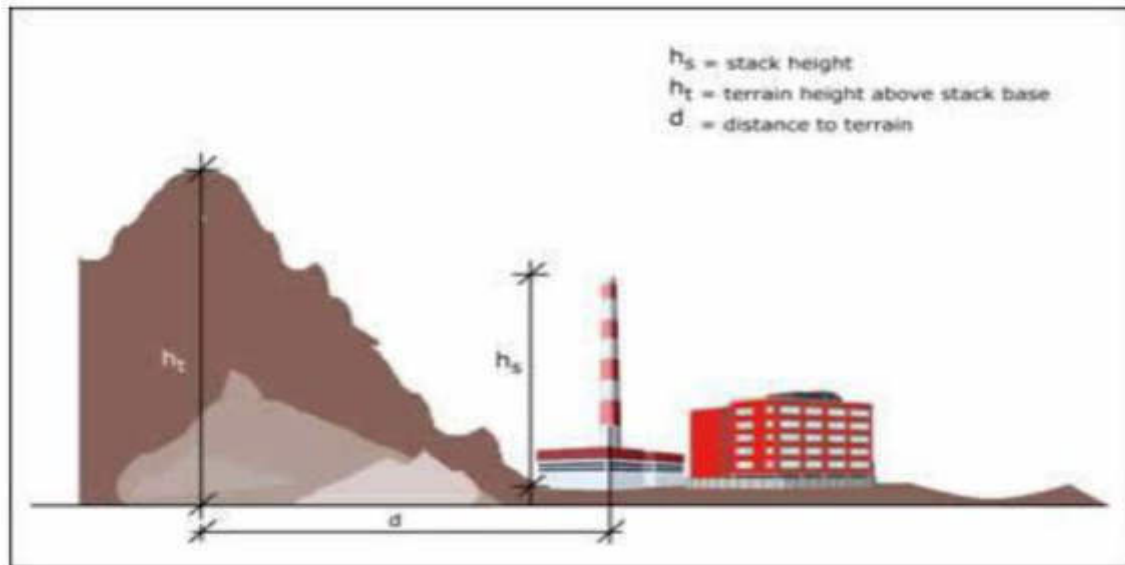
Figure 14: 4km X 4km Domain (100m X 100m Grid) Google Earth Overlay



Terrain Effects

Terrain elevations have a large impact on the air dispersion and deposition modelling results. Terrain elevation is the elevation relative to the facility base elevation (Figure XXX).

Figure 15: Terrain effects in AERMOD SYSTEM



The AERMOD model utilized elected terrain using Shuttle Radar Topography Mission (SRTM3) terrain data processed by AEMAP terrain processor. This option assumes terrain height exceeds stack base elevation; model receptors are also assumed on elevated terrain. Terrain elevations for receptors in the receptor pathway are also considered. Elevated terrain is selected, and receptor heights are not specified, then it is assumed to have a value of 0.0 meters. Figures 16 to 17 provides the SRMT terrain elevation used in the modelling. Complex terrain illustrated in figures are those elevations defined as anywhere within 50 km from the stack, are above the top of the stack being evaluated in the air modelling analysis.

Surface characteristics at the measurement site influence boundary layer parameter estimates. These influences are quantified through the albedo, Bowen ratio, and surface roughness length. The surface roughness length is the height at which the mean horizontal wind speed approaches zero and is related to the surface roughness characteristics of the terrain. It is not equal to the physical dimensions of the obstacles to the wind flow but is generally proportional to them. The surface roughness length dialog provides empirically determined surface roughness length values (from Sheih et al., 1979) for various land use types for each season. In order to better quantify these characteristics, frequency that these characteristics change (annual, seasonal, or monthly) and the number of different sectors have been specified in the modelling.

