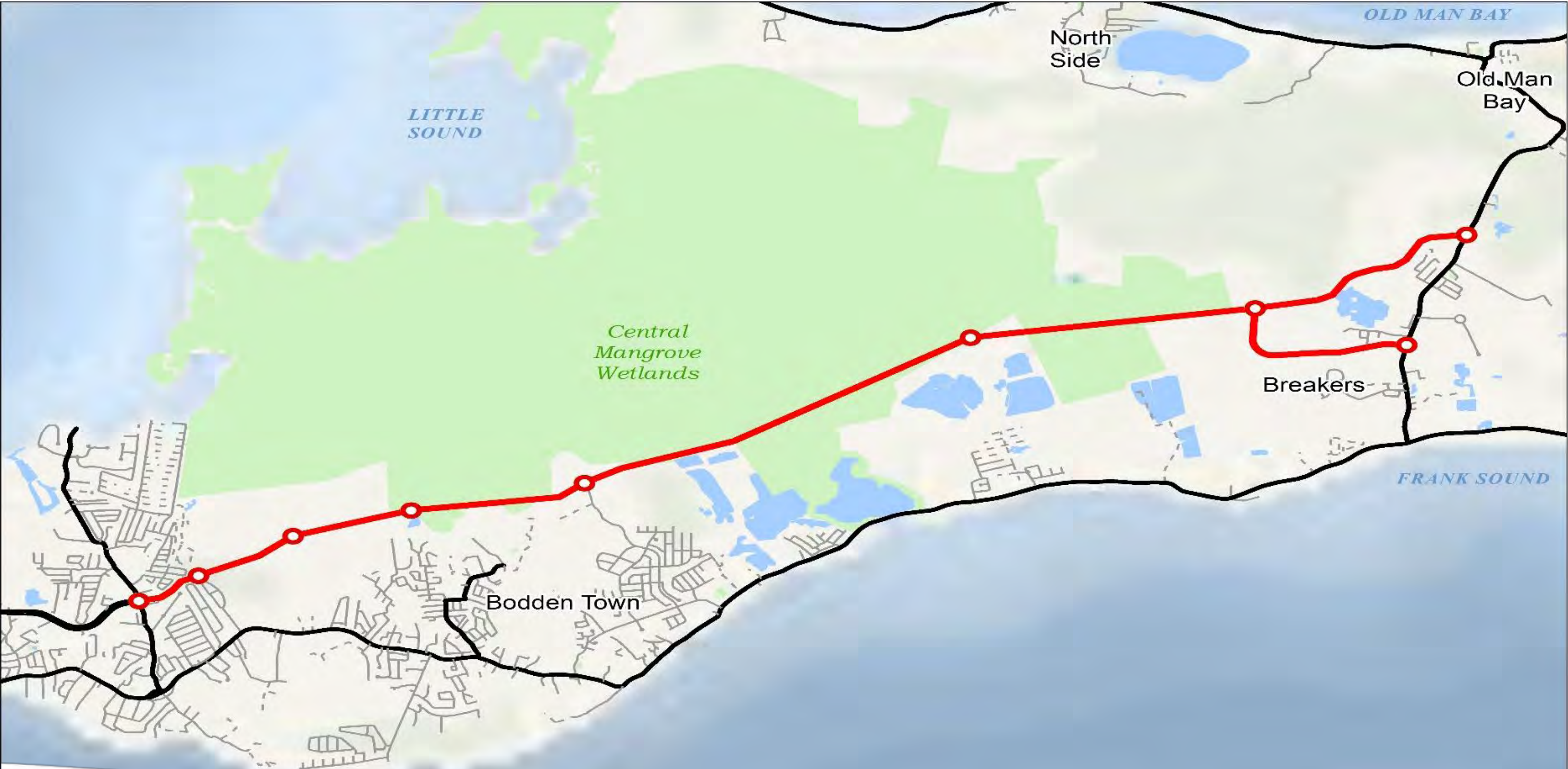

Final Terms of Reference Environmental Impact Assessment for the East-West Arterial Extension:

Section 2 (Woodland Drive – Lookout Road)
Section 3 (Lookout Road – Frank Sound Road)

NATIONAL ROADS AUTHORITY

April 4, 2023

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List of Terms

BNL	Baseline Noise Levels
C	Celsius
CBA	Cost Benefit Analysis
CIEEM	Chartered Institute of Ecology and Environmental Management
CIG	Cayman Islands Government
CM	Centimetres
CO	Carbon Monoxide
CO^2	Carbon Dioxide
Council	National Conservation Council
CPI	Ministry of Commerce, Planning, and Infrastructure
CRTN	Calculation of Road Traffic Noise
CSF	Critical Success Factor
DEH	Department of Environmental Health
DMOY	Do Minimum Opening Year
DMRB	Design Manual for Roads and Bridges: Noise and Vibration Manual
DoE	Department of the Environment
DoP	Department of Planning
DSFY	Do Something Future Year
DTM	Digital Terrain Model
EAB	Environmental Assessment Board
EDGAR	Emissions Database for Global Atmospheric Research
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
ES	Environmental Statement
EWA	East-West Arterial
F	Fahrenheit
FDOT	Florida Department of Transportation
FHWA	Federal Highway Administration
FT	Feet
GHG	Greenhouse Gases
H&H	Hydrologic & Hydraulic
Ha	Hectare
IEMA	Institute of Environmental Management and Assessment
IFC	International Finance Corporation
IPCC	Intergovernmental Panel on Climate Change
KM	Kilometres
KM^2	Square Kilometres
KPH	Kilometres Per Hour
LID	Low Impact Design or Development
LOAEL	Lowest Observable Adverse Effect Level
LOS	Level of Service
M	Metre
Mi	Miles
Mi^2	Square Miles
MPH	Miles Per Hour

NEP	National Energy Policy Unit
NO^2	Nitrogen Dioxide
NOEL	No Observable Effect Level
NRA	National Roads Authority
NRCS	Natural Resources Conservation Service
NTCI	National Trust for the Cayman Islands
SO^2	Sulphur Dioxide
SOAEL	Significant Observable Adverse Effect Level
TDM	Traffic Demand Model
TNM	Traffic Noise Model
ToR	Terms of Reference
TT	Travel Time
TTI	Travel Time Index
UNFCCC	United Nations Framework Convention on Climate Change
VMT	Vehicle Miles Travelled
WAC	Water Authority Cayman
WRA	Whitman, Requardt and Associates, LLP
Yd^3	Cubic Yards

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Appendices

Executive Summary

The National Roads Authority (NRA) is the Government entity responsible for planning, design, construction, and maintenance of public roads on the island of Grand Cayman. In 2022, the NRA acquired the services of Whitman, Requardt & Associates, LLP to perform an Environmental Impact Assessment (EIA) for the East-West Arterial (EWA) Extension, Sections 2 and 3. The corridor is gazetted as an approximate 10-mile (16.09 kilometres [km]), 160-foot-wide (48.77 metres[m]), roadway from Woodland Drive in Bodden Town, to Frank Sound Road in North Side. At its eastern end, the gazetted roadway also includes an 80-foot-wide (24.38 m) southern connector road. The proposed road will:

- Create a highly disaster-resilient “central highway”;
- Serve as an emergency route when coastal roads are compromised;
- Reduce travel times between George Town and East End, North Side and Bodden Town; and,
- Promote public transportation (dedicated bus lines).

The Environmental Assessment Board (EAB), a subcommittee of the National Conservation Council (Council), in accordance with Section 3(13) of the National Conservation Act of 2013, will oversee the preparation and implementation of the EIA. The EAB is chaired by the Director for the Department of Environment (DoE), who is a Council member. The Deputy Director of the DoE and the Director of Planning, also Council members, are statutory members. For this project, other members include the Water Authority Cayman (WAC) and the Public Works Department’s Major Projects Office.

The EIA will undertake the necessary environmental studies for the proposed EWA Extension study area to determine the best location and design for constructing the new highway facility. Avoidance and minimisation efforts will be implemented to reduce impacts to environmental resources, as well as impacts to existing communities and community resources, such as noise and stormwater management. Remaining unavoidable impacts will be identified and mitigated to the greatest extent possible. The assessment will address at a minimum:

- Route Alignment and Assessment of Alternatives;
- Socio-economic Considerations;
- Hydrology and Drainage (including climate resiliency);
- Geo-Environmental;
- Terrestrial Ecology;
- Cultural and Natural Heritage Sites;
- Greenhouse Gas Emissions; and
- Noise and Vibration.

Chapter 1

Proposed East-West Arterial Extension

1 Proposed East-West Arterial Extension

In accordance with the EIA Directive, the DoE issued a Screening Opinion on 12 October 2016 for a 10-mile extension of the East-West Arterial which extended eastward from the Hirst Road intersection to just beyond the Frank Sound Road intersection at what was proposed to be the Ironwood Village and Golf Club intersection. At its Special General Meeting of 26 October 2016, the Council reviewed the Screening Opinion and took a decision to require an EIA of the proposed road extension. The NRA were informed of this requirement.

On 24 September 2019, the Ministry of Commerce, Planning, and Infrastructure (Ministry of CPI) submitted information indicating that they were currently proposing only part of the road previously considered in October 2016 and that the Ministry wished to proceed with the construction of the portion of the East-West Arterial Extension from Hirst Road to Lookout Gardens. At a meeting with NRA and Ministry officials on 22 October 2019 it was agreed that Phase 1 from Hirst Road to Woodland Drive could be constructed prior to the EIA being completed because it is within a densely developed area with minimal environmental concerns and minimal opportunity for amending the design of the route. It was also confirmed on 22 October 2019 that an EIA would need to be conducted for the route from Woodland Drive to Lookout Gardens.

This was endorsed by the Council at its meeting on 30 October 2019 and an EAB was empanelled to guide the EIA. On 19 November 2019, in accordance with the Directive, a Scoping Opinion was issued by the EAB for the portion of road from Woodland Drive to Lookout Gardens. The proponents (the Ministry of Commerce, Planning, and Infrastructure [CPI] and NRA) did not commence an EIA for this portion of the road at that time.

On 9 October 2021, the NRA requested a Scoping Opinion for the proposed East-West Arterial Extension from the Woodland Drive area to Frank Sound Road. This Scoping Opinion was issued on the 5 November 2021 and outlines the likely significant effects of the EWA Extension project which will need to be assessed under the EIA framework. These ToR provide a greater level of detail on the studies and assessments which will be carried out on those identified direct, indirect, and cumulative effects on the natural and developed environment. Establishing measures that will avoid, minimise, and/or mitigate these concerns is a primary objective of the EIA.

1.1 Project Background

1.1.1 Project Description

The EWA Extension comprises three sections. Section 1 extends between Hirst Road and Woodland Drive which is currently under construction. Section 2 as proposed is from Woodland Drive to Lookout Road, and Section 3 as proposed is from Lookout Road to Frank Sound Road. The corridor for Sections 2 and 3 is gazetted as an approximate 10-mile-long (16 km), 160-foot-wide (49 m), roadway from Woodland Drive, in Bodden Town, to Frank Sound Road in North Side. At its eastern end, the gazetted roadway also includes an 80-ft-wide (24 m) southern connecter road.

1.1.2 Need for the Project

The Cayman Islands are made up of three independent islands: Grand Cayman, Little Cayman, and Cayman Brac, situated in the Caribbean Sea west of Jamaica and south of Cuba. Grand Cayman, at roughly 76 square miles (mi2) (197 square-kilometres [km2]) is the largest of the three islands having a population of over 69,000 people, representing roughly 97% of the total Cayman population. The geography of the Cayman Islands is unique, being extremely flat with its highest elevation being 71 ft. (21 m) above sea level.

The Cayman Islands are facing increasing challenges from climate change and sea level rise; particularly, to infrastructure in low lying coastal areas. Existing coastal roads are especially vulnerable and without an alternative travel corridor, portions of Grand Cayman become isolated during a major storm, such as during Hurricane Ivan. Elevating roads has become a standard flood abatement measure; however, doing so requires more right-of-way, which can be a constraint when residential and commercial properties are directly adjacent to the roadway. Transportation resilience is critical for the stability and safety of the population. It will be a major evaluation criterion in the EIA document for all alternatives including the no-build.

With its flat topography and minimal rise above sea level, Grand Cayman is susceptible to climate change and the effects of sea-level rise. During extreme weather events, the lone coastal route, Bodden Town Road, easily becomes compromised and inaccessible, stranding East End residents from accessing goods and services mainly located on the west side of Grand Cayman. In addition, with Bodden Town Road being the only roadway providing access between the east and west districts, it is frequently congested during the morning and evening peak commuting hours.

In May 2005, the proposed EWA Extension corridor **(Figure 1)** was initially planned and gazetted by the NRA in the Cayman Islands Gazette, Extraordinary Supplement, Number 13/2005, in accordance with Section 25 of the Roads Law (2000 Revision), now Section 26 under the Roads Law (2005 Revision). The 2005 EWA Extension corridor, from Hirst Road to Frank Sound Road, was part of the NRA's long-term projection for road infrastructure expansion and network improvements and constituted a modification to the existing Development Plan. The EWA Corridor with Collector Road Connection was published in the Cayman Islands Extraordinary Gazette No 13 of 2005.

The EWA Extension was proposed to provide Grand Cayman with an additional travel route between the districts of North Side/East End and George Town/West Bay to aid in easing the traffic congestion currently experienced on the coastal, two-lane Bodden Town Road. This is especially important for emergency services, enhancing evacuation capability, user delay, and travel time reliability for employment opportunities, equity, and overall quality of life when Bodden Town Road is unpassable or compromised. In addition to operational factors, a multimodal safety component is also important to provide insight into potential safety benefits and/or implications of the EWA Extension.

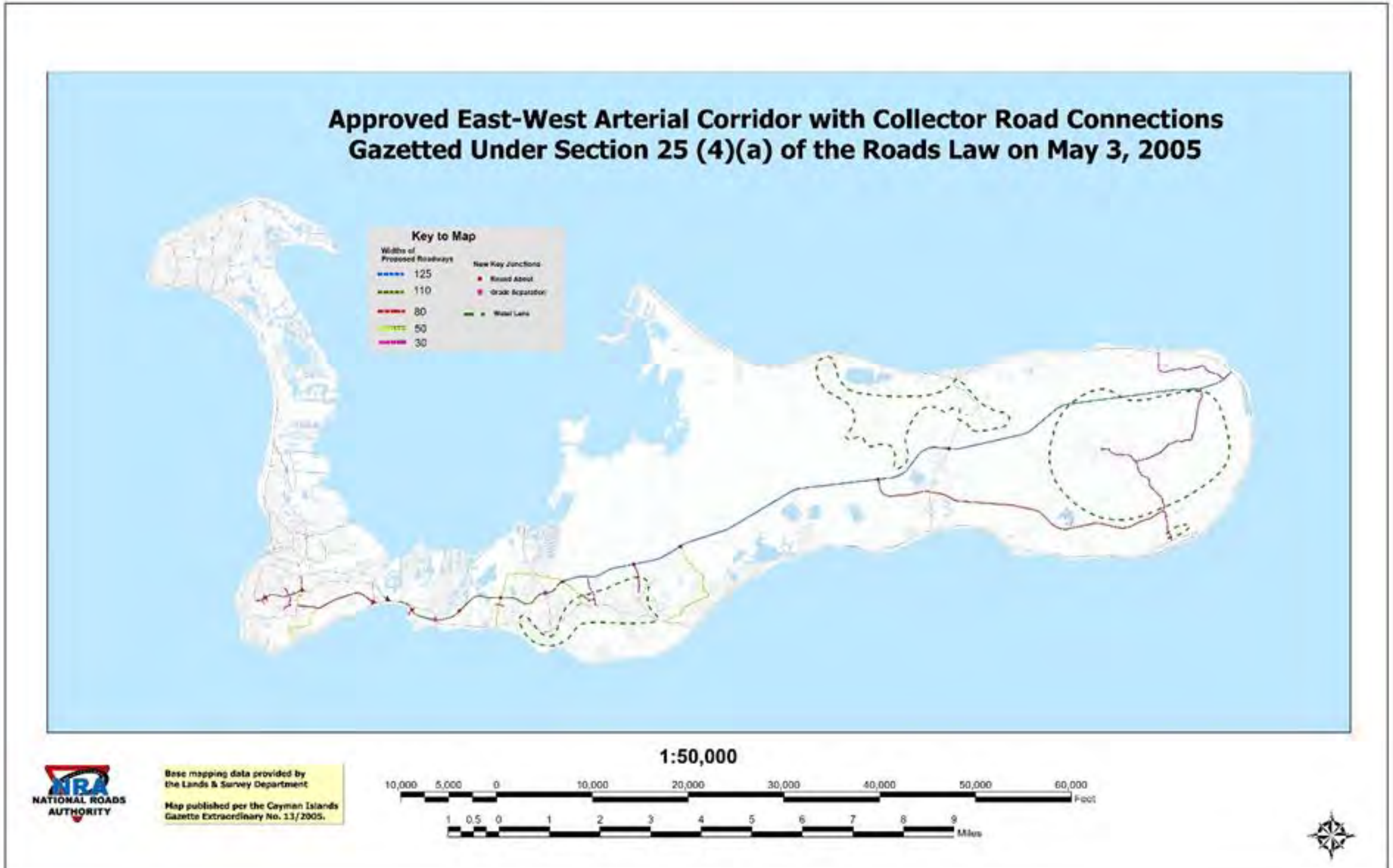

Figure 1: NRA's long-term 2005 plan including EWA Extension

From NRA 2005 Long-term plan

Additionally, the NRA, in their long-term planning, recognized the need for a transportation network that is highly disaster-resilient and climate-resilient. Storm surges combined with wave action have been responsible for much of the roadway damage caused by hurricanes, especially in the low-lying coastal areas. With climate change and sea level rise, hurricanes are only expected to increase in intensity and rainfall, resulting in reoccurring damage to coastal roadways. The EWA Extension would serve as a central and alternative route when low-lying coastal areas are compromised by storm surges.

The United Kingdom defines climate resilience as "the ability to anticipate, prepare for, and respond to hazardous events, trends, or disturbances related to climate (Ramboll, 2022)." Essentially, climate resiliency is the ability to manage and respond to the effects of climate change without further increasing their impacts. Resiliency has three main aspects: **preparation,** which involves building infrastructure and services to withstand the effects of climate change; **adaptation,** which involves the ability for infrastructure and services to respond flexibly to any potential effects; and **recovery**, which involves plans and courses of action to respond to and resolve any negative effects of climate change. In developing the EWA Extension Corridor, consideration will be given to ensure that any development is adequately able to prepare, adapt, and recover from any potential effects of climate change.

1.1.3 Project Study Area

The proposed EWA Extension study area encompasses Section 2, from Woodland Drive to Lookout Road; and Section 3, from Lookout Road to Frank Sound Road within Bodden Town and North Side districts, northwards to North Sound and south to the coastline **(Figure 2).** This area encompasses the initially identified EWA Extension Corridor, which has been gazetted to encompass an area to allow room for future expansions as well as buffer areas. This study area is sufficiently wide enough to allow for the identification of other roadway and multi-modal alternatives. This study area was also established to evaluate potential indirect effects, which are impacts caused by the project, which occur later in time or removed in distance, but are reasonably foreseeable to occur. This area is outlined in red in **Figure 2**. It should be noted that much of the land within the study area and specifically within the direct project footprint is under private ownership.

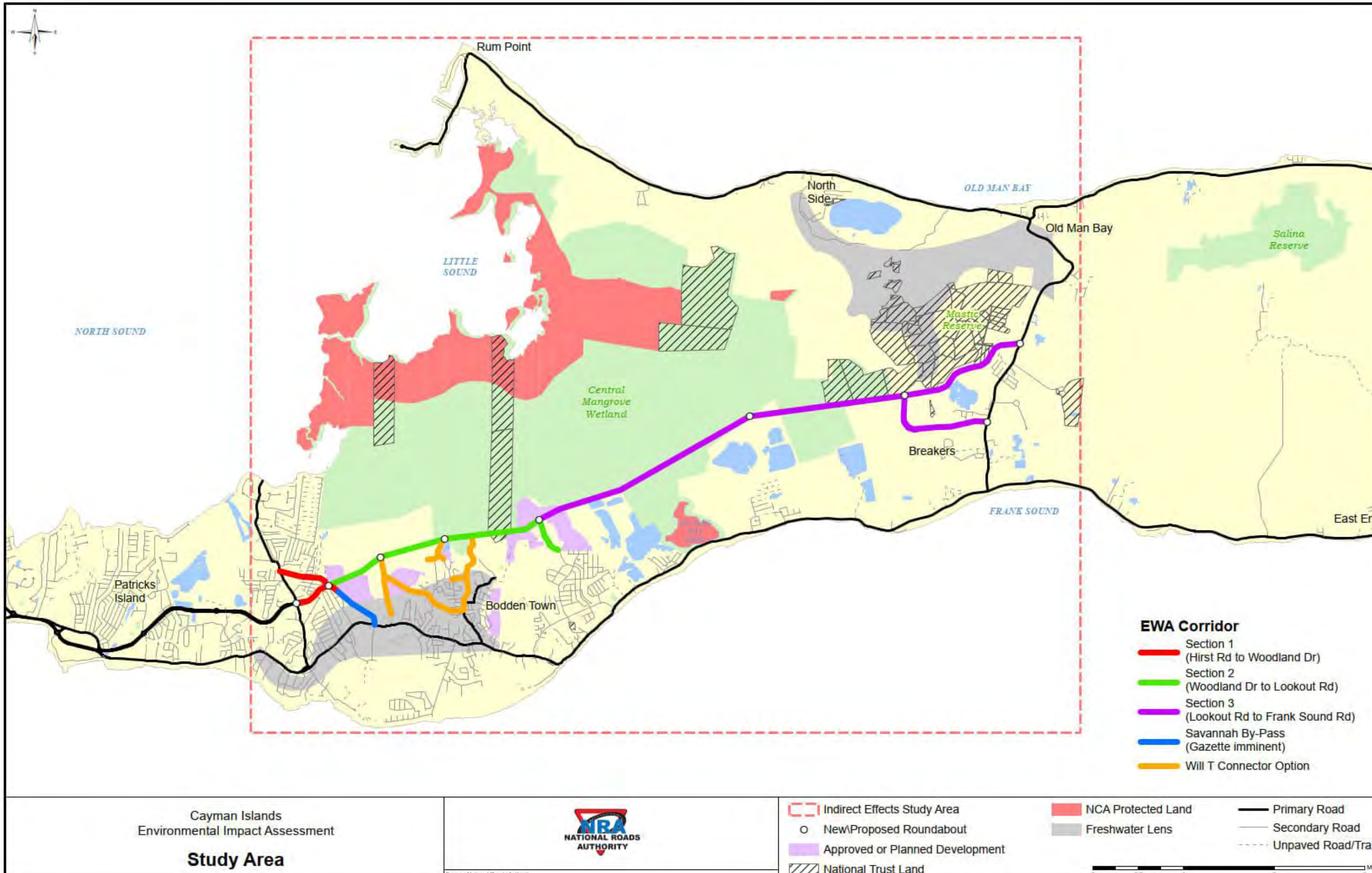

Figure 2: Study area limits established for EWA Extension EIA and associated roadways

1.2 Summary of Current Conditions

1.2.1 Population

The Cayman Islands are made up of three independent islands: Grand Cayman, Little Cayman, and Cayman Brac, situated in the Caribbean west of Jamaica and south of Cuba. Grand Cayman is the largest of the three islands with a population of almost 69,000 people, representing roughly 97 percent (%) of the total population. Cayman Brac and Little Cayman have a population of just over two thousand people, making the total population of the Islands just above 71,000 people (Economic and Statistics Office, 2022).

The Cayman Islands population comprises both Caymanians and non-Caymanians, representing 53.5% and 46.5% of the population, respectively (Economic and Statistics Office, 2022). Of the non-Caymanian population, residents are from 162 different countries and territories from around the world, with the highest percentage of people being born in Jamaica, the Philippines, the United Kingdom, and the United States. Furthermore, a significant number of Caymanians hold dual citizenship in another country, such as the United Kingdom (UK), Jamaica, the United States, and Canada (Economic and Statistics Office, 2022).

The island of Grand Cayman is separated into five districts: West Bay, George Town, Bodden Town, North Side, and East End. George Town is the most populated district of the five, with just under 35,000 residents, followed by the districts of West Bay and Bodden Town, with roughly 15,000 residents in each district. North Side and East End are the least populated districts on Grand Cayman, with under 2,000 residents in each district (Economic and Statistics Office, 2022).

1.2.2 Geography, Wildlife, & Natural Areas

The geography of the Cayman Islands is unique, being primarily flat with limited elevation and they are relatively small, being just under 100 mi^2 (259 km^2) total across the three islands. Grand Cayman's geography is made up of mangroves, forests, and coral reefs. Mangroves comprise approximately 30 mi^2 (78 km^2) or 36% of Grand Cayman's total land area. The Central Mangrove Wetland is a fundamental component to the natural ecosystem of the Cayman Islands. It is home to numerous animal and plant species, such as the native West Indian Whistling Duck, where 83% of the population can be found (Bradley et al, 2004). Mangroves are also essential as a natural defence mechanism reducing the impacts of storm surges or other extreme environmental events, filtering out nutrients, and acting as natural carbon sequesters, removing and storing carbon dioxide from the atmosphere (Alongi, 2012).

There are four species of mangroves that are found on the Cayman Islands: red mangroves, white mangroves, black mangroves, and buttonwood. All four of these species are present in the Central Mangrove Wetland, with each providing different ecological benefits to the ecosystem. The Grand Cayman Parrot is a subspecies of the Cuban Parrot and is one of two endemic parrot species on the Island, the other being the Cayman Brac Parrot. The Grand Cayman Parrot has historically relied on black mangroves for nesting. Older tree trunks within black mangroves develop hollow trunks which are then used by the Grand Cayman Parrot for nesting. This reliance on black mangroves highlights the importance of the Central Mangrove Wetland on the species present on the Island. Sea level rise is a major challenge to Black Mangrove populations in that they depend on shallow seawater habitats with high saline concentrations to which they have uniquely adapted.

Located east of Bodden Town is the protected area of the Meagre Bay Pond. Meagre Bay Pond is a 2.0 mi (3.22 km) pond surrounded by roughly 300 ft. (91.4 m) of mangroves. In 1976, the area was originally designated as an Animal Sanctuary to protect the resident and migratory birds that relied on this area. Following the implementation of the National Conservation Act of 2013, the Meagre Bay Pond was re-designated as a Protected Area, which allowed for the development of a management plan to promote the protection and conservation of the area (DoE, 2020).

Additionally, the Mastic Reserve contains the largest contiguous area of primary dry forest remaining on Grand Cayman and represents one of the last remaining examples of Caribbean subtropical, semi-deciduous dry forests (NTCI, 2022). In 1992, the Mastic Reserve was founded following the donation of 145 acres (58 ha) of land to the National Trust for the purpose of protection and conservation of the old-growth forest and has since grown to 834 acres (338 ha). Prior to its establishment, the area was historically used as a passageway to traverse the many wetlands on the Cayman Islands. In 1995, the passageway was re-established as an official trail, the Mastic Trail, allowing users to experience the natural, undisturbed areas of Grand Cayman (National Trust, 2022).

Like the Central Mangrove Wetland, the Mastic Reserve serves as primary habitat to a variety of plants, and animals. Identified by BirdLife International, the Mastic Reserve is recognized as an Important Bird Area (IBA), providing habitat for threatened and near-threatened bird species such as the Vitelline Warbler, the White-crowned Pigeon, and the Grand Cayman Parrot. Visitors can find these bird species living in the endemic Silver Thatch Palms, Royal Palms, Mahogany, or Cedars. The Reserve is also home to several endemic species, including four reptile species, five butterfly species, and ten plant species, and has the highest level of endemism in the Cayman Islands (Bradley et al., 2004).

Grand Cayman contains four freshwater lenses: the Lower Valley freshwater lens, the North Side freshwater lens, the East End freshwater lens, and the South Sound freshwater lens. They not only provide a stable drinking water and agricultural water source but are also integral to the water flow systems of the Central Mangrove Wetland. While there are four freshwater lenses on Grand Cayman, the Lower Valley and North Side freshwater lenses will be relevant to the EWA Extension. There is a minor possibility for the project to impact the East End freshwater lens; therefore, a review of the potential impacts will be evaluated by the EIA. Sea level rise is also a threat to freshwater by influencing groundwater elevations of seawater.

1.2.3 Roadway Connections

Grand Cayman residents and visitors alike face a variety of mobility and traffic movement issues. Much of the development on Grand Cayman is within George Town and West Bay districts, establishing the districts as the commercial, financial, and tourist hubs. As a result, many residents from East End, North Side, and Bodden Town must commute to George Town and West Bay for work.

Within West Bay, George Town, and Bodden Town there exists a network of local streets, major roadways, and highways connecting the various communities of Grand Cayman. In West Bay, Esterly Tibbetts Highway is a four-lane divided highway connecting southeast West Bay to northern George Town. Within George Town, Linford Pierson Highway, Crewe Road, Shamrock Road, and the existing EWA are the major arterial roadways connecting to other local streets and coastal areas (Google Maps, 2022). Currently, the Linford Pierson Highway is being expanded from two lanes of travel to six lanes, significantly increasing its capacity (NRA, 2022). The existing four-lane EWA begins in the Grand Harbour region of George Town and connects George Town to Poindexter Road; from that point, it is a two-lane divided roadway to Hirst Road.

In place of highway ramp exits to connect to local roads, roundabouts are being used to help maintain the flow of traffic and prevent delays and stoppages. As of January 2022, there were more than two dozen roundabouts on Grand Cayman; many which are three-lane roundabouts. Shamrock Road extends from Grand Harbour in George Town, to just past the Bodden Town Primary School in Bodden Town, where it becomes Bodden Town Road and ultimately, connects to Frank Sound Road. Frank Sound Road is the only centrally located road on Grand Cayman.

Historically, those that resided on the Cayman Islands relied on the sea to make a living, with shipbuilding and fishing being the primary income sources. In the North Side and East End, the network of roadways and transportation infrastructure has been guided by this history and has been localised in coastal areas. The major coastal road begins with Bodden Town Road which travels east along the coast, being renamed several times as Sea View Road, Old Robin Road, and North Side Road, before terminating as Rum Point Road on the north side of the island (Google Maps, 2022). This coastal roadway has only one lane of travel in each direction, greatly limiting the roadway capacity and creating travel issues for the residents of East End, North Side, and Bodden Town, many of whom rely on the coastal roads to commute to work.

In 2022, the NRA conducted traffic modelling to determine the existing roadway and traffic conditions, as well as estimate future traffic conditions because of continued population growth and development, specifically the development of the EWA Extension. The NRA utilized Travel Demand Modelling (TDM) to estimate travel behaviour and demand for the future by using existing travel and population data. The process of TDM incorporates four phases to determine future conditions: trip generation (number of trips estimated), trip distribution (where the trips go), mode choice (how trips are divided among types of travel), and trip assignment (the predicted trip route).

The traffic modelling completed by the NRA found that 47% of registered voters live east of the Grand Harbour neighbourhood and are subjected to heavy AM and PM peak travel period congestion. (NRA, 2022). During the AM peak travel period, traveling from Old Man Bay in North Side to the Government Administration Building in George Town takes roughly 90 to 120 minutes, often with a travel speed between 10 – 15 miles per hour (mph) (16-24 kilometres per hour [kph]). In the PM peak travel period, this route takes roughly 50 to 60 minutes. With the construction of the EWA Extension, it is estimated that the AM peak travel period would be reduced to approximately 60 minutes in 2026. The PM peak travel period is estimated to be reduced to 50 minutes in 2026 (NRA, 2022).

It should be noted that separate from this study, the NRA recognizes the need for improvements to the existing roadways west of the study area. The NRA is actively developing a multimodal improvement plan to reduce congestion, which includes the area between the Tomlinson and Silver Oaks Roundabouts. The potential impacts of this project to areas further west will be addressed as part of secondary and cumulative impacts of this study.

Chapter 2

Environmental Impact Assessment Process

2 Environmental Impact Assessment Process

2.1 Legal Requirements

This section establishes the legislative and policy framework relevant to the Environmental Impact Assessment (EIA) process and the preparation of an Environmental Statement (ES). Relevant policy and legislative frameworks will be utilised to establish the scope of studies and ensure conformity with any existing guidelines and standards.

2.1.1 International Finance Corporation of World Bank Group's Performance Standards on Environmental and Social Sustainability

The International Finance Corporation (IFC), a member of the World Bank Group, developed Performance Standards on Environmental and Social Sustainability. These standards establish baseline requirements for doing business sustainably, creating guidelines for identifying and subsequently addressing potential risks and impacts to environmental and social sustainability. The EIA will utilise these standards where appropriate to properly assess the potential risks.

> *"To provide guidance on how to identify sustainability risks and impacts and are designed to help avoid, mitigate, and manage them as a way of doing business in a more sustainable way."*

2.1.2 Cayman Islands Constitution Order, 2009

The Cayman Islands Constitution Order of 2009 was developed in order to establish the powers and activities of the legislative, executive, and judicial branches of government, as well as the rights of all citizens. Section 18 of this Constitution provides the basis for the legal protection of the environment, and states the following:

> *(1) Government shall, in all its decisions, have due regard to the need to foster and protect an environment that is not harmful to the health or well-being of present and future generations, while promoting justifiable economic and social development.*
>
> *(2) To this end government should adopt reasonable legislative and other measures to protect the heritage and wildlife and the land and sea biodiversity of the Cayman Islands that –*
>
> *(a) limit pollution and ecological degradation;*
>
> *(b) promote conservation and biodiversity; and*
>
> *(c) secure ecologically sustainable development and use of natural resources.*

2.1.3 Environment Charter, 2001

In 2001, the governments of the Cayman Islands and United Kingdom entered into an agreement establishing the responsibilities of each government in the protection and conservation of the environment, known as the Environment Charter. This Charter provides guiding principles for the protection of the environment, and the commitments and responsibilities of each government in ensuring environmental protection.

2.1.4 Public Management and Finance Act, 2020 Revision

The rules and regulations regarding the use of government funds and implementation of government projects by "Statutory Authorities and Government Companies" are established in the Public Management and Finance Law, 2013. This act delineates the differences between 'core government' authorities and 'statutory authorities.'

2.1.5 National Roads Authority Act, 2016 Revision

The National Roads Authority (NRA) was established in July of 2004 to build and maintain the roads in the Cayman Islands. The establishment of the National Roads Authority, as well as the rules, regulations, and responsibilities of the NRA are authorised through the National Roads Authority Act, 2016 Revision.

2.1.6 Roads Act, 2005 Revision

The Roads Law, 2005 Revision, provides guidelines for the development and building of roads on the Cayman Islands. This law establishes the basis for which roadways in the Cayman Islands must be developed and implemented, and any necessary legal requirements for roadway development and implementation.

2.1.7 National Conservation Act of 2013

The National Conservation Act (NCA) of 2013 (Parliament of the Cayman Islands, 2013) was developed to "promote and secure biological diversity and the sustainable use of natural resources in the Cayman Islands." As a result of the NCA, the National Conservation Council was established in order to guide and oversee the implementation of the NCA. This Council comprises members from the Ministries of the Cayman Islands Government, as well as additional members listed below, and others appointed by the Office of the Cabinet:

- Director of the Department of Environment;
- Deputy Director of Research in the Department of Environment;
- Member from Department of Agriculture;
- Member from Department of Planning;
- Member nominated by the National Trust and appointed by the Cabinet; and,
- Eight persons appointed by the Cabinet with at least one person from West Bay, George Town, Bodden Town, North Side, East End, Little Cayman, and Cayman Brac.

The NCA establishes the basis for the appointment of an EAB, which is comprised of technical and subject matter experts and exists to guide the EIA process.

2.1.8 Directive for Environmental Impact Assessments, 2016

The development of an EIA with the results summarised in an Environmental Statement is required under the Directive for Environmental Impact Assessments, Section 43 of the National Conservation Act ('the EIA Directive'). This directive was issued in conjunction with Sections 3(12)(j) and 43(2)(c) of the National Conservation Act.

Section 41(3) of the National Conservation Act establishes the basis for the policy's framework, and states the following:

> *"Every entity shall, in accordance with any guidance notes issued by the Council, consult with Council and take into consideration any views of the Council before taking any action including the grant of any permit or license and the making of any decision or the giving of any undertaking or approval that would or would be likely to have an adverse effect on the environment generally or any natural resource."*

2.2 Environmental Impact Assessment Process

The need for an EIA was originally discussed in 2005 during initial planning. In 2016, with the gazettal of the EIA Directive, the Council required an EIA for the road.

Discussions between the NRA and the Council centred around the need to conduct an EIA for the proposed EWA Extension between Hirst Road in George Town to Frank Sound Road in North Side. The EWA Extension is proposed to be constructed in three segments: Section 1 from Hirst Road to Woodland Drive, Section 2 from Woodland Drive to Lookout Road, and Section 3 from Lookout Road to Frank Sound Road. The EAB determined through their 2019 Scoping Opinion, that Section 1 did not require an EIA since it is in a heavily disturbed and populated area. However, an EIA was required for Sections 2 and 3.

The EAB's final EIA Scoping Opinion for the EWA Extension, from Woodland Drive to Frank Sound Road, was issued on 5 November 2021. The EIA Scoping Opinion identifies those environmental impacts arising from the project which will likely be significant, and which will need to be addressed as part of the EIA. The process for approving the Terms of Reference, Environmental Statement, and the Environmental Management Plan is outlined in **Figure 3**.

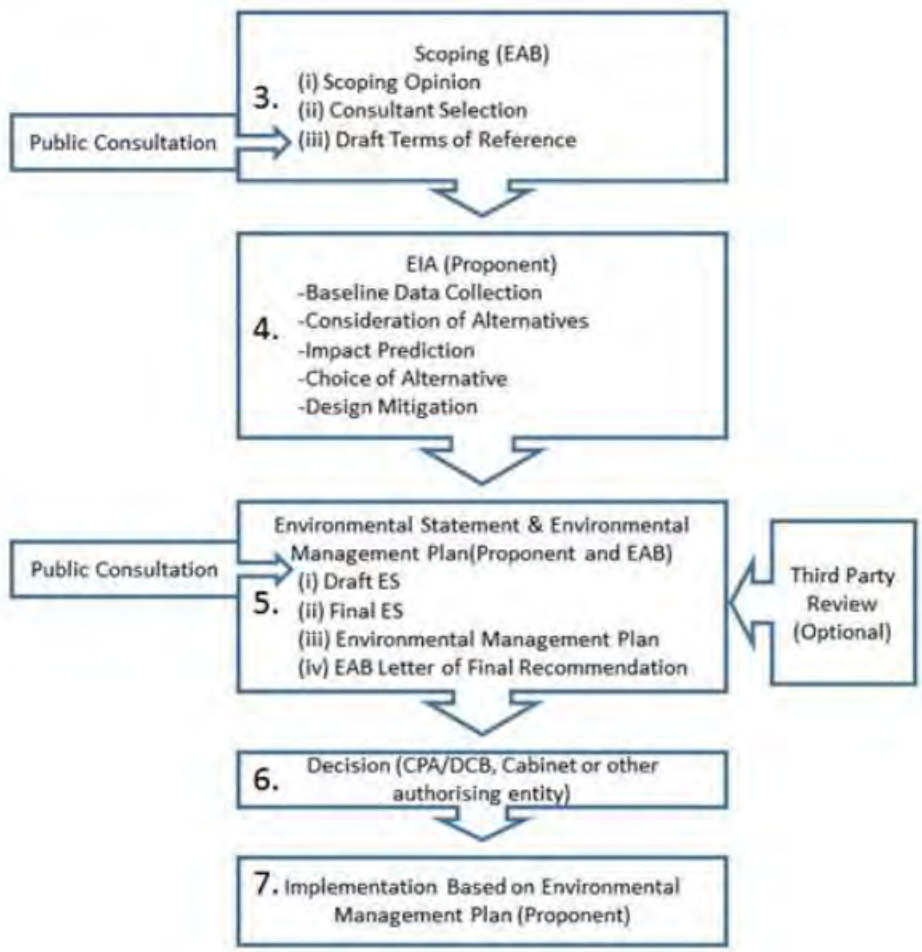

Figure 7: Excerpted EIA Directive from NCC

From EIA Directive

2.3 Terms of Reference

The Terms of Reference (ToR) refine the scope of the EIA established in the Scoping Opinion, including through public consultation. They provide a consistent protocol for assessing a project's potential to cause environmental, social, and economic harm. The ToR identifies the applicable environmental laws and regulations, establish the assessment methodologies, and guide the overall activities required for the environmental studies. Chapter 4 of this document describes the potentially affected resources, the existing conditions, potential project impacts, and potential mitigation measures that may be investigated. Specifically, this ToR will address the following resources:

- Socio-Economic Considerations;
- Hydrology and Drainage (including climate resiliency);
- Geo-Environmental;
- Terrestrial Ecology;
- Cultural and Natural Heritage Trust-Protected Areas;

- Greenhouse Gas Emissions; and,
- Noise and Vibration.

Aside from these identified resources, this ToR also specifies the need to assess key areas of uncertainty in the implementation of the EWA Extension, issues arising from choosing a "no-build" or "do nothing" scenario, any potential cumulative impacts, or indirect effects, and finally provide conclusions and recommendations on how the effects on these resources can best be avoided or mitigated.

2.4 Environmental Impact Assessment

The EIA evaluates the potential direct and indirect effects of a project on the environment and ensures that the mitigation of impacts to minimize or eliminate these effects are properly considered prior to any development occurring. The assessment starts with the baseline data collection to establish and understand the existing environmental conditions against which likely significant effects will be assessed. An important aspect of the EIA is the consideration of alternatives, including a ''no-build'' situation, whereby no road is constructed. This involves the evaluation and assessment of reasonable alternatives to the proposed EWA Extension, and the effects on the environment. Other key requirements of an EIA include the following:

- Describe and state the need for the project;
- Confirm the nature of the proposal;
- Identify the range of likely effects on the environment;
- Identify and agree on methodologies to be employed;
- Define data availability and further data gathering required;
- Set the indicative thresholds and significance criteria to be used in evaluation of impacts; and,
- Identify mitigation measures to be secured in an Environmental Management Plan.

2.5 Environmental Statement

Following the completion of the EIA, an ES will be developed to summarise the results of the EIA. The ES will act as a guidance document for decision makers by providing them with any necessary information and the technical studies regarding the potential environmental effects of the project. The following information will be included in the ES, at a minimum:

- Description of the development;
- Description of the alternatives studied and the reason for selecting the chosen alternative;
- Description of any potential environmental effects that could occur because of project development;
- An evaluation of impact significance and a description of the likely significant effects of the development on the environment;
- Description of any other direct, indirect, or cumulative effects the project may have on the environment;
- Description of mitigation measures to avoid or mitigate the environmental effects;

- Non-technical summary; and,
- Any difficulties that occurred during the EIA process.

2.6 Environmental Management Plan

Using the results of the EIA, an Environmental Management Plan (EMP) will be developed. This EMP will establish the basis and plan for environmental monitoring and mitigation during project implementation.

2.7 Public Consultation and Stakeholder Engagement

2.7.1 Public Consultation

Due to the nature of this project and its potential impact on the residents of Grand Cayman, public consultation will be imperative in project development. The National Conservation Act's EIA Directive establishes two requirements for public involvement during the development of an EIA.

The first is during development of the draft ToR. The draft ToR document will be available on the DoE's website for a total of 21 consecutive days. The notice of availability for the ToR will be advertised twice, minimum, in the local press within the 10-day period immediately prior to the start of the 21-day review period. The second public consultation opportunity is during development of the draft ES. The draft ES document will also be available on the DoE's website for a total of 21 consecutive days. As with the publication of the ToR, publication of the ES will be advertised at least twice in local press within the 10-day period prior to the start of the 21-day review period.

During the ToR and ES review periods, the public can submit comments directly to the EAB c/o the DoE, either via email, direct mail or hand delivery to the offices of the DoE. These comments will then be jointly assessed by the EIA consultants and the EAB and relevant changes will be incorporated into the final documents. Responses to all comments received will be appended to the Final ToR and ES respectively. For the EWA project, two public meetings will be held during each review period to allow the public to review the project and engage with the EWA Extension project team regarding any questions or concerns they have about the project. These two public meetings will be held on Grand Cayman, with one meeting each on the eastern and western sides of the island to provide opportunities to all Cayman residents. These meetings will be held at least 7 days prior to the end of the public consultation review period.

The public comments and responses from the draft ToR public involvement effort are included in Appendix A thru Appendix D.

2.7.2 Stakeholder Engagement

In addition to public meetings and the publication of relevant documents, stakeholder engagement will be conducted throughout the EIA process. A variety of outreach and communication strategies may include stakeholder meetings, targeted meetings and interviews, project newsletters, and website updates. Stakeholders would be engaged at key decision-making points in the project, such as identification of alternatives, assessment of impacts and development of avoidance measures and mitigation strategies, and reviewing alternatives to discuss findings and identify preferred solution(s). The information gathered from this outreach will allow the NRA and its partner agencies to hear insights and potential impacts first-hand, which can help inform their future decisions.

Chapter 3

Assessment of Corridor Alternatives

3 Assessment of Corridor Alternatives

3.1 Roadway Operations

The EAB's EIA Scoping Opinion states that the objectives for assessing roadway alternatives and future operations is to ensure that the preferred EWA Extension Corridor design offers the best outcome for both the surrounding communities and for preserving the unique environments of Grand Cayman. Transportation investments have major influences on society, with a wide variety of economic, social, and environmental considerations. An analysis of forecasted land uses along with a determination of future travel needs projected through traffic modelling data will be used to guide the design of the EWA Extension. Current policies, including the Development Plan and the National Energy Policy, will also be consulted in guiding the design and measures needed to provide a new roadway facility that effectively meets the transportation needs while best avoiding and minimising impacts to the natural, cultural, and human environments.

For the population projections, the future year 2026, 2036, and 2046 forecasted volumes will be developed using growth rates from the 2021 Census and approved development data. Beyond future year 2046, a scenario planning approach will be applied to and pivoted off of the 2046 projections to reflect the larger level of uncertainty when estimating to future year 2074 (i.e., 50-year projection). Up to three (3) land use/population scenarios, referred to as "Alternate Futures" will be evaluated for future year 2074, which may include geographical-based and/or intensity-based components. Alternate Futures will be determined with the Department of Planning and consultation with key governement ministries; and may include a variety of population estimates (e.g., low/medium/high) and/or travel demand management strategies such as adding employment east of George Town, staggered work or school hours, accounting for sea level rise, or densification of development.

The development of the typical sections and intersection concepts for Section 2 and Section 3 will use the traffic volumes from existing roads near the study area and anticipated future traffic volumes to determine the appropriate number of lanes for the future corridor and roundabouts. Roundabout concepts will be developed with enough detail to show the approximate impacts to the areas around the intersection. Typical sections were initially designed for the proposed EWA Extension, from Hirst Road to Lookout Gardens; additional facilities were also proposed to provide multimodal accessibility such as for pedestrians, bicyclists, and/or transit **(Figure 4).** It should be noted that the designs in Figure 4 are examples to show the varying levels of detail and subject to change based on the findings of the EIA.

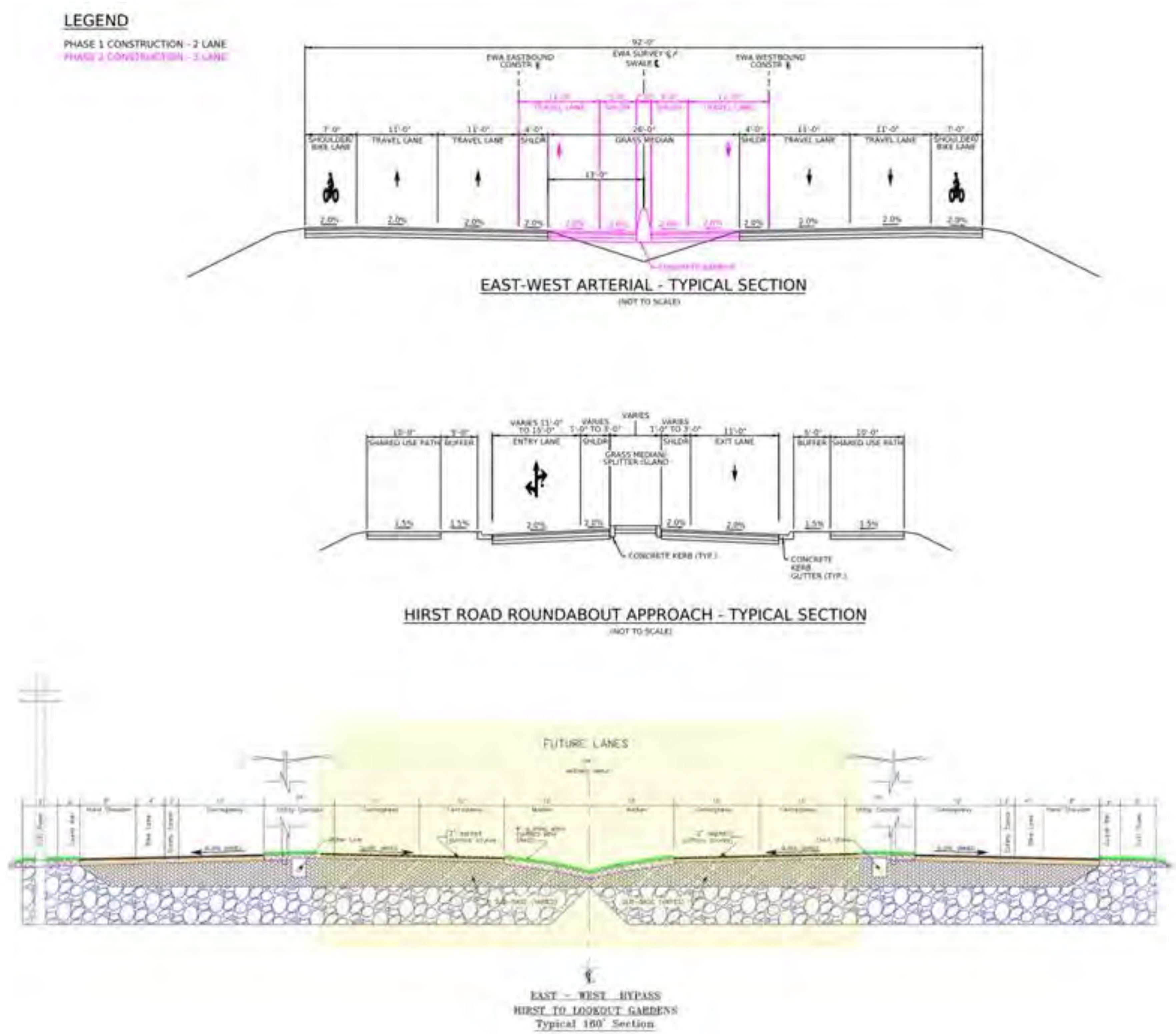

Figure 8: Example Typical Sections with Multimodal Accessibility

Source: National Roads Authority

3.2 Alternative Solutions and Analysis

It has been projected that current traffic congestion, fuelled by population increases over the coming years, will continue to worsen due to the lack of roadway options that interconnect the eastern with central and western districts of Grand Cayman. **Figure 5** and **Figure 6** capture the October 2019 AM peak westbound traffic congestion along Shamrock Road as motorists travelled toward the western half of the island. The EWA Extension project would provide a disaster-resilient alternative route and improve traffic conditions while offering an enriched quality of life through improved mobility and accessibility for residents and visitors alike.

Figure 9: Shamrock Road near Countryside Shopping Village

The focus of the analysis will be to ensure that the design of the project provides the best possible outcome for meeting the existing and projected travel needs while effectively preserving the environment as well as accommodating the needs of the surrounding communities.

Figure 10: Shamrock Road near Ocean Club Condominium Complex

With the focus on improving connectivity, safety, and emergency evacuation capability, an initial longlist of alternative solutions will be identified, which may include the No-Build, On-Alignment, EWA Extension, alternate alignments, and mass transportation options. Note that all alternatives will take into consideration future sea level rise estimates by 2074, including necessary mitigations. Additionally, the proposed corridors would have the width and ability to include alternative modes of transportation as deemed appropriate (or solely passenger transit), as well as pedestrian facilities.

Each Build Alternative will be designed to the concept level in an effort to meet the Critical Success Factors (CSFs) of the project (e.g., engineering feasibility, traffic operations, multimodal safety). During development of the alternatives, environmental and cultural features that need to be avoided entirely, or encroachment minimised, will be identified. These alternatives would then undergo a high-level transportation and environmental screening process to determine the viability of each alternative and determine which one(s) should move forward based upon CSFs, as well as constraints and dependencies (e.g., construction considerations and the evaluation of mitigation opportunities for unavoidable impacts). Through each step the alternatives will be further refined, and will be narrowed down based upon CSFs, constraints and dependencies, as well as the results of the Cost Benefit Analysis (CBA).

The steps in the alternative development process are illustrated below **(Figure 7**) and described on the following page:

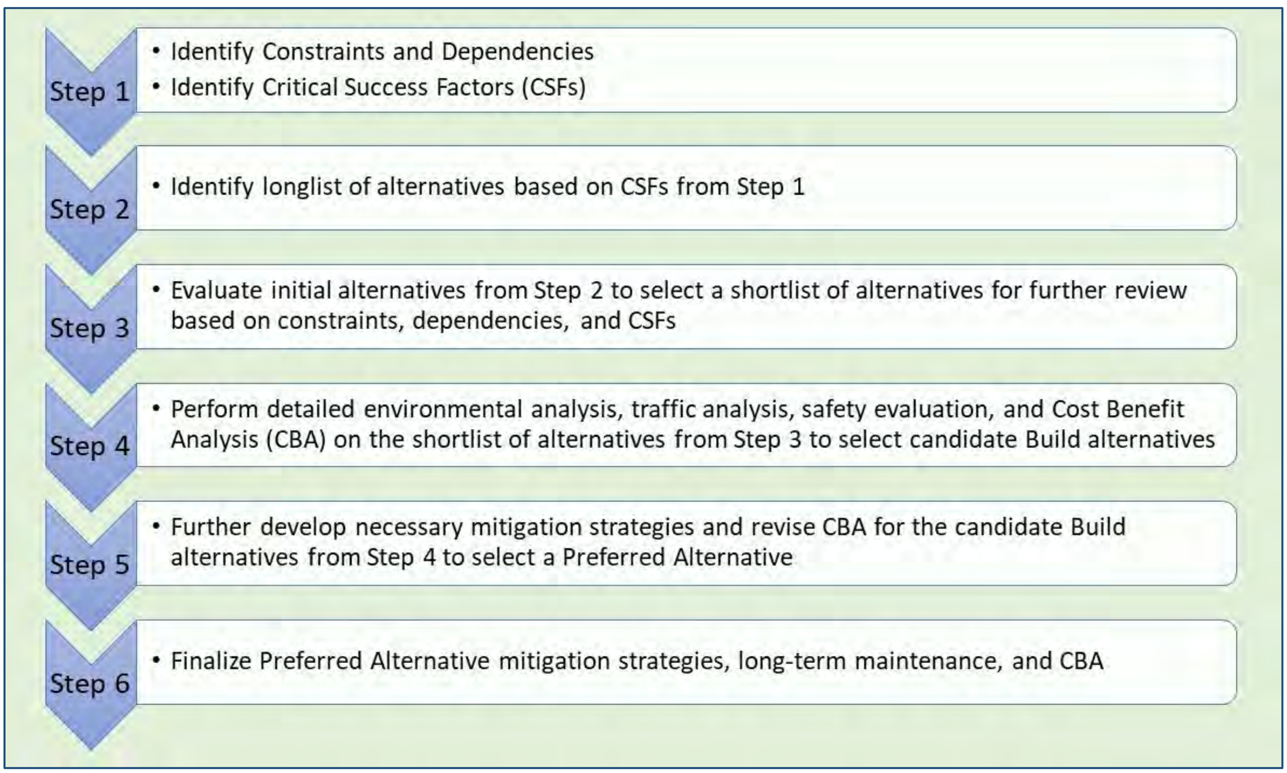

Figure 11: Steps of Alternative Solutions Evaluation

Step 1: Clearly identify the constraints and dependencies, as well as the CSFs

- Create a baseline of the project area to identify constraints and dependencies of the project. Engineering constraints such as unstable rock areas, along with environmental constraints, such as wetlands or proximity to Protected Areas, cultural or natural heritage sites, will be overlaid on a GIS-based map so the areas without constraints, can be identified. For example, existing condition information will be identified and mapped for resources described in Section 4 below. The goal is to avoid mangroves, wetlands, Protected Areas, species of concern, cultural or natural heritage sites and any other sensitive areas to the extent possible. Additionally, existing and proposed residential and community facilities will be mapped with the goal to set the roadway back from current and known planned developments to minimise construction- and operational-related disturbances for those facilities.
- Clearly define the CSFs of the project. These would be the goals of what the completed project would accomplish.

Step 2: Identify longlist of alternatives, based on CSFs from Step 1, which could be capable of being constructed.

Step 3: Evaluate longlist of alternatives identified in Step 2 based on the CSFs and constraints and dependencies, including a high-level traffic analysis. A shortlist of alternatives, including the No-Build, will be identified to move forward to Step 4. An explanation will be provided for why selected alternatives were eliminated from further consideration.

Step 4: Additional analysis would be conducted on the shortlist of alternatives that move forward from Step 3 to select candidate build alternatives. This would include the following analyses:

- A comparison matrix of alternatives and the No-Build will be developed. The comparison matrix will include sustainability topics (community well-being, program-project management, and environmental stewardship). Sustainability measures will include:
    - Cost Effectiveness – the level to which the sustainable action will be estimated to be cost effective in terms of life cycle costs (short and long term);
    - Environmental and Natural Resource Conservation – the level to which environmental resources (wildlife, water quality, air quality, virgin materials, etc.) are being conserved, protected, or enhanced by the sustainable action;
    - Ease of Implementation – the level to which implementing the sustainable action is viable and easy to perform based upon NRA contractual and policy procedures or existing operating conditions and circumstances;
    - Community Context Sensitivity- the level to which the sustainable action promotes, maintains and/or enhances the local/regional community or driving public by improving their safety quality of life and sense of place.
- A traffic analysis will be conducted from a multimodal perspective of project mobility benefits and impacts for each of the alternatives and for Years 2026, 2036, and 2046, and 2074. These future year traffic projections will be developed and based upon growth rates

from the census along with known approved and planned land development, which will provide a future land use condition. This analysis will feed back into the roadway design to determine the solution(s) that meet the CSFs, which may include refinements such as number of through lanes, intersection configurations, and turn bay lengths at intersections.

- A multimodal qualitative or quantitative safety evaluation will also be conducted to determine potential safety benefits and/or implications for each of the alternatives.
- A CBA will be performed to provide a monetary measure of the relative economic desirability of project alternatives, weighed against non-monetised effects, and impacts of the project. The CBA will include performance metrics such as:
    - Travel time reliability (TTR) for employment opportunities, equity, and overall quality of life as well as enhancement to local tourism sector;
    - User delay (e.g., loss of productivity) based on the additional travel time spent in the vehicle due to congestion;
    - Travel time (TT) to key destinations such as the George Town/Owen Roberts Airport, the George Town Cruise Port, the Camana Bay and Seven Mile Beach areas, schools, hospitals/healthcare, etc.;
    - TT to outlying tourist attractions such as Botanic Park, Cayman Crystal Caves, and Rum Point;
    - Travel Time Index (TTI), which is used to measure the severity of recurring congestion; it is a proportion of travel time compared to free-flow travel time (Travel Time / Free-Flow Travel Time);
    - Vehicle Miles Travelled (VMT) – used to compare both operational and air quality factors;
    - Overall roadway network Level of Service (LOS);
    - Fuel usage (e.g., unit – gallons) based on speed distribution of % VMT;
    - Emissions (e.g., unit metric tonnes CO_2) – based on speed distribution of % VMT;
    - Land use accessibility to occupational, recreational, and shopping areas/facilities within a certain amount of time (e.g., opportunities within 25 minutes);
    - Vehicle throughput;
    - Overall network performance (e.g., unit – delay per mile);
    - Intersection delay and LOS;
    - Maximum queues (e.g., unit – feet);
    - Multimodal safety assessment using crash modification factors (CMFs) qualitatively or quantitatively to evaluate potential safety benefits and/or implications;
    - As well as other measures deemed appropriate after discussions with stakeholders.

Step 5: Based upon the evaluations in Step 4, candidate Build alternatives and the No-Build alternative will be further developed through detailed engineering analyses and the development of necessary mitigation strategies. The CBA candidate Build alternatives will be refined and a Preferred alternative will be selected.

Building upon the comparison matrix from Step 4, will be an expanded matrix (**Table 1**) for the refined preliminary alternatives to summarize the anticipated impacts (direct, indirect, and cumulative) to each resource element and the severity of the impacts on the alternatives selected to be evaluated in the EIA.

Table 1: Summary of Anticipated Impacts by Alternative.

Alternatives	No-Build	Alt. 1	Alt. 2
Socio-Economic Impacts:			
Hydrology & Drainage Impacts:			
Geo-Environmental Impacts:			
Terrestrial Ecology Impacts:			
Cultural & Natural Heritage Impacts:			
Greenhouse Gas Impacts:			
Noise & Vibration Impacts:			
Traffic Operational Impacts			
Multimodal Safety Impacts			

Step 6: Based upon the evaluations in Step 5, a Preferred alternative(s) will be selected.

Chapter 4

Key Potential Impacts and Considered Mitigation Measures

4 Key Potential Impacts and Considered Mitigation Measures

4.1 Overview of Assessment Parameters

The implementation of a transportation improvement project has the potential to affect social, economic, natural, and cultural resources; therefore, it is essential that the existing environmental conditions and potential project related impacts are identified and understood. Previously, Figure 2 showed the area that would be directly impacted by the construction of the proposed roadway; however, each resource may have a different buffer around the construction area to evaluate impacts. To identify the extent of the impacts, a matrix similar to that shown in **Table 2** will be developed for each affected resource.

Table 2: Example Table for Significance Evaluation of Impacts on Affected Resources.

		Importance/Sensitivity of Resource			
		High	**Medium**	**Low**	**Negligible**
Magnitude of Change	High	Very Substantial	Substantial	Moderate	None
	Medium	Substantial	Substantial	Moderate	None
	Low	Moderate	Moderate	Slight	None
	Negligible	None	None	None	None

In addition, the assessment will identify whether effects are:

- Direct or indirect,
- Certain or potential,
- Secondary or induced,
- Short, medium or long term,
- Permanent or temporary, and
- Positive or negative (beneficial or adverse).

Additionally, as described in Paragraph 5 of Schedule 2 of the EIA Directive (NCC, 2016), the evaluation must evaluate the potential indirect and cumulative effects of the proposed roadway, both positive and negative. As noted in Section 1.1.3, indirect effects are impacts caused by the project, which occur later in time or removed in distance, but are reasonably foreseeable to occur. Cumulative impacts are the effects of past and present actions, and effects of reasonably foreseeable future actions by others on the same resources of concern.

Indirect effects could occur as a result of the direct impact, such as changes to water flow after the construction of the roadway. Induced residential or commercial growth could also occur due the new access provided by the new roadway and/or reduced commute times. The impacts caused by these new developments would also be considered as indirect effects. For this analysis, the potential for induced growth will be evaluated within approximately 1.5 miles of each new access point. The area that is protected from development, such as NCA lands, would be excluded, then the impact associated with the remaining land would be estimated and evaluated. The effect of increased traffic associated with any new developments shall also be included in the qualitative discussion.

Several proposed developments have been identified and shown on **Figure 8**. Through coordination with stakeholders and government agencies as well as discussions with the public at the public meetings, the status of these developments will be confirmed, and any new proposed developments or other projects will be identified. The impact of these projects combined with the proposed roadway and past actions will be assessed to determine the cumulative effect to each resource of concern.

The assumed induced growth areas and the identified developments/projects will be described at the beginning of the section that discusses the analyses and impacts so that all analyses include the same list of developments/projects. The direct, indirect, and cumulative effects of each resource topic shall be described within their respective sections.

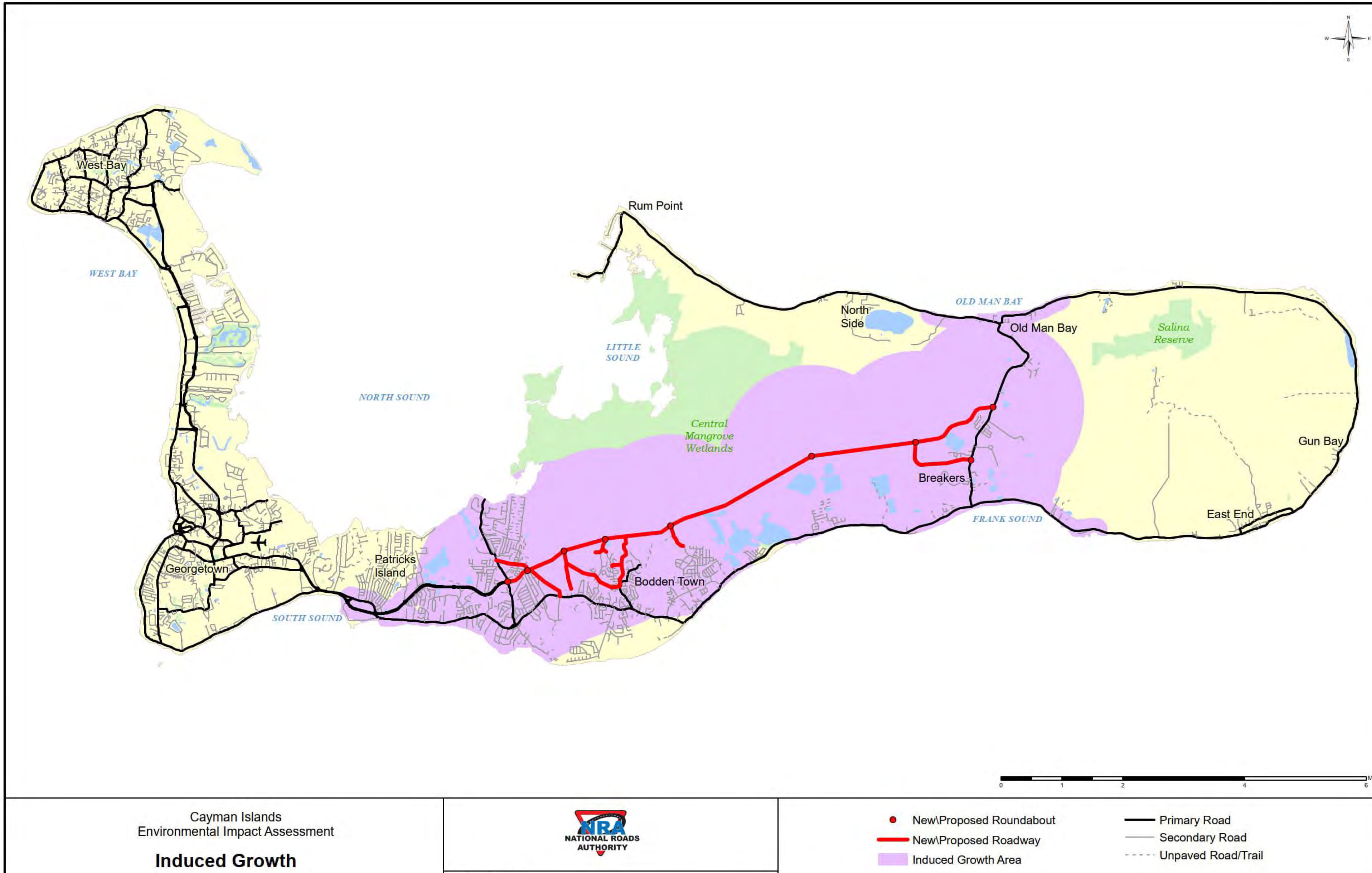

Figure 12: Induced Growth Study Area

4.2 Socio-Economic

4.2.1 Introduction

Social-economic components such as employment, income, and education affect how humans and communities live. Assessing the proposed project's potential to affect changes in these factors will aid in providing an understanding of the comprehensive and interrelated needs of individuals and the local communities.

4.2.2 Baseline Conditions

The Cayman Islands are made up of three independent islands: Grand Cayman, the western-most island, Cayman Brac, the eastern-most island, and Little Cayman, located just west of Cayman Brac. With nearly 70,000 people, Grand Cayman has approximately 29,000 households; of which only 25% include children and 80% having a vehicle (Census, 2021). **Figure 9** generally illustrates the distribution of population and employment centres on Grand Cayman.

Grand Cayman comprises five districts: West Bay, George Town, Bodden Town, North Side, and East End. With Owen Roberts International Airport and the George Town Cruise Port located in George Town, both George Town and West Bay are the primary locations for commercial and retail businesses such as hotels and restaurants, with a mix of residential uses **(Figure 10).** Further east, Bodden Town, North Side, and East End, are primarily residential with some minor retail and community facilities interspersed along the main roadway. Bodden Town is currently the fastest growing district, almost tripling in size since the turn of the 21st century, while North Side and East End remain relatively sparse (Economic and Statistics Office, 2022).

The population of the Cayman Islands is relatively young, with more than 91% of the population being under the age of 65 and making up much of the workforce. Unemployment in the Cayman Islands comprises 5.7% of the working age population, which is lower than the 2021 global unemployment rate of 6.2% (Economic and Statistics Office, 2022).

The economy of the Cayman Islands relies heavily on the tourism and the financial services industry, which represent roughly 17% and 32% of the Gross Domestic Product (GDP) of the Cayman Islands, respectively. Before the COVID-19 Pandemic, the Cayman Islands had more than one million visitors each year.

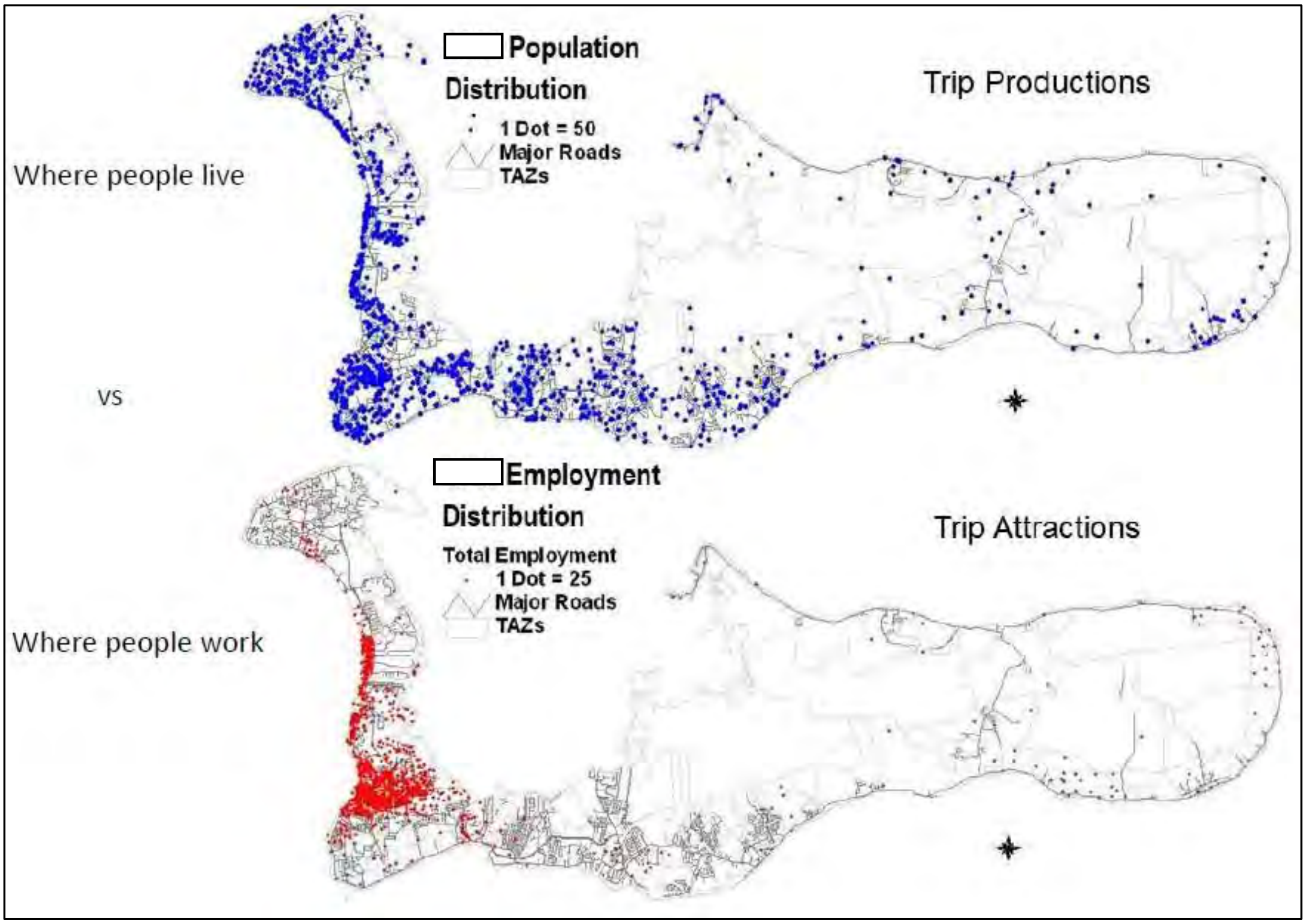

Figure 13: Distribution of Population vs Employment Centres on Grand Cayman

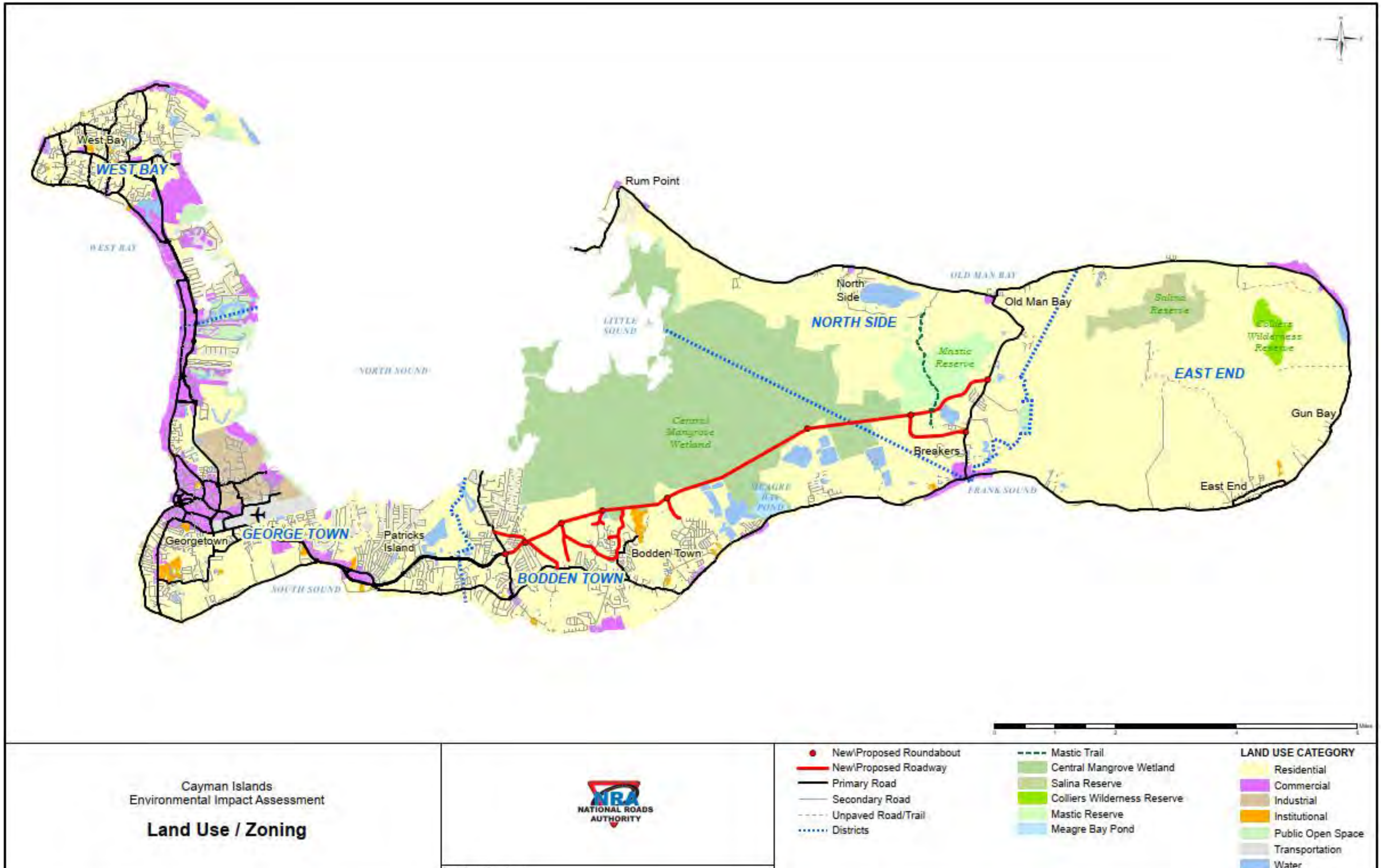

Figure 10: Land use and zoning on Grand Cayman

4.2.3 Applicable Standards and Guidelines

To evaluate the potential social and economic effects of the project, the EIA will consider the established rules and regulations of the Cayman Islands. Relevant laws applicable to this project include:

- Workmen's Compensation Act, 1996 Revision,
- Land Acquisition Act, 1997 Revision,
- Poor Person's Relief Act, 1997 Revision,
- Tourism Act, 2002 Revision,
- Employment Act, Law 3 of 2004,
- Education Act, Act 48 of 2016,
- Trade Union Act, 2019 Revision,
- Public Health Act, 2021 Revision,
- Labour Act, 2021 Revision, and,
- Data Protection Act, 2021 Revision.

Relevant planning documents and data applicable to this project include:

- The Cayman Islands' 2021 Census of Population and Housing Report,
- Draft National Planning Framework
- Existing Land Use and Community/Emergency Facilities,
- Approved and Proposed Developments,
- Existing and Proposed Utilities,
- National Tourism Management Plan 2019-2023,
- GO EAST: A Strategy for the Sustainable Development of the Eastern Districts of Grand Cayman,
- Compendium of Statistics, 2021,
- Cayman Islands Government 2022-2024 Strategic Policy Statement, and,
- United Nations Sustainable Development Goals, 2015.
- Meagre Bay Pond Management Plan

4.2.4 Potential Impacts

Socioeconomic status encompasses both objective characteristics (e.g., income or education) and subjective characteristics (e.g., people's sense of their placement). Groups that will be evaluated include residents, businesses, short-term renters, and marginalised/vulnerable groups. The socio-economic study area includes the entire Grand Cayman Island, since the effects to population, employment, and businesses could affect the entire island.

As part of the EIA, the following components shall be analysed in consideration of potential socioeconomic benefits and impacts in comparison to a ''no-build'' scenario:

- Aesthetics "Quality of Life"
    - The effect on traffic measures, such as travel time and level of service, compared to existing and future conditions;

  - The effect of the project on accessing adjacent land, including environmentally sensitive lands;
  - The potential for changes to existing environmental conditions due to changes in tourism;
  - The potential for changes to community resiliency from new roadway facility compared to existing and future impacts of sea-level rise under a "no-build" scenario (for this project, community resiliency is assumed to be the ability of communities to prepare, adapt, and recover from any negative impacts to the social, physical, and environmental health of the community);
  - The potential for changes to the noise and visual, environment for land uses located along the new roadway and connector roadways; and,
  - The effect of the project on lifestyle/wellness associated with changes to commute times.
- Access & Mobility
  - The project's effect on access needs along and adjacent to the project corridor based on an analysis of trip origination and destinations;
  - The projects effect on community mobility and connectivity;
  - The potential for changes in evacuation routes;
  - The potential for increased transit reliability for existing routes and anticipated transit benefits associated with the new facility;
  - The potential for changes in tourism as a result of increased or decreased access to resources; and,
  - Potential for impacts on economic resiliency as a result of tourism changes.
- Income & Economics
  - The potential for job creation during project construction and implementation;
  - The prioritisation of equitable business and employment opportunities; and,
  - Effects to tourism based upon improved access.
- Housing
  - The potential for relocations necessary for project construction;
  - The potential for new development; and,
  - The potential for impacts to housing availability and affordability.

