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Cayman Islands Government

National Solid Waste Management Strategy for the Cayman Islands

Final Report.

June 2016

Amec Foster Wheeler Environment
& Infrastructure UK Limited

Report for

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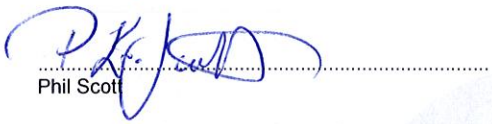

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Doc Ref. 36082 Final Report 16229i1

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Document revisions

No.	Details	Date
1	Draft Report 15517i1	October 2015
2	Draft Report 15517i2	October 2015
3	Draft Report 15517i3	October 2015
4	Draft Report 15517i4	October 2015
5	Draft Report 15517i5	February 2016
6	Draft Report 15517i6	March 2016
7	Final Report 16229i1	June 2016

Purpose of this Report

This document is the draft National Solid Waste Management Strategy (NSWMS) for the Cayman Islands. It sets out key policies and objectives for the future management of solid waste and the delivery of an Integrated Solid Waste Management System (ISWMS) within the Cayman Islands. It also identifies important steps and actions that will be taken to deliver the ISWMS. These actions will be targeted to improve the sustainability of waste management practices, make increased use of waste as a resource and ensure the protection of the environment and amenity of the islands.

Overview

Each year over 60,000 tons (short tons) of solid waste is produced on the Cayman Islands. The majority of this waste is produced on Grand Cayman (approximately 62,400t in 2014) with smaller quantities produced on Cayman Brac (est. 2,240t in 2014) and Little Cayman (est. 200t in 2014).

The vast majority of solid waste produced on the Cayman Islands is disposed of in three landfills that are operated by the Department of Environmental Health (DEH). These are located on Grand Cayman (George Town), Cayman Brac and Little Cayman. George Town landfill is by far the largest of these facilities and has been in continuous use since the mid 1960's. Records indicate that the landfill on Cayman Brac has been in operation since the 1970's and landfill on Little Cayman since the early 1990's. However, the Cayman Islands Government (CIG) recognises that there are strong drivers to change solid waste management practices with increasing pressure to minimise the overall amount of waste produced and to be more responsible and sustainable in the way that waste is then managed.

The future collection, treatment and disposal of waste in Cayman Islands will be underpinned by the National Solid Waste Management Policy (NSWMP) which has been established by the CIG. This sets out the vision values, and strategic direction for the delivery of a new ISWMS following a public consultation exercise undertaken in June/July 2015.

Long and short listed options for change and improvement in the way that waste is managed on the islands have been systematically appraised to develop options that the CIG will seek to develop and deliver as part of the implementation of the NSWMS. These options cover a variety of areas ranging from recycling depots through-out provisions through to the treatment of the residual waste that remains after recycling. These options collectively contribute to:

- The enhanced sustainability of waste management practices;
- Waste reduction;
- Increased reuse and recycling;
- The recovery of energy from residual waste;
- Substantially reduced dependence on increasingly expensive and unsustainable landfill;
- Protection of environment;
- Self-sufficiency as far as this is pragmatically deliverable; and
- The polluter pays principle.

The options analysis has also facilitated the development of a reference project that shows that the aspirations and aims encompassed within NSWMP and strategic waste management objectives can be attained along with the approximate costs associated with key elements of reference project delivery.

The Reference Project

The reference project comprises the waste management options that have been assessed as having the most potential for fulfilling the vision, values, and strategic direction established by the NSWMP and which are likely to be successful in the unique setting of the Cayman Islands. The purpose of developing a reference project is two-fold:

1. To show that the NSWMP can be delivered by a particular solution and the estimated cost of doing so (demonstrating that the objectives are attainable and so that the affordability of their delivery can be assessed), without constraining any future procurement/delivery options (allowing innovation within the market). Most commonly the lowest cost option that meets the NSWMP and CIG objectives is selected for this purpose.
2. Alternatively, the reference project can be used to define the solution that best fits the NSWMP, CIG objectives and affordability criteria and sets out clearly that this is what the CIG intends to deliver (i.e. the that CIG will go to market for a specific technology/solution). This may not be the lowest cost option and can include specific criteria with particular local significance (e.g. political commitment, site constraints, etc.).

In summary the reference project comprises the following:

- Waste reduction measures – including waste education and pragmatic waste minimisation initiatives (e.g., home composting/ material return schemes such as beverage containers);
- The reuse and refurbishment of bulky waste;
- Community recycling depots and Household Waste Recycling Centre's recycling facilities;
- Transfer and bulking facilities (one per island);
- The windrow composting of yard/garden waste and Household Waste Recycling Centre's;
- The potential introduction of kerbside yard and garden waste (post 2020);
- The potential introduction of kerbside dry recyclable collections with a Materials Recovery Facility (post 2020);
- The treatment of residual waste in a waste recovery plant (Waste to Energy Facility enabled for the production of combined heat and power and is used as an example of this);
- The provision for potential for landfill mining at the George Town landfill subject to feasibility (using a mechanical treatment plant); and
- Closure of the landfills on the Little Cayman and Cayman Brac.

The table below sets out how the reference project described performs against the vision, values and strategic directions set out by the CIG in the NSWMP. The reference project exhibits a high degree of compatibility with the NSWMP and demonstrates that vision, values and strategic direction can be delivered by an integrated waste management solution.

The Mapping of Vision, Values, and Strategic Directions against the Reference Project

Ref		Criteria	Vision	Values	Strategic Direction	Objectives	Performance of the Reference Project
1a		Compatibility with PPP		We will pursue mulit-sectorial partnerships and collaboration for the integrated and efficient delivery of waste management services and programmes.	Establish partnerships with community and business groups with a view to achieving the strategic direction for sustainable waste management in the Cayman Islands.	Promote multi-sectorial partnerships and collaboration for the integrated and efficient delivery of waste management services and programmes.	The reference project provides for major capital facilities (e.g. a Waste to Energy plant) that is likely to be commercially viable and attractive for a PPP initiative. The reference project will also provide opportunities for the community and business through the reuse, recycling and recovery of waste that would otherwise be landfilled.
1c		Whole lifecycle cost		We believe that the generators of waste should be responsible and bear their proper share of costs for waste management.	Implement a waste management system that is principally financed on the basis that the waste producer pays.	Evaluate and adjust the current financing framework for waste management to ensure that the waste producer pays proportionate to the waste that they generate.	Options for the financing of the reference project will include the charging of fees for waste collection and treatment as well as revenue opportunities from the sale of recyclates and recovered energy.
1d		Short term cost/funding		We believe that the generators of waste should be responsible and bear their proper share of costs for waste management.	Implement a waste management system that is principally financed on the basis that the waste producer pays.		Options for the financing of the reference project will include the charging of fees for waste collection and treatment as well as revenue opportunities from the sale of recyclates and recovered energy.

Ref		Criteria	Vision	Values	Strategic Direction	Objectives	Performance of the Reference Project
2a		Waste hierarchy		We will apply the waste hierarchy preference to reduce, reuse, recycle, and recover prior to the final resort of disposal.	Reduce the proportion of solid waste being landfilled by diverting waste in accordance with the sustainable waste management hierarchy.	Promote the development of improved practices and facilities for solid waste management which are demonstrably consistent with the waste management hierarchy. CIG will lead by example by examining how it purchases, uses, and manages materials, with the objective of reducing consumption and waste.	The reference project provides a considerable movement up the waste hierarchy by providing for waste reduction, increased reuse and recycling and the recovery of energy from residual waste in preference to landfill. The reference project will assist the delivery of this objective by providing enhanced waste reduction, re-use, recycling and recovery opportunities for use by CIG in the decision making process.
2b		Recycling potential				Implement and expand programmes to reduce, re-use, and recycle waste materials. Develop and implement initiatives and incentives to support waste segregation at the source, both at households and businesses, for the purpose of reducing, reusing, and recycling.	The reference project provides greater access to residents for recycling through the provision of recycling depots, windrow composting and household waste recycling centres in the short term with the later introduction of kerbside collection systems and a materials recovery facility.

Ref		Criteria	Vision	Values	Strategic Direction	Objectives	Performance of the Reference Project
2c		Carbon impact/greenhouse gas		We will pursue waste management opportunities that have the potential to reduce greenhouse gas emissions and reduce our dependence on fossil fuels.			The reference project produces a substantially reduced carbon impact over the existing landfill arrangements.
2d		Energy generation/green energy		We will pursue waste management opportunities that have the potential to reduce greenhouse gas emissions and reduce our dependence on fossil fuels.			The waste to energy facility used for the treatment of residual waste in the reference project will generate renewable and sustainable from waste that would otherwise be landfilled. This will produce green energy for use on the Cayman Islands and reduce dependence on electricity derived from fossil fuels.
2e		Life cycle environmental impact		We will ensure that environmental impacts of waste management are assessed and understood, and that measures are undertaken to protect human health and the environment. We will implement sustainable waste management in a manner that respects the needs of future generations.			The reference project produces substantial lifecycle benefits across all measured lifecycle indicators over the existing waste management system. By following the waste management hierarchy the reference project will deliver a more sustainable integrated waste management system for the Cayman Islands.

Ref		Criteria	Vision	Values	Strategic Direction	Objectives	Performance of the Reference Project
3b		Training/education		We believe in the enhancement of personal responsibility for waste management through advocacy, education and the creation of opportunities to help realize the national vision for waste management.	Broaden the understanding of sustainable waste management issues and practices throughout the entire community of the Cayman Islands.		Waste education and the promotion of waste reduction is a key focus for the reference project. The reference project will also provide opportunities for training and education by introducing new waste management practices (e.g. providing opportunities for waste re-use) and facilities (that are technically more sophisticated than landfill).
3c		Public acceptability aesthetics		We will pursue multi-sectorial collaborations and partnerships with various stakeholders to achieve our vision for waste management in the Cayman Islands.		Establish a framework to encourage multi-stakeholder collaboration. Institute a programme of awareness, promotion, education, and publicity in partnership with community groups, schools, and other organisations.	The focus on waste reduction and education within the reference project can only be achieved through widespread engagement with all stakeholders and community groups. In addition waste reuse and recycling will also provide opportunities for beneficial engagement with local charities and third sector organisations.

Ref		Criteria	Vision	Values	Strategic Direction	Objectives	Performance of the Reference Project
3d		Political buy -in		We will ensure there is an appropriate legal, regulatory, and institutional framework, and embrace good governance principles, to support achieving the national vision for waste management.	Apply good governance principles to strengthen institutional capacity and leadership.	Establish enabling public health and waste management legislation, regulations, and enforcement.	The delivery of the reference project will need to be accompanied by the introduction of a new regulatory and enforcement regime suited to control of the integrated waste management system.
4a		Track record/Proven technology				Apply a process, based on recognised best practice, for the assessment and mitigation of health and environmental impacts of existing and proposed waste management practices.	The practices and technologies encompassed within the reference project have an extensive operational track record and demonstrable record of commercial deliverability.
4c		Applicability to island environment		We will ensure that economies of scale are considered in determining suitable waste management practices, having due regard for the geographical aspects of the Cayman Islands.			The reference project will provide access to the integrated waste management system throughout the Cayman Islands, including Cayman Brac and Little Cayman. The reference project would deliver the closure of the landfill facilities on the sister islands by providing alternative means of managing waste.

Ref		Criteria	Vision	Values	Strategic Direction	Objectives	Performance of the Reference Project
5a		Planning/site assessment			Manage waste in a manner protective of human health, the environment and local amenities.	Establish enabling public health and waste management legislation, regulations, and enforcement.	The delivery of the reference project and the associated waste management facilities will be subject to planning approval including environmental impact assessment.
5b		Integration across all islands	Integrated, sustainable, and effective waste management for the Cayman Islands.		Broaden the understanding of sustainable waste management issues and practices throughout the entire community of the Cayman Islands.		The reference project will require waste education across the islands. It will also provide access to the integrated waste management system throughout the islands. The reference project would deliver the closure of the landfill facilities on the sister islands by providing alternative means of managing waste.
5c		Remediation of existing landfills				Assess the remaining capacity and develop a short and long-term management plans for each of the landfill sites, including measures to ensure that the sites do not pose an on-going risk to the environment or human health.	The reference project results in a much reduced demand for landfill on Grand Cayman and landfill mining (if feasible) may enable continuation at George Town while the landfill is remediated. The landfills on Cayman Brac and Little Cayman would close.

Ref		Criteria	Vision	Values	Strategic Direction	Objectives	Performance of the Reference Project
6a		Diversion of waste from landfill			Reduce the proportion of solid waste being landfilled by diverting waste per the sustainable waste management hierarchy.		The reference project results in a substantial diversion of waste away from landfill through enhanced waste recycling and waste recovery. The diversion of residual waste from landfill will strive to exceed 90%.

Key Recommendations and Actions

In developing this solid waste management strategy the CIG has developed the vision, value and strategic directions set out in the NSWMP and tested a variety of waste management options against them in order to develop the reference project. In doing so it sought to identify those options that are most compatible with the polices and will which will:

- Deliver the best value to residents of Cayman Islands;
- Deliver sustainable waste management practices;
- Provide social benefit to local community; and
- Promote movement up the waste hierarchy.

The waste management hierarchy is at the heart of the modern approach to managing waste. The hierarchy firstly focuses on waste reduction, and then examines each subsequent option before disposal is finally considered.

The Waste Hierarchy

Reduction	Using less material in design and manufacture, keeping products for longer, using less hazardous materials;
Re-use	Checking, cleaning, repairing, refurbishing, whole items or spare parts;
Recycling	Turning waste into a new substance or product. Includes composting if it meets quality protocols;
Recovery	Energy is recovered from waste through a variety of methods such as thermal treatment and digestion; and
Disposal	Landfill and incineration without energy recovery.

In delivering this solid waste management strategy for the Cayman Islands based on the reference project and the NSWMP, the Cayman Islands Government (CIG) through its implementation will promote the waste hierarchy. Furthermore, CIG intends to do this in a way that promotes sustainability, the use of waste as a resource and enhances the amenity of the Cayman Islands to the material benefit of its residents.

Waste Reduction and Re-use

Waste can be prevented by both business and the general public by thinking about what we need and buy. For example, residents can reduce waste by using cotton shopping bags instead of plastic shopping bags

and avoiding over-packaged products where possible. The CIG is committed to deliver measures that help reduce the amount of waste produced within the Cayman Islands and this is enshrined within the NSWMP.

Re-using waste helps to reduce the impact that waste management has on the environment. This can be as simple as passing things we no longer need on to other people to use, for example by giving items to friends or charity shops.

The CIG intends to promote waste education and awareness initiatives, prevention measures and re-use activities. In particular the CIG seeks to work closely with local third sector organisations to promote the reuse of bulky waste for the benefit the local community. Key activities may include*:*

Promotional Activities

- Periodic residents leaflets – reinforcing the waste hierarchy;
- Newspaper, radio and television adverts and interviews;
- National competitions and awards;
- Advertising panels promoting the waste hierarchy and initiatives on refuse collection vehicles;
- Facebook and similar social media vehicles;
- Dedicated campaigns (e.g. reduce food waste); and
- The establishment of community and third sector waste re-use groups.

Waste Reduction and Education Activity

- The consideration of restrictions on the use of certain materials such as plastic shopping bags;
- School waste awareness education initiative;
- Community events and shows;
- Waste Reduction Volunteers;
- Junior Recycling Officers; and
- Potential visitor centre at a new waste management facility.

Recycling and Composting

Recycling and composting is one of the most visible ways in which waste can be managed more sustainably. The CIG intends to provide greater access to recycling facilities for residents of the Cayman Islands.

The CIG will target improved recycling performance. This will be initially achieved through the introduction of recycling depots facilities located in suitable locations (such as supermarket car parks) to which residents can deliver separated recyclables including paper, cardboard, metal cans, glass and plastics. This will be supplemented by improved recyclables segregation at the drop off facility at the George Town landfill which will be converted to a Household Waste Recycling Centre (HWRC). Further HWRC's will later be introduced for Cayman Brac and Little Cayman and will be considered for other locations on Grand Cayman.

Further recycling opportunities (including the introduction of kerbside recyclable collections for commercial and residual waste) will be explored as part of the procurement process for new waste management facilities. This is because the collection of mixed dry recyclable materials will require a materials recovery facility to processes the recyclables.

The solid waste currently received at the landfills located in George Town and Cayman Brac contain a considerable amount of organic/ yard waste. This material has the potential to be composted using relatively simple technology and converted in to useful compost/soil conditioner that then be beneficially applied to land. The CIG will undertake trials to establish the feasibility of composting the organic/yard waste with the aim of establishing windrow composting facilities on Grand Cayman and Cayman Brac.

Recovery

For residual waste that is not recycled or composted the next best option is to treat the waste so that energy can be recovered from it. This is a better alternative to sending waste to landfill where it can break down and produce harmful greenhouse gases.

The CIG intends to procure waste recovery capacity that is sufficient to treat all suitable residual waste tonnages on the Islands, so that waste sent to landfill can be minimised. The options appraisal process short listed a number of options that would be suitable for the treatment of residual waste. These are briefly described below.

Waste to Energy (WtE) with or without combined heat and power

In WtE facilities waste is combusted and the resulting energy is recovered through using the combustion gases produced to drive a steam turbine. The majority of the electricity produced is usually exported to the national grid.

Heat in the form of hot water or steam can also be used (e.g. to cool nearby buildings or for desalination plants) and where this is done the process is called Combined Heat and Power (CHP). Infrastructure is needed to transfer the heat to users using a pipe network and new boilers for end-users. Laying a pipe network can be expensive and the overall costs depend on the number of end-users who will commit to use the heat, their annual demand, and the distances the heat has to travel.

Outputs from WtE facilities include incinerator bottom ash which can be used in aggregate manufacture and may also contain metals that can be recycled. Air pollution control residues are also produced and these are sent to a hazardous landfill and/ or treatment.

The footprint of a WtE facility can be relatively small when compared to other residual waste treatment facilities and the recovery of energy significantly improves the carbon impact of the waste management solution. The architectural design of WtE facilities is varied and can range from iconic buildings, to industrial buildings, or designs that blend with the local landscape and environment.

Disposal

Although the CIG intends to use landfill as the last option for the management of solid waste, it is acknowledged that there will continue to be a reduced landfill requirement in future for the following reasons:

- Not all waste can be economically recycled;
- Not all waste is suitable for recovery;
- Residual waste treatment facilities produce residues that need to be disposed of; and
- There will be a need for disposal capacity should facilities be closed for maintenance.

The CIG intends to therefore consider the feasibility of landfill mining at George Town landfill as means of extending the life of this facility whilst it is also remediated. Any new landfill facilities will be engineered to modern standards and include containment measures an environmental control facilities for both non-hazardous and hazardous wastes.

Institutional and Regulatory Recommendations

To enable the effective regulation of future waste management services and facilities Amec Foster Wheeler recommends:

- That the proposed development of major new waste management facilities are subject to a planning process that includes the production of an Environmental Impact Assessment (this is currently consistent with practice on the Cayman Islands);
- A CIG regulatory function is established that is independent of waste management operations;
- That waste management facilities can operate only with a specific permit/licence issued by the regulator;

- The permits should establish the operational conditions, environmental standards and health and safety measures that each waste management facility must operate in accordance with. The approach to the application of the environmental standards should as far as possible be consistent with those applied to determination of a planning application;
- Waste facility operators are required to monitor their activities in accordance with the requirements of the permit/licence and report the results of this process to the regulator;
- The regulator would scrutinise permits and licence compliance, undertake periodic permit/license reviews, carry out periodic facility assessments and inspections and implement enforcement action in the event of non-compliance. Such enforcement actions could include corrective notices, activity cessation notices, financial deductions and criminal prosecution; and
- Primary regulation is introduced to bring in to effect the new regulatory regime.

The CIG legislative framework for the management of solid waste will require amendment and augmentation to enable the effective regulation of new and alternative waste management facilities that are considered in this NSWMS. In particular, aspects of the Public Health (Garbage and Refuse Disposal) Regulations 2011 will require revision to enable the delivery of solid waste to a non-landfill waste treatment plant. New regulations will be needed to ensure that any waste management facilities are operated and managed to an appropriate standard. Amec Foster Wheeler recommend that this is accomplished through a licensing/ permit system that is overseen by an independent CIG regulatory body. Primary legislation would be needed to both introduce the permit and licensing system and empower the regulatory body.

Glossary

~	Approximately
AD	Anaerobic Digestion
ATT	Advanced Thermal Treatment
BOT	Build Operate Transfer
BOOT	Build Own Operate and Transfer
BTO	Build Transfer Operate
CapEx	Capital expenditure
CHP	Combined Heat and Power
CLO	Compost Like Output
DBM	Design Build and Maintain
DBOM	Design Build Operate Maintain
DBO	Design Build and Operate
DBFM	Design Build Finance and Maintain
DBFO	Design Build Operate Finance
DBFMO	Design Build Finance Maintain and Operate
DEH	Department of Environmental Health
FY	Financial Year
MH&C	Cayman Islands Ministry for Health and Culture
HWRC	Household Waste Recycling Centre
ISWMS	Integrated Solid Waste Management System
IVC	In-Vessel Composting
k	Thousand
MBT/MT	Mechanical Biological Treatment/Mechanical Treatment
MRF	Material Recovery Facility
MSW	Municipal Solid Waste
NSWMP	National Solid Waste Management Policy
NSWMS	National Solid Waste Management Strategy
OBC	Outline Business Case

OpEx	Operating expenditure
PAYT	Pay As You Throw
PPP	Public Private Partnership
RDF	Refuse Derived Fuel
RFP	Request For Proposal
SOC	Cayman Islands Strategic Outline Case for an ISWMS dated 24 April 2014
SRF	Solid Recovered Fuel
WtE	Waste to Energy
WTS	Waste Transfer Station

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1. Introduction

This document is the draft National Solid Waste Management Strategy (NSWMS) for the Cayman Islands. It sets out key policies and objectives for the future management of solid waste and the delivery of an integrated solid waste management system (ISWMS) within the Cayman Islands. It also identifies important steps and actions that will be taken to deliver the ISWMS. These actions will be targeted to improve the sustainability of waste management practices, make increased use of waste as a resources and ensure the protection of the environment and amenity of the islands.

Background

Amec Foster Wheeler Environment & Infrastructure UK Ltd. (Amec Foster Wheeler) has been commissioned by the Cayman Islands Government (CIG) to assist in the delivery of an ISWMS for the Cayman Islands. This work is being delivered in three main phases:

- Phase 1: The preparation of a NSWMS for the Cayman Islands and the delivery of environmental and site investigations at the George Town, Cayman Brac and Little Cayman landfills;
- Phase 2: Preparation of an Outline Business Case to deliver the NSWMS; and
- Phase 3: The procurement of new waste management services and infrastructure in line with the NSWMS.

This draft NSWMS is a key step leading towards the completion of Phase 1.

1.1 Regional, Geographic and Demographic Context

Location

The Cayman Islands are a British Overseas Territory located in the western Caribbean Sea. The territory comprises the three islands, Grand Cayman, Cayman Brac and Little Cayman which are located in the northwest of the Caribbean Sea, approximately 430 miles (700 km) south of Miami, 227 miles (366 km) south of Cuba, and about 310 miles (500 km) northwest of Jamaica. George Town, the capital of the Cayman Islands is situated on the western shore of Grand Cayman. Cayman Brac and Little Cayman are also referred to as the sister islands.

Grand Cayman, the largest of the three islands, has an area of about 76 square miles and is approximately 22 miles long with an average width of four miles. Its most striking feature is the shallow, reef-protected lagoon, the North Sound, which has an area of about 35 square miles. The island is mostly a low-lying limestone base, with the highest point about 60 ft. above sea level.

Cayman Brac lies about 89 miles northeast of Grand Cayman. The island is approximately 12 miles long with an average width of 1.25 miles and has an area of about 15 square miles. Its terrain is the most prominent of the three islands. The Bluff, a massive central limestone outcrop, rises steadily along the length of the island up to 140 ft. above the sea at the eastern end.

Little Cayman lies five miles west of Cayman Brac and is approximately ten miles long with an average width of just over 1 mile. It has an area of about 11 square miles. The island is low-lying with a few areas on the north shore rising to 40 ft. above sea level.

There are no rivers on any of the islands. The coasts are largely protected by offshore reefs and in some places by a mangrove fringe that occasionally extends into inland swamps.

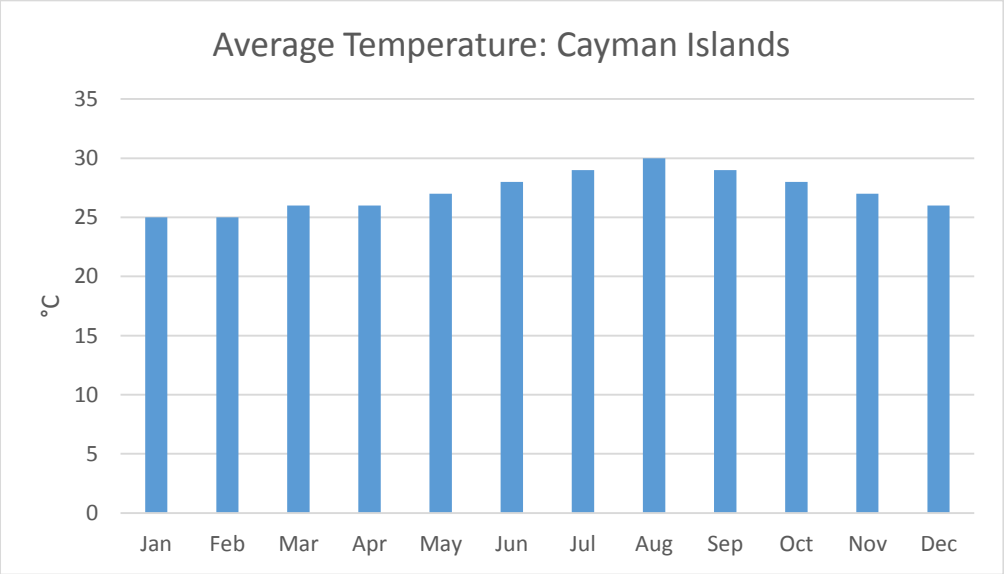
Climate

Located in the northwest Caribbean, the three Cayman Islands enjoy mainly tropical weather conditions with slight seasonal variations. The unique position places the Cayman Islands far enough north to be affected by

cold fronts during the winter and still within the belt that is influenced by tropical waves and hurricanes during the summer. Climatically the year can be divided into two seasons, the wet, summer season, generally from mid-May through October, and the dry, winter season, from November to April.

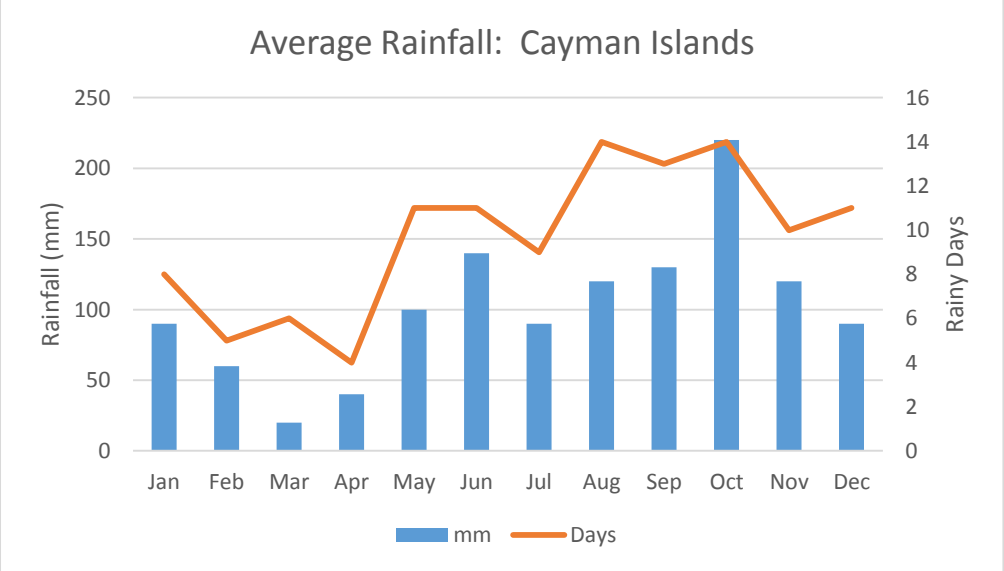
The temperature, summer or winter, seldom goes lower than 21°C (70°F) or higher than 30°C (90°F). The average, as shown in Figure 1.1, is 25°C (78°F) in the winter and about 30°C (86°F) in the summer.

Figure 1.1: Temperature Data



The average annual humidity in 2010 was 77%. Rainfall varies over the islands and seasonally. In 2010 rainfall totalled 60.3 inches. The wettest month was September with 14.9 inches recorded. The driest month is March with 0.2 of an inch recorded, as illustrated in Figure 1.2

Figure 1.2: Rainfall Data



Between May and October the prevailing winds are from east to south; from December to April, the coolest season of the year, the prevailing winds are from the northeast to northwest. A major natural hazard are the tropical cyclones that form during the Atlantic hurricane season from July to November

In September 2004 Grand Cayman was hit by Hurricane Ivan. This created an 8 foot storm surge which flooded many areas of the island. An estimated 83% of the dwellings on the island were damaged including

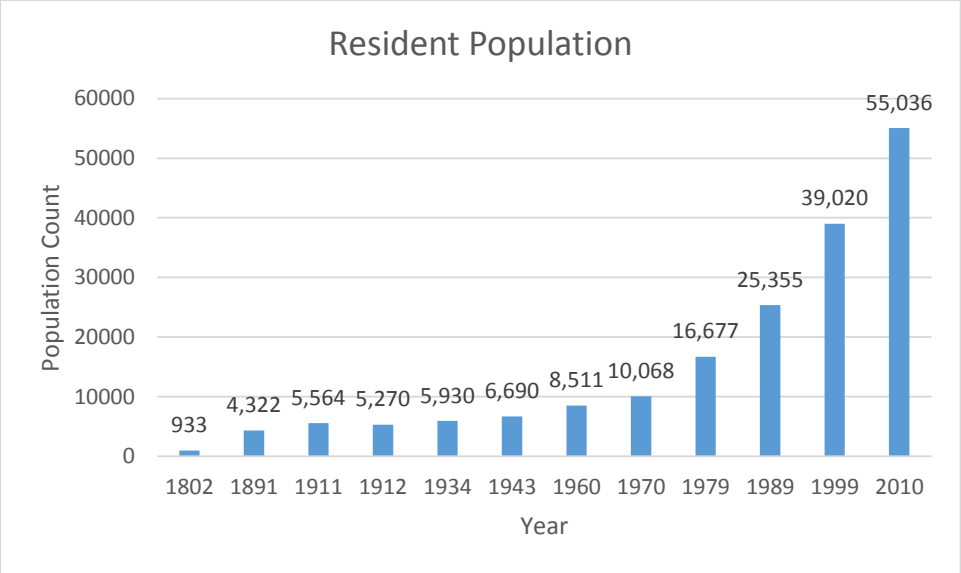
4% which required complete reconstruction. A reported 70% of all dwellings suffered severe damage from flooding or wind. Another 26% sustained minor damage from partial roof removal, low levels of flooding, or impacts with floating debris. Power, water and communications were disrupted for months in some areas.

Due to the tropical location of the islands, more hurricane or tropical systems have affected the Cayman Islands than any other region in the Atlantic basin; it has been brushed or directly hit, on average, every 2.23 years.

Housing/ Population

The 2010 census was completed by 22,760 households whose members were recorded as residents of the Cayman Islands. The population was counted at 55,456 and this represents a 41% growth upon the population from the previous 1999 census as shown in Figure 1.3. The increase in population amounts to an annual growth rate of approximately 3.1% and this growth is expected to continue with population projected to rise to 60,000 by 2020.

Figure 1.3: Population Data



The vast majority of the population (95.8%) reside on Grand Cayman with the remaining 4.2% residing in the sister islands of Cayman Brac and Little Cayman (only about 170 individuals are permanently resident on Little Cayman). On Grand Cayman the majority of the population is distributed to the west and south west of the island, 51% of the population live in the capital George Town, 20.4% in the west bay area and 19.2% in Bodden Town.

The distribution of households follows a similar pattern to the distribution of the population with 54.2% of households located in George Town, 20% in West Bay and 16.7% in Bodden Town. The sister islands accounted for 4.5% of households. Since the previous census data in 1999 7,853 households were added across the Cayman Islands representing a 52.7% increase. The highest rate of household increase was in Bodden Town with a 95.1% increase, while west bay and north side grew by 56.1% and 53% respectively.

The average household size recorded during the 2010 census was 2.4 persons per household which represented a decrease from the 1999 census which recorded 2.6 persons per household. It was also recorded that almost 1 in every 3 households (32.4%) was a single person household.

The majority of households within the Cayman Islands are either detached houses (40.8%) many of which have gardens, or apartments (27.7%). Detached houses represent the highest proportion of housing in all of the Grand Cayman districts and the sister Islands with the exception of George Town, where a higher proportion of people live in apartments and townhouses.

As well as a rising residential population the Islands are also a popular tourist destination which leads to high population fluctuations. The Cayman Islands department of tourism stated that during 2015 there were 385,379 stay over visitors (travelling via air and staying in hotels) and 1,716,812 visitors from cruise ship arrivals. Further growth in the tourism sector is anticipated in the short, medium and long term.

81% of the population belongs to the working age group (between15-65) and is split almost evenly between men and women.

In 2010 the top 5 industries by employment were wholesale and retail (12.1%), construction (11.3%), financial services (10.4%), activities of households as employers (8.6%), and general public administration (8.2%).

2. Waste Management Arrangements

2.1 How Much Waste is Managed in the Cayman Islands?

Waste Types

The solid waste routinely collected on the Cayman Islands can be classified in to four main types, these are:

- Residential waste;
- Commercial waste;
- Biomedical (Clinical) / Infectious waste; and
- Hazardous waste.

In addition non-routine wastes arise from the following activities:

- The collection of bulky residential waste; and
- Clean up events.

The residential and commercial waste streams are the most compositionally diverse and are made up of discrete elements that are separately categorised by waste type at the weighbridge located at George Town landfill. These categories are:

- Mixed commercial waste;
- Construction and demolition wastes;
- Metal waste;
- Pallets;
- Cardboard;
- Food waste;
- Oils;
- Expired liquors;
- Foams;
- Sand;
- Waste water sludge;
- Mixed residential (or household waste);
- Yard waste (or garden waste);
- Derelict vehicles;
- Batteries;
- Bulky residential waste;
- Christmas trees; and
- Deceased animals.

Historical Tonnage Data

Each year over 60,000 tons of solid waste is produced on the Cayman Islands. The majority of this waste is produced on Grand Cayman (62,386t in 2014) with smaller quantities managed on Cayman Brac (est. 2,240t in 2014) and Little Cayman (est. 200t in 2014). A typical breakdown of the annual tonnages delivered to George Town landfill is shown in Table 2.1 (tonnages were sourced from the Department of Environmental Health (DEH).

Table 2.1: Amount and Types of Waste Managed at George Town Landfill 2013-14

Waste Type	Tons	Waste Management Method
Commercial Waste*	26,515.0	Disposed of to Landfill
Construction and Demolition	7,187.2	Partially recycled
Yard Waste	9,740.0	Disposed of to Landfill
Residential Waste - N.B. (1) includes plastic and glass waste (2) some private contractors exist which currently divert some plastic and glass away from the George Town Landfill.	10,479.6	Disposed of to Landfill
Metal Waste	11,126.1	Recycled
Pallets	1,533.0	Disposed to Landfill
Cardboard	1,605.9	Disposed to Landfill
Derelict Vehicles	279.1	Recycled
Tyres	395.0	Recycled
Batteries	311.1	Recycled
Aluminium Cans	10.5	Recycled
Oil	38.2	Recycled
Natural Christmas Trees	20.7	Recycled
Clinical & Infectious	178.7	Diverted through incineration
Sand used as landfill cover material	33.4	Disposed to Landfill
Food Waste	120.6	Disposed to Landfill
Expired Liquor	6.7	Disposed to Landfill
Bulk Waste	159.3	Disposed to Landfill
Special Waste (waste water sludge)	37.2	Disposed to Landfill
Foam	1.7	Disposed to Landfill
Deceased Animals	8.5	Disposed to Landfill

- -Note that Commercial Waste includes all waste collected by front end loading collection vehicles, whereby a significant amount is from larger condominium complexes that use and pay for this service, hence it is called “Commercial” however it is “Residential” in character.

Waste Composition

There are limited compositional data available for the collected waste streams on Grand Cayman and none available for Cayman Brac and Little Cayman. Furthermore, the information that is reported is aged (dated 2003) and is of uncertain reliability (as the methodology of producing the compositional analyses is not described).

Up to date and reliable compositional data are important to the development of a waste management strategy and the procurement of waste management solution because it is a significant factor in determining the suitability, design and sizing of facilities (e.g. determining the calorific value (CV) of waste to be combusted) and the anticipated performance of the solution (e.g. recycling rate, contamination/reject levels).

The available compositional data for Grand Cayman are derived from a single source and provided in Table 2.2.

Table 2.2: Grand Cayman Composition Data

Waste Category	Composition from WDOR. 2003 Report
Newsprint	5.0%
Office paper	1.8%
Other paper	12.6%
Corrugated cardboard	11.7%
Glass bottles	2.8%
Glass other	0.7%
Plastic bottles	1.9%
Plastic other	9.1%
Wood	7.3%
Dirt, Brick, Rubble	3.7%
Yard waste	18.6%
Aluminium cans	0.8%
Aluminium other	0.4%
Metal cans	2.0%
Ferrous metals	2.3%
Non-Ferrous metals	0.7%
Textiles	5.3%
Food waste	5.4%
Miscellaneous organics	5.5%
Miscellaneous other	2.4%

2.2 Summary of Current CIG Waste Services

The DEH has responsibility for providing and operating a waste collection service and disposal facilities capable of dealing with the wastes generated within the Cayman Islands.

The current waste management infrastructure consists of 3 landfills, one on each island; a single operational clinical waste incinerator, 1 welding and maintenance area; 1 vehicle washing bay; and a recycling/ processing area for selected recyclables.

Recent Waste Education and Minimisation Initiatives

In March 2015 CIG initiated a waste education and awareness initiative. Students throughout the Cayman Islands were invited by the DEH to enter the Waste Pyramid Essay & Poster Competition.

The purpose of the competition was to raise awareness about the new waste management hierarchy of "Reduce, Reuse, Recycle, Recover, and Dispose" in Waste Management in the Cayman Islands. This new waste management hierarchy will be incorporated into the new Integrated Solid Waste Management Policy. The DEH aims to get students involved in the process of reducing, reusing, recycling, recovering and safe disposal whereby the students can express what this means to them, to Caymanian society and to the environment, through involvement in the Waste Pyramid Essay & Poster Competition; and by efforts post-competition.

Where Does the Waste Go?

The vast majority of solid waste produced in the Cayman Islands is disposed of in three landfills that are operated by DEH. These are located on Grand Cayman (George Town), Cayman Brac and Little Cayman. George Town landfill is by far the largest of these facilities and has been in continuous use since the mid 1960's. Records indicate that the landfill on Cayman Brac has been in operation since the 1970's and the landfill on Little Cayman since the early 1990s. None of the sites are formally engineered or lined and the waste deposited at Little Cayman landfill is routinely burned.

The George Town landfill is located in an industrial zone, adjacent to the Esterley Tibbetts Highway, with access via Seymour Drive, off North Sound Road. The George Town landfill does not have a liner and has not been formally engineered as a containment facility in accordance with modern international standards. The George Town landfill's official opening hours are 7 am to 6:30 pm Monday to Saturday, and a public drop-off area at the entrance of the landfill is open 24 hours. Further information on the George Town landfill is provided in Section 3.

The Cayman Brac landfill is located on the south side of the island, opposite the public beach. It follows similar waste management procedures as the George Town landfill. Cayman Brac's official landfill hours are 7am to 5pm Monday to Friday, 7am to 3pm Saturday. Further details on Cayman Brac landfill can be found in Section 3.

The Little Cayman landfill is located on the south side of the island, next to the Power & Light Plant. Municipal waste delivered to the site was formerly burnt in a special air curtain incinerator but this unit is now non-operational and the delivered waste is commonly set alight without any formal control. Little Cayman landfill's official open hours are 7am to 5pm Monday to Friday, 7am to 3pm Saturday.

None of the landfills operated by DEH require the payment of a gate fee by parties depositing waste. The deposit of materials at the landfills is therefore free of charge to all users including residents, commercial companies and CIG itself.

Recycling

The following materials are recycled by the DEH:

- Aluminium cans;
- Batteries (lead and household);
- Contaminated oil;

- Electronic and electrical waste;
- Hazardous materials;
- Natural Christmas trees (January);
- Scrap metals / derelict vehicles;
- Used cooking oil; and
- Used motor oil.

Recycling activities are primarily carried out at the landfills located at George Town and on Cayman Brac where the separately delivered materials are kept separate and stored/stockpiled for the purpose of recycling or a specialised form of disposal.

All recyclables are stored at a recycling area at the George Town landfill. Once sufficient quantities are collected, recyclables are prepared and shipped overseas to a recycling plant. Recyclables received at Cayman Brac are stored at the landfill until arrangements are made for shipping to Grand Cayman for further processing.

All recyclables collected through the DEH recycling program are shipped overseas for recycling (with the exception of Christmas Trees).

As shown in Table 2.1, several of the solid waste streams delivered to George Town landfill are segregated and in some cases stockpiled for recycling. These include aluminium cans (Figure 2.1), a proportion of the used oils and some of the construction and demolition wastes, derelict vehicles and used tyres that are delivered to the site.

Figure 2.1: Baled Aluminium Cans at George Town Landfill ready export prior to recycling

A small number of private sector waste management organisations are also actively recycling small quantities of aluminium cans, glass and plastics from multi-family and commercial premises (Figure 2.2).

Figure 2.2: Private Sector Recycling at Commercial Premises on Grand Cayman

In general, the quantities of waste that are effectively recycled are moderate compared to the overall waste tonnages that are managed. These recyclables are largely restricted to a limited number of higher value materials (such as aluminium cans) that are subsequently exported and other construction and demolition wastes that can be recycled or re-used locally (e.g. for engineering and cover materials on the landfills).

2.3 How Does the DEH Deliver Waste Services?

Under the Public Health Law (2002) Revision the DEH provides for public sector waste collection services throughout the islands and operates the principal waste management facilities. The department also undertakes environmental monitoring (and this includes the sampling and analysis of surface water, groundwater and leachate samples at the George Town landfill). The department also contributes to the Steering Committee for the NSWMS project and is responsible for the enforcement of the Public Health Act.

The Waste Collection Services

The DEH collects the following waste streams:

- Residential waste;
- Commercial waste;
- Biomedical / Infectious waste; and
- Hazardous waste.

The DEH operates both a residential and a commercial waste collection service on Grand Cayman, Cayman Brac and Little Cayman. In addition there are a number of private sector organisations that also offer commercial waste collection services on Grand Cayman.

Residential waste is collected by DEH free of charge from properties once per week. This service is primarily delivered using a fleet of conventional rear loading refuse collection vehicles (Figure 2.3). No residential waste receptacles are provided by DEH and residents use bins of various designs and capacities or the storage of waste prior to collection.

Figure 2.3: Rear Loading Refuse Collection Vehicle used on Little Cayman

The chargeable commercial waste collection service is operated by DEH throughout the Cayman Islands is available to hotels, supermarkets, restaurants and other commercial properties. The collection frequency

varies according to the terms of the agreement between DEH and the contracted commercial party and in some cases involves the daily collection of waste. The service is provided via a fleet comprising front loading vehicles, roll on roll off vehicles and grab trucks (Figure 2.4)

Figure 2.4: A Grab Truck used for Commercial Waste Collections on Cayman Brac

As part of the commercial waste collection service DEH provides a range of different receptacles to customers which are serviced by the appropriate waste collection vehicles. Table 2.3 summarise the types and number of commercial containers currently service by DEH.

Table 2.3: The Type, Size and Number of Commercial Waste Receptacles.

	Container Size (Cubic yards)	Number Serviced	Total
Grand Cayman			
Front Loading	8	471	
	4	110	
	2	34	
Roll-on/off			
Compactor	28	10	
Open Top	20	38	
	28	2	
Skiff	8	89	

	Container Size (Cubic yards)	Number Serviced	Total
Rear Loader	8	10	
	2	5	
Grand Total for Grand Cayman			**769**
Cayman Brac			
Rear Loader / Brac	8	19	
Roll –Off / Brac	20	2	
Little Cayman			
Rear Loaders / Little Cayman	8	6	
Total for Cayman Brac & Little Cayman			**27**

The waste collection fleet operated by DEH is summarised in Table 2.4. This includes a range of vehicles up to 16 years in age of various makes and models with design payloads ranging from 5.5 to 18 tons. The majority of the DEH fleet operate from a leased depot located at off Lincoln Way, George Town.

Table 2.4: DEH Waste Collection Vehicle Fleet at the start of 2015

	Make	Model	Year	Payload (lb)
Front Loaders	Autocar	Xpeditor WX64	2004	32,360
	Autocar	Xpeditor WX64	2004	37,560
	Mack	MR688S	2003	35,340
Rear Loaders	International	7300	2003	10,420
	International	7400	2003	22,940
	International	7400	2003	23,220
	Mack	MR688S	2004	29,000
	International	5900	1999	25,500
	Mack	GU812E	2010	11,321
	Mack	GU813	2010	11,161
	Mack	MR688S	2004	27,540
	Freightliner	M2-106	2014	25,860
	Freightliner	M2-106	2014	25,860
Roll on Roll off	Mack	MR688S	1999	32,480
	Sterling	LT-8511	2002	35,580

	Make	Model	Year	Payload (lb)
	Kenworth	T800	2005	32,780
	Mack	MR688S	1999	32,140
	Kenworth	T800	2005	30,320
Grab Trucks	Sterling	LT-8511	2001	29,700
	Sterling	LT-8500	2007	27,680
	Sterling	LT-8511	2001	31,240
	Sterling	LT-8500	2006	29,020

In addition to the routine waste collection services operated by DEH there is also a non-routine and periodic services provided for:

- The collection of bulky residential waste; and
- Clean up events.

Residential Waste

Residential waste is collected at the kerbside from residents on Grand Cayman, Cayman Brac and Little Cayman. Rear-loading compactor vehicles with three man crews, one driver and two collectors, are used for single family residences and small, multi-residence dwellings.

Residents using the service are required to do the following:

- Each bag or container should not exceed 40 pounds in weight (approximately 18kg);
- Place garbage in water tight, metal or plastic garbage containers with tight-fitting lids;
- Place containers in front of premises or to the side of property on the street, immediately beside the property before 4:30am; and
- Sharp objects such as pieces of metal, tree branches, glass or needles should not protrude from any bags or containers.

Commercial Waste Collection

Commercial waste collection is accomplished through container rental and servicing. Several sizes and types of containers are available and can be rented on a daily, monthly or annual basis. The servicing frequency can be arranged from once per month to six days per week. There are several commercial waste collection companies operating on the Cayman Islands including: Island Waste Carriers and Junk.

Waste is not accepted from cruise ships although smaller boats may deposit small amounts of waste for disposal.

Biomedical (Clinical) / Infectious Waste Collection

Biomedical/infectious waste is collected separately and the waste that is collected on Grand Cayman is disposed of at the clinical waste incinerator located at George Town landfill. The 2 hospitals at Grand Cayman produced around 131 tons of waste that is incinerated each year. Biomedical/infectious waste collected on Cayman Brac is currently landfilled in a discrete hazardous waste pit excavated in the landfill on Cayman Brac (although these materials were previously burnt in a now dis-used incineration unit).

Litter / Roadside Collection

DEH provides a road side litter collection service on Grand Cayman and Cayman Brac. Details of this service are:

- Central George Town is cleaned every working day;
- All other Grand Cayman districts are cleaned on a weekly basis; and
- Areas on Cayman Brac are cleaned on a weekly basis.

Bulky Waste Collection

Large bulky items such as bicycles, furniture, tyres and redundant appliances are not collected as part of the routine residential or commercial waste collection services. These items are either taken to the landfill sites directly by residents, collected by DEH for a fee, or are gathered as part of the periodic DEH collection sweep. DEH conducts a special clean-up campaign for bulk waste where a collection service is offered from various locations, usually in November/December.

Hazardous Waste Management

DEH requests service users ensure that hazardous wastes are separated from other wastes and at each landfill, there is a designated storage area for all hazardous materials that enter the landfill. At each designated area, hazardous materials are stored and processed for shipping overseas to the United States where it is disposed of in accordance with United States Environmental Protection Agency (US EPA) regulations.

2.4 How Does CIG Deliver its Waste Management Services?

Institutional and Organisational Responsibilities

The organisational structure of the CIG is shown in Figure 2.5. Those ministries and departments with direct responsibilities with regard to the management of waste on the Islands include:

- The Ministry of Health and Culture: The Ministry has responsibility for the production of the NSWMS and procurement of an integrated waste management system for the Cayman Islands, and chairs the Steering Committee for this project. The Ministry also administers the DEH;
- The DEH: The department provides the public sector waste collection services throughout the Cayman Islands and operates the principal waste management facilities. The department also undertakes environmental monitoring (and this includes the sampling and analysis surface, groundwater and leachate samples at George Town landfill). The department also contributes to the Steering Committee for the NSWMS project; DEH is also responsible for enforcement of the Public Health Act;
- The Ministry of Lands, Agriculture. Housing and Infrastructure: The Ministry administers the Departments of Planning and Public Works amongst others. The Department of Planning will be responsible for the permitting the development of new waste management infrastructure;
- The Ministry of Financial Services, Commerce and the Environment: The Ministry administers the Department of the Environment amongst others;
- The Department of Public Works is project managing the production of the NSWMS and procurement of the integrated waste management system and contributes to the Steering Committee for the project; and
- The Department of the Environment: The department has an overarching interest and responsibility for the protection of the environment on the Cayman Islands and contributes to the Steering Committee for the NSWMS project.

Figure 2.5: Cayman Islands Government Organisational Structure

CAYMAN ISLANDS GOVERNMENT ORGANISATIONAL STRUCTURE

Effective 1 January 2015 *Information correct as of the issue date, but subject to change. Information vetted by the Deputy Governor's Office.

CAYMAN ISLANDS GOVERNMENT

LEGISLATIVE ASSEMBLY

SPEAKER
Hon. Juliana O'Connor-Connolly, JP

DEPUTY SPEAKER
Hon. Anthony S. Eden, CBE, JP

PREMIER
Hon. Alden McLaughlin, MBE, JP

DEPUTY PREMIER
Hon. Moses Kirkconnell, JP

CABINET MINISTERS:
Hon. Alden McLaughlin, MBE, JP
Hon. Moses Kirkconnell, JP
Hon. D. Kurt Tibbetts, CBE, JP
Hon. Osbourne Bodden, JP
Hon. Marco Archer, JP
Hon. Wayne Panton, JP
Hon. Tara Rivers, JP

CABINET MEMBERS:
First Official Member, Deputy Governor
Hon. Franz Manderson, Cert. Hon., JP
Second Official Member, Attorney General
Hon. Samuel Bulgin, QC, JP

GOVERNMENT BACKBENCH MEMBERS
Mr. Joseph Hew
Mr. Winston Connolly
Mr. Alex Panton
Mr. Roy McTaggart

LEADER OF THE OPPOSITION (LoO)
Hon. W. McKeeva Bush, OBE, JP

OFFICIAL OPPOSITION MEMBERS
Capt. A. Eugene Ebanks, JP
Mr. Bernie Bush

INDEPENDENT MEMBERS
Mr. Ezard Miller, JP
Mr. Arden McLean, JP

COUNCILLORS
Mr. Joseph Hew (Tourism)
Mr. Winston Connolly (Education & Employment)
Mr. Alex Panton (Computer Services & eGovernment, Culture)
Mr. Roy McTaggart (Financial Services, Health)

EXECUTIVE/ JUDICIAL RELATIONSHIPS
ACCOUNTABILITY LINES
POLICY GUIDANCE
WORK RELATIONSHIP

LEGISLATIVE ASSEMBLY

AUDITOR GENERAL / CHIEF OFFICER
Mr. Alastair Swarbrick

COMPLAINTS COMMISSIONER/ CHIEF OFFICER
Ms. Nicola Williams

ACTING INFORMATION COMMISSIONER/ CHIEF OFFICER
Jan Liebaers

COMMISSIONS
Judicial & Legal Services Commission
Human Rights Commission
Commission for Standards in Public Life
Constitutional Commission
Anti-Corruption Commission
Civil Service Appeals Commission

Advisory Committee on the Prerogative of Mercy
National Security Council
Parole Commissioners Board
Prisons Inspection Board

DIRECTOR OF PUBLIC PROSECUTIONS/CHIEF OFFICER
Ms. Cheryll Richards, JP
Office of the Director of Public Prosecutions

HER EXCELLENCY THE GOVERNOR
Mrs. Helen Kilpatrick, CB

Deputy Governor

PREMIER
Hon. Alden McLaughlin, MBE, JP

DEPUTY PREMIER
Hon. Moses Kirkconnell, JP

THE CABINET
MINISTERS
Hon. Alden McLaughlin, MBE, JP
Hon. Moses Kirkconnell, JP
Hon. D. Kurt Tibbetts, CBE, JP
Hon. Osbourne Bodden, JP
Hon. Marco Archer, JP
Hon. Wayne Panton, JP
Hon. Tara Rivers, JP
OFFICIAL MEMBERS
Hon. Franz Manderson, Cert. Hon., JP
Hon. Samuel Bulgin, QC, JP

Chief Justice of the Cayman Islands
Hon. Justice Anthony Smellie, QC

Grand Court Puisne Judges
Hon. Justice Alexander Henderson
Hon. Justice Charles Quin, QC
Hon. Justice Angus Foster
Hon. Justice Andrew Jones
Hon. Justice Sir Peter Cresswell
Hon. Justice Richard Williams

Cayman Islands Court of Appeal President
Rt. Hon. Sir John Goodwin
Appeal Court Judges
Hon. Justice C. Moncrieff, JA
Hon. John Martin, QC, JA
Hon. Sir George Newman
Hon. Sir Bernard Rix, QC

SUMMARY COURT
CORONER'S COURT
DRUG REHABILITATION COURT

Magistrates/Summary Court and Coroner's Court
Chief Magistrate
Her Honour Nova Kirk, JP
Magistrates
His Honour Valdis Foldats, JP
Her Honour Kirsty-Ann Gunn, JP

COURTS ADMINISTRATION
CHIEF OFFICER
JUDICIAL ADMINISTRATOR
Ms Kevin McCormac, JP

DEPUTY GOVERNOR & HEAD OF THE CIVIL SERVICE
Hon. Franz Manderson, Cert. Hon., JP
PORTFOLIO OF THE CIVIL SERVICE (POCS)

ATTORNEY GENERAL
Hon. Samuel Bulgin, QC, JP
PORTFOLIO OF LEGAL AFFAIRS (PLA)

MINISTER
Hon. Alden McLaughlin, MBE, JP
HOME AFFAIRS, HEALTH & CULTURE (HA/H&C)

MINISTER
Hon. Osbourne Bodden, JP
COMMUNITY AFFAIRS, YOUTH & SPORTS (CA/Y&S)

MINISTER
Hon. Tara Rivers, JP
EDUCATION, EMPLOYMENT & GENDER AFFAIRS (EE&GA)

MINISTER
Hon. Moses Archer, JP
FINANCE & ECONOMIC DEVELOPMENT (F&ED)

MINISTER
Hon. D. Kurt Tibbetts, CBE, JP
PLANNING, LANDS, AGRICULTURE, HOUSING & INFRASTRUCTURE (PLA/H&I)

MINISTER
Hon. Moses Kirkconnell, JP
DISTRICT ADMINISTRATION, TOURISM & TRANSPORT (DA/T&T)

MINISTER
Hon. Wayne Panton
FINANCIAL SERVICES, COMMERCE & ENVIRONMENT (FSC&E)

CABINET SECRETARY/ CHIEF OFFICER
Mrs Samuel Rose, JP

departments & sections:
- Cabinet Secretariat
- Policy Coordination Unit
- Protocol Office
- Freedom of Information Unit
- Premier's Office
- Government Information Services
- Radio Cayman
- CIG TV

authorities, boards & committees
- Immigration Appeals Tribunal

CHIEF OFFICER
Mrs. Gloria McField-Wilson, JP

departments & sections:
- Civil Service College
- Public Sector Reform
- Strategic and Corporate Human Resources
- Internal Audit
- HR Audit
- Legislative Department
- National Archive
- Commissions Secretariat

authorities, boards & committees
- Records Advisory Committee
- Public Service Pension Board

Deputy Governor's Office

departments & sections:
- Parole Board Secretariat
- Prisons Inspection Board Secretariat
- ACPM Secretariat
- Strategic Reforms Implementation Unit

authorities, boards & committees
- Civil Aviation Authority
- Air Transport Licensing Authority

SOLICITOR GENERAL/ CHIEF OFFICER
Ms. Jacqueline Wilson

departments & sections:
- Law Revision
- Legal Department
- Legislative Drafting Department
- Law Reform Commission
- Financial Reporting Authority
- Cayman Islands Law School

authorities, boards & committees
- Grand Court Rules Committee
- Legal Advisory Council
- Law Revision Commission
- Anti-Money Laundering Steering Group

CHIEF OFFICER
Mr. Eric Bush, JP

departments & sections:
- Immigration
- Police (Budget & Support)
- Public Safety Communications
- Hazard Management Cayman Islands
- Prisons
- Fire
- Community Rehabilitation
- Computer Services
- London Office

authorities, boards & committees
- Business Staffing Plan Board
- Cayman Brac and Little Cayman Immigration Board
- Caymanian Status & Permanent Residency Board
- Work Permit Board
- National Hazard Management Executive
- National Hazard Management Council
- e-Government Advisory Committee
- National Drug Council

CHIEF OFFICER
Ms. Jennifer Ahearn, JP

departments & sections:
- Health Regulatory Services
- Mosquito Research & Control Unit
- Environmental Health

authorities, boards & committees
- Health Services Authority
- Health Practice Commission
- Medical & Dental Council
- Council for Professions Allied with Medicine
- Nursing & Midwifery Council
- Pharmacy Council
- Cayman Islands National Museum
- Cayman National Cultural Foundation
- National Gallery

CHIEF OFFICER
Ms. Dorine Whittaker, JP

departments & sections:
- Department of Children and Family Services
- Department of Counselling Services
- Department of Sports
- Youth Services Unit
- Cadet Corps

authorities, boards & committees
- Adoption Board
- Children and Youth Services (CAYS) Foundation
- National Sports Council
- National Youth Commission

CHIEF OFFICER (Acting)
Mr. Christen Suckoo

departments & sections:
- Education Services
- Labour and Pension
- National Workforce Development Agency
- Public Libraries
- Sunrise Adult Training Centre
- Educational Standards Assessment Unit (ESAU)
- Gender Affairs Unit

authorities, boards & committees
- Caribbean Examinations Council National Committee
- University College of the Cayman Islands
- Education Council and Education Board for Cayman Brac and Little Cayman
- National Pensions Board
- Public Library Management Committee
- Labour Tribunals and Labour Appeals Tribunals
- Gender Equality Tribunal

CHIEF OFFICER/FINANCIAL SECRETARY
Mr. Kenneth Jefferson, JP

departments & sections:
- Economics and Statistics Office
- Risk Management
- Treasury
- Finance Administration
- Customs

authorities, boards & committees
- Public Sector Investment Committee
- Central Tenders Committee
- Cayman Islands National Insurance Company

CHIEF OFFICER
Mr. Alan Jones, JP

departments & sections:
- Planning
- Agriculture
- Facilities Management
- Lands & Survey
- Public Works
- Vehicle and Equipment Services
- Temporary Housing Unit
- Vehicle & Drivers' Licensing
- Petroleum Inspectorate
- Postal Services

authorities, boards & committees
- Animal Welfare Advisory Committee
- Veterinary Board
- Land Surveyors Board
- Water Authority
- National Roads Authority
- Electricity Regulatory Authority
- Street Naming & Numbering
- Information & Communications Technology Authority
- Development Control Board
- Electrical Trade Licensing Board of Examiners
- Central Planning Authority
- National Housing Development Trust (NHDT)
- Planning Appeals Tribunal
- Development Plan Tribunal
- Sister Islands Planning Tribunal

CHIEF OFFICER
Mr. Steve Ebanks, JP

departments & sections:
- District Administration
- Tourism
- Public Transport Unit
- Sister Islands Sports
- National Weather Service

authorities, boards & committees
- Port Authority
- Airports Authority
- Cayman Turtle Farm
- Cayman Airways
- Hotel Licensing Board
- Mira Cayman Committee
- Public Transport Board
- Tourism Advisory Council
- Tourism Attractions Board
- Tourism Apprenticeship Training Programme Council
- National Festival Committee & District Committees
- Sister Islands Affordable Housing Development Corporation

CHIEF OFFICER
Dr. Dax Basdeo, JP

departments & sections:
- Financial Services Secretariat
- Department of Commerce & Investment
- General Registry
- Tax Information Authority
- Liquor Licensing Unit
- Environment
- Marketing & Communications Unit

authorities, boards & committees
- Financial Services Council
- Financial Services Legislative Committee
- Cayman Islands Monetary Authority
- Cayman Islands Stock Exchange
- Auditors Oversight Authority
- Trade and Business Licensing Board
- Maritime Authority of the Cayman Islands
- Film Commission Advisory Board
- Special Economic Zone Authority
- Cayman Islands Development Bank
- Marine Conservation Board
- Beautification Committee
- Liquor Licensing Board
- cinematograph board

DEH has 86 personnel that are involved in the delivery of the solid waste management service these include:

- 4 staff involved in management functions;
- 48 staff undertaking the waste collection service;
- 17 staff involved in landfill operations;
- 11 staff engaged in the litter collection; and
- 6 staff carrying recycling operations.

The DEH operates the existing landfill facilities in George Town, Cayman Brac and Little Cayman and undertakes some monitoring of the environment surrounding George Town landfill. In this capacity DEH is self-monitoring, however the department does not undertake this function in relation to formal Cayman Island regulatory standards or requirements. The lack of defined national standards and an independent regulatory body, has, in Amec Foster Wheeler's view; potentially contributed to the current situation where the impact of the landfills upon the local environment and amenity is unclear and has raised local concerns. This has been exacerbated by the lack of containment of these facilities and the restricted funding available to DEH to both operate and monitor the landfill sites to modern standards.

Funding

As indicated in the Table 2.5, DEH's solid waste revenue is largely generated from fees on vehicle disposals and removals, incinerations, container rentals and servicing. An annual budget allocation from the CIG represents just under 50% of DEH's overall revenue. There is limited revenue from recycling (most recently scrap metal sales) and no tipping fees are charged for landfill disposal.

Additionally, fines are issued under the Litter Law and Public Health Law however these do not constitute a material source of revenue for DEH. DEH funding is also generated by "upfront" solid waste management fees on imported goods. However it is Amec Foster Wheeler's understanding from interviews with DEH personnel that in practice, these fees do not flow directly to DEH.

Table 2.5: DEH Funding Breakdown

Cayman Islands Solid Waste Annual Revenue			
Current Revenue Streams	**Services**	**CI$**	**US$**
Garbage fees	Annual container rentals Commercial container servicing Incinerators Daily container rentals Grapple truck service Litter bin rentals Derelict vehicle removals	2,630,000	3,140,299
Recycling revenues	Scrap metal sales Other recycling	30,000	35,821
Vehicle disposal fees	Tires Batteries Imported vehicle	708,000	845,373
Third party subtotal		**3,368,000**	**4,021,493**
Cabinet revenue	Budget allocation	3,132,552	3,740,361
Total		**6,500,552**	**7,761,853**

Source: CIG Strategic Outline Case

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3. Environmental and Site Investigations

3.1 Introduction

Initial Reconnaissance Visit November 2014

In November 2014 Amec Foster Wheeler undertook an initial reconnaissance visit to the existing waste management facilities located on Grand Cayman (Figure 3.1), Little Cayman and Cayman Brac. This work enabled the recovery of historical waste management data from the islands, the gathering of background information on the waste management facilities and some initial site monitoring at the landfill sites.