Figure 16: SRMT Terrain Elevation

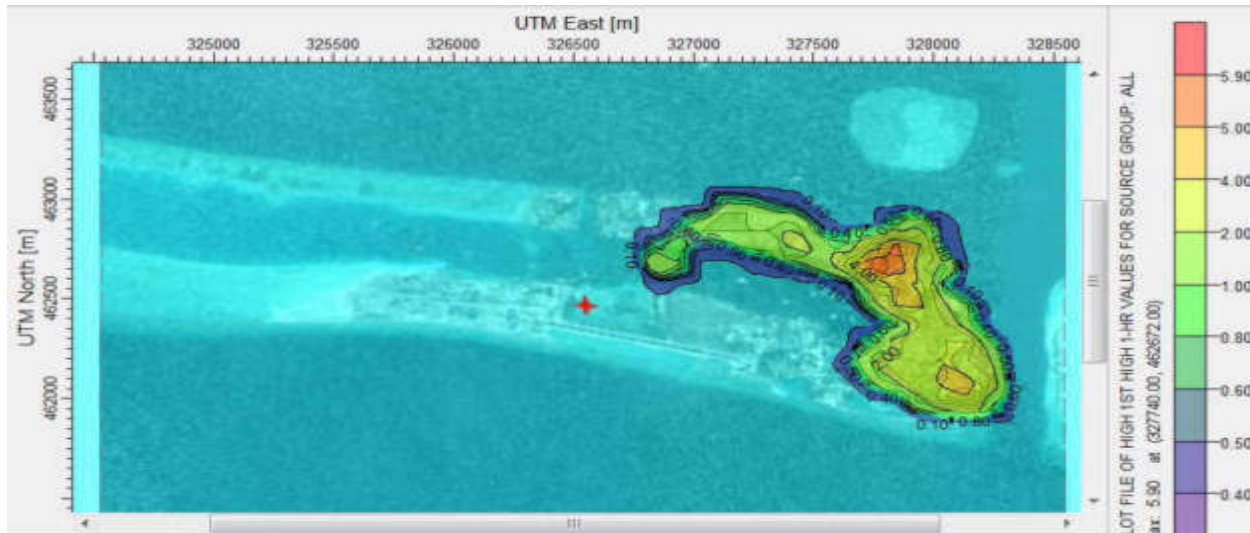


Figure 17: SRMT Terrain Elevation Google Earth Overlay



Area Sensitive Receptors (ASRs)

Area Sensitive Receptors (ASRs) include, but are not limited to residential areas, hospitals, schools, daycare facilities, elderly housing and convalescent facilities. These are areas where the occupants are more susceptible to the adverse effects of exposure to air pollutants. Extra monitoring and abatement efforts must be taken when dealing with contaminants and pollutants in close proximity to areas recognized as ASRs.

For the WTE plant and for the purpose of assessing potential impacts, Thilafushi islands' industrial areas are considered as ASRs as there are identified facilities with workers quarters. ASRs are located in the following area and details are provided in the figure and table below: (1.) ASR1-ENE; (2.) ASR2-SSE; (3.) ASR3-NNE; (4.) ASR4- SSW; (5.) ASR5-NNW 474 to 1273 meters upwind and downwind directions from the center of the domain at Universal Transverse

Mercator (UTM) coordinates Easting 326540 and Northing 462472. This AERMOD Report includes results of the dispersion model showing the highest predicted ground level concentrations (GLC) in the ASRs.

Figure 18: Location of the ASRs and SRMT Terrain



Table 2: UTM Coordinates of Location of Area Sensitive Receptors (ASRs)

	Long	Lat
ASR1	327811.66	462535.58
ASR2	327938.27	462105.3
ASR3	326838.73	462821.63
ASR4	326087.04	462454.99
ASR5	326415.56	462929

Building Downwash

Building downwash occurs when the aerodynamic turbulence induced by nearby buildings cause a pollutant emitted from an elevated source to be mixed rapidly toward the ground (downwash), resulting in higher ground-level concentrations. Influence of buildings have been also considered in the model. The following building dimension and location (stack and Diesel genset) have been considered for the WTE plant. WTE dimensions: Approx. Length x width x height [m]: 100 x 70 x 30 Surrounded buildings location have been considered according land use plan, topographical survey and google earth maps. The height of the buildings have been considered to maximum 10 m¹³.