4.2.5 Assessment Methodology

The assessment will include identifying statistics and trends of the area, identifying data from before COVID-19 as well as recent data. This analysis will identify changes in tourism as well as other effects associated with the change in the world economy. Data collected for Districts intersected by the study area will be used to identify the location of marginalised persons, types of businesses, residential neighbourhoods.

This baseline information will be collected from secondary data sources including, but not limited to local population census data, government planning documents, international financial institutions' statistics, nongovernmental organisations (NGOs) and business reports. Additionally, primary data sources will include consultation via email and virtual meetings with key stakeholders, local community and business representatives, and NGOs. This list of stakeholders will be developed during the initial public and agency outreach.

Relevant socio-economic indicator data will be gathered including information on income sources and livelihoods, and access to employment and business opportunities, as well as social services such as education and health.

This information will be used to identify potential impacts of the proposed project and the level of possible changes to the community, economic benefits, employment opportunities, housing, and health & wellbeing. The evaluation shall include:

- Effects caused by additional accessibility to the existing communities of Bodden Town, North Side, and East End;
- The potential changes to the local economy, including growth in residential development and land value changes;
- Assessment of the existing land uses based upon aerial imagery and field visits, as well as proposed changes to land uses based upon proposed development plans;
- Identification of existing public infrastructure, including water, sewer, and utilities;
- Determination to what extent that existing public infrastructure facilities can support new growth in the area;
- Evaluate the economic and social stratification of the neighbourhoods and identify how the project could affect this stratification;
- Evaluate impacts to travel patterns to work, school, and community facilities;
- Evaluate impacts to travel-related costs;
- Evaluate emergency service providers access routes/response times;
- Evaluate the creation of physical and/or visual boundaries;
- Assess the effects of temporary workers with potential impacts to local inhabitants; and,
- Evaluate the potential for new developments.

Unequal impacts to any marginalised or vulnerable groups will be identified and established for significance. Significance will be determined using clearly defined qualitative criteria considering:

- Sensitivity of socio-economic receptors (individuals or social or economic groups), determined by their vulnerability to change or ability to take advantage of opportunities; criteria would include those with income below the average, no access to vehicles, renters, persons over 65; and,
- Magnitude of impacts, determined by effect on receptors, wellbeing, which refers to the financial, physical, and emotional conditions of people or groups.

4.2.6 Mitigation Measures

Potential mitigation measures for unavoidable socio-economic impacts will be identified. Measures and practices will be suggested that have the potential to minimise the possible impacts of the project construction including, but not limited to:

- Identifying measures to maximise the use of local employment;
- Reviewing existing planning and zoning policies and regulations to account for project components and providing recommendations for updates or revisions; and,
- Recommending updates or new policies to encourage the location of new developments that would minimise impacts to existing communities and natural resources.

4.3 Hydrology and Drainage, Including Climate Resiliency

4.3.1 Introduction

Hydrology and drainage are important processes on Grand Cayman that support the health and safety of residents and natural resources. The Digital Terrain Model (DTM) and local observations indicate that during storms and hurricanes, flood waters drain from the south to the north through the Central Mangrove Wetland. The construction of the proposed roadway along the southern boundary of the Central Mangrove Wetland will impact these natural drainage processes. As part of the EIA, the applicable standards and guidelines will be reviewed, and the baseline conditions will be assessed for the Island's hydrology and drainage processes. Potential impacts of the proposed project, along with potential mitigation measures that avoid or minimise impacts of the proposed roadway project, will be identified in the EIA.

4.3.2 Baseline Conditions

4.3.2.1 Data Gathering Methodology

Although the study area includes the part of the island along the proposed roadway alignment, hydrology and drainage topics are inclusive to the entire island. An initial review of published data and publicly available information will be used to develop the existing conditions considerations. Information on hydrology and drainage, including topography, climate, tropical storms and hurricanes, storm surge and flood risk, and mangroves, along with climate and land use changes will be collected and analysed to define the hydrology and drainage processes. This review may determine gaps in available information that will need to be addressed in the specific studies that follow. The following describes each of these components that will be included in the EIA.

4.3.2.2 Hydrology and Drainage Overview

Hydrology and drainage on the Island are influenced by topography, geology, climatic factors, tropical storms and hurricanes, and a large mangroves population. The flat and low-lying island is vulnerable to winds and flooding caused by hurricanes and tropical storms. There are two dominant seasons: the wet, hot summer season and the relatively cooler, dry winters. In the wet, hot summer season, rain is generated by thunderstorms, tropical storms, hurricanes, or evapotranspiration from vegetation. In the dry winter months, occasional surges of cooler air from continental North America are the major producers of rainfall. Flooding varies on Grand Cayman, generally depending on the underlying bedrock formation. Areas that have underlying rock formations with high permeability typically do not flood unless they occur at the water table. Areas with less permeable bedrock are highly prone to surface water flooding. Mangroves, specifically the Central Mangrove Wetland, have an important role in the hydrologic cycle, including rainfall generation, local freshwater hydrology, groundwater replenishment, and hurricane protection.

Within the study area, the hydraulic function is largely determined by the flow of rainfall runoff and storm surge flows from the area south of the Central Mangrove Wetland, including parts of Northward, Bodden Town and Frank Sound toward the wetlands due to the change of elevation. In addition, the surface rock along Section 2 in the vicinity of the Lower Valley Fresh Water lens results in overland flow from storm surges crossing into the Central Mangrove Wetland via a "V" in this formation at the western end of Section 2 and at other, less-defined areas along what will become the southern edge of Section 2 EWA Extension. A map showing surface flow is found in **Figure 11.**

4.3.3 Topography

Grand Cayman is irregularly shaped with an approximate area of 76 mi^2 (197 km^2). The island is relatively flat, low-lying, and has no natural external drainage system. The maximum elevation is approximately 71 ft. (20 m) above sea level. The low-lying topography is vulnerable to winds and flooding caused by hurricanes and tropical storms. The island lacks rivers and streams due to the negligible elevation and the porous limestone rocks.

4.3.4 Climate

Grand Cayman has a tropical marine climate and is hot and humid throughout the year. The overall average temperature is 80.8°F (27.1°C) (Johnston & Cooper, 2022) and the average annual relative humidity between 2011 and 2021 was 79% (Economics and Statistics Office, 2022) Since it is located in the north-west Caribbean, the island is affected in the winter by cold fronts and influenced by tropical waves and is subjected to tropical storms and hurricanes with very intense rainfall during the summer. The dry, relatively cold months are from late November to mid-April. Winter cold fronts bring cooler temperatures, stronger winds and rough sea swells known locally as a 'Nor-wester', which occur suddenly and can be severe, with sustained wind speeds of up to 40 knots (60 knots gust). The wet season of warm, rainy summers is from mid-May through October. In July to November, low pressure systems moving west across the Caribbean frequently bring weather conditions ranging from weak tropical waves to hurricanes. The region has increasing higher average and extreme temperature events as average temperatures have increased approximately 3.9°F (2.2°C) over the past 40 years, at a rate of around 0.09°F (0.06 °C) annually (Pinnegar et. al, 2022).

The average precipitation is almost 55 in (139 cm) a year, with rainfall amounts increasing from east to west due to the evaporation of water in the Central Mangrove Wetland that is deposited as rainfall in the western side of the island. Observational trends appear to show a decrease in total precipitation, but an increase in rainfall intensity resulting in an increased occurrence of flood and drought events. Fewer but more severe rain events in recent years were observed from rainfall data collected at the Owen Roberts International Airport (Pinnegar et. al, 2022). During summer months, rainfall is typically the result of tropical thunderstorms or localised rain, generated from the evaporation of water in the central mangroves. In the dry winter months, occasional surges of cooler air from continental North America are the major producers of rainfall although precipitation is of much shorter duration and lesser amount than summer. Typically, heavy showers are interspersed by long dry spells during summer, which leads to periodic flooding in low-lying areas and depressions as well as moisture deficiency which is accentuated by shallow soil depth and low water holding capacities.

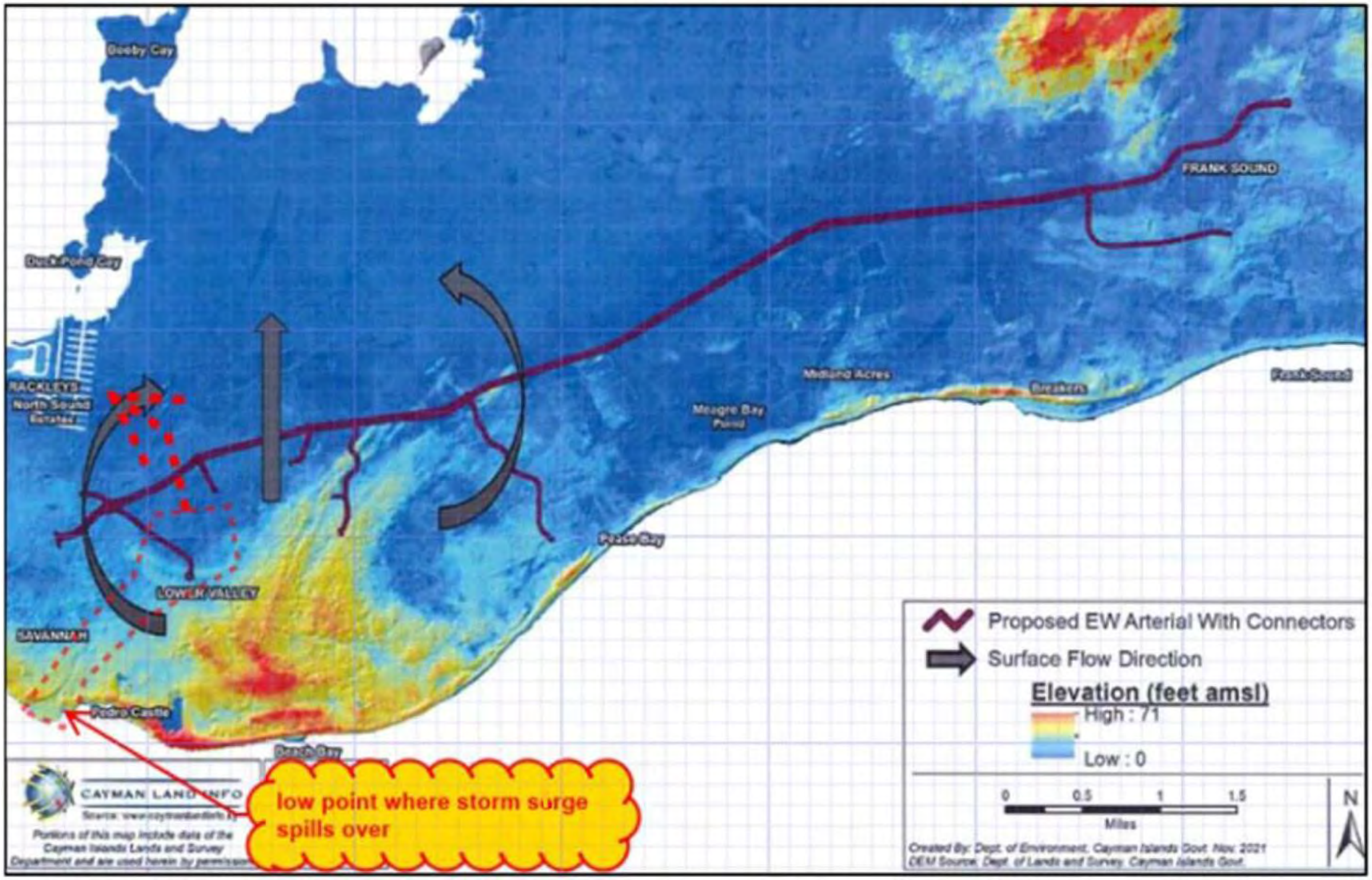

Figure 11: Surface flow drainage. Low point locally known as "Savannah Gully"

From Cayman Islands Department of Environment

4.3.5 Tropical Storms and Hurricanes

Hurricanes are a major climatic factor because the Island is located within the Caribbean hurricane belt, a region of the Atlantic Ocean that extends from the Gulf of Mexico to north of the Lesser Antilles where hurricanes are most likely to form. The months of September, October and November are typically the most active for hurricanes, when storms tend to form in the southern Caribbean and move north. The intense tropical storms and hurricanes are accompanied by very intense rainfall. Storm surges combined with wave action are responsible for much of the damage usually caused by hurricanes, especially in large, low-lying coastal settlements.

On average, the Cayman Islands are affected, brushed, or hit by hurricanes every 2.23 year and directly hit by hurricanes every 9.06 years. More recently, hurricanes have increased in intensity and rainfall, which is likely a result of warming ocean temperatures and more moisture in the air. Hurricanes have been more active in the North Atlantic Ocean since the 1980s, and on average, the quantity, strength, and number of hurricanes that intensify has increased (Colbert, 2022). The proportion of very intense tropical cyclones (Category 4 and 5) is anticipated to increase globally with increased warming (IPCC, 2021).

Hurricane Ivan was a Category 5 Atlantic hurricane that occurred in September 2004 and is considered one of the most impactful hurricanes recorded in the Caribbean region. It caused sustained winds of 160 mph and gusts of up to 217 mph, producing storm surges of 8 to 10 ft. (2.4-3.0 m) and wave heights of 20-30 ft. (6.1-9.1 m). The storm surges flooded large portions of the coastal areas and deposited major amounts of sand over roads, houses, and infrastructure. Most of the Island low lying areas were under water during and following the storm and widespread property damage resulted. It is estimated that the hurricane caused CI $2.86 billion (US $3.4 billion) in damages across the Cayman Islands, equivalent to over 180% of GDP (Pinnegar et. al, 2022).

4.3.6 Storm Surge and Flood Risk

There are two main types of flooding on the Island- coastal and surface water. Coastal flooding has caused much damage in the Cayman Islands with both the intensity of tropical storms and their frequency. Coastal flooding occurs because of the combined increase in water level from storm surge and waves on an elevated sea level. Due to the overall low elevation of Grand Cayman, coastal flooding extends to large areas of the island even in less severe storms (Category 3).

Surface water flooding typically occurs when a tropical depression settles over the island, and it rains for days. There are few surface water flow paths, and surface water flooding is typically widespread and of low velocity. Flooding varies on Grand Cayman, generally depending on the underlying bedrock formation. Areas that have underlying rock formations with high permeability, such as the Cayman Formation and Pedro Castle Formation, typically do not flood unless they occur at the water table. Rainfall either evaporates, percolates, or accumulates in depressions. Areas with underlying Ironshore Formation are much less permeable and are highly prone to surface water flooding. Much of the Ironshore surface when unbroken is “case hardened” and only allows water to percolate down sinkholes, which are very variable in terms of spacing and distribution, and which, like deep wells, cease to function in lower lying areas when the groundwater horizon surges during prolonged and heavy rainfall events. Even with the case-hardened surface broken, the Ironshore rocks are quite clay-like and are not as permeable as the Cayman and Pedro Castle formations. Developed and undeveloped areas with low elevation and/or soil, peat, or cap rock with low permeability are also prone to frequent flooding. More information on geology, including Figure 14: Sketch Map of Surface Geology can be found in Section 4.4.2 Geo-Environmental Baseline Conditions.

No generally accepted, delineated floodplain mapping exists for the Cayman Islands; however, the proposed EWA Extension corridor, like much of Grand Cayman, is low-lying and likely vulnerable to tidal flooding and hurricane/tropical storm-associated flooding, both of which can create numerous potential hazards. Novelo-Casanova and Suarez (2010) delineated flood zones resulting from hurricanes according to hurricane categories on the Saffir-Simpson Scale. The level of exposure to hurricanes and associated flooding and storm surge varies along the proposed roadway alignment. The proposed roadway in the western area near the Central Mangroves is within an area of high exposure and the proposed eastern roadway section is within an area of moderate exposure. Storm surges combined with wave action are responsible for much of the damage usually caused by hurricanes, especially in large, low-lying developed coastal areas.

The dense vegetation on the Cayman Islands appears to provide flood protection by intercepting and absorbing rainwater before it reaches the ground runoff conditions, holding back water temporarily, and mitigating peak flows that cause the greatest flooding by slowing the passage of water through the catchment. These conditions appear to act as a source of friction against moving water, resulting in a reduction of wave heights. In addition, soil cohesion is increased through the presence of root systems, reducing sediment load in flood waters.

4.3.7 Mangroves

Mangroves are important for both the terrestrial and marine ecology of Grand Cayman as they provide many ecosystem services, such as influencing hydrology and stormwater water drainage patterns; protection of beaches and coastlines from storms, waves, and floods; reduction of beach and soil erosion; providing nursery grounds, food, shelter, and habitat for a wide range of aquatic species; and carbon sequestration. Mangroves prevent erosion by acting as buffers and catching alluvial materials, thereby stabilizing land elevation by sediment accretion that balances sediment loss. They functionally act like a natural water treatment plant by retaining heavy metals, trapping sediments, and providing chemical buffering and water quality maintenance.

Mangroves are flow-through ecosystems. Tidal streams begin at the terrestrial edge of the inland side from ground water, springs, and stormwater runoff and continue to the sea. Tidal streams facilitate the exchange of tidal waters in and out of the mangrove area. Tidal fluctuation brings saltwater up estuaries against the outflow of freshwater, and transports sediments, nutrients, and clean water into the mangrove habitat, which is important for mangrove distribution. When tidal streams are disturbed, a mangrove may dry out, and die over time.

Mangroves are sensitive to environmental factors. Mangroves prefer low wave energy and are very sensitive to soil modifications, mainly due to shifts in substrate elevation relative to water level. The normal hydrologic patterns, including depth, duration, and frequency of tidal inundation and tidal flooding, influence the distribution and growth of existing natural mangrove plant communities. In addition, a change in salinity can result in a change or loss of mangrove species.

Specifically, the Central Mangrove Wetland is part of a large-scale water flow system, filtering and conditioning the surface water and shallow ground water which flows into the North Sound and provides a constant flow of nutrients, which form the base of a complex food chain for both terrestrial and marine wildlife. In addition, the Central Mangrove Wetland has an important role in the hydrologic cycle of the Island, including rainfall generation, local freshwater hydrology, groundwater replenishment, and hurricane protection. An estimated 40% of the rainfall in western districts is because of evapotranspiration in the Central Mangrove Wetland (Bradley et al, 2004). The evaporation of water from mangrove swamps creates a seaward hydraulic gradient for the regional flow regime (Ng et al, 1992). The evaporative loss for Grand Cayman is estimated to be approximately 75% to 85%. In addition, under normal conditions, a seaward hydraulic gradient drains ground water into the sea.

4.3.8 Applicable Standards

Applicable standards will be reviewed to ensure the project adheres to regulations and follows the most up-to-date guidance. Since there are no specific standards for water quality in the Cayman Islands, the British and International standards will be assessed, along with consultation with the Cayman Islands Government.

The following standards will be reviewed during preparation of the EIA:

- The Environmental, Health and Safety Guidelines, General EHS Guidelines: Environment (IFC, 2007) Wastewater and Ambient Water Quality - provides supplementary international guidance on water quality;
- Stormwater Management (Cayman Islands Planning Department and NRA) Guidelines Levels (2008) - provides national guidance on the formation of Stormwater Master Plans and primarily focuses on management of stormwater volume;
- Florida Department of Transportation (FDOT) Drainage Manual (January 2023) and associated FDOT Handbooks and Florida Administrative Code Rule Chapter 62-777 Contaminant Clean-up Target Levels;
- Consultation with DoE, WAC and Department of Environmental Health (DEH) to determine the applicable standards that should be adopted for this part of the assessment;
- EIA Directive (2016) issued in accordance with the National Conservation Act (2013);
- United States Department of Agriculture Natural Resources Conservation Service (NRCS) National Engineering Handbook, 2021; and,
- International standards such as the UK’s and Canada’s Environmental Quality Standards.

4.3.9 Potential Impacts

Potential impacts from the proposed project may include a change of water circulation patterns, increase of stormwater runoff volume and velocity, decrease of water quality, and impact on the ecology of natural resources. Potential receptors include the adjacent developed areas, Central Mangrove Wetlands, the Mastic Reserve, the Meagre Bay Pond and the Lower Valley and North Sound freshwater lenses. Potential impacts to be further assessed shall include:

- A damming effect caused by the construction of the proposed roadway changing the water circulation patterns, which may result in:
  - Restricting hydrology to the Central Mangrove Wetland north of the proposed EWA Extension of hydrology and causing inundation of the mangroves and adjacent developed areas south of the proposed roadway;
  - Alterations of hydrology, water flow, water levels, surface drainage, salinity levels, nutrient balance, oxygen concentration or temperature that may be harmful to mangrove trees and wildlife or the ecological or aesthetic value of the area or that may exacerbate erosion; and,
  - Damage to existing drainage infrastructure and subsequent flooding of neighbouring properties or infrastructure.
- Impacts on groundwater and surface water flows and drainage patterns may impact both the Lower Valley and North Side freshwater lenses;
- Increase of stormwater run-off volume and velocity from impervious surfaces (pavement), which may potentially increase flood risk;
- Temporary storage and stockpiling of materials may change surface water drainage patterns and locally increase flood risk;
- The loss of mangroves reduces transpiration, may increase runoff, and could reduce floodplain roughness, which in turn could increase run-off velocity and reduce protection from tropical storms and hurricanes. In addition, the cutting or drowning of mangroves may decrease precipitation on the western end of the island;
- The proposed roadway has the potential to release contaminants that may potentially pollute sensitive habitats and the underlying aquifers; and,
- The potential negative impact on hydrology may impact the ecology of the Central Mangrove Wetlands, the Mastic Reserve, and the Meagre Bay Pond Protected Area.

4.3.10 Assessment Methodology

An assessment will be completed as a part of the EIA development to gather critical information and fully understand the hydrology, drainage, hydrogeology, and geology characteristics and the potential impacts of the proposed roadway construction within the study area. The assessment methodology presented below overlaps with the assessments addressed in Section 4.4.5 as all four features are intertwined. This information will be used to determine if potential impacts from the construction of the proposed roadway can be avoided or minimised especially for water flow, water quantity and quality and sensitive habitats, including the Central Mangrove Wetland, Meagre Bay Pond, and the Mastic Reserve, and the developed areas south of the proposed roadway corridor.

The scope of the assessment shall include a review of applicable regulations, rainfall analysis, determination of drainage patterns, flood risk assessment addressing risks to neighbouring residential communities and other sensitive receptors with flood and hydraulic modelling, stormwater management plan with mitigation measures, water quality assessment, study of sensitive habitats, and impact of sea-level rise and climate change. Additional investigations shall be required, such as:

- Identification of applicable Governing Regulations, including regulations for stormwater and for the protection of the Central Mangrove Wetland and Mastic Reserve, and Meagre Bay Pond;
- Compilation and analysis of existing rainfall data for Grand Cayman, including large storms and tropical cyclones, to determine design rainfall amounts for flooding assessments and roadway storm water designs;
- Review existing drainage infrastructure mapping from the NRA;
- Conduct a site visit to confirm the local topography, verify the existing drainage network, and identify potential surface water flow paths;
- Review of 2004 Hurricane Ivan flood map;
- Analysis of daily rainfall for water quality assessments;
- Analyse inland conveyances and watersheds hydrology. Determine watersheds, storm runoff, and hydrologic and hydraulic effects of the proposed roadway on the watersheds and receiving water bodies and lands. Additionally, determine storm runoff for roadway drainage conveyance, embankment heights, and bridge dimensions and elevations.
    - For the large and extreme storms, use the US National Resources Conservation Service, NRCS, Type III storm hydrograph and the NRCS soil cover-complex method to determine runoff volume, hydrographs, and rates;
    - The soil-cover complex runoff curve number will be determined from observation and research on the soils and vegetation covers in Grand Cayman literature in comparison to the published runoff curve numbers. Future land build out will be included in the runoff calculations;
    - Time of concentration for the runoff from the most hydraulically distant point in the watershed to the point of analysis will be determined using the NRCS segmental method, the average velocity method, or a combination of both methods.
    - The appropriate hydrograph shape factors will be determined following the Florida Department of Transportation Drainage Design Guide;
    - Runoff volumes generated by the hydrographs will be used to assess overland flow captured by ponds, quarries, and significant depressions. What is not captured will be part of the hydrograph and peak flow rates used for analyses at points of interest and for future design of the East-West Arterial bridges and any impoundments associated with the roadway;
    - If the data from Hydrologic Research and Analyses generate sufficient rainfall intensities for short duration, high rainfall storms (five minutes to one hour) the rainfall intensities calculated will be used with the rational method for calculation

    of peak flow rates. The rational method and peak flow rates will be utilized for future design for roadway conveyances with small contributing drainage areas; and,
  - Ridge lines, watersheds, and drainages along with their conveyances will be plotted using the topographic mapping.
- A Hydrologic and Hydraulic Analysis to determine flood water level/design water level;
  - Calculate flood water surface elevations without the effects of storm surge and wave run-up using the US Army Corps of Engineers Hydraulic Engineering Centre River Analysis System, HEC-RAS, software model;
  - Use modelling methods, such as the US Federal Highway Administration HY-8 Culvert Hydraulic Analysis for uniform flow calculations for pipes less than full capacity, hydraulic grade lines for pipe systems flowing full, manning's normal depth analyses for ditches, and culvert analyses;
  - Sheet flow methods will be utilized where runoff is concentrated by the topography and channel hydraulics will not adequately characterize the flow; and,
  - Using the flood and conveyance elevations, alternatives can be considered for the East-West Arterial elevation roadway and bridge elevations can be determined. Impacts upon existing roads, quarries, ponds, lands, and existing and proposed communities can be made with runoff elevation and widths determined.
- Develop topographic mapping for the Hydraulic Analyses and mapping of the data using topographic mapping provided by the NRA with field observations and data obtained from other sources;
- Evaluate soils and geology information to determine the runoff curve number for the hydrologic analyses. Data from the Cayman Islands Government, past experience, and field observations will be utilized for the soils and geologic hydrologic components. In addition to the dense vegetation and the limestone and dolostone underneath, the large amounts of evaporation will also be a factor to determine the runoff coefficient;
- Satellite Imagery/ Geographical information will be utilized with the topographic data to develop base mapping;
- Evaluate future land use patterns; for estimating flood peak discharge at arbitrary points of crossing structures such as bridges, viaducts, culverts, etc. With the NRA and Planning coordination, the future land use patterns and their effects on the hydrology will be characterized. Areas for development will be incorporated into the analyses with their corresponding changes in runoff and flow patterns. Existing roadways and developed areas will be observed in the field for their hydrologic responses during the rains. Key future land use areas include:
  - Lookout Gardens;
  - Lower Valley Area;
  - Northward Area watershed; and
  - Breakers and Frank Sound Areas.
- Assess and design culvert/bridge conveyances using 1-dimensional and 2-dimensional H/H models (e.g. HEC-Ras and HEC-RAS 2D) and embankment "flow-though" in lowland floodplains (e.g. "Darcy" flow models) to minimise flood risk and environmental impacts; and,

- Consider sea level rise and climate change in the project's hydrologic/flooding assessments and stormwater management evaluation and perform an assessment of risk significance. Sea level rise and climate change will be projected out to 50 years. The assumed height of sea level rise is 1.64 feet (0.5 meter) for the year 2074.

4.3.11 Mitigation Measures

Mitigation measures will be assessed that avoid or minimise the potential hydrology and drainage impacts and protect residents and natural resources. These potential mitigation measures evaluated during preparation of the EIA and/or recommended by the EIA for further consideration during preliminary and final design may include:

- Consideration of flow through the aggregate roadway embankment to prevent the "damming" effect of the roadway;
- Maintain water flow with the use of box culverts to reduce the potential of altering salinity and hydrological gradients;
- Identify portions of the road that should be elevated to preserve hydrological flow in critical areas;
- Corridor-wide implementation of culverts or other "levelling" devices;
- Identification of, along with any necessary mitigation measures, existing drainage infrastructure or overland flow routes which may be affected by the proposed roadway;
- Design the roadway to be accessible during intense rainfall events and not increase flood risk to surrounding properties or infrastructure. Address stormwater management and flood risk for existing and future development along the EWA corridor from a regional perspective to provide greater resiliency to the effects of climate change;
- Design of drainage infrastructure with adequate capacity to safely convey the design rainfall intensity and minimise potential flood and water quality impacts, as well as to provide greater resiliency to the effects of climate change. Select stormwater management options to avoid or minimise impact on Lower Valley and North Side freshwater lenses, Meagre Bay Ponds, Central Mangrove Wetland, and Mastic Reserve. Ensure that hydrological regimes are maintained and surface water flow into the Central Mangrove Wetland is minimally impacted. Identification of appropriate locations to discharge stormwater from the roadway;
- Implement deep wells within individual catch basins. Restrict catch basin and well drainage areas to less than 6,000 square feet and provide adequate pre-treatment of roadway runoff to minimise discharge of floatable debris, oil, grease or other pollutants which could impede long-term well function;
- Assess potential for Green Stormwater Infrastructure and Low Impact Design or Development (LID) approaches, which manage stormwater runoff and water quality of both small and large storm events and reduces the amount of polluted stormwater runoff using nature-based solutions. Potential structures may include bioretention cells, bioswales, vegetated swales, raingardens, bioretention basins, and enhanced stormwater basins with natural ecological functions. Consider use of native plantings and wetland plants to filter pollutants;

- Ensure that the road design and storm water drainage system, including discharge points, takes into consideration the effect of climate change, including more frequent, larger storms and sea level rise;
- Reduce soil compaction with the use of low-impact construction vehicles and/or mats;
- Proper siting of temporary stockpiles to maintain drainage; and,
- Use best practice pollution prevention techniques during construction.

4.4 Geo-Environmental

4.4.1 Introduction

Geo-environmental processes on Grand Cayman contribute to sourcing potable water to residents and support natural resources. The construction of the proposed EWA Extension may affect the existing geo-environmental systems within the island. As part of the EIA, the applicable standards and guidelines will be reviewed, and the baseline conditions will be assessed for the Island's geo-environmental processes. Potential impacts of the proposed project along with potential mitigation measures that avoid or minimise impacts of the proposed roadway project will be identified in the EIA.

4.4.2 Baseline Conditions

4.4.2.1 Data Gathering Methodology

Although the study area includes the part of the island along the proposed roadway alignment, most geo-environmental topics are inclusive to the entire island. An initial review of published data and publicly available information will be used to develop the existing conditions considerations. This will include trial pit information collected in 2008 within the vicinity of the proposed roadway between Hirst Road and Lookout Gardens, and in 2014 for the proposed road corridor between Lookout Road and Frank Sound Road. Information on geology, soils, peat and hydrology along with climate and land use changes will be collected and analysed to define the geo-environmental processes. The following describes each of these components that will be included in the EIA.

4.4.2.2 Geology

Grand Cayman is generally low-lying, with the highest areas being approximately 71 ft. (22 m) above sea level. Grand Cayman is located on the Cayman Ridge which forms the southern margin of the North American plate. The Cayman Ridge is a block, uplifted above the surrounding seafloor, that is bounded by dipping fault planes. A map of the Caribbean area and a cross section showing the Cayman Ridge are in Figures 12 and 13, respectively. **Figure 12** is from Ren and Jones (2017) which was modified from Jones (1994) based on Perfit and Heezen (1978) and MacDonald and Holcombe (1978). **Figure 13** is from Jones (1994).

Carbonate rock reaching back 30 million years old is exposed on Grand Cayman. A sketch map showing the surface geology is in **Figure 14**, which is from Ren and Jones (2017) and modified from Jones (1994) and Ng (1990). The Bluff Group is divided (from oldest to youngest) into the Brac Formation, the Cayman Formation, and the Pedro Castle Formation. The name of the Bluff Group suggests its cliff-forming habit. The Brac Formation is not exposed on Grand Cayman.

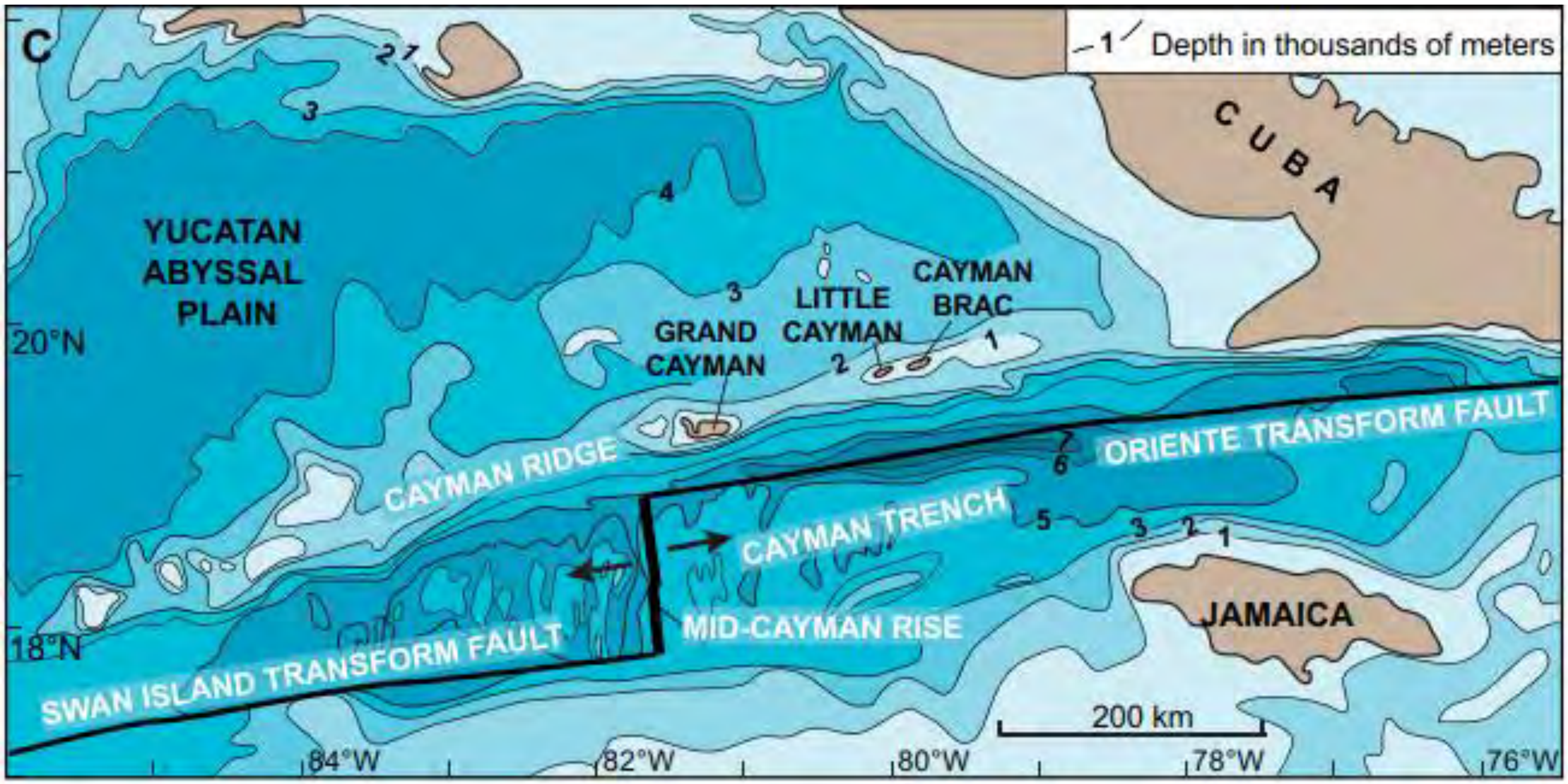

Figure 14: Map of the Caribbean Area

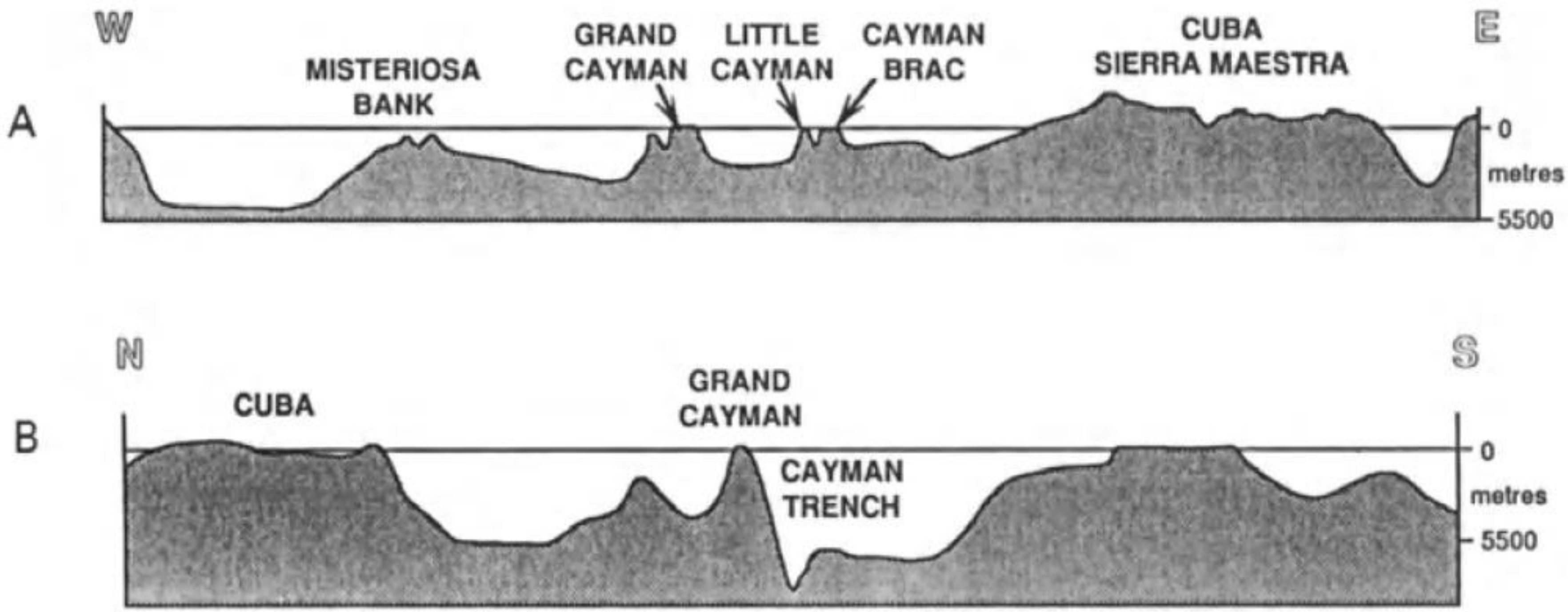

Figure 15: Cross section of Cayman Ridge. (A) Location of Grand Cayman on Cayman Ridge (B) Cayman Trench

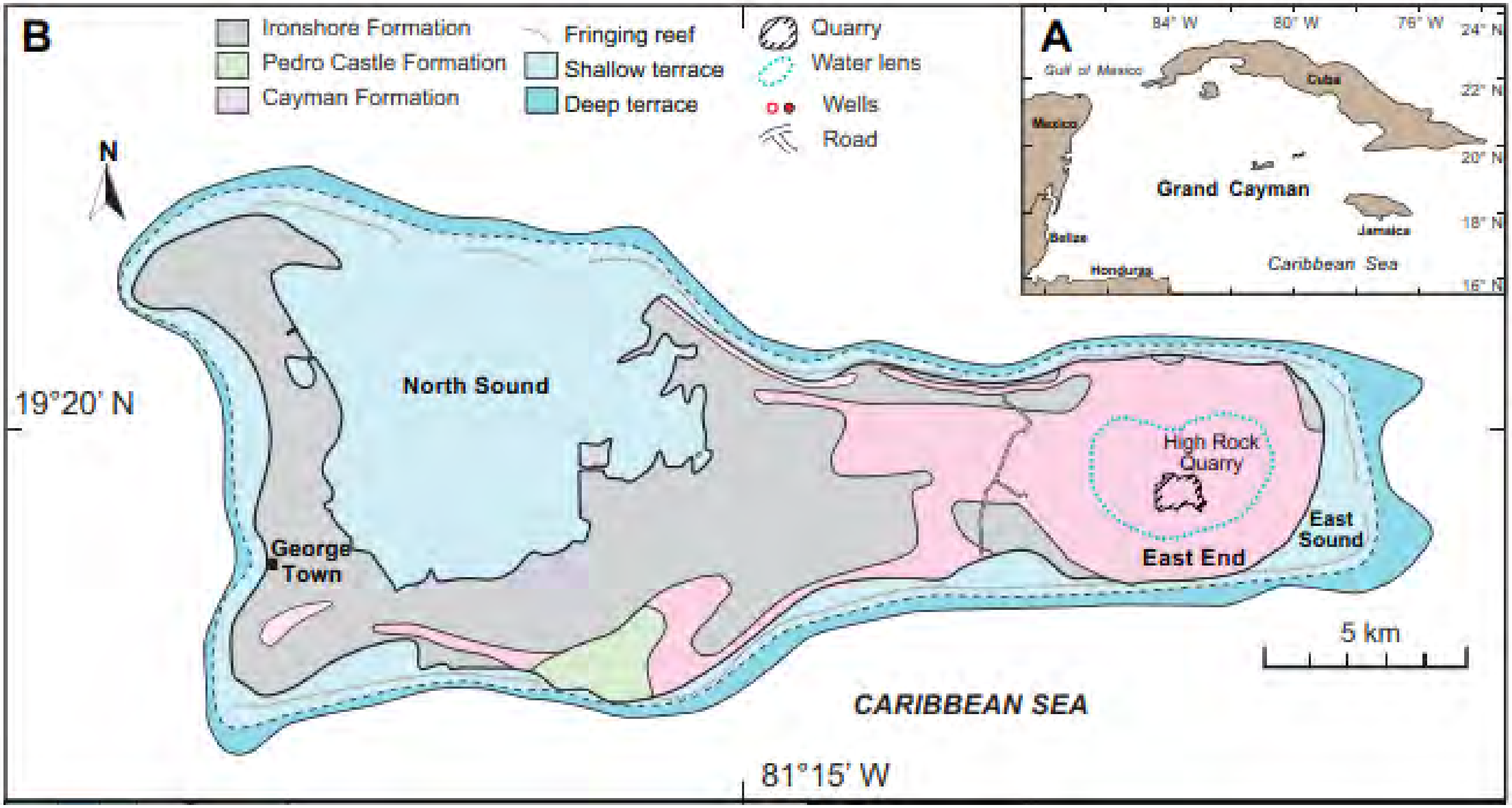

Figure 16: Sketch Map of Surface Geology

The Cayman Formation underlies the study area. It consists of relatively hard, microcrystalline dolostone containing the mineral dolomite (calcium magnesium carbonate). The thickness of the Cayman Formation is approximately 69 ft. (21 m), but it may be greater. Exposed Cayman Formation may have an irregular surface from karst landscape development, and it commonly has caves.

The Pedro Castle Formation overlies the Cayman Formation. The Pedro Castle Formation outcrops mainly in the southernmost part of Grand Cayman which is called Lower Valley. It is approximately 33 to 49 ft. (10 to 15 m) thick, or less where eroded. The Pedro Castle Formation may be relatively soft close to its stratigraphic contact with the underlying hard Cayman Formation.

Surrounding and partially onlapping the Bluff Group is the Ironshore Formation. Its thickness ranges from a thin veneer to 29.5 ft. (9 m). The Ironshore Formation consists of friable, poorly consolidated reef limestone, calcarenite, and oolitic limestone. The Ironshore Formation is the surficial geologic unit in most of western Grand Cayman.

4.4.2.3 Soils

Soils are generally thin on Grand Cayman. The sediments in the extensive mangrove swamps have a particular sequence which is described as transgressive by Woodroffe (1981). The basal unit is a crust that formed on rock during subaerial conditions predating the marine transgression, colloquially referred to as "caprock" by locals. Overlying the crusts is plastic mud deposited in seasonal floods. On top of the mud is peat formed from mangrove vegetation in an intertidal environment.

The NRA has developed conceptual plans and a subsurface profile for Section 2 of the EWA Extension (dated 2008) from approximately STA 0+00 ft. to 155+00 ft. STA 0+00 is at the existing terminus of the EWA, which is located at the intersection with Hirst Road, and STA 155+00 is at the Lookout Gardens. In addition, the NRA has developed similar information for part of Section 3 (dated 2014) between stations 155+00 and 455+00, which extends from the Lookout Gardens to Frank Sound Road. Their subsurface profiles include data from test pits along the project alignment. The spacing between test pits was typically 300 ft. (91.4 m), although the spacing was closer in some areas.

The test pits measured the depth to rock, and soil and peat thicknesses. In places, rock was at the land surface. At its deepest, the top of rock was approximately 14 ft. (4.3 m) below the land surface. Some test pits encountered a layer of soil up to about 1 ft. (0.30 m) thick on top of bedrock. Resting on this thin soil (or directly on top of bedrock) was a peat layer. Several test pits encountered the water table at, or just below the land surface.

It is anticipated to be necessary to excavate below weak materials such as peat and carbonate-derived residuum to construct the highway. Secondary and creep settlement is a risk to consider when soils are left in place. Karst landscape conditions including voids may influence the project, for example for foundations bearing on rock.

4.4.2.4 Peat

Mangrove-derived peat deposits underlie most of the mangrove swamps and cover the bedrock in many areas of Grand Cayman. Peat is mainly composed of organic remains from the mangroves themselves, principally from the two mangrove species *Rhizophora mangle* and *Avicennia germinans*. Peat deposits are fibrous, with abundant roots and rootlets. The peat does not have carbonate, and molluscs are rare. Much of the peat is less than 3 ft. (1 m) thick, but locally may be as thick as 20 ft. (6 m).

Peat has historically been connected to climate change as it has been determined to sequester greenhouse gases. It is anticipated that peat underlies a portion of the proposed roadway alignment. Trial pit data collected in 2008 within the vicinity of the proposed roadway between Hirst Road and Lookout Gardens demonstrated that much of the proposed roadway does not have significant peat depths. However, there are areas close to Lookout Gardens with approximately 5 ft. (1.5 m) in depth on average and up to 14 ft. (4.3 m) thick.

For the roadway construction, peat and other unsuitable material may need to be removed and replaced with aggregate to create a firm foundation. The aggregate material will need to be mined from the existing authorised commercial quarries. In August 2018, the Water Authority estimated that there are approximately 32 million cubic yards (yd^3) (244 million cubic metres) of aggregate in the authorised commercial quarries. An alternative to removing peat and replacing with aggregate is to elevate the proposed roadway using bridges and other design options.

4.4.2.5 Hydrogeology

Since 1982, the Water Authority in the Cayman Islands has operated as a water and wastewater utility and regulatory agency to protect and manage groundwater. It operates a central sewerage system, and it regulates on-site wastewater treatment systems. The Water Authority operates a central water supply system that uses reverse osmosis treatment of saline groundwater. The Water Authority, under the Water Authority Act (2022) Revision, is charged with the management, control, and protection of water resources.

Ng and Beswick (1994), and Jones, Ng, and Hunter (1997) described groundwater occurrence in the Cayman Islands. An unconfined aquifer exists in fractured carbonate rock. The unconfined aquifer is hydraulically connected with the ocean, and the water table elevation is typically less than 1.6 ft. (0.5 m) above Mean Sea Level. Owing to the high permeability of the karst rock, surface streams are absent, and the water table gradient is low. Freshwater lenses consist of three zones: a freshwater zone with a chloride concentration less than or equal to 600 milligrams per litre (mg/l); and a brackish zone (chloride of 600 to 19,000 mg/l); and a saline zone where chloride is at least 19,000 mg/l. The water zones radiate around the water lenses. In other areas, there is only brackish water underlain by saline water or there is only saline water.

Freshwater occurs in Grand Cayman in lens-shaped bodies beneath topographic highs in the Bluff Group. Tidal oscillations generate mixing of brackish and fresh water. The source of the freshwater on Grand Cayman is precipitation. Recharge of the lenses mainly occurs during large rainstorms. There are dynamic hydrogeological conditions at the boundaries of the larger freshwater lenses, in particular the boundary between potable and brackish water, which is a major contributor to the development of cave networks. Most of the larger known cave systems are situated near these boundaries.

The Hydrogeological Survey of Grand Cayman (a 1:50,000-scale map) shows the locations and dimensions of the three largest, usable freshwater lenses on the island **(Figure 15)**. Figure 15 is from Jones et. al. (2001), which was modified from Ng (1990). The Lower Valley Lens is the smallest and is about 2.5 mi (4 km) long and about 0.6 mi (1 km) wide. It underlies and/or is adjacent to Section 1 and Section 2 of the highway project. The North Side Lens is larger and exists about 0.6 mi (1 km) north of the east end of Section 3. The East End Lens is the largest lens. Its edge is about 2.5 mi (4 km) east of the limit of Section 3.

4.4.2.6 Future baseline

Climate and land use change could affect the geo-environmental conditions within the project area in the future. Climate change could affect the amount, intensity and duration of rainfall, temperature, and evapotranspiration, as well as occurrence of extreme weather (e.g., hurricanes). In addition, it has been predicted that the Cayman Islands may experience a decrease of between 0.4 and 2 in (10 and 50 mm) in annual rainfall totals between 2011 and 2099 (National Climate Change Committee, 2011). The Intergovernmental Panel on Climate Change predicts that there is a likely decrease in rainfall during the boreal summer in the Caribbean and that this drying trend will likely continue in the coming decades (Arias et al., 2021). Between December 2021 and November 2022, the rainfall monthly totals were 4.9% lower than the 30-year average (Cayman Islands National Weather Service, 2022). The change in rainfall patterns, evaporation, and extreme weather could impact the recharging of the freshwater lenses.

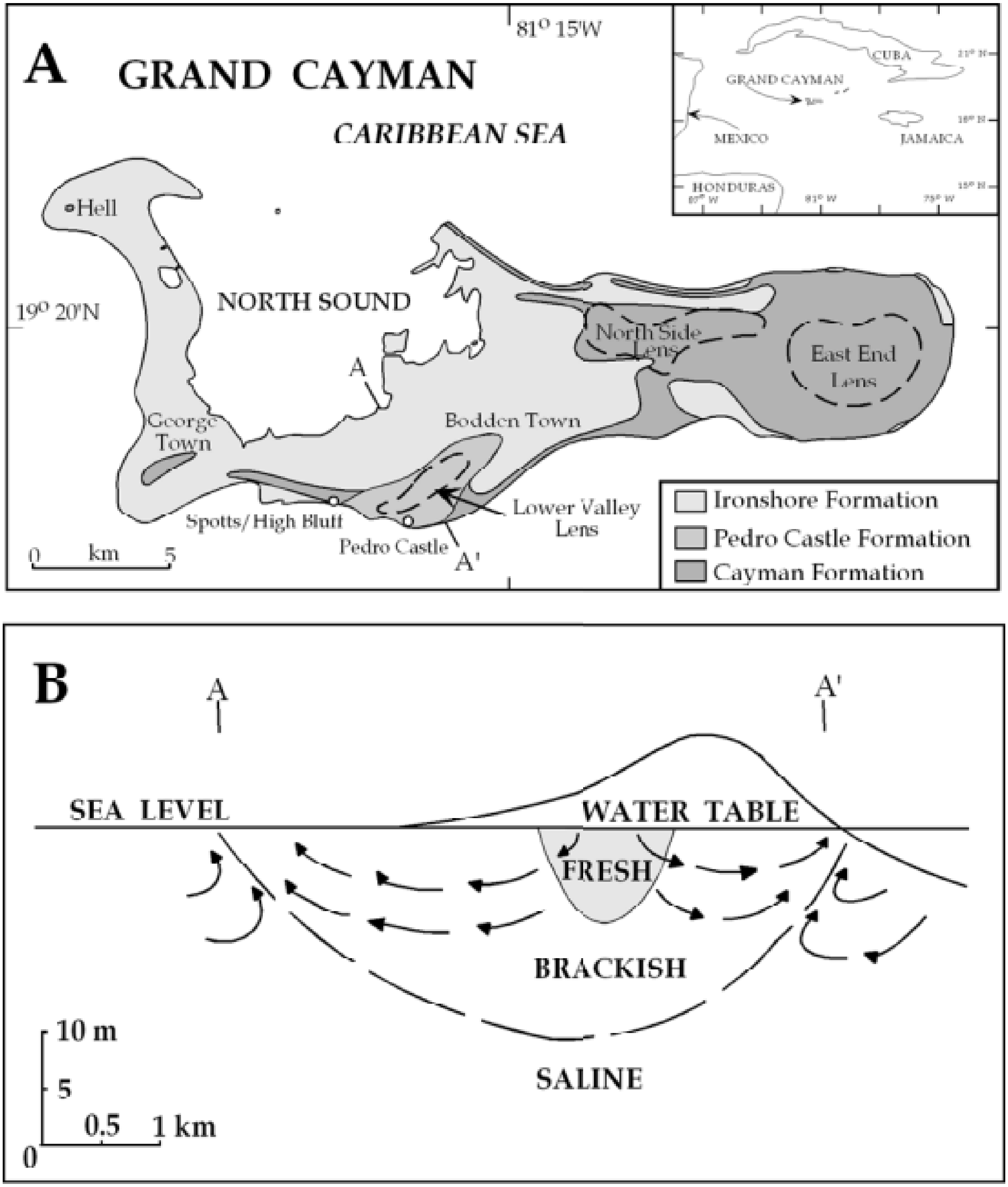

Figure 17: Location of the Freshwater lenses (A) and the cross section of the Lower Valley freshwater lens (B)

4.4.3 Applicable Standards

Applicable standards will be reviewed to ensure they are considered during project development and follow the most up-to-date guidance. Currently, there are no specific standards for water quality or geo-environmental assessment in the Cayman Islands. Therefore, assessments and analyses will be guided using UK and International standards from the United States including the State of Florida along with consultation with the Cayman Islands Government.

The following standards will be reviewed and applied as appropriate:

- Consider international standards such as the UK and Canadian Environmental Quality Standards. The Environmental, Health and Safety Guidelines, General EHS Guidelines: Environment (International Finance Corporation (IFC), 2007);
- Stormwater Management (NRA) Guidelines Levels (2008) which provides guidance on the formation of Stormwater Master Plans and primarily focuses on management of stormwater volume;
- Florida Department of Transportation (FDOT) Drainage Manual (January 2023) and associated FDOT Handbooks and Florida Administrative Code Rule Chapter 62-777 Contaminant Clean-up Target Levels;
- Directive for EIAs (2016) issued in accordance with The National Conservation Act (2013);
- Water Authority Act (2022 Revision) which states in Section 19 that groundwater vests in the name of the Crown and appoints the WAC as the custodian of groundwater in the name of, and on behalf of, the Crown;
- Cayman Islands Development and Planning Regulations (2022), specifically Regulation 18. Mangrove Buffer zones and Regulation 19. Land above water lenses;
- United States Department of Natural Resources Conservation Service (NRCS) National Engineering Handbook (2021); and,
- Consultation with DoE, WAC, and DEH to determine the applicable standards that should be adopted for this part of the assessment.

4.4.4 Potential Impacts

Potential impacts that may occur due to the construction of the proposed project include changes to the quantity and quality of peat and groundwater. Potential receptors include the adjacent developed areas, Central Mangrove Wetland, the Lower Valley and North Side freshwater lenses, and possibly the East End freshwater lens. The potential impacts from the proposed EWA Extension project centres on the freshwater lenses which are critically important water supplies on Grand Cayman. Potential impacts include the addition of impermeable surfaces that could diminish groundwater recharge or redirect stormwater away from the freshwater lenses. Certain changes in recharge could potentially negatively influence hydraulic conditions in and around freshwater lenses or degrade the quality of recharging water. In addition, changes in drainage patterns also have the potential to impact the freshwater lenses.

The potential impacts that shall be investigated include:

- Peat may potentially be removed, covered over, compacted, and contaminated, which may impact the Central Mangrove Wetland. The peat substrate is required for new growth for many species of flora, including but not limited to true mangroves. It's a vital component of a healthy wetland ecosystem and also sequesters and purifies toxins from the surrounding groundwater. An unknown factor is how currently undeveloped lands south of the proposed road corridor will impact drainage conveyance, given there are no proper regulations to ensure developments are built in a sustainable manner with functional drainage plans;
- The removal of peat may contribute to the release of greenhouse gases (see Section 4.7);
- The disturbance of peat during construction may contribute to the release of hydrogen sulphide, which could potentially cause health impacts for construction workers. Although poorly ventilated working conditions will likely be infrequent during construction of the roadway as most of the work will be conducted above ground, eye and lung irritation could be a potential hazard in the event that a particularly deep succession of peat is encountered during excavation activities;
- Changes in drainage patterns/stormwater management within the study area may potentially impact the developed areas south of the EWA and possibly the area east of Frank Sound Road;
- The freshwater lenses can be damaged as potential sources of potable supply if the groundwater flow system supporting the lens undergoes changes that could diminish the volume of freshwater and may result in eventual salt-water contamination of all but the shallowest wells used to abstract fresh groundwater;
- Soil compaction and the increased impervious surface (pavement) may result in reduced infiltration, which may impact the recharge rate and water level in the Lower Valley and North Side freshwater lenses;
- Storm-water drainage patterns and recharge rates may be impacted if the project requires construction of vertical stormwater drainage wells, or other means for the conveyance or drainage of stormwater;
- Temporary dewatering during the construction phase for the excavation for the proposed roadway foundations may result in localised and temporary decline in groundwater levels and deterioration in groundwater quality via induced saline intrusion; and,
- The potential release of contaminants may impact water resources. Due to the karst geology of the Cayman Islands and the absence of shallow low permeability confining zones, contaminants released directly (e.g., spillages) or indirectly (via surface water runoff) from the proposed roadway have the potential to migrate into the underlying aquifers leading to deterioration in groundwater quality.

4.4.5 Assessment Methodology

An assessment will be completed as a part of the EIA to gather critical information to fully understand the geo-environmental characteristics and the potential impacts of the proposed roadway construction within the study area. This information will be used to determine if potential impacts from the construction of the proposed roadway can be avoided or minimised especially for mangrove peat and to the water quantity and quality of the Lower Valley, North Side, and East End freshwater lenses.

The scope of the assessment will include a review of applicable regulations, a mangrove peat assessment, a proposed aggregate quantity assessment, and a freshwater lens assessment in the study area, if necessary. The other components related to determining the geo-environmental processes will be completed for the entire study area as part of the Hydrology and Drainage effort, described in Section 4.1.

Other additional investigations shall include:

- Identification of applicable Governing Regulations, including the Water Authority Act (2022 Revision);
- Development of a hydrogeological model for the study area;
- A mangrove peat assessment will be completed to map the location and depth of mangrove peat within the project area. A geotechnical review will be completed, and an underlying stratigraphy assessment will be prepared. The trial pit information collected in 2008 will reviewed and supplemented with data collected from new pits further east along the corridor, as needed, to establish average peat depths and total volume of peat expected to be removed;
- A proposed aggregate quantity assessment will be completed by estimating the amount of aggregate required for fill based on proposed roadway design;
- If necessary, the Freshwater Lens Study would include researching the water budget for groundwater recharge with data available from the Water Authority – Cayman and developing a water budget for use as a base model for the proposed effects of the East-West Arterial on infiltration, which will be used to determine the effects upon the groundwater and freshwater lenses. In addition, the existing water quality and quantity data of the Lower Valley and the North Side freshwater lenses will be reviewed;
- Review assessment of impacts of canals on the project area and freshwater lenses from the 1980's to evaluate the potential impact of shallow conveyance canals that drain stormwater from the project area on freshwater lenses;
- Site investigations will be completed to confirm the local topography and verify the existing drainage network of the freshwater lenses; and,
- Identification of the interaction of potential stormwater wells and other stormwater management approaches with the freshwater lenses will be completed; and
- Identification of cumulative impacts and the selection of potential avoidance and mitigation opportunities.

4.4.6 Mitigation Measures

Mitigation measures will be assessed that avoid or minimise the potential geo-environmental impacts. These potential mitigation measures may include:

- Salvage and reuse mangrove peat, to the greatest extent possible;
- Ensure that aggregate for fill can be obtained from the licensed reserve in commercial quarries. Reduce need to fill by elevating roadway and employing other design options;
- Avoid placing staging and stockpile areas and access on peat and on or near freshwater lenses;
- Protecting peat and existing ground near freshwater lenses from compaction during construction with the use of low-impact construction vehicles and/or mats;
- Recommending portable hydrogen sulphide detectors and personal protection equipment, such as tight safety goggles and gas masks, during peat disturbance when working in poorly ventilated conditions to minimise health impacts from the potential release of hydrogen sulphide;
- Assessing the interaction of the wells and the freshwater lenses to prevent inadvertent draining of the lenses into underlying Karst formations through a comprehensive subsurface (i.e., drilling) program to determine the underlying stratigraphy to ensure minimal impacts to resources;
- Evaluate protection from regional head changes by requiring careful designing of the roadway in portions of the flow system supporting the lenses;
- Designing mitigation measures to maintain good water quality in the discharged water;
- Developing best practice pollution prevention techniques to minimise release of contaminants during construction and operation;
- Developing construction plans so that any discharges from the site to ground and surface water must meet applicable water quality discharge criteria;
- Determining stormwater management options that will avoid or minimise impacts on Lower Valley and North Side freshwater lenses and ensure that hydrological regimes are maintained, and aquifers are recharged like existing conditions;
- Designing stormwater systems so they will be effective with rising sea level both from surface and ground water, i.e., pump stations rather than gravity-based systems; and,
- Use of elevated structure in highly vulnerable areas.

4.5 Terrestrial Ecology

4.5.1 Introduction

The findings in the EIA Scoping Opinion included concern that the proposed EWA Extension Corridor could significantly affect ecological resources directly from construction activities and indirectly through operation of the roadway, resulting in a loss of function and value. Government commitments under the Cayman Islands Environmental Charter, NCA, and the National Biodiversity Action Plan require that this functional loss be evaluated with the goal of achieving No Net Loss of Biodiversity.

4.5.2 Baseline Conditions

The diverse habitats of Grand Cayman include dry forests, dry shrublands, and dwarf shrublands, typically occurring on land that is at least 6 ft. (1.8 m) above the groundwater table. Additional habitat types that are present within the island include: seasonally flooded forests, mangrove forests, coastal shrublands, and mangrove shrublands, along with limited sedge, tidally flooded succulents, and beach sand communities. The local climate is influenced by the location of the Islands and can be described as a tropical marine climate with two distinct seasons: a wet season from May through November and a relatively dry season from December through April (see prior discussion of climate trends in Section 4.1.4).

During the EIA process, technical reports, publications, government documents, websites, and the following GIS datasets, provided by the DoE, will be reviewed to develop a thorough understanding of the baseline existing conditions within, adjacent to, and in the vicinity of the proposed EWA Extension Corridor.

- Grand Cayman Landcover and Habitat (2018);
- Dry Forest Above 20-ft Elevation;
- Grand Cayman National Trust Sites (2022); and,
- Grand Cayman National Conservation Act Sites (2022).

Ecological resources identified within, adjacent to, or in the vicinity of the proposed EWA Extension Corridor **(Figures 16** and **17** and **Table 3)** include two National Trust sites, four NCA protected sites, and NCA marine protected resources. The remaining habitat within the Central Mangrove Wetland is also highly functional and biodiverse. Not included in the table but also of importance are ecologically sensitive areas that are not yet designated as Protected Areas under either the National Conservation Act or the National Trust Act immediately adjacent to the north and south of the proposed EWA Extension Corridor that may be affected by the proposed project. Marine turtle nesting beaches and critical habitat are located along the northern and southern side of Grand Cayman and will be considered when analysing the proposed EWA Extension Corridor.

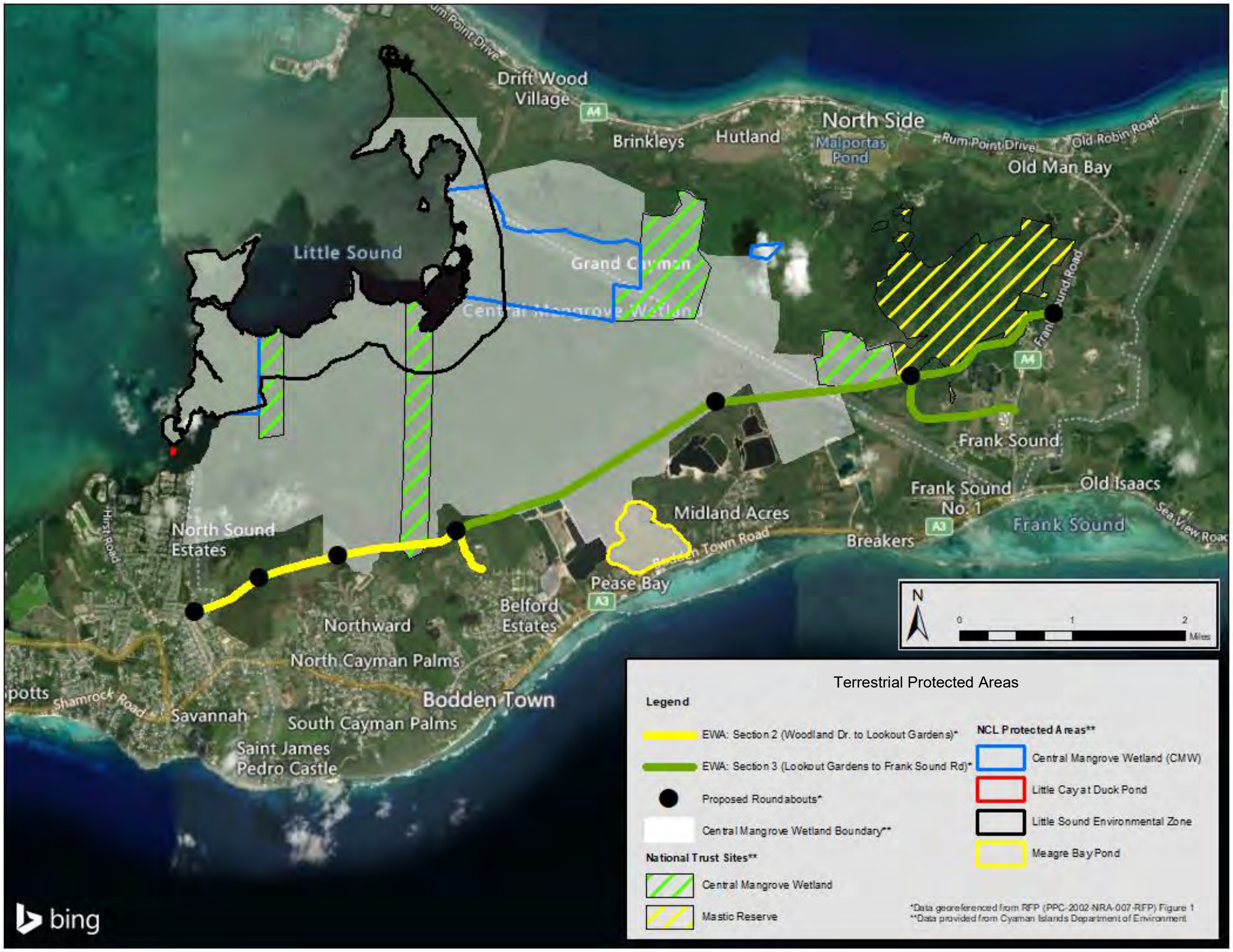

Figure 18: Map of Terrestrial Protected Areas

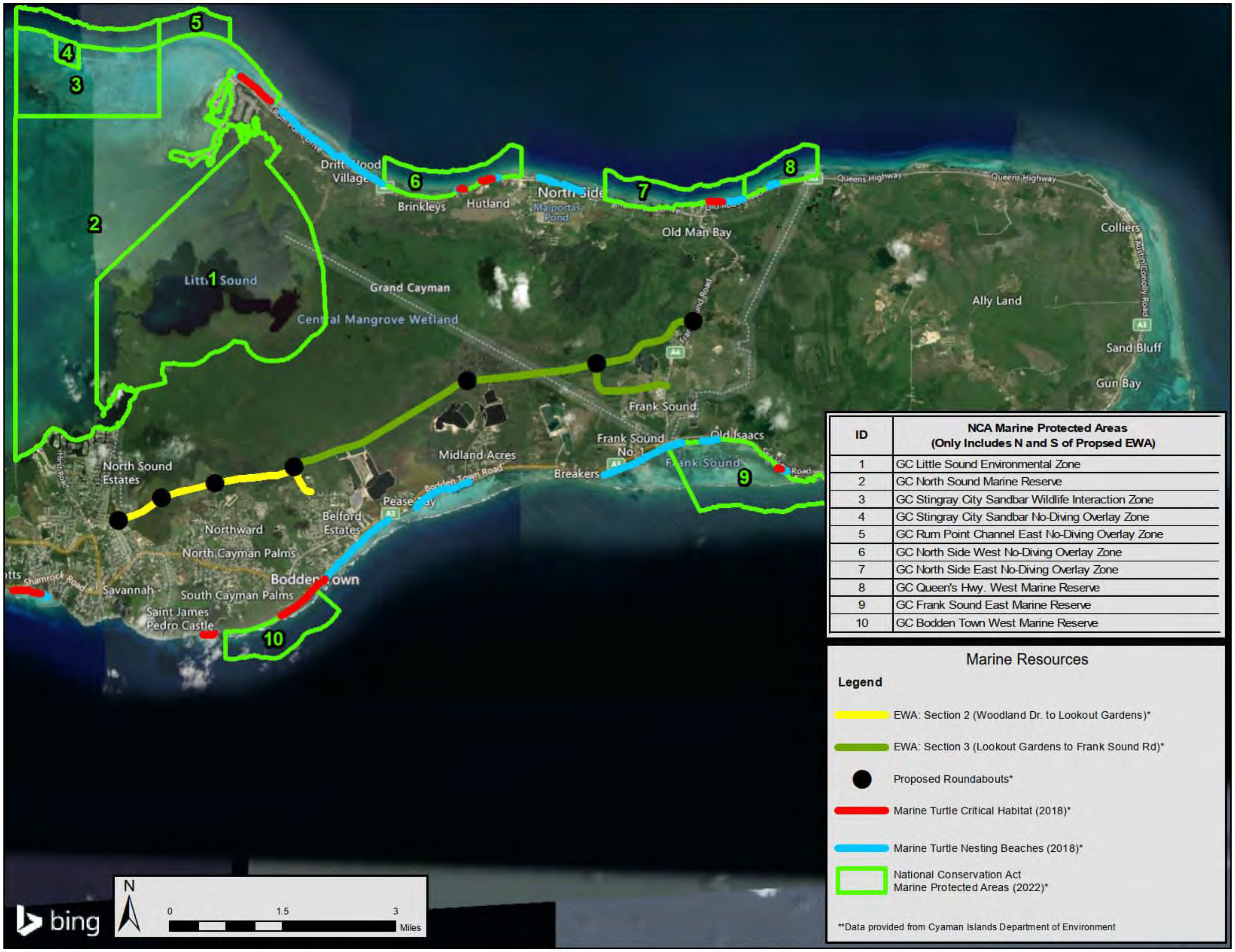

Figure 19: Marine Resources and Marine Protected Areas

Table 3: Protected and proposed-for-protection sites within, adjacent to, or in the vicinity of the proposed EWA Extension Corridor.

Resource Name	Governing Entity	Approximate Distance and Direction from the proposed EWA Extension Corridor	Description
Central Mangrove Wetland Parcels	National Trust and NCA	Intersected Section 2 EWA Extension, ~1.6 mi (~2.6km) north of Section 2 ~1.5 mi (~2.4 km) north of Section 3	The Central Mangrove Wetland regulates nutrient flows to North Sound; provides storm and wave protection; sequesters carbon; and provides habitat for a wide assemblage of species. Meets criteria for designation as a Ramsar site*
Mastic Reserve	National Trust	Intersected by Section 3 EWA Extension (Section 3)	The Mastic Forest is the home to endemic flora and fauna and a rare variety of black mastic tree (*Termenalia eriostachya var margaretiae*). Also stores carbon, regulates overland water flow, and prevents degradation of the underlying freshwater lens.
Little Cay at Duck Pond	NCA	~1.4 mi (~2.25 km) northwest of Section 2	Small island located south of the Little Sound Environmental Zone
Little Sound Environmental Zone	NCA	~1.4 mi (~2.25 km) north of Section 3	Large, protected swath of the Central Mangrove Wetland that encircles the Little Sound.
North Sound Marine Reserve	NCA	~1.25 mi (~2 km) northwest of Section 2 ~4.5 mi (~7.25 km) northwest of Section3	A 13,838 ac (5,600 ha) semi-enclosed, shallow lagoon, historically fringed with mangrove swamp to the west, south, and east, and with an exposed fringing reef to the north.
Meagre Bay Pond and Animal Sanctuary	NCA has an adopted Management Plan	~0.6 mi (~1 km) south of Section 3	Pond with ~300-ft (~91-m)-wide band of surrounding mangroves. Provides seasonally important foraging habitat to resident and migratory birds. Meets criteria for designation as a Ramsar site*
Marine Turtle Critical Habitat	NCA	Designated shorelines north and south of the study area	Designated Marine Turtle Critical Habitat Protection Zones
Marine Turtle Nesting Beaches	NCA	Designated shorelines north and south of the study area	Designated Marine Turtle Nesting Beaches

*Ramsar Site: wetlands of international importance that have been designated under the criteria of the Ramsar Convention on Wetlands for containing representative, rare, or unique wetland types or for their importance in conserving biological diversity. The Ramsar Convention provides the only international mechanism for protecting sites of global importance and is thus of key conservation significance.

Portions of the proposed EWA Extension Corridor will be contiguous with identified areas of wetlands and uplands, including the Central Mangrove Wetland and Mastic Forest. Each of these ecosystems are unique and important to Grand Cayman. The Central Mangrove Wetland is about 8,500-acres (3,440-ha) in size and comprises approximately 30 percent of Grand Cayman, making it the largest contiguous mangrove wetland in the Caribbean. Much of the wetlands are still in their natural state and are comprised of dense red (*Rhizophora mangle*), black (*Avicennia germinans*), and white mangroves (*Laguncularia racemosa*) with buttonwoods (*Conocarpus erectus*) in more upland parts.

The Central Mangrove Wetland provides carbon storage, local climate regulation, water flow regulation, water quality improvement, habitats for wetland dependent species, and coastal protection. The Central Mangrove Wetland provides filtered water and nutrients to the North Sound which provides the base for the North Sound food web. The North Sound is directly linked to the Central Mangrove Wetland; consequently, effects to the Central Mangrove Wetland will also affect the North Sound ecosystem.

The Little Sound Environmental Zone is a large, protected swath of the Central Mangrove Wetland that encircles the Little Sound. Adjacent to the Little Sound is the North Sound, a 3,838 acres (~5,600 ha) semi-enclosed, shallow lagoon, historically fringed with mangrove swamp to the west, south, and east, and with an exposed fringing reef to the north. Both the Little Sound and North Sound provide habitat and nurseries for fish, clear water diving, and support many livelihoods on Grand Cayman.

The Mastic Forest is approximately 1,571.6 acres (636 ha) in size and is the largest contiguous evergreen woodland remaining on Grand Cayman. It represents one of the last remaining examples of Caribbean subtropical, semi-deciduous dry forest. The forest is largely untouched, other than selective logging and small-scale agriculture that occurred in the past. The part of Grand Cayman containing the forest has been above water nearly 1.9 million years longer than the rest of the island and is the location where the native flora and fauna evolved. Grand Cayman's endemic orchids, trees, and birds inhabit this area along with other rare and protected species including a rare variety of black mastic tree (*Termenalia eriostachya var margaretiae*). Functions provided by the forest include carbon storage, local climate regulation, water for human consumption, water flow regulation, habitats, and water quality treatment.

4.5.3 Applicable Standards and Guidelines

The establishment of existing baseline conditions information described in Section 4.3.2 will be supplemented through consultation with local environmental organizations, field surveys, and available hydraulic and hydrologic modeling information. This baseline information will provide a reference for comparison for evaluating the potential effects from the construction of the proposed EWA Extension Corridor. The Chartered Institute of Ecology and Environmental Management's (CIEEM) *Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater, Coastal and Marine* (Updated April 2022), will be used as guidance to develop the methods to identify current baseline conditions.

In addition to the CIEEM guidelines, other legislation and relevant Cayman guidance materials that will be consulted as part of the ecological studies include, but are not limited to:

- Cayman Islands National Biodiversity Action Plan (2009);
- National Trust Law (2010 Revision);
- National Conservation Act (2013);
- National Conservation (General) Regulations (2016);
- The Mangrove Conservation Plan (2020);
- National Conservation (General) (Amendment) Regulations (2021);
- Development and Planning Act (2021 Revision); and,
- Development and Planning Regulations (2022 Revision).

The Cayman Islands are also included in the UK's ratification of the following Conventions, which will also be consulted as part of the ecological studies:

- Convention on Biological Diversity;
- Convention on Wetlands of International Importance (Ramsar Convention); and ,
- Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention).

4.5.4 Potential Impacts

The potential impacts from the construction and operation of the proposed EWA Extension Corridor on terrestrial ecology will be determined during the EIA study. Additionally, potential secondary impacts to marine resources downstream and upstream of the project will be evaluated. As previously noted in the baseline conditions discussion, effects to the following ecological resources will be analyzed: the Central Mangrove Wetland, Meagre Bay Pond and Animal Sanctuary, Mastic Reserve, Little Sound Environmental Zone, North Sound Marine Reserve, mangrove habitat to the north and south of the proposed EWA Extension Corridor, Marine Turtle Critical Habitat, and Marine Turtle Nesting Beaches. The zone of influence for determining project impacts will be refined based on the data collected, the engineering designs, and on field assessments performed during the EIA studies. Direct and temporary impacts will be evaluated for the construction phase as will secondary, indirect, and cumulative impacts for the operation of the EWA Extension.

These effects to ecologic features from the construction and operation of the proposed EWA Extension Corridor will include, but are not limited to:

- Loss of habitat and habitat fragmentation;
- Loss of species through disturbance or wildlife-vehicle collisions;
- Restriction of animal migratory movements;
- Fugitive dust;
- Construction and roadway runoff (sedimentation and/or contamination);
- Construction and traffic noise;

- Light trespass into surrounding natural areas; and,
- Reduced hydrologic connectivity.

4.5.4.1 Potential Receptors

Potential receptors include those ecological features that are determined to be unique in context to the proposed project. An ecological feature as defined in the CIEEM Guidelines, pertains to habitats, species and ecosystems and their functions/features. Unique ecological features can be those that are rare; threatened; sensitive to anthropogenic impact; and/or designated or protected by international, national, and/or local regulations. The terrestrial and marine ecological features listed below, but not limited to, have been initially identified as potential receptors:

- Central Mangrove Wetland;
- Mastic Reserve;
- Little Sound Environmental Zone;
- North Sound Marine Reserve;
- Meagre Bay Pond Protected Area;
- Migratory birds;
- Protected Species (flora and fauna); and,
- Marine Protected Species.

The identification of any additional receptor sites will be evaluated as part of the EIA studies.

4.5.5 Assessment Methodology

Baseline existing conditions as described in Section 4.3.2 will be refined through continued desktop and field review assessments. Field biologists will characterize and map ecological features within, adjacent to, or in the vicinity of the proposed EWA Extension Corridor using hand-held GPS receivers. The use of drone technology to collect field data will also be utilised, as appropriate. Floral and faunal species and their respective habitats that may be affected directly or indirectly within, adjacent to, or in the vicinity of the proposed EWA Extension Corridor will be evaluated for potential construction and operational impacts including habitat fragmentation and roadway mortality.

Potentially impacted wetlands will be evaluated not only in terms of size and type, but also using established wetland functional tests that have been developed in the United Kingdom or in the United States. These tests have been designed and refined to not only look at quality and quantity of wetland vegetation but also the diversity they create for faunal species. The most relevant and current test is the Uniform Mitigation Assessment Method (UMAM) that provides a standardized rapid assessment method (RAM) tool for the determination of compensatory mitigation requirements to offset unavoidable impacts to mangrove wetlands and surface waters. UMAM evaluates the functionality of unavoidable impacts to tropical wetland ecological systems, including plant cover, benthic communities, and uplands in support of protecting wetlands. A detailed discussion of the importance of hydrology to the Central Mangrove Wetland and surrounding natural areas was explained in Section 4.3, but is noted here as well, as an important component of the terrestrial and marine ecology to be evaluated.