The initial site visits and data recovery exercise enabled Amec Foster Wheeler to develop an initial view of the waste management systems and practices in use on the Islands.

Using the data collected during the reconnaissance visits, Amec Foster Wheeler was able to compile initial site based conceptual models and risk assessments for each of the existing landfill sites, and to identify existing data gaps.

Figure 3.1: George Town Landfill

The output of the initial environmental and site investigation work is contained in the Amec Foster Wheeler report dated January 2015 issued to the CIG[1], which sets out:

- An initial conceptual model for each of the landfills sites;
- The outcome from the initial site based risk assessment ; and
- Recommendations for further site based works at each of the landfill sites.

Following the completion of the first round site investigation report Amec Foster Wheeler prepared and issued a proposal to the CIG for a further set of site- based investigations. These works were specifically

[1] Amec Foster Wheeler (2015) Phase1 Environmental and Site Investigation Report

targeted to facilitate the refinement of the initial site based risks assessments, fill data gaps and up-date aged historical information. The works encompassed the installation and instrumentation of new groundwater monitoring wells, the collection of gaseous, groundwater, surface water, and biological samples from within and around the landfills. These proposals were accepted and approved by CIG and Amec Foster Wheeler commenced a second round of environmental and site investigation works on the 6th April 2015.

Site Investigations April 2015

Following Amec Foster Wheeler's recommendations arising from the initial site reconnaissance and preliminary risk assessments, CIG commissioned further environmental site investigation works on and around the operational landfills sites located on Grand Cayman, Cayman Brac and Little Cayman. These commenced on the 6th April 2015 and were completed on the 21st April 2015. The works included the drilling of several new monitoring boreholes at the George Town and Cayman Brac landfill sites under the supervision of Amec Foster Wheeler (Figures 3.2 and 3.3).

Figure 3.2: Borehole Installation on Cayman Brac

Figure 3.3: Borehole Installation at George Town landfill

A wide range and number of environmental samples were also recovered for analysis and interpretation, these included samples of:

- Surface waters (including the North Sound, local dykes and canals);
- Groundwater (from existing and new monitoring wells);
- Sediment (including the North Sound, local dykes and canals);
- Soil samples;
- Landfill gas;
- Deposited dust;
- Air;
- Marine vegetation (from North Sound); and
- Surface vegetation.

The samples were collected by Amec Foster Wheeler with assistance from the Departments of Environment, Environmental Health and Public Works (Figures 3.4 to 3.6). These were then dispatched for laboratory analysis.

Figure 3.4: Dust Sampling

Figure 3.5: The Collection of Surface Water Samples from the Dyke to the North of George Town landfill

Figure 3.6: Gas and Emissions Monitoring at George Town Landfill

The analytical results from the environmental site work have been used to:

- Update the conceptual model for each of the landfills sites;
- Inform and update the site based risk assessments; and
- Develop recommendations on management and future remediation of the landfill sites.

The outcomes for each landfill site are summarised in Sections 3.2 to 3.4 below.

3.2 George Town Landfill

The George Town landfill (Figure 3.7) is located to the north of central George Town towards the western coast of Grand Cayman. It is owned by CIG and operated by the DEH.

Waste disposal at the site began in the mid 1960's and up until about 1985 the volume of waste deposited in the landfill was reduced by burning. The older landfill area is therefore likely comprised of ash towards the base. The northern and central part of the site was acquired in 1989 and this comprises the main body of the active landfill. The southern part of the site was acquired in 1991.

The total site area is approximately 73 acres (30 hectares) in extent and the site boundary is identified on Figure 3.7 and the majority of the site has historically received inputs of waste materials, the exceptions being the western margin of the site, to the west of Esterley Tibbets Way and the north west margin of the site, to the north of the drainage channel.

The landfill is characterized by a mound rising to 77 ft. (23.6 m) above mean sea level (MSL) and was formed by tipping over an area of former mangrove swamp which was partially excavated to recover the underlying marls (calcareous soils). The landfill forms a prominent feature that is visible over a wide area of western Grand Cayman and from across the North Sound.

Figure 3.7: Aerial Photograph of George Town Landfill

The site has no formal engineered containment (i.e. a basal lining system). Part of the site is capped with a thin layer of soil materials and has been re-vegetated.

The access road to the George Town landfill is from Seymour Road located to the south of the site. At the entrance to the site (Figure 3.8) is a small wooden gatehouse which is manned during normal working hours. The entrance is not gated (although it does have a barrier) and Amec Foster Wheeler understands that the landfill can be accessed by residential, commercial and industrial vehicles for the purpose of depositing wastes during operational hours. Those delivering waste to the facility are not levied any charge for this service.

There is a single weighbridge (weigh scale) and associated building located close to the top of the site access road and near to the equipment storage area. Amec Foster Wheeler understands that prior to March 2015 the weighbridge was not manned continuously and was therefore not operated during a portion the landfill opening hours. As a consequence, there is likely to be significant historical under recording of the waste tonnages being deposited at the site.

Figure 3.8: George Town Landfill Site Entrance

Just to the south of the site entrance is a waste drop-off area that is used by members of the public (Figure 3.9). The area comprises a raised hard standing concrete platform, accessed directly off the main road leading in to the landfill site. Waste brought in to the drop off area can be placed in to a number of hook lift skips set at a lower level around two sides of the platform. At the time of the visits the skips contained mixed waste including bagged household waste and garden waste.

There is some limited provision at the drop area for segregation of some specific wastes for recycling or separate disposal. These wastes include tyres and electrical goods. No site personnel were actively directing members of the public in the use of the drop off area during the periods when Amec Foster Wheeler visited the site.

Figure 3.9: The Drop-off Area at George Town Landfill

The main landfill mound is located in the north east part of the site. It covers an area of approximately 25 acres (10 hectares). This area is partially soil covered on the lower part of the western flank, it otherwise comprises compacted but uncovered waste. In places shallow contaminated ponds of standing water/leachate were observed (Figure 3.10).

Figure 3.10: Leachate Contaminated Surface Water

A flat lying area in the north-western part of the site has largely been infilled with demolition and related wastes from the disaster clean-up operations following Hurricane Ivan in 2004. It originally comprised areas of open water arising from previous marl abstraction. This area also contains piles of scrap metal and tyres (Figure 3.11).

Figure 3.11: Stockpiled Used Tyre and Metals

An arsenic contaminated waste containment pit, which comprises a small geomembrane lined and capped area; is located in the eastern part of the Hurricane Ivan in-fill. Amec Foster Wheeler understands that this contains ash from the burning of treated timber waste arising from the post Hurricane Ivan clean up. The ash is reported to have a high arsenic content due the insectides/fungicides originally used to treat the timber. No construction records were made available for this area but there are some marker posts indicating its position which were observed on the ground.

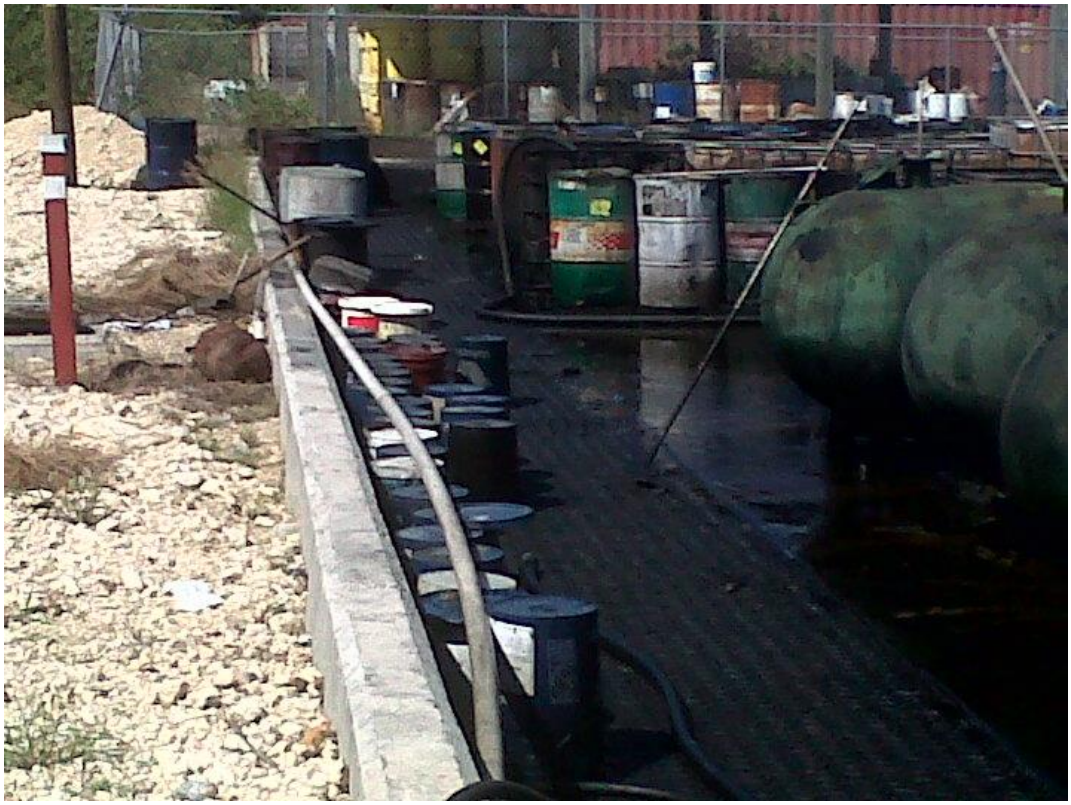
Both operational and redundant site plant is stored on a flat stoned area in the southern part of the site. The operational plant includes excavators, a refuse compactor and hook lift trucks. Skips and shipping

containers are also stored in this area. There are a number of steel sheeted buildings used variously for the storage of materials (e.g. aluminium cans), the storage of equipment (e.g. a bailer) and for plant maintenance. The buildings are also used for storage of source segregated aluminium cans which are baled onsite. Several items of redundant equipment (e.g. tyre shredders and a broken compactor) are also stored outside of the buildings.

On the southern margin of the equipment storage area are the following facilities:

- A waste oil storage area (Figure 3.11). Waste oils and fuels are stored within a concrete surfaced and bunded hard standing where they are tested and segregated before being pumped into larger shipping tanks prior to export for subsequent off-island recycling or treatment;
- Covered and fenced hazardous waste storage compound. This is used for the storage of hazardous waste such as paints and household chemicals. These are subsequently transferred off-island for treatment/disposal; and
- On site laboratory used for the testing of waste oils and chemicals delivered to the site.

Figure 3.12: The Bunded Oil Storage Area



During the site inspection in November 2014 Amec Foster Wheeler dipped the monitoring borehole MW16 located between the western canal and the waste oil storage area. Groundwater within the well was seen to be visually contaminated with black oils. This suggests that the oil containment bund system is breeched on occasion, possibly by overtopping during heavy rainfall events.

Clinical and infectious waste tonnages on Grand Cayman are treated in a clinical waste incinerator located in the north-east location of the George Town landfill (Figure 3.13). As well as treating clinical waste, the incinerator is also used to periodically burn confidential documents and drugs seized by the Royal Cayman Islands Police Service.

The incinerator is a diesel fuelled, batch oxidation system rated at 4 tons per day. The unit was installed in 2008 following its purchase from Enerwaste International Inc. Data records indicate that the unit runs intermittently (approximately twice per week). This intermittent cycle is probably responsible for the observable damage to the refractory lining of the primary combustion chamber. The extent of this damage (cracking and chipping) will probably result in failure of the unit within the next two or three years.

In addition the practice of manually charging the primary chamber with several days of clinical waste prior to incineration is probably resulting in a short period during each burn cycle when the emissions form the unit will be visible and contain partial combustion products.

Bottom ash from the clinical waste incinerator is deposited in George Town landfill.

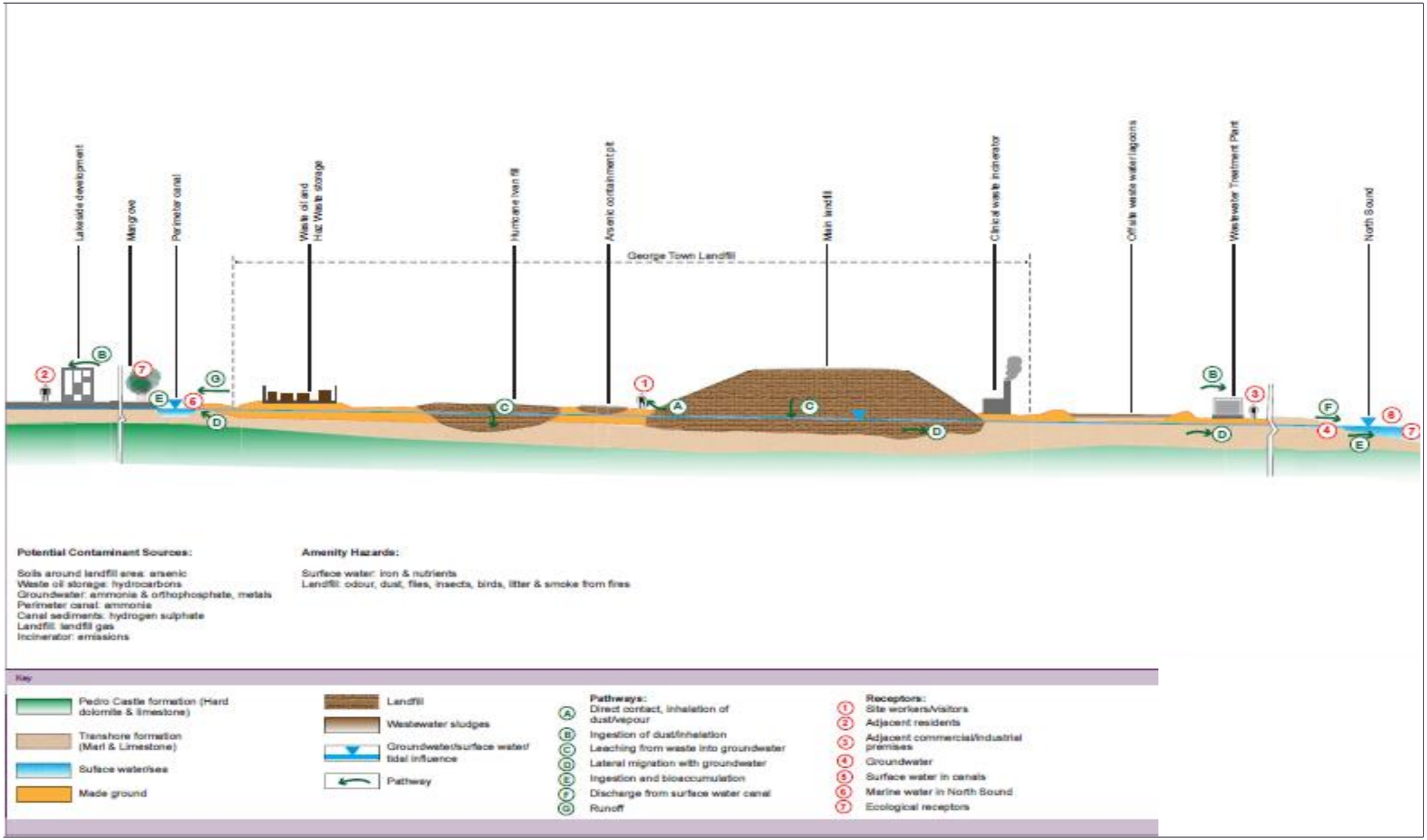
Figure 3.13: The Clinical Waste Incinerator Located at George Town Landfill

Conceptual Model

A conceptual model has been prepared for the landfill site which identifies potential contaminants and amenity related hazards, potential pathways and receptors. The conceptual model considers both onsite and offsite sources. The conceptual model is summarised in Figure 3.14 and this discussed further in the Amec Foster Wheeler report data August 2105[2].

[2] Amec Foster Wheeler(2015) Phase 2 Environmental and Site Investigations: Interpretative Report

Figure 3.14: George Town Landfill Conceptual Model



Summary of Potential Contamination and Hazards

On-Site Sources

From the assessment of historical and current activities and the environmental monitoring data (which have been screened, where appropriate, against generic assessment criteria) the potential on-site sources are identified in Table3.1. These include contaminants and amenity related hazards.

Table 3.1: Summary of On-site Potential Contamination and Hazards at George Town Landfill

Location	Source	Contaminant (C) or Hazard (H)	Type	Source Quantitative Data Y= yes N= no	Comment
Soils around waste area	Unknown, could be from former waste burning	C	Arsenic	Y	Exceeds Florida soil clean-up assessment criteria but generally below UK assessment criteria. Noted at three locations. Arsenic containment pit onsite
Waste Oils storage area	Hydrocarbons	C	Hydrocarbons	Y	Oil contamination noted by Amec Foster Wheeler within well MW16. 0.84mg/l DRO in surface water at SW12
Groundwater	Leaching from wastes	C	Ammonia	Y	The Florida clean-up standard of 28 mg/l has been exceeded in MW10 and new monitoring well MW21 which had the highest result yet recorded at the site in 2015
Groundwater	Leaching from wastes	C	Iron	Y	Detected above the clean-up level of 3 mg/l with results ranging up to 11 mg/l
Groundwater	Leaching from wastes	H	Orthophosphate	Y	Found at reduced concentrations in surface waters
Surface water canal	Leaching from waste and groundwater base flow	C	Ammonia	Y	The April 2015 sampling identified concentrations of between 2.0 and 6.5 mg/l in the perimeter canals
Surface water canal	Leaching from waste and groundwater base flow	C/H	Metals	Y	The sample from SW3 recorded exceedences of the relevant clean-up levels for copper and lead.
Surface water canal	Leaching from waste and groundwater base flow	H	Elevated nutrients	Y	Nitrogen and orthophosphate in canal with potential eutrophication impact to North Sound
Surface water canal	Runoff	H	Turbidity/dissolved solids	Y	Some historical issues noted
Sediment at canal mouth to North Sound	Historical run-off	C	Sulphate	Y	Potentially associated with hydrogen sulphide generation
Incinerator	Stack emission	C/H	Combustion products	N	No emission test data

Location	Source	Contaminant (C) or Hazard (H)	Type	Source Quantitative Data Y= yes N= no	Comment
Landfill area	Landfill gas	C	Methane and carbon dioxide	Y	Methane potentially explosive and carbon dioxide an asphyxiant
Landfill area	Landfill gas	C/H	Hydrogen sulphide	Y	Hydrogen sulphide elevated in one of the gas probes
Landfill area	Landfill gas	C/H	Trace gas components	Y	Trace gases are a source of odour and a potential hazard within the landfill
Landfill area	Municipal waste	H	Dusts	Y	Measured deposition rate less than guideline value but limited data
Landfill area	Municipal waste	H	Smoke from fires	N	Combustion products
Landfill area	Municipal waste	H	Vermin attracted to the wastes	N	Spread of food scraps and bones
Landfill area	Municipal waste	H	Flies and insects	N	Pest control carried out
Landfill area	Tyre storage	H	Combustion products from accidental fires in tyre storage areas	N	Combustion products from tyre burning have the potential to impact offsite residential users
Landfill area	Municipal waste	H	Scavenging birds	N	Scavenging birds attracted to the landfill could increase the bird strike risk to aircraft

Off-Site Sources

From the assessment of historical and current activities a number of contaminative activities or, hazards have been identified and are associated with off-site activities. These are set out in Table 3.2.

Table 3.2: Summary of Off-site Potential Contamination and Hazards at George Town Landfill

Location	Source	Contaminant (C) or Hazard (H)	Type	Quantitative Data Y= yes N= no	Comment
Wastewater sludge lagoons	Sludge decomposition	C	Hydrogen sulphide	N	Hydrogen sulphide generation from former/active sludge lagoons indicated by monitoring
Wastewater sludge lagoons	Sludge decomposition	H	Odour	N	Odour generation from former/active sludge lagoons
Various Industrial Premises	Soil and aggregate storage	H	Dusts	N	Various sources of dust generation on industrial premises to the south east and south of the site

Receptors and Pathways

Receptor groups have been identified in Table 3.3 together with some notes on their status.

Table 3.3: Receptors at George Town Landfill

Receptor Groups	Comments
Site workers and visitors	Site has open access and members of the public can access out of hours
Adjacent residents	Lakeside development and Parkside Close located approximately 330ft (100m) from site boundary and downwind of the site. The Camana Bay development is located approximately 0.5 miles beyond the northern boundary.
Adjacent commercial/industrial premises	Industrial and commercial premises to the south and east of the site. The airport is located approximately 1mile beyond the southern boundary of the site.
Groundwater	Groundwater is brackish and in continuity with perimeter canals. There are public water supply (PWS) abstractions approximately 1 mile from the site; this water is treated.
Surface water in canals around the landfill	The canals are tidal and brackish water. There is no recreational use.
Marine water in North Sound	There is no specific water quality designation for the area of western part of North Sound adjacent to the landfill. However other parts of the Sound are used diving and wildlife interaction and these activities indicate the quality of water required to sustain them.
Ecological receptors	Some birds were noted in the 'leachate' ponds onsite. The canals are fringed by mangroves which are a roost for birds. Iguanas swim in the canals and were also seen on the landfill. Some large fish were observed in the eastern part of the North Canal during the April 2015 water sampling. North Sound contains a diverse marine ecology.

Potential pathways are considered in Table 3.4.

Table 3.4: Potential Receptors and Pathways at George Town Landfill

Receptor	Pathway
Site workers and visitors	Dermal contact, direct contact, ingestion, inhalation
Adjacent residents	Ingestion of dusts, inhalation
Nearby residents and people	Ingestion of dusts, inhalation
Adjacent commercial/industrial premises	Ingestion of dusts, inhalation
Groundwater (including PWS extraction)	Leaching and migration
Surface Water (canals and North Sound)	Run-off (to canal only), migration and groundwater base flow
Ecological receptors offsite	Ingestion and bioaccumulation from contaminated waters/sediments. Eutrophication from elevated nutrients affecting marine ecology in North Sound.

Risk Assessment Methodology

The development of the conceptual models have identified a number of potential contaminant and hazard linkages (contaminant/hazard-pathway-receptor linkages) between receptors and the landfill site.

Each contaminant linkage has been qualitatively assessed using the following criteria:

- Potential consequence of contaminant/hazard linkage;
- Likelihood of contaminant/hazard linkage; and
- Risk classification.

The updated environmental risk assessment for the site is included in Appendix A. This comprises an analysis of potential contaminant/hazard linkages (contaminant/hazard-pathway-receptor) between potential receptors and the landfill site.

Risk Assessment Outcomes

The outcomes from the risk tables in Appendix E are summarised below. Some further commentary on the rational for the classification of each risk is given in the tables. The first summary for each receptor considers contaminants and the second amenity hazards. Amenity risk is based on the identification of a potential hazard or nuisance for which there are no generic assessment criteria.

Site Workers and Visitors

Potential risks to site workers and visitors from arsenic in soils are assessed as moderate. The potential risks from hydrogen sulphide, other landfill gas trace components (such as volatile organic compounds or VOC's) and methane (as a potentially explosive gas) are also all assessed as moderate. The risks to site workers/visitors from hydrocarbons from the waste storage area is assessed as moderate/low, assuming appropriate PPE is worn.

Adjacent Residents

The potential risks from landfill gas trace components and from methane (as a potentially explosive gas) are both assessed as moderate/low. Potential risks to adjacent residents from arsenic in soils are assessed as low.

Potential dust nuisance to adjacent residents is assessed as medium and odour nuisance as high. Potential risks associated with scavenging animals and birds, pests (e.g. flies) mosquitoes and contaminated waters used for recreational purposes are assessed as medium. There is a potential high risk associated with nuisance and potential health impacts from landfill fires.

Adjacent Commercial/Industrial Users

The potential risks from landfill gas trace components and from methane (as a potentially explosive gas) from landfill gas are assessed as moderate/low, although the potential risks from landfill gas trace components from contaminated sediments are assessed as moderate. Potential risks to adjacent commercial/industrial users from arsenic in soils are assessed as low.

The potential for the landfill to contribute

Groundwater

The risks to groundwater from hydrocarbons (spills and overtopping of bunds) are assessed as moderate. Potential risks to groundwater from arsenic are assessed as negligible and low with regard to ammonia.

Surface Water Canals

Potential risks to surface water canals from both hydrocarbons (spills and overtopping of bunds) are assessed as high. Risks from ammonia and orthophosphate (from groundwater base flow) are assessed as moderate, and from iron are assessed as moderate/low.

Sediments at the mouth of the North Canal are a possible source of hydrogen sulphide with a moderate risk to humans.

North Sound

The potential risk to water quality in North Sound (adjacent to the canal discharge) from ammonia in canal water is assessed as high. The potential risks to water quality from ammonia from contaminated groundwater is assessed as moderate/low and from metals in canal water is assessed as moderate.

The potential risk to North Sound ecology from ammonia in the canal in the canal is assessed as high as elevated levels were recorded at the mouth of the canal.

Elevated nutrients, iron and solids in the canal pose a potential high risk to aquatic vegetation adjacent to the mouth of the canal from sediment and iron blanketing and eutrophication.

A more detailed assessment of potential impacts on North Sound is outside the scope of this study and is included as a recommendation for further study.

Void assessment and Estimated Remaining Life of George Town Landfill

Waste Inputs

The CIG has provided data on waste tonnages as recorded at the site weighbridge for material entering the George Town landfill site. The data includes some materials such as scrap metal which are stockpiled at the site pending recycling and as such do not enter the landfill disposal area. Having screened the data the estimated tonnages entering the landfill disposal area in 2012, 2013 and 2014 were 53,835, 57,826 and 54,488 tons respectively. Anecdotal information is that not all loads entering the site were necessarily weighed and recorded so these figures are likely to be underestimates.

From early 2015 the CIG conducted a more thorough capture and weighing of loads entering the site. Based on four months of recorded data the projection for the rest of 2015 indicates that the amount of waste entering the landfill disposal area in 2015 will be approximately 70,400 tons.

To account for future growth in waste generation, a year on year growth rate of 3% has been assumed from 2015. This is consistent with the baseline waste flow modelling undertaken for the development of the NSWMS for the Cayman Islands.

Topographical Survey Data

The Lands & Survey department of the CIG has supplied topographical survey data for the George Town landfill site dated April-June 2004, June 2008, June 2013 and July 2015.

Volumetric Calculation

Digital Terrain Models (DTM's) were created using McCarthy Taylor Systems Ltd. LSS software package from the topographical survey information provided.by the CIG.

DTM's for the 2013 and 2015 surveys were used to provide a figure for the total volume of waste placed in the landfill during the 25 month period between surveys. This equates to an average 6,114 yd^3/month (4,674 m^3/month)). Based on the weighbridge data for the period the average monthly tonnage was 4,583 US tons which gives a placed density of approximately 0.98 tons/m^3.

This density was then used to calculate the estimated volume of waste entering the landfill for the next 5 years (based on the estimated yearly tonnage for 2015 with a 3% year on year growth).

Table 3.5 shows the projected tonnages and equivalent placed volumes for each year.

Table 3.5: Projected Waste Volumes

Year	Estimated Tonnage (tons)	Estimated Volume (m^3)	Estimated Volume (yd^3)
2016	70,400	69,024	90,280
2017	72,513	71,095	92,989
2018	74,688	73,228	95,779
2019	76,929	75,425	98,652
2020	79,237	77,688	101,612

Landfill Footprint

Figure 3.15 shows the landfill footprint based on the July 2015 survey and based on the projected volumetric inputs the expansion of the landfill footprint on a year by year basis. The following assumptions have been made in the modelling of the landfill expansion:

- Filling will continue to the west in a series of strips constrained to the south by the arsenic waste containment cell which will not be disturbed or overfilled;
- The current stockpiles of scrap metal and tyres in the expansion area will be progressively removed down to surrounding ground level;
- Wastes in the expansion area will be placed directly on the existing ground surface with no re-profiling or construction of containment; and
- The top of the waste will fall gently from the current western edge level of 50.8 feet on the cross section line shown on Drawing 36082/SHR/06X to 43.4 feet for the July 2020 landform in order to provide drainage from a future capping system to the site edge (note the final site level would be slightly higher as restoration soils would need to be placed above the engineered cap.

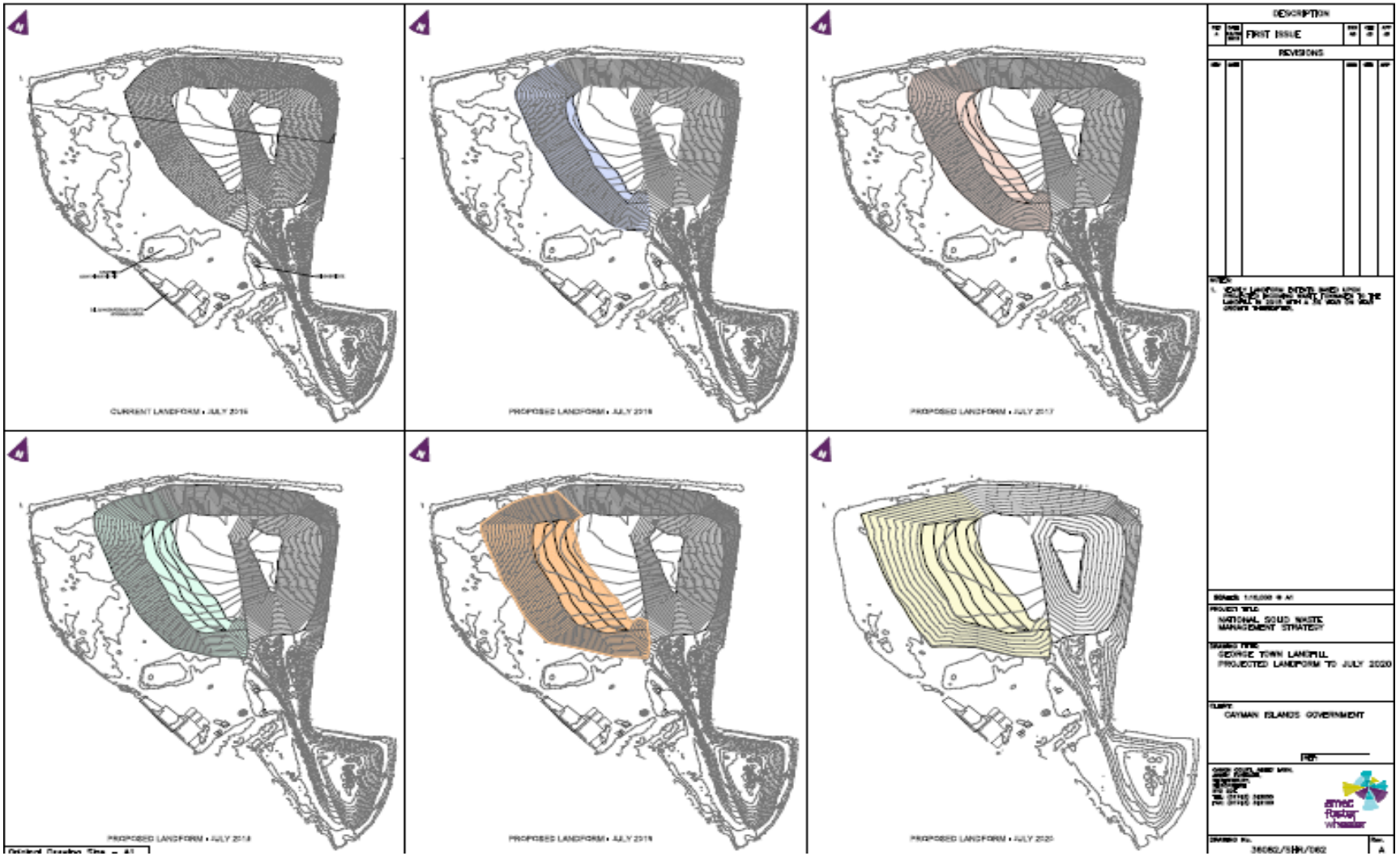
The modelling provides an indication of the remaining land in the west of the site which could be used for other waste activities and/or creation of an engineered containment cell for residual waste. It is noted the expansion and remaining land is all underlain by fill comprising Hurricane Ivan wastes which extends below the water table.

Remaining Lifespan

Based on the void space analysis and the above associated assumptions, the existing George Town landfill site will be more or less at capacity by the summer of 2021. Construction of a residual waste cell within the site after this period is likely to be difficult. The CIG should therefore consider alternative land to accommodate new waste management facilities including an alternative landfill area for residual waste/APC (Air Pollution Control) residues. Such new landfill facilities would need to be engineered to modern standards and include containment measures and environmental control facilities for both non-hazardous and hazardous wastes.

Early diversion of waste prior to 2021 (through reduction and recycling) and potential landfill mining at George Town landfill could provide some additional flexibility on the use of the existing landfill void and prolong the life of the landfill for a limited number of years.

Figure 3.15: George Town Landfill Footprint and Projections



3.3 Cayman Brac Landfill

The Cayman Brac landfill is located on the southern side of the island off South Side West Road as shown on Figure 3.16. The landfill site is understood to have been operational from at least 1978.

Figure 3.16: Aerial View of Cayman Brac Landfill

The landfill site is owned by the CIG and operated by the DEH. The total site area (excluding that south of the road) is approximately 20 acres (8 hectares). The northern part of the site has been used for municipal waste disposal by land raising against a natural cliff or bluff of limestone which runs along the northern margin of the site. The lower south western part of the site is used for storage of scrap metal (to the west of the site road) and the disposal of green waste to the east. The south east quadrant of the site has not been filled and includes a pond, known as the Red Shrimp Lagoon (Figure 3.17).

Figure 3.17: The Red Shrimp Lagoon

The landfill is predominantly a waste mount formed by tipping over an area of former scrub. The site has no formal engineered containment (i.e. a basal lining system). Part of the municipal waste area is capped with a thin layer of soil materials but there has been no re-vegetation.

The access road to the site is off South Side Road West, it is located to the north of the road and approximately 280 feet (85m) from the beach. A gravel internal road leads from the entrance in to the landfill and is not gated. A small hut which is manned during normal working hours is located off the access road. The site has no further security measures and can be readily accessed outside of normal working hours.

A scrap metal and waste tyre stockpile area is located to the west of the access road and comprises mixed scrap including end of life vehicles and white goods (Figure 3.18). The scrap is poorly sorted and contains some plastic and timber. Site operatives indicated that the current stockpiles have accumulated over a period of several years. The northern end of the scrap metal stockpile pile is scorched and partially burnt out from a fire which is understood to have occurred in 2010. During early 2015 the accumulated tyres were containerised and transferred to the George Town landfill site and work has started on processing some of the scrap metal stockpile.

Figure 3.18: Stockpiled Scrap Metal at Cayman Brac

Waste oil and car batteries are stored in various containers adjacent to the scrap metal storage area. The oils are transferred into an ISO tank for ultimate off-island transfer. There is no secondary containment of the oil transfer area and there is some evidence of oil spills. Soil contaminated with oil is sometimes scrapped up and disposed in a pit excavated into the municipal waste within the site.

The active part of the landfill is located in the north western part of the site and comprises a wedge of in-filled waste built up against the rock face of the limestone bluff (up to approximately 26 feet (8m) in thickness). It is approximately 2.2 acres (1 hectare) in extent. The waste is largely uncovered except in part of the southern flank. The waste comprises mainly black bag materials from household collections with some commercially collected materials including wooden pallets and cardboard (Figure 3.19).

Figure 3.19: Waste Deposited at Cayman Brac Landfill

Green waste is stored to the east of the access road where it decomposes. The green waste deposits are contaminated and contain other municipal wastes. Amec Foster Wheeler understand that green waste was previously shredded at the site but this is no longer the case. Green waste has been deposited right up to the western edge of the Red Shrimp Lagoon.

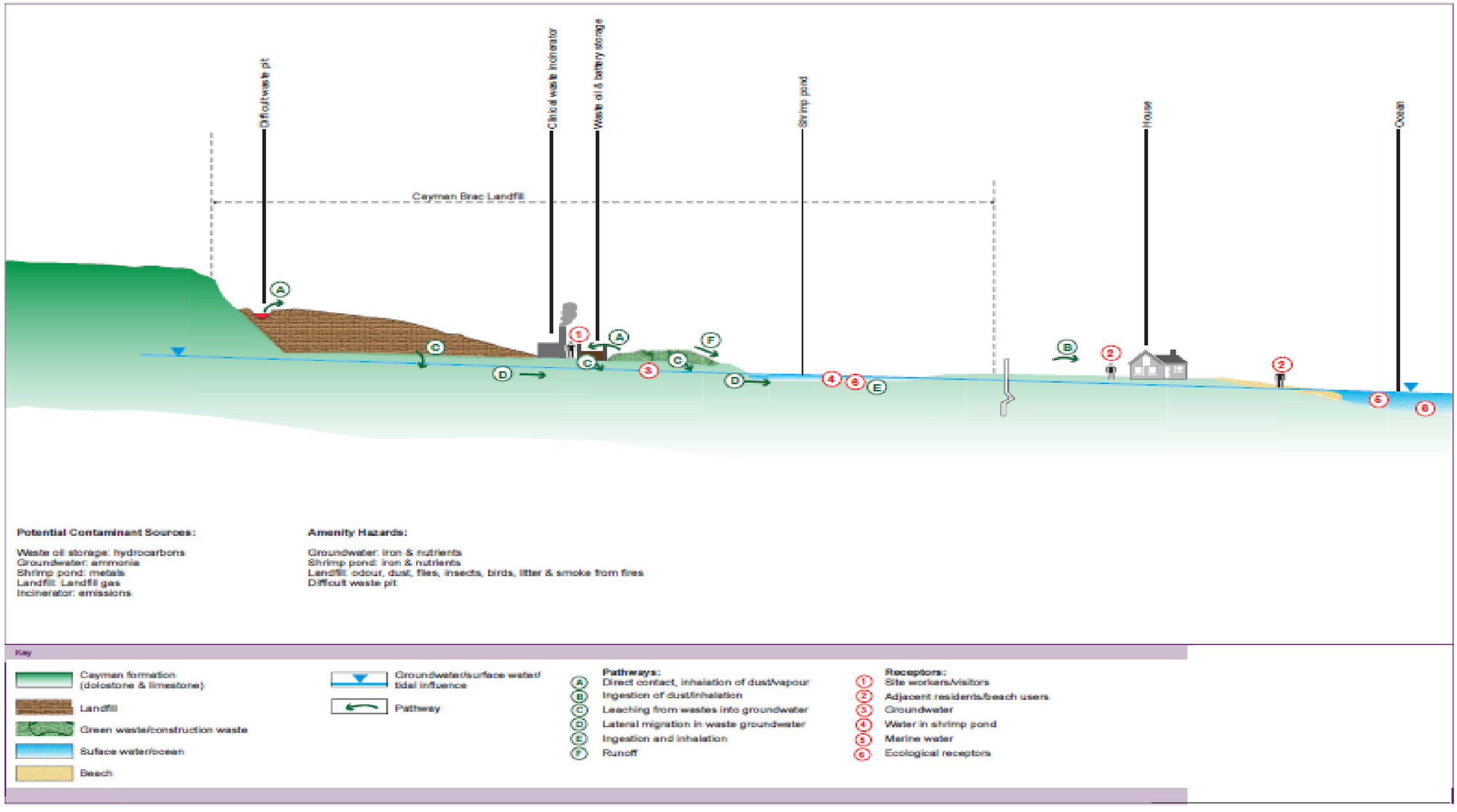
A thin layer of fill in the north east corner of the site is understood to consist of demolition waste and related debris arising from clean-up associated with Hurricane Paloma in 2006. More recent construction and demolition waste has been deposited up to the northern edge of the Red Shrimp Lagoon. A pit is excavated in the area for the disposal of clinical waste when the on-site incinerator is out of service and for disposal of sewage sludges and oil contaminated waste from spill clean-up.

A small clinical waste incinerator is located to the east of the access road. This is a diesel fired unit and was not in operation at the time of the site visits. Ash from the unit is disposed of within the landfill area. Adjacent to the incinerator are containers of aluminium cans collected for recycling.

Conceptual Model

A conceptual model has been prepared for the site which identifies potential contaminants and amenity related hazards, potential pathways and receptors. The conceptual model considers both onsite and offsite sources. The conceptual model is summarised in Figure 3.20.

Figure 3.20: Cayman Brac Landfill Conceptual Model



Summary of Potential Contamination and Hazards

On-Site Sources

From the assessment of historical and current activities and environmental monitoring data (which have been screened against generic assessment criteria) the potential on-site sources are identified in Table 3.6.

Table 3.6: Summary of On-site Potential Contamination and Hazards at Cayman Brac Landfill

Location	Source	Contaminant (C) Hazard (H)	Type	Quantitative Data Y= yes N= no	Comment
Waste Oils storage area	Hydrocarbons	C	Hydrocarbons	Y	Some surface spills noted. DRO detected in surface water samples from BSW1 and BSW2 and groundwater samples CB1-CB4 in April 2015. GRO detected in groundwater sample CB4.
Groundwater	Leaching from wastes	C	Ammonia	Y	Detected up to 18mg/l in CB2 but not above Florida clean-up standard
Surface water	Leaching from wastes	C	Metals	Y	Elevated concentrations of copper and lead in surface water samples.
Incinerator	Stack emission	C/H	Combustion products	N	No emission test data and incinerator currently out of use.
Landfill area	Landfill Gas	C/H	Landfill gas trace components/bioaerosols	Y	Odours
Landfill area	Landfill Gas	C	Methane and carbon dioxide	Y	Methane is potentially explosive and carbon dioxide an asphyxiant
Landfill area	Municipal waste	H	Smoke from fires	N	Combustion products
Landfill area	Municipal waste	H	Flies and insects	N	Site has a pest control regime
Landfill area	Municipal waste	H	Scavenging animals	N	Evidence of scavenging animals on site
Landfill area	Clinical Waste	H	Biohazards	N	Disposal in uncovered pit within the landfill (clinical waste incinerator not in operation)

Off-Site Sources

No off-site contamination sources or hazards have been identified.

Receptors and Pathways

Receptor groups have been identified in Table 3.7 together with some notes on their status.

Table 3.7: Cayman Brac Landfill Receptors

Receptor Groups	Comments
Site workers and visitors	Site has open access and members of the public can access out of hours
Adjacent residents	Three properties located immediately south of the site.
Adjacent public recreation areas	Public beach located 230 ft (70m) south of the site
Groundwater	Groundwater is brackish. There are no known abstractions in the vicinity of the site.
Surface water in Red Shrimp Lagoon	Brackish water with possible groundwater base flow.
Marine water	Potential groundwater mixing along the coastline
Ecological receptors	Some birds were noted in the Red Shrimp Lagoon. This forms part of The Marshes wetland area. National Trust for the Cayman Islands own wetland 850 ft (260 m) west of the site. A marine park is located offshore.

Potential pathways are considered in Table 3.8.

Table 3.8: Cayman Brac Potential Receptors and Pathways

Receptor	Pathway
Site workers and visitors	Dermal contact, direct contact, ingestion, inhalation
Adjacent residents	Ingestion of dusts, inhalation
Adjacent public recreation area	Ingestion of dusts, inhalation
Groundwater	Leaching and migration
Surface Water (shrimp pond)	Run-off, migration and groundwater base flow
Marine Water	Groundwater base flow/mixing

Risk Assessment Methodology

The development of the conceptual models have identified a number of potential contaminant and hazard linkages (contaminant/hazard-pathway-receptor linkages) between receptors and the landfill site. These are tabulated in Appendix H. Each contaminant linkage has been qualitatively assessed using the following criteria:

- i) Potential consequence of contaminant/hazard linkage;
- ii) Likelihood of contaminant/hazard linkage; and
- iii) Risk classification.

The updated environmental risk assessment for the site is included in Appendix B. This comprises an analysis of potential contaminant/hazard linkages (contaminant/hazard-pathway-receptor) between potential receptors and the landfill site.

Risk Assessment Outcomes

The outcomes from the risk tables in Appendix B are summarised below. The first paragraph summary for each receptor considers contaminants and the second amenity hazards.

Site Workers and Visitors

The potential risks from landfill gas trace components are assessed as moderate to low and from methane (as a potentially explosive gas) as moderate. The risks to site workers/visitors from hydrocarbons from the waste oil storage spills is assessed as low, assuming appropriate PPE is worn.

The risk to site users and visitors from the clinical waste disposed in the uncovered pit within the landfill is assessed as medium.

Adjacent Residents

The potential risks from landfill gas trace components are assessed as low and from methane (as a potentially explosive gas) as moderate/low.

Potential dust and odour nuisance to adjacent residents is assessed as medium. There is a potential medium risk associated with nuisance from landfill fires. Potential risks associated with pests (i.e. insects) are assessed as medium and are low with respect to scavenging animals and birds.

Groundwater

Potential risks to groundwater from hydrocarbons are assessed as moderate and from ammonia are assessed as low.

Red Shrimp Lagoon

The potential risks to the Red Shrimp Lagoon from metals leached from the landfill are assessed as moderate.

Potentially elevated nutrients and iron from run-off and groundwater base flow have as assessed medium impact on water quality in the shrimp pond.

Ocean

The potential risk to the ocean from ammonia in groundwater is assessed as low.

There is an assessed medium risk to water quality from potentially elevated nutrients and iron in groundwater base flow.

3.4 Little Cayman Landfill

The Little Cayman landfill is located in the central part of the island off Olivine Kirk Drive. The entrance is located to the west of the road and beyond an area occupied by the island power generation plant. It is approximately 0.5 miles (0.8km) from the north coast. Figure 3.21 identifies the site location.

Little Cayman landfill site is owned by the CIG and operated by the DEH. The site is believed to have become operational sometime shortly before1994.

The total site area is approximately 50 acres (21 hectares) of which approximately 2.2 acres (1 hectare) has received waste materials. The site is flat lying and has very little infrastructure. Deposited municipal wastes are regularly set-alight and the landfill largely comprises a burning ground with piles of unburned refuse (Figure 3.22).

Figure 3.21: Aerial View of Little Cayman Landfill

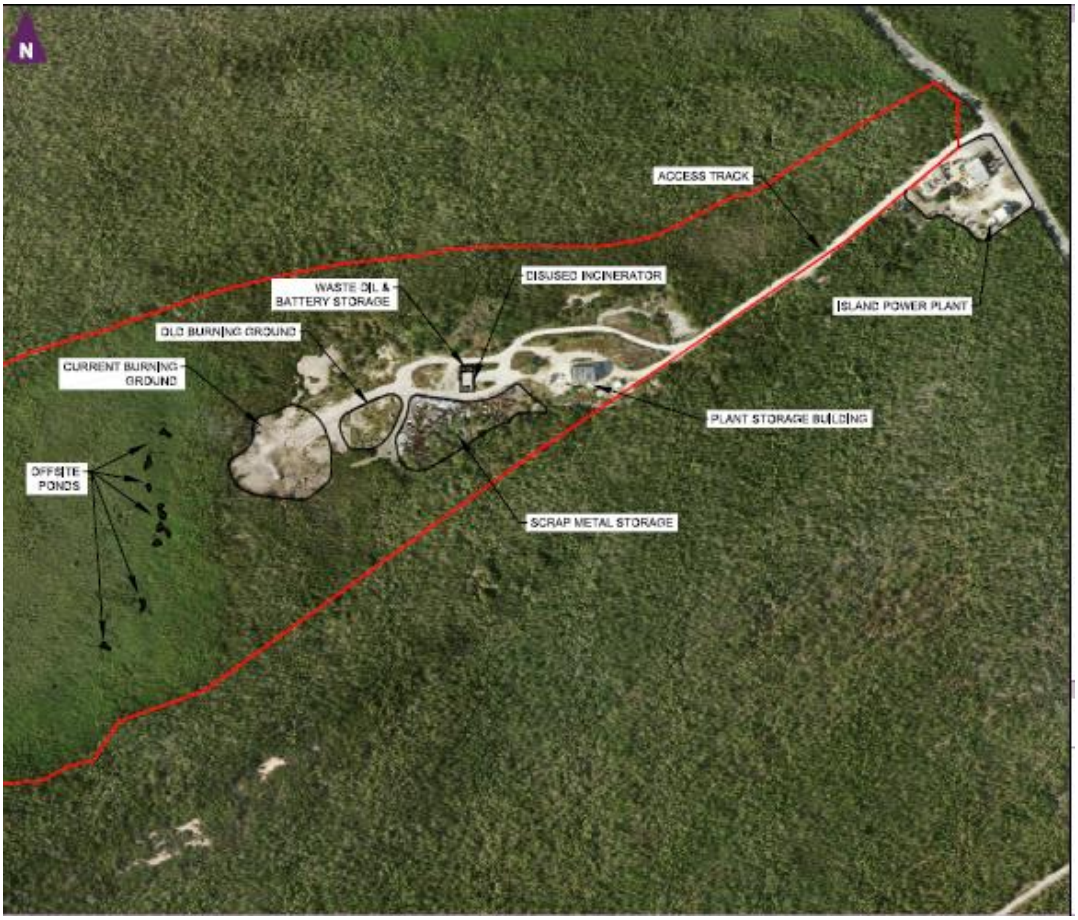


Figure 3.22: Burnt Waste at Little Cayman Landfill

There is no weighbridge at the site and no data on input tonnages, although these are likely to be small considering the resident population of the island is approximately 170. The site has no security measures and can be readily accessed outside of normal working hours

A scrap metal storage area is located to the south of the access road and comprises mixed scrap including end of life vehicles and white goods (Figure 3.23). The scrap is poorly sorted and contains some plastic and timber. Site operatives indicate the current pile has accumulated over a period of several years.

Figure 3.23: Little Cayman Landfill Scrap Metal Stockpile

Waste oil, drummed waste and car batteries are stored in various containers and areas at the eastern end of the site but drum of wastes were also found to be randomly distributed over the site. In some cases the drums showed evidence of extensive corrosion, other exhibited obvious signs leakage and several appeared to be distorted under internal pressure (Figure 3.24). The areas of stored oil drums and batteries (Figure 3.25), pending ultimate off-island transfer, have no secondary containment and show some evidence of leakage. The quantities observed would suggest a number of years of accumulation. An illegal oil disposal pit was found at the site during the April 2015 inspection.

Figure 3.24: Leaking and Distorted Drummed Wastes at Little Cayman Landfill

Figure 3.25: Stockpiled Batteries at Little Cayman Landfill

Municipal wastes are deposited at the western end of the site and are regularly set alight. Deposits were found to be smouldering during an Amec Foster Wheeler site visit. The waste comprises mainly household waste with wooden pallets, cardboard and a significant proportion of vegetation/green waste. The ash/clinker residues from the burning are estimated to be up to 3 feet (0.9m) thick. At the eastern end of the burning area the ash contains an abundance of glass and metal debris.

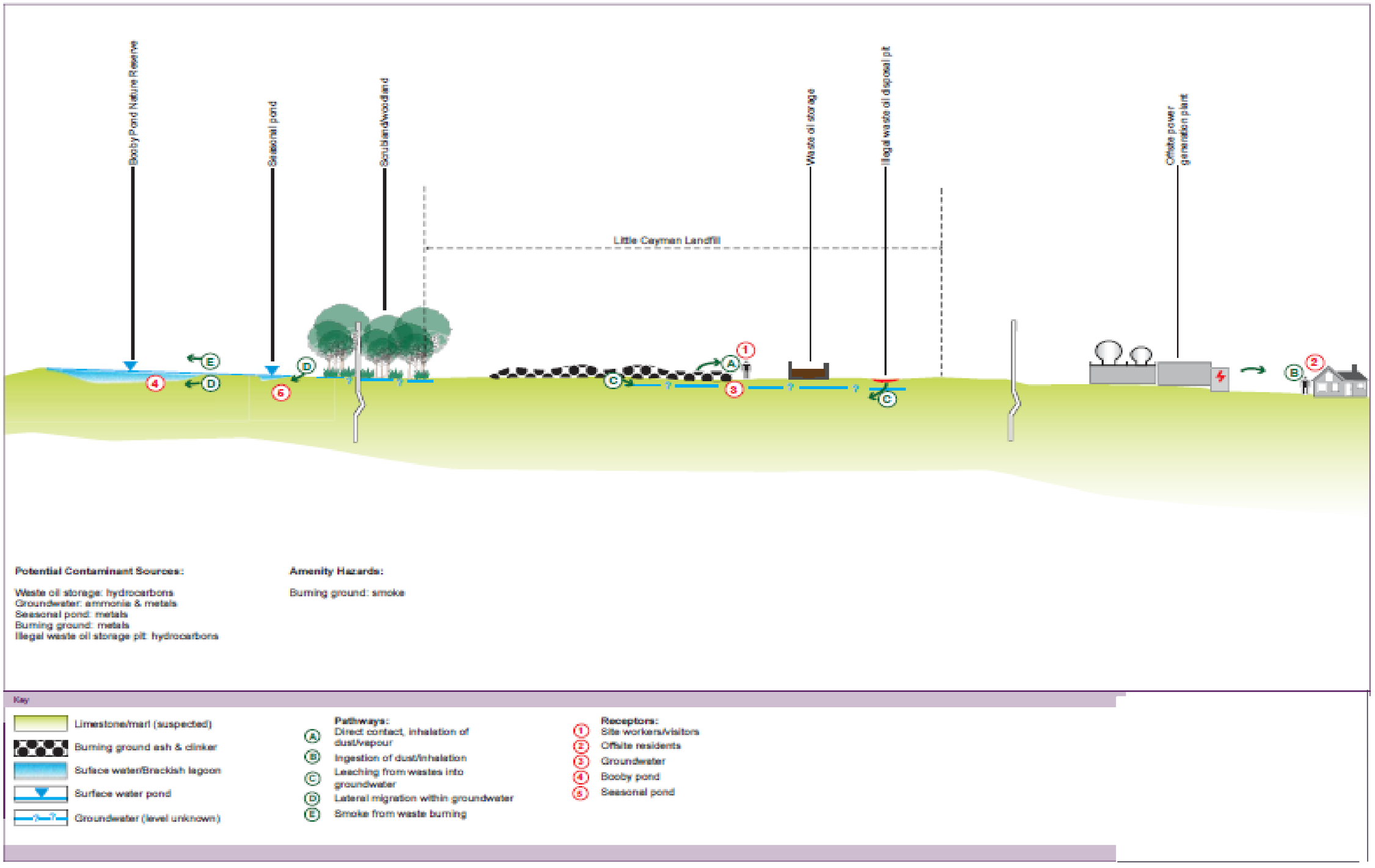
A disused small curtain burn incinerator is located at the eastern end of the site. Waste used to be tipped into the unit from an adjacent ramp prior to controlled combustion. It has not been used for some years and is now partially filled with unburnt refuse.

A cladded plant storage building is located at the eastern end of the landfill area. This was locked at the time of the site visit. It is understood this building is used to store vehicles associated with waste collection.

Conceptual Model

A conceptual model has been prepared for the site which identifies potential contaminants and amenity related hazards, potential pathways and receptors. The conceptual model considers both on-site and off-site sources. The conceptual model is included as Figure 3.26.

Figure 3.26: Little Cayman Landfill Conceptual Model



Summary of Potential Contamination and Hazards

On-Site Sources

From the assessment of historical and current activities and the limited environmental monitoring data (which have been screened against generic assessment criteria), the potential onsite sources are identified in Table 3.9.

Table 3.9: Summary of Little Cayman Landfill On-site Potential Contamination and Hazards

Location	Source	Contaminant (C) Hazard (H)	Type	Quantitative Data Y= yes N= no	Comment
Waste Oils storage area	Hydrocarbons	C	Hydrocarbons	Y	Some surface spills noted. DRO detected in both surface water samples, GRO in surface water sample LSW2.
Illegal waste oil disposal pit	Hydrocarbons	C/H	Hydrocarbons	N	Illegal waste oil disposal pit at the site, near the plant storage building.
Groundwater	Leaching from burning area	H/C	Metals	Y	Arsenic, copper and lead detected above relevant standards in soil samples submitted for leaching tests
Offsite pond	Leaching from waste and groundwater base flow	H/C	Metals	Y	Copper and lead above relevant Florida clean-up levels
Burning Ground	Ash and clinker	C	Metals	Y	Arsenic above relevant Florida clean-up level in soils
Burning Ground	Smoke	C/H	Combustion products	N	

Little Cayman Landfill Off-Site Sources

The Island power generation facility is located east of the landfill area. This is a diesel powered facility and a potential source of hydrocarbon contamination. No other off-site contamination sources or hazards have been identified.

Receptors and Pathways

Receptor groups have been identified in Table 3.10 together with some notes on their status.

Table 3.10: Little Cayman Landfill Receptors

Receptor Groups	Comments
Site workers and visitors	Site has open access and members of the public can access at any time.
Offsite residents	The nearest properties are some 0.35 miles south of the site.
Groundwater	Groundwater depth and quality is unknown. There are no known abstractions in the vicinity of the site.
Surface water in offsite ponds	Most likely brackish water with possible groundwater base flow.
Booby Pond nature reserve	Internationally important site approximately 0.5 miles south-west of the site.

Potential pathways are considered in Table 3.11.

Table 3.11 Little Cayman Landfill Potential Receptors and Pathways

Receptor	Pathway
Site workers and visitors	Dermal contact, direct contact, ingestion, inhalation
Adjacent residents	Ingestion of dusts, inhalation of smoke
Groundwater	Leaching and migration
Surface Water (offsite ponds)	Run-off, migration and groundwater base flow
Fauna in Booby Pond nature reserve	Smoke and combustion products from waste burning

Risk Assessment Methodology

The development of the conceptual models have identified a number of potential contaminant and hazard linkages (contaminant/hazard-pathway-receptor linkages) between receptors and the landfill site. These are tabulated in Appendix J. Each contaminant linkage has been qualitatively assessed using the following criteria:

- i) Potential consequence of contaminant/hazard linkage;
- ii) Likelihood of contaminant/hazard linkage; and
- iii) Risk classification.

The risk assessment criteria assessment methodology is provided within the Task 2 investigation factual report.

The updated environmental risk assessment for the site is included in Appendix C. This comprises an analysis of potential contaminant/hazard linkages (contaminant/hazard-pathway-receptor) between potential receptors and the landfill site.

Risk Assessment Outcomes

The outcomes from the risk tables in Appendix C are summarised below. The first paragraph summary for each receptor considers contaminants and the second amenity hazards.

Site Workers and Visitors

Potential risks to site workers and visitors from combustion products and metals in soils are assessed as moderate/low and from hydrocarbons in soils are assessed as low.

Adjacent Residents

Potential dust and odour nuisance to adjacent residents is assessed as low due to the distance from the landfill. Potential risks associated with scavenging animals/birds and insects are assessed as low and medium, respectively.

There is also a potential medium risk associated with nuisance from landfill fires.

Groundwater and Off-site Pools

Potential risks to groundwater from hydrocarbons are assessed as moderate and from metals are assessed as moderate/low. Risks to groundwater from ammonia are assessed as low. Risks to offsite pools from metals are assessed as moderate/low.

There is also a potential medium risk to offsite pools associated with elevated nutrients, iron and solids.

Booby Pond

Potential risks to the Booby Pond from air transport of smoke and combustion products is assessed as medium.

4. Solid Waste Management Drivers and Policy

4.1 Regional Context

Solid waste management is a critical problem for a number of small Caribbean nations. Many factors render the management of solid waste in the Caribbean complex. These factors include population density, limited available resources, unavailability of scale-efficient technologies and competition for land use. According to a report by Willard Phillips and Elizabeth Thorne entitled Municipal Solid Waste Management in the Caribbean[3], the growing rate of solid waste generation per capita coupled with the fact that most Caribbean countries are heavily reliant on tourism are two structural characteristics that present particular challenges for the management of waste in Caribbean economies. Furthermore, Phillips and Thorne state that stop-over tourists generate at least twice the amount of waste as local residents, while cruise ship passengers generate up to four times the amount generated by local residents.

Another common issue among Caribbean countries is that residential solid waste collection is undertaken at no cost to households. Generally, the cost of waste services is typically funded through a budgetary allocation from the central government. The absence of specific disposal fees to the household provides no incentive to reduce generated waste which directly contributes to the challenges of managing solid waste in Caribbean countries.

In order to effectively address the issues discussed above, many Caribbean nations are either undergoing a revision of their respective waste disposal programs or have already implemented a waste management scheme designed to alleviate disposal issues.

The Bahamas[4,5,6,7]

The Department of Environmental Health is responsible for solid waste collection and disposal in the country. In 2014, the government outsourced its waste management program to a private enterprise, Renew Bahamas, which has the responsibility of managing and operating the nation's largest landfill for a period of five years. Residential waste is collected free of charge for all islands excluding the city of Freeport located on the Island of Grand Bahama. Medium and large commercial organizations are required to obtain private hauler services for the collection of waste. The majority of waste is disposed of at the New Providence landfill.

Like many other Caribbean countries, The Bahamas faces a number of critical waste management issues. Issues include frequent fires at the New Providence landfill, a facility that is approaching its capacity and the improper disposal of garbage. Additionally, there is no legislated waste separation system in place; therefore recyclables and non-recyclables are typically mixed together and taken directly to the (New Providence) landfill for disposal.

Various companies offer free recycling services, however, these facilities are predominately privately owned. Some recycling companies in New Providence pay waste generators for the deposit of recyclables. A new Materials Recycling Facility (MRF) is being built on the Island of New Providence to help sort and separate the waste. Composting facilities are also available however they are not as prevalent. There is one biodiesel facility, however the diesel produced at this plant is not sold to the public but is instead used to run the company's fleet of vehicles. Around the country, waste management campaigns are led by both the government and private enterprises primarily aimed at educating the community to practice the concept of "reduce, reuse, recycle".

The Grand Bahama Port Authority operates a free trade zone in the main city of Freeport hence The Grand Bahama Utility Company, a licensee of The Grand Bahama Port Authority, is legally appointed as the entity responsible for refuse collection in Freeport. Residents and businesses alike are charged for waste collection

[3] W, Phillips and E. Thorne (2013): Municipal Solid Waste Management in the Caribbean
[4] Bahamas government website
[5] Renew Bahamas website
[6] Freeport By-laws
[7] Bahamas Waste website

within the city limits. Waste collection fees are levied based on the type of customer. Customers are categorized as single family, apartment or business. Special fees are also levied for the disposal of vehicles or septic waste.

Barbados[8,9]

Barbados has implemented an integrated solid waste management program which commenced in 1993 with a feasibility study. The management of waste in Barbados is the primary responsibility of three major agencies:

- The Environmental Protection Department – Responsible for the monitoring and regulation of the solid waste management and government operated solid waste disposal sites;
- The Sanitation Service Authority ("SSA") – responsible for the collection, transportation and disposal of all household solid waste as well as the operations of Barbados' four disposal sites; and
- The Solid Waste Project Unit ("SWPU") – responsible for the implementation of the Integrated Solid Waste Management Program.

In Barbados, generators of household waste are provided with free waste collection whereas generators of commercial and bulky waste are required to pay for waste collection. In 2014, Barbados introduced a municipal solid waste tax that was strongly opposed by the local population and subsequently repealed in 2015. The tax was levied to assist with the management of solid waste within the country. In 2015, a new tipping fee of US$40.00 was introduced.

Barbados is faced with issues of high levels of waste production and in some cases illegal dumping. As a result Barbados has developed many initiatives in an effort to combat these problems through its agencies. The SSA has established a committee for the prevention of illegal dumping which aims is to educate communities about the problems associated with illegal dumping. Additionally, Barbados has multiple recycling centers that are primarily owned by the private sector. SSA and SWPU collaborate to encourage recycling on the island. Significant developments over the past years have resulted in the establishment of the Solid Waste Management Centre which is a partnership between the government's Solid Waste Project Unit and Sustainable Barbados Recycling Centre. This center has resulted in the recovery of significant volumes of recyclables that previously would have been landfilled. Through the operation of this facility approximately 70% of the waste is expected to be diverted away from landfilling and towards the production of useful products including recyclables, compost, aggregates and mulch.