¹³ Environmental and Social Impact Assessment (ESIA) Waste to Energy Facility Thilafushi

Figure 19: Building Coordinates

Coordinates		Tier Corners		
	North West: 4°10'58.73"N, 73°26'11.51"E	#	X Coord [m]	Y Coord [m]
	North East: 4°10'58.87"N, 73°26'22.20"E	1	326463.89	462526.01
	South West: 4°10'50.71"N, 73°26'9.74"E	2	326793.57	462529.66
	South East: 4°10'48.09"N, 73°26'20.87"E	3	326751.00	462198.00
		4	326408.81	462279.78

If stacks for new or existing major sources are found to be less than the height defined by EPA's refined formula for determining GEP height, then air quality impacts associated with cavity or wake effects due to the nearby building structures should be determined. (EPA 1986)

Figure 20: Building Perimeter of WTE Plant





Figure 21: Building Area of WTE Plant

GEP STACK HEIGHT = $H + 1.5L$

In EPA's refined formula for determining GEP stack height, consider Building Downwash for point sources that are within the GEP 5L Area of Influence of a building. For point sources within the GEP 5L Area of Influence, Building Downwash information (direction-specific building heights and widths) should be included in your ISC3 modeling project. Using AERMOD View, you can easily calculate these direction-specific building heights and widths. For regulatory applications, a building is considered sufficiently close to a stack to cause wake effects when the distance between the stack and the nearest part of the building is less than or equal to five (5) times the lesser of the building height or the projected width of the building.

DISTANCE FROM STACK-BLDG $\leq 5L$

For building downwash analyses with direction-specific building dimensions, wake effects are assumed to occur if the stack is within a rectangle composed of two lines perpendicular to the wind direction, one at 5L downwind of the building and the other at 2L upwind of the building and by two lines parallel to the wind direction, each at 0.5L away from each side of the building, as shown below. L is the lesser of the height and projected width of the building for the particular direction sector. This rectangular area has been termed a **Structure Influence Zone (SIZ)**.