The results of the desktop and field reviews along with the hydraulic and hydrologic modeling data will be used to identify potential ecological effects of the proposed EWA Extension Corridor. The significance evaluation of the effects to ecological resources will be assessed by considering the following characteristics and assessed based on criteria presented in **Table 4**:

- Positive or negative – environmental change resulting in improved or reduced environmental quality;
- Extent – the spatial or geographical area over which the environmental change may occur;
- Magnitude – the size, amount, intensity or volume of the environmental change;
- Duration – the length of time over which the environmental change may occur;
- Frequency – the number of times the environmental change may occur;
- Timing – the periods of the day/year during which an environmental change may occur; and,
- Reversibility – whether the environmental change can be reversed through restoration actions.

Table 4. Magnitude of Change in Terrestrial Ecology Resources.

Magnitude of Change	Criteria and Resultant Effects
High	The change permanently (or over the long-term) affects the conservation status of a habitat/species, reducing or increasing the ability to sustain the habitat or the population level of the species within a given geographic area. Relative to the wider habitat resource/species population, a large area of habitat or large proportion of the wider species population is affected. For protected sites, integrity is compromised. There may be a change in the level of importance of the receptor in the context of the project.
Medium	The change permanently (or over the long term) affects the conservation status of a habitat/species reducing or increasing the ability to sustain the habitat or the population level of the species within a given geographic area. Relative to the wider habitat resource/species population, a small-medium area of habitat or small-medium proportion of the wider species population is affected. There may be a change in the level of importance of this receptor in the context of the project.
Low	The quality or extent of protected sites or habitats or the sizes of species' populations, experience some small-scale reduction or increase. These changes are likely to be within the range of natural variability and they are not expected to result in any permanent change in the conservation status of the species/habitat or integrity of the protected site. The change is unlikely to modify the evaluation of the receptor in terms of its importance.
Very Low	Although there may be some effects on individuals or parts of a habitat area or protected site, the quality or extent of sites and habitats, or the size of species populations, means that they would experience little or no change. Any changes are also likely to be within the range of natural variability and there would be no short-term or long-term change to conservation status of habitats/species receptors or the integrity of designated sites.
Negligible	A change, the level of which is so low, that it is not discernible on designated sites or habitats or the size of species' populations, or changes that balance each other out over the lifespan of a project and result in a neutral position.

4.5.6 Potential Mitigation Measures, Environmental Enhancements and Educational Opportunities

Mitigation measures will be investigated to offset unavoidable impacts from the proposed EWA Extension Corridor. The goal in developing mitigation measures is to best compensate for the functional loss resulting from unavoidable project impacts. Mitigation measures will be evaluated using the Natural England's Biodiversity Metric 3.1 Calculation Tool with the goal of achieving No Net Loss of Biodiversity. There is also opportunity for environmental enhancements and education; focusing on ecological regional improvements. Potential measures that may be investigated include, but are not limited to:

- Replacement of property;
- Conservation;
- Replanting/establishment of habitat;
- Dedicated wildlife crossings or protective fencing;
- Creation of hydrological components;
- Viewshed enhancements/Visual screening;
- Landscaping;
- Land contouring; and,
- Environmental awareness campaigns.

4.6 Cultural and Natural Heritage Sites

4.6.1 Introduction

Cultural and Natural Heritage sites are important resources on Grand Cayman. These heritage site resources include both designated features protected by legislation and features of national or local archaeological, historical, or architectural interest. Based on the type and location of the proposed project the studies for the EIA will focus on terrestrial heritage resources within the project study area.

Heritage site resources are identified and/or protected under the following legislation:

- NCA – Under Part 3-Conservation of Land, the Cabinet may designate any area of Crown Land or Cayman waters as a "protected area".
- National Trust Act
  - National Trust for the Cayman Islands (NTCI) ownership or management of specific sites – allows the NTCI to protect those sites from offences "for actions which could harm Trust property or otherwise contravene the purposes of the Trust." (National Trust Law, 2010 Revision).
  - Heritage Register – records the Islands' "natural, historic and cultural resources which are recognised and designated by the Council of the National Trust as being nationally significant and worthy of preservation." Entries are predominantly historic homes, civic and religious structures. Listing on the Heritage Register does not afford individual sites legal protection.
- Public Lands Act – affords legal protection to resources that are located within the public right of way.

4.6.2 Baseline Conditions

The EAB's EIA Scoping Opinion identified the proposed EWA Extension having the potential to impact two NTCI owned or managed areas: portions of the Central Mangrove Wetland and the Mastic Reserve. The Mastic Trail within the Mastic Reserve is also protected by the Public Lands Act, since it is within the public right of way.

The proposed EWA Extension has the potential to affect natural features from the southern portion of the Central Mangrove Wetland, along with the connection between the Mastic Trails' trailhead and parking lot. The Central Mangrove Wetland is one of the largest intact mangrove wetlands in the Caribbean and it is important to the health of Grand Cayman's ecosystem (NTCI, 2022). This mangrove wetland provides area for fish nurseries, storm protection, conditioning the flow of nutrients into North Sound, and filtration of surface water.

The Mastic Reserve contains the largest contiguous area of primary dry forest remaining on Grand Cayman and represents one of the last remaining examples of Caribbean subtropical, semi-deciduous dry forests (NTCI, 2022). It is home to several Cayman endemic species such as the Black Mastic tree, white-crowned pigeon, and Grand Cayman parrot. The forest regulates overland water flow and prevents degradation of the North Side freshwater lens, which it sits over. The

Mastic Reserve was established in 1992 and the 2.3-mile Mastic Trail was opened to the public in 1995, both providing recreational opportunities for hiking, wildlife viewing, and cultural identity.

4.6.3 Applicable Standards

A comprehensive review of applicable standards will be completed to ensure the project adheres to the required regulations and follows the most up-to-date guidance. Coordination with the DoE Research and Assessment Section will be undertaken to assist in determining the applicable standards that will be used for the assessment. The following standards will be reviewed and incorporated into the studies, as appropriate:

- National Environmental Policy Framework, 2002;
- National Biodiversity Action Plan, 2009;
- National Trust Act (2010 Revision);
- International Finance Corporation (IFC) Performance Standards (PS) on Environmental and Social Sustainability, 2012 such as:
    - PS No. 1: Assessment and Management of Environmental and Social Risks and impacts;
    - PS No. 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources;
    - PS No. 8: Cultural Heritage.
- National Conservation Act, 2013 and ancillary documents such as Species Conservation Plans and Management Plans;
- Directive for EIAs (2016) issued in accordance with The National Conservation Act (2013); and,
- Public Lands Act (2020 Revision)
- Development and Planning Act, 2021.
- Principles of Cultural Heritage Impact Assessment in the UK, 2021; and
- World Heritage Resource Manual: Guidance and Toolkit for Impact Assessments, 2022
- Institute of Environmental Management & Assessment (IEMA) Principles of Cultural Heritage Impact Assessment.

4.6.4 Potential Impacts

The proposed EWA Extension has the potential to affect portions of cultural and natural heritage sites within the project study area including the Central Mangrove Wetland, the Mastic Reserve and the Mastic Trail. The EIA studies shall investigate potential construction impacts including but not limited to:

- Land use changes – partial and full loss of property:
    - Severance or loss of features such that the physical or visual integrity of a cultural and natural heritage site is compromised and the ability to understand and appreciate the remaining elements may be diminished;
    - Permanent or temporary alteration and/or visual intrusion into the cultural and natural heritage site affecting the setting or character of a designated site; and
    - Access to the cultural and natural heritage site.

- Overall habitat reduction;
- Noise impacts associated with temporary construction and with the operation of the proposed EWA Extension;
- Cumulative effects from the accumulation of different effects on the same resource, or accumulation of impacts; and,
- Affects due to the potential release of contaminants that may potentially pollute sensitive habitats and the underlying aquifers.

4.6.5 Assessment Methodology

The assessment will gather critical information to understand the characteristics and the potential impacts of the proposed EWA Extension project on cultural and natural heritage site resources. The assessment will describe potential direct, indirect, and cumulative effects to the known heritage site resources within the study area and consider the protocol in the case of a discovery of unknown archaeological sites. Consultation with Cayman Island groups including, but not limited to the DoE, the National Museum, and the NTCI, along with local community members will be completed to aide in identifying any additional known and potential future heritage site resources during the assessment process.

The assessment shall include:

- A review of published data and publicly available information, including but not limited to:
  - The Land Reserve Fund;
  - The Historic Buildings and Sites Inventory;
  - The Conservation and Historic Preservation Awards;
  - National Trust Mastic Reserve and Trail data;
  - National Trust Central Mangrove Parcel data;
  - Published and unpublished sources (documentary material, archaeological and architectural studies, fieldwork reports, local histories); and,
  - Geographic Information System / Geotechnical data.
- A review of Mapping/Cartographic information.
- A review of the appropriate standards and guidelines as outlined in Section 4.4.3.
- A review of assessment guidance materials including but not limited to:
  - The Assessment and Management of Environmental and Social Risks and Impacts; PS Nos. 1, 6, and 8.
  - IEMA Principles of Cultural Heritage Impact Assessment in the UK; and
  - World Heritage Resource Manual: Guidance and Toolkit for Impact Assessments
- Consultation with project stakeholders including but not be limited to:
  - DoE;
  - NTCI;
  - Cayman Islands National Museum;
  - Cayman Islands National Archive;
  - Non-profit organizations;

- Interested stakeholders; and,
- Local community.

Based on the guidance documentation outlined above, the analysis will be divided into the following key steps:

Step 1. Establish understanding of cultural and natural heritage site resources:
Update baseline condition to include all reviewed material and consultation efforts noted above. This step will also include confirmation/identification of cultural and natural heritage site resources, establishment of current resources status, field reviews to determine each identified resource's current condition and sensitivity to impact, and coordination with project stakeholders to determine the context of each resource's importance. For example, is it important locally, nationally, or some combination. This data will be combined, and a scale will be developed to establish each resource's intolerance to change based on designated agreed upon status [the scale would be from 1 to 5 with 1 being the least intolerant to change] (**Table 5**). For example, if an identified resource's level of sensitivity is considered "very high" and importance is considered "high", then it would be given a value of 15, which would be most intolerant to change, whereas a resource considered "very low" in sensitivity and importance would be less intolerant of change (perhaps due to its use, a parking lot, that is only used by locals to access a trail, where minor changes would not affect the use of the property or its character).

Table 5: Understanding the Importance of Resources

Intolerance to Change		Importance of Resource		
		High (3)	Medium (2)	Low (1)
Sensitivity of Resource	Very High (5)	15	10	2
	High (4)	12	8	4
	Medium (3)	9	6	3
	Low (2)	6	4	2
	Very Low (1)	3	2	1

Step 2. Evaluate impacts:
This step will highlight the proposed changes that could potentially effect/impact the cultural and natural heritage site resources and will include an assessment of the change in the baseline condition if the proposed project is implemented. Equally important will be the assessment of how the baseline condition would change in the future without the proposed project. To properly consider these effects (direct, indirect, and cumulative) relative to these changing conditions and building upon the scale of importance developed in Step 1, the degree of the effect will be developed by determining the changes incurred by the resources and whether the change is considered significant. The degree of impact would also use a scale similar to that noted above. For example, shifting trail access may be a low degree of impact, whereas removing a substantial amount of forest from the Central Mangrove Wetland would be a high degree of impact. The impact value would then be combined with the intolerance to change to develop a weighted effect to each resource (**Table 6**).

Table 6: Evaluating the Degree of Impacts

Weight of Impact		Degree of Impact		
		High (3)	Medium (2)	Low (1)
Intolerance to Change	Very High (5)	15	10	5
	High (4)	12	8	4
	Medium (3)	9	6	3
	Low (2)	6	4	2
	Very Low (1)	3	2	1

Step 3. Document impacts:
Based on the impact findings, recommendations will be provided on potential opportunities to avoid or minimise impacts of the proposed EWA Extension upon the cultural and natural heritage site resources and compiled into a Cultural and Natural Heritage Sites memorandum that will be appended to the EIA.

4.6.6 Mitigation Measures

The EIA study will identify potential mitigation measures to compensate for the unavoidable impacts of the proposed EWA Extension. Potential mitigation measures may include, but are not limited to:

- Replacement of property;
- Conservation
- Replanting/establishment of habitat;
- Creation of hydrological components;
- Viewshed enhancements/Visual screening;
- Regional ecological restoration;
- Consideration of wildlife crossings to avoid habitat fragmentation;
- Landscaping;
- Land contouring; and,
- Environmental awareness campaigns

4.7 Greenhouse Gas Emissions

4.7.1 Introduction

The proposed project will require the removal of peat during construction, decreasing the amount of greenhouse gas (GHG) storage (specifically carbon storage), which would allow more GHG emissions to be released into the atmosphere. The main GHGs associated with peat removal are carbon dioxide (CO_2) and methane (CH_4). This assessment will include a quantitative annual and aggregated emissions total associated with the construction of the project. Operational GHG emissions based on expected traffic volumes and vehicle fleet will also be quantitatively determined for both pre- and post-construction operations. Pre-construction will include the expected GHG emissions for current traffic patterns, while post-construction will consist of the expected GHG emissions from the new arterial.

4.7.2 Baseline Conditions

The DoE states that the Cayman Islands emitted a total of metric tonnes of CO_2 in 2014 was 714,000, with the majority derived from the energy supply and transportation sectors (DOE, 2022). Additionally, the European Commission's Emissions Database for Global Atmospheric Research (EDGAR) provides emission estimates for the Caymans through 2021 (European Commission, 2022). In the framework of the United Nations Framework Convention on Climate Change (UNFCCC), countries are developing national emissions inventories and propose/implement actions to mitigate GHG emissions. CO_2 emissions, which are mainly responsible for global warming are still increasing at world levels despite climate change mitigation agreements. In this context, EDGAR provides an independent estimate of greenhouse gases for each world country, based on a robust and consistent methodology stemming from the latest Intergovernmental Panel on Climate Change (IPCC) guidelines and most recent activity data.

The EDGAR data are broken down into five general categories which are provided in **Figure 18** from 2010-2021. The decrease in 2020 and abrupt increase in 2021 are most likely a direct reaction to the COVID-19 pandemic and reopening. In a literature search, it was noted that there are multiple GHG datasets that illustrate minor differences of island-wide emissions, but generally the levels are generally similar. Greenhouse gas emissions do not have a direct effect on receptors, although they do influence overall changes in climate over a prolonged period.

In September 2011, the National Climate Change Committee issued a draft Climate Change Policy, which is undergoing revisions and updates. The updated policy's goals will be incorporated into the EIA process once it's released. The current policy outlines a series of goals which include:

- Reducing GHG emissions in line with national targets;
- Setting a national GHG reduction target;
- Encouraging energy conservation and renewables;
- Creating and maintaining a more environmentally responsible tourism sector; and,
- Developing and adopting an energy code and supporting legislation to increase energy efficiency amongst all sectors.

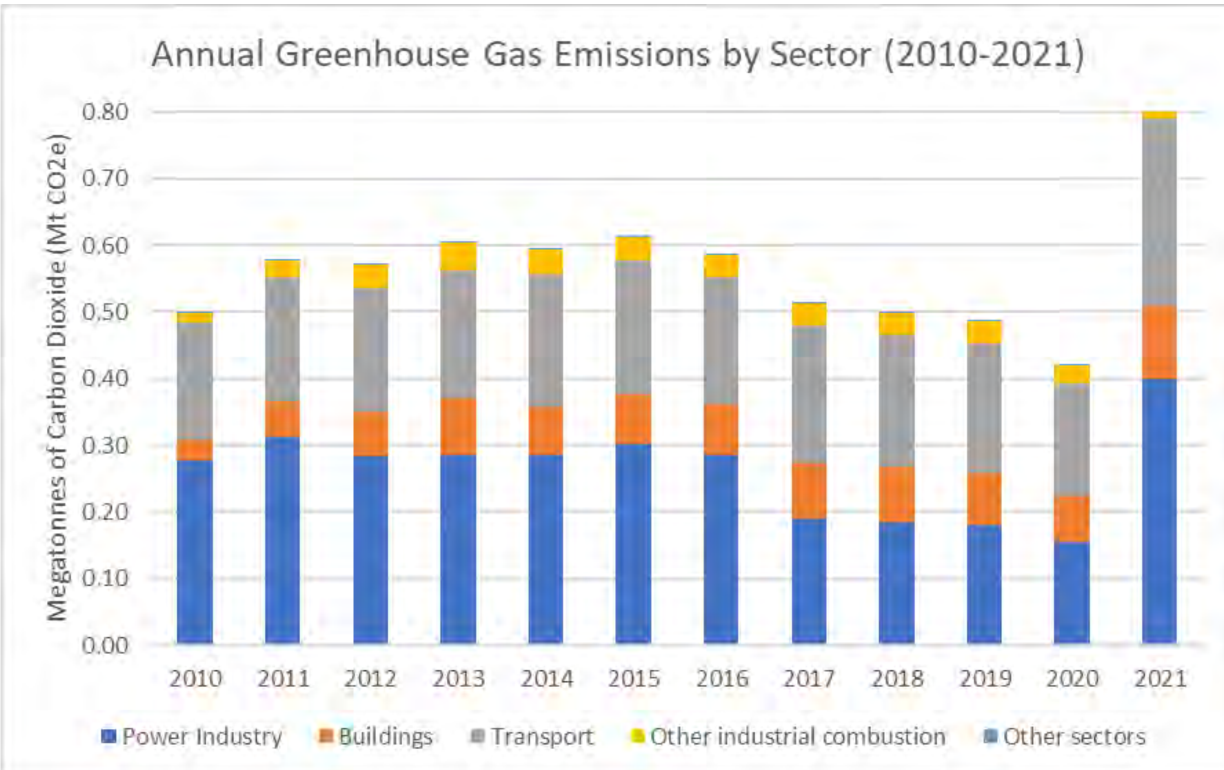

Figure 20:21 Annual Greenhouse Gas Emissions by Sector in the Cayman Islands (2010-2021)

Additionally, the National Energy Policy Unit (NEP) developed the National Energy Policy 2017-2037 (NEP, 2021). The focus is to utilise more renewable energy, promote energy efficiency/conservation measures, and reduce reliance of imported fossil fuels. As of 2014, the Cayman Islands produced 12.3 metric tons of CO_2 equivalent per capita. The 2030 goal is to reduce that to 4.8. Ultimately, the policy is geared toward 62% utility solar, 3% wind, 3% waste to energy and 2% distributed solar by 2037 (NEP, 2021).

4.7.3 Applicable Standards

Reporting on GHG emissions for the Cayman Islands is undertaken by the UK as part of its GHG emissions inventory obligations under the UNFCCC and the Kyoto Protocol. As part of this agreement, greenhouse gas emissions are reported annually by the Department of Environment for electricity generation and fuel consumption. Data is also collected and submitted on solvent use, waste management, mobile machinery, aircraft and air transport, shipping, and agriculture and forestry.

The air quality analysis will rely on standards and guidance as summarized below.

- Cayman Public Health Law, 2002 Revision;
- International Finance Corporation Guidance Note 3, 2006;
- Draft Cayman Islands' Climate Change Policy, 2011;
- UK National Highways: Introduction and General Requirements for Sustainable Development and Design (GG103), Revision 0, 2019;

- Cayman Islands National Energy Policy 2017-2037 (*2022 Progress Report forthcoming*), and,
- UK National Highways Carbon Tool Guidance Version 2.5, 2022.

4.7.4 Potential Impacts

The construction of the EWA extension will consist of potential GHG emissions associated with construction equipment and the removal of peat overburden within the project corridor. During construction, it is anticipated that there will be two primary sources of short-term GHG emissions: the operation of heavy equipment via combustion of diesel fuel, and tailpipe emissions from the vehicles that deliver the construction materials.

The removal of peat overburden is another source of GHG emissions of a more permanent nature. Peat and vegetation are terrestrial "sinks" that store atmospheric GHGs (specifically CO_2 and methane). Trial pit information collected in 2008 between Hirst Road and Lookout Road, showed that the proposed road corridor contains peat, although not in significant quantities. The proposed study area for the EWA Extension now stretches to Frank Sound Road, approximately 8 miles east of Lookout Road. The volume of peat may be much higher in the eastern sections, given the elevation and the characteristics of the wetlands in the corridor. When these carbon sinks are disturbed or removed, its potential to store carbon is reduced. This loss will be incorporated into the overall project impacts.

4.7.5 Assessment Methodology

The analysis will utilise the trial pit information collected from 2008 and supplement it with data collected from new pits further east along the proposed corridor, as needed, to establish average peat depths and total volume of peat expected to be removed. This data will be analysed to develop an accounting of: 1. the loss of carbon storage from the peat removal, which leads to increased GHG emissions, and 2. the release of GHG as the exposed peat begins decomposing. The analysis will also examine the loss of carbon sequestration services provided by the mangroves.

The GHG analysis will include the following emission sources to establish project totals.

- Construction Equipment tailpipe emissions;
- Material/delivery vehicle tailpipe emissions;
- Peat removal carbon sequestration losses; and,
- Road material (concrete, asphalt etc.).

A blended approach of modelling software and emissions factors guidance, as appropriate, including the IPCC Inventory Software, Version 2.691, with guidance from the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (2006 IPCC Guidelines) and the *2013 Supplement to the 2006 IPCC Guidelines: Wetlands – Methodological Guidance on Lands with Wet and Drained Soils, and Constructed Wetlands for Wastewater Treatment* and the recommendations published in the December 2014 U.S. EPA Report EPA-420-R-14-030, *Emission Factor for Tropical Peatlands Drained for Oil Palm Cultivation: Peer-Review Report.* The analysis will include researching the current state of academic research into carbon sequestration in tropical and non-tropical peat and apply more recent emissions factors where appropriate, including reviewing the IPCC's Emission Factor Database and US EPA datasets.

Additional sources of GHG are associated with construction and heavy-goods vehicle movements from the demucking operations and production of concrete and aggregate material operations. The diversity of engine categories, sizes, and applications complicates the process of analysing non-road vehicles. Modelling is essential to identifying and assessing sources, forecasting future activity and emissions, and evaluating the impacts of potential projects.

The analysis will review favoured non-road emissions inventory models from the U.S. EPA (MOVES3 – NONROAD), European Environment Agency, and International Council on Clean Transportation to determine the most appropriate model to calculate non-road emissions in the Cayman Islands. These emissions are likely to be addressed by generating g/veh-hr emission rates for each type of construction equipment (equipment type and horsepower rating). These g/veh-hr rates will then be applied to project-specific activity data, such as number of units of each type of equipment and hours of operation during each phase of construction. A qualitative review of alternatives and route options, including the "no-build" alternative, will be provided along with a quantitative assessment of the preferred route. It should be noted that MOVES3 is also capable of generating methane emission factors for the construction equipment that are likely to be used on this project for earth/peat-moving, demucking, and heavy material haulage.

Operational emissions inventory development will also utilise MOVES3. The No-Build Alternative will include an evaluation of current traffic patterns at the worst-case intersections based on specific traffic data. These may include total number of vehicles per link (i.e. northbound left turn and northbound through), length of each link and the representative average speed. This scenario would be representative of 2023, but the vehicle fleet representative of the Caymans in the model would be approximately 15-20 years behind from an emission standards perspective on average.

Post-construction operational GHG emissions will be applied at the end of the construction schedule for the Year 2074. It will again be assumed that the vehicle emissions are 15-20 behind the model year.

To calculate non-road emissions, the analysis will make general assumptions regarding the following:

- Expected construction schedule;
- Expected total disturbance area;
- Construction activity
    - Total number of workdays per year
    - Daily schedule of operations (hr/day)
    - Expected type of equipment, size, and number (i.e., four 400 hp bulldozers)
- Expected number of material trucks per construction activity per day;
- Expected number of round-trip material trucks trips per day (i.e., 5 total trucks, 3 round trips per day for activity A); and,
- Expected round trip maximum distance (miles).

The United States Environmental Protection Agency (USEPA) and the State of Florida determines that 25,000 metric tonnes of GHG emissions requires reporting to the agency, and 100,000 metric tonnes equates to a large or major source. For the purposes of this analysis, the GHG project significance threshold will be equivalent to the large source threshold. If the project exceeds 100,000 metric tonnes CO_2e on an annual basis, mitigation measures as described in Section 4.7.6 will be implemented to reduce emissions. However, many of the mitigation measures will be utilized regardless of the projected emission totals. It should also be noted that all construction related GHG emissions will be short-term. Lastly, all scenario GHG emissions will be quantified and compared to each other and discussed qualitatively in a real-world context. This likely includes the use of the USEPA's GHG Equivalency Calculator[1]

4.7.6 Mitigation Measures

Greenhouse gases generated from road construction activities can include heavy vehicle emissions, type of pavement materials and methods, removal of vegetation, and soil disturbance. Potential mitigation measures to control or reduce greenhouse gas emissions are:

- Lowering asphalt production temperature and increasing recycling rates;
- Using cement clinker substitutes in concrete;
- Using scrap-based steel;
- Ensuring efficient use of materials (i.e., "right-sizing");
- Maintaining machinery frequently or replacing with newer machinery;
- Installing engine retrofit devices;
- Restricting vehicle idling;
- Using robust materials that require less maintenance, repair, and refurbishment;
- Choosing materials that can be reused or recycled instead of landfilled;
- Reducing amount of vegetation removed;
- Landscaping bare areas to re-establish vegetative cover; and,
- Revising road design to reduce the need for removal of peat overburden.

[1] USEPA Equivalency Calculator - https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

4.8 Noise and Vibration

4.8.1 Introduction

Noise and vibration generated by the construction and operation of a new road can change the environment. This can lead to effects on adjacent residential properties, protected species or other noise-sensitive developments. These effects may be increased if the construction is carried out during evening hours, when people are generally more sensitive to noise.

The assessment of noise and vibration will consider effects from construction noise, construction vibration, and operational noise caused by vehicles. Operational vibration is dependent on a well-maintained road surface free of irregularities and vehicle weight limit restrictions, thus operational vibration is unlikely to have the potential for significant adverse effects and will not be considered.

4.8.2 Baseline Conditions

Currently, there is no information available to quantify the baseline noise level for the EWA Extension study area. An initial desktop review of maps and aerial photography indicates that the main sources of noise in the vicinity of the EWA corridor would be ambient noise associated with the existing residential neighbourhoods, light commercial businesses, and quarries located south of the proposed EWA Extension corridor. The main source of noise for the uses along Bodden Town Road, Shamrock Road, and Frank Sound Road would be the traffic noise along the way.

To document baseline noise levels, noise monitoring shall be performed. To document hourly sound levels over a 24-hour period, two (2) long-term (24-hour) unattended measurements are proposed (**Figure 19**), one along the existing roadway and one in the vicinity of the proposed alignment. Additionally, approximately seven (7) short-term (20-minute) attended measurements would be conducted in the vicinity of the new alignment, Frank Sound Road, Bodden Town Road, and Shamrock Road (20-minutes is typically sufficient to obtain a representative value of steady background and ambient noise). For measurements along existing roadways, traffic shall be conducted concurrently. The measurement devices shall be Type I ANSI sound level meters. Measurements shall be carried out under dry conditions when the road surface is dry and wind speeds are 11.2 mph (5 m/s) or less.

In accordance with the Design Manual for Roads and Bridges, (DMRB), the study area for the new roadway shall extend approximately 2,000 ft (600 m) to each side of the proposed roadway, and 165 ft (50 m) to each side of existing roadways.

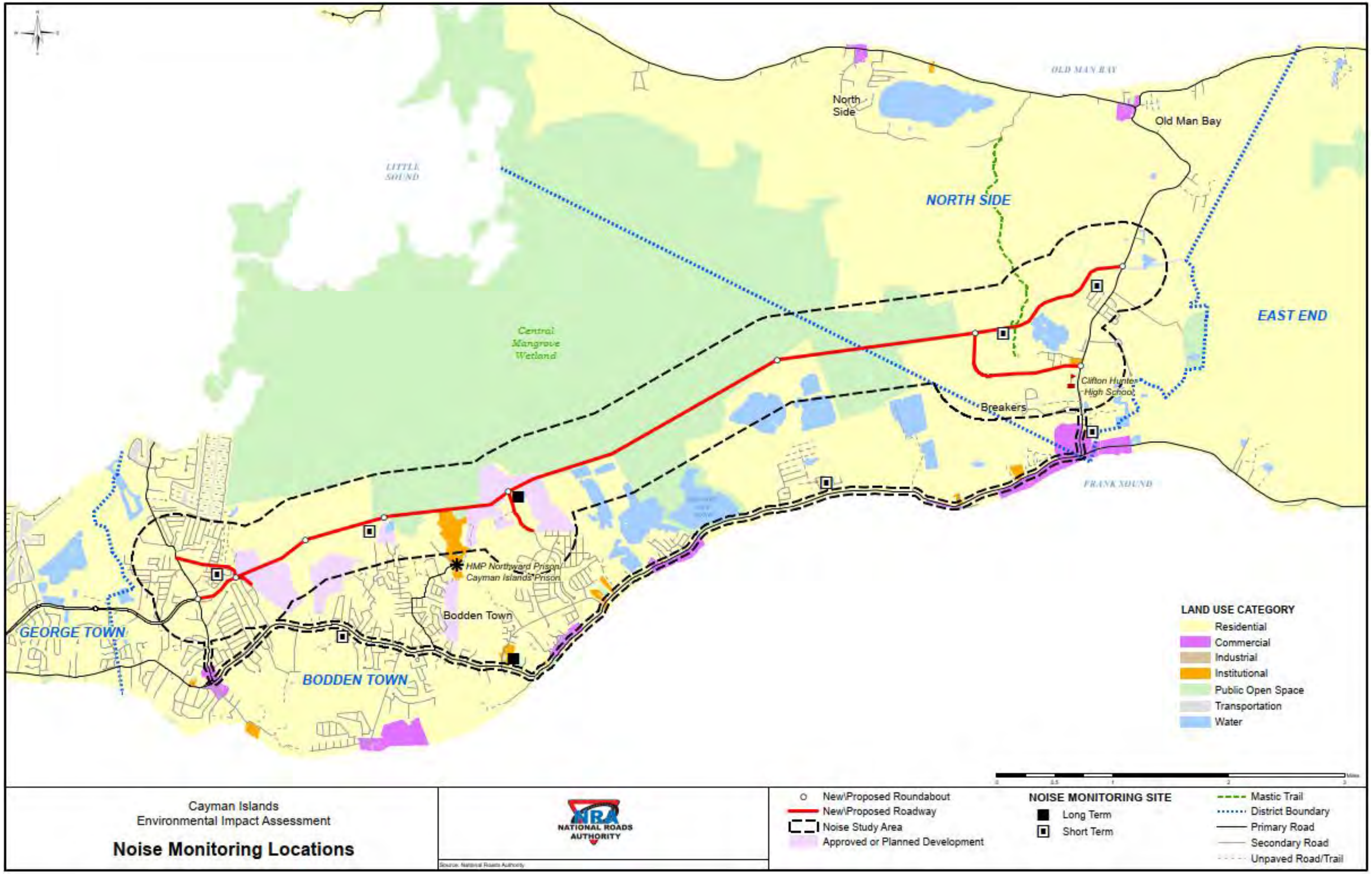

Figure 19: Noise Monitoring Locations

4.8.3 Applicable Standards

Since the Cayman Islands Government does not have published standards or guidance on noise and vibration, this assessment will rely on the DMRB Noise and Vibration Manual, reference document LA 111, supplemented by the Institute of Environmental Management and Assessment (IEMA) Guidelines for Environmental Noise Impact Assessment.

Additional applicable standards to be considered are as follows:

Operation Noise:

- The Noise Policy Statement for England, 2010;
- Guidelines for Environmental Noise Impact Assessment, Institute of Environmental Management and Assessment, 2014;
- Development and Planning Act, 2021 Revision; and,
- Development and Planning Regulations, 2022.

Construction Noise:

- BS 5228: Code of practice for noise and vibration control on construction and open sites; Part 2: Vibration, British Standards Publications, 2014;
- Cayman Islands Builders Act, 2020 Revision;

Construction Vibration:

- BS 6472: Code of practice for noise and vibration control on construction and open sites – Part 1: Noise, British Standards Publications, 2018;
- BS 5228: Code of practice for noise and vibration control on construction and open sites; Part 2: Vibration, British Standards Publications, 2014;
- Cayman Islands Builders Act, 2020 Revision;

4.8.4 Potential Impacts

The proposed EWA Extension has the potential to generate noise and vibrations at a level to affect sensitive receptors. Construction noise levels can range from barely perceptible to annoying or even hazardous. Ground vibration associated with construction can create a wide range of issues for structures, from foundations cracking or softening the soil causing the structure to settle, depending on the amplitude, frequency, duration, and the engineering properties of the structure.

Adjacent to the EWA corridor, there are potential sensitive/local receptors that have been initially identified through aerial photography. Sensitive receptors that may experience construction or operational noise impacts may include residential and other properties close to the proposed project, as well as along roads that may intersect with the proposed project, including the following:

- Residential housing along Will T Road, Fig Tree Drive and Dominica Drive;
- Cayman Islands Prison and HMP Northward Prison;
- Potential residences and dwellings along Lookout Road;
- Users of the Mastic Trail;
- Protected species within the Mastic Reserve and Central Mangrove Wetland;

- Housing west of the Frank Sound Fire Station; and,
- Clifton Hunter High School.

The significance of the effect is dependent on both the sensitivity of the receptor and the magnitude of the impact at the receptor. Receptor sensitivity and the assessment criteria for magnitude of change is derived from the criteria in the DMRB.

The DMRB determined the significance of noise effects by establishing the no observed effect level (NOEL) and both the lowest observable adverse effect level (LOAEL) and the significant observable adverse effect level (SOAEL) for all noise sensitive receptors within the corridor during the time periods when they are typically in use (for example schools would only need daytime LOAELs and SOAELs). NOEL is the "level below which no effect can be detected…below this level, there is no detectable effect on health and quality of life due to the noise." LOAEL is "the level above which adverse effects on health and quality of life can be detected." SOAEL is "the level above which significant adverse effects on health and quality of life occur" (DMRB). DMRB established LOAEL and SOAEL for operational noise, as shown in **Table 7.**

Table 7: Operational Noise LOAELs and SOAELs

Time Period	LOAEL	SOAEL
Day (06:00 – 24:00)	55 dB $L_{A10,\ 18hr}$ (façade)	68 dB $L_{A10,\ 18hr}$ (façade)
Night (23:00 – 07:00)	40 dB L_{night} outside (free-field)	55 dB L_{night} outside (free-field)

The magnitude of impact for both operation of the new facility and construction traffic on the existing roadways is based upon the Baseline Noise Level (BNL). **Table 8** displays the Magnitude of Impact that would occur for sensitive receptors located near the roadway, during the long-term. The long-term analysis compares the Do Minimum Opening Year (DMOY) to the Do Something Future Year (DSFY). For the purposes of this analysis, the magnitude of operational noise will be studied for the long-term. **Table 9** displays the Magnitude of Impact that would occur for sensitive receptors near roadways used for construction traffic.

Table 8: Magnitude of Operational Change at Receptors

Long Term Magnitude	Long Term Noise Change (dB $L_{A10,\ 18hr}$, or L_{night})
Major	≥ 10
Moderate	5.0 - 9.9
Minor	3.0 - 4.9
Negligible	≤ 3.0
Note: Difference in change of baseline noise level and operational noise level	
* Design for Roads and Bridges – LA 111 Noise and Vibration	

Table 9: Magnitude of Impact at Receptors

Magnitude of Impact	Increase in BNL of Closest Public Road Used for Construction Traffic (dB)
Major	≥ 5.0
Moderate	≥ 3.0 and ≤ 5.0
Minor	≥ 1.0 and ≤ 3.0
Negligible	≤ 1.0
* Design for Roads and Bridges – LA 111 Noise and Vibration	

4.8.5 Assessment Methodology

A noise model shall be prepared using the U.S. Federal Highway Administration (FHWA) Traffic Noise Model ® (TNM v3.1). TNM v3.1 is the United States approved highway noise prediction model. FHWA's TNM calculates sound levels in a similar approach to the UK's Calculation of Road Traffic Noise (CRTN) spreadsheet calculations; however, TNM is composed of many variables that allows for the calculation of many receptors at once at varying distances with variations accounting for vehicle type and speed, as well as topography and shielding. This software creates a 3-D model of the existing roadways, the proposed roadways, noise-sensitive receptors, and topography to use traffic volumes and speeds to predict sound levels. The noise data collected during the short-term monitoring, as well as field notes, topography, and aerials shall be used to develop the existing model. Traffic data collected along existing roadways shall be entered into the model. The results shall then be compared to the data collected during noise monitoring (validation) to ensure the model accurately reflects existing conditions of the area.

Additional modelling points will then be added to represent noise-sensitive receptors that would most likely be affected by the proposed development. This would include existing or planned residential dwellings, schools, hospitals, community facilities, places of worship, open air amenities (including the Mastic Trail), cemeteries, farms/kennels, and wildlife sites (including the Mastic Preserve and the Central Mangrove Wetlands). The sound levels reported from the model would represent the BNL.

Operational Noise Impact Analysis

Existing DMOY and DSFY TNM-classified hourly traffic volumes and speeds calculated from traffic diagrams (for all roadways carrying traffic within the project corridor) will be input into the validated TNM models and TNM model elements will be incorporated into the validated TNM model(s) to represent the project design. TNM-predicted traffic noise levels will be evaluated at all project noise-sensitive receptors for the DMOY and DSFY conditions. Traffic noise impacts will be assessed per the DMRB criteria. DSFY noise level impact contours will be identified to assist land use planning efforts by the local governments.

Construction Noise Impact Analysis

Project-related construction noise will be evaluated for potential impacts to noise-sensitive receptors throughout the project corridor, and in areas of anticipated project construction activities outside the project corridor, specifically along construction haul routes. The degree of noise impact will vary, as it is directly related to the types and number of equipment used. Any noise impacts that do occur, as a result of roadway construction measures, are anticipated to be temporary in nature and will cease upon completion of the project construction phase. While noise levels will vary for different construction tasks, the maximum expected noise levels would occur from stages of construction involving heavy equipment.

All residences and exterior frequent-human-use areas near the proposed alignment are most likely to be temporarily impacted by loud construction activities. Should extremely loud construction noise activities such as usage of pile-drivers and impact-hammers (jack hammer, hoe-ram) be needed, they will provide sporadic and temporary construction noise impacts in the near vicinity of those activities. It is the recommendation that construction activities that will produce extremely loud noises be scheduled during times of the day when such noises will create as minimal disturbance as possible.

Construction Vibration Impact Analysis

Construction vibration is rarely associated with building interruption or damage, but may, at times, reach levels of perception and annoyance to the general population in areas closest to the source. Continuous vibration inducing activities (i.e., pile driving) can increase the possibility of damage and perception, depending on the receiver's positioning to the source. These types of vibration effects are also contingent upon source, path, and receiver adjustments. In most cases, peak vibrations due to construction activities will only last as long as the immediate impact and then quickly dissipate to less significant levels. A qualitative assessment of vibration influences from the proposed project will be undertaken to predict possible impacts to adjacent land uses. Assumptive adjustments to the source, along the path, and at the receiver will be applied to identify the sensitivity and magnitude of the vibration effects.

To calculate construction noise and vibration impacts, the analysis will make general assumptions regarding the following:

- Expected construction schedule;
- Expected total disturbance area;
- Construction activity
  - Total number of workdays per year
  - Daily schedule of operations (hr/day)
  - Expected type of equipment, size, and number (i.e., four 400 hp bulldozers)
- Expected number of material trucks per construction activity per day;
- Expected number of round-trip material trucks trips per day (i.e., 5 total trucks, 3 round trips per day for activity A); and,
  Expected round trip maximum distance (miles)

4.8.6 Mitigation Measures

While some noise and vibration disturbances to populated residential areas may be inevitable given the inherently noisy operations associated with a road construction project, the NRA is committed to control and minimise construction noise and vibration using all reasonable (i.e., cost implications) and feasible (i.e., physically achievable) means available.

At the conclusion of the noise and vibration impact assessment, the Project Team will analyse the feasibility and reasonableness of potential noise mitigation measures for those locations meeting or exceeding the DMRB SOAEL criteria. Primary abatement measures that would be analysed would be alteration of vertical or horizontal alignments.

The noise and vibration assessment will also include an evaluation of potential construction-related impacts and an evaluation of feasible noise and/or vibration mitigation measures where major impacts are expected. This analysis will be conducted in accordance with DMRB LA 111 and IEMA Guidelines for Environmental Noise Impact Assessment.

Noise compatible land use planning is one of the most effective means to prevent future traffic noise impacts. The compatibility of highways and neighbouring local areas is essential for continued growth and can be achieved if local governments and developers require and practice noise-sensitive land-use planning. Information from the noise analysis will be shared with the local jurisdiction with zoning control for their consideration should they choose to develop policies and/or ordinances to limit the growth of noise-sensitive land uses located adjacent to roadways.

Chapter 5

Summary of Direct, Indirect, and Cumulative Effects

5 Summary of Direct, Indirect, and Cumulative Effects

The following matrix (**Table 10**) will be completed to summarize the severity of direct, indirect, and cumulative impacts from each resource element (i.e., none, slight, moderate, substantial, very substantial) by alternative evaluated in the EIA, including a summary of key issues and recommended mitigation measures.

Table 10: Summary of Severity of Direct, Indirect, and Cumulative Impacts

Criteria	Beneficial Impact		No Impact	Adverse Impact		Cause & Mitigation
	Extent	Short or Long Term		Extent	Short or Long Term	
Socio-Economic Impacts:						
Hydrology & Drainage Impacts:						
Geo-Environmental Impacts:						
Terrestrial Ecology Impacts:						
Cultural & Natural Heritage Impacts:						
Greenhouse Gas Impacts:						
Noise & Vibration Impacts:						

Chapter 6

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Appendix A

Verbal Public Comments and Responses

NATIONAL ROADS AUTHORITY

Date	Public Comment Transcription	Response
7 Feb 2023	*Why is the public consultation and feedback coming prior to an environmental study as opposed to after when the public would be more educated on what you are going to do?*	The National Conservation Act's EIA Directive establishes a public involvement period for the draft ToR and draft Environmental Statement (ES). Section 2.7 of the Terms of Reference (ToR) discusses public consultation and stakeholder engagement, which includes a variety of outreach strategies to be utilised as the EIA process moves forward. There will be more public participation throughout the process and there will be another opportunity for formal public consultation once the Environmental Impact Assessment (EIA) is completed and the ES is drafted.
7 Feb 2023	*What is the current budget for the environmental mitigation, and have you considered reaching out to schools and other organisations for fund raising as I'm sure there would be organisations willing to help?*	Thank you for your participation in the ToR review process. We acknowledge that schools and other organisations would be a great resource when we start looking into mitigation measures. The project would aim to avoid and minimise impacts to natural resources. For impacts that cannot be avoided, then mitigation measures will be developed. A budget has not been established for this mitigation.
7 Feb 2023	*I'm worried about the mitigation for hydrology on the Northside Freshwater Lens. Are you planning basins to capture the water?*	See Section 4.3.11 of the ToR for more information regarding hydrology and drainage mitigation measures. We will be conducting a hydrological assessment and the effect that the project may have on the Freshwater Lenses. We have not completed these assessments yet but will be looking at a broad range of stormwater management options and are open to suggestions. Thank you for your comment.
7 Feb 2023	*Will you be doing any noise abatement for this roadway?*	See Section 4.8.6 of the ToR for more information regarding potential noise mitigation measures. Noise sensitive receptors (e.g., residences, schools, religious facilities, and recreational areas) will be evaluated for noise impacts and feasible abatement measures.
7 Feb 2023	*In your professional opinion should we be tampering with the largest continuous mangrove system in the Caribbean [Central Mangrove]? Or is it important enough to be fully left alone?*	See Section 4.5 of the ToR for more information regarding terrestrial ecology (including the Central Mangrove). We will be assessing any negative or beneficial impacts as part of the EIA process. This information will be provided to the public and decision makers who will ultimately decide the best alternative and decision moving forward.

Date	Public Comment Transcription	Response
7 Feb 2023	*Why is there not being any marine ecological assessment being included as part of the EIA since the mangroves affect North Sound and reefs?*	We are evaluating indirect and cumulative impacts as part of the EIA, which would include if project impacts are anticipated to extend out to North Sound. Marine ecology will be evaluated within the Terrestrial Ecology section of the EIA. Please see Section 1.1.3 of the ToR which identifies the study area as extending north to include Little Sound, and Section 4.3 and 4.5 of the ToR which discuss the importance of North Sound in regards to hydrology and terrestrial ecology impacts.
7 Feb 2023	*Please evaluate the noise impact on the Mastic Trail; which is important for the heritage and eco-tourism.*	See Section 4.8.4 of the ToR which identifies the Mastic Trail as a noise sensitive area. Potential noise impacts will be evaluated as part of the EIA process.
7 Feb 2023	*How are you going to plan for the transportation when we [Cayman] double our population every 10 years? There have been a number of plans that have been dismissed in regard to planning and infrastructure. I just don't want this country [Cayman] to waste its money on another study that will be put in the basement.*	Thank you for your participation in the ToR review process. Policy on population growth is outside the ambit of the NRA and this EIA. However, there are no official Grand Cayman population or employment forecasts that extend far enough to meet the needs for the life-cycle cost evaluation. Therefore, the NRA will develop the future projections based upon growth rates from the census along with known approved land development for 2026, 2036, and 2046.
7 Feb 2023	*What plans are there to sort out the George Town traffic so that we can get through Savannah? The road as-is is fast until we reach Bodden Town.*	The NRA is actively developing plans to reduce congestion between the Tomlinson and Silver Oaks Roundabouts as part of a multimodal plan. Issues with George Town traffic do however fall outside the scope of the current EIA study.
7 Feb 2023	*Are we going to study the existing traffic in the corridors that we have and look at what we can do to reduce the number of vehicles on our roads instead of building more roads?*	From a multimodal perspective, this EIA will look at the current traffic and transportation system as well as anticipated future traffic growth based on the 2021 Census data and proposed developments. The proposed corridor would have the width and ability to include alternative modes of transportation as deemed appropriate in the future. However, it is outside the ambit of the NRA and this EIA document to establish and implement policies and/or operations regarding an alternative public transportation system or vehicle limitations/reductions. Such responsibilities fall under the Ministry responsible for Transport and the Public Transport Unit, who will be consulted as stakeholders during the study.

NATIONAL ROADS AUTHORITY

Date	Public Comment Transcription	Response
7 Feb 2023	*The proposal of this road is bad planning, and it would affect our island's most important ecological resource [the Central Mangrove].*	Your comment has been noted and will be included in the administrative record for this ToR. We will be evaluating mangroves and their many functions as part of the EIA process. Alternatives to avoid or mitigate mangrove impacts will also be evaluated.
7 Feb 2023	*I acknowledge the need for this roadway in regards to storm surge, coastal flooding, and traffic. If there is an alternative that is less damaging to the Central Mangrove I would like to see that come forward.*	Your comment has been noted and will be included in the administrative record for this ToR. An Assessment of Corridor Alternatives is included in Chapter 3 of the ToR and alternatives to avoid or minimize mangrove impacts will be evaluated. The goal is to avoid mangroves, wetlands, species of concern, cultural or natural heritage sites and any other sensitive areas to the extent possible. Methodologies to avoid or mitigate mangrove impacts will be evaluated, such as bridging and use of culverts, as described in Section 4.3 of the ToR. Other mitigation measures to protect or mitigate for impacts to the mangroves and terrestrial ecology will be considered, as described in Section 4.5 of the ToR.
7 Feb 2023	*There should be a public forum where the public can discuss this problem and value people's potential solutions.*	Thank you for your participation in the ToR review process. Section 2.7 of the ToR discusses public consultation and stakeholder engagement, which includes a variety of outreach strategies to be utilised as the EIA process moves forward.
7 Feb 2023	*Will there be an assessment on ecological services loss? Will this be included in the cost-benefit analysis?*	Thank you for your suggestion and participation in the ToR review process. Section 4.5 of the ToR discusses how potentially impacted wetlands will be evaluated not only in terms of size and type, but also using established wetland functional tests, such as using the Uniform Mitigation Assessment Method (UMAM). UMAM evaluates the functionality of unavoidable impacts to tropical wetland ecological systems, including plant cover, benthic communities, and uplands in support of protecting wetlands. This information will be used in the comparison of alternatives.
7 Feb 2023	*Where did the 1-mile radius come from around the roundabouts that is being evaluated for development?*	The 1-mile radius is focused on expected, direct induced growth. From our previous professional experience, specific induced-growth tends to occur within this 1-mile radius. Based on additional comments received, we have updated this to be a 1.5-mile radius around the proposed roundabouts.

NATIONAL ROADS AUTHORITY

Date	Public Comment Transcription	Response
7 Feb 2023	*I was sent an analysis of the E-W Arterial Road by ARDENT Consulting Engineers that is not worth the paper it is written on. Will this report be used or referenced in the EIA?*	The referenced report was submitted to the NRA. A formal separate technical response will be provided regarding this document. This response is outside of the EIA process as the Ardent Report largely relates to the Purpose and Need for the project along with suggested alternatives rather than the Terms of Reference. The response will in no way impact the EIA process, which will ultimately provide objective information on the potential environmental and societal costs as well as the potential benefits once the Terms of Reference is approved. However, a specific response was warranted since the subject report has been broadly circulated. Below is a brief synopsis of the report and the corresponding high-level response: In many ways the report highlights the ongoing efforts of the NRA to improve multimodal transportation throughout Grand Cayman; the power of objective data and analysis that the NRA has deployed to help alleviate congestion; and to improve the overall quality of life and economic competitiveness for Caymanians with a safer and more efficient roadway network. Based on a review of the report, the articulation of a few key points listed below may help Ardent Consulting Engineers and their local constituency better understand local conditions and the overall planning process: • The unique nature of transportation on Grand Cayman and the essential needs of the island's residents and visitors; • The overall state of transportation investments and planning actively occurring in the Cayman Islands and resiliency needs; and, • Where the East-West Arterial (EWA) Environmental Impact Assessment (EIA) falls within the overall project development process in the Cayman Islands. Since the Ardent Report was focused on questions regarding the transportation needs and potential solutions, this response is focused on providing a better understanding of the unique challenges and travel patterns on Grand Cayman that relate to needs and solutions.

Date	Public Comment Transcription	Response
7 Feb 2023	*Why is it that there is an EIA between Woodland Drive and Lookout Road?*	The National Conservation Council (NCC) of Cayman was implemented in 2016 and EIAs became a requirement for projects with the potential for significant impacts. Based on evaluation by the Department of Environment (DoE), this roadway project warrants an EIA.
7 Feb 2023	*The east end of the island has been marginalised and this roadway will help them with family life and spending less time in traffic or on the school bus.*	Thank you for your participation in the ToR review process. This issue will be acknowledged in the Socio-Economic review of this project.
7 Feb 2023	*Can you explain why there are two arterials at Frank Sound?*	The two arterials at Frank Sound were initially identified as part of a long-term plan developed in 2005 and shown on Page 12 of the ToR. While this extension would be much further out in time, the cumulative effects that could occur due to this potential future arterial will be assessed.
7 Feb 2023	*Why is an EIA a year to complete? And has the year started yet? And why can't there be a phased approach to do the first section to Lookout Road?*	The timeframe will begin once the ToR is approved, so it has not yet started. The timeframe is not yet established and is needed in order to complete the due-diligence and evaluate all aspects of the project properly (environmental field studies, public outreach, drainage analysis, etc.). As far as phasing Section 2 and Section 3, it would take approximately the same timeframe to do each individual section and associated EIAs. Therefore, it is more efficient in cost and time savings to complete both sections under one EIA.
7 Feb 2023	*What is the purpose of the EIA? To find a reason not to build this road or to identify sensitive areas and mitigate for impacts?*	The EIA process was established to objectively evaluate all viable alternatives including the evaluation of impacts by not building the corridor.
7 Feb 2023	*I have a lot of concerns that you are getting misinformation. The Mastic Trail was built to provide access for farming and economic reasons. The trees in the Mastic Reserve were all harvested in the 1930-1950's. I am of the view that any environmental concerns can be properly addressed and mitigated.*	Thank you for your participation in the ToR review process. This will be evaluated as part of the EIA process. The National Trust, who manages the Mastic Trail and Mastic Reserve, will be included as a project stakeholder.

Date	Public Comment Transcription	Response
7 Feb 2023	*The Terms of Reference should make the assumption that the road needs to be built and will be built. I would like the EIA to focus on environmental mitigation. Because I have not heard anything tonight that cannot be mitigated.*	Your comment has been noted and will be included in the administrative record for this ToR. However, the purpose of the EIA is to assess multiple alternatives (including the Do Nothing alternative). Mitigation measures will be considered for all alternatives with the goal of No Net Loss of Biodiversity. RES, who is included on the team to provide ecological assessment and mitigation planning, is the United States' largest ecological restoration company with a focus on water quality, environmental mitigation, and climate and flooding resilience projects. RES' Florida team, who is included on this project, has experience developing successful mangrove mitigation projects to offset impacts associated with transportation projects.
7 Feb 2023	*Will you be addressing these traffic pinch points as it comes into Grand Harbor? And how this new roadway would change or increase the amount of traffic coming to this point?*	The NRA is actively developing plans to reduce congestion between the Tomlinson and Silver Oaks Roundabouts as part of a multimodal plan. For this EIA process and in accordance with the ToR, the potential impacts due to the EWA will be addressed as part of secondary and cumulative impacts.
7 Feb 2023	*Does the NRA know the percentage of commuter traffic that goes beyond Woodland Drive?*	Traffic conditions will be evaluated later in the EIA process.
9 Feb 2023	*Is there a weighting applied to the different areas mentioned (Greenhouse emissions, loss of flora and fauna, etc.)? How do you decide which is a priority over the other?*	We acknowledge the importance of considering all the environmental and socio-economic impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process. The aim of the EIA process is to provide an objective evaluation of all identified alternatives that meet the purpose and need of the project. As part of public outreach, the NRA will distribute a survey to understand what impacted resources are most critical for comparing the three primary scenarios contemplated for the EIA study.

Date	Public Comment Transcription	Response
9 Feb 2023	*How do you intend to get the feedback from the individuals here (at the public meeting) today?*	We will be formally recording and answering all of the questions and comments posed tonight. They will be considered as we move forward in the EIA process. Section 2.7 of the ToR discusses public consultation and stakeholder engagement, which includes a variety of outreach strategies to be utilised. As part of public outreach, the NRA will distribute a survey to understand what impacted resources are most critical for comparing the three primary scenarios.
9 Feb 2023	*How do you quantify the current loss of productivity in regard to traffic and how does that play into the road extension project?*	The loss of productivity will be quantified as part of the Cost Benefit Analysis that is then used to compare the three primary scenarios.
9 Feb 2023	*Is it planned to have a rail corridor in the middle of this roadway?*	The proposed corridor would have the width and ability to include alternative modes of transportation as deemed appropriate in the future. However, it is outside the ambit of this project and the NRA to evaluate or establish and implement policies regarding an alternative public transportation system on Grand Cayman – the relevant stakeholders will be consulted during the study.
9 Feb 2023	*Is this area [Central Mangrove] still being proposed as a Ramsar site?*	There is currently no active proposal to designate the entire Central Mangrove area as a Ramsar site.
9 Feb 2023	*Are you looking at the impacts to the mangroves as a habitat for juvenile species who use them as a nursery? And the impacts on fish stock?*	Thank you for your participation in the ToR review process. We will be evaluating mangroves and their many functions as part of the EIA process. Alternatives to avoid or mitigate mangrove impacts will be evaluated. Potential impacts to fish nurseries will be evaluated as discussed in Section 4.5 of the ToR.
9 Feb 2023	*There is flooding in Bodden Town and bottlenecking, and a lot of private development that has blocked expansion. Why does it seem like you are picking and choosing environmental studies?*	The NRA cannot speak to previous planning or development decisions. This EIA is being completed based upon NCC requirements and will address the E-W Arterial Roadway.
9 Feb 2023	*If we fix today's traffic jams for today's populations, what are we planning for later if we don't set a ceiling for population?*	The EIA will evaluate future traffic demands based upon anticipated population growth. However, policy on population is outside the jurisdiction of the NRA and this EIA.

Date	Public Comment Transcription	Response
9 Feb 2023	*In order to keep a transparent process, it is vital to make the public aware of and understand the weighted matrix of the project.*	Thank you for your participation in the ToR review process. This is just the first step in the public involvement process. Please see Section 2.7 of the ToR which discusses public consultation and stakeholder engagement. Additionally, as part of public outreach, the NRA will distribute a survey to understand what impacted resources are most critical for comparing the three primary scenarios.
9 Feb 2023	*Suggest that you stop persons from entering the Grand Harbor roundabout between 7am and 9am. This will help mitigate traffic congestion issues. Why is there a bus-stop right at the apex of a turnout?*	Thank you for your participation in the ToR review process. The NRA is actively developing plans to reduce congestion in other areas of the Grand Cayman, however these issues fall outside the scope of the current EIA study.
9 Feb 2023	*In the weighted scale, consider the water table and water lens heavily. It is essential to all of us.*	Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process. We acknowledge and agree that the hydrological features of the wetland ecological system are extremely important and need to be maintained and not impacted. As part of public outreach, the NRA will distribute a survey to understand what impacted resources are most critical for comparing the three primary scenarios.
9 Feb 2023	*Why wasn't a northern spur through Frank Sound considered?*	Thank you for your suggestion and participation in the ToR review process. The proposed EWA Extension corridor was initially planned and gazetted by the NRA in the Cayman Islands Gazette, Extraordinary Supplement, Number 13/2005, in accordance with Section 25 of the Roads Law (2000 Revision), now Section 26 under the Roads Law (2005 Revision). The location of this gazetted corridor was to minimise substantial impacts to the wetland/mangrove areas. Potential additional connections and alignments may be considered that meet the Purpose and Need of this project.

Date	Public Comment Transcription	Response
9 Feb 2023	*Is this EIA an exercise in futility? Is the road being built or not? Is it the intent of the government to build the road? NRA instructed by Cabinet to complete the EIA. Is the point of the EIA just to tell them how to build the road and it will be built regardless?*	An EIA is required per the NCC. The purpose of an EIA is not to make a decision, but to outline the potential impacts and advise how they can be avoided or mitigated through different alternatives. The EIA will give the public and decision makers the information they need to make an informed decision on the project. The EIA process is designed to objectively evaluate project alternatives and impacts from doing nothing. The aim is a recommended alternative that meets the project need with the least impact.
9 Feb 2023	*The EIA would be evaluated by the NCC at some point and then the NRA would make the final Cabinet recommendation? It appears that this is a lengthy, convoluted process. The Cabinet and the Cabinet alone is the decision maker in this situation.* *With the environmental and land acquisition processes required, we will not see this roadway built anytime in this current administration.*	Yes, the ultimate decision will be with the Cabinet and the summary of the timeline and process length is correct. The NRA is following the processes required by the NCC. The process does take time to make sure that the proper studies and due diligence is completed in order to make the best-informed decision.
9 Feb 2023	*Why is the boxed area (study area on presentation slide), being the only area being considered when we still have traffic coming from two other districts?*	The study area shown is primarily focused on environmental impacts. Additional items, such as traffic, are being analysed for areas outside of the boxed area on the presentation slide. Thank you for your comment and we will work to clarify this as we move forward in the EIA process.
9 Feb 2023	*How can the mangroves help someone stuck in traffic when there is a fatal accident and people have to sleep in their cars because they can't get home?*	We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process. Please refer to Section 4.2 of the ToR which addresses Socio-Economic issues, such as mobility. As part of public outreach, the NRA will distribute a survey to understand what impacted resources are most critical for comparing the three primary scenarios (see Section 2.7 of the ToR regarding public consultation and stakeholder engagement).

Date	Public Comment Transcription	Response
9 Feb 2023	*Could both sides of the road be zoned as environmentally sensitive land as a mitigation measure for impacts to mangrove?*	Thank you for your participation in the ToR review process. This is a mitigation measure which can be evaluated as we move forward in the EIA process. We have not evaluated impacts and mitigation measures at this point in time. While designating the area to each side of the corridor as "environmentally sensitive land" is outside the jurisdiction of the NRA, the Department of Planning, National Trust, and Department of Environmental will be invited to participate as project stakeholders in the EIA process.
9 Feb 2023	*What other information aside from the EIA will the government rely on to make the decision on the roadway? The EIA seems to focus on environmental impacts only.*	The EIA will be a comprehensive evaluation of natural, physical, and socio-economic and cultural resources.
9 Feb 2023	*What percentage of the Central Mangrove area would this roadway impact?*	Thank you for your participation in the ToR review process. This will be quantified later in the EIA process but has not been evaluated at this point. Terrestrial Ecology, including the Central Mangrove, is discussed in Section 4.5 of the ToR. The project would aim to avoid and minimise impacts to natural resources. For impacts that cannot be avoided, then mitigation measures will be developed.
9 Feb 2023	*What considerations are being given to other modes of moving people around other than cars that would be more efficient and environmentally friendly?*	The proposed corridor would have the width and ability to include alternative modes of transportation as deemed appropriate in the future. However, it is outside the ambit of this project and the NRA to evaluate or establish and implement policies regarding an alternative public transportation system on Grand Cayman – the relevant stakeholders will be consulted during the study.
9 Feb 2023	*We should be making a lot of these comments and questions out to our representatives and decision makers. I hope that the decision makers are listening to what we have to say tonight and that we can also get input from those who do not have a car and couldn't make it tonight.*	Your comment has been noted and will be included in the administrative record for this ToR.
9 Feb 2023	*We are killing corals from untreated sewage.* *Do you agree or disagree that sewage standards are following best available technology? Are we going to be addressing this issue in the EIA?*	Thank you for your participation in the ToR review process. Sewage standards and regulations are outside the scope of this EIA document.

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Date	Public Comment Transcription	Response
9 Feb 2023	*Can you tell me outside of rush hours how much time will be saved to travel from the East end to the centre of George Town and from North side civic centre to the centre of George Town?* *Also, during the evening rush hour how much time will be saved going to opposite way?* *I want to know what the measurable objectives are for travel time change.*	Section 3.2 of the ToR describes the Alternative Solutions and Analysis, in which the EIA will evaluate travel time benefits as part of the overall user benefits for each of the three primary alternatives for future years 2026, 2036, and 2046.
9 Feb 2023	*What happens if this doesn't go as planned and traffic continues to build-up even with this road?*	The EIA will be evaluated to best fit anticipated future scenarios. Alternative modes of transportation and usage of the roadway can be evaluated as-needed in future scenarios.
9 Feb 2023	*Will the greenhouse gas report cover the tail-pipe emissions of vehicles along the roadway day-to-day?*	Section 4.7 of the ToR has been revised to note that we will assess the greenhouse gases associated with tail pipe emissions during operation of the facility.
9 Feb 2023	*Can Cabinet completely ignore this whole entire process since the ultimate decision comes down to them? Is this a process in futility?*	An EIA is required per the NCC. The purpose of an EIA is to provide the public and decision makers the information they need to make an informed decision on the project. The ultimate decision will be made by the Cabinet.
9 Feb 2023	*Approximately 200 to 400 cars imported each month, mainly from Japan. As recent as 25 years ago, there was no access to these Japanese vehicles. There are many rogue traders who bring cars solely for profit with no concern for how many cars are too many cars. On average, 50% of population have a car, some have multiple. Police are overwhelmed by sheer volume of on-road vehicles, which gives the perception they are not enforcing the rules.*	Your comment has been noted and will be included in the administrative record for this ToR. Policy of vehicle ownership, importation, or implementation of a public transportation system are outside the jurisdiction of the NRA and this EIA.
9 Feb 2023	*Most cars typically have a 3-yr max life for cars before being landfilled at "Mt. Trashmore". A small percentage of vehicles are scrapped for the metal, but not enough to make a difference. 25% of on-road cars are not licensed or insured, which makes regulating them even more difficult. Additionally, drivers are not respectful of giving the right-of-way or yielding to oncoming traffic, especially with regards to clogging intersections or "blocking the box."*	Your comment has been noted and will be included in the administrative record for this ToR. Policy of vehicle ownership, importation, or implementation of a public transportation system are outside the jurisdiction of the NRA and this EIA.

Date	Public Comment Transcription	Response
9 Feb 2023	*There needs to be a proper, nationalised transport system with a consistent and reliable bus schedules and easy-to-access bus stops. Consider restricting the volume of vehicles being imported and/or restricting who is allowed to own and operate vehicles. An example is how Bermuda restricts their on-road vehicular access.*	Your comment has been noted and will be included in the administrative record for this ToR. While policy regarding number of cars and bus schedules is outside the jurisdiction of the NRA and this EIA, the Department of Planning, National Trust, and Department of Environmental will all be invited to participate as project stakeholders in the EIA process.
9 Feb 2023	*Along with a transit system, provide safe corridors/lanes for alternate forms of travel, such as scooters, bicycles, etc. Scooters are currently being driven recklessly and are a safety issue, also they're difficult to regulate (registration not required) and to get them to comply with road travel rules.*	There are options and possibilities for the corridor. These different considerations for modes of transportation will have to be considered and costed as alternatives. The cross-section of the potential roadway is not set at this point in the process.
9 Feb 2023	*There are pinch points where all traffic converges during morning commutes and causes traffic to come to a standstill. Additionally, drivers try coming in from other "back" roads that disrupts the flow. There needs to be a way to restrict that traffic. Traffic issues: Grand Harbor, Bobby Thompson, Prospect, etc..*	The NRA is actively developing plans to reduce congestion between the Tomlinson and Silver Oaks Roundabouts as part of a multimodal plan. For this EIA process and in accordance with the ToR, the potential impacts due to the EWA will be addressed as part of secondary and cumulative impacts.
9 Feb 2023	*On-going political opinions have blocked or tabled discussions on any restrictions regarding vehicle ownership and operation, importation of vehicles, and transit system regulation.*	Your comment has been noted and will be included in the administrative record for this ToR. While policy regarding number of cars and bus schedules is outside the jurisdiction of the NRA and this EIA, the Department of Planning, National Trust, and Department of Environmental will all be invited to participate as project stakeholders in the EIA process.

Appendix B

Written Public Comments and Responses

NATIONAL ROADS AUTHORITY

Hello I am an overnight visitor to your island from the USA. Look at the affect development had on hurricane storm surge in the USA, and development along river flood plains. Miles of concrete will fail in your next hurricane and result in more flooding. Other possible solutions to reduce peak traffic are: Work schedules with different and ending starting times, Alternate work schedules with a Monday or Friday off, Alternate school starting and ending times, and Using a lane going in the opposite direction during rush hour. This solution would require some driver learning and clear signage. See you again in April. [redacted] Ballwin, Mo.	**Response:** Thank you for your participation in the ToR review process. Sections 4.3.5 and 4.3.6 of the ToR address Tropical Storms and Hurricanes and Storm Surge and Flood Risk. We acknowledge your suggestions on alternative policy changes to reduce peak traffic; however, these proposed policies are outside the scope of the NRA and this EIA.

Dear Department of Environment, I would respectfully add my voice and concerns to those who are against this road being built. There is little point my reiterating what has already been said, but my concern for the potential negative environmental impact is real. I am also worried that opening up this highly sensitive area will allow developers carte-blanche access to pristine land lots which can then sold at huge profit. Can this be allowed? Recent research has also revealed a far greater current population in Cayman than was previously thought, with, for example, some say 12 additional people coming to live in Cayman every day. All these people need to live somewhere, and travel, often daily, from A to B. How will this affect the already dire rush-hour traffic? On a more positive note, I would humbly make a suggestion as to a possible solution. It may have been considered before and dismissed, but might there be a possibility of building an above-ground monorail to solve the issue. I'm envisaging something along the lines of the Tri-Rail in Florida, stretching from Miami Airport north. It would obviate the need to build more roads, and improve residents' commuting experiences. I am no engineer/planner but it might include the following: Build a monorail (consisting of two tracks thus back and forth) from East End to George Town, then turn north to West Bay. A modern, possibly solar-powered system, consisting of passenger carriages and some freight wagons. Stops at points along the route to collect/discharge passengers, eg at Bodden Town, Prospect, Savannah, George Town, Camana Bay, West Bay etc etc. The carriages would be fully air-conditioned with free WiFi and appropriate lavatories. The system would run 24/7. One might suggest use of this system be offered free to all users, with penalties for road users. There might be compulsory use for all government employees and their families, including all current politicians. The project might incorporate travel to stops on either side of the North Sound where water taxis could be deployed for more rapid access across to and from the western peninsula. Page 1 of 2	**Response:** Thank you for your participation and suggestions in the ToR review process. From a multimodal perspective, this EIA will look at the current traffic and transportation system as well as anticipated future traffic growth based on the 2021 Census data and proposed developments. The proposed corridor would have the width and ability to include alternative modes of transportation as deemed appropriate in the future. This corridor may also be considered a limited access facility to discourage land development to the north. Alternate options that are evaluated could include the use of passenger transit either on-alignment or off-alignment and with or without the associated roadway. However, it is outside the ambit of the NRA and this EIA document to establish and implement policies regarding the required use of an alternative public transportation system on Grand Cayman or land use planning and zoning for development – the relevant stakeholders will be consulted during the conduct of the study.

The freight wagons could be deployed during the night hours, and carry all marl loads (and other building supplies) from the quarries to the various current Dart building projects, plus those proposed across the island in the near future, such as that of Schilling. Another solution might be a tunnelling network, as Elon Musk has instituted in Los Angeles, but I would think the geology of the island would preclude that suggestion. Anyway, as a (very long-term) citizen who remains hugely concerned about Cayman's rapid over-development, I humbly submit these ideas. Yours sincerely Page 2 of 2	

NATIONAL ROADS AUTHORITY

Subject: Re: [EXTERNAL] Re: EWA Extension with Lite Rail Transportation Good morning Mr. Thibeault, I have added you via the project job order collaboration email link for comment. I have sent the architect the Nation Roads Authority Terms of Reference document to read and adapt into the current design, which currently beginning updated to best suit the terms of reference document. You can assist this with Mrs Ebanks-Petrie. As any minor or major project I embark on to design to solve a problem will always put the impact on environment conservation first. I strongly believe that my design approach is the best way forward. It will reduce traffic congestion, lower C02 greenhouse gas carbon footprint emissions by 90% this is because people would prefer to leave their vehicle home or in the tram or twin station parking lot to save on fuel than to drive from East End and North Side to Central George Town. I have asked the architect that I am working with on this project to place drainage and sewage holding in the ground near the structure or embedded into the design structure. I would like to take on all the difficult task your office is facing in terms of both in design and technical civil aspect of each task ahead that NRA is struggling with at the current moment. I respectfully await your response and comments on the current updated design for the EWA highway project, to which you now have full access to review. Kind regards, Page 1 of 6	**Response:** Thank you for your suggestion and participation in the ToR review process. Section 1.1.2 of the ToR describes the Purpose and Need, in which this EIA will focus on providing a disaster- and climate-resilient alternative route to connect the east and central/west districts; meeting the current and projected multimodal travel needs through improved traffic conditions; preserving the unique environment of Grand Cayman; and providing an enriched quality of life through mobility and accessibility for residents and visitors alike. The proposed corridor would have the width and ability to include alternative modes of transportation as deemed appropriate in the future. Alternate options that are evaluated could include the use of passenger transit either on-alignment or off-alignment and with or without the associated roadway. However, it is outside the ambit of the NRA and this EIA document to establish and implement policies and/or operations regarding an alternative public transportation system on Grand Cayman. Such responsibilities fall under the Ministry responsible for Transport and the Public Transport Unit, who will be consulted as stakeholders during the study.

There would be two grand central station in which central George Town would have the larger one and on the receiving end of the rail way, would be located at east end in the Google earth screenshot images below. I have highlighted it in yellow. Where the new grand central lite train or rather metro tram rail station. Instead of increasing carbon foot print with more transport buses. The train will reduce significantly carbon and noise pollution foot print significantly. In addition would add to the tourism economy which increase government income of revenue back into the economy to aid in fighting inflation. The location on the Google Earth map system screenshot you will notice there is a line that where another bridge would go over the wetland water connecting the round about and intersection. this would be a new scenic route for tourist visitors for both travel and sight seeing. The original straight line is the first bridge at Hirst Road and Woodlands Drive. Page 3 of 6	

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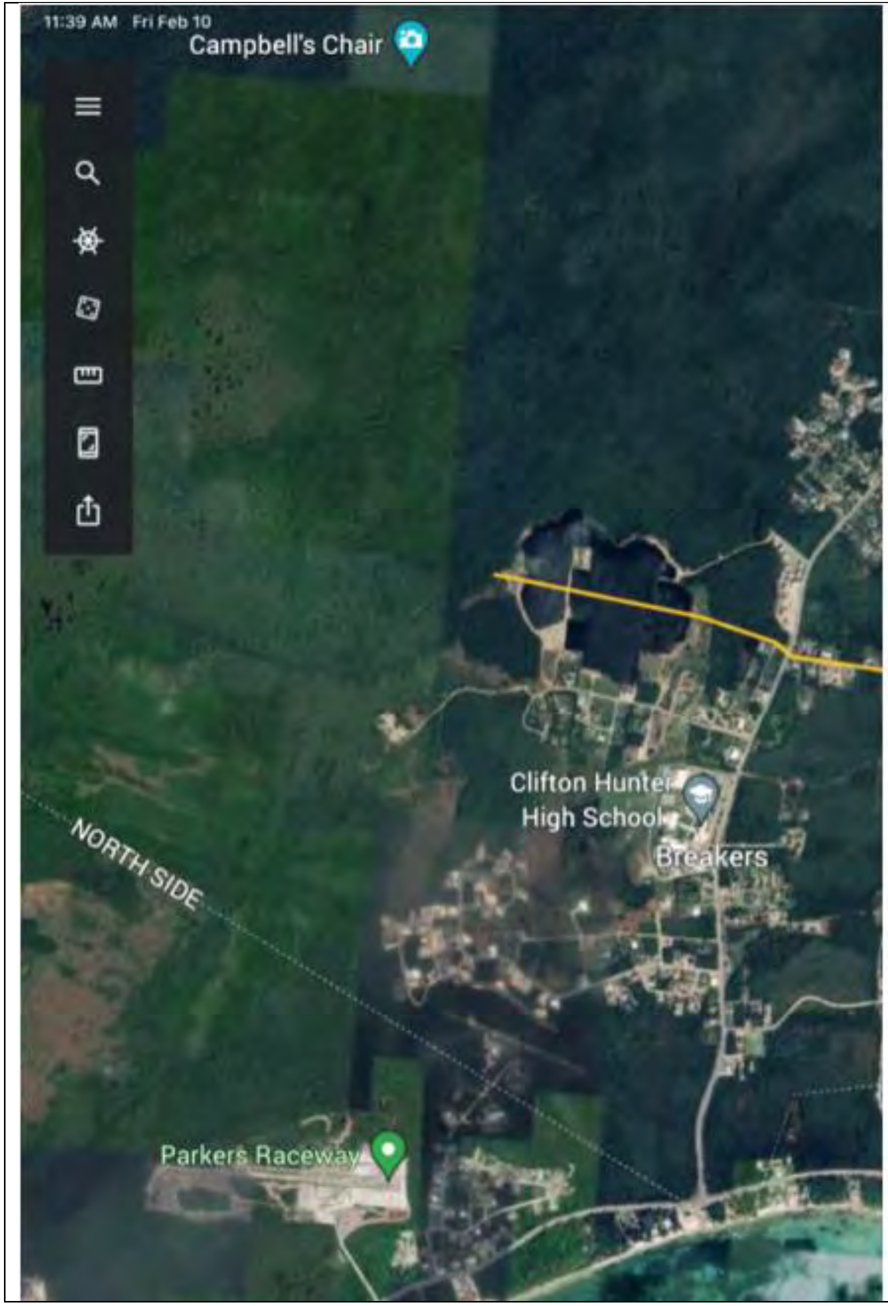

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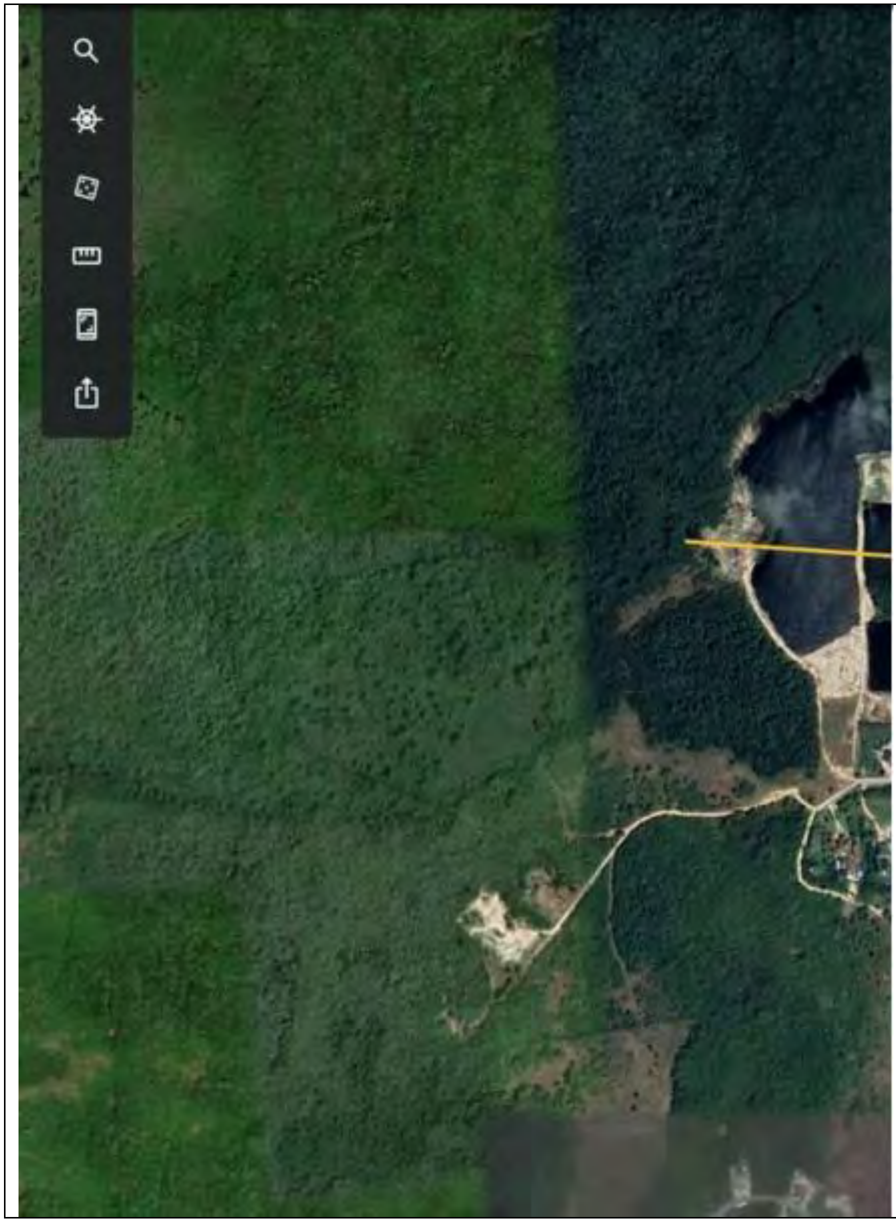

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Subject: Fwd: [EXTERNAL] Re: EWA Extension with Lite Rail Transportation Dear Department of Environment, Here below is my solution which I am proposing to considering. I have been in conversation with Mr. Denis Thilbaeult Assistant Director of the National Roads Authority (NRA). <u>EWA Extension with Lite Rail Transport Proposal Soultion.</u> Here I proposed as a economic and environmental solutions to the new East-West Arterial (EIA) story. I am proposing a bridge or series of bridges along with three grand central station, which will be situated in central George Town, Lookout Gardens Bodden Town after the first bridge install between the mouth of Arterial Road to wood land drive then after there would be a series of either T-junctions on each lane of the bridge or roundabouts. These bridge(s) will be placed over the wet lands and for a lite rail Linked system running through the existing median of the highway that new east arterial road expansion will meet and join with the existing west highway road. Once the current bridge design will be completely finished I will demonstrate how the new EAst-West Arterial Highway will justify to both the Department of Environment (DoE) and PACT government that my solution is both qualitative and quantitative feasible. This because of the EIA use my design as a demonstration because the people of cayman General go on perception as well as the context of the wording publicly published to them that they may perceive my proposal as positive and this major project could go forward. The current design will use a vehicle traffic four lane, with two following in either direction and lite rail train or tram system running in the middle. The tram I'm proposing to use is already in operation in Europe as cayman adopts both American and United Kingdom road standards. The bride or bridges in two separate places which will be placed mainly over the wet water by using a pill pillion with pillion head style placed beneath the bridges super structure as the main support. The pills which will be 20ft spaced apart from each other but 45ft from the bridge entrance ramp and the opposite side existing ramp underneath by inserted in to middle of the water between the edge of Hirst Road and Woodland Drive. The bridge would connect with a roundabout and T-junction. That motorist would be able to exist at north sound in the Woodland Drive area or continue to Bodden Town lookout Garden where the other grand Central station will be situated with a four floored multil car park. Page 1 of 9	**<u>Response:</u>** Thank you for your suggestion and participation in the ToR review process. This EIA will look at the current and projected multimodal travel needs; the proposed corridor would have the width and ability to include alternative modes of transportation as deemed appropriate to address these needs. Alternate options that are evaluated could include the use of passenger transit either on-alignment or off-alignment and with or without the associated roadway. However, it is outside the ambit of the NRA and this EIA document to establish and implement policies and/or operations regarding an alternative public transportation system on Grand Cayman. Such responsibilities fall under the Ministry responsible for Transport and the Public Transport Unit, who will be consulted as stakeholders during the study.