[8] Barbados National assessment Report, 2010

[9] Solid waste and recycling in Barbados. http://businessbarbados.com/trending/green-business/solid-waste-and-recycling-in-barbados/

Bermuda[10,11,12,13]

Bermuda's Ministry of Works and Engineering has commissioned the Waste Management Section to assume full responsibility for the safe disposal of all household and commercial waste and recycling. Included in this mandate is the collection of special waste, composting, the operation of the airport facility where bulky metal waste is used for landfill and enforcement of the Waste and Litter Control Amendment Act, 2011.

Although Bermuda has a single marine fill, the country faces multiple unique problems in waste management. Bermuda is the third most densely populated place on earth which results in the generation of more rubbish per capita than most industrialized nations. In addition to the problem of high waste generation, in 2012 Bermuda stored more asbestos per square mile than anywhere else in the world. Numerous initiatives have been implemented over the years in an effort to tackle Bermuda's waste management issues including the "Let's Slash the Trash" campaign spearheaded by the Bermuda Environmental Alliance and the construction of waste treatment facilities.

In 1987, the government of Bermuda engaged a Swiss company, the Von Roll Ltd., to study and design a waste treatment facility for the island which included the design and construction of a Waste to Energy (WtE) facility. As a result, the Tynes Bay Waste Treatment Facility was established. Following this, Bermuda launched The Marsh Folly Waste Treatment Facility, a 25 acre composting plant. The facility ordinarily receives approximately 100 truckloads of horticultural waste per day and a charges tipping fee of $25 per truck, however following Hurricanes Fay and Gonzalo inputs rose to 1,200 trucks a day and the gate fee was temporarily abolished. The facility operates under licensing agreement with the Environmental Authority (EA), an independent body that sets and monitors operational and environmental standards in Bermuda. Finished compost must meet or exceed EA standards for concentrations of heavy metals and pesticide contamination. Creating the compost on the island negates the need for imported materials for use as soil improver and the compost produced at Marsh Folly is widely used by landscapers, farmers and homeowners free of charge.

Solid waste is collected from residents bi-weekly and is taken to the Tynes Bay WtE Facility which treats an average of 70,000 tons of waste annually. Residents are encouraged to pre-sort items, separating cans and bottles for recycling. Bermuda also offers free curb-side recycling for the bi-weekly collection of tin, aluminum and glass. Recyclables are taken to an MRF for processing and either shipping abroad or use on island. In March of 2015 it was announced that the MRF will close its operations for one year in an effort to reduce the national deficit.

British Virgin Islands[14]

The Department of Waste Management is primarily responsible for the collection and disposal of solid waste, while protecting human health and the environment in the British Virgin Islands ("BVI"). Three unlined landfill sites are currently in operation in the country on the islands of Tortola, Virgin Gorda and Anegarda. A waste transfer station has been built on Jan van Dyke with collected waste dispatched by barge to Anegarda.

Open burning is a common practice as BVI has seen a three-fold increase in waste volumes over the last decade. No proper recycling facilities are currently in place therefore most waste is typically landfilled or incinerated. Glass, however, is collected and re-used by a local company to make and sell glass products. Additionally, derelict vehicles are also collected by a private recycler who crushes the vehicles and then ships the scrap metal to a recycling plant located in a nearby country. Plans are underway to develop a recycling system as private institutions are liaising with the government and local recyclers to implement a viable recycling system.

[10] Government of Bermuda Waste Management website
[11] Tynes Bay Waste Treatment Facility website
[12] The Royal Gazette. 2015. Recycling Plant to close for One Year.
[13] Bermuda Environmental Alliance website
[14] Department of Waste Management website

The Department of Waste Management provides a variety of services at no cost to the residential public. These include but are not limited to:

- Residential waste collection;
- Waste incineration;
- Dead animal removal; and
- Mulch supply.

BVI has set specific policies regarding the handling of waste:

- Commercial establishments that generate more than two to three bags of trash are required to take their waste directly to the incinerator facility and are prohibited from utilizing residential dumpsters;
- Residents are required to take their bulk waste (refrigerators, stoves, mattresses, etc.) directly to the incinerator facility and are prohibited from depositing them around residential dumpsters; and
- Commercial and construction waste are to be separated prior to being transported to the incinerator, particularly combustible from non-combustible waste.

Dutch Caribbean[15,16]

The Dutch Caribbean refers to the six island territories of the Kingdom of the Netherlands namely Aruba, Bonaire, Curaçao, Saba, Sint Eustatius and Sint Maarten. Countries in the Dutch Caribbean face similar issues with regard to waste management which include land scarcity. Most of the solid waste generated in the Dutch Caribbean is landfilled due to the lack of separate waste collection and recycling systems. Like many other Caribbean countries, the Dutch Caribbean has developed many policy proposals on effective waste management, however, many are never realized mainly due to a shortage of manpower and financial resources.

Selibon N.V. is responsible for the collection and processing of waste in Bonaire. Selibon services the entire Bonaire with the exception of remote Kunukus. Waste is collected in containers of varying sizes loaned to individuals and leased to businesses. A general waste collection and disposal fee is levied via the electricity and water bills which accounted for 48% of the income generated by Selibon N.V., Bonaire's waste management organization, in 2012. Bonaire charges a flat fee of US$10.75 for households and US$16.13 for businesses. Additionally, in 2006, a waste tax was introduced for businesses. There are two landfills in Bonaire.

Various initiatives have been implemented over the years to assist in reforming the waste management process:

- In 2009, Aruba was faced with a severe landfill capacity problem. The country's landfill was quickly running out space to deposit trash so the government contracted a private international company which developed a facility to convert solid waste into a pathogen-free, environmentally safe medium called Fluff;
- In 2015, the Saba Commission of Public Works signed the "Green Deal, better waste management Caribbean Netherlands." This is expected to assist in improving waste management in the country as well as encouraging recycling. As a means to promote recycling, Saba has committed to distribute boxes in central areas for the collection of old batteries; and
- In Bonaire, various projects are in the pipeline inclusive of an incinerator, a composting facility and a recycling center.

[15] Island of Aruba chooses Wastaway Technology to Solve Trash Problem. http://www.prweb.com/releases/2009/01/prweb1865244.htm

[16] The Bonaire Reporter, Year 21 Issue 17.

Jamaica[17,18,19,20]

In 1996, the government of Jamaica started a project to improve solid waste management services across the island which led to the establishment of the National Solid Waste Management Authority and the National Solid Waste Management Act. The National Solid Waste Management Authority is responsible for solid waste disposal and has developed an integrated service delivery strategy which is implemented through its regional offices.

A number of waste management issues are prevalent in Jamaica ranging from the rapid generation of waste as a result of a growing population to improper waste containerization which is not regulated. This creates a problem particularly in low income areas where improper waste containers are typically used.

Jamaica has eight disposal sites for use by both residents and visitors. Residential waste disposal services are provided free of charge. The cost associated with this service is paid for through property taxes. Businesses however are required to pay for waste collection services. Presently, incinerators as used for the disposal of medical waste however the incinerators are plagued by poor design. In 2012, Jamaica opened its first state-of-the-art non-incineration automated medical waste plant. Jamaica has taken other steps to improve its waste management system including establishing recycling centers and levying fines for pollution.

Saint Lucia[21,22]

The Saint Lucia Solid Waste Management Authority ("SLSWMA") is responsible for the collection of solid waste from households and government establishments. SLSWMA provides free waste collection for residents but does not offer collection services to businesses. All business owners are required to contract the services of a licensed waste hauler or to transport waste to the disposal facilities themselves.

SLSWMA operates two solid waste management facilities, namely Deglos Sanitary Landfill and the Vieux-Fort Solid Waste Management Facility. At both facilities the practice of waste diversion is applied. Ferrous and non-ferrous metals, glass containers, and used acid are removed from the waste and sent to local recyclers for export. Additionally, waste oil is stored in specialized waste oil storage containers and collected by a private company for use as a supplementary fuel. All other waste is typically disposed of in the landfill. Saint Lucia has multiple private recycling centers and a composting facility. As of December 1997, Saint Lucia established an environmental levy in the amount of US$1.50 (EC$4.08). This fee is paid by every visitor to island.

Trinidad and Tobago[23,24]

According to the 2015 National Waste Recycling Policy of Trinidad and Tobago ("T&T"), the primary method of disposal of waste is landfilling. There are presently nine disposal sites receiving a combined total of ~1,000 tons of waste per day. Of the nine disposal sites, three are close to capacity but still receiving waste. These three landfills cover a combined area of ~0.75 km and levy tipping fees. The Beetham landfill, the largest, receives approximately 65% of this country's waste. In addition to landfill capacity concerns, illegal dumping and landfill fires are two common waste management issues faced by T&T.

The Trinidad and Tobago Solid Waste Management Company Limited ("SWMCOL") was the first waste management operation in the Caribbean and offers solid and liquid waste collection, landfill management, recycling and consultancy services. In T&T, waste collection is done by sub-contracted private companies. Waste collection is administered free of charge for households however businesses pay for waste collection and disposal.

[17] Jennifer Post. 2007. Solid Waste Management in Jamaica: An Investigation into Waste Reduction.
[18] National Solid Waste Management Authority website
[19] Modern Medical Waste Plant Opens. 2012. http://jis.gov.jm/modern-medical-waste-management-plant-opens/
[20] National Solid Waste Management Authority operations secretary
[21] Saint Lucia Solid Waste Management Authority website
[22] Saint Lucia Solid Waste Management Authority Operation Department Report (2011-2012)
[23] Trinidad and Tobago Solid Waste management Company Limited website
[24] Trinidad and Tobago's National Waste Recycling Policy

Several initiatives have been undertaken to strengthen the strategic framework for solid waste management in the country. Among these are the National Environmental Policy, an integrated solid waste management policy, a national waste recycling policy and the municipal policy framework for solid waste management. Additionally, SWMCOL has successfully implemented various programs and projects aimed at improving waste management in the country including:

- Developed and executed a pilot waste separation for collection project;
- Developed Bottle Recovery Facility at the Beetham Landfill;
- Launched the Dead Animal Removal Team;
- Developed and executed a national clean-up program;
- Administered the Community Environmental Improvement initiative on behalf of government;
- Developed an integrated waste disposal system at Studley Park in Tobago;
- Developed and executed a Pilot Dry Cell Battery Collection Project in partnership with the National Petroleum Marketing Company of Trinidad and Tobago; and
- Implemented the Community-based Environmental Protection and Enhancement Program on behalf of the Government.

Turks and Caicos Islands[25,26]

The storage, collection, transport, treatment and disposal of solid waste presents a significant environmental health challenge for the Turks and Caicos Islands ("TCI"). The TCI Government has subcontracted solid waste disposal to the private sector on the island of Providenciales and Grand Turk, via a multi-year contract, at no direct cost to businesses or households.

However, the solid waste facility on the main tourism island of Providenciales is in a remote location and many commercial and residential customers, including many of the hotels located on Providenciales, elect to pay private collection companies, particularly those focused on recycling efforts. Waste collection on other inhabited islands is handled by private service providers with disposal on landfills predominantly located on Government land.

Section 51 of the TCI Public and Environmental Health Ordinance, allows for a fund to be established via imposition of an environmental levy on prescribed items imported into the TCI to be used to compensate contractors for collecting the prescribed items and for consumers, retail or otherwise, for presenting the prescribed items to the contractors. To date this levy has not knowingly been imposed.

U. S. Virgin Islands[27]

The Virgin Island Waste Management Authority ("VIWMA") is responsible for developing and implementing a waste management program for the country. VIWMA provides free in-house and contract collection services through curbside and bin site drop-off points for residents only. Apartment owners (4 units or more) and commercial and industrial businesses are required to self-haul or employ a private hauler to collect and dispose of their waste. In April 2015, VIWMA participated in a hearing where it appealed for the implementation of a $56 annual charge for the collection of residential waste. Additionally, efforts have been made by VIWMA to include a tire disposal fee in the cost of vehicle registration.

Currently, there are 4 disposal sites on St. Croix, 26 sites on St. Thomas and 28 bin sites on St. John. These disposal sites are for use for the disposal of household waste only. The U.S. Virgin Islands has guidelines that exist for the proper operation of a landfill. Two landfills, the Anguilla Landfill on St. Croix and the Bovoni Landfill on St. Thomas, are currently under contract management services which is supervised by VIWMA.

VIWMA oversees multiple recycling programs. This organization collects and disposes electronic waste, fluorescent bulbs, scrap metal and tires, aluminum cans, household hazardous waste and used motor oil.

[25] Turks and Caicos Island Development Strategy 2013-2017
[26] Ministry of Health and Human Services: Tender for Procurement, Installation & Operation of a Redemption Center
[27] Virgin Island Waste Management Authority website

4.2 National Context

Historically the Cayman Islands have been a tax-exempt location and the CIG has never levied income tax, capital gains tax, or any wealth tax. The CIG provides a free waste collection service to all residents although a charge is levied for the collection of commercial waste. Furthermore no landfill gate fee charged for any party delivering solid waste to one of the three landfills operated by the DEH. As a consequence the CIG provides largely subsidised waste management services throughout the islands.

The three landfills were used for the disposal of most of the solid waste generated in Cayman Islands are relatively aged and are not engineered facilities. The landfills are not lined, and are a potential source of contamination. This potential contamination poses a threat to ecology in the aquatic environment and may present human health issues. Furthermore there are no major institutional and practical drivers in place to reduce waste production, reuse waste and promote recycling and waste recovery.

It is also clear that the current waste management infrastructure cannot support the long term waste needs of the Cayman Island. The existing facilities are inadequate and do not meet the key principals of sustainable waste management.

In December 2013 the CIG issued a policy directive for its DEH to develop a comprehensive solid waste management system that will be developed to be sustainable, cost effective, environmentally sound, and will consider the local and geographical restraints.

4.3 Legislation and Policy

Legislative Framework

Caymanian legislation relating to solid waste management is made under the litter and public health laws and includes the following regulations.

Public Health (Garbage and Refuse Disposal) Regulations 2011

These regulations make the use of the public solid waste collection service mandatory for all with the exclusion of large commercial establishments exempted from the requirement by the DEH. It also sets out that solid waste collected by both the DEH and others parties collecting from exempt large commercial establishments must deliver the solid waste to designated landfill disposal sites. Users of the DEH collection service must use waste containers that meet minimum standards set out in the regulations and set waste out on their appointed collection days (twice per week for residents).

The regulation also specifies minimum requirements for the disposal of dead animals and sets out the amounts and basis of the payment of waste collection fees (including residential and commercial premises).

Public Health (Quarantine Amendment) Regulations 2011

These regulations amend the Public Health (Quarantine) Regulations 1997 to the effect that introduces fines for offences of the regulations and a maritime declaration of health.

Public Health (Miscellaneous Fees) Regulations 2011

These regulations establish a series of fees payable to the CIG for various forms of environmental testing (e.g. indoor air quality, wastewater) and training.

The Ship (Sanitation Control) Regulations 2011

These regulations empower the Port Health Officer to undertake ship sanitation inspections in circumstances where the ship does not have a valid Ship Sanitation Control Certificate and to enforce disinfection.

Public Health (Infectious Waste) Regulations 2002

These regulations establish an approval system and sets out requirements that must be met for the installation and operation of infectious waste incinerators and autoclaves. They also set out requirements for the planning, packaging, recording and reporting of infectious waste movements and treatment. The landfilling of infectious waste is only permitted following its treatment.

The Litter Law (1997 Revision)

The Litter Law brings in to effect fines and convictions for litter offences.in public places. The law also address derelict vehicles and their removal.

Conclusion

The Caymanian legislative framework for the management of solid waste will require amendment and augmentation to enable the effective regulation of new and alternative waste management facilities that are considered in this solid waste management strategy. In particular aspects of the Public Health (Garbage and Refuse Disposal) Regulations 2011 will require revision to enable the delivery of solid waste to non-landfill waste treatment plant. New regulations will be needed to ensure that any management facilities are operated and managed to an appropriate standard.

The licensing and permitting requirements would be tailored to the specific waste management facility but should introduce operational controls, reporting and minimum standards relating to environmental emissions. The operator of the facility would be required to pay an annual license/permit fee.

National Solid Waste Management Policy

The NSWMP has been developed as part of the solid waste management strategy development process to provide an overarching guiding policy that outlines the vision, values, strategic directions and the objectives with regards to the future management of solid waste on the Cayman Islands. The policy consequently provides a key foundation to the direction of solid waste management for the Cayman Islands and the consideration and assessment of waste management options as part of this process.

The NSWMP was issued for public consultation in June 2015 and this consultation process closed in July 2015.

Policy Framework and Development Process

The development of the NSWMP drew on several existing documents issued or commissioned by the CIG, that contain broad based policy guidance, high level strategic objectives and other relevant information and recommendations. In addition, the process examined and identified criteria considered important to the delivery of a future waste management system for the Cayman Islands. This was achieved through the consideration of several initial contextual themes from which the weighted criteria (Table 4.1) were developed with wider ranging consideration of the potential impacts and benefits associated with a new and sustainable solid waste management system for the Cayman Islands. The criteria and their relative weightings were developed by the Project Steering Committee through a workshop and critical review process.

Table 4.1: Weighted Criteria

Ref	Theme	Criteria	Weighting
1a	Finance	Compatibility with PPP	1
1b	Finance	Revenue potential	3
1c	Finance	Whole Lifecycle Cost	4
1d	Finance	Short term cost/funding	3
2a	Environmental	Waste Hierarchy	4
2b	Environmental	Recycling potential	4
2c	Environmental	Carbon impact/greenhouse gas	1
2d	Environmental	Energy generation/green energy	3
2e	Environmental	Life cycle environmental impact	3
3a	Social	Employment	3
3b	Social	Training/Education	4
3c	Social	Public acceptability aesthetics	2
3d	Social	Political buy in	4
4a	Technical	Track record/Proven technology	4
4b	Technical	Simplicity	4
4c	Technical	Applicability to island environment	2
4d	Technical	Market off takes	2
4e	Technical	Diversion of waste from landfill	4
5a	Sites	Planning/site assessment	4
5b	Sites	Integration across all islands	3
5c	Sites	Remediation of existing landfills	4

Key – Weighting of 1 = low importance, 2 = moderate importance; 3 = important; 4 = very important

The vision, values, strategic directions and objectives set out the NSWMP were derived from detailed consideration of the criteria augmented by policy guidance derived from other relevant existing Government documents. This process described in detail within the in the NSWMP[28]

The framework for draft NSWMP is set out as:

- Vision;
- Value Statements (“Values”);

[28] Ministry of Health and Culture Cayman Island Government (2015): National Solid Waste Management Policy for the Cayman Islands: For Public Consultation.

- Strategic Directions; and
- Objectives relating to the Strategic Directions.

Vision and Values

Vision

"Integrated, sustainable, and effective waste management for the Cayman Islands".

Values

The CIG believes that the following value statements should guide the efforts in realising the vision of an "*integrated, sustainable, and effective waste management for the Cayman Islands":*

- We will implement sustainable waste management in a manner that respects the needs of future generations;
- We will apply the waste hierarchy preference for reduce, reuse, recycle, and recover prior to the final resort of disposal;
- We believe that the generators of waste should be responsible and bear their proper share of costs for waste management;
- We will ensure that environmental impacts of waste management are assessed and understood, and that measures are undertaken to protect human health and the environment;
- We will pursue waste management opportunities that have the potential to reduce greenhouse gas emissions and reduce our dependence on fossil fuels;
- We will ensure that economies of scale are considered in determining suitable waste management practices, having due regard for the geographical aspects of the Cayman Islands;
- We will pursue multi-sectorial collaborations and partnerships with various stakeholders to achieve our vision for waste management in the Cayman Islands;
- We believe in the enhancement of personal responsibility for waste management through advocacy, education, and the creation of opportunities to help realise the national vision for waste management; and
- We will ensure there is an appropriate legal, regulatory, and institutional framework, embracing good governance principles, to support achieving the national vision for waste management.

Strategic Directions and Associated Objectives

The strategic directions and associated objectives set out in the NSWMP are reproduced in Table 4.2 below.

Table 4.2: Strategic Directions and Objectives

Strategic Direction	Objective
1. Apply good governance principles to strengthen institutional capacity and leadership.	1.1. Establish enabling public health and waste management legislation, regulation, and enforcement. 1.2. Establish a framework to encourage multi-stakeholder collaboration.
2. Broaden the understanding of sustainable waste management issues and practices throughout the entire community of the Cayman Islands.	2.1. Institute a programme of awareness, promotion, education, and publicity in partnership with community groups, schools, and other organisations.

Strategic Direction	Objective
3. Manage waste in a manner protective of human health, the environment and local amenities.	3.1. Apply a process, based on recognised best practice, for the assessment and mitigation of health and environmental impacts of existing and proposed waste management practices. 3.2. Assess the capacity and develop a long-term management plans for each of the landfill sites, including measures to ensure that the sites do not pose an on-going risk to the environment or human health.
4. Reduce the proportion of solid waste being landfilled by diverting waste per the sustainable waste management hierarchy.	4.1. Implement and expand programmes to reduce, re-use, and recycle waste materials. 4.2. Promote the development of improved practices and facilities for solid waste management which are demonstrably consistent with the waste management hierarchy. 4.3. CIG will lead by example by examining how it purchases, uses, and manages materials, with the objective of reducing consumption and waste.
5. Implement a waste management system that is principally financed on the basis that the waste producer pays.	5.1. Evaluate and adjust the current financing framework for waste management to ensure that the waste producer pays proportionate to the waste that they generate. 5.2. Develop and implement initiatives to support waste segregation at the source, both households and businesses, for the purpose of reducing, reusing, and recycling.
6. Establish partnerships with community and business groups with a view to achieve the strategic directions for sustainable waste management in the Cayman Islands.	6.1. Promote multi-sectorial partnerships and collaboration for the integrated and efficient delivery of waste management services and programmes.

4.4 Future Waste Projections

Baseline Waste Tonnage Model

A baseline waste flow tonnage model has been developed with a 50 year strategic horizon beginning with the year 2015 and ending in 2065. This is based on sub-modules produced for each of the three islands to enable future treatment and transfer facilities to be sized appropriately and to take into account local circumstances.

The base line data used to develop the model has been provided by the Ministry of Home Affairs, Health and Culture and sourced from the DEH. Initially annual data returns for George Town landfill on Grand Cayman and Cayman Brac landfill for the reporting periods of July – June for the following years were used:

- 2011-12;
- 2012-13; and
- 2013-14.

However in March 2015, the DEH requested that every load entering George Town landfill be weighed to enable the comprehensive recording of tonnage data. It was apparent from a review of the data collected from March and April 2015 that the historic annual return data were not accurate and may significantly underestimate the tonnages disposed of.

To address this weighbridge data for March to July 2015 has been pro-rated up to a full 12 months (using the average of the four months). This has then been used as the basis for future waste projections for Grand Cayman Island within the baseline model. Table 4.3 shows the pro-rated data for the year 2015. As additional data become available this will be continue to be added to the model and it will update

automatically. However the model will have be “frozen” at key reporting points and this was done after the receipt of the July weighbridge data for the production of the NSNMS.

Table 4.3: Amount and Types of Waste Managed at George Town Landfill Pro-Rated for Full Year 2015

	Tons	Current method of management
Commercial Waste (includes condominiums)	31,080	Disposed of in Landfill
Yard Waste	15.142	Disposed of in Landfill
Residential Waste	11,849	Disposed of in Landfill
Metal Waste	1,448	Recycled
Pallets	6,31	Disposed of in Landfill
Cardboard	2,647	Disposed of in Landfill
Island wide government clean up	43	Disposed of in Landfill
Mixed waste	1,545	Disposed of in Landfill
Food Waste	180	Disposed of in Landfill
Expired Liquor	26	Disposed of in Landfill
Bulk Waste	199	Disposed of in Landfill
Special Waste (waste water sludge)	23	Disposed of in Landfill
Deceased Animals	49	Disposed of in Landfill
Construction and Demolition	6,934	Partially recycled
Derelict Vehicles	557	Recycled
Tyres	351	Recycled
Batteries	23	Recycled
Christmas Tree	20	Recycled
Paper recycling	379	Recycled
Chemicals	37	Recycled?
Confidential waste & contraband	2	Diverted through incineration
Medical Waste	115	Diverted through incineration
TOTAL	**73,289**	

The annual data returns for Cayman Brac landfill were used for waste projections in Cayman Brac as accurate data recording by waste type does not take place on the Island and not all waste deliveries are weighed.

As there are no data for waste generation on Little Cayman the waste production rate (kg/ capita/ yr) on Cayman Brac was applied to the assumed population on Little Cayman (170 people).

Although it is acknowledged that the data used for Cayman Brac and Little Cayman are likely to be inaccurate, the tonnages are relatively small in comparison to the data for Grand Cayman. Therefore the effects of any under reporting for the smaller two islands is likely to be easier to mitigate through practical operational and design measures. The following data from the annual reports were used for the development of the baseline waste flow model for Cayman Brac:

- Total waste managed/ incinerated at Cayman Brac landfill (tons); and
- Total infectious waste incinerated / managed at Cayman Brac Landfills (tons);

Modelling Assumptions

To project waste generation in to the future and estimate the tonnages that need to be managed the baseline waste flow model contains several assumptions. These are described below.

Population

Population data for each island was drawn from population reports for 2013 from the Economics and Statistics Office for the Government of the Cayman Islands[29]. Table 4.4 shows the population distribution between the main districts on Grand Cayman and Cayman Brac and Little Cayman islands.

Table 4.4: Population Distribution

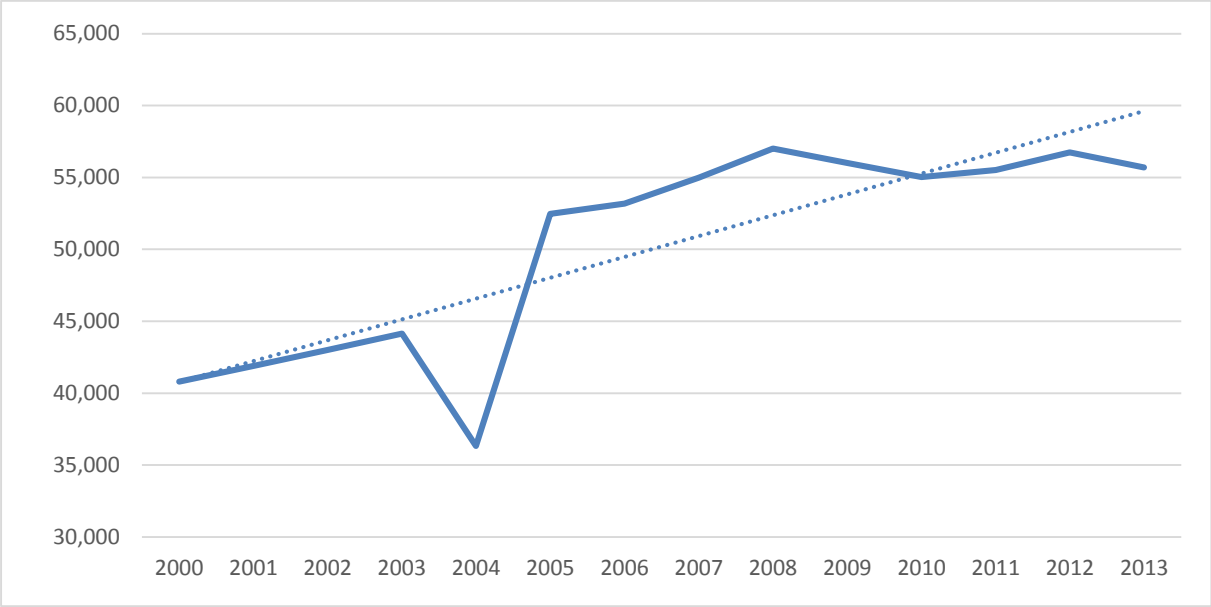
	2013 Population	% of 2013 Population
Cayman Brac & Little Cayman islands	1,922	3.45%
East End	1,292	2.32%
North Side	1,361	2.44%
Bodden Town	11,243	20.19%
West Bay	10,728	19.26%
George Town	29,144	52.33%

Within the overall 3.45% of the total population that is located on Cayman Brac and Little Cayman Islands, 91% is assumed to be on Cayman Brac and 9% on Little Cayman. This is based on the estimated population of 170 people for Little Cayman (http://www.littlecayman.com/our-island/island-history/).

Population data over the previous 13 years show fluctuations, but a general upwards trend. The large drop in 2004 is due to the relocation of residents directly after Hurricane Ivan and then the rise in 2005 is due to the return of residents.

[29] http://www.eso.ky/populationandvitalstatistics.html

Figure 4.1: Cayman Islands Population Trend



Waste Growth

The modelled waste generation rates were projected in line with forecast increases in population with an additional underlying waste growth rate per capita being applied. Three waste growth profiles were modelled based on differing population growth assumptions: low, medium and high, being: 2%, 3% and 4% increases per year respectively. The increases in population are based on the assumptions used by PBS & J[30].

In the baseline waste flow model, the Grand Cayman waste yield per capita is calculated using the pro-rata tonnage for 2015 and the projected population in 2015. The projected population is based on the known population in 2013 with the growth rate for each profile. The underlying waste growth is applied to the increased population projections.

For Cayman Brac and Little Cayman, the waste yield per capita for 2014 was calculated average of the waste per capita for the in line with the annual data returns for Cayman Brac for the years: 2011-12, 2012-13, and 2013-14. This was based on known population and waste tonnage data. For 2015 onwards the waste yield is the same for each profile, but as the population increases the total waste for each profile are different.

For the baseline waste flow model the waste growth projections do not account for the future impacts of any waste minimisation initiatives.

The high, medium and low population growth rate profiles used are provided in Tables 4.5 to 4.7.

Table 4.5: Waste Growth Assumptions – Grand Cayman

	Population growth	Waste generation per capita (tons/ capita/ year)
High	4%	1.33
Medium	3%	1.30
Low	2%	1.28

[30] Interim Report of the Waste Disposal Options Review Committee (WDOR)', revised June 5 2003 (referenced in this report as 'WDOR, 2003 report').

Table 4.6: Waste Growth Assumptions – Cayman Brac

	Population growth	Waste generation per capita (tons/ capita/ year)
High	4%	1.43
Medium	3%	1.43
Low	2%	1.43

Table 4.7: Waste Growth Assumptions – Little Cayman

	Population growth	Waste generation per capita (tons/ capita/ year)
High	4%	1.43
Medium	3%	1.43
Low	2%	1.43

Modelled Waste Composition

Information on general waste composition was taken from Table 3.0 of Appendix 4 of the *WDOR, 2003 report.* The DEH estimates on waste composition, specifically the 'average composition' were generally applied for the production of the baseline waste flow model. However these were supplemented by adjustments made to further divide the categories into sub categories. These were based on comparable splits of waste types derived from data for the Isle of Wight, UK. The composition used in the model is provide below in Table 4.8.

The composition data has been applied to the residential and commercial waste on all islands (where applicable) in the baseline model.

Table 4.8: Waste Composition Used in Baseline Model

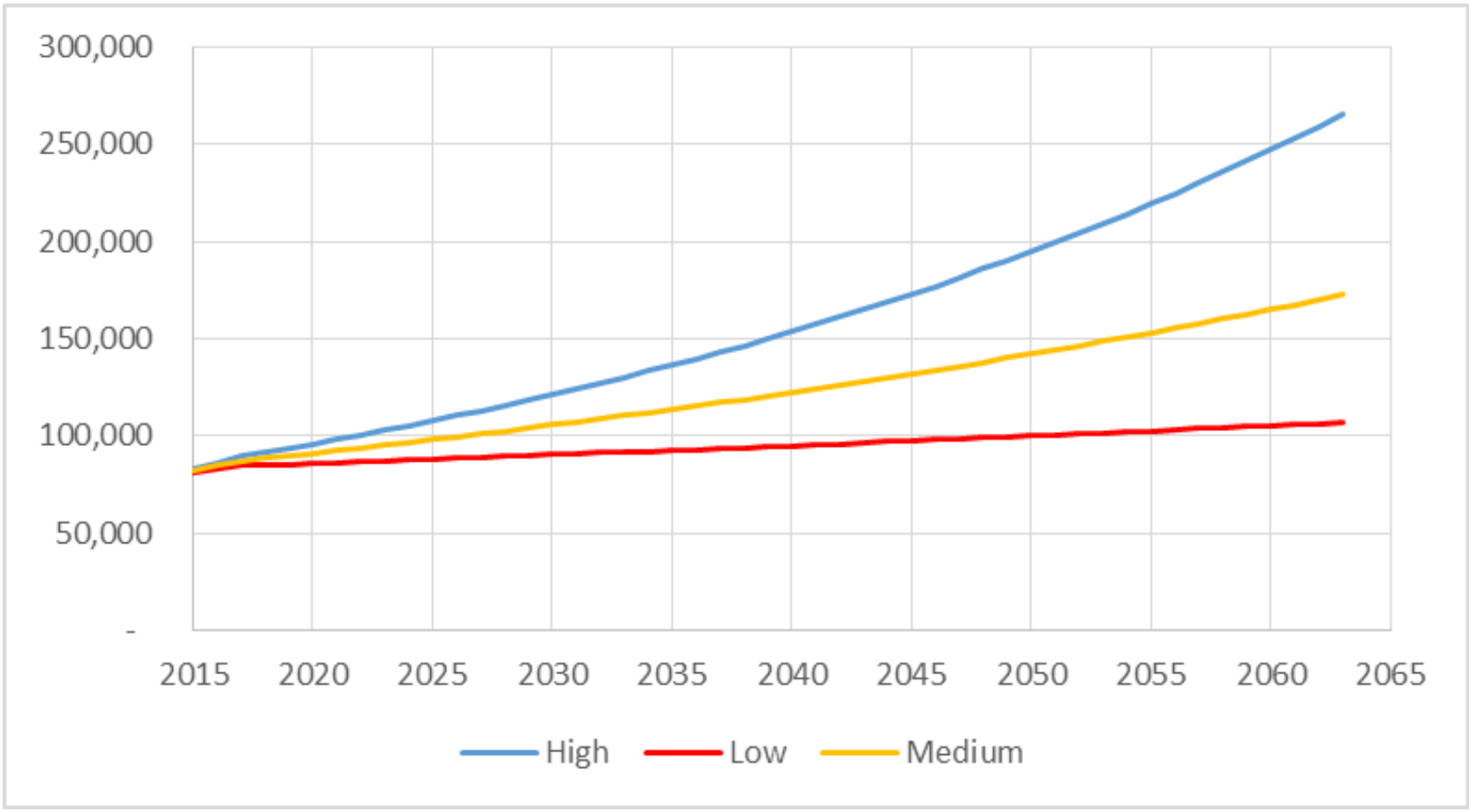
	Composition from WDOR. 2003 Report	New categories	Reasoning/ Comment	Composition used
Newsprint	5.0%	Recyclable paper	Newsprint, office paper and half other paper assumed to be recyclable.	13.1%
		Non-recyclable paper	Half other paper assumed to be recyclable.	6.3%
Office paper	1.8%		See above	-
Other paper	12.6%		See above	-
Corrugated cardboard	11.7%	Recyclable card	Based on split seen on Isle of Wight.	11.5%
		Non-recyclable card		0.2%
Glass bottles	2.8%			2.8%
Glass other	0.7%			0.7%

	Composition from WDOR. 2003 Report	New categories	Reasoning/ Comment	Composition used
Plastic bottles	1.9%			1.9%
Plastic other	9.1%	Other dense plastic recyclable	Based on the split of these categories found on the Isle of Wight – applied to 9.1% 'plastic other'.	2.2%
		Other dense plastic non - recyclable		1.7%
		Plastic film recyclable		2.2%
		Plastic film non – recyclable		3.0%
Wood	7.3%			7.3%
Dirt, Brick, Rubble	3.7%			3.7%
Yard waste	18.6%		Assumed to be green garden waste.	18.6%
Aluminium cans	0.8%			0.8%
Aluminium other	0.4%			0.4%
Metal cans	2.0%		Assumed to be ferrous cans.	2.0%
Ferrous metals	2.3%			2.3%
Non-Ferrous metals	0.7%			0.7%
Textiles	5.3%			5.3%
Food waste	5.4%			5.4%
Miscellaneous organics	5.5%			5.5%
Miscellaneous other	2.4%			2.4%
Total	100%			100%

Tonnage Projections

Figure 4.2 shows projected tonnages with waste growth applied at rates 4% (high), 3% (medium) and 2% (low). This shows that unless waste growth is constrained by waste reduction measures then over a 50 year horizon the amount of waste requiring management on the island will rise to between 100,000 and 250,000 tons per annum.

Figure 4.2: Waste Tonnage Projections



Note: High – 4%, Medium – 3%, Low – 2%

4.5 Key Findings

The fundamental need to improve the systems and practices for the management of solid waste in Cayman Islands is not driven by policy and regulatory compliance but by an urgent recognition that the current practices and systems are not sustainable, pose a potential threat the environment and local amenity and do not make best use of a potential resource that could benefit the community of the islands. Indeed, the NSWMP for the Cayman Islands has been developed during the course of producing this draft NSWMS and recommendations have been provided in order strengthen the regulatory framework for future developments.

The key drivers underpinning the need for change can be summarised as follows:

- The landfills on the islands are all aging facilities that have not been formally engineered to protect the environment or public health;
- Current existing waste management infrastructure cannot support the long term waste needs of the Cayman Islands;
- Landfill disposal of solid waste is not a sustainable and modern practice as it wastes potentially valuable resources (e.g. recyclables) and produces adverse environmental impacts (e.g. odour) and emissions (e.g. the emission of methane which is a potent greenhouse gas). Landfill disposal if the lowest tier of the waste hierarchy;
- The main landfill located at George Town is the highest point on Grand Cayman and as an operational site causes visual intrusion over a wide area and an adverse impact on the local amenity;
- At current rates of infill, George Town landfill has a limited remaining capacity and will be filled to completion within a relatively short period of time (approximately 6 years);
- Solid waste is being disposed of while it could be segregated and used productively to produce renewable energy (displacing reliance on imported fossil fuels), compost and soil conditioners (which are sparse on the islands) and reusable and recyclable materials;
- Residents of the Cayman Islands are generally not provided with good facilities, information and the services to promote the reuse, recycling and recovery of waste and to thereby divert it from landfill; and
- Population growth and the increasing quantities waste that are associated with is are not sustainable and will produce greater issues and problems in future if left unchecked and continues to be managed in the same way.

5. Modern Waste Management Technologies and Practices

5.1 Recycling and Composting Technologies

Materials Recovery Facilities

MRFs are facilities that are designed to sort commingled recyclables through a series of equipment such as trommels, magnets, eddy – current separators and the use operatives on manual picking lines.

The range of materials that are sorted varies but commonly includes paper, cardboard, plastic and ferrous and non-ferrous metals. Glass can also be sorted but may cause some problems if paper becomes contaminated with glass shards.

Figure 5.1: The Material Recycling Facility at the Padworth Integrated Waste Management Facility UK

Windrow Composting

Windrow composting of garden waste is a relatively simple form of waste treatment. The process employs natural aerobic biological degradation processes to degrade waste into a useful compost that can be applied to land or used in horticulture.

Window composting can be undertaken in the open air (on landfill sites or hardstandings) or in partially enclosed buildings (e.g. dutch barns) and usually uses rudimentary mobile plant (turning equipment and screens). The level of process control is usually low with monitoring restricted to periodic temperature sampling. As a consequence product control can be variable and the composting process can take a variable amount of time (requiring sites of considerable physical area).

Due to lack of effective emissions control, the location of windrow composting facilities can be significantly influenced by their proximity to potential receptors due to odour and the emission of bioaerosols.

Figure 5.2: Windrow Composting

In Vessel Composting

In Vessel Composting (IVC) facilities are enclosed treatment systems for inputs of organic waste (i.e. horticultural and food wastes). The facilities are designed to enable high degree of process and emission monitoring and control. The composting process is usually undertaken in a series of stages (primary, secondary and maturation). Where food waste inputs are accepted an additional stage includes pasteurisation.

The organic waste is treated biologically in the presence of oxygen, with controlled moisture addition and temperature control. The process does not allow the generation of any energy, although the compost produced can be used as a soil amendment in a variety of agricultural and domestic applications.

Figure 5.3: An In-Vessel Composting Facility

5.2 Recovery

Anaerobic Digestion

Anaerobic digestion (AD) is the process by which organic materials, in an enclosed vessel, are broken down using natural bacteria in the absence of oxygen. The process produces biogas (consisting mainly of methane and CO_2). The biogas can be combusted to produce electricity and heat, upgraded and cleaned for injection into a gas distribution network, or can be used to produce vehicle fuel.

The anaerobic process also produces a digestate, which contains water, minerals and approximately half of the carbon from the incoming materials, which can be used as a land bio-fertiliser[31].

Digesters typically use mesophilic bacteria or thermophilic bacteria to break down the waste; the main difference between the bacteria is the optimum temperature for growth:

- Mesophilic bacteria have an optimal temperature for growth between 30-40°C, therefore these digesters are usually operated at temperatures around 35°C; and
- Thermophilic bacteria have an optimal temperature range of 50-60°C, therefore these digesters are usually operated as close as possible to 55°C.

Mesophilic digestion systems are generally more stable than thermophilic systems due to the fact that a wider diversity of bacteria grows at the lower temperatures and these bacteria are generally more adaptable to changing environmental conditions. However the thermophilic digestion offers the advantages of faster reaction rates resulting in shorter retention times[32].

There are two main types of AD processes, wet and dry AD, the type of process chosen will depend on the feed stock which is being processed in the facility.

Figure 5.4: A Wet Anaerobic Digestion Plant

[31] http://www.omafra.gov.on.ca/english/engineer/facts/07-057.htm (viewed 29/07/2014)
[32] http://www.walesadcentre.org.uk/technologies/mesophilicandthermophilicsystems.aspx (viewed 29/07/2014)

Wet AD

Wet AD is used to treat materials with a low solid content (usually the incoming solids are less than 15%), such as animal slurry mixed with industrial and municipal food wastes. Wet digesters are nearly always constant flow digester and the mixture has to be continuously stirred to prevent suspended solids from depositing. The process can also be prone to operational issues from floating components in the waste. The residence time for wet AD processes is usually 60 to 95 days[33]. A number of authorities in the UK use wet AD facilities to treat source separated food waste and these include the West London Waste Authorities, Gwynedd and Flintshire County Council.

Dry AD

Dry AD is more suited to treat materials with a higher solid content such as energy crops and co-collected food and green waste. Usually the incoming material has a dry matter content of around 15 – 50%. Dry digesters tend to be thermophilic[34] using either a batch or a continuous plug flow system to treat the material. The residence time for this process is usually from 9 to 45 days.

Thermal Treatment Systems

There are a number of thermal technologies that are principally used to treat mixed municipal waste (MSW) and produce energy, including direct combustion and Advanced Thermal Treatment (ATT) (Pyrolysis and Gasification). The difference between these technologies is how the waste is processed, for example combustion directly releases the energy in the waste, whereas gasification thermally treats the waste to generate secondary products (gas, liquid and/or solid) from which energy can be generated[35].

Conventional Waste to Energy Plant (WtE)

The typical WtE process steps are outlined in the Figure 5.6. The waste is delivered to the waste reception and handling point where it is fed in to the combustion process (the grate). This process requires oxygen to ensure the wastes fully combust. The waste is normally combusted at temperatures in the excess of 850^{o}C and is converted into carbon dioxide and water. Non-combustible materials such as metals and glass will remain as a solid and are known as bottom ash. The bottom ash can be used as a recycled aggregate; end markets for this material include road paving and cement blocks.

WtE facilities are typically required to have a permit to operate, the permit will include emission limit values which are set to control the release of certain substances into the atmosphere. To allow the facility to meet these values the flue gases produced from the combustion of the waste must be cleaned prior to release. The clean-up of these gases produces a solid residue which includes fly-ash, lime / bicarbonate and carbon; these residues are normally classified as hazardous waste.

In WtE plants, heat from the burning waste can be used to produce steam. The steam is used for heating, or it is used to turn turbines to generate electricity. The amount of energy recovered from the waste depends on the amount of waste combusted, the energy value of the waste processed, and the efficiency of the combustion process.[36]

[33] http://www.greenandpleasant.org.uk/anaerobic-digestion/wet-and-dry-anaerobic-digestion (viewed 29/07/2014)

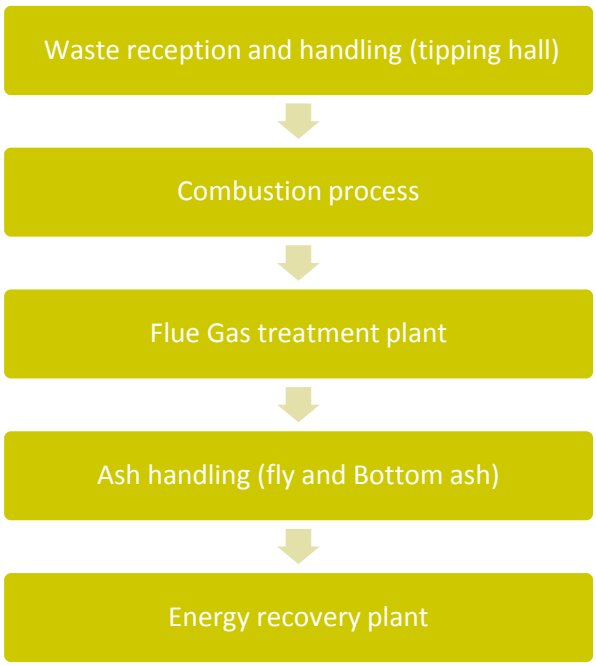
[34] http://www.wrap.org.uk/content/anaerobic-digestion-1 (viewed 29/07/2014)

[35] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/221036/pb13889-incineration-municipal-waste.pdf (viewed 29/07/2014)

[36] http://www.unep.or.jp/ietc/estdir/pub/msw/sp/sp5/SP5_3.asp (viewed 29/07/2014)

Figure 5.5: A Newly Constructed Waste to Energy Facility

Figure 5.6: Typical WtE Process Steps



Combined Heat and Power (CHP)

WtE facilities can also use an energy recovery plant to produce both heat and power from the combustion process, known as a Combined Heat and Power (CHP) plant. The thermal and electrical generating efficiencies of the CHP plant will depend on the splitting of the two forms of energy, heat and power. It uses a greater proportion of the fuel energy compared to conventional methods, reducing the energy wasted as low-grade heat when generating electrical or mechanical power[37].

The equipment used in a CHP system that provides the motive power to drive the electrical generator and produces the heat is generally a gas turbine, steam turbine or internal combustion engine. The different types of processes available mean that, a CHP plant can use a variety of fuels and provide for various heat demands, either in the form of hot water or steam. Uses could include the cooling of buildings, refrigeration and desalination.

Advanced Thermal Treatment (ATT) Gasification with Combined Heat and Power (CHP)

Gasification involves the partial oxidation of the waste and this means that oxygen is added but the amounts are not sufficient to allow the fuel to be completely oxidised and full combustion to occur. The temperatures used are normally in excess of 650°C. The process is largely exothermic (heat producing) but some heat may be required to initialise and sustain the gasification process.

The municipal waste would typically require some mechanical preparation and separation of glass, metals and inert materials (such as rubble) prior to processing. The main product is a syngas, which contains carbon monoxide, hydrogen and methane. Typically, the gas generated from gasification will have a net calorific value (NCV) of 4-10MJ/Nm^3. One of the key issues of using syngas in energy recovery at ATT facilities is related to tar generation. The deposition of tars can cause blockages and other operational challenges. The application of a higher temperature secondary processing phase can be used to clean-up the syngas prior to application in energy recovery systems[38].

As described above, CHP uses heat that would have otherwise been wasted from the process. The CHP system takes the excess heat from one or more of the following components: the gasifier itself, cooling components, the internal combustion engine, the gas turbine, or the electric generator. This reclaimed thermal energy can then be used to dry the fuel, for space heating, or even for cooling and refrigeration. Gasification CHP gives a gas suitable for use in micro-turbines, fuel cells and SI engines.

[37] https://www.gov.uk/government/policies/reducing-demand-for-energy-from-industry-businesses-and-the-public-sector--2/supporting-pages/combined-heat-and-power-chp (viewed 29/07/2014)

[38] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/221036/pb13889-incineration-municipal-waste.pdf

Figure 5.7: A Waste Gasification Plant

Mechanical Biological Treatment (MBT)

MBT Producing Solid Recovered Fuel (SRF)

Mechanical Biological Treatment technology uses a variety of technologies to separate Municipal Solid Waste (MSW). MBT uses a combination of mechanical and biological processes to sort the waste. The mechanical part, which is the physical stage of an MBT process, can include size reduction/shredding of the waste, separation of ferrous and non-ferrous metals, heat/steam treatment and screening and/or size reduction of outputs. The mechanical separation stage is typically at the front end of the process, although it can also be used at the back end of the process to take out further contaminants and or reduce particle size. The biological element can include aerobic decomposition to anaerobic digestion (AD), or can be a combination of the two, the aim being to remove moisture from the waste, and produce a homogenous consistent fuel, often known as a Solid Recovered Fuel (SRF)[39]. Such plant are sometimes termed Bio-driers.

SRF is a specialist fuel product which generally has a high calorific value. The SRF can then be sent on to a third party thermal treatment facility. SRF produced within the UK is often exported to other European Countries including Denmark, Germany, the Netherlands, Norway and Sweden. SRF is normally produced to a fuel standard specified by the receiving plant and can be produced to the European standard specifications set out in CEN1535940. In the UK it is typically derived from pre-sorted commercial & industrial (C&I) waste or rejects from MRF activities, however there is market evidence that some MSW sourced SRF is being produced and is commercially viable (West and East London are currently exporting MSW (Municipal Solid Waste) sourced SRF), and typically has a Net CV or >15 MJ/kg[41].

[39] http://www.ciwm.co.uk/CIWM/InformationCentre/AtoZ/MPages/Mechanical_Biological_Treatment.aspx
[40] European Standard for Solid Recovered Fuels. Specifications and Classes BS EN 15359:2011 http://shop.bsigroup.com/en/ProductDetail/?pid=000000000030202007
[41] CIWM (2013), Research into SRF and RDF Exports to Other EU Countries

MBT Producing a Stabilised Product for Landfill

This type of Mechanical Biological Treatment (MBT) facility, sometimes termed Bio-stabilisers, although similar in certain respects to Bio-driers is primarily designed to stabilise residual waste prior to landfill.

The facilities are designed to mechanically recover some low grade recyclables, such as ferrous and non-ferrous metals, plastics and a glass/grit fraction. A separated organic rich fraction is then composted or digested in an enclosed environment and microbially degraded (bio stabilised) to reduce the biodegradable content of the waste (usually in several controlled stages). This compost-like output (CLO) is conventionally disposed of to landfill but in some cases can be used in landfill engineering and similar land restoration projects (subject to quality controls).

The technology can be configured in a number of ways and by using equipment from different technology providers and the quality of the output, in terms the residual biodegradability of the CLO, can rely very much on the different processing techniques used.

The technology usually requires a large amount of space (land take) and can be energy intensive.

Figure 5.8: The Reception Halls for an MBT Facility

6. Waste Strategy Objectives and Long List Options

6.1 Waste Strategy Objectives

Amec Foster Wheeler's commission from the CIG is also targeted to deliver a new ISWMS for the Cayman Islands that:

1. Adheres to the internationally accepted waste management hierarchy for solid waste management (see Figure 6.1);

Figure 6.1: The Waste Hierarchy

2. Minimises the risks of immediate and future environmental pollution and harm to human health; and
3. Accommodates the islands waste growth over a 50 year period with interim reviews every five years.

This solid waste management solution will aim to be environmentally sound and cost neutral (i.e. at no greater cost than the existing system for CIG) that:

- Integrates programmes for collection, processing, recycling and disposal, with Waste to Energy (WtE) as a technology;
- Balances public and private sector services in order to ensure public health and safety and the protection of the environment;
- Takes into consideration the needs of all three islands; and
- Utilises a Public Private Partnership (PPP) if applicable.

The solution will also be targeted to promote the principles of:

- Sustainable waste management – managing waste in a manner that does not compromise the needs of future generations;
- The waste hierarchy – implementing the sequential preference for waste prevention, reuse, recycling and recovery prior to the final resort to disposal;
- The polluter/waste producer pays – ensuring those that generate waste are responsible and bear their proper share of the costs for waste management;
- Environmental protection – by ensuring that environmental impacts of future waste management practices are fully assessed and understood and that measures are undertaken to avoid environmental damage and harm to human health;
- Climate change – by pursuing opportunities for waste to energy and managing waste in such a way as to reduce greenhouse gas emissions;
- Proximity principle – ensuring that economies of scale are considered in determining suitable waste management practices in relation to geographical aspects of waste generation;
- Use of waste as an energy resource – thereby reducing the dependence on fossil fuels for energy production; and
- The adoption of a collaborative approach – by encouraging and facilitating partnership with all stakeholders.

6.2 Waste Strategy Options - Long List

In November 2014 a workshop was convened to develop a series of weighted evaluation criteria against which an initial long list of waste management options could be evaluated for potential consideration as part of the NSWMS. This workshop was attended by the CIG Officers from the Ministry of Health, Sports, Youth and Culture, Department of Environmental Health, Department of Environment, Public Works Department and the Water Authority, as well as by Amec Foster Wheeler project staff.

The weighted criteria developed at the workshop are set out in Table 6.1.

Table 6.1: Weighted Long List Assessment Criteria

Ref	Theme	Criteria	Weighting
1a	Finance	Compatibility with PPP	1
1b	Finance	Revenue potential	3
1c	Finance	Whole Lifecycle Cost	4
1d	Finance	Short term cost/funding	3
2a	Environmental	Waste Hierarchy	4
2b	Environmental	Recycling potential	4
2c	Environmental	Carbon impact/greenhouse gas	1
2d	Environmental	Energy generation/green energy	3
2e	Environmental	Life cycle environmental impact	3
3a	Social	Employment	3

Ref	Theme	Criteria	Weighting
3b	Social	Training/Education	4
3c	Social	Public acceptability aesthetics	2
3d	Social	Political buy in	4
4a	Technical	Track record/Proven technology	4
4b	Technical	Simplicity	4
4c	Technical	Applicability to island environment	2
4d	Technical	Market off takes	2
4e	Technical	Diversion of waste from landfill	4
5a	Sites	Planning/site assessment	4
5b	Sites	Integration across all islands	3
5c	Sites	Remediation of existing landfills	4

Amec Foster Wheeler compiled a draft list of waste management options to be evaluated against the long list evaluation criteria. This long list comprises viable waste management options that have been deployed as part of waste management solutions elsewhere in North America and Europe.

The long list of options are shown in Table 6.2 grouped within several service delivery areas (including waste collection, recycling and waste treatment etc.). The long list was issued to the workshop participants as part a long list options scoring worksheet.

Table 6.2: Long List of Waste Management Options

Option Ref	Service Area	Option Description
1	Collection	Recycling Depots/HWRCs
2	Collection	Segregate Dry Materials
3	Collection	Co-mingled Dry Materials
4	Collection	Segregated Garden
5	Collection	Segregated Food and Garden
6	Collection	Co-mingled Food and Garden
7	Collection	All in residual
8	Minimisation	Education
9	Minimisation	Returns schemes (e.g. bottles)
10	Minimisation	Home Composting
11	Reuse	Bulky waste reuse
12	Reuse	WEEE reuse

Option Ref	Service Area	Option Description
13	Reuse	Other reuse (e.g. nappies)
14	Recycling	Bulking Stations
15	Recycling	Clean MRF
16	Recycling	Dirty MRF
17	Recycling	Windrow
18	Recycling	IVC
19	Recycling	AD
20	Treatment	MBT stabilisation to Landfill
21	Treatment	MT/MBT SRF Export
22	Treatment	MT/MBT SRF ATT
23	Treatment	MT/MBT SRF WtE
24	Treatment	WtE
25	Disposal	Landfill

Key

ATT _ Advanced Thermal Treatment (e.g. Gasification)

AD – Anaerobic Digestion

WtE – Waste to Energy

IVC – In Vessel Composting

HWRC - Household Waste Recycling Centre

MBT – Mechanical Biological Treatment

MRF – Materials Recovery Facility

MT – Mechanical Treatment

SRF- Solid Recovered Fuel

WEEE – Waste Electrical and Electronic Equipment.

6.3 Long List Option Appraisal

Using the scoring mechanism shown in Table 6.3, workshop participants were asked to score each long list waste management option against each criterion and to enter these scores into the long list options scoring worksheet. Where a score of zero was applied this represented a “knockout” score within the scoring mechanism and resulted in the overall score for the option being assigned a zero.

Table 6.3: Evaluation Criteria Scoring

Score	Guide	Interpretation
0	Unacceptable option	A knockout score which means the option is fundamentally unacceptable & should not be pursued as part of the Waste Management Strategy
1	Incompatible with criteria	The option does not contribute to the delivery of the criteria
2	Moderate compatibility with criteria	The option performs moderately against the criteria
3	Compatible with criteria	The option performs well against the criteria
4	Highly compatible with criteria	The option performs very well against the criteria

The results from the longlist evaluation worksheets were collated by Amec Foster Wheeler to produce recommendations for the short listing of waste management options for detailed consideration as part of the development of the NSWMS.

Consultation on the National Solid Waste Management Policy for the Cayman Islands

In June 2015 the CIG published a draft NSWMP[42] for public consultation. This consultation process ran from 16th June to 15th July 2015 and was announced through a press release and was reported in the local newspapers, radio and television.

The purpose of the NSWMP is to provide an overarching guiding policy that outlines the vision, values, strategic directions and the objectives with regards to the future management of solid waste on the Cayman Islands. The document consequently proposed a series vision, values, strategic directions and objectives and sought the public's views on these as a guiding policy. Collectively these principles represent a key foundation to the production of the short-listed options for the production of the NSWMS.

The consultation process confirmed that the vision, values, strategic directions and objectives set out in the draft NSWMP were appropriate, with the vast majority of consultees either agreeing or strongly agreeing with the vision, values, strategic directions and objectives.

[42] Ministry of Health and Culture Cayman Island Government (2015): National Solid Waste Management Policy for the Cayman Islands

Comparative Analysis

Process

In order to review the initial recommendations for the short listing of waste management options and examine their consistency with the NSWMP, Amec Foster Wheeler undertook a comparative analysis of the long list waste management options evaluation undertaken; both before and after the consolidation of the results of the public consultation exercise on the NSWMP. This process comprised three stages:

- The vision, values, strategic directions and objectives set out in the NSWMP policy were mapped on to comparable long list evaluation criteria originally developed at the workshop. Where no comparable vision, values, strategic directions and objectives were identified, the relevant evaluation criterion was deleted;
- The weightings applied to the individual criteria used in the initial long list evaluation were removed. This is because the vision, values, strategic directions and objectives in the NSWMP have no equivalent weighting; and
- The original scoring for each long list waste management option from the initial long list evaluation exercise was applied to the revised unweighted criteria to produce an updated set of scores.

The results of the criteria mapping exercise described in the first point listed above are shown in Table 6.4.

Table 6.4: The Mapping of Vision, Values, and Strategic Directions against Evaluation Criteria

Original Evaluation Criteria			Allocated Vision, Value and Strategic Directions				
Ref	**Theme**	**Criteria**	**Vision**	**Value**	**Strategic Direction**	**Objectives**	**Comment**
1a	Finance	Compatibility with PPP		We will pursue multi-sectorial partnerships and collaboration for the integrated and efficient delivery of waste management services and programmes.	Establish partnerships with community and business groups with a view to achieve the strategic directions for sustainable waste management in the Cayman Islands.	Promote multi-sectorial partnerships and collaboration for the integrated and efficient delivery of waste management services and programmes.	
1b	Finance	Revenue potential					No applicable vision, value, strategic direction or objective.
1c	Finance	Whole Lifecycle Cost		We believe that the generators of waste should be responsible and bear their proper share of costs for waste management.	Implement a waste management system that is principally financed on the basis that the waste producer pays.	Evaluate and adjust the current financing framework for waste management to ensure that the waste producer pays proportionate to the waste that they generate.	
1d	Finance	Short term cost/funding		We believe that the generators of waste should be responsible and bear their proper share of costs for waste management.	Implement a waste management system that is principally financed on the basis that the waste producer pays.		
2a	Environmental	Waste Hierarchy		We will apply the waste hierarchy preference for reduce, reuse, recycle, and recover prior to the final resort of disposal.	Reduce the proportion of solid waste being landfilled by diverting waste in accordance with the sustainable waste management Hierarchy.	Promote the development of improved practices and facilities for solid waste management which are demonstrably consistent with the waste management hierarchy.	

Original Evaluation Criteria			Allocated Vision, Value and Strategic Directions				
Ref	**Theme**	**Criteria**	**Vision**	**Value**	**Strategic Direction**	**Objectives**	**Comment**
						CIG will lead by example by examining how it purchases, uses, and manages materials, with the objective of reducing consumption and waste.	
2b	Environmental	Recycling potential				Implement and expand programmes to reduce, re-use, and recycle waste materials. Develop and implement initiatives to support waste segregation at the source, both at households and businesses, for the purpose of reducing, reusing, and recycling.	
2c	Environmental	Carbon impact/greenhouse gas		We will pursue waste management opportunities that have the potential to reduce greenhouse gas emissions and reduce our dependence on fossil fuels.			
2d	Environmental	Energy generation/green energy		We will pursue waste management opportunities that have the potential to reduce greenhouse gas emissions and reduce our dependence on fossil fuels			
2e	Environmental	Life cycle environmental impact		We will ensure that environmental impacts of waste management are assessed and understood, and that measures are undertaken			

Original Evaluation Criteria			Allocated Vision, Value and Strategic Directions				
Ref	**Theme**	**Criteria**	**Vision**	**Value**	**Strategic Direction**	**Objectives**	**Comment**
				to protect human health and the environment. We will implement sustainable waste management in a manner that respects the needs of future generations			
3a	Social	Employment					No applicable vision, value, strategic direction or objective.
3b	Social	Training/Education		We believe in the enhancement of personal responsibility for waste management, through advocacy, education and the creation of opportunities to help realize the national vision for waste management.	Broaden the understanding of sustainable waste management issues and practices throughout the entire community of the Cayman Islands.		
3c	Social	Public acceptability aesthetics		We believe in the enhancement of personal responsibility for waste management through advocacy, education, and the creation of opportunities to help realise the national vision for waste management.		Establish a framework to encourage multi-stakeholder collaboration. Institute a programme of awareness, promotion, education, and publicity in partnership with community groups, schools, and other organisations.	
3d	Social	Political buy in		We will ensure there is an appropriate legal, regulatory, and institutional framework, embracing good governance principles, to support achieving	Apply good governance principles to strengthen institutional capacity and leadership.	Establish enabling public health and waste management legislation, regulation, and enforcement.	

Original Evaluation Criteria			Allocated Vision, Value and Strategic Directions				
Ref	**Theme**	**Criteria**	**Vision**	**Value**	**Strategic Direction**	**Objectives**	**Comment**
				the national vision for waste management.			
4a	Technical	Track record proven technology				Apply a process, based on recognised best practice, for the assessment and mitigation of health and environmental impacts of existing and proposed waste management practices.	
4b	Technical	Simplicity					No applicable vision, value, strategic. direction or objective.
4c	Technical	Applicability to island environment		We will ensure that economies of scale are considered in determining suitable waste management practices, having due regard for the geographical aspects of the Cayman Islands.			
4d	Technical	Market off takes					No applicable vision, value, strategic direction or objective.
5a	Sites	Planning/site assessment			Manage waste in a manner protective of human health, the environment and local amenities.	Establish enabling public health and waste management legislation, regulation, and enforcement.	

Original Evaluation Criteria			Allocated Vision, Value and Strategic Directions				
Ref	**Theme**	**Criteria**	**Vision**	**Value**	**Strategic Direction**	**Objectives**	**Comment**
5b	Sites	Integration across all islands	Integrated, sustainable, and effective waste management for the Cayman Islands.		Broaden the understanding of sustainable waste management issues and practices throughout the entire community of the Cayman Islands.		
5c	Sites	Remediation of existing landfills				Assess the capacity and develop a long-term management plans for each of the landfill sites, including measures to ensure that the sites do not pose an on-going risk to the environment or human health.	
6a	Technical	Diversion of waste from landfill			Reduce the proportion of solid waste being landfilled by diverting waste per the sustainable waste management hierarchy.		