Figure 22: AERMOD Source Influence Zones of buildings to plume dispersion

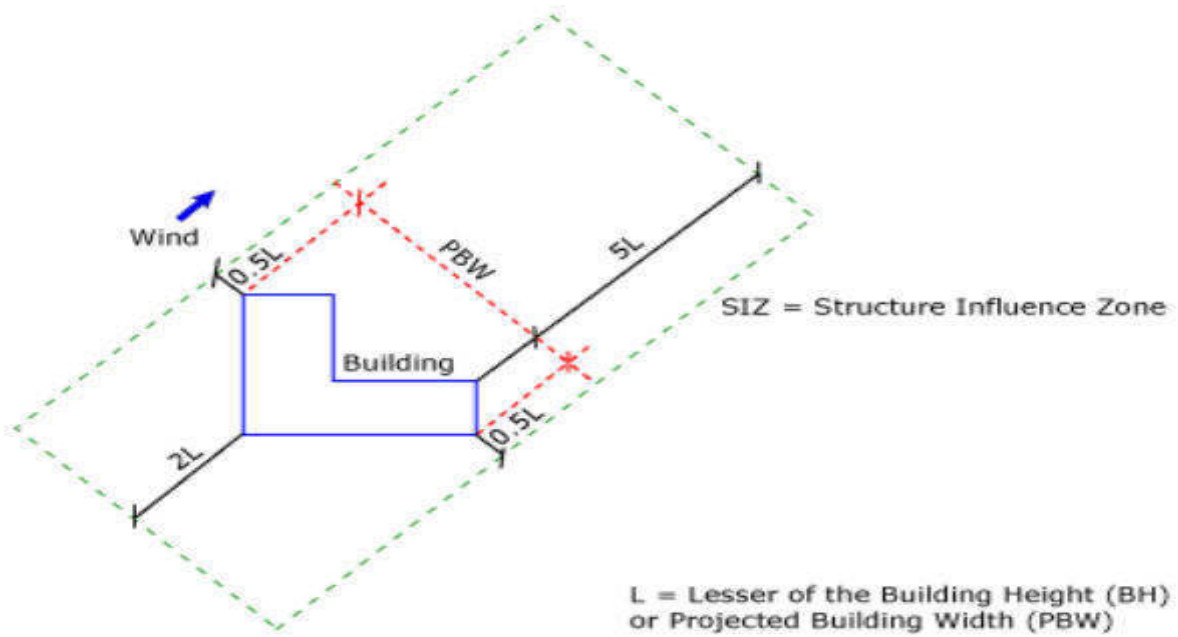


Figure 23: Building Source Influence Zones of buildings to plume dispersion



Stack-Building Preliminary*
 Stack Stack Base Elevation GEP** GEP Stack
 Name Height Differences EQN1 Height Value

S1	50.00	0.00	0.00	75.00	75.00
S2	50.00	0.00	0.00	75.00	75.00
GSSTACK	10.20	0.00	0.00	75.00	75.00

Results are based on Determinants 1 & 2 on pages 1 & 2 of the GEP Technical Support Document. Determinant 3 may be investigated for additional stack height credit. Final values result after Determinant 3 has been taken into consideration. ** Results were derived from Equation 1 on page 6 of GEP Technical Support Document. Values have been adjusted for any stack-building base elevation differences. Note: Criteria for determining stack heights for modeling emission limitations for a source can be found in Table 3.1 of the GEP Technical Support Document.

Table 3: AERMOD BPIP

Building Downwash Information

BPIP output is in meters

SO BUILDHGT S1	30	30	30	30	30	30
SO BUILDHGT S1	30	30	30	30	30	30
SO BUILDHGT S1	30	30	30	30	30	30
SO BUILDHGT S1	30	30	30	30	30	30
SO BUILDHGT S1	30	30	30	30	30	30
SO BUILDHGT S1	30	30	30	30	30	30
SO BUILDWID S1	351.19	381.98	412.65	430.78	435.82	427.53
SO BUILDWID S1	406.15	372.43	331.04	333.25	366.41	408.78
SO BUILDWID S1	438.74	455.36	458.15	447.02	422.31	384.76
SO BUILDWID S1	351.19	381.98	412.65	430.78	435.82	427.53
SO BUILDWID S1	406.15	372.43	331.04	333.25	366.41	408.78
SO BUILDWID S1	438.74	455.36	458.15	447.02	422.31	384.76
SO BUILDLEN S1	334.01	366.41	408.78	438.74	455.36	458.15
SO BUILDLEN S1	447.02	422.31	384.76	351.97	381.98	412.65
SO BUILDLEN S1	430.78	435.82	427.62	406.43	372.88	331.66
SO BUILDLEN S1	334.01	366.41	408.78	438.74	455.36	458.15
SO BUILDLEN S1	447.02	422.31	384.76	351.97	381.98	412.65
SO BUILDLEN S1	430.78	435.82	427.62	406.43	372.88	331.66
SO XBADJ S1	-233.2	-225.5	-232.06	-231.58	-224.05	-209.72
SO XBADJ S1	-189.02	-162.58	-131.19	-95.82	-89.99	-92.92
SO XBADJ S1	-93.02	-90.3	-84.83	-76.78	-66.41	-57.66
SO XBADJ S1	-100.82	-140.91	-176.72	-207.16	-231.31	-248.43
SO XBADJ S1	-258	-259.73	-253.57	-256.15	-291.99	-319.73
SO XBADJ S1	-337.76	-345.52	-342.79	-329.64	-306.48	-274
SO YBADJ S1	-79.78	-101	-113.41	-122.37	-127.61	-128.94
SO YBADJ S1	-126.29	-119.81	-107.86	-65.81	-42.29	-27.67
SO YBADJ S1	-12.21	3.63	19.35	34.49	48.58	61.19