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There will be smaller sheltered rail drop off stations along the way such as at school, airport and Caymana Bay this approach would encourage people to leave their vehicles parked in the security monitored parking multistory parking lot situated and attached to the main grand train stations. In the design there is also covered glass canopy walkways that pedestrian wishing to walk along the highway and bridge system from say woodland drive to Grand Harbor way can be sheltered out if the elements of rain, wind and the sunlight heat wave. The bridge will have a outer walkway for the roads maintenance to both clean the interior and exterior surfaces of the walkway, the water and chemical cleaning would drain down in situated drainage holes where road work workers could weekly use suction hose to remove foreign objects, water sludge from the drainage sewage holes. Yes I'm aware that central wetlands habitat is at state but my first and foremost priority with the design is not to impact the conservation site which not only are home to our endanger bird and wild life population but also stop the flood sea water problem people Bodden Town is facing and the constant traffic congestion between the hours of 5:00AM and 9:30AM. The tram system will generate revenue for the government at the same time reduce traffic congestion by 90% this because tram system that I'm proposed to integrate into the new EWA highway system the existing roads and highway, bypass system will I turn provide also tourist attraction as sense of scenery which never seen before and also access to Northside beach and restaurant areas. <u>Qualitative Research Study Analysis Advice.</u> The qualitative study has already been conducted according to Mr. Thilbaeult during our phone call today through soil depth sampling. Where the proposed solution pills will be placed in the ground or waterbed, the pills will be made of cement and the main bridge structure would also be made of cement with wire cable support, anti-corrosion and none expansion tensile strength material will be used to build the structure. By using this approach there will not be a negative environmental impact effect to the water table or water lens where the pills that will need to be placed directly in the water, water-wetland area such as the national trust area. The off bridge road could go around the existing wetland but the government would have to lease private land over a period of years. Where the tram system can pay for the lease during the peak hours of 5am-9:30am easing the traffic for people who would use the new proposed lite rail or tam system as quick and effective way to drop their children off at school in the morning as there will be lite rail or tram system sheltered plate forms at each school or important place such as grocery stores main for those that do not own an motor vehicle or can not drive either due to being wheelchair bound or simply do-not have the ability to drive. This will also solve the bottle neck problem mainly in the Grand Harbor area. Which I already in the process of address and bringing the concept to both the Department of Environment and National Roads Authority for economic and environmental feasibility review. Page 2 of 9	

Quantitative Research Study Analysis Advise. The current population on Grand Cayman is nearly 70,000 post the 2020-2023 COVID-19 pandemic period according to world population review https://worldpopulationreview.com/countries/cayman-islands-population The SNCF lite rail or CAF Tram system I'm proposing to use to lower greenhouse gas carbon footprint print can transport during the high peak hours of 5am - 9:30am 422 people if two or more lite rail train transport or tram system is used on the new cayman rail country to city system. That will be 1266 cars and people off the road coming from East End and Northside heading to town for work and for school drop off during the peak morning time. During the hours normal hours of 9:45am to 4:00pm this could be used by tourist who arrive on the cruise ship to tour the island and generate revenue for the government. As there will some many frequent trips by the kite rail or tram needed to transport the tourist across the nation to tourist destinations. What am asking the Department of Environmental to publish what I have currently designed and ask the general public how many people would use this new proposed system especially the individuals from Bodden Town who were complaining about the flooding on the existing roads near the water front area of Bodden Town, who would just preferred to drive on the four lanes of the bridge and center median countersunk lite rail system with option to cross at intersection and using stop lights and rail road barrier crossing stem to slow the traffic until the tram has completely crossed and it's safe to proceed. It's just a simple qualitative survey at this point as the proposed rail or tram line reduce noise pollution. Here is the links and pictures of the lite rail transport system and bridge I'm proposing to Department of Environment, Pact Government, National Road Authority to build. Building material the cost of the rail line or trans or train has not been factored into this as of yet. As this just a simple proposal to publish to the people which that is my solution to the current traffic problem they are facing. The current bridge design is currently being updated to be aesthetically pleasing. https://www.caf.net/en/soluciones/proyectos/proyecto-tranvia.php Page 3 of 9	

https://m.youtube.com/watch?v=PNXBioVfjmA

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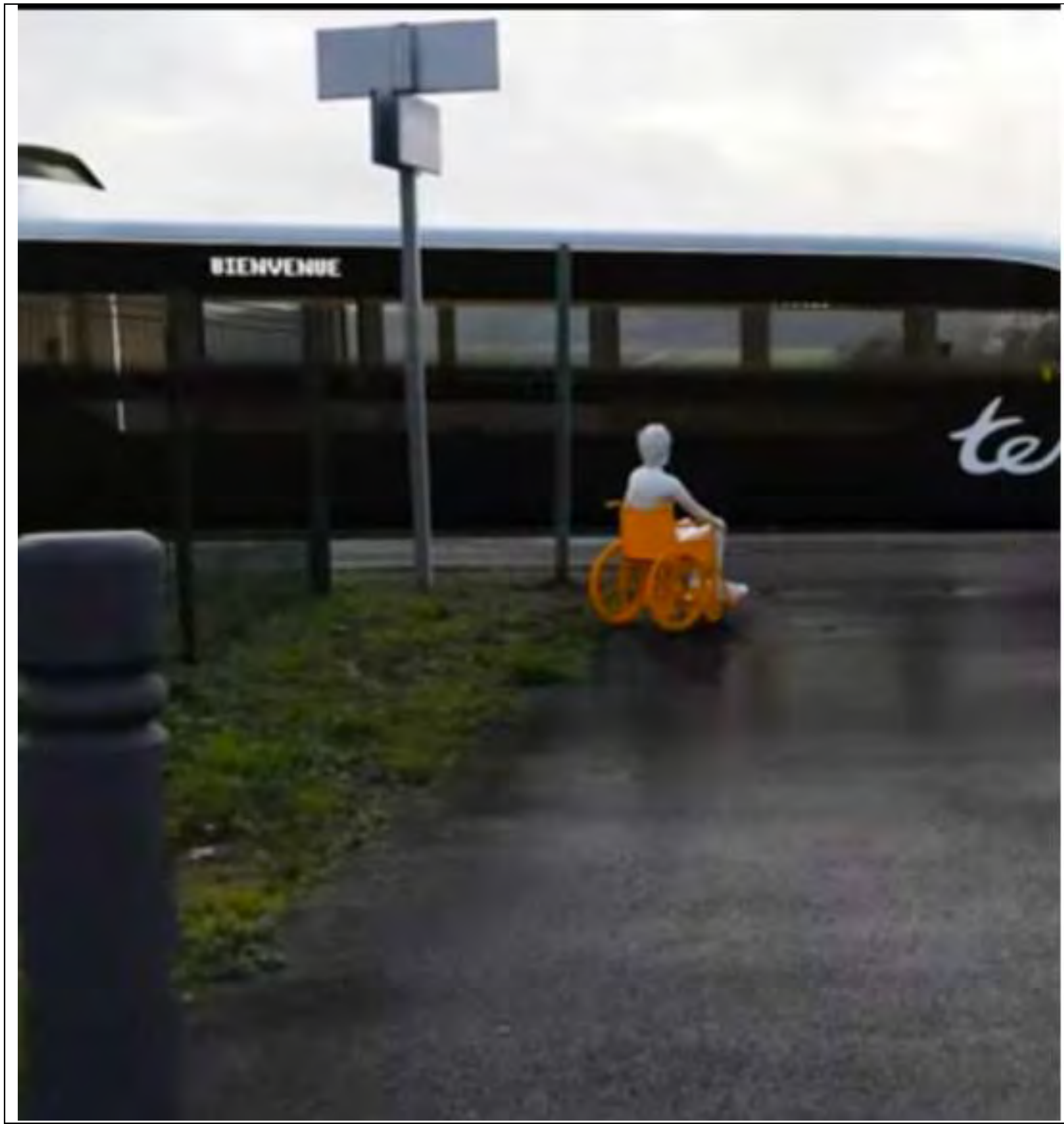

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Image © 2023 Airbus
Image © 2023 Maxar Technologies

Subject: [EXTERNAL] ToR comments for the East-West Arterial Attn: Environmental Assessment Board The Central Mangrove Wetlands are the largest contiguous wetland in our region. We are meant to be preserving it and we note the high importance this is being given in the Terms of Reference. These mangroves are vitally important to our ecosystem and what a lot of Caymanian's, especially our youth, call the ecological heart of Grand Cayman. In response to the draft Terms of Reference, please include the following proposals which would help to negate some of the environmental concerns: 1) **Drop the road further south and introduce a causeway around Meagre Bay Pond (see attached PDF).:** The elevation would need to be considered carefully so as to minimize impact to the wildlife sanctuary. Pull off rest /viewing stops could be incorporated that you see on many nature highways demarking wildlife parks. A very rough alignment of the route being proposed is attached with the intention to go through or below existing quarry access. An overview was discussed with Joyce Barkley, one of the consultants at the Thursday 9th February public consultation and a resident of Bodden Town familiar with the quarries, in which we impressed that this was not an unrealistic proposal- the road becomes a functional highway as a through corridor, the quarries could be replanted with fringe habitat, the solar farm potentially expanded over the dead water pans as well as many other options. The quarry areas are damaged and uninhabitable land which could be repurposed and by realigning the road we would be meeting constitutional and international standards to protect nature and not to deforest prime habitat. These quarries have little commercial value once they reach end of life. A rehabilitation project example is the former Sin Seng Quarry in Singapore which is now restored to a wetland nature park and rifle range: https://thelongnwindingroad.wordpress.com/2022/11/16/a-park-with-a-view-rifle-range-nature-park/ Page 1 of 3	**Response:** Thank you for your suggestion and participation in the ToR review process. The responses below are numbered to follow the numbering provided in the comment. 1. Thank you for your suggested alignment. The NRA will coordinate with the stakeholders, including Sustainable Cayman, to identify and discuss potential additional alternatives and alignments that could be considered as part of the EIA process.

2) **Rezone both sides of the road as being 'environmentally sensitive land'.:**

This can also be referred to as a wildlife corridor and potentially the wider environmental concerns could be mitigated along the route using natural solutions to address biodiversity, drainage, noise and light abatement, water filtration, food security. On disturbed land, embankments would need to be replanted with trees and could also include fruit trees. Rewilding nature would be the objective to avoid high maintenance.

Please include a conservation easement as mitigation for lost habitat along the entire length of any road alignment of the East-West corridor.

3) **Remove the Roundabouts:**

The roundabouts are simply aiding development and the destruction of an extremely sensitive eco-system which goes against S18 of our Constitution and S1.3(d) of our 1997 Development Plan "to preserve the natural assets of the Island for their value in protection from the elements and their natural beauty" and S1.3(h) to protect areas of environmental significance.

4) **Increase the Induced Growth Study area to 1.5miles**:

The road will effectively facilitate the opening up of interior land to the construction of canal development which will have a severe negative impact on the sensitive eco-system which we are seeking to protect. The road is a direct contributor. See study: https://www.researchgate.net/publication/46577885_Increasing_development_in_the_surroundings_of_U_S_National_Park_Service_holdings_jeopardizes_park_effectiveness

5) **Designate the Central Mangrove Wetlands as a Wildlife Sanctuary**

Whether considered part of the EIA or not, the site meets the criteria to be deemed a Ramsar Site and there has and should still be an objective to protect the wetland for nature. The mechanism for doing this as a mitigation for through access should be considered.

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2. The intent of NRA's alignment for the limited access corridor was to locate the corridor at the northern edge of existing developments to encourage a northern limit to development. While land use planning and zoning is outside the ambit of the NRA, the Department of Planning will be invited to participate as a project stakeholder in the EIA process.

3. The proposed roundabouts are located at junctions where it is anticipated that some form of traffic control is necessary. The remaining corridor is proposed to be treated as a limited access corridor.

4. The NRA agrees that the induced growth study area could be increased to 1.5 miles to better evaluate potential development along the corridor. This has been updated in the Final ToR document.

5. Thank you for the suggestion for designating the Central Mangrove Wetlands as a Wildlife Sanctuary; however, this is outside the ambit of the NRA. The Department of Planning, National Trust, and Department of

6) **Incorporate Sustainable Road Construction and alternatives to using high carbon emitters such asphalt and concrete:** Roadway construction is one of the most significant contributors to total greenhouse gas emissions. Set objectives to meet a smooth, safe and sustainable highway and consider new technology or practices for road surfacing. This can help with maintenance, longevity, noise abatement, earthquake sinkholes and the effects of storm inundation. https://www.worldhighways.com/wh3/feature/road-surfacing-case-sustainability 7) **Work with Natural Solutions:** As part of the overall stormwater abatement we need to incorporate bioswales not just gravel and stormwater drains and ducting. There is no question that our road infrastructure is aesthetically unappealing and bioswales provide numerous benefits to offsetting the greenhouse gases produced in road construction. The concern that vegetation is too difficult to maintain is not an argument against the overall benefit. https://www.buildings.com/landscaping-outdoors/article/10186596/how-bioswales-provide-aesthetic-stormwater-management Thank you for considering the above. With kind regards, Page 3 of 3	Environmental will be invited to participate as project stakeholders in the EIA process. 6. Thank you for the provided resource. We do acknowledge that construction is a high carbon emitter and will evaluate Greenhouse Gas Emissions per Section 4.7 of the ToR. Feasible and reasonable alternative construction technologies and practices will be considered. 7. Thank you for the provided resource. We will evaluate Hydrology and Drainage per Section 4.3 of the ToR. Feasible and reasonable alternatives to stormwater abatement, including bioswales, will be considered. Additional detail has been added to Section 4.3 to describe the types of mitigation that may be considered.

NATIONAL ROADS AUTHORITY

Subject: [EXTERNAL] East-West Arterial Extension Hello Sirs, I'm not a Caymanian however this is my new home for the time I'll be allotted/allowed to work here and so this country and everything about it concerns me just as everyone else living here. I watched the presentation online and I have a question/suggestion seeing that the mangroves are the largest in the Caribbean and very important to the ecosystem here. Can there be overhead roads over the mangroves to protect them or even bridges over them? Having these overhead roads can limit the footprint on the ground that would immediately affect the mangroves. Also, noise suppression barriers can be placed on the overhead roads/bridges that will eliminate or suppress noise so the local wildlife will not be affected. I hope this can be considered. Kindest regards,	**Response:** Thank you for your participation in the ToR review process. Bridging, culverts, and other mitigation measures to protect the terrestrial ecology and hydrology will be considered, as described in Section 4.3 of the ToR. Noise impacts and potential mitigation measures will also be evaluated as described in Section 4.8 of the ToR.

Subject: [EXTERNAL] Environment Assessment Board ! **Importance:** High Hello, I had the pleasure of viewing your presentation for the EIA of the North West route by the NRA. My understanding of this future document is that it will be a crucial guideline to understand the impacts created from the development, meaning it will need to work hard and look outside of Cayman for solutions, innovative natural solutions. I have listed below a couple of points I think would be useful for the EIA 1. Will designers be consulted on innovative mitigation solutions? -Especially the environmental impact. I've noticed the team is mostly engineers and scientist, is there no need for a Urban Design or Landscape Architect perspective on this? They would be able to assist with suitable mitigation strategies - preferable one familiar with the Caribbean and our vernacular. Not a city planner. -There's potential for this road to become a green spine, new habitat creation, new nature trails, a sense of place. - Will it include studies of other similiar situations/precedents and how they were mitigated (successfully) Page 1 of 2	**<u>Response:</u>** Thank you for your suggestion and participation in the ToR review process. The responses below are numbered to follow the numbering provided in the comment. 1. The team is well equipped to develop a successful mitigation approach. RES, who is included on the team to provide ecological assessment and mitigation planning, is the United States' largest ecological restoration company with a focus on water quality, environmental mitigation, and climate and flooding resilience projects. RES' Florida team, who is included on this project, has experience developing successful mangrove mitigation projects to offset impacts associated with transportation projects. Our team includes biologists, engineers, landscape architects, and geologists who will draw upon previous experiences as well as our understanding of this project's unique nature and location to develop suitable mitigation strategies/solutions. 2. Future development along the corridor will be assessed under induced growth as described in Section 4.1 of the ToR. The intent of NRA's alignment for the limited access corridor was to locate the corridor at the northern edge of existing developments to encourage a northern limit to development. While land use planning and zoning is outside the ambit

2. Will the study include the risks impacts from future developments along the new road? -Will it set protocols/method statement to be included? 3. Will a study be done on the past road developments? -A list of lessons learned? One example is the Easterly Tibbetts Hwy, and the influx of iguanas after the construction of it due to the habitat disturbance. Something we are still struggling with. 4. Will a public infrastructure study be included? -Both existing and future mitigation -Why is the solution more roads for more cars, can alternative transport be explored as a mitigation? It's good that you are doing an assessment like this, but analysis is not enough for it to be successful. This will provide the bare bones of the project and set the tone for future developers and stakeholders. Hope this helps in some way. Page 2 of 2	of the NRA, the Department of Planning will be invited to participate as a project stakeholder in the EIA process. 3. Thank you for the provided lesson learned. The NRA will coordinate with the stakeholders and will utilize public input to discuss potential concerns of the new corridor to try to minimize or avoid similar issues with this project. 4. From a multimodal perspective, this EIA will look at the current traffic and transportation system as well as anticipated future traffic growth based on the 2021 Census data and proposed developments. The proposed corridor would have the width and ability to include alternative modes of transportation as deemed appropriate in the future. Alternate options that are evaluated could include the use of passenger transit either on-alignment or off-alignment and with or without the associated roadway. However, it is outside the ambit of this project and the NRA to evaluate or establish and implement policies regarding an alternative public transportation system on Grand Cayman. Such responsibilities fall under the Ministry responsible for Transport and the Public Transport Unit, who will be consulted as stakeholders during the study.

Subject: [EXTERNAL] EWA Terms of Reference questions for feedback Good day, I accidentally sent these questions to Sustainable Cayman instead of you. Sorry I'm so late. 1. Is rezoning on both sides of the road as 'environmentally sensitive land' (thereby preventing ribbon development along the road), likely to be achievable? 2. Are there loopholes to rezoning that developers are able to make use of? For example, is the fine for transgressing the rezoned land law, a genuine deterrent to developers or is it merely an extra building cost? 3. 3.1 Is the ground & surface water regime well understood for the surrounding habitat? 3.1.1 Does the water in the area feed into the island's underground aqueduct system (as in provide household water for any people via drilled wells)? 3.1.2 If yes, will the pollution produced both pre- and post-construction be quantified and determined safe for people to use throughout the use of the road. 3.2 Will the amount of pollution (fuel emissions etc) running into the surrounding wetlands be quantified for both during construction- and also use of the road (as a function of estimate traffic over time)? 3.2.1 Is there reference data to accurately predict the extent to which ongoing run-off pollution will affect animals, birds, crustaceans, insects and plants in the wetland? 3.2.2 Are there mitigating measures that can be implemented in the case that pollution is found to impact the habitat more than estimated in the EIA? For example, would heavy emitters, like large trucks, be excluded from using the road? 4. Has the impact of future hurricanes been considered in the context of removing the middle section of this mangrove, which provides an element of hurricane protection? Kind regards	<u>**Response:**</u> Thank you for your participation in the ToR review process. The responses below are numbered to follow the numbering provided in the comment. 1. While designating the area to each side of the corridor as "environmentally sensitive land" is outside the ambit of the NRA, the Department of Planning, National Trust, and Department of Environmental will be invited to participate as project stakeholders in the EIA process. 2. Similarly, land use planning and zoning, as well as rezoning, is outside the ambit of the NRA. 3. At this point in the EIA process, we have not completed the technical studies, which will include water flow and water quality; however, Hydrology and Drainage (Section 4.3) and Geo-Environmental (Section 4.4) will be evaluated as part of the EIA. Mitigation measures, such as best use practices for pollutant prevention will be evaluated for construction and operational use. 4. Sections 4.3.5, 4.3.6, and 4.3.7 of the ToR address Tropical Storms and Hurricanes, Storm Surge and Flood Risk, and Mangroves. The inter-relationship of these resources will be evaluated as part of the EIA. Detailed evaluation has not occurred yet at this point in the EIA process.

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Subject: [EXTERNAL] Re: EWA Terms of Reference questions for feedback 3.1.1 is supposed to read: 3.1.1 Does the water in the area feed into the island's aquifer system (as in provide household water for any people via drilled wells)? On Thu, Feb 9, 2023 at 9:46 AM Robyn Tourle <robyntourle@gmail.com> wrote: Good day, I accidentally sent these questions to Sustainable Cayman instead of you. Sorry I'm so late. 1. Is rezoning on both sides of the road as 'environmentally sensitive land' (thereby preventing ribbon development along the road), likely to be achievable? 2. Are there loopholes to rezoning that developers are able to make use of? For example, is the fine for transgressing the rezoned land law, a genuine deterrent to developers or is it merely an extra building cost? 3. 3.1 Is the ground & surface water regime well understood for the surrounding habitat? 3.1.1 Does the water in the area feed into the island's underground aqueduct system (as in provide household water for any people via drilled wells)?	**<u>Response:</u>** Thank you for clarifying. See responses on the above page.

NATIONAL ROADS AUTHORITY

Hello, I reviewed this document and I have a number of questions: (1) What is the purpose of this road? Almost all traffic occurs much further to the west around the Hurley's roundabout and George Town. (2) Is the Central Mangrove Wetland Forest to the north of this road subject to development? Is the Government going to restrict this land for conservation? (3) If I can surmise that this road is primarily about unlocking access to land for special interest groups to develop it, albeit under the guise of helping the public, has anyone started an online petition to prevent this road or anything to publicly protest this road? (4) Since this is an issue of national concern, can this be elevated to referendum / public vote (similar to the 2019 Port Vote)? Kind regards,	**<u>Response:</u>** Thank you for your participation in the ToR review process. The responses below are numbered to follow the numbering provided in the comment. 1. Section 1.1.2 of the ToR describes the Purpose and Need, in which this EIA will focus on providing a disaster and climate-resilient alternative route to connect the east and central/west districts; meeting the current and projected multimodal travel needs through improved traffic conditions while preserving the unique environment of Grand Cayman; and providing an enriched quality of life through mobility and accessibility for residents and visitors alike. 2. While designating the Central Mangrove Wetland Forest for conservation is outside the ambit of the NRA, the Department of Planning, National Trust, and Department of Environmental will be invited to participate as project stakeholders in the EIA process. 3. Section 3.2 of the ToR describes the Alternative Solutions and Analysis, in which the intent is to ensure the roadway design provides the best possible outcome for meeting the existing and projected travel needs while effectively preserving the environment as well as accommodating the needs of the surrounding

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	communities. To improve connectivity, safety, and enhance emergency evacuation capability, three primary alternatives will be considered to determine which alternative(s) would effectively meet the Purpose and Need of the project. The initially proposed roadway alignment and limited access functionality was to discourage land development to the north. Stakeholder and public outreach will continue to be conducted throughout the EIA process. 4. The results of the EIA study and its assessments will inform the policy and decision makers once the study has been completed. Upon completion of the study and presentation of the results, the CIG will assess how it wishes to pursue the implementation of the road project; at that point, if there is a desire for a referendum to be held regarding the construction of the roadway, the public will have that option. At this point, the NRA is seeking input on the scope of the study to be carried for assessing impacts of the road corridor, the NRA is not seeking permission to construct the roadway.

Subject: [EXTERNAL] East-West Arterial Extension Firstly, I would like to address the existing two-way traffic, single lane Bodden Town road. On any given day drivers traversing this road can be faced with one or more of the many situations that can take place on a public road. I will begin to address a few of these, beginning with the most common, as simple as having two vehicles stopping for a chat on the shoulder of the road, which in most cases doesn't exist, so a portion of the lane is most times being obstructed. Inquizitive passerby drivers will always be slowing down and rubber necking to see what's going on, and eventually traffic comes to a standing halt down the caterpillar chain. It's very embarrassing to mention that if it rains on any given day, our drivers cannot drive, and that's definitely causing a terrible traffic back up. There are often times the numerous utility companies blocking a lane for tree trimming, road crossings or trench cutting, servicing overhead cables, providing new services and the likes. From these sorts of obstructions on this particular road, it causes a 20 - minute drive to sometimes turn into anyway from one and a half to two hours. God forbid if there is a road fatality anywhere on this road, traffic will completely stop as the Police will block off the entire area, that has left people sitting in their cars in excess of 6 hours, and in some cases on more than one occasion, to sleep the night in their cars. A more critical situation, due to the shoreline roads being in low lying areas, a major hurricane devasted 75 to 80% of our roads on the entire south side of the island. Resulting from this was a horrific amount of sand covering the roads, up 3 and 5 feet in dept in some places, with an additional vast amount of debris and destruction rendering the roads impassable. In some areas one could only guess where the road once was, as it was not apparent that anything existed there before. Sand could be seen blocking the roads from the foot of Guard House Hill, to where one could reach driving a vehicle, and as far up as to the Megie Bay Pond which also had sand in it. It took 3 days of continuous attempts to reach up to East End driving a Dodge Durango 4x4. Despite the emergency, no emergency vehicle could reach to the eastern districts to render any assistance there. Page 1 of 2	**Response:** Thank you for your participation in the ToR review process. We acknowledge and address your concerns within the ToR (particularly Sections 1.1.2 and 3.2) as this EIA will focus on providing a disaster- and climate-resilient alternative route to connect the east and central/west districts; meeting the current and projected multimodal travel needs through improved traffic conditions; preserving the unique environment of Grand Cayman; and providing an enriched quality of life through mobility and accessibility for residents and visitors alike. To improve connectivity, safety, and enhance emergency evacuation capability, three primary alternative options will be considered to determine which alternative(s) would effectively meet the Purpose and Need of the project.

Just like our Planning Department plans a residential sub-division for future development, and there are plans approved to build a house, the same should be applied to the infrastructure of this country for the future. This main arterial road should have been already existing as a future development plan for this country. The patching up and piecemealing of roads, to address the grow problem is not working. People should not be spending 4 hours a day in traffic trying to get to work, and on top of that school children having to finish dressing and eating their breakfast in moving cars. This in itself is a danger when we think of the distraction it causes to the parent driver of those cars having to do so. Think about the unnecessary stress and strain, physically, mentally and psychologically this is causing on our people. Imagine the effect this is causing on the learning aspects of the kids in schools and the effects being caused to the people in their workplaces. Having this new road in place will provide the infrastructure needed to access cheaper properties, making it less expensive for business to invest in the eastern districts. Hence, some people can work in the areas they live, thus alleviating the amount of traffic traveling to town. This will lend to a healthier and more productive Cayman as a people, not having to waste unproductive hours in traffic. We all know that it will commute traffic much faster and reduce the likeliness of head on collisions that most times causes fatalities. It helps greatly to alleviate the possibilities of the eastern districts being cut off in disasters. It provides for the redirection of traffic in the event of one side of the highway becoming block, so traffic can continue, and our people should not have to sleep in their cars anymore. Page 2 of 2 Regards	

Public Meetings for the Draft Terms of Reference for the EIA for the East-West Arterial Extension, Sections 2 & 3 – Comment Sheet

(1) Do not destroy mangrove wetland
(2) Drop the road south through quarries
(3) Remove north branch of road above mastic trail
(4) Public transit

See MAP

Response: Thank you for your participation in the ToR review process.

1. We will be evaluating mangroves and their many functions as part of the EIA process. Alternatives to avoid or minimize mangrove impacts will be evaluated as part of the EIA (Section 3.2 of the ToR) and mitigation measures for mangrove impacts will be evaluated (Section 4.5.6 of the ToR).
2. and 3. Thank you for your suggested alignment. The NRA will coordinate with the stakeholders to identify and discuss potential additional alternatives and alignments that could be considered as part of the EIA process.

4. From a multimodal perspective, this EIA will look at the current traffic and transportation system as well as anticipated future traffic growth based on the 2021 Census data and proposed developments. The proposed corridor would have the width and ability to include alternative modes of transportation as deemed appropriate in the future. However, it is outside the ambit of the NRA and this EIA document to establish and implement policies and/or operations regarding an alternative public transportation system on Grand Cayman. Such responsibilities fall under the Ministry responsible for Transport and the Public Transport Unit, who will be consulted as stakeholders during the study.

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Public Meetings for the Draft Terms of Reference for the EIA for the East-West Arterial Extension, Sections 2 & 3 – Comment Sheet	
HOW ABOUT USING OVER PASSES @ OUR HURLEY'S + SILVER OAKS ROUNDABOUTS TO IMPROVE FLOW INSTEAD OF SPEEDING OUR LEAST PROBLEMATIC TRAFFIC INTO THE JAM? WOULDN'T THAT BE MORE EFFECTIVE USE OF OUR FUNDS? IF THIS IS ACTUALLY ABOUT INCREASING (NOT TRAFFIC) OUR POPULATION, SHOULDN'T WE BE PLANNING A CEILING (CAP) ON POPULATION INSTEAD? FIX THE CHOKE POINTS INSTEAD OF INCREASING THE FLOW COMING INTO THEM PLEASE!	**Response:** Thank you for your participation in the ToR review process. The NRA is actively developing plans to reduce congestion between the Tomlinson and Silver Oaks Roundabouts as part of a multimodal plan. For this EIA process and in accordance with the ToR, the potential impacts due to the EWA will be addressed as part of secondary and cumulative impacts. The EIA will evaluate future traffic demands based upon anticipated population growth. However, policy on population is outside the ambit of the NRA and this EIA document.

If there is development around Crewe Rd. to decrease the bottle neck what will the impacts be on traffic during the construction? Why not look at alternatives like ~~car~~ number of cars per household & public transportation improvements?

Are the impact on fish nurseries being looked at?

If you are talking about electric vehicles we'll have to change to renewable energies which would incorporate CUC who do not have any incentive to change to renewable energy. So what will you do to get CUC to co-operate?

Response: Thank you for your participation in the ToR review process.

For this EIA process and in accordance with the ToR, the potential impacts due to the EWA will be addressed as part of secondary and cumulative impacts.

The proposed corridor would have the width and ability to include alternative modes of transportation as deemed appropriate in the future. However, it is outside the ambit of the NRA and this EIA document to establish and implement policies regarding number of cars per household and public transportation improvements.

Potential impacts to fish nurseries will be evaluated as discussed in Section 4.5 of the ToR.

Any policy on the use or promotion of electric cars is outside the ambit of the NRA and this EIA document. The responsible Ministry respective for that subject matter will be consulted as a study stakeholder.

As a matter of compromise on the environment would it be better to have the road on pillars or pilots to ~~max~~ minimize environmental damage and if this question has been asked before, can they quickly elaborate on what their response to that was	**<u>Response:</u>** Thank you for your participation in the ToR review process. Bridging, culverts, and other mitigation measures to protect the terrestrial ecology and hydrology will be considered, as described in Section 4.3 of the ToR.

NATIONAL ROADS AUTHORITY

In the presentation it stated with the new road there would be more developement due to road. So, this is a temporary solution. ~~Are~~ Is this just putting a bandaid over a womb? We need to address the situation. Tearing down thousands of mangroves which play a vital part in the environment especially beginning in the Caribbean where we face hurricanes each year. I am a born and raised Caymanian and would be very disappointed to see thousands of mangroves get destroyed for a road. A road we are not sure will solve the traffic congestion. It might work temporarily, but we need to look at long term! Please, allow the people to have a voice in this decision.	**Response:** Thank you for your participation in the ToR review process. The intent of NRA's alignment for the limited access corridor was to locate the corridor at the northern edge of existing developments to encourage a northern limit to development. However, in order to estimate the potential for future development along the corridor, induced growth will be evaluated in the vicinity of each new roundabout as described in Section 4.1 of the ToR. It should be noted that the NRA does not have ambit to make planning or zoning changes; however, the Department of Planning will be invited to participate as a project stakeholder in the EIA process. We will be evaluating mangroves and their many functions as part of the EIA process. Alternatives to avoid or minimize mangrove impacts will be evaluated as part of the EIA (Section 3.2 of the ToR) and mitigation measures for mangrove impacts will be evaluated (Section 4.5.6 of the ToR).

HOW MUCH AGGREGATE FILL WILL BE NEEDED? WHERE WILL IT COME FROM? COST? WHO IS PROVIDING THE POPULATION GROWTH NUMBERS/DATA?	**<u>Response:</u>** Thank you for your participation in the ToR review process. We do not currently have information on aggregate quantity, location, or cost. The next phase of the EIA process will evaluate different alternatives and provide detailed analysis of each. There will be additional opportunities for public outreach and comment throughout the process. Population growth numbers are based off the 2021 Census data and proposed developments.

What is the ~~reason~~ goal for this meeting at this time? Why not prior to the road plan being finalized? What does the CIG departments hope to achieve?	**Response:** Thank you for your suggestion and participation in the ToR review process. The National Conservation Act's EIA Directive establishes a public involvement period for the draft ToR and draft Environmental Statement (ES). Section 2.7 of the ToR discusses public consultation and stakeholder engagement, which includes a variety of outreach strategies to be utilized as the EIA process moves forward. There will be more public participation throughout the process and there will be another opportunity for formal public consultation once the Environmental Impact Assessment (EIA) is completed and the ES is drafted.

I have no objections to the East West arterial road. However, I would like the section that passes through 55A 59 either eliminated or moved from its current position that disects 55A 59 as we currently use and need that parcel of land for grazing cattle and fruit farming. Plus I want to be able to leave it for my grandkids to continue to enjoy and build their homes on. Happy to find a resolution with you.

Response: Thank you for your participation in the ToR review process. Additional alternatives and alignments will be evaluated as part of the EIA process. This comment regarding parcel usage will be taken into consideration.

SSA S9 – [redacted] Road disecting property used for cattle farming Also security issue beside the school.	**<u>Response:</u>** Thank you for your participation in the ToR review process. Additional alternatives and alignments will be evaluated as part of the EIA process. This comment regarding parcel usage and school security will be taken into consideration.

Let The Road go. Thought The bland will Need it in The future. IN The 10 years we will Be HAPPy we DiD So	**Response:** Thank you we acknowledge your comment.

NATIONAL ROADS AUTHORITY

22

Date February 3, 2023

Dear National Road Authority

Please dont cut down the Central Mangrove wetland, and I'll tell you why. Mangroves are home to fish and sharks. Birds have homes in mangroves too! They help protect us from storms! Please dont cut down the mangroves! Protect Central Mangrove Wetland!

From

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

23  Date Febuary 5, 2023 Dear National Rods Authority Mangrovs are more Inportent then just a sily Rod I will tell you why? they give Nursery for fish and Sharks. They protect us from erosion. and Storms. They keep the ocean and. reefs clean from runoff. They are a filter for the water. Don't bild a Rod! From		**Response:** Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

25

Date February 3, 2023

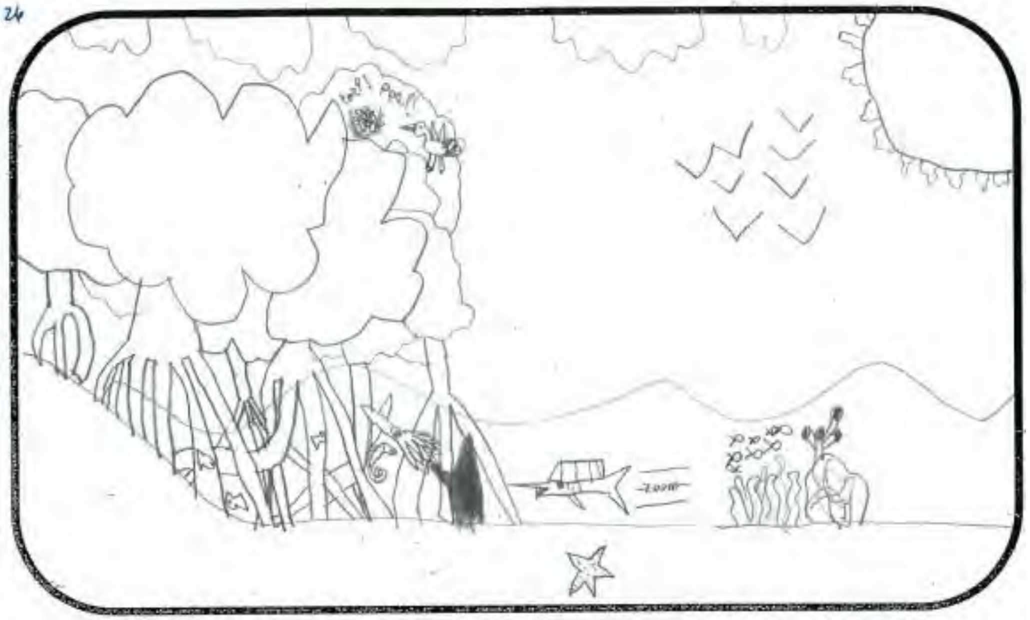
Dear National Roads Authority,

Don't build this road through these mangroves! They are a nursery for baby anamals and birds. They protect us from erosion and storms. They keep our oceans clean and healthy. They stop climate change. This is the bigest mangrove wetland in the Caribbean!

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

NATIONAL ROADS AUTHORITY

24



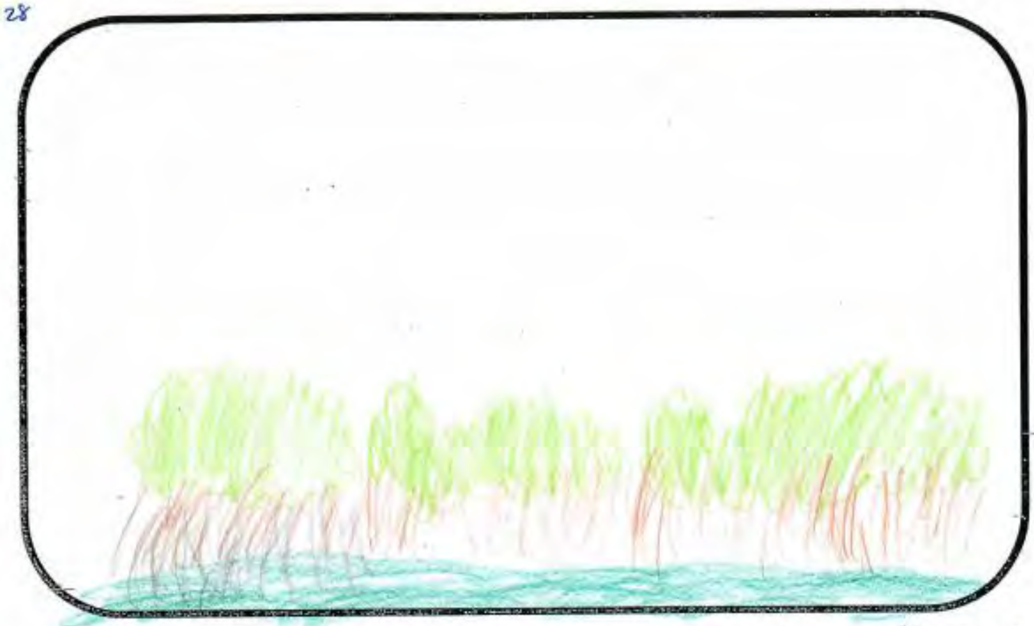
Date feb 3 2023

Dear National Roads Authority

please don't kill the mangroves! if you build a Road through them they will die! mangroves Store carbon wich helps Stop climate change!, they protecect US from Storms! they are a Nursery for fish and Sharks. Provide Shelter for birds and Stop Runoff from getting into the Saltey ocean and hurting the Reef!

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

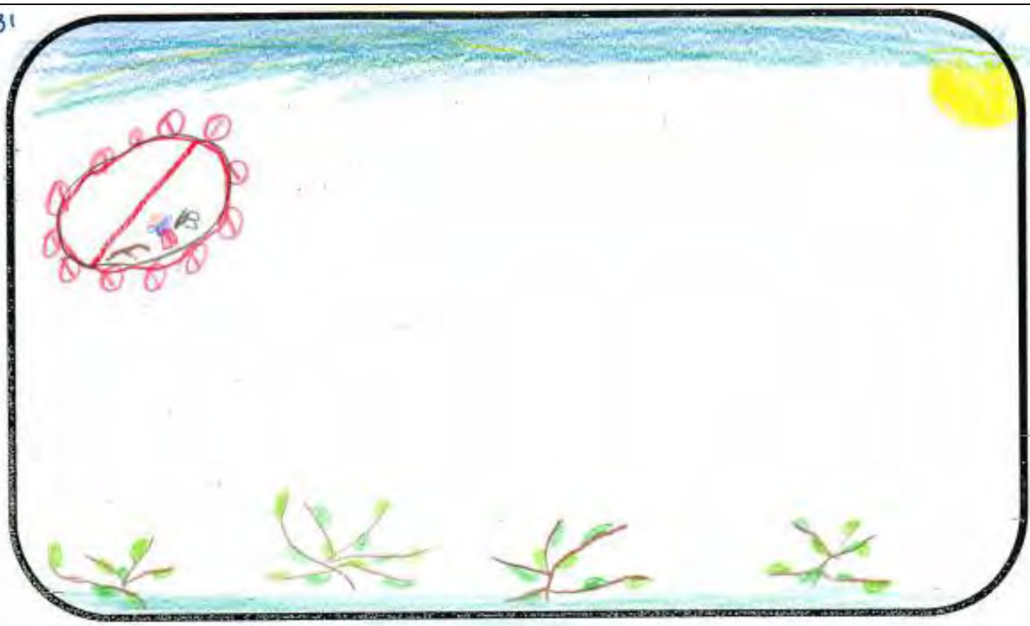
17  Date Feb 3 2023 Dear National Roads Authority, Mangroves or more inpotent then just a silly road! Mangroves Protect us from Storms. And from eroshin. cayman has enough roads! And why do you whant a silly old road. From	**Response:** Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

28  Date Febru ry 3, 2023 Dear National Roads Authaildy mangroves protect us from climate chang and aso from storms. Mangrovs are very speci to us. Mangroves are homes for fish aso keep the water clean. don't build the road		**Response:** Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

23  Date February 2, 2023 Dear National Roads Authority Please don't destroy the Mangrove just for a silly road. Mangroves help us to get fresh water and air and keep our ocean clean. please don't make a silly road because Mangrove allso help us agenst climate change. From,	**<u>Response:</u>** Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

30  Date February 3, 2023 Dear National Roads Authority, Don't build a new road through the Mangroves! Because Mangroves protect us from storms. They are also homes for birds and they provide shelter. Mangroves also Keep the ocean and the reegs clean and they also are a filtter for the water. From	**Response:** Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

31



Date Feburary 3, 2023

Dear National Roads Authority,

Mangroves are so important to us please don't cut down our Mangroves and turn It in to a Road. They protect us From erosion and it's a nusery for Fish and sharks. They also protect us From storms and Hurricanes.

From,

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

32

Date Febuary 3 2023

Dear National raods Authoriy,

Please don't build a silly road mangroves are better because. They protect us from storms, make a nursery for fish and sharks. And keeps the ocean clean. They Also give birds a home and provide shelter. Last they are a filter for the water.

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

33

Date Feb 3, 2023

Dear National Roads Authority.

Don't Build a Silly road You are Desderoing mangroves. Let me tell you a reasen why you shoudint Build a road. They Protect us from storm's. mangroves nursery For fish and shark's. They filter our water. They make good homes for Birds.

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

Date Febuary 3rd

Dear National Roads Authority,

Mangroves are more important then a road! I'll show you how. They store carbon to here against climate change. Protect us from storms and erosion. They keep the ocean and reef clean from runoff. They are a filter fo the ocean. They are a nursery for all sorts of baby mangrove animals and give homes to the animimals that live there.

From.

<u>Response:</u> Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

NATIONAL ROADS AUTHORITY

35

Date Febuary 3, 2023

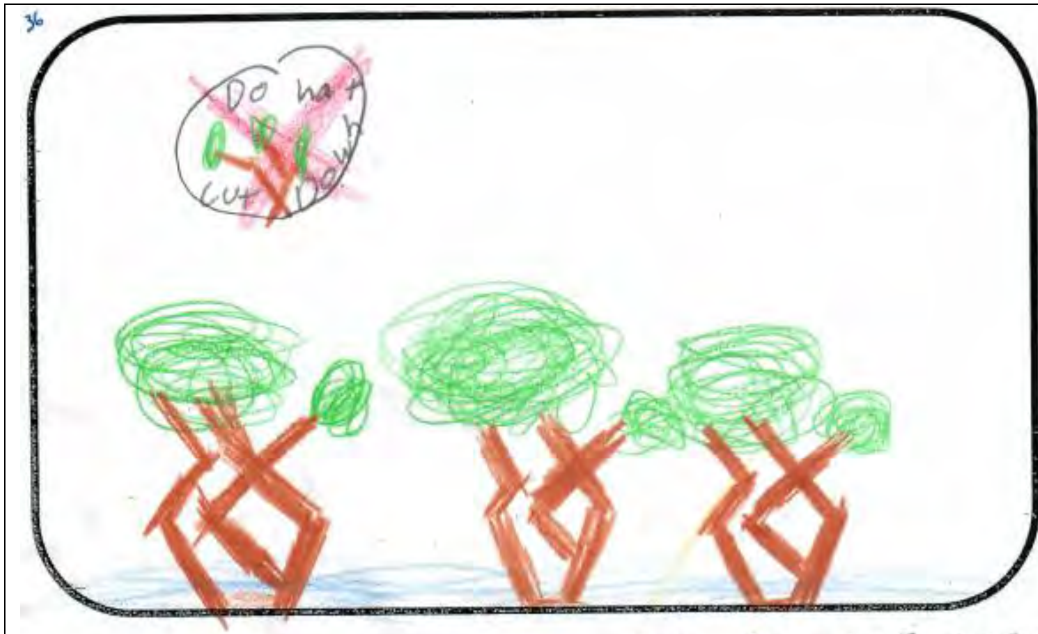
Dear National Roads Authority,

Mangroves are protecting us from storms and help keep the ocean and reefs clean from runoff. They also filter the water. They can also be nurserys for fish and sharks. Help protect us form erosion! Please don't build the really really silly road!!!

From,

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

36



Date febuary 7 2023

Dear National Roads Authoity,

Please do not cut down the Mangrove. Because mangrove are Raelly Special to cayman they Portect Baby Anamals. There Shelter for other Anamals. They keep the ocean clean. Do you want to swim in a clean Ocean? So thats all the Rasons why you Shoud not cut down the mangrove

From,

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

37

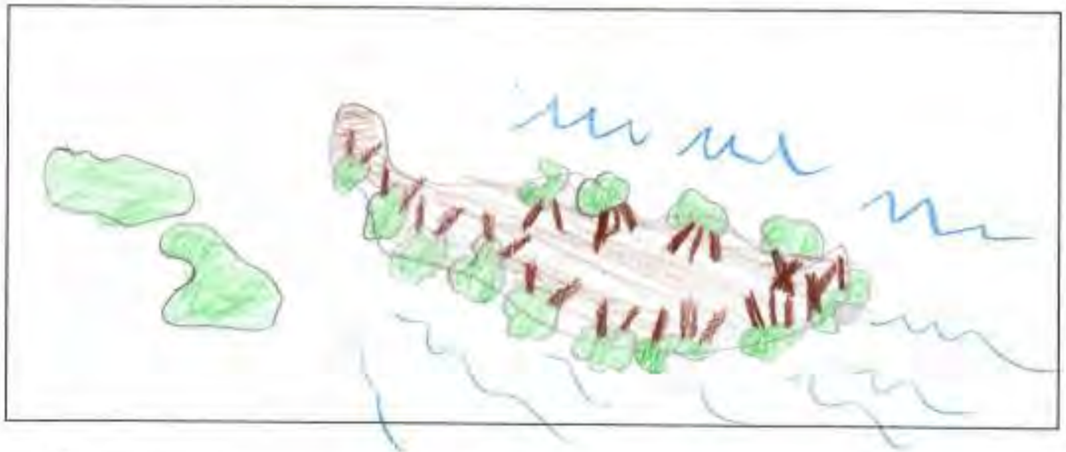
Name ______ Date Febraary 3rd

Dear Govenor, We need theese mangrose. they preserv ocean life, homes, for fish, and natur, its a ridiculus fing to do. pleas stop.

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

38

Name ___ Date Feb 3rd 23



Dear Sir, We have a problem in the Cayman Islands. People are choping down our mangroves. We have three reasons to not cut down our mangroves. Mangroves portect us from erosion and give homes to animals. They all so give us clean water.

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

NATIONAL ROADS AUTHORITY

39 From Name ___ Date ___  Dear Governor, We do not want you to destroy our mangroves. It is so ridiculous we need your mangrovs because it ~~g~~ protecs us, they are homes for fish and gives us clean air. Page 1 of 2	**Response:** Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process. Future development along the corridor will be assessed under induced growth as described in Section 4.1 of the ToR. It should be noted that the NRA does not have ambit to make planning or zoning changes.

Our mangroves are mole inpant than the roads and if we do not have mangroves than the fish will not have homes! and if we give you one road you will want more and then when kids go on a Fild trip it will only be roads! and it will not be fun! So do not cut down our man groves! Page 2 of 2	

NATIONAL ROADS AUTHORITY

40

Name ______ Date ______

Dear Gorvement, please stop cuting down our mangroves. We know there is alot of. traffic. the mangroves are importent because It makes homes for fish. And It stops us from erosion And it makes clean water.

Page 1 of 2

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

Mangroves are more importent then roads! please do not cut down mangroves find a diffrent Solution.	Page 2 of 2	

Name

Date Feb 3rd

Dear Sir, we know there is a lot of trafic. But we need our mangroves. Mangrovs provide Oxygen, fish homes, and protecs us from erosion and hricanes. Mangroves are more inpotant than roads! Please do not cut our mangroves!

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

NATIONAL ROADS AUTHORITY

42

Name Date

Dear King Charles we have a Problem in the Cayman islands. a combony' is trying to destroy the mangroves and replace them with roads so can you tell them to stop. and we are .

Page 1 of 2

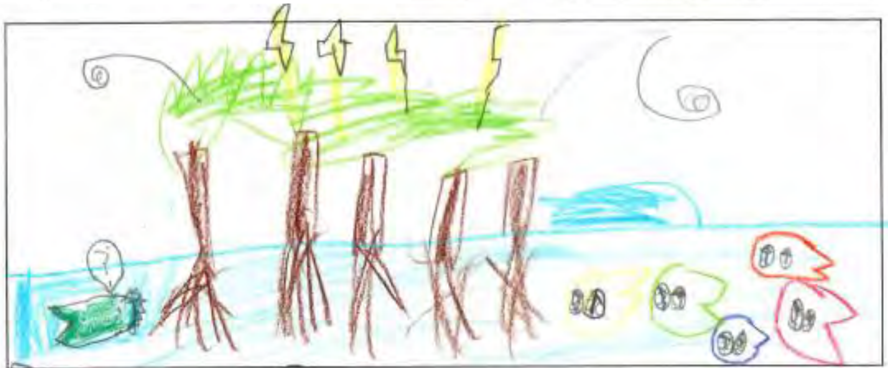
Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

Future development along the corridor will be assessed under induced growth as described in Section 4.1 of the ToR. It should be noted that the NRA does not have ambit to make planning or zoning changes.

consernd that thay are going to put more roads and then condoes. So please stop them. Page 2 of 2	

43

Name ___ Date Feb 3rd 2023



Dear Governor, dont
destroy our mangroves!
We will lose fish, nature,
ocean life. So much more
like oxygon. We will
lose fish because
Mangroves are their homes.
Were losing nature because
mangroves are nature.

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

44

Name

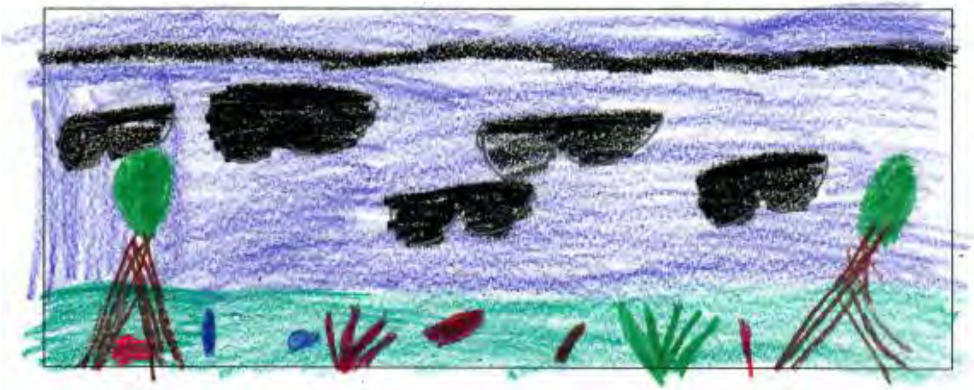
Date Feb 3rd 2023

Dear Governor, do not destroy our mangoves. they make fish homes and protect us from horicanes. they stop the waves from geting on land and protect the fish so the fish can hide from their pretatrs. It is so ridiculous.

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

45

Name _ Date Feb 3rd 2023



To Governor, On our Island peple are going to cut down our Mangroves. We have to Stop them. Hear are three resons why we need Mangroves: They give homes to anamals, they give okschin to us, and give clean water to the ocean. Pleace help us Goernor.

<u>Response:</u> Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

NATIONAL ROADS AUTHORITY

46

Name ____ Date Feb 3rd

Dear Governor We need our Mangroves. One of the reasons is because mangroves give oxygen to Cayman. They give homes to fish. They stop erosion too. Put your brain to work! We need our beautiful mangroves not roads!

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

47

Name _ Date Feb. 3rd 2023

Dear King Charles, We have a problem. Peopel are destroying our beautiful mangroves! And replaceing them with roads. This is happening in Grand Cayman. Please can you help us?

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

48

Name Date

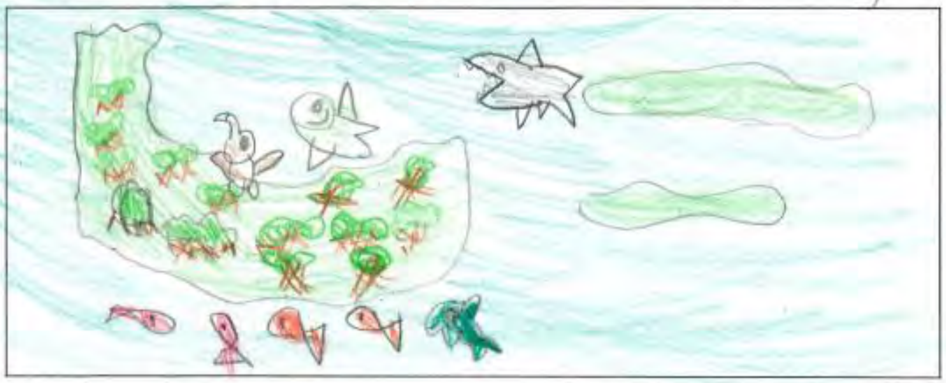
Dear Sir, we have notice that you are going to chop down are Mangroves and replaceing the with roads! you Shoudn't chop down are Mangroves because Mangroves potect us from hurecanes and they stop soonomeas and there fishes homes thats why you Shoudnt chop down mangroves

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

49 Name Date Feb 3rd 2023  Dear Sir, we know that there is alot of trafik, but it is ridiculous to distroy our mangroves! Because our ocean animals wont' have homes anymore but if you don't distroy our mangroves little fish will have homes.	**Response:** Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

50

Name ________ Date Feb, 3rd, 2023

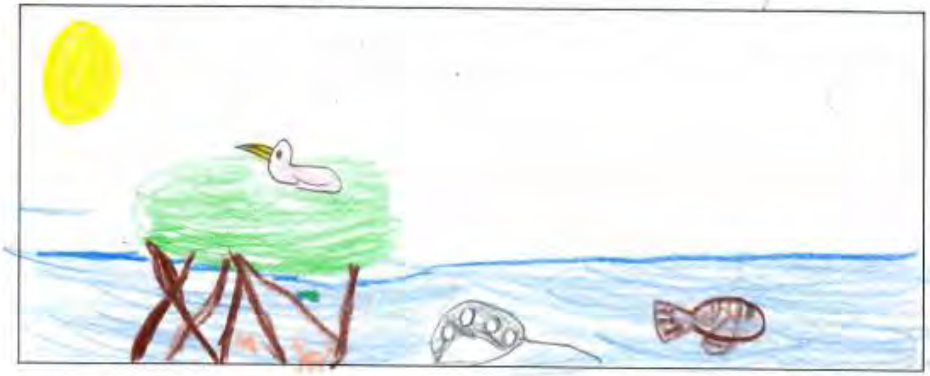


Dear King Charles, We have a problem in Grand Cayman. Pepole are destroying our super mangroves. Mangroves are so important because they provide oxagane, clean water, help animals and protect us from Storms. So can you help please?

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

NATIONAL ROADS AUTHORITY

51 Name ______ Date Febuary 3rd 2023  Dear the Gorvement, I Know that you want to make the roads. Well Mangroves provide fresh air and clean warter. It protects birds from Huricanes and big waves. They are important please do not destray them.		**Response:** Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

52 Name ___ Date Feb 3rd 2023  Dear Governor, please do not cut down our Magroves to make roads. Mangroves protect us from huricanes. They give us clean oxeyen and they give homes to sea life and birds. We want to preserve our natural beaty. We need Mangroves more than Page 1 of 2	**<u>Response:</u>** Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

NATIONAL ROADS AUTHORITY

roads and buildings. Pepole can just get up erlier to get to work and school. Page 2 of 2		

53

Name ______ Date Feb 3rd 2023

Dear Sir, We Know that there is a lot of traffic but it is ridiculous. to get rid of our mangroves! Mangroves give nursrys for baby fish and clean water. What will we do when there is a storm you are crazy! We need mangroves.

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

5

Name:

Dear National Roads Authority,

Please do not cut down our mangroves. Mabe insted of cuting them down mabe you can make a bridge over the mangroves. why you shouldint cut them down is becaus Lots of baby fish Live under the tree And also on the top of the tree birds can sit on the branches. from:

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

Bridging, culverts, and other mitigation measures to protect the terrestrial ecology and hydrology will be considered, as described in Section 4.3 of the ToR.

Name:

Dear National Roads Authority, these mangroves should not be taken away. We do not want you to take the homes of many creatures, including birds, fish, and even shark pups! You should go over or around the mangroves. My classmates agree with me. We have each others support. From:

7. You must stop!

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

Bridging, culverts, and other mitigation measures to protect the terrestrial ecology and hydrology will be considered, as described in Section 4.3 of the ToR.

NATIONAL ROADS AUTHORITY

Name:

Dear NaShnl Rod Athorute
You Sud that mae a hiy
way thro the magrovs you
sShud mak a brij ovr
it.

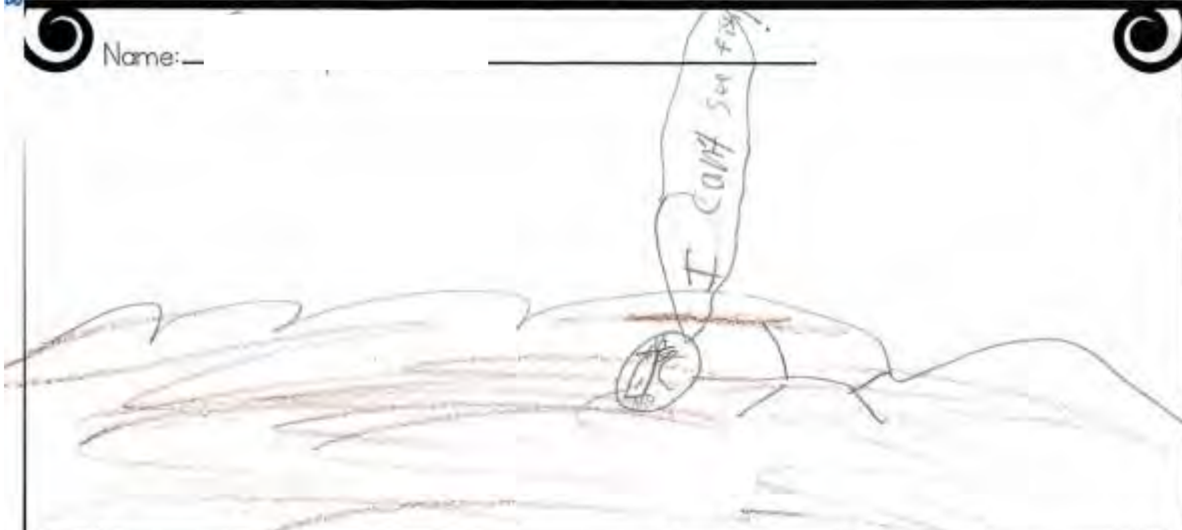
Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

57

Name:

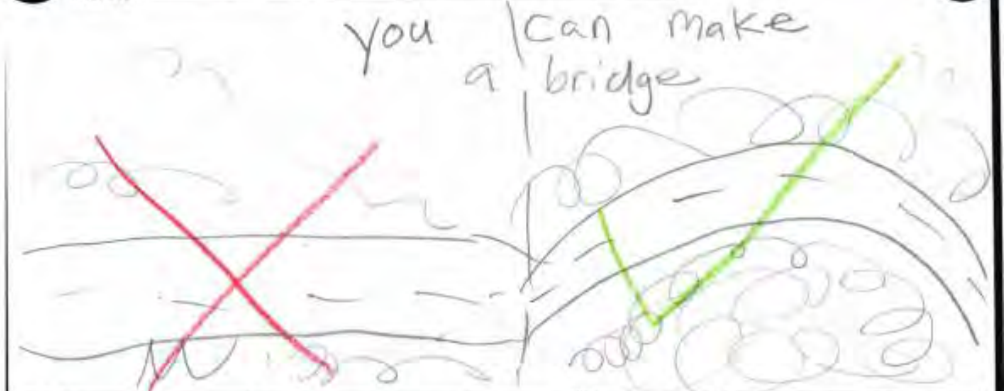
Dear National Roads Autority, I like magroves, beacous It protect our island from erosion. and Keep our ocean Blue. So pleas Keep mangroves. from

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

Name:  Dear national roads atority, Do not cut 170 acers of mangrots. Because mangrovs stop tsunamis from killing peaple and thay keep our ocean water clean. If our water isint clean than you cant snorkle (look at fish) From	**<u>Response:</u>** Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

59

Name:

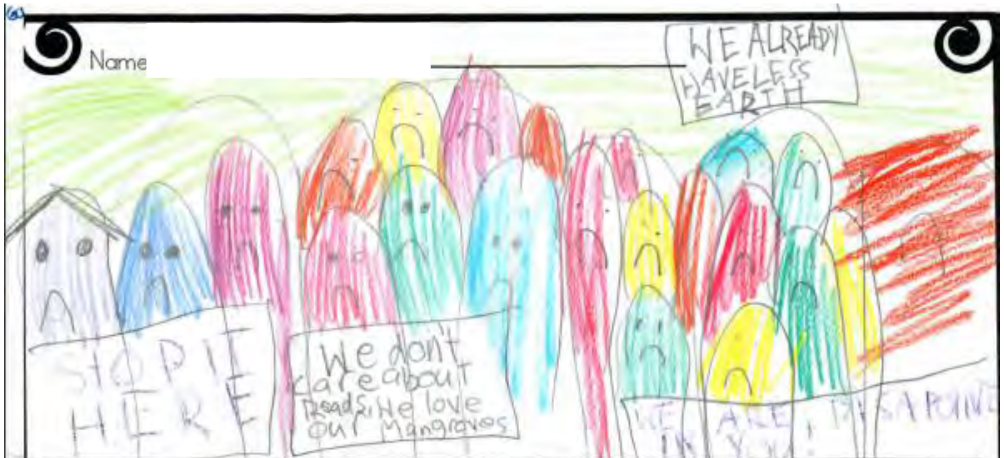


Dear National Roads Authority I am a student at CIS and I Like Mangroves. Did you know that Mangroves Hellp increase tourism, witch bringes Money to cayman? And It's the bigest in the Caribbean, and with out them our clear Water Will be So Markey plas ther wil be way more tsunamis from

<u>Response:</u> Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

Bridging, culverts, and other mitigation measures to protect the terrestrial ecology and hydrology will be considered, as described in Section 4.3 of the ToR.

Name



Dear National Roads Authority, You should not take these 174 acres of Mangroves away. And I'm pretty sure my class agrees with me, I may be little but I know lots about Earth. If you want to be someone who destroys earth, do what you do. But I'm just saying you should stop it right here. From ....

Stop it here!

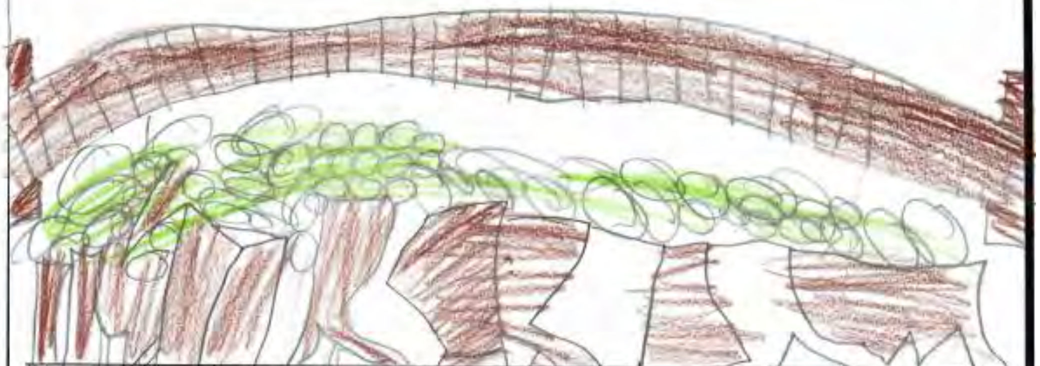
Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

Name:

Dear National Roads Authority
protect our isand from
erosion. Please don't cut down
the mangroves. Mangroves are
habitats for animals like birds
and fish. Mangroves are also
nurseries for baby animals.
Help Cayman by protecting the
mangroves!

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

Name:



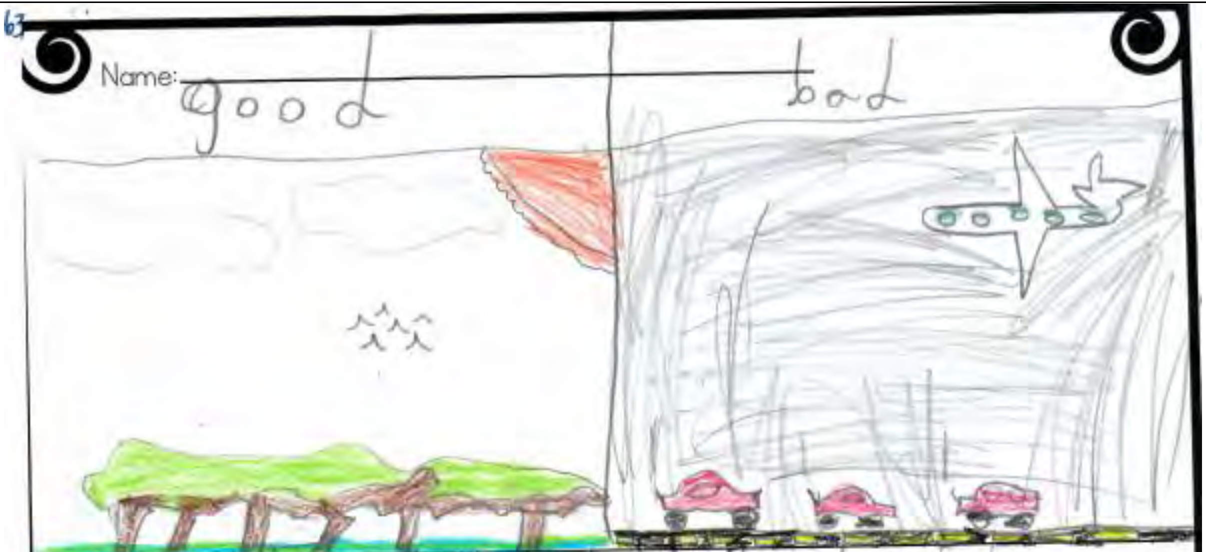
Dear National Roads Authority,
Please don't cut down our mangrove
because they protect our
island from erosion, keep
our ocean waters blue
and they make a
habitut for birds, fish
and other animals. Insted
you can build a brige
over the mangroves.

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

Bridging, culverts, and other mitigation measures to protect the terrestrial ecology and hydrology will be considered, as described in Section 4.3 of the ToR.

63

Name:



Dear National Roads Authority did you think of makeing a road over the mangroves? Mangroves help the enviroment by makeing fish nurseys. And prevent Cayman from erosion. The mangroves give us oxagon to.

Love

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

Bridging, culverts, and other mitigation measures to protect the terrestrial ecology and hydrology will be considered, as described in Section 4.3 of the ToR.

Name:  Dear National Roads Authority Mangroves Protect our island from erosion. you also could make a roads over the mangroves. Mangroves Portect the animals and Fish that live there Love	**<u>Response:</u>** Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process. Bridging, culverts, and other mitigation measures to protect the terrestrial ecology and hydrology will be considered, as described in Section 4.3 of the ToR.

NATIONAL ROADS AUTHORITY

Name:

Dear National Roads Authority, please do not cut down the mangroves to make a new road because they protect our island from erosion. They keep our ocean waters blue. They are a habitat for birds, fish and other animals. They are a nursery for baby animals, they provide oxygen for us and they help increase tourism, which brings money to Cayman.

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

Name:-

Dear National Roads Authority, please donot take down our mangroves. They are homes to other animals they keep our waters clear blue. they also provide oxygen for us and we need oxygen! And they help increase tourism, which brings money to cayman and they protect our island from erosion they are very important tome i love mangroves we hope you dont take out any mangroves. from

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

NATIONAL ROADS AUTHORITY

Name: Dear National Rouds Authority,  You are hurting Fish and Birds, and your hurting Cayman Island and you don't know how sad we are that our future will be gross and dirty. and please try to think abox the future for you and us.	**Response:** Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

68

Febuary 2

Dear:

National Roads Authority,
My name is Alex
today is Febuary 2nd.
my birthday is the 6th
of Febuary and my
birthday wish is I
want to have a happy
and healthy future.
please protect Our
beautiful mangroves.
I know it's boring
and long

to sit in trafic

Plz go to Page 2

Page 1 of 3

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

but our Safety is way more inpontant. Also mangroves protect the island from erosion and huricanes, and keeps our Ocean waters blue and healthy. plz turn to page 3 Page 2 Page 2 of 3	

mangroves also provide homes. please help our future. thanks for listening. Bye love Page 3 Page 3 of 3	

69

February 2nd 2023

Dear National Road Authority,

I am a Second grade Student yes a Road would brake down trafic but it would harm my Future. Mangroves do good things they: protect us from erosion and huricans, they keep our ocean waters blue, are habitat to birds and marine life, provide oxygen for us, and are protection for baby animals.

Kind Regards

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

70

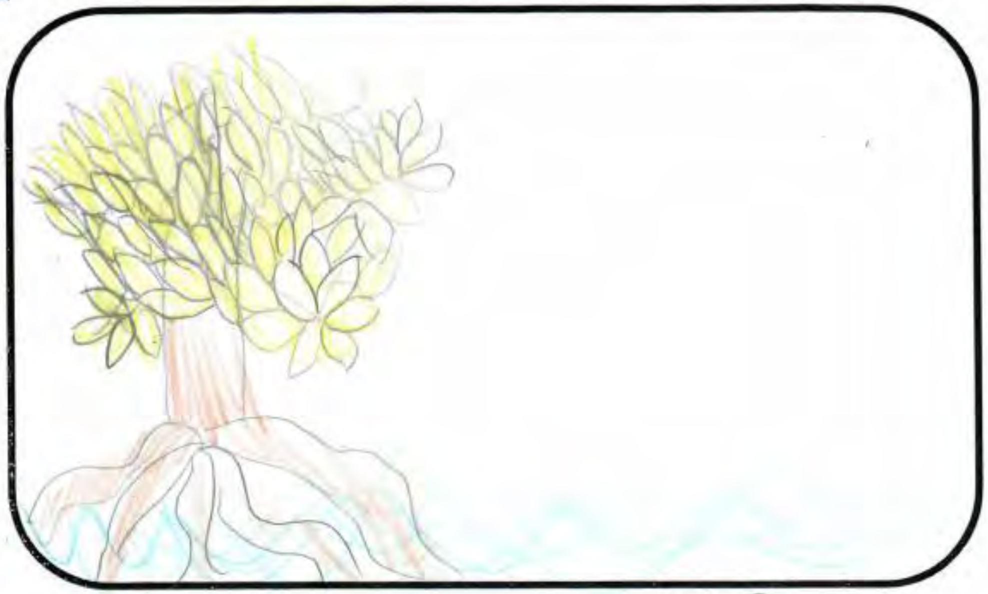
Dear: National roads authority,

I am a 2nd grade student my name is , please do not take away the mangroves because they provide oxygen for us and they protect our island from erosion and mangroves keep our ocean waters blue and it is also protection for baby marine life.

thank you for listening

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

NATIONAL ROADS AUTHORITY



Date Feb 2 2023

Dear National Roads Authorty,

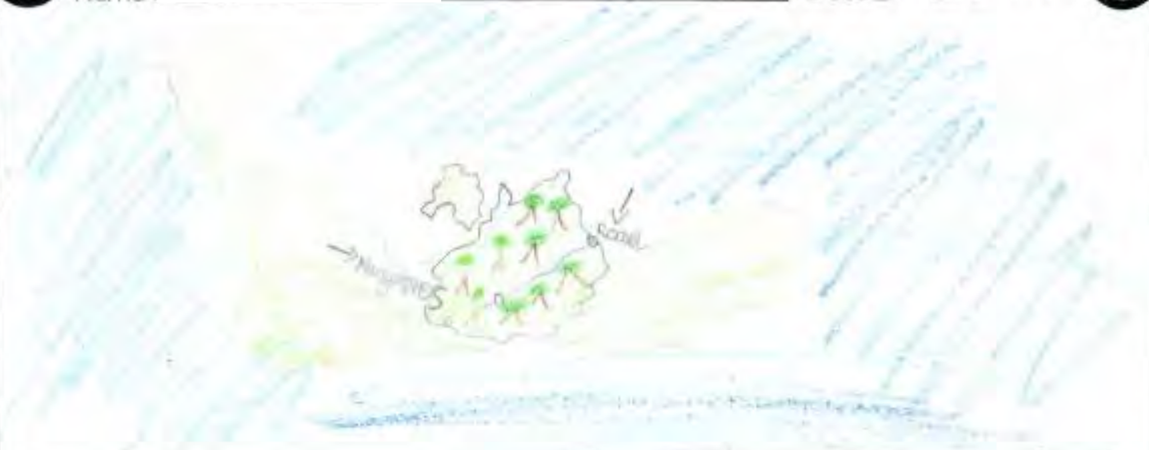
Please don't build a Road trouth the mangoves becase mangroves protect us from hrucanes and mangroves protect fish to and other sea animals. Can you please find a other place to build a road where it wont hurt the mangroves. Thank you for lisening.

From

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

Name:

Date 2·2·23



Dear National Roads Authority,

you are hurting the mangroves if you are going to build this new road then there won't be enough mangroves for baby animal for them to hide from predators like baracudas, and it makes me feel upset when you do this my future.

From

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

73

Date

Dear National Rods Athority
please do not cut down the mangroves. Utherwise we will not have as much oxegen for us. And it protects our island from hurricanes

NO New rod!

From

I'am Not tElling You my Name!

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

Date ____________

Dear National Roads Authority

Please Portect our mangrows that are our future.

From,

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

75

Date Febyorare

Dear National Roads Authority

I don't think you shou ld make the rob decus the Fish wont hav the one war to liv.

I hink you cob mac a brij in sted of a rod on the Flor. the brij can Go ovr the mangrovs

From,

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

Bridging, culverts, and other mitigation measures to protect the terrestrial ecology and hydrology will be considered, as described in Section 4.3 of the ToR.

NATIONAL ROADS AUTHORITY

76 Mon Feb 6 Dear National Roads Authority, Please do not cut down the mangroves. It will make traffic better but mangroves protect us and the future. Mangrove are homes for many animal's and they protect us from erosion. It also helps if theres storms. Please protect mangroves! kind regards	**Response:** Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

77

Date Feb, 2, 2023

Dear National Road Authority

I heard you are planing to build a new road between the mangroves. This makes me feel upset because mangroves are inportant because they keep us safe from erosion and damage from hurricanes.

Love From.

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

Name:

Dear national Roads Authority
I dont think that you should make the Road. It is hurting our future becase the mangroves give us oxygen and protects our island. They also help our envierment. Please dont make the Road. Also it keeps babby animals safe and is a habitat. love

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

19

Date

Dear National Roads Authority

please DO NOT destroy Cayman. You DON't know How sad we will be when it becomes all gross. I know we all Hate traffic But we need mangroves for more oxygen.

From,

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

NATIONAL ROADS AUTHORITY

8C

Date Feb 2

Dear National Roads Authority
I saw you are building a New Road But the problem Is that it is going through the mangroves. Mangroves protect us from erosion. and give us oxygen. So please think about our future.

From.

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

NATIONAL ROADS AUTHORITY

81

Date Feb

Dear National Roads Authory,

my name is

please Dont cut down the man grove's Becose the mangrove By protect our island From storms and hurricanes and save our Fish.

From,

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

NATIONAL ROADS AUTHORITY

82

Date

Dear National roads Authority

I'm sorry but we Dont want to hurt our mangroves, we want to keep them save and I know you are working hard on the Road but it hurts our envirment. Please think about making the road somewhere else.