The mapping process resulted in the deletion of four of the original evaluation criteria because they did not feature in the NSWMP as vison, value or strategic direction. These were namely:

- 1b Revenue potential;
- 3a Employment;
- 4b Simplicity; and
- 4d Market off takes.

Revised Long List Evaluation Results

The comparative results of the pre and post consultation long list evaluation process are shown in Table 6.5 and summarised in Figures 6.2 and 6.3. These show that the revised scoring of the long list has resulted in a more compressed outcome with range of scores ranging from 31 to 59 for the twenty five long list waste management options considered. This compares to a spread of 104 points from the original evaluation. This is principally due to the removal of the criteria weightings but is also in part from the deletion of four original criteria.

The results show that the post consultation long list evaluation has not materially impacted on the ranking of the individual waste management options produced by the original evaluation process. No individual waste management option has moved more than four places in the ranking (see Table 6.5); with the majority of options moving no more than two places in their relative ranking. In conclusion, those waste management options that scored highly in the original long list evaluation process did so again in the revised evaluation and the same applies to those options that scored low. This can be seen by comparing Figures 6.2 and 6.3.

Table 6.5: Comparative Analysis Results

Ref.	Category	Long List Option	Weighted Score	Rank	Unweighted Revised Score	Revised Rank	Rank Movement
1	Collection	Recycling depots/HWRCs	219	6	56	6	0
2	Collection	Segregate Dry Materials	190	18	49	18	0
3	Collection	Co-mingled Dry Materials	218	7	56	7	0
4	Collection	Segregated Garden	220	5	56	5	0
5	Collection	Segregated Food and Garden	209	13	54	13	0
6	Collection	Co-mingled Food and Garden	203	15	51	15	0
7	Collection	All in residual	184	22	48	22	0
8	Minimisation	Education	184	21	49	20	1
9	Minimisation	Returns scheme	213	11	54	12	-1
10	Minimisation	Home Composting	190	18	51	16	2
11	Reuse	Bulky	192	17	48	21	-4
12	Reuse	WEEE	196	16	49	19	-3
13	Reuse	Other	177	23	44	24	-1
14	Recycling	Bulking Stations	216	8	55	11	-3
15	Recycling	Clean MRF	208	14	53	14	0
16	Recycling	Dirty MRF	175	24	44	23	1
17	Recycling	Windrow	230	1	59	1	0
18	Recycling	IVC	215	9	55	9	0
19	Recycling	AD	226	3	58	3	0
20	Treatment	MBT stabilisation to Landfill	190	20	49	17	3
21	Treatment	MT/MBT SRF Export	214	10	55	8	2
22	Treatment	MT/MBT SRF ATT	210	12	55	10	2
23	Treatment	MT/MBT SRF WtE	223	4	57	4	0
24	Treatment	WtE	228	2	59	2	0
25	Disposal	Landill	126	25	31	25	0

Figure 6.2: Pre-Consultation Long List Evaluation Results

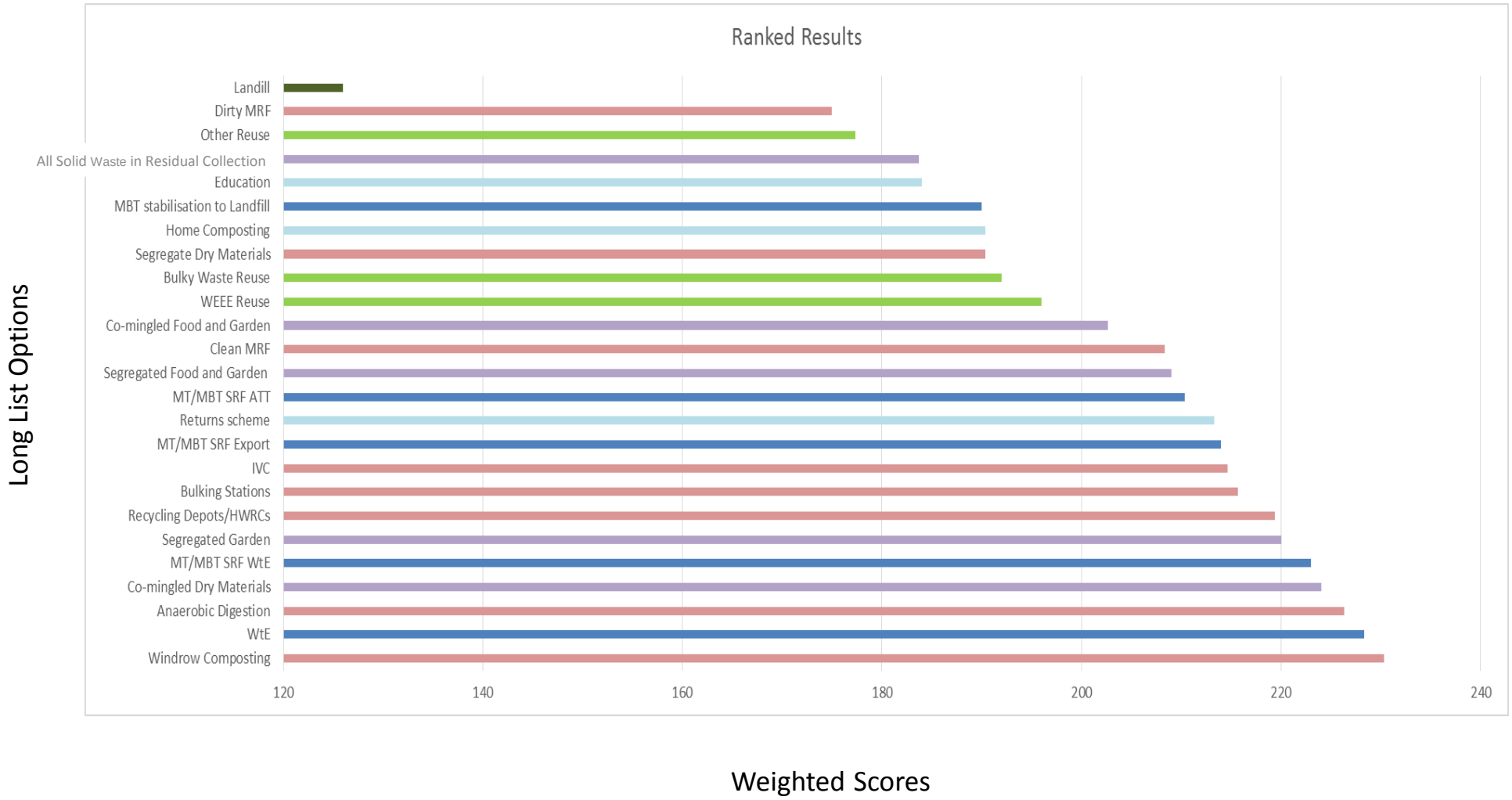
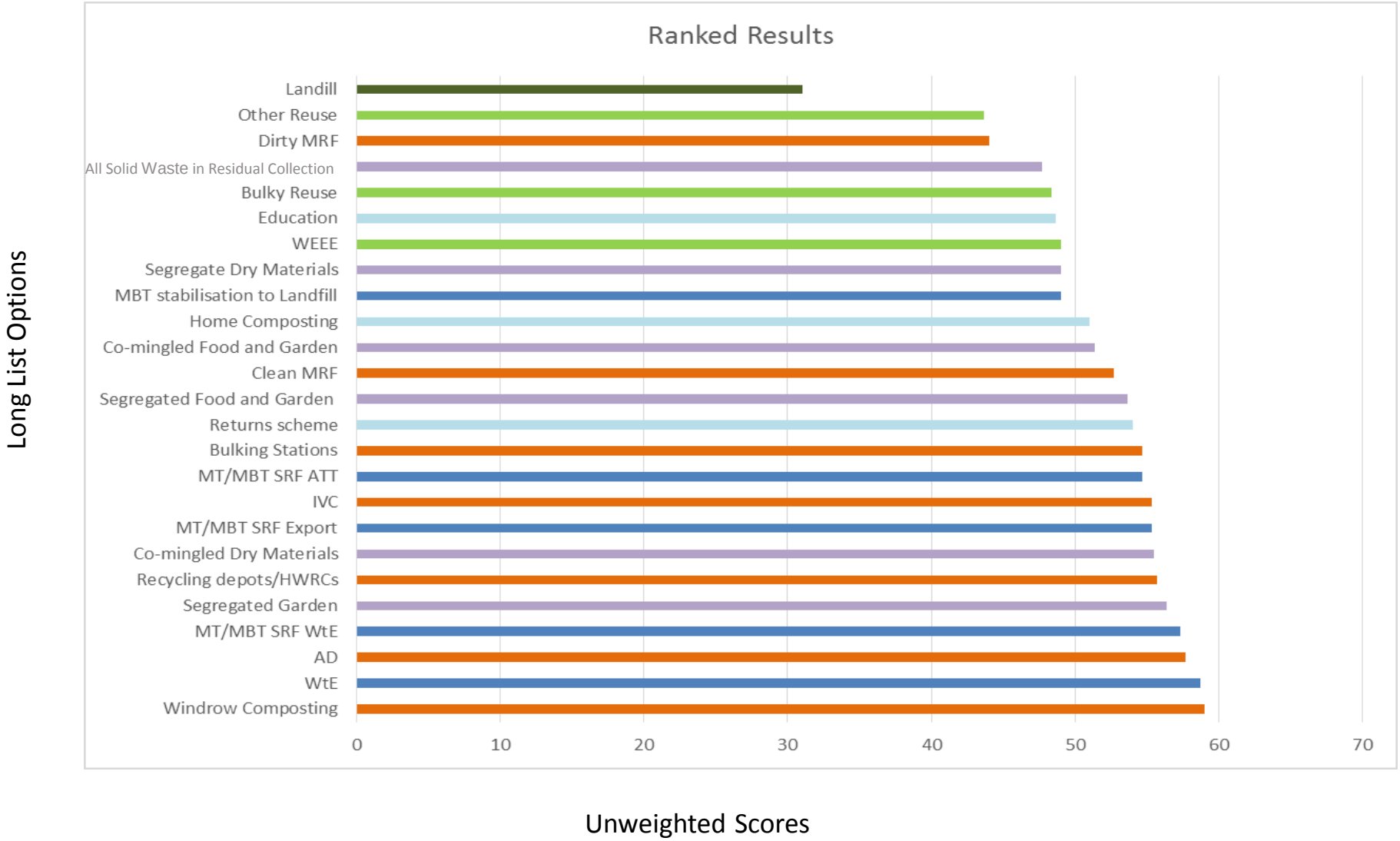


Figure 6.3 Post-Consultation Long List Evaluation Results



7. Appraisal of Short List Strategy Options

7.1 Waste Strategy Options - Short List

The modelling of the short list options comprises a waste flow model that projects the tonnage of waste that will flow through an integrated waste management system over each year of the project term. The ISWMS will comprise a mixture of one or more of the short list options selected from the list presented in Table 7.1. The waste flow model has been used to appropriately size the facilities and infrastructure required to deliver the integrated waste management system and consequently estimate the financial cost and revenues associated with system and to assess lifecycle and environmental impacts. This has enabled a detailed comparative analysis of the performance and the relative impacts of each option.

Table 7.1: Recommended Short List Options

Short list Scenario/Option Components	Option/Component Description
1	Introduction of recycling depots and HWRC network to enhance the collection of segregated recyclables and garden waste.
2	The collection of co-mingled dry recyclables and processing of these materials in a clean MRF prior to market.
3	The collection of segregated garden/yard waste and windrow composting of the collected material.
4	The collection of segregated garden waste through and HWRC network and the windrow composting of the collected material.
5	The separate collection of food waste and use “wet” AD for treatment.
6	Waste education/return schemes, home composting
7	Bulky Waste reuse, WEEE reuse, Other reuse
8	MT/MBT to produce SRF/RDF for export to an off- shore facility
9	Advanced thermal treatment (pyrolysis/gasification)
10	MT/MBT to produce SRF/RDF for WtE
11	Conventional WtE
12	The “as is” waste management system/ Landfill

Note: The residual waste treatment options shown as Options 8 to 11 are combined with other options higher in the waste management hierarchy (waste reductions and the collection of co-mingled recyclates) to produce the modelled ISWMS’s.

Acronyms

Acronym	Meaning
AD	Anaerobic Digestion
CHP	Combined Heat and Power
HWRC	Household Waste Recycling Centre
MBT	Mechanical Biological Treatment
MRF	Materials Recovery Facility
MT	Mechanical Treatment
RDF	Refuse Derived Fuel
SRF	Solid Recovered Fuel
WEEE	Waste Electrical and Electronic Equipment
WtE	Waste to Energy

7.2 Short List Options Evaluation

Introduction

The component options comprising the modelled ISWMS's are shown in Table 7.2. It is assumed that all options would be implemented at the same time with the exception of the residual waste treatment – only one of these would be implemented.

The options shown in 7.2 have been assembled into a number of waste management scenarios representing the elements of an integrated waste management system.

Table 7.2: Options used in the Scenario Modelling

Community Sites	Recycling	Organic Waste Treatment	Minimisation and Reuse	Residual Treatment
1. Recycling Depots and Household Waste Recycling Centres (HWRC's)	2. Clean Materials Recovery Facility (MRF)	3. Windrow composting from kerbside	6. Education and home composting	8. Mechanical Treatment (MT) making Solid Recovered Fuel (SRF) for export
		4. Windrow composting from HWRC	7.Bulky waste reuse	9. Advanced Thermal Treatment (ATT)
		5. Wet Anaerobic Digestion (AD)		10. MT making SRF for treatment in on – island Waste to Energy (WtE) Plant (CHP ready)
				11. Conventional WtE Plant (CHP ready)
				12. Existing Landfill (with improvements)

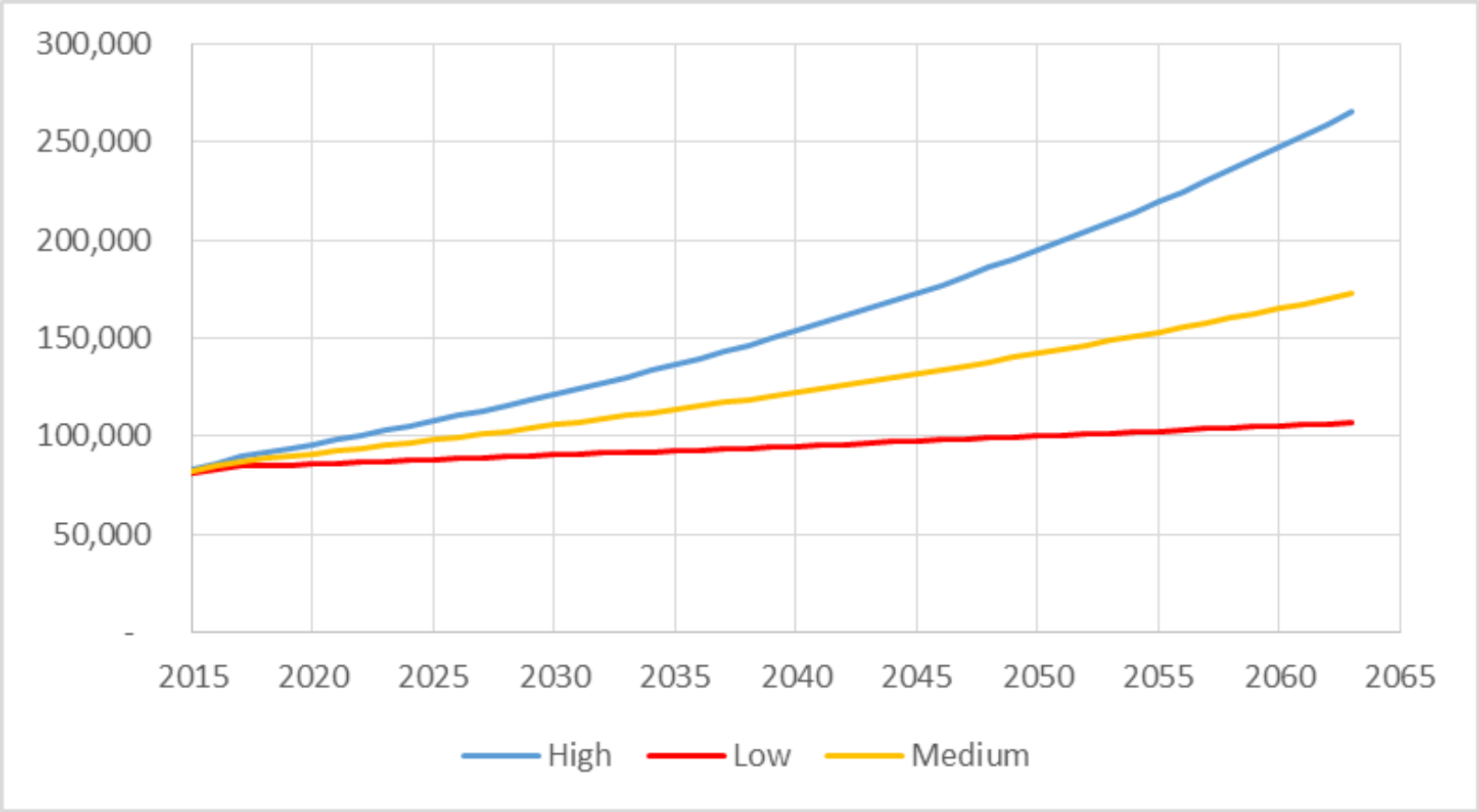
Common Elements

The scenarios modelled contain a number of common elements and these are described below in relation to the waste management hierarchy.

Waste Reduction

The importance of waste reduction measure as part of an integrated waste management system is highlighted by the compounded waste growth profile shown in Figure 7.1. This shows that under lying waste growth linked to population growth if left unchecked would result in a considerable increase in the tonnage of solid waste requiring management each year. This would have significant financial and environmental impacts.

Figure 7.1: Waste Tonnage Projections



Note: High - 4%, Medium - 3%, Low – 2%

For the purpose of comparative modelling the medium waste growth rate has been assumed but this has been off-set by a waste minimisation function of 1% per annum applied from 2020.

Waste Re-use

The waste minimisation function described above has been supplemented by a waste re-use function that has been applied across all of the modelled scenarios. This has been applied at rate of 0.5%.

Recycling and Composting

CIG is committed to providing increased access to recycling facilities for the residents of the Cayman Islands. In the short term this is likely to be achieved through the provision of community recycling facilities comprising;

- A recycling depot network located in supermarket car parks and similar accessible locations; and
- A refurbished and upgraded drop off facility at the George Town landfill to provide a Household Waste Recycling Centre (HWRC) supplemented by an additional new HWRC for Grand Cayman, Cayman Brac and Little Cayman. These sites will be important for the reception of segregated waste fractions such as yard waste.

Kerbside collection of other waste fractions such as mixed dry recyclables, food waste will provide enhanced rates of recycling and could be introduced at a later date. However, this will be dependent on the new facilities being available to receive and process the collected fractions.

Large quantities of separated yard waste are currently being delivered to the landfills located on Grand Cayman and Cayman Brac. These tonnages can potentially be treated by relatively simple windrow composting technology to produce a beneficial compost or soil conditioner. This has been assumed across all of the waste management scenarios with a windrow plant located on Grand Cayman, augmented with a smaller facility on Cayman Brac.

Waste Recovery

A residual waste recovery facility has been assumed for each waste management scenario with the exception of the landfill baseline. These recovery technologies are different for each modelled scenario. Those scenarios that have CHP, have been modelled as CHP ready facilities only and do not include financial provision for a heat distribution network as this will be largely determined by location and site specific factors. However the lifecycle (WRATE) modelling has included the environmental benefits that an operating WtE CHP facility would deliver to demonstrate the positive environmental effects of this technology.

Disposal

The landfill disposal of waste that cannot be recycled or recovered and process residues (such air pollution control residues from waste recovery plant) will be required for all scenarios. However the capital and operating costs associated with this function has not been included in the cost estimates at this stage although they will be examined for the Outline Business Case. This is due to the uncertainty concerning how long George Town landfill will continue to provide landfill capacity. At current rates of infill it is expected the landfill will be full in year 2021 however this could be extended by the early diversion of waste in to recycling and composting and potentially by landfill mining. The anticipated cost of providing an alternative landfill would be expected to be approximately CI$54/t of capacity provided as a capital cost and with an operational cost of CI$ 22/t.

It is assumed across all scenarios that the existing landfills on Cayman Brac and Little Cayman will close when the transfer and treatment facilities are available.

Other Common Elements

Three waste transfer stations have also been modelled, one for each island. The majority of the waste collected on the sister islands can be transferred to Grand Cayman for treatment or for bulk haulage to off-

island treatment/ markets. It is assumed that the waste transferred from the sister islands will be transported to the relevant waste management facilities on Grand Cayman. The third waste transfer station is on Grand Cayman and will be used for the import of waste from Cayman Brac and little Cayman, the bulking of recyclates and for waste requiring export (e.g. derelict vehicles, gas canisters and household hazardous waste).

For several options that involve the collection of segregated fractions of kerbside collected waste (i.e. the source separation of dry recyclable, and/or food waste from residual waste) it has been assumed that as far as practicable this would be achieved using the existing waste collection resources and vehicles by altering operational practices and collection frequencies. This should enable one segregated fraction to be collected along with residual waste collected on a weekly basis. The expansion of a kerbside collection system beyond this could be achieved by the lifecycle replacement of the existing refuse collection fleet with more flexible multi-compartment vehicles.

Table 7.3: Scenario Make Up

Scenario A	Scenario B	Scenario C	Scenario D
Mechanical Treatment (MT) making Solid Recovered Fuel (SRF) for export	**ATT**	**MT making SRF for treatment in on – island Waste to Energy (WtE) Plant (CHP ready)**	**Conventional WtE Plant (CHP ready)**
HWRC and Recycling Depots	HWRC and Recycling Depots	HWRC and Recycling Depots	HWRC and Recycling Depots
MRF	Materials Recovery Facility	Materials Recovery Facility	Materials Recovery Facility
Windrow Grand Cayman	Windrow Grand Cayman	Windrow Grand Cayman	Windrow Grand Cayman
Windrow Cayman Brac	Windrow Cayman Brac	Windrow Cayman Brac	Windrow Cayman Brac
AD	Anaerobic Digestion	Anaerobic Digestion	Anaerobic Digestion
Waste Transfer Stations on all islands	Waste Transfer Stations on all islands	Waste Transfer Stations on all islands	Waste Transfer Stations on all islands

Financial Assumptions

The financial modelling identified both the capital costs associated with the construction of the facilities, and the ongoing operational costs of the facilities (including any income revenue from the sale of power).

The development of the capital and operating (revenue) cost model was based on the application of a number of assumptions. These assumptions were drawn from a number of previous projects Amec Foster Wheeler has worked on as Technical Adviser and the assumptions are summarised in Table 7.4 below.

The average order of costs presented in this section are based on ‘rough order costs’ which have been sourced from Amec Foster Wheeler’s internal database. These costs have been compiled from various sources, including recent waste procurement projects (Private Finance Projects (PFI) and Public Private Partnership (PPP) projects at various stages in the bidding process), information from technology suppliers and published literature. All capital and operating costs are best estimates at this time, based on knowledge of similar schemes covered by the Amec Foster Wheeler cost database (this largely derived from UK projects using European technologies). The costs are accurate to +/- 50% as many unknowns remain (e.g. site locations, ground conditions, material import costs etc.).

Capital expenditure (termed ‘CapEx’) includes all costs associated with the delivery of the required infrastructure. This includes the design, preparation, management and construction costs for the delivery of each facility. The Capex does not include site specific costs for activities such as land acquisition, land remediation, and connections to wider energy distribution networks. These are addressed at this stage through the level of accuracy applied to the estimates. Design and management costs included within the Capex estimates encompass professional fees (e.g. planning, permitting, architectural and engineering fees) together with a design or project manager to co-ordinate design requirements and construction. Construction costs include the supply of labour, materials and equipment (sometimes referred to as ‘plant’ costs) together

with preliminaries such as site supervision, temporary accommodation. Electrical grid connection costs are not included as these will be site specific.

The on-going operational expenditure (termed 'OpEx') include all fixed and variable annual costs, including staffing, maintenance, utility costs, licensing, and fuel. Lifecycle costs reflect the need to periodically replace elements of equipment and plant during the operational lifespan of facilities.

Actual costs will vary according to the method of procurement, market conditions and risk profile adopted. Movement in foreign exchange rates can also significantly affect actual costs, depending on the country of origin for major equipment items.

The CapEx estimates for the WtE and ATT with CHP options assume that the relevant facilities are CHP enabled (ready) only. This means that they are equipped with suitable turbines and valves to facilitate the off take of steam. The CapEx does not include provision for a heat distribution network as this will depend of the location of the facilities and the requirements of the off take markets.

Table 7.4: Financial Assumptions

Option	**Annual Design Capacity** (US tons)	**CapEx** (CI$/ US ton of annual design capacity)	**OpEx** (CI$/US ton throughput)	**Lifecycle Replacement Costs** (% of OpEx or CI$/US ton throughput)
WtE power only	50,829	$1,214	$58	$4
WtE CHP (ready)	50,829	$1,214	$58	$4
ATT power only	50,829	$1,173	$31	$18
ATT CHP (ready)	50,829	$1,173	$31	$18
MT	50,829	$229	$25	$9
SRF treatment on island	40,663	$1,401	$38	$22
SRF Treatment off island	40,663	$94.50 Gate Fee		
AD	2,300	$1,041	$105	2.5%
Windrow Composting				
Grand Cayman	34,851	$57	$17	2%
Cayman Brac	582	$152	$29	3%
MRF	13,900	$338	$25	4%
Waste Transfer Station				
Grand Cayman	8,202	$114	$11	3%
Cayman Brac	3,595	$137	$14	4%
Little Cayman	250	$183	$23	4%
Recycling Depots		$228,564 (Estimated Total costs)	$57,141	1.0%

Additional treatment costs

There are a number of additional costs that will require location specific assumptions to be made so that they can be encompassed within the modelled options at the Outline Business Case stage. Amec Foster Wheeler will seek to agree with the CIG a suitable approach to producing appropriate cost assumptions for these elements for inclusion in the Outline Business Case. These include a landfill gate fee and off island transportation costs.

Additional assumptions

Costs were converted from metric tonnes in UK sterling to short tons and Cayman Island dollars. The following assumptions were used:

- 1 short ton = 0.907 metric tonnes; and
- £1 = CI$1.26.

General assumptions used in the cost modelling

1. All solid waste is managed on the islands; unless otherwise stated (i.e. bulked for off-island transport or SRF treatment off-island);
2. No income is assumed for recyclables;
3. All waste is reported in short tons; and
4. All costs are reported in CI $.

Estimated Costs and Exclusions

The costs estimates for each of the modelled options at this stage provide a comparative analysis of the baseline CapEx and OpEx for each solution on a nominal basis. At this strategic stage these estimates have an accuracy of +/- 50% which is normal for a waste strategy and reflects the lack of detail concerning site and project specific circumstances (e.g. land acquisition and remediation costs, and abnormal site costs such as the need for specialised foundations etc.).

The strategic cost estimates do not constitute a full Net Present Value (NPV) financial assessment. The NPV model will be developed at the Outline Business Case stage with the specialised financial input of KPMG.

There are a number of costs that will be the same for all the options and so have not been included for the comparison of the options at this stage. These will need to be included when the Outline Business Case is developed with the specialist financial support of KPMG. This will be based on a fully costed Reference Project against which the full financial implications and affordability of the project can be assessed and it can also be used to inform the relative evaluation of tenders during the procurement process. The costs excluded from the modelling at this strategic stage are:

- Any additional collection of waste and associated costs (i.e. vehicles, staff);
- Combined Heat and Power (CHP) distribution network;
- Business rates;
- Import duties;
- Interest charges;
- Depreciation of assets and residual value;
- Inflation;
- Procurement costs;
- Insurance payments; and
- Profit margins.

The Results of the Comparative Cost Estimation

For comparative purposes the nominal costs of each scenario have been compiled from the estimated capital costs (CapEx), operational cost (OpEx) and lifecycle costs for the integrated waste management system. Please note that these costs do not represent real or NPV cost estimates. Full financial modelling will be undertaken by KPMG at the Outline Business Case stage.

Figures 7.2 and 7.3 below provide the gross cost comparison of each of the scenarios. The error bars represent the level of confidence in the figures (i.e. 50%). These estimates represent costs over 25 years, as this is the general industry standard accepted life of waste facilities. Furthermore it is highly unlikely that CIG would place a 50 year waste management contract which included the full lifecycle replacement of the facilities at year 25, as this would be unlikely to provide best value or the best available technologies at that time.

Figure 7.2: Comparative Summary of Overall Baseline Costs for Each Scenario

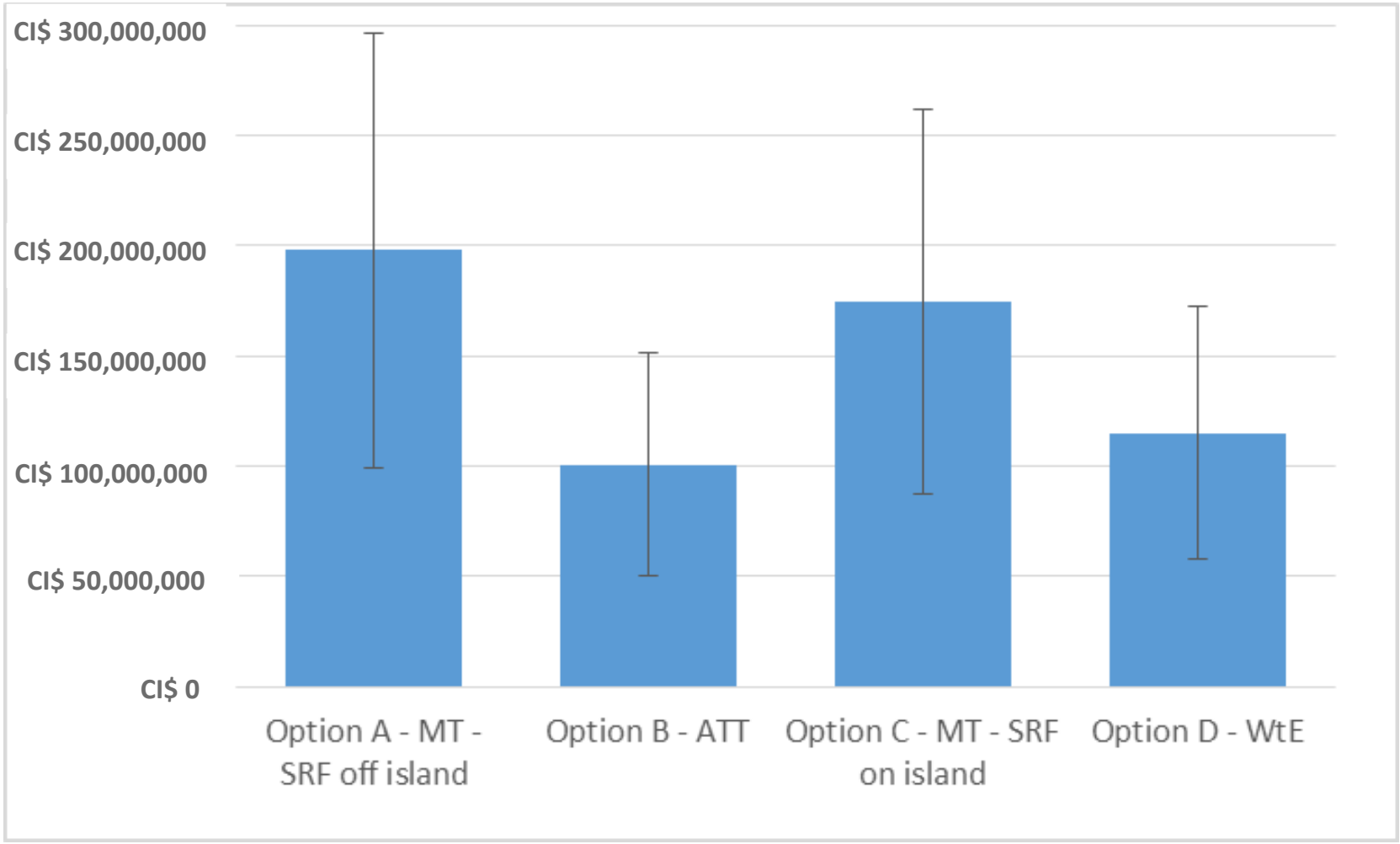
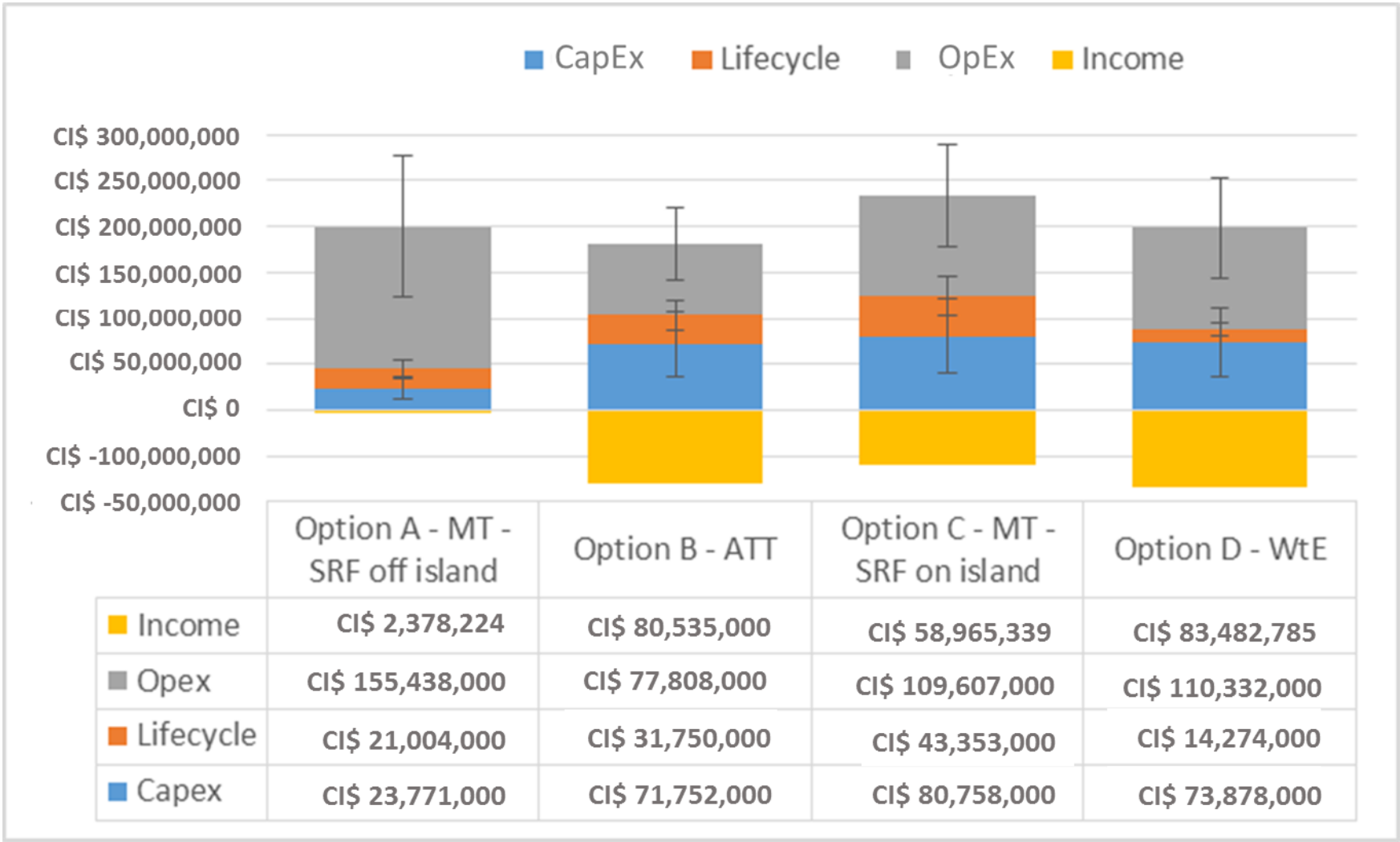


Figure 7.3: Summary of Baseline Costs of Each Option Group Broken Down to Elements

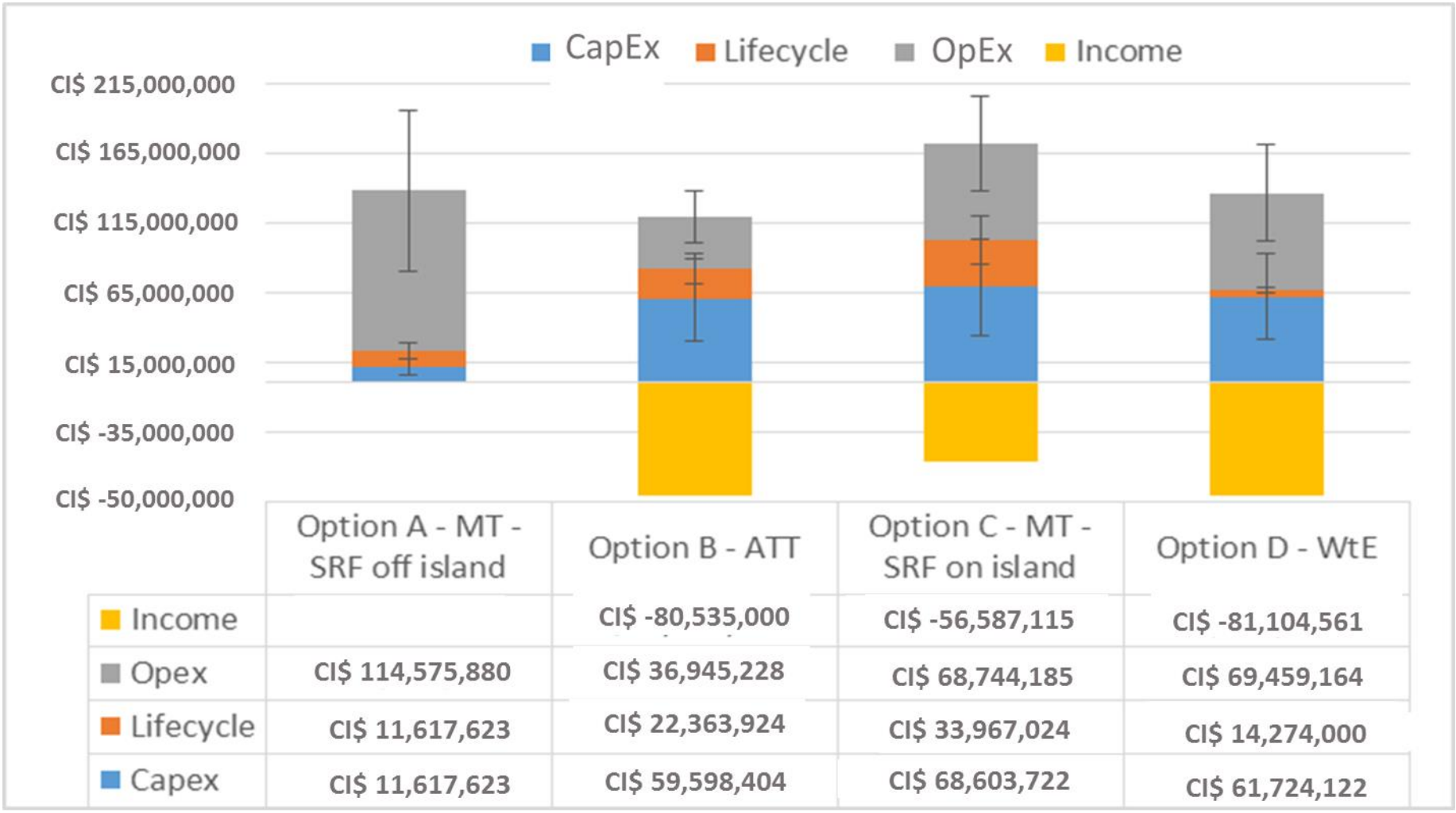


	Option A - MT - SRF off island	Option B - ATT	Option C - MT - SRF on island	Option D - WtE
Income	CI$ 2,378,224	CI$ 80,535,000	CI$ 58,965,339	CI$ 83,482,785
Opex	CI$ 155,438,000	CI$ 77,808,000	CI$ 109,607,000	CI$ 110,332,000
Lifecycle	CI$ 21,004,000	CI$ 31,750,000	CI$ 43,353,000	CI$ 14,274,000
Capex	CI$ 23,771,000	CI$ 71,752,000	CI$ 80,758,000	CI$ 73,878,000

For the overall costs of each scenario, income comes from electricity sales from the AD facility and the thermal treatment facilities. No sales from heat have been included (CHP option).

Figure 7.4 shows the cost of each of the residual waste treatment options associated with each scenario.

Figure 7.4: Residual Waste Treatment Option Cost Breakdown Comparisons

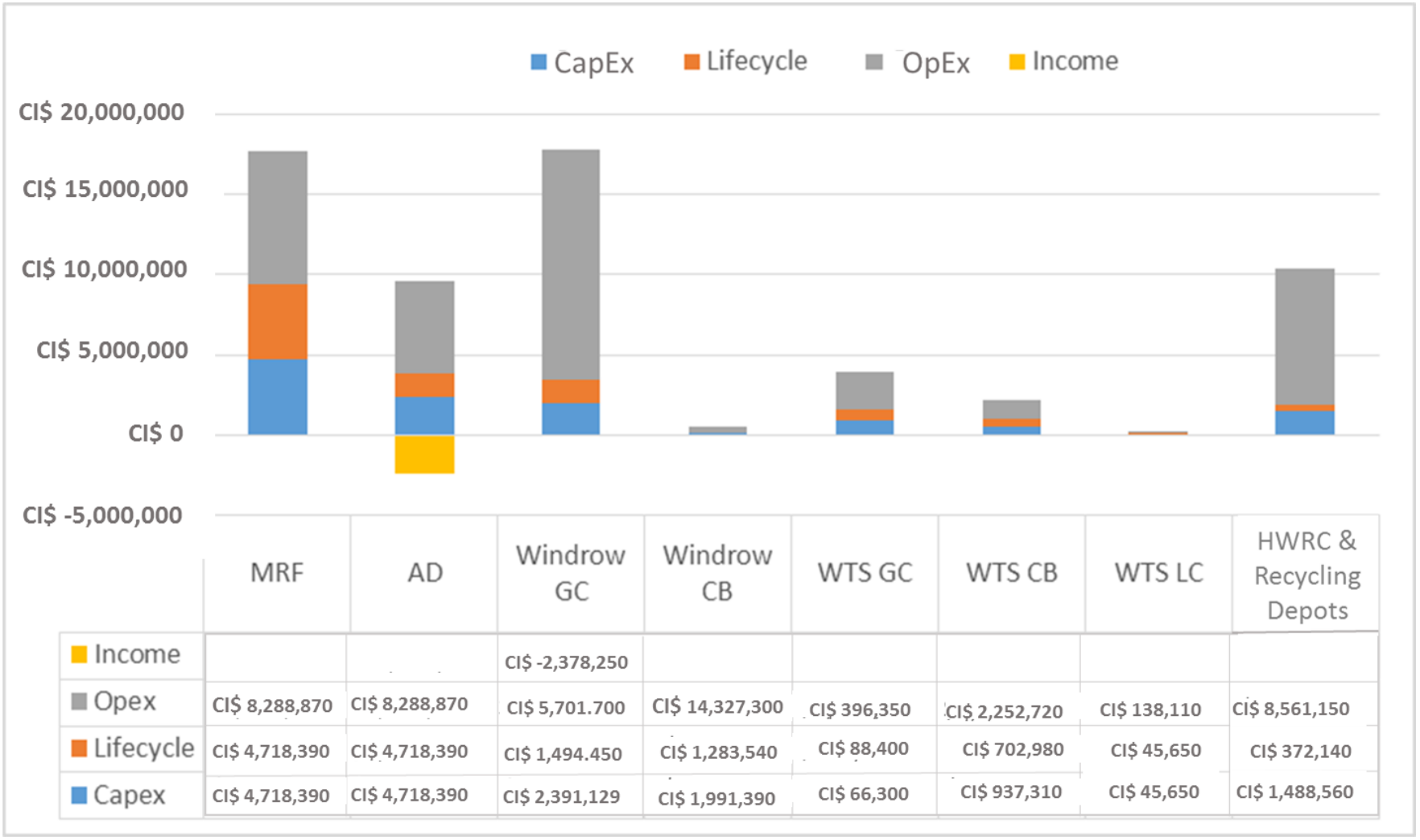


	Option A - MT - SRF off island	Option B - ATT	Option C - MT - SRF on island	Option D - WtE
Income		CI$ -80,535,000	CI$ -56,587,115	CI$ -81,104,561
Opex	CI$ 114,575,880	CI$ 36,945,228	CI$ 68,744,185	CI$ 69,459,164
Lifecycle	CI$ 11,617,623	CI$ 22,363,924	CI$ 33,967,024	CI$ 14,274,000
Capex	CI$ 11,617,623	CI$ 59,598,404	CI$ 68,603,722	CI$ 61,724,122

There is no income for the residual treatment in option A; as the solid recovered fuel (SRF) would be taken off-island and the electricity generated would be used by users local to the off take facility.

Figure 7.5 shows the costs associated with each of the other facilities that are included with all of the four options as shown in Figures 7.2 and 7.3. For a conservative position no income has been assumed for the sale of dry recyclates; as this will be subject to prevailing market conditions.

Figure 7.5: Other Facility Cost Breakdown Comparisons



	MRF	AD	Windrow GC	Windrow CB	WTS GC	WTS CB	WTS LC	HWRC & Recycling Depots
Income			CI$ -2,378,250					
Opex	CI$ 8,288,870	CI$ 8,288,870	CI$ 5,701.700	CI$ 14,327,300	CI$ 396,350	CI$ 2,252,720	CI$ 138,110	CI$ 8,561,150
Lifecycle	CI$ 4,718,390	CI$ 4,718,390	CI$ 1,494.450	CI$ 1,283,540	CI$ 88,400	CI$ 702,980	CI$ 45,650	CI$ 372,140
Capex	CI$ 4,718,390	CI$ 4,718,390	CI$ 2,391,129	CI$ 1,991,390	CI$ 66,300	CI$ 937,310	CI$ 45,650	CI$ 1,488,560

Note- Costs exclude landfill.

The smaller facilities are generally cheaper due to lower throughput, despite having higher CI$/ ton costs. The total operating costs are high as they occur each year and are higher than the lifecycle costs.

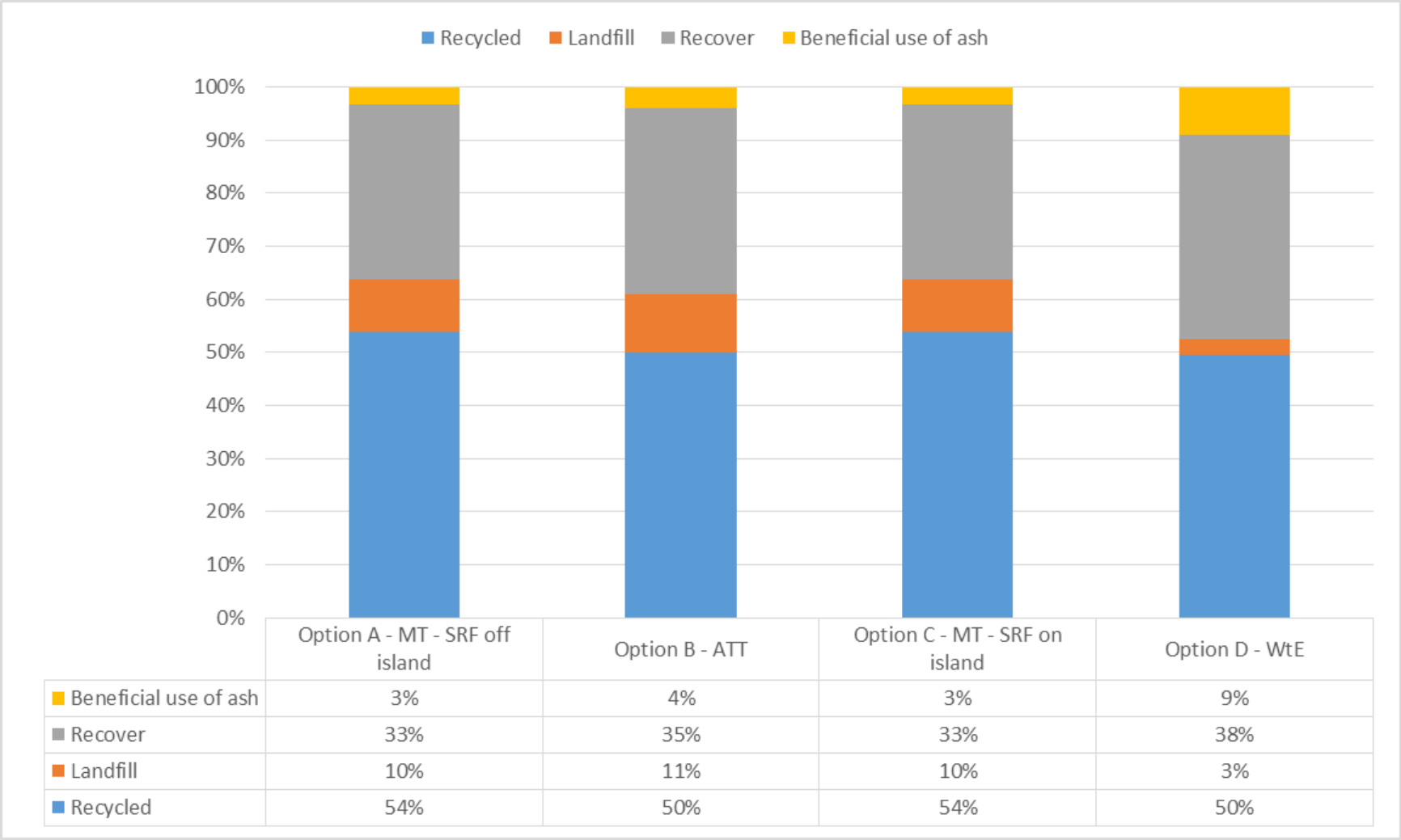
Operational Performance

Figure 7.6 shows the operational performance of the four scenarios in terms of recycling, recovery, beneficial use of ash, and landfill. This is presented over the 45 years, assuming the strategy is for 50 years and facilities are actually implemented after 5 years. The performance is shown in percentage terms, and views the whole waste lifecycle from cradle to grave looking at waste sent to recovery as well as any resultant ash being beneficially used or sent to landfill. The performance also includes the non-residual treatment facilities, but as these are all the same for each option, any difference can be attributed to the residual waste treatment processes.

If the options were not implemented, there would be little opportunity to increase operational performance beyond the existing performance.

Generally the WtE option sends less waste to landfill; as more of the ash can be beneficially used and the process is more flexible to the variable nature of the input waste, so there are fewer pre-treatment rejects.

Figure 7.6: Operational Performance of the Grouped Options.



	Option A - MT - SRF off island	Option B - ATT	Option C - MT - SRF on island	Option D - WtE
Beneficial use of ash	3%	4%	3%	9%
Recover	33%	35%	33%	38%
Landfill	10%	11%	10%	3%
Recycled	54%	50%	54%	50%

Environmental and Lifecycle Assessment (LCA)

The environmental and lifecycle assessment of shortlisted options has been carried using the Waste Resources Assessment Toolkit for the Environment (WRATE). The model has been developed by the UK Environment Agency (EA) to enable the modelling of the potential effects of current and future waste services and facilities on the environment. As an LCA tool WRATE considers the impact of solid waste from the point of collection through to either the point of final disposal or the point whereby the waste has been processed into a material available for use again within the materials chain.

Default Impacts

WRATE measures the potential impact on the environment through six parameters or default impacts:

- **Abiotic Resource Depletion (kg antimony equivalent)** – Use of non-renewable and renewable resources. Abiotic resources are non-living things, including land, water, air and minerals;
- **Global Warming Potential (kg carbon dioxide equivalent)** – Measure of what mass of Greenhouse Gases are estimated to contribute to global warming, a relative scale that compares emissions to Carbon Dioxide;
- **Human Toxicity (kg 1,4-dichlorobenzene equivalent)** – This covers a number of different effects: acute toxicity, irritation/corrosive effects, allergenic effects, irreversible damage/organ damage, genotoxicity, carcinogenic effects, toxicity to reproductive system/teratogenic effects, and neurotoxicity. The equivalence factors are determined for emission to different compartments: air, water, and soil and exposure via different media: air water, and soil;
- **Freshwater Aquatic Ecotoxicity (kg 1,4-dichlorobenze equivalent)** – Toxicity towards ecosystems can be regarded as either chronic (causing long lasting illness) or acute (short term/ immediate effects);
- **Acidification (kg Sulphur Dioxide equivalent)** – Emissions of acidifying compounds such as sulphur dioxide and nitrous oxides attack leaves and acidify the soil which can result to changes in the ecosystem; and
- **Eutrophication (kg Phosphate equivalent)** - is caused by the increase of chemical nutrients, typically compounds containing nitrogen or phosphorus.

Modelling Assumptions

WRATE models require information on the year of the study (to inform the energy mix used in the calculations), the waste tonnages; composition and the types of processes to be used as a minimum. WRATE includes a range of standard processes which have been developed through information obtained by the UK Environment Agency's Waste Technology Data Centre and the modelled short list options were based on one of these technologies with certain elements adjusted to reflect the specific technology.

Short List Modelling

The short list options used waste data shown in Table 2.1 and have been combined to generate a matrix of waste management options for input in to WRATE software. In addition the existing baseline waste management system has been modelled for comparative analysis. In total. this produced 33 different combinations of options that were modelled and each of these contained a number of stream that are collected, recycling and organic waste treatment and a residual waste treatment and disposal method. These combinations of options are listed in Table D1 of Appendix D, with a breakdown of what they comprise. Appendix D also contains the comprehensive results for all the combinations of options that have been modelled.

Lifecycle Modelling Results

The results of the lifecycle assessment modelling for scenarios A, B, C and D and for scenarios C and D with CHP are shown in Table 7.5 and are summarised in Figures 7.7 to 7.12. These provide comparative data for each modelled scenario for each of the lifecycle parameters determined using WRATE.

Table 7.5: Summary of Characterised Environmental Impacts

Impact Assessments	climate change: GWP 100a	acidification potential: average European	eutrophication potential: generic	freshwater aquatic ecotoxicity: FAETP infinite	human toxicity: HTP infinite	resources: depletion of abiotic resources
Scenario	**kg CO2-Eq**	**kg SO2-Eq**	**kg PO4-Eq**	**kg 1,4-DCB-Eq**	**kg 1,4-DCB-Eq**	**kg antimony-Eq**
Baseline - Landfill	111,529,326	4,092	29,352	240,407	2,213,360	4,753
Option A - MT SRF off island	-20,181,224	-397,581	-8,473	-3,707,763	-35,827,613	-272,673
Option B - ATT	-15,982,407	-348,559	-10,228	-3,275,133	-31,929,450	-242,019
Option C = MT WtE on island	-20,871,713	-401,720	-9,013	-3,861,531	-37,539,165	-277,837
Option D - WtE	-22,117,519	-459,091	-8,791	-3,936,997	-33,182,662	-278,481
Option C MT WtE & with CHP	-28,230,957	-420,950	-10,785	-4,058,440	-38,581,656	-325,520
Option D WtE with CHP	-30,961,687	-482,200	-10,921	-4,173,638	-34,435,503	-335,785

Figure 7.7: Combined Scenarios – Climate Change Impact (kg CO2-Eq)

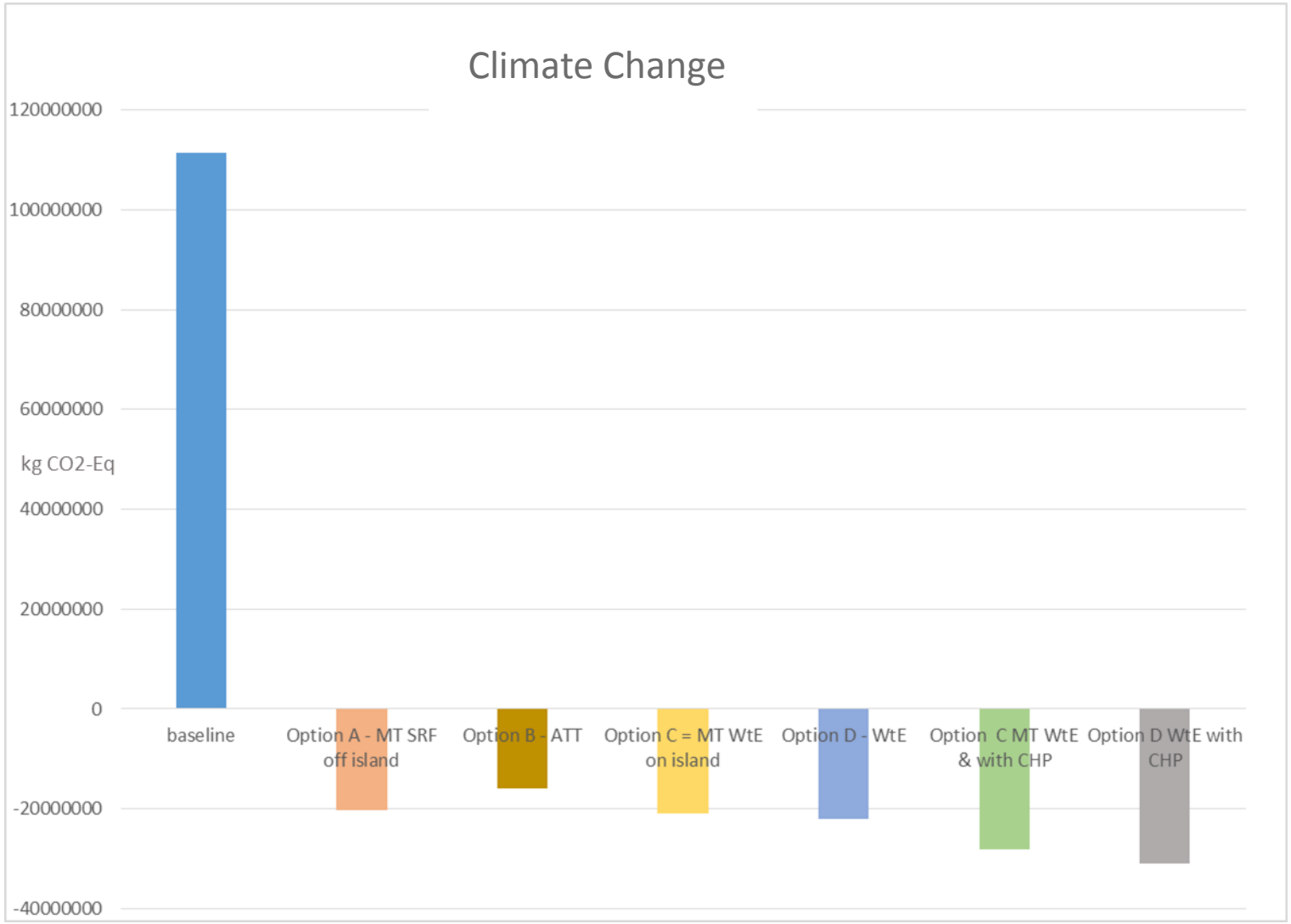


Figure 7.8: Combined Scenarios– Acidification Potential (kg SO2-Eq)

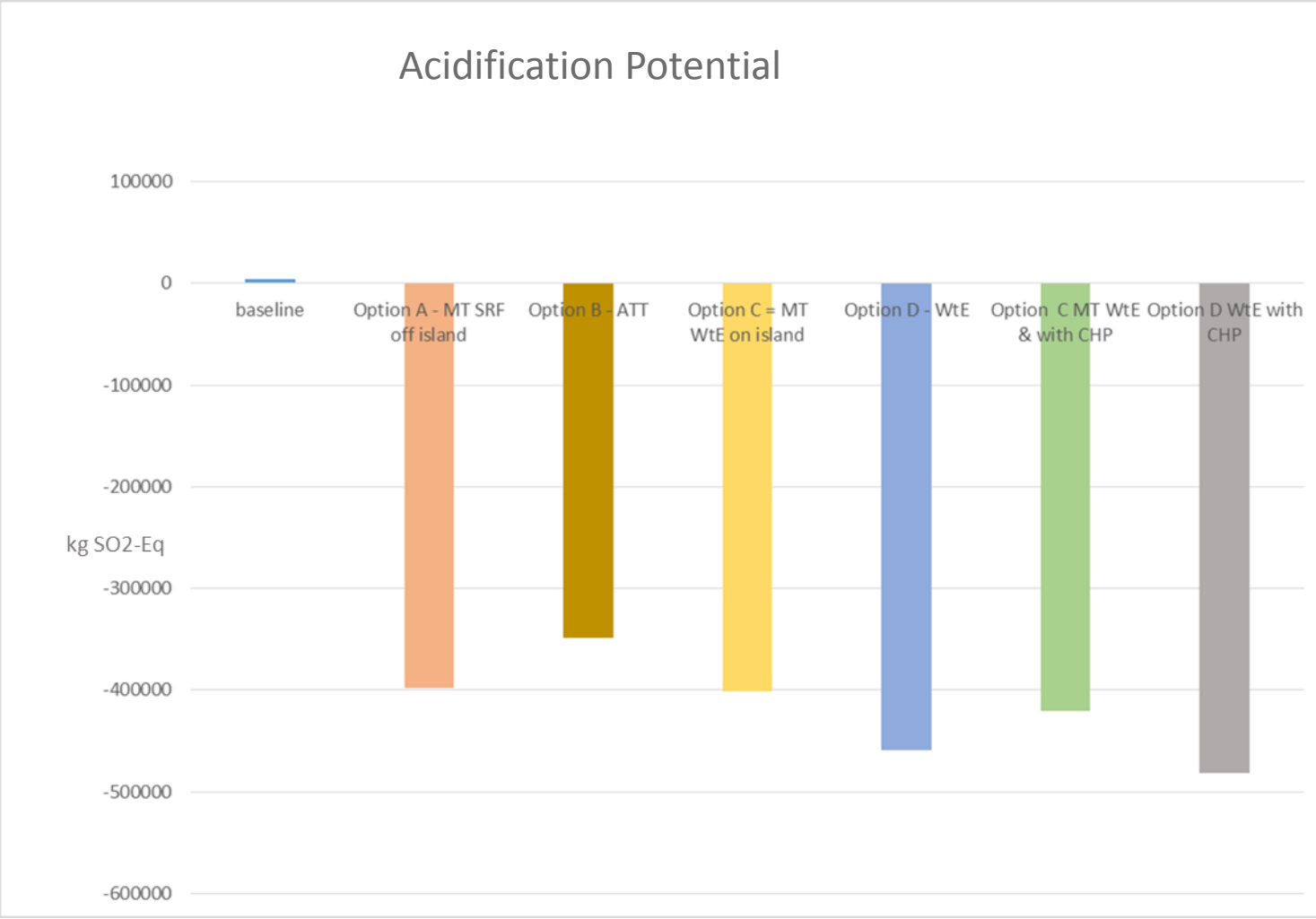


Figure 7.9: Combined Scenarios – Eutrophication Potential: Generic (kg PO4-Eq)