SO YBADJ S1	79.78	101	113.41	122.37	127.61	128.94
SO YBADJ S1	126.29	119.81	107.86	65.81	42.29	27.67
SO YBADJ S1	12.21	-3.63	-19.35	-34.49	-48.58	-61.19
SO BUILDHGT S2	30	30	30	30	30	30
SO BUILDHGT S2	30	30	30	30	30	30
SO BUILDHGT S2	30	30	30	30	30	30
SO BUILDHGT S2	30	30	30	30	30	30
SO BUILDHGT S2	30	30	30	30	30	30
SO BUILDHGT S2	30	30	30	30	30	30
SO BUILDWID S2	351.19	381.98	412.65	430.78	435.82	427.53
SO BUILDWID S2	406.15	372.43	331.04	333.25	366.41	408.78
SO BUILDWID S2	438.74	455.36	458.15	447.02	422.31	384.76
SO BUILDWID S2	351.19	381.98	412.65	430.78	435.82	427.53
SO BUILDWID S2	406.15	372.43	331.04	333.25	366.41	408.78
SO BUILDWID S2	438.74	455.36	458.15	447.02	422.31	384.76
SO BUILDLEN S2	334.01	366.41	408.78	438.74	455.36	458.15
SO BUILDLEN S2	447.02	422.31	384.76	351.97	381.98	412.65
SO BUILDLEN S2	430.78	435.82	427.62	406.43	372.88	331.66
SO BUILDLEN S2	334.01	366.41	408.78	438.74	455.36	458.15
SO BUILDLEN S2	447.02	422.31	384.76	351.97	381.98	412.65
SO BUILDLEN S2	430.78	435.82	427.62	406.43	372.88	331.66
SO XBADJ S2	-234.41	-227.89	-235.56	-236.08	-229.42	-215.79
SO XBADJ S2	-195.6	-169.47	-138.19	-102.71	-96.57	-98.98
SO XBADJ S2	-98.38	-94.8	-88.33	-79.18	-67.62	-57.66
SO XBADJ S2	-99.6	-138.51	-173.22	-202.66	-225.95	-242.37
SO XBADJ S2	-251.42	-252.84	-246.57	-249.26	-285.41	-313.67
SO XBADJ S2	-332.4	-341.02	-339.29	-327.25	-305.26	-274
SO YBADJ S2	-72.88	-94.42	-107.34	-117.01	-123.11	-125.44
SO YBADJ S2	-123.9	-118.59	-107.86	-67.02	-44.69	-31.17
SO YBADJ S2	-16.71	-1.73	13.29	27.91	41.68	54.19
SO YBADJ S2	72.88	94.42	107.34	117.01	123.11	125.44
SO YBADJ S2	123.9	118.59	107.86	67.02	44.69	31.17
SO YBADJ S2	16.71	1.73	-13.29	-27.91	-41.68	-54.19
SO BUILDHGT GSSTACK	30	30	30	30	30	30
SO BUILDHGT GSSTACK	30	30	30	30	30	30
SO BUILDHGT GSSTACK	30	30	30	30	30	30
SO BUILDHGT GSSTACK	30	30	30	30	30	30
SO BUILDHGT GSSTACK	30	30	30	30	30	30
SO BUILDHGT GSSTACK	30	30	30	30	30	30
SO BUILDWID GSSTACK	351.19	381.98	412.65	430.78	435.82	427.53
SO BUILDWID GSSTACK	406.15	372.43	331.04	333.25	366.41	408.78
SO BUILDWID GSSTACK	438.74	455.36	458.15	447.02	422.31	384.76
SO BUILDWID GSSTACK	351.19	381.98	412.65	430.78	435.82	427.53
SO BUILDWID GSSTACK	406.15	372.43	331.04	333.25	366.41	408.78
SO BUILDWID GSSTACK	438.74	455.36	458.15	447.02	422.31	384.76
SO BUILDLEN GSSTACK	334.01	366.41	408.78	438.74	455.36	458.15
SO BUILDLEN GSSTACK	447.02	422.31	384.76	351.97	381.98	412.65
SO BUILDLEN GSSTACK	430.78	435.82	427.62	406.43	372.88	331.66