From,

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

NATIONAL ROADS AUTHORITY

83

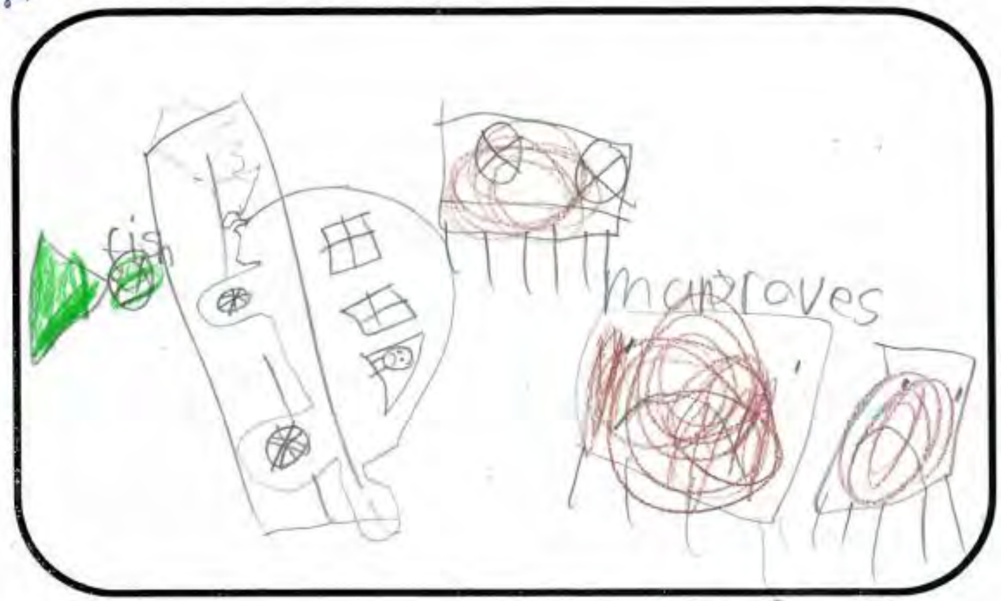
Date Feb 2, 2023

Dear National Roads Authority,

I am writig to you about the new road you are makiring. I feel upset because the mangroves will be chopped down then wen the hurakane comes then it will blow Down some bildings. thaks for lising.

From,

Response: Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

84  Date february Dear national Roads athority Please dont make the road it will afect my future. Because we need more oxygen. Because the road will be going throo the mangrovs. And you will have too cut the mangroves down so Please do not make the road. From,	**<u>Response:</u>** Thank you for your participation in the ToR review process. We acknowledge the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

Subject: East West Arterial Project | Transport Review To: F.A.O. Environmental Assessment Board CC: Ministry of Sustainability, Ministry of Roads and Infrastructure, Ministry of Finance, Auditor General, Opposition CC: National Roads Authority, Cayman Islands Dept. of Environment Good afternoon, We hope all is well. As you know, Sustainable Cayman is an organisation with a mission to promote environmental sustainability and conservation of our natural assets and therefore we have a keen interest in resolving the best outcome for transport connectivity and quality of life in the Cayman Islands for both current and future communities. We have obtained a Transport Review by ARDENT Consulting Engineers out of the United Kingdom. We attach a copy of the report which we hope will be a valuable contribution to the data input for the Terms of Reference for the EIA, and also more broadly. This is available on our website and will be shared with the wider public: https://sustainablecayman.org/important-documents. Page 1 of 2	**Response:** Thank you for your participation in the ToR review process. The ARDENT report has been received by the project team and a formal separate technical response will be provided regarding this document. This response is outside of the EIA process as the Ardent Report largely relates to the Purpose and Need for the project rather than the Terms of Reference. However, a specific response was warranted since the subject report has been broadly circulated. One item that does relate to the Terms of Reference is the suggestion of passenger transit instead of a new roadway. The ToR has been revised to incorporate the evaluation of alternate options that could include the use of passenger transit either on-alignment or off-alignment and with or without the associated roadway. Following is a brief synopsis of the remaining portions of the report and the corresponding high-level response: In many ways the report highlights the ongoing efforts of the NRA to improve multimodal transportation throughout Grand Cayman; the power of objective data and analysis that the NRA has deployed to help alleviate congestion; and to improve the overall quality of life and economic competitiveness for Caymanians with a safer and more efficient roadway network.

NATIONAL ROADS AUTHORITY

Importantly, the document provides solutions and options available to meet the needs of the island in what we believe is a more sustainable, long term and environmentally friendly approach. In a wider context, it is Sustainable Cayman's view that taking care of our environment provides for a better quality of life, health and well-being. This is one of the main components of why we need to ensure that the proper decisions are taken today to build for a safer and more resilient future. The Central Mangrove Wetland is essentially part of our Critical National Infrastructure given the ecosystem services it provides. Undermining it would also go against multi-national policy agreements and our own Constitution to protect our environment. We encourage our decision makers to make decisions in line with best international practice by protecting this green infrastructure. We trust the report is well received and look forward to receiving your feedback and hope that you will take the time to discuss and share the report within your own networks. With kind regards, **Find us on Social Media:** sustainablecayman.org Sustainable Cayman is a registered NPO in the Cayman Islands NP-612 --	Based on a review of the report, the articulation of a few key points listed below may help Ardent Consulting Engineers and their local constituency better understand local conditions and the overall planning process: • The unique nature of transportation on Grand Cayman and the essential needs of the island's residents and visitors; • The overall state of transportation investments and planning actively occurring in the Cayman Islands and resiliency needs; and, • Where the East-West Arterial (EWA) Environmental Impact Assessment (EIA) falls within the overall project development process in the Cayman Islands. We acknowledge the importance of considering all the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process.

Page 2 of 2

Less cars on the road would also help congestion, has the gov't thought of limiting the number of Cars brought on Island School busses for private schools would ease morning congestion Someone should build an office park/complex in Eastern district so employees would commute against prevailing traffic	**<u>Response:</u>** Thank you for your participation in the ToR review process and for your suggestions. While policy regarding number of cars, school bus usage, and employment locations is outside the ambit of the NRA and this EIA, the Department of Planning, National Trust, and Department of Environmental will all be invited to participate as project stakeholders in the EIA process.

1. Please do NOT build any Public road in the Central Mangrove Wetlands. 2. It is not necessary to put the road in the National Trust property. The N.T., property is preserved for the Public/the people of the Cayman Islands. 3. If this proposed road is built, development will inevitably follow. The Central Mangrove Wetlands must be preserved and not developed.	**Response:** Thank you for your participation in the ToR review process. 1. We will be evaluating mangroves and their many functions as part of the EIA process. Alternatives to avoid or mitigate mangrove impacts will be evaluated. 2. The NRA will coordinate with the stakeholders, including the National Trust, and other stakeholders, to identify and discuss potential additional alternatives and alignments that could be considered as part of the EIA process. 3. Thank you for the suggestion for preserving the Central Mangrove Wetlands; however, land use planning and designation of conservation land is outside the ambit of the NRA. The Department of Planning, National Trust, and Department of Environmental will be invited to participate as project stakeholders in the EIA process. Induced growth will be evaluated as part of the EIA process (see Section 4.1 and Figure 8 of the ToR) and discussed with stakeholders.

I love the proposed additions to the current E/W arterial which I use several times a week. The traffic on Shamrock Highway is continuous due to rush hour, trucks, road work + tree/brush work and is, of course, worse in rush hour. The addition of this extension would increase safety (esp. if lanes were divided) and could decrease commute time. The Central Mangrove Wetlands could be protected while safer roads could be achieved. Good luck with this project!	**Response:** Thank you for your participation in the ToR review process. We acknowledge your comment.

Environmental Management Unit

From:	DOE
Sent:	20 February 2023 16:33
To:	Environmental Management Unit
Subject:	FW: [EXTERNAL] Public Consultation Comments on Draft NRA EWA Terms of Reference for Environmental Impact Assessment
Attachments:	2023-02-01 Grand Cayman East West Arterial - Preliminary Transport Review (Revision 3).pdf; Sustainable Cayman ToR Consultation Response FINAL 20FEB23.pdf

From: Sustainable Cayman [mailto:sustainablecayman@gmail.com]
Sent: Monday, February 20, 2023 4:26 PM
To: DOE <DOE@gov.ky>
Subject: [EXTERNAL] Public Consultation Comments on Draft NRA EWA Terms of Reference for Environmental Impact Assessment

Dear DoE,

We are pleased to enclose our submission in respect of comments for the above together with the accompanying report.

Kindly acknowledge receipt.

With kind regards,

Find us on Social Media:

sustainablecayman.org

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Page 1 of 13

<u>Response:</u> Thank you for your participation in the ToR review process and submission of the *Ecosystem Services Provided by Two Potential Protected Areas in the Cayman Islands* report prepared by the National Trust for the Cayman Islands. This report has been included as an appendix to the Final ToR and will be taken into account in the EIA process.

Sustainable Cayman PREPARING TODAY FOR A BETTER TOMORROW 20 February 2023 *Via Email only* **To**: Department of Environment, Environmental Centre, 580 North Sound Road, George Town, Grand Cayman. **Subject: Draft National Roads Authority East West Arterial Extension Terms of Reference for Environmental Impact Assessment Public Consultation Comments** Dear Department of Environment, Sustainable Cayman is a registered NPO established for the purpose of promoting sustainability, climate resilience, and public participation in the Cayman Islands as it relates to the equitable management of natural resources and upholding the rights of citizens for a healthy and sustainable environment in the Cayman Islands. We recognize the importance of protecting the Central Mangrove Wetlands (CMW), the largest remaining contiguous mangrove wetland in the region, its critical ecosystem services and natural capital value. We also recognise the urgent need to alleviate the traffic congestion which is negatively impacting the quality of life of residents of the Eastern Districts. We are also greatly invested in ensuring an effective modern transportation system, including an efficient public transit system, is implemented. We are pleased to see an Environmental Impact Assessment (EIA) is being undertaken on the proposed East West Arterial (EWA) extension project and we welcome the opportunity to respond to the Terms of Reference (ToR). There are many aspects of the ToR which we commend to help tackle society's clear need for improved transport infrastructure. In particular, the inclusion of the alternative solution of improvements to the Bodden Town Road and the recognition of critical ecosystem services that the CMW provides to Caymanian society. There are however some indispensable improvements which we believe will need to be made for the ToR to be fit-for-purpose and ensure the EWA does not make the traffic problem even worse. Cayman's EIA process helps meet basic international lending standards for projects. The International Finance Corporation-World Bank (IFC) Environmental and Social Performance Standards should be reviewed and incorporated into the EIA process. In particular, Performance Standard 6, *Biodiversity Conservation and Sustainable Management of Living Natural Resources*, details measures that projects should take to protect and conserve biodiversity, maintain the benefits from ecosystem services, and to promote the sustainable management of living natural resources. Page 2 of 13	**<u>Response:</u>** Thank you for your participation in the ToR review process. The referenced International Finance Corporation-World Bank (IFC) Performance Standards on Environmental and Social Sustainability is included in Section 2.1.1 of the ToR. Specific Performance Standards, such as Performance Standard 6, are not individually specified at this point in the EIA process. Based upon the IFC Performance Standards, Performance Standard 1 is applicable to all projects and Performance Standards 2 through 8 are dependent on project circumstances. The responses below are numbered to follow the numbering provided in the comment. The responses begin on page 4 to be closer to the detail provided by the commenter.

Compliance with these standards is required for all projects funded by the Caribbean Development Bank (CDB), and should be for all private lending. The CDB states that they will not finance or support operations that significantly convert or degrade impacts on critical, natural, and protected habitats, and will instead promote the conservation, protection and management of natural resources. The CDB and the IFC define critical habitats as natural or modified habitats with high biodiversity value that may include regionally significant and or highly threatened or unique ecosystems – a criteria which the CMW and dry forest habitats on Grand Cayman meet. Importantly, any project which impacts critical habitats is required to demonstrate a Biodiversity Net Gain in accordance with the IFC Standards.

Our consultation response addresses four critical considerations which we believe the ToR must include in order for the EIA to achieve its objectives. It also includes further important considerations which we believe should be included in the ToR.

CRITICAL CONSIDERATIONS:

1. Induced growth should assess all land and the entirety of any land parcels whose borders fall within one and a half miles (1.5) of the proposed EWA Extension project, and other alternatives assessed based, on historic deforestation and development trends
2. Impacts to critical marine resources, wildlife and habitats are missing and should be assessed within a marine ecology chapter
3. Mitigation measures for habitat loss should include critical habitat re-establishment at a ratio of 1:30 and demonstration of Biodiversity Net Gain in accordance with the IFC Standards
4. It is crucial that the potential loss of Natural Capital, such as rainfall, and mitigation/offsetting costs associated with achieving at least a No Net Loss of biodiversity should be included within the Cost Benefit Analysis in the Alternative Alignment Evaluation

OTHER CONSIDERATIONS:

5. The impacts of lighting on terrestrial and marine wildlife, such as the threatened Cayman parrots and West Indian whistling ducks and mating green, loggerhead, and hawksbill turtles, should be assessed
6. Land use forecasting and traffic modelling should be based on a 'worse-case' scenario in line with historic development trends
7. Embedded Greenhouse Gas (GHG) emissions, such as those associated with mining aggregate and shipping, should be included within the Cost Benefit Analysis in the Alternative Alignment Evaluation
8. Implementation of public and active transport methods should be factored in when assessing environmental and socio-economic impacts of alternative options
9. The improvements to the Bodden Town Road alternative should factor in public transport, active transport methods and road upgrades to key bottlenecks

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10. Biosecurity risks and mitigation measures should be included in the ToR 11. Alternative solutions to the proposed EWA Extension project should be assessed in the 'Alternative Alignments Evaluation' which should therefore be named 'Alternative Solutions Evaluation' 12. Important clarifications on the use of Natural England's Biodiversity Metric 3.1 are required 13. Additional standards and guidelines should be used for evaluating potential effects to terrestrial and marine ecology 14. Consider implications of the draft National Planning Framework (Plan Cayman) and proposed Natural Resource Preservation Overlays Details for each consideration are provided under each of the headings below. **1. Historic development trends and lack of a development plan mean that induced growth should be assessed for the entirety of unprotected land parcels whose border falls within one and a half miles (1.5) of the proposed EWA Extension project:** - Section 4.1 Overview of Assessment Parameters states that "*Induced residential or commercial growth could also occur due the new access provided by the new roadway and/or reduced commute times. The impacts caused by these new developments would also be considered as indirect effects. Typically induced growth is anticipated within approximately one mile of each new access point, the area that is protected from development, such as NCA lands, would be excluded, then the impact associated with the remaining land would be estimated and evaluated.*" We are pleased to see that induced growth will be assessed as an indirect impact within the EIA. - Historic development trends show that, in the absence of the National Conservation Act/National Trust of the Cayman Islands, protection and any modern development plan zoning, mangroves and wetland habitats are destroyed at alarming rates https://fb.watch/iPqttkK49v/. For example, Grand Cayman history shows 72% mangrove deforestation and wetland habitat loss over ~40 years following roads being built along West Bay[1]The Development Plan and zoning maps have not been updated since 1997 and are therefore not in-line with international sustainable development frameworks and standards. If the proposed EWA Extension project is built where it is gazetted, it will provide access to large areas of privately owned land within the CMW and unlock it for deforestation and development. For these reasons, we believe the one-mile radius proposed in the ToR to assess induced growth is highly inadequate. - Given these considerations, induced growth forecasts should use a 'worst case' scenario when modeling potential environmental impacts. Induced growth should assess all land and the entirety of any land parcels whose borders fall within one and a half miles (1.5) of the proposed EWA Extension project, and of any other alternatives being assessed. This use of a 'worst-case' scenario is recognised in the guidance adhered to in the ToR: The Chartered Institute of Ecology [1] DOE Earth Day (2020); '*Earth Day 2020 – Climate Action*' Available: https://doe.ky/earth-day-2020-climate-action/ Sustainable Cayman, PO Box 61, George Town, Grand Cayman, KY1-1102, Cayman Islands www.sustainablecayman.org | info@sustainablecayman.org Registered as an NPO in the Cayman Islands NP-612 Page 4 of 13	1. We agree with the suggestion to increase the induced growth study area to 1.5 miles to better evaluate potential development along the corridor. The 1.5-mile buffer is located off of the proposed roundabout locations as the primary arterial corridor is anticipated to be limited access. This has been updated in the Final ToR document. The results from this analysis would then be coordinated with the stakeholders, including the Department of Planning, and the public to determine if changes should be made to the access points or other policies to reduce the potential for development.

and Environmental Management's (CIEEM) *Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater, Coastal and Marine.* **2. Impacts to marine resources, wildlife and habitats are missing and should be assessed:** - Section 4.5.2 Baseline Conditions states "*The Central Mangrove Wetland provides filtered water and nutrients to the North Sound which provides the base for the North Sound food web. The North Sound is directly linked to the Central Mangrove Wetland; consequently, effects to the Central Mangrove Wetland will also affect the North Sound ecosystem.*" Section 4.6.2 Baseline Conditions also states that the CMW provides nursery grounds, food, shelter, and habitat for a wide range of aquatic species. However, in the terrestrial ecology chapter, Section 4.5.4.1 Potential Receptors, while the CMW, migratory birds and protected species of flora and fauna are listed as features identified as potential receptors, marine species and habitats associated with the CMW and the North Sound are not. Indeed, it appears that an entire chapter for marine ecology is absent from the ToR, which is a critical omission. This chapter is crucial for economic and environmental considerations in the EIA. - Given the stated link between the two ecosystems, marine species and habitats should be listed as potential receptors under a marine ecology chapter and all potential direct and indirect impacts to them assessed. Such impacts should include changes in hydrology, disturbance to sediment and nutrient flows, loss of habitat and restriction of movement for aquatic species, loss of nursing grounds for juvenile aquatic species, roadway runoff including water contamination by pollutants and lighting. **3. Mitigation measures for habitat loss should include re-establishment of mangrove and dry forest at a ratio of 30:1 and demonstration of Biodiversity Net Gain in accordance with IFC lending standards:** - Section 4.5.6 Mitigation Measures states, "*Mitigation measures will be investigated to offset unavoidable impacts from the proposed EWA Extension project.*" However, these mitigation measures do not mention the mitigation hierarchy. This is an elementary standard that should be applied, as detailed in the CIEEM *Guidelines for Ecological Impact Assessment in the UK and Ireland* and in the IFC PS6 *Biodiversity Conservation and Sustainable Management of Living Natural Resources*. As previously mentioned, the IFC Standards define critical habitats as natural or modified habitats with high biodiversity value that may include regionally significant and or highly threatened or unique ecosystems – a criteria which both the CMW and dry forest habitats meet. Lenders that require compliance with the IFC Standards, such as the CDB, require projects to provide a Biodiversity Net Gain if any critical habitats are unavoidably impacted as part of the project. - We recommend the text in this section is amended to state that "*mitigation measures will follow the mitigation hierarchy throughout project design and the EIA process, specifically giving priority to avoidance of impacts to critical habitats, and where this is unavoidable, demonstrating that the project can achieve a No Net Loss in biodiversity at a minimum in accordance with IFC Standards.*" In order to compensate for direct impacts to critical habitats, mangrove and dry forest habitats, we recommend that mitigation measures define habitat Sustainable Cayman, PO Box 61, George Town, Grand Cayman, KY1-1102, Cayman Islands www.sustainablecayman.org | info@sustainablecayman.org Registered as an NPO in the Cayman Islands NP-612 Page 5 of 13	2. As noted in your comment, we are evaluating indirect and cumulative impacts as part of the EIA, which would include the assessment of whether the project could indirectly impact on marine ecology. The assessment of potential indirect effects to marine ecology has been added to the Terrestrial Ecology section of the EIA, see Section 4.5 of the ToR. 3. Mitigation Measures – As discussed in Section 4.5.1 of the ToR, the goal of the project is to achieve No Net Loss of Biodiversity. The project would aim to avoid, then minimise impacts. For impacts that cannot be avoided, the NRA would mitigate the impacts as described in Section 4.5.6 of the ToR. Mitigation ratios cannot be established prior to the EIA studies being completed. Furthermore, the NRA agrees that long-term monitoring of mitigation is necessary and should be included as part of the EIA. Section 2.6 of the ToR addresses the Environmental Management Plan (EMP), which would establish monitoring and mitigation during project implementation.

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replacement requirements at a ratio of 30:1, meaning that for every one acre of habitat lost 30 acres are replaced. This ratio is used in UK standards[2] when compensating for irreplaceable habitats, like ancient woodland (the UK's equivalent to mangrove forest and dry old-growth forest), as Natural England's Biodiversity 3.1 Metric does not recognise irreplaceable habitats.

- Given that the proposed EWA Extension project is expected to result in the direct deforestation of 174 acres of terrestrial habitat, the majority of which is critical habitat (mangrove or dry forest), Sustainable Cayman does not see how it is possible for the proposed project to achieve the desired No Net Loss of biodiversity as stated in the ToR.

- Protecting habitat or funding the conservation of protected areas is not included as a mitigation measure. We request that protecting the CMW, dry forest and other ecological important habitats in perpetuity is included as a mitigation measure, either via designation as a NCA land or land is purchased and donated to the people of the Cayman Islands as a protected National Park

- Promised mitigation measures can fail due to a lack of monitoring and maintenance. There is no provision within the ToR that details long-term monitoring and evaluation of mitigation measures after project completion to ensure their effectiveness. We therefore recommend the addition of the following section: "*4.5.7 Monitoring and Evaluation – Long-term monitoring measures will be identified to allow evaluation of the success or otherwise of ecological mitigation measures required to offset the impact of the proposed EWA Extension project and included in the Environmental Management Plan (EMP). In addition, the resourcing and mechanisms for reporting monitoring results will be made clear, along with the resourcing of any remedial measures needed to ensure mitigation measures are successful and fully meet their required objectives.*"

[2] Natural England and the Forestry Commission (2018); '*Standing Advice: Ancient Woodland and Veteran Trees.*' Available: https://www.csaenvironmental.co.uk/wp-content/uploads/2018/01/2018-Website-Article-New-Guidance-on-Ancient-Woodland-v3.pdf

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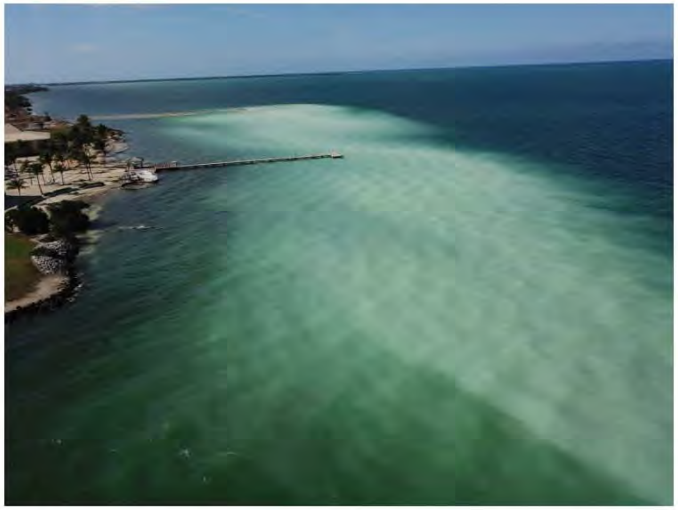

Figure 1. Sediment pollution due to coastal works dredging for Heritage Holdings Ltd, 2017.

4. It is critical that the potential loss of Natural Capital and mitigation/offsetting costs associated with achieving at least a No Net Loss of biodiversity should be included within Cost Benefit Analysis in the Alternative Alignment Evaluation:

- Section 3.2 Roadway Alignment Alternatives and Analysis details the process that will be undertaken for the Alternative Alignment Evaluation. 'Cost Effectiveness' and 'Environmental and Natural Resource Conservation' are listed as sustainability measures that will be assessed in the comparison matrix for the alternatives. We are pleased to see that the ToR recognise the ecosystem services that the CMW provides. The monetary cost of these ecosystem services to Grand Cayman's economy is known as Natural Capital Value. These ecosystem services that should be assessed as Natural Capital Value include but are not limited to:
  - Storm surge protection
  - Water filtration
  - Reduction in soil erosion
  - Nursery for fish stocks which supports fisheries and reefs
  - Carbon sequestration and storage
  - Contribution to rainfall - estimated to contribute 40% of the rainfall in the western districts[3]

[3] Bradley, P.E., Cottam, M., Ebanks-Petrie, G., & Solomon, J. (2004); '*Important Bird Areas of the Cayman Islands*. BirdLife International.' http://datazone.birdlife.org/userfiles/file/IBAs/CaribCntryPDFs/cayman_islands_(to_uk).pdf

The Cayman Islands: Natural History and Biogeography edited by M.A. Brunt, J.E. Davies

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4. The NRA acknowledges the importance of considering all of the environmental impacts of the project, including impacts to the mangroves and the wetlands, as well as quality of life, and will have more detailed information, alternatives, and mitigation measures as we move forward in the EIA process. Regarding the Cost Benefit Assessment, any mitigation costs associated with mitigating impacts to the mangroves and wetlands would be included in the calculations.

   Additionally, as part of public outreach, the NRA will distribute a survey to understand what impacted resources are most critical for comparing the three primary alternative scenarios.

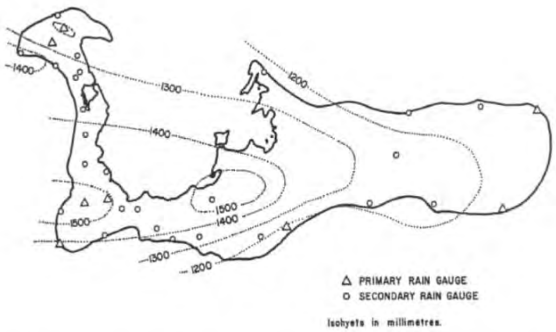

Figure 2. Distribution of mean annual rainfall across Grand Cayman, for the 21-year period 1976-1987.

- We request that the estimated Natural Capital Value lost as a result of the proposed EWA Extension project and other alternatives assessed is included within the Alternative Alignment Assessment. In addition, we request that any mitigation costs, such as those associated with mitigating any impacts to critical habitats to achieve Biodiversity Net Gain in accordance with the IFC Standards, are included within the Alternative Alignment Assessment.

5. The impacts of lighting on terrestrial and marine wildlife should be assessed:

- The potential impact of lighting on wildlife is not included within the ToR. Lighting during construction and operation often negatively impacts wildlife through disturbance and disorientation. Species known to be negatively impacted by lighting are fish, birds (particularly migrating birds), bats and sea turtles (including nesting females and hatchlings). The negative impacts of lighting are often amplified on bridges and elevated structures as elevated lights can be seen from further away, resulting in a greater Zone of Influence for lighting on these structures than for ground-level lighting.
- The impacts of lighting on terrestrial, marine and avian species should be assessed and appropriate mitigation measures included, such as wildlife-friendly spectrum bulbs, downward facing and cowled lighting, and lighting turned off outside of peak hours. The DoE provide information online on turtle-friendly lighting and the UK's Bat Conservation Trust '*Bats and artificial lighting in the UK*' Network Rail *Minimising impact of artificial lighting on people and wildlife'* documents provide best practice guidance for reducing lighting impacts to birds, bats and other wildlife. These guidelines should be followed when detailing lighting mitigation measures.

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5. Thank you for the references regarding the potential impact of lighting on terrestrial and marine wildlife. Light is noted as a potential impact in Section 4.5.4 of the ToR and a potential mitigation measure (Viewshed enhancements/Visual screening) is included. Further evaluation and assessment of light impact will occur as part of the EIA dependent on identified species and sensitivity.

6. There are no official Grand Cayman population or employment forecasts that extend far enough to meet the needs for the life-cycle cost evaluation. The NRA will develop the future projections based upon growth rates from the census along with known approved land development for 2026, 2036, and 2046. This will provide a reasonable future land use condition, assuming a 'worst-case' land use condition would not be consistent with international standards as they are often used to over-justify new capacity and result in extreme over-building of roadways. This not only results in higher impacts to the environment but also results in wasting public funding in constructing and maintaining infrastructure that is not necessary. This is not in keeping with the NRA's goals.

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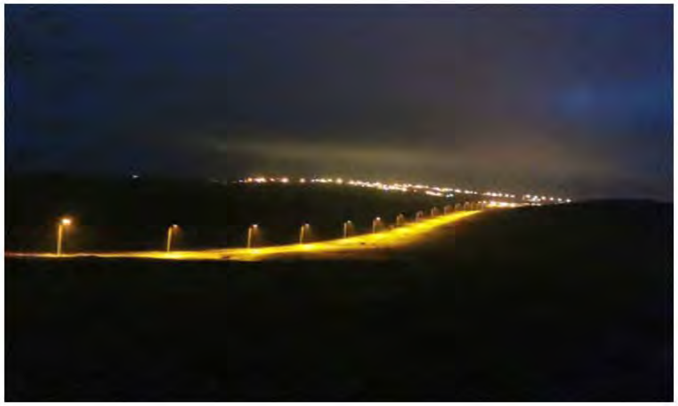

Figure 3. Example of wildlife-friendly lighting.

6. Land use forecasting and traffic modelling should be based on a 'worse-case' scenario:

- Section 3.1 Roadway Operations states *"An analysis of forecasted land uses along with a determination of future travel needs projected through traffic modelling data will be used to guide the design of the EWA Extension. Current and emerging policies, including the Development Plan and the National Energy Policy, will also be consulted in guiding the design and measures needed to provide a new roadway facility that effectively meets the transportation needs while best avoiding and minimising impacts to the natural, cultural, and human environments."*
- As detailed in section 1, given the lack of an updated development plan and the historic rates of development seen in Grand Cayman to-date, the potential for induced development across large areas of unprotected, privately-owned land within the CMW and other areas of Grand Cayman is significant. Induced growth should therefore be assessed on a 'worst-case' scenario basis where all unprotected, privately-owned land whose parcels start within 1.5 miles of the proposed EWA Extension project, and of any other alternatives being assessed, is assumed to be developed.
- In order to accurately forecast and assess the long-term effectiveness on traffic of the proposed EWA Extension project and other assessed alternatives, traffic modelling should be conducted based on this 'worst-case' scenario. Land use forecasting and traffic modelling should be conducted by an independent organisation who have access to all the raw traffic data across the whole island to provide an impartial and unbiased analysis. Without this, the EWA risks being a white elephant, having contributed to the traffic problem, rather than resolve it.

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The NRA will use their Traffic Demand Model for the transportation evaluation. The model covers the whole island and is a world-class model that follows international standards and can be used to evaluate the transportation impacts of both land development scenarios as well as multimodal transportation investment. The model has been thoroughly validated and calibrated to base conditions and reviewed by a 3rd party independent of the model developers. Since its development the model has been proven to successfully predict the unique traffic congestion on the island as well as provide realistic evaluations of the operations impacts of traffic improvements which has allowed the NRA to systematically reduce bottlenecks and improve the quality of life for Caymanians. The use of this local model will prevent the project from becoming a "white elephant" as noted since it has been proven several times to realistically represent transportation on the island. Grand Cayman has unique traffic patterns and driving characteristics, which would make the development and application of another independent model both impractical as well as time consuming.

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7. Embedded Greenhouse Gas (GHG) emissions and those associated with mining aggregate and shipping should be included within the Cost Benefit Analysis in the Alternative Alignment Evaluation: - Section 4.7.5 Assessment Methodology states *"The GHG analysis will include the following emission sources to establish project totals: Construction Equipment tailpipe emissions; Material/delivery vehicle tailpipe emissions; Peat removal carbon sequestration losses; Road material (concrete, asphalt etc.); and Ancillary materials (crash barriers)."* - We request that a GHG emissions comparison is produced for the Alternative Alignment Evaluation to the proposed EWA Extension project and alternative solutions for both construction and operation. We request that the assessment includes embedded GHG emissions, including those associated with quarrying, concrete, and tarmac production, as well as emissions associated with construction-related shipping, and operational traffic emissions. Operational traffic emissions should be forecast in line with the 'worst-case' land use forecast and traffic modelling projections. **8. Implementation of public and active transport methods should be factored in when assessing environmental and socio-economic impacts of alternative options:** - Section 1.1.2 Purpose and Need states in relation to the proposed EWA Extension project that *"While not responsible for operation of the public transit system, the NRA has considered options to promote the use of public transportation and other forms of mobility by including dedicated bus lanes and pedestrian/bicycle lanes and facilities."* We agree that the National Roads Authority have a duty to provide safe roads for all road users, this includes pedal bikes, scooters, and motorbikes and other recognised road users, not just cars. However, public transport is not mentioned anywhere else in the ToR. Measures such as safe bus and bike-only lanes and routes across the island would bypass traffic dramatically increasing journey times for bus and bike users, and a reliable and affordable bus transportation system and bike hire scheme would provide alternative transport options that benefit all Caymanians. - We request that the relevant government departments responsible for public transportation are actively engaged in the EIA process to ensure that the public transport and other modes of active transport are appropriately assessed to measure their environmental and socio-economic impacts on the traffic and resilience problems the EWA Extension project and alternative solutions are aiming to solve. **9. The improvements to Bodden Town Road alternative should factor in public transport, active transport methods and road upgrades to key bottlenecks:** - Section 3.2 Roadway Alignment Alternatives and Analysis details three primary alternatives that will be considered within the EIA, one of which is improvements to Bodden Town Road. This alternative to the proposed EWA Extension project includes *"providing alternative routes for emergency vehicle passage, when the road is compromised; dedicated lanes for transit and safe pedestrian/bicycle use; and a road design that will be resilient to climate changes and extreme weather events."* Sustainable Cayman, PO Box 61, George Town, Grand Cayman, KY1-1102, Cayman Islands www.sustainablecayman.org | info@sustainablecayman.org Registered as an NPO in the Cayman Islands NP-612 Page 10 of 13	Regarding the request for independent land use and modeling consultants, there was an independent selection process of the EIA team. The staged selection started with a vetting of teams by the EAB to determine independent qualifications. The final selection was then conducted by the NRA with independent review by outside consultants. This independent process was established to objectively select a highly qualified team of local and international experts. 7. The NRA has revised the ToR, as described in Section 4.7 of the ToR, to include the analysis of GHG associated with operational traffic emissions. The NRA will follow the methodology provided by the US EPA's "Greenhouse Gas Equivalencies Calculator, which can be accessed at https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator. However, it is not feasible to evaluate GHG associated with mining and shipping aggregate due to the variability of these values dependent on material availability at the time of project construction and global supply chain.

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- We request that provision for a bus system and bus and bike-only lanes and routes, as detailed above, are included in this alternative option, as well as road upgrades to key bottlenecks within the road network, making it a more holistic solution to solving the traffic and climate resilience issues the island faces.
- We also request that the impact of these provisions on current and projected traffic modelling, along with those already listed in the description for this alternative, are included within the assessment and compared against other assessed alternatives.
- The Transport Review produced by Ardent Consulting Engineers[4] appended to this consultation response provides an assessment of the traffic modelling conducted to date and the effectiveness of the proposed EWA Extension project on the existing traffic issue which we believe may be of value to the Alternatives Analysis Evaluation.

10. Biosecurity risks and mitigation measures should be included in the ToR:

- There is no mention of biosecurity within the ToR. IFC Standards require that projects implement measures to avoid alien species introductions and spreading of established alien species, including the transportation of substrates and materials which may harbor alien species. Measures should also be taken to eradicate alien species from the natural habitats within the project area.
- We therefore recommend that section 4.5.6 Mitigation Measures, includes biosecurity measures to eradicate and/or manage invasive alien species risks.

11. Alternative solutions to the proposed EWA Extension project should be assessed in the 'Alternative *Alignments* Evaluation' which should therefore be named 'Alternative *Solutions* Evaluation':

- Section 3.2 Roadway Alignment Alternatives and Analysis details three primary alternatives that will be considered to determine which alternative(s) would effectively meet the purpose and need of the project. The wording of the text then changes from 'Roadway Alternatives' to 'Alternative Alignments', implying that all alternatives that will be assessed are various alignments of the proposed EWA Extension project. However, this is not the case of the third alternative solution listed, improvements to Bodden Town Road, nor is it the case for other alternative solutions that could resolve the traffic and climate resiliency problems the proposed EWA Extension project aims to solve.
- Whilst the EWA Extension project could provide a disaster-resilient alternative route and improve traffic conditions, its high cost would use up financial resources that are increasingly being needed to combat the effects of climate change on the Cayman Islands economy and communities, notably increased storminess, flooding and sea level rise. This is why detailed consideration should be given in the EIA to a range of transport options giving priority to options that provide the greatest Cost Benefit Ratio. There is not an endless pot of money, and cheaper alternatives provide better scope to protect communities and quality of life.

[4] The Transport Review is also available online at: https://sustainablecayman.org/important-documents

8. We acknowledge the importance of alternative transportation schemes and will include relevant government departments (including the Cayman Public Transport Unit) as project stakeholders.

9. Multimodal elements may be considered as part of the proposed Bodden Town Road typical section. However, it is outside the ambit of the NRA and this EIA document to implement policies and/or operations of a public transportation system. Such responsibilities fall under the Ministry responsible for Transport and the Public Transport Unit, who will be consulted as stakeholders during the study. A formal response to the Ardent Consulting Engineer's report will be provided separately.

10. Thank you for your suggestion on biosecurity risks and associated IFC Standards for reference. We acknowledge that IFC standards are included in Section 2.1.1 of the ToR and will be evaluated for inclusion where applicable in the EIA. As biosecurity would be dependent on sourcing, transportation, and sensitive resources, it will be evaluated later on in the EIA process once these factors are identified.

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- We therefore request that all other reasonable alternative solutions that exist that could resolve these issues are assessed, and hence the Alternative Alignment Evaluation and subsequent wording in the ToR and EIA that refer to alternatives, use 'Alternative *Solutions*' rather than 'Alternative *Alignments*'.
 	
12. Clarifications on the use of Natural England's Biodiversity Metric 3.1 are required:
 	
- Section 4.5.6 Mitigation Measures also states, "*Mitigation measures will be evaluated using the Natural England's Biodiversity Metric 3.1 Calculation Tool with the goal of achieving No Net Loss of Biodiversity.*"
- We are really pleased to see the inclusion of a target to achieve a No Net Loss of biodiversity within the ToR. However, Natural England's Biodiversity Metric 3.1 has been developed for UK Habitat Classification and does not include categories for the habitat types found in Grand Cayman and in the scope of the EWA Extension project. The Biodiversity Net Gain policy in the UK (for which the Biodiversity Metric was created) excludes 'irreplaceable habitats' from the metric. We would argue that mangrove and old-growth dry forest qualify as 'irreplaceable habitats'.
- We request that the EIA consultants clarify how the habitats assessed in the EIA, including irreplaceable mangrove, old-growth dry forest and marine habitats directly linked to the CMW in the North Sound, will be categorised and incorporated into the Biodiversity Metric 3.1.
 	
13. Additional standards and guidelines should be used for evaluating potential effects to terrestrial and marine ecology:
 	
- Section 4.5.3 Applicable Standards and Guidelines should include the following international standards and guidelines for evaluating potential effects to terrestrial and marine ecology:
  - The IFC Performance Standards on Environmental and Social Sustainability, 2012:
    - PS No. 1: Assessment and Management of Environmental and Social Risks and impacts;
    - PS No. 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources;
  - National Conservation Act, 2013 and ancillary documents such as Species Conservation Plans and Management Plans.
 	
14. Consider implications of the draft National Planning Framework (Plan Cayman[5]) and proposed Natural Resource Preservation Overlays:
 	
- The draft National Planning Framework (Page 27/Section 4.0) proposes Natural Resource Preservation Overlays (NRPO) to ensure that future development is sensitive to these unique and important natural and ecological features, including the CMW 'Create a Natural Resource
 	
[5] Plan Cayman https://www.plancayman.ky/get-involved/
 	
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	11. The title will be updated to "Alternative Solutions Evaluation." However, it is not feasible to evaluate all other reasonable alternative solutions that exist; they must be practical and meet the Purpose and Need. Based on the analysis findings, the three primary alternatives may include refinements such as alignment and/or elevation adjustments, the number of through lanes, intersection configurations, and turn bay lengths at intersections to provide the solution(s) that meet the Purpose and Need. The proposed corridor would have the width and ability to include alternative modes of transportation as deemed appropriate. Therefore, as part of this alternative solutions evaluation, pedestrian facilities will be included, and if the CIG's Public Transport Unit concurs, a designated transit route may also be considered, under their guidance, along the proposed corridor.

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Preservation Overlay (NRPO) and identify the properties that are included in this Overlay, such as the Barkers area, the Central Mangrove Wetland, … the Mastic Reserve and any other ecologically important lands.'

- Two recent rezone applications to the Central Planning Authority for land within the CMW were turned down (CPA/28/22): "It was resolved to not pursue the proposed rezone as it is not consistent with the draft National Planning Framework (Plan Cayman) submitted to the Ministry PAHI on September 29, 2022 based on a resolution of the Authority at its meeting on September 14, 2022."

This response has been compiled with the assistance of professional consultants with appropriate expertise as part of the Wetlands Thrive Life Survives initiative.

We look forward to your response and we would be pleased to meet with you to engage in further discussion on these important issues.

Sincerely,
Sustainable Cayman

[redacted]

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12. We acknowledge the clarification requested on habitat categorization. Habitat categorisation is not available at this time as the environmental studies have not yet taken place. Habitat categorisation and opportunities for comment and review will be available as we move forward in the EIA process.

13. Thank you for the suggested references. The National Conservation Act (2013) and National Conservation (General) Regulations (2016) are already included as applicable standards under Section 4.5.3. As discussed above, the IFC standards are referenced in Section 2.1.1 of the ToR for evaluation throughout the EIA process and subsections.

14. We appreciate the relevant planning documents. The Department of Planning will be included as a project stakeholder to ensure compliance with any relevant zoning. Relevant zoning overlays provided by the Department of Planning will be evaluated as part of the EIA process.

Subject: [EXTERNAL] Comments re Terms of Reference for the EWA EIA I am writing to share my thoughts on the Terms of Reference for the EWA EIA. Firstly, I would like to thank the parties involved in setting up this public forum. Both the NRA and the DOE have made great efforts to inform the public and allow them to be involved at this early stage of a large infrastructure project for Cayman. I have listened to the live stream of the second meeting held last week, reviewed the Terms of Reference and also read the Transport Review commissioned by Sustainable Cayman. **My comments:** • Existing upgrades to our roadways and a coastal road known as BP40 linking Pedros to Manse road will go a long way towards easing traffic congestion and providing alternative routes for emergency vehicles. • The most compelling comment from the meeting was from Mr. Howard when he suggested that certain government departments should be relocated to Savannah above the main pinch point at Grand Harbour. The graphs showing where people live and where people work (*Terms of Reference Figure 9: Distribution of Population vs Employment Centres on Grand Cayman)* clearly demonstrates that if the work places were better distributed the traffic problem would be solved and we could avoid building huge highways on our tiny island. Government is on of our largest employers and a simple survey of all government employees to ascertain where they live would inform this process. **The environment** There is a saying 'get your big rocks in first' - it means protect the important things first before you accommodate everything else. Our big rocks are our environment. The Central Wetland is out beating heart and if we allow any development to nibble at it's edges we set the touch paper for it's destruction, slowly but surely it **will** shrink every few years until a generation or so from now it will have gone. We should not ever allow this process to start. We really do need to have the debate now about setting a population cap to ensure Cayman remains a healthy and happy place to live for future Caymanians. It is a brave government that will open that discussion - but it simply has to be done. It is the main issue from which all these other pressures flow - development, ports, space, healthy environment.	**Response:** Thank you for your participation in the ToR review process. The NRA will coordinate with the stakeholders and the public to identify and discuss potential additional alternatives and alignments that could be considered as part of the EIA process. From a multimodal perspective, this EIA will look at the current traffic and transportation system as well as anticipated future traffic growth based on the 2021 Census data and proposed developments. While it is outside the ambit of the NRA and this EIA document to establish and implement policies regarding making land use decisions or setting a population cap, the NRA would invite the Department of Planning to become a stakeholder for the project and to determine if either of these issues could be undertaken as part of that department's future planning. We will be evaluating mangroves and their many functions as part of the EIA process. Alternatives to avoid or mitigate mangrove impacts will be evaluated.

Subject: [EXTERNAL] Comments on the East-West Arterial Extension Environmental Impact Assessment Dear Environmental Assessment Board, I am writing to provide comments on the draft terms of reference (ToR) for the East-West Arterial Extension Environmental Impact Assessment (EIA). I appreciate the opportunity to provide input on this important project. Firstly, I would like to request that the EIA includes an assessment of tailpipe emissions and greenhouse gas (GHG) emissions during the operation and life of the East-West Arterial Extension as the current EIA ToR draft appears to only include assessment of GHG during construction, which is a gross oversight. It is important to note that the transition to electric vehicles moving a glacial pace and will take years to complete all the while internal combustion engines will continue to operate with no emission testing regulations in place to ensure emission standards and targets are meet. Secondly, I recommend that the EIA includes measures and policy suggestions to reduce traffic congestion in the no-build scenario. The potential benefits and costs of these measures should also be thoroughly analyzed and discussed in the EIA. The benefits and costs of encouraging the use of public transportation or active transportation infrastructure could include reduced traffic congestion, improved air quality, and enhanced physical activity levels. For example, the creation of a government body responsible for the transport network of the Cayman Islands in the vein of Transport for London and Singapore's Land Transport Authority and detailed in the Land Transport White Paper, titled "A World Class Land Transport System". Finally, I suggest that the EIA places greater emphasis on measures of people moved instead of just vehicles and the number of vehicle trips reduced. This approach will provide a more comprehensive assessment of the project's impact on the community. For example, government initiatives and programs to shift away from the current car dependent paradigm to alternative modes of transportation such as walking, biking, or public transit, that can reduce the number of private vehicle trips taken while simultaneously increasing the number of people moved and the carrying capacity of existing road infrastructure, create a healthier populace, and allow those who are currently underserved and neglected by the current car dependent paradigm to be able participate in our community without needing to have access to a car. Thank you for considering my comments. I look forward to seeing the final EIA report.	**<u>Response:</u>** Thank you for your participation in the ToR review process. The NRA plans to incorporate operational GHG emissions into the EIA and has updated the Final ToR to include this. This EIA will look at the current and projected multimodal travel needs; the proposed corridor would have the width and ability to include alternative modes of transportation as deemed appropriate in the future. Alternate options that are evaluated could include the use of passenger transit either on-alignment or off-alignment and with or without the associated roadway. However, it is outside the ambit of the NRA and this EIA document to establish and implement policies and/or operations regarding an alternative public transportation system on Grand Cayman. Such responsibilities fall under the Ministry responsible for Transport and the Public Transport Unit, who will be consulted as stakeholders during the study.

Subject: [EXTERNAL] East West Arterial Good afternoon, This road is overdue and the people of this country needs it. I see no reason why the east west arterial cannot be built without causing major environmental issues. Put in culverts were needed and have an engineer design environmentally friendly concrete pillings. To place the road above ground were needed to protect the mangroves, wetlands and avoid flooding. With the building of the road, the Government needs to compromise with the people by placing heavier restrictions on transport policies. In terms of who is eligible to own a private vehicle. They also need to put a ban on used Japanese vehicles being imported. We cannot continue to allow over 1000 vehicles arriving every month increasing the traffic. Just look at the statistics of how many used Japanese vehicles imported over the last few years. The population statistics from the 2020/2021 census has proven there are more foreign nationals than Caymanians. There is no need for every work permit holder to have a car. With policies focused on transport the Government needs to liase with the private sector to promote group transport for company staff who are only on island for a short period of time. Get a proper public transport system in place with large buses.	**Response:** Thank you for your participation in the ToR review process. We acknowledge your support of the roadway and implementation of regulations on vehicles. Policy of vehicle ownership, importation, or implementation of a public transportation system are outside the ambit of the NRA and this EIA. We will evaluate Hydrology and Drainage per Section 4.3 of the ToR. Feasible and reasonable alternatives to stormwater abatement, including bioswales, will be considered. Additional detail has been added to Section 4.3 to describe the types of mitigation that may be considered.

We are the Cayman Islands Mangrove Rangers, a team of passionate Caymanians utilizing our diverse skills to protect Cayman mangroves. Our mission is to educate residents on the importance of a healthy coastal environment for our nation, which is comprised of wetlands, sea grasses, and coral reefs, and to protect this important ecosystem for the health and safety of our Islands. Wetlands are one of the most valuable coastal ecosystems on the planet, offering many natural services that protect humanity's best interests. We have lost 3,900 acres of pristine mangrove forests in the western area of Grand Cayman. With only 1,500 acres of mangroves left (38%!) in this area, we are committed to protecting this important ecosystem. In addition, the 8,500-acre Central Mangrove Wetlands - the largest contiguous mangrove forest in the Caribbean - is under serious threat of development, such as the development proposed in the NRA's Draft Terms of Reference for the Environmental Impact Assessment for the East-West Arterial Extension. The Mangrove Rangers supports the proposed EWA Extension being built in the least ecologically-sensitive area, with a design that avoids and minimizes impacts to environmental resources such as the Central Mangrove Wetlands, which are proposed to be affected by the extension in its current form. The Mangrove Rangers, along with other like-minded organizations, are not anti-development but rather pro-sustainable development. We advocate for development that balances economic growth with our environment's finite and fragile resources. The TOR acknowledges that Grand Cayman is an extremely flat island susceptible to sea level rise, and that hurricanes are expected to increase in intensity and frequency due to climate change. We concur, and thusly are in support of infrastructure upgrades that do not degrade our sensitive wetland environments, which are critical to mitigating climate change and sea level rise long-term. Our support would be in favor of infrastructure development in areas that do not require mangrove deforestation, such as what is being proposed in the TOR in the EWA Extension option (vs the No Build Option). Our Islands cannot afford to lose these vital wetlands, as their wholeness equates to our long-term health and safety. Healthy wetlands = healthy humans, a healthy economy, and a healthy environment.	**<u>Response:</u>** Thank you for your participation in the ToR review process. We acknowledge the importance of the Central Mangrove Wetland and will invite the Cayman Island Mangrove Rangers to participate in the stakeholder engagement process of the EIA. We will be evaluating mangroves and their many functions as part of the EIA process. Alternatives to avoid or mitigate mangrove impacts will be evaluated. Sections 4.3.5, 4.3.6, and 4.3.7 of the ToR address Tropical Storms and Hurricanes, Storm Surge and Flood Risk, and Mangroves. The inter-relationship of these resources will be evaluated as part of the EIA. Detailed evaluation has not occurred yet at this point in the EIA process. The NRA will coordinate with the stakeholders, including the Mangrove Rangers, to identify and discuss potential additional alternatives and alignments that could be considered as part of the EIA process.

1. Request for marine ecology section to be included in the study scope The sections of the TOR around page 49 regarding Mangrove Hydrology and page 68 regarding Terrestrial Ecology speak about possible impacts to the Central Mangrove Wetland's functions. The Central Mangrove Wetland ecology is tightly connected to the North Sound seagrass and north wall reef ecosystems, and thus the NTCI believe that there should be a marine ecology section within the scope of the study. Any change to the CMW functional health could lead to increased sediment, freshwater, and pollutant runoff into the North Sound. This is in addition to a reduction of marine species nursery ecosystem and other potential impacts. The importance of the North Sound and North Wall Reef to the tourism, recreational, and seafood industries, as well as cultural importance to Caymanians merits a close study of how any affects to the CMW would affect the marine ecology. **2. Request for thorough investigation of peat depth** Are the previously dug pits (pg. 61) for testing the peat depth along the route of the proposed roadway representative of the wetter areas at the eastern end of the proposal? More peat could be expected in the wetter mangrove areas and a thorough investigation of these areas should be completed to give a best estimate of the actual situation on the ground for section 3 of the road. This has obvious implications for both the construction costs and methods as well as potential GHG emissions/sequestration potential. **3. Request for accurate existing aggregate quantification** On page 61 the report notes that aggregate for the road would be mined from the existing authorized quarries. The estimate of remaining aggregate in the existing mines is from the Water Authority in 2018, there has been significant development on island since that point using that aggregate. I believe this study should use an updated estimate to take the 2018 to 2023 use of aggregate into account to see if there is sufficient aggregate in existing mines for the project. a. If there is not sufficient aggregate in existing mines, will a new quarry be created? i. If a new quarry is planned will there be an EIA process for that mine? **4. Request to consider extreme noise emitters and their effect on the Mastic Trail** With regards to noise monitoring on page 89 the NTCI has concerns about the assumed level of operational noise from the future roadway. With several roundabouts and the terminus of the road at Frank Sound Rd., traffic will slow at several points. Our concern is the noise from trucks using compression braking to slow (an unfortunately common practice in Grand Cayman despite the low speed limits and flat terrain) will be far louder than normal operational traffic estimates, a further concern is that the sound from compression braking emanates from the upright Page 1 of 3	Response: Thank you for your participation in the ToR review process. The responses below are numbered to follow the numbering provided in the comment. 1. As noted in your comment, we are evaluating indirect and cumulative impacts as part of the EIA, which would include if project impacts are anticipated to have indirect impacts on marine ecology. The evaluation of marine ecology has been added to Section 4.5 of the ToR, Terrestrial Ecology. 2. Please see Section 4.4.5 of the ToR (Page 66), which explains that a peat assessment will be completed within the project area to supplement the previously completed studies. 3. The methods, material, and availability of material needed for construction will be determined during the design of the project. The focus of the EIA is to develop viable alignment options in concert with the analysis of environmental and social impacts, then compare the impacts associated with each alternative.

mufflers of trucks and may escape normal noise mitigation measures. We believe that this added noise should be taken into consideration in the noise modeling of the road. **5. Request Include the Salina and Colliers Reserves in cumulative impacts** Based on the remarks of Mr. Denis Thibeault at the February 7th public meeting, it seems the plans of the NRA are to continue building the East End connector roads seen on page 12 of the document in Figure 1., these roads cross several protected and ecologically sensitive areas including the National Trust's Salina and Colliers Reserves. These reserves are where the releases of the Grand Cayman Blue Iguana take place and are the only place where this endangered species exists in the wild. Based on the stated intent of the NRA to continue with this roads plan, "being instructed to build all the way to East End", these roads must be included in this EIA as cumulative impacts. **6. Request to investigate need for northern connector that crosses the Mastic Trail/Reserve** On page 76 of the document it is noted that the Mastic Trail was 'reopened" to the public in 1995. While the National Trust undertook work to make the trail visitor friendly, this characterization minimizes the importance of the trail to the Cayman Islands. The trail is a historic right of way which has existed for more than 120 years, created by William Steven. Watler to access the farmlands of North Side. The National Trust owns much of the property along the trail but the trail itself is not owned by the NTCI. The historic importance of the trail should be taken into account when looking at any potential impacts to it. The trail is an important recreational and ecotourism attraction. It is the largest accessible terrestrial green space on Grand Cayman. Its importance to the mental health and well-being of its users should be taken into account, especially in light of recent studies which show the importance of time in nature to human's mental health. We would like the study to investigate the necessity of the two connections to Frank Sound Road, especially the northern connector which bisects the trail and goes through the National Trust's Mastic Reserve. **7. Request to consider need for a sustainable development plan and re-zoning** Increasing access for development is not stated as a goal of the road in the executive summary, however it seems to many to be one of the main outcomes of the road. Please look at past development in other areas of the island and consider the lack of a sustainable development plan meaning that most developments are considered in a vacuum where the only important issue is the potential value for the landowner. With increased access and the current zoning and planning regime the probable development north of the road would be devastating to the CMW. We would like to see consideration for zoning changes to mitigate the impact to the north of the road. **8. Request to consider the public need for a holistic approach to the traffic problem** Page 2 of 3	4. The traffic noise analysis will evaluate the anticipated number of large trucks versus cars as their noise profiles are modelled differently. However, several studies have shown that the effects of compression brakes cannot be modeled. The restriction of the use of compression brakes is typically delegated to local law enforcement. 5. The referenced graphic is from the NRA's long-term plan gazetted on May 3, 2005. The current EIA does not cover further east expansion as this is not planned or funded at this time. 6. The importance of the Mastic Trail is acknowledged and the evaluation of impacts to the trail is described in Section 4.6 of the ToR. The northern arterial at Frank Sound was initially identified as part of a long-term plan developed in 2005 and shown on Page 12 of the ToR. Additional alternatives and alignments will be evaluated as part of the EIA process. 7. This ToR will consider direct, indirect, and cumulative impacts that are a result of the development of the EWA Extension. All impacts will be evaluated regardless of their extent. However, land use planning and zoning is outside the ambit of the NRA and this EIA document. However, the NRA would invite the Department of Planning to

Will the study look at the effect of increased development and its potential to wipe out any benefits of decreased traffic for North Side and East End residents? More and more roadway analysis worldwide shows that new/expanded roads often quickly return to their former level of traffic, if not worse levels, due to increased development induced by the road construction. The study should consider measures to ensure this does not happen.

9. **Request to investigate impact on home affordability for Caymanians**

How will speculation due to increased road access affect property prices in East End and North Side? This is noted in the assessment on page 42 but should be thoroughly investigated in the context of how Cayman's past development has led to property values out of the reach of the average resident.

10. **Request to consider sea level/water table rise due to climate change**

On page 60, it is noted that many test pits hit water at or just below the surface. With anticipated sea level rise and the noted connection of the groundwater in Cayman to the ocean (Pg. 61), will the study address the potential for the water table to rise and what measures must be taken to "future proof" the road for this possibility?

11. **Request that consideration to be given to all possible alternative alignments**

The NTCI believes consideration should be given to an alternate alignment of the road further from the gazetted corridor. For example, the study should look further south onto drier land which could, among other benefits, be potentially less expensive to build on, have a smaller direct impact on the mangrove ecosystem, a smaller indirect impact on the hydrology, and a smaller cumulative impact via future development.

12. **Request to consider a wider approach to the EIA process following the strategic outline for a Cargo Port project in Breakers**

Based on the Port Authority of the Cayman Islands released outlined plans for a new cargo port on February 16th with their preferred option being the quarries near Breakers, I believe consideration should be given to the cumulative effects of these infrastructure projects proposed by different government agencies in isolation without even the mention that the other project exists. In this specific case, how would the increased truck traffic from this port affect the function and impacts of the new EW Arterial extension? An EIA process is impossible to complete properly when several massive infrastructure projects are proposed in the same area without any indication of a connection. People who may support the road in isolation might oppose it if they knew that it was going to lead to a massive port project or vice versa. We believe this highlights even further the need for an overall development plan so these agencies work in tandem instead of separately and the Caymanian public can truly understand the scope of the changes that are being planned. If not, then the case for each project becomes easier to make as the degradation of the environment from the last project becomes the new baseline, as opposed to understanding what the ultimate goal is and getting to decide if that is what the people want.

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become a stakeholder for the project and to determine if either of these issues could be undertaken as part of that department's their future planning.

8. From a multimodal perspective, this EIA will look at the current traffic and transportation system as well as anticipated future traffic growth based on the 2021 Census data and proposed developments. The proposed corridor would have the width and ability to include alternative modes of transportation as deemed appropriate in the future.

9. Thank you for your recommendation regarding impact to home affordability. This has been included in Section 4.2.4 of the ToR as a potential Socio-economic impact.

10. The effects of sea level rise and increased impacts of climate change will be evaluated in the EIA process. Sections 4.3.5, 4.3.6, and 4.3.7 of the ToR address Tropical Storms and Hurricanes, Storm Surge and Flood Risk, and Mangroves. The inter-relationship of these resources will be evaluated as part of the EIA. Additionally, Section 1.1.2 establishes the basis for climate resiliency and its importance. Detailed evaluation has not occurred yet at this point in the EIA process.

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	11. The NRA will coordinate with the stakeholders, including National Trust, to identify and discuss potential additional alternatives and alignments that could be considered as part of the EIA process. 12. We acknowledge the presence of other development plans on Grand Cayman. The Port Authority of the Cayman Island, along with additional applicable agencies, will be included as stakeholders throughout the EIA process. Inclusion of aspects from the proposed Cargo Port project, such as anticipated traffic volumes, will be evaluated as part of the EIA process.

Appendix C

Ardent Transport Review

NATIONAL ROADS AUTHORITY

ARDENT | CONSULTING ENGINEERS

TRANSPORT REVIEW

CIRCULATION	:	**Melanie Carmichael (Sustainable Cayman)**
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DATE	:	**01 February 2023**
SUBJECT	:	**Grand Cayman Island - East-West Arterial Road Extension**

1. Introduction

My name is Kevin Kay. I am a Divisional Director with Ardent Consulting Engineers (ACE) based in their London and Edinburgh offices. I have a Bachelor of Science in Geography and a Masters of Science in Sustainable Environment Management, both from the University of Plymouth in the United Kingdom. I am a Chartered Transport Planning Professional (CTPP) and a Fellow of the Chartered Institution of Highways and Transportation (FCIHT).

The views expressed are my own and are not intended to confer wider sanction by the organisation.

2. Overview

Context

The Cayman Islands is an island group and overseas territory of the United Kingdom in the Caribbean Sea comprising the islands of Grand Cayman, Little Cayman and Cayman Brac. The island of Grand Cayman it 22 miles long and 8 miles wide, as shown in Figure 1.

Figure 1. Grand Cayman Geography

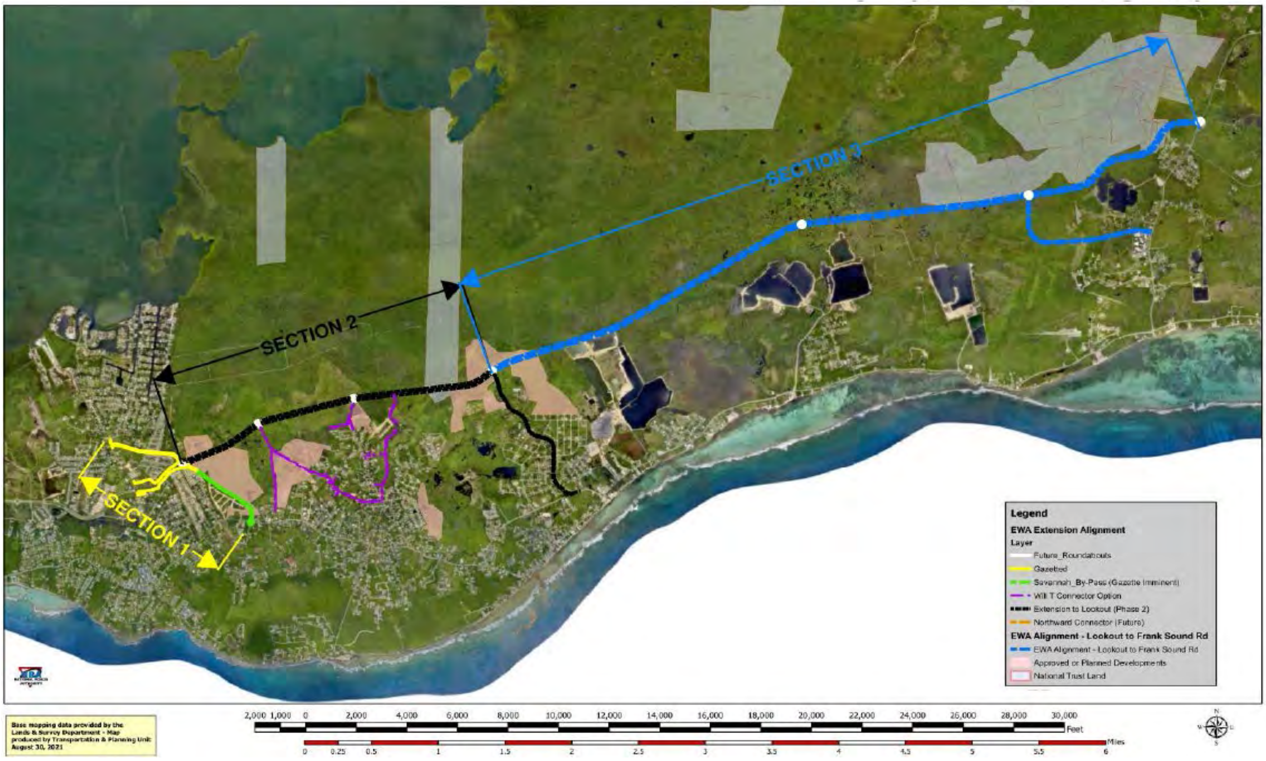
The network of roads and highways has a total length of 785 km[1]. For each of the country's 68,136 inhabitants this puts the Cayman Islands in 47th place in the global ranking in terms of road network density, as of 2021.

The Road Scheme

The East-West Arterial Road Extension (the 'project' or 'EWA Extension') is a road-based scheme covering some 13km (or 8 miles) between Hirst Road, to the west, and Frank Sound Road to the east, with various 'spurs' extending southwards to meet existing roads.

The indicative alignment for the EWA Extension is shown in Figure 2 below.

Figure 2. East-West Arterial Road Extension Alignment



According to the published EIA Scoping Report[2] (2023), the study area for the scheme encompasses the proposed route's footprint, which is represented by a 10-mile-long (16 km), 160-ft-wide (49 m) multi-lane highway and associated roundabouts.

The proposed configuration of the road comprises three lanes in each direction, central medians and cycle tracks, as shown in Figure 3 below. This is therefore a significant scheme, akin to a high-standard inter-urban road or motorway.

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[1] https://www.worlddata.info/america/cayman-islands/transport.php.

[2] Terms of Reference Environmental Impact Assessment for the East-West Arterial Extension (30 January 2023)

Figure 3. Proposed Cross-Section of East-West Arterial Road Extension

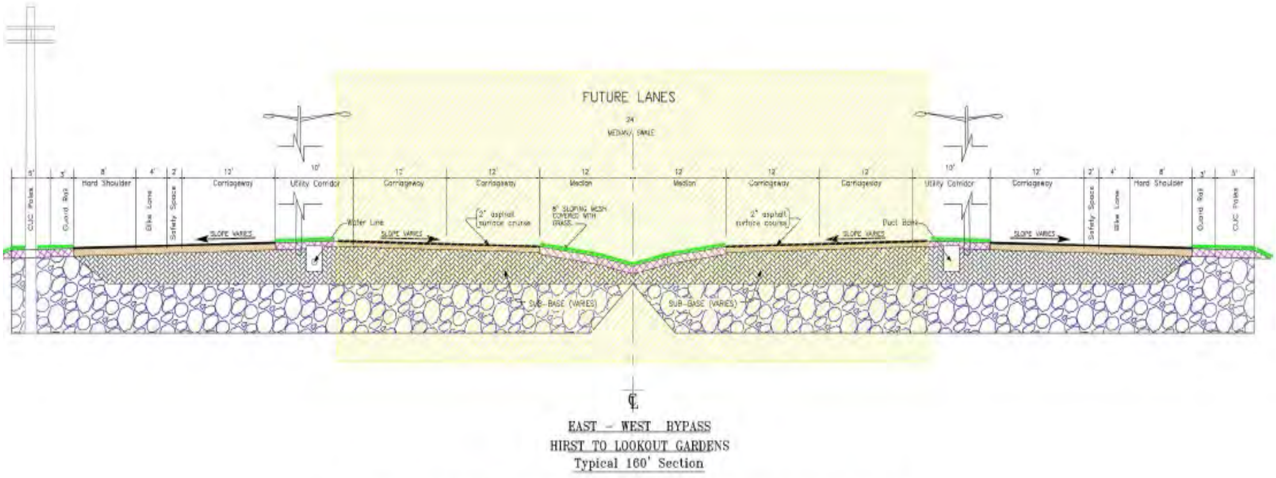


Figure 4: Original EWA Extension typical section proposed between Hirst Road and Lookout Gardens

Source: EIA Terms of Reference EIA for the East-West Arterial Extension (30 January 2023)

Proposer

The National Roads Authority (NRA) is the proposer for the project. It was created on 1st July 2004 by the National Roads Authority Law (2004). In accordance with its terms of reference, the organisation:

> *"… aims to enhance transport development in the Cayman Islands by building and maintaining a safe and efficient network of roads, in partnership with a Board of Directors, the Ministry, Cabinet, and the private sector, having regard to national and economic growth strategies."*

There does not appear to be a co-ordinated body or single Ministry that seeks to reconcile the transport mobility of the islands with spatial planning objectives. Rather, in the case of the project, the NRA seeks to respond to the identified traffic demands arising from the economic growth agenda.

The Rationale

The project has been discussed since 2004 (then called 'Central Highway') when Hurricane Ivan caused damage to existing coastal roads. This meteorological event caused some areas of Bodden Town and Lower Bay / East End to be temporarily cut-off.

This led to plans being drawn up to address the issues experienced, as well having an eye on climate change resilience, in light of the vulnerability of existing infrastructure and communities to coastal storm events as well as to secure improved emergency vehicle access.

So the plans have been drawn for this project in part because of the resilience that a more central highway corridor would provide, as an alternative to the existing southern coastal road.

It is understood that the project may also offer opportunities for new land-uses and new developments to be zoned by expanding the scope of accessible areas across the island, with the additional implications this would have in terms of additional traffic generation and other environmental effects.

With the prospect of growth being more constrained in western areas of the island, there are likely to be greater development pressures in eastern districts in the future, including but not limited to meeting the needs of the following:

- Health City Cayman Islands;
- Ironwood Resort;
- Arnold Palmer Golf Course;
- Morritt's Reef Resorts expansion;
- Additional residential development zoning in Bodden Town.

In this respect, the NRA has been asked to meet the directives of the Government in looking ahead and accommodating the needs of the Development Plan for Grand Cayman.

Current Status

Beyond its terminal point at Hirst Road in Savannah, an initial phase (Section 1) of the project is progressing (as shown in Figures 4 and 5)

Figure 4. East-West Arterial Extension (Section 1 - Hirst Road to Woodlands Drive)

Source: National Roads Authority

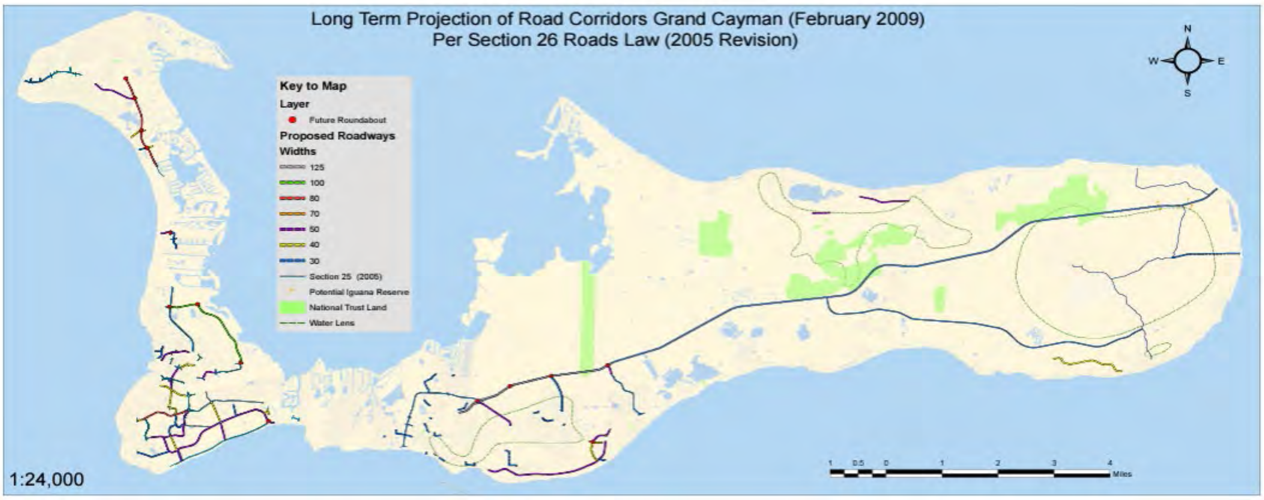
Figure 5. Construction of E-W Arterial Extension (Section 1)

3. Background

Regulations

In 2005, a 'Section 25 Gazette[3]' under the Road Law (now Roads Act) was passed, which allows the Government to develop a long-range plan, including making an amendment under the Development Plan for this a 'central' road corridor. Figure 6 shows the proposed Section 26 gazette that was endorsed by the NRA Board of Directors in February 2009 and was forwarded to the Ministry of Works.

Figure 6. Section 286 Long-term Roads Plan[4]



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3 https://www.caymanroads.com/documents/Approved-Gazetted-Section25-E-W-Arterial-and-Collector-Corridors---24by36-20200313012530.pdf

4 https://www.caymanroads.com/documents/Section-26---2009---SH---Mar-20200313012629.pdf

The above is intended to guide the long-term road development aspirations for Grand Cayman Island.

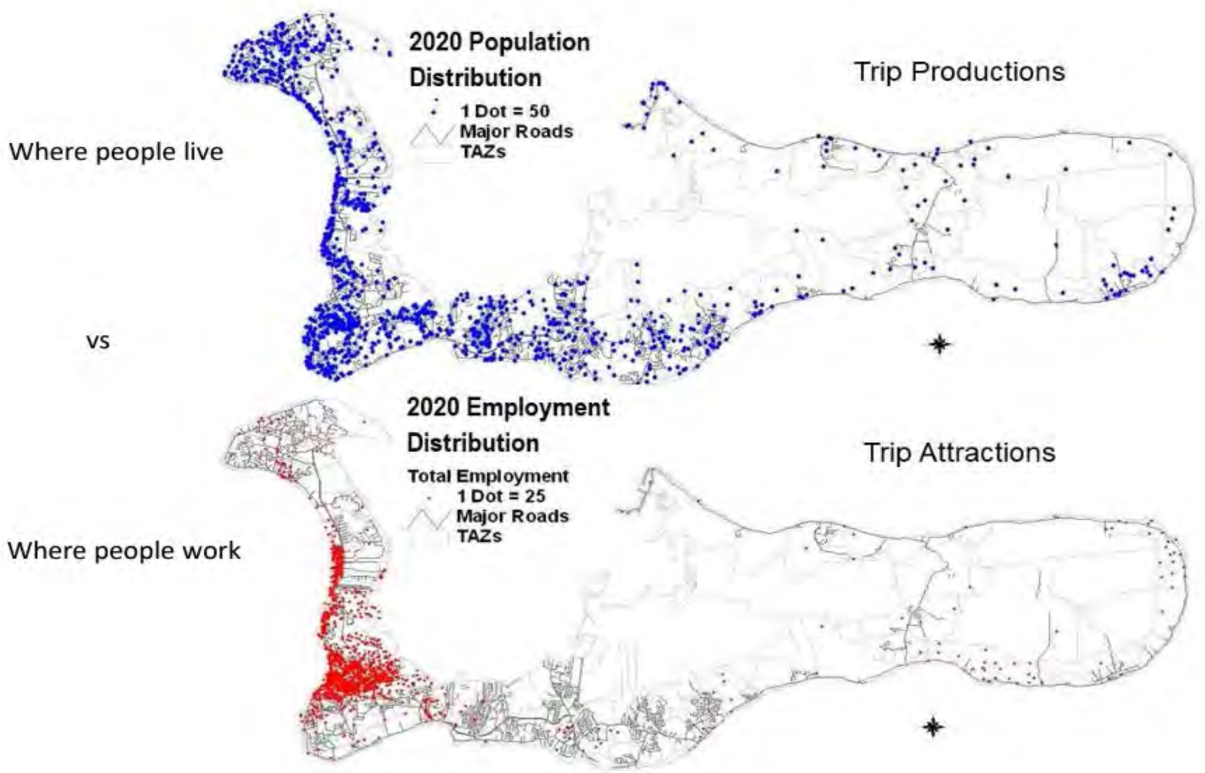
In 2021, ten elected independents came together to form a new Government. Using the acronym PACT ('People-driven, Accountable, Competent and Transparent'), the Government stated that it intended to proceed with the EWA Extension on Grand Cayman in order to help reduce traffic problems to and from the Eastern Districts.

Travel Demand

Grand Cayman's population is spread out across the island, while employment tends to be concentrated to the west around George Town. A geographical distribution is shown in Figure 7 below.

This means that patterns of traffic are subject to a 'funnelling' effect with a large number of westbound movements being experienced during the morning peak and eastbound in the evening peak, but largely dissipating as one moves further eastwards.

Figure 7. Distribution of Population and Employment on Grand Cayman



Source: NRA

It could be argued from the above patterns that there is less justification for new road infrastructure serving the eastern neighbourhoods of the island, owing to the lower residential density. This is compared to recognised 'pinch points' further west where there is a greater need to manage conflicting streams of traffic.

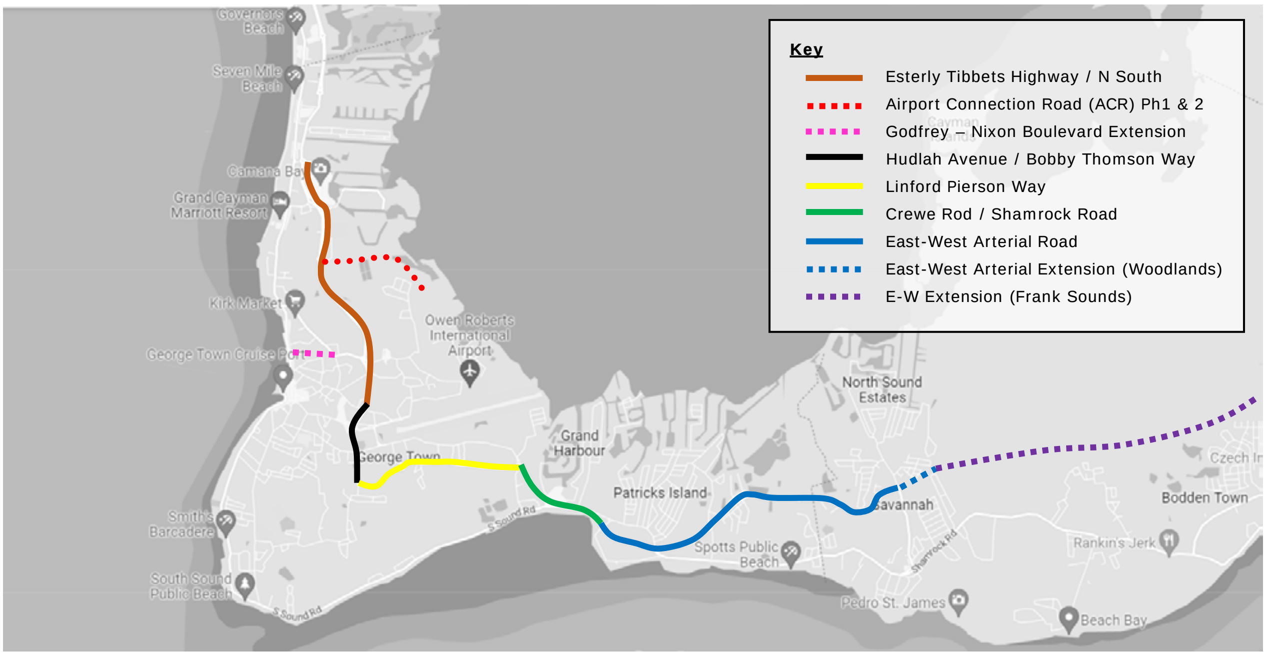
The existing single carriageway road links in Eastern Districts meet the expected demand for car travel, although improvements to junction capacity cannot be excluded in helping to smooth out issues in certain locations.

Existing Infrastructure

The extent of the road network matches observable residential and employment patterns/densities, with a concentration of the 'higher order' primary roads and dual carriageways increasing towards George Town. From a hierarchical point of view, the various residential areas feed traffic to the primary highway network from a number of secondary roads, which themselves are served by tertiary streets.

In these more heavily trafficked areas, the primary roads include the Esterley Tibbetts Highway, Bobby Thomson Way, Linford Pierson Highway which connect with the existing EWA. Together these all form a main 'spine' serving approximately one third of the island. This is shown in Figure 8.