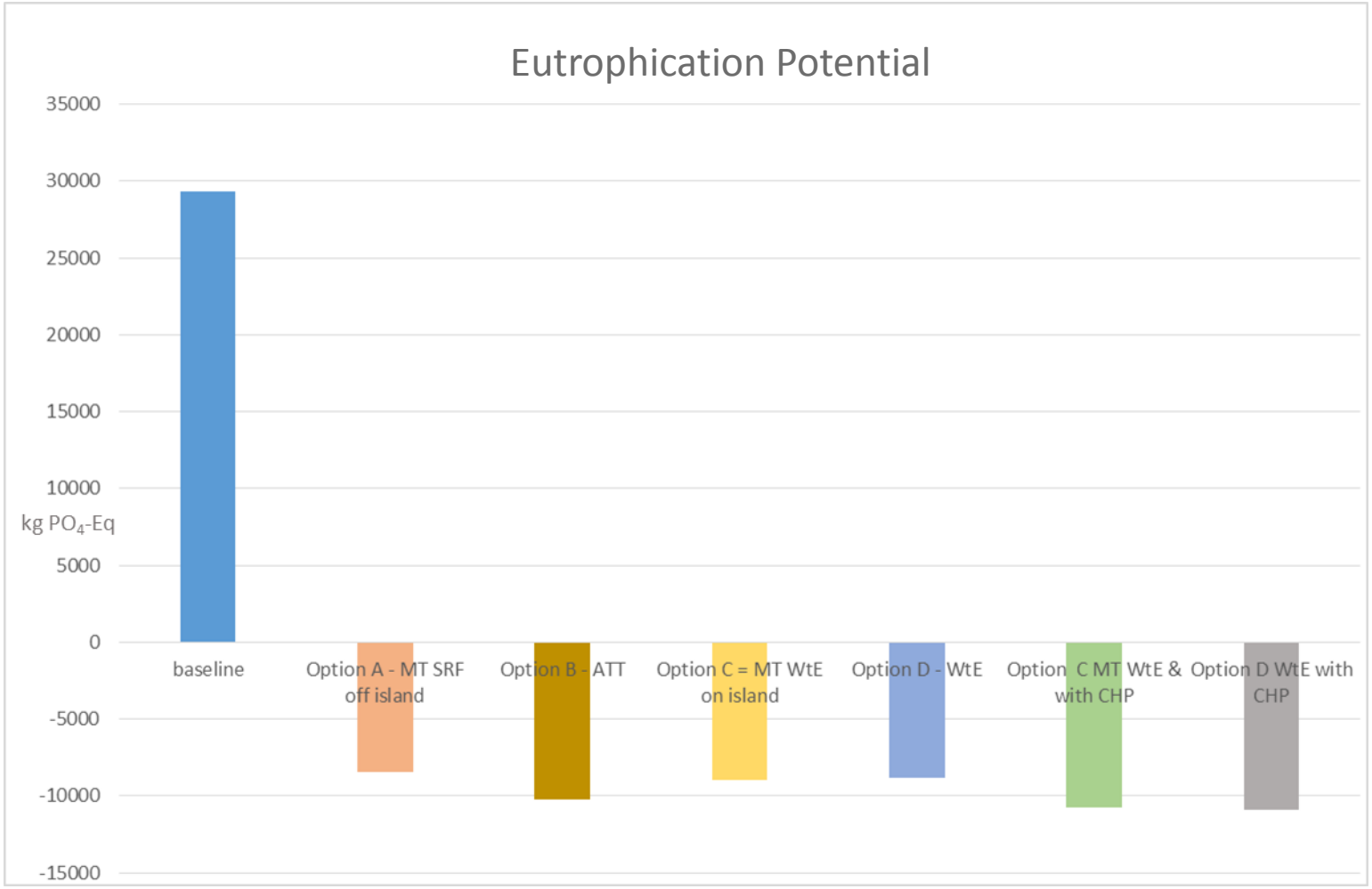


Figure 7.10: Combined Scenarios – Freshwater Aquatic Ecotoxicity (kg 1,4-DCB-Eq)

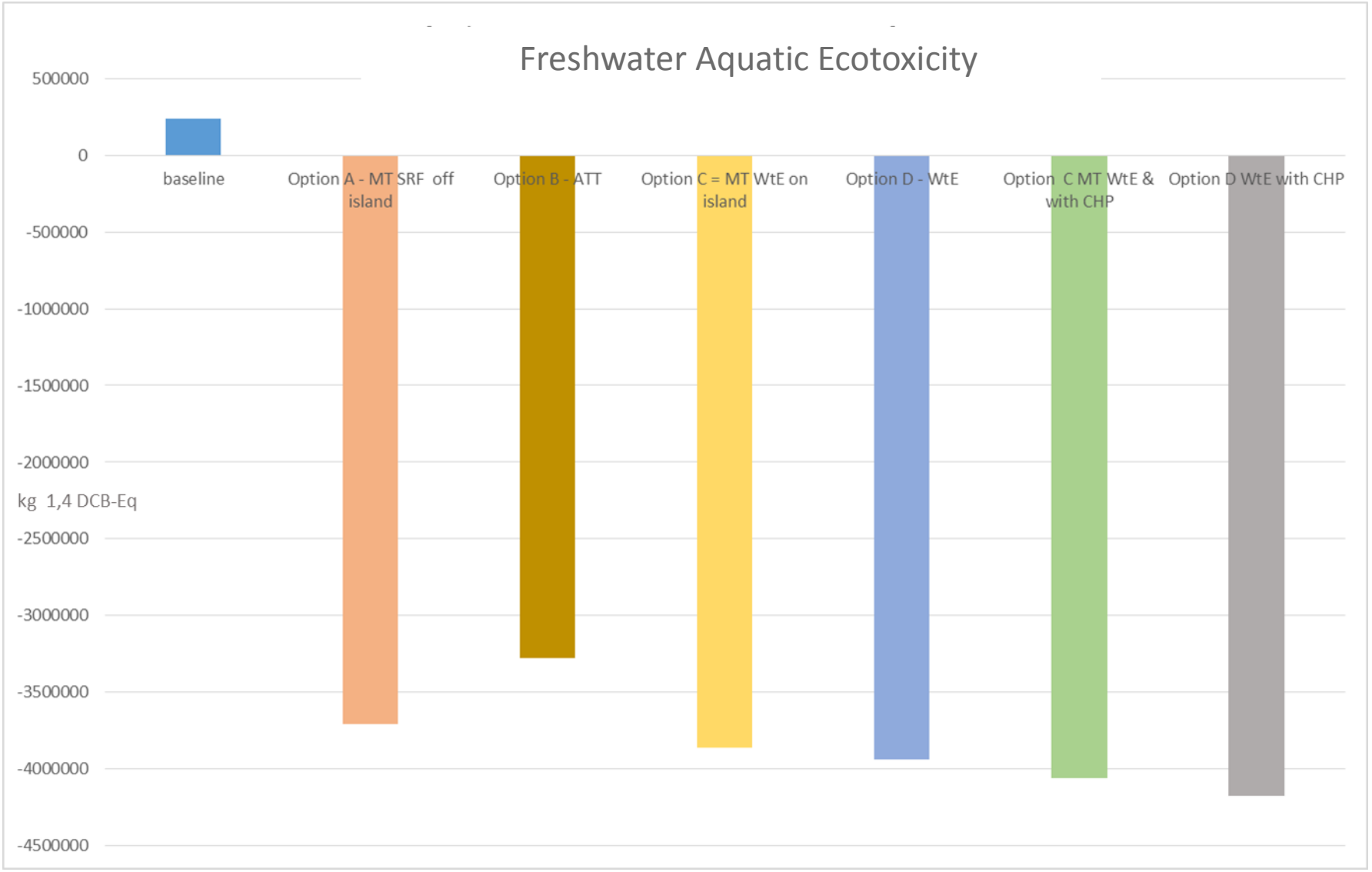


Figure 7.11: Combined Scenarios – Human Toxicity (kg 1,4-DCB-Eq)

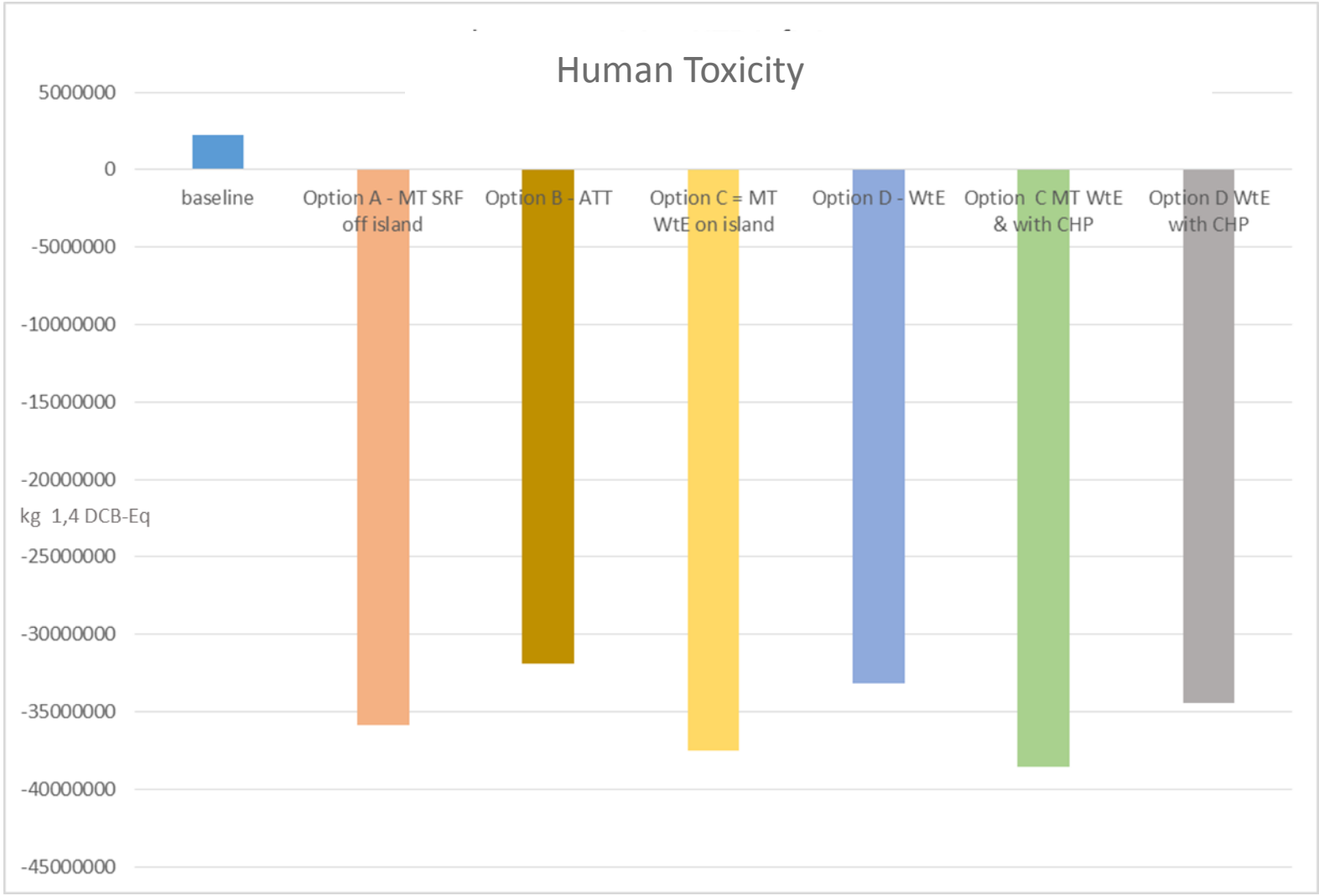
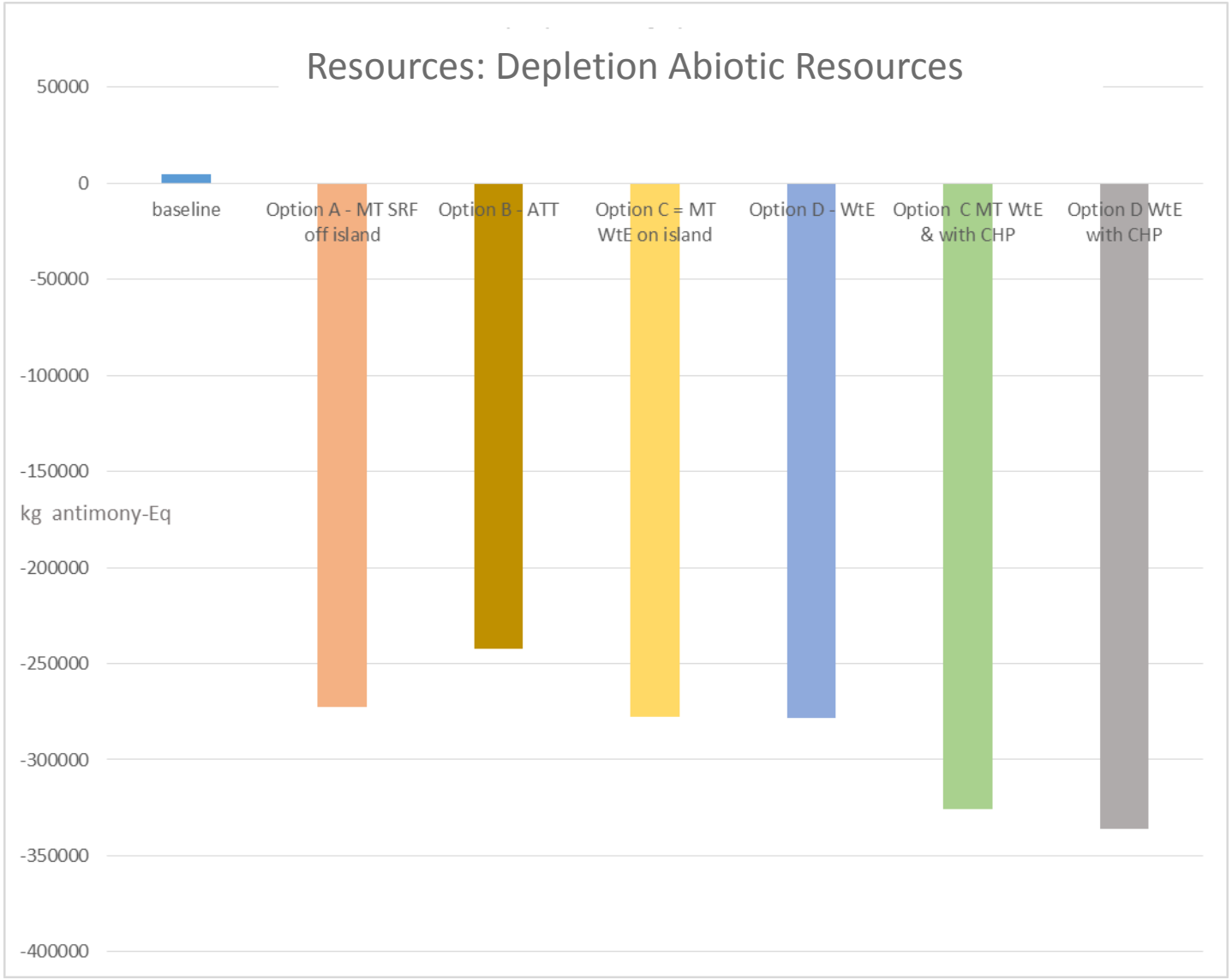


Figure 7.12 Combined Scenarios – Depletion of Abiotic Resources (kg antimony-Eq)



Conclusions

The assessed options all improve on the baseline position (the existing landfill based waste management system) for the global warming potential, acidification potential, eutrophication indicators, freshwater aquatic ecotoxicity, human toxicity indicator and abiotic resource depletion.

All of the options with on island WtE have been modelled both with and without CHP. These results show that the delivery of an active CHP based solution provides enhanced environmental performance and improved lifecycle characteristics.

In summary, all of the principle waste management scenarios (A, B, C and D) deliver significantly improved lifecycle/environmental impacts over the existing baseline and this is shown across all of the modelled parameters. With the exception of the baseline, the quantity of residual waste disposed of to landfill for each scenario is a fairly similar and therefore the performance of the scenario in terms of minimal environmental impact has been largely determined on the capacity of the scenario to offset the use of fossil fuels through recovery of electricity and heat. However, the reuse, recycling and composting of waste also contribute to the improved performance.

7.3 Short List Options Appraisal Outcome

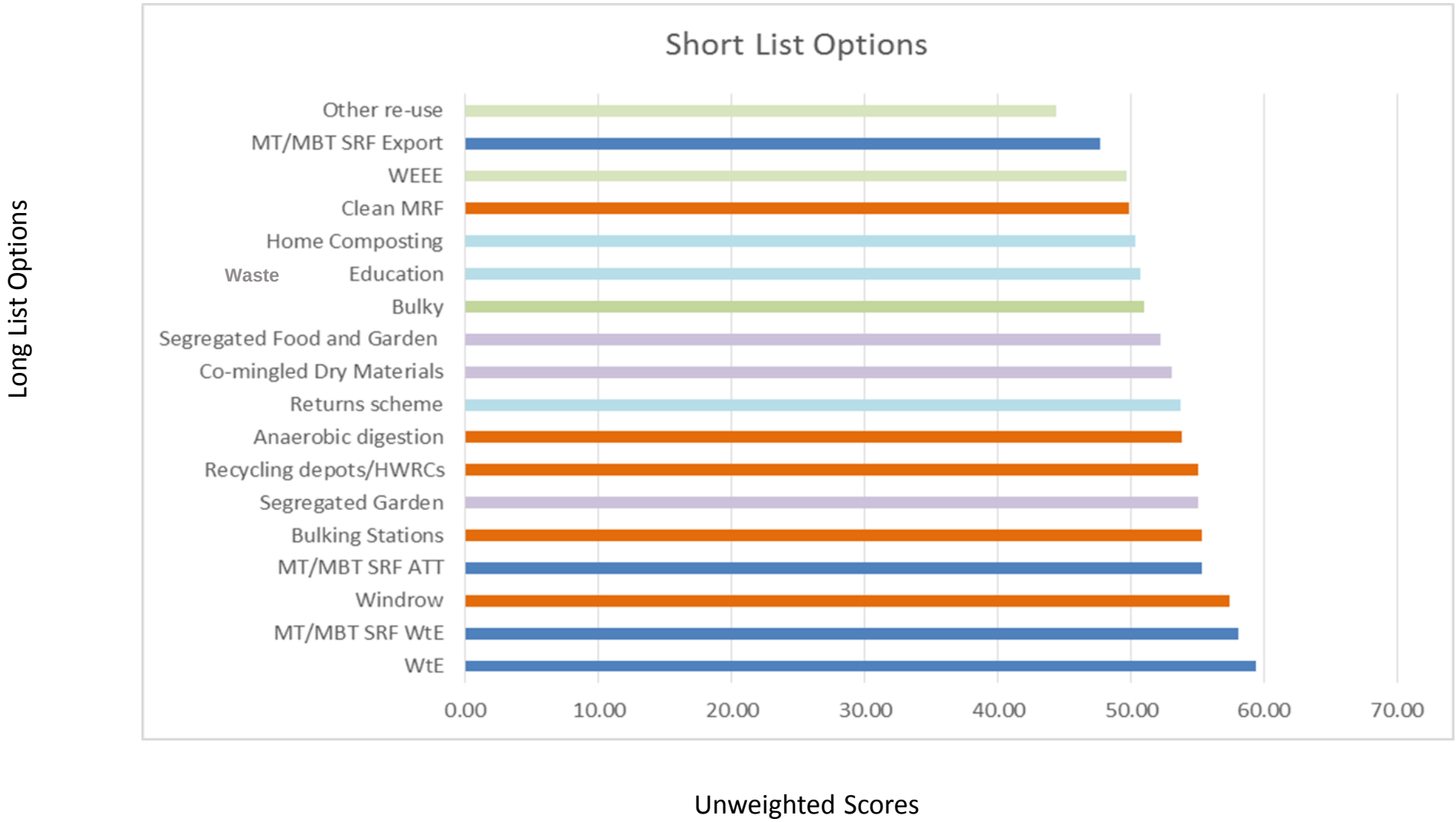
Using the results of the financial, performance and lifecycle assessment Amec Foster Wheeler adjusted the unweighted option appraisal scores used for the long list analysis for the following criteria and applied these to the short listed options.

- Whole lifecycle costs;
- Short term cost/funding;
- Lifecycle Impacts;
- Recycling Potential;
- Clean/Renewable Energy Generation; and
- Carbon Impact.

This generated the short list option appraisal results shown in Figure 7.13 and these have been used to construct the reference project discussed in Section 8. However the separate collection of food waste and treatment in an anaerobic digestion has been omitted from the reference project for the following reasons:

- The amount of food waste that could be recovered by providing kerbside collection is comparatively low and the tonnage will not result in a commercially viable anaerobic digestion facility:
- The collection of kerbside food waste is likely to require the introduction of a separate fleet specialised waste collection vehicles, prompting a disproportionate capital outlay in relation to the amount of food waste collected; and
- The disposal of digestate from the wet anaerobic digestion plant will be difficult on the Cayman Islands. Without agricultural soil application of the digestate to land is unlikely to provide practical benefit and could give rise to ground and surface water pollution (please note that dry Anaerobic Digestion was screened out at the long list stage as this would need to fed by mixed yard and food waste collections).

Figure 7.13: Performance of the Short Listed Options



8. Reference Project

8.1 Introduction and Purpose

The reference project developed as part of this draft NSWMS comprises the waste management options that have been assessed as having the most potential for delivering the CIG policies and strategy objectives, and which are likely to be successful in the unique setting of the Cayman Islands.

The purpose of developing a reference project is two-fold:

- To show that the CIG's policies and strategic objectives can be delivered by a particular solution (mix of the options considered) and the estimated cost of doing so (demonstrating that the objectives are attainable and affordability of their delivery assessed) without constraining any future procurement options (i.e. the CIG can go to the market on a technology neutral basis). Most commonly the lowest cost option that meets these objectives is selected as the reference project for this purpose; and
- In addition the reference project may be used to define the solution that best fits the CIG's policies, objectives and affordability criteria and sets out that this is what the CIG intends to deliver (i.e. the that CIG will go to market for a specific technology/solution). This may not be the lowest cost options and can include specific criteria with particular local significance (e.g. political commitment, site constraints, compatibility with existing services).

The assessment of waste management options considered as part of the preparation of this draft waste strategy are set out in Sections 6 and 7.

The reference project will developed and used as the basis for the production of the Outline Business Case (please refer to Section 11).

8.2 Meeting Policies and Objectives

Table 8.1 below sets out how the reference project described in Section 8.3 performs against the vision, values and strategic directions set out the NSWMP. The reference project exhibits a high degree of compatibility with the NSWMP and demonstrates that vision, values and strategic direction can be delivered by an integrated waste management solution.

Table 8.1: The Mapping of Vision, Values and Strategic Directions against the Reference Project

Ref		Criteria	Vision	Values	Strategic Direction	Objectives	Performance of the Reference Project
1a		Compatibility with PPP		We will pursue multi-sectorial partnerships and collaboration for the integrated and efficient delivery of waste management services and programmes.	Establish partnerships with community and business groups with a view to achieving the strategic directions for sustainable waste management in the Cayman Islands.	Promote multi-sectorial partnerships and collaboration for the integrated and efficient delivery of waste management services and programmes.	The reference project provides for major capital facilities (e.g. a Waste to Energy plant) that is likely to be commercially viable and attractive for a PPP initiative. The reference project will also provide opportunities for the community and business through the reuse, recycling and recovery of waste that would otherwise be landfilled.
1c		Whole lifecycle cost		We believe that the generators of waste should be responsible and bear their proper share of costs for waste management.	Implement a waste management system that is principally financed on the basis that the waste producer pays.	Evaluate and adjust the current financing framework for waste management to ensure that the waste producer pays proportionate to the waste that they generate.	Options for the financing of the reference project will include the charging of fees for waste collection and treatment as well as revenue opportunities from the sale of recyclates and recovered energy.
1d		Short term cost/funding		We believe that the generators of waste should be responsible and bear their proper share of costs for waste management.	Implement a waste management system that is principally financed on the basis that the waste producer pays.		Options for the financing of the reference project will include the charging of fees for waste collection and treatment as well as revenue opportunities from the sale of recyclates and recovered energy.

Ref		Criteria	Vision	Values	Strategic Direction	Objectives	Performance of the Reference Project
2a		Waste hierarchy		We will apply the waste hierarchy preference to reduce, reuse, recycle, and recover prior to the final resort of disposal.	Reduce the proportion of solid waste being landfilled by diverting waste in accordance with the sustainable waste management hierarchy.	Promote the development of improved practices and facilities for solid waste management which are demonstrably consistent with the waste management hierarchy. CIG will lead by example by examining how it purchases, uses, and manages materials, with the objective of reducing consumption and waste.	The reference project provides a considerable movement up the waste hierarchy by providing for waste reduction, increased reuse and recycling and the recovery of energy from residual waste in preference to landfill. The reference project will assist the delivery of this objective by providing enhanced waste reduction, re-use, recycling and recovery opportunities for use by CIG in the decision making process.
2b		Recycling potential				Implement and expand programmes to reduce, re-use, and recycle waste materials. Develop and implement initiatives and incentives to support waste segregation at the source, both at households and businesses, for the purpose of reducing, reusing, and recycling.	The reference project provides greater access to residents for recycling through the provision of recycling depots, windrow composting and household waste recycling centres in the short term with the later introduction of kerbside collection systems and a materials recovery facility.

Ref		Criteria	Vision	Values	Strategic Direction	Objectives	Performance of the Reference Project
2c		Carbon impact/greenhouse gas		We will pursue waste management opportunities that have the potential to reduce greenhouse gas emissions and reduce our dependence on fossil fuels.			The reference project produces a substantially reduced carbon impact over the existing landfill arrangements.
2d		Energy generation/green energy		We will pursue waste management opportunities that have the potential to reduce greenhouse gas emissions and reduce our dependence on fossil fuels.			The waste to energy facility used for the treatment of residual waste in the reference project will generate renewable and sustainable from waste that would otherwise be landfilled. This will produce green energy for use on the Cayman Islands and reduce dependence on electricity derived from fossil fuels.
2e		Life cycle environmental impact		We will ensure that environmental impacts of waste management are assessed and understood, and that measures are undertaken to protect human health and the environment We will implement sustainable waste management in a manner that respects the needs of future generations.			The reference project produces substantial lifecycle benefits across all measured lifecycle indicators over the existing waste management system. By following the waste management hierarchy the reference project will deliver a more sustainable integrated waste management system for the Cayman Islands.

Ref		Criteria	Vision	Values	Strategic Direction	Objectives	Performance of the Reference Project
3b		Training/education		We believe in the enhancement of personal responsibility for waste management through advocacy, education and the creation of opportunities to help realise the national vision for waste management.	Broaden the understanding of sustainable waste management issues and practices throughout the entire community of the Cayman Islands.		Waste education and the promotion of waste reduction is a key focus for the reference project. The reference project will also provide opportunities for training and education by introducing new waste management practices (e.g. providing opportunities for waste re-use) and facilities (that are technically more sophisticated than landfill).
3c		Public acceptability aesthetics		We will pursue multi-sectorial collaborations and partnerships with various stakeholders to achieve our vision for waste management in the Cayman Islands.		Establish a framework to encourage multi-stakeholder collaboration. Institute a programme of awareness, promotion, education, and publicity in partnership with community groups, schools, and other organisations.	The focus on waste reduction and education within the reference project can only be achieved through widespread engagement with all stakeholders and community groups. In addition waste reuse and recycling will also provide opportunities for beneficial engagement with local charities and third sector organisations.

Ref		Criteria	Vision	Values	Strategic Direction	Objectives	Performance of the Reference Project
3d		Political buy-in		We will ensure there is an appropriate legal, regulatory, and institutional framework and embrace good governance principles to support achieving the national vision for waste management.	Apply good governance principles to strengthen institutional capacity and leadership.	Establish enabling public health and waste management legislation, regulations and enforcement.	The delivery of the reference project will need to be accompanied by the introduction of a new regulatory and enforcement regime suited to control of the integrated waste management system.
4a		Track record/Proven technology				Apply a process, based on recognised best practice, for the assessment and mitigation of health and environmental impacts of existing and proposed waste management practices.	The practices and technologies encompassed within the reference project have an extensive operational track record and demonstrable record of commercial deliverability.
4c		Applicability to island environment		We will ensure that economies of scale are considered in determining suitable waste management practices, having due regard for the geographical aspects of the Cayman Islands.			The reference project will provide access to the integrated waste management system throughout the Cayman Islands, including Cayman Brac and Little Cayman. The reference project would deliver the closure of the landfill facilities on the sister islands by providing alternative means of managing waste.

Ref		Criteria	Vision	Values	Strategic Direction	Objectives	Performance of the Reference Project
5a		Planning/site assessment			Manage waste in a manner protective of human health, the environment and local amenities.	Establish enabling public health and waste management legislation, regulations and enforcement.	The delivery of the reference project and the associated waste management facilities will be subject to planning approval including environmental impact assessment.
5b		Integration across all islands	Integrated, sustainable, and effective waste management for the Cayman Islands.		Broaden the understanding of sustainable waste management issues and practices throughout the entire community of the Cayman Islands.		The reference project will require waste education across the islands. It will also provide access to the integrated waste management system throughout the islands. The reference project would deliver the closure of the landfill facilities on the sister islands by providing alternative means of managing waste.
5c		Remediation of existing landfills				Assess the remaining capacity and develop short and long-term management plans for each of the landfill sites, including measures to ensure that the sites do not pose an on-going risk to the environment or human health.	The reference project results in a much reduced demand for landfill on Grand Cayman and landfill mining (if feasible) may enable the continuation of landfilling at George Town while the landfill is remediated. The landfills on Cayman Brac and Little Cayman would close.

Ref		Criteria	Vision	Values	Strategic Direction	Objectives	Performance of the Reference Project
6a		Diversion of waste from landfill			Reduce the proportion of solid waste being landfilled by diverting waste per the sustainable waste management hierarchy.		The reference project results in a substantial diversion of waste away from landfill through enhanced waste recycling and waste recovery. Diversion of residual waste from landfill will exceed 90%.

8.3 An Integrated Solid Waste Management System

The evaluation of the short listed options suggest that the reference project could be made up of the following recommended options:

- Waste reduction measures – including waste education and pragmatic waste minimisation initiatives (e.g., home composting/ material return schemes such as bottles);
- The reuse and refurbishment of bulky waste;
- Community recycling depots and HWRC recycling facilities;
- Transfer and bulking facilities (one per island);
- The windrow composting of yard/garden waste from landscaping operations and HWRC's;
- The potential introduction of kerbside yard and garden waste (post 2020);
- The potential introduction of kerbside dry recyclable collections with a Materials Recovery Facility (post 2020); and
- The treatment of residual waste in a Waste to Energy Facility (CHP enabled).

Reference Project Performance and Outline Costs Estimate

This section summarises the environmental performance and estimated outline costs of the reference project. The details of the reference project components are shown in Table 8.2.

Table 8.2: Reference Project Details

	Facility Location	Maximum Facility Capacity (tons)	Facility On line Date
Waste to Energy facility with CHP	Grand Cayman	53,000	2019/20
Materials Recovery Facility	Grand Cayman	11,400	2019/20
Windrow Facility	Grand Cayman	34,900	2017/18. Upgrades to existing facility.
Household Waste Recycling Centre	Grand Cayman	5,400	2016/17
Recycling Depots	Grand Cayman	1,300	2016/17
Bulking and Transfer Station	Grand Cayman	4,100	Already in use, but to be upgraded with another contract
Waste Transfer Station	Cayman Brac	3,600	2019/20. Will include areas for segregation of recyclables.
Windrow Facility	Cayman Brac	600	2019/20. Will be built to take kerbside green waste collected.
Waste Transfer Station	Little Cayman	300	2019/20. Will include areas for segregation of recyclables
Mechanical Treatment of Mined Landfill Waste	Grand Cayman	11,400	2019/20, This will produce approximately 5% recyclables and a solid recovered fuel for treatment in spare capacity in the WtE facility.

The majority of the waste collected on the sister islands would be transferred to Grand Cayman for treatment or for bulk haulage to off-island treatment/ markets. It is assumed that the waste transferred from the sister islands will be transported to the relevant waste management facilities on Grand Cayman. The third waste transfer station is on Grand Cayman and will be used for the reception of sister island wastes and potentially for the bulking of recyclates; waste requiring export and wastes that have been segregated (i.e. metals, gas canisters and chemicals).

It has been assumed that as far as practicable kerbside collection of waste will be achieved using the existing waste collection resources and vehicles; by altering operational practices and collection frequencies.

To size the HWRC, it is assumed half of the recyclables that are currently separated for recycling on Grand Cayman will be taken to the HWRC, along with 10% of the recyclables that are forecast to be captured in the future.

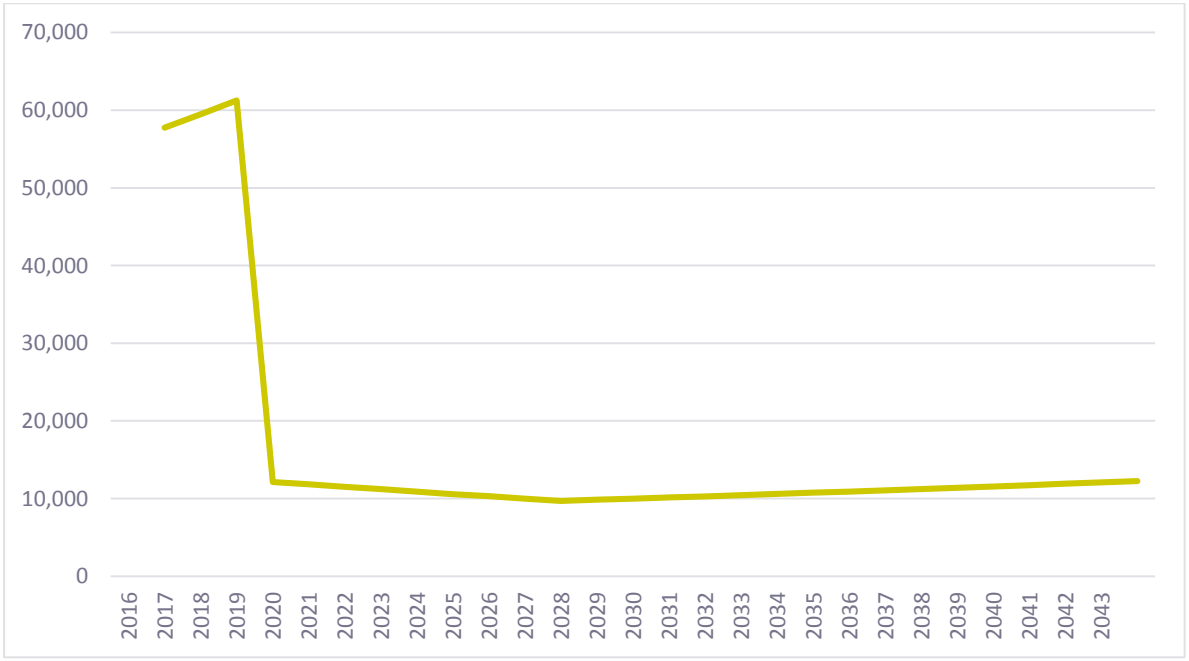
To size the Recycling Depots, it is assumed 10% of the recyclables that are forecast to be captured in the future will be via the Recycling Depots.

Landfill

Some waste will continue to be sent to landfill as not all wastes are suitable for recycling or thermal treatment. A fraction of the incinerator bottom ash (IBA) that cannot be reused in the construction industry will need to be sent to landfill. There will also be Air Pollution Control Residues from thermal treatment that will need to be sent to a separate hazardous landfill cell.

These tonnages result in the landfill requirement tonnage profile shown in Figure 8.1.

Figure 8.1: Landfill Requirement Profile (tonnage per year)



IBA that can be reused would be managed in a specialised IBA recycling facility to produce material that can be used in road building and construction products.

Potential Landfill Mining

CIG has indicated that they are interested in exploring the feasibility of mining the existing deposits at George Town landfill to extract recyclables, recover energy from the waste and to extend the life of George Town landfill.

The reference project therefore contains an 11,400 ton per annum mechanical pre-treatment facility and this is costed to be built in 2019/20.

Financial Assumptions

The financial model for the reference project provides outline capital costs associated with the construction of the reference project facilities, and their ongoing operational costs (including any income revenue from the sale of power).

The development of the capital and operating (revenue) cost model was based on the application of a number of assumptions. These assumptions are summarised in Table 8.3 below.

The costs presented in this section are based on estimates which have been sourced from Amec Foster Wheeler's internal database. These costs have been compiled from various sources, including recent waste procurement projects (including PFI and PPP projects at various stages in the bidding process), information from technology suppliers and published literature. The costs are accurate to +/- 50%.

Capital expenditure (termed 'CapEx') includes all costs associated with the delivery of the required infrastructure with the exception of site specific costs (and therefore excludes the cost of land acquisition, site remediation and similar costs). The excluded cost are however encompassed in the level of accuracy applied to the cost estimate. The CapEx estimate does include the design, preparation, management and construction costs for the delivery of each facility. Design and management costs include professional fees (e.g. planning, permitting, architectural and engineering fees) together with a design or project manager to co-ordinate design requirements and construction. Construction costs include the supply of labour, materials and equipment (sometimes referred to as 'plant' costs) together with preliminaries such as site supervision, temporary accommodation. Electrical grid connection costs are not included as these will be specific to the site selected for the development of the relevant facility.

The on-going operational expenditure (termed 'OpEx') includes all fixed and variable annual costs, including staffing, maintenance, utility costs, licensing, and fuel. Lifecycle costs reflect the need to periodically replace elements of equipment and plant during the operational lifespan of facilities.

Actual costs will vary according to the method of procurement, market conditions and risk profile adopted. Movement in foreign exchange rates can also significantly affect actual costs, depending on the country of origin for major equipment items.

The CapEx estimates for the CHP option for the WtE facility assume that it is CHP enabled (ready). This means that it is are equipped with suitable turbine and valves to facilitate the off take of steam(for cooling systems or a desalination system). The CapEx does not include provision for a heat distribution network; as this will depend of the location of the facility and the requirements of the off take market.

Table 8.3: Financial Assumptions

Option	CapEx (CI$/US ton)	OpEx (CI$/ US ton)	Lifecycle replacement costs (% of OpEx or CI$/ US ton)	Electricity generation (kWh per US ton of waste)
WtE CHP (ready)	$1,214	$58	$4	540
Windrow				
Grand Cayman	$57	$17	2%	
Cayman Brac	$152	$29	3%	
MRF	$338	$25	4%	
Waste Transfer Station				
Grand Cayman	$114	$11	3%	
Cayman Brac	$137	$14	4%	
Little Cayman	$183	$23	4%	
HWRC	$126	$29	1%	
MT for landfill mining	$229	$25	$9	

In addition CapEX and OpEX estimates have been included for the provision of recycling depots. The total CapEX and OpEX for these have been estimated to be CI$228,564 and CI$57,141 in total.

Additional Treatment Costs

There are a number of additional costs (e.g. landfill fees) that will require location specific assumptions to be made so that they can be encompassed within the modelled options. Amec Foster Wheeler will seek to agree with CIG on a suitable approach to producing appropriate cost assumptions for these elements for inclusion on the Outline Business Case.

Estimated Costs and Exclusions

The outline cost estimate for the reference project is at this stage based solely on the baseline CapEx and OpEx on a nominal basis. At this strategic stage the estimate has an accuracy of +/- 50% which is conventional for a waste strategy and reflects the lack of details concerning site and project specific circumstances (e.g. land and remediation costs, site abnormals etc.).

The strategic cost estimate does not constitute a full Net Present Value (NPV) financial assessment. The NPV model will be developed at the Outline Business Case stage with the specialised financial input of KPMG.

There are a number of costs that have not been included at this stage. These will need to be included when the Outline Business Case is developed with the specialist financial support of KPMG. This will be based on a fully costed reference project against which the full financial implications and affordability of the project can be assessed and can also be used to inform the relative evaluation of tenders during the procurement process. The costs excluded from the modelling at this strategic stage are:

- Any additional collection of waste and associated costs (i.e. vehicles, staff);
- CHP distribution network;
- Business rates;

- Import duties;
- Interest charges;
- Depreciation of assets and residual value;
- Inflation;
- Procurement costs;
- Insurance payments; and
- Profit margins.

Summarised Cost Estimate

Figures 8.2 to 8.5 below provide the gross cost comparison of each of component of the reference project. The error bars represent the level of confidence in the figures (i.e. +/- 50%). The costs shown represent costs over 25 year operational lifespan, which is consistent with a conventional industry standard. All costs are expressed in $CI dollars.

Figure 8.2: Summary Costs for WtE

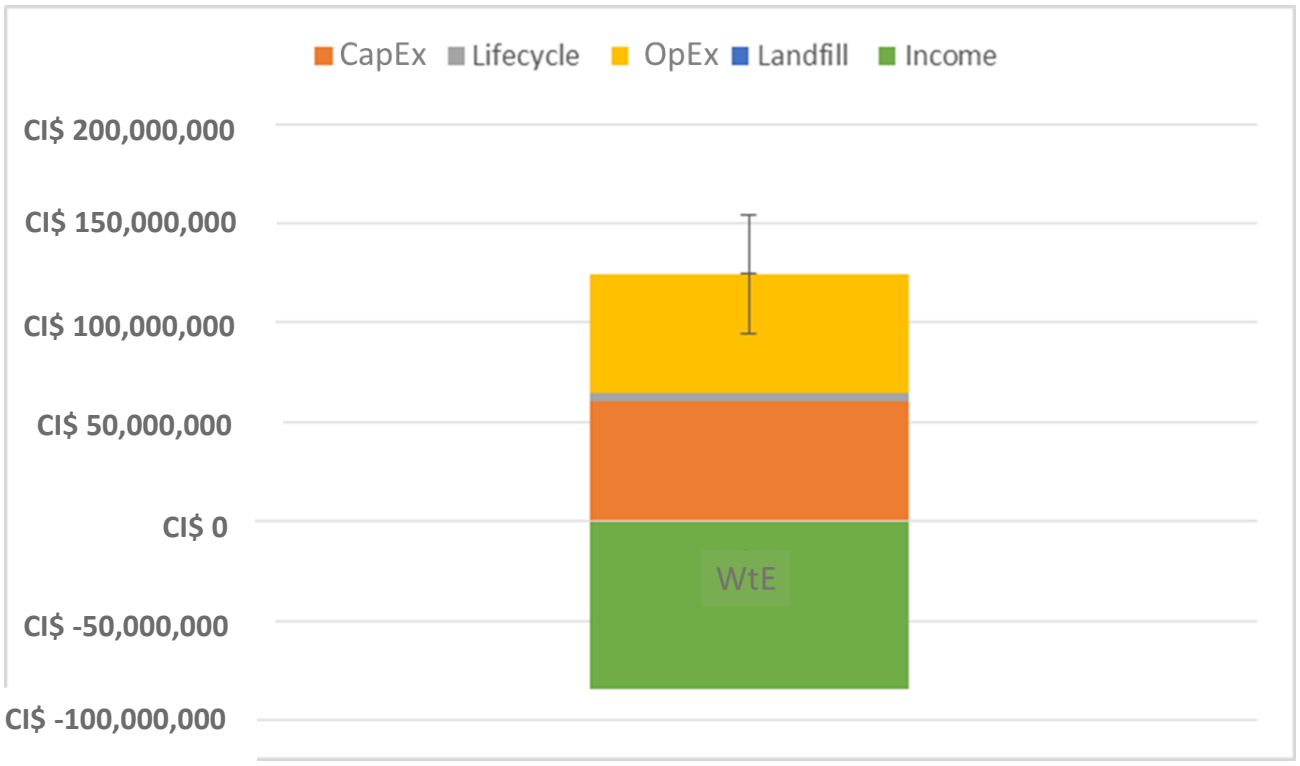


Figure 8.3: Summary Costs for Reference Project Option That Would be Introduced Early by CIG (i.e. Recycling Depots, HWRC's and Window Composting on Grand Cayman)

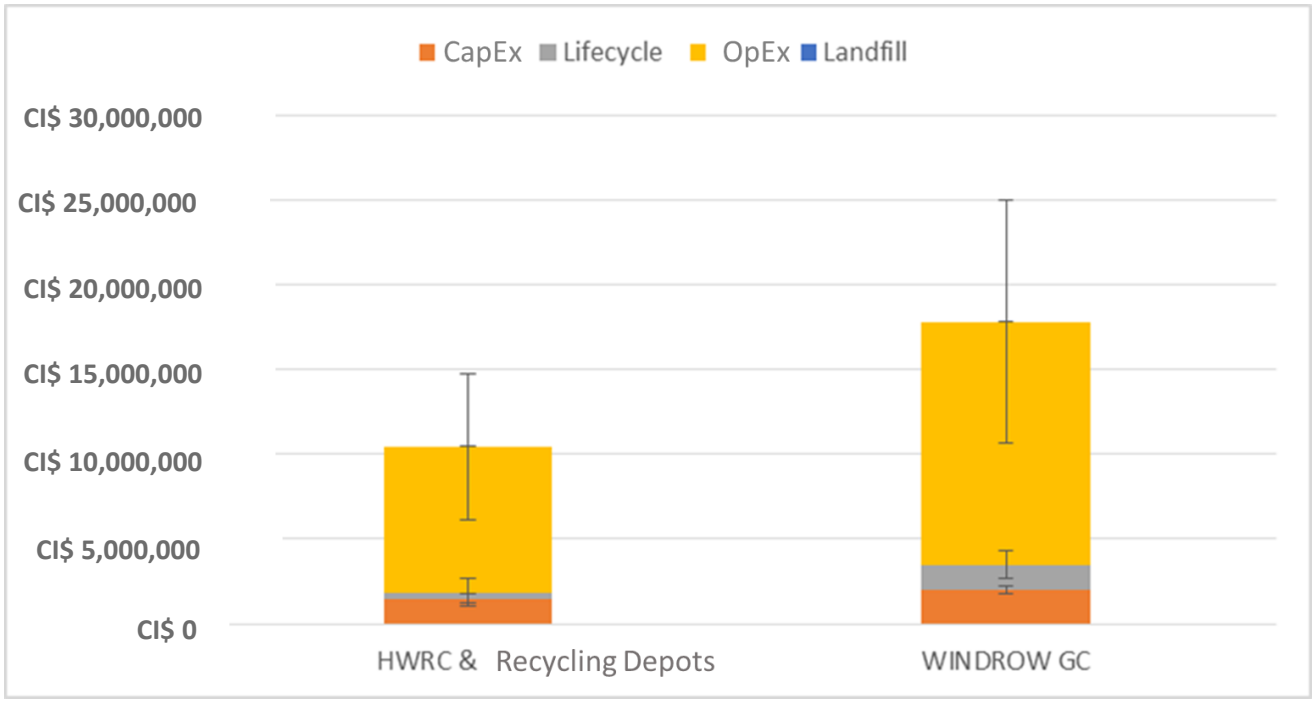


Figure 8.4: Summary of Costs for Other Waste Treatment Facilities That are Part of Reference Project

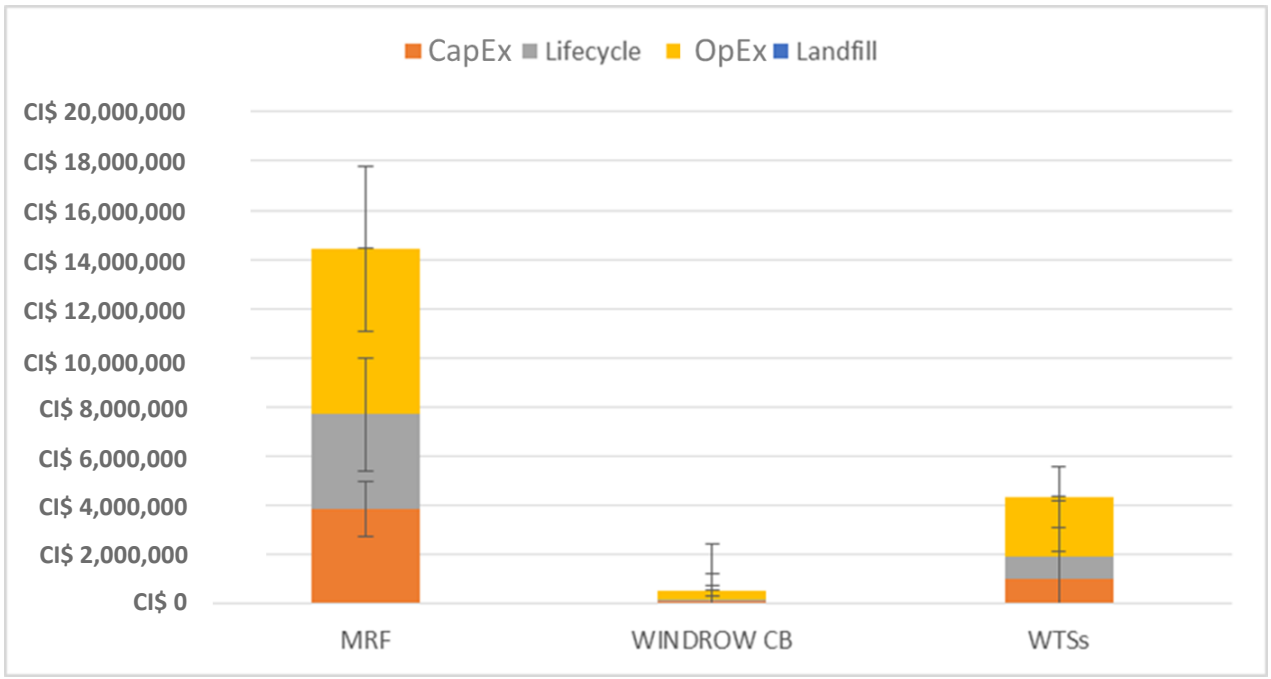
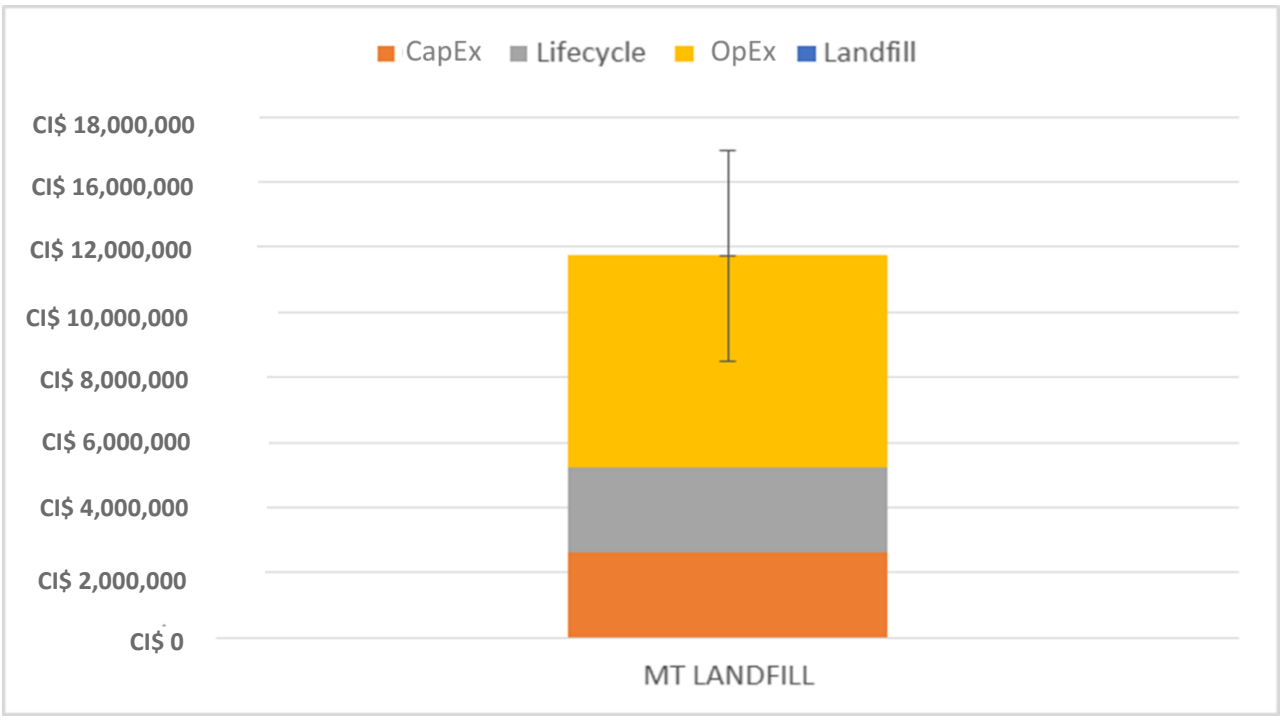


Figure 8.5: Costs of Mechanical Treatment of Mined Landfill Waste



The smaller facilities are generally cheaper due to lower throughput, despite having higher CI$/US ton costs. The operating costs are high as they occur each year for the life of the facility.

Total costs are summarised in Table 8.4.

Table 8.4: Reference Project Costs ($CI)

	CapEx	Lifecycle	OpEx	Income	Total
Early introduction elements Grand Cayman HWRC Recycling Depots Windrow on Grand Cayman	CI$ 3,479,957	CI$ 1,865,686	CI$ 22,898,526	-	**CI$ 28,244,169**
Reference Project WtE facility MRF WTS	CI$ 65,151,794	CI$ 9,568,641	CI$ 69,319,601	CI$ -84,213,851	**CI$ 59,826,185**
Landfill					
Landfill Mining MT	CI$ 2,615,941	CI$ 2,615,941	CI$ 6,505,187	-	**CI$ 11,737,069**
Total	**CI$ 71,247,692**	**CI$ 14,050,268**	**CI$ 98,723,314**	**CI$ -84,213,851**	**C$I 99,807,423**

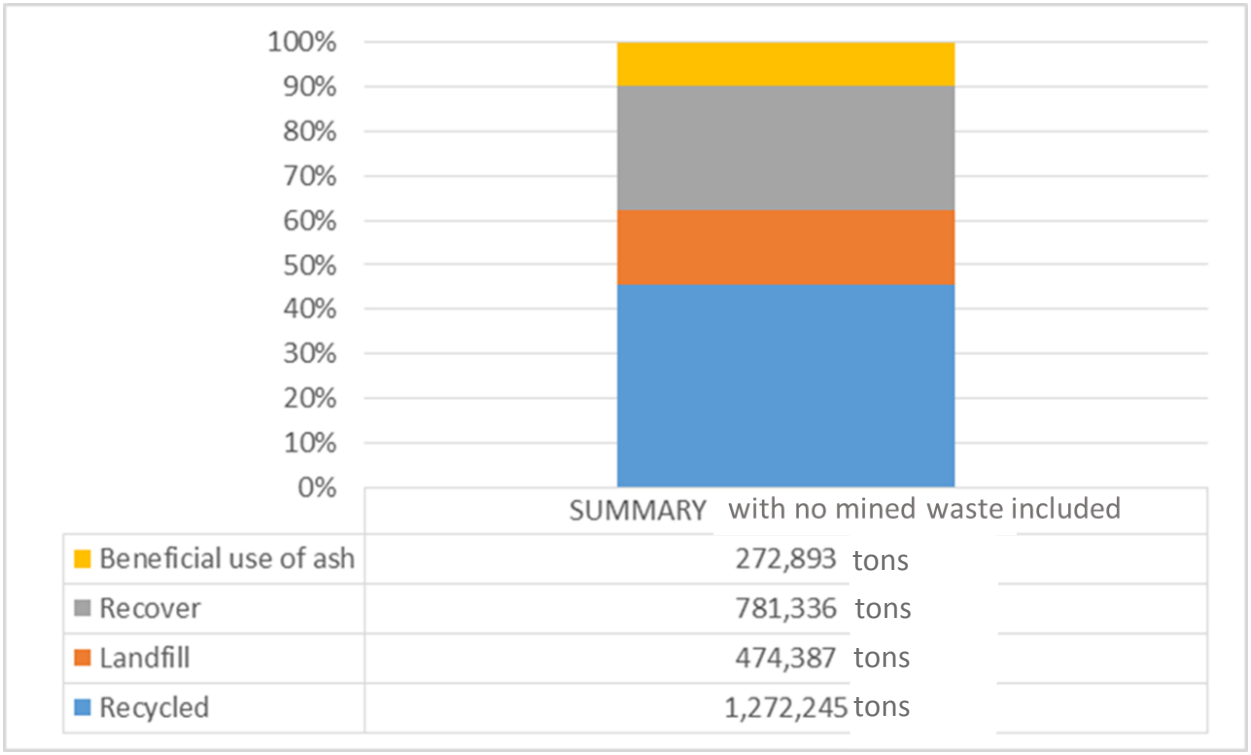
These costs are nominal (i.e. have not been indexed) and no uplift has been added to the UK base costs the estimates are derived from.

These costs currently exclude any cost for sending waste to landfill.

Environmental Performance

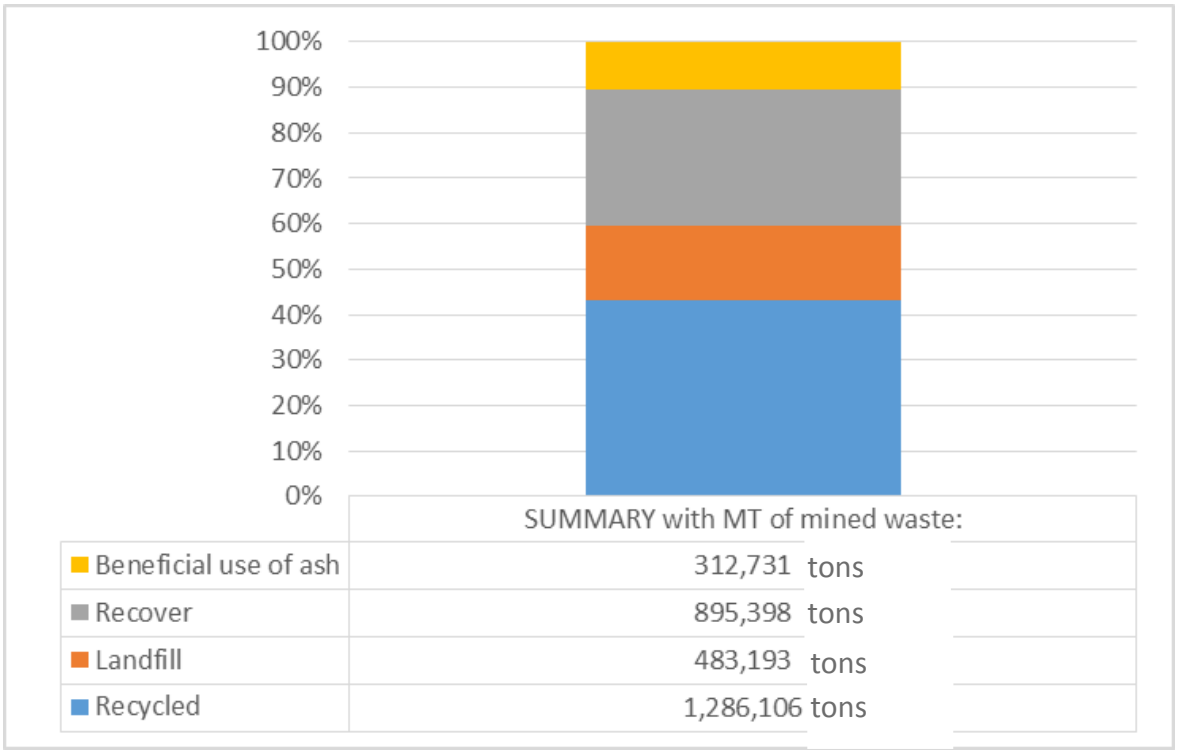
Figure 8.6 below shows the environmental benefit of the reference project excluding the mechanical treatment of mined landfill waste. This covers 28 years period (comprising a 3 year procurement and construction period and a 25 year operational period) from 2016/17 to 2043/44. This therefore covers the time when the HWRC, Recycling Depots and windrow composting on Grand Cayman will be introduced as well as the larger facilities that will be operational from 2019/20. The performance is shown as 100% of all waste tonnages, and views the whole waste lifecycle from cradle to grave looking at waste sent to recovery; as well as any resultant ash being beneficially used or sent to landfill.

Figure 8.6: Environmental Performance of Reference Project Excluding Mechanical Treatment of Mined waste



Similar to Figure 8.6, Figure 8.7 shows the environmental performance, but with the addition of the mechanical treatment of mined landfill waste. This increases the amount of waste being managed but the recycling rate is reduced, as the proportion of waste recycled does not increase linearly with the total increase in waste. The addition of the MT does divert more waste from landfill due to the thermal treatment of the mined and mechanically treated waste. The use of the mined waste in the thermal treatment facility will generate electricity and off-set fossil fuel use. There is also an environmental benefit of remediating the existing landfill site.

Figure 8.7: Environmental Performance of Reference Project Including Mechanical Treatment of Mined Waste



9. Strategy Implementation

This section sets out some of the strategy implementation, contracting and procurement options available to the CIG through which it could deliver the objectives of the waste management strategy and implement the delivery of an integrated waste management solution serving the requirements of the Cayman Islands. The principal advantages and disadvantages of these options are examined and some key practical considerations required to facilitate the delivery of the reference project are identified.

9.1 Package of Services/Works

Several elements of the Reference Project include a potential range of works and services required to implement the NSWMS. These can be packaged and procured in a number of ways. These include:

- Recycling depots siting, delivery and servicing;
- HWRC design, construction and management;
- Waste collection;
- An open windrow composting facility design and build;
- Windrow composting of collected yard waste operations;
- Waste transfer station design and build;
- Waste transfer station operation and haulage;
- MRF design build and operation;
- Residual waste treatment; and
- Landfill disposal.

These works and services can potentially be packaged for procurement in a number of ways. Significant factors in determining the most appropriate package for the CIG will include:

- Delivering value for money;
- The procurement schedule in relation to service requirement deadlines;
- Market interest in the packages; and
- Effective risk management (through good competition and contractual risk transfer).

The range of service to be tendered and the treatment of assets is a fundamental step in determining the most appropriate tendering route and impact on the procurement timetable. A clear decision will be required from the CIG prior to any issue of a Request for Proposal (RFP) notice (see below) concerning the services to be packaged and procured together or separately. This process could be informed through a soft market testing exercise.

In the absence of soft market testing data it is considered that the following should be considered:

- Packaging of early works and services identified in overall delivery schedule to ensure these are not delayed by more complex packages;
- Packaging of several design and build contracts may offer value for money due to the enhanced scale of development and greater degree of works cohesion and co-ordination (e.g. HWRC construction and alteration, transfer station design and build);
- There may be advantages in packaging the operation/service contracts (e.g. for several transfer stations). This may offer greater service cohesion as well value for money due to the enhanced scale of the contracts and reduced management costs; and

- Packaging the combined range of integrated works, services and the financing of these deliverables (this includes a number of defined lots).

9.2 Contracting Options

Table 9.1 outlines some of the principal contracting options available to the CIG. The most appropriate of these for any particular service/works package will depend on several factors. These include:

- The scope of the works/service;
- The availability of existing waste management capacity and infrastructure and its ownership;
- The cost and affordability of the required services and infrastructure; and
- The specified contractual requirements.

Table 9.1: Principal Contracting Options

Contracting Options	Type of Contract	Notes
1	**Service Contract/Agreements**	Projects procured in this way typically make use of existing waste management infrastructure to provide a service to the Local Authority. In return for the service the Authority will pay a monthly sum or a gate fee per tonne. The Authority would set out in detail the specification for service to be delivered by the contractor. An example of this arrangement currently used by Cheshire East Council is the mixed dry recyclate off take carried out under contract by United Paper Mills.
2	**Design and Build (DB)**	This option involves the construction of facilities as capital projects usually procured under Public Works Contracts. As such the Authority would finance the capital project from internal budgets/reserves or through prudential borrowing. The Authority will define the specification for the required works and contract directly with a construction company or engineering, procurement and construction (EPC) contractor for the delivery of the works. The Authority may then operate the facilities or source a separate operational contractor.
3	**Design Build Finance and Operate (DBFO)**	This option involves projects where the contractor is required by the Authority to finance the capital investment required to facilitate all works needed to deliver the services. This may be done on balance sheet or through project finance and appropriate bank loans. The Authority will set out outline service requirements and the contractor (normally a waste management contractor) will design and build facilities required to deliver the service requirement. The contractor will then operate the facilities and provide the relevant services to the Authority, for which the Authority will pay a monthly sum or gate fee. Due to the period required for the payback of capital investment, DBFO contracts may typically have periods of between 15 and 30 years (depending on the scale of the capital investment).
4	**Public Private Partnering**	This option involves the selection of contractor who will be required to deliver service requirements that are likely to change and evolve with time. The Authority, in selecting such an approach, primarily seeks to identify the contractor who it considers it can work with most effectively to deliver such changes without re-sought to further procurement. Such contracts are often based on DBFO type contract documentation, augmented by appropriate controls over contract variations to ensure value for money is maintained (e.g. open book accounting, agreed profit levels, service benchmarking etc.).

