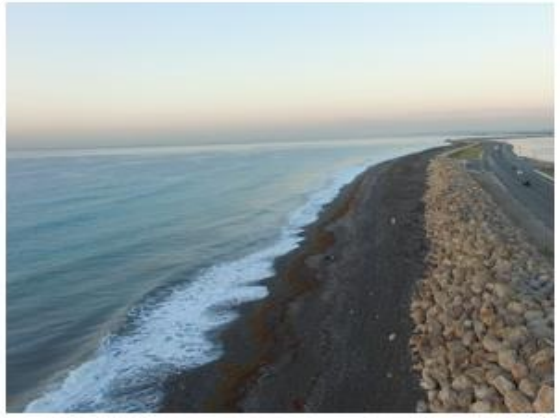
Various Environmental, Zoning & Other Baseline Studies for NMIA

Deliverable 8



December 2020

Prepared by: CEAC Solutions, CL Environmental, Kucera International, Mona Geoinformatics, Interplan Planning Consultants & West Communications

Outline

1. Project Objectives
2. Noise Study & Ecological Inventory
3. Airport Zoning Update
4. Obstacle Limitation Surface
5. Climate Change Adaptation
6. GIS/GPS Mapping
7. CCA TAG, COC and Stakeholder Consultations

Project Objectives

Project Objectives

The “Various Environmental, Zoning and other Baseline Studies” for the Norman Manley International Airport developed by AAJ was done to provide a diagnosis of the current situation of the airport and future obligations regarding the PPP. This project is a combination five (5) sub-projects, namely:

1. Noise Exposure
2. GIS/GPS Asset Mapping
3. Airport Zoning
4. Obstacle Limit Surface
5. Climate Change Adaptation

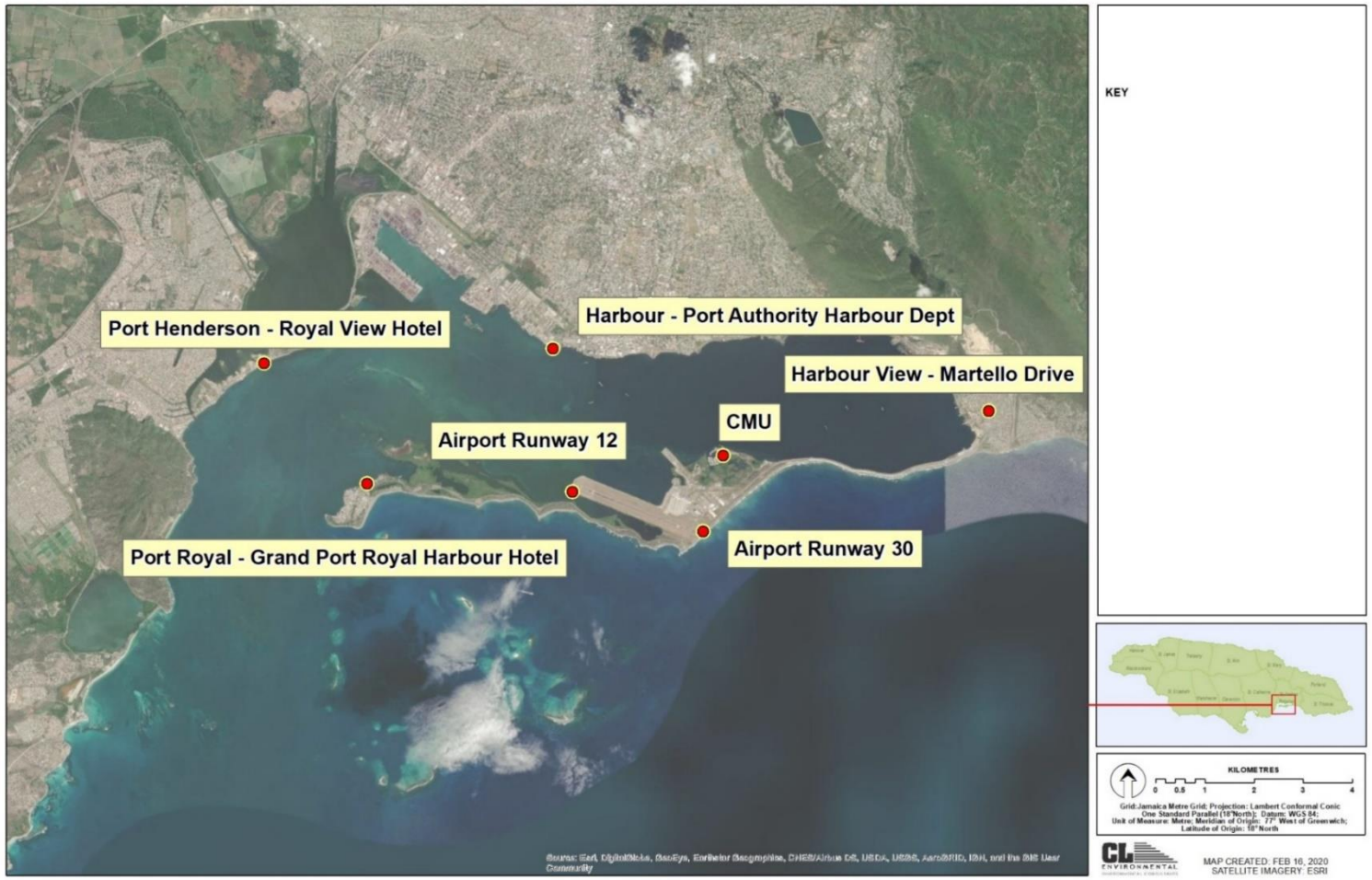
NOISE STUDY

Aims and Objectives

1. Generate results of the NMIA noise survey, recommendations and implementation strategies.
2. Noise contour preparations against prevailing land use and compatibility issues on and within designated radii from NMIA.
3. Outlining of mechanisms that encapsulate the aspirations for the airport and also protect the long-term viability of the airport through combining land use planning and airport operational controls.

Ambient Noise Survey Stations

Seven (7) noise meters were set up at each location to collect data every second for twelve (12) days (March 13 – 24, 2020).



Findings - % Noise Source Exceedance

Percentages of aircraft and non-aircraft noise sources (motor vehicle, traffic, construction, people talking, bird calls etc.) which exceeded the respective NRCA Land Use Noise Guidelines at each monitoring location.

Location	% of Noise from Aircraft	% of Noise from Non-Aircraft Sources
Airport Runway 12	100%	0%
Airport Runway 30	100%	0%
CMU - Petro Caribe Development Fund Building	42%	58%
Port Authority Harbour Dept.	0%	100%
Harbour View - Martello Drive	0%	100%
Port Henderson - Royal View Hotel	44%	56%
Grand Port Royal Harbour Hotel	30%	70%

Findings - Noise Contour Modelling

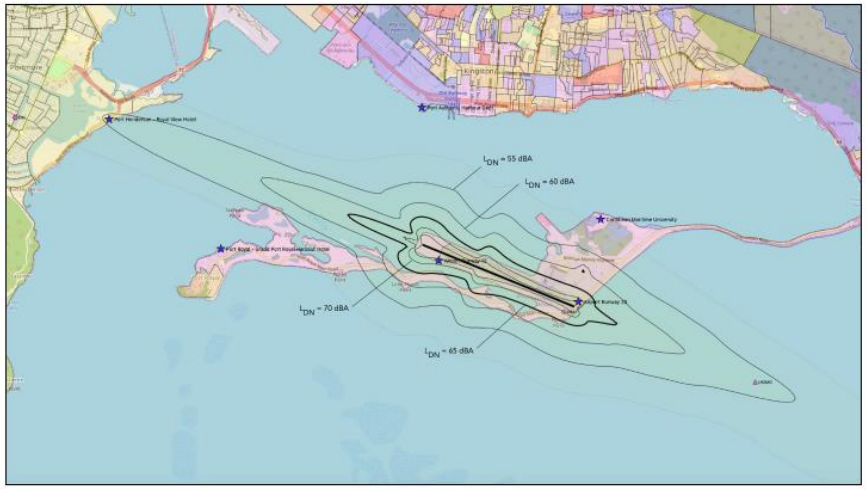
Three (3) scenarios were modelled, namely:

I. **Existing scenario (82 daily flight operations)**
   - The 55 LDN level does not affect any population centres around the airport

II. **Future Baseline High (123 daily flight operations)**
   - The 55 LDN noise contour extends past the Royal View Hotel in Port Henderson affecting an estimated 560 people.

III. **Future Vision 2030 scenario (180 daily flight operations)**
   - The 55 LDN noise contour extends past the Royal View Hotel in Port Henderson affecting an estimated 8,474 people

Baseline High Scenario L_{DN} Noise Contours for the Normal Manley International Airport. 123 Daily Flight Operations. Source of Map: OpenStreet.



Detail of Baseline High Scenario L_{DN} Noise Contours for the Normal Manley International Airport. 123 Daily Flight Operations. Source of Map: OpenStreet.

Findings - Noise Contour Modelling

Noise mitigation strategy for departures from Runway 30:

- **Reduced Thrust Settings (noise abatement)** - Engage airlines to use reduced thrust takeoffs for night departures from Runway 30 when wind conditions do not allow departures from Runway 12.

Noise mitigation strategy for departures from Runway 30:

- **Reduced Thrust Settings (noise abatement) -** Engage airlines to use reduced thrust takeoffs for night departures from Runway 30 when wind conditions do not allow departures from Runway 12.

Conclusion

1. The analysis shows that under current conditions the airport noise contours below the 55 L_{DN} level do not affect any population centers around the airport. The baseline noise analysis also shows that the 75 L_{DN} level contour is nearly contained within the airport boundary as recommended by ICAO and FAA criteria.

2. Three out of the five non-runway monitoring stations had noise levels attributed to aircrafts, which exceeded the respective NRCA guidelines. These three stations were: Grand Port Royal Harbour Hotel, Port Henderson Royal View Hotel and the Caribbean Maritime University (CMU).

3. Two future scenarios were modeled using the FAA AEDT 3c model: a) a Baseline High and b) Vision 2030 scenario with 180 daily operations.

Recommendations

1. A noise abatement departure may also be possible because aircraft departing West would reduce thrust (and flatten their climb profile) as they overfly populated areas to the West at night.

2. Land use planning for the potentially affected areas might consider restrictions on additional development, requiring noise abatement measures. This might include noise attenuation building materials (walls and glazing) and other measures.

3. Reduced thrust settings for runway 30 departures. Engage the airlines to use reduced thrust takeoffs for night departures from runway 30 when wind conditions do not allow departures to the East (runway 12).

4. Reduced thrust takeoffs common technique that airlines use because it increases engine life reducing maintenance cost.

Limitations / Difficulties Encountered

1. No access to the runway to setup our noise meters on the inside of the boundary fencing closer to Runways 12 and 30. As a result the meters were set up on the outside of boundary fencing, over 100 metres away from each runway.
2. Noise equipment malfunction during ambient noise monitoring exercise resulted in missing data on some days for 3 locations:
    - CMU
    - Port Authority Harbour Dept.
    - Port Henderson Royal View Hotel
3. Covid-19 Pandemic:
    - Borders and Caribbean Maritime University (CMU) were shut therefore noise from air traffic would have been reduced during our ambient noise monitoring exercise

ECOLOGICAL INVENTORY

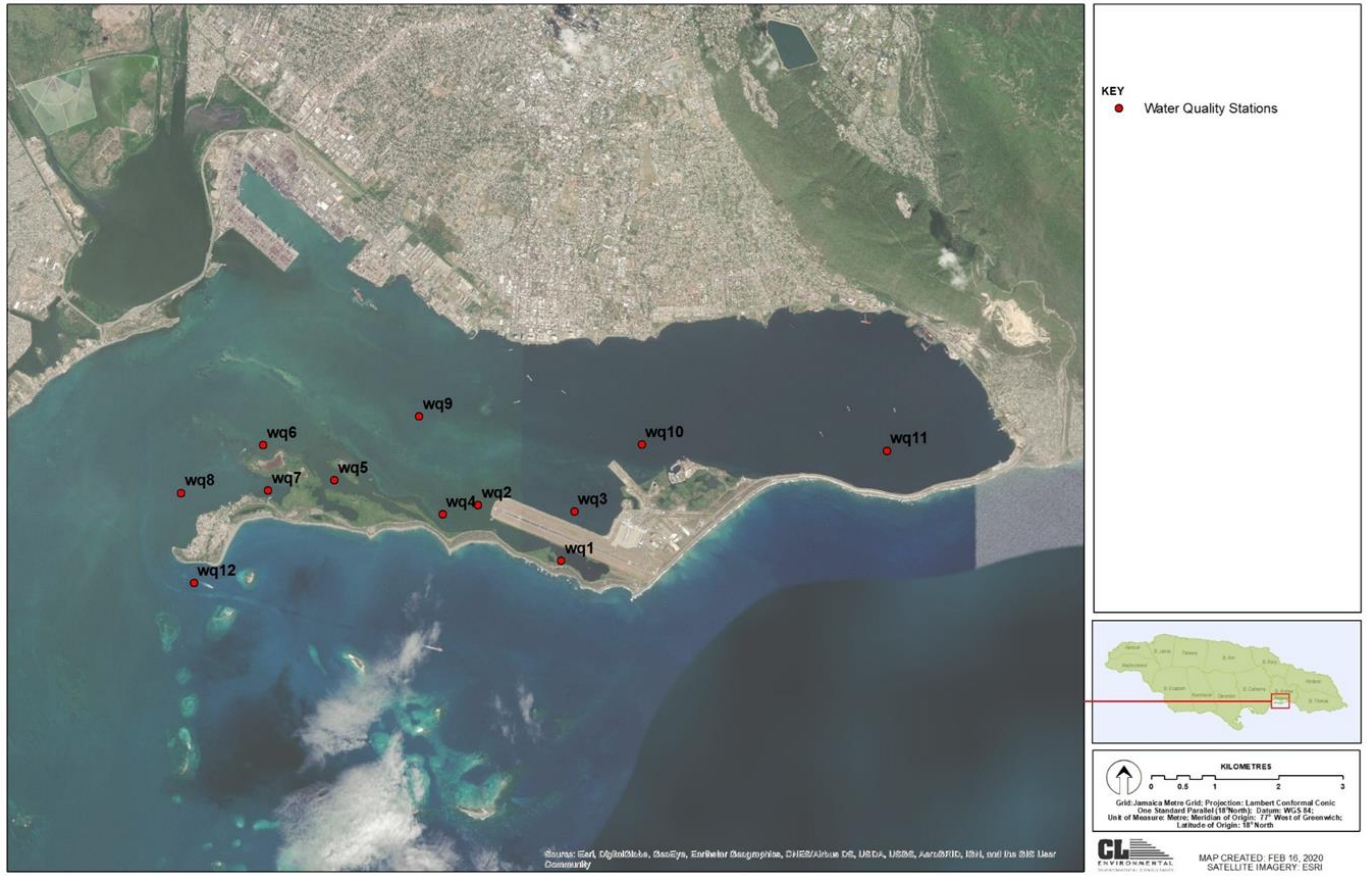
Ecological Inventory

Background

- The project is composed of Restricted Use areas of airport lands and areas reserved for conservation.
- Varying conditions of the marine environment surrounding the NMIA facility are like the conditions found throughout Kingston Harbour.
- The main sources of pollutants within the harbour originate mainly from run off and fluvial input (Webber & Kelly, 2003), which contributes to the harbour being generally eutrophic.

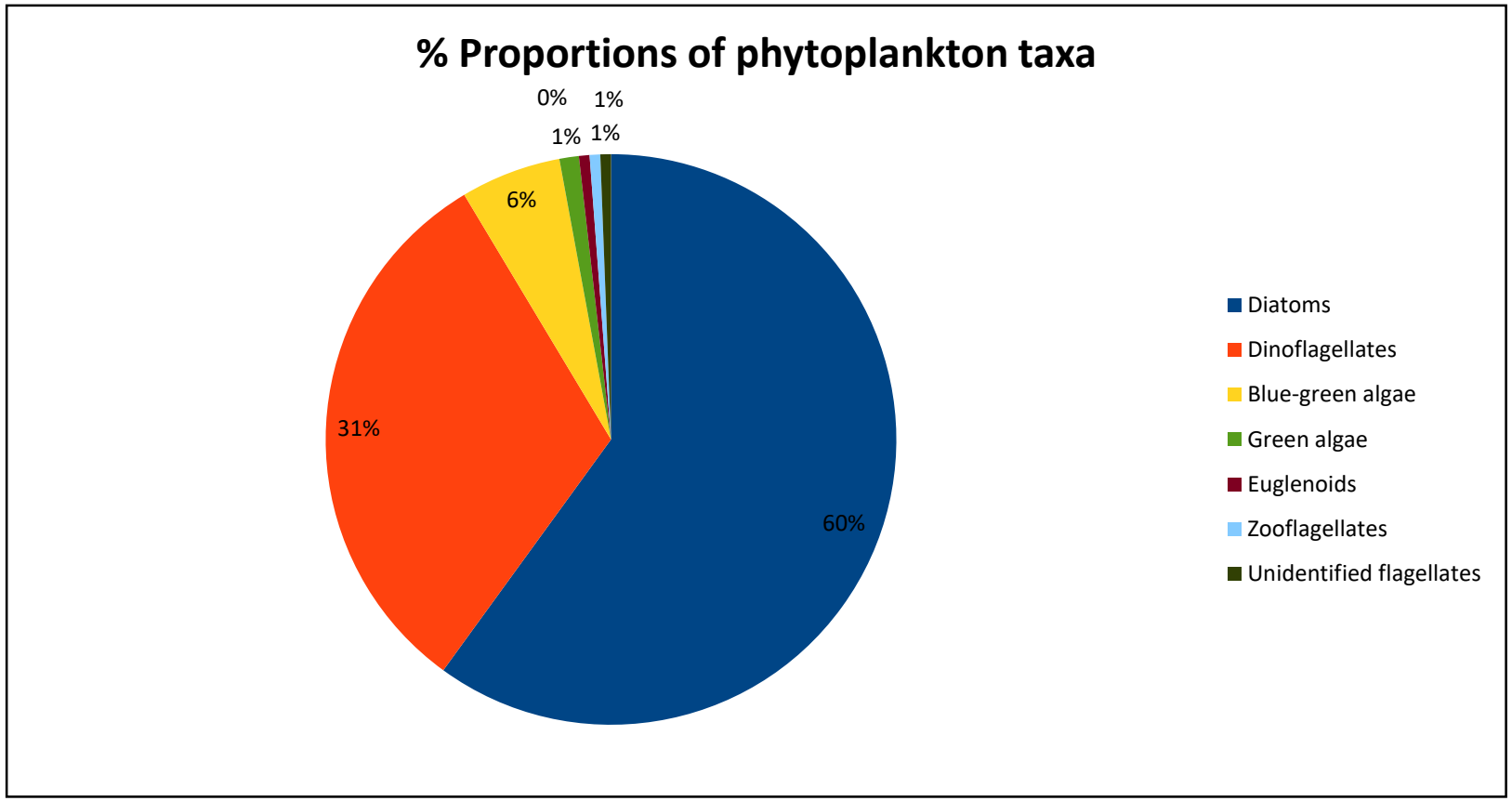
Water Quality sample stations

Water quality analysis at twelve (12) stations across the harbour and within the vicinity of the airport environment were conducted on three (3) occasions: February 26, 2020, March 26, 2020, and April 9, 2020.



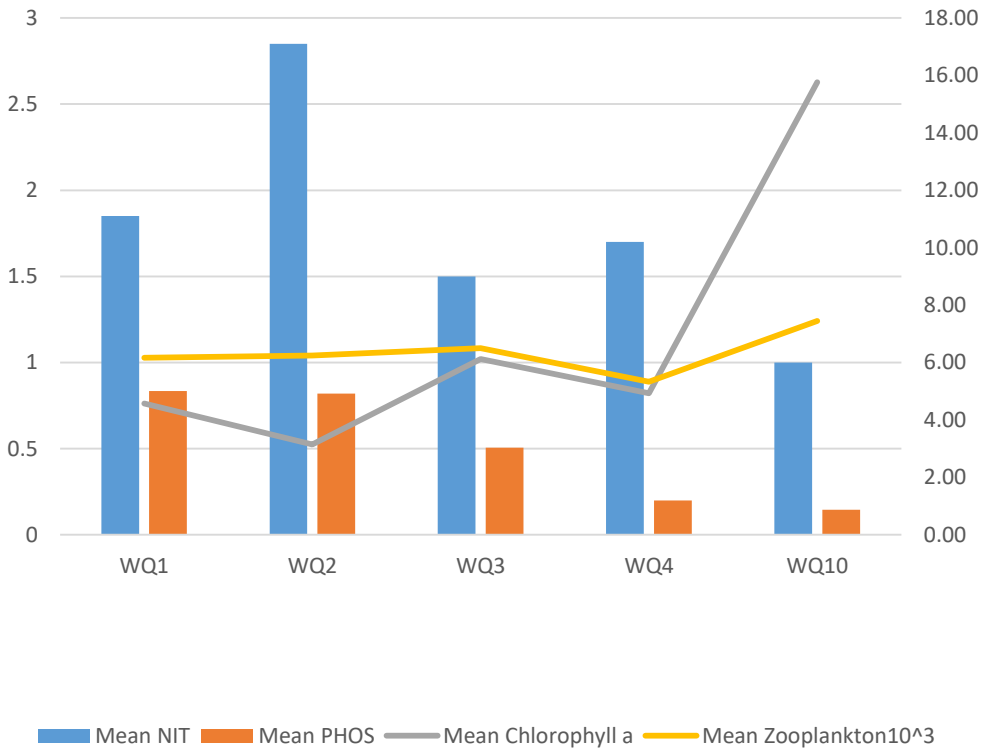
Plankton Communities

The phytoplankton community of Kingston has moderately low diversity, high abundance values and dominated by diatom species which indicates that the area continues to be a eutrophic body of water.



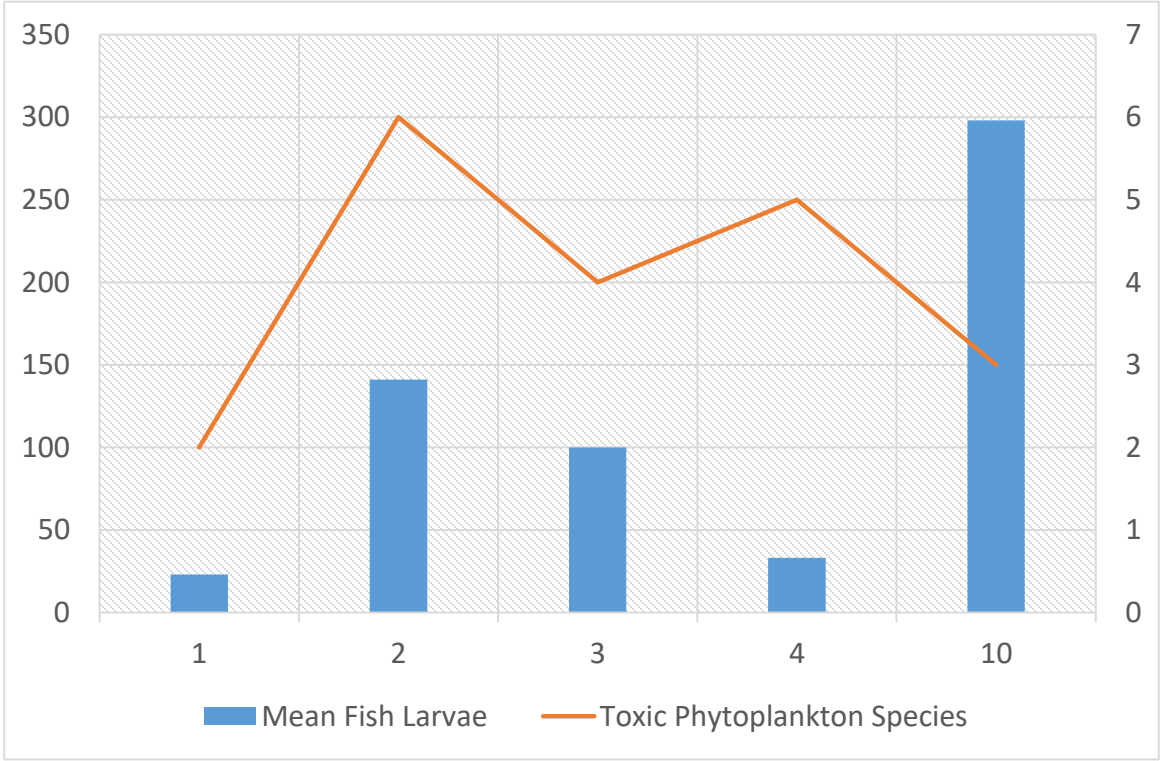
Water Quality and Plankton Stations 1, 2, 3, 4 and 10

- High levels of Phosphates and Nitrates indicate Eutrophic conditions
- All stations exceeded the NEPA standards (Nitrates 0.007- 0.014, Phosphates 0.001-0.003)
- Station 10 had much larger plankton which utilizes the Nitrates and Phosphates
- Each station indicated eutrophic conditions for Mean Zooplankton

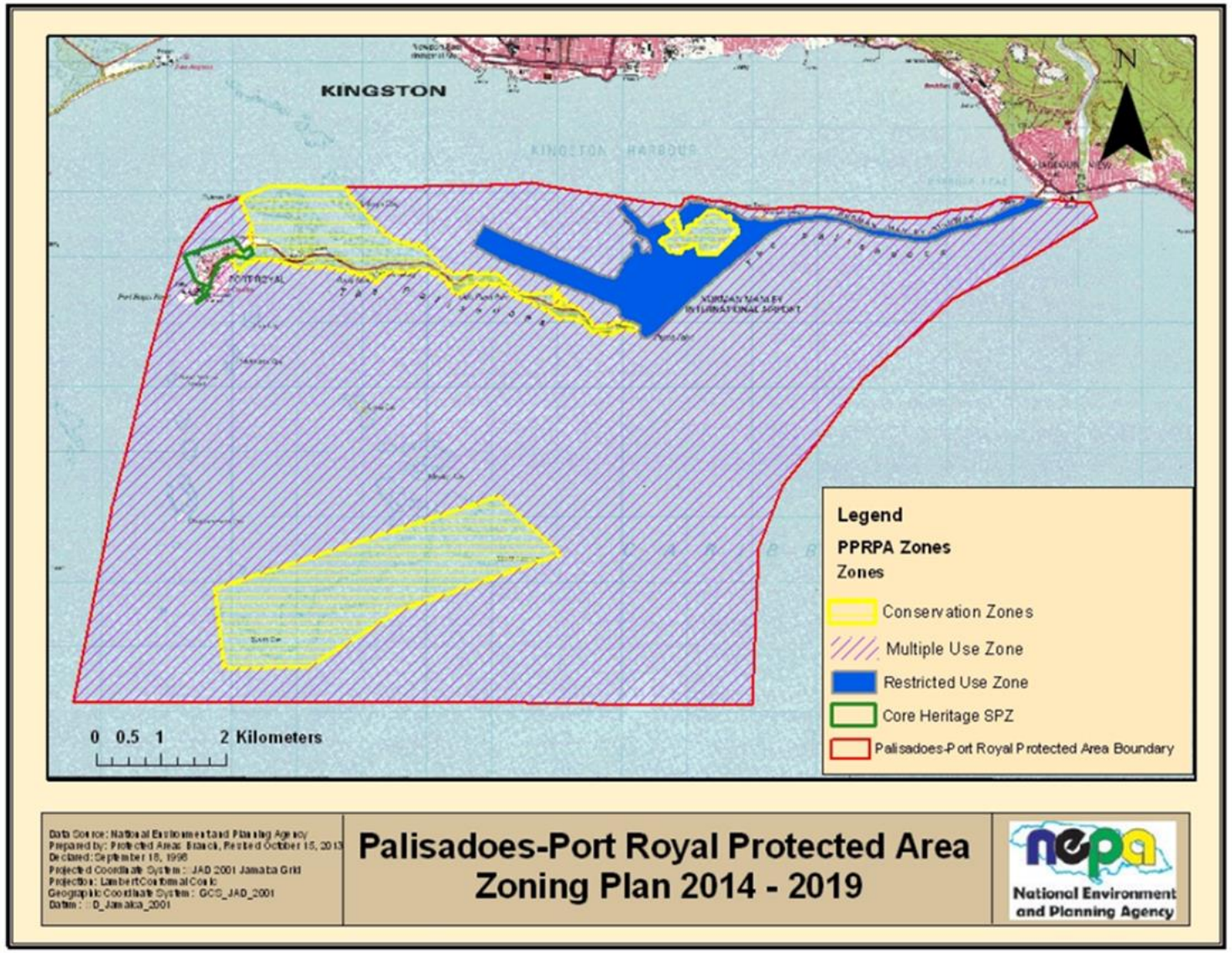


Water Quality and Plankton Stations 1, 2, 3, 4 and 10

- No conch larvae was found at any station
- Lobster larvae counts were very low, with a mean of 1 at Stations 1 and 4
- Seven (7) potentially toxic phytoplankton species were identified in the water samples within the direct vicinity of the Airport.
- These species have the ability to produce toxins which may poison fish and shellfish.
- Noteworthy- mangrove and seagrass areas had little or no larvae



Ecological Inventory and Zonation



- The NMIA facility is currently zoned for Restricted Use.
- There are three (3) areas, in proximity to the NMIA facility, categorized as Conservation Zones
- Remaining coastal areas are deemed Multiple Use Zones.