Figure 8. Primary Road Network and Projects



Given that these areas are those subject to the greatest demand by traffic, they have consequently been the subject of recent highway infrastructure improvements. These have included the following[5]:

- Widening of Linford Pierson Highway (to three lanes). See Figure 9.
- Widening of Shamrock Road (between Grand Harbour and Crewe Road. See Figure 10.
- The CUC roundabout improvement project (King's Sports Centre)
- The Airport Connection Road (ACR)
- Godfrey – Nixon Boulevard Extension

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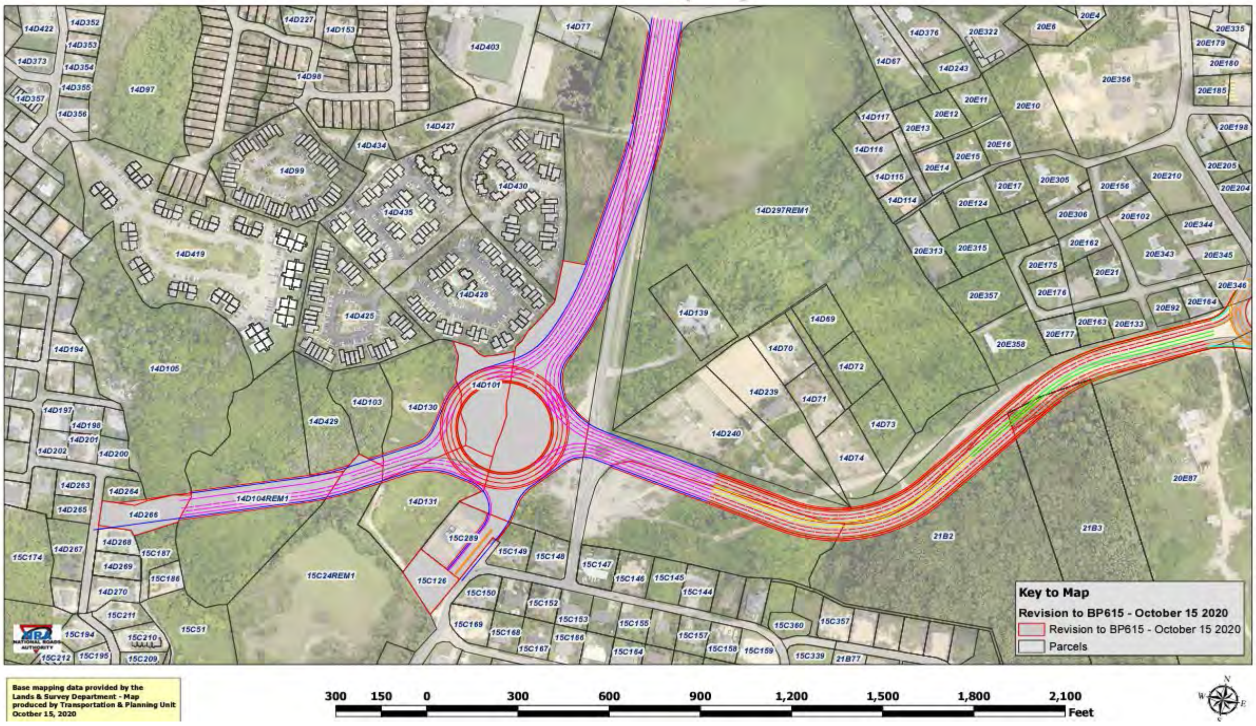
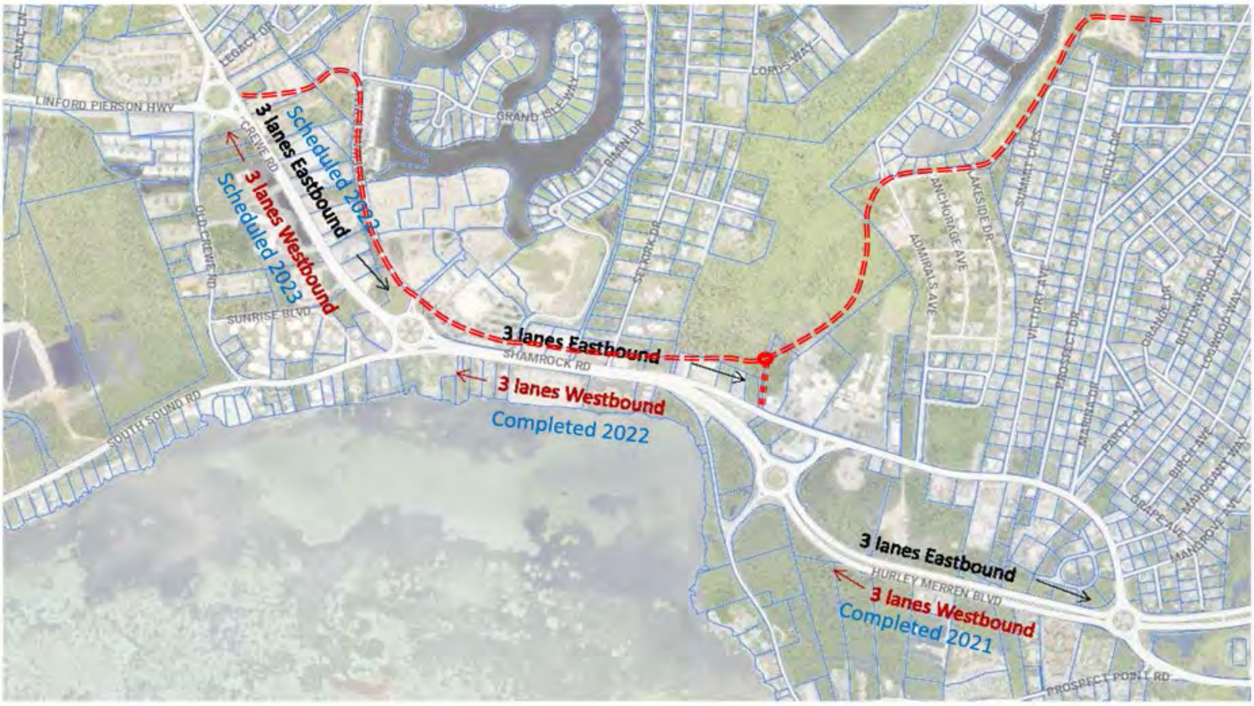
[5] https://www.caymancompass.com/2020/02/17/road-projects-focus-on-quick-wins/

Figure 9. Proposed Linford Pierson / BTW Highway Works (under construction)



Source: NRA[6]

Figure 10. Crewe Road, Shamrock & Hurley Merren Boulevard Widening Works



Source: NRA[7]

6 https://www.caymanroads.com/upload/files/3/622b6baecbb65.pdf

7 https://www.caymanroads.com/documents/HURLEY-MERREN-BLVD-6-lane-EXPANSION-20220405133932.pdf

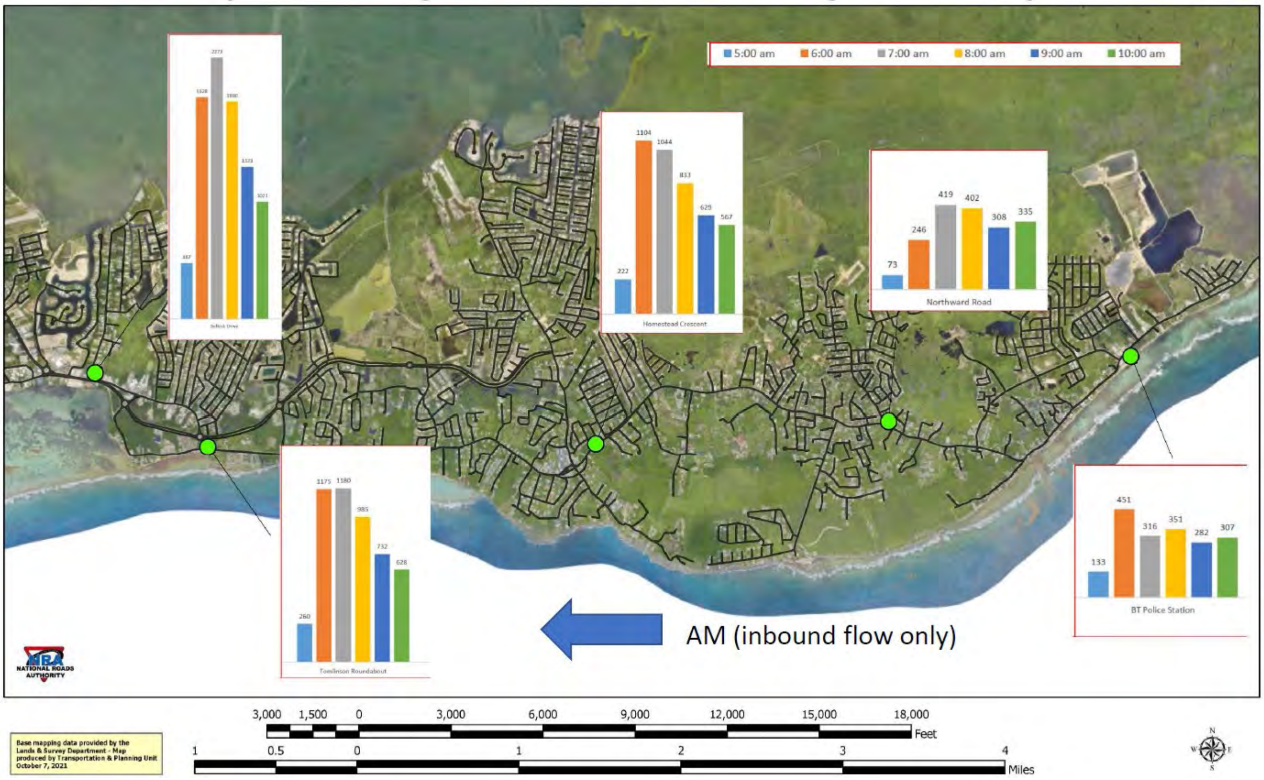
Widening of the existing East-West Arterial Road has also taken place on Hurley Merren Boulevard (3-lanes) and further sections are planned to be upgraded further east.

4. Existing Conditions

Traffic Data

Existing traffic flow information form the NRA is presented below in Figure 11, covering the AM peak period (05:00-10:00).

Figure 11. Traffic Flow (AM Peak – Westbound)



Source: NRA

The traffic data suggests that the existing primary road east of Savannah accommodates a maximum westbound traffic flow of c.1,000 vehicles per hour (vph) on Shamrock Road (at Homestead Crescent). This decreases by half (c.400-500) further east at Northward Road, with a further reduction to c. 300-400 at Bodden Town Road.

On the face of it, the recorded traffic volumes should be within the link capacity of the road network to accommodate, as the directional limit of single carriageway road (7.3m) would be between 1,300-1,500vph depending on the degree of frontage access.

The levels of traffic recorded on the eastern sections would not seem to justify the creation of the EWA Extension, based on current traffic flows.

Even if one was to account for the anticipated level of growth in the eastern districts, and the consequential increase in traffic that would occur as a result, it is difficult to see how the NRA could justify any infrastructure beyond the Hirst Road / Shamrock Road connector (see Figure 19). While Section 2 (Hirst Road to Lookout Gardens) may be seen as an opportunity to release further land for development, it would not appear to be justifiable based on highway capacity alone. The case for Section 3 is even more doubtful on traffic grounds alone.

It is noted, however, that journey time reliability is an important consideration for the NRA, with the following plots shown in Figure 12 and 13 being used to show the variability in the accessibility levels from the North Shore areas.

Figure 12. AM Peak Westbound Journey Times

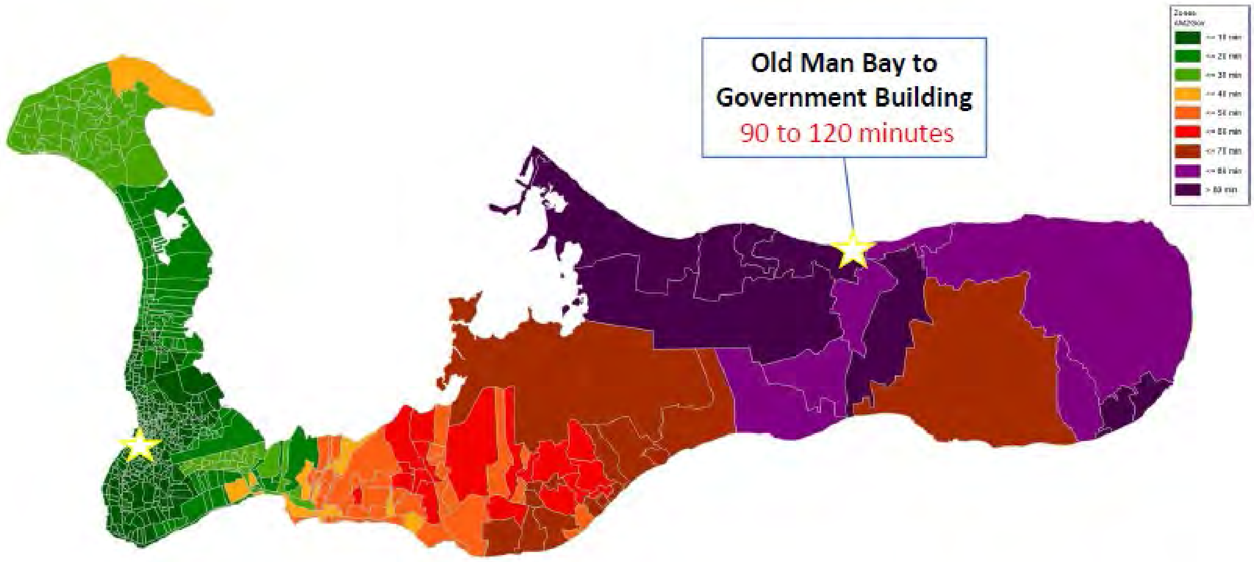
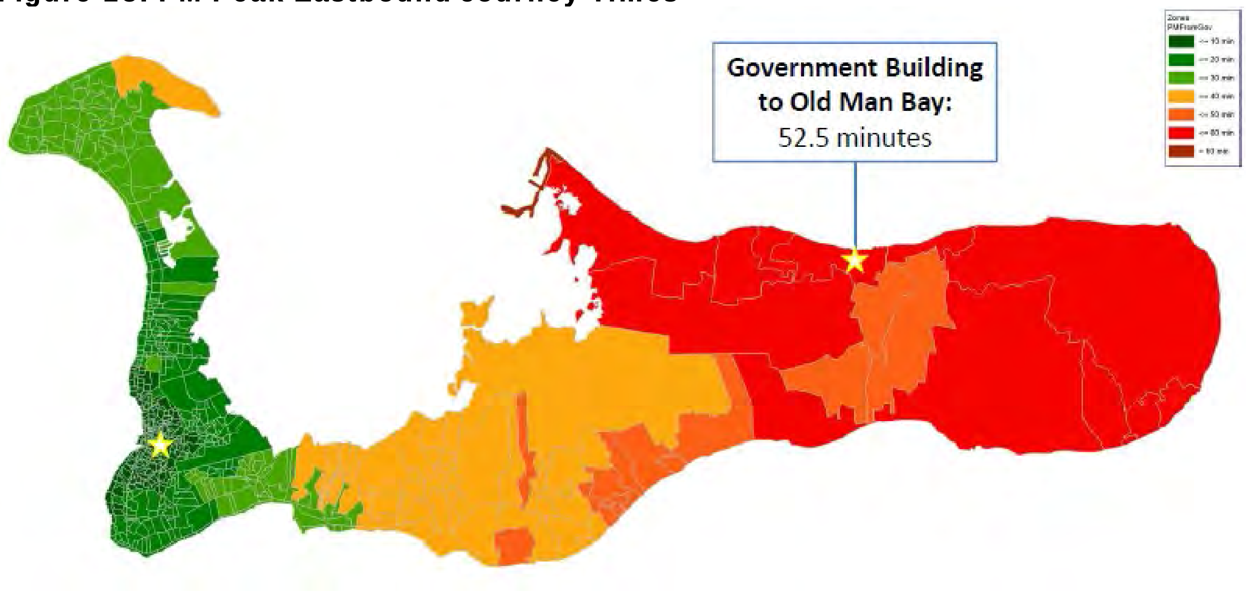


Figure 13. PM Peak Eastbound Journey Times



The following journey times are presented for the following ‘intervention’ scenarios:

- Status Quo.
- Bobby Thompson Way widening (4 lanes).
- East-West Arterial (to Lookout Gardens) only.
- East-West Arterial + Bobby Thompson Way widening.
- East-West Arterial + Bobby Thompson Way widening + Shamrock Road West widening 6 lanes.

The review of the journey time benefits for the different scenarios are presented in Table 1.

Table 1. Journey Time Benefit from different scenarios

AM PEAK HR (6:30 am to 8:30 am) OLD MAN BAY to GOVT Admin Building				
Status Quo (i.e. marginal improvements)	BTW (4 lanes) Widening only	E-W Arterial (to Lookout Gdns) only	EWA + BTW combined	EWA + BTW + SHAMROCK (6lanes)
90 mins to 120 mins 13 mph avg spd	**~75 mins** 15 mph avg spd	**~75 mins** 15 mph avg spd	**~62 mins** 18 mph avg spd	**45-50 mins** 28 mph avg spd

PM PEAK HR (4:30 pm to 6:30 pm) Govt Admin Building to Old Man Bay				
Status Quo (i.e. marginal improvements)	BTW (4 lanes) Widening only	E-W Arterial (to Lookout Gdns) only	EWA + BTW combined	EWA + BTW + SHAMROCK (6lanes)
50 to 60 mins 19 - 23 mph avg spd	**~57 mins** 20 mph avg spd	**~54 mins** 21 mph avg spd	**~50 mins** 23 mph avg spd	**~45 mins** 25 mph avg spd

Source: NRA[8]

The above data suggests that much of the journey time benefits reported for the EWA Extension, when taken in isolation, are similar to those that would be achieved through the widening of Bobby Thomspon Way, i.e. from 90 to 75 minutes in the AM peak and from up to 60 minutes to 57/54 minutes in the PM peak.

In combination, both schemes would achieve further journey time savings in the AM peak but with more marginal benefits in the PM peak.

Overall, what the above data suggests is that the effect of infrastructure improvements taking place on existing highway corridors (i.e. Bobby Thompson Way and Shamrock Road) would be far greater than those which could be achieved by the EWA Extension.

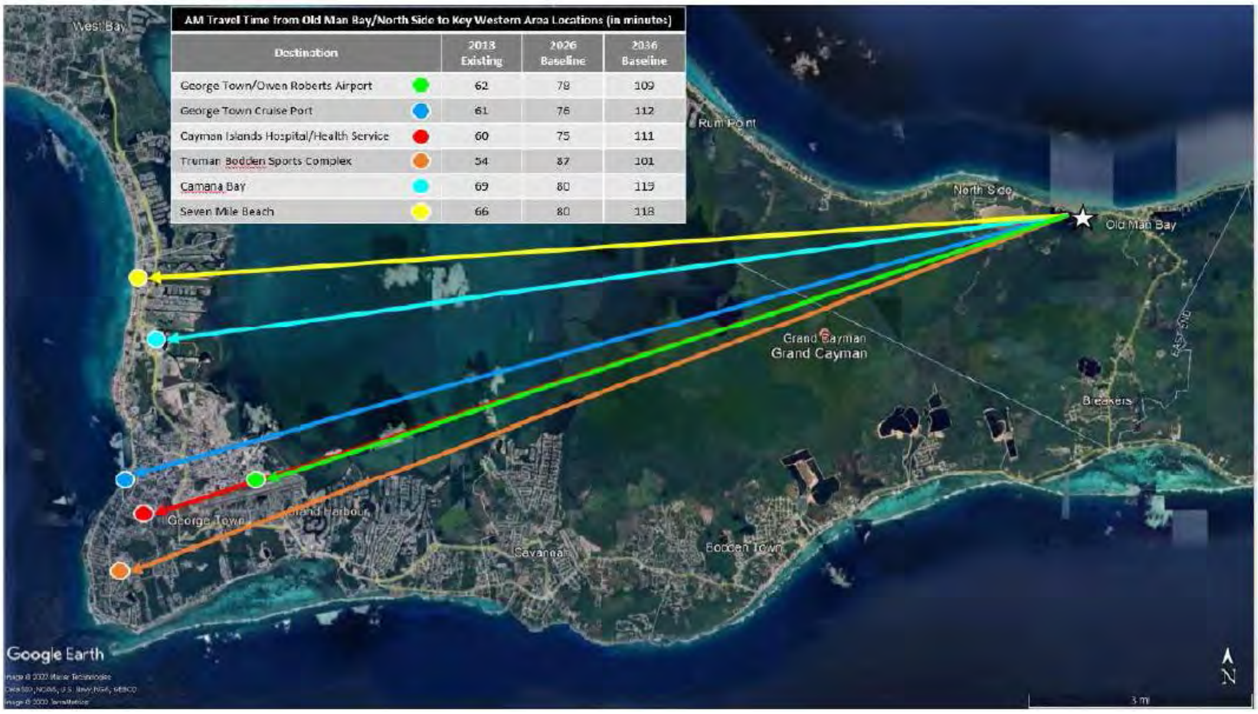
It would therefore seem beneficial to prioritise those infrastructure projects that rely on the existing roads, rather than through the creation of new roads, with the environmental implications that this would entail.

It is also the case that all of the journey time information is presented for an Origin-Destination (O-D) involving 'Old Man Bay' to destinations in George Town (see Figure 14). In reality, this will only apply to a much smaller proportion of the overall traffic on the island.

Focusing on the longest trips is therefore likely to 'skew' the apparent benefits of the EWA Extension when in fact the majority of drivers will be making shorter trips and not using the sections in question (most particularly Section 3).

[8] https://www.caymanroads.com/upload/files/4/62509727cb477.pdf

Figure 14. Journey Times to Key Destinations from Old Man Bay Under Different Scenarios.



AM Travel Time from Old Man Bay/North Side to Key Western Area Locations (in minutes)

Destination	2018 Existing	2026 Baseline	2036 Baseline
George Town/Owen Roberts Airport	62	78	109
George Town Cruise Port	61	76	112
Cayman Islands Hospital/Health Service	60	75	111
Truman Bodden Sports Complex	54	87	101
Camana Bay	69	80	119
Seven Mile Beach	66	80	118

Source: NRA

A more appropriate comparison would be to consider journey times from Bodden Town, which is forecast to experience greater levels of future (already zoned) growth, and thus traffic.

For 'intermediate' origins/destinations such as these, car journeys would likely benefit disproportionately from the accessibility that would be provided by the Shamrock Road connector (Figure 19) and, to a lesser extent Section 2 of the EWA Extension, which could provide some relief to the existing corridor.

Other highway improvements could be implemented to provide further East-West connectivity through corridors that are parallel to Shamrock Road, but without resorting to the level of infrastructure proposed through the EWA Extension. One example would be to progress with the construction of Gazetted route BP40 (see below), which would increase the number of East-West routes between Bodden Town and Shamrock Road (at the Countryside Shopping Village). This would provide some additional capacity while serving areas zoned for development.

What is clear, however, is that the lower levels of traffic experienced on roads between Bodden Town, Frank Sound and North Side are less likely to lead to vehicular delays, as the traffic recorded will not trigger the link capacity thresholds on the relevant roads. As such, the same comparative journey time benefit, and therefore the business case, will be much weaker for Section 3 of the project.

Even then, it has been proving that the pinch-points are not in Bodden Town itself but further west where traffic from multiple locations converge. It has already been shown by the NRA that these issues are being addressed by existing infrastructure improvement proposals.

The case for the EWA Extension is therefore unfounded on the grounds of providing vehicular traffic benefits alone.

Public Transport

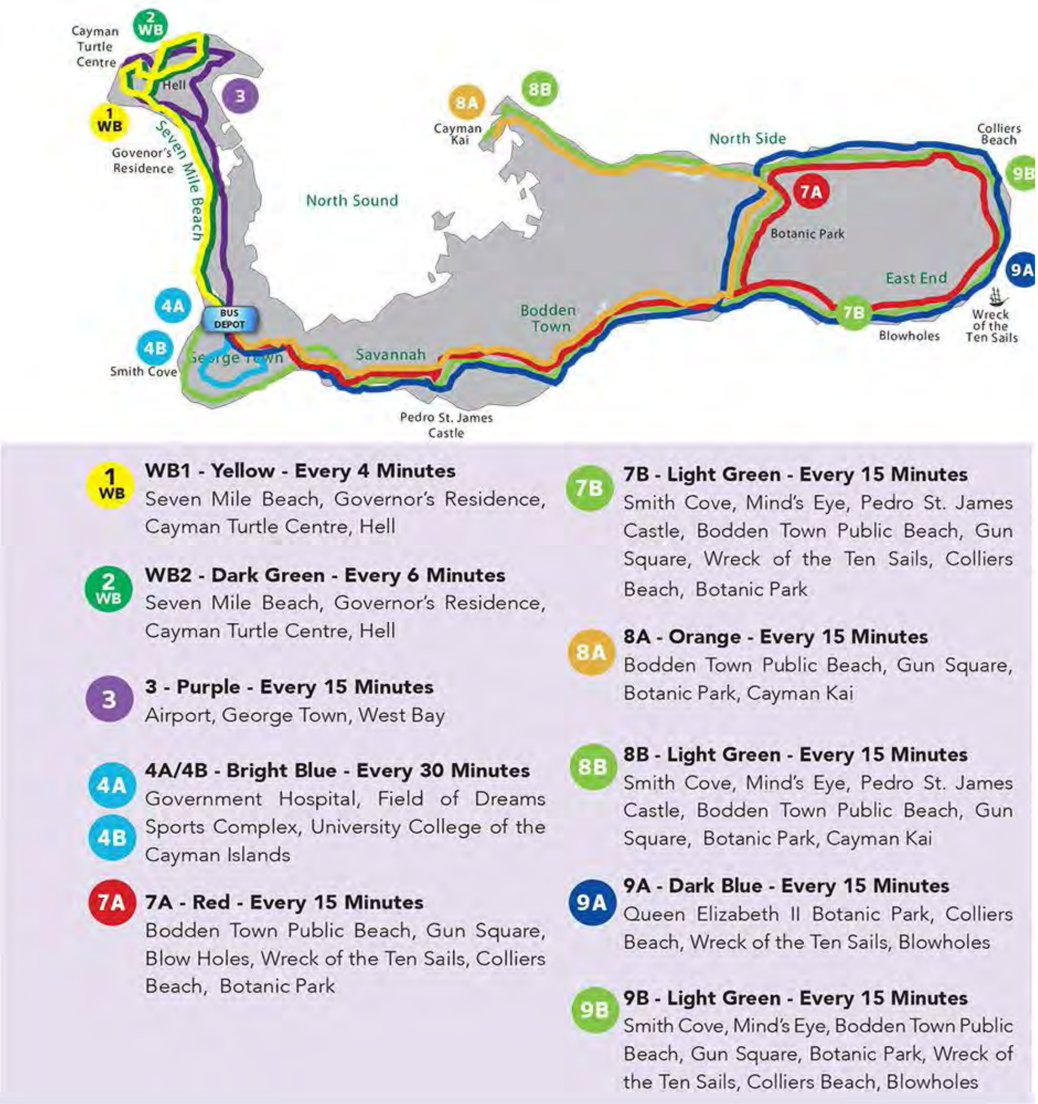
There are eleven bus routes operating across Grand Cayman with 125 designated bus shelters and bus stops dotted across the island. Figure 15 shows the extent of the network.

All routes run to and from the bus depot in central George Town, where there is a Public Transport Inspector on duty from 7am-7pm Monday-Friday to supervise all bus operations. Limited services are provided on a Sunday. Most buses comprise a 'mini-bus' type of operation, carrying between 14-29 passengers. These are run by private operators rather than the public sector.

Because of the private nature of the operation, it is understood that there have been anecdotal reports and complaints that buses will go to Bodden Town and Frank Sound (from George Town) on a regular basis but will often turn around and drive back to town rather than complete their route around to North Side and East End, especially if their bus is empty.

There has also been much speculation that congestion issues associated with the volume of traffic on Grand Cayman could encourage the Government to implement peak-time bus services using more conventional buses.

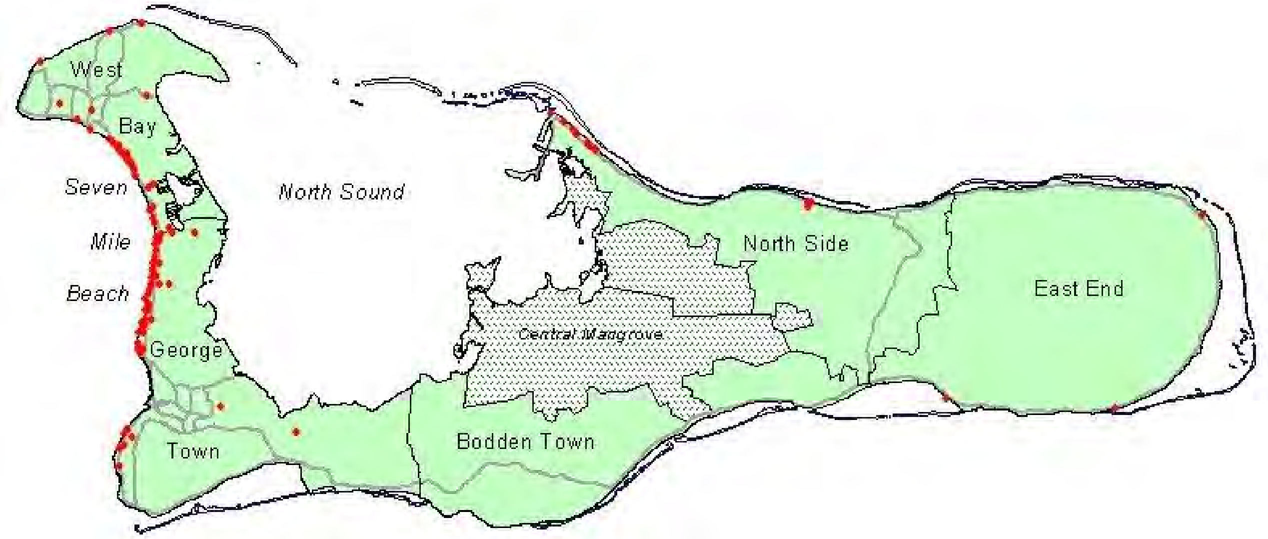
Figure 15. Public Transport (Bus) Network



5. Transport-related Environmental Considerations

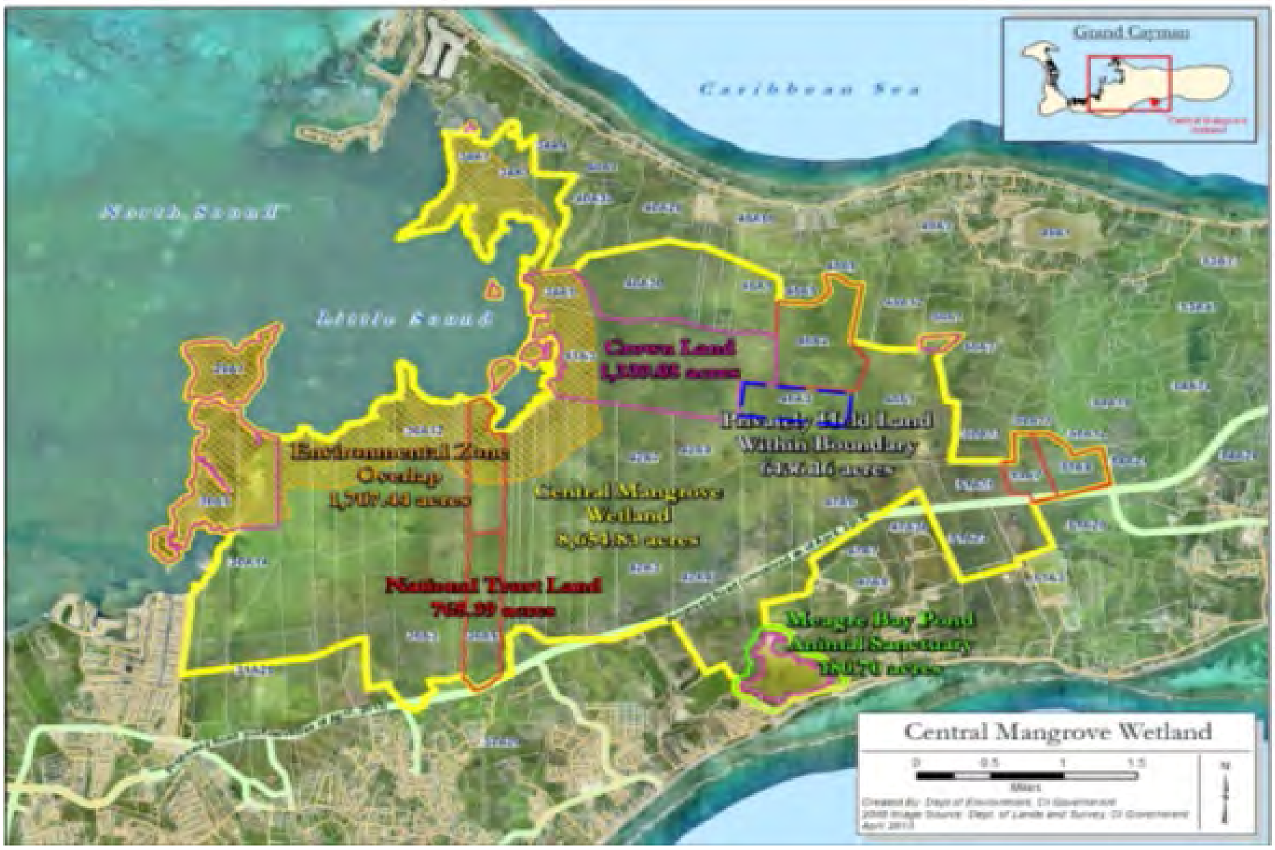
As shown indicatively below in Figure 16 and 17, the project would cross environmental sensitive areas, including areas covered by the Central Mangrove.

Figure 16. Extent of Mangrove Areas



Source: The Application of a Spatial Decision Support System to Tourism-Based Land Management in Small Island States (2000)

Figure 17. Extent of the Central Mangrove (with Longer-Term Road Plan)



Source: Department of Environment

The method of construction for the road would need to respond appropriately to the hydrology of the Mangrove areas in order to ensure its hydrology is not affected.

This goes as much for the tidal movement of waters as it does in terms of the means of treatment for the road drainage, including what methods would be adopted for intermediate treatment through appropriate means of attenuation (and petrol interceptors).

At this stage, little has been presented relating to the proposed design for the project to reach a judgement on the conformity of the design and how sensitive it has been to the geography and ecology along the proposed alignment. More sensitive environmental solutions may also have an increased cost, which then needs to feed back into the Benefits/Cost ratios for the scheme.

A study[9] in 2018 highlighted the risk that the Government's economic growth priorities may be contributing to further habitat loss in Grand Cayman. It states that:

> *"The demand for real estate by international investors initially attracted by the island's financial services, along with that of the professionals employed to provide these services, has been one of the key drivers of mangrove wetland clearance. Interview results suggest the hypothesis that these dynamics have persisted due to the alignment of political forces that has emerged in their defense: a state structurally-dependent on development fees for revenues and dependent for political support on landowners and the development and real estate industries."*

While the above statement strays into the political sphere, it would appear to be the case that the rationale for the EWA Extension is partly driven by a need to improve the accessibility to land for development, more than it would be about meeting some marginal journey time savings from populations located furthest away from the (employment) poles of attraction.

The resilience point, including improving access for emergency vehicles, could potentially be met through other means (e.g. BP40, see below).

6. Alternative Interventions

Approach to the Assessment

In determining the benefits arising from the project, any comprehensive assessment cannot be done in isolation from considering other measures that could be implemented to achieve similar aims. This is because:

- Most business cases should rely on a sequential assessment of the following:
  - The Strategic Case
    - Is there a robust case for change?
    - What is the outcome that this scheme is trying to achieve?
    - Is the proposed scheme the best way of achieving the outcome?
  - The Socio-Economic Case
    - What are the benefits to users and the environment?

[9] Environmental destruction in the new economy: Offshore finance and mangrove forest clearance in Grand Cayman' Geoforum, Volume 97, December 2018, Pages 155-168

- The Commercial Case
  - What are the full costs of the scheme? Is the Benefit Cost Ratio (BCR) positive?
  - Is the project viable, both in terms of capital construction and maintenance (i.e. whole life cycle)?
- The Financial Case
  - Where are the funds going to come from (e.g. capital investment, private toll)?
- The Management Case
  - Are the institutional frameworks compliant with the on-going operation of the project.

- The EIA process usually requires an assessment to be conducted of what the 'reasonable alternatives' would be to the project.

In both cases, the assessment of the project should look to present the variety of options that exist to deal with the identified issue(s), to determine if the choice of scheme is the optimal way to address the problems that are being experienced.

Such an assessment should also prove that the BCR of the project are positive and that it confers sufficient value-for-money to justify its implementation.

At this stage, it is not known if the design of the road will have progressed to an extent where detailed construction costs can be established to inform that value-based assessment.

One particular aspect would be to outline if the total costs of the project, including all associated construction and environmental mitigation, has been detailed.

Environmental Impact Assessment

The EIA Scoping Report[ii] (2023) considers Section 2 and Section 3 together, however, the impact/benefit equation for the two sections will be very different. East of Bodden Town, the traffic levels make it difficult to justify the EWA Extension, in part or in whole.

The robustness of the EIA will also depend on specifying a set of realistic 'reasonable alternatives'. In this respect, at present the document covers the following:

- Scenario 1a-1x: This is limited to consideration of 'alternative alignments' of essentially the same roadway scheme. The inference is that those different alignments (and methods of construction, including option from 'bridged' sections to address the flooding concerns) would be considered in determining the best road option to take forward.
- Scenario 2: A 'no build' option which will be a means of demonstrating how worse existing conditions would be without the scheme. This seems to be considered as a mere counterpoint to skew the balance of benefits for Scenario 1.
- Scenario 3: Improvements to Bodden Town Rd, but with the pre-judged conclusion that such an option would have implications for a need to acquire property resulting in residential/commercial relocations.

While the EIA study intends to consider alternatives, these seek to pre-judge the merits of the EWA Extension scheme, with a focus of the assessment being on different alignments. The assessment ought to:

- Consider EWA Section 2 and Section 3 separately and in combination. This is because the merits of one may be very different in technical (and environmental) terms than the other.
- Consider different configurations of the two sections involving single carriageways and dual-carriageway options. This is because the underlying data does not support a requirement for consistency in terms of the level of infrastructure required along the route of the EWA Extension.

Other interventions could also have formed part of a more holistic approach to the assessment of the congestion problems experienced on the island, against the objective of securing longer-term sustainable growth across the island, from a 'menu' comprising the following:

Alternative Road-Based Schemes

New or Improved Highway Corridors

The EIA Scoping Report[ii] (2023) itself identified the following alternatives:

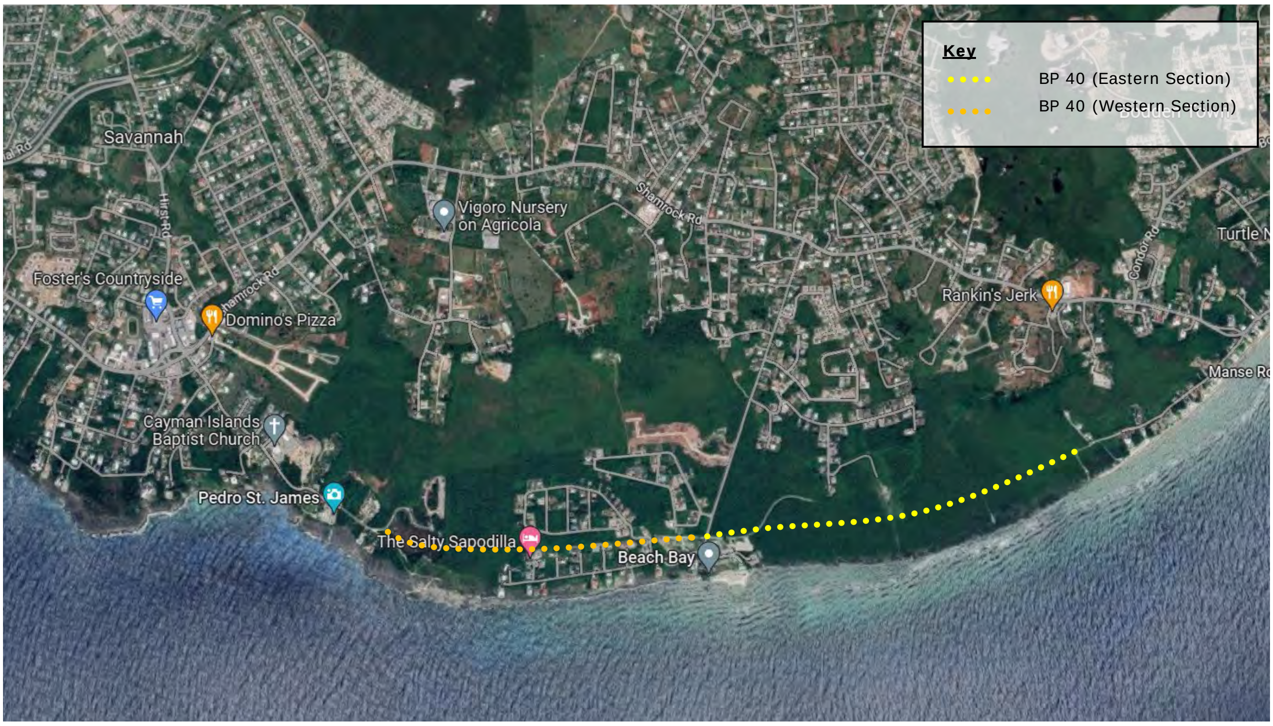
- Gazetted Corridor option: This would include improvements to existing road corridors, mainly around the elevation of roadways in places to facilitate proper drainage and reduce the risk of causing flooding.
- Bodden Town Rd improvements: This would provide alternative routes for emergency vehicle passage when the road is compromised; dedicated lanes for transit and safe pedestrian/bicycle use. Adding or widening lanes may create a need to acquire property resulting in residential/commercial relocations.

As one of the objectives of the East-West Arterial Extension is to provide additional highway capacity to meet East-West demand, other improvements could be made to increase the number of other East-West road corridors.

The coastal road referred to as BP40, for example, was gazetted in 1979 but was never constructed. As shown in Figure 18, the alignment would stretch from Manse Road to Pedro Castle, with an intermediate connection with Beach Bay Road.

It is understood that the construction of the section from Manse Road to Beach Bay Road is being advanced through an agreement between the Government and the developer of a new 'The Residences at Mandarin Oriental' accommodation scheme.

Figure 18. Gazetted Road Alignment BP40 (Indicative)



Some observations on this route are that:

- It would provide additional resilience for emergency vehicles, as this would offer an alternative to Shamrock Road.
- Its alignment is more in keeping with the patterns of land zoned for future development.
- It would facilitate greater connectivity with existing residential, employment and tourism areas around Bodden Town, leading to a greater potential for 'local living'.
- It would provide additional connectivity for potential public transport services.

The nature of the underlying geology (i.e. coastal bluff) means that:

- Lower costs of construction as it requires comparatively less excavation and fill.
- The land also sits much higher above sea level compared to lower levels of areas situated in other wetland areas (where parts of the East-West Arterial Extension would be sited)

The topography of the BP40 route therefore offers greater resilience to storm surges/overtopping events, which was one of the justifications advanced for the EWA Extension.

In this respect, it is interesting to note that Page 48 of the EIA Scoping Report states that:

> *"No generally accepted, delineated floodplain mapping exists for the Cayman Islands; however, the proposed EWA Extension corridor, like much of Grand Cayman, is low-lying and likely vulnerable to tidal flooding and hurricane/tropical storm-associated flooding, both of which can create numerous potential hazards."*

The alignment for the BP40 route could therefore achieve similar resilience benefits in a much shorter time frame than the East-West Arterial Extension and with less consequent impacts.

Other 'Pinch Point' Locations

As outlined above, there are a number of highway infrastructure schemes which have been proposed or are under construction.

Understandably, these schemes are located towards the western part of the island, where the higher traffic levels are experienced.

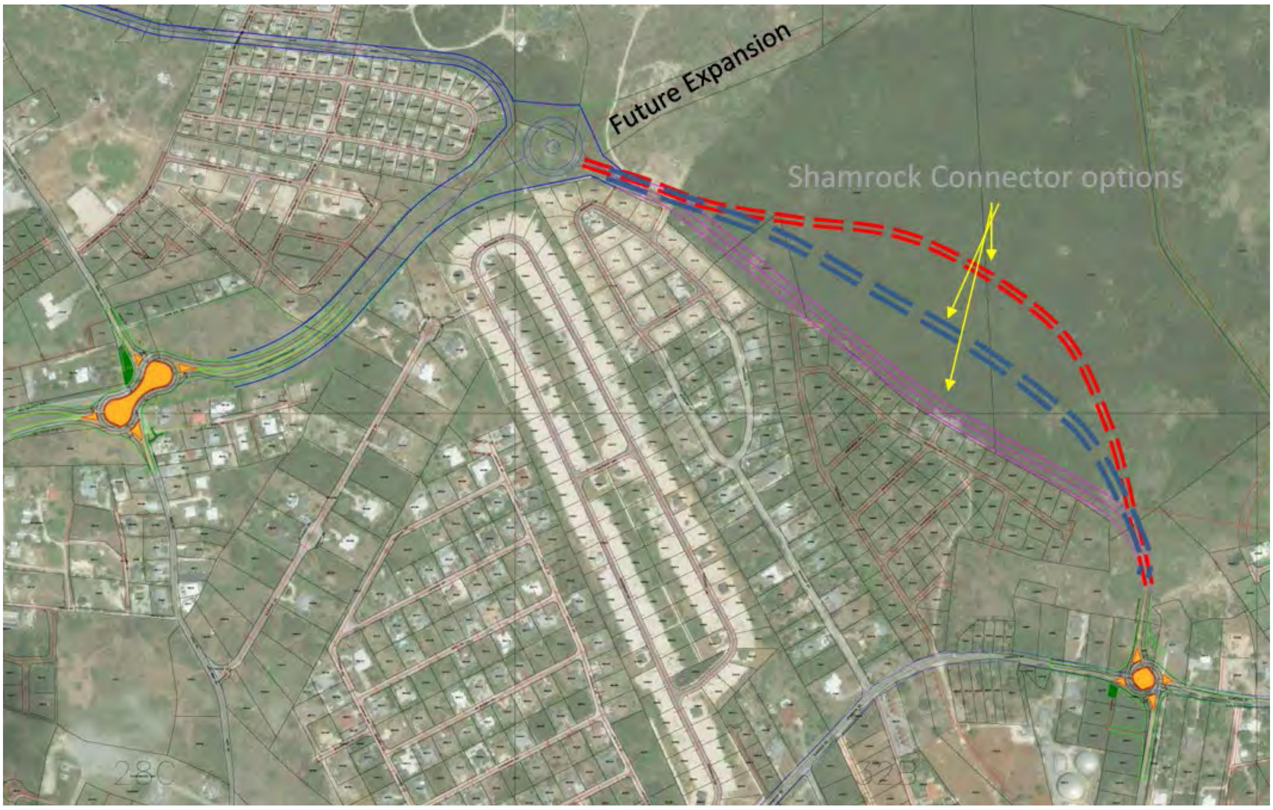
In the context that some of these schemes have not yet been fully completed, nor established a new degree of equilibrium in terms of network operations, it is too early to establish the journey time savings benefits that they will offer.

It is also the case that these schemes are likely to have a greater effect overall, because they will cater for the needs of a greater number of users than the EWA Extension project would, especially Section 3.

As such, there may be highway schemes that could achieve improvements to network operations in other locations where greater journey time benefits could be achieved.

The Woodlands-Shamrock Road scheme (shown in 'in green' in Figure 19) would deliver an important link in itself to the existing EWA, providing some relief for traffic on Shamrock Road.

Figure 19. Snapshot of E-W Arterial Extension (Section 1)



Source: NRA[vii]

The potential could also exist to create a bus gate on Shamrock Road, so that most vehicular traffic (except for intermediate local access) would be diverted to the existing EWA. This is discussed further below.

Bus Services

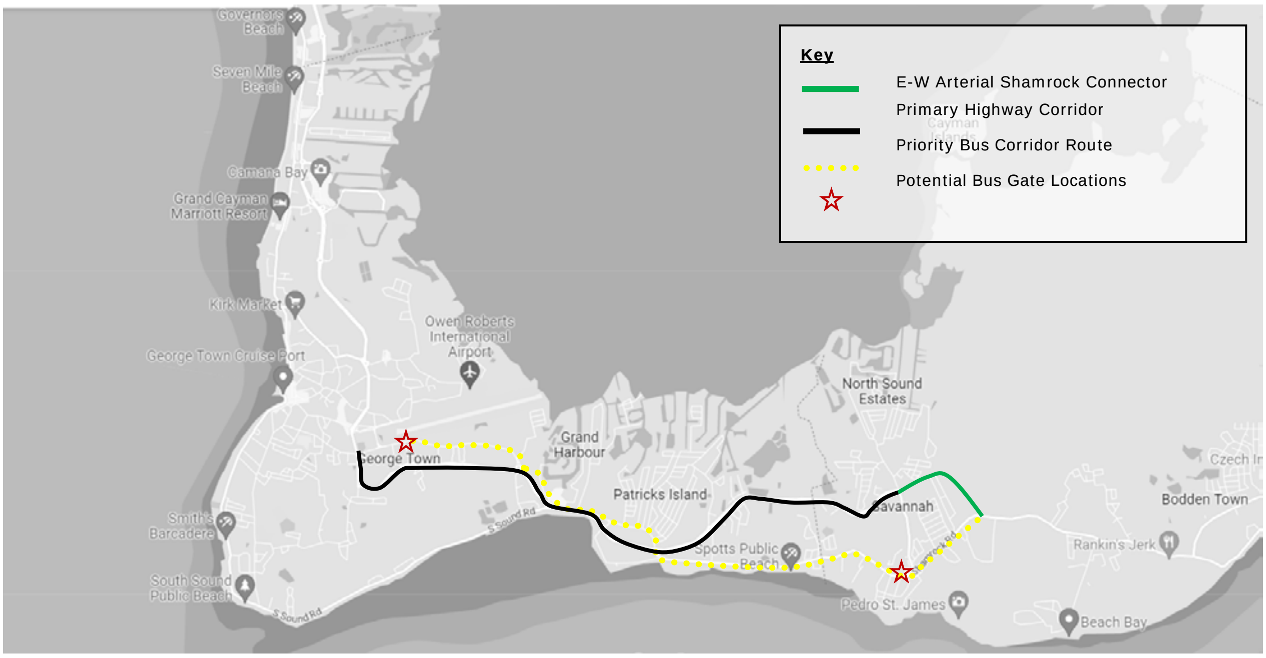
Bus services are largely a private sector affair and, while that is not necessarily a bad thing, there is scope for the Government to take a more active role in the provision of bus services in order to encourage greater modal shift.

While the main focus of infrastructure improvements has been on carriageway lane widening, bus priority measures could be included at key 'pinch points' or junctions to reduce bus journey times (comparative to the car) or improve reliability.

Short sections of bus lanes on the approach to roundabouts or signal optimisation at controlled junctions could be considered as part of future plans.

The Shamrock Road Connector to the EWA (Section 1) at Hirst Road could provide some traffic relief for Shamrock Road while allowing an element of priority to be provided for buses and cyclists. This could be further facilitated by carefully placed bus gates, as shown for example in Figure 20.

Figure 20. Potential Public Transport / Cycle Priority Corridor



The bus gate would balance the priority for traffic to use the existing EWA, while providing a more sustainable modes focused corridor for travel East-West to/from George Town.

Buses are able to make use of existing roads, with strategically positioned bus gates that would remove elements of through-traffic. This would provide semi-priority corridors and more reliable journey times (while maintaining vehicular access to existing properties).

The reduced traffic on re-allocated secondary routes would be conducive to an increase in cycling.

Cycling

The idea of a National Cycle Network for Grand Cayman could have a degree of traction locally. The topography and favourable weather on the island would generally be favourable for cycling.

In urban areas, this could be a substitute for short-distance car trips which would in turn provide some capacity relief.

A comprehensive plan would have the benefits of linking together what can appear to be a disparate and dis-jointed network of cycle infrastructure together and promote a more consistent messaging around the benefits of cycling.

Water-Based Transport

Many of the issues highlighted by the NRA are the journey time issues experienced by longer-distance car travel from communities on the North Side and Eastern District. Given the travel times and the unique geography of Grand Cayman, options could be looked at for introducing water-based transport options across North Sound (e.g. Water Cay – Camana Bay) with onward public transport connections to George Town.

Demand Management

Focusing on alternative demand management measures should also be looked at in greater detail, in managing down rather than simply accommodating the traffic impacts of future growth.

Car Parking

For example, people's decision to use the private car for some journeys will be dependent on the availability and price paid for car parking at their destination(s).

A review of car parking charging within George Town would offer a means of determining the travel choice sensitivities, as this would influence the volumes or frequency of vehicular trips.

At the other end of the spectrum, some towns and local authorities in other parts of the world have implemented Workplace Parking Levies for businesses, in areas where the stock of public car parking is otherwise lower overall.

The benefits of such demand management measures can include:

- A reduction in vehicle miles, which would comply with sustainable development principles, by tackling the climate crisis.
- The opportunity for additional revenue generation created could offer a means of funding better public transport services (or other forms of sustainable travel) across Grand Cayman Island, which in turn would act as a further incentive for modal shift.

Vehicle Taxation

From Census information published in July 2022, it is estimated that 79.9% of households own a motor vehicle, with an average of 1.7 per household[ix].

There is also evidence that car ownership rates have increased faster than population growth, which creates additional pressures on the road network.

Figure 21: Population and Vehicle Ownership

Source: Economic and Statistics Office (ESO)[10]

Some form of differentiation in the taxation regime for households with higher multiple vehicle ownership (e.g. >2 cars) could be employed to ensure the majority of Caymanians continue to have access to a primary vehicle, but without encouraging a family's reliance on excessive ownership.

Road Pricing

While perhaps a more locally controversial suggestion, many cities have considered different methods of road pricing, including time-limited congestion charging or toll roads, to ensure a better spread of traffic within the peak hours or geographically-based restrictions, supported by investment in public transport infrastructure (e.g. Park and Ride).

Active Travel

The substitution of short-distance car trips for walking and cycling journeys could be delivered with greater investment in local pedestrian and cycling infrastructure.

Such measures would be best suited to built-up areas, such as in and around George Town, where the potential for short journeys exist. This would reduce the impact of background traffic, releasing traffic capacity for use by longer-distance car users.

The School Run

The latest 2021 Census data, shown in Table 2 below, indicated that around 67% of all persons attending school do so by private car. Conversely, the number of students using walking and cycling is low.

10 The Future of the Rush Hour: The Story in Data, Cayman Compass (June 2022)

Table 2. Persons Attending School by Type of School and Main Means of Transportation to School (20210

	Total	Day Care / Nursery / Preschool	Primary School	Middle / High / Secondary School	Vocational Institution	Community College	University / College	Special Education	Other	DK/NS
Total	**14,664**	**1,647**	**4,519**	**4,287**	**151**	**369**	**3,211**	**130**	**289**	**61**
Private Vehicle	9,937	1,575	3,774	2,590	65	271	1,521	60	74	9
School Bus	2,060	11	553	1,343	13	23	52	58	6	-
Public Bus	221	3	16	45	1	15	135	4	1	-
Walking	333	19	59	66	3	3	179	-	3	-
Bicycle	27	-	5	10	1	-	11	-	-	-
Taxi	16	-	-	-	-	1	15	-	-	-
Motorcyle/Moped	5	-	-	-	-	1	4	-	-	-
Boating	6	-	2	-	-	-	1	1	1	1
None	1,821	21	65	187	64	47	1,227	6	195	8
DK/NS	238	17	45	47	3	8	66	1	8	43

Source: Economics and Statistics Office Government of the Cayman Islands[11]

School travel planning or the creation of a 'Safer Routes to School' programme, supported by low-impact improvements to infrastructure in key places could encourage more students to use sustainable modes, thereby reducing the dependence and (particularly in the morning).

Another alternative would be to undertake a study into the potential introduction of free or discounted bus travel to all students.

7. Conclusions

The preliminary conclusions which can be drawn from this high-level review are as a follows:

- Spatial planning in Grand Cayman is characterised by the concentration of employment (and to a lesser extent retail) in western areas of the island.
- This creates a 'funnelling' effect whereby there are high levels of traffic at peak times; westbound in the morning and eastbound in the evening.
- The pressures caused by traffic has led the National Roads Authority (NRA) to propose and construct a number of significant road infrastructure projects, including:
    - The widening of Linford Pierson Way, Crewe Road / Shamrock Road and existing sections of the East-West Arterial Road.
    - A slight extension to the E-W Arterial Road is being constructed from Hirst Road to Woodlands, with a future extension eastwards to Shamrock Road.
- Increased development and zoning for development in the eastern regions are likely to put some additional pressures on traffic.
- The proposal for the East-West Arterial Road Extension is for a 49m corridor (160ft) comprising three lanes in each direction, central medians and cycle tracks. It represents a significant level of infrastructure investment which is incongruous with the natural character of the surrounding area.

11 The Cayman Islands' 2021 Census of Population and Housing Report (July 2022)

- The traffic flows (present or future) would not justify this level of infrastructure, from the existing or forecasted 'with future growth' projections.
- The analysis completed by the NRA suggests that:
    - o The greatest journey times benefits arising from the proposed E-W Arterial Extension will be felt from origins/destinations beyond Frank Sound. However, these will affect relatively fewer people.
    - o Other infrastructure schemes could deliver equal or greater journey time benefits as the E-W Arterial extension project, particularly as they would apply to a greater number of road users.
- The analysis of available traffic data suggests that, further east, the volumes of vehicular movements are of an order (i.e. 300-400vph each way) which the existing capacity of a single carriageway (c.1300-1500vph) would be capable of easily accommodating.
- There would appear on the face of it to be little highway link capacity justification for a further continuation of the EWA eastwards under current spatial planning conditions. The immediate rationale for the Section 3 of the E-W Arterial Road are particularly difficult to justify on highway capacity or journey times alone.
- For users with 'intermediate' origins/destinations such as Bodden Town, some journey times benefits could arise from the Shamrock Road Connector (See Figure 19) to Hirst Road, as this has the potential to provide some relief to existing areas along Shamrock Road.
- However, there will be some significant variability in the benefits arising from EWA Extension Section 2 and 3 by account of the number of users for whom these routes would be a logical choice for travel.
- It is also the case that other forms of intervention could be implemented by the Government to 'manage down' the impact of traffic through modal shift, with investment in alternative modes of transport such as public transport, active travel infrastructure and other demand management measures (e.g. parking charges, differential taxation, road pricing).
- It is also possible to add to the density of East-West routes by relying on existing gazetted road corridors such as the BP40 route, whereby:
    - o It would provide additional resilience for emergency vehicles, as an alternative to Shamrock Road but also because of the advantage of topography and geology.
    - o Its alignment is more in keeping with the patterns of land already zoned for future development, rather than relying on new 'releases' and the impacts thereof on fauna and flora.
    - o It would facilitate greater connectivity with existing residential, employment and tourism areas around Bodden Town, leading to a greater potential for 'local living'.
- This is against a backdrop of a Strategic Case for the project, which should realistically have presented the variety of options available that deal with the identified issue(s). This is similar to an EIA process that requires an assessment of all 'reasonable alternatives'.

- While the EIA Scoping Report[ii] (2023) intends to consider alternatives, these seek to pre-judge the merits of the EWA Extension scheme, with a focus of the assessment being on different alignments. In truth, the assessment ought to:
    - Consider Section 2 and Section 3 parts of the EWA project alignments separately and in combination. This is because the merits of one may be very different in technical (and environmental) terms than the other.
    - Consider different configuration of the two sections involving single carriageways and dual-carriageway options. This is because the underlying data does not support a requirement for consistency in terms of the level of infrastructure required along the route of the EWA Extension.
- Other interventions could also have formed part of a more holistic approach to the assessment of the congestion problems experienced on the island, against the objective of securing longer-term sustainable growth across the island.
- Ultimately, even if the assessment criteria were revised, the assessment should also prove that the Benefit Cost Ratio of the project are positive and that it confers sufficient value-for-money to justify its implementation. That would not be limited to the construction and maintenance costs for the scheme but also any mitigation measures that would be required to mitigate any of the environmental impacts, particularly on the Central Mangrove area.

Appendix D

Ecosystem Services Provided by Two Potential Protected Areas in the Cayman Islands

NATIONAL ROADS AUTHORITY

Ecosystem Services Provided by Two Potential Protected Areas in the Cayman Islands

NATIONAL TRUST CAYMAN ISLANDS

DARWIN INITIATIVE

PRESERVATION FOR GENERATIONS

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Childs, C., MacDonald, M.A., Bradbury, R.B. (2015). Ecosystem services provided by two potential protected areas in the Cayman Islands. National Trust for the Cayman Islands.

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Introduction

The most effective and efficient way to conserve natural areas is to prevent the conversion or degradation of intact habitat. With rapid population growth and continued development pressures, there is a recognised need for society to protect key natural areas. Not only do such natural areas ensure the conservation of biodiversity, they are also critical to the continued functioning of processes that ensure the well-being of human populations (Millennium Ecosystem Assessment, 2005). Around the world, protected areas provide livelihoods for large numbers of people and are the primary source of drinking water for many of the world's largest cities. Protected areas are also recognized as important for both ecosystem-based mitigation and adaptation responses to climate change. Well-managed protected areas yield significant benefits for human societies and national economies far beyond their boundaries (UNEP, 2014a).

In the Cayman Islands, factors such as economic success and consequent development, rapid population growth, and invasive species are taking a toll on natural areas, and the resulting deforestation threatens habitats such as mangrove wetlands and ancient dry forests. Experts insist that more protected areas are urgently needed to secure habitat for threatened and endangered wildlife (Bradley and Norton, 2009). In September 2001, the Cayman Islands Government and the United Kingdom signed an Environment Charter under which both governments committed to the preservation of the environment. The Cayman Islands is also party to a number of multilateral environmental agreements, notably the Convention on Biological Diversity ("Rio Convention"), the Convention on Wetlands of International Importance ("Ramsar Convention"), the Specially Protected Areas and Wildlife protocol to the Cartagena Convention (the "SPAW Protocol"), the Convention on the Conservation of Migratory Species of Wild Animals ("Bonn Convention"), as well as the Aichi Biodiversity Targets. These agreements place obligations on the Cayman Islands government to protect the environment and require the establishment and maintenance of a system of protected areas in order to safeguard the country's biodiversity (DaCosta-Cottam et al, 2009). Cayman's network of protected areas must therefore be expanded to maintain these international agreements. The protection of large natural areas is also important for the maintenance of natural assets such as groundwater, marine life and ecotourism attractions. The establishment of protected areas is therefore a sensible investment in Cayman's future and could have significant economic and environmental benefits for the entire community.

The National Trust for the Cayman Islands (NTCI) is a statutory body with a charter to preserve sites of cultural and historic interest in the islands as well as to provide protection for local natural resources and wildlife. As part of this charter, the NTCI has established a protected area system through the purchase and donation of private land, giving priority to areas rich in biodiversity as protection of native plants and animals is best achieved by protecting the habitats upon which they depend. The Trust owns 1341 ha of environmentally important lands including the Booby Pond Nature Reserve, Brac Parrot Reserve, Mastic Reserve and Trail, Salina Reserve, and portions of the Central Mangrove Wetland (UKOTCF, 2014). The government holds a few areas as Animal Sanctuaries as well, adding approximately 100 ha to the total (J. Olynik, personal communication, September 18, 2014). Although the National Trust manages several protected areas, until 2014 there was no protected area legislation in the Cayman Islands, and as yet no areas have been designated under the new legislation. The Cayman Islands are therefore lagging behind on international goals for protected area designation. Aichi Biodiversity Targets urge that signatories achieve 17% of total land mass for protection by 2020, yet only 5% of Cayman's natural areas are protected by the Trust. In awareness of the need to increase the number of areas set aside, in 2012 the National Trust launched the 10 x 20 Challenge to achieve protected status for 10% of the total land mass of the Cayman Islands by 2020 (National Trust, 2012). By 2014, the Trust succeeded in adding 46 ha to their protected areas on the three islands, bringing the total land under protected area designation by both the Trust and the government to 5.53% of the land mass (P. Watler, personal communication, September 12, 2014). Clearly there is still much work to be done.

What are ecosystem services?

The Millennium Ecosystem Assessment was carried out between 2001 and 2005 to assess the effects of ecosystem change on human societies and to establish actions to enhance the conservation and sustainable use of natural areas. The assessment focused on the ties between ecosystems and human welfare and, in particular, on "ecosystem services" (Millennium Ecosystem Assessment, 2005). Ecosystem services are the benefits that people receive from nature, including food production, recreation and the appreciation of nature. Other services provided by ecosystems that are not so familiar include the regulation of climate, purification of air and water, flood protection, soil formation and nutrient cycling. Environmental assets, like other assets, provide benefits that improve economic performance and social progress. Enhancing or diminishing the condition of environmental assets, our natural capital, can then increase or reduce the benefits we can derive from them in the future. It is important to understand what ecosystem services are provided to us by our natural areas and what the consequences may be if we decide to alter those areas (DEFRA, 2007).

In Cayman, intact ecosystems are important for the continued provision of the services these areas provide for human society every day. Critical ecosystem services provided by our natural areas include: resilience in the face of tropical storms and the effects of climate change; provision of crops, livestock and fish; stable precipitation patterns; and our beautiful clear water. Perhaps one of the most economically important reasons to protect our natural areas is to maintain the high quality of our tourism product. Any changes that affect tourism could cause harmful repercussions to our economy. The protection of key areas ensures that human society continues to enjoy the benefits that these ecosystems provide. Knowing that these services exist, what areas are most important for the delivery of those services, and what pressures are being put upon them, can help decision-makers make well-informed choices.

Mangroves in the Caribbean strongly influence the community structure of fish on neighbouring coral reefs. While many fish species use mangroves as a nursery, the largest herbivorous fish in the Atlantic, the Rainbow Parrotfish, has a functional dependency on mangroves and has suffered extinction after mangrove removal. Herbivorous fish maintain reef health by keeping algal growth at bay, a service made even more important as our oceans warm. Mangrove deforestation is likely to have severely deleterious consequences for the ecosystem function, fisheries productivity and resilience of coral reefs and therefore on an economy dependent on dive tourism (Mumby et al, 2004).

Cayman Islands' Geography and Ecology

The Cayman Islands are located in the western Caribbean, south of Cuba and northwest of Jamaica (Figure 1). The country is made up of three islands - Grand Cayman, Cayman Brac, and Little Cayman.

Figure 1. Map showing location of the Cayman Islands, Grand Cayman to the west, Cayman Brac and Little Cayman to the east (Graphic Maps).

Grand Cayman is the largest of the three islands and is home to most of the human population. It is approximately 35 km long and 6 km wide. One of its more obvious features is North Sound, a 56 km^2 semi-enclosed, shallow lagoon, historically fringed with mangrove swamp to the west, south, and east, and with an exposed fringing reef to the north. Grand Cayman is low-lying, with the highest point about 22 m above sea level (Cayman Land Registry, accessed November 24, 2014), but with an average height of only 2 m. Cayman Brac lies 143 km northeast of Grand Cayman and is 19 km long, with an average width of 2 km. The Bluff, a massive central limestone outcrop, rises steadily along the length of the island up to 43 m above the sea at the eastern end. Little Cayman is 8 miles west of Cayman Brac and is approximately 16 km long with an average width of about 2 km. The island is low-lying with a few areas on the north shore rising to 12 m above sea level. All three Cayman Islands are flat limestone with low elevation and no rivers and therefore have little sediment runoff, creating extremely clear waters offshore and making the Cayman Islands one of the most popular snorkeling and scuba diving areas in the world. The coasts are largely protected by offshore reefs and in some places by a mangrove fringe that sometimes extends into inland swamps (CI Govt, 2011).

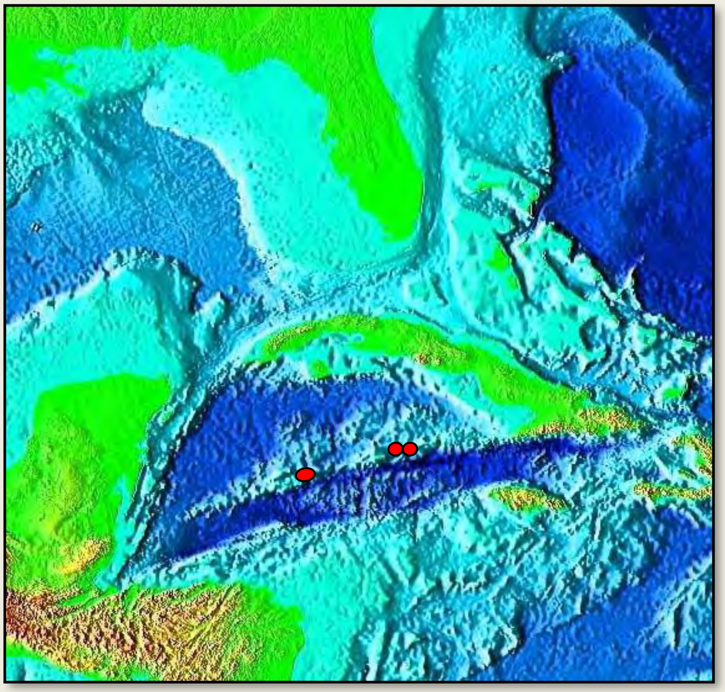


Figure 2 – Position of the Cayman Islands on the Cayman Ridge (adapted from Wikimedia Commons).

Geographically, the Cayman Islands are essentially mountain peaks on the Cayman Ridge, which extends westward from Cuba (Figure 2). Parts of the Cayman Islands have remained continually above water during the last two million years, despite fluctuations in the global sea level. During that time, the islands were gradually colonised by animals and plants from the neighbouring Greater Antilles, as well as from Central America and the eastern Caribbean. Over time many of these species evolved into the unique species and subspecies now found only in the Cayman Islands (CI Govt, 2011).

The two dominant terrestrial ecosystems found in the Cayman Islands are mangrove swamp formations, which occupy more than half of Grand Cayman and a third of Little Cayman, and dry evergreen woodlands and thickets, which are found on limestone and dolomite karst terrain above sea level. At one time the forests of Cayman were dominated by tall mahogany and ironwood, but the dry woodlands of Grand Cayman and Cayman Brac have a long history of disturbance and timber extraction. The tropical hardwoods of this region regenerate and grow very slowly. Today's woodlands are therefore usually secondary growth, with primary vegetation being restricted to the most inaccessible areas including the Mastic Forest. The low elevation dry woodlands on all three islands are also of regional importance for biodiversity conservation as this forest type has been lost throughout much of the Caribbean (Procter & Fleming, 1999).

The Cayman Islands enjoy the highest standard of living in the Caribbean and have experienced rapid population growth, primarily through immigration. Since the 1970s, the population has increased at a rapid rate, almost doubling every 10 years. Tourist numbers have also grown rapidly in recent years and now tourism is a mainstay of the economy, accounting for about 70% of GDP and 75% of foreign currency earnings. The expansion of the tourism industry combined with population growth have driven the rapid development of urban and man-modified areas and associated infrastructure, including roads (DaCosta-Cottam et al, 2009).

Cayman is reliant on external inputs to maintain the human population. Several commercial crop and livestock farms are in operation, and backyard gardens yield a wide variety of produce, but agriculture and fishing represents only 0.3% of the GDP and 1.9% of the labour force. Nearly 90% of the islands' food and consumer goods are imported. With no rivers or lakes and limited groundwater sources, most of the population is reliant on water obtained from reverse osmosis by water companies. Septic tanks are the norm except for the highly developed Seven-Mile Beach corridor (CIA, 2014). The thin fresh water lenses, which are water sources for agriculture and domestic use in more rural areas, have experienced overuse and sewage pollution, but are now managed and protected as a common resource (WAC, 2014).

Issues Facing the Natural Environment in the Cayman Islands

Small islands such as Cayman are by their very nature economically, socially and physically vulnerable. They are import-dependent because they are unable to produce all the goods and services to meet domestic needs and must therefore rely on tourism to generate foreign exchange. They are highly vulnerable to climate change because of their low elevation as well as their dependence on the natural resource base for livelihoods and tourism activities. There are also limited places for people to live, space for infrastructure, areas for waste disposal, agricultural production, industrial development, and areas of natural resource and biodiversity preservation (DaCosta-Cottam et al., 2009).

Figure 3. Aerial image of Grand Cayman showing highly developed western end, North Sound, the Central Mangrove Wetland, and the Mastic Forest (adapted from Moby Dick Divers, 2013).

Development pressures are the main threat to biodiversity in the Cayman Islands (Figure 3). Construction is the third major commercial activity after tourism and financial services and so is encouraged by the government. The western end of Grand Cayman is almost completely developed and has led to an urban environment with related traffic and human congestion. In 1980 there were over 5,000 acres of wetland and mangrove habitat on the western side of Grand Cayman but today just a fraction of the mangroves remain, with more than 66 percent of those areas being lost by 2010 (CNS, 2010). Dry tropical forests are under increasing pressure as the population moves eastward away from this heavily built, high priced western end of Grand Cayman. To sell property, many landowners believe they must completely clear the property to show the land dimensions and topography. This practice has led to significant areas of clearing, often well in advance of any sales, and results in immediate and long-term damage to the ecological value of the land. Invasive species, such as wild tamarind (*Leucaena leucocephala)*, considered one of the world's most invasive species by the IUCN, then colonise the cleared area, compromising both the cleared site and impacting neighbouring parcels (Lowe et al., 2000). In addition, mangroves, traditionally regarded as valueless swamp, are being converted into highly-profitable estates through canalisation and back-filling to create canal lots with boating access. The impact of these urban and man-modified areas on native habitat extends beyond the immediate footprint of the altered property. Fragmentation of habitat introduces invasive species, blocks natural drainage, and interrupts wildlife corridors (DaCosta-Cottam et al., 2009). As a result of development, 46% of Cayman Islands' native plants are now threatened with extinction. Scientists warn that if measures are not taken, complete deforestation may occur on all three islands by the end of the century (Kew, 2014).

Increasing urbanisation of the Cayman Islands also means that the vast majority of current and future generations are growing up in highly developed and modified urban and suburban areas. As a result, society will become increasingly familiar with an environment in which exotic species dominate over native and this standard is then regarded as the norm. The effect of these shifting baselines is to undermine and confuse traditional knowledge, skew cultural development and reduce the impetus for conservation of native species (DaCosta-Cottam et al., 2009). Caymanians are rightfully concerned that local heritage and customs are being lost and must therefore be treasured. The importance of our local natural heritage must be recognized, valued, and preserved as well.

Cayman is also at risk from environmental hazards including storm surge-related coastal inundation, rain-induced inland flooding, and wind and rain associated tropical cyclone impacts. Climate change is expected to exacerbate the frequency and intensity of these hazards. Most biological systems are already under pressure from land use change, over-exploitation and pollution. Storm events may have an even greater effect on native species and habitats under such circumstances, increasing the likelihood that they could drive several endemic species to extinction. Increases in tropical storm intensity could particularly affect the dry inland forest communities because regeneration is very slow. Other anticipated impacts on biodiversity include inundation of coastal mangroves, the increase of coral diseases and bleaching episodes, and the erosion of sea turtle nesting beaches. Ocean acidification from climate change is likely to harm coral reefs by slowing coral growth and making reefs more vulnerable to erosion and storms, while warming oceans will promote an overgrowth of algae. Soil and aquifer salinization from sea level rise will adversely affect the health of low-lying habitats, disrupting critical ecosystem processes upon which agriculture and water sectors depend (DaCosta-Cottam et al., 2009).

TESSA – A Way to Measure Ecosystem Services

It is important for decision makers to understand how change to a site will affect ecosystem services and the distribution of any benefits within human populations. There are, however, relatively few methods that have been developed to collect this information that are both easy and inexpensive. The Toolkit for Ecosystem Service Site-based Assessment (TESSA) has recently been developed to remedy this situation and to aid policymakers in making the most informed choices (http://tessa.tools/). TESSA is designed to provide guidance on assessing and monitoring ecosystem services to individuals with only moderate technical knowledge and minimal financial resources and so can be performed relatively easily in the field. The protocol's key to success lies in the utilization of the local knowledge of key stakeholders from the region. Local people have a unique understanding of the region including history, political forces, and local challenges, but perhaps most importantly, they have a passion for the area that no foreign expert can replace. TESSA guides these local non-specialists through a process to identify which ecosystem services may be important at a site. It also evaluates the magnitude of benefits that people obtain from their ecosystems currently, compared with those expected under alternative future scenarios. By having a better understanding of the benefits that people obtain from these natural areas and the consequences of altering them, stakeholders are better able to make well-informed decisions about how to move ahead together as a society (Peh et al, 2013).

The Workshop

In order to understand how ecosystems and human well-being are connected in Cayman, the NTCI, in conjunction with the Anguilla National Trust (ANT) and the U.K. Royal Society for the Protection of Birds (RSPB), held a meeting for key stakeholders in Cayman. Using the TESSA protocol, participants assessed the ecosystem services provided by key sites considered to be important natural areas on the three islands. The sites were considered if they were a part of the NTCI's Heritage Register or designated as an Important Bird and Biodiversity Area (IBA). The Heritage Register is a list of unique and important natural areas compiled with local knowledge while an IBA is an area recognized as being globally important habitat for the conservation of bird populations (http://www.birdlife.org/datazone/info/ibacriteria). The sites were then ranked by comparing characteristics such as the size and condition of the site, presence or absence of endemic and/or threatened fauna and flora, as well as the uniqueness of the site (Appendix A). The highest ranked sites were then shortlisted for consideration at the workshop.

Twenty stakeholders were able to attend and discussed fifteen different sites throughout the Cayman Islands. Nine organizations were represented including the Cayman Department of Environment, the National Trust, Cayman Islands Tourism Association, Department of Agriculture, Water Authority-Cayman, as well as interested citizens. Two experienced representatives from the RSPB were present as well to aid in the process. There was a brief orientation meeting and then the participants broke into five groups of four individuals from varying backgrounds and different areas of expertise to evaluate one site in the morning and another in the afternoon. Some sites were grouped together if they were similar in location and habitat type. It was determined that the separate, small wetland areas of Little Cayman and Cayman Brac could be considered as one unit on each island (excepting Booby Pond Nature Reserve, which has particular characteristics) as the hydrology is connected on each island and the pressures and likely impacts are similar. Participants used protocols described in TESSA and were asked to identify the current and future drivers of change to their site as well as the alternative land cover that might result as a consequence of these changes within the next 10 years. They then considered what services are being provided by the ecosystem currently and how delivery of those services might change considering the drivers of change expected in the future (Appendix B).

While TESSA provides a framework for local stakeholders to easily assess local natural areas for their importance for ecosystem services, certain aspects of the methodology must be kept in mind. The TESSA process involves the subjective analysis of the sites and their probable futures by local individuals and, as such, can result in varied outcomes depending on the participants involved. In this workshop, this likelihood was moderated by the use of several individuals in each group from multiple backgrounds, although some degree of difference may still be observed between groups. Participants are also instructed to consider a future scenario in 10 years, although this may not be adequate to include slow but significant drivers of change that could completely devastate an ecosystem over the longer term. With these characteristics in mind, TESSA is particularly useful in aiding local non-specialists to understand the ecosystem services provided by natural areas and the immediate dangers that exist to these ecosystems.

Forces that are leading to the rapid loss of natural areas were identified (Figure 4). Residential and commercial development is the strongest driver of change in the Cayman Islands. Rapid population growth, combined with the lack of a sustainable development plan, has led to large areas of deforestation and an increase in urban environments. Other human pressures were found to be significant as well, including the building of roads and airports, quarrying, agriculture, fire and pollution. Invasive species are also taking a toll on natural areas. Green iguanas (*Iguana iguana*) have quickly spread throughout Grand Cayman while the Sister Islands are at high risk of eventual colonization as well. Rats, feral cats and dogs, and several species of invasive plants are also problematic for the native flora and fauna. Flat, low-lying islands in the tropics are predicted to be some of the most hard-hit areas in the future as a consequence of climate change. Sea level rise will inundate low areas, tropical storms are expected to be more powerful, and rainfall may decrease significantly. Natural areas help to mitigate those effects as mangroves can protect nearby areas from storms by absorbing wind and wave energy before it impacts human structures. Mangroves are also land-builders and have been shown to be capable of keeping pace with sea level rise in some areas of the world. Precipitation due to evapotranspiration from forested areas may also mitigate the effects of lessened rainfall due to worldwide changes.