Contracting Options	Type of Contract	Notes
5	**Hybrid/Refinanced**	Several recent waste management procurements have been agreed on a conventional DBFO approach but with planned refinancing (e.g. using prudential borrowing) of the capital element of the project at planned point in time. This has typically planned for Service Commencement following the construction and commissioning of the relevant facilities. This approach offers the potential to provide overall cost efficiencies by reducing the cost of borrowing capital improved allocation of risk and enhanced operational flexibility.

Note variants of these primary options have been employed elsewhere e.g. design build and operate (DBO).

9.3 Funding and Financing Options

Funding – which is critical to the financing solution – refers to determining the means by which the providers of capital will be repaid, through user fees, government budgeting allocations or other revenue models. Although waste collection and disposal fees are the prime source of funding for waste management companies, these organizations have the ability to generate funding from a variety of other sources. In the following overview, funding mechanisms have been divided into the following categories:

- Direct charges;
- Indirect charges; and
- Revenues from waste treatment.

Direct Charges

Direct charges include all revenue generated for the activities involved in the waste removal and disposal process. Direct user charges act as incentives to reduce waste generation while providing a revenue source for the waste management entity(ies). Direct charges can be considered to follow the polluter / generator pays concept as the party responsible for producing the waste ultimately bears the cost for the proper disposal of the waste.

Normal Waste Collection fee

Waste management basic user charges include collection and disposal fees charged to residences and commercial enterprises. Waste collection fees are the charges levied for the pick-up and disposal of waste. Generally, fees would vary based on the type of client (residential, commercial or industrial), amount of waste collected or size of waste bin (small, medium, large or, extra-large), frequency of waste collection and/or the type of waste collected. Normally, general waste collection fees are an ongoing contractual arrangement between the waste management company and the generator of the waste. Fees are remitted to the waste management company on a monthly or annual basis.

Pay As You Throw (PAYT)

The PAYT model is a type of waste collection fee used by some waste management companies. Under this model, waste is measured by weight or size while units are identified using different types of bags, tags or containers.

There are three main types of PAYT programs:

1. Full Unit Pricing

Under the full unit pricing model users pay in advance for all the garbage they want collected by purchasing a tag, custom bag, or selected size container.

2. Partial Unit Pricing

With partial unit pricing the local authority or municipality decides the maximum number of bags or containers of garbage available to users and uses taxes to pay for these collections. Additional bags or containers can be purchased in cases where the user exceeds the permitted number. Similarly, waste management companies can provide garbage containers at a base cost and charge users for additional bags or containers.

3. Variable Rate Pricing

Waste management companies provide disposal bins on an ongoing basis or for short term usage. Variable rate pricing allows waste management companies to rent containers of varying sizes with the price corresponding to the amount of waste generated.

Special Waste Collection Fee

Special waste is garbage that requires special handling and disposal in order to prevent contamination. Waste disposal companies provide special waste collection and disposal services for a fee according to the type and amount of special waste presented for disposal. Special waste includes the following:

- Asbestos containing materials;
- Defective food items;
- International waste from ships and aircrafts;
- Pharmaceutical waste;
- Biomedical waste;
- Used tyres; and
- Offal (poultry waste).

Gate Fee / Tipping Fee

As an alternative to garbage collection, individuals and businesses can opt to drop off their waste at disposal sites or transfer stations. A gate fee or tipping fee is the charge levied by the waste disposal company for the receipt of a given quantity of waste. Gate fees are generally charged per load / ton or are based on the source and type of the waste. Typically, a minimum gate fee applies for the receipt of waste.

Waste to Energy Gate Fee

Waste to Energy (WtE) is waste recovery method in which solid waste is burned at high controlled temperatures so as to convert it to residue which helps reduce its volume and produce energy. Waste management companies charge a fee to provide this service. WtE gate fees are normally levied based on the amount and type of waste being presented for treatment.

Recycling Fee

Recycling is the process of collecting, sorting, assembling, transporting and converting waste products into new usable products. Recycling is a key component of an ISWMS and can help to reduce pollution (air and water), reduce volume of waste in landfills, lower greenhouse gas emissions and reduce typical energy usage. Recycling centers charge varying fees depending on the type of item being recycled. Recycling plants typically accept the following list of items for recycling:

- Ferrous and non-ferrous metals;
- Plastics;
- Paper and cardboard; and
- Glass.

Surcharges

A surcharge is an add-on fee and represents a charge over the basic disposal fee amount. Surcharges can be applied to disposal bills for a variety of reasons including charges for items in excess of the minimum quantity, charges for special items or charges for fuel usage (an indirect charge) to collect waste. Items for which a surcharge is levied vary from country to country but can include yard waste, food waste, hazardous waste and recyclables. Fuel surcharges can be incorporated into the standard waste collection fees and are sometimes tied directly to some fuel index.

Indirect Charges

Indirect charges provide revenue generated from services that are not directly linked to the garbage disposal or collection process. Many Caribbean countries do not have explicit garbage collection fees for households. Instead, costs are indirectly covered through the collection of government taxes which often are not waste specific. The main indirect funding mechanisms are summarized below.

Taxes

Government legislation can require taxes or a levy to be added to a general waste disposal fee charged by the waste management company. This fee, charged by the government, may or may not reflect the costs for provision of a service rendered or goods. An example is an environmental tax which can be implemented as a means of discouraging acts that are not environmentally responsible. This fee is usually collected at the landfill facility or can be incorporated into the collection fee bill. On the other hand, the government can mandate that a waste collection and disposal tax be levied as opposed or in addition to billing general waste disposal fees.

Tariffs

A variation of a tax system is the implementation of a tariff. Waste disposal fees can be included in utility services bill as a tariff. This concept is based on the assumption that the amount of utilities consumed by each household or organization positively correlates with the amount of waste generated. Businesses and larger or more affluent households are expected to consume more utilities and also generate more solid waste. The tariff for the waste collection is typically linked to water or power usage.

Revenue From Waste Treatment

Solid waste management companies can generate additional revenue by converting the waste collected from consumers to usable products which can be sold; thereby providing tangible returns from the collection and treatment of solid waste. The below outlines two of the main ways that waste management companies access other revenue streams as a result of waste treatment.

Composting

The aerobic conversion of waste materials into soil additives is called composting. Compost can be created by using biodegradable organic materials from households and businesses. Composting promotes sustainable agriculture and is commonly sold as an organic soil amendment.

Waste to Energy

Waste to Energy is quickly becoming a widely recognized source for energy. The process involves converting non-recyclable waste items into useable heat, electricity, or fuel through a variety of processes. Thermal treatment in conventional waste combustion plants the most common source of WtE however, a number of other technologies have emerged such as gasification and anaerobic digestion. A listing of common energy products derived from waste are detailed below.

- Electricity - steam raised from the combustion of waste can used to drive turbines and produce electricity that can either be supplied in to a national grid network or by direct wire to particular market off take; and

- Heat – low pressure steam from the combustion of waste can take off at valve beyond the turbine to be used to supply heat to applications such as a refrigeration plant and desalination facilities. The take-off of the heat will however result in a reduced electrical generation efficiency for the waste to energy plant.

Financing Mechanisms

On the high side, estimated capital expenditure for each of the highest cost shortlisted options is over CI$70 million. There are several options for delivery and financing:

- Self-financing ("equity") – The government / sponsoring authority uses recurrent revenue and/or cash reserves under a traditional procurement delivery model whereby the public sector is responsible for the capital and operating costs of a project, bearing both construction and operational risk. Public sector revenue or reserves may be sourced from general funds or from specific waste / environmental charges (such as duty on imported goods).

  It is understood that this option would not be attractive to the CIG, primarily because the CIG would be required to allocate significant funds upfront to underwrite the Project's capital costs.

- Debt – The sponsoring authority uses borrowings such as bank debt or bonds to finance a project under a traditional procurement delivery model as described above. The debt may be undertaken at a central government or sponsoring authority level or issued under a project financing structure whereby the project is ring-fenced from the authority/government. In any case, the government/authority would typically need to contribute a minimum level of equity.

  Even if the Project were ring-fenced with no recourse to the CIG and with debt service payment supported by third party user fees, this may not be a viable option given that it is in conflict with the CIG's stated objective in its 2015/16 Strategic Policy Statement not to undertake any new borrowings for the forecast period (which runs through fiscal year 2017/18). However, the Project is assumed to commence outside this timeframe so with the country's improving fiscal situation, the CIG may be willing to consider some debt funding.

- Public Private Partnership (PPP)– There is no single definition of a PPP, but it is generally considered to be an arrangement, usually long term, between a government/authority and a private entity to provide a service that would traditionally be provided by the public sector. PPPs contribute private sector resources (capital and expertise) to projects while allocating risks (such as construction, financing, demand/revenue, operational and maintenance expenses) between the government and private party in varying degrees, depending on the form of PPP.

- Two commonly used PPP structures are:

1. Build-Operate-Transfer ("BOT")

   The private sector builds, designs and operates an asset for the life of the contract and hands control back to the public sector at the end

   The public sector finances construction of the asset and retains ownership as well as ultimate responsibility for the provision of the public service

   Build-Transfer-Operate ("BTO") is a variation of BOT whereby the private sector hands control of the asset over to the public sector at completion of construction, rather than at the end of the contract.

   A BOT model (and its derivations) would require the CIG to finance capital costs itself. As previously noted, such a structure would not be a suitable option as it is not in line with the CIG's debt management objectives or would require self-financing.

2. Build-Own-Operate-Transfer ("BOOT") / Design-Build-Finance-Maintain-Operate ("DBFMO")

   The private sector designs, finances, builds, operates and maintains an asset which it owns for the life of the contract after which it hands control and ownership to the public sector.

While the public sector retains ultimate responsibility for the provision of the public service, it does not finance construction of the asset nor does it own the asset until expiration of the contract.

A BOOT or DBFMO model (and the derivations) is more aligned to the CIG's goal of achieving cost neutrality. Depending on the final whole life costing and delivery model selected, funding contributions by the CIG can be limited to a predetermined annual budget allocation supplemented by funding contributions from user fees and other revenues as discussed in the Funding Mechanism section.

If the CIG was to convert its existing annual budgetary allocation for the DEH to a PPP/project finance payment, it is estimated that this could support a debt size of approximately CI$ 23.7 million, based on assumed financing parameters. Including the existing third party revenue could size the debt at an estimated CI$ 49.3 million.

The list of PPP models provided above is not exhaustive as there are other variations to these structures. In addition there are also lease/concession/management contract models under which the government retains ownership of an asset but bears responsibility for its design, build and financing, which may not be suitable for the CIG.

9.4 The Procurement Process

The Tender Process

Procurement Process Administration

The procurement process will require careful administration with the timely delivery of information and the reply to questions and queries. In addition, there are likely to be requirements for interviews, dialogue and meetings with potential contractors and potentially site visits to be organised and fairly administered. The clarification of some issues may require input from technical, financial and legal specialists and this will have to be efficiently administered to ensure that a response can be given.

Request for Proposals (RFP)

The issuing of a RFP is often the first formal step in the tender process. It is essential that the information given in the RFP is correct as errors can potentially undermine the remainder of the procurement exercise and could lead to an award of contract being challenged.

Tender Submission

The tender process under the competitive dialogue process can comprise a number of discrete phases designed to optimise effort and resources, identify and focus on the best proposed solutions and enable the progressive short listing of companies. Key stages can include:

- Invitation to Submit Outline Solutions (ISOSs);
- Invitation to Submit Detailed Solutions (ISDS); and
- Final Tender.

Each of these elements requires the issue of appropriate documentation and instructions by the Authority.

Tender Documentation

The contract documentation will need to be developed and agreed to prior to the issue of an invitation to tender and must be supplied either with the invitation or soon after their request from potential service providers. Draft documents will need to undergo technical and legal review by the CIG prior to their endorsement and authorisation for issue.

The contract documents will normally include:

- Introduction and Context;
- Background Information;
- Instruction to Tenderers;
- Administrative Forms;
- Project Agreement or Conditions of Contract;
- Technical and Performance Specifications;
- Pricing Schedules & Bid Forms;
- Payment Mechanism;
- Evaluation Criteria; and
- Risk Allocation Matrix.

Clarification of Queries and/or Pre Tender Submission Meeting

There is likely to be a series of queries and questions posed by potential service providers prior to the submission of their tenders. The CIG will be expected to deal with these promptly and fairly.

Return of Tenders

The date for the return of tenders must be specified in the documents issued with the invitation to tender. The receipt of tenders and official opening of these documents will need to comply with standing orders set by the CIG.

Tender Evaluation Process

It is of extreme importance that the evaluation of tenders adheres to the pre-defined selection criteria and is conducted in a fair and even manner. This requires the development and sign off of a completed evaluation system prior to the receipt of completed tender documents. Best practice is to provide the evaluation methodology as early as possible, and ideally with the invitation to tender. Amec Foster Wheeler recommends that the method and personnel to be used in tender evaluation process is established before the invitation to tender is issued and that the administration of this activity ensures that the evaluation is both open and auditable.

9.5 Affordability and Risk

One key objective of the NSWMS is that it be cost neutral for the CIG. The funding gap is calculated as the difference between the total revenue generated by the CIG budgetary contributions as well as current third party payments and the total capital, operating and lifecycle (maintenance and replacement) costs. That is to say, the funding gap represents the quantum of new revenue that must be generated to make an option affordable.

As discussed in the financing mechanisms section above the capital expenditures are likely to be financed through a PPP structure. Based on KPMGs experience, illustrative financing terms are assumed to be:

- 75% debt – 7.0% annual interest rate, quarterly amortizing payment, 25-year term with interest accruing through the end of the 2-year construction period and fully amortizing on the original principal plus accrued interest over the remaining 23 year period; and
- 25% equity – 13.0% required return on investment with annual dividend payments beginning when operations commence.

Ultimately financing terms will be based on factors included, but not limited to, the sovereign credit rating, level of collateral provided, underlying funding mechanism and amortization schedule.

Total capital expenditure during the planning and construction period fiscal year 2018/19, as well as total lifecycle (periodic refurbishment) costs and operating expenses from fiscal year 2019/20 to fiscal year 2043/44, are summarized for each option in the following Table 9.2:

Table 9.2: Short Listed Option Costs (over 25 years)

Shortlist Options (CI$k) – costs over 25 years (2019/20 – 2043/44)

Option	CapEx	Lifecycle	OpEx
A	CI$ 23,771k	CI$ 21,004k	CI$ 133,749k
B	CI$ 71,752k	CI$ 31,750k	CI$ 77,808k
C	CI$ 80,758k	CI$ 43,353k	CI$ 109,607k
D	CI$ 73,878k	CI$ 14,274k	CI$ 110,322k

A Waste Transfer Station (WTS) has been modelled for each of the three islands. The majority of the waste collected on Cayman Brac and Little Cayman is assumed to be transferred to Grand Cayman for treatment either on- or off-island. The WTS on Grand Cayman would be used for the bulking of recyclables and waste requiring export. The baseline waste flow model prepared by Amec Foster wheeler considers a waste reuse rate of 0.5% and a waste minimization rate of 1.0% from 2019 onwards. A medium growth rate of 3.0% annually has been applied to waste growth per capita. The planning and construction phase is expected to take place in fiscal year 2018/19, with operations starting in fiscal year 2019/20.

Table 9.3: WTS Overview (CI$/t of Capacity)

WTA Overview

Option	OpEx	Lifecycle costs	Total new cost
Grand Cayman	CI$ 90	CI$ 28	CI$ 217
Cayman Brac	CI$ 6	CI$ 2	CI$ 12
Little Cayman	CI$ 47	CI$ 20	CI$ 119
Total	**CI$ 143**	**CI$ 50**	**CI$ 348**

Funding Gap

Based on information provided by Amec Foster Wheeler and the CIG, KPMG have analysed the average annual funding gap for each option as the annual average of total new costs, being the sum of:

- OpEx;
- Lifecycle costs (periodic refurbishment);
- Financing costs (returns to capital providers for initial CapEx); and
- WTS costs (operating and lifecycle).

Separate costs for waste collection/disposal versus the landfills were not available and have been excluded from the analysis. In Table 9.4 the funding gap of each option has been assessed:

Table 9.4: Annual Average Funding (CI$k)

Annual average funding gap (CI$k)

Option	OpEx	Lifecycle costs	Financing cost	WTS costs	Total new costs	WtE revenue	Net funding gap
A	CI$ 5,350	CI$ 840	CI$ 2,507	CI$ 348	**CI$ 9,046**	CI$ 0	**CI$ 9,046**
B	CI$ 3,112	CI$ 1,270	CI$ 7,316	CI$ 348	**CI$ 12,047**	CI$ 3,221	**CI$ 8,826**
C	CI$ 4,384	CI$ 1,734	CI$ 8,519	CI$ 348	**CI$ 14,985**	CI$ 2,263	**CI$ 12,722**
D	CI$ 4,413	CI$ 571	CI$ 7,793	CI$ 348	**CI$ 13,244**	CI$ 3,244	**CI$ 9,881**

The funding gap is reduced by revenue from energy generation, which results in relatively similar net funding gaps for options A, B and D, with option C remaining significantly higher.

10. Conclusions and Recommendations

10.1 Conclusions

Landfill Remediation and Restoration Options

This section on landfill remediation and restoration options considers the findings of the Task 2 Environmental Investigations Interpretative Report July 2015 and observations made during visits to the three landfill sites on Grand Cayman, Cayman Brac and Little Cayman.

Based on the site visits undertaken as part of environmental investigations in November 2014 and April 2015 Amec Foster Wheeler made observations which addressed a number of current waste management issues and operational practices and suggested recommendations for improvement or further assessment as appropriate. Some of the more strategic recommendations include:

- Measures that can be implemented in the short to medium term to enhance waste reduction, re-use and recycling;
- Improved segregation of waste with, for example, yard (green) and wood waste diverted from the George Town landfill;
- Preventing further expansion of the burning area at Little Cayman landfill;
- Removal of stockpiled waste tyres at all the sites;
- Removal of stockpiled metal at all the sites;
- Removal of used batteries and drummed wastes at Little Cayman landfill;
- The construction of contained waste oil facilities at the Cayman Brac and Little Cayman landfill sites;
- A feasibility study to examine the potential for landfill mining at George Town landfill; and
- A feasibility study for landfill gas extraction and potential power generation at the George Town landfill site.

The continued operation of the landfill sites up to the time of ultimate closure will have a bearing on the types and quantities of waste to be landfilled in the interim and this will have some influence on the landfill restoration proposals.

10.2 Initial Options for Future Landfill Remediation and Restoration

George Town Landfill

The George Town landfill site is expected to continue to be in operation while the new Integrated Solid Waste Management System is developed and implemented through the procurement and construction of alternative waste management facilities. During this time the footprint of the site will continue to expand (refer to Figure 3.15). The site does not have any basal containment and no areas have been capped or formally restored to date. The old landfill area in the south east has naturally re-vegetated. The remaining areas have waste at surface with a thin soil cover in the west. The site is generating landfill gas which is dispersing into the atmosphere. The wastes are prone to leaching with an associated impact on groundwater and surface water quality. The remaining capacity at the site is in the west, over an area underlain by waste derived from Hurricane Ivan, which contains piles of scrap metal and tyres.

The principal issues relating to landfill closure and restoration are summarised in the following sections.

Landfill Gas Management

George Town landfill is generating landfill gas which is currently dispersing from the waste surface into the atmosphere. There is the potential to collect and recover the landfill gas for combustion in a gas engine to produce electricity and a feasibility study is recommended. The main issues in terms of landfill gas recovery and utilisation include:

- That the site is uncapped, which makes it more difficult to recover the gas. The potential for fires on and within the site is also exacerbated by the site being uncapped and progressive capping would improve gas collection efficiency and reduce the potential for fires;
- A gas pumping trial would give some indication as to the capacity of the potential gas resource and how effective this might be to recover the gas without and with a capping system in place;
- The site will continue to expand over the next few years which will increase the overall gas resource; and
- It is recommended that initial consultation should take place on the requirements and potential cost for provision of an electricity export connection.

The feasibility study on landfill gas should include a cost benefit analysis. There is the potential for revenues from landfill gas utilisation to offset some of the capping and restoration costs, as well as reducing greenhouse gas emissions.

Landfill Mining

There is potential for mining some of the wastes from the George Town landfill, which could be a potential feedstock if processed for a WtE solution. More recent wastes disposed of at the George Town site appear contain a considerable percentage of plastics, cardboard and wood, but the challenge would be in the separation of these materials from other wastes such as metal and stones to generate a product suitable for inclusion within a WtE option. Operators of such plants have specific requirements for the quality of the waste inputs and these input criteria underpin the process guarantees provided by the technology supplier.

If landfill mining is potentially feasible then this could greatly reduce the volume of waste within the site. The downside is that the likely low input rates into a WtE or similar plant would mean the mining would take place over many years with a consequential delay in final capping and restoration. Furthermore, the mining process could in itself result in adverse environmental impacts such as the release of odours, gas and leachate and these would need also need to be considered in detail. It should also be noted that the quality of the combustible fraction (e.g. wood and cardboard) will also reduce with time as a result of on-going biodegradation within the landfill, so these materials become less attractive and viable as a fuel with time. As such it is only the more recent wastes (and wastes which will be placed between now and landfill closure) that are potentially suitable for recovery.

It is recommended that the feasibility of recovering some of the existing waste and it's suitability as potential fuel is examined. This could be undertaken by trial excavation in different parts of the waste mass and then manually and mechanically segregating the recovered material into different waste fractions, weighing these and obtaining samples for analysis.

Landfill Capping

The George Town landfill (possibly with the exception of the old landfill area) will require capping with a low permeability cover system to limit rainfall infiltration and leaching and also to reduce landfill gas emissions. It would also promote gas recovery and utilisation. Various forms of artificial sealing systems are available for use in capping such as polyethylene geomembranes and geosynthetic clay liners (GCL's). The latter is considered most appropriate as it is less combustible, considering the historical problems with fires in the waste mass within the landfill.

The sealing layer will need some soil cover to protect the layer and provide a media for the establishment of vegetation. The final restoration will need to be designed so that it is suitable for the proposed end use of the site and whether this will have some form of public access (such as a park). There are no soil materials available within the landfill site and a general scarcity of soil materials on Grand Cayman.

Compost generated from diversion and treatment of yard (garden) waste is a potential source of soil, but this would meet only a small part of the demand for restoration soils. Alternative sources of materials should therefore be considered and some of the strategic development projects under consideration on Grand Cayman such as the cruise ship berthing and airport expansion could generate suitable materials and offer mutual benefit in terms of providing a disposal route for excess soil. These potential opportunities should be explored.

A staged approach to the capping and restoration of the main landfill area is recommended. Waste disposal is complete to the eastern and northern flanks of the main landfill which could be restored first and landscaped to reduce the overall visual impact of the site. These flanks generally contain older waste which has less potential for recovery as part of any landfill mining initiative. Capping could then be extended from the eastern and northern flanks into the centre of the site. The programme for the capping works will need to consider:

- Availability of funding for the works;
- The final height of the site (i.e. will the existing high point require lowering and some re-profiling undertaken);
- The availability of restoration soils;
- Drivers in terms of any significant deterioration in environmental impact (i.e. groundwater and surface water quality);
- Co-ordination with landfill gas management/recovery; and
- Integration with any landfill mining/recovery operation.

Capping of the old landfill area in the south east of the site is an option but is of a lesser priority. The following factors require weighting in consideration of the overall benefit in capping this area:

- This area is filled to a lower height than the main landfill area and is generally well vegetated, it therefore has a much lower visual impact than the main landfill area;
- The wastes are older and in the lower levels will contain ash from historical waste burning activities, as such they are unlikely to be suitable for beneficial recovery;
- Landfill gas recovery from this area is expected to be marginal, but should be assessed based on the proposed landfill gas trial on the wider site;
- Without capping and gas recovery this part of the site will still release landfill gas into the atmosphere, but to a much lesser degree than the main site area;
- As the wastes are older the leaching potential and associated impact on groundwater and surface water is expected to be less than the main landfill area;
- This part of the site is further away from the adjacent residential receptors compared to the main landfill area, and
- Depending on the intended final site use, without formal engineered capping this part of the site would not be suitable for public access.

Landfill Capacity and Residual Waste Management

The Cabinet Policy Guidance within the Strategic Outline Case for the ISWMS (April 2014) states that there shall be no investigation of alternative landfill sites. The George Town landfill site is therefore a resource for the management of any residual waste which cannot be reduced, re-used, recycled or recovered. An initial capacity study has been undertaken to determine the area of land available at the projected landfill closure, which corresponds to the commencement of an alternative waste management solution arising from the NSWMS. Figure 3.15 shows the landfill footprint, based on the July 2015 survey, and based on the projected volumetric inputs the expansion of the landfill footprint on a year by year basis.

The following assumptions have been made in the modelling of the landfill expansion:

- Waste input into the landfill disposal area in 2015 will be 70,400 tons with an annual increase of 3% thereafter;
- Filling will continue to the west in a series of strips constrained to the south by the arsenic waste containment cell which will not be disturbed or overfilled;
- The current stockpiles of scrap metal and tyres in the expansion area will be progressively removed down to surrounding ground level;
- Wastes in the expansion area will be placed directly on the existing ground surface with no re-profiling or construction of containment; and
- The top of the waste will fall gently from the current western edge level of 50.8 ft to 43.4 ft for the July 2020 landform in order to provide drainage from a future capping system to the site edge (note the final site level would be slightly higher as restoration soils would need to be placed above the engineered cap).

The modelling gives an indication of the remaining land in the west of the site which could be used for other waste activities and/or creation of an engineered containment cell for residual waste. By July of 2020 the modelling predicts that the landfill will have extended to within approximately 200ft to 260ft (60m to 80m) from the western site boundary.

Expansion of the landfill to the west is not particularly desirable as it moves the waste disposal area closer to the adjacent residential receptors in the Lakeside area. The associated environmental impacts (noise, dust, odour and visual) need to be considered. Odour is expected to be one of the key issues and could be, in part, mitigated by early establishment of a landfill gas management system and improved site management (e.g. the application of cover material). However, the landfill is not the only source of odour in the area and other adjacent facilities (e.g. the existing waste water treatment ponds) are also contributory to local odour.

It is noted the expansion and remaining land is all underlain by fills comprising Hurricane Ivan waste which extend below the water table. This would make the construction of any future waste containment cell difficult even if there was a sufficient footprint available. Such ground conditions are also a potential constraint to the development of buildings associated with any alternative waste management operation. The Hurricane Ivan waste would require removal and replacement with compacted engineering fill to facilitate building construction and the materials balance for such an operation would need to be considered.

Most alternative waste management systems continue to generate some form of residual waste (e.g. fly ash or air pollution control residues from waste to energy plant or bulky wastes from refuse derived fuel processes), which will still require management by landfilling. Management of such wastes would need to be in a fully engineered and contained cell and this land requirement needs to be balanced with demands for other waste treatment processes at the site. Provision for management of wastes arising from any future damaging hurricane event also requires consideration. Optimisation of the remaining land within the site is therefore a key management issue.

Cayman Brac Landfill

There are considerable accumulations of stockpiled derelict vehicles and bulky waste at the Cayman Brac. landfill. It is recommended these stockpiled wastes are re-packaged, removed from site and dispatched to Grand Cayman for further treatment and disposal.

The Cayman Brac landfill occupies a relatively small footprint and there is capacity in the medium term to continue landfill operations until alternative facilities are made available. In the long term there is an option to close the site with existing waste generated on the island separated for recycling, where feasible, and the residual waste transferred to Grand Cayman for treatment within a future waste management system. Some form of locally beneficial waste treatment such as the composting of yard and landscaping waste should be considered on the existing site with appropriate operational controls and management. The site has sufficient land area, either side of the access road, to be developed as a waste reception, transfer and recycling facility for the island; however this may be more efficiently sited at the location adjacent to the existing barge landing.

The landfill has a relatively low environmental impact and as such a “soil only” capping of the existing wastes may be an appropriate risk based outcome, without the need for an artificial sealing layer. The site is not expected to produce sufficient landfill gas for commercial recovery and as such passive venting of the gas through a soil cap is likely to be an acceptable solution.

In terms of restoration material there is a nearby quarry that could be used to supply crushed limestone and marl to cover the wastes, with site composted yard/green waste used to provide a final cover layer for the establishment of vegetation. The existing onsite green waste area could be excavated, screened and shredded to provide part of the final soil cover and in so doing relocate some of this material away from the Shrimp Pond.

Little Cayman Landfill

There is considerable accumulation of stockpiled derelict vehicles, batteries, bulky waste and drummed wastes at Little Cayman landfill. In some cases the drums are leaking or distorted under pressure and present a potential hazard to people accessing the site. It is recommended these stockpiled wastes are carefully re-packaged, removed from site and dispatched to Grand Cayman for further treatment and disposal. In the case of the drummed waste; this operation should be subject to careful planning with appropriate health and safety assessments and the operation carried under careful and professional supervision.

Residual and yard wastes on Little Cayman are currently managed by open burning. This practice is undesirable and there is the potential for the municipal and commercial waste (associated with the tourist trade) to be recycled and the residual waste transferred to Grand Cayman. Yard waste could be composted in a controlled way on the existing site although this may be more efficiently and effectively managed by transferring this waste to Grand Cayman or Cayman Brac for treatment.

On cessation of burning the site is anticipated to naturally regenerate and restoration requirements should be minimal and could include application of a layer of composted material.

There is sufficient land at the site to enable the development of a waste reception, transfer and recycling facility for the island; however this may be more efficiently sited at location adjacent to the existing barge landing.

10.3 Promoting the Waste Hierarchy and Delivering Policy

In developing this solid waste management strategy the CIG has developed the vision, values and strategic directions set out in the NSWMP and tested a variety of waste management options against them. In doing so it sought to identify those options that are most compatible with the policies:

- Will deliver best value to residents of the Cayman Islands;
- Deliver sustainable waste management practices;
- Provide social benefit to local community; and
- Promote movement up the waste hierarchy.

The waste management hierarchy is at the heart of the modern approach to managing solid waste. The hierarchy firstly focuses on waste reduction, and then examines each subsequent option before disposal is finally considered.

Figure 10.1: The Waste Hierarchy

- Reduction — Using less material in design and manufacture; keeping products for longer and using less hazardous materials;
- Re-use — Checking, cleaning, repairing, refurbishing, repair, whole items or spare parts;
- Recycling — Turning waste into a new substance or product. Includes composting if it meets quality protocols;
- Recovery — Energy is recovered from waste through a variety of methods such as thermal treatment and digestion; and
- Disposal — Landfill.

In developing this solid waste management strategy for the Cayman Islands; and the NSWMP the CIG aims to promote the waste hierarchy. Furthermore, it aims to do this in a way that promotes sustainability, the use of waste as a resource and enhances the amenity of the Cayman Islands to the material benefit of its residents.

Waste Reduction and Re-use

Waste can be reduced by both business and the general public by thinking about what we need and buy. For example, residents can reduce waste by using cotton shopping bags instead of plastic shopping bags and avoiding over-packaged products where possible. The CIG is committed deliver measures that help reduce the amount of waste produced within the Cayman Islands and this is enshrined within the NSWMP.

Re-using waste helps to reduce the impact that waste management has on the environment. This can be as simple as passing things we no longer need on to other people to use, for example by giving items to friends or charity shops.

The CIG will promote waste education and awareness initiatives, prevention measures and re-use activities. In particular the CIG seeks to work closely with local third sector organisations to promote the reuse of bulky waste for the benefit the local community. Key activities may include*:*

Promotional Activities

- Periodic resident leaflets – reinforcing the waste hierarchy;
- Newspaper, radio and television adverts and interviews;
- National competitions and awards;
- Advertising panels promoting the waste hierarchy and initiatives on refuse collection vehicles;

- Facebook and similar social media vehicles;
- Dedicated campaigns (e.g. reduce food waste); and
- The establishment of community and third sector waste re-use groups.

Waste Reduction and Education Activity

- The consideration of restrictions on the use of certain materials such as plastic shopping bags;
- School waste awareness education initiatives;
- Community events and shows;
- Waste reduction volunteers;
- Junior recycling officers; and
- Potential visitor centre at the new waste management facility.

Further examples and case studies of waste reduction and reuse schemes are provided in Appendix E.

Recycling and Composting

Recycling and composting is one of the most visible ways in which waste can be managed more sustainably. The CIG will provide greater access to recycling facilities for residents of the Cayman Islands.

The CIG will target improved recycling performance. This will be initially achieved through the introduction of recycling depots facilities located a suitable locations (such as supermarket car parks); whereby residents can deliver separated recyclables including paper, cardboard, metal cans, glass and plastics. This will be supplemented by improved recyclables segregation at the drop off facility at George Town landfill; which will be converted to a HWRC. Further HWRC's will later be introduced for Cayman Brac and Little Cayman and will be considered for other locations on Grand Cayman.

Further recycling opportunities (including the introduction of kerbside recyclable collections for commercial and residual waste) will be explored as part of the procurement process for new waste management facilities. This is because the collection of mixed dry recyclable materials will require a materials recovery facility to processes the recyclables.

The solid waste currently received at the landfills located at George Town and Cayman Brac contain a considerable amount of organic yard waste. This material has the potential to be composted using relatively simple technology and converted in to useful compost/soil conditioner that then can be beneficially applied to land. The CIG will undertake trials to establish the feasibility of composting the organic/yard waste with the aim of potentially establishing windrow composting plants on Grand Cayman and Cayman Brac.

Recovery

For residual waste that is not recycled or composted the next best option is to treat the waste so that energy can be recovered from it. This is a better alternative to sending waste to landfill where it can break down and produce harmful greenhouse gases or leach out into surrounding water bodies.

The CIG would procure waste recovery capacity that is sufficient to treat all residual solid waste arising on the Cayman; so that waste sent to landfill can be minimised. The options appraisal process short listed a number of options that would be suitable for the treatment of residual waste. These are briefly described below.

Waste to Energy (WtE) With Combined Heat and power

In WtE facilities waste is combusted and the resulting energy in the combustion gases is recovered into stream to drive a steam turbine. The majority of the electricity produced is usually exported to the national grid.

Heat in the form of hot water or steam can also be used (e.g. to heat or cool nearby buildings or for desalination) and where this is done the process is called Combined Heat and Power (CHP). Infrastructure is needed to transfer the heat to users using a pipe network and new boilers for end-users. Laying a pipe network can be expensive and the overall costs depend on the number of end-users who will commit to use the heat, their annual demand, and the distances the heat has to travel.

Outputs from WtE facilities include incinerator bottom ash which can be used in aggregate manufacture and may also contain metals that can be recycled. Air pollution control residues are also produced and these are sent to hazardous landfill and or treatment.

The footprint of a WtE facility can be relatively small when compared to other residual waste treatment facilities and the recovery of energy significantly improves the carbon impact of the waste management solution. The architectural design of WtE facilities is very varied and can range from iconic buildings, industrial buildings or designs that blend with the local landscape and environment.

Advanced Thermal Treatment (ATT) With Combined Heat and Power

ATT is similar to traditional WtE plants, although the various sub-processes that occur are separated, often with the intent of achieving a greater degree of overall process control. Some suppliers of ATT technologies promote the concept that gases such as hydrogen, methane or ammonia can eventually be extracted from the process, but this is not yet proven at a commercial scale.

Disposal

Although the CIG will use landfill as the last option for the management of solid waste, it is acknowledged that there will continue to be a reduced landfill requirement in future for the following reasons:

- Not all waste can be economically recycled;
- Not all waste is suitable for recovery;
- Recovery waste treatment facilities produce residues that need to be disposed of; and
- There will be a need for disposal capacity should facilities be closed for maintenance.

Based on the void space analysis and associated assumptions described in Section 3 (Figure 3.15), the existing George Town landfill site will be more or less at capacity by the summer of 2021. Construction of a residual waste cell within the site after this period is likely to be difficult. The CIG should therefore consider alternative land to accommodate new waste management facilities including an alternative landfill area for residual waste/APC residues. Such new landfill facilities would need be engineered to modern standards and include containment measures an environmental control facilities for both non-hazardous and hazardous wastes.

Early diversion of waste prior to 2021 (through reduction and recycling) and potential landfill mining at George Town landfill could provide some additional flexibility on the use of the existing landfill void and prolong the life of the landfill for a number of years.

The management and disposal of waste derived from hurricane damage is addressed by The Cayman Island National Hazard Management Plan[43]. However opportunities for the improved management of hurricane waste will be explored through the delivery of the ISWMS.

10.4 Institutional and Legislative Recommendations

To enable the effective regulation of future waste management services and facilities; Amec Foster Wheeler recommends:

[43] The National Hazard Management Executive (2014): The Cayman Island National Hazard Management Plan; Volume 3A National Hurricane Plan.

- That the proposed development of major new waste management facilities are subject to a planning process that includes the production of an Environmental Impact Assessment (this is currently consistent with practice on the Cayman Islands);
- A Government regulatory function is established that is independent of waste management operations;
- That waste management facilities can operate only with a specific permit/licence issued by the regulator;
- The permits should establish the operational conditions and environmental and health and safety standards that each waste management facility must operate in accordance with. The approach to the application of the environmental standards should as far as possible be consistent with those applied to determination of a planning application;
- Waste facility operators are required to monitor their activities in accordance with the requirements of the permit/licence and report the results of this process to the regulator;
- The regulator would scrutinise permits and licence compliance; undertake period permit/license reviews, carry out periodic facility assessments and inspections and implement enforcement action in the event of non-compliance. Such enforcement actions could include corrective notices, activity cessation notices, financial deductions and criminal prosecution; and
- Primary regulation is introduced to bring in to effect the new regulatory regime.

The Caymanian legislative framework for the management of solid waste will require amendment and augmentation to enable the effective regulation of new and alternative waste management facilities that are considered in this solid waste management strategy. In particular, aspects of the Public Health (Garbage and Refuse Disposal) Regulations 2011 will require revision to enable the delivery of solid waste to a non-landfill waste treatment plant. New regulations will be needed to ensure that any management facilities are operated and managed to an appropriate standard. Amec Foster Wheeler recommend that this is accomplished through a licensing/ permit system that is overseen by an independent Government regulatory body. Primary legislation would be needed to both introduce the permit and licensing system and empower the regulatory body. These changes to both the institutional and legislative frameworks would be required prior to the commencement of the operational phase for the major new waste management infrastructure introduced as part of the implementation of the NSWMS.

10.5 Other Recommendations and Actions

Operational Issues

Based on site visits undertaken as part of environmental investigations in November 2014 and April 2015 Amec Foster Wheeler has made a number of operational observations. These observations address a number of current waste management issues and operational practices and result in recommendations for improvement or further assessment. The full list of observations and recommendations are provided in Table 10.1.

Some of the more strategic recommendations include:

- Measures that can be implemented in the short to medium term to enhance waste reduction, re-use and recycling;
- Improved segregation of waste with, for example, yard (green) and wood waste diverted from the George Town landfill;
- Preventing further expansion of the burning area at the Little Cayman landfill;
- Removal of stockpiled waste tyres at all the sites;
- Removal of stockpiled metal at all the sites;
- Removal and repackaging of drummed waste and used batteries at the Little Cayman landfill;

- The construction of waste oil facilities at the Cayman Brac and Little Cayman sites;
- A feasibility study for landfill gas extraction and potential power generation at the George Town site;
- A feasibility study for landfill mining at the George Town Landfill; and
- Replacement of the clinical waste incinerator at the George Town landfill with a more appropriate unit within the medium term.

Table 10.1: Key Issues, Observations and Recommendations

Key

1 - Short term priority
2 - Medium term priority
3 - Longer term priority

Ref No	Category	Issue	Comment	Options/Recommendations	Priority
	Strategic Waste Management				
1		Existing Waste Management System (general)	The existing waste management system in the Cayman Islands primarily relies on a network of aging and engineered landfills. The potential impact of these facilities on the surrounding environment has been assessed in work conducted by Amec Foster Wheeler in parallel with the development of the NSWMS.	It will take 3 to 4 years for major waste management facilities that can reduce the current reliance on landfill to be procured and constructed. There is therefore a clear need to preserve and make best use of the landfill capacity during the intervening period. However a long term remediation and restoration plan should be developed for each of the three landfill facilities. Should it be determined that the landfills are having an acute impact upon receptors within the local environment then specific mitigation measures to alleviate these impacts should be developed and implemented as matter of priority.	3 1
2		Waste Hierarchy and Sustainability	With the exception of the moderate recycling of particular waste streams (e.g. aluminium cans), by both public and private sector (e.g. Junk) waste that arises on the islands is either landfilled or burnt in the clinical waste incinerator at George Town landfill. As a consequence the waste management practices of the islands as whole lie low in the waste management hierarchy with the vast majority of the tonnage being landfilled.	There are a number of short and long term actions that can potentially be implemented to enhance waste reduction, re-use and recycling on the islands in line with the waste management hierarchy. In the short to medium term the CIG could initiate several waste minimisation, reuse and recycling initiatives designed to increase waste awareness and inject initial momentum to relatively simple gains. These could include measures set out under items 4 to 7 below. In the medium to long term the introduction of new waste collection practices and facilities will have the potential to make considerable movement up the waste management hierarchy by diverting waste from landfill into more sustainable forms of waste management. Work to procure a new integrated and more sustainable waste management system for the islands has been initiated by the CIG.	1 -3

Ref No	Category	Issue	Comment	Options/Recommendations	Priority
3		Landfill Resource	No effective segregation of waste is taking place at the George Town landfill site. For example loads of commercial yard waste containing vegetation and loads of pallets have been directly disposed in the landfill.	Improved supervision and segregation of yard (green) waste and timber.	1-2
			No effective segregation of wastes within the public drop off area at the George Town landfill site.	Supervision of the drop off area is required and consideration to close this out of hours (see 19 below management of drop off area).	2
4		Waste Reduction	The CIG has initiated a waste awareness campaign promoting the 4 R's through a school competition in 2015.	Sustained campaigns to raise waste awareness through education, community engagement and publicity should be planned and implemented. Specific communication and promotional activities could be co-ordinated with key stages and developments in the waste management systems and with community events. It is recommended that a forward looking stakeholder education, engagement and communication plan is developed CIG with targets to reduce waste arising per person.	1
			Empirical observations on the landfills sites and elsewhere suggested the waste being disposed of contains a considerable proportion of plastic packaging and materials.	Consideration could be given to policies and initiatives targeted to reduce the use of packaging and disposable commodities (such as plastics; glasses, and grocery bags).	2
			Specific initiatives to minimise the arisings of specific wastes could be considered and introduced.	Specific waste reduction initiatives could include for example a used nappy laundering system, the provision of home composting units etc.	2-3
5		Waste Segregation	There is limited opportunity for residents and commercial businesses to segregate waste in order to facilitate re-use and recycling.	The drop off area at George Town landfill should be optimised to enhance the segregation of recyclable materials (e.g. metals, specific Construction materials, compostable garden /yard waste etc.). Consideration should also be given to the supervision of this area to ensure that materials delivered by residents are segregated (i.e. a meet and greet system) and that capacity to segregate remains available (i.e. container's do not overflow).	1
			Residents have little opportunity to divert waste materials away from the residual waste into re-use and waste recycling.	In the short term consideration should be given to introduction of a distributed community re-use and recycling system (recycling depots network).This would involve the siting of containers (Recycling Depots) at optimum locations (such as supermarket car parks) or for deposit of segregated re-useable and dry recyclable materials (e.g. books, aluminium cans, paper and card).	1
				In the short medium term a site search could be initiated for the potential introduction of a limited number of larger community waste recycling facilities that	1-2

Ref No	Category	Issue	Comment	Options/Recommendations	Priority
		Waste Segregation (cont'd)		are capable of receiving a wider range of waste for re-use, recycling and disposal. These would be equivalent to an enhancement of the current drop off area located at George Town landfill, but for wider range of wastes (e.g. bulky waste, construction and demolition wastes, recyclables). The sites could also be designed with capacity to receive periodic waste surges resulting from hurricane damage; thereby acting as buffers and alleviating pressure on key waste management facilities.	
				In the medium to long term consideration should be given to the introduction of recyclable collection from residential and commercial properties.	2-3
6		Re-Use and Recycling	Residents have little opportunity to divert waste materials away from the residual waste into re-use and waste recycling.	See the options and recommendations under Ref. No. 5 above.	1-3
			Recyclate markets and supply chains.	The DEH currently has off island markets for limited range of materials, however the stockpiled quantities of certain materials (used tyres, scrap metal) suggests that movement to market is intermittent. If a wider range of materials is to be collected for both re-use and recycling then a forward looking materials marketing plan should be developed. This should seek to identify on island marketing opportunities and off island markets for the targeted materials.	1-2
			Storage Capacity	Dedicated storage capacity for targeted re-useable and recyclable materials will be required that are compatible with quality standards required to effectively market the materials. Some covered storage capacity is available at George Town landfill.	1-3
			Processing of re-useable materials and recyclables	There is currently very limited capacity available on the islands to process re-useable and recyclable materials (although redundant tyre shredders were observed at George Town landfill). As a consequence the CIG will need to rely on the collection of segregated materials and export markets in the short term. In the longer term it may be possible to add value to recyclate streams by introducing an on island processing plant and this may also facilitate the targeting of a wider range of materials and the collection on co-mingled recyclates.	3

Ref No	Category	Issue	Comment	Options/Recommendations	Priority
7		Organic Waste	Processing capacity (composting)	Empirical observations suggest that are large quantities organic garden/yard waste of being received at the landfills and this material provides an opportunity to produce a useable soil supplement or compost that could be used locally. To achieve this a suitable location and processing/composting plant will be required. For windrow composting a suitable site would provide sufficient space for both primary composting and maturation and should be located at least 500m from a receptor. The required plant for windrow composting is relatively simple (comprising macerators, sieves, mechanical turners and temperature monitoring and irrigation equipment). Amec Foster Wheeler would recommend that initial composting trials undertaken on the garden/yard waste accepted at the landfill sites.	1-2
			Storage capacity for garden/yard	The garden and yard waste accepted at the landfills is in some cases being separately stockpiled; however significant cross contamination was also observed. To facilitate the composting of this material and the production of a quality soil improver and compost observations suggest that are large quantities organic garden/yard waste are being received at the landfill as soil replacement/compost therefore more effective segregated storage capacity would be required.	1-2
			Food Waste	More sophisticated and complex forms of organic waste treatment are required to treat food/kitchen waste and comingled food and yard waste. These include in-vessel composting and anaerobic digestion. The suitability of these options for deployment on the islands will be examined as part of the NSWMS and potential introduction delivered through a procurement process.	3
8		Lack of Disposal Charges	Waste can currently be disposed of at the DEH operated landfills by residents, private companies and others free of any charge. As a consequence there is no financial incentive to reduce the quantity of waste being produced.	The current lack of gate fees for landfill disposal runs contrary to the principal that the polluter should pay. The introduction of gate fees should be considered as a measure to both reduce the quantity of waste requiring disposal and providing funds for landfill operations and/or alternative waste management initiatives.	1-2

Ref No	Category	Issue	Comment	Options/Recommendations	Priority
9	**Existing Operations**	Landfill Capacity and Void Space	Remaining capacity of the site for waste disposal or waste treatment operations is unknown.	Consider preservation of part of remaining land area for waste treatment areas and/or engineered cell for future residual waste.	1
			Cayman Brac - No topographical survey information for the landfill. Input rates are low; so no capacity issues in the short to medium term.	The landfill on Cayman Brac should be closed when alternative waste management options are made available. This is likely to comprise a WTS/HWRC.	3
			Little Cayman – Site operates with municipal wastes regularly set alight and burned. No operational controls apparent and area of burning is expanding considerably.	Take measures to prevent further expansion of the burning area (for example by placing large rocks to prohibit vehicle access).	1-2
				The landfill on Little Cayman should be closed when alternative waste management options are made available. This is likely to comprise a WTS/HWRC.	3
10		Site Security and Access	George Town Landfill	Public should only be able to access the landfill tipping area when they have large loads (which are unsuitable for depositing in the skips at the drop –off area by the site entrance.) Otherwise the gatehouse should prohibit entry. If the gatehouse is unmanned then it is recommended the drop-off area and site access road be gated to prohibit unauthorised access. The gate in the north east of the site road (by the clinical waste incinerator) should also be kept locked; when not in use by operations staff.	2
			Cayman Brac – landfill site is not secure and can be accessed by the public out of hours (out of hours tipping was observed by Amec Foster Wheeler during the site investigation). Potential for health and safety risks on site and also for illegal dumping.	Secure the site by repairing and locking the access gates when the site is not manned.	1-2
			Little Cayman – landfill site access is not secure and there is evidence of uncontrolled dumping taking place.	Site is unmanned and so it is difficult to restrict access. Consider installation of CCTV camera on access road to record vehicle movements in and out the site. Amec Foster Wheeler recommend the installation of fencing and lockable gate.	2

Ref No	Category	Issue	Comment	Options/Recommendations	Priority
11		Health and Safety (general)	Public should not be able to access the landfill areas except expressly for the purpose of depositing waste under supervision.	Drafting and implementation of policy on public access and site specific health and safety procedures to be followed by site staff and site visitors. This should include provisions with regard to appropriate personal protection equipment.	1
			No scavenging (for example searching out parts from end of life vehicles) should be allowed.	This practice should be discontinued on the grounds of health and safety.	1
12		Accumulation and Stockpiling of Tyres	Large volume of tyres stockpiled at George Town landfill. A contract is currently being drafted by the DEH for treatment and removal. Removal of tyres will free up land for other waste operations and remove risk of tyres catching fire.	Progress with tyre removal contract at George Town landfill. Once the stockpiles are cleared provisions should be introduced in order manage future accumulations to avoid large stockpiles.	1-2
			Majority of used tyres have now been removed from Cayman Brac. Large stockpiles should not be allowed to accumulate in the future.	Provisions should be introduced in order manage future accumulations to avoid large stockpiles.	1-2
			Relatively few tyres are stockpiled at Little Cayman landfill. These should be removed to Grand Cayman for processing.	Provisions should be introduced in order manage future accumulations to avoid large stockpiles.	2
13		Accumulation and Stockpiling of Metals and End of Life Vehicles	Large volumes (11 years +) of scrap metal are stockpiled at George Town landfill. Current work is ongoing to sort through the stockpiles to remove non-metal and debris; which would otherwise make the material unsuitable for recycling. The stockpiles take up a substantial amount of space.	Produce definitive programme for sorting and procure a contract for removal of scrap metal off island.	1
			Some baling of scrap metal and end of life vehicles has taken place at Cayman Brac, but progress slow due to unreliable equipment.	Repair bailer and continue to bale and transfer to Grand Cayman for onward movement to recycling market.	2
			Several years of accumulation of scrap metal and end of life vehicles are stockpiled at Little Cayman Landfill.	Plan to bale and transfer to Grand Cayman for onward recycling.	2

Ref No	Category	Issue	Comment	Options/Recommendations	Priority
14		Inoperative Equipment	There is insufficient operable equipment on George Town landfill site for routine waste management operations (e.g. no working excavator or water truck for damping dust).	Identify equipment critical to waste operations and purchase or hire-in. If purchased; maintenance regime needs to be put in place and critical spares held to minimise risk of downtime.	2
			At the time of the site visit there was no working excavator on the Cayman Brac landfill site. In addition the inoperable excavator has broken windscreen which presents a health and safety issue.	Measures to repair and temporarily replace key equipment quickly needs to be put in place. This may include the temporary hire of replacement equipment.	1
15		Clinical Waste Management	The clinical waste incinerator in operation at George Town landfill with ash transferred to the landfill.	Review of incinerator operations and clinical waste management practices; including an assessment of stack emissions. Develop and implement a planned maintenance schedule to reduce downtime. Plan for the replacement of the clinical waste incinerator in the medium term.	2
				The clinical waste incinerator should be operated in way that ensures that waste in combusted at the appropriate design temperature.	1
			Incinerator at the Cayman Brac landfill has been inoperable for some time (> 6 months) and clinical waste is landfilled.	Carry out feasibility of refurbishment or replacement of incinerator. Also see reference number 23 below.	1
16		Accumulation of Waste Oils	Waste oils are managed within a contained area at the George Town landfill; but there is evidence of some spillage and overtopping of the containment bund (as evidenced by product in monitoring well MW16).	Improved management procedures and application to reduce the risk of containment breach. Bail or pump out product from the monitoring well.	1
			Waste oils at Cayman Brac are not stored in any containment. Oil containers recently consolidated for transfer into a large shipping tank but no transfer pump was available.	Transfer existing oils into shipping tank. Create contained area or bunded storage tank for ongoing waste oil storage.	1
			There is no effective management of waste oil at Little Cayman landfill and evidence of a number of years accumulation of various containers, some of which show evidence of spills, leaks and in some cases pressurisation.	Transfer existing oils into a shipping tank. Please note that leaking drums and drums that appear to be under pressure may present specific hazardous to site staff and site visitors. This hazard should risk assessed and appropriate protocols and safety measures put in place.	1
				Create contained area or resident bunded storage tank for ongoing waste oil storage.	1

Ref No	Category	Issue	Comment	Options/Recommendations	Priority
		Accumulation of Waste Oils cont'd	There is also an illegal waste oil disposal pit at the site.	Prevent access to illegal oil disposal pit and programme the remediation of this area.	1-2
17		Landfill Gas: Explosion and Flammability; Asphyxiation	Landfill gas is being generated at the George Town and Cayman Brac landfill sites. The gas is flammable and potentially explosive; so no sources of naked flame should be used on the landfill areas. Landfill gas is also an asphyxiant. There should be no man entry into any confined spaces (e.g. pits) within or adjacent to the landfill areas.	Produce and implement control and monitoring procedures. In particular the potential hazard posed to enclosed areas and building on and near to the George Town Landfill should be examined and appropriate surveys and monitoring undertaken.	1
		Landfill Gas as an Energy Source	The landfill gas produced at George Town landfill could be captured and used to produce energy as part of the remediation and restoration of the landfill site.	A feasibility study to assess potential utilization of landfill gas at George Town should be undertaken as an input into the development of a landfill remediation and restoration plan.	2
18		Management of Drop Off Area (George Town Landfill)	There is no effective management or segregation of wastes at the public drop off area at the entrance to the George Town site. Waste becomes mixed within designated skips making it unsuitable for recycling.	Supervision of drop off area required and consideration to close this out of hours. Consider converting the drop area into a HWRC. Supply of specific recycling skips suited to larger storage and recycling initiatives and markets.	1-2 1
19		Weighbridge Operations	Observation and data analysis suggests that not all waste entering the George Town site is weighed. This gives potential misleading data on waste inputs and future forecasts. There are no weighbridges at the Cayman Brac and Little Cayman sites.	Planned maintenance to reduce potential for weighbridge to be out of action. Improved staffing and recording. Amec Foster Wheeler understand that this has already been addressed by the CIG and the DEH. No change proposed; but number and type of vehicles using the Cayman Brac site should be recorded and some means of applying an average vehicle load determined	1

Ref No	Category	Issue	Comment	Options/Recommendations	Priority
20		Green (yard) Waste Management	At George Town landfill some segregation of green (yard) waste undertaken; but in a piecemeal manner (see landfill resource above).	Improved supervision and resources to divert green waste from the landfill.	1-2
			Material chipped and spread across Hurricane Ivan waste area.	Improved supervision in green waste segregation.	1-2
			At Cayman Brac landfill some attempt is made to segregate green (yard) waste into a separate area; but this material is contaminated with debris making it potentially unsuitable for shredding and composting. Green waste area is adjacent to the Red Shrimp Lagoon with some impact on surface water quality	Improved supervision and management of green waste segregation.	1-2
			Composted green waste is a valuable resource as soil for landfill restoration.	Assess the feasibility of establishing windrow composting facilities on Grand Cayman and on Cayman Bra	1-2
	Environmental				
21		Contamination of Groundwater and Surface Waters with Landfill Leachate	Assessed as part of Task 2 environmental review following recent monitoring.	Cognizance of Task 2 environmental report and associated recommendations.	1-2
				Continued surface water monitoring.	1
				Study into eutrophication in North Sound adjacent to the landfill	2
22		Dust Management	No effective dust management at George Town landfill. Considerable dust generated by vehicle movements along unsurfaced access roads; with potential to impact off-site receptors.	Implement dust control using a water truck to damp down access roads (water supply available from onsite fire wells).	1-2
			Dust deposition monitoring and sampling recently undertaken.	Enforce site speed limits to minimise dust generation.	1-2
23		Air Quality and Odour	At George Town landfill air quality is impacted by fugitive release of landfill gas (containing hydrogen sulphide) and from odour from the animal burial pit. There are also hydrogen sulphide odours associated adjacent areas, particularly the wastewater treatment works.	Cover the carcasses immediately after materials are placed in the disposal pit.	1
			At Cayman Brac and Little Cayman landfills odours are not a significant issue.	Clinical waste should be covered daily with a layer of soil or compost (see clinical waste burial above).	1

Ref No	Category	Issue	Comment	Options/Recommendations	Priority
24		Landfill Fires and Noxious Emissions	Accidental fires at the George Town and Cayman Brac landfills are not uncommon and become a particular problem if they spread to areas with stockpiled tyres. The emissions from such fires also present a potential hazard to human health and adverse impact on local amenity.	Improved security and limit on public access (see reference number 10 above site security and access). No open flames or sources of combustion to be allowed in landfill areas (see reference number 17 above landfill gas). Covering or capping the wastes. Monitoring for airborne poly-aromatic hydrocarbons (PAH) to be undertaken downwind with the next landfill fire. Note that the DEH has suitable equipment for monitoring; but will need to obtain suitable sampling cartridges.	1 1 2-3 Incident dependent
25		Visual Intrusion	The active areas of landfills at George Town and Cayman Brac are readily visible from public areas. In the case of the George Town landfill, it is visible from a substantial area; including a number of residential and commercial areas; as well the off shore cruise liner anchorage.	The remediation and restoration plans for the landfills should take in to account the visual intrusion caused by the landfills and seek to mitigate adverse impacts.	2-3
	Data and Information				
26		Waste Tonnage Data	The weighbridge at George Town landfill has not been operated consistently throughout the working day; whilst waste has been delivered to site. As a consequence the historical waste data reported for George Town landfill is likely an underestimate of the tonnage accepted at the site.	Since March 2015 weighbridge data have been collected on continuous basis at George Town landfill; (the data suggest a 30% to 50% uplift on the historical reported data for the equivalent month). A waste flow model has been developed by Amec Foster Wheeler that enables monthly weighbridge reports to be entered and used for future projections. The outputs from this model will need to be frozen at key stages; so that they can be used for key documents (e.g. production of the outline business case).	In progress
			The landfill sites at Cayman Brac and Little Cayman are not equipped with weighbridges.	A method of monitoring waste deliveries at these sites (e.g. CCTV) and determining average vehicle loads would enable improved tonnage estimation.	2
27		Waste Composition Data	There is a lack of any modern waste composition data.	Waste composition data are required so that appropriate waste management processes and facility capacities can be determined (e.g. the calorific value of the waste). The data also enables seasonal fluctuations in composition to be determined (e.g. the Christmas period, seasonal influences). Such information will be essential at the procurement phase for a new integrated waste management system. A seasonal waste composition study should be initiated prior to the procurement phase of the solid waste management project.	1

Ref No	Category	Issue	Comment	Options/Recommendations	Priority
28		Landfill Mining Feasibility Study	Needed to assess the viability of mining waste deposits form George Town landfill and provide estimated remaining lifespan.	To include composition and Calorific Value analyses.	1

11. Next Steps and the Outline Business Case

11.1 Outline Business Case and Procurement

Following the finalisation of the NSWMS a fully costed Outline Business Case (OBC) will be developed. The OBC will address the implementation and delivery of the NSWMS including the future procurement of new waste management services and infrastructure. The initiation of the procurement of new waste management systems and services for the ISWMS is planned for 2016.

11.2 Forward Timetable

An outline timetable for the delivery of a new integrated solid waste management system (ISWMS) is provide in Table 11.1 below.

Table 11.1: Outline Provisional Timetable

Activity	Start	Completion
Outline Business Case	December. 2015	April 2016
Procurement of ISWMS	April 2016	December 2016
Construction	January 2017	January 2019
Commissioning	January 2019	September 2019
Operations	October 2019	onwards

During the development of the NSWMS, requirements for additional work and plans that will be needed for the effective delivery of a new and modern ISWMS have been identified and are shown in Table 11.2.

Table 11.2: Additional Work and Plans

Work/Plan	Estimated delivery	Comment
ISWMS communications plan	2nd quarter 2016	Required to identify key opportunities and methods for communications and consultation during the delivery of the ISWMS.
Waste awareness and education plan	2nd quarter 2016	Needed to promote waste re-use, recycling and recovery and the success of the ISWMS.
Landfill mining facility study	end 2016	To assess the feasibility of mining waste at George Town landfill.
Solid waste composition study	end 2016	Required to support the procurement of the ISWMS and identify the potential impact hotel expansion on the islands.
Landfill remediation plan – Little Cayman	2017	Needed to support the safe and beneficial closure of Little Cayman Landfill.
Landfill remediation plan – Cayman Brac	2017	Needed to support the safe and beneficial closure of Cayman Brac Landfill.
Landfill remediation plan – George Town	2017-18	Needed to support the safe and beneficial closure of George Town Landfill.

11.3 Future Stakeholder Consultation

Consultation Activities / Options

CIG will continue to undertake stakeholder consultation as part of the implementation of the NSWMS. The approach to this will be specifically targeted through the use of multimedia (including radio and television) to ensure that all parties are provided with relevant information and can then respond with their views and opinions. To facilitate this CIG will develop a forward looking communications and consultation plan.

Table 11.3 provides an outline of the different consultation mechanisms that the CIG may wish to consider "rolling out" subsequent consultation stages during the delivery of the ISWMS. It should be noted that in no way is it recommended that all of the options listed should be implemented. Rather the aim has been to present a 'tool-kit' of possible mechanisms from which an appropriate selection can be made, according to the stage of consultation, budget and / the topic upon which stakeholders' views are sought. To assist with any selection, the table below also presents advantages and disadvantages of each technique.

Table 11.3: Potential Consultation Mechanisms / Activities

Technique	Description	Advantages	Disadvantages
Leaflets/brochures	Written material used to convey information.	Can potentially reach a wide audience, or be targeted towards particular groups.	Information may not be readily understood and may be misinterpreted. May be treated as junk mail.
Newsletters	Written material used to convey information that may involve a series of publications.	Ongoing contact, information can be updates. A flexible form of publicity that can be designed to address the changing needs of the audience. Good potential for feedback.	Not everyone will read a newsletter (particularly important to note if trying to communicate detailed information).
Consultation Reports	A written summary of responses received following a consultation.	Can potentially reach a wide audience, or be targeted towards particular groups.	Circulation may be limited. There may also be problems with misinterpretation of information.
Exhibitions/displays (unmanned)	Exhibits/displays set up in public areas to convey information.	People can view the displays at a convenient time and at their leisure. Graphic representations, if used, can help people to visualise proposals.	Information may not be fully understood or may be misinterpreted. No staff available to respond to questions/receive comments.
Advertising	Advertisement placed to announce proposals, arrangements for meetings or other activities.	Depending on the circulation of the publication, the advert could potentially reach a large audience.	The information will only reach those who read the publication in which the advert is placed. Only limited information can be presented.
Noticeboards	An information board to notify an audience about a proposed activity.	Depending on the positioning of the noticeboard, the noticeboard could reach its targeted audience.	The information will only reach those who read the notice in which the noticeboard is placed. Only limited information can be presented.
Local newspapers	An article published in a local newspaper to convey information about a proposed activity.	A potentially cheap form of publicity and often effective means of reaching a local audience.	Circulation may be limited. There may also be problems with misinterpretation of information.
National newspapers	An article published in a national newspaper to convey information about a proposed activity.	Potential to reach a very large audience.	Unless an activity has gained a significant profile it may not be of sufficient interest to national press. The audience may also be restricted to particular sector.
Television and Radio	Use of television and radio to convey information about a proposed activity.	TV and radio have a potentially large audience. People may be more likely to watch or listen to a broadcast than read leaflets and brochures.	Broadcasts alone may be insufficient, further information may need to be made available. Relatively expensive.
Video/DVD	Production of video to convey information, may incorporate computer graphics and other images.	Under the control of the producer. Can be watched at viewers' convenience.	Can be perceived as biased. Relatively expensive to produce if the final product is to look professional and credible.