SO BUILDLEN GSSTACK	334.01	366.41	408.78	438.74	455.36	458.15
SO BUILDLEN GSSTACK	447.02	422.31	384.76	351.97	381.98	412.65
SO BUILDLEN GSSTACK	430.78	435.82	427.62	406.43	372.88	331.66
SO XBADJ GSSTACK	-225.28	-220.93	-230.99	-234.03	-229.96	-218.9
SO XBADJ GSSTACK	-201.19	-177.36	-148.15	-114.44	-109.7	-113.12
SO XBADJ GSSTACK	-113.1	-109.65	-102.86	-92.95	-80.21	-68.69
SO XBADJ GSSTACK	-108.73	-145.47	-177.79	-204.71	-225.41	-239.26
SO XBADJ GSSTACK	-245.83	-244.94	-236.61	-237.54	-272.28	-299.53
SO XBADJ GSSTACK	-317.68	-326.17	-324.76	-313.48	-292.67	-262.97
SO YBADJ GSSTACK	-61.16	-81.29	-93.2	-102.29	-108.26	-110.91
SO YBADJ GSSTACK	-110.13	-106	-96.83	-57.89	-37.73	-26.6
SO YBADJ GSSTACK	-14.66	-2.27	10.18	22.32	33.79	44.23
SO YBADJ GSSTACK	61.16	81.29	93.2	102.29	108.26	110.91
SO YBADJ GSSTACK	110.13	106	96.83	57.89	37.73	26.6
SO YBADJ GSSTACK	14.66	2.27	-10.18	-22.32	-33.79	

8.4 INPUT DATA IN THE DISPERSION MODEL (SOURCE PATHWAY)

The following parameters have been provided the ADM:

Table 4: Input Data for AERMOD Model Run 2 X 250 T/YR MW WTE Boiler and 0.8 MW Diesel Generator set

APSE	Capacity T/day	X Long	Y Lat	Stack Temp. °C	Stack Temp. (K)	VFR (Ncm/sec)	Stack Diam (m)	Stack Area (m ²)	Stack Ht. (m)
Boiler 1	250	4.183004N;	73.437155 E	144	417	16.07	1.5	1.76715	50.00
Boiler 2	250			144	417	16.07	1.5	1.76715	50.00
Genset 1	0.8 MW	4.182394	73.43737	400	673	3.4638889	0.5	0.13	10.2

UTM Coordinates (Boiler): 326540.00 N 462472.00 E

UTM Coordinates (Generatorset): 326556.96N 462460.97 E

Table 5: DESIGN EMISSION CONCENTRATION

TD /TD	PM10	CO	N0x	SOx	Hg	HCl	Hf	NH3	DF
mg/Nm ³									
5.00	0.50	50.00	150.00	50.00	0.03	10.00	1.00	10.00	0.10
5.00	0.50	50.00	150.00	50.00	0.03	10.00	1.00	10.00	0.10
79.95	nd	300	319.968	nd	nd	nd	nd	nd	nd

Table 6: DESIGN EMISSION STRENGTH

TD /TD	PM10	CO	N0x	SOx	Hg	HCL	Hf	NH3	DF
g/sec									
0.0804	0.0080	0.8036	2.4107	0.8036	0.0005	0.1607	0.0161	0.1607	0.0016
0.0804	0.0080	0.8036	2.4107	0.8036	0.0005	0.1607	0.0161	0.1607	0.0016
0.2769	nd	1.0392	1.1083	nd	nd	nd	nd	nd	nd