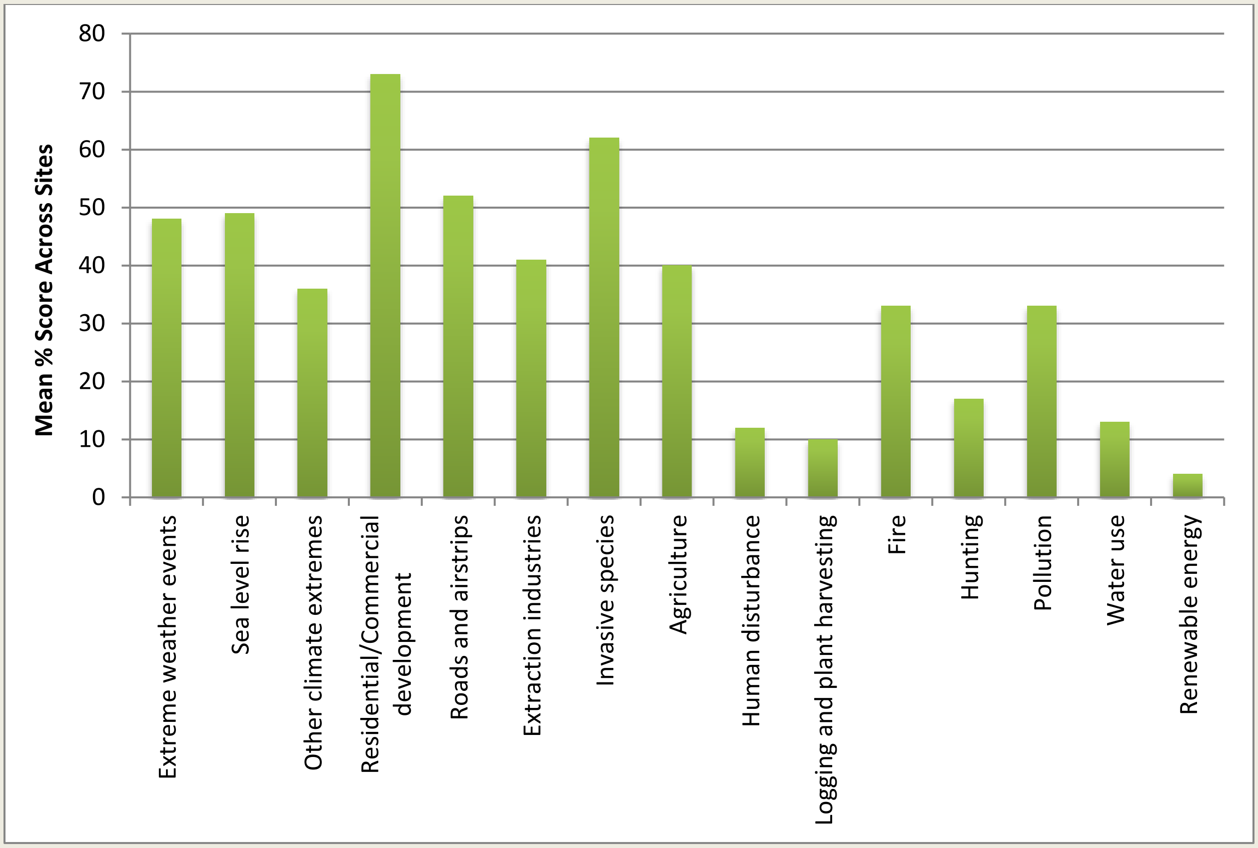


Figure 4. Drivers of change in the Cayman Islands (averaged stakeholder responses from TESSA Rapid Ecosystem Service Assessment Reports).

Several overall trends were visible from the completed reports. Natural areas on all three islands were found to contribute significantly to human welfare and prosperity in the Cayman Islands (Table 1). The ecosystem services delivered vary according to the type of habitat, but almost all of them are important for carbon storage, a benefit felt worldwide as increasing carbon pollution accelerates climate change. The cultural benefits afforded by our natural areas are also of significance to the resident human population. Tourism is the mainstay of the economy of the Cayman Islands and a pristine environment complete with indigenous species is thought to be crucial for the continued attraction of visitors. The familiar "sun, sand, and sea" model is no longer enough to differentiate Cayman from its neighbors and to attract the modern tourist who often demands authentic, unique cultural or wildlife encounters while traveling (Brown, 2014). Natural areas of Cayman are also critical for the continued health of our limited freshwater resources. Vegetated areas are known to slow the runoff rate after storm events, thereby improving the water quality and recharge rate of aquifers, while helping to prevent flooding. Forested areas have also been shown to increase precipitation downwind due to the abundant evapotranspiration that occurs in tropical hot and humid environments. Natural areas are helpful in the biological control of pest species as well. Healthy populations of indigenous bat and bird populations are known to be critical in the fight against mosquitoes, for example. Mangrove ecosystems are also crucial for coastal protection during storms and as a nursery area for fish populations. Without critical natural areas, the human residents of the Cayman Islands would find life much more difficult as the services these areas provide disappear.

Table 1. Ecosystem services identified for each site by stakeholders using TESSA protocol.

	Carbon Storage	Local Climate Regulation	Water for Human Use	Water Flow Regulation	Water Quality Improvement	Erosion Control	Coastal Protection	Harvested Wild Goods	Cultivated Goods	Biological Control	Cultural Benefits
Bluff Forest	X	X	X							X	X
Booby Pond Nature Reserve	X			X							X
Brac Wetlands	X			X							X
Central Mangrove Wetlands	X	X		X	X		X	X			X
Colliers Wilderness Reserve	X		X		X						X
Crown Cliff Faces of the Bluff							X			X	X
Crown Wetlands	X	X		X			X			X	X
East End Forest	X		X		X						X
Long Bridge Wetland and Royal Palm Forest	X										X
Mastic Forest	X	X	X	X	X					X	X
Salina Reserve	X		X		X						X

Although each natural area provides important ecosystem services to the surrounding and global communities, the TESSA protocol made it clear that the Central Mangrove Wetland and the Mastic Forest deliver more services than the other areas considered (Table 1). It was therefore decided to quantify those services as much as possible to aid decision makers and community members in making informed choices as to the future of the country's natural areas.

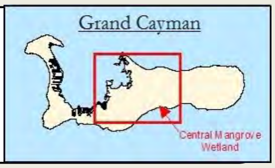
(Russell A. Mittermeier)

(Donna Mann)

Central Mangrove Wetland (CMW) – Grand Cayman - OVERVIE

Some facts and figures

AREA: 3440 ha (30% of Grand Cayman)
PROTECTION STATUS: 19% protected under the Marine Conservation Law, 7% owned and protected by the National Trust for the Cayman Islands, 9% owned by the Crown and unprotected, and 75% privately owned and unprotected.
CONSERVATION STATUS: edges of wetland at high risk of development



The Site: The Central Mangrove Wetland is the largest contiguous mangrove wetland in the Caribbean. It is also unique within the region in terms of its geomorphology and vegetation zonation patterns (National Trust, 2013a). Much of this wetland is still in its natural state although the edges have been encroached upon by quarries, agriculture, and residential and commercial development, as well as the building of a new major arterial road. Except for areas of open water, it is densely covered by a canopy of Red (*Rhizophora mangle*), Black (*Avicennia germinans*) and White (*Laguncularia racemosa*) Mangroves which are joined by Buttonwoods (*Conocarpus erectus)* in the more upland areas (Bradley et al., 2008). This area is an IBA (Bradley et al., 2008) and home to many important species, including many that are of conservation concern (Appendix C).

The Issues: Mangroves are one of the Cayman Islands' most undervalued and severely impacted habitats (Appendix D). This area is almost entirely unprotected and in serious danger of being lost. The wetlands on the western side of the island have for the most part already been removed. The main threat to this region is residential development, including an active application in the southwestern part of the site. Granting the application for this proposed development will set a precedent for further encroachment. The construction of an arterial road through the southern portion of the area will lead to further development and loss of wetland areas (DaCosta-Cottam et al., 2006). Sea level rise also poses a major threat to mangrove ecosystems through sediment erosion, inundation stress and increased salinity at landward zones. These problems will be exacerbated for mangrove stands that are subjected to 'coastal squeeze' - areas where landward migration is impossible due to human development. Mangroves of low-relief islands such as Cayman that are of a carbonate structure and lack rivers are probably the most sensitive to sea level rise, owing to their sediment-poor environments and subsequent slow rates of sediment accretion (Ellison, 1994).

Ecosystem Services: The ecosystem services of the CMW are numerous and critical to the health of Grand Cayman and its residents (Appendix E). Worldwide, it is estimated that mangroves provide $57,000/hectare/year in ecosystem services (UNEP, 2014b). Mangroves are vital for storm protection - evidence suggests that mangroves can reduce the height of wind and waves thereby protecting human structures located behind them. Mangrove forests are among the world's most productive ecosystems, producing organic carbon well in excess of the ecosystem requirements and contributing significantly to the global carbon cycle. In addition, saturated air rising above the CMW in the heat of the day forms rapidly developing clouds that are carried west by the prevailing winds and then deliver rain over the highly populated and verdant central and western districts of Grand Cayman. This process is believed to contribute a large part of western Grand Cayman's rainfall which is 40% greater than in the eastern districts. The CMW is therefore bordered by some of Grand Cayman's best agricultural land. This area is part of a large scale water flow system, filtering, conditioning, and providing a flow of nutrients into North Sound forming the base of a complex food chain. The clear seas surrounding Grand Cayman are due to the physical and biological filtration of land surface water through the mangrove areas (Giglioli, 1994). North Sound then provides additional area for fish nurseries and clear water for diving, supporting many livelihoods in the Cayman Islands. The entire living system of North Sound is linked to the CMW, and would be severely impacted if the wetland were ever destroyed (National Trust, 2012). There is likely to be a tipping point if development continues beyond which the CMW may no longer be able to perform its current functions adequately. The loss of the CMW was found to have more significant negative effects on ecosystem services than any other site investigated.

Carbon Storage

Introduction

Mangroves are intertidal forests found exclusively in tropical and subtropical latitudes. More than 50% of Grand Cayman was originally covered in mangrove forests (Brunt & Burton, 1994) but most of the wetlands on the western end of the Island have been converted to residential and commercial development. The 3500 ha Central Mangrove Wetland (CMW), in the centre of the Island, is being encroached upon from all sides. Sea level rise and development pressures are likely to reduce the size of the CMW and diminish the services provided by this ecosystem.

Mangroves are well-known for their ecosystem services. They are often biodiversity hotspots, while performing other functions such as nutrient cycling, fisheries production, and protection from coastal erosion and storm activity (FAO, 2005). Mangroves are also thought to be some of the best ecosystems in the world for carbon sequestration and therefore important for climate change mitigation (Twilley et al., 1992). These highly productive regions have anoxic sediments and high rates of sediment accretion leading to large sediment carbon stores which act as underground reservoirs or carbon "sinks" (Santos et al., 2011). Mangrove soils have been found to represent between 49 and 99% of the total mangrove ecosystem carbon store (Donato et al., 2011). Sediments suspended in the water column are deposited in mangroves during flooding. The extensive root system of mangroves enhances this trapping process and slows the forces of erosion along the shoreline (Adame et al., 2015). These coastal wetland habitats have higher rates of carbon sequestration and contain more carbon per hectare than terrestrial forests, making them important sites of "blue carbon" (Figure 5) (McLeod et al., 2011). If released to the atmosphere, the carbon stored in a typical hectare of mangroves could contribute as much to GHG emissions as three to five hectares of tropical forest. A hectare of intact mangroves may contain carbon with a climate impact equivalent to 958 cars on US roads each year (Murray et al., 2011).

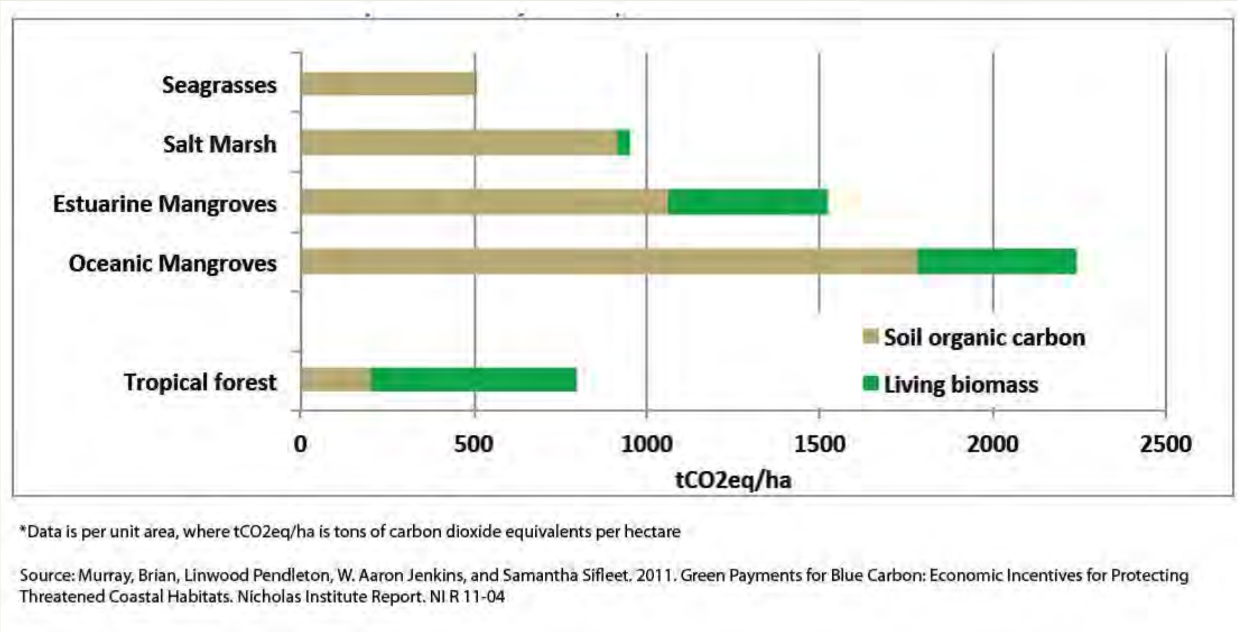


Figure 5. Carbon storage abilities of different habitat types (the Cayman Islands are home to oceanic mangroves).

Despite the importance of these coastal ecosystems, mangroves have been disappearing at a global rate of 1-2% loss per year for the past half a century, with estimates of total loss in coverage between 30-50% (Donato et al., 2012). Grand Cayman has lost much of its original mangrove cover and what remains is currently unprotected by any government legislation. Mangrove land-use conversion through deforestation and degradation results in the immediate release of carbon stored in vegetation biomass (Houghton, 1995) while also exposing the soil to oxygen, releasing carbon stored in sediment (Pendleton et al., 2012). Growing recognition of land-use conversion as a significant source of CO_2 emissions has prompted various international bodies to initiate policies such as Reducing Emissions from Deforestation and Forest Degradation (REDD+) in order to give a financial value to carbon stored in forests to encourage conservation and restoration (Chevallier, 2012). At the international climate meetings in Paris in December 2015, an International Partnership for Blue Carbon was formed to further promote the protection and restoration of mangrove ecosystems as well as other coastal habitats (Hunt, 2015). Because of their large ecosystem carbon stocks, as well as the numerous other critical ecosystem services they provide, Cayman's mangroves are potentially well suited to these climate change mitigation strategies.

<u>Methods</u>

Field sampling was conducted in a fairly undisturbed mangrove area adjacent to the North Sound Estates region of Grand Cayman to investigate organic carbon storage in this ecosystem type. Transects were performed using Kauffman and Donato's (2012) protocols for sampling carbon stocks in a mangrove forest (Figure 6). In this design, circular plots were established perpendicular to the marine-mangrove ecotone. This technique was intended to capture the variation in mangrove ecosystems that occur along a gradient from marine edge to uplands. As the dwarf mangroves found in this region are dense but fairly uniform, aboveground biomass was measured in 6 half-circle plots with a radius of 2m (6.3m^2).

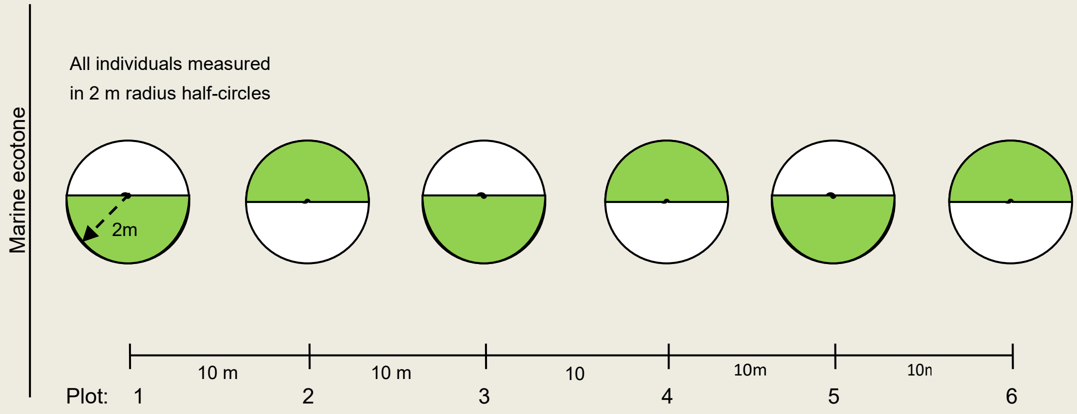


Figure 6. Schematic of plot layout for mangrove transects (from Kauffman & Donato, 2012).

Five transects were performed: three in an upland, seasonally flooded area of the CMW and two nearby in the fringing, tidally flooded mangroves bordering North Sound. The locations chosen were not random as access to this area is difficult and systemic sampling of mangroves is widely recognized as credible (Pearson et al., 2007). Instead the mangroves were assessed from North Sound Estates where access was relatively easily gained. The team sampled the marine mangroves starting from North Sound and moving inland going south. Upland mangroves were accessed using existing dyke roads built for mosquito control and were sampled in a northerly direction. Each transect had 6 plots 10 meters apart (5 transects with 6 plots = 30 points sampled). The transects were marked and GPS coordinates noted so that work may be repeated in future years to monitor changes in the ecosystem.

Measurements were recorded at each plot including the species present, their diameter at breast height (dbh), the number of seedlings, crown area and height, canopy cover, pneumatophore density, and the number of dead trees and their status. For stilt rooted species (e.g. *Rhizophora mangle*), stem diameter was measured above the highest stilt root (Komiyama et al. 2005). In most surveys of upland forests, only trees >10 cm dbh are measured as smaller trees often constitute a relatively insignificant proportion of the total ecosystem carbon stock (Cummings et al. 2002). For many mangroves however, including those of this region, smaller trees dominate the stand composition, and therefore all of the trees with stems higher than breast height were measured and recorded. Standing dead trees were uncommon and, if present, were included with live trees. Litter is a small component of the total ecosystem carbon stock and therefore not usually sampled (Kauffman and Donato, 2013). Soil samples were also collected near the centre of each plot.

Soil Carbon

Soil carbon is often the largest pool in a mangrove ecosystem and accurate measurement of it is vital to understanding the importance of this ecosystem service to Grand Cayman and will help to understand long-term dynamics associated with climate change and/or land management. Soil samples were collected to determine soil depth, bulk density and carbon concentration by taking a soil core for sediment analysis. Sediment coring was carried out using a 6.2cm diameter open-face peat auger, designed to minimize sediment compaction. Organic litter was removed from the sediment surface and then the corer was twisted to the maximum depth of the corer head and carefully removed from the sediment. Cores were made in a representative area of sediment taking care to avoid large root structures. Soil samples were taken from as deep as the corer would allow (from 70 to 130 cm). The soil was removed from the auger in 10 cm sections using a 30 ml scoop. The sediment subsamples were then secured in airtight sample bags and labeled to record the plot number and core sample depth. The soil samples were dried in a specialized oven at 60^0C for at least two days. They were then weighed, repackaged, and sent to a soil laboratory in the US where they were analysed to determine the concentration of carbon in the sediments. Three sediment characteristics were measured to estimate soil organic carbon stores: bulk density, organic carbon content and sediment depth.

Sediment bulk density is the dry mass of soil in relation to a given volume and will depend largely on the mineral composition of the sediment including particle size and sediment types present within the soil (Adame et al., 2013). Organically rich mangrove peats and muds typically have low dry bulk densities compared to sandy sediments with higher mineral content. Bulk density was determined using the following equation (Donato et al., 2011):

Bulk density (g/cm3) = dry weight (g)/sample volume (cm3)

Two methods were used to estimate soil organic carbon, the Loss-on-Ignition (LOI) method and elemental analysis via dry combustion. In the LOI method, organic matter in a sample is determined by heated destruction followed by the use of a conversion factor to calculate the organic carbon concentration. Elemental analysis via dry combustion is considerably more accurate than LOI, but the procedure is expensive and often specialized instruments are located only in limited laboratories. It is recommended that comparisons of values for organic carbon obtained from both methods on replicate samples be used to estimate organic carbon concentrations (Beasey et al., 2013). In order to investigate the relationship between organic matter from LOI and organic carbon from dry combustion, all 213 soil samples were professionally tested using the LOI method and 20 of these same samples were also tested by dry combustion by Ward Laboratories in Nebraska, USA. Linear regression was used to establish a relationship between the two test results and this was compared to the commonly used conversion factor of 1.724 (g organic matter/1.724 = g organic carbon) (Chmura et al., 2003). The relationship found between organic matter and organic carbon was then used to estimate organic carbon content from LOI data.

The size of the sediment organic carbon store per sampled depth interval was calculated by the following equation:

Soil organic carbon (g/cm^2) = OC content (%)*Bulk Density (g/cm^3)*sampled depth interval (cm)

It is estimated that the CMW has an average sediment depth of 240 cm (Burton, 2015) from field surveys done in the early 1990s (Brunt and Burton, 1994). Due to the fact that sediment accretion in mangroves is generally 1-2mm/yr (Fujimoto et al., 1999), and estimated at 0.88-0.90 mm/yr for Grand Cayman (Woodroffe, 1981), this figure is thought to be a conservative estimate. Carbon values for sediment deeper than the corer samples were extrapolated by following the trend line of the known values. Carbon stocks at risk in the CMW were estimated using a conservative assumption that the first meter of soil is disturbed when mangrove habitats are converted or damaged. Development for agriculture may disturb less than one meter of soil but urban development is understood to disturb even deeper layers as soil is often completely excavated to achieve stabilization of sediment for building purposes.

Vegetation Carbon

To determine the carbon pool associated with the aboveground component of the forest, the biomass of each tree was determined and then multiplied by its specific carbon concentration using a published allometric equation. These equations are necessary to infer oven-dry aboveground biomass of trees. A number of publications report allometric equations for mangroves around the world, but here species-specific figures derived for Florida in the United States (Smith and Whelan, 2006) were used as this study was the closest geographically to the Cayman Islands (Table 2). South Florida also shares many geologic and climatic features with Cayman and the mangrove species assemblages are the same. Mangrove ecosystems here are composed almost exclusively of three species: Red Mangrove (*Rhizophora mangle*), Black Mangrove (*Avicennia germinans*), White Mangrove (*Laguncularia racemosa*), and Green Buttonwood (*Conocarpus erectus*). As there is no specific equation for Green Buttonwood or Lancewood (*Randia aculeata*), the equation for White Mangrove was used for these species due to their often similar physiognomy and the fact that White Mangrove's equation would give the most conservative estimation of biomass (Smith and Whelan, 2006).

Table 2. Allometric equations used to calculate mangrove biomass (from Smith and Whelan, 2006).

Species	Aboveground (AGB) Equation	R^2; N	ρ
Rhizophora mangle	$AGB = 0.722D^{1.731}$	R2 = 0.94 N = 14	0.83
Avicennia germinans	$AGB = 0.403D^{1.934}$	R2 = 0.95 N = 8	0.661
Laguncularia racemosa	$AGB = 0.362D^{1.930}$	R2 = 0.98 N = 10	0.60

B = biomass (kg), H = height (m), D = diameter at breast height (cm), ρ = wood density (g/cm^3)

Belowground tree biomass often comprises a high proportion of the carbon pool in mangrove ecosystems. An estimation of this figure was therefore calculated using the formula developed by Komiyama et al. (2005) where BGB = tree belowground biomass (kg), ρ = wood density (g/cm^3), and D = tree diameter at breast height (cm):

$$BGB = 0.199*\rho^{0.899}*(D)^{2.22}$$

The amount of carbon present in the trees was then calculated from the biomass figures. Since the carbon concentration of wood is usually a little less than 50%, it is common practice to convert biomass to carbon by multiplying by 0.48.

Deforestation and forest degradation result in greenhouse gas emissions dominated by CO_2, with other trace gases such as CH_4 also being released (Guild et al., 2004). Hence, the organic carbon stores (Mg/ha) of both the soil and the vegetation were converted into units of carbon dioxide equivalents (CO2e) by multiplying by 3.67, the ratio of molecular weights between carbon dioxide (44) and carbon (12). Reporting in CO_2e is considered conservative, as carbon losses in the form of methane (CH_4) and other greenhouse gases often have higher global warming potentials than that of CO_2 (Kauffman et al., 2012).

<u>Results</u>

Soil Carbon

The dry bulk density (g/cm3) of sediments ranged from 0.104 to 0.421 g/cm3, with the highest bulk densities found at greater soil depth. The fringing mangroves were found to have higher bulk densities at all depths (Table 3).

Table 3. Soil bulk densities (red numbers were obtained from extrapolation from known sample values in black).

Horizon	Seasonally Flooded Upland	Tidally Flooded Fringing
10	0.131674	0.167542
20	0.129031	0.175619
30	0.134163	0.187258
40	0.126752	0.181842
50	0.126983	0.174152
60	0.13419	0.221048
70	0.146287	0.181252
80	**0.139437**	0.176873
90	**0.141114**	0.182867
100	**0.142792**	0.234717
110	**0.14447**	0.234458
120	**0.146147**	0.232811
130	**0.147825**	0.3045
140	**0.149503**	**0.259164**
150	**0.15118**	**0.267012**
160	**0.152858**	**0.274861**
170	**0.154536**	**0.282709**
180	**0.156213**	**0.290557**
190	**0.157891**	**0.298406**
200	**0.159569**	**0.306254**
210	**0.161246**	**0.314102**
220	**0.162924**	**0.32195**
230	**0.164602**	**0.329799**
240	**0.166279**	**0.337647**
Average	0.146986	0.247392

As the LOI method of soil carbon testing is known to have serious shortcomings (Kauffman, 2011), this method was checked against the dry combustion method for accuracy and correction. This study found that the relationship between organic matter from LOI and organic carbon content from dry combustion was more significant than that predicted by using the 1.724 conversion factor used in various other studies (Chmura et al., 2003). The conversion factor estimates (represented by the red line in Figure x) consistently underrepresented carbon values. The relationship found by linear regression between the two testing techniques was therefore used even though the R^2 value was low at 0.2448 (Figure 7).

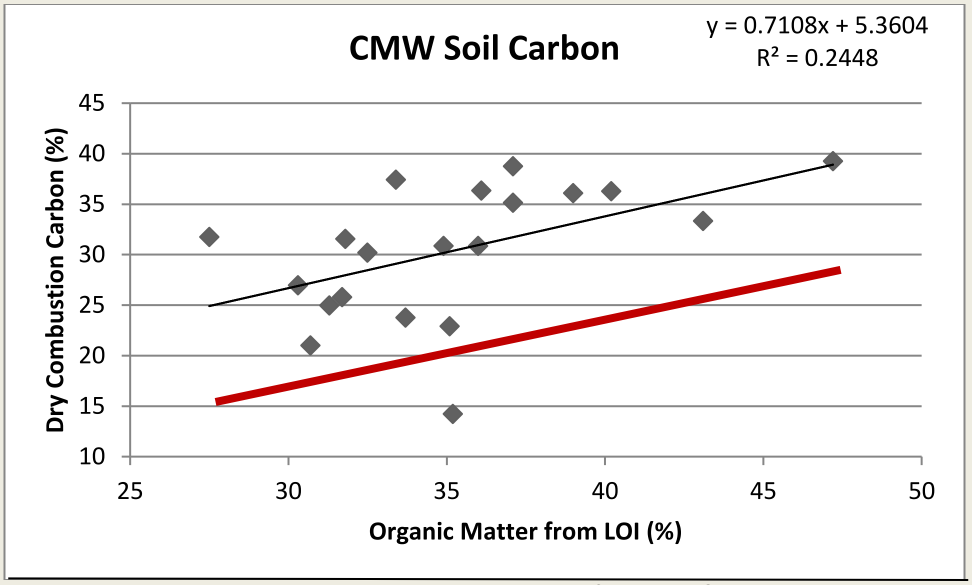


Figure 7. Relationship between soil organic matter values found by LOI and dry combustion, by both linear regression (black line) and conversion factor (red line).

To improve the accuracy of organic carbon estimation, linear regression was used separately for each sampled region. The R^2 values were improved for both habitat types (Figure 8). These relationships were then used to calculate the organic carbon content of the soil for each region separately.

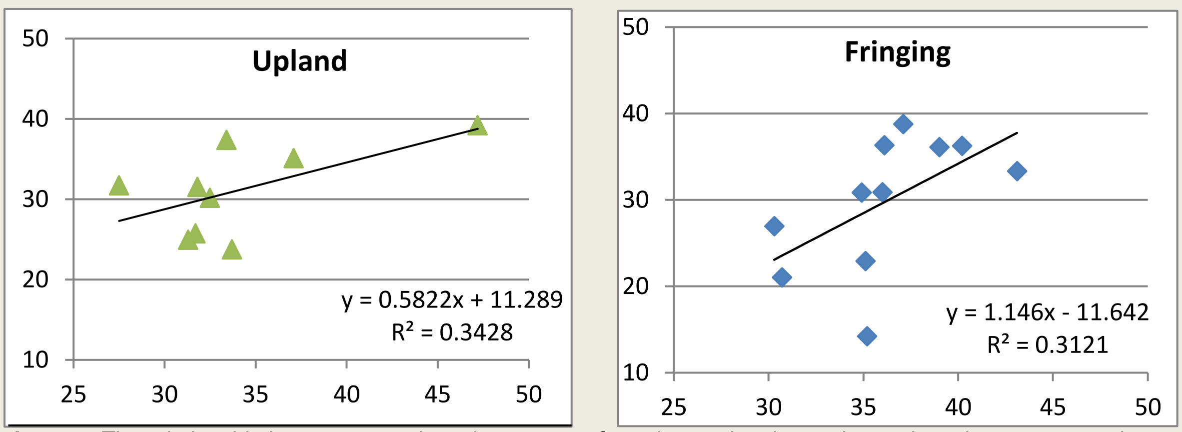


Figure 8. The relationship between organic carbon content from dry combustion and organic carbon content estimated from LOI in the two habitat types.

Using known information about the size of each habitat type, it is possible to calculate the organic carbon stored in the soils of the CMW (Table 4). There are approximately 3496 ha in the CMW, of which 71 ha are man-modified and 114 ha are water. Of the natural vegetated areas, about 666 ha are fringing mangroves while 2645 ha are upland mangrove habitats, totaling 3311 ha. Sediments in the tidally flooded, fringing mangroves had 35% higher organic carbon content than upland, seasonally flooded areas but represent less area over the study region. It is common to measure the organic carbon content in the top meter of sediment as this surface level is most often disturbed by anthropogenic activities. In the CMW, the top meter of sediment contains 1.51 x 10^6 Mg of carbon, or 456 Mg/ha. However, in wetland organic soils, the entire belowground pool may be susceptible to loss through tidal and storm surges, as well as decomposition following land-cover change (Kauffman, 2011). The organic carbon stored in the entire soil layer down to bedrock (estimated at 240 cm) of the CMW is 3.89 x 10^6 Mg, or 1175 Mg/ha, of carbon. The total carbon density was converted to CO_2 e by multiplying the carbon stock by 3.67, the ratio of molecular weights between carbon dioxide and carbon (Kauffman, 2011). The CMW of Grand Cayman has a total CO_2e of 4330.6 Mg/ha, or 1680.9 Mg/ha for the top meter of sediment (Megagram = metric tonne).

Table 4. Organic soil carbon content for the Central Mangrove Wetland (CMW) (highlighted values are those extrapolated from core samples).

Soil Depth	Organic Carbon (%)		Thickness per layer (cm)	Bulk Density (g/cm3)		Soil Carbon (g/cm2)		Soil Carbon (Mg/ha)	
	Fringing	Upland		Fringing	Upland	Fringing	Upland	Fringing	Upland
-10	29.59	33.38	10	0.17	0.13	0.50	0.44	49.58	43.96
-20	27.74	32.02	10	0.18	0.13	0.49	0.41	48.72	41.31
-30	29.41	33.27	10	0.19	0.13	0.55	0.45	55.08	44.64
-40	29.01	33.86	10	0.18	0.13	0.53	0.43	52.76	42.92
-50	29.63	31.28	10	0.17	0.13	0.52	0.40	51.61	39.72
-60	30.19	32.21	10	0.22	0.13	0.67	0.43	66.73	43.23
-70	30.10	31.41	10	0.18	0.15	0.55	0.46	54.56	45.95
-80	29.91	31.42	10	0.18	0.14	0.53	0.44	52.91	43.80
-90	30.09	31.15	10	0.18	0.14	0.55	0.44	55.02	43.95
-100	26.95	30.88	10	0.23	0.14	0.63	0.44	63.26	44.09
-110	29.33	30.61	10	0.23	0.14	0.69	0.44	68.76	44.22
-120	26.52	30.34	10	0.23	0.15	0.62	0.44	61.74	44.34
-130	26.06	30.07	10	0.30	0.15	0.79	0.44	79.36	44.45
-140	27.53	29.80	10	0.26	0.15	0.71	0.45	71.36	44.56
-150	27.35	29.54	10	0.27	0.15	0.73	0.45	73.03	44.65
-160	27.17	29.27	10	0.27	0.15	0.75	0.45	74.68	44.74
-170	26.99	29.00	10	0.28	0.15	0.76	0.45	76.29	44.81
-180	26.80	28.73	10	0.29	0.16	0.78	0.45	77.88	44.88
-190	26.62	28.46	10	0.30	0.16	0.79	0.45	79.44	44.94
-200	26.44	28.19	10	0.31	0.16	0.81	0.45	80.97	44.99
-210	26.26	27.92	10	0.31	0.16	0.82	0.45	82.47	45.03
-220	26.07	27.65	10	0.32	0.16	0.84	0.45	83.95	45.06
-230	25.89	27.39	10	0.33	0.16	0.85	0.45	85.39	45.08
-240	25.71	27.12	10	0.34	0.17	0.87	0.45	86.81	45.09
TOTAL SOIL CARBON (Mg/ha) – entire soil depth								**1,632.35**	**1,060.39**
TOTAL SOIL CARBON FOR CMW (Mg) - entire soil depth								**1,087,592.13**	**2,804,719.62**
TOTAL SOIL CARBON (Mg/ha) – top meter of soil								**550.23**	**433.57**
TOTAL SOIL CARBON FOR CMW (Mg) - top meter of soil								**366,600.6**	**1,146,774**
TOTAL SOIL CARBON FOR CMW OVERALL (Mg)								3.89×10^6 (1175/ha)	
TOTAL SOIL CARBON FOR CMW OVERALL (Mg) – top meter of soil								1.51×10^6 (456/ha)	
TOTAL SOIL CO^2e FOR CMW OVERALL (Mg/ha)								4330.6	
TOTAL SOIL CO^2e FOR CMW OVERALL (Mg/ha) – top meter of soil								1680.9	

Vegetation Carbon

On all 5 transects, only 5 tree species were found. In the tidally flooded, fringing mangrove forest, Red Mangrove dominated the landscape while White Mangrove and Green Buttonwood were the more common species in the tidally flooded upland area. Both forests were very dense. The upland forest was observed to have 22,751 stems/ha, while the fringing forest had approximately 12,169 stems/ha. The aboveground tree biomass was calculated to be 62.92 Mg/ha in the fringing mangroves and 102.99 Mg/ha in the upland forest. As mentioned previously, the CMW contains 666.27 ha of tidally flooded mangroves and 2644.99 ha of seasonally flooded areas. It is therefore possible to calculate that the CMW contains 41,921.71 Mg fringing and 272,407.52 Mg upland tree biomass, for a combined 314,329.23 Mg.

The belowground tree biomass was also calculated. It was determined that the fringing mangroves contain 31.70 Mg/ha, while there are 58.58 Mg/ha in the upland regions. By analyzing the area of both ecosystems, we calculate 21,120.76 Mg and 154,943.51 Mg in the respective locations, combined for a total of 176,064.27 Mg of belowground biomass. It can therefore be calculated that the CMW has a total vegetation biomass, both above and belowground, of 490,393.5 Mg (Table 5).

Table 5. Biomass of vegetation in the CMW.

Component	**Coastal Fringe (Mg or t)**		**Upland Mangroves (Mg or t)**		**Total CMW (Mg or t)**
	Total	per hectare	Total	per hectare	
Aboveground trees	41,921.71	62.92	272,407.52	102.99	**314,329.23**
Belowground trees	21,120.76	31.70	154,943.51	58.58	**176,064.27**
Total	**63,042.47**	**94.62**	**427,321.03**	**161.57**	**490,393.5**

The carbon content is understood to be approximately 48% of the total aboveground biomass and 39% of that found belowground. The CMW therefore contains about 150,878.03 Mg C aboveground biomass while holding a belowground carbon value of 68,665.07 Mg. Combined, the CMW then has 219,543.1 Mg C stored in vegetation. To convert these findings to CO^{2}e, the figures are multiplied by 3.67 to reflect the ratio of molecular weights between carbon dioxide and carbon. Including the soil component, the fringing forest is therefore calculated to contain 6146.97 Mg/ha CO^{2}e while the upland forest stores 4156.90 Mg/ha of CO^{2}e (Table 6).

Table 6. Carbon pools in the CMW

Component	**Coastal Fringe (Mg or t)**		**Upland Mangroves (Mg or t)**		**Total CMW (Mg or t)**
	Total	per hectare	Total	per hectare	
Aboveground trees	20,122.42	30.20	130,755.61	49.44	150,878.03
Belowground trees	8,237.10	12.36	60,427.97	22.85	68,665.07
Total vegetation	**28,359.52**	**42.56**	**191,183.58**	**72.29**	**219,543.10**
Total soil	1,087,592.13	1,632.36	2,804,719.62	1060.39	3.89 x 10^6
Top meter soil	366,600.6	550.23	1,146,774	433.57	1.51 x 10^6
Total (vegetation + entire soil profile)	**1,115,951.65**	**1,674.92**	**2,995,903.20**	**1132.67**	**4.11 x 10^6**
CO^{2}e (veg + top meter soil)	**1,449,503.64**	**2,175.54**	**4,910,304.32**	**1,856.51**	**6.36 x 10^6**
CO^{2}e (vegetation + entire soil profile)	**4,095,542.56**	**6,146.97**	**10,994,964.70**	**4,156.90**	**15.09 x 10^6**

The amount of carbon stored in the vegetation, both above and belowground, was found to be a small fraction of that stored in the soil (Figure 9). In the coastal fringe habitat, the soil contained 97.5% of the carbon, while the soil of the upland mangroves stored 93.6% of the carbon for the region.

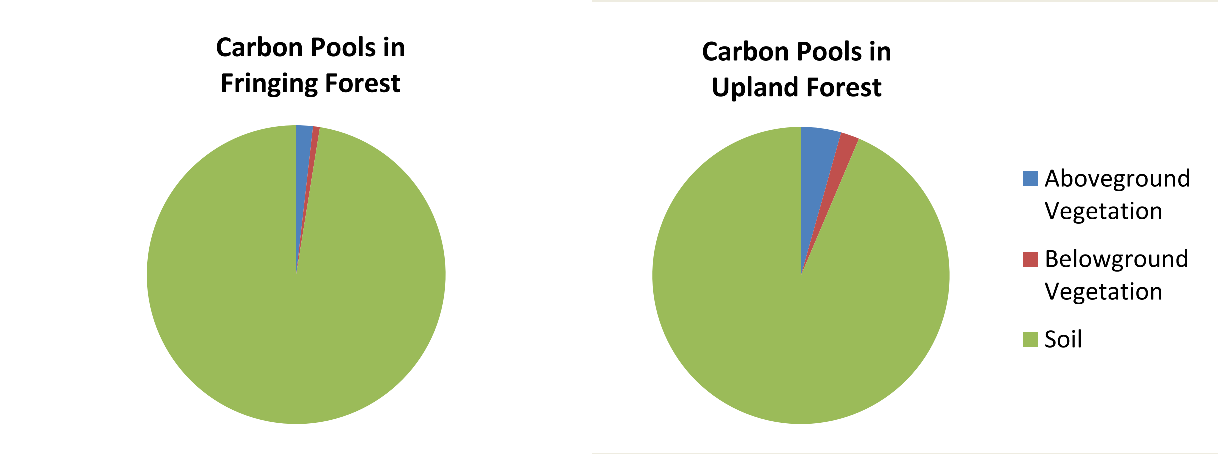


Figure 9. Ecosystem carbon pools of the CMW, Grand Cayman.

Discussion

Carbon storage in the CMW ranged from 1132.67 Mg/ha (upland) to 1,674.92 Mg/ha (fringing). Grand Cayman's mangrove ecosystems are therefore a significant sink for CO_2. In comparison, the mangroves of the Montecristi Province in Northwest Dominican Republic have C stocks ranging from 706 to 1131 Mg/ha (Kauffman et al., 2014) and the mean C stocks in mangroves worldwide are estimated at 784.5 ± 73.5 Mg/ha (Adame et al., 2015). Oceanic mangroves such as those found in Grand Cayman are among the highest carbon pools of any forest type in the world while being among the most vulnerable to the effects of land-use and land-cover change, as well as to global climate change including sea level rise (Gilman et al., 2008).

Because mangrove ecosystems are so rich in carbon, deforestation or disturbance of these regions results in large emissions of CO_2 to the atmosphere (Lovelock et al., 2011). Using a conservative assumption that the first meter of soil is disturbed when mangrove habitats are converted or damaged, carbon stocks at risk in the CMW were estimated to be 2,175.54 $MgCO_2e$/ha in the fringing mangroves and 1,856.51 $MgCO_2e$/ha in the upland mangrove ecosystems. This amount of CO_2e would be released from the loss of vegetation and disturbance of the upper meter of sediment following disturbance from land conversion. In comparison to a paper that compiled 64 literature estimates of CO_2e released from the upper meter of sediment, the value found for the CMW was at the high end of the range of values presented, with most estimates falling between 800-3000 Mg/CO_2e (Sifleet et al., 2011) (Figure 10).

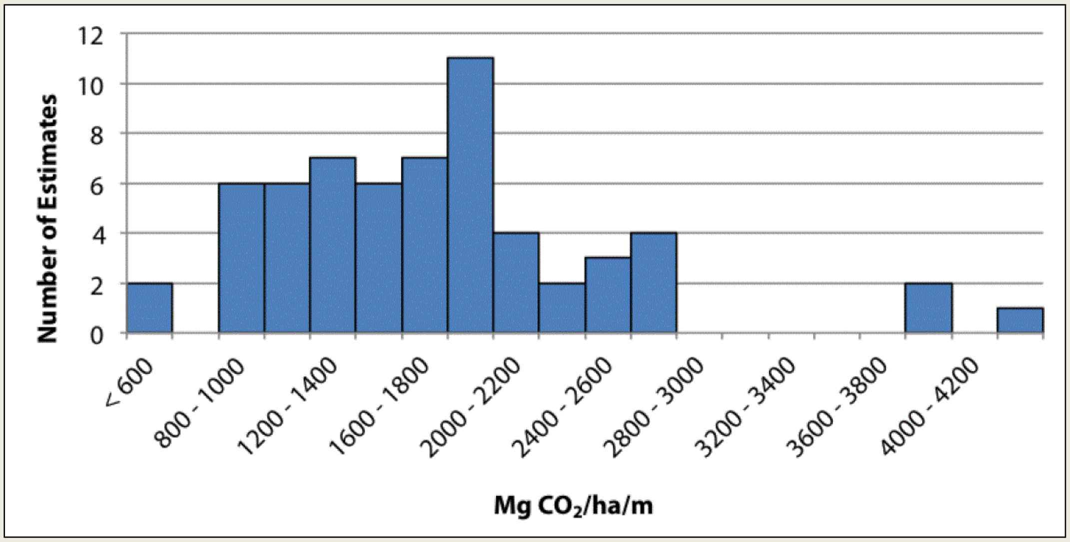


Figure 10. Estimates of carbon contained in the top meter of soil beneath mangrove forest (Sifleet et al., 2011).

Development pressures are very real along the edges of the CMW. Canal-front development, road building, and agriculture (including farming and ranching) are all land use changes that are being felt along the margins of the region. If 5% of the CMW was lost, it can be estimated that a significant quantity of CO_2e would be liberated to the atmosphere. If the mangrove loss were in a fringing, tidally flooded area, approximately 360,161 Mg of CO_2e and would be lost, while 307,345 Mg of CO_2e would be emitted from development of an upland area. For reference, this figure correlates to taking between 64,704 and 75,824 vehicles off the road for a year (EPA, 2015). Mangrove loss to sea level rise is not included in this estimation due to uncertainty in the rate of future sea level rise and the unknown ability of the mangroves in this carbonate, riverless setting to maintain their elevation. While some loss of mangrove areas may be expected as sea levels rise, current rates of loss due to anthropogenic habitat conversion are very high in Grand Cayman, and these losses probably represent a greater threat to mangroves and to the continued provision of coastal defense services than sea level rise (McIvor et al., 2013).

It is important to understand that the oxidation of existing carbon in the top layer of soil is only one biogeochemical process that is affected by the loss of the mangrove ecosystem. When mangrove trees are cleared for development, often the entire tree including the root systems are removed (Saunders et al., 2010). Destabilization of the sediment and enhanced oxygenation leads to increased microbial decomposition at depth as well, another significant source of CO_2 emissions (Pendleton et al., 2012). Deforestation also inhibits the forest's sediment trapping ability and removes root production and turnover as a source of organic matter input, processes considered to be the main driver in peat formation and carbon sequestration (Middleton et al., 2011). Of course, the photosynthetic sequestration of carbon by the vegetation that is removed is also lost (Adame et al., 2013).

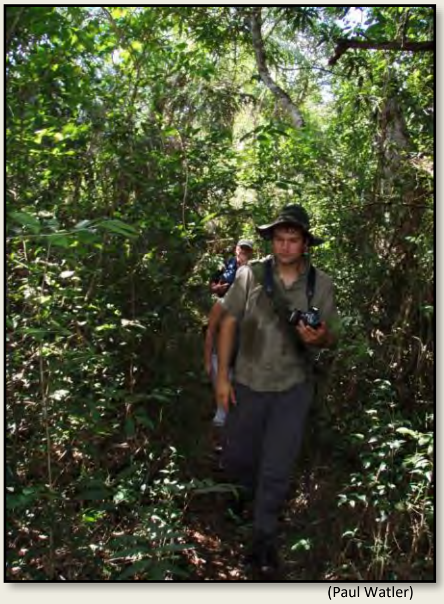
Given that soil organic carbon stores have been shown to compromise the majority of mangrove ecosystem carbon stocks in a number of studies (Schmidt, 2008; Donato et al., 2012; Adame et al., 2013), recent efforts in "blue carbon" science have been focused on how to quantify these emissions to aid in the development of carbon mitigation schemes (Pendleton et al., 2011). The results of this study indicate that mangroves with deep sediments such as the CMW should considered high priority for REDD+ schemes and sustainable management practices.

Conclusions

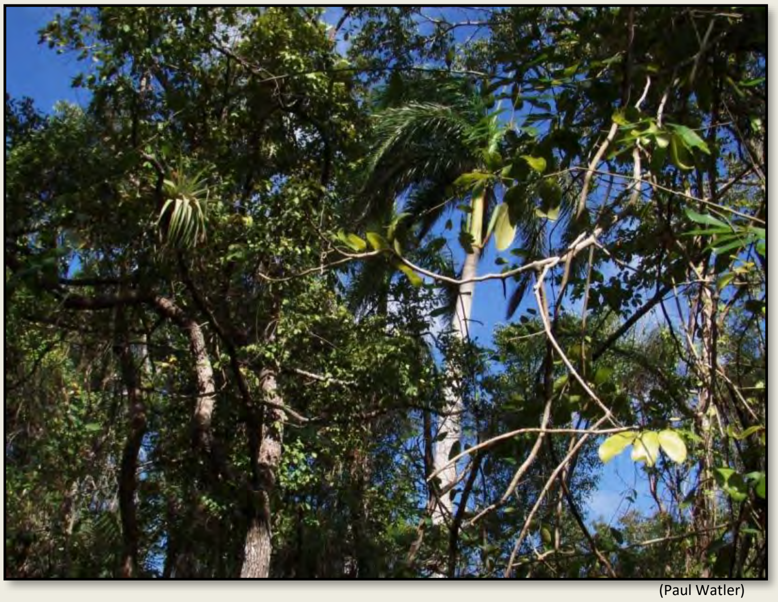
Grand Cayman is a vulnerable area primarily composed of low-lying, oceanic mangroves; ecosystems most at risk from storm surges and sea level rise and yet the most effective at carbon sequestration (Gilman et al., 2008). There is also a history of mangrove removal and degradation on the island. Maintaining carbon cycling capacity through national emission reduction strategies and mangrove protection legislation has great potential to reduce harmful carbon emissions, increase storage capacity and preserve coastal resources (Chevallier, 2012).

Mechanisms that establish payments for blue carbon protection could value ecosystem preservation over habitat conversion, potentially altering economic incentives and inducing landowners, managers, and the government to forgo conversion. Mangroves are by far the coastal ecosystem with the greatest blue carbon value; at a carbon price of \$15/t CO_2e, the average gross returns are over \$18,000/ha for oceanic ecosystems such as those found in Grand Cayman. Oceanic mangroves have greater blue carbon values than estuarine mangroves due to greater carbon density in the top meter of soil (Murray et al., 2011). Mangrove protection is now included in REDD+ which was officially adopted as Article 5 in the new climate agreement achieved in Paris in December 2015, a key step to protect some of the largest and most vulnerable carbon stocks on Earth (WWF, 2015). Although the Cayman Islands is not eligible to participate in REDD+ as an Annex 1 country, the adoption of these parameters by the international community sets clear goals for forest preservation worldwide.

Around the globe, coastal habitats are lost due to market forces that give landowners an incentive to convert natural areas to other uses. Habitats are also lost because governments have been unwilling or unable to create or enforce environmental regulations that would protect the continued ecological sustainability of ecosystems. The absence of mechanisms to pay landowners, managers, or governments to protect the carbon stored in coastal habitats greatly undermines incentives to protect these areas (Murray et al., 2011). Grand Cayman is no different. Land prices here are very high, making purchase by the National Trust for land preservation difficult. It has been recommended that the government of the Cayman Islands use existing environmental protection funds to purchase critical CMW land for preservation purposes (Bradley, 2013). New incentives to value blue carbon protection should also be pursued.



(Paul Watler)

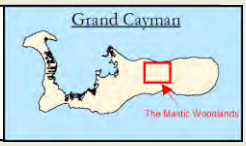


(Paul Watler)

Mastic Forest – Grand Cayman - OVERVIEW

Some facts and figures

AREA: 636 ha
PROTECTION STATUS: 341 ha (54%) owned by the National Trust
CONSERVATION STATUS: new roadways are encroaching upon the area



The Site: The Mastic Forest comprises the largest contiguous area of primary evergreen woodland remaining on Grand Cayman. This area is also of international significance as it represents one of the last remaining examples of Caribbean subtropical, semi deciduous dry forest which has otherwise been cleared throughout much of the West Indies. Apart from a moderate degree of selective logging and small scale agriculture in the past, these woodlands are almost completely undisturbed. The Mastic Forest has been continuously above water for more than two million years, as opposed to the rest of the island which emerged 125,000 years ago, and is thus where the native flora and fauna evolved. It is now home to a variety of animals and plants (Appendix F), including all of Cayman's endemic orchids, trees and birds including the near-threatened Vitelline Warbler, the White-crowned Pigeon and the Grand Cayman Parrot. It is additionally the main habitat for a very rare variety of Black Mastic tree (*Termenalia eriostachya var. margaretiae)* which is unique to Grand Cayman. The NTCI regards protection of this area as one of the organization's highest priorities (Heritage Register, in-press). The Trust set up the Mastic Reserve in 1992, a protected area of the forest (341 ha) which includes the Mastic Trail (NTCI, 2012). The trail is a 4-km traditional footpath that runs from north to south and is now a popular ecotourism site.

The Issues: The National Trust owns and manages a significant portion of the forest (54%) but the remainder is unprotected private land. Specific threats to the endemic parrots include illegal felling of nesting trees and removal of young for the illegal pet trade; predation by rats and feral cats; and illegal shooting as a crop pest. There are plans for urban development on all boundaries of the forest (Bradley et al., 2008). The building of a new major arterial road on the southern boundary of the forest to the eastern side of Grand Cayman, as well as a new road into the northern boundary of the area, will bring residential development and the expansion of agriculture production and associated deforestation. Where development takes place, the land cover will be radically changed and there will be associated degradation of neighboring land. Such habitat losses would contribute to the continued loss of biodiversity on Grand Cayman. The roadways would additionally act as a barrier to wildlife movement and are an avenue for invasive species. It is expected that National Trust holdings in the Mastic Reserve that border the roads will be degraded. The roads will also cause forest fragmentation and edge effects that will lessen the ability of the area to support healthy populations of endemic wildlife (Appendix G). The health of this forest is critical to the support of biodiversity on the island.

Ecosystem Services: The Mastic Forest provides many ecosystem services for the people of Grand Cayman (Appendix H). The trees store carbon and the forest contributes to regulating overland water flow. The forest prevents degradation of the water lens over which it sits. It is also an important site for tourism and recreation as it is the most important terrestrial eco-tourism site on the island. It is expected that the degradation and disruption of the Mastic Trail would outweigh any benefits from improved access. Farmers and other landowners may profit from development, while tourists and locals who enjoy the trail and the forest as they are would lose access to that service.

Carbon Storage

Introduction

The Mastic Forest is an example of the now rare Caribbean subtropical, semi-deciduous dry forest and is the largest contiguous area of primary evergreen woodland remaining on Grand Cayman. Although this area supports large trees, they grow on a karst terrain almost devoid of soil. It is surrounded by agriculture and commercial and residential development which is encroaching from various sides, although the heart of the forest remains undisturbed. It is home to a variety of endemic animals and plants, many of which are threatened.

The Mastic Forest provides many ecosystem services for the people of Grand Cayman. It is an important site for tourism and recreation, contributes to regulating overland water flow, and prevents degradation of the water lens over which it sits. This old growth forest supports large trees that are important for carbon sequestration, while the sediment is often too thin to be a significant reservoir of carbon. The soil is often only represented by accumulations of humus in the pockets and grykes, or deep fissures, of the limestone karst (Huggins et al., 2007). On the northern side of the Mastic Forest, the land levels out and there is sufficient soil for agriculture. This soil, called “red mold,” is reddish in color and highly mineral in nature (Mailer, 2014) (Figure 11).

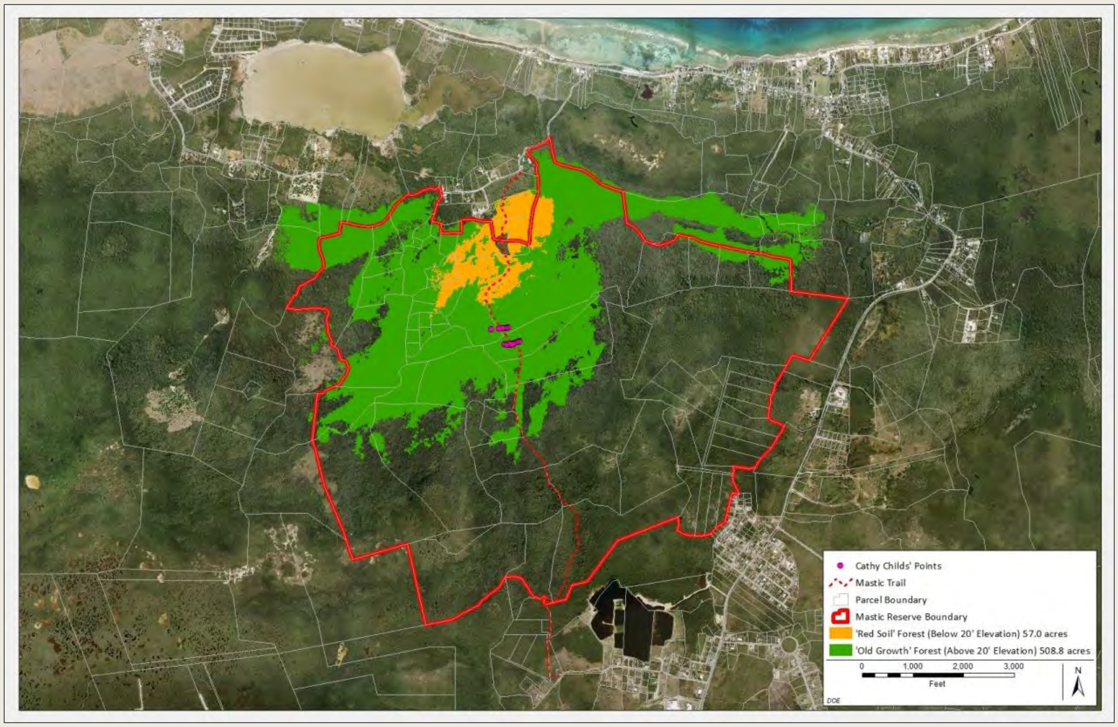


Figure 11. Image showing old growth forest and “red mold” soil habitats in the Mastic Forest (Olynik, 2015).

Methods

To measure the soil and vegetative carbon present in the Mastic Forest ecosystem, transects were run through the old-growth forest following protocols modified from Kauffman et al. (2011). Using the Mastic Trail to access the forest, six 50 m belt transects were performed using continuous sampling procedures (Figure 12). The transects were 5 m wide (2.5 metres either side of the transect). The area sampled was therefore 250 m^2 for each transect, and 1500 m^2 total (50m x 5m = 250 m^2 x 6 transects = 1500 m^2). Vegetation characteristics of the forest were noted to determine aboveground biomass including the species present, their height and diameter at breast height (dbh) for all individuals with a dbh greater than 10 cm (unless a single tree had smaller individual branches at dbh that added up to more than 10 cm), and the canopy cover. Every 10 m, a soil sample was taken for sediment analysis.

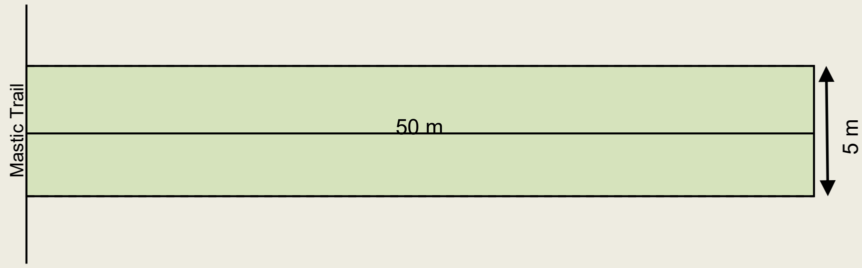


Figure 12. Schematic of belt transect procedure used for Mastic transects.

Soil Carbon

Sediment sampling was carried out using a 30 ml scoop to collect the soil (if present). Twelve soil samples were also collected from the "red mold" area to the north of the old-growth forest. The sediment samples were then secured in airtight sample bags and labeled to record the plot number. Once in the lab, they were dried in a specialized oven at 60^0C for at least two days. They were then weighed, repackaged, and sent to a soil laboratory in the US where they were analysed to determine the concentration of carbon in the sediments.

The three sediment characteristics measured to estimate soil organic carbon stores were bulk density, organic carbon content and sediment depth. Sediment bulk density is the dry mass of soil in relation to a given volume and will depend on the mineral composition of the sediment including particle size and sediment types present within the soil (Adame et al., 2013). Bulk density was determined using the same methods outlined for the CMW (Donato et al., 2011):

Bulk density (g/cm3) = dry weight (g)/sample volume (cm3)

Organic carbon content was determined by the Loss on Ignition (LOI) analysis corrected using the results of dry combustion measurements. In order to investigate the relationship between organic matter from LOI and organic carbon from dry combustion, all 36 soil samples were professionally tested using the LOI method and 3 of these same samples were also tested by dry combustion by Ward Laboratories in Nebraska, USA. Linear regression was used to establish a relationship between the two test results. The relationship found between organic matter and organic carbon was then used to estimate organic carbon content from LOI data.

The size of the sediment organic carbon store per sampled depth interval was calculated by the following equation:

$$\text{Soil organic carbon (g/cm}^2\text{) = OC content (\%)*Bulk Density(g/cm}^3\text{)*sampled depth interval (cm)}$$

It is estimated that the old-growth Mastic Forest has an average sediment depth of 5 cm as soil was only found in the rock surfaces and fissures where humus would collect. Many areas are completely devoid of soil and are instead bare karstic terrain. The soil in the "red mold" area to the north of the forest was estimated to be 15 cm thick in the sampled regions, although it may be deeper in soil pockets (Mailer, 2014).

Vegetation Carbon

A single allometric equation was used to calculate carbon storage for each tree encountered on the transects. Allometric equations are necessary to infer oven-dry aboveground biomass of trees and eliminate the need to cut down, dry, and weigh each tree. This equation was developed by Chave et al. (2014) by analyzing a global database of directly harvested trees at 58 sites, spanning a wide range of climatic conditions and vegetation types (4004 trees ≥ 5 cm trunk diameter). A single equation was developed that holds across tropical vegetation types, with no detectable effect due to region or environmental factors. Wood specific gravity, included in this equation, is an important predictor of aboveground biomass and was retrieved for each species from the World Agroforestry Database (2015). For unknown species, an average figure derived from the known species present was utilized. The equation used was:

$$\text{Biomass (kg)} = 0.0673 * (\rho D^2\, H)^{0.976}$$

where ρ is specific gravity in g/cm3, D is the diameter at breast height in cm, and H is height in m. The amount of carbon present in the trees was then calculated from the biomass figures by multiplying by 0.48 to account for the carbon percentage of wood. The belowground component of the vegetation is not as significant as it is in a mangrove ecosystem. An estimation of this figure was calculated using the allometric equation developed by Cairns et al. (1997) and used in other tropical dry forest studies (Sundarapandian, 2013):

$$\text{BGB} = \exp\,(-1.0587 + 0.8836 \text{ x } \ln \text{AGB})$$

As deforestation and forest degradation result in greenhouse gas emissions dominated by CO_2, with other trace gases such as CH_4 also being released, the soil organic carbon store (Mg/ha) was converted into units of carbon dioxide equivalents (CO2e) by multiplying by 3.67, the ratio of molecular weights between carbon dioxide and carbon (Guild et al., 2004). As stated in the CMW section, reporting in CO_2e is considered conservative, as carbon losses in the form of methane (CH_4) and other greenhouse gases often have higher global warming potentials than that of CO_2 (Kauffman et al., 2012).

Results

Soil Carbon

The dry bulk density (g/cm^3) of sediments found in the old growth forest ranged from 0.15 to 0.33 g/cm^3 (Table 7). Conversely, the "red mold" soil nearby had higher bulk densities of 0.35 to 0.64 g/cm^3 with densities increasing with depth (Table 8) indicating a higher mineral content and less pore space between soil particles. The organic carbon content of the old growth soil was significantly higher than that found in the "red mold" (0.34 compared to 0.27 g/cm^2), but because that sediment was so shallow or nonexistent, the "red mold" area had a higher carbon value per hectare (79.75 instead of 34.02 Mg/ha).

Table 7 – Organic soil carbon content for the Mastic Forest.

Plot Number	Organic Carbon (%)	Thickness per layer (cm)	Bulk Density (g/cm³)	Soil Carbon (g/cm²)	Soil Carbon (Mg/ha)
1,0	0	0	0	0	0
1,10	43.07	5	0.21	0.4480	44.80
1,20	38.05	5	0.18	0.3469	34.69
1,30	39.03	5	0.22	0.4255	42.55
1,40	43.75	5	0.25	0.5561	55.61
1,50	39.22	5	0.16	0.3032	30.32
2,0	0	0	0	0	0
2,10	0	0	0	0	0
2,20	46.69	5	0.19	0.4336	43.36
2,30	41.67	5	0.19	0.4038	40.38
2,40	40.93	5	0.23	0.4711	47.11
2,50	13.26	5	0.33	0.2193	21.93
3,0	31.14	5	0.28	0.4291	42.91
3,10	38.73	5	0.18	0.3393	33.93
3,20	47.61	5	0.19	0.4473	44.73
3,30	22.01	5	0.20	0.2226	22.26
3,40	33.77	5	0.21	0.3613	36.13
3,50	43.07	5	0.15	0.3239	32.39
4,0	43.20	5	0.19	0.4089	40.89
4,10	45.46	5	0.16	0.3643	36.43
4,20	40.63	5	0.19	0.3850	38.50
4,30	36.03	5	0.19	0.3492	34.92
4,40	34.26	5	0.17	0.2889	28.89
4,50	37.75	5	0.19	0.3572	35.72
5,0	36.77	5	0.22	0.4111	41.11
5,10	37.56	5	0.17	0.3149	31.49
5,20	28.07	5	0.33	0.4560	45.60
5,30	36.65	5	0.21	0.3843	38.43
5,40	50.06	5	0.24	0.6069	60.69
5,50	0	0	0	0	0
6,0	43.56	5	0.19	0.4069	40.69
6,10	42.59	5	0.21	0.4540	45.40
6,20	40.87	5	0.23	0.4713	47.13
6,30	41.91	5	0.24	0.5110	51.10
6,40	0	0	0	0	0
6,50	42.52	5	0.16	0.3465	34.65
AVERAGE SOIL CARBON (including zeros)					34.02
TOTAL SOIL CARBON FOR MASTIC FOREST (old growth forest)					**700.12 Mg**
TOTAL CO_2e FOR MASTIC FOREST (old growth forest)					**25,719.8 Mg**

Table 8. Average organic soil carbon content for samples of "red mold" soil north of Mastic Forest.

Soil Horizon	Organic Carbon (%)	Thickness per layer (cm)	Bulk Density (g/cm3)	Soil Carbon (g/cm2)	Soil Carbon (Mg/ha)
-5	12.68	5	0.44	0.2683	26.83
-10	10.88	5	0.50	0.2672	26.72
-15	9.95	5	0.55	0.2620	26.20
TOTAL SOIL CARBON PER SAMPLED DEPTH					79.75
TOTAL SOIL CARBON FOR "RED MOLD" AREA					**1,834.25 Mg**
TOTAL SOIL CO_2e FOR "RED MOLD AREA					**6,731.7 Mg**

The Loss on Ignition (LOI) method of testing for organic carbon concentration was checked against the dry combustion method for accuracy and correction. This study found that the relationship between organic matter from LOI and organic carbon content from dry combustion were well correlated, although the small number of samples made the finding statistically less significant (Figure 13). The relationship found by linear regression between the two testing techniques was therefore used to correct the LOI figures as LOI is prone to inaccuracies (Santisteban et al., 2004).

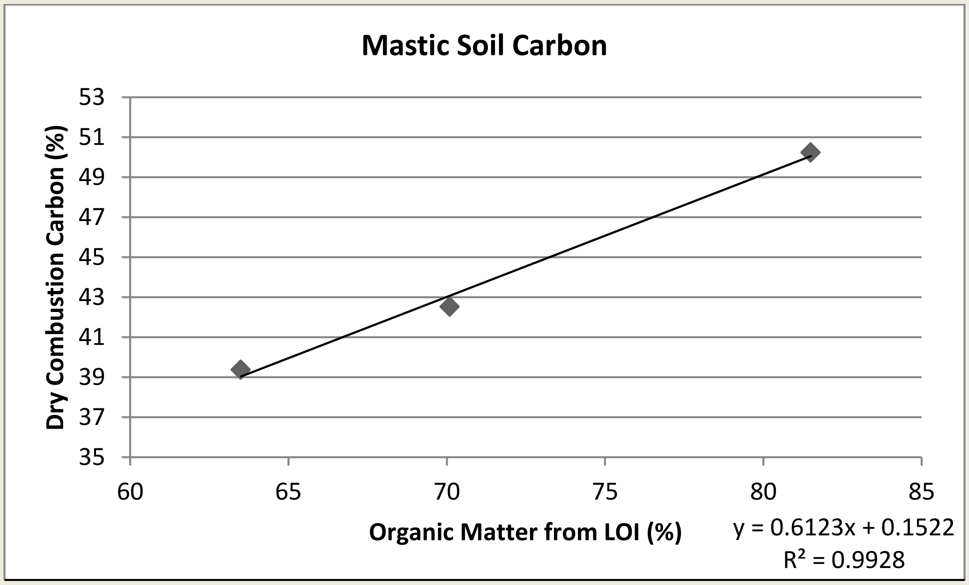


Figure 13. Relationship between soil organic matter values found by LOI and dry combustion determined through linear regression.

Using known information about the size of each habitat type, it is possible to calculate the organic carbon stored in the soils of the Mastic Forest. There are approximately 206 ha of old growth Mastic Forest and 23 ha of "red mold" soil areas. Therefore, it is estimated that 7008.12 Mg (34.02 Mg/ha) of carbon is stored in the soil of the old growth Mastic Forest and 1834.25 Mg (79.75) in the "red mold" soil. The total carbon density was converted to CO_2e by multiplying the carbon stock by 3.67, the ratio of molecular weights between carbon dioxide and carbon (Kauffman, 2011), yielding 25,719.8 Mg and 6731.7 Mg CO_2e respectively.

For comparison, the CMW contains 1.51 x 10^6 Mg of carbon in the top meter of sediment (550 Mg/ha in the fringing and 434 Mg/ha in the upland mangroves). The organic carbon stored in the entire soil layer down to bedrock (estimated at 240 cm) of the CMW is 3.89 x 10^6 Mg of carbon (1632 Mg/ha in the fringing and 1060 Mg/ha in the upland mangroves).

The “red mold” soil was tested for fertility in the lab and was found to be good soil for many of the local crops (Table 9). All of the key soil parameters were within optimal levels. Magnesium levels appear high, but soils with a high CEC value are able to hold abundant magnesium (Spectrum Analytic, 2015).

Table 9. Basic soil characteristics of “red mold”soil.

Soil Sample	pH	Texture	CEC (Cations)	%K Sat	%Ca Sat	%Mg Sat	%Na Sat
1	7.8	loamy sand	35.9	2	68	29	1
2	7.8	loamy sand	36.4	1	68	30	1
3	7.4	loamy sand	27.6	2	71	26	1
4	7.8	loamy sand	25.9	2	74	23	1
Optimal	**pasture**	**vegetables**	**11-50**	**2-5**	**60-75**	**7-20**	**0.5-5**

Vegetation Carbon

On all 6 transects, 40 species were found, 5 of which were unknown. Of the trees sampled, Narrowleaf Ironwood (*Gymnanthes lucida*) had the highest specific gravity (1.1 g/cm^3), followed by Pepper Cinnamon (*Canella winterana*) (0.99 g/cm^3) and Wild Sapodilla (*Sideroxylon salicifolium*) (0.96 g/cm^3). The highest biomass was achieved by the largest trees however, including a Wild Fig (*Ficus aurea*) (1887.12 kg), a Red Birch (*Bursera simaruba*) (753.54 kg), and a Yellow Mastic (*Sideroxylon foetidissimum*) (650.24 kg). These were outliers though as the average tree biomass in the old growth Mastic Forest was 118.55 kg. Red Birch was the species that had the highest biomass in the forest as it occurred at a high frequency and at large sizes (Appendix J).

From these transects it was determined that the tree biomass of the old growth Mastic Forest is 195.21 Mg/ha aboveground and 0.15 belowground, for a total of 195.35. It is estimated that this part of the forest represents 206 ha, and therefore a total biomass of 40,242.1Mg (Table 10). Biomass estimates can be converted to the carbon content of biomass by using a factor of 48% per dry mass. The old growth Mastic Forest is then calculated to store 19,316.21 (Kaufmann, 2013). When multiplied by 3.67 to convert to CO^2e, this part of the forest is found to be storing 25,719.8 Mg CO^2e in the soil and 70,890.48 MgCO2 in the trees, for a total of 96,610.28 Mg CO^2e. The large trees in this forest are impressive for carbon storage, holding more than twice the carbon stored in the trees of the CMW. But when sediment carbon stores are included in the comparison, it is found that the soil and trees in this part of the Mastic have a total CO_2e of 9.7 x 10^4 Mg/ha, while the soils and vegetation of the CMW contain 6.36 x 10^6 Mg of carbon (in the top meter) or 1.51 x 10^7 Mg of carbon (including entire soil layer down to bedrock).

Table 10. Biomass in the old growth Mastic Forest.

Component	**Old Growth Mastic Forest**	
	Mg/ha	Mg
Aboveground trees	195.21	40,170
Belowground trees	0.15	30.9
Total vegetation	**195.35**	**40,242.1**

Table 10. Carbon pools in the Mastic Forest compared to the CMW.

Component	Old Growth Mastic Forest		CMW		
	Mg/ha	Mg	Fringing (Mg/ha)	Upland (Mg/ha)	Total CMW (Mg)
Aboveground trees	93.70	19,302.2	30.20	49.44	150,878.03
Belowground trees	0.072	14.83	12.36	22.85	68,665.07
Total vegetation	**93.77**	**19,317.03**	**42.56**	**72.29**	**219,543.10**
Total soil	34.02	7008.12	1,632.36	1060.39	3.89×10^6
Top meter soil	n/a		550.23	433.57	1.51×10^6
Total (vegetation + entire soil profile)	**127.79**	**26,325.15**	**1,674.92**	**1132.67**	**4.11×10^6**
CO^2e (veg + top meter soil)	n/a	n/a	**2,175.54**	**1,856.51**	**6.36×10^6**
CO^2e (vegetation + entire soil profile)	**469**	**96,613.3**	**6,146.97**	**4,156.90**	**1.51×10^7**

Discussion

Although the carbon storage of the Mastic Forest is low when compared to the CMW (Table 10), the trees are found to be significant for carbon storage compared to other forests of this type. A tropical dry forest in Mexico occuring in similar karstic terrain was found to contain 115 MgC/ha compared to the Mastic's 195.35 MgC/ha (Dai et al., 2013). The authors of that study found that the carbon balance of dry tropical forests of this region is sensitive to human and natural disturbances and climate change. Studies indicate that most of the carbon resides in the old growth (high dbh) trees, and therefore extra care is required to protect such trees in the dry forest (Chaturvedi, 2011).

Land use changes are being felt along the margins of the Mastic Forest including residential and commercial development, road building, and agriculture (including farming and ranching). If 5% of the old growth Mastic was lost, it can be estimated that 4,830.67 Mg of CO_2e would be liberated to the atmosphere from disruption of the soil and the loss of the trees.

If the "red mold" area to the north of the Mastic were converted to agricultural use, it is likely that little of the carbon would be lost. This area is mostly secondary growth and as such, does not contain the very large trees of the old growth forest. Much of the agriculture of this region also makes use of high biomass crops including mangoes. This soil of this area was also found to be of a good quality for agricultural use.

Conclusions

The Mastic Forest is a unique area of the island, and indeed in the world, as this ecosystem type has been lost over much of its range. If the forest were converted to housing, agriculture, or roads, many ecosystem services would be lost including carbon from the large trees found in the old growth forest. The old growth forest and the large trees must be protected. If agriculture must move into the region, it is recommended that it be restricted to the secondary growth forest on the "red mold" soil while maintaining a buffer zone around the old growth forest. It may be possible to incorporate some agriculture into the region while conserving these forests by working with private landowners to develop environmentally friendly farming techniques.

In Costa Rica, a Payment for Environmental Services Program (PES) was established with the Forestry Law of 1996. This program recognizes a range of environmental services derived from natural forests and agroforestry systems including carbon fixation, hydrological services (including the protection of aquifers), biodiversity protection, and the provision of scenic beauty (Subak, 2000). Such a program in the Cayman Islands could aid in the protection of both the CMW and the Mastic Forest.

Tourism and Recreation

Introduction

The Mastic Forest is a unique tourism site in the Cayman Islands, representing an accessible two-million year old forest. This is one of very few terrestrial areas where tourists can experience the wilderness of Grand Cayman. Visitors are able to access the forest by using the Mastic Trail, a traditional 4-km footpath, traversing the central part of the island from north to south; the forest is effectively inaccessible for recreation apart from the trail. It is primarily visited by stay-over visitors and residents, as it is too far from the port for cruise ship passengers to visit. The NTCI markets the trail as a tourism resource and its guided hike has won a Certificate of Recognition from the travel website, TripAdvisor, and is ranked #29 of their most popular things to do on the island (TripAdvisor, 2015). Other tour operators, some of whom are located in the district of North Side next to the park, also offer guided hikes.

Methods

To estimate the recreational value of the Mastic Forest, the current number of visits to the Mastic Trail was estimated, as well as the number that would take place should the forest be subject to adjacent development and degradation. A travel cost method was used to assess the value of the site to visitors, although qualitative information about the benefits that people receive from visiting the Mastic Forest was also collected.

Visitors to the Trail were given the opportunity to complete surveys. Self-administered surveys were offered to Mastic Trail visitors in a physical paper format posted at both ends of the Trail from April through October 2015, while online surveys were shared via the NTCI website and Facebook page in July and August of 2015. Completed surveys were collected from the trailheads on a weekly basis.

Results

A total of 46 survey forms were completed at the Trail locations and 26 online. The people who responded online tended to be local residents (92%) while those who completed surveys on the Trail were mostly tourists (74%), the majority of whom were from the USA (68%). Most online respondents (59%) indicated that they return on a yearly basis, whereas those that were surveyed on the Trail were usually first-time visitors (63%). Basic demographic questions indicated that visitors to the Mastic Trail that completed surveys onsite were of a fairly even age distribution, while online respondents reported an older group of hikers (Figure 14). Both groups of respondents represented a fairly even gender mix.

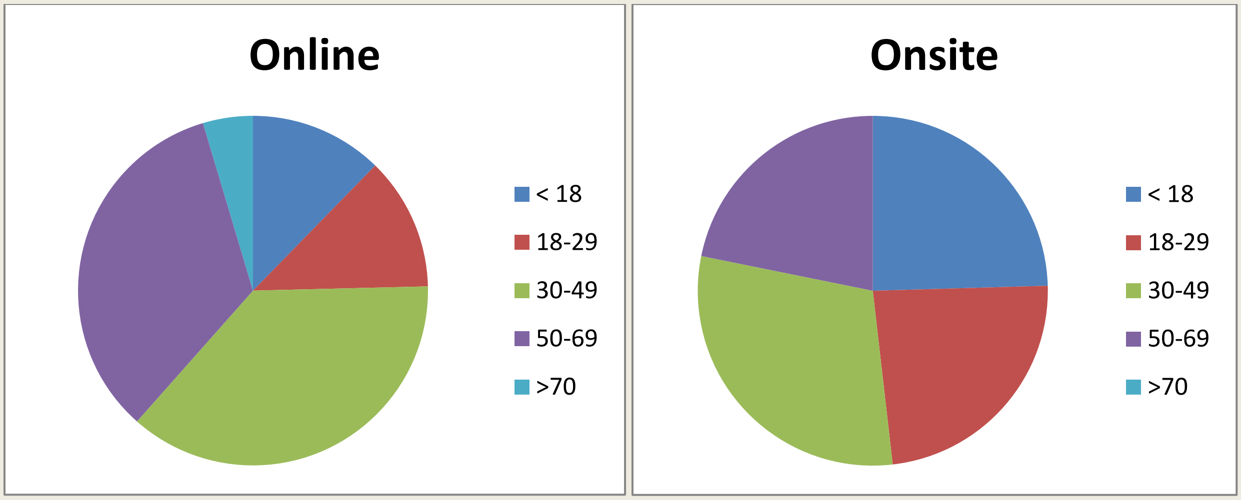


Figure 14. Age distribution of Mastic Trail hikers.

The number of visitors to the trail was calculated for each of the months of survey. These numbers were compared to monthly tourism numbers (air arrivals only) in the Cayman Islands (CI Department of Tourism, 2015), which indicated that 0.46% of these visited the Mastic Trail. This proportion was then applied to the months of the year when cameras were not in place to estimate an annual number of visitors, calculated at 1772 tourists. Based on the proportion of tourist to resident respondents completing the on-site surveys (the online surveys were considered more likely to be biased), it is calculated that 76% of visitors were international tourists, and 24% were Cayman residents.