Technique	Description	Advantages	Disadvantages
Site visits/ meetings	Organised case studies through site oriented meetings to provide first-hand experience of a particular activity and the issues involved.	Issues brought to life through real examples.	Often difficult to identify a site which replicates all issues. Not suitable for larger groups of people.
Exhibits/displays (manned)	Exhibits or displays set up in public areas to convey information and staffed by specialists who can provide information, answer questions and receive comments.	People can view the displays at a convenient time and at their leisure. Graphic representations, if used, can help people visualise proposals. One to one contact can be achieved.	Requires a major commitment of staff time. Not always well-attended and may therefore only attract a small proportion of third parties.
Staffed telephone lines	A telephone number for people to call to obtain information, ask questions or make comments about proposals or issues.	A convenient way of receiving comments from interested parties. Not intimidating, therefore easier for people to participate and provide comments. Promotes a feeling of accessibility.	Discussions over the telephone may not be as good as face to face. Operating staff may not have sufficient technical knowledge at hand to respond to questions.
Internet	A web-site on the Internet used to provide information or invite feedback. Care should be taken to keep information up to date. More interactive forms of participation on the Internet may be developed e.g. on-line forums and discussion groups.	The audience is potentially global. Costs are reduced as no printing or postage costs are incurred. A convenient method of participation for those with Internet access.	Not all interested parties will have access to the Internet. Alternative means of information will also be required.
Public meetings	A formal gathering of interested and affected parties to present and exchange information and views on a proposal.	If run well, can provide a useful way of meeting other stakeholders. Demonstrates that the proponent is willing to meet with other interested parties.	Whilst appearing simple, can be one of the most complex and unpredictable methods. Public meetings can be intimidating and may be hi-jacked by interest groups or vocal individuals. May result in poor consultation.
Surveys, Interviews & Questionnaires	Encompasses a range of techniques for obtaining information and opinions. May be self-administered, conducted face-to-face, by post, over the telephone or via the Internet.	Can gather information from people who would not attend public meetings or become involved in other activities. Confidential surveys may result in more candid responses where difficult issues are being discussed. Can be used to easily identify existing situation.	Surveys can have poor response rate. Responses may not be reflective of everyone's opinions and may only relate to the time of answering. Designing an effective questionnaire can be costly and effective delivery time-consuming.
Workshops	Meetings for a limited number of participants, which can be used to provide background information, discuss issues and gain feedback on concerns and priorities.	Can provide a more open exchange of ideas and facilitate mutual understanding. Useful for dealing with complex, technical issues as they allow more time for explanation and discussion. Can be targeted at specific stakeholder groups.	To be most effective, only a small number of people can participate. There is therefore a risk that a full range of interests are not effectively represented.

Technique	Description	Advantages	Disadvantages
Staffed event	Hiring staff to manage stakeholder relations at an event.	Can provide communities with an accessible point of contact to ask questions and raise grievances.	If the quality of interaction and response times in resolving grievances is poor, this may affect local attitudes toward construction activity and moreover, toward development in general.
Focus groups/ forums	A meeting of invited participants designed to gauge the response to proposed actions and gain a detailed understanding of people's attitudes, values and priorities.	Provides a quick means of gauging what public reaction to a proposal is likely to be.	Selection of group members may exclude some sectors of the community. Groups require facilitation and, as a series of groups may be required, can be time-consuming.
Open-house	Interested parties are encouraged to visit a designated location e.g. at a site or operational building, on an informal basis to find out about a proposal and provide feedback.	An effective way of informing the public and other interested parties. People can visit at a convenient time, view materials and ask questions as necessary.	Preparation for and staffing of the open house may require considerable resources.
Community Advisory/Liaison Groups	Small groups of people representing particular interests or areas of expertise e.g. community leaders meet to discuss issues of concern and provide an informed input.	Can consider issues in detail and highlight the decision-making process and the complexities involved. Also enables more targeted and relevant discussions. Promotes a feeling of trust.	Not all interests may be represented at each group. Requires significant commitment from participants. A longer term process requiring more resources than some other methods.
Citizen's Juries	A group of citizens selected to be representative of the community brought together to consider a particular issue. Evidence is received from expert witnesses and cross-questioning can occur.	Can consider issues in detail in a relatively short period of time.	Not all interests may be represented as those seeking to be involved may have own agenda. Limited timescale may limit time to fully consider information. Requires significant commitment from participants.
Consensus Conference	A forum at which a citizen's panel, selected from the general public, questions 'experts' on a particular topic, assesses responses , discusses the issues raised and reports its conclusions.	Can provide a unique insight into the ways in which issues are perceived by members of the public. Suited to dealing with controversial issues of public concern.	Not all interests may be represented. Limited time-scale for consideration of issues. Requires significant commitment from participants.
Visioning	A technique for developing a shared vision of a desirable future for a local community.	Develops a common view. Allows participants to express aspirations - they are involved in ideas generation not just consultation on pre-decided options. Promotes trust and sense of purpose.	Lack of control over the outcome. Needs to be used in the early stages of the decision-making process to allow scoping to be of value. People can find it difficult to contribute to a 'blank sheet'.

Future Stakeholder Engagement

Consultation on the NSWMP and NSWMS has already taken place. Consequently, specific consideration is given in this technical note to the engagement opportunities that the remainder of the overall waste project may present i.e. most notably the development of the OBC and the subsequent waste management contract procurement process.

Outline Business Case

It is considered that the development of the OBC presents opportunities for both imparting information to Cayman Islands citizens / stakeholders, as well as carrying out genuine, meaningful consultation – seeking views of stakeholders on the development of the OBC. Key potential engagement points could include:

- **Launch stage** – information giving only stage, providing stakeholders with background information about the OBC process, how it will be developed and what the purpose of the exercise is. Given that a preferred option would already have been identified (via consultation) through the development of the NSWMS, opportunities for eliciting views at this stage would be limited. It is therefore suggested that mechanisms for engagement focus on those which are effective 'information givers' e.g. leaflets, newsletters, exhibitions (manned and unmanned), internet, newspapers etc.; and
- **Consultation on the draft OBC** – it is considered that an opportunity arises here for genuine consultation. Most notably asking views and testing public opinion on the assumptions used to arrive at the detailed financial appraisal of the preferred solution. To reflect the fact that public opinion could be sought at this stage, it is recommended that mechanisms for engagement focus on those which are effective 'opinion gatherers' e.g. leaflets, advertising (for other planned events), manned exhibitions, workshops, community liaison groups, citizen's juries / panels etc.

Procurement Process

It is considered that once the CIG enters into the procurement phase of the overall ISWMS project, opportunities for engagement become limited and tied to the formal stages of the procurement process (when confidential information can be released). It is especially considered that engagement during this phase of the project would generally be restricted to information giving exercises. Notwithstanding this, there is scope for the CIG to consider inviting specific stakeholders onto the procurement evaluation team.

Key potential engagement points could include:

- Launch of the procurement process;
- Various short-listing / de-selection stages of the process;
- Announcement of preferred bidder; and
- As noted above, for the imparting of information, it is suggested that mechanisms for engagement focus on those which are effective 'information givers' e.g. leaflets, newsletters, exhibitions (manned and unmanned), internet, newspapers etc.

Post Procurement

It is also worth noting that the project team may wish to consider opportunities post procurement for working with the appointed contractor on stakeholder engagement / community consultation associated with the inevitable need to prepare and consult on the associated planning application(s) and other required permit / licence applications.

Appendix A
Risk Assessment for Georgetown Landfill

Appendix A1: George Town Landfill - Summary of Potential Environmental Risks

Item No.	Area/ Building	Potential Pollutant (Source)	Potential Receptor	Potential Pathway to Receptor	Associated Hazard	Potential Consequence of S-R Link	Likelihood of Source-Receptor Linkage	Significance: Risk Classification	Comment
1	Soils around landfill	Arsenic	Site workers/visitors	Ingestion	Toxic	Medium	Likely	Moderate	Concentrations above Florida soils clean-up levels at some locations
2	Soils around landfill	Arsenic	Adjacent residents	Ingestion of wind blown dust	Toxic	Medium	Unlikely	Low	Limited wind blown dust potential. No arsenic detected in dust samples.
3	Soils around landfill	Arsenic	Adjacent comercial/industrial users	Ingestion of wind blown dust	Toxic	Medium	Unlikely	Low	Limited wind blown dust potential. No arsenic detected in dust samples.
4	Soils around landfill	Arsenic	Groundwater	Leaching	Groundwater contamination	Mild	Unlikely	Negligible	The dissolution of arsenic is based on the chemistry of the water and the soil. Factors that affect arsenic mobility include pH, dissolved oxygen (DO), oxidation-reduction potential , specific conductivity, temperature, and soil conditions (McLean et al., 1992). Arsenic not detected in groundwater above Florida clean-up standard.
5	Waste Oil storage area	Hydrocarbons	Site workers/visitors	Dermal contact/inhalatio n	Toxic: chronic toxicity	Medium	Low	Moderate / Low	Assumed site staff wear appropriate PPE
6	Waste Oil storage area	Hydrocarbons	Groundwater	Spills to ground and overtopping of bund	Water pollution	Mild	High	Moderate	Contamination in MW16
7	Waste Oil storage area	Hydrocarbons	Surface water canal	Runoff and groundwater base flow	Water pollution	Medium	High	High	Potential for groundwater in MW16 to impact adjacent canal. 0.84mg/l DRO in surface water at SW12 in 2015.
8	Groundwater	Ammonia	Surface water canal	Groundwater base flow	Surface water contamination	Mild	High	Moderate	Ammonia recorded in perimeter canals, harmful to acquatic organisms. Ammonia detected above Florida clean-up standard in MW10 and MW21 in 2015. The observed ammonia concentrations in the perimeter canals reflect poor water quality based on UK guideline values.
9	Groundwater	Orthophosphate	Surface water canal	Groundwater base flow	Surface water contamination	Mild	High	Moderate	Elevate orthosphosphate concentrations recorded in groundwater and to a lesser extent in surface waters.
10	Groundwater	Iron	Surface water canal	Groundwater base flow	Surface water contamination	Mild	Likely	Moderate / Low	Detected above the clean-up level of 3 mg/l with results ranging up to 11 mg/l
11	Groundwater	Ammonia	Water supply wells	Groundwater migration	Groundwater contamination	Medium	Unlikely	Low	Water supply wells located approx 1 mile away to south east, shallow groundwater gradient anticipated to the east. Abstraction from >150ft and water treated for potable supply

Appendix A1: George Town Landfill - Summary of Potential Environmental Risks

Item No.	Area/ Building	Potential Pollutant (Source)	Potential Receptor	Potential Pathway to Receptor	Associated Hazard	Potential Consequence of S-R Link	Likelihood of Source-Receptor Linkage	Significance: Risk Classification	Comment
12	Groundwater	Ammonia	North Sound	Groundwater base flow	Marine water contamination	Medium	Low	Moderate / Low	Consequence reflects ecological designation of receptor. Ammonia detected in North Sound as mouth of North Canal at 2.5 mg/l in 2015 but concentration falls with distance into the North Sound.
13	Surface water canal	Ammonia	North Sound	Surface water flow	Marine water contamination	Medium	High	High	Ammonia recorded in perimeter canals, harmful to acquatic organisms. Ammonia detected above Florida clean-up standard in MW10 and MW21 in 2015. The observed ammonia concentrations in the perimeter canals reflect poor water quality based on UK guideline values.
14	Groundwater	Ammonia	North sound ecology	Groundwater migration	Toxic	Medium	Low	Moderate / Low	Consequence reflects ecological designation of receptor. Ammonia detected in North Sound as mouth of North Canal at 2.5 mg/l in 2015 but concentration falls with distance into the North Sound.
15	Surface water canal	Ammonia	North sound ecology	Surface water flow	Toxic	Medium	Likely	Moderate	Ammonia recorded in perimeter canals, harmful to acquatic organisms. Ammonia detected above Florida clean-up standard in MW10 and MW21 in 2015. The observed ammonia concentrations in the perimeter canals reflect poor water quality based on UK guideline values. Ammonia detected in North Sound as mouth of North Canal at 2.5 mg/l in 2015 but concentration falls with distance into the North Sound.
16	Surface water canal	Metals	North Sound	Surface water flow	Marine water contamination	Medium	Likely	Moderate	The sample from SW3 recorded exceedences of the relevant clean-up levels for copper and lead.
17	Contaminated sediments	Hydrogen sulphide and trace compounds	Site workers/visitors	Inhalation	Toxic	Medium	Likely	Moderate	WHO guideline values were exceeded in three locations in the first 2015 survey, which were all either adjacent to the North Canal or the landfill boundary with the water treatment works.
18	Contaminated sediments	Hydrogen sulphide and trace compounds	Adjacent comercial/industrial users	Inhalation	Toxic	Medium	Likely	Moderate	WHO guideline values were exceeded in three locations in the first 2015 survey, which were all either adjacent to the North Canal or the landfill boundary with the water treatment works.

Appendix A1: George Town Landfill - Summary of Potential Environmental Risks

Item No.	Area/ Building	Potential Pollutant (Source)	Potential Receptor	Potential Pathway to Receptor	Associated Hazard	Potential Consequence of S-R Link	Likelihood of Source-Receptor Linkage	Significance: Risk Classification	Comment
19	Landfill Gas	Hydrogen sulphide and trace compounds	Site Workers/visitors	Inhalation	Toxic	Medium	Likely	Moderate	The highest H2S reading within landfill, away from the boundaries, was 80.16 ppb, which is below the WHO long-term and short-term average guideline values. However, trace landfill gas components were detected at concentrations typical of landfill gas in gas probes.
20	Landfill Gas	Hydrogen sulphide and trace compounds	Adjacent residents	Inhalation	Toxic	Medium	Low	Moderate / Low	Air quality modelling concludes that modelling of hydrogen sulphide emissions showed that short-term (hourly) average concentrations at the nearest residential receptors were likely to exceed the WHO odour nuisance guideline concentration by a significant margin. For the remaining trace organic micro-pollutants, none of these was forecast to exceed relevant assessment criteria as a result of surface emissions from the landfill site.
21	Landfill Gas	Hydrogen sulphide and trace compounds	Adjacent comercial/industrial users	Inhalation	Toxic	Medium	Low	Moderate / Low	Air quality modelling concludes that modelling of hydrogen sulphide emissions showed that short-term (hourly) average concentrations at the nearest residential receptors were likely to exceed the WHO odour nuisance guideline concentration by a significant margin. For the remaining trace organic micro-pollutants, none of these was forecast to exceed relevant assessment criteria as a result of surface emissions from the landfill site.
22	Landfill Gas	Methane	Site Workers/visitors	Migration	Explosion	Severe	Low	Moderate	Assumes site management practices limit potential for methane explosion
23	Landfill Gas	Methane	Humans (neighbouring site users)	Migration	Explosion	Severe	Unlikely	Moderate / Low	Potential for subsurface migration limited by high groundwater table and perimeter canals

Appendix B
Risk Assessment for Cayman Brac Landfill

Appendix B1: Cayman Brac – Summary of Potential Environmental Risks

Item No.	Source	Potential Contaminant	Potential Receptor	Potential Pathway to Receptor	Associated Hazard	Potential Consequence of Source-Receptor Link	Likelihood of Source Receptor Link	Significance: Risk Classification	Comment
1	Municipal wastes	Ammonia	Groundwater	Leaching	Groundwater contamination	Mild	Likely	Moderate/ Low	Groundwater is tidally influenced so ammonia can be released in to the marine environment. Ammonia detected in 2015 groundwater samples (up to 18mg/l) but not above Florida clean-up standard.
2	Municipal wastes	Metals	Shrimp pond	Leaching	Water pollution	Medium	Likely	Moderate	Copper and lead above clean-up standards in surface water samples'
3	Waste oil storage spills to ground	Hydrocarbons	Site workers/visitors	Dermal Contact Ingestion	Toxic	Mild	Low	Low	Assumed site staff wear appropriate PPE.
4	Waste oil storage spills to ground	Hydrocarbons	Groundwater	Migration	Groundwater contamination	Medium	High	Moderate	Some surface spills noted. DRO detected in surface water samples, groundwater samples CB1 – CB4 in April 2015. GRO detected in groundwater sample CB4.
5	Landfill gas	Hydrogen sulphide and trace compounds	Site workers/visitors	Inhalation	Toxic	Medium	Low	Moderate / Low	H2S not detected at landfill surface during 2015 survey. However trace landfill gas components were detected at concentrations typical of landfill gas in gas probes.
6	Landfill gas	Hydrogen sulphide and trace compounds	Adjacent residents	Inhalation	Toxic	Medium	Unlikely	Low	Unlikely due to dispersion.
7	Landfill gas	Methane	Site workers/visitors	Migration	Explosion	Severe	Low	Moderate	Site not capped so surface migration potential limited.
8	Landfill gas	Methane	Adjacent residents	Migration	Explosion	Severe	Unlikely	Moderate / Low	Potential subsurface migration limited due to shallow groundwater table.

Appendix C
Risk Assessment for Little Cayman Landfill

Appendix C1: Little Cayman Landfill – Summary of Potential Environmental Risks

Item No.	Area/ Building	Potential Pollutant (Source)	Potential Receptor	Potential Pathway to Receptor	Associated Hazard	Potential Consequence of S-R Link	Likelihood of Source-Receptor Link	Significance: Risk Classification	Comment
1	Waste oil storage	Hydrocarbons	Site workers and visitors	Dermal Contact Inhalation	Toxic	Mild	Low	Low	Some surface spills noted. Illegal oil disposal pit at the site, near the plant storage building Likelihood assumes site staff have appropriate PPE.
2	Waste oil storage	Hydrocarbons	Groundwater	Migration	Groundwater contamination	Medium	Likely	Moderate	Some surface spills noted. Illegal oil disposal pit at the site, near the plant storage building.
3	Burning ground	Ammonia	Groundwater	Leaching	Groundwater contamination	Mild	Low	Low	No quantitative data on ammonia.
4	Burning ground	Metals	Groundwater	Leaching	Groundwater contamination	Mild	Likely	Moderate / Low	Metals detected above relevant Florida surface water clean-up target or marine surface water criteria in soil samples submitted for leaching test analysis.
5	Burning ground	Metals	Site workers and visitors	Dermal Contact Ingestion	Toxic	Mild	Likely	Moderate / Low	Arsenic detected above Florida clean-up target in soils.
6	Burning ground	Combustion products from burning	Site workers and visitors	Inhalation	Toxic	Mild	Likely	Moderate / Low	Regular uncontrolled burning of waste.
7	Groundwater	Metals	Offsite ponds	Groundwater baseflow	Water pollution	Medium	Low	Moderate / Low	Copper and lead detected above Florida clean-up target in surface water samples. Likelihood reflects dilution between source and receptor.

Appendix D
Detailed WRATE Results.

D1 Detailed WRATE Lifecycle Modelling Results

The environmental and lifecycle assessment of shortlisted options has been carried using the Waste Resources Assessment Toolkit for the Environment (WRATE).

Default Impacts

WRATE measures the potential impact on the environment through six parameters or default impacts:

- **Abiotic Resource Depletion (kg antimony equivalent)** – Use of non-renewable and renewable resources. Abiotic resources are non-living things, including land, water, air and minerals;
- **Global Warming Potential (kg carbon dioxide equivalent)** – Measure of what mass of Greenhouse Gases are estimated to contribute to global warming, a relative scale that compares emissions to Carbon Dioxide;
- **Human Toxicity (kg 1,4-dichlorobenzene equivalent)** – This covers a number of different effects: acute toxicity, irritation/corrosive effects, allergenic effects, irreversible damage/organ damage, genotoxicity, carcinogenic effects, toxicity to reproductive system/teratogenic effects, and neurotoxicity. The equivalence factors are determined for emission to different compartments: air, water, and soil and exposure via different media: air water, and soil;
- **Freshwater Aquatic Ecotoxicity (kg 1,4-dichlorobenze equivalent)** – Toxicity towards ecosystems can be regarded as either chronic (causing long lasting illness) or acute (short term/ immediate effects);
- **Acidification (kg Sulphur Dioxide equivalent)** – Emissions of acidifying compounds such as sulphur dioxide and nitrous oxides attack leaves and acidify the soil which can result to changes in the ecosystem; and
- **Eutrophication (kg Phosphate equivalent)** - is caused by the increase of chemical nutrients, typically compounds containing nitrogen or phosphorus.

Modelled Options and Comb

In total. this produced 33 different combinations of options that were modelled and each of these contained a number of stream that are collected, recycling and organic waste treatment and a residual waste treatment and disposal method. These combinations of options are listed in Table E1 with a breakdown of what they comprise.

The combinations of options that are equivalent to scenarios A, B, C and D used in the cost estimation: are 30(8E), 22 (9E), 14 (10E) and 6 (11E) respectively (and these are highlighted in yellow).

Table D1
Options Matrix of Modelled Short List Options

		Collected Waste Streams					Waste Treatment/Processing Technologies/Options				
Scenario	Scenario ref.	Residual Waste	Mixed Dry Recycling	Delivered Yard waste	Kerbside Segregated Food Waste	Kerbside Segregated Organic Waste	Residual Treatment	Recycling	Organic Treatment	Food Treatment	Treatment option number as in Table 7.1 of Report
1 - Baseline	12A	BAU	BAU	BAU	BAU	BAU	Op12 'As Is'	BAU	BAU	BAU	12
2	11A	BAU	BAU	BAU	BAU	BAU	Op11 WtE	BAU	BAU	BAU	11
3	11B	BAU	Op2 - co-mingled	BAU	BAU	BAU	Op11 WtE	Op2 - MRF	BAU	BAU	11
4	11C	BAU	Op2 - co-mingled	BAU	BAU	Op4 - yard waste	Op11 WtE	Op2 - MRF	Op3 - windrow	BAU	11
5	11D	BAU	Op2 - co-mingled	Op3 - yard waste	BAU	Op4 - yard waste	Op11 WtE	Op2 - MRF	Op3 - windrow	BAU	11
6	11E	BAU	Op2 - co-mingled	Op3 - yard waste	Op5 - food waste	Op4 - yard waste	Op11 WtE	Op2 - MRF	Op3 - windrow	Op5 - wet AD	11
7	11F	BAU	BAU	BAU	BAU	Op4 - yard waste	Op11 WtE	BAU	Op3 - windrow	BAU	11
8	11G	BAU	BAU	Op3 - yard waste	BAU	Op4 - yard waste	Op11 WtE	BAU	Op3 - windrow	BAU	11
9	11H	BAU	BAU	Op3 - yard waste	Op5 - food waste	Op4 - yard waste	Op11 WtE	BAU	Op3 - windrow	Op5 - wet AD	11
10	10A	BAU	BAU	BAU	BAU	BAU	Op10 SRF for WtE	BAU	BAU	BAU	10
11	10B	BAU	Op2 - co-mingled	BAU	BAU	BAU	Op10 SRF for WtE	Op2 - MRF	BAU	BAU	10
12	10C	BAU	Op2 - co-mingled	BAU	BAU	Op4 - yard waste	Op10 SRF for WtE	Op2 - MRF	Op3 - windrow	BAU	10
13	10D	BAU	Op2 - co-mingled	Op3 - yard waste	BAU	Op4 - yard waste	Op10 SRF for WtE	Op2 - MRF	Op3 - windrow	BAU	10
14	10E	BAU	Op2 - co-mingled	Op3 - yard waste	Op5 - food waste	Op4 - yard waste	Op10 SRF for WtE	Op2 - MRF	Op3 - windrow	Op5 - wet AD	10
15	10F	BAU	BAU	BAU	BAU	Op4 - yard waste	Op10 SRF for WtE	BAU	Op3 - windrow	BAU	10
16	10G	BAU	BAU	Op3 - yard waste	BAU	Op4 - yard waste	Op10 SRF for WtE	BAU	Op3 - windrow	BAU	10

		Collected Waste Streams					Waste Treatment/Processing Technologies/Options				
Scenario	Scenario ref.	Residual Waste	Mixed Dry Recycling	Delivered Yard waste	Kerbside Segregated Food Waste	Kerbside Segregated Organic Waste	Residual Treatment	Recycling	Organic Treatment	Food Treatment	Treatment option number as in Table 7.1 of Report
17	10H	BAU	BAU	Op3 - yard waste	Op5 - food waste	Op4 - yard waste	Op10 SRF for WtE	BAU	Op3 - windrow	Op5 - wet AD	10
18	9A	BAU	BAU	BAU	BAU	BAU	Op9 ATT	BAU	BAU	BAU	9
19	B	BAU	Op2 - co-mingled	BAU	BAU	BAU	Op9 ATT	Op2 - MRF	BAU	BAU	9
20	C	BAU	Op2 - co-mingled	BAU	BAU	Op4 - yard waste	Op9 ATT	Op2 - MRF	Op3 - windrow	BAU	9
21	9D	BAU	Op2 - co-mingled	Op3 - yard waste	BAU	Op4 - yard waste	Op9 ATT	Op2 - MRF	Op3 - windrow	BAU	9
22	9E	BAU	Op2 - co-mingled	Op3 - yard waste	Op5 - food waste	Op4 - yard waste	Op9 ATT	Op2 - MRF	Op3 - windrow	Op5 - wet AD	9
23	9F	BAU	BAU	BAU	BAU	Op4 - yard waste	Op9 ATT	BAU	Op3 - windrow	BAU	9
24	9G	BAU	BAU	Op3 - yard waste	BAU	Op4 - yard waste	Op9 ATT	BAU	Op3 - windrow	BAU	9
25	9H	BAU	BAU	Op3 - yard waste	Op5 - food waste	Op4 - yard waste	Op9 ATT	BAU	Op3 - windrow	Op5 - wet AD	9
26	8A	BAU	BAU	BAU	BAU	BAU	Op8 SRF for export	BAU	BAU	BAU	8
27	8B	BAU	Op2 - co-mingled	BAU	BAU	BAU	Op8 SRF for export	Op2 - MRF	BAU	BAU	8
28	8C	BAU	Op2 - co-mingled	BAU	BAU	Op4 - yard waste	Op8 SRF for export	Op2 - MRF	Op3 - windrow	BAU	8
29	8D	BAU	Op2 - co-mingled	Op3 - yard waste	BAU	Op4 - yard waste	Op8 SRF for export	Op2 - MRF	Op3 - windrow	BAU	8
30	8E	BAU	Op2 - co-mingled	Op3 - yard waste	Op5 - food waste	Op4 - yard waste	Op8 SRF for export	Op2 - MRF	Op3 - windrow	Op5 - wet AD	8
31	8F	BAU	BAU	BAU	BAU	Op4 - yard waste	Op8 SRF for export	BAU	Op3 - windrow	BAU	8
32	8G	BAU	BAU	Op3 - yard waste	BAU	Op4 - yard waste	Op8 SRF for export	BAU	Op3 - windrow	BAU	8
33	8H	BAU	BAU	Op3 - yard waste	Op5 - food waste	Op4 - yard waste	Op8 SRF for export	BAU	Op3 - windrow	Op5 - wet AD	8

Key: AD – Anaerobic Digestion; MRF – Material Recovery Facility; ATT- Advanced Thermal Treatment; BAU – Business as usual (i.e. no change to current waste management practice); .SRF – Solid Recovered Fuel; WtE – Waste to Energy

Lifecycle Modelling Results

The detailed results of the lifecycle assessment modelling for the options is shown in Table D2 and are summarised in Figures D1 to D12. These provide comparative a data for each modelled option for each of the lifecycle parameters determined using WRATE. The references used in the Tables and Figures refer to the scenario references set out in column 2 of Table D1. Those scenario references highlighted blue in Table D2 column 1 do not include combined heat and power (CHP), those highlighted in red in Table D2 column 1 have been modelled with an operational combined heat and power waste to energy facility (where the scenario contains an WtE plant).

Table D2
Characterised Lifecycle and Environmental Impacts

Impact Assessments	climate change: GWP 100a	acidification potential: average European	eutrophication potential: generic	freshwater aquatic ecotoxicity: FAETP infinite	human toxicity: HTP infinite	resources: depletion of abiotic resources
Unit	kg CO2-Eq	kg SO2-Eq	kg PO4-Eq	kg 1,4-DCB-Eq	kg 1,4-DCB-Eq	kg antimony-Eq
baseline	111529326	4092	29352	240407	2213360	4753
Op11 A	-25764436	-535044	-13234	-4228581	-34918467	-306822
Op11 B	-25674964	-517751	-13189	-4207055	-36289708	-308175
Op11 C	-22898749	-472587	-9791	-3997427	-33869295	-284955
Op11 D	-22122769	-459954	-8840	-3938907	-33192290	-278465
Op11 E	-22117519	-459091	-8791	-3936997	-33182662	-278481
Op11 F	-22988221	-489881	-9835	-4018953	-32498054	-283602
Op11 G	-22212242	-477248	-8884	-3960433	-31821049	-277112
Op11 H	-22206992	-476385	-8835	-3958523	-31811421	-277128
Op10 A	-23185746	-455162	-12858	-4085542	-39861896	-298371
Op10 B	-23151611	-443754	-12639	-4025438	-40114794	-298974
Op10 C	-21368789	-411521	-9840	-3898144	-38107010	-282402
Op10 D	-20870925	-402508	-9057	-3862676	-37545529	-277774
Op10 E	-20871713	-401720	-9013	-3861531	-37539165	-277837
Op10 F	-21402920	-422929	-10059	-3958248	-37854111	-281800
Op10 G	-20905056	-413915	-9277	-3922780	-37292631	-277172
Op10 H	-20905844	-413128	-9232	-3921635	-37286267	-277234
Op9 A	-17784696	-395639	-15828	-3412387	-33242713	-257232
Op9 B	-18126188	-387044	-15636	-3443871	-34509646	-260437
Op9 C	-16447859	-357533	-11471	-3312881	-32498394	-245950
Op9 D	-15979193	-349282	-10306	-3276377	-31935943	-241906
Op9 E	-15982407	-348559	-10228	-3275133	-31929450	-242019
Op9 F	-16106354	-366127	-11663	-3281397	-31231461	-242746
Op9 G	-15637687	-357876	-10497	-3244894	-30669009	-238701
Op9 H	-15640901	-357153	-10419	-3243649	-30662517	-238814
Op8 A	-22977046	-452031	-12288	-4078266	-39830489	-296777
Op8 B	-22391755	-438575	-11910	-3869238	-38392749	-293281
Op8 C	-20662115	-407138	-9257	-3743809	-36393009	-277115
Op8 D	-20179140	-398349	-8515	-3708863	-35833781	-272601
Op8 E	-20181224	-397581	-8473	-3707763	-35827613	-272673
Op8 F	-20601822	-418097	-9430	-3772115	-35778831	-275881
Op8 G	-20118847	-409307	-8688	-3737168	-35219602	-271367
Op8 H	-20120930	-408539	-8647	-3736069	-35213434	-271439
Op11 A	-36524700	-563160	-15824	-4516491	-36442736	-376541
Op11 B	-35939101	-544570	-15661	-4481690	-37743697	-374679
Op11 C	-32070596	-496553	-11999	-4242835	-35168554	-344382
Op11 D	-30988805	-483120	-10975	-4176133	-34448228	-335911
Op11 E	-30961687	-482200	-10921	-4173638	-34435503	-335785
Op11 F	-32656196	-515143	-12163	-4277637	-33867593	-346244
Op11 G	-31574405	-501710	-11139	-4210934	-33147267	-337773
Op11 H	-31547287	-500790	-11084	-4208439	-33134542	-337647

Impact Assessments	climate change: GWP 100a	acidification potential: average European	eutrophication potential: generic	freshwater aquatic ecotoxicity: FAETP infinite	human toxicity: HTP infinite	resources: depletion of abiotic resources
Unit	kg CO2-Eq	kg SO2-Eq	kg PO4-Eq	kg 1,4-DCB-Eq	kg 1,4-DCB-Eq	kg antimony-Eq
Op10 A	-32060230	-478351	-14995	-4322994	-41119031	-355872
Op10 B	-31734520	-466181	-14705	-4255089	-41330626	-354586
Op10 C	-29013402	-431496	-11681	-4102689	-39189925	-331934
Op10 D	-28252841	-421796	-10835	-4060192	-38591231	-325604
Op10 E	-28230957	-420950	-10785	-4058440	-38581656	-325520
Op10 F	-29339108	-443665	-11970	-4170595	-38978330	-333221
Op10 G	-28578547	-433966	-11124	-4128097	-38379636	-326891
Op10 H	-28556663	-433119	-11074	-4126346	-38370061	-326806
Op9 A	-17784696	-395639	-15828	-3412387	-33242713	-257232
Op9 B	-18126188	-387044	-15636	-3443871	-34509646	-260437
Op9 C	-16447859	-357533	-11471	-3312881	-32498394	-245950
Op9 D	-15979193	-349282	-10306	-3276377	-31935943	-241906
Op9 E	-15982407	-348559	-10228	-3275133	-31929450	-242019
Op9 F	-16106354	-366127	-11663	-3281397	-31231461	-242746
Op9 G	-15637687	-357876	-10497	-3244894	-30669009	-238701
Op9 H	-15640901	-357153	-10419	-3243649	-30662517	-238814
Op8 A	-31851529	-475220	-14425	-4315718	-41087624	-354278
Op8 B	-30974663	-461002	-13977	-4098888	-39608580	-348893
Op8 C	-28306728	-427113	-11097	-3948354	-37475924	-326647
Op8 D	-27561056	-417637	-10292	-3906379	-36879483	-320431
Op8 E	-27540468	-416810	-10245	-3904673	-36870103	-320356
Op8 F	-28538010	-438833	-11341	-3984461	-36903049	-327302
Op8 G	-27792337	-429357	-10536	-3942486	-36306608	-321086
Op8 H	-27771749	-428530	-10490	-3940780	-36297228	-321011

Figure D1
Combined Scenarios No CHP – Climate Change Impact

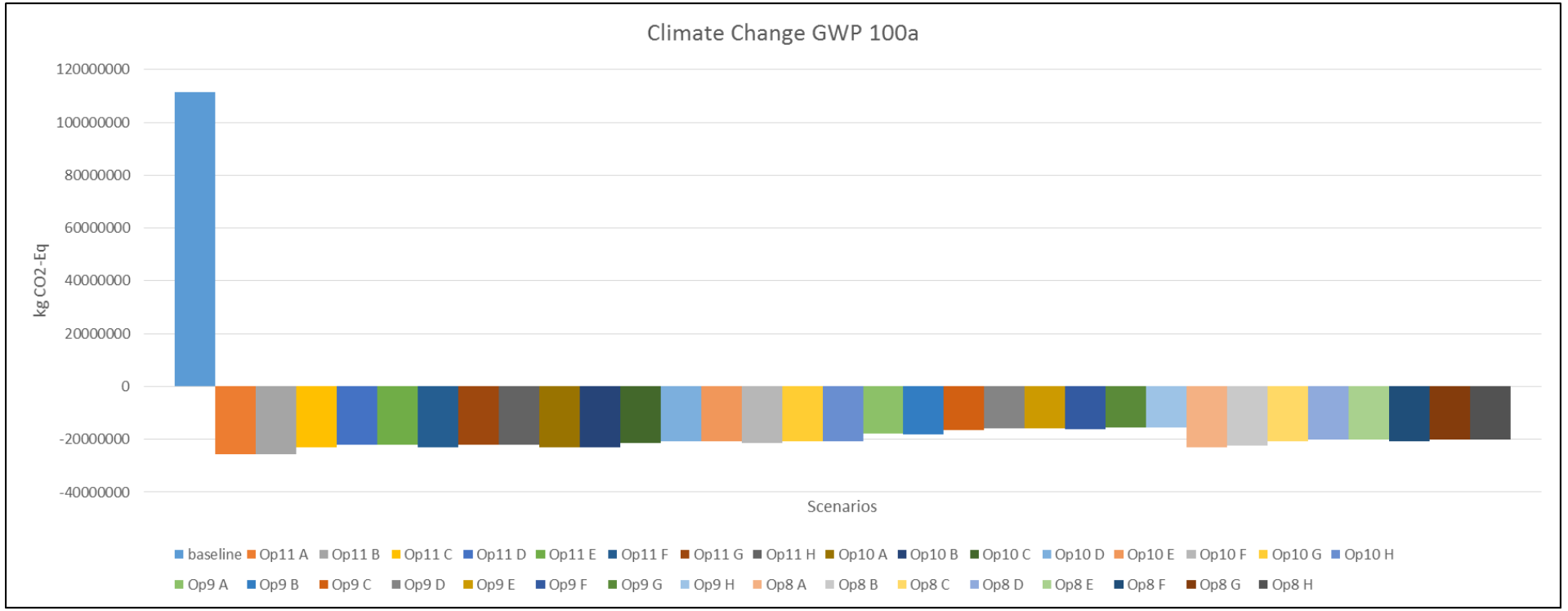


Figure D2
Combined Scenarios No CHP – Acidification Potential

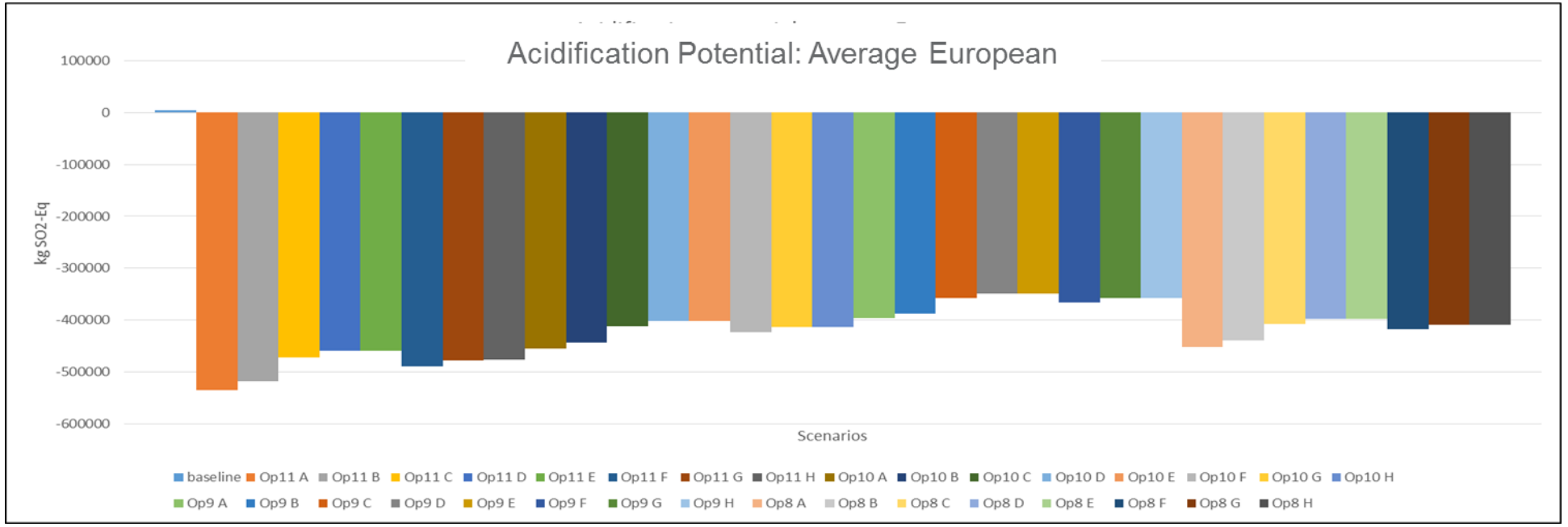


Figure D3
Combined Scenarios No CHP – Eutrophication Potential: Generic

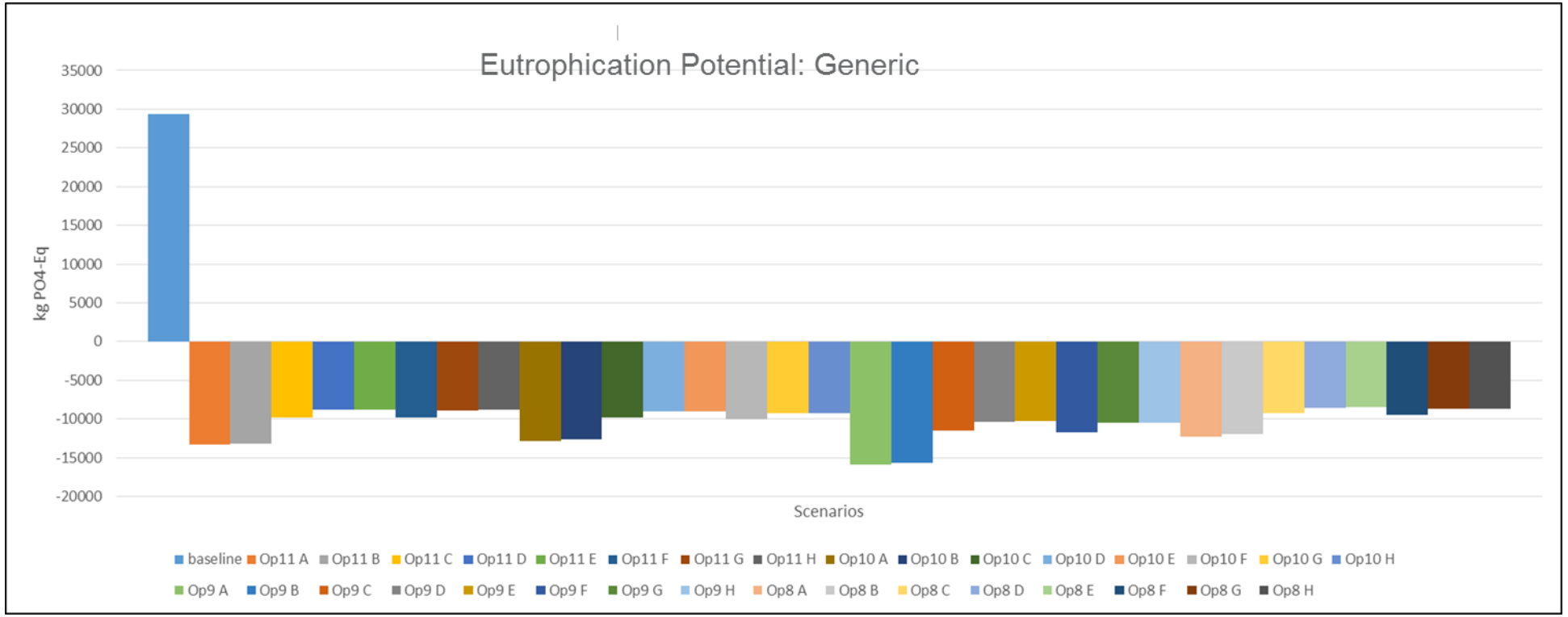


Figure D4
Combined Scenarios No CHP – Freshwater Aquatic Ecotoxicity

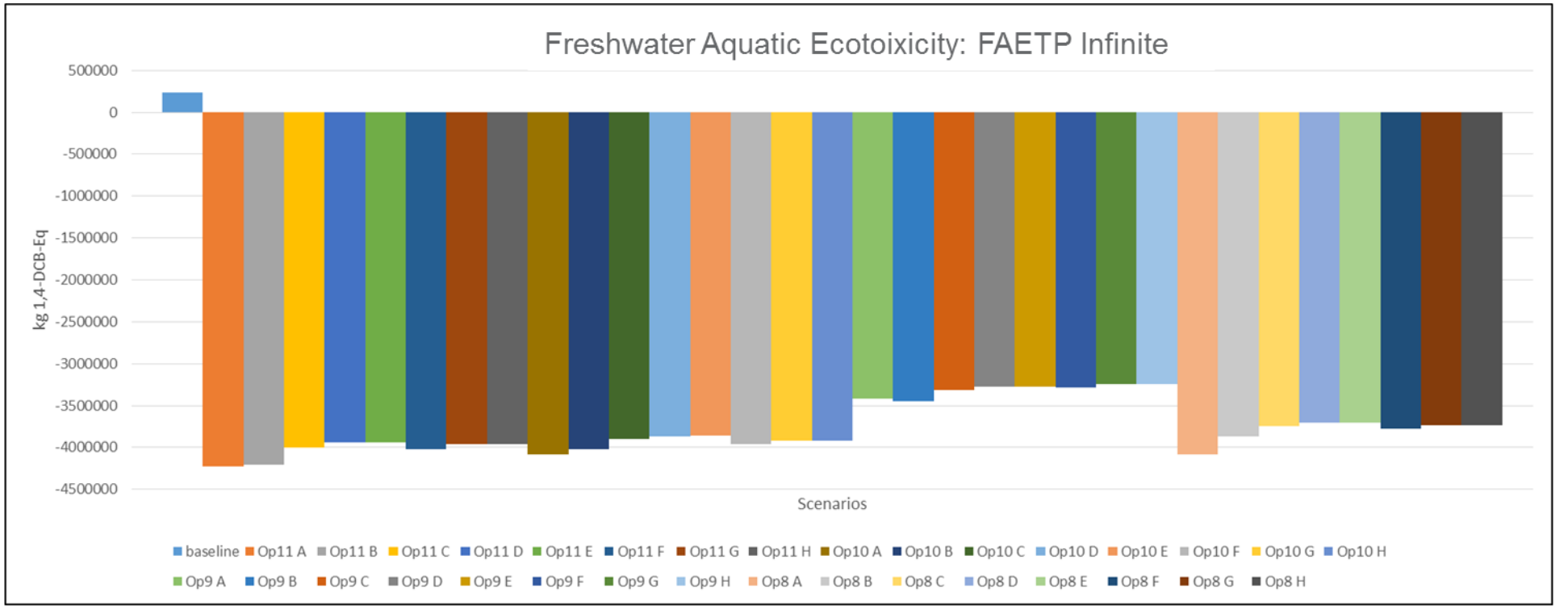


Figure D5
Combined Scenarios No CHP – Human Toxicity

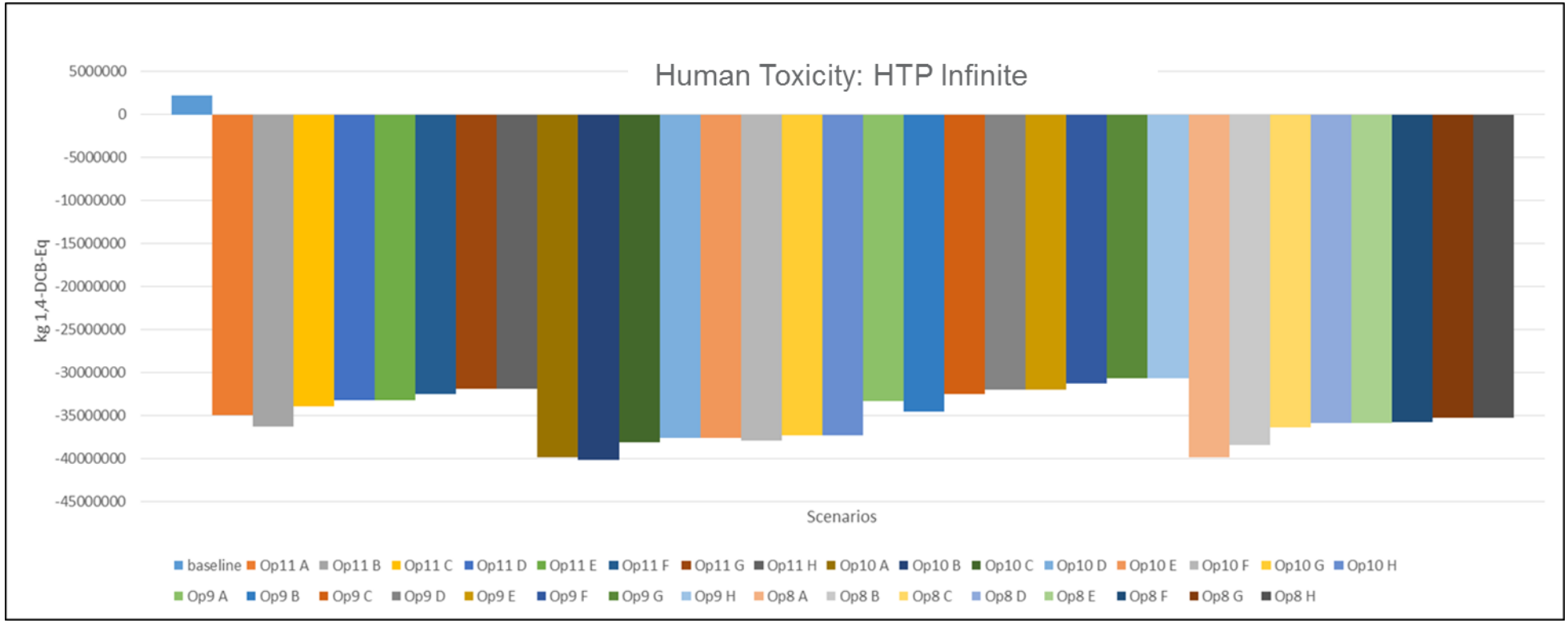


Figure D6
Combined Scenarios No CHP – Depletion of Abiotic Resources

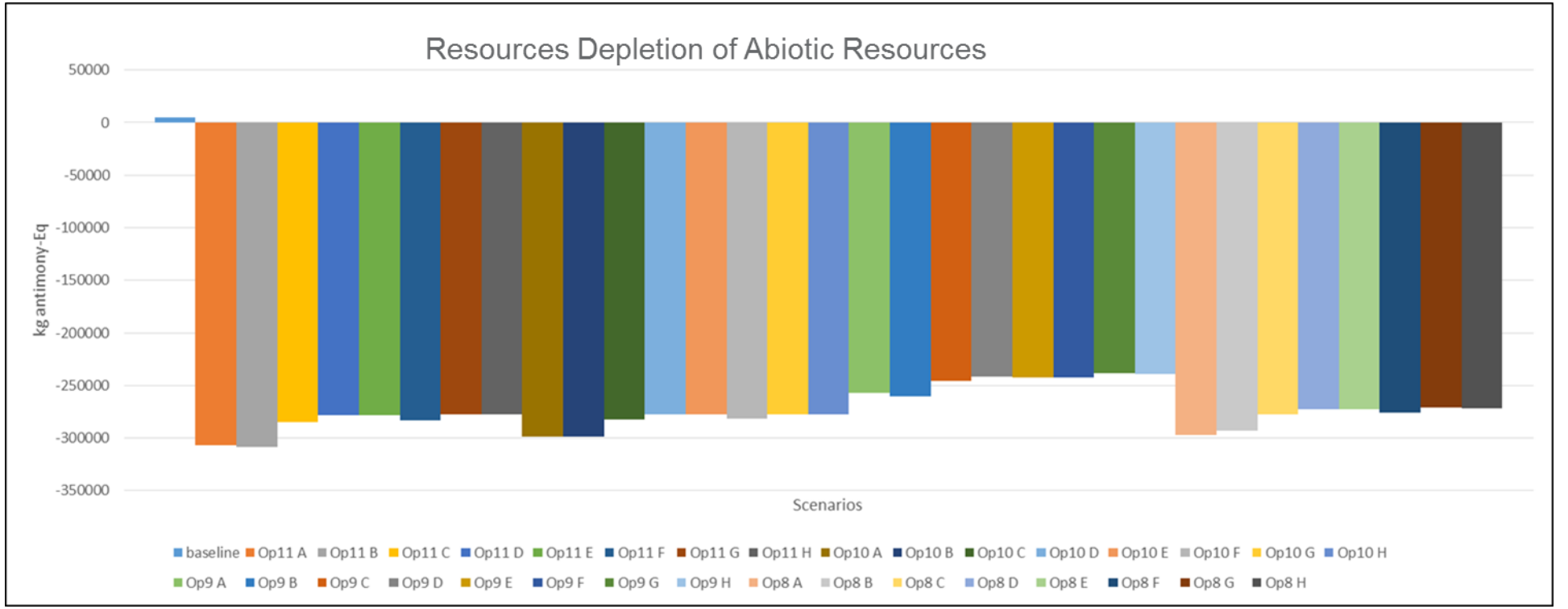


Figure D7
Combined Scenarios With CHP – Climate Change Impact

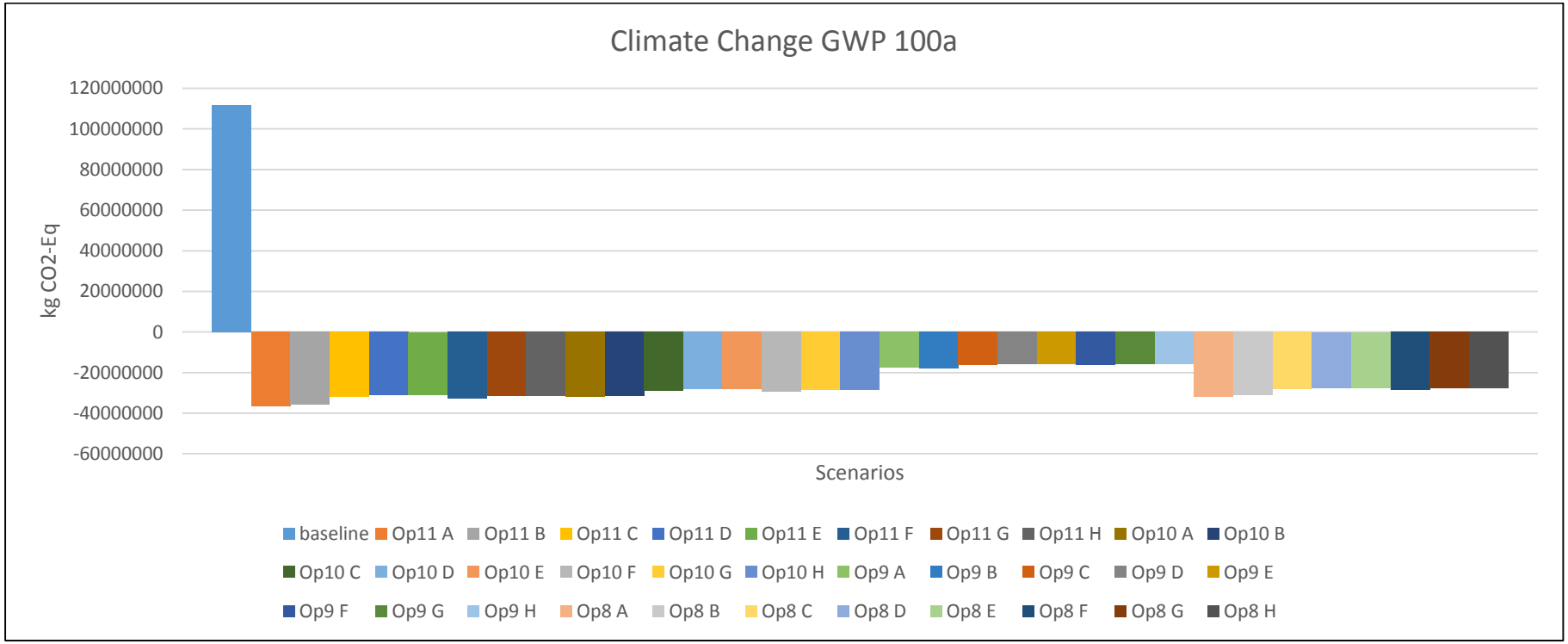


Figure D8
Combined Scenarios With CHP – Acidification Potential

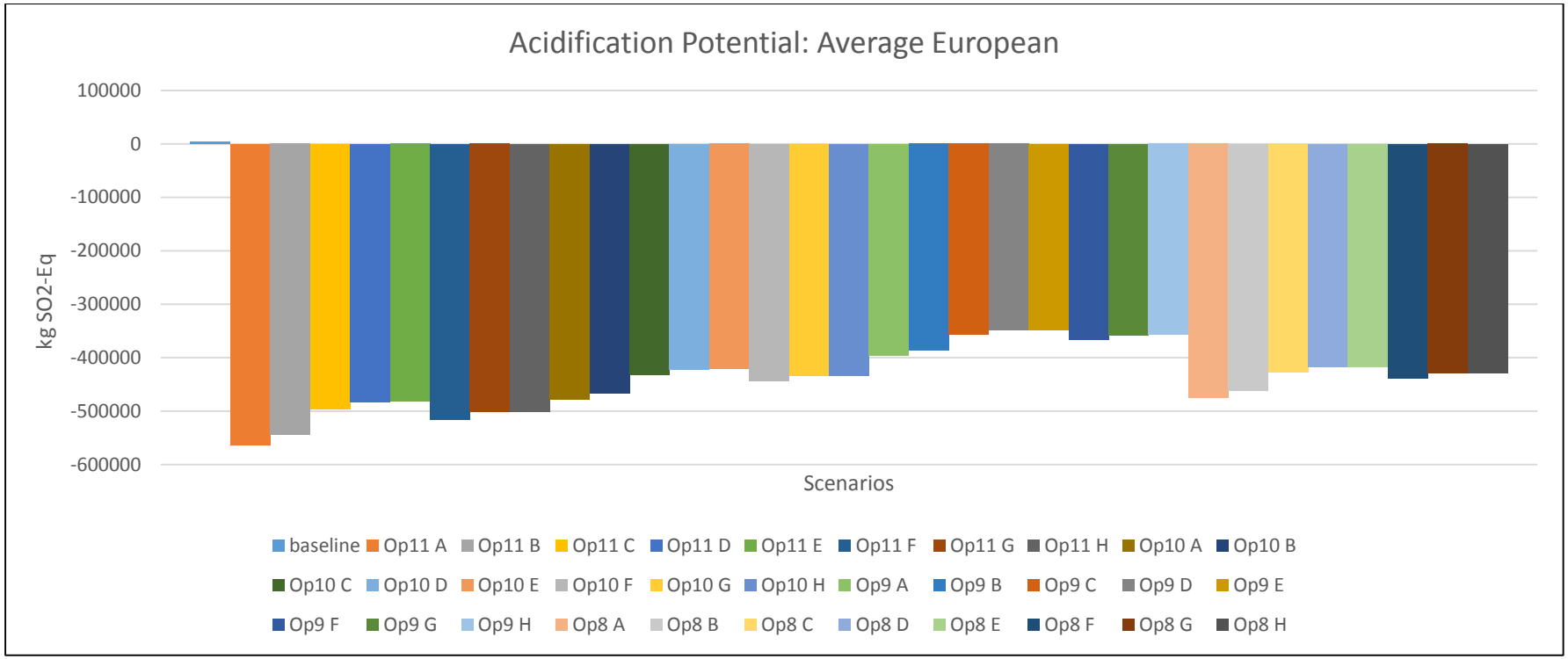


Figure D9
Combined Scenarios With CHP – Eutrophication Potential

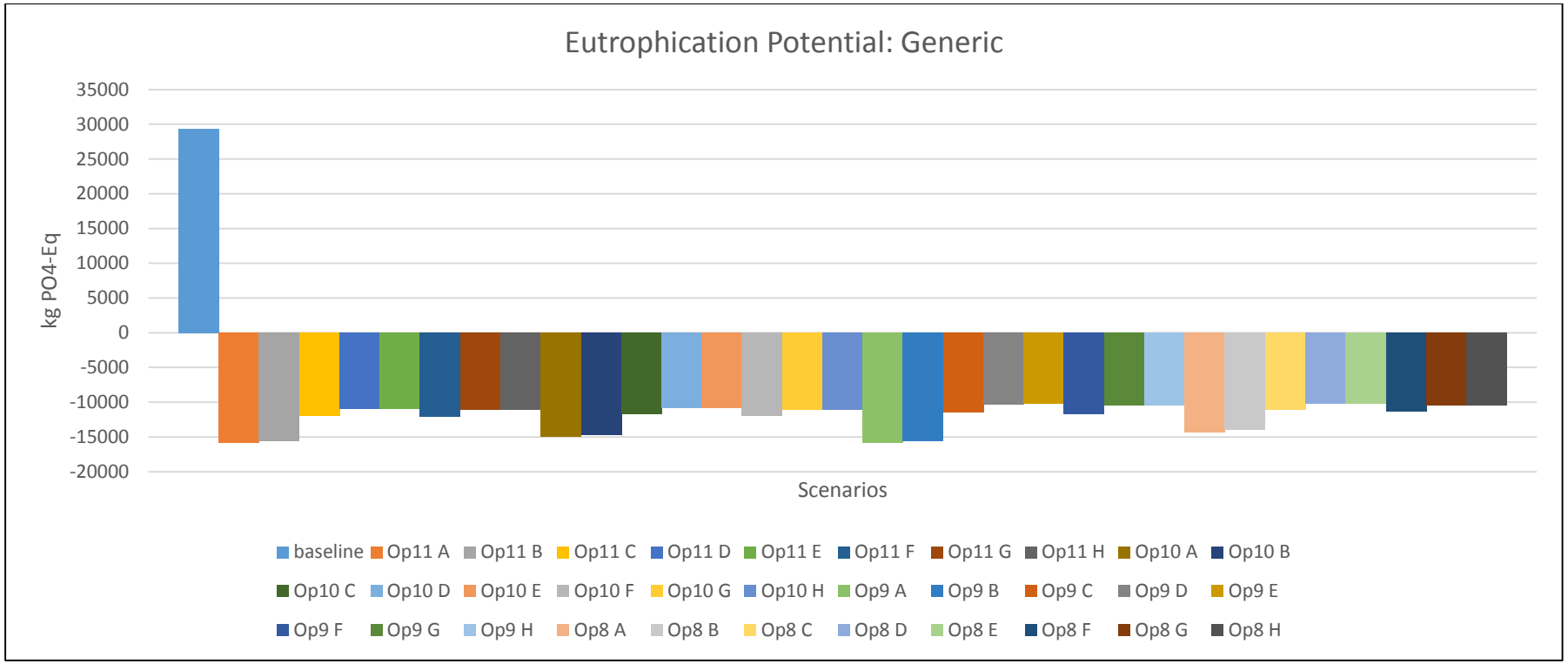


Figure D10
Combined Scenarios With CHP – Freshwater Aquatic Ecotoxicity

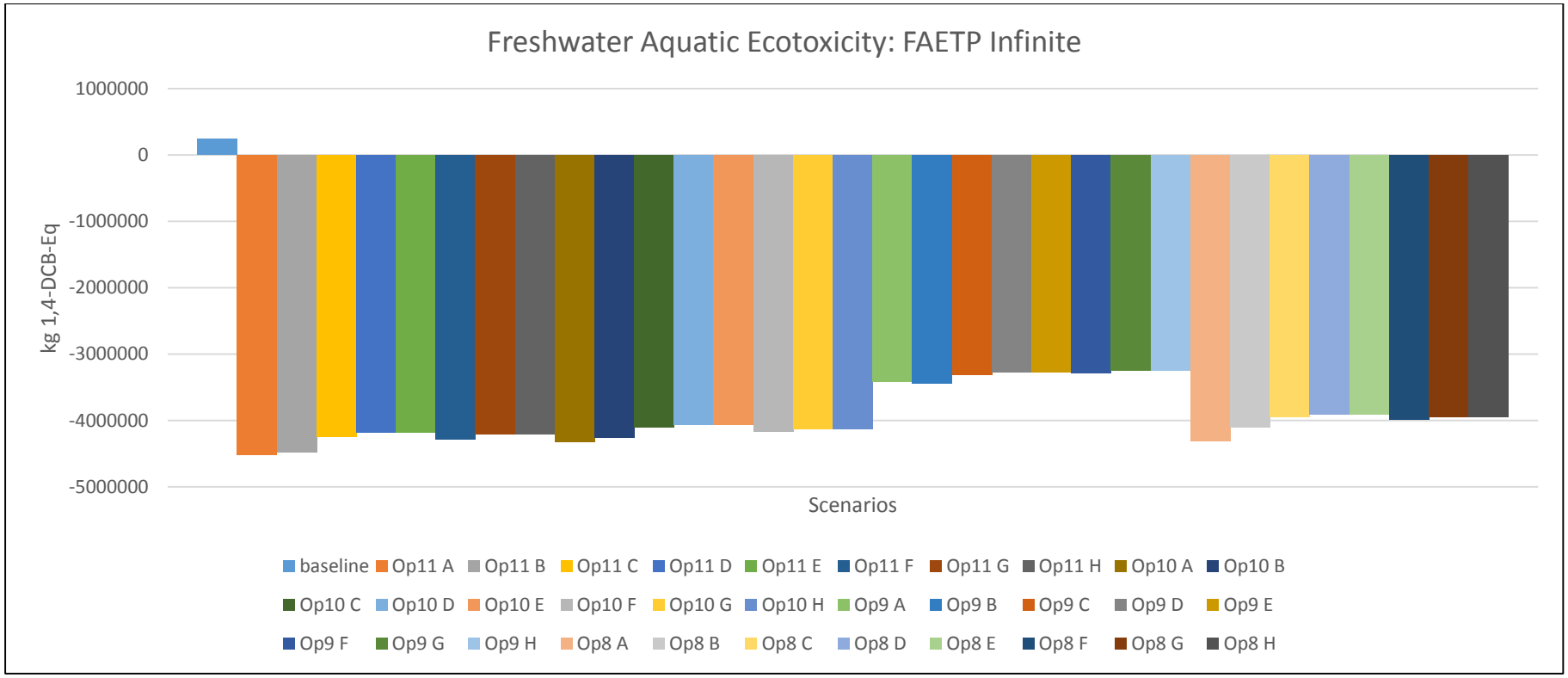


Figure D11
Combined Scenarios With CHP – Human Toxicity

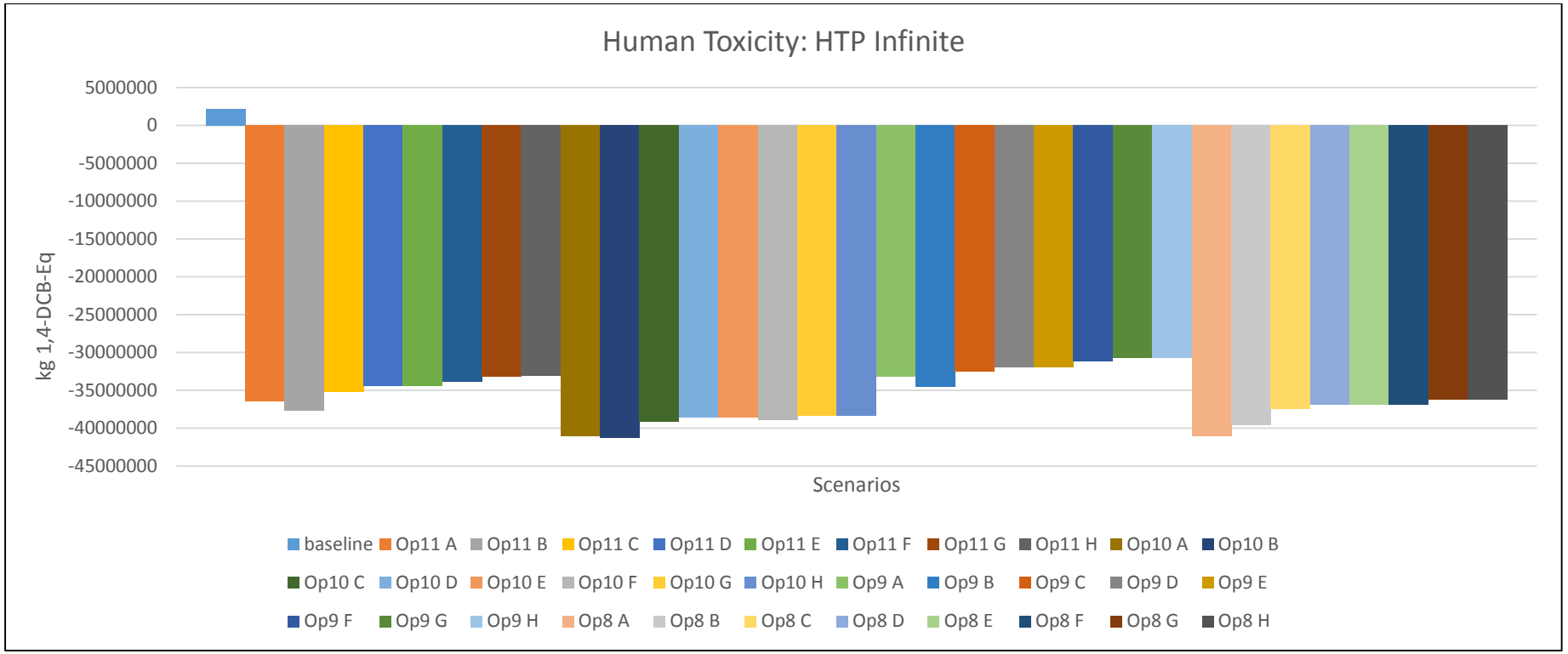
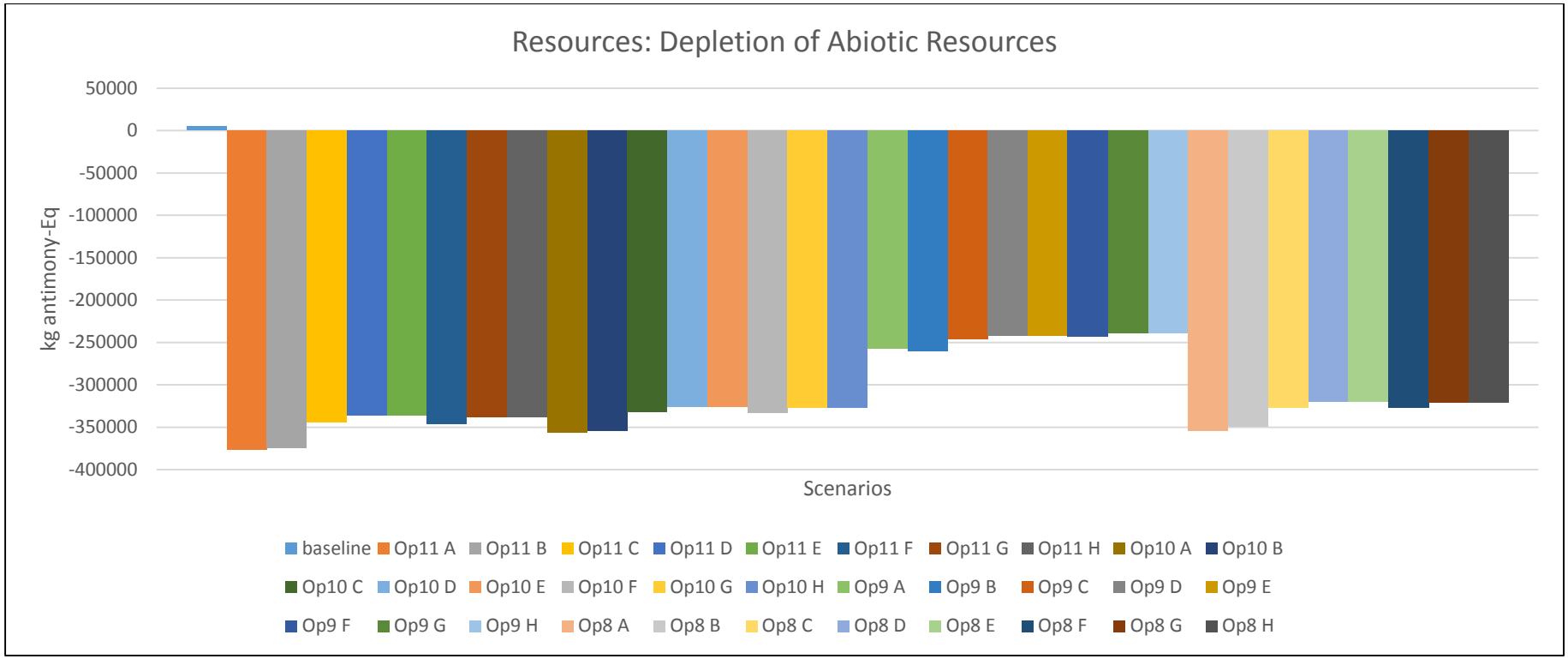


Figure D12
Combined Scenarios With CHP – Depletion of Abiotic Resources



Appendix E
Waste Initiatives

E1 Waste Minimisation Initiatives

Activities, initiatives, programmes and campaigns designed to foster a change in behaviour with the ultimate goal of reducing the amounts and environmental impacts of wastes generated.