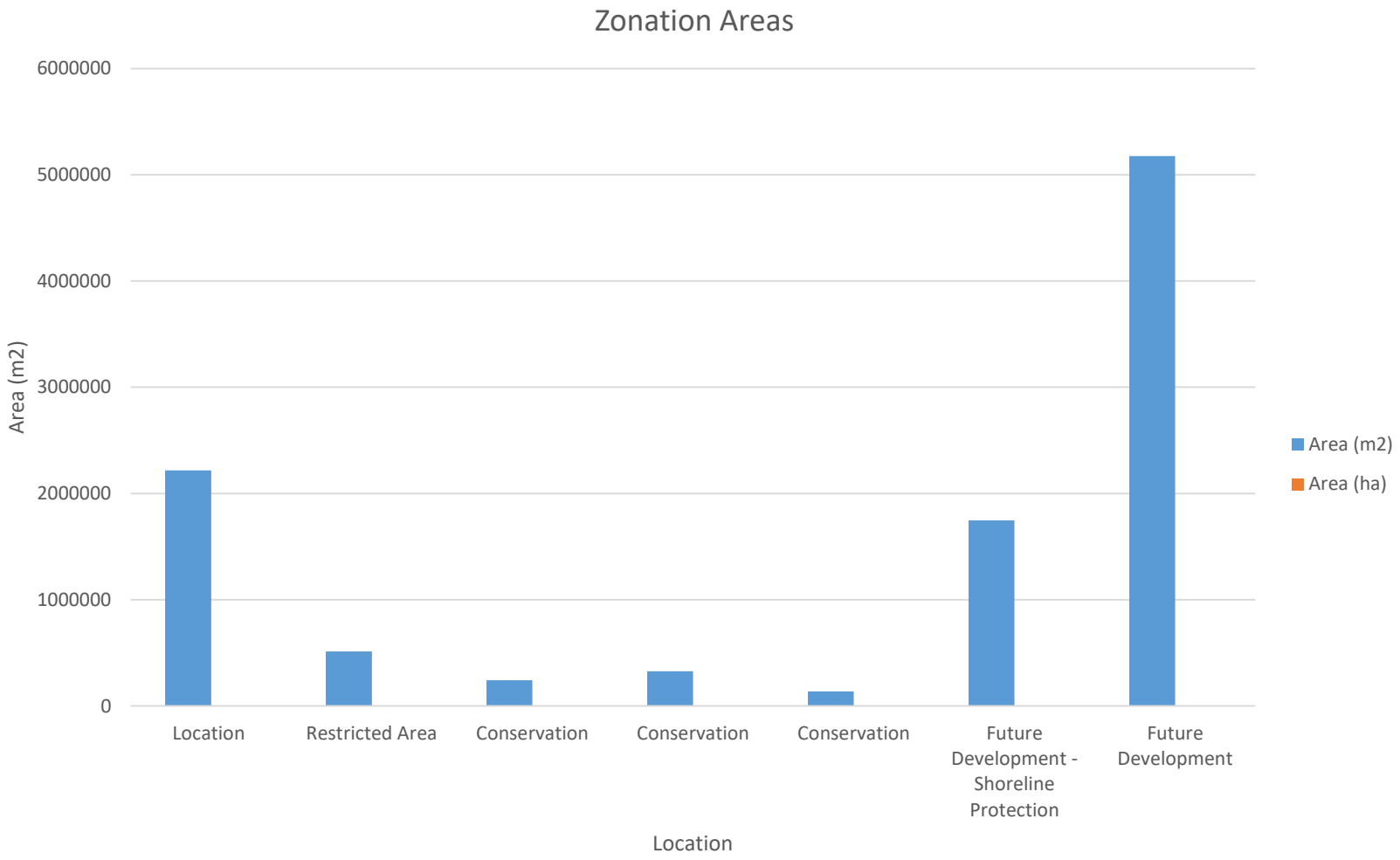
Ecologically Sensitive Habitats/Areas

Sensitive Areas/Habitat	Location	Airport lands and Potential development Areas	Zone of Influence	Potential Impacts
RAMSAR Wetlands and Mangrove Habitats	The mangroves of the PPPR received international recognition when they were designated RAMSAR site (i.e. Wetland of international importance) under the RAMSAR Convention for the Protection of Wetlands and Waterfowl.	yes	yes	Potential habitat and species loss of Mangrove areas with Conservation significance Mangrove areas with major anthropogenic influences
Seagrass Beds	Along sections of the Palisadoes, around sections of the cays and in nearshore sections around NMIA	yes	Yes	Major anthropogenic influences. Potential habitat and species loss
Reef/Coral Areas	Coral Cays, Barrier Reef, Along the seaward side Palisadoes and extremely limited on the harbour side	Yes	Yes	A poor to moderate coral reef community located along the seaward side, near the runway - within the zone of influence but with limited hard corals and other species. Currently having both natural and anthropogenic influences
Beach and Dune Habitats	Along the seaward side Palisadoes and limited on the harbour side	Yes	Yes	Potential habitat and protected species loss anthropogenic influences

Sensitive/Protected Species

Sensitive/Endangered Fauna	Occurrence/ Location	Airport lands and Potential development Areas	Zone of Influence	Impacts
American Crocodile (Crocodylus acutus)	PPRA and NMIA marine environment and lands	Yes	Yes	Limited- slightly positive- afforded some protection by reduced human access to breeding areas
Hawksbill Turtle (Eretmochelys imbricata)	Nests on many of the Coral Cays and Parts of the Mainland	Yes	Yes	Limited- slightly positive- afforded some protection by reduced human access to nesting areas Possible loss of habitat with future developments
Green Turtle (Chelonia mydas)	Nests on many of the Coral Cays and Parts of the Mainland	Yes	No	Limited- slightly positive- afforded some protection by reduced human access to breeding areas Possible loss of habitat with future developments
West Indian Manatee (Trichecus manatus) Endangered	Historically observed within PPRA	Historically	Historically	Manatees have not been reported in this area in a very long time and are unlikely to return
Magnificent Frigatebirds (Fregata magnificens)	PPRA and NMIA marine environment and lands	Yes	Yes	None- expected similarity in noise climate to the current state

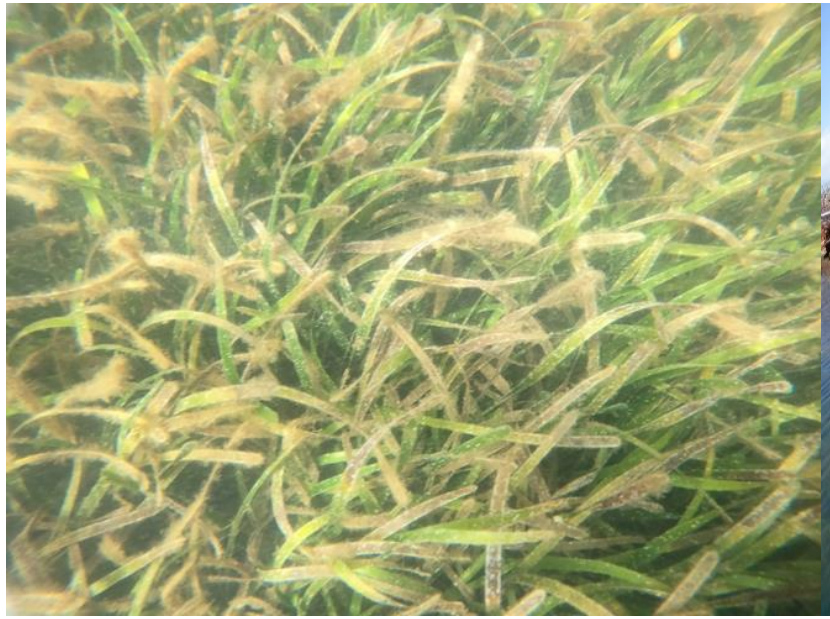
Benthic Habitat Map



Seagrass Areas	
Location	Area/Length
Old Runway	3.95 ha
SGC1	0.7 ha
SGC3	0.3 ha
Lagoon bed length	1384.23m
Mangrove Areas	
Location	Area/Length
Lagoon Runway	5.05 ha
Old Runway	5.04 ha
Coastal/ Dune	1712.7 m

Seagrass and Epiphytic Community

- Seagrass beds and associated mangrove areas were identified. Beds were dominated by Thalassia testudinum with varying density and distribution
- Three (3) sites sampled around NMIA are a good representation of the seagrass communities within that area of the inner Kingston Harbour
- Seagrass meadows closely associated with the NMIA are relatively the healthier seagrasses found within the harbour



Habitat Map

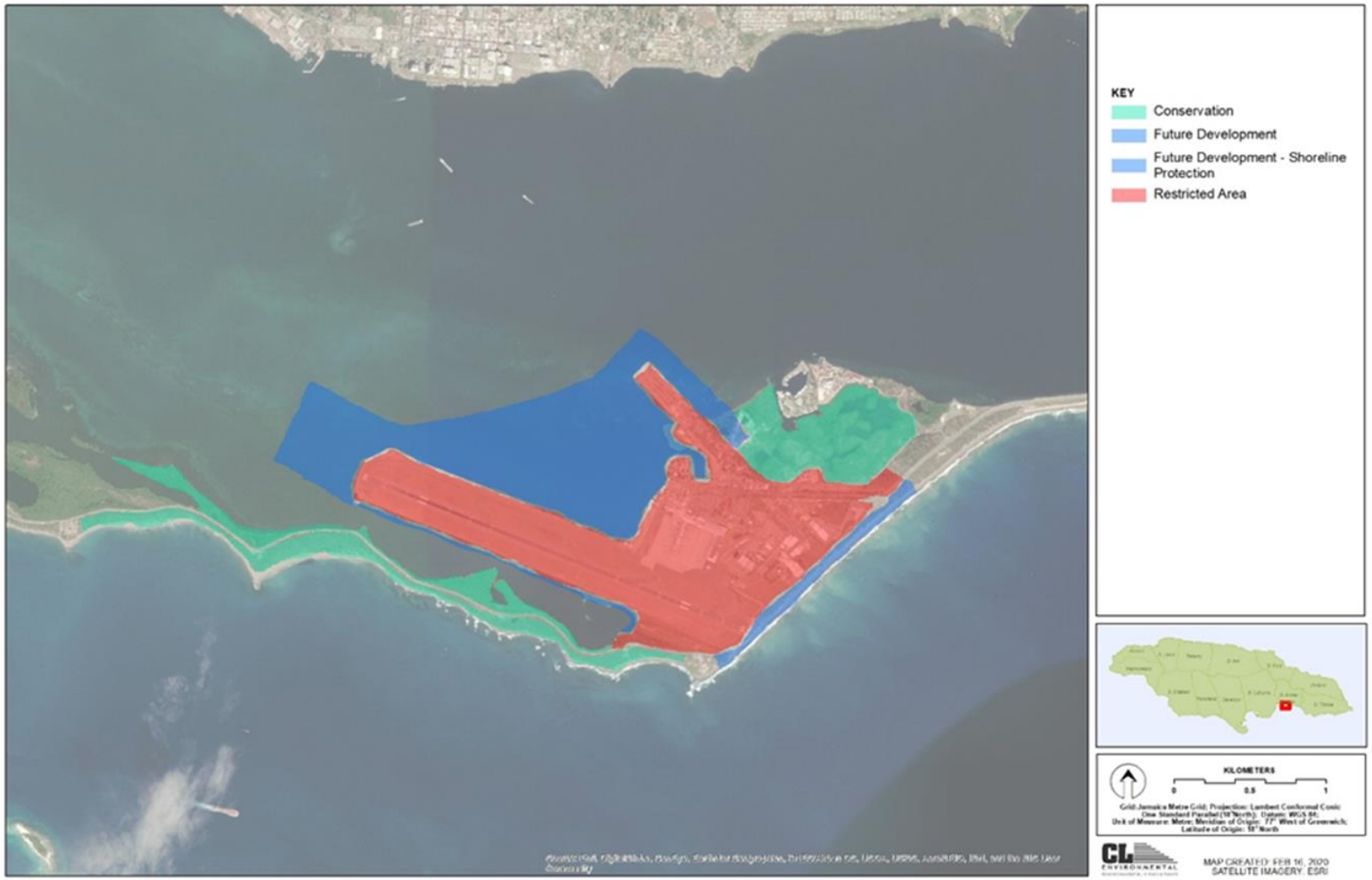
Ecologically Sensitive Habitats in PPRPA

Mangroves and Dunes

- Some Mangrove and Dune areas fall within the development zones of the airport.
- These require special mitigation
- Areas surrounding the airport zones should be conserved.
- We recommend the following zonation of the airport lands

Pelicans in mangroves

Proposed Zonation



Recommended zonation of Airport lands and Ecologically Sensitive Habitat

Summary

It was can be deduced that the phytoplankton community of Kingston Harbour area is presently typical of the area with a moderately low diversity, high abundance values and dominated by diatom species which indicates that the area continues to be a eutrophic body of water (Simmonds, 1998; Ranston et al. 2003). Water Quality around the airport boundaries had high levels of phosphates and nitrates which indicate eutrophic conditions and can result in toxic plankton or algal blooms.

The mangrove forest exhibits the expected Caribbean mangrove forest tree zonation with a low species diversity as very few non-mangrove species are found within the mangroves areas. Red Mangrove dominates the majority of the mangrove forest, however there was strong evidence of a transition to Black mangroves in some areas based on that species more capable of adapting to anthropogenic pressures.

Conclusion

1. There is potential for the proposed development to impact negatively on the phytoplankton community of the harbour primarily via reduction of abundance and community diversity and stimulation of blooms particularly of potentially toxic species via dredging and other construction activities. These primary impacts can lead to important secondary environmental and human health impacts.
2. The phytoplankton community should therefore be carefully monitored during and after construction phases and any measures that can be put in place to reduce changes in physico-chemical parameters of the site waters during construction, should be deployed.

Recommendations

1. More research be done on the seagrass communities of Kingston harbour and the surrounding area to see how resilient these communities really are and how quickly they can potentially bounce back from major disturbances.

2. In the event of Construction of any kind near the marine environment the following is recommended:
    - Silt screens be placed at strategic areas to protect the seagrass meadows from being smothered.
    - Special modifications should also be made to ensure that there is no significant loss or damage to the mangrove environment as well.
    - If mangrove forests need to be removed, it is recommended that this removal be kept as minimal as possible and replanting exercises done at suitable places along the Palisadoes coastline.
    - Additionally, it is suggested that good construction practices are employed in how materials are disposed of in the construction site to limit the amount of potential solid waste being washed into the mangroves and the seagrass.

Limitations / Difficulties Encountered

1. Covid-19 Pandemic: Borders were shut on March 21, 2020.
2. Staff and Lab facilities were either closed or quarantined. This resulted in delays as well as the loss of the second plankton sample (not viable as a result of the extended hold time).
3. Team members had to self quarantine for any flu or cold symptoms. This caused delays and disruptions in sampling times.

AIRPORT ZONING

Aims of Zoning Component

To review existing literature and conduct fieldwork where necessary, regarding the following:

1. 2013 Master Plan, land use and zoning issues
2. Airport zoning analysis
3. Compatible and incompatible land use assessment and land use plan
4. Support to Airport Zoning adaptation Procedures

Objectives of Zoning Component

The objectives of the Airport Zoning study were:

1. To determine the airport locality boundaries
2. To determine existing incompatible land use within the airport locality
3. To specify land use to be permitted within the airport locality
4. To develop zoning ordinances/regulations for the designated areas.
5. To determine measures to be taken to protect the safety and welfare of property owners, residents and businesses in the airport locality
6. To identify and determine the effectiveness of current local and international legislations, regulations and policies for airport land use planning and zoning

Proposed Zoning Policy And Land Use Map

- Current zoning and regulations governing the airport are outdated and ineffective and restrict the continued development and expansion of the airport, consistent with international and local regulations and the 2013 masterplan
- Compatible or incompatible land use relating to the airport is becoming detrimental when analysing the parameters of bird hazard, noise impact and obstruction surfaces

Proposed Zoning Policy And Land Use Map

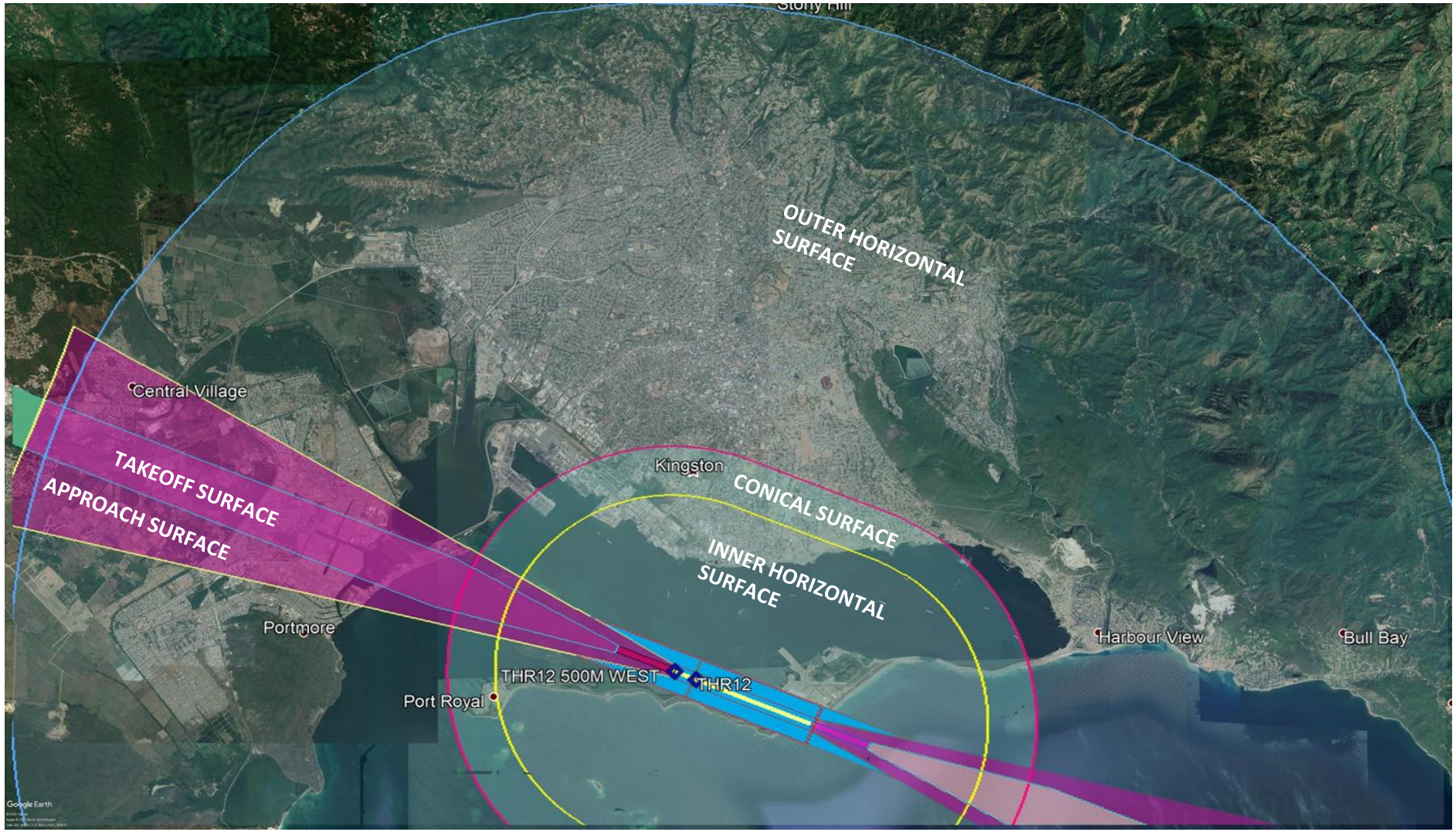
Therefore an Airport Zoning Plan was created to included the Development Order of the 3 Municipalities which the NMIA Airport Zone relates to namely, Kingston &St Andrew, Portmore and St. Thomas.

The overlay zoning divides the airport's imaginary and land surfaces into 4 zoning districts, namely,

1. Airport district
2. Runway Approach and Departure District (Noise Control):
3. Overflight, Height and Wildlife Limitation District
4. Overflight and Height Limitation District

These 4 zones outlines specific ordinances, their purpose/intent, relation to other zoned areas, permitted and prohibited uses; use restrictions; approvals and permits; administration; appeals and review; penalties and severability.

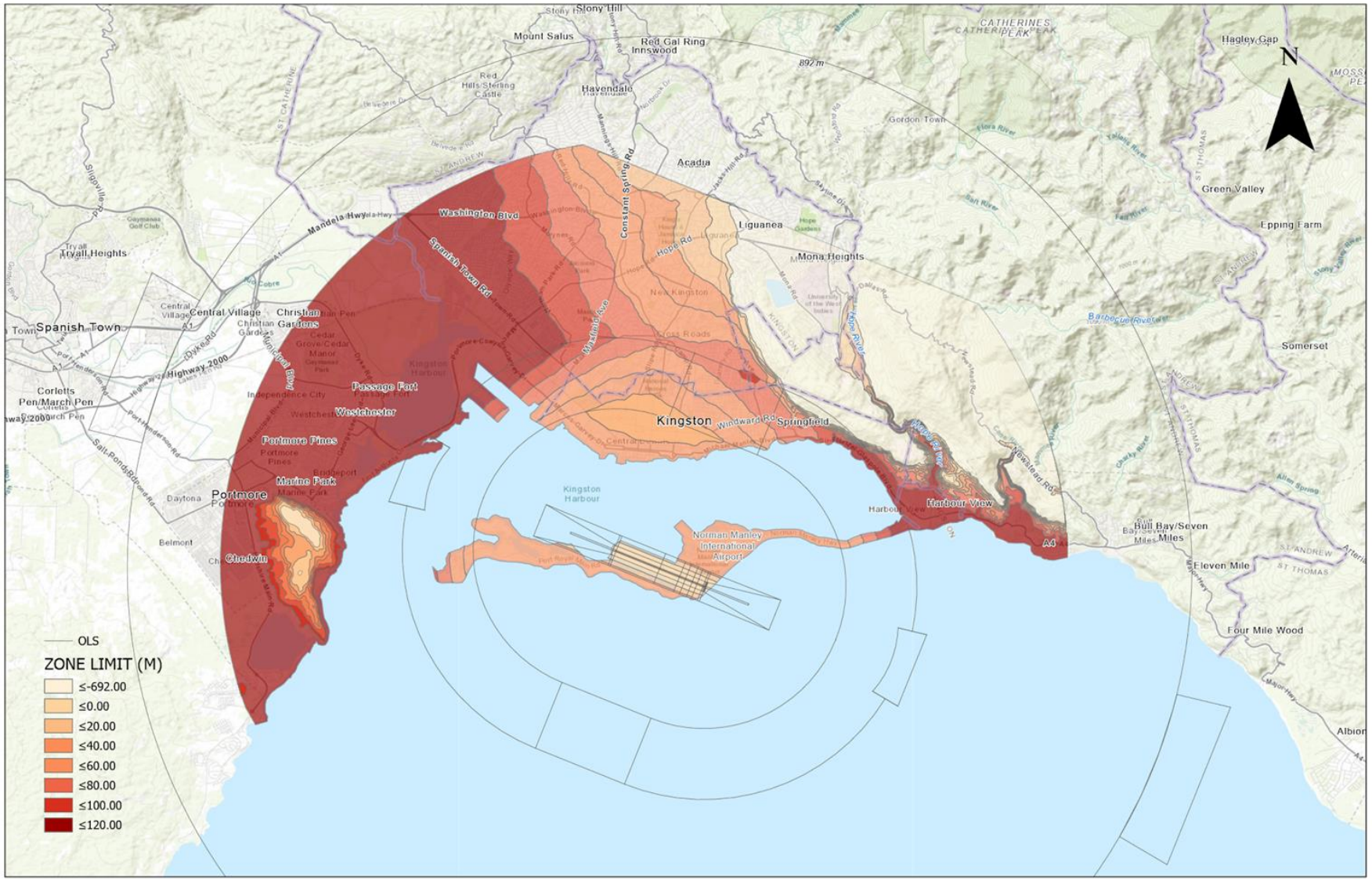
NMIA Zoning Limits



LEGEND

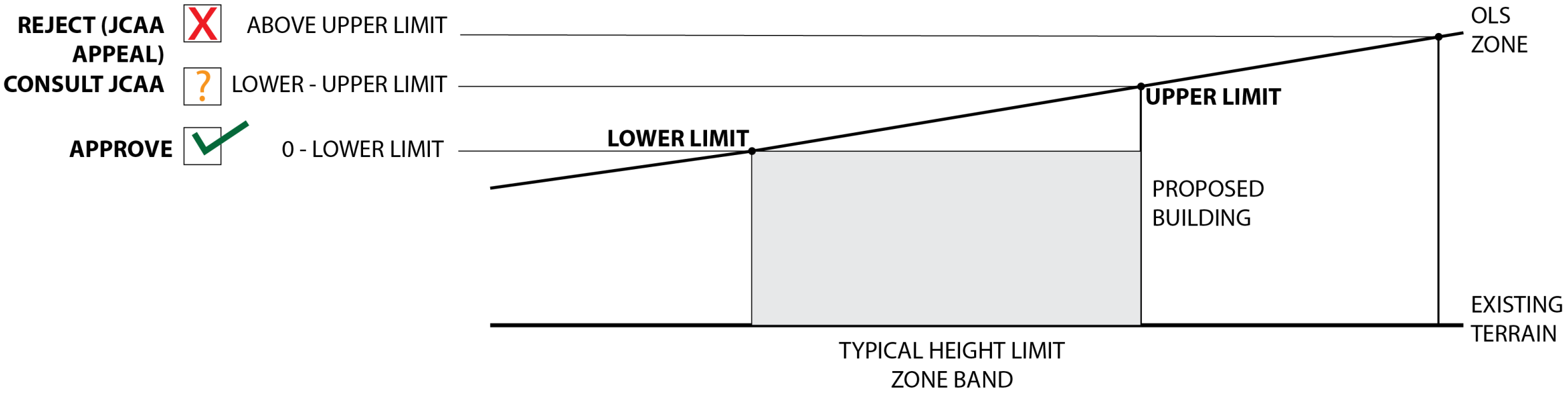
- Outer Horizontal Surface Extent
- Conical Surface
- Inner Horizontal Surface Extent
- Transitional Surface
- Runway Strip

Proposed Height Limitation Zones Map

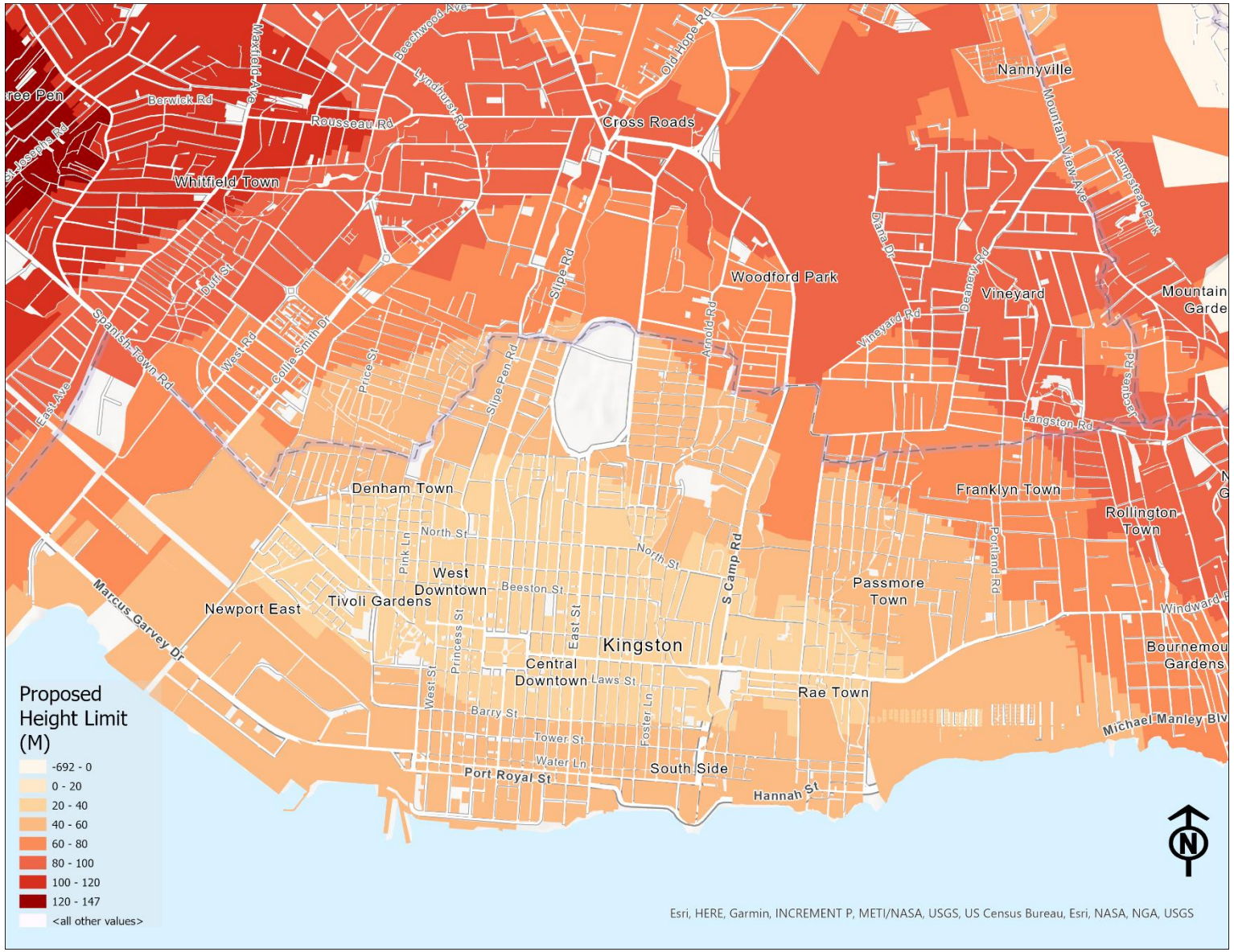


Zone 1 - Airport District
Zone 2 - Runway Approach and Departure District (Noise Control)
Zone 3 - Overflight, Height and Wildlife Limitation District:
Zone 4 – Overflight and Height Limitation District:

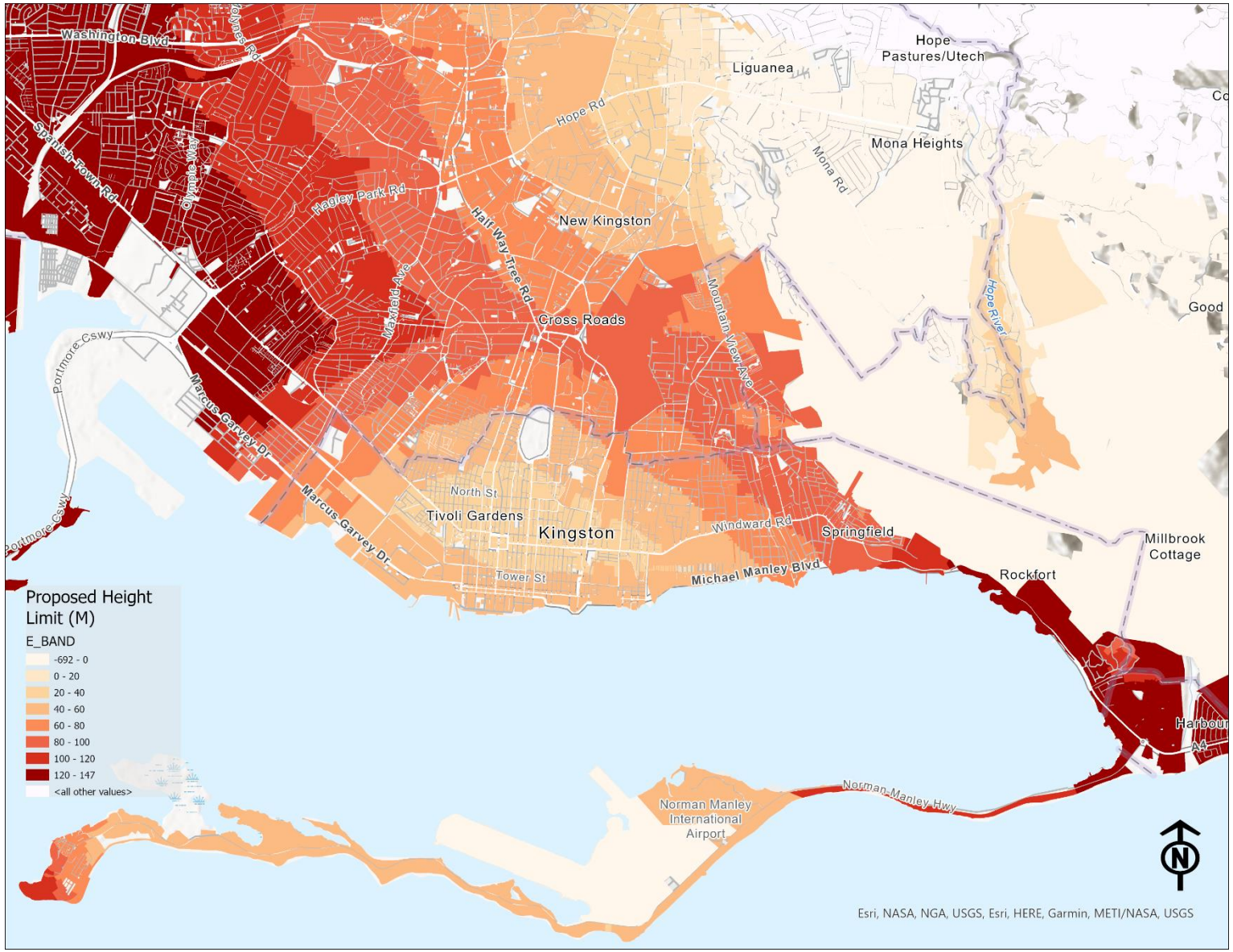
Proposed Height Limitation



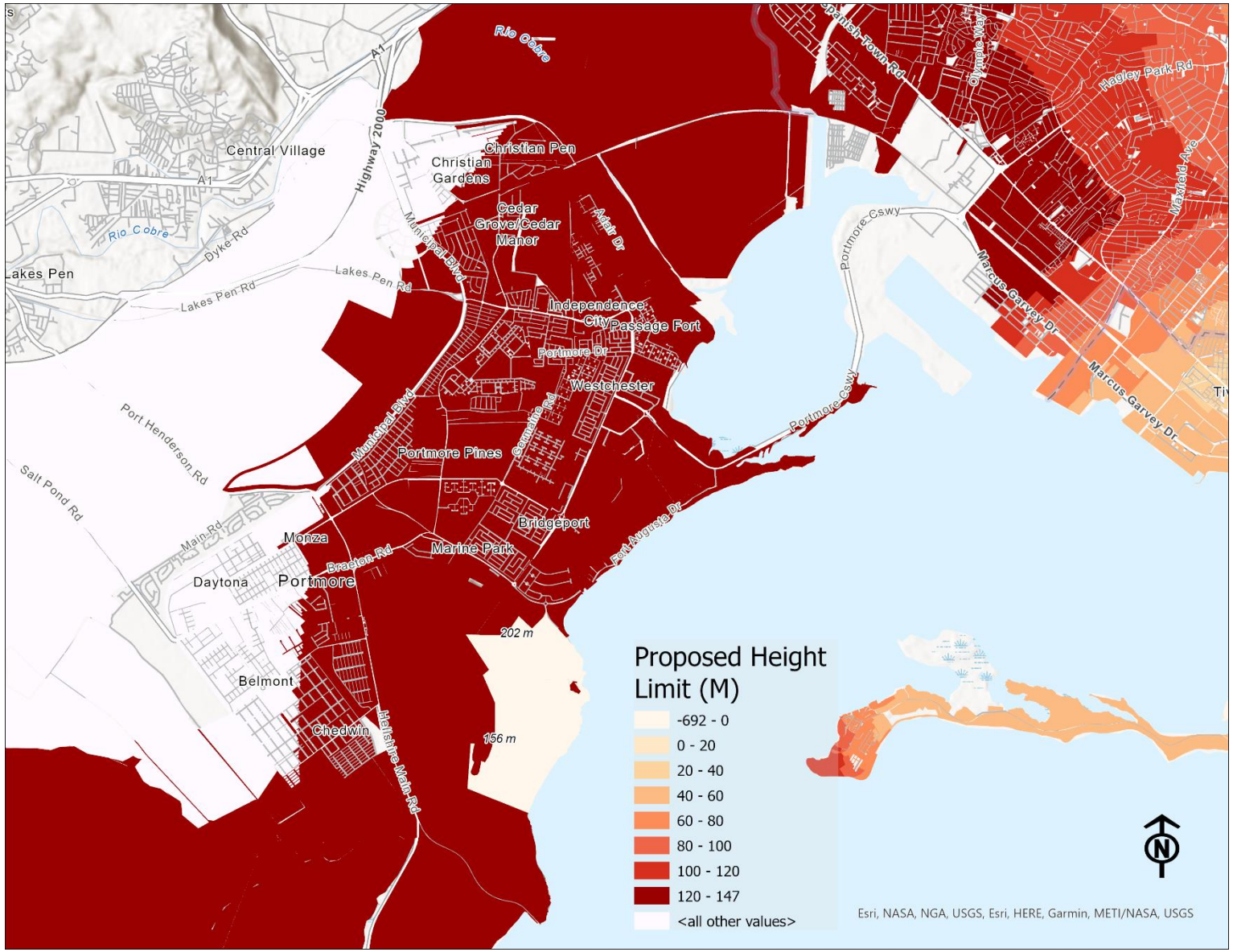
Proposed Height Limitation Zones Map – Downtown Kingston



Proposed Height Limitation Zones Map – St. Andrew



Proposed Height Limitation Zones Map – Portmore



Propose Zoning Policy And Land Use Map

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The overlay zoning divides the airport's imaginary and land surfaces into 4 zoning districts, namely,

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These 4 zones outlines specific ordinances, their purpose/intent, relation to other zoned areas, permitted and prohibited uses; use restrictions; approvals and permits; administration; appeals and review; penalties and severability.

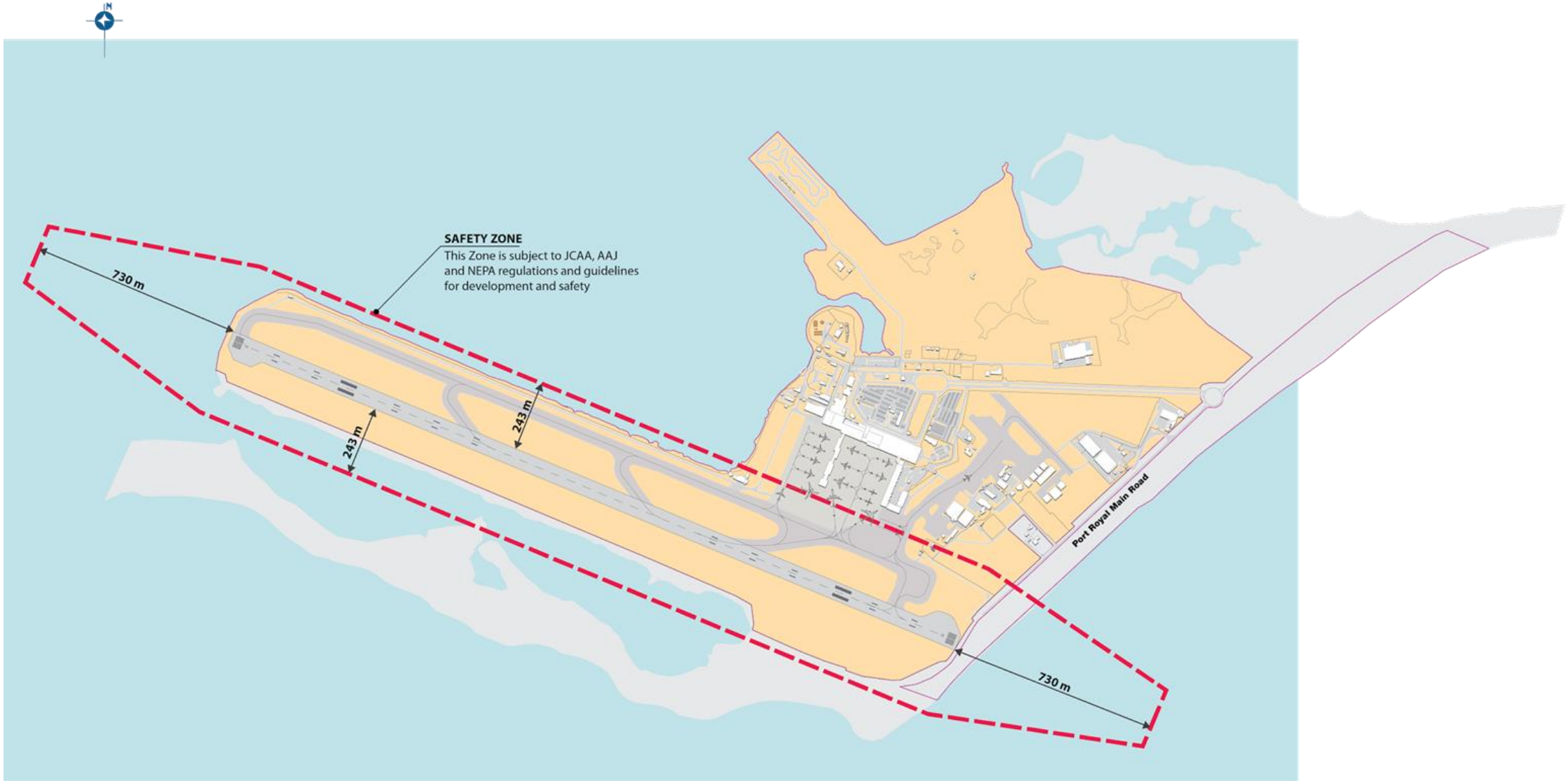
Proposed Draft Zoning Guidelines

- Provisions will be made for the submission of applications for variations to the zoning policy. Determinations of whether to grant a variance will depend on the determinations made by the JCAA as to the effect of the proposal on the operation of air navigation facilities and the safe, efficient use of navigable air space.

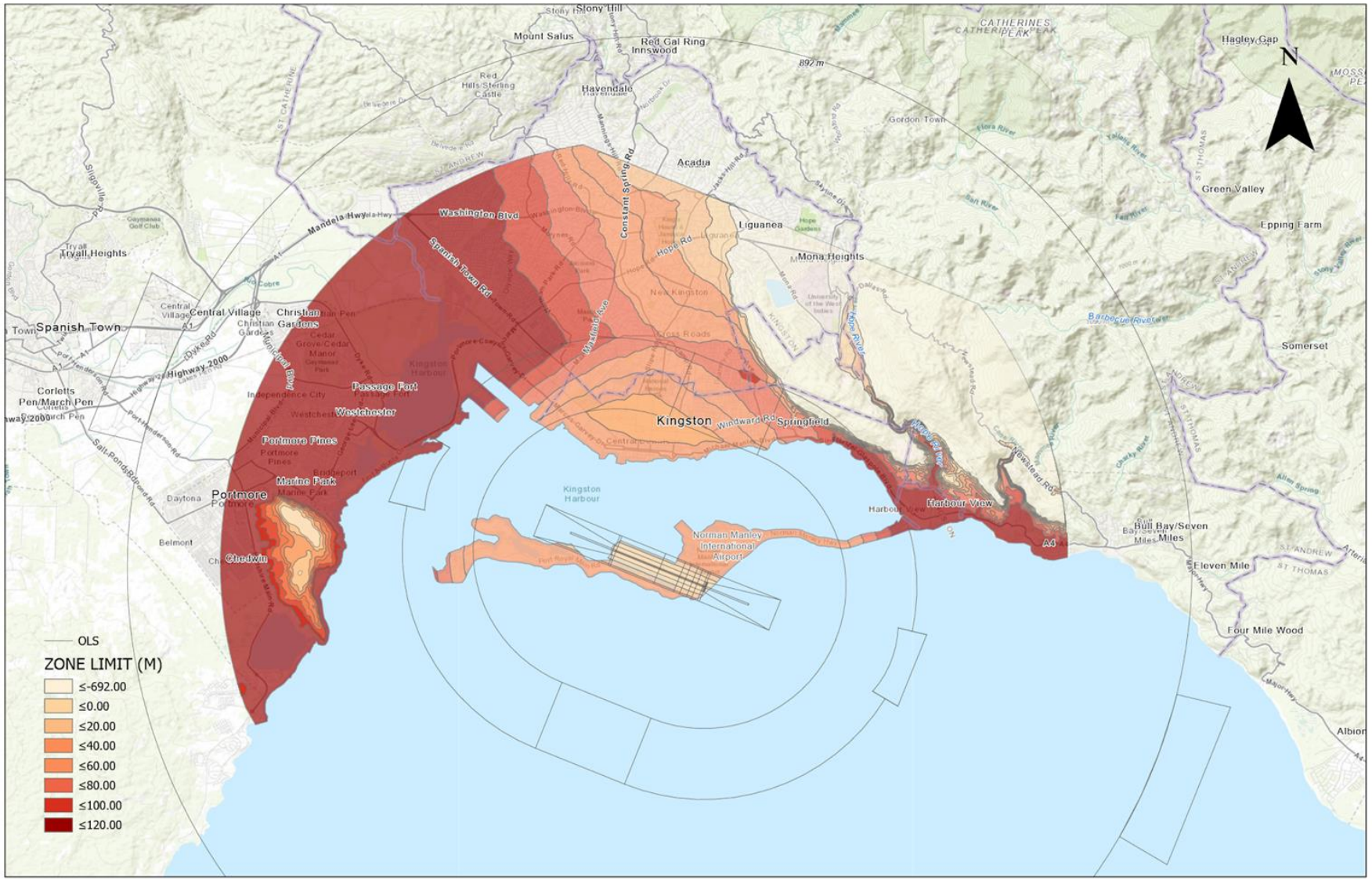
- Any person aggrieved or affected by a decision or action of the department made in the administration of any application governed by the airport zoning policy may appeal such decision or action to the Appeals Board.

- In case of any violation of the airport zoning policy, the relevant local authority may institute appropriate legal action against the violating party.

Proposed Safety Zone Map



Proposed Height Limitation Zones Map



Zone 1 - Airport District
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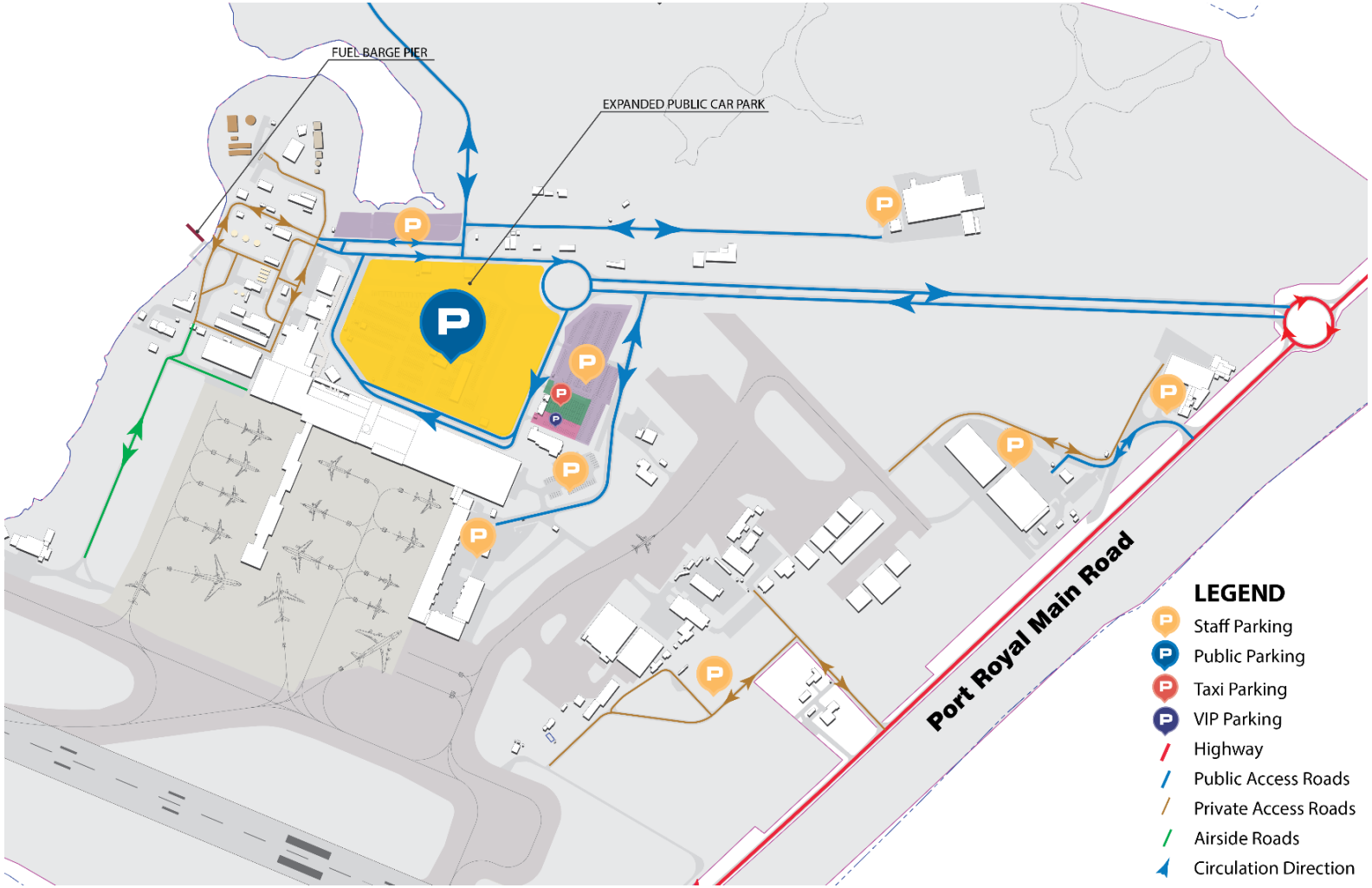
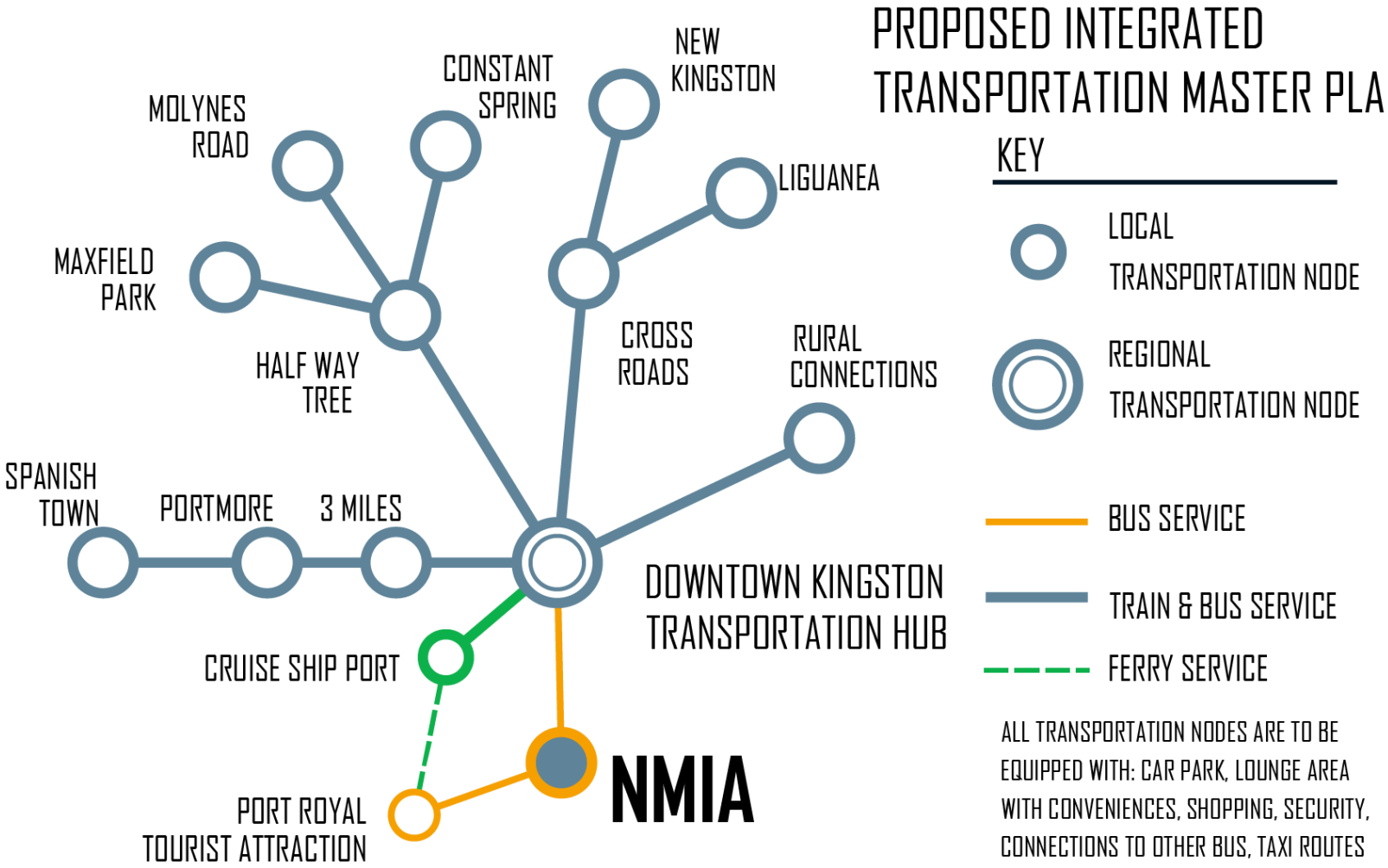
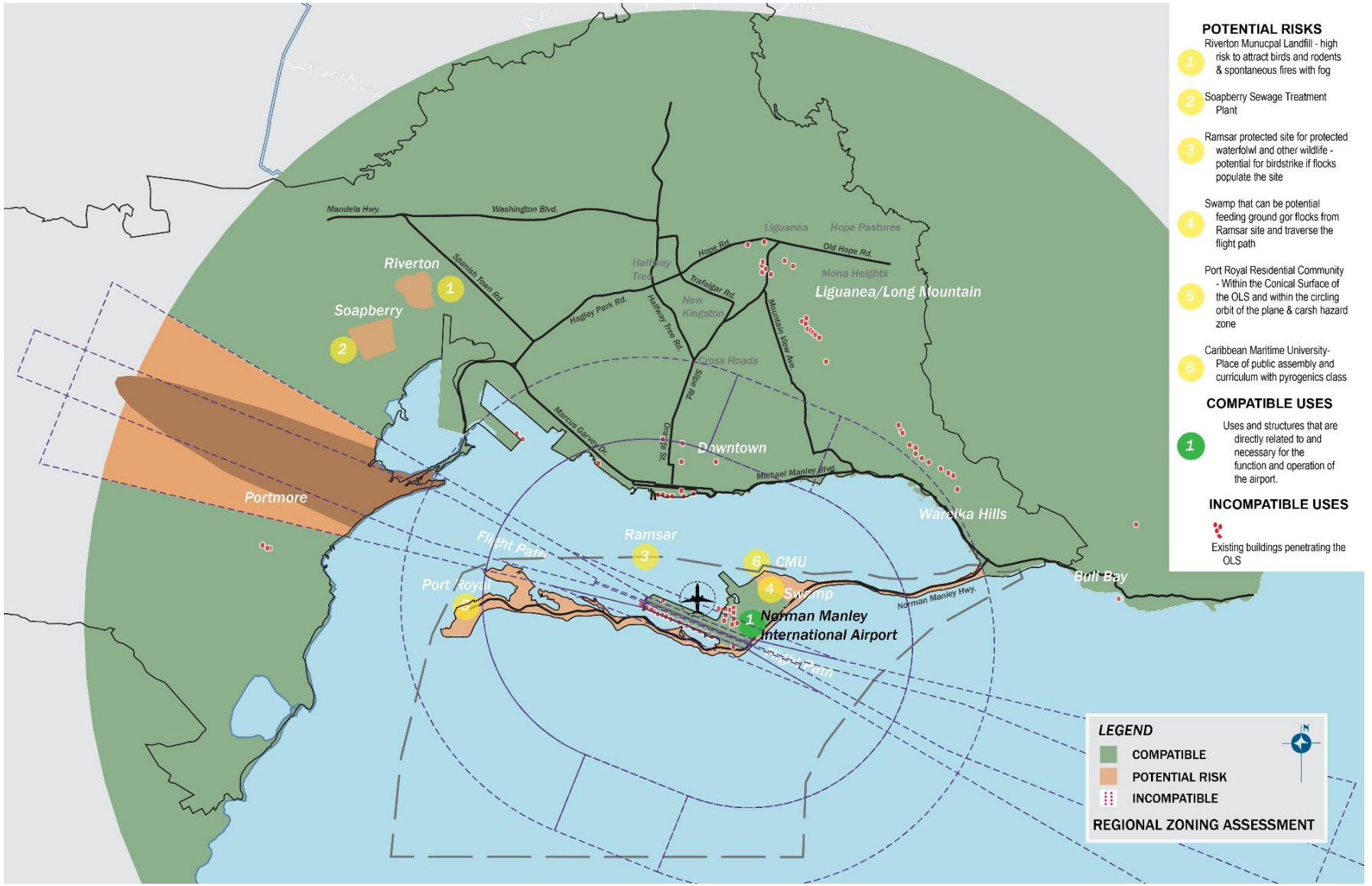
Proposed Internal Transportation Adjustment



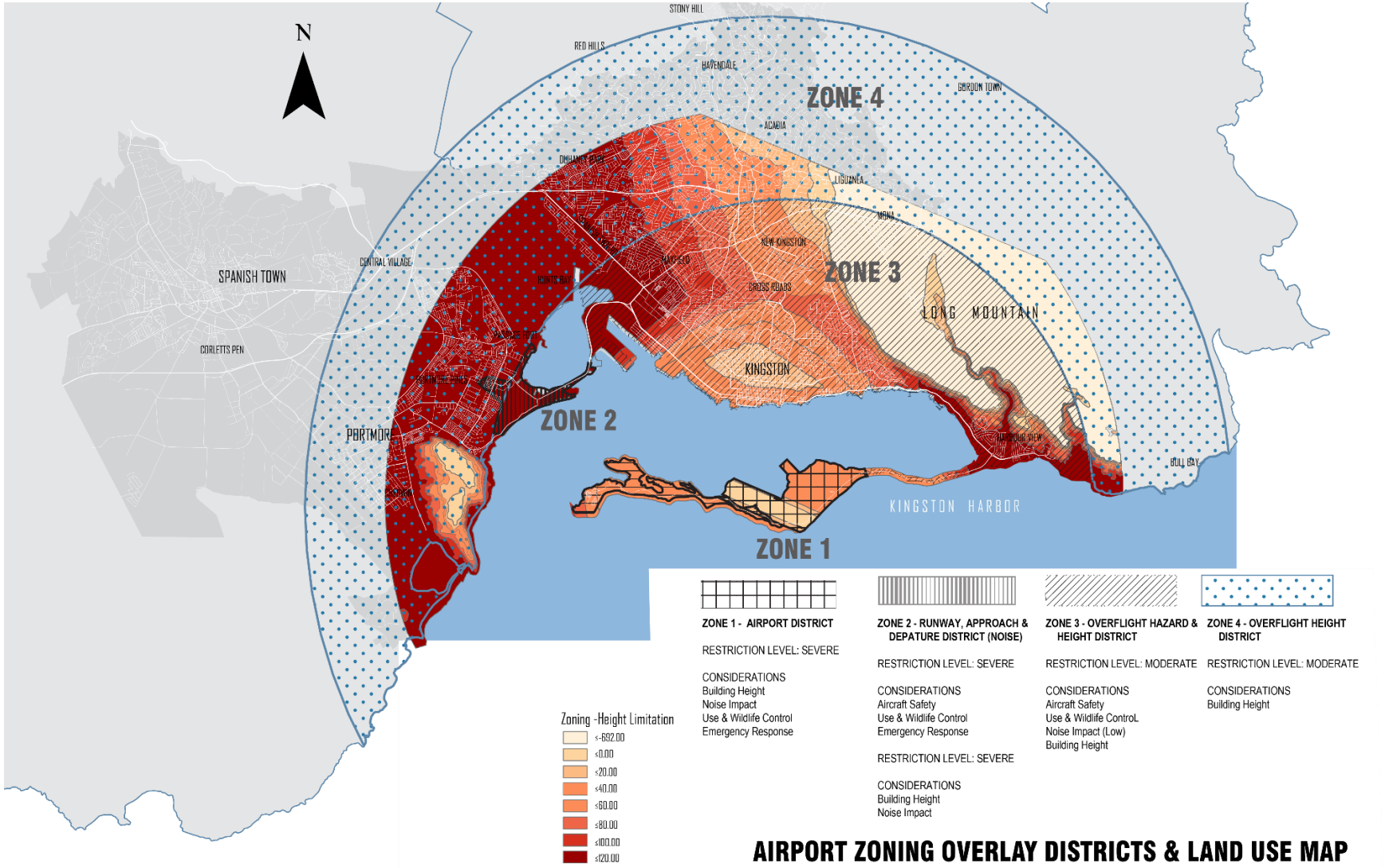
Proposed Regional Transportation Linkages



Regional Zoning Assessment



Proposed Zoning Map



Recommendations

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- Any person aggrieved or affected by a decision or action of the department made in the administration of any application governed by the airport zoning policy may appeal such decision or action to the Appeals Board.

- In case of any violation of the airport zoning policy, the relevant local authority may institute appropriate legal action against the violating party.

Limitations / Difficulties Encountered

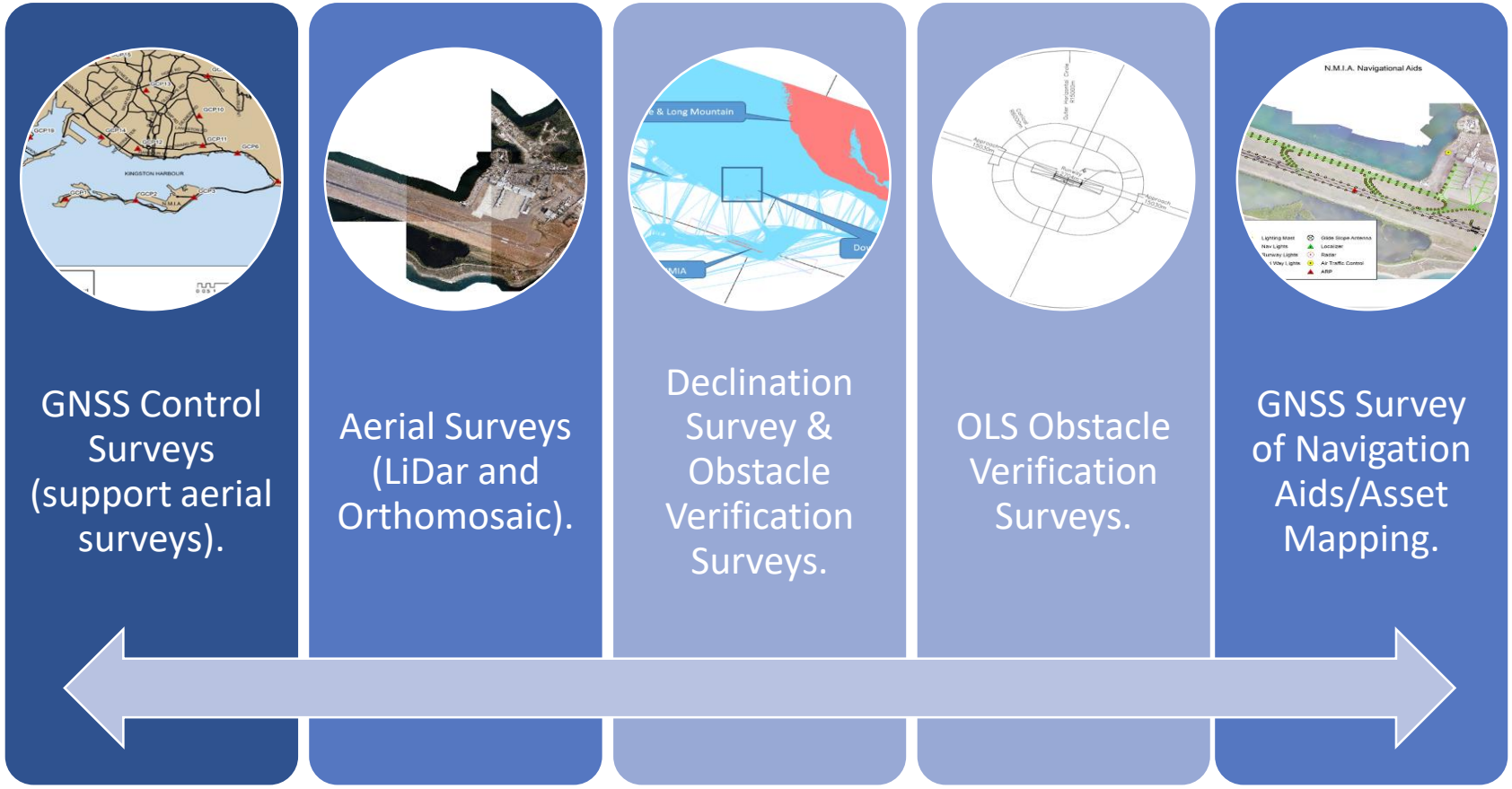
1. Covid-19, which impacted every facet of the project including field access, timely in person communication as well as observation of airport operations at normal operating conditions and capacities
2. Access to the airport site, lengthy delays in acquiring access in order to complete walkthrough and observation exercises led to delays in completion of deliverables
3. Delays in the access to existing information led to duplication of efforts

OBSTACLE LIMITATION SURFACE

INTRODUCTION

The surveys took place over an eight month period and set the basis from which analysis, maps and reports could be made.

Specific Objectives (TOR):



PROJECT OBJECTIVES

CEAC Solutions Ltd was commissioned by Airport Authority of Jamaica (AAJ) to:

1. Defined OLS in keeping with the International Civil Aviation Organization (ICAO) Annex 15 regulations
2. Develop an Airport Zoning Plan to assist in the preservation, continued development and expansion of the airport, consistent with international and local regulations, policies and the 2013 Master Plan

TEAM MEMBERS

CEAC Solutions Limited

Interplan Planning Consultants

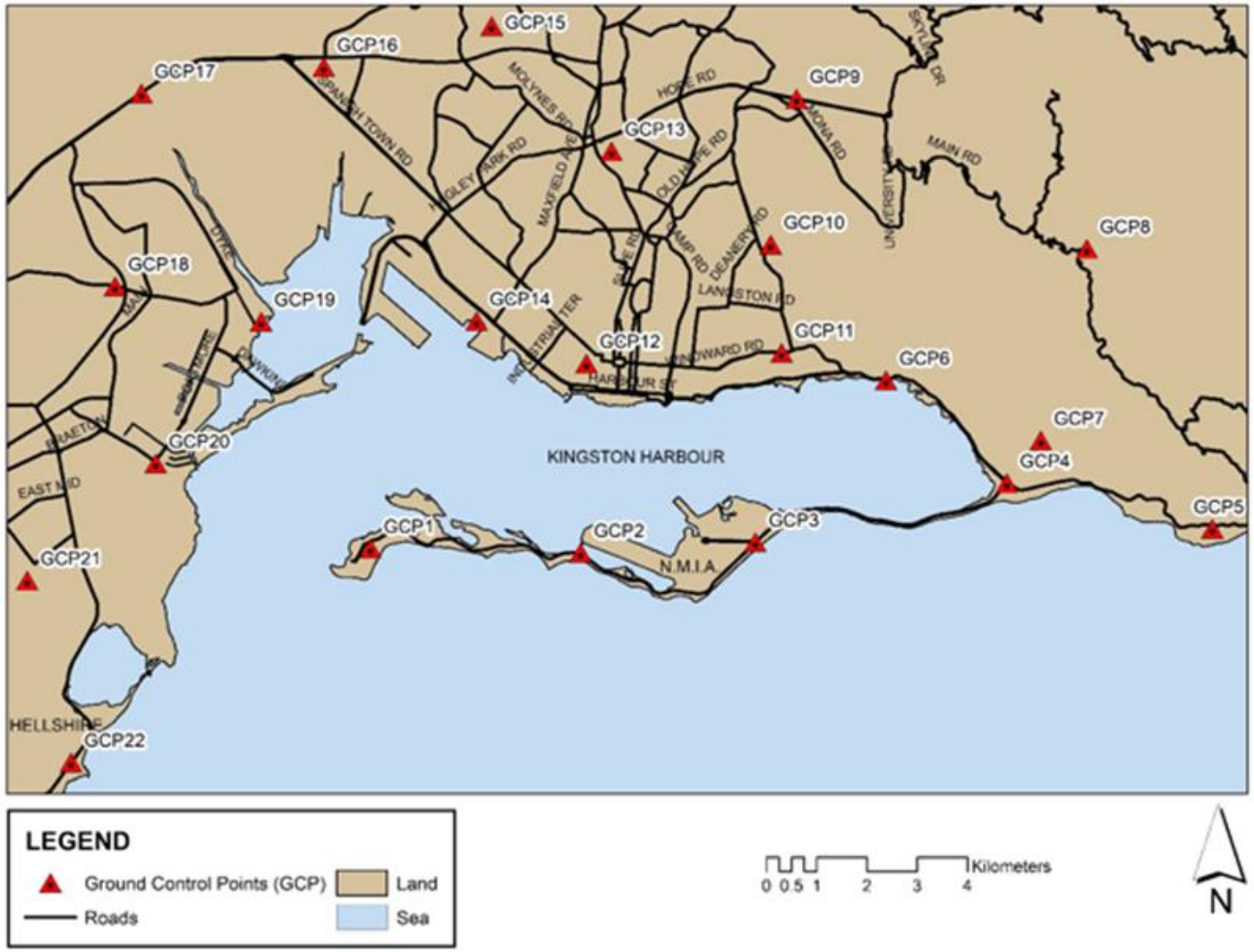
Kucera International Inc.

GNSS CONTROLS

LiDar Ground Control Points (GCP)

- This survey was necessary as it supported the aerial survey by providing it with ground controls relative to a horizontal and vertical datum.
- 22 GCPs were established and surveyed and was spatially distributed over the Aerial Survey area which encompassed parts of Kingston and Portmore..
- The GCPs were observed using Static Global Navigation Satellite System (GNSS) surveying techniques which had a minimum observation time of 60 minutes for each GCP.

GNSS CONTROLS

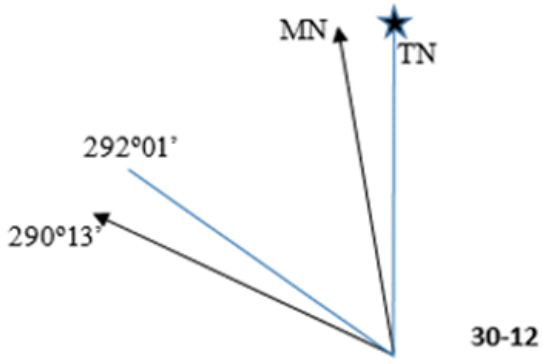


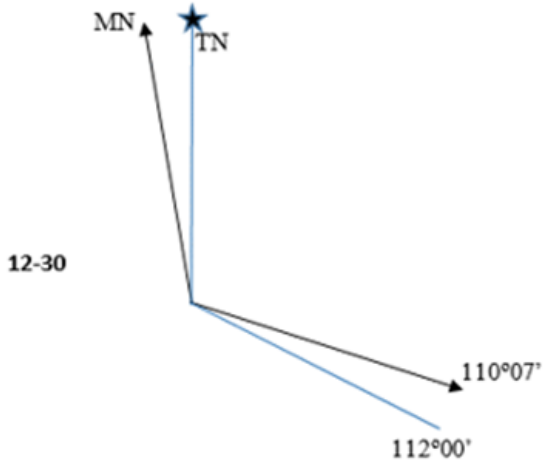
AERIAL SURVEYS

- The aerial surveys commenced in January 2020 and ended in February 2020.
- It was done from a light manned aircraft outfitted with a photogrammetry aerial camera (for imagery) and a LiDar sensor for terrain/topographic data.

Runway Declination

- The declination survey was done to ascertain the current magnetic Declination of NMIA runway at present.
- Two surveys were executed for calculating the Declination value namely:
  - Compass Survey (Magnetic North)
  - GNSS Static Survey (True North)
- The declination value was calculated and found to be 7°57’48” west.

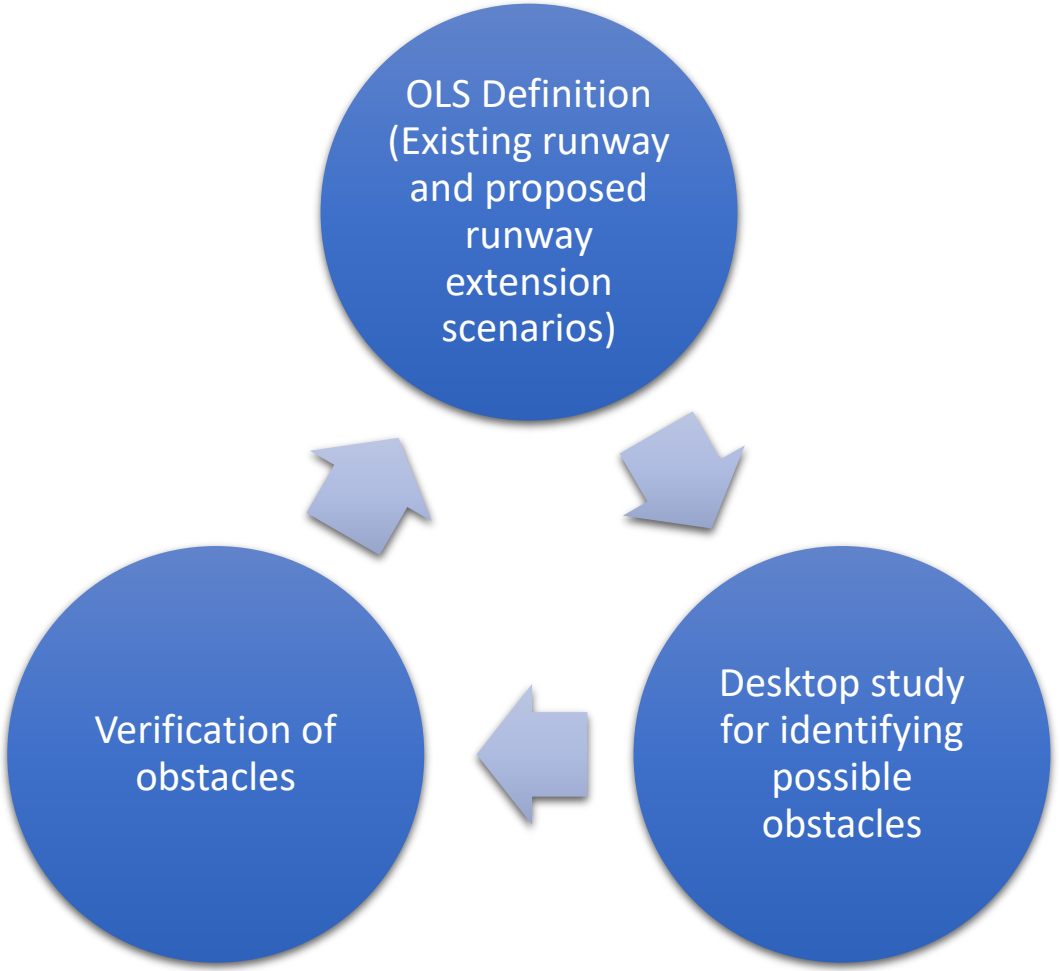




OLS OBSTACLE VERIFICATION

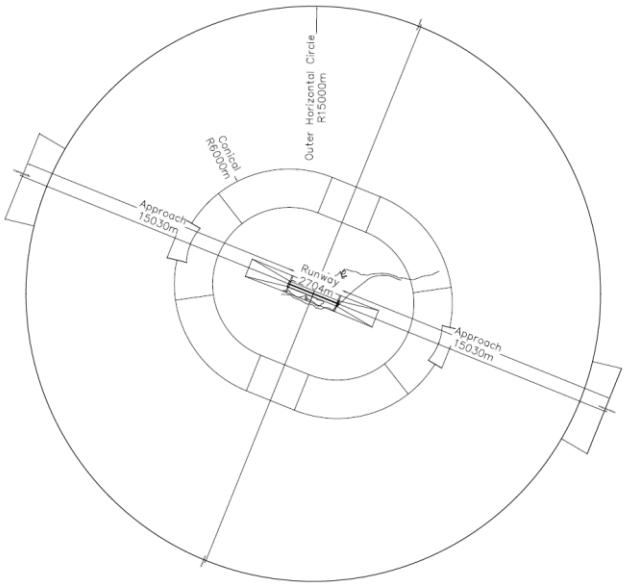
OLS OBSTACLE VERIFICATION

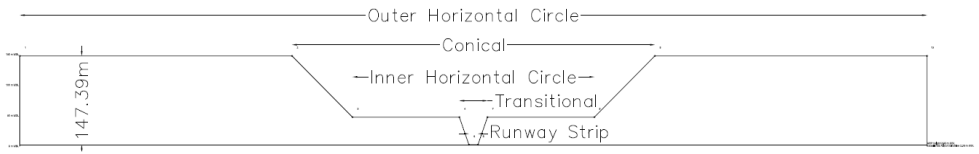
The OLS was executed in three (3) components as follows:



Obstacle Limitation Surface (OLS): Model

- The OLS is a mathematically derived 3D model.
- Defines the airspace around the airport which should be free of obstacles ensuring the safe operations of aircrafts.
- OLS models were created for 2 scenarios (existing and proposed runway extension).
- A horizontal radius extent of 15km and a vertical height of 147m approximately.

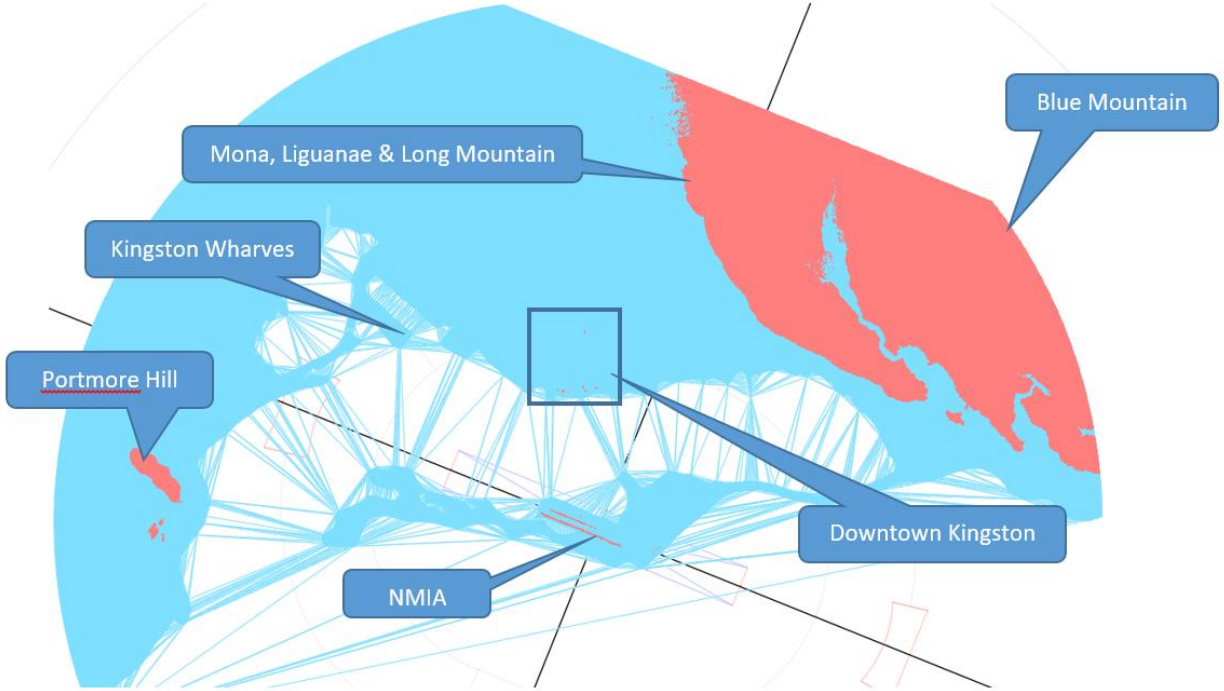




Obstacle Limitation Surface (OLS) Analysis

The OLS model was created using a 3rd party program extension to Autodesk Civil 3D called SkySafe and ICAO Annex 14 regulations.

The desktop study was done to identify possible obstacles that pierced the mathematically derived OLS surface using the digital surface model (DSM) of terrain from the previous aerial survey and identified approximately 93 potential obstacles.

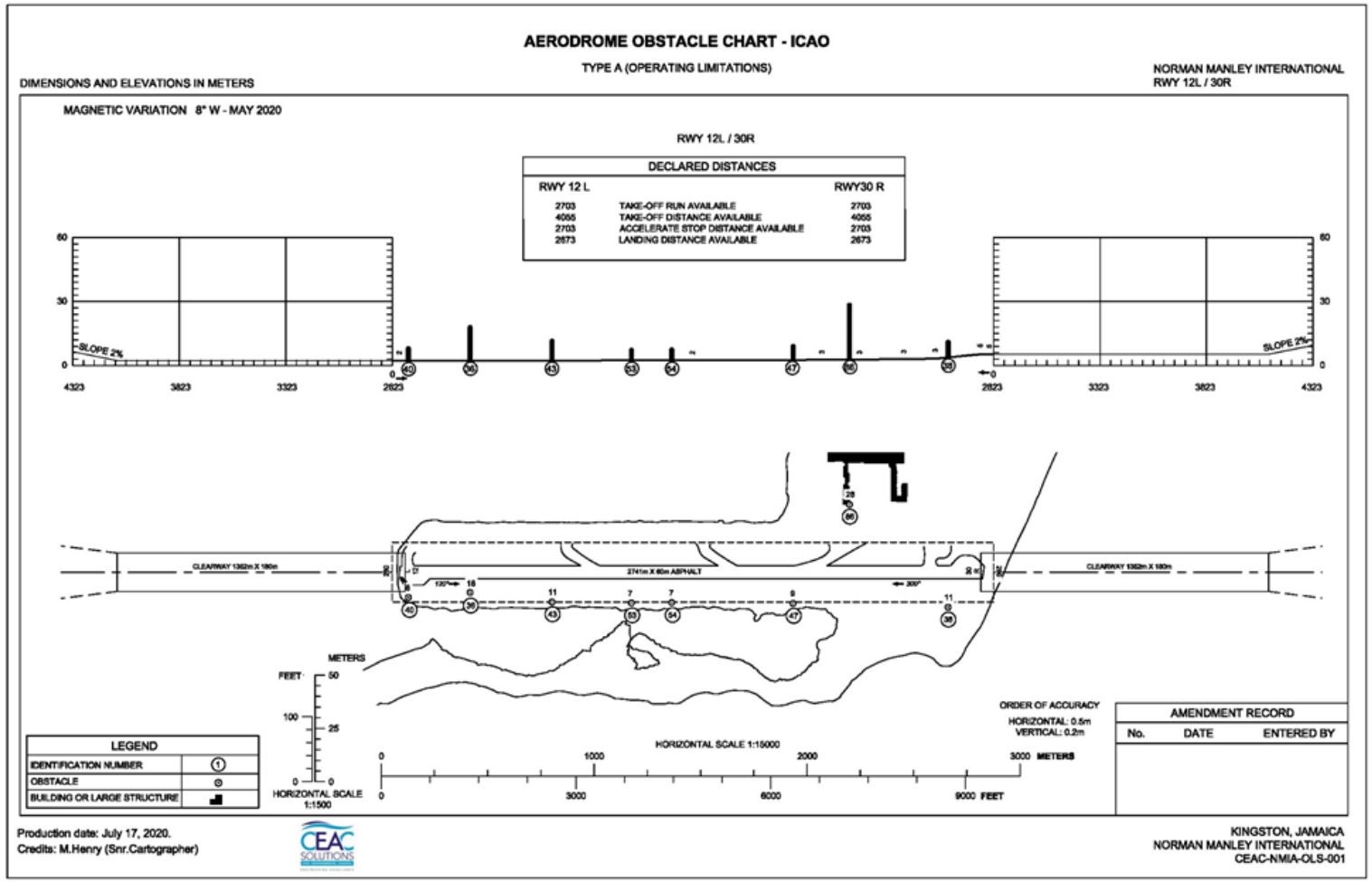


OLS OBSTACLE VERIFICATION

The verification of the identified obstacles were done using a total station to observe the heights of the highest points of 93 potential obstacles.

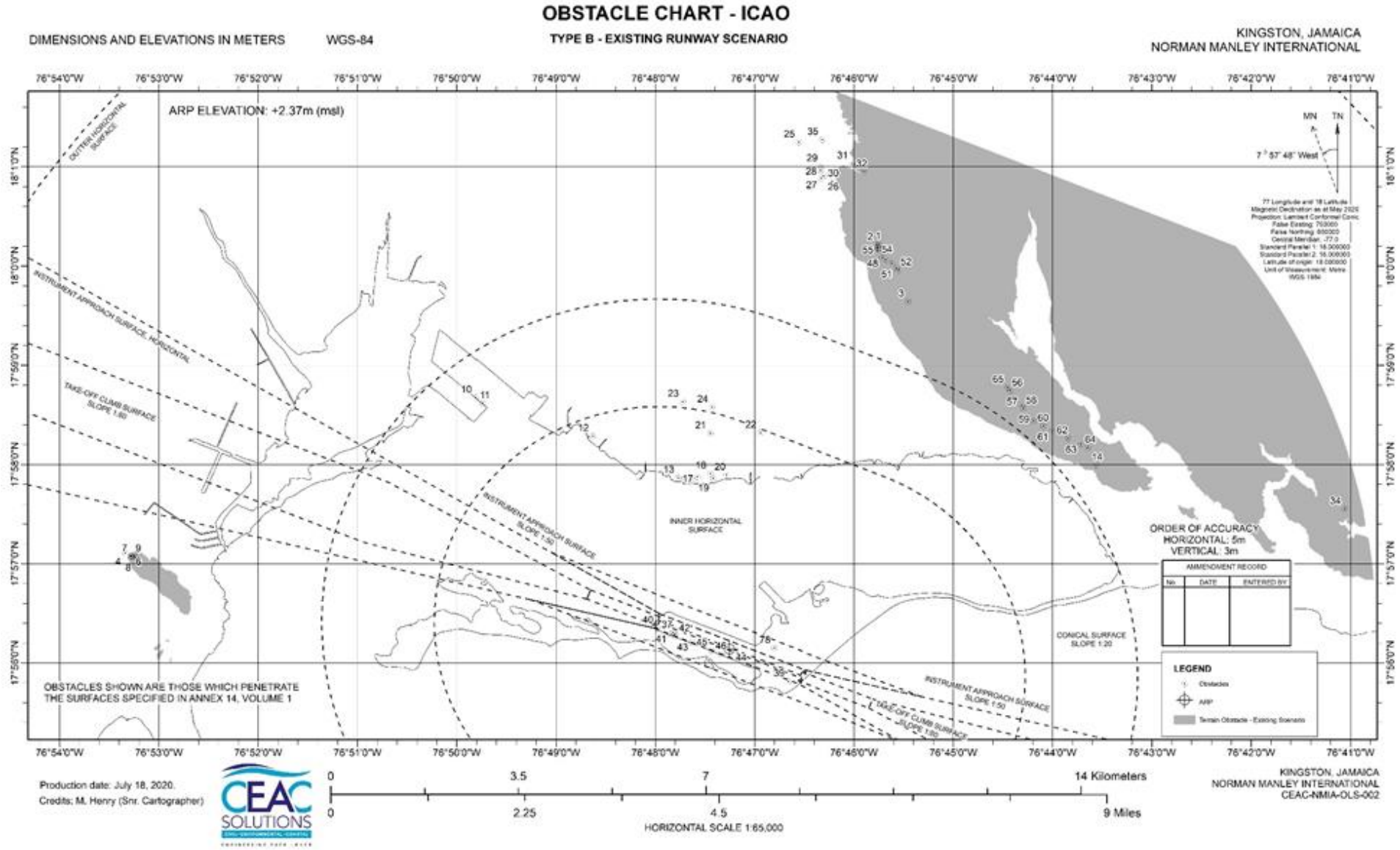
OLS OBSTACLE VERIFICATION

An obstacle charts were created which followed the ICAO Aeronautical Chart Manual and obstacle and terrain obstacles were presented in an eTOD format.

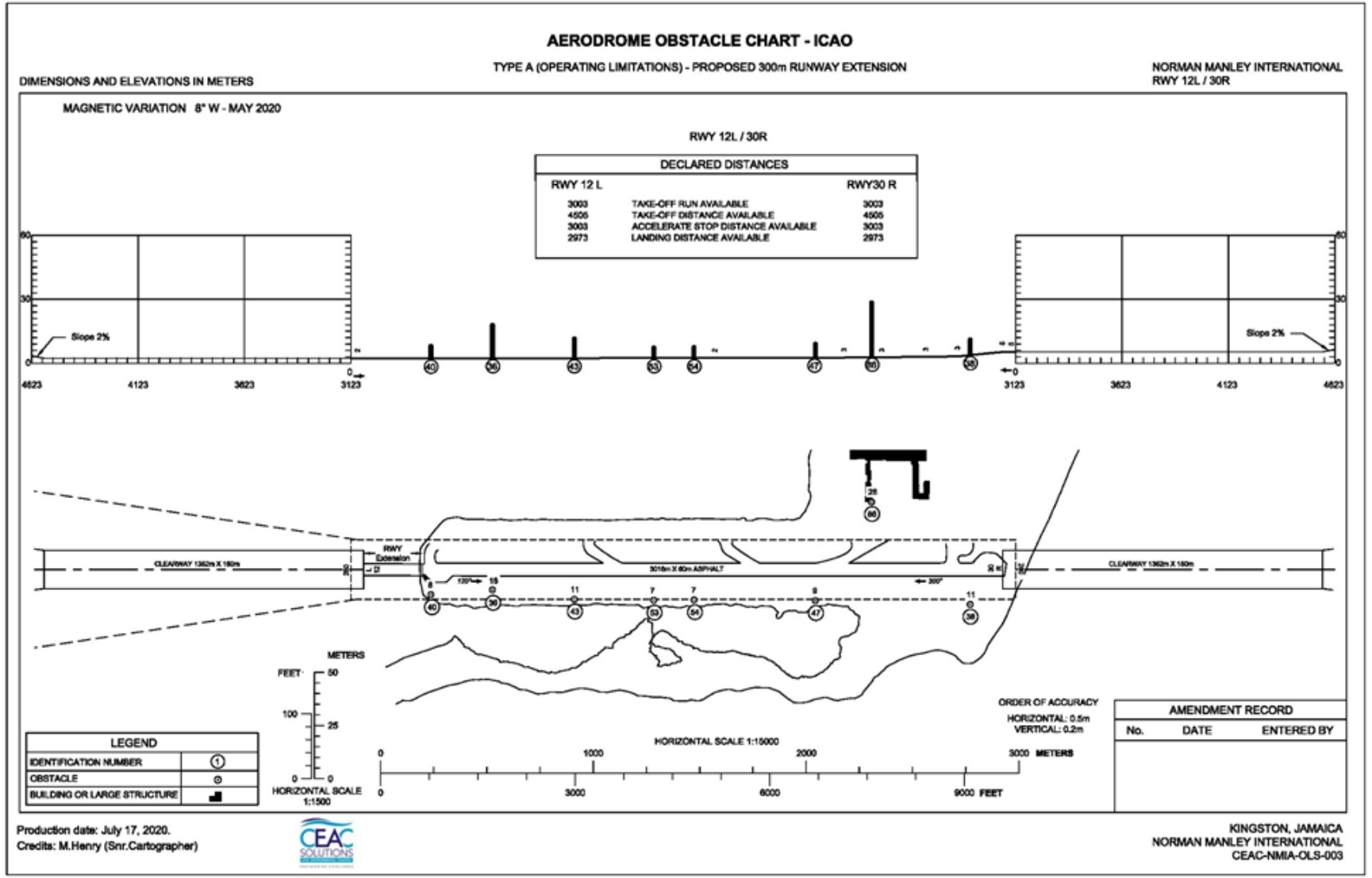


Obstacle Limitation Surface

OLS OBSTACLE VERIFICATION

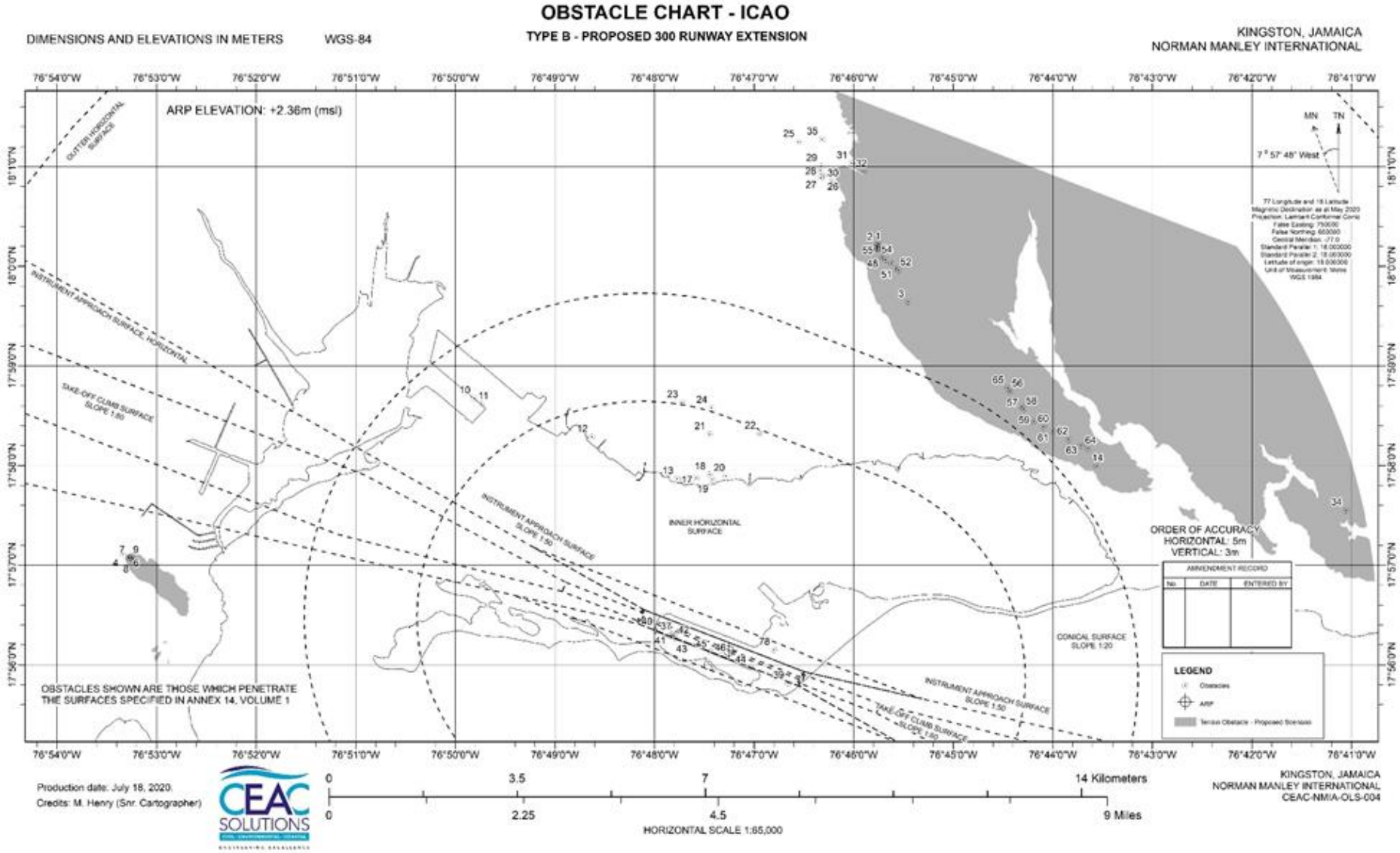


Obstacle Limitation Surface (OLS)



Obstacle Limitation Surface

OLS OBSTACLE VERIFICATION



Obstacle Limitation Surface

OLS OBSTACLE VERIFICATION

Verified obstacles in eTOD format.

ID	TYPE	LATITUDE	LONGITUDE	DESCRIPTION	ELEVATION	LENGTH	LIGHTED	GROUP	SEQUENCE
0	Water Tank	N 18 0 13.2	W 76 45 44.9	crest of tank. (dome shaped cover)	280.62	9.73	NO	NO	10
1	Water Tank	N 18 0 12.8	W 76 45 46	pipe on top of the tank.	278.42	7.249	NO	NO	10
2	Water Tank	N 17 59 38.5	W 76 45 27.2	Round Object on Tank Top	375.84	8.2	NO	NO	10
3	Antenna	N 17 57 6.6	W 76 53 20.4	(antenna) on top of tower.	176.23	45.8	NO	NO	10
4	Antenna	N 17 57 4.8	W 76 53 17	(iron rod) on top of tower.	196.18	38.716	YES	NO	10
5	Antenna	N 17 57 4.3	W 76 53 16.4	(beacon) on top of tower.	200.12	41.808	YES	NO	10
6	Antenna	N 17 57 4.4	W 76 53 16.6	(iron rod) on top of tower.	202.67	44.441	YES	NO	10
7	Antenna	N 17 57 3.8	W 76 53 14.2	(antenna) on top of tower.	203.35	32.125	NO	NO	10
8	Antenna	N 17 57 4.4	W 76 53 14.6	(satellite dish) on to of tower.	184.5	17.718	NO	NO	10
9	Crane	N 17 58 40.5	W 76 49 48.5	Highest Point on Crane	115.73	115.48	YES	NO	10
10	Crane	N 17 58 37	W 76 49 44.3	Highest Point on Crane	115.69	115.35	YES	NO	10
11	Smoke Stack	N 17 58 17.2	W 76 48 37.7	Top of smoke stack	48.67	45.89	NO	NO	10
12	Bldg	N 17 57 52	W 76 47 46.1	Antenna Pole on Top of Digicel bldg	59.49	56.04	NO	NO	10

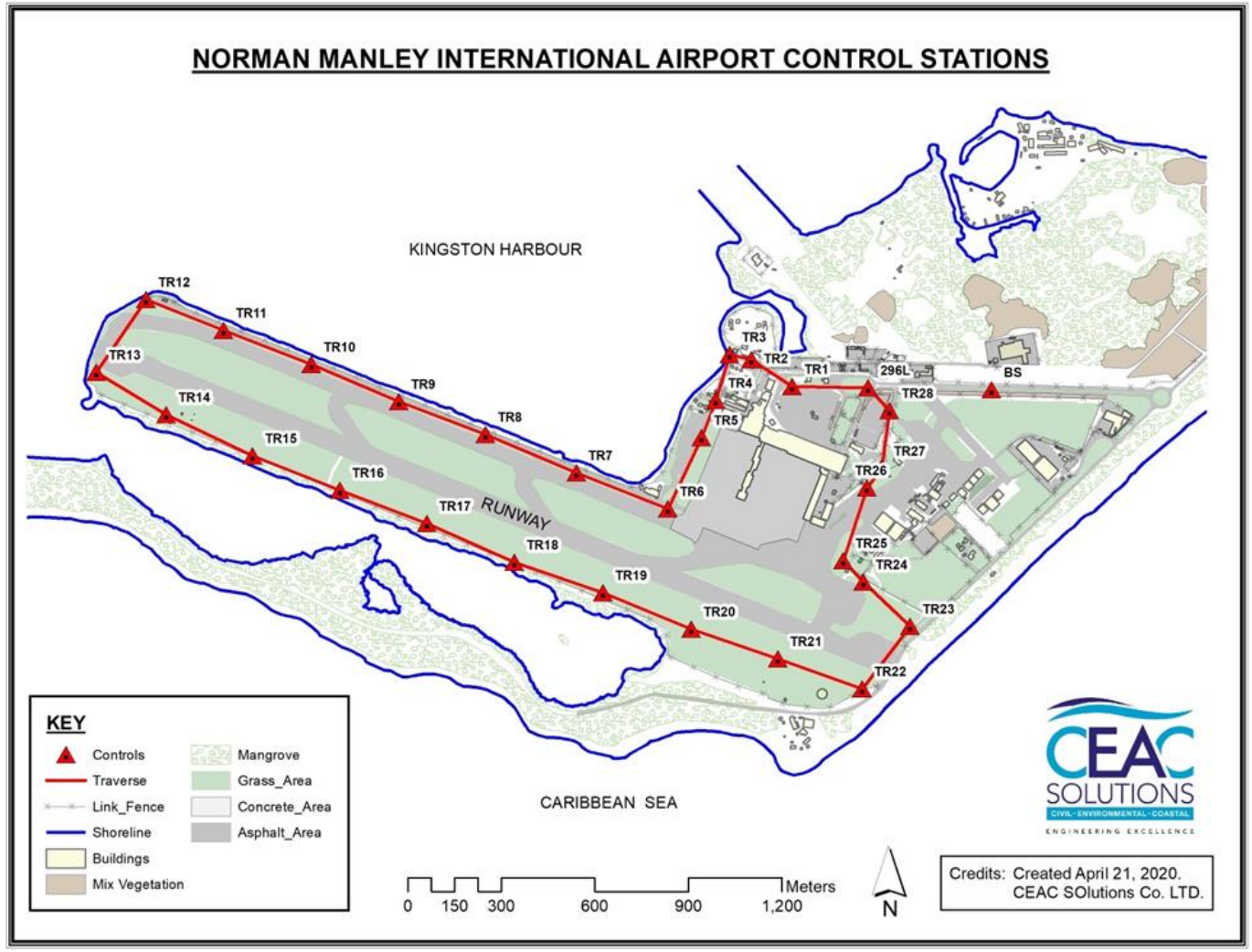
OLS OBSTACLE VERIFICATION

OLS OBSTACLE VERIFICATION:

The data for the assets and navigational aids were collected using Global Navigation Satellite System (GNSS) Real-time Kinematic (RTK)

OLS OBSTACLE VERIFICATION

Established Traverse Controls (NMIA)



OLS OBSTACLE VERIFICATION

- The assets were grouped in two main groups namely:
  - Landside features and airside features.
- An onboard GIS data collection features of the GNSS data collector, features were mapped and attributes associated with each feature were recorded in point format.
- The Navigational aids comprises mainly of lighting features on and around the runway.

Summary

- The verification of these obstacles was done over a week and a half period where eighty-two (82) objects out of ninety-three (93) identified obstacles were observed
- Eleven of the identified obstacles could not be observed due to access issues. These eleven (11) obstacles were electrical poles located on the Long Mountain hill. These obstacles were presented in the ICAO Chart Type A & B and in an eTod format as well (comma separated value file), see Table 4.2 .

Conclusions

1. The major terrain obstacles identified based on the OLS model for the existing runway scenario shows the possible terrain obstacles (natural & man-made features) mostly in the Blue Mountain, Mona, Liguanea, Long Mountain and Portmore hills.

2. Obstacles were also found in the Downtown Kingston, Kingston Wharves and NMIA property. These obstacles were mostly buildings and in the case of the NMIA property was the property fence along the southern edge of the runway.

3. Declination shows the variation between True North and Magnetic North and changes over time at different rates depending on location and magnetic pull. Based on the observed compass readings and the geographic coordinates of the runway ends, the calculated declination for the runway alignment (30-12) is 7$_{o}$ 57’ 48” West.

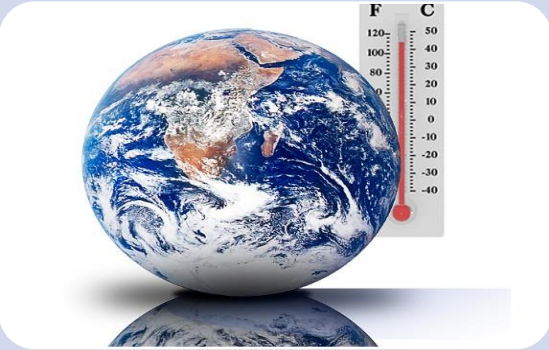
4. **It would be recommended that this survey be conducted on a yearly basis.**

Limitations / Difficulties Encountered

1. The verification of these obstacles was done over a week and a half period where eighty-two (82) objects out of ninety-three (93) identified obstacles were observed
2. Eleven of the identified obstacles could not be observed due to access issues. These eleven (11) obstacles were electrical poles located on the Long Mountain hill. These obstacles were presented in the ICAO Chart Type A & B and in an eTod format as well (comma separated value file), see Table 4.2 .

CLIMATE CHANGE ADAPTATION

Aims and Objectives



Evaluate susceptibility to climate variability and change.

Execute cost analysis of adaptation options

Formulate six (6) feasible projects to strengthen resilience

Impact of Hurricanes

Event Year	Impacts
Hurricane Ivan (2004)	Approximately 310 meters of the shoreline being heavily impacted and overtopped
Dean (2007)	Approximately 2.65km of the shoreline in a critical state
Hurricane Sandy (2012)	Two day shut down of the airport

Vulnerability and Risk Assessment

STEP 1: Hazard

- ***Hazard Assessment***
- ***Review Catalog of Hazard Occurrences Probability of occurrence Spatial location***

STEP 2: Exposure

- ***Asset Inventory***
- ***Identification of elements at risk – Roads, bldgs.***
- ***Data Collection***
  1. ***Road condition survey***
  2. ***GPS location of buildings***
  3. ***Revetment Condition***
  4. ***Drainage Condition survey***

STEP 3: Vulnerability

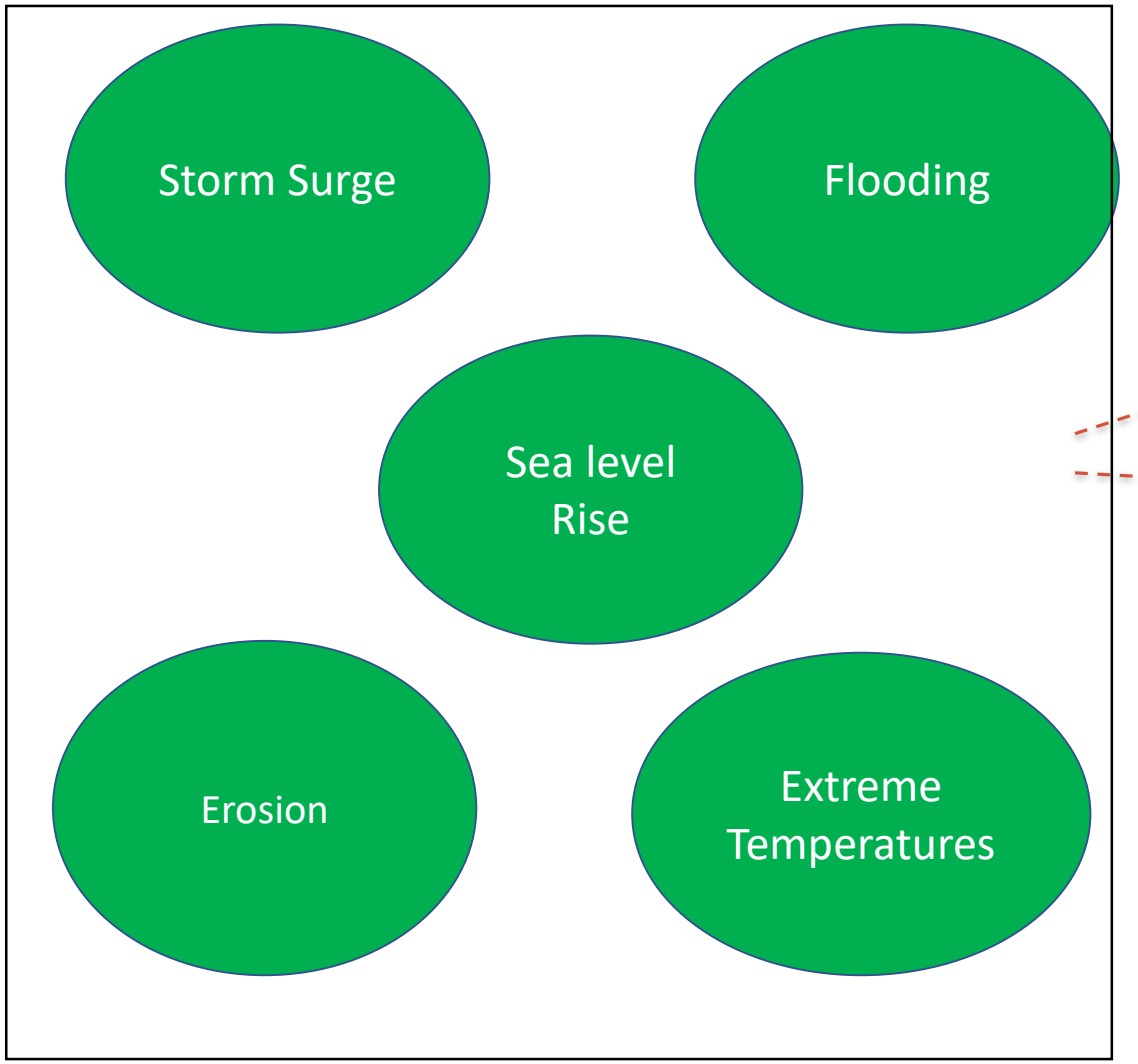
- ***Vulnerability***
- ***Generation of risk curves***

STEP 4: Risk

- ***Damage & Lost***
- ***Estimate damage and Loss Monetary***

Risk = Hazard * Exposure * Vulnerability

Priority Hazards Studied in Assessment



Approach

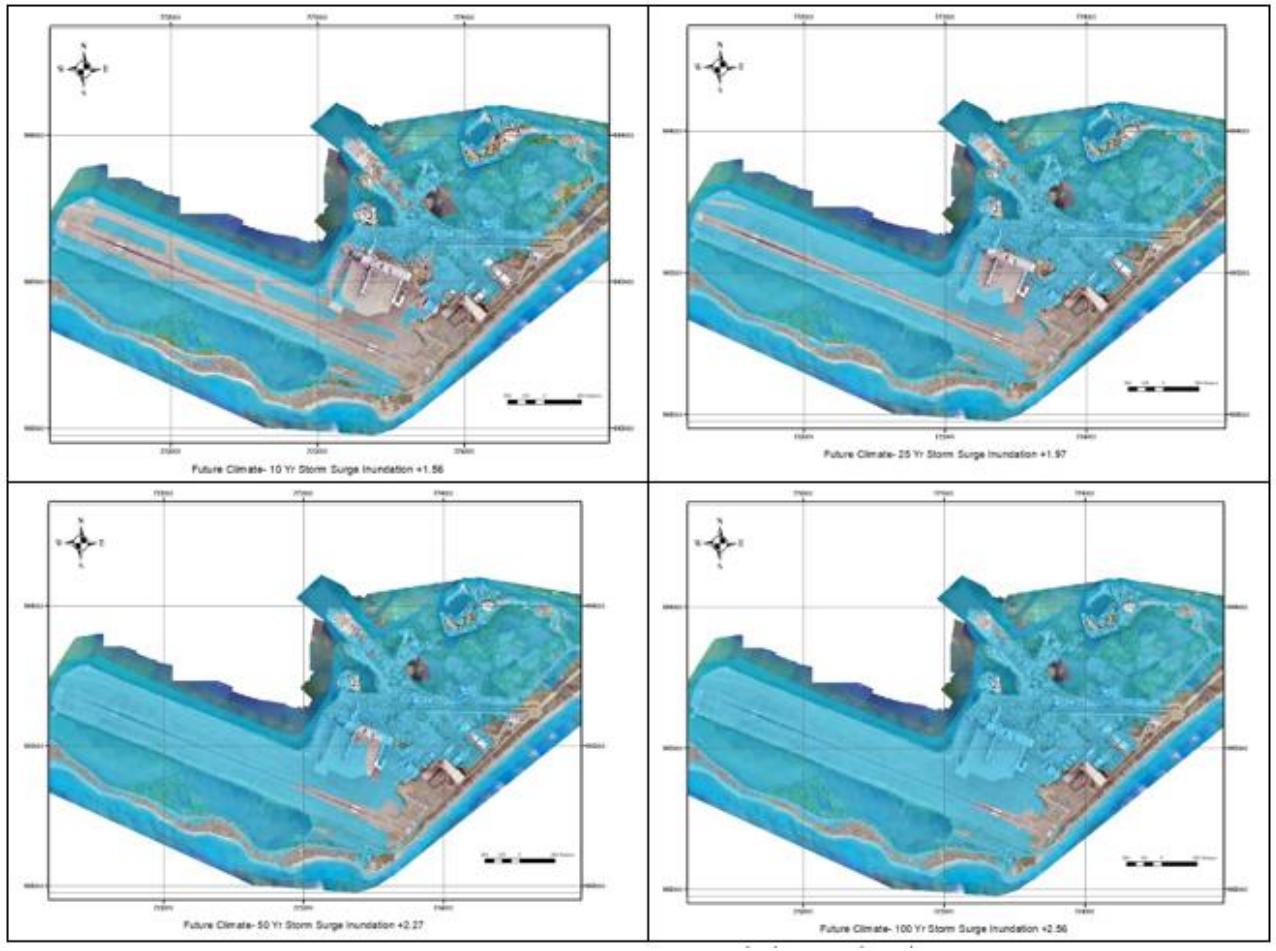
Storm Surge (m) (Future Climate RCP 8.5)

CEAC Storm Surge Model JONSWAP Wind-Wave Model

Return Period (Years)	RCP 2.6	RCP 6	RCP 8.5
10	1.32	1.34	1.41
25	2.14	2.22	2.22
50	2.80	2.93	2.94
100	3.51	3.73	3.79

Palisadoes flooded

Terminal building flooded



Modeling Approach

1. Rainfall Assessment (Future Climate)

i. Meteorological related data:
- Daily Rainfall data;
- Climate change predictions;

2. Water Surface Modeling- (Hydraulic Model)

Channel geometry developed from:
- Digital Elevation Model
- field measurements

Characteristics of catchments:
- Land Use/ Land cover;

iii. Topography

The HECRAS hydrological modelling system was utilized in simulating the peak flows

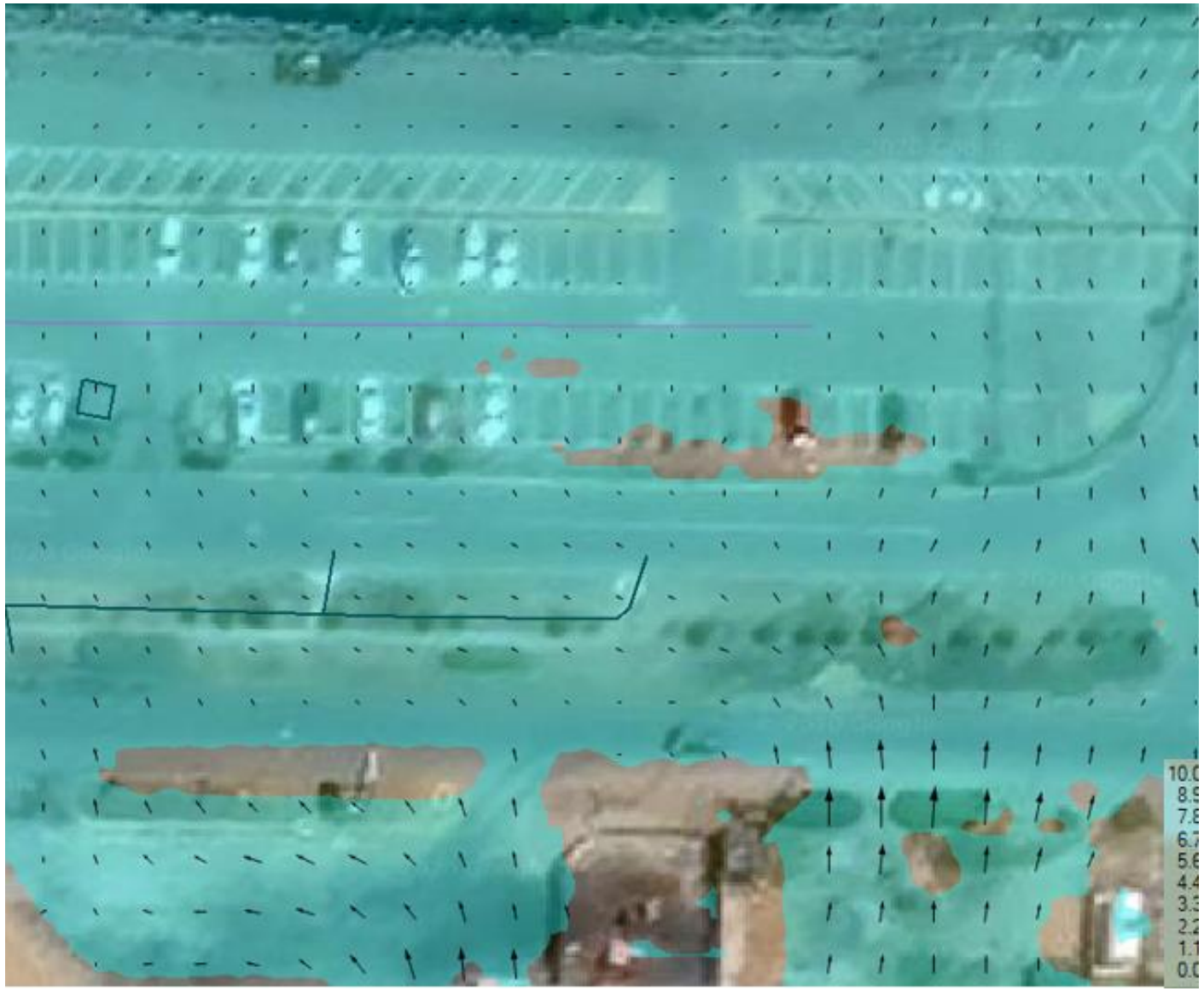
3. Flood Extent Mapping

Water surface elevations exported to ArcGIS and flood extent mapped using elevation grids and model cross-section locations

Flood Risk Analysis

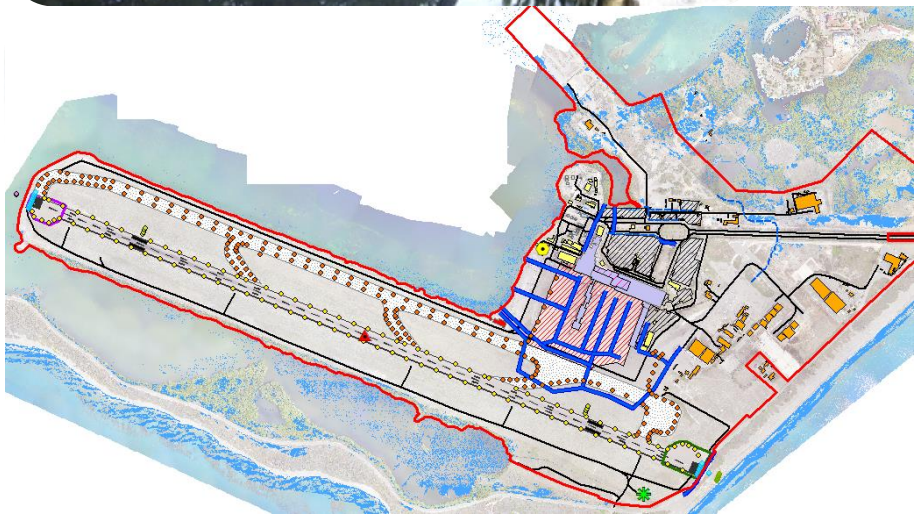
Results

- The results of the flood plain analysis reveal that short term intense rainfall creates widespread inundation but with relatively low flood depths
- Most Vulnerable areas are:
  - Queen's warehouse,
  - car park 14
  - East airfield



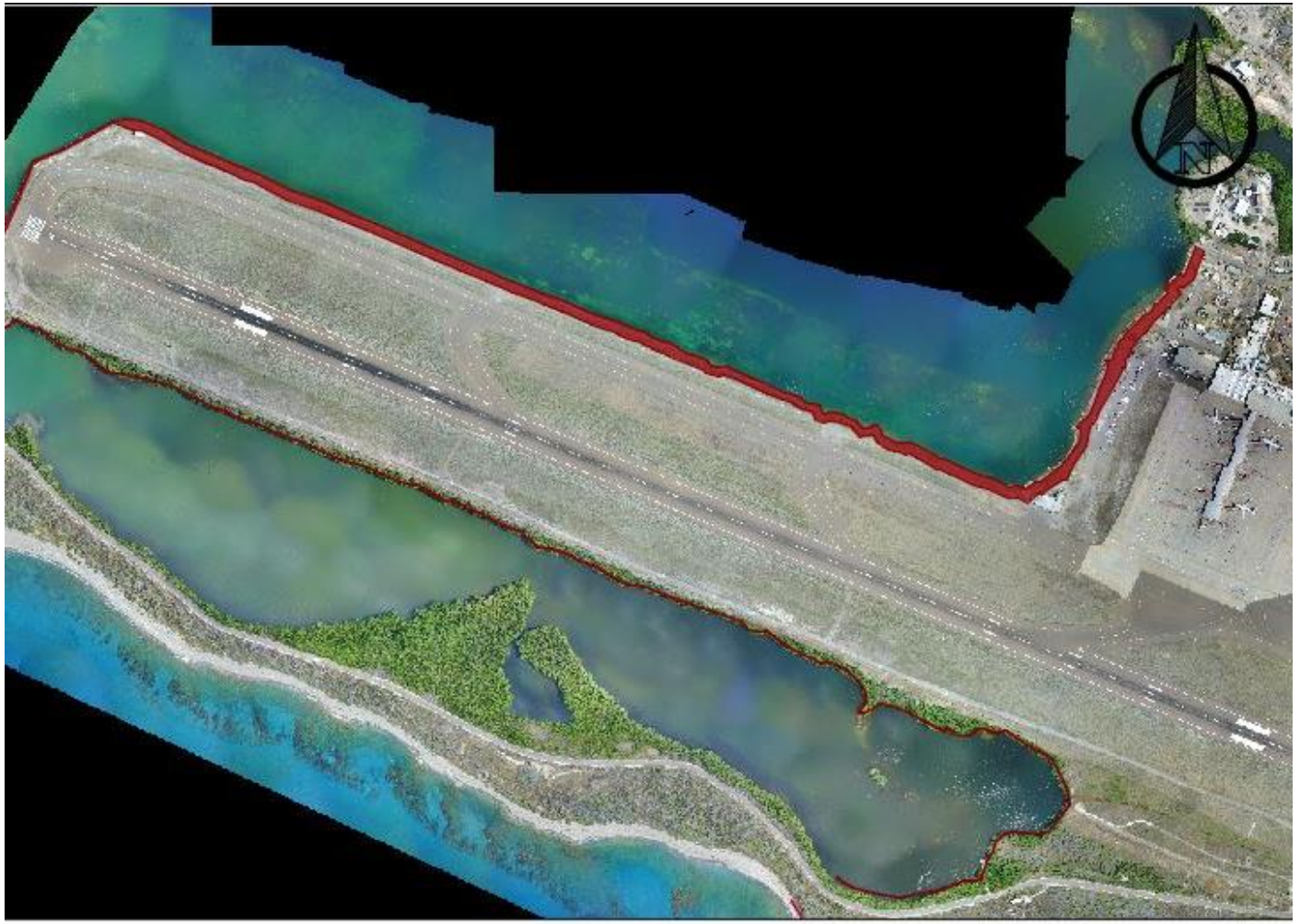
Sea-level Rise

Sea Level Rise (m) South Coast (-77.157W, 17.142N)					
Centered	2025	2055		End of Century	
Averaged	2020-2029	2050-2059		2080-2100	
	Mean	Mean	Range	Mean	Range
RCP2.6	0.14	0.34	0.31 – 0.37	0.60	0.53 – 0.67
RCP4.5	0.14	0.36	0.32 – 0.40	0.68	0.59 – 0.78
RCP6.0	0.14	0.35	0.31 – 0.39	0.69	0.58 – 0.80
RCP8.5	0.15	0.40	0.35 – 0.45	0.90	0.74 – 1.08



Long-term Erosion

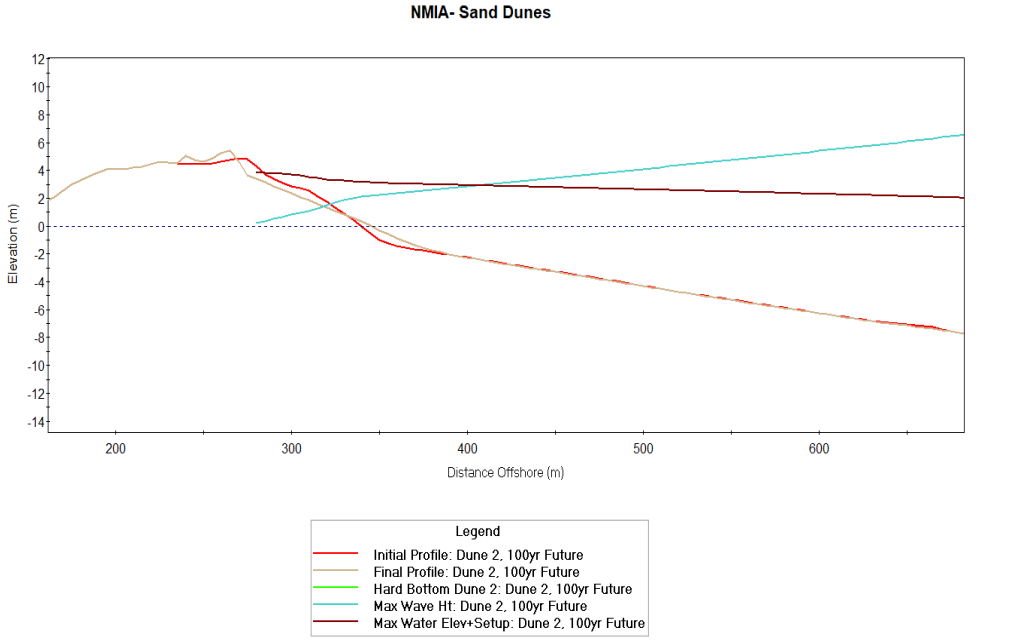
It is estimated that sea level rise accounts for approximately 1.2- 28.7 m of erosion along the Harbour side.



Short-term Erosion

Short-term Erosion (Harbour-side)

Location	100-yr RP	
	Depth on Land (m)	Extent on Land (m)
Fire Station	1.2	15
Fire Station -600m	1.5	19
600m - Runway 12	0.7	16
Control Tower	0	6
West Substation	1.4	3

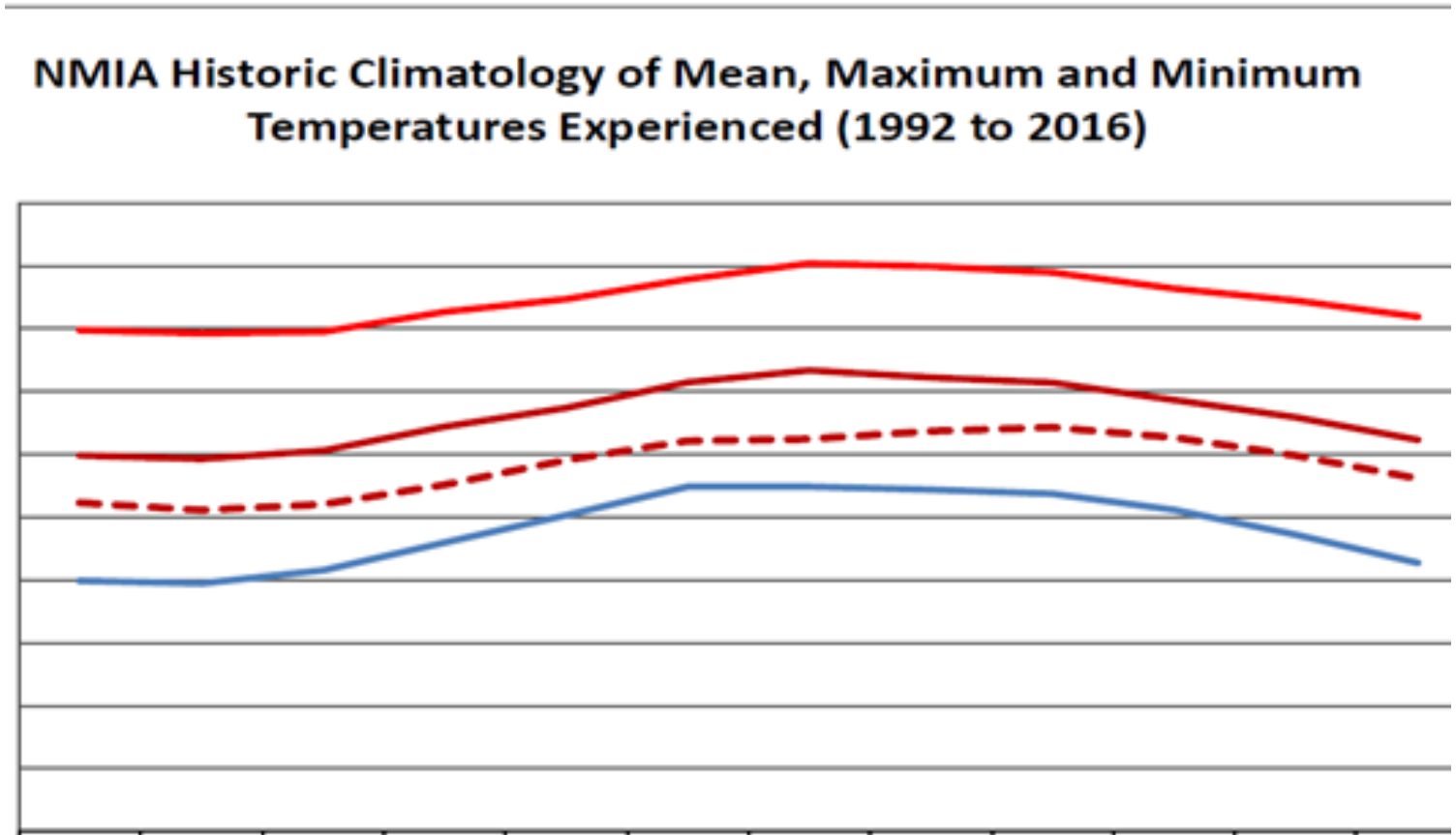


Short-term Erosion (Caribbean-side)

Alignment	Crest Elevation (m)	Maximum Extent of Erosion	
		100-yr Future	
		Vertical (m)	Horizontal (m)
Dune 1	6.7	0.8	9
Dune 2	4.9	1.1	10
Dune 3	5.8	1.3	13
Dune 4	6.5	1.1	8

Mean Air Temperature Climatology

- The mean observed air temperature climatology, for the period of 1992 to 2016; was collected.
- Over the next 25 years temperatures are expected to increase by 1.3˚ C (RCP 8.5)



Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
22.968	22.892	23.308	24.188	25.06	25.976	25.968	25.876	25.74	25.232	24.448	23.54
30.956	30.8564	30.904	31.54	31.95	32.584	33.076	32.98	32.792	32.284	31.892	31.38
26.9593	26.8611	27.1185	27.8852	28.4808	29.2981	29.6778	29.4444	29.2833	28.737	28.1778	27.464
25.4624	25.2157	25.4054	26.0345	26.8234	27.4325	27.4893	27.7381	27.8609	27.5333	26.9618	26.232

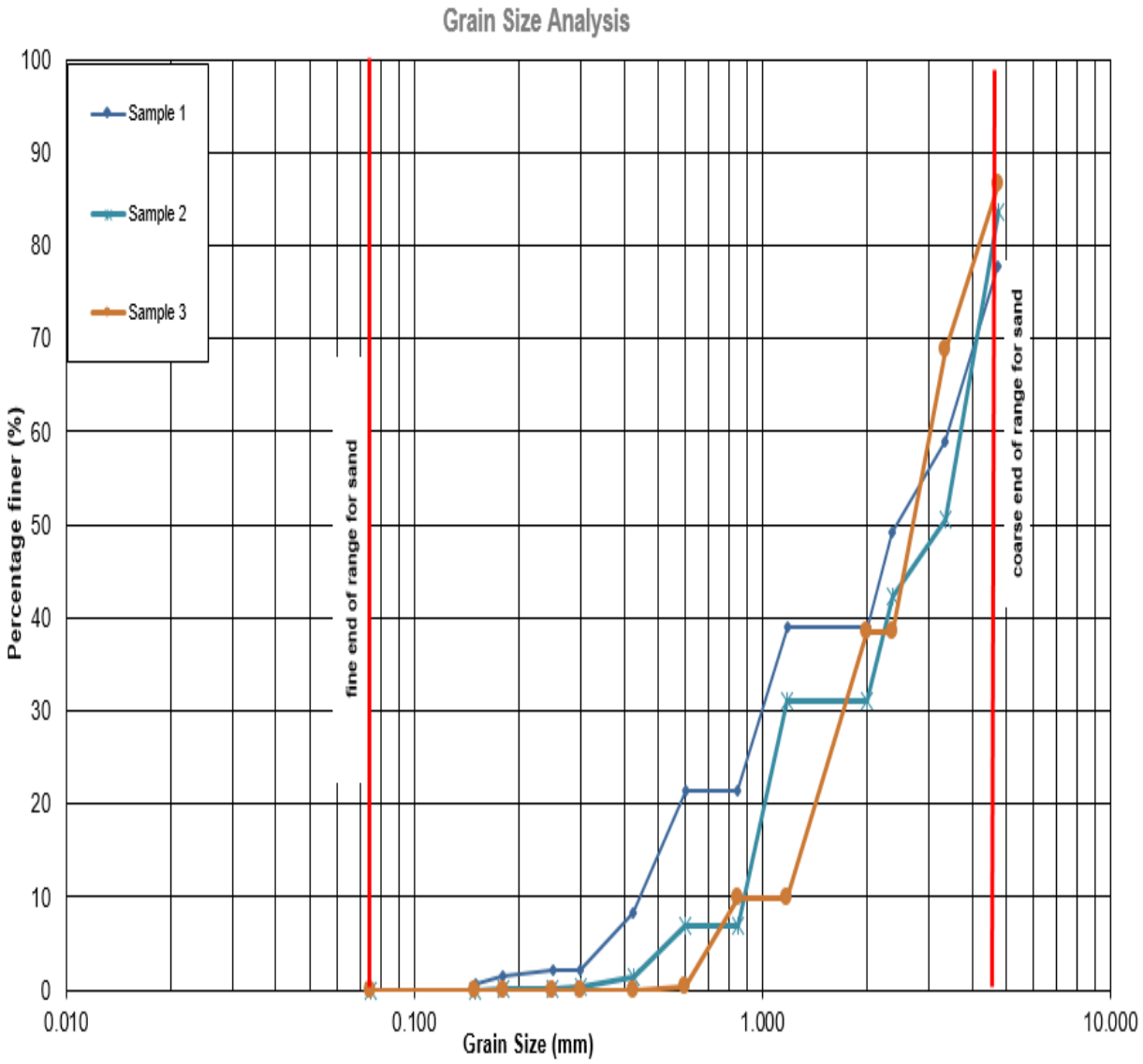
DATA COLLECTION

Sediments and Grain size Analysis

Three (3) sand samples were collected along the shoreline on April 1, 2020.

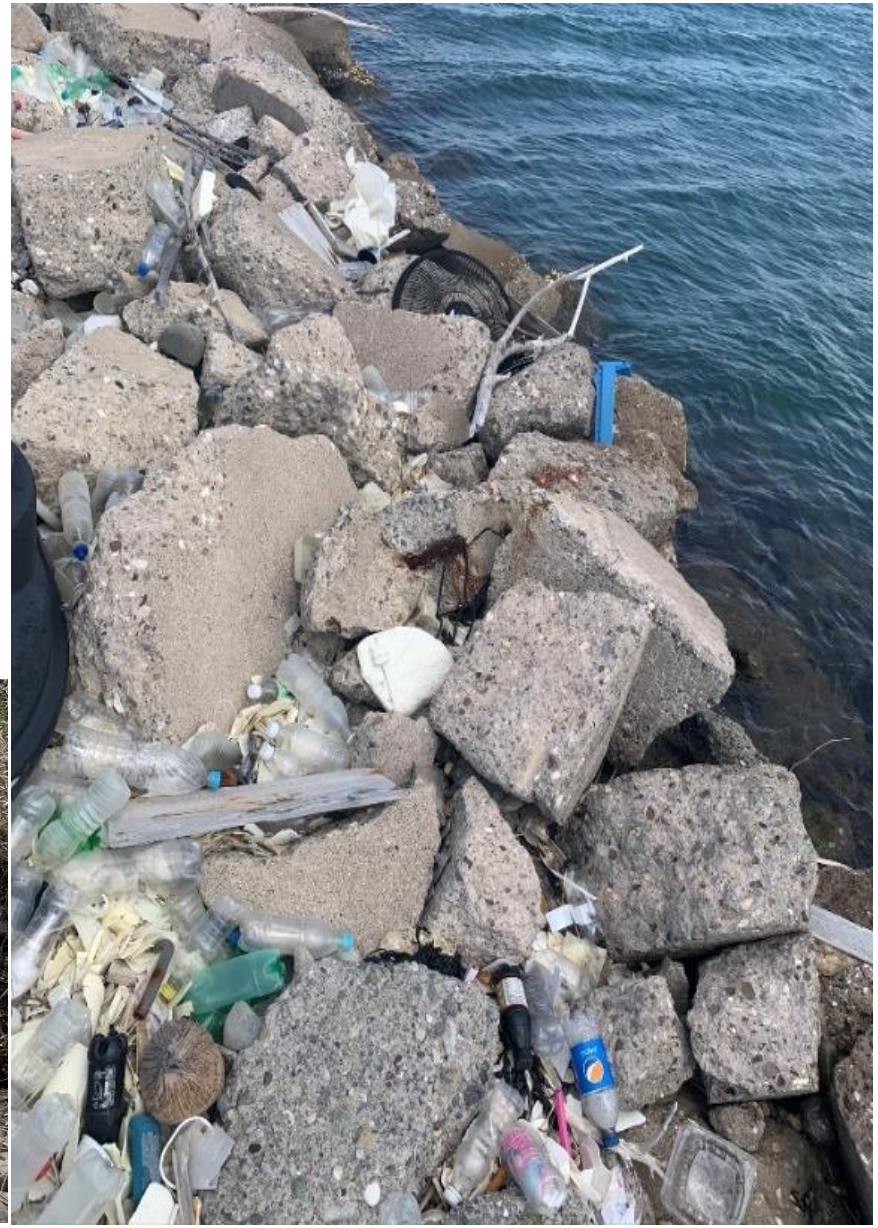
Grain size Analysis

Location on beach cross section	Location 1	Location 2	Location 3
Mean Grainsize (mm)	3.472	4.662	2.736
Mean (phi)	-1.796	-2.221	-1.452
Description	gravel	gravel	gravel



Revetment and Mangroves Condition Assessment

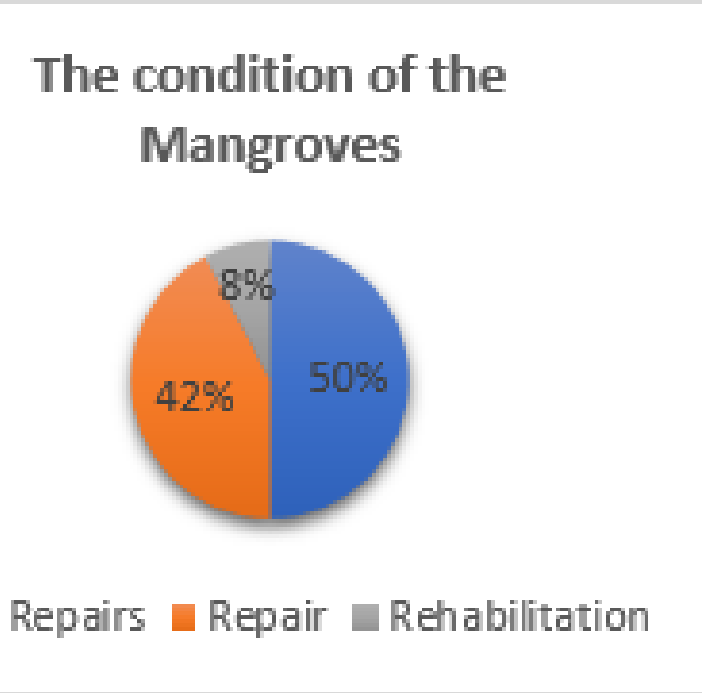
- On the 16th of June, a Condition Assessment of the revetment and mangroves was undertaken
- The standard damage ratings from descriptions in CIRIA (2007) was used to evaluate the vulnerability and need for rehabilitation or repair.

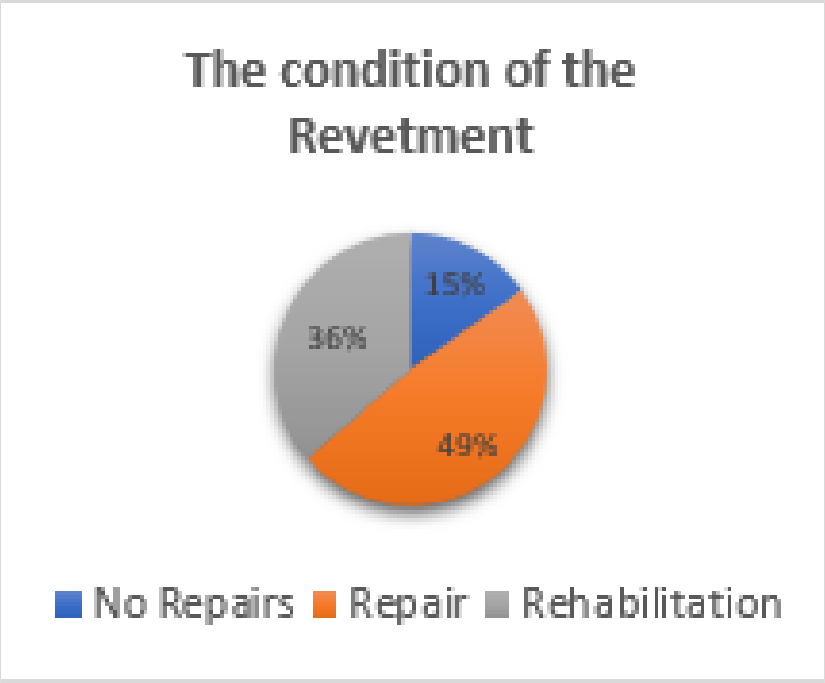


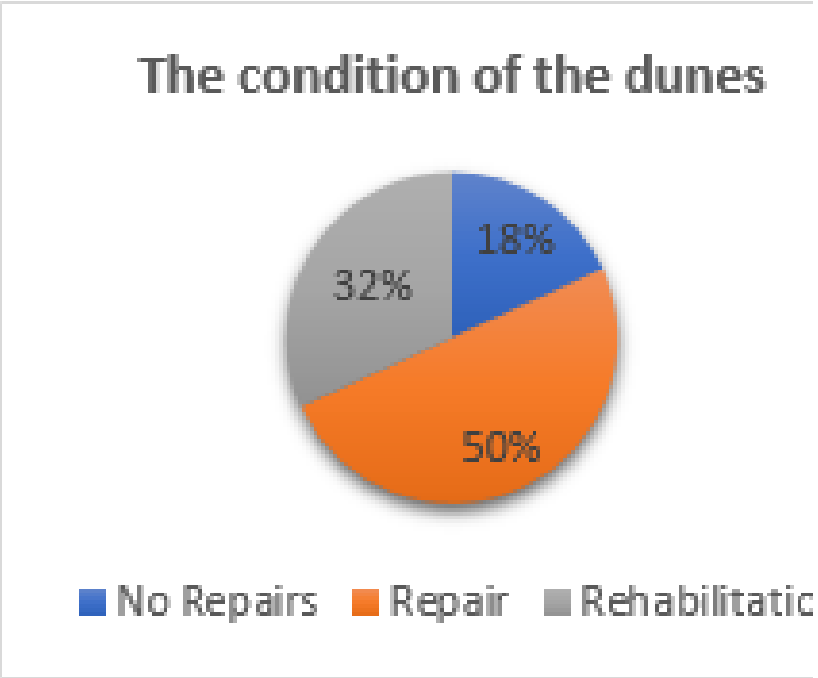
Risk Assessment

The risk assessment was broken down into three components:

$$\textbf{Risk} = \textbf{Condition } score_i \times \textbf{ Hazard } score_i \times \textbf{Exposure } score_i$$







Condition Assessment

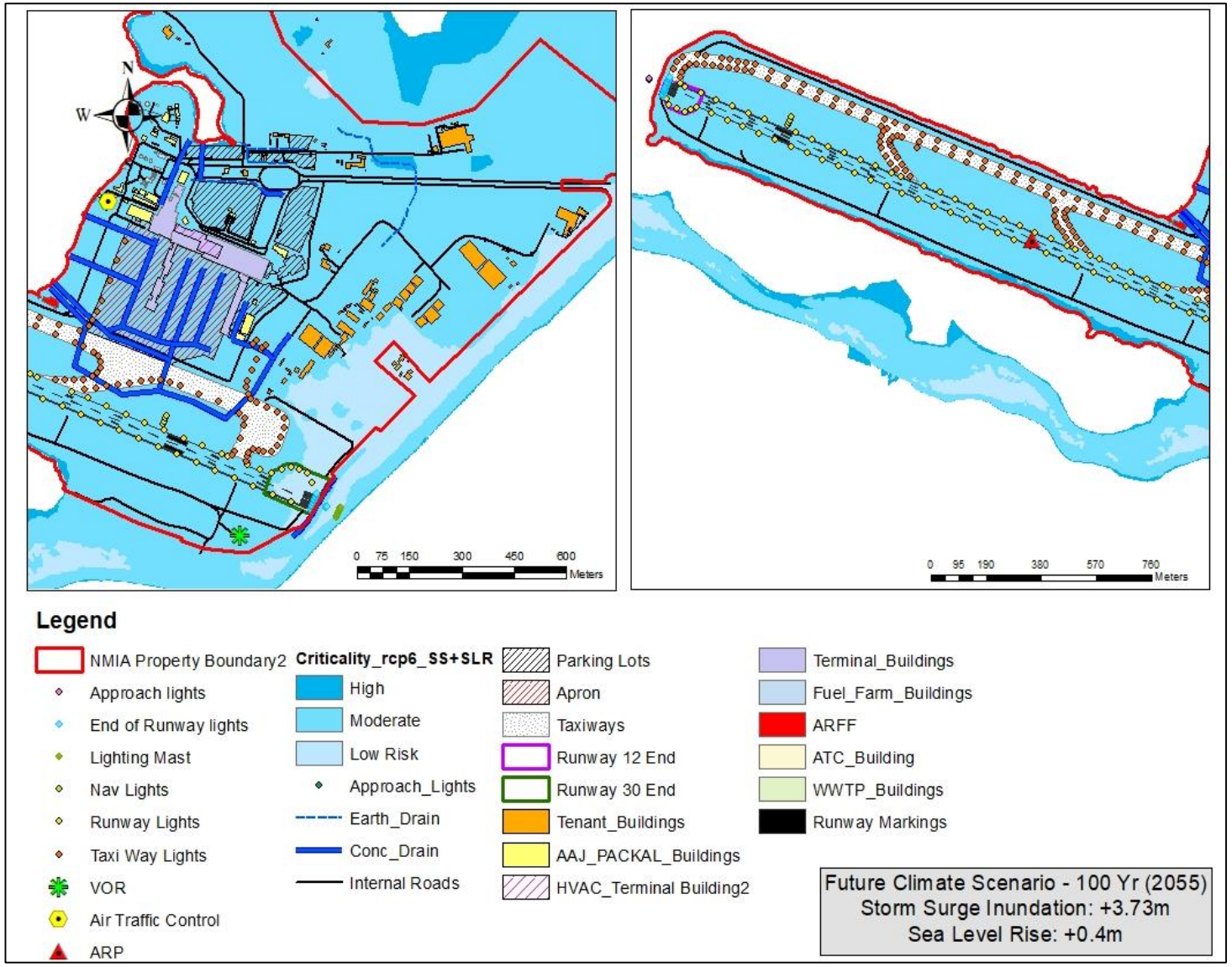
The standard damage ratings from descriptions in CIRIA (2007) was used to evaluate the vulnerability and need for rehabilitation or repair. Ciria, Cur. "CETMEF (2007)

	Revetment	Mangroves	Dunes
No repairs	Slight movement Depressions < ¼ diameter of armour stone Bridging <1/2 diameter	>10 meters width from shoreline to water line	Vegetation width >40 meters and no blow outs
Repairs	Some voids with underlayer visible in some sections	Gaps or breaks in canopy that extend from shoreline to water line >5 meters	Blow outs that extend from dune face part way to back of dune
Rehabilitation	Armour fully displaces Loss of under layer is evident.	Width < 10 meters and breaks in canopy > 5 meters	Vegetation width < 40 meters Blow outs that extend from dune face to back of dune

VULNERABILITY ASESSMENT

Vulnerability Assessment

The location of the Norman Manley International Airport defines vulnerability posed by storm surge to be high, particularly with considerations for sea level rise.



Vulnerability Assessment Matrix

- Vulnerability matrix (Lopez, 2016) was used evaluate effects of climate change.
- The application of this matrix depicted the criticality of assets
- All critical service are vulnerable:
  - Taxiway
  - Terminal/support buildings
  - Carparks
  - Electrical-mechanical assets
  - Dunes

Hazard

Assets

		Sea Level Rise (SLR)		Extreme Events			Temperature	Precipitation	Bio-div
Airport Components	**Exposure metric**	**Sea Level**	**shoreline erosion (EBP)**	**Storm surge**	**Erosion**	**Flooding**	**Surface temperature**	**Rainfall**	**Desertification**
Infrastructure									
Roads and parking									
Internal road network (airside and landside)	length	2	1	4	1	4	2	1	1
Parking lots	area	2	1	4	1	4	2	1	1
Drainage system	length	4	1	2	1	2	2	2	1
Access to airport									
Palisadoes	length	2	2	6	2	2	2	1	1
Runway, taxiways and aprons									
Runway (including southern edge)	area	2	4	6	4	4	4	1	2
Taxiway (including northern edge)	area	2	2	6	2	4	4	1	2
Apron	area	2	1	6	1	4	2	1	1
R12 end	length and area	2	4	4	4	6	4	1	2
R30 end	length and area	4	4	6	4	6	4	1	2
Buildings									
Terminals	number and ground floor area	2	1	6	1	6	2	1	1
Offices-AAJ/PACKAL	number and ground floor area	2	1	6	1	6	2	1	1
Offices-Tenants	number and ground floor area	2	2	4	2	4	2	1	1
Operations									
ARFF, Fuel farm	number of tanks and buildings	2	4	6	4	6	6	1	1
Lighting and navigation aids		2	2	2	2	2	2	1	1
Approach lights	number	4	6	6	6	6	2	1	1
NAVAIDS	number	2	2	6	2	6	2	1	1
ATC Tower	number	2	2	2	2	2	2	1	1
HVAC - Terminal building	number of units	2	2	2	2	2	4	1	1
Water and waste water system		2	2	2	2	2	2	1	1
Water storage	number	2	2	2	2	2	4	2	1
WWTP	number	2	2	2	2	2	2	1	1

Low (3)	Medium (6)	High (9)	High (12)

CLIMATE CHANGE ADAPTATION OPTIONS

Climate Change Adaptation Options

Eleven (11) adaptation measures were derived from the vulnerability assessment conducted prior.

Cleaning of public car park and all drain that exists

Revetment Rehabilitation

Pavement Rehab – Taxiway and Apron

To address road pavement (roundabout/gas station) performance raise

Raising car park 14

Solar shading to departure glazing

Climate Change Adaptation Options cont.

Eleven Adaptation measures were derived from the vulnerability assessment done in D3.

Raising of Transformer

RSS Feed

Rehab and enhancement of dunes

Energy Centre

Palisadoes Dunes

ADAPTATION ASSESSMENT CRITERIA

Adaptation Assessment Criteria

The BASE Evaluation Criteria for Climate Adaptation (BECCA) criteria was be utilized to develop adaptation assessment criteria that reflects the needs of the adaption option.

Criteria	Indicators
Cost comparison	highest cost = 5
Design life	short design life = 5
Level of exposure	valuable assets exposed = 1
Severity of risk	long timeframe = 5
Level of resilience	longer design life = 1
Environmental Side Effects	higher environmental impacts = 5
Social Side Effects	higher social impacts = 5
Efficiency	high efficiency=1

ADAPTATION ASSESSMENT METHODLOGY

Adaptation Assessment Methodology

- The Multi-criteria analysis (MCA) was adopted in this study to carry out the Adaptation Assessment.
- Brooks et al. (2009) defines MCA as “any structured approach used to determine overall preferences among alternative options, where the options accomplish several objectives”.

ADAPTATION ASSESSMENT MATRIX

Results of Adaptation Assessment Methodology

Options	Cost Estimate (USD Million)	Comparison	Design life	Exposure	Severity	Potential restraints	Level of resilience	Environmental Side Effects	Social Side Effects	Efficiency	Final Score (Rank)	Rank
Upgrading and cleaning drains	$0.3	1	2	1	3	1	1	2	1	2	1.56	1
Harbour revetment rehabilitation + Mangrove replanting	$7.4	4	1	2	2	2	2	4	1	5	2.56	5
Airside pavement rehabilitation (taxiway, apron* and runway)	$11.1	5	2	1	1	5	1	1	1	5	2.44	3
Landside road pavement	$0.5	1	2	3	4	4	2	1	3	4	2.67	8
Raising car park 14	$0.1	1	2	3	4	1	1	1	1	2	1.78	2
Solar shading to departure glazing	$0.5	1	2	4	5	3	2	1	1	3	2.44	3
Rehab and enhancement of dunes	$3.0	3	2	1	3	3	3	2	2	4	2.56	5
RSS Feed	$0.03	1	5	4	4	2	3	2	1	1	2.56	5
Bunded Energy Center	$0.1	1	5	3	3	2	3	3	1	2	2.56	7
Elevating transformers, generators and control panels	$0.42	2	1	2	3	2	2	2	1	2	1.89	4
Elevating air fuel pumps	$0.03	1	1	2	3	2	2	2	1	2	1.78	2

Cost Analysis

For each option the Net Present Value, Cost and Benefit Analysis and the Internal Rate of Return (IRR) was calculated.

NPV

Net Present Value

Value of all future cash flows discounted to the present.

BCR

Benefit-Cost Ratio

ratio between the discounted incremental benefits and the discounted incremental costs

IRR

Internal Rate of Return

average earning power of the money used in the project

Cost and Benefit Analysis Output

	Proposed Adaptation Options	Cost (USD Millions)	Annualized Do Nothing (USD Million)	IRR (%)	BCI
Infrastructure modification	Upgrading and cleaning drains	$0.57	$0.65	32%	4.73
Structural	Harbour revetment rehabilitation+ Mangrove replanting	$3.98	$0.22	7%	1.34
	Airside pavement rehabilitation (taxiway, apron* and runway)	$1.72	$3.10	6.4%	1.20
	Landside road pavement	$2.27	$2.32	22%	1.91
	Raising car park 14	$0.42	$0.29	65%	3.11
Design modifications	Solar shading to departure glazing	$0.77	$0.41	53%	5.75
Enhancement of vegetation, wetlands and natural barriers	Rehab and enhancement of dunes	$4.46	$9.68	2%	1.63
Technological	RSS Feed	$0.02	-		
	Bunded Energy Center	$0.37	$0.37	13%	2.30
	Elevating transformers, generators and control panels	$1.40	$0.48	34%	6.90
	Palisadoes Dune rehabilitation	$4.22	$2.33	55%	6.86

Ranking of options based on evaluation criteria

The results generated by the Multi-Criteria Analysis (MCA) deduced the following:

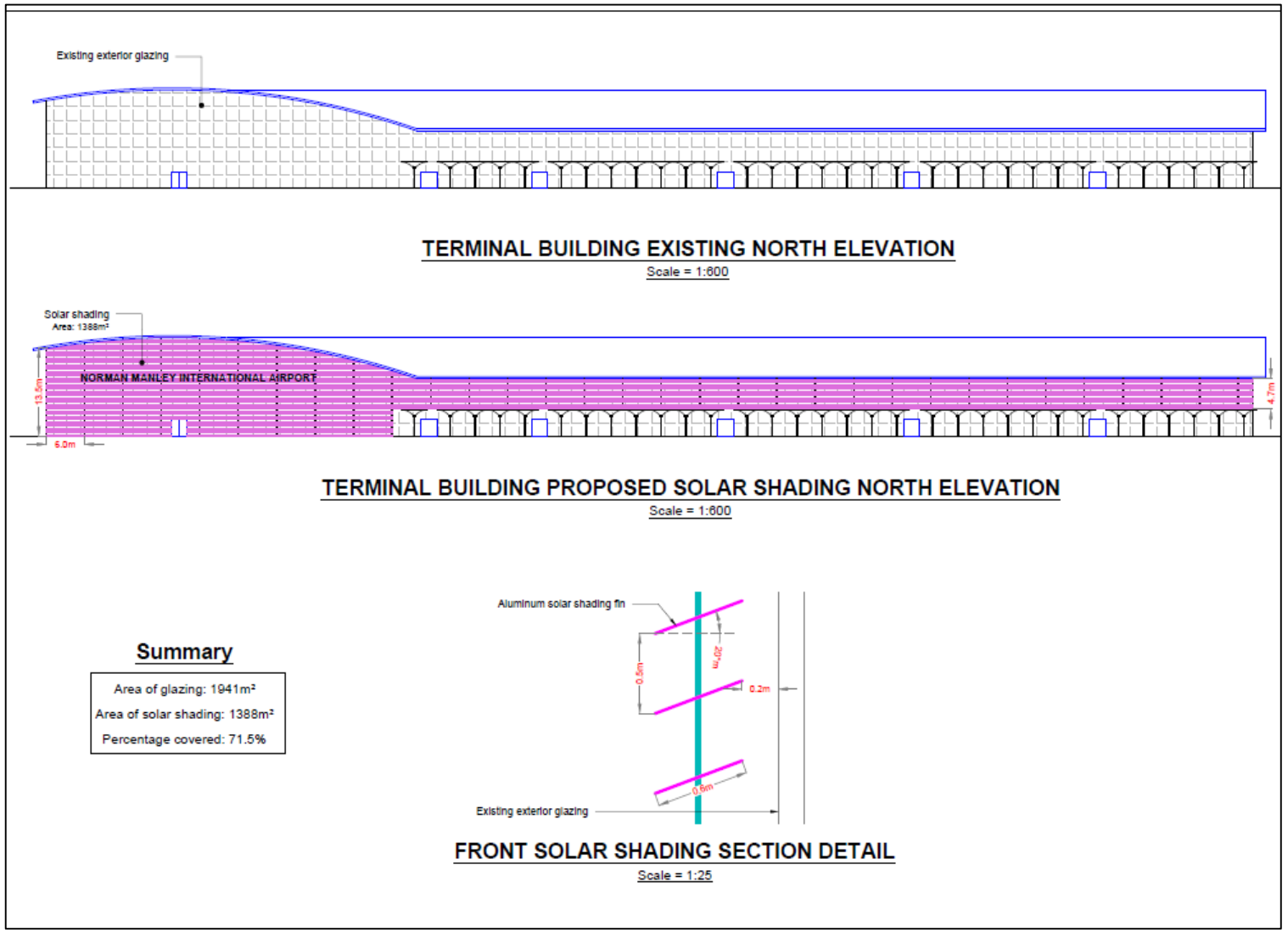
Proposed Adaptation Options	Rank
Elevating transformers, generators and control panels	1
Solar shading to departure glazing	2
Raising car park 14	3
Bunded Energy Center	4
Palisadoes Dune rehabilitation	5
Upgrading and cleaning drains	6
Climate Change Website	7
Rehab and enhancement of dunes	8
Landside road pavement	9
Harbour revetment rehabilitation+ Mangrove replanting	10
Airside pavement rehabilitation (taxiway, apron* and runway)	11

RECOMMENDATIONS

Solar Shading

It is recommended that the use of fixed external louvre shaders on its large north and south facing windows is placed on the Terminal Building to reduce the energy consumption.

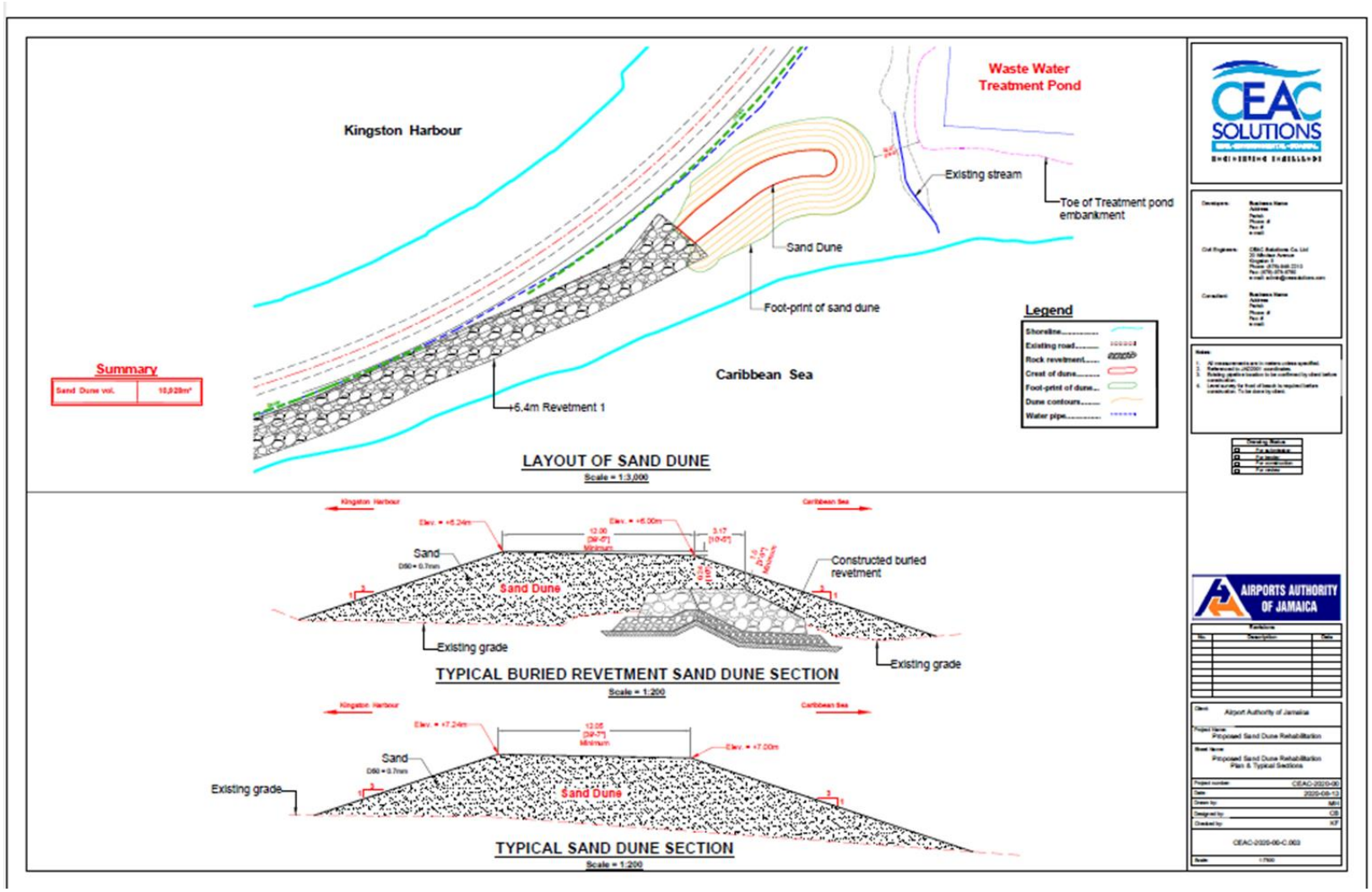
Timeframe	3 Months
Cost	$0.77 Million



Palisadoes Dunes

It is recommended, that dunes be placed over the low lying revetment to protect the roadway against 100 RP Year storm surges.

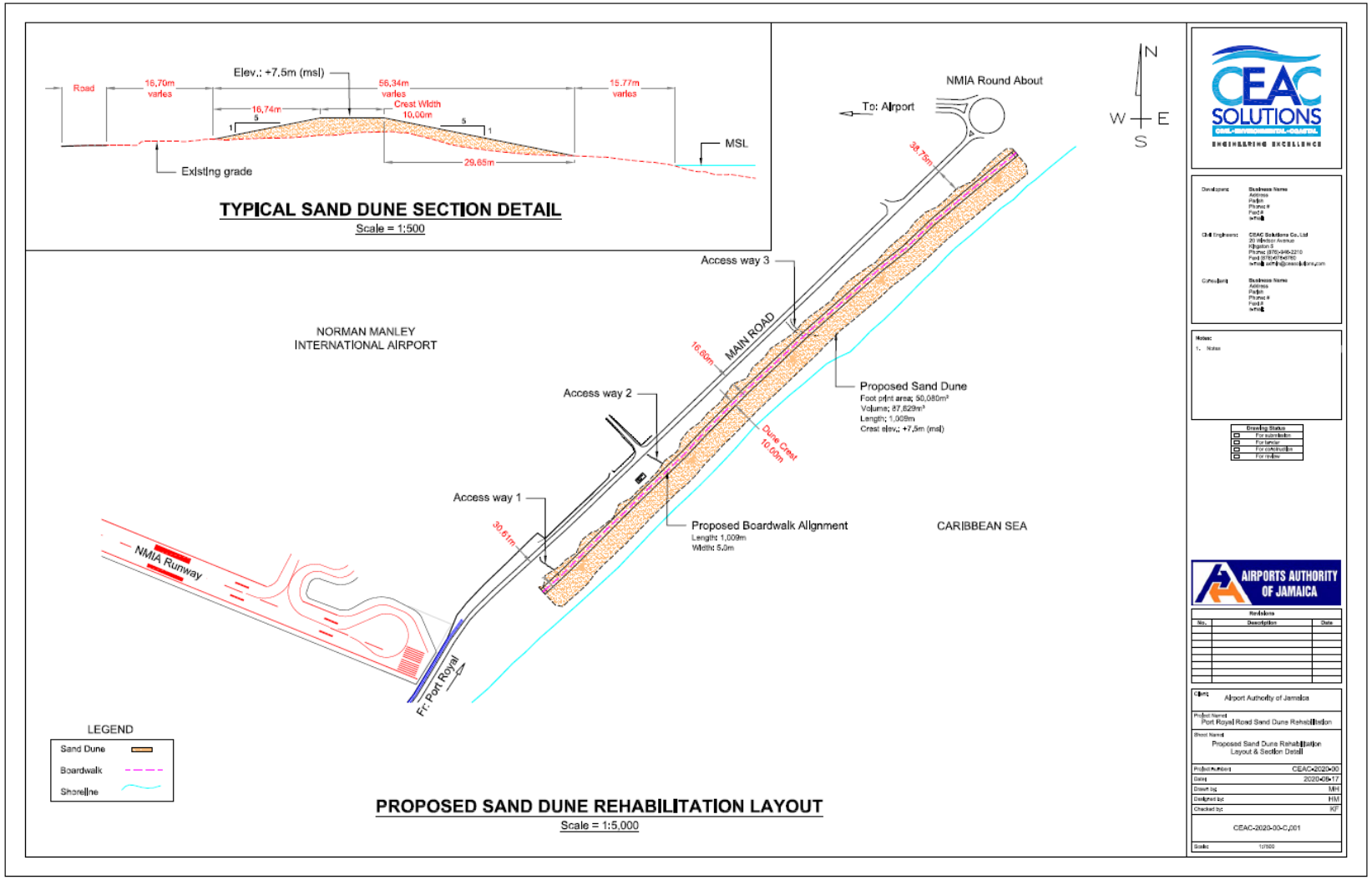
Timeframe	6 Months
Cost	$4.22 Million



Port Royal Dunes

Most sections of the dunes along Port Royal Road are expected to experience over washing in 100- yea storm event. Therefore, it is recommended the crest elevations and slope, for the dunes to be raised to +7.5m to withstand 50- and 100 year storm events.

Timeframe	3 Months
Cost	$4.46 Million

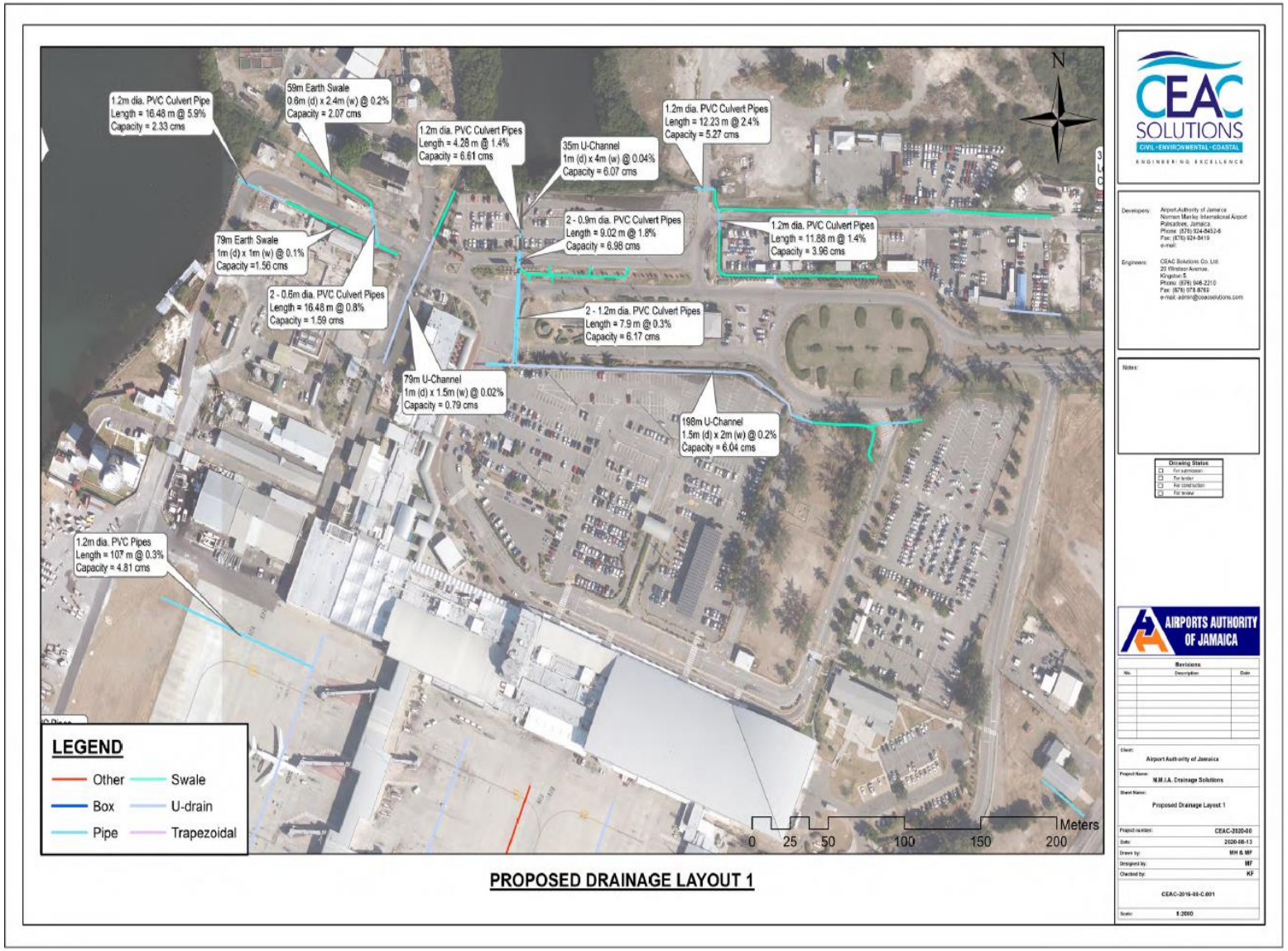


Drainage and Flood Enhancement

It is recommended that a maintenance plan be made and executed to ensure that drains aren't blocked after rainfall events by debris and silt.

All drains that were under capacity to be upgraded to meet the 25 yr. return period runoff flows + 25% freeboard.

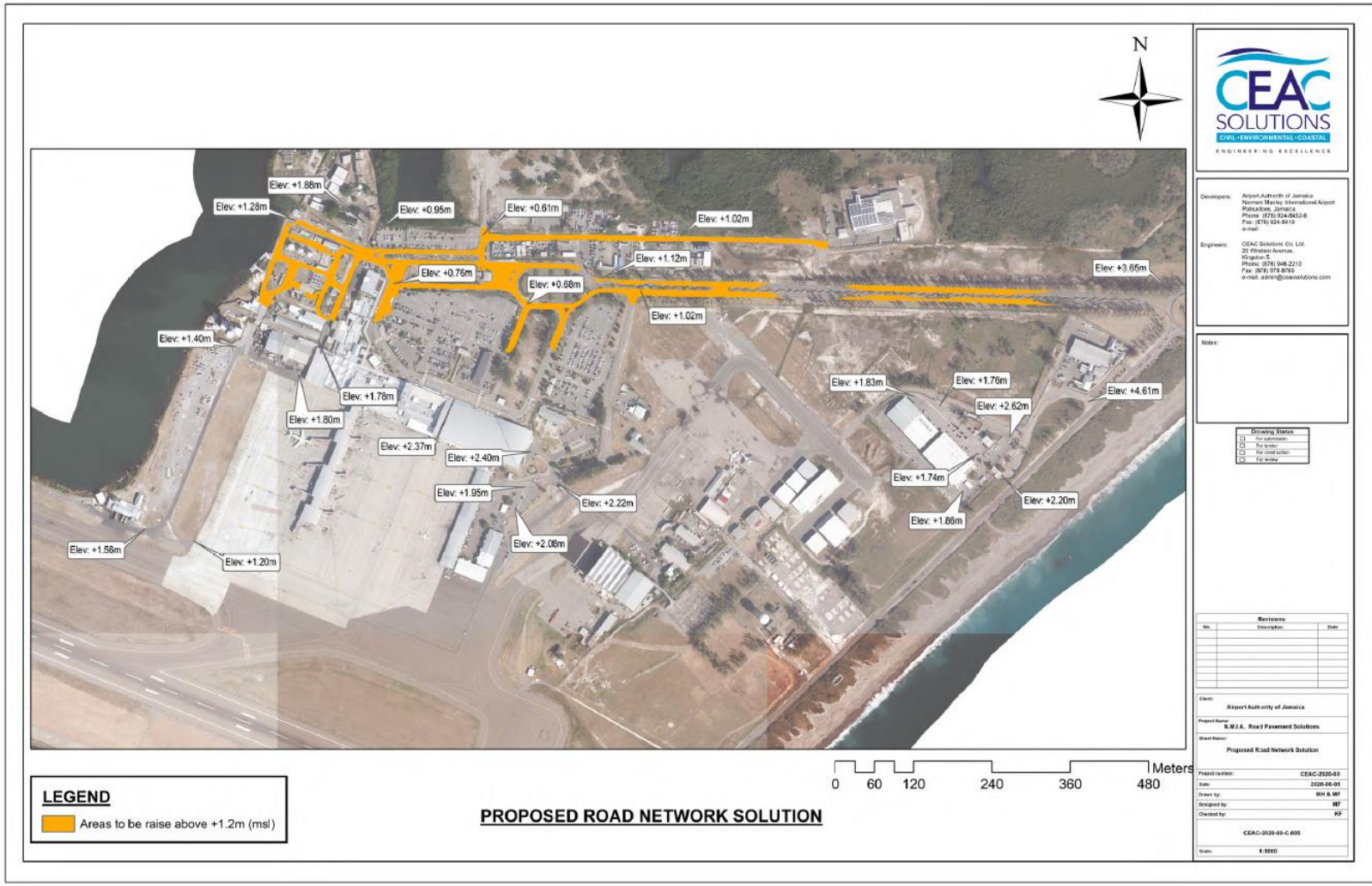
Timeframe	6 Months
Cost	$0.57 Million



Landside Pavement

It is recommended that the sub-base would be raised approximately 0.1m above the projected (2050 – 2059) SLR elevation of 0.45 m while the elevation of the top of the pavement will be 1.3m above MSL.

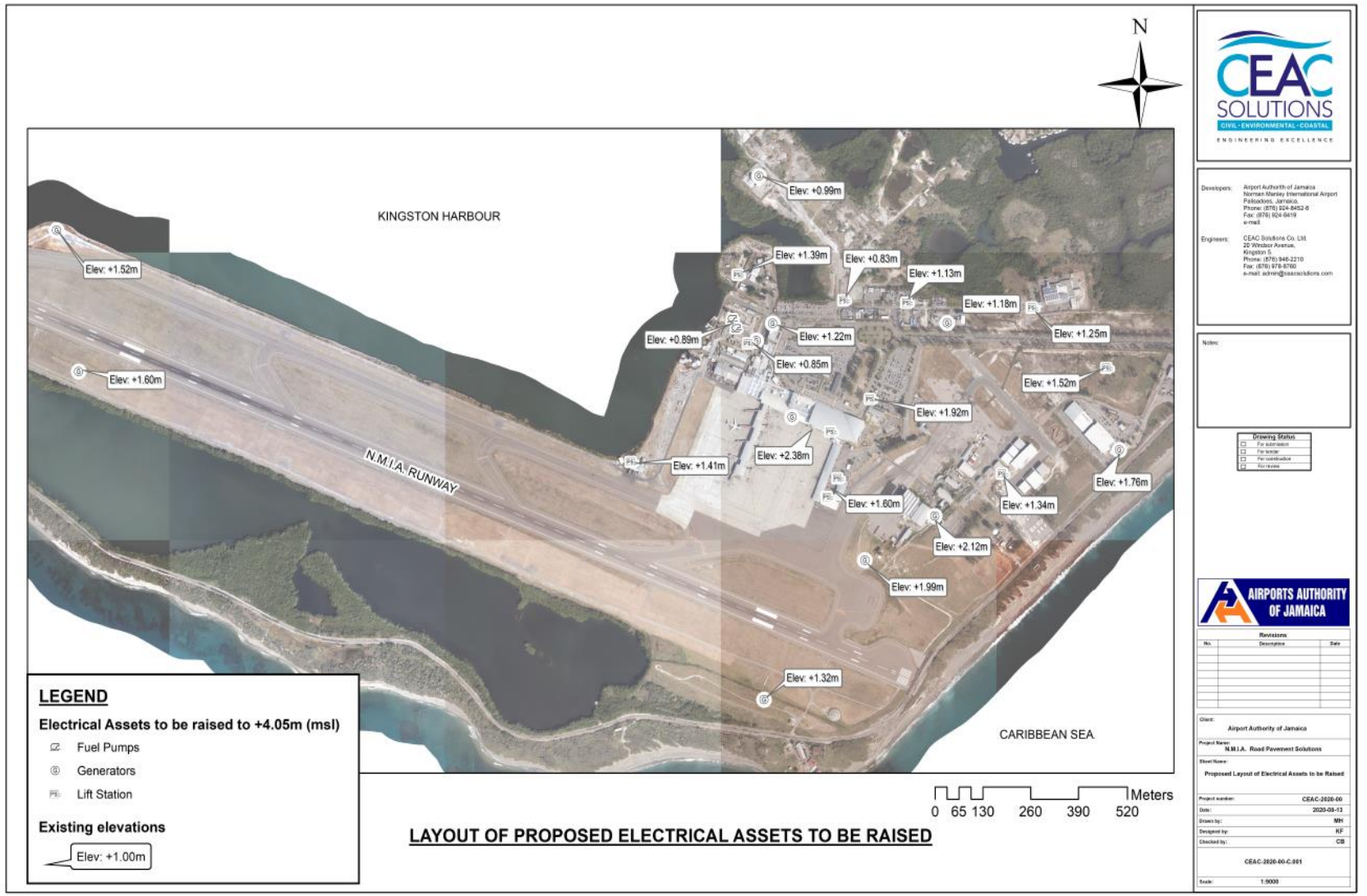
Timeframe	3 Months
Cost	$2.27 Million



Flood proofing electro-mechanical assets

It was recommended that a flood protection mechanism is implemented for the electro-mechanical assets by offering protection against 100 RP Year storm surges (3.6m)and the effects of seal level (RCP 8.5) rise under the future climate.

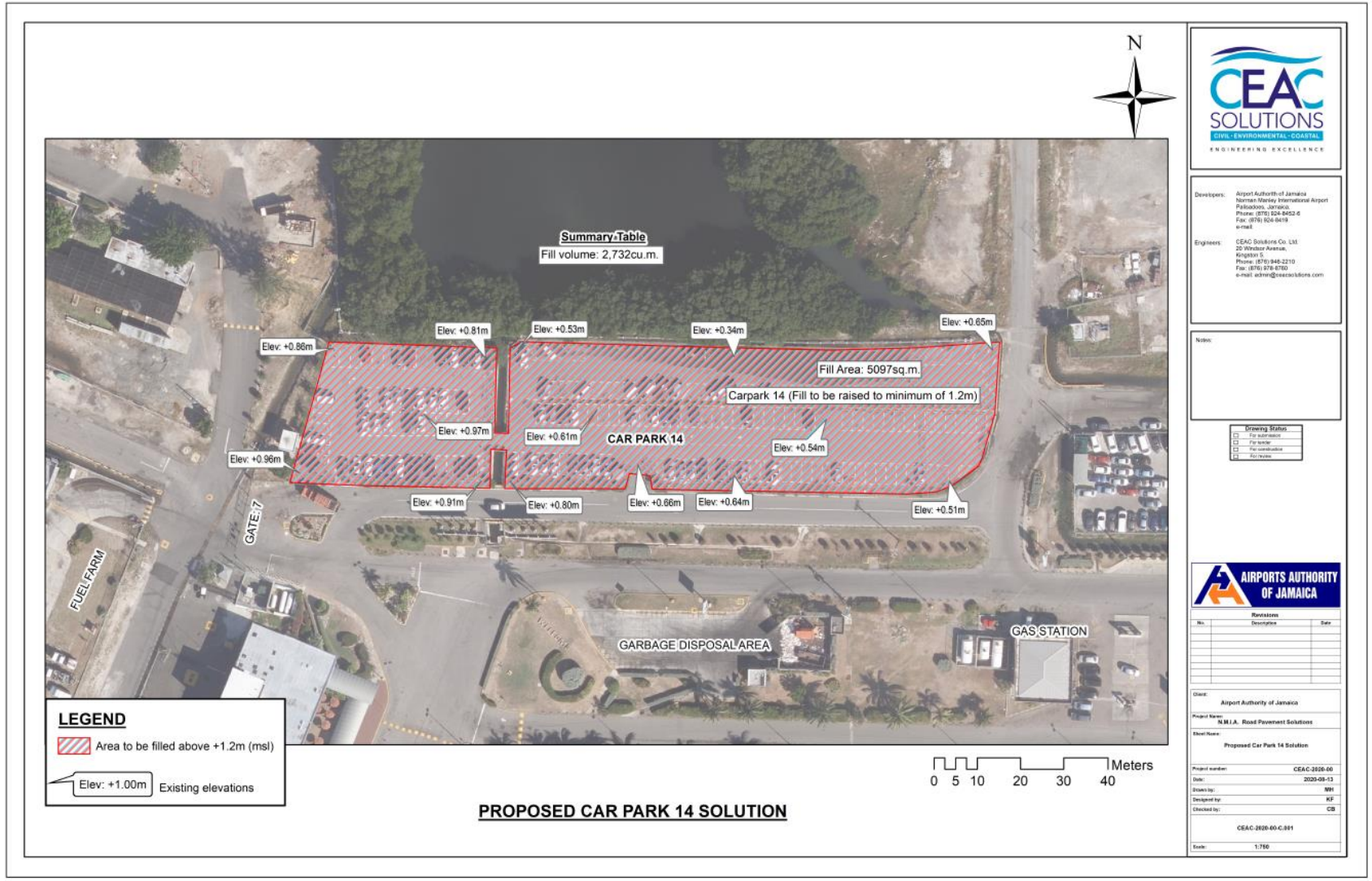
Timeframe	12 Months
Cost	$1.4 Million



Carpark 14

It was recommended that the sub-base is at least 0.6m above the projected SLR elevation (0.45 m) and the elevation of the top of the pavement being 1.3m above MSL.

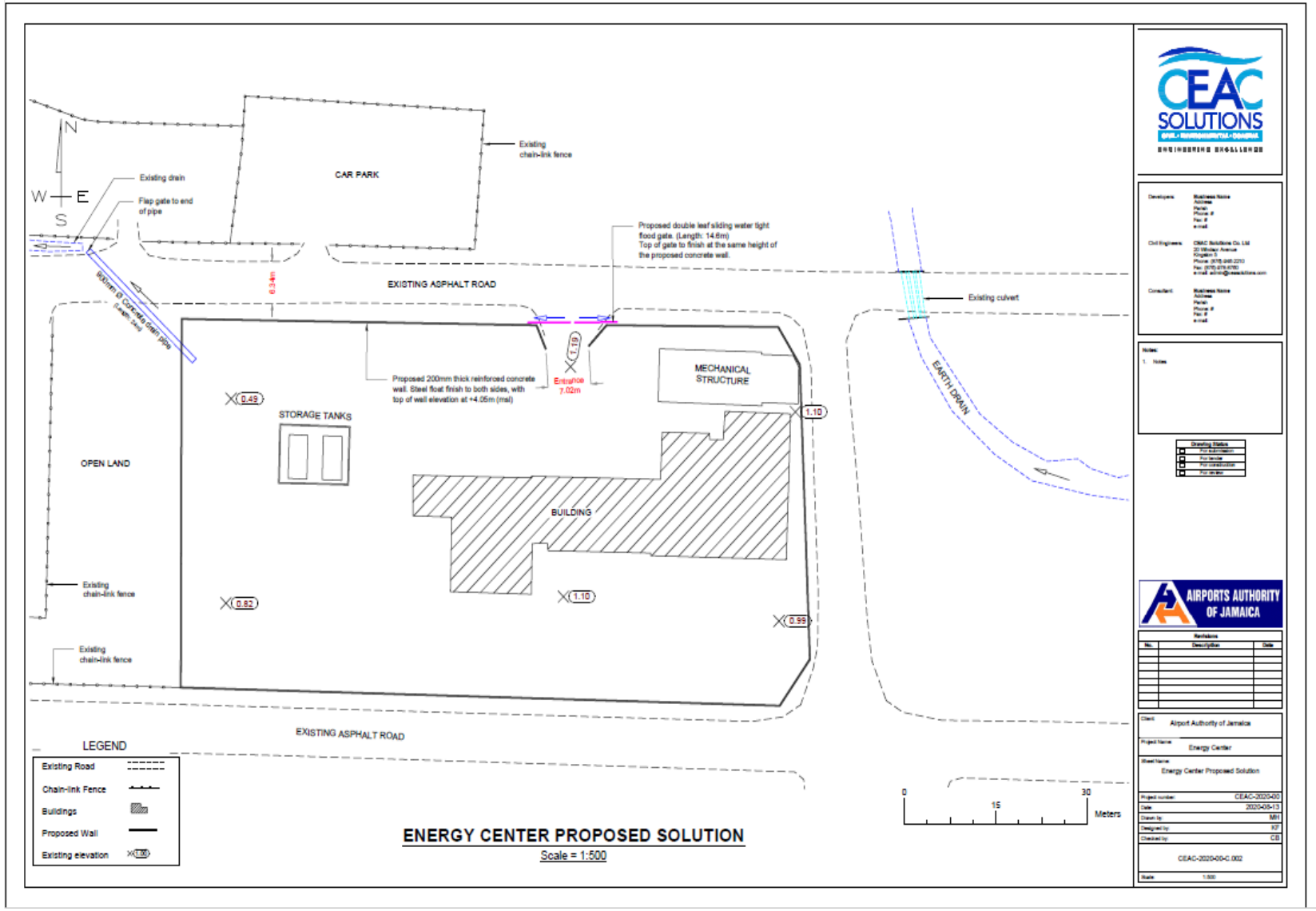
Timeframe	3 Months
Cost	$0.42Million



Flood Proofing Energy Centre

It is recommended, that flood protection for the NMIA Energy Centre is implemented to offer protection against 100 RP Year storm surges.

Timeframe	7 Months
Cost	$0.57 Million

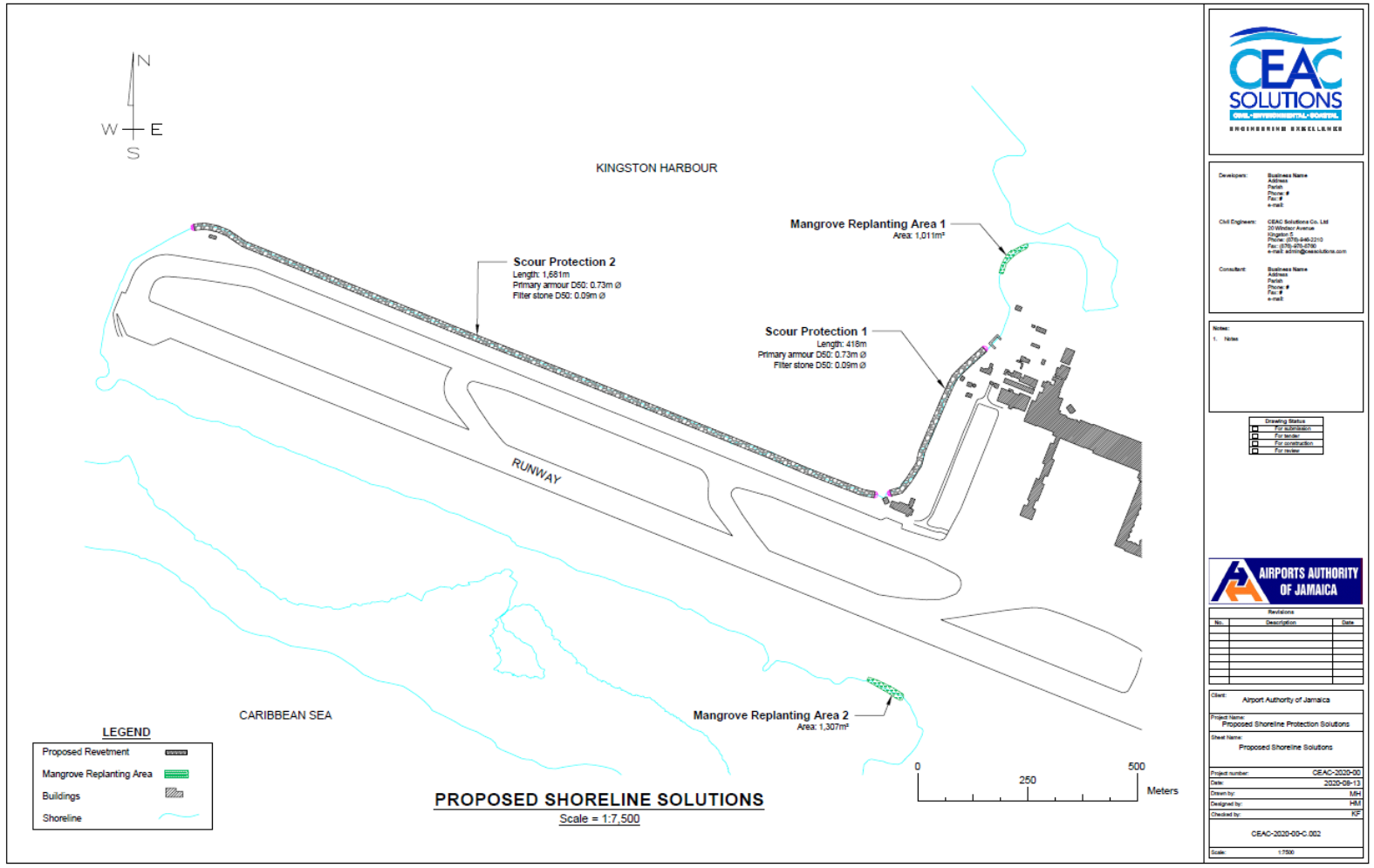


Climate Change Adaptation

Revetment and Mangrove Rehabilitation

It was recommended revetment scour protection be constructed, and the mangroves replanted. The height of the proposed revetment is 2.6 m and it is expended to extend 2099m along the property boundary.

Timeframe	12 Months
Cost	$3.98 Million

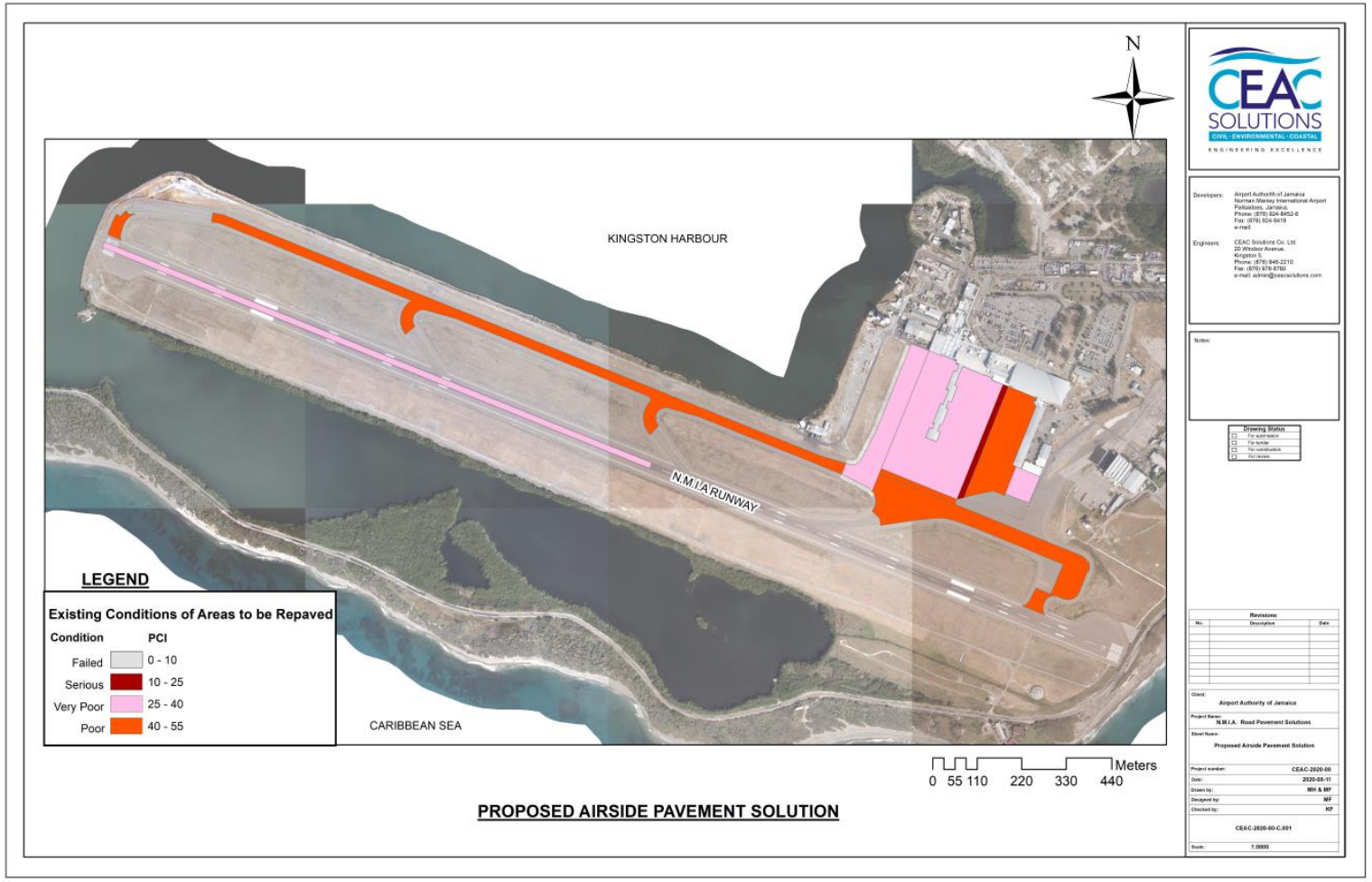


Climate Change Adaptation

Airside Pavement Rehabilitation

The comprehensive rehabilitation of the airside pavement was proposed to significantly reduce the possibility of a runway excursion for the following twenty (20) years.

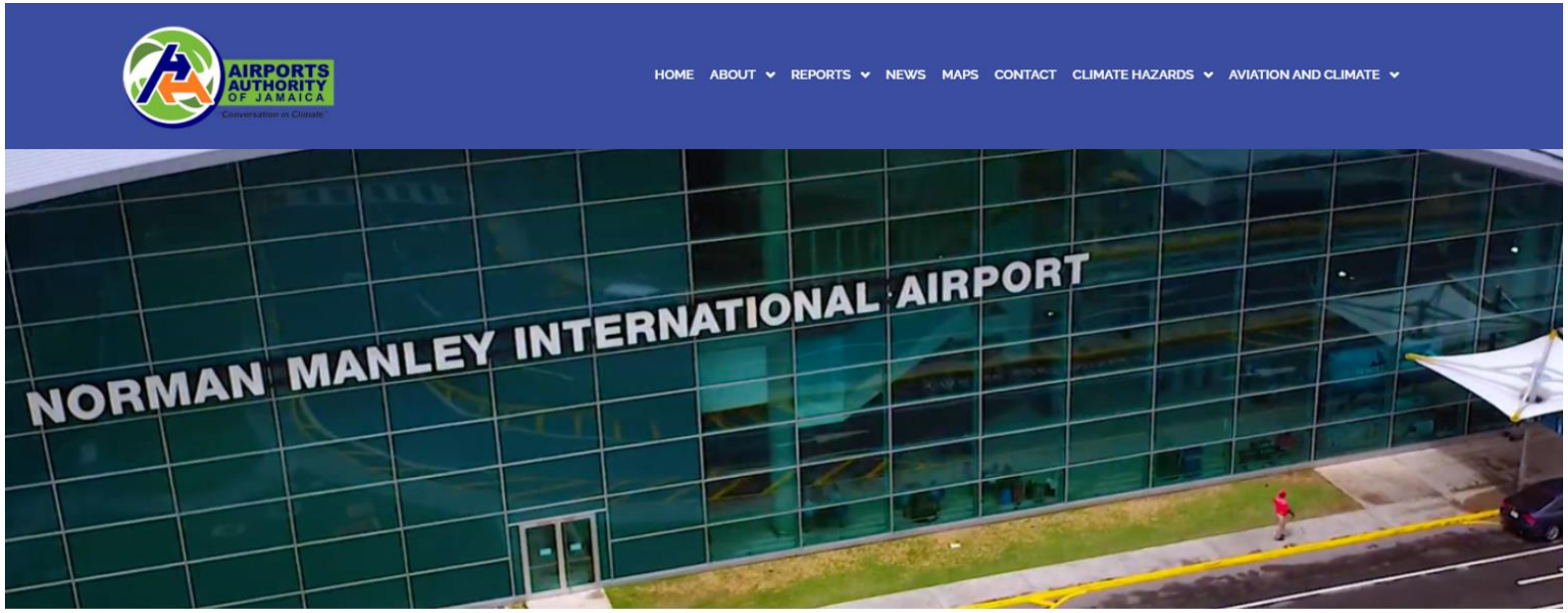
Timeframe	6 Months
Cost	$1.72 Million



Climate Change Website

It is recommended that a Climate Change Website is implemented as it acts as a repository of data and information that will facilitate informed decision-making and can keep stakeholders informed as well.

Timeframe	2 Months
Cost	$0.02 Million



Summary

	Proposed Adaptation Options	Cost (USD Millions)	Timeframe (months)	Category (Short or Long Term)
Infrastructure modification	Upgrading and cleaning drains	$0.57	6	Long Term
Structural	Harbour revetment rehabilitation and Mangrove replanting	$3.98	12	Long Term
	Airside pavement rehabilitation (taxiway, apron and runway)	$35.50	12	Long Term
	Landside road pavement	$2.27	6	Long Term
	Raising car park 14	$0.42	3	Short Term
Design modifications	Solar shading to departure glazing	$0.77	3	Short Term
Enhancement of vegetation, wetlands and natural barriers	Rehab and enhancement of dunes	$4.46	3	Long Term
Technological	Climate Change Website	$0.02	3	Short Term
	Bunded Energy Center	$0.37	7	Short Term
	Elevating transformers, generators and control panels	$1.40	12	Long Term
	Palisadoes Dune rehabilitation	$4.22	3	Long Term

Summary

- From the data it was deduced that the location of the Norman Manley International Airport causes the level of vulnerability posed by storm surge to be moderate and will increase when sea level rise is factored in.
- To reduce the vulnerability of the Airport and its assets to future climate, eleven (11) adaptation projects were conceptualized to mitigate the risks posed to the airport
- All eleven (11) options were determined to be economically feasible based on the cost analysis executed, hence all options can be done.
- It is important that the minimum floor level elevation for all proposed building infrastructure should be constructed above the 100-year storm surge elevation.

GIS/GPS ASSET MAPPING

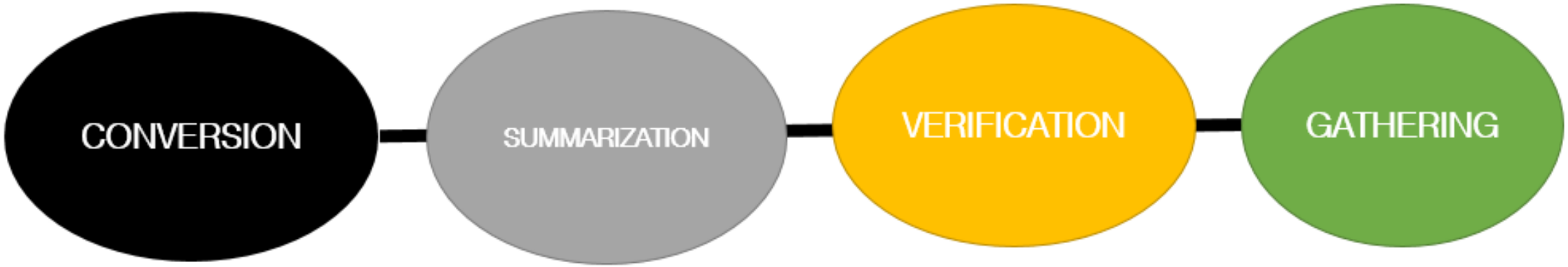
Overview

GIS/GPS Asset Mapping refers to the process by which the location, properties and geospatial extent of over 6,000 airport assets were abstracted in real-time using the most appropriate feature classes (points, polylines and polygons) .

This component of the project took place over a six-month period – beginning in April 2020 and ending in September 2020.

Overview

This phase of the project was carried out in a four-step logical data process as detailed below:



Overview

Using these 4 logical steps, the asset mapping team was able to achieve three main objectives namely:

1. The creation of a data dictionary and the recommendation of a list of software and hardware that can be used to facilitate accurate real-time data collection for planning, analysis, mitigation and response.

2. The mapping and recording of accurate geospatial data for approximately 6,000 airport facilities and infrastructure using the Global Navigation Satellite System (GNSS) Real-time Kinematic (RTK) observation method.

3. The creation of an *Airport GIS Database* with spatial and attribute data on electrical & mechanical facilities, civil structures, and natural features.

GIS/GPS Asset Mapping

Airport GIS Database System

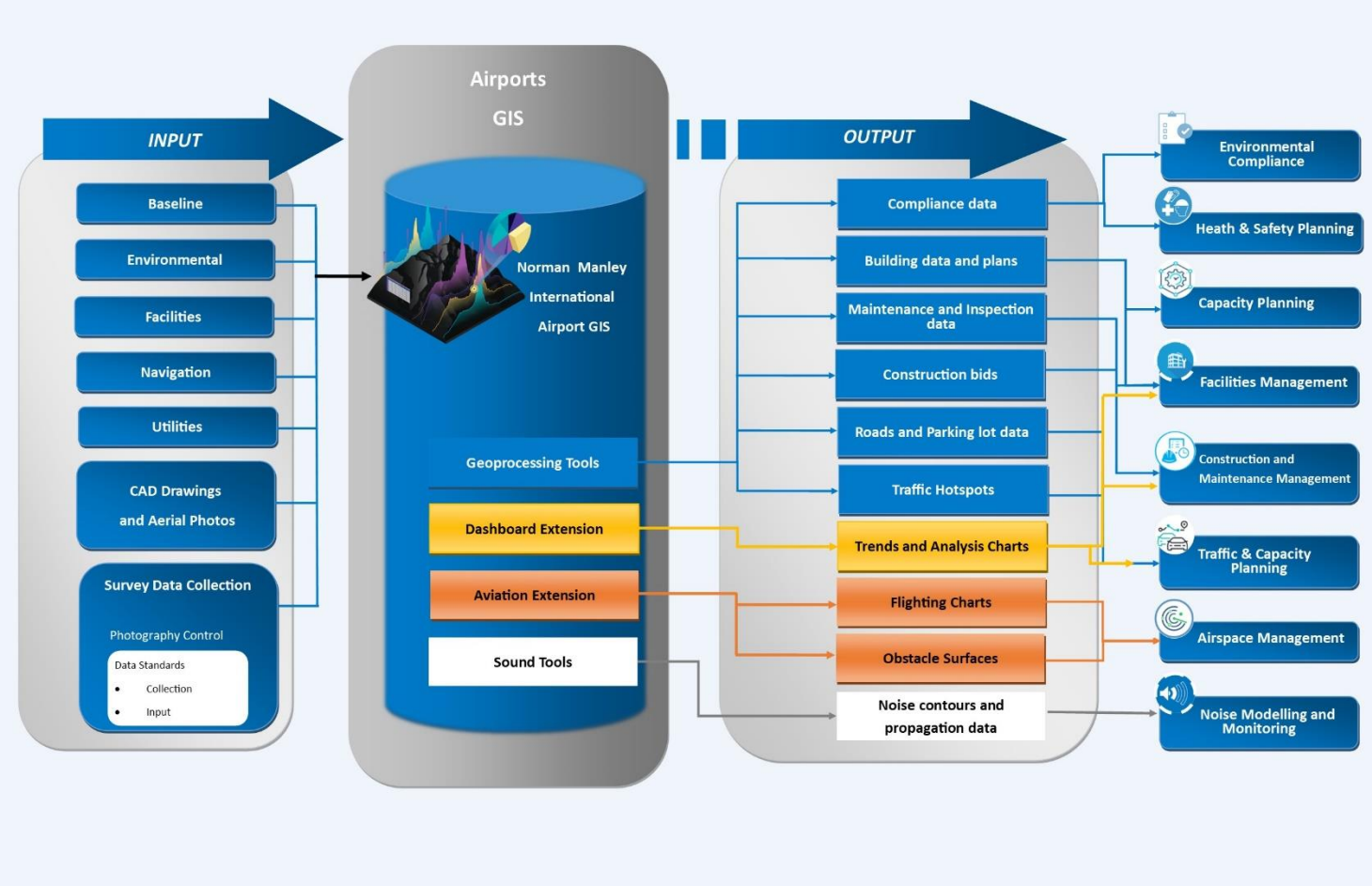


Diagram showing the Proposed framework for the GIS Database System

Airport GIS Database System

These airport features have been categorized into five (5) main feature datasets:

Diagram showing the GIS Database System Design

Classification of Airport Assets

Feature Dataset	Definition
Baseline	This category is comprised of all the airport assets that provide the necessary background detail to orient the location of the airport map
Environment	This category is comprised of vegetation found in and around the airport alongside the subset of airport assets that are involved in the filtration, treatment and proper disposal of storm water and other contaminated water from the airport property.
Facilities	This category comprises of the manmade subset of infrastructure which provides shelter and various modes of conveniences for both employees and patrons alike on the airport property.
Navigation	This category comprises of is any sort of marker which aids the traveler in navigation, usually nautical or aviation travel.
Utilities	This category is comprised of all the assets that function in supplying the airport with electricity, gas, water, or sewerage.

Table 1: Definition of the five feature datasets into which the airport assets have been classified

Baseline Feature Dataset