A travel cost method was employed to estimate the value of the site for recreation. Because the profile of international tourists and residents was so different, the price per visitor was calculated separately for these two categories. For local residents, the travel cost was considered to be the cost incurred to get to the Trailhead from their home. Local visitors to the Trail drove an average of 40 km (24.86 miles) round trip from their homes to the forest. Using the Cayman government policy of reimbursement for personal vehicle use of 50 cents per mile, the cost of travel for residents to visit the Trail is $12.43 CI ($15.54 US). For international tourists, the travel cost was considered to be a proportion of their total (self-reported) holiday spend. Surveys indicated that international tourists spent an average of $310 for one day of their visit (average spend of $2563.63 for an entire stay of 8.27 days), which they used to visit the Mastic Trail. Although most visitors indicated that they did not come to the Cayman Islands specifically to see the Mastic Forest (89.3%), they did choose to spend a significant portion of a day of their vacation hiking the Trail. Almost all international holidays are booked for multiple reasons, and we consider it reasonable to assign this value to the Mastic Forest. Local visitors therefore spend $6,608.85/year to visit the Trail, while tourists spend $417,483.20/yr, for a total of $424,092.05 USD per year added to the economy.

As cruise ship visitors are unable to visit the Mastic Forest in their time on the island, we know that tourists that visited the Mastic Trail are all stay-over visitors. Visitors to the Mastic Trail are therefore above-average contributors to the local economy as statistics indicate that the average stay-over tourist to the Cayman Islands spends $1103.07 ($82.14 for cruise ship visitors) (Baird, 2014), and our respondents reported an even higher average spend of $2,563.63. Many of the Mastic visitors dined at restaurants after their hike (61.5% onsite respondents, 44% online) and the restaurants they chose were overwhelmingly in the districts of North Side and East End (87.5% onsite, 100% online). The National

Trust offers a guided trail hike. Their Field Officer led 342 visitors on the Trail in 2014 and earned $10,270 USD for the non-profit organization.

If the Mastic Forest were altered significantly by roads and subsequent residential and commercial development, much of the Mastic's tourism and recreational value would be degraded. All of the online respondents indicated that they believe that an undisturbed forest is important to the Cayman Islands. Many (77% online) took the time to write comments to further clarify the importance of protecting this site (Appendix K). Most respondents stated that they visit to appreciate nature and wildlife (89.04% online, 85.42% onsite). When asked to imagine a scenario in which a road is built next to the Mastic Forest and the forest becomes degraded (through the introduction of invasive species or the extension of residential areas to the edge of the forest), respondents strongly indicated that their enjoyment of the area would decrease (94% onsite, 84% online). Of the people that responded, 70% of tourists and 75% of residents said that they would never return to the Mastic Trail under this scenario. Translating this to dollars lost, we can calculate that degradation of the natural ecosystem of the Mastic Forest would cost the economy $292,238.24 tourist dollars and $4,956.64 local spend, for a total of $297,194.88 per year.

Discussion

Although the number of visitors hiking the Mastic Trail is small compared to overall tourism figures for the Cayman Islands, it may play a significant role in the local economy of North Side, the district where the Mastic Forest is located. Income levels per capita in the eastern districts of North Side and East End are below the national average (Tourism Company, 2009). The Mastic Trail lures visitors away from the busy 7-Mile-Beach corridor, helping to support restaurants, trail guides, and other businesses in the eastern districts. The Mastic Forest therefore benefits the inhabitants of these districts while also boosting the overall diversity of experiences offered by the Cayman Islands as a destination.

From a tourism perspective, the Eastern Districts are rich in cultural and ecological value that represent a change from the sun and beach vacation that most visitors come to Cayman to experience. This is particularly significant as Grand Cayman lacks mountains, rivers, or archaeological sites that offer a diversity of tour options in neighbouring island countries. Nature-based tourism is a growing niche market in the tourism industry. Studies reveal that the typical ecotourist is a mature consumer, generally over the age of 35, educated to at least a college education, from middle to high-income households, and of a relatively equally-shared gender spread. The length of stay in the destination ranges from 8 to 21 days, with the average length being two weeks. Accommodations above the 2-star range are typically demanded. The ecotourist is interested in wilderness experiences and seeing wildlife in their natural habitat (IDB, 2014). The Mastic Forest is an important attraction for the ecotourist traveler visiting the Cayman Islands and can bring much needed funds to the eastern districts.

Although the eastern districts have much to offer, they have remained relatively unknown to visitors. The Mastic Forest is a largely untapped resource that could potentially draw more high-end visitors and their expenditures to this less visited end of the island. The Mastic Trail and its significance as the only access into this unique ecosystem is therefore estimated to be of high importance to the ecotourism potential of Grand Cayman, as well as to North Side and East End Districts. If a significant portion of the forest and the Trail were transformed to residential or commercial developments and roads, this important tourism resource would be degraded or lost.

Conclusions

The ecosystem services provided by natural areas are often overlooked in policy making decisions. It is only when the areas have been changed that we value the services that have disappeared. It is therefore important that ecosystem services are valued to better account for the costs associated with ecosystem degradation and to recognise the substantial economic benefits from better management of natural areas. Carrying out an evaluation of ecosystem services helps to incorporate the value of the natural environment, and the ecosystem services it provides, into policy decisions to ensure that society can maintain a healthy and resilient natural environment now and for future generations.

The Cayman Islands are rapidly developing with little thought for how the future will look. Many drivers of change are affecting the islands in concert and together could cause irreparable harm to our natural areas (Appendix I). It is important that we understand the critical ecosystem services provided by our natural areas before we decide to allow their conversion to more roads, homes, and shopping areas. Development should proceed with a plan in mind, ensuring the sustainable use of our resources. Protection from storms, nurseries for fish destined for human consumption, the health of the coral reefs that attract our visitors, maintenance of the quality and the recharge rate of the few freshwater lenses Cayman possesses are just a few of the many services where we rely upon intact ecosystems to provide for us. Immediate protection of the areas that provide the most important flows of ecosystem services is critical if we are to ensure that we are able to continue enjoying these services into the future.

The Mastic Forest and the Central Mangrove Wetland provide many irreplaceable services to the human populations of the Cayman Islands. These sites have survived to the present day because of their remote locations and difficulty of access. Those deterrents to development have become less important and many natural areas are now in danger of imminent and permanent change. If our natural areas are lost, Cayman's residents will suffer irreparable harm as the essential ecosystem services these sites provide are lost. These key sites that deliver the most critical ecosystem services should be designated protected areas immediately in order to guarantee that their essential functions continue to be delivered to the people of the Cayman Islands for years to come.

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Appendix A. Rapid Ranking Checklist (adapted from J. Johnson, ANT).

Site Name	Size	Size Value	Environmental Value	Internationally Protected Species	Locally Protected Species	Native or Endemic Plants or Animals	IBA	Condition of Site	Surrounding Development	Ownership	Uniqueness of Area	Total Points	**Ranking**
Grand Cayman													
Central Mangrove Wetland (CMW)	3	2	3	3	3	3	3	3	2	1	3	29	1
Mastic Forest	3	2	3	3	3	3	3	3	2	3	3	31	1
Barkers Peninsula	3	2	2	0	3	3	0	2	3	1	3	22	2
Blue Hole	1	1	1	3	3	3	0	1	1	2	3	19	2
Collier's Pond Animal Sanctuary	3	2	3	3	3	3	0	3	3	1	2	26	2
Collier's Wilderness Reserve	3	2	3	3	3	3	0	3	3	2	2	27	1
East End Forest	3	2	2	3	3	3	3	2	2	2	2	27	1
Ironwood Forest	3	2	2	3	3	3	0	2	1	1	3	23	2
Governor Gore Bird Sanctuary	1	3	2	3	3	3	0	1	3	3	2	24	2
Long Bridge Wetland and Palm Forest	3	2	2	3	3	3	3	3	2	1	2	27	1
Malportas Pond	3	2	2	3	3	3	0	2	2	2	1	23	2
Old Man Bay Bat Caves	3	2	3	3	3	3	0	2	2	1	3	25	2
Pedro Bluff Tropicbird Zone	1	2	1	3	3	3	0	2	3	1	3	22	2
Salina Reserve	3	2	3	3	3	3	3	3	3	3	3	32	1
Salt Creek - Batabano Coastline	3	2	2	0	3	3	0	1	1	1	3	19	2
Ventner's Cistern	1	3	2	0	3	3	0	2	3	1	3	21	2
Western Mangrove Cays	1	1	1	0	3	3	0	3	3	2	1	18	2
Lower Valley Forest	3	2	2	3	3	3	0	2	2	1	1	22	2
Little Cayman													
Bloody Bay Forest and Mangroves	3	2	3	3	3	3	0	2	2	1	2	24	2
Booby Pond Nature Reserve	3	2	3	3	3	3	3	3	2	3	3	31	1
Cenarion Snail Zone	1	3	2	3	3	3	0	0	1	1	3	20	2
Central Mahogany Forest	3	2	2	3	3	3	3	3	3	2	3	30	1

Crown Wetlands	3	1	3	3	3	3	3	3	3	2	1	28	1
Key Iguana Nesting Sites	2	2	3	3	3	3	0	2	2	2	3	25	2
Point of Sand	2	2	2	0	3	3	0	2	3	1	3	21	2
South Hole Sound	3	1	3	3	3	3	0	2	1	2	3	24	2
Cayman Brac													
Big Channel Bluff Road	1	1	1	0	3	3	0	1	2	1	1	14	2
Bluff Forest	3	2	3	3	3	3	3	2	2	1	3	28	1
Brac Marshes and Haymon's Pond	2	2	3	3	3	3	0	1	2	1	3	23	2
Caves	3	2	3	0	3	3	0	2	2	1	3	22	2
Crown Cliff Faces of Bluff	3	2	3	3	3	3	0	3	3	2	3	28	1
Double Sinkhole	1	1	1	0	3	3	0	3	2	1	1	16	2
Iguana Plateux	1	3	1	3	3	3	0	1	2	1	3	21	2
Mountain	1	1	1	0	3	3	0	1	2	1	1	14	2
NE Point Brown Booby Rookery	1	3	1	3	3	3	0	2	2	2	2	22	2
Old Lighthouse Road Park	3	2	2	3	3	3	0	3	3	1	2	25	2
Saltwater Pond	2	2	2	0	3	3	0	1	1	2	3	19	2
S Bluff Edge Booby Nesting Zone	1	3	1	3	3	3	0	3	3	2	2	24	2
Splits	3	2	3	3	3	3	0	3	2	3	2	27	2
Westerly Ponds	3	2	2	0	3	3	0	1	1	2	3	20	2

Size: **1** – 0-3 ha, **2** – 4-8 ha, **3** – greater than 8 ha

Size value: **3** - small areas (under 3 ha) that are rich ecologically**,** **2** - larger sites with rich ecological value, **1** - large or small sites with low ecological value

Environmental Value: **3 -** highest scores if an area captures both flora & fauna on a broad scale or is of great ecological value (e.g coastal protection or safeguard from flooding), maximum scores if an area is adjacent to/bordering a protected area

Protected Species: both locally and internationally protected species (IUCN, CITES, etc.), **3** – if present, **0** – none present

Native or Endemics Present (Plants/Animals)**:** **3** – if present, **0** – none present

IBA (Important Bird Area): **3** – yes, **0** – no

Condition of Site: absence of pollution or other degradation, **3** – excellent, **2** – good, **1** – fair, **0** – poor

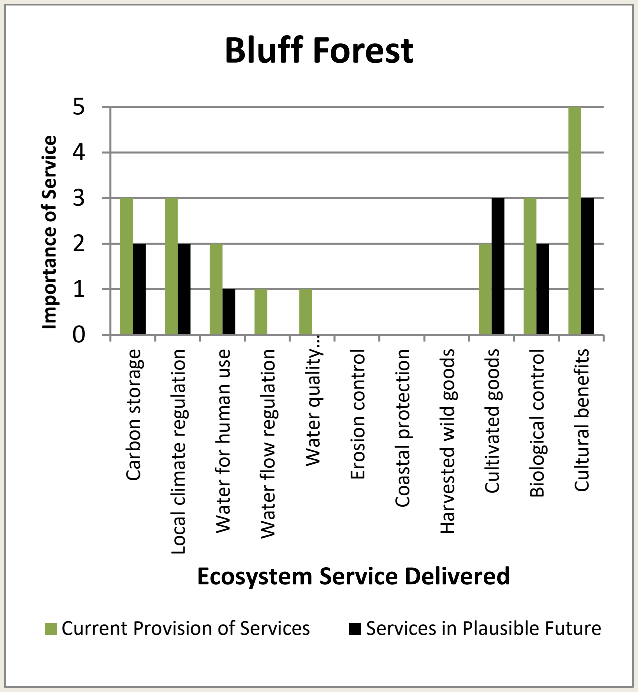
Surrounding Development: less development warrants a higher score, **3** – little development, **2** – medium, **1** - high

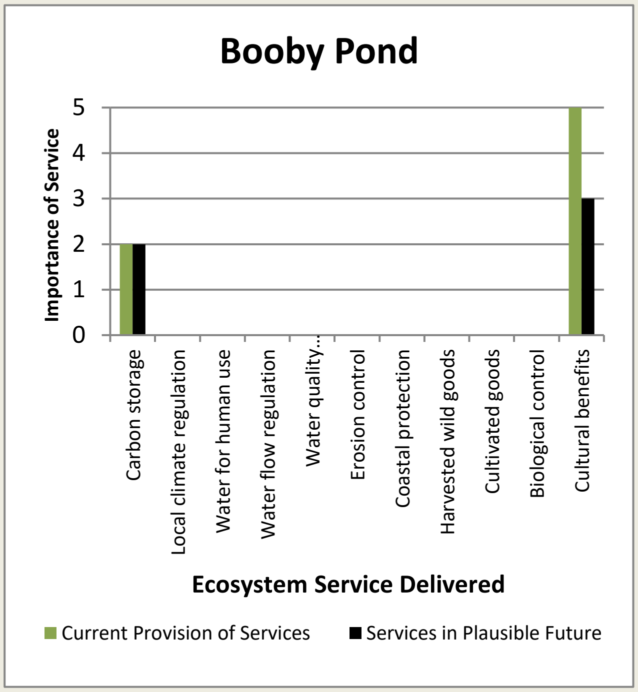
Ownership: **3** - National Trust, **2** – Crown, **1** – Private

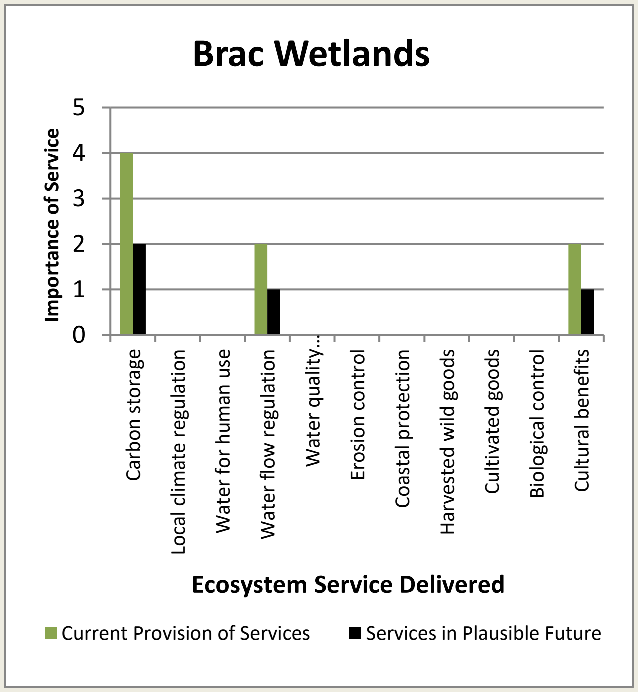
Uniqueness of Area: all of island considered, **3** – high, **2** – medium, **1** – low

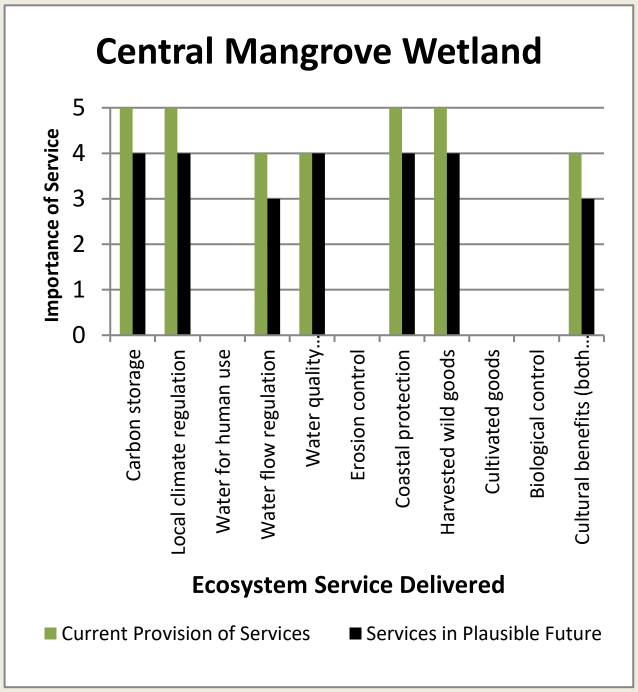
Ranking: **1** – high priority for protected area status (>27), **2** – medium priority, **3** – low priority (<13)

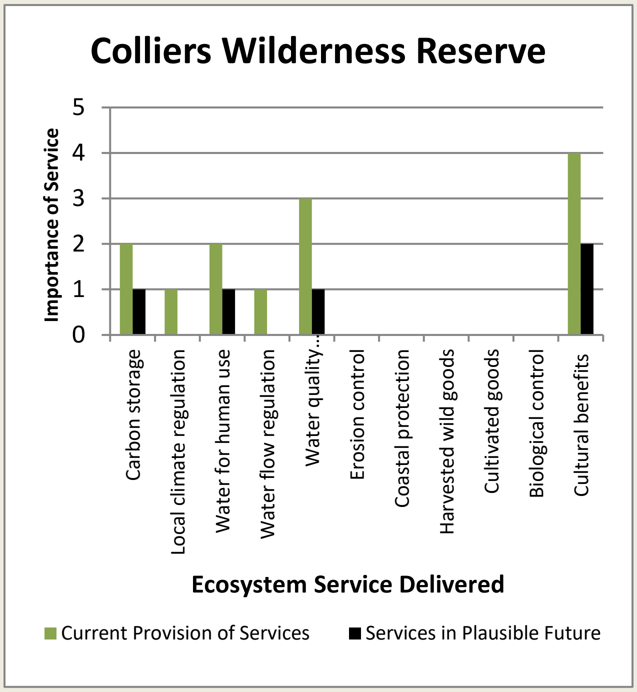
Appendix B. Ecosystem services provided by site in current state and under scenarios in which expected threats occur (over ten year time frame).

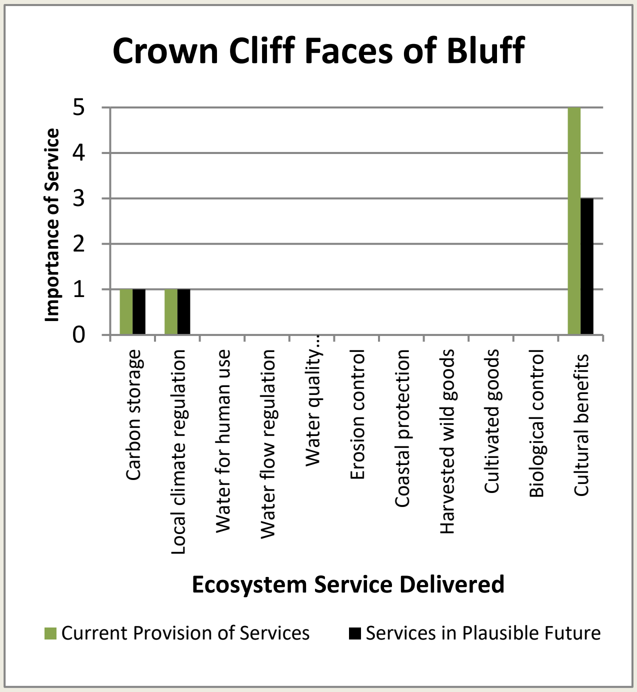


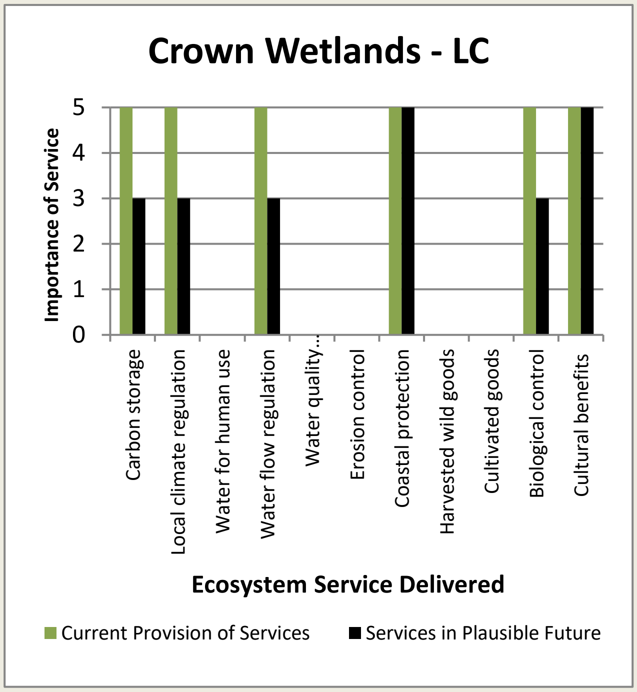


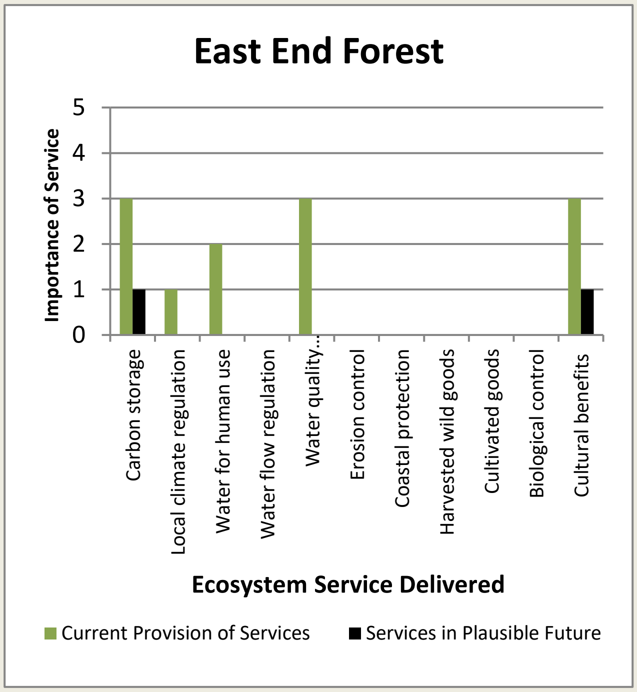


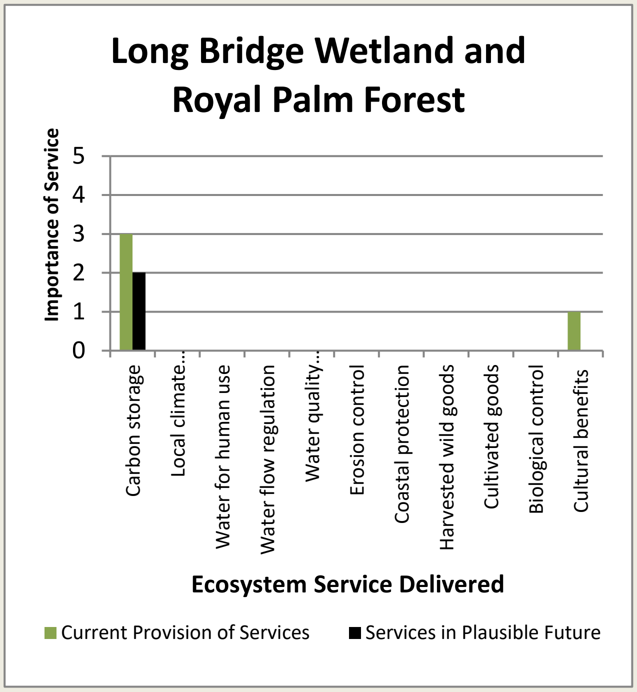


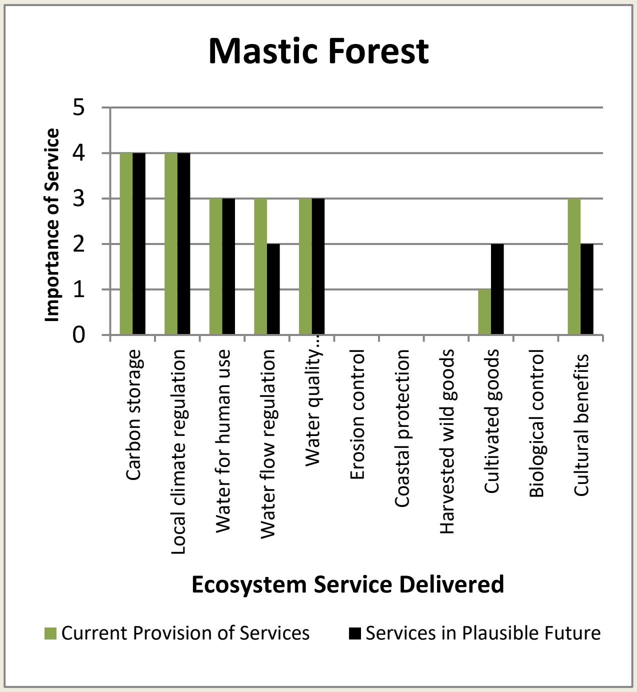

Colliers Wilderness Reserve
Importance of Service
5
4
3
2
1
0
Carbon storage
Local climate regulation
Water for human use
Water flow regulation
Water quality…
Erosion control
Coastal protection
Harvested wild goods
Cultivated goods
Biological control
Cultural benefits
Ecosystem Service Delivered
Current Provision of Services
Services in Plausible Future

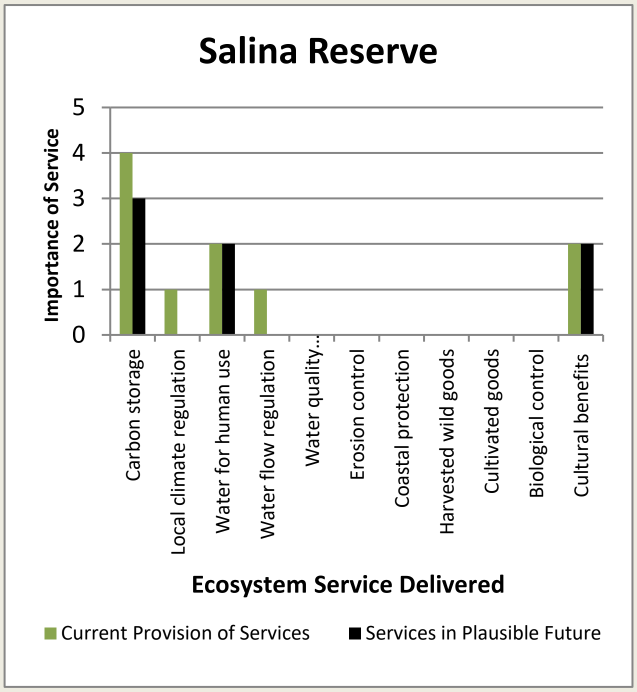

Crown Cliff Faces of Bluff
Importance of Service
5
4
3
2
1
0
Carbon storage
Local climate regulation
Water for human use
Water flow regulation
Water quality…
Erosion control
Coastal protection
Harvested wild goods
Cultivated goods
Biological control
Cultural benefits
Ecosystem Service Delivered
Current Provision of Services
Services in Plausible Future


Crown Wetlands - LC
Importance of Service
5
4
3
2
1
0
Carbon storage
Local climate regulation
Water for human use
Water flow regulation
Water quality…
Erosion control
Coastal protection
Harvested wild goods
Cultivated goods
Biological control
Cultural benefits
Ecosystem Service Delivered
Current Provision of Services
Services in Plausible Future


East End Forest
Importance of Service
5
4
3
2
1
0
Carbon storage
Local climate regulation
Water for human use
Water flow regulation
Water quality…
Erosion control
Coastal protection
Harvested wild goods
Cultivated goods
Biological control
Cultural benefits
Ecosystem Service Delivered
Current Provision of Services
Services in Plausible Future


Long Bridge Wetland and Royal Palm Forest
Importance of Service
0
1
2
3
4
5
Carbon storage
Local climate…
Water for human use
Water flow regulation
Water quality…
Erosion control
Coastal protection
Harvested wild goods
Cultivated goods
Biological control
Cultural benefits
Ecosystem Service Delivered
Current Provision of Services
Services in Plausible Future


Mastic Forest
Importance of Service
0
1
2
3
4
5
Carbon storage
Local climate regulation
Water for human use
Water flow regulation
Water quality…
Erosion control
Coastal protection
Harvested wild goods
Cultivated goods
Biological control
Cultural benefits
Ecosystem Service Delivered
Current Provision of Services
Services in Plausible Future


Salina Reserve
Importance of Service
0
1
2
3
4
5
Carbon storage
Local climate regulation
Water for human use
Water flow regulation
Water quality…
Erosion control
Coastal protection
Harvested wild goods
Cultivated goods
Biological control
Cultural benefits
Ecosystem Service Delivered
Current Provision of Services
Services in Plausible Future

Appendix C. Key Species Found in Mangrove Ecosystems in the Cayman Islands (DaCosta-Cottam et al., 2009).

Category	**Detail** (protection under National Conservation Law)	**Scientific Reference**
Mammals	All bats (protected under part 1)	Chiroptera
Birds	All birds (protected under part 1, unless specifically listed in part 2). Of special significance to this habitat:	Aves
	Grand Cayman parrot	*Amazona leucocephala caymanensis*
	Greater Antillean grackle	*Quiscalus niger caymanensis*
	West Indian Whistling-duck	*Dendrocygna arborea*
	White-crowned pigeon	*Patagioenas leucocephala*
Reptiles	Hickatee (Taco River Slider)	*Trachemys decussata angusta*
Fish	All bony fish - *except those specifically listed in Part 1 or elsewhere in Part 2*	Teleostei species
	Mosquito fish	*Gambusia xanthosoma*
	Mosquito fish	*Limia caymanensis*
Invertebrates	Echinoderms	Echinodermata all species
	Sponges	Porifera all species
	White Land crab	*Cardisoma guanhumi*
	Lobsters	Palinura species
	Spiny lobster	*Panulirus argus*
	Queen conch	*Strombus gigas*
Corals	All soft corals (including Gorgonians & Telestaceans)	Anthozoa all species
Plants	Black mangrove	*Avicennia germinans (= nitida)*
	Buttonwood	*Conocarpus erectus*
	White mangrove	*Laguncularia racemosa*
	Red mangrove	*Rhizophora mangle*
	Green algae	Chlorophyta species
	Brown algae	Phaeophyta species
	Red algae	Rhodophyta species

Appendix D. Current Factors Affecting Mangrove Ecosystems in the Cayman Islands (DaCosta-Cottam et al., 2009).

Driver of Change	Effect
Buffer zone erosion	Mangrove buffer zones are regularly eroded by development and canalisation for access.
Roads construction	Interruption of natural drainage systems by poorly designed roads projects has resulted in the drowning and death of significant tracts of mangrove, including Tarpon Lake on Little Cayman following Hurricane Gilbert, and South Sound and Prospect on Grand Cayman following Hurricane Ivan. The currently gazetted central bypass road on Grand Cayman has the potential to significantly impact the Central Mangrove Wetland and encourage development into this area.
Quarrying	Several quarries are currently operative within the Central Mangrove Wetland, Grand Cayman, with approximately 100 acres currently slated for expansion of activities.
Cut and fill	This is the development practice of filling low-lying wetland with spoil gained from excavation of associated canal systems. “Cut and fill” causes immediate physical damage to mangroves through land clearance and is usually accompanied by the filling and residential development of land immediately adjacent the canal. Canalisation also reduces the effectiveness of mangroves as a storm buffer, and contributes to fragmentation and weakening of the habitat.
Residential development	Mangroves were once the dominant form of vegetation along the western peninsula of Grand Cayman. Residential development has resulted in the removal of almost all mangroves from the area, and has also directly impacted the southern and western edges of the Central Mangrove Wetland. The ecological impact of residential development is often exacerbated by canalisation.
Planning	Under the Land Surveyors Regulations (1996 Revision) 28 (3), in areas of mangrove coastline, the high water mark is defined “the edge of the mangrove vegetation”, regardless of the extent of tidal inundation landward of this point. As such, landowners legally own land to the extent of the mangrove fringe. Under the Development and Planning Regulations, the minimum set-back for development in mangrove areas is 75 ft from the high water mark: the high water mark being defined as the seaward extent of mangrove. This is a nonsensical legislation, as it means that, effectively, a landowner might increase the area of land under their ownership by planting mangroves at the seaward extent. Once established, the landowner might then legally extend development to the newly established high water mark. In the Cayman Islands, the impracticalities of this law regularly result in planning disputes associated with the clearance and development of mangroves. In many cases, back-filling mangrove is not regarded as constituting “development”, resulting in the extensive loss of vegetation even within the 75ft set-back.
Natural cycles	The seaward extent of mangroves is subject to natural perturbation, most especially associated with severe storm events. Large areas of mangrove were impacted by the high winds associated with Hurricane Ivan; however, in areas where natural drainage has been preserved recovery is well underway.
Sea defences	Inappropriate construction of sea defences along naturally dynamic areas of the foreshore result in the focusing and redirection of wave energy, inhibiting the ability of mangroves to establish and survive seaward of the defence, and so undermining the effectiveness of mangroves as a functional buffer to storm surge.
Invasive species	Weeping willow (*Casuarina equisetifolia)* is capable of infiltrating and establishing in areas of disturbed seasonally flooded mangrove forest, especially on dyke roads and in areas where fill grades into undisturbed wetland.
Climate	Factors associated with climate change, particularly increase in severity of storms have the potential to impact mangroves, especially in areas where the natural forest buffer has become fragmented, or weakened as a result of land clearance, development or canalisation.
Marine pollution	Mangroves are susceptible to oil spill, and represent a difficult environment in which to mount an effective oil-spill response.
Laying of pipelines and cables	The last major project of this nature was undertaken by Caribbean Utilities Company in 2000. The Department of Environment assisted with the restoration of damaged mangrove.
Public education	In recent years, public awareness regarding the ecological value of mangroves has grown, especially in the younger generation, due in part to the education programmes of the National Trust for the Cayman Islands and the Department of Environment. During the course of 1996-9 proposals to designate protected zones for the Central Mangrove Wetland in the Development Plan met with vociferous opposition. As a result, the majority of the Central Mangrove Wetland remains without any legal protection to this day.

Appendix E. Assets and Services of Mangrove Ecosystems in the Cayman Islands (DaCosta-Cottam et al., 2009).

Assets or Services	**Contribution**
Biodiversity	Contributes significantly to the biodiversity of both terrestrial and marine ecosystems.
Marine nursery	Contributes to biodiversity through provision of a secure nursery area. Protected from large predators within the matrix of the mangrove root system, the larvae and juvenile forms of many reef and open sea species grow in mangroves, before moving seaward as they mature. Spiny lobster *Panulirus argus* spend up to two years maturing in mangrove roots. Many fish typically associated with coral reefs are obligate mangrove dwellers in their juvenile stages.
Birdlife	Most significant from a terrestrial perspective with respect to its complement of birdlife. Provide an important roost for several species of local significance, including West Indian Whistling-duck (*Dendrocygna arborea*) and Greater Antillean grackle (*Quiscalus niger*). Black mangrove (*Avicennia germinans*) provides nesting habitat for a significant proportion of the islands' Grand Cayman parrot (*Amazona leucocephala caymanensis*) and the White-crowned pigeon (*Patagioenas leucocephala*). Mangrove is also of particular value to resident and migratory waders, such as the Snowy egret (*Egretta thula*).
Flora	While the floral diversity of mangrove is predominately restricted to the three mangrove species and buttonwood, dry keys within the mangrove complex contribute to the floral diversity of the system, with species such as Mahogany (*Swietenia mahagoni*), Red birch (*Bursera simaruba*) and Manchineel (*Hippomane mancinella*). The endemic and critically endangered herb *Agalinis kingsii* also occurs locally with in mangrove shrubland in the CMW.
Crabs	Provides habitat to a variety of crabs, including *Eurytium limosum* and *Aratus pisonii*, the grapsid crab (*Sesarma angustipes*), the fiddler crab (*Uca speciosa*), and land crabs including *Gecarcinus lateralis* and the White Land crab (*Cardisoma guanhumi*). Habitat loss and busy coastal roads inflict a heavy toll on land crabs, which of necessity undertake periodic mass-migration to the sea to lay their eggs.
Water clarity	The submerged matrix of coastal mangrove roots slows water currents, encouraging deposition of sediment, and aggregated by the root network. As such, mangroves constitute an environment of accretion and land building, representing a sink for marine sediment, and a trap for sediment carried in terrestrial run-off. Improvement of water clarity benefits other coastal habitats, including seagrasses and coral reefs.
Nutrient regulation	Mangroves slow and regulate the release of nutrients into the marine environment, and contribute to the input of carbon and other nutrients, forming a basis of the nearshore foodweb. This slow introduction of nutrients also maintains the natural nutrient-poor status of local waters, deterring the algal proliferation commonly associated with nutrification, which can impact marine habitats, most especially coral reefs, and to a lesser extent seagrasses.
Carbon sink	Mangroves are a highly productive system. Estimates of the global storage of carbon by mangroves varies widely, however, a synthesis of the available data on carbon fluxes in mangrove ecosystems indicates that mangrove ecosystems are a significant carbon sink.
Coastal protection	The deep rooting systems of mangroves impede storm surge, reducing coastal erosion, and damage to coastal property during severe weather.
Rainfall production	Saturated air derived from the moist understory, and transpiration from the leaf surface, rises above the Central Mangrove Wetland and develops into localised cloud. The clouds are carried westward by the prevailing wind, contributing to the rainfall of central and western Grand Cayman. Rainfall in these areas is some 40% higher than in districts on the windward side of the Central Mangrove Wetland.
Freshwater	The hydrological influences and ironpan formation associated with large mangrove areas contribute to elevation of the freshwater table in land peripheral to the wetland, resulting in the formation of some of the island's most fertile farm and grassland. Canalisation and development disrupt this function, causing salinisation of freshwater lenses, and depleting terrestrial freshwater availability.
Aesthetic	Traditionally, mangroves have been regarded as worthless land, and a breeding ground for mosquitoes. In 1965 the Mosquito Research and Control Unit, MRCU, was established, and rapidly implemented a systematic dyking and canalisation programme, in combination with ground-based fogging, and aerial application of larvicide. The effect was to radically reduce the population of mosquitoes throughout the islands, however, local attitudes to mangrove or "swamp" improved little. With the concurrent economic boom associated with the advent of the banking and tourism industry, mangroves were quickly targeted for profitable residential and canal development.

Appendix F. Key Species Found in Forest Ecosystems in the Cayman Islands (DaCosta-Cottam et al., 2009).

Category	**Detail** (protection under National Conservation Law)	**Scientific Reference**
Mammals	All bats (protected under part 1)	Chiroptera
Birds	All birds (protected under part 1, unless specifically listed in part 2). Of special significance to this habitat:	*Aves*
	Grand Cayman parrot	*Amazona leucocephala caymanensis*
	Brac parrot	*Amazona leucocephala hesterna*
	Northern flicker	*Colaptes auratus gundlachi*
	White-crowned pigeon	*Patagioenas leucocephala*
	Caribbean dove	*Leptotila jamaicensis collaris*
	West Indian woodpecker	*Melanerpes superciliaris caymanensis*
	Western spindalis	*Spindalis zena salvini*
	Red-legged thrush	*Turdus plumbeus coryi*
	Loggerhead kingbird	*Tyrannus caudifasciatus caymanensis*
	Cuban bullfinch	*Melopyrrha nigra taylori*
	Thick-billed vireo	*Vireo crassirostris alleni*
	Yucatan vireo	*Vireo magister caymanensis*
Reptiles	Western Grand Cayman Blue-throated anole	*Anolis conspersus conspersus*
	Eastern Grand Cayman Blue-throated anole	*Anolis conspersus lewisi*
	Cayman racer	*Alsophis cantherigerus*
	Yellow galliwasp	*Celestus crusculus maculatus*
Invertebrates	Soldier crab (Hermit)	*Coenobita clypeatus*
	Cayman Brown Leaf butterfly	*Memphis vericordia danielana*
	Swallowtail butterfly (endemic)	*Heraclides andraemon tailori*
	Cayman Zoe julia	*Dryas iulia zoe*
	Little Cayman cicada	*Diceroprocta caymanensis*
	Grand Cayman cicada	*Diceroprocta cleavesi*
	Cayman Brac cicada	*Diceroprocta ovata*
Plants		*Aegiphilia caymanensis*
		Buxus bahamensis
		Casearia staffordiae
	Ironwood	*Chionanthus caymanensis*
	Ghost orchid	*Dendrophylax fawcettii*
		Encyclia kingsii
		Epiphyllum phyllanthus var. plattsii
	Old George	*Hohenbergia caymanensis*
		Pisonia margarettiae
		Pleurothallis caymanensis

Plants (cont.)		*Terminalia eriostachya margaretiae*
		Tolumnia (= Oncidium) calochilum
		Tolumnia (= Oncidium) variegata
		Allophylus cominia var. caymanensis
	Cayman Silverbush	*Argythamnia proctorii*
		Beloglottis costaricensis
	Yoke wood	*Catalpa longissima*
	Cedar	*Cedrela odorata*
		Celtis trinervia
	Ironwood	*Chionanthus caymanensis*
	Silver Thatch palm	*Coccothrinax proctorii*
		Colubrina arborescens
	Clamcherry	*Cordia laevigata*
		Crossopetalum caymanense
		Daphnopsis americana
		Dendropanax arboreus
		Drypetes sp.
	Smokewood	*Erythroxylum confusum*
		Faramea occidentalis
		Jatropha divaricata
		Licaria triandra
	Lignum vitae	*Lignum vitae*
		Margaritaria nobilis
	Banana orchid	*Myrmecophila thomsoniana minor / thomsoniana*
		Oeceoclades maculata
		Prosthechea cochleata
		Rauvolfia nitida
		Tillandsia festucoides
		Trichilia havanensis
	Bull rush	*Zamia integrifolia*
	Satinwood	*Zanthoxylum flavum*

Appendix G. Current Factors Affecting Forest Ecosystems in the Cayman Islands (DaCosta-Cottam et al., 2009).

Driver of Change	Effect
Fragmentation	Forests in the Cayman Islands are highly susceptible to fragmentation. Fragmentation interrupts wildlife corridors, introduces invasive species and exposes extensive areas of forest to damaging edge effects, including wind shear, ingress of light, and modification of microclimate.
Invasive species	When intact, the closed tree canopy restricts the amount of light reaching the forest floor, and limits the potential for establishment of invasive species. When the canopy is disrupted, however, either by natural events or fragmentation, invasive species quickly colonise disturbed areas. Once established, edge effects enable ingress of invasive species from the margins of disturbance further into the interior of the forest.
Residential development	Forests typically occupy high ground. Given the low-lying nature of the majority of the land surface of the Cayman Islands, high ground is prized for development – either directly, or as a source of aggregate with which to fill low-lying properties. This has resulted in the clearance of significant tracts of dry forest in the past 30 years.
Speculative clearance	The complete clearance of all vegetation from a saleable lot, to demonstrate its extent and topography, is a common practice in the Cayman Islands. This results in immediate and long-term damage to the ecological value of the land. Regardless of whether a sale is forthcoming, invasive species colonise the cleared area, compromising both the cleared site and impacting neighbouring parcels. Speculative clearance removes any option for a prospective buyer to maintaining native vegetation outside of the footprint of any new development.
Non-native landscaping	As forested areas become increasingly fragmented, they become more susceptible to ingress of invasive species and edge effects, and less functional as viable refugia for native plants and wildlife. Non-native-landscaping of surrounding areas restricts wildlife corridors and seed transport systems, isolating remnant forest stands ecologically.
Agricultural development	Soil pockets in forest areas have typically provided some of the most fertile farming land in the Islands. Traditionally, small pockets of soil-rich land were cleared by hand and planted with fruit trees. Larger areas were also cleared, and seeded with grass for rough grazing of cattle. In some cases, traditional farm land has now been abandoned, and is reverting back to woodland, however, for the most part, traditional farmlands are been replaced by suburban development.
Lack of public education	There is a popular misconception that forested areas are more extensive than they are, due to an inability to differentiate native and invasive species. There is a general lack of understanding of how little “visible greenery” of the islands constitutes native vegetation. The homogenous curtain of invasive species lining roads and colonising disturbed areas belies the diversity of species and structure in the interior of the ancient forest.
Fire	Dry forest has been subject to significant fire damage, in the most part arising from fires for agricultural clearance getting out of control, and arson adjacent to suburban areas. Damaged areas are susceptible to colonisation by invasive species.

Appendix H. Assets and Services of Forest Ecosystems in the Cayman Islands (DaCosta-Cottam et al., 2009).

Assets or Services	Contribution
Biodiversity	Dry forest represents the most biodiverse of all terrestrial habitats in the Cayman Islands. Those at higher elevations (the Mastic Forest) are structurally complex and ancient, possibly existing above sea level for the last 2.5 million years. Biodiversity is highest in areas where the forest lies adjacent to wetlands. In this situation, moist air derived from the wetland bathes the understory, providing a humid environment beneath the trees canopy; conducive to the profuse growth of epiphytes, including bromeliads and orchids.
Rare plants	Dry forests include the Cayman Islands' most significant assemblies of rare and endemic plants and trees.
Birds	Dry forest supports a diversity of resident and migratory birds. Fruiting trees provide food and shelter for nest-builders. The living and dead trucks of large forest trees provide a home for cavity nesters.
Bats	Dry forest is an important habitat for several species of bat including the White-shouldered bat (*Phyllops falcatus).*
Cultural identity	Dry forest supports many species which have played a significant role in the development of the Cayman Islands, and contribute to our cultural identity, including Ironwood (*Chionanthus caymanensis);* the National Tree, Silver Thatch palm (*Coccothrinax proctorii);* the National Bird, the Cayman parrot *(Amazona leucocephala);* and the National Flower, the Banana orchid (*Myrmecophila thomsoniana).*
Hedonic value	Dry forest supports the largest and most profuse flora in the Cayman Islands. The strong visual aesthetic of the forest, combined with its ancient nature and cultural value contributes to its appreciation as a natural environment. Natural forest vistas represent a significant and tangible component of the popular perception of an "unspoilt" environment.
Recreation	Forest trails are enjoyed by local walkers, birdwatchers and by overseas visitors interested in the natural environment. The closed tree canopy which typifies dry forest provides forest trails with shade throughout the course of the day; making forest walks one of few outdoor activities in Cayman, which can be undertaken in the shade.
Nature tourism	Local guides are employed to escort visitors on forest trails.

Appendix I. Biomass figures for the CMW.
(RM = Red Mangrove, BM = Black Mangrove, WM = White Mangrove, BW = Green Buttonwood, LW = Lancewood)

Upland Mangroves

Transect	Point	Species	Stem Diameter (cm)	Aboveground Biomass (kg)	Belowground Biomass (kg)
1	50	BW	2.38	1.93	0.86
		BW Dead	1.66	0.96	0.39
		WM	1.16	0.48	0.17
		WM	2.04	1.43	0.61
		WM	1.73	1.04	0.42
		WM	1.72	1.03	0.42
		WM	5.07	8.31	4.62
		BW	1.4	0.69	0.27
		WM	3.56	4.20	2.11
	40	WM	3.06	3.13	1.51
	30	BW	4.5	6.60	3.54
		BW	4.5	6.60	3.54
		BW	2.1	1.52	0.65
		BW Dead	3.1	3.21	1.55
		WM	2.6	2.29	1.05
		WM	3.85	4.88	2.51
		WM	2.3	1.81	0.80
	20	WM	2.3	1.81	0.80
		WM	2	1.38	0.59
		WM	2.31	1.82	0.81
		WM	1.27	0.57	0.21
		WM	2.65	2.37	1.09
		WM	1.33	0.63	0.24
		WM	1.17	0.49	0.18
		WM	1.65	0.95	0.38
		WM	2.36	1.90	0.85
		WM	1.28	0.58	0.22
		WM	2.85	2.73	1.29
		WM	1.36	0.66	0.25
		WM	2.25	1.73	0.76
		WM	2.35	1.88	0.84
		WM	3.3	3.63	1.78
		WM	2	1.38	0.59
		WM	1.79	1.11	0.46
	10	BM	6.6	15.50	9.05
		BM	1.31	0.68	0.25
		WM	3.43	3.91	1.94
		WM	3.32	3.67	1.80
		WM	1.96	1.33	0.56
		WM	1.09	0.43	0.15
		BM	1.63	1.04	0.41
		BM	1.63	1.04	0.41
		WM	5.19	8.69	4.87
		WM	2.46	2.057	0.93
		WM	3.13	3.27	1.58
		WM	1.38	0.67	0.26
		WM	3.17	3.36	1.63
		WM	3.19	3.40	1.65
	0	RM	6.46	18.24	10.59
		RM	9.94	38.46	27.56
		RM	7.52	23.73	14.84
		WM	8.6	23.03	14.93
		WM	4.35	6.18	3.29
		WM	12.25	45.58	32.74
		WM	10.31	32.68	22.33
2	50	WM	2.4	1.96	0.88
		WM	2.35	1.88	0.84
		WM	3.24	3.50	1.71

Transect	Point	Species	Stem Diameter (cm)	Aboveground Biomass (kg)	Belowground Biomass (kg)
2	50	WM	3.72	4.57	2.32
		WM	4.07	5.44	2.84
		WM	3.87	4.93	2.54
		WM	2.5	2.12	0.96
		WM	4.06	5.41	2.82
	40	BW	10.3	32.62	22.28
		BW	4.17	5.70	2.99
		BW	8.89	24.55	16.07
		BW	3.44	3.93	1.95
		BW	2.48	2.09	0.94
		WM	5.25	8.88	4.99
		WM	2.17	1.61	0.70
		WM	1.64	0.94	0.38
		WM	2.42	1.99	0.89
		WM	1.7	1.01	0.41
		WM	2.62	2.32	1.07
		WM	3.24	3.50	1.71
	30	WM	1.93	1.29	0.54
		WM	1.34	0.64	0.24
		WM	1.54	0.83	0.33
		WM	1.32	0.619	0.23
		WM	2.2	1.66	0.72
		WM	1.57	0.86	0.34
		WM	1.25	0.56	0.21
		WM	2.5	2.12	0.96
		WM	3.09	3.19	1.54
		WM	3.44	3.93	1.95
		WM	2.86	2.75	1.30
		WM	1.21	0.52	0.19
		WM	3.76	4.66	2.38
		WM	2.36	1.90	0.85
		WM	1.43	0.72	0.28
		WM	1.36	0.66	0.25
		WM	1.46	0.75	0.29
		WM	2.19	1.64	0.72
		WM	2.19	1.64	0.72
		WM	2.55	2.21	1.00
		WM	1.51	0.80	0.31
		WM	1	0.36	0.13
		WM	2.21	1.67	0.73
	20	BW	5.5	9.72	5.53
		WM	3.6	4.29	2.16
		WM	1	0.36	0.13
		LW	2.55	2.20	1.01
		LW	9.87	30.04	20.27
		LW	10.05	31.11	21.10
		LW	9.14	25.90	17.09
	10	WM	3.03	3.08	1.47
		WM	1.75	1.07	0.44
		WM	1.5	0.79	0.31
		WM	1.55	0.84	0.33
		WM	2.08	1.49	0.64
		WM	3.56	4.20	2.11
		WM	5.78	10.70	6.18
		WM	1.68	0.99	0.40
		WM	1.66	0.96	0.39
		BW	4.47	6.51	3.49
		BW	7.41	17.28	10.73
		BW	5.54	9.86	5.62
		BW	3.62	4.33	2.19
		BW	1.45	0.74	0.29
		BW	7.03	15.61	9.54

Transect	Point	Species	Stem Diameter (cm)	Aboveground Biomass (kg)	Belowground Biomass (kg)
2	0	WM	2.28	1.78	0.78
		WM	1.79	1.11	0.46
		WM	1.22	0.53	0.20
		WM	3.21	3.44	1.67
		WM	5.1	8.40	4.68
		WM	6.32	12.71	7.53
		BW	3.48	4.02	2.00
		WM	3.36	3.75	1.85
		WM	4.44	6.43	3.44
		WM	1.52	0.81	0.32
		WM	3.07	3.15	1.52
3	50	BW	7.5	17.68	11.02
		BW	2.87	2.77	1.31
		BW	4.21	5.80	3.06
		BW	4.51	6.63	3.56
		BW	2.58	2.25	1.03
		BW	4.15	5.64	2.96
		BW	4.62	6.94	3.76
		BW	5.3	9.05	5.10
		RM	1.82	2.04	0.64
		BW	3.03	3.08	1.47
		BW	3.65	4.40	2.23
		BW	3.58	4.24	2.13
		BW	3.47	4.00	1.99
		BW	4.14	5.62	2.95
		BW	4.12	5.57	2.91
		BW	2.31	1.82	0.81
		BW	7.01	15.52	9.48
		BW	2.33	1.85	0.82
		BW	1.96	1.33	0.56
		BW	2.08	1.49	0.64
		BW	1.36	0.66	0.25
		BW	3.81	4.79	2.45
		BW	5.07	8.31	4.62
	40	BW	3.79	4.74	2.42
		BW	1.66	0.96	0.39
		BW	5.53	9.82	5.60
		BW	3.91	5.03	2.59
		BW	2.27	1.76	0.78
		BW	2.71	2.48	1.15
		BW	8.42	22.11	14.24
		BW	4.63	6.97	3.78
	30	BW	11	37.03	25.78
		BW	2.32	1.84	0.81
		BW	2.9	2.83	1.34
		LW	3.3	3.63	1.78
		LW	1.52	0.81	0.32
		BW	4.25	5.91	3.12
		BW	1.57	0.87	0.34
	20	BW	4.19	5.75	3.03
		BW	4.84	7.59	4.17
		BW	3.09	3.19	1.54
		BW	2.87	2.77	1.31
		BW	7.73	18.75	11.78
		BW	3.69	4.50	2.28
		BW	1.96	1.33	0.56
		BW	1.4	0.69	0.27
		BW	1.93	1.29	0.54
		BW	1.89	1.24	0.52
		BW	1.36	0.66	0.25
		BW	4.53	6.68	3.60
		BW	2.88	2.79	1.32

Transect	Point	Species	Stem Diameter (cm)	Aboveground Biomass (kg)	Belowground Biomass (kg)
3	20	LW	3.79	4.74	2.42
		LW	3.24	3.50	1.71
		LW	1.99	1.37	0.58
		BW	2.86	2.75	1.30
		BW	2.47	2.07	0.94
		BW	1.34	0.64	0.24
		BW	4.61	6.91	3.74
		BW	3.52	4.11	2.06
		BW	1.13	0.46	0.17
		BW	1.03	0.38	0.13
		BW	1.01	0.37	0.13
		BW	1.12	0.45	0.16
		RM	1.29	1.12	0.30
		BW	2.48	2.09	0.94
		BW	3.98	5.21	2.70
		BW	3.81	4.79	2.45
	10	BW	2.7	2.46	1.14
		LW	3.06	3.13	1.51
		BW	0.78	0.22	0.07
		BW	0.29	0.03	0.01
		BW	0.64	0.15	0.05
		BW	1.8	1.13	0.46
		BW	1.37	0.67	0.25
		BW	1.63	0.93	0.37
		BW	0.8	0.24	0.08
		BW	0.97	0.34	0.12
		BW	2.98	2.98	1.42
		BW	1.4	0.69	0.27
		BW	1.19	0.51	0.19
		BW	1.46	0.75	0.29
		BW	2.87	2.77	1.31
		BW	3.3	3.63	1.78
		BW	3.21	3.44	1.67
		BW	2.39	1.95	0.87
		BW	7.21	16.39	10.09
		BW	5.84	10.92	6.32
		BW	2.17	1.61	0.70
		BW	1.61	0.91	0.36
		BW	1.32	0.62	0.23
		BW	3.55	4.18	2.09
		BW	1.05	0.40	0.14
		BW	5.46	9.58	5.45
		BW	1.54	0.83	0.33
		BW	1.13	0.46	0.17
		LW	1.92	1.28	0.54
		BW	3.25	3.52	1.72
		BW	3.25	3.52	1.72
		BW	1.66	0.96	0.39
		BW	1.06	0.41	0.14
		BW	1.23	0.54	0.20
		BW	0.73	0.20	0.06
		BW	3.25	3.52	1.72
		BW	4.88	7.72	4.24
		BW	1.69	1.00	0.40
		BW	1.02	0.38	0.13
	0	BW	2.06	1.46	0.63
		BW	3.24	3.50	1.71
		BW	2.18	1.63	0.71
		BW	1.47	0.76	0.30
		BW	3.29	3.61	1.77
		BW	2.94	2.90	1.38
		BW	3.18	3.38	1.64

Transect	Point	Species	Stem Diameter (cm)	Aboveground Biomass (kg)	Belowground Biomass (kg)
3	0	BW	4.13	5.59	2.93
		BW	3.92	5.06	2.61
		BW	2.9	2.83	1.34
		BW	1.94	1.30	0.55
		BW	2.02	1.41	0.60
		BW	2.75	2.55	1.19
		BW	4.67	7.09	3.85
		BW	2.95	2.92	1.39
		BW	2.13	1.56	0.67
		BW	2.32	1.84	0.81
		BW	1.48	0.77	0.30
		BW	1.34	0.64	0.24
Fringing Mangroves					
Transect	**Point**	**Species**	**Stem Diameter (cm)**	**Aboveground Biomass (kg)**	**Belowground Biomass (kg)**
4	50	RM	2.71	4.06	1.54
		RM	2.71	4.06	1.54
		RM	2.71	4.06	1.54
		RM	2.71	4.06	1.54
		RM	2.71	4.06	1.54
		RM	2.71	4.06	1.54
		RM	2.71	4.06	1.54
		RM	2.71	4.06	1.54
		RM	0.6	0.30	0.05
	40	RM	7.9	25.84	16.55
		RM	4.54	9.91	4.84
	30	RM	1.79	1.98	0.61
		RM	1.48	1.42	0.40
		RM	1.26	1.08	0.28
		RM	1.05	0.79	0.19
		RM	1.23	1.03	0.27
		RM	0.89	0.59	0.13
		RM	2	2.40	0.78
		RM	1.34	1.20	0.32
		RM	1.62	1.66	0.49
		RM	1.16	0.93	0.23
		RM	1.42	1.32	0.37
		RM	4.32	9.09	4.33
		RM	3.08	5.06	2.05
	20	RM	9.5	35.56	24.93
		RM	1	0.72	0.17
		RM	1.6	1.63	0.48
		RM	1.1	0.85	0.21
		RM	2.2	2.83	0.97
		RM	0.9	0.60	0.13
	10	RM	1.7	1.81	0.55
		RM	3.9	7.6	3.45
		RM	3	4.84	1.93
		RM	3	4.84	1.93
		RM	3	4.84	1.93
		RM	3	4.84	1.93
		RM	3	4.84	1.93
		RM	3	4.84	1.93
		RM	3	4.84	1.93
		BM	2	1.54	0.64
		BM	4.2	6.47	3.32
	0	RM	1.4	1.29	0.36
		RM	1.4	1.29	0.36
		RM	1.4	1.29	0.36
		RM	1.4	1.29	0.36
		RM	1.4	1.29	0.36
5	50	RM	2.1	2.61	0.87

Transect	Point	Species	Stem Diameter (cm)	Aboveground Biomass (kg)	Belowground Biomass (kg)
5	50	RM	8.2	27.56	17.98
		RM	2.5	3.53	1.29
		WM	6.9	15.06	9.16
		RM	1.6	1.63	0.48
		RM	3.7	6.95	3.07
	40	RM	2.1	2.61	0.87
		BM	2.8	2.95	1.35
		RM	5.1	12.12	6.27
		RM	2.7	4.03	1.53
		RM	3.9	7.62	3.45
	30	RM	1	0.72	0.17
		RM	0.8	0.49	0.10
		RM	2.8	4.29	1.66
		RM	2.3	3.05	1.07
		RM	3.2	5.41	2.23
		RM	4.8	10.91	5.48
		RM	2.4	3.29	1.18
		RM	3.2	5.41	2.23
	20	RM	4.5	9.76	4.75
		RM	2.1	2.61	0.87
		RM	3.8	7.28	3.26
		WM	14	58.98	44.04
		BM	4.6	7.71	4.06
		BM	2	1.54	0.64
		RM	1.9	2.19	0.70
		RM	3.8	7.28	3.26
		RM	2.9	4.56	1.79
		RM	1.6	1.63	0.48
	10	WM	2.8	2.64	1.24
		RM	3.4	6.01	2.55
		RM	1.5	1.46	0.41
		RM	1.5	1.46	0.41
		RM	1.5	1.46	0.41
		RM	1.5	1.46	0.41
		RM	1.5	1.46	0.41
		WM	3.9	5.01	2.58
	0	RM	2.6	3.77	1.40
		RM	2.6	3.77	1.40
		RM	2.6	3.77	1.40
		RM	2.6	3.77	1.40
		RM	2.6	3.77	1.40
		RM	2.6	3.77	1.40
		RM	2.6	3.77	1.40
		RM	2.6	3.77	1.40

Appendix J. Tree characteristics in the Mastic Forest.

Species	Stem diameter (cm)	Height (m)	Specific Gravity	Aboveground Biomass (kg)	Belowground Biomass (kg)
Bastard Mahogany	18.2	15.24	0.665	185.9267	35.10773
Yellow Mastic	34.4	24.384	0.895	1361.98	203.9698
Bull-hoof	19	15.24	0.7538	228.5269	42.12787
Wild Jasmine	15	9.144	0.5203	60.93655	13.10179
Pepper Cinnamon	12.6	10.668	0.9848	93.94097	19.20557
White Wood	19	15.24	0.5894	179.7445	34.07424
Red Birch	12.5	9.144	0.3056	25.39581	6.045889
Bull-hoof	12.1	4.572	0.7538	29.24676	6.849182
Wild Jasmine	12.6	9.144	0.5203	43.35818	9.699032
Red Birch	14.3	10.668	0.3056	38.38395	8.708976
Red Birch	32.3	15.24	0.3056	266.7358	48.29453
Wild Jasmine	14.8	7.62	0.5203	49.68413	10.93932
Pepper Cinnamon	16.3	15.24	0.9848	219.941	40.72623
Red Birch	18.6	15.24	0.3056	90.8254	18.64165
Wild Fig	43.5	15.24	0.44	680.6898	110.5112
Ironwood	18.3	18.288	0.6785	228.9742	42.20071
Wild Fig	35	18.288	0.44	532.0101	88.88639
Wild Jasmine	14.3	10.668	0.5203	64.52139	13.78055
Ironwood	12.8	12.192	0.6785	76.71684	16.05839
Red Birch	21	10.668	0.3056	81.26542	16.89683
Wild Jasmine	11.2	7.62	0.5203	28.83636	6.76419
Smokewood	10	7.62	0.8023	35.27247	8.082146
Wild Jasmine	11	3.048	0.5203	11.3835	2.975348
Cabbage	10.5	9.144	0.6708	38.92246	8.81685
Red Birch	42	13.716	0.3056	401.8291	69.36548
Wild Calabash	16	9.144	0.7381	97.23142	19.79878
Wild Calabash	9.2	9.144	0.7381	33.01249	7.622836
Wild Calabash	11.3	9.144	0.7381	49.31438	10.86736
Wild Calabash	4.5	9.144	0.7381	8.174012	2.220446
Cabbage	24.3	12.192	0.6708	265.1444	48.03984
Ironwood	22	15.24	0.6785	274.5428	49.54141
Ironwood	11	15.24	0.6785	70.95771	14.98841
Ironwood	12.5	15.24	0.6785	91.06875	18.68578
Red Birch	22	13.716	0.3056	113.7281	22.73931

Species	Stem diameter (cm)	Height (m)	Specific Gravity	Aboveground Biomass (kg)	Belowground Biomass (kg)
Pepper Cinnamon	15	10.668	0.9848	132.0267	25.94354
Wild Calabash	10	9.144	0.7381	38.84762	8.801868
Broadleaf	12.7	7.62	0.7	49.23157	10.85123
Picklewood	14	6.096	0.8	54.56029	11.88274
Pepper Cinnamon	15.2	12.192	0.9848	154.3443	29.78261
Smokewood	11.5	9.144	0.8023	55.36036	12.03658
Antirea	15	7.62	0.561726	54.96284	11.96018
Wild Fig	65.3	15.24	0.44	1504.28	222.6897
Spanish Elm	10.7	12.192	0.7687	61.07733	13.12853
Wild Calabash	10.3	10.668	0.7381	47.83687	10.57915
Cedar	11.8	7.62	0.4294	26.47221	6.271765
Cabbage	13.2	10.668	0.6708	70.7195	14.94395
Wild Jasmine	16.9	9.144	0.5203	76.90996	16.0941
Cabbage	14.2	13.716	0.6708	104.2247	21.0519
Wild Jasmine	13.5	9.144	0.5203	49.60886	10.92468
Wild Jasmine	14.7	10.668	0.5203	68.09124	14.45213
Smokewood	11.5	10.668	0.8023	64.34858	13.74793
Cabbage	13	12.192	0.6708	78.19814	16.33205
Bastard mahogany	11	12.192	0.665	55.96244	12.15217
Cabbage	11.5	9.144	0.6708	46.48587	10.31472
Wild Fig	38.5	18.288	0.44	640.794	104.768
Red Birch	27.5	12.192	0.3056	156.7153	30.1865
Cabbage	11.2	10.668	0.6708	51.31596	11.25619
Cabbage	15	10.668	0.6708	90.76304	18.63034
Red Birch	21	10.668	0.3056	81.26542	16.89683
Bastard Strawberry	15.5	12.192	0.7579	124.1804	24.57636
Red Birch	20.5	13.716	0.3056	99.08371	20.13168
Red Birch	21	10.668	0.3056	81.26542	16.89683
Red Birch	15	13.716	0.3056	53.85039	11.74603
Yellow Ironwood	15	12.192	0.995	151.9251	29.36976
Jasmine	17.2	7.62	0.5203	66.62211	14.17626
Cabbage	18	10.668	0.6708	129.56	25.51477
Red Birch	16.3	9.144	0.3056	42.63673	9.556293
Fiddlewood	15.5	6.096	0.66	55.15962	11.998
Cabbage	14.5	9.144	0.6708	73.08515	15.3848

Species	Stem diameter (cm)	Height (m)	Specific Gravity	Aboveground Biomass (kg)	Belowground Biomass (kg)
Red Birch	18.6	12.192	0.3056	73.05049	15.37835
Wild Jasmine	11.1	4.572	0.5203	17.21127	4.287229
Wild Fig	82	12.192	0.44	1887.116	272.0872
Cabbage	12.2	7.62	0.6708	43.66488	9.75963
Red Birch	19.5	7.62	0.3056	50.63611	11.12432
Red Birch	10.8	7.62	0.3056	15.97923	4.014898
Cabbage	12	9.144	0.6708	50.5127	11.10036
Yellow Mastic	10.8	7.62	0.895	45.60638	10.14209
Wild Fig	13	9.144	0.44	39.13012	8.858401
Cabbage	17	9.144	0.6708	99.6954	20.24146
Red Birch	19.5	9.144	0.3056	60.49803	13.01844
Wild Fig	15.6	12.192	0.44	73.96278	15.54793
Wild Fig	10	12.192	0.44	31.04803	7.220607
Red Birch	23	7.62	0.3056	69.88847	14.78867
Fiddlewod	15.5	10.668	0.66	95.24154	19.44032
Yellow Mastic	19.7	9.7536	0.895	187.5933	35.38566
Yellow Mastic	16.8	10.3632	0.895	145.8546	28.33037
Wild Nut	10.7	8.8392	0.561726	32.85543	7.590782
Ironwood	15.7	10.3632	0.6785	97.52722	19.85199
Cabbage	13.5	10.668	0.6708	73.89081	15.53456
Wild Jasmine	10.8	7.0104	0.5203	24.76093	5.912142
Red Birch	14.6	10.0584	0.3056	37.74068	8.579885
Cabbage	16.5	10.3632	0.6708	106.2724	21.41695
Wild Fig	24	11.2776	0.44	158.9135	30.56033
Red Birch	11	7.0104	0.3056	15.26751	3.856471
Pepper Cinnamon	18.2	10.668	0.9848	192.5711	36.21405
Black Mastic	24.5	10.3632	0.654	224.2813	41.43556
Red Birch	11	8.5344	0.3056	18.49899	4.569456
Cabbage	20.3	11.2776	0.6708	172.9679	32.93661
Fiddlewood	13.5	7.3152	0.66	50.32528	11.06396
Yellow Mastic	15	11.8872	0.895	133.6602	26.22696
White Wood	12.9	10.668	0.5894	59.59577	12.84674
Sole Anum	16.8	9.7536	0.5894	91.44586	18.75413
Red Birch	15.5	11.2776	0.3056	47.42591	10.49881
Bull Hoof	10.6	4.8768	0.7538	24.05657	5.763292

Species	Stem diameter (cm)	Height (m)	Specific Gravity	Aboveground Biomass (kg)	Belowground Biomass (kg)
Cabbage	18.3	11.5824	0.6708	144.9912	28.18214
Cabbage	15.5	9.7536	0.6708	88.6589	18.24819
Wild Jasmine	13	11.5824	0.5203	58.04484	12.55087
Cabbage	15.7	10.0584	0.6708	93.67726	19.15792
Cabbage	13.35	9.4488	0.6708	64.22098	13.72384
Mahogany	24	12.192	0.6246	241.3816	44.21501
Red Birch	12.5	10.668	0.3056	29.51903	6.905492
Cedar	12.5	8.8392	0.4294	34.24174	7.873103
Wild Fig	50	12.8016	0.44	753.5364	120.8987
Wild Fig	61.1	12.8016	0.44	1114.467	170.8445
Red Birch	14.9	10.0584	0.3056	39.26924	8.886224
Wild Jasmine	10.6	7.62	0.5203	25.89786	6.151378
Red Birch	17	11.2776	0.3056	56.79688	12.31214
Cabbage	15.7	10.0584	0.6708	93.67726	19.15792
Cabbage	15.5	9.4488	0.6708	85.95378	17.75534
Ironwood	21.5	10.0584	0.6785	174.983	33.27542
Red Birch	12.5	8.2296	0.3056	22.91409	5.520764
Red Birch	22.3	10.9728	0.3056	93.92164	19.20208
Cabbage	17.1	11.2776	0.6708	123.749	24.50092
Ironwood	21.65	11.8872	0.6785	208.7849	38.89544
Red Birch	13.7	9.144	0.3056	30.37192	7.081494
Unknown a	10.15	7.9248	0.561726	26.64313	6.307534
Red Birch	25.6	9.7536	0.3056	109.6059	22.00948
White Wood	15	12.192	0.5894	91.13278	18.69739
Cabbage	10.6	10.668	0.6708	46.08673	10.23642
Cabbage	10.15	10.668	0.6708	42.34485	9.498466
Red Birch	13.95	8.2296	0.3056	28.38855	6.671289
Wild Sapodilla	10.4	8.5344	0.9595	50.6483	11.12669
Wild Sapodilla	19.7	11.5824	0.9595	237.4414	43.57667
Red Birch	10.1	10.9728	0.3056	20.01289	4.89835
Cabbage	11.45	10.668	0.6708	53.57562	11.69305
Cabbage	16	10.668	0.6708	102.9488	20.82401
Red Birch	14.85	10.9728	0.3056	42.47023	9.523311
Wild Jasmine	10.4	8.2296	0.5203	26.89908	6.361045
Mango	17.4	9.4488	0.5986	96.38739	19.64684

Species	Stem diameter (cm)	Height (m)	Specific Gravity	Aboveground Biomass (kg)	Belowground Biomass (kg)
Wild Sapodilla	26.8	13.716	0.9595	510.6744	85.72916
Maiden Plum	6	2.7432	0.59	3.556781	1.064453
Maiden Plum	5	2.7432	0.59	2.491698	0.777241
Maiden Plum	5.4	2.7432	0.59	2.8956	0.887574
Unknown b	11.5	11.5824	0.561726	49.23802	10.85249
Unknown b	20	11.5824	0.561726	145.0203	28.18714
Unknown b	8.25	10.668	0.561726	23.76173	5.700833
Unknown c	5.35	10.668	0.561726	10.2025	2.700882
Unknown c	10.6	10.668	0.561726	38.75762	8.783846
Unknown c	3.65	10.668	0.561726	4.836773	1.396644
Ironwood	11	9.7536	0.6785	45.90196	10.20015
Red Birch	26	12.192	0.3056	140.463	27.403
Cabbage	13.9	9.7536	0.6708	71.67369	15.12197
Cabbage	18.9	9.4488	0.6708	126.5875	24.99684
Red Birch	13.9	12.8016	0.3056	43.38899	9.705122
Cabbage	10.3	10.668	0.6708	43.57498	9.741871
Cabbage	12.7	8.2296	0.6708	50.91015	11.1775
Red Birch	12.3	10.0584	0.3056	27.00771	6.383737
Cabbage	11.7	8.5344	0.6708	44.94626	10.01227
Red Birch	31.2	9.7536	0.3056	161.2648	30.95953
Red Birch	14.2	8.2296	0.3056	29.39011	6.878837
Sweet Wood	12.1	7.9248	0.4947	33.16671	7.654293
Sweet Wood	5.5	7.9248	0.4947	7.11694	1.964712
Sweet Wood	3	7.9248	0.4947	2.179948	0.690658
Sweet Wood	5.25	7.9248	0.4947	6.499146	1.813227
Sweet Wood	3.6	7.9248	0.4947	3.111773	0.945876
Sweet Wood	5.65	7.9248	0.4947	7.500737	2.058042
Sweet Wood	3.75	7.9248	0.4947	3.36988	1.014875
Yellow Mastic	29.5	15.5448	0.895	650.2405	106.1316
Yellow Mastic	19.15	11.5824	0.895	209.9207	39.08232
Yellow Mastic	16	11.5824	0.895	147.81	28.66572
Yellow Mastic	24.7	11.5824	0.895	344.9898	60.62029
Red Birch	36.5	9.144	0.561726	372.5766	64.88414
Broadleaf	10.75	7.62	0.7	35.55725	8.139777
Broadleaf	4.35	7.62	0.7	6.080648	1.709663

Species	Stem diameter (cm)	Height (m)	Specific Gravity	Aboveground Biomass (kg)	Belowground Biomass (kg)
Broadleaf	7.4	7.62	0.7	17.15375	4.274567
Broadleaf	1.4	7.62	0.7	0.66506	0.241931
Duppy Bush	8.8	8.2296	0.6427	23.86003	5.721666
Duppy Bush	4.3	8.2296	0.6427	5.896187	1.663754
Cabbage	20	14.6304	0.6708	216.606	40.18009
Cedar	23.7	11.2776	0.4294	151.4121	29.28211
Wild Jasmine	10.6	10.0584	0.5203	33.95815	7.815461
Narrowleaf Ironwood	10.7	6.7056	1.1	48.34756	10.67888
White Wood	11.2	12.192	0.5894	51.52501	11.2967
Cedar	16.45	11.5824	0.4294	76.1924	15.96135
White Wood	10.8	13.1064	0.5894	51.50416	11.29266
Yellow Mastic	17.5	14.3256	0.895	216.656	40.18828
Yellow Mastic	17.6	14.3256	0.895	219.0792	40.58519
Bull Hoof	14.5	7.3152	0.7538	65.87068	14.03488
Red Birch	13.5	12.192	0.3056	39.07918	8.848209
Red Birch	18.9	13.1064	0.3056	80.88016	16.82603
Red Birch	11.85	12.8016	0.3056	31.777	7.370201
Yellow Mastic	13.1	13.716	0.895	117.9891	23.49048
Cabbage	18.75	11.5824	0.6708	152.0323	29.38806
Red Birch	10.4	12.192	0.3056	23.48459	5.642041
Yellow Mastic	11.6	11.5824	0.895	78.90122	16.46174
Yellow Mastic	19.3	15.8496	0.895	289.481	51.91584
Wild Jasmine	13.15	7.62	0.5203	39.44663	8.921683
Yellow Mastic	11.1	12.192	0.895	76.11565	15.94714
Pompero	18.95	12.192	0.561726	137.2313	26.84517
Pepper Cinnamon	16.4	13.716	0.9848	200.8316	37.58329
Yellow Mastic	12.4	11.5824	0.895	89.87127	18.46851
Unknown d	11	9.7536	0.561726	38.1746	8.666992
Red Birch	21.4	13.716	0.3056	107.7523	21.68026
Red Birch	13.4	13.716	0.3056	43.20831	9.669404
Red Birch	12.4	13.1064	0.3056	35.52611	8.133479
Maiden Plum	8.8	7.0104	0.59	18.76903	4.628343
Maiden Plum	4.7	7.0104	0.59	5.517554	1.568988
Cabbage	13.4	13.716	0.6708	93.07059	19.04825

Species	Stem diameter (cm)	Height (m)	Specific Gravity	Aboveground Biomass (kg)	Belowground Biomass (kg)
Cabbage	14.7	14.0208	0.6708	113.9262	22.7743
Red Birch	19	10.668	0.3056	66.84374	14.21792
Red Birch	18.9	10.668	0.3056	66.15873	14.0891
Red Birch	11.9	10.0584	0.3056	25.31982	6.029901
Red Birch	12.55	10.3632	0.3056	28.92007	6.781537
Pepper Cinnamon	11.7	10.0584	0.9848	76.75201	16.06489
Cabbage	13.2	10.668	0.6708	70.7195	14.94395
Red Birch	22.1	10.9728	0.3056	92.2844	18.90601
Wild Jasmine	9.1	11.2776	0.5203	28.18974	6.62999
Wild Jasmine	7.75	11.2776	0.5203	20.60436	5.02605
Burn Nose	14.1	12.192	0.52	71.46924	15.08385
Red Birch	27.5	15.24	0.3056	194.8478	36.5921
Red Birch	11.2	15.24	0.3056	33.74362	7.771817
Red Birch	27.4	13.716	0.3056	174.5612	33.20455
Red Birch	13.8	13.4112	0.3056	44.76897	9.977364
Red Birch	21	14.3256	0.3056	108.3585	21.788
Red Birch	13.15	14.3256	0.3056	43.45441	9.718051
Red Birch	15.6	14.0208	0.3056	59.39559	12.8086
Red Birch	14.5	14.0208	0.3056	51.49503	11.29089
Red Birch	8	11.5824	0.3056	13.38517	3.433185
Red Birch	10	11.5824	0.3056	20.69151	5.044828
Red Birch	21.5	15.5448	0.3056	122.866	24.34637
Ironwood	18.4	16.1544	0.6785	205.0331	38.27719
Ironwood	11.6	9.144	0.6785	47.80779	10.57347
Red Birch	25.55	15.24	0.3056	168.7894	32.23254
Ironwood	16.3	14.6304	0.6785	146.9224	28.51355
Red Birch	15.4	10.668	0.3056	44.35823	9.896436
Fiddlewood	10.4	9.7536	0.66	40.04645	9.041448
Cabbage	18.9	14.6304	0.6708	193.9605	36.44483
Red Birch	11	11.5824	0.3056	24.92244	5.946206
Red Birch	26.5	13.4112	0.3056	159.996	30.7442
Cabbage	14.75	10.0584	0.6708	82.93161	17.20258
Red Birch	21.15	14.0208	0.3056	107.5922	21.6518
Cabbage	13.6	11.8872	0.6708	83.31352	17.27256
Red Birch	26.3	14.9352	0.3056	175.1089	33.29658

Species	Stem diameter (cm)	Height (m)	Specific Gravity	Aboveground Biomass (kg)	Belowground Biomass (kg)
Unknown e	6.6	6.096	0.561726	8.902349	2.394389
Unknown e	3.55	6.096	0.561726	2.653387	0.821642
Unknown e	4.7	6.096	0.561726	4.588702	1.333158
Average				**118.5472**	**21.96194**