E1.1 Prevention and Minimisation

The UK government in 2013 provided a summary of the existing measures that comprised its waste prevention program[1]. These are government activities which aim to, or have resulted in waste prevention. All of the adopted waste prevention initiatives are summarised in the report, ranging from the implementation of levies and taxes, through placing requirements on public and private organisations responsible for managing wastes, to local level funding for waste awareness initiatives. The report itself forms an educational resource that may be used to assist organisations to understanding the context and high level, regulatory initiatives adopted to engrain waste minimisation in the UK.

The different approaches to waste minimisation initiatives can be summarised by the following headlines:

- Measures that can affect the framework conditions related to the generation of waste:
  - Economic instruments, regulations and planning measures to promote the efficient use of resources;
  - Promotion and funding of research into cleaner more resource efficient products and technologies; and
  - Development of effective and meaningful metrics for waste generation and associated environmental impacts.
- Measures that can affect the design and production and distribution phase;
  - Promotion of eco-design (systematic integration of environmental aspects into product design with the aim to improve the environmental performance of the product throughout its whole life cycle);
  - Provision of information on waste prevention techniques to facilitate the implementation of best available techniques by industry;
  - Organisation of training of competent authorities in the application of waste prevention regulations;
  - Measures to discourage waste production at installations not covered by the environmental permitting regulations;
  - Support to businesses through: awareness campaigns; financial support or decision making support;
  - Voluntary agreements, consumer/producer panels or sectoral negotiations; and
  - Promotion of creditable environmental management systems.
- Measures that can affect the consumption and use phase of products and services;
  - Economic instruments as incentives for clean purchases or the introduction of an obligatory payment by consumers for a given article or element of packaging that would otherwise be provided free of charge;
  - Awareness campaigns and information provision directed at the general public or a specific set of consumers;

- Promotion of creditable eco-labels;
- Agreements with industry, such as the use of product panels such as those being carried out within the framework of Integrated Product Policies or with retailers on the availability of waste prevention information and products with a lower environmental impact;
- Integration of environmental and waste prevention criteria into contracts for public services and infrastructure; and
- Promotion of the reuse and/or repair of appropriate discarded products or of their components.

Each of these 16 approaches to waste minimisation have been used to varying degrees in the UK and Europe. Names of the 100+ initiatives that fall under each of the approaches are provided in Table E0.1 below.

Summaries for several of the more significant initiatives are provided here, with further details for all of the identified initiatives being provided in the 2013 Defra report[2].

Table E0.1 Approaches to Waste Minimisation, and examples of Initiatives Adopted in the UK

Measures that can affect the framework conditions related to the generation of waste	
Economic instruments, regulations and planning measures to promote the efficient use of resources	
Aggregates Levy[3]	Landfill Tax[4]
Local waste prevention plans[5]	Producer Responsibility Regulations[6]
Restriction of chemicals use[7]	Resource Security Action Plan[8]
Reuse Credits[9]	Site Waste Management Plans[10]
Hazardous Waste National Policy Statement[11]	Waste Hierarchy[12]
Waste Management Planning[13][14]	Waste Minimisation Act[15]
Promotion and funding of research into cleaner more resource efficient products and technologies	
Action Based Research	Business Resource Efficiency and Waste (BREW) programme[16]
Business Waste Prevention Evidence Review[17]	Defra research on reuse[18][19]
Further benefits of business resource efficiency[20]	Future of manufacturing
Household Waste Prevention Evidence Review	Lifecycle assessment for disposables and reusable nappies
Longer product lifetimes	Product Sustainability Forum
Research on business actions to influence consumer demand for low carbon goods	Sustainable Business Evidence Plan
Innovate UK	Waste and Resources Evidence Plan
WRAP research on the benefits of reuse	WRAP research on waste prevention and resource efficiency
Development of effective and meaningful metrics for waste generation and associated environmental impacts	
Business waste metrics	Waste Prevention and Carbon tool for local authorities
WasteDataFlow and waste statistics	
Measures that can affect the design and production and distribution phase	
Promotion of eco-design (systematic integration of environmental aspects into product design with the aim to improve the environmental performance of the product throughout its whole life cycle)	
Design Specifications and Tools	Designing out waste in construction

Measures that can affect the framework conditions related to the generation of waste	
Ecodesign Directive implementation	Knowledge Transfer Networks
Resource Efficient Business Models (REBus)	
Provision of information on waste prevention techniques to facilitate the implementation of best available techniques by industry	
Environment Agency Sector Plans	Help for businesses on improving resource efficiency
Household Waste Prevention Toolkit	Lifetime optimisation tool
Local waste prevention information aimed at businesses	Reducing hazardous waste
Remanufacturing tools for industry	Waste prevention reviews for business
Organisation of training of competent authorities in the application of waste prevention regulations	
Updated training for Environment Agency Officers	
Measures to discourage waste production at installations not covered by the environmental permitting regulations	
Waste Regulations	
Support to businesses through: awareness campaigns; financial support or decision making support.	
Environment Agency support for business	Farm waste management plans
Local waste minimisation clubs	Standards
Waste Prevention Loan Fund	
Voluntary agreements, consumer/producer panels or sectoral negotiations	
Ashdown Agreement on Plasterboard Waste	Courtauld Commitment on packaging waste & reducing food waste
Food and Drink Federation's Five-fold Environment Ambition	Halving Waste to Landfill
Home Improvement Agreement	Hospitality and Food Service Voluntary Agreement
Pilot product roadmaps	Resource Efficiency Action Plans in the construction sector
Responsibility deal with the direct marketing sector	Sustainable Clothing Action Plan
Promotion of creditable environmental management systems	
British Standard BS8555	EMAS

Measures that can affect the framework conditions related to the generation of waste	
ISO 14001	
Measures that can affect the consumption and use phase of products and services	
Economic instruments as incentives for clean purchases or the introduction of an obligatory payment by consumers for a given article or element of packaging that would otherwise be provided free of charge	
Charges for single use plastic carrier bags	
Awareness campaigns and information provision directed at the general public or a specific set of consumers	
Community Waste Prevention Funds	European Week for Waste Reduction
Food date-marking guidance	Fresher for longer campaign
Greener Living Fund	Local authority initiatives
Love Food Hate Waste campaign	Nesta Waste Reduction Challenge prize
Reusable (Real) Nappies campaigns	SWAP NOW Project
Training for Community Waste Advisers	Zero Waste Places Initiative
Promotion of creditable eco-labels	
European Union Ecolabel	Green Claims Guidance
Agreements with industry, such as the use of product panels such as those being carried out within the framework of Integrated Product Policies or with retailers on the availability of waste prevention information and products with a lower environmental impact	
Included above under 'Voluntary agreements, consumer/producer panels or sectoral negotiations'	
Integration of environmental and waste prevention criteria into contracts for public services and infrastructure	
Government Buying Standards	Greening Government Commitment
Sustainable Procurement - Training Programme	Sustainable Public Procurement - Flexible Framework
Promotion of the reuse and/or repair of appropriate discarded products or of their components	
Carpet reuse	Consumer protection legislation
Furniture Reuse organisations and frameworks	Local authority Bulky Waste Collections
London Olympics 2012	Promotion of reuse activities by local authorities
Reuse and repair events	Reuse at Household Waste Recycling Centres
Reuse Forum	Reuse Networks

Measures that can affect the framework conditions related to the generation of waste	
Reward and Recognition Fund[21]	WRAP guidance to local authorities and their partners for improving the reuse of household bulky waste

E1.2 Measures That Can Affect the Framework Conditions Related to the Generation of Waste

Economic instruments, regulations and planning measures to promote the efficient use of resources

Charges on misused resources

Aggregates Levy

The Aggregates Levy is a tax on rock, sand and gravel which has been commercially exploited in the UK and put to use as an aggregate. It was introduced in 2002 and is currently charged at £2 per tonne of aggregate.

The levy aims to address some of the environmental damage caused by the extraction and transportation of aggregate, namely noise, dust, loss of visual amenity and loss of biodiversity. Through its exemptions the levy also looks to incentivise the use of recycled aggregates and by-product or waste materials from non-aggregate extraction. Thereby shifting demand away from the use of quarried aggregates i.e. non-renewable, natural resources.

Landfill Tax

Introduced in 1996, Landfill Tax is the main driver to push waste up the hierarchy towards more sustainable waste management options such as recycling, composting and ultimately prevention. The tax is payable for each tonne of waste sent to landfill with a lower rate for solid inert waste and a higher rate for all other wastes.

Landfill Tax incentivises minimisation of the amount of waste produced and disposed. Each year since 2011 the Tax has increased, rising from £24 per tonne in 2007 to the current (2015) rate of £82.60 per tonne. A floor has been placed underneath this rate so it will not fall below £80 per tonne until at least 2020, thus providing some cost stability to the waste management sector.

Credits for improved use of resources

Reuse credits

In the UK waste collection and disposal authorities can pay credits to third parties who collect or reuse household waste. The purpose of the scheme is to make the savings in disposal and collection costs which result from recycling household waste available to third parties, including charitable organisations.

This option has been taken up by some local authorities, for example, Devon's local authorities support the community sector through the provision of reuse credits. The community sector has developed a network of "Refurnish" shops at which repaired items are resold to the public with lower prices for those on low incomes. There is also a large workshop where the long-term unemployed and those with learning difficulties are trained to repair goods.

Producer responsibility regulations

WEEE Directive

The Waste Electronic and Electrical Equipment (WEEE) Directive seeks to minimise the amount of WEEE being generated and to promote the reuse, recycling and other forms of recovery. This is achieved primarily by requiring the manufacturers of EEE to part fund the management of WEEE.

Batteries Directive

The Batteries Directive (2006/66/EC) aims to minimise the negative impacts of batteries and accumulators on the environment and increase battery recycling rates. It also prohibits the marketing of some batteries containing hazardous substances, and prohibits the disposal of automotive & industrial batteries into landfill and by incineration.

End of Life Vehicles Directive

The ELV Directive (2000/53/EC) aims to make the dismantling and recycling of end of life vehicles more environmentally sound. It sets clear quantified targets for reuse, recycling and recovery of vehicles and their components.

Packaging

The UK has a statutory producer responsibility regime for packaging which places an obligation on businesses that make or use packaging to ensure that a proportion of the packaging they place on the market is recovered and recycled, fulfilling the requirements of the EU Packaging and Packaging Waste Directive. The scheme is controlled through the issuing of Packaging Recovery Notes (PRNs) which are generated by recyclers when they recycle packaging waste. PRNs can then be purchased to enable producers to meet their obligations. Being a weight based system incentivises light-weighting and packaging removal as any reduction in packaging lowers the recycling obligation, requiring fewer PRNs.

Responsible management regulations

REACH is a European Union Regulation concerning the Registration, Evaluation, Authorisation and restriction of Chemicals. REACH has several aims in relation to waste prevention including protection of human health and the environment from the use of chemicals and promoting the use of alternative methods for assessing the hazardous properties of substances.

Resource plans

Local waste prevention plans

A number of local authorities have developed and published their own waste prevention programmes or plans to drive waste prevention activities in their local areas. Some local authorities are working together, often through formal waste partnerships, to deliver waste prevention activities. Examples include:

- North London Waste Prevention Plan (2012-2014)[22];
- Municipal Waste Prevention Strategy for West London (2011-2015)[23]; and
- Merseyside Waste Prevention Plan (2011-2015)[24].

Resource security action plan

The Resource Security Action Plan: Making the most of valuable materials, published in March 2012[25] provides a framework for business action to address resource risks, and sets out high level actions to build on the developing partnership between government and businesses to address resource concerns.

Site waste management plans

Site waste management plans were a requirement for all construction projects in England over £300,000. The aim of the initiative was to encourage the effective management of materials by ensuring that waste was considered at all stages of a construction project, from the design stage right through to completion. The initiative ran between 2008 and 2013, when the regulations were repealed through a later initiative to remove regulations that were either ineffective or held back growth. In response to the consultation, many respondents said they would continue to use the plans on a voluntary basis.

National policies

In the UK local authorities must have regard to the relevant national policy documents when preparing waste plans and taking decisions on applications for infrastructure developments. Which in turn requires developers to align their proposed developments with national policy statements.

Waste management planning

There are two national planning policy documents which must be taken into account when preparing waste plans and taking decisions on waste applications.

The national planning policy on waste[26]. This states that the overall objective of Government policy on waste is to protect human health and the environment by producing less waste and by using it as a resource wherever possible in line with the Waste Hierarchy.

The second policy document is the National Planning Policy Framework[27] which sets out how minimising waste and pollution can contribute to protecting and enhancing our natural, built and historic environment, with waste management being identified as one of the key strategic priorities for local authority plan making.

Hazardous waste national policy

The Hazardous Waste National Policy Statement sets out the strategic need and justification of Government policy for the provision of nationally significant hazardous waste infrastructure. It will be used to guide decisions made by the Planning Inspectorate.

Waste hierarchy

The waste hierarchy ranks the various approaches to managing wastes and gives preference to the techniques that are least environmentally damaging and most resource efficient.

Businesses and organisations that produce or handle waste must take reasonable measures to prevent waste and apply the waste hierarchy when transferring waste. The waste hierarchy is also incorporated into the environmental permitting regime. Conditions in new and revised permits (for activities that have the potential to affect the environment) place a duty on the permit holder to apply the hierarchy.

Waste minimisation act

In the UK, there had been uncertainty on whether local authorities could legally develop projects or initiatives specifically designed to reduce the quantity of waste produced in their areas. The waste minimisation act provided legal clarity which enabled local authorities to take action to reduce waste produced in their area, but did not introduce any statutory duties or waste minimisation targets.

Promotion and funding of research into cleaner more resource efficient products and technologies

Evidence strategy

Waste and Resources Evidence Plan

The development of strategies in the UK are required to be based on evidence of the efficacy of the strategy options considered. The Waste and Resources Evidence Plan[28] sets out the waste and resources evidence priorities for the period 2013/14 - 2017/18. Resource and waste management contributing to sustainable economic growth is a key policy outcome for the Waste Programme, and waste prevention is the top, near-term evidence priority identified. Evidence work on waste prevention is viewed in the context of wider resource efficiency.

Funding for research

Action Based Research

The ABR programme focussed on seeding and developing the practical application of new ideas and projects looking at waste prevention and resource efficiency from a number of angles. For example one project explored the barriers and benefits of a Product Service System, where the consumer purchases the use or utility of a product, while the producer retains ownership of the product itself.

Research on reuse

This Defra funded report[29] looked into the social aspect of reuse and the monetary value of socio-economic benefits. The review showed that in England about 1,000 third sector organisations (such as charities) were responsible for diverting around 500,000 tonnes of waste from landfill per year, and that most organisations do undertake waste minimisation activities. It quoted a £5.98 return for every £1 invested by local authorities.

Future of manufacturing

This report[30] took a long term and strategic look at manufacturing out to 2050, to:

- Identify and analyse important drivers of change affecting the UK manufacturing sector;
- Identify important challenges and opportunities that lie ahead and which require action by government and industry; and
- Advise how government policy needs to be re-focussed and re-balanced so that it is better positioned to support the growth and resilience of UK manufacturing over coming decades.

The aim of this report was to inform further development of the government's industrial and sector strategies. The report identifies sustainable and green technologies as being important for future manufacturing activities, such as those that deliver improved environmental performance of products or those that minimise the use of hazardous substances. It also sets out a three stage shift to sustainable manufacturing following a move to a more circular economy.

Lifecycle assessment for disposable and reusable nappies

This research, funded through several government initiatives, assessed the environmental impacts of disposable and reuseable nappies. The key finding was that the impacts for reusable nappies are highly dependent on the way they are laundered with consumers' behaviour after purchase determining most of the impacts from reusable nappies.

Funding for advice

Business Resource Efficiency and Waste programme

The BREW programme was designed to incentivise businesses to reduce the amount of waste they send to landfill, and also to assist them in developing ways to achieve this. Two of the initiatives funded were:

- Envirowise which offered businesses free, independent, confidential advice and support on practical ways to increase profits, minimise waste and reduce environmental impact; and
- The National Industrial Symbiosis Programme (NISP) that aimed to help waste materials be used as an input material for another industry.

Household Waste Prevention Evidence Review

This Defra commissioned review[31] looked at how which waste prevention is practised at the household level; what the barriers and motivations are; and what options and measures exist to encourage waste prevention behaviour, either by engaging directly with households or through the products and services provided to them (including waste collection services). The review contains further examples of existing activities.

Business Waste Prevention Evidence Review

This second Defra commissioned review[32] mapped and collated the available evidence on business waste prevention. Six sectors (construction & demolition, food & drink, hospitality, retail, automotive and office-based services) were selected, but within these businesses a broad range of activities, products, materials, services and approaches were covered. This review also contains further examples of existing activities.

Longer product lifetimes

Two evidence studies looked at the potential for reducing environmental impacts (including waste) through longer product lifetimes. The first report included assessment of the environmental, social and economic impacts of a range of policy options and their potential effectiveness in achieving this goal[33], and the second report looked at public attitudes to longer product lifetime[34].

Sustainable Business Evidence Plan

The Sustainable Business evidence programme[35] works with partners across government, business and civil society to improve the integration of social, environmental and economic drivers to build a sustainable approach to growth.

The programme comprises a range of primary and secondary research to understand consumption behaviours and approaches to encourage a shift to a more circular economy. This includes a range of innovative action based research projects focussed on delivering business resource efficiency.

Innovate UK

The aim of Innovate UK[36] is to: fund, support and connect innovative businesses to accelerate sustainable economic growth.

Sustainable economic growth encompasses waste minimisation, and the organisation (under a previous name) made funding available for feasibility studies into the re-design of products, components and systems to retain material within the economy over several cycles of use. Other circular economy themed funding competitions have been for:

- Materials innovation for a sustainable economy. To invest in innovative collaborative research and development encouraging the development and application of sustainable materials, products and processes; and
- Design Challenges for a circular economy. That invested in collaborative research and development to encourage companies to rethink the design of products, components and/or

services, with the potential to reduce their environmental impact by a factor of four. Thus stimulating development of a 'circular economy,' using materials which are designed to be used again, rather than ending up as waste.

WRAP research projects

The Waste and Resources Action Programme (WRAP)[37] have commissioned and undertaken a significant number of studies covering a wide range of topics - all in relation to waste minimisation and resource efficiency. Project range from food waste prevention and consumer research on reuse and repair, to resource efficient business models. Pilot projects are often used to test techniques, with reports made available to businesses and local authorities in the UK.

Development of effective and meaningful metrics for waste generation and associated environmental impacts

Business waste metrics

The Business Waste Prevention Evidence Review (noted above) examined and mapped the metrics used to quantify waste prevention in the business waste context. The Review identified the following learning points for best practice in measuring waste prevention:

- Ensure that savings are attributed according to whether savings were implemented and the extent to which the initiative was responsible;
- Ensure ease of comparison by developing common metrics and following common assumptions and methodologies for calculating them; and
- Ensure that metrics are credible to business by keeping them appropriate and simple, and by reporting the financial impacts that are observed by business.

WasteDataFlow

This web based data system replaced a number of traditional waste management surveys. The system allows local authorities to report essential information on the waste they manage and provides a single comprehensive data return which can be used to monitor progress against household waste recycling target which is a the requirement of the revised Waste Framework Directive requirement.

E1.3 Measures That Can Affect the Design and Production and Distribution Phase

Promotion of eco-design (systematic integration of environmental aspects into product design with the aim to improve the environmental performance of the product throughout its whole life cycle)

Implementation of the Ecodesign Directive

The UK's Ecodesign for Energy-related Products Regulations aims to improve the environmental performance of products throughout the life-cycle, by integration of environmental aspects at a very early stage in product design.

Knowledge Transfer Networks

Knowledge Transfer Networks are designed to stimulate innovation through higher levels of research and development and knowledge transfer. Overall the Networks aim to improve and quicken knowledge exchange between businesses, and between businesses and academic institutions. There are currently 15 Knowledge Transfer Networks, including the Environmental Sustainability Network which covers resource efficiency and waste management. The 'eco-i net' network aims to support the creation, research,

development and commercialisation of existing and new eco-innovative products, services and technologies working across the full innovation cycle.

Provision of information on waste prevention techniques to facilitate the implementation of best available Techniques by industry

Help for businesses on improving resource efficiency

The Waste and Resources Action Programme (WRAP) developed a range of tools and publications to help businesses use resources more efficiently, reduce waste, and save money. These tools include:

- An interactive tour of typical business premises that highlights opportunities for resource efficiency in the workplace. The examples used in the "Green Town" tool are: a pub, a restaurant, an office, hotel and a factory;
- A free online training course accredited by the Chartered Institution of Waste Management targeted for small and medium-sized enterprises/ organisations, "On course for zero waste";
- Waste hierarchy tool, with which businesses can generate their own tailored publication designed to help them understand the waste hierarchy;
- An online toolkit designed to help local authorities prioritise and plan waste prevention activities. The "Household waste prevention toolkit" is structured to enable local authority officers to either work through a step-by-step process and develop their own waste prevention plan, or to access to information on waste prevention activities, through the provision of advice, case studies, checklists and templates. The tool acts as a central point bringing together good practice gathered from local experience and includes a facility which allows the application of local data to develop business cases with quantitative predictions of waste reduction and financial savings; and
- An online tool to help retailers, brands, buyer and/or designers understand the ‘optimum life’ of products and identify where the greatest environmental savings can be made. By analysing different scenarios the "Lifetime optimisation tool" illustrates whether life extension or manufacturing a new product would be more beneficial, and how long a new product should be used to have less impacts than the original.

Local waste prevention information aimed at businesses

A number of local authorities in the UK have chosen to support businesses through guidance and advice on resource efficiency and managing waste in their region. Examples include; Leeds City Council who produced a Business Waste Handbook (funded by the Environment Agency and available to businesses in all 22 local authority areas of Yorkshire and the Humber) and North London Waste Authority which has produced a waste prevention booklet aimed at businesses in their area.

Chemical Stakeholder Forum

The Forum produced a pamphlet which provides an accessible introduction to the process of substitution, i.e. the replacement of a substance, process, product or service by another that maintains the same functionality. Substitution aims to reduce the negative impacts on human health and the environment and improve resource efficiency over the whole life cycle of the replacement.

Organise training of competent authorities, application of waste prevention regulations

Formal training for Environment Agency Officers

Environment Agency officers who regulate waste facilities undergo a six month programme of mandatory training and accompanied site visits before they are assessed for their warrants. Initial training is followed by 18 months of on the job development which is assessed to ensure that officers understand the legislative

requirements and can advise the businesses they regulate. This development programme is independently assessed and endorsed by the Chartered Institution of Wastes Management (CIWM).

Measures to discourage waste production at installations not covered by the Environmental permitting regulations

Waste Regulations

The Regulations contain a general provision that requires all establishments to apply the waste hierarchy to the recovery and disposal of waste.

Support to businesses through: awareness campaigns; financial support or decision making support.

The perception in the UK is that these types of measures are likely to be particularly effective where they are aimed at and adapted to small and medium sized enterprise (SME = fewer than 250 employees). The ultimate aim of all of these initiatives is to reduce the amount of wastes generated, and to minimise the environmental impact of the wastes that continue to be produced.

Environment Agency support for business

The UK Environment Agency have developed and made available two tools to assist SMEs and public bodies, these are:

- A software tool (WRATE) to model the environmental impacts of an organisation's activities - including waste management impacts; and
- The Resource Efficiency Appraisal Development (READ) set of tools which can be used to benchmark how well businesses and organisations manage resources such as materials, waste and packaging.

Farm waste (and resource) management tools

The UK Environment Agency (in conjunction with several other funding bodies and technical experts), have provided several tools to help farmers understand and manage the nutrient balances for their production processes. These freely available software tools include:

- A nitrogen calculator, to estimate the nitrogen content of manures produced by pigs and poultry. The ENCASH tool allows for different types of housed production methods, specific dietary input and a range of manure management systems. Nitrogen application to land is controlled in the UK to prevent damage to water resources;
- The MANNER-NPK software which provides a quick estimate of the crop availability and fate of nitrogen, phosphate and potash from applications of organic manure. The tool can also be used to provide estimates of the financial value of organic manure application relative to current fertiliser prices; and
- Nutrient plans for individual fields are supported by the PLANET software. This tool can be used to calculate fertilizer recommendations for the major nutrients and lime, and for most agricultural and horticultural crops, and allows nutrient application plans to be updated during the growing season.

Management plans of this type are one way of helping to improve the efficiency of farm businesses, helping them to reduce waste, avoid fertiliser overuse and save money, as well as helping to comply with environmental management standards. Nutrient management plans help ensure the best use is made of inorganic fertilisers and maximises the benefit of nutrients in organic manures applied to the soil. While crop protection plans can help to optimise pesticide use while minimising their environmental impact.

Waste standard

The Waste Standard aims to recognise and encourage organisations that take a best practice approach to measuring and managing their solid and hazardous waste, achieving real reductions in waste streams year-on-year, or demonstrating that waste is being dealt with more effectively, for example through increased recovery, recycling or reuse. The certification provides a framework for organisations to enhance their operational sustainability, improving resource efficiency at the same time as cutting costs[38].

Financial support to develop resource efficient business models

The Waste Prevention Loan Fund was set up to support organisations to develop innovative, more resource-efficient ways of doing business. The remit of the fund was to support both commercial and third sector businesses to:

- Pilot innovation in their business model to reduce the products and resources consumed;
- Increase capacity for reuse and repair; and
- Develop new ideas to prevent waste.

Voluntary agreements, consumer/producer panels or sectoral negotiations

Courtauld Commitment on packaging waste & reducing food waste

The Courtauld Commitment is a voluntary agreement by business to reduce packaging waste.

Over 40 signatories (90% of the packaging sector) signed up for Phase 1 which ran between 2005 and March 2010. It had three targets:

- An absolute halt in packaging growth by 2008;
- An absolute reduction in packaging waste by 2010; and
- A reduction in household food waste of 155,000 tonnes by 2010.

Phase 2 which ran between 2010 and 2012, began the move from weight-based targets to new metrics which considered wider environmental impacts. This phase aimed to:

- Reduce the weight, increase recycling rates and increase the recycled content of all grocery packaging. Ultimately to reduce the carbon impact of this grocery packaging by 10%;
- Reduce UK household food and drink waste by 4%, through: consumer advice/information, improvements to packaging, better date/storage labelling; and
- Reduce traditional grocery product and packaging waste in the grocery supply chain by 5%.

Phase 3 runs from 2013 to 2015, and aims to further reduce the weight and carbon impact of household food waste, grocery product and packaging waste, both in the home and the UK grocery sector. Targets, against a 2012 baseline, are to:

- Reduce household food and drink waste by 5% - this represents a 9% reduction in real terms to counter the expected increase in food purchased;
- Reduce traditional grocery ingredient, product and packaging waste in the grocery supply chain by 3% - signatories will have to make an 8% reduction in real terms to counter the expected increase in production and sales; and
- Improve packaging design through the supply chain to maximise recycled content as appropriate, improve recyclability and deliver product protection to reduce food waste, while ensuring there is no increase in the carbon impact of packaging – it is anticipated that signatories will have to make a 3% reduction in real terms to counter the expected sales increase.

Food and Drink Federation's Five-fold Environmental Ambition

Running since 2007, the Food and Drink Federation's Five-fold Environmental Ambition includes aiming to:

- Reduce their CO_2 emissions by 20% by 2010 against a 1990 baseline, and to send a clear message about the urgency of the problem by striving towards a 30% reduction by 2020 compared to 1990;
- Send zero food and packaging waste to landfill from 2015;
- Make significant reductions in the levels of packaging reaching households through the Courtauld Commitment;
- Embed environmental standards in members' food transport practices to achieve 'fewer and friendlier' food transport miles; and
- Reduce the environmental and social impacts of the food chain by 20% by 2012 compared with 2002.

Promotion of creditable environmental management systems

EMS

Defra promotes use of EMAS (the EU Eco Management and Audit Scheme), and Environmental Management Systems (EMS) in general. EMS registered organisations are required to monitor their environmental performance and to produce an annual public statement on that performance. Organisations will themselves publicise their registration and certification to the EMS, to demonstrate their environmental credentials.

EMAS has six core indicators including energy efficiency; water; biodiversity; emissions; waste (tonnes) and material efficiency (annual mass-flow of different materials used). Correct implementation of an EMS should see reduced impacts from each of the relevant key indicators year on year.

General promotion of EMS will encourage adoption of alternative management systems, such as BS8555 and ISO 14001, which will result in overall waste management and environmental benefits.

E1.4 Measures That Can Affect the Consumption and Use Phase

Economic instruments as incentives for clean purchases or the institution of an obligatory payment by consumers for a given article or element of packaging that would otherwise be provided free of charge

Charges for single-use plastic carrier bags

A number of retailers in the UK apply a charge to single-use plastic carrier bags. For example, in 2007 M&S introduced a 5p food carrier bag charge, across the UK, with the proceeds from the charge being donated to environmental causes. In 2012/13 M&S used 274 million single-use carrier bags, a reduction of 58% since 2006/07 (657 million) and roughly level with 2011/12 (269 million).

Awareness campaigns and information provision directed at the general public or a specific set of consumers

Community Waste Prevention Funds

Several local authorities offer funding to local organisations to support waste prevention related activities.

For example Cumbria County Council offered a fund to support new and innovative waste prevention initiatives, working directly with the community to encourage the key practices of reduce, reuse and recycle,

and subsequently improving quality of life for the people in Cumbria. Grants of £2,000-£15,000 were offered for activities promoting at least two of the following:

- Decrease municipal waste arisings (e.g. a community composting scheme);
- Increase the amount and range of materials reused and recycled (e.g. a wood reuse scheme);
- Increase the number of households involved in the 3 Rs (reduce, reuse and recycle); and
- Link with wider sustainable benefits, e.g. creating volunteer opportunities.

Food date-marking guidance

Published by Defra in 2011, the aim of the date-marking guidance is to help ensure dates on food packaging are applied consistently, making it easier for consumers to understand. This includes the use of 'use-by' labels when the food could be unsafe after that date versus the 'best-before' date, to indicate when the food is no longer at its best, but is still safe to eat.

Local authority initiatives

There is a wide range of initiatives undertaken by local authorities providing information to local residents on reducing waste. Common subjects covered by these initiatives include; reducing "junk mail", home composting, promoting reusable nappies, furniture reuse schemes via bulky waste collections and civic amenity sites.

For example, North Yorkshire County Council, in partnership with City of York Council, district and borough councils, charity shops and reuse organisations across the area worked together on a reuse campaign 'Choose2Reuse'. The aims of which were to:

- Increase the quantity of good quality donations to charity shops and reuse organisations;
- Encourage more people to buy more pre-owned goods; and
- Increase the number of people involved in volunteering in 'reuse' activities.

Reusable ("Real") Nappies campaigns

There have been several campaigns to promote the use of reusable nappies.

For example, the Women's Environmental Network (WEN) has campaigned since 1989 to raise awareness of the environmental impacts associated with disposable nappies and to promote the use of washable cloth ('real') nappies. WEN developed and established the Real Nappies for London scheme which is now run by London Community Resource Network (LCRN). In partnership with LCRN, WEN also runs a Real Nappy Exchange, which puts buyers and sellers of used real nappies in touch with one another.

Some local authorities offer incentives to encourage the use of reusable nappies to reduce waste arisings and avoid waste management costs. These incentives aim to either reduce the upfront costs to families or enable families to trial examples before investing in this option. Examples of incentives offered include:

- A proportion of cash back (varies subject to waste management costs incurred by the Council) when providing proof of purchase for reusable nappies and accessories for example, Derbyshire County Council has provided a real nappy incentive cash-back scheme whereby a £25 voucher is provided to encourage people to use real nappies;
- Access to trial kits and/or a library of different styles of reusable nappies to test before purchase;
- Free samples to test before purchase;
- An interest free loan or payment scheme to support investment in purchasing reusable nappies; and

- A voucher to provide money off purchasing reusable nappies and accessories, or a nappy laundry service, for example, Devon County Council operates a reusable nappy incentive scheme which allows parents to save 20% on their first purchase of real nappies.

Promotion of creditable eco-labels

European Union Ecolabel

The EU Ecolabel is a flower symbol which can be used by goods and services that meet a set of agreed stringent environmental standards. It is a voluntary scheme designed to provide consumers with better information on the environmental impact of products and enable easy identification of the best performing products. The scheme places emphasis on consumer demand to transform markets, and actively encourages the design, production, marketing and use of products which have a reduced environmental impact during their entire life cycle.

Ecolabel addresses waste prevention in a number of ways including:

- "Fitness for use" criteria;
- Durability requirements (e.g. 2 year guarantees for dishwashers, 5 year lifetime for furniture, 10,000 hours for light bulbs);
- Designing in ease of repair (e.g. 7 years availability of parts for TVs);
- Designing in ease of upgrade (e.g. memory upgrades in PCs);
- Designing in ease of recycling;
- Minimising packaging; and
- Designing easy-to-recycle packaging.

This voluntary approach applies to products and to services and sets demanding environmental criteria so that only a small share of the very best products available on the market actually meets them. UK licensed companies are under no obligation to inform Defra about how many products they sell. Products can be licensed/labelled in another EU country and sold in the UK (and vice versa).

Green Claims Guidance

Environmental (or 'green') claims and labels enable businesses to highlight the environmental impact and qualities of products and services to help consumers make informed buying choices. This includes demonstrating to consumers where efforts have been made to prevent waste to reduce the environmental impact of a product and service compared to similar items on the market.

In 2011, Defra produced a revised Green Claims Guidance and an accompanying 'quick guide' in the form of a pro-active toolkit which advises businesses on how to make clear and accurate environmental claims on products, services and in marketing and advertising, with the aim of helping consumers make more informed judgements about what they buy and prevent misleading claims. In addition to self-declared environmental claims, the guidance also highlights a number of other ways to communicate product environmental information, including through labelling or standardised declaration schemes.

The revision of the guidance notes originally developed in 2003 was in response to increasing confusion around green claims following their growth in number between 2006 and 2007/08, as well as new jargon being used in environmental claims.

The updated Green Claims guidance is designed to make products' environmental claims more robust for the benefit of customers while enabling businesses to keep abreast of a fast-developing market, thus helping to restore public faith in environmental advertising and act as a resource for companies developing more sustainable products.

Agreements with industry, such as the use of product panels such as those being carried out within the framework of Integrated Product Policies or with retailers on the availability of waste prevention information and products with a lower environmental impact

Initiatives categorised by this approach also fall under "Voluntary agreements, consumer/producer panels or sectoral negotiations".

Integration of environmental and waste prevention criteria into contracts for public services and infrastructure

Government Buying Standards

The Government Buying Standards (GBS) are designed to make it easier for government buyers to make sustainable purchases. They include specifications that all government buyers must follow when procuring a range of products; information about sustainable procurement and how to apply it when buying and direct links to websites with lists of products that meet the standards. Many of the criteria in these standards relate to waste prevention. A wide range of items are covered from construction to cleaning products and services, electrical goods to water using products.

Greening Government Commitment

The Greening Government Commitments set ambitious targets for government departments and their agencies. These are designed to: reduce carbon emissions by 25%, reduce waste generated by 25%, buy more sustainable and efficient products by embedding Government Buying Standards into contracts, and reduce water use to best practice benchmarks (by 2015, against a 2009/10 baseline). Transparency is a key factor of these commitments with a promise to report publicly on progress and, in addition, a commitment to transparency on a range of issues such as biodiversity protection on the government estate.

Promotion of the reuse and/or repair of appropriate discarded products or of their components

Carpet reuse

Carpet Recycling UK (CRUK) aims to boost the recovery carpets and carpet tiles in the UK. Projects for carpet tile recycling and reuse include a nationwide collection and recycling take-back programme. This recycling initiative aims to ensure zero goes to landfill by turning old tiles into new flooring products or using them in other recycling initiatives. In 2011, an estimated 750,000 carpet tiles were reused or recycled, representing a landfill diversion rate of 1.4%.

Furniture Reuse Organisations and Networks

There is a wide range of furniture reuse organisations, many of which have drawn together into networks to increase reuse and share best practice.

In general, Furniture Reuse Organisations (FROs) provide opportunities through an increase in repair and reuse of furniture and selected electrical items, and social benefits through increased job and training opportunities in the local area. They also benefit consumers through increased product choice and low cost quality items, as well as helping to increase the product lifetimes of furniture and electrical items.

London 2012 Olympics

A number of sustainability targets were set for the Olympic Games which included;

- Resource efficiency: 80 per cent, by mass, of materials and products brought to site to be returned for reuse in the hire market or reused in a permanent facility off-site;
- Responsible sourcing: No new manufacture of PVC associated with the project and use of HFCs was restricted; 90 per cent, by mass, of new products' manufacturing locations to be disclosed on the Supplier Ethical Data Exchange (Sedex);
- All timber to be in accordance with LOCOG policies with a preference for FSC certification with full chain of custody; and
- Waste management: 90 per cent, by mass, of waste generated on site to be reused, recycled or composted. Zero waste sent direct to landfill.

WRAP guidance to local authorities and their partners for improving the reuse of household bulky waste

The guidance provides information for local authorities on the policy drivers, benefits, options and costs for household waste collection, reuse and recycling; including definitions of bulky waste and advice on how local authorities can work civil society organisations in achieving good rates of reuse and recycling. The guide has been used to run a series of workshops and support projects.

E2 Waste Education Initiatives

E2.1 Introduction

In support of Central Government efforts to reduce the amount of waste generated across the UK, local authorities have devised a range of waste reduction and minimisation initiatives specifically for their areas. Information is most freely available on the local authority run initiatives targeted at householders and school children - in support of the National Curriculum. All of these initiatives involve awareness building, educating residents in the benefits of waste reduction and recycling, and encompass a very wide range of activities.

E2.2 National Publicity Initiatives

Love Food Hate Waste

The Love Food Hate Waste[1] initiative aims to raise awareness of the need to reduce food waste and help householders take action. The programme demonstrates that through adopting straightforward techniques in the home householders can all waste less food.

The initiative is lead in the UK by WRAP (the Waste and Resources Action Program[2]) working with a wide range of partners, including community organisations, chefs, UK Governments, UK businesses, trade bodies and local authorities.

The initiative runs a range of publicity and awareness campaigns, and provides a number of tools to assist with food waste reduction. Several tools are available online including: Find your perfect portion; Savvy Storage; Money Saving App; The naked Truth, and a meal planning tool.

Perfect Portion Plan

Provides advice and practical tips on how to plan, buy and prepare the correct amount of food for your specific requirements.

Savvy Storage

Provides advice and information on the most effective ways to store different types of food.

Money Saving App

This smartphone app allows users to access several tools to help keep track of: food planning; shopping; cooking meals, and making the most of leftovers. Recipe ideas are also available to help use up forgotten foods, and meal leftovers.

The Naked Truth

Provides infographics showing the benefit of food packaging, and the relative environmental impacts from disposing of food waste and packaging waste.

Resource Library

The Resource Library Website allows user to download Love Food Hate Waste materials and information.

[1] http://england.lovefoodhatewaste.com/content/about-us-2
[2] http://www.wrap.org.uk/

Newsletter

"The Bite" newsletter provides regular updates in a tried and tested format, including:

- What Love Food Hate Waste has been up to;
- Food waste news;
- Hints and tips from newsletter readers;
- News about Love Food Hate Waste events; and
- Tasty recipes to try at home.

Recipes

Recipes can be filtered by recipe type (e.g. Great for Kids; Time Savers; Cook Once - Eat Twice), food type (e.g. Meat, Vegetables, Cakes, Salad), and specific ingredients. This facility allows householders to search for a suitable recipe according to the ingredients already in the kitchen.

The initiative runs a series of events across the UK to encourage adoption of food waste reduction techniques. Examples of these 'live' events include: Cascade Training and 10 Cities.

Cascade Training

Training groups of individuals via businesses, councils and community groups, who then pass this information on to others.

Pledges & Displays

The campaign has a presence at local fates and fairs. This includes display stands promoting the 'Love Food Hate Waste' message. Team members encourage visitors to make a personal pledge to "do one thing differently" to help reduce the amount of food waste that they personally produce.

Recycle Now

Recycle Now[3] is the national recycling campaign for England, supported and funded by Government, managed by WRAP and used locally by over 90% of English authorities. They provide advice on why and how to reduce, reuse and recycle unwanted household items.

E2.3 Waste Education for Householders

Examples of initiatives to provide information, educate and change the waste management / disposal behaviour of householders include the initiatives below.

Charity Shop and Reuse Map

The Edinburgh Charity Shop and Reuse Map is a comprehensive guide to donating and buying from charity shops and reuse projects. It provides information on what type of donations each shop or project accepts and how to get in contact with them. Funded by City of Edinburgh Council, and delivered by Changeworks[4] the Map is an on-line resource. Users can enter the type of item that they want to donate or reuse, and the area of the City that they are looking in, the search then returns the details of shops/ projects and businesses that reuse / re-sale that type of item, and map showing the location of the organisation[5].

[3] http://www.recyclenow.com/
[4] http://www.changeworks.org.uk/what-we-do/waste/waste-projects
[5] http://changeworks.proggable.com/

Too Good to Waste

Too Good to Waste is an online guide to practical ways to Reduce, Reuse, Repair and Recycle in Edinburgh, the Lothians and the Scottish Borders[6]. Users can search the database for a large range of household items and consumable products (an A to Z listing is provided). The search then suggests ways to Reduce, Reuse, Repair, Recycle, or responsibly dispose of those items, providing contact details for organisations located in the region that are able to assist.

The initiative is produced by Changeworks and is supported by the City of Edinburgh Council and Scottish Borders Council[7].

The Real Nappy Project

The Real Nappy Project[8] encourages parents in Edinburgh and the Lothians to use reusable nappies instead of disposables. Offering parents expert advice on using cloth nappies at regular "Nappuccino" coffee mornings and community events, and providing trial kits so that parents can try out real nappies before investing in them.

The key benefits of using real nappies are advertised thus:

- Modern cloth nappies are easy to use and will keep your baby comfortable and dry without bringing them into contact with dyes, perfumes or absorbency chemicals. Elasticated legs and waist provide excellent containment; and
- You could also save £500 by using cloth nappies until your child is potty trained – and avoid sending 4,000 disposable nappies to landfill.

"Nappuccino" Coffee Mornings

Are organised monthly at a couple of locations across the region. These offer an informal friendly one-stop event to answer all of a prospective user's questions, and provide the necessary products[9].

Real Nappies Factsheet

The online fact sheet[10] provides potential uses with all of the information they could need to start use, including: details of types, costs, where to buy real nappies and trial kits, and organisations that will provide loans for the purchase of real nappies.

Guide to Using Nappies

This online fact sheet[11] provides further information and an overview to the designs, materials, stages of real nappy use (uses change as the child ages), and suggestions on where to find second hand supplies of real nappies.

Food Waste Collections in Somerset

A project aiming to increase food waste recycling and cut the amount going to landfill was undertaken by Somerset Waste Partnership in March 2015. 115,000 households in selected districts received a food recycling guide[12] and a supply of kitchen caddy liners (caddies having been supplied previously). Stickers providing a reminder that food waste should be recycled were also put on refuse bins.

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[6] http://changeworks.interactive.co.uk/tgtw/frameset.html
[7] http://www.changeworks.org.uk/what-we-do/waste/waste-projects
[8] http://www.changeworks.org.uk/what-we-do/waste/waste-reduction-advice-and-behaviour-change/how-to-reduce-reuse-recycle/real
[9] http://www.changeworks.org.uk/news-and-events/events
[10] http://www.changeworks.org.uk/resources/real-nappies-factsheet
[11] http://www.changeworks.org.uk/sites/default/files/Real_Nappy_Guide.pdf
[12] http://www.somersetwaste.gov.uk/trials/

Rewards for Recycling

This eight month campaign was run by Waste Aware North East[13], to increase the recycling of aerosols, glass jars and hard plastic bottles. Residents using the recycling collections could participate in a chance to win a share of a £10,000 prize fund. The scheme worked by issuing unique stickers to residents that registered on-line to take part in the campaign. Stickers were then placed directly onto items set out for recycling, and each month five residents were selected at random (via their stickered recyclable items) to receive a cash prize.

The campaign was open to 650,000 householders living in the Durham, Gateshead, Northumberland, South Tyneside and Sunderland Council areas, with winners being given the option to keep their prize, or to nominate a community group to receive the cash[14] [15].

E2.4 Waste Education for Schools

Examples of initiatives to provide information, educate and change the waste management / disposal behaviour of school children (and by default their families) include the initiatives below.

Eco-Schools

The Eco-Schools programme is an international initiative designed to encourage whole-school action for the environment by empowering young people to take action towards an economically, socially and environmentally just world. It is an award scheme that accredits schools that make a commitment to continuously improve their environmental performance. It is also a learning resource that raises awareness of environmental and sustainable development issues through activities linked to curricular areas[16] [17].

The programme was developed in 1994 by the Foundation for Environmental Education (FEE), following the UN Conference on Environment and Development (Rio Earth Summit) in 1992, which identified the need to involve young people in finding solutions to environmental and sustainable development challenges at a local level was identified.

Introduced into the UK in 1995, there are now 59 countries throughout the world involved in the Eco-Schools programme. The programme is managed in each country by one organisation affiliated to the FEE.

The scheme has been particularly successful in Scotland because in 2001 involvement in the programme was adopted by the Scottish Executive as a performance measure for one of their national priorities in education "Values and Citizenship". As part of the School Improvement Framework, Local Authorities were asked to report on “the number/percentage of primary and secondary schools within their area that are participating in the Eco-Schools Award or similar accredited environmental award.”

The programme is essentially an Environmental Management System that engages school children of all ages, and involves them in the decision making process. Schools are encouraged to select the environmental topics that they want to focus and improve on (Waste Minimisation, School Grounds, Biodiversity, Energy, Transport, Health and Well-being, Food and the Environment, Water, and Sustaining our World) with Litter being the only 'compulsory' topic.

Schools Against Waste

Schools Against Waste is an interactive online learning programme for Key Stages 1 to 4 which is freely available for schools in the North East of England. The courses on the website are designed for schools working towards environmental awards such as the Eco-Schools programme. On completion students will receive a certificate of achievement for each course completed. The content has been designed to engage

[13] http://www.wasteawarenortheast.org.uk/about
[14] http://www.wasteawarenortheast.org.uk/Rewards-for-Recycling
[15] http://www.recycle-more.co.uk/nerewards/
[16] http://www.eco-schools.org/menu/about/eco-schools-2
[17] http://www.keepscotlandbeautiful.org/media/560023/EcoSchools-Overview.pdf

students and incorporates a dynamic mix of videos, interviews and interactive games to assist and build on the learning process[18].

Finish your food

The Finish your Food project run by Changeworks for Edinburgh City Council[19] is aimed at engaging children and teachers in activities that encourage primary school pupils and their parents to eat all their food. From interactive assemblies to workshops with fun resources like Mr Silly Sausage, the initiative builds in behaviour change and then measures success through food waste audits.

E2.5 Waste Education for Businesses

Examples of initiatives to provide information, educate and change the waste management / disposal behaviour of businesses include the initiatives below.

Tourism Sector

Green Key

The aim of this FEE programme is to develop and manage an eco-label for leisure organisations[20] [21]. There are four goals of programme:

- Environmental education for sustainable development of the owner, staff, stakeholders (suppliers), and clients;
- Reduction of the impacts of the facility;
- Economical management as a reduction of consumption induces a reduction of costs; and
- Marketing strategy with the promotion of the label and the facilities awarded.

Certification to the eco-label requires positive action on the full range of environmental and sustainability issues, including waste minimisation. For example inclusion in the hotel scheme requires actions under the following headings[22]:

- Environmental Management;
- Staff Involvement;
- Guest Information;
- Water;
- Washing and Cleaning;
- Waste;
- Energy;
- Food and Beverage;
- Indoor Environment;
- Parks and Parking Areas;
- Green Activities; and
- Administration.

[18] http://www.schoolsagainstwaste.co.uk/
[19] http://www.changeworks.org.uk/projects/finish-your-food
[20] http://www.fee-international.org/en/menu/programmes/green-key
[21] http://www.green-key.org/
[22] http://www.green-key.org/menu/criteria/hotels/green-key-hotel-application-form-2012-2015-hotels.pdf

Waste Directory North East

This online resource[23] provides a directory of recycling and waste management organisations in the North East of England. The search facility allows users to search by the type of material that they are concerned with, and their postcode. The search returns a list of organisations that can manage that type of item through reuse, recycling or safe disposal. Contact and web site details are then made available to the user, to continue their enquiry directly with the relevant organisation.

This particular directory allows service providers to manage their own profile and directory entry, so reducing the need for administrator oversight.

WRAP

WRAP provide a wide range of information, much of it aimed at helping businesses and organisations prevent and reduce waste generation.

Waste Prevention

WRAP provide a range of online resources to assist businesses with waste reduction[24]. These are predominantly resources for the food and drink retail and manufacturing sectors, including:

- Latest waste data for the UK food and drink supply chain;
- Information on the Courtauld Commitment (voluntary agreement by food and drink producers to reduce waste generation);
- Supplier listing and contact details for reusable packaging organisations; and
- Tools and guidance for design teams to 'design out waste'.

Waste Reduction

A range of resources have been made available to assist organisations reduce[25] the amount of waste they produce, including:

- Guidance and templates for 'recycling on the go' facilities;
- Good practice guidelines for recycling collection systems; and
- Guidance on sustainable procurement practices.

E2.6 Measuring the Efficacy of Waste Education Initiatives

With the aim of waste education initiatives being to change the waste disposal behaviour of householders, the best way to measure the efficacy of an initiative is to measure the types and amounts of waste being disposed of before and after undertaking a specific campaign. However, householders are exposed to a number of waste and environmental awareness initiatives at any one time, so it can be difficult to isolate the effects of an individual campaign. Gross National and Regional data indicate that waste disposal behaviour in the UK is evolving, with more recyclable and compostable materials being collected separately, and a reduction in the overall tonnage of waste collected. But this general trend should be seen with the backdrop of a financial recession, in combination with changes in waste collection regimes as well as waste and environmental awareness initiatives.

[23] http://www.wastedirectoryne.co.uk/
[24] http://www.wrap.org.uk/category/subject/waste-prevention
[25] http://www.wrap.org.uk/category/subject/waste-reduction

One study[26] [27] that was specifically designed to determine the efficacy of different waste education campaigns, was carried out in Greater Manchester with funding assistance from the European Life plus programme. The aim of this study was to determine the efficacy of waste awareness and education campaigns at changing the waste disposal behaviour in several low performing areas of Manchester, which could be described by the headlines 'Deprivation', 'Transience', 'Faith and Culture' and 'Apartments'. Education campaigns were designed to be effective with the householders in each of these types of area, and waste disposal behaviour (waste tonnage and material types) were assessed before and after each campaign.

In the 'Deprivation' area three campaigns were trailed:

- Recycling Rewards - A community based rewards scheme in support of local schools - saw increased participation (%) and increased tonnages of separately collected pulpables (34%), commingled (29%), organics (8%), and produced a reduction in residual waste arisings;
- Celebrating Recycling Achievements - Involving the community to plan and run a family, fun event focused on recycling - saw high levels of attendance and positive changes in behaviour - increased participation (%) and increased tonnages of separately collected pulpables (3%), commingled (8%), organics (24%), and a reduction in residual waste arisings; and
- Business and Community - Established local businesses as key information points in the community - increased participation (%) and increased tonnages of separately collected pulpables (19%), commingled (4%), organics (29%).

In the 'Transience' area three campaigns were trailed:

- Private Rental - Initiated to increase waste prevention, reuse and recycling behaviours in privately rented properties through innovative communication and engagement methods - saw increased participation (%) and increased tonnages of separately collected pulpables (19%), commingled (4%), organics (29%);
- Golden Bin - Encouraged participation by providing targeted rewards delivered through popular social media channels - saw an increase in the levels of awareness in two recycling streams, and a high recall of the campaign at 87%; and
- Recycling Games - Engaged with students in a fun way through the development of a competitive recycling game for use at events - resulted in an increased awareness by 59% and a decrease in barriers to recycling - an increase (88%) in the use of recycling facilities, and 25% of survey respondents claimed to recycle more.

In the 'Faith and Culture' area three campaigns were trailed:

- Faith - Developed to address the problem of low participation where there was a high proportion of a single faith - saw decreases in participation (%) and reduced tonnages of separately collected pulpables (-4%), commingled (-39%), organics (-7%), and a reduction in residual waste arisings;
- Culture - Developed from within the community to incorporate the cultural ideals and sensitivities of those living within it - saw decreases in participation (%) and reduced tonnage of separately collected pulpables (-17%), commingled (-33%), organics (-13%), and an increase in residual waste arisings; and
- Diverse Communities - Working with communities who have a high proportion of households with a mix of different faiths and cultures - resulted in increased participation (%) in collections for pulpables (26%) commingled (10%), organics (18%), and a reduction in residual waste arisings.

[26] http://www.cornerstonedm.co.uk/clients/GMWDA/GMWDA-Review-Brochure/GMWDA-Project-Brochure.html
[27] http://upandforward.recycleforgreatermanchester.com/download-area/

Three campaigns were trailed in 'Apartments':

- Ambassadors - Used resident volunteers to improve communication - saw a quarter of residents change their recycling and waste disposal behaviour;
- Bags and caddies - Provided recycling aids to help store items and carry them to communal facilities - saw a quarter of residents change their waste disposal behaviour following the campaign, 75% recall of the campaign, and an increase in committed recyclers;
- Facilities - Increased participation by improving communal facilities - saw a saw a quarter of residents change their behaviour following the campaign, 75% recall of the campaign, and an increase in committed recyclers; and
- Diverse Communities - Working with communities who have a high proportion of households with a mix of different faiths and cultures - resulted in increased participation (%) in collections for pulpables (26%) commingled (10%), organics (18%), and a reduction in residual waste arisings.

Footnotes for pages E1 to E19. Please note that the footnotes for pages E20 to E26 are appended to individual pages.

[1] DEFRA, 2013, Waste prevention programme Summary of existing measures [Available] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/264904/pb14093-wpp-measures-list-20131211.pdf (05 April 2015)
[2] DEFRA, 2013, Waste prevention programme Summary of existing measures [Available] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/264904/pb14093-wpp-measures-list-20131211.pdf (05 April 2015)
[3] https://www.gov.uk/government/publications/revenue-and-customs-brief-6-2015-reinstatement-of-aggregates-levy-exemptions-exclusions-and-reliefs
[4] https://www.gov.uk/business-tax/landfill-tax
[5] https://www.gov.uk/government/publications/waste-prevention-programme-for-england
[6] https://www.gov.uk/government/publications/2010-to-2015-government-policy-waste-and-recycling/2010-to-2015-government-policy-waste-and-recycling#appendix-7-packaging-waste---producer-responsibility-regimes
[7] http://www.hse.gov.uk/reach/
[8] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69511/pb13719-resource-security-action-plan.pdf
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[13] https://www.gov.uk/government/publications/national-planning-policy-for-waste
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[16] https://www.gov.uk/government/publications/business-resource-efficiency-and-waste-brew-programme
[17] http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=17499
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[19] http://randd.defra.gov.uk/Document.aspx?Document=WR0506_8334_FRP.pdf
[20] http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=2&ProjectID=16943
[21] https://www.gov.uk/household-reward-and-recognition-scheme-guidance-for-local-authorities
[22] http://www.nlwa.gov.uk/docs/nlwa-general-documents-and-plans/2012-14-waste-prevention-plan-final.pdf 6 May 2015]
[23] http://www.hounslow.gov.uk/waste_prevention_strategy_2011_2015.pdf [6 May 2015]

[24] http://www.merseysidewda.gov.uk/wp-content/uploads/2012/10/RESOURCES-Waste-Prevention-SupplReport-L.pdf [6 May 2015]
[25] https://www.gov.uk/government/publications/resource-security-action-plan-making-the-most-of-valuable-materials [6 May 2015]
[26] Planning Policy Statement 10: Planning for Sustainable Waste Management [Available] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/11443/1876202.pdf [07 May 2015]
[27] http://planningguidance.planningportal.gov.uk/ [07 May 2015]
[28] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/221054/pb13932-evidenceplan-waste-resources.pdf
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[33] http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=17047
[34] http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=17254
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[38] http://www.carbontrust.com/client-services/footprinting/footprint-certification/carbon-trust-waste-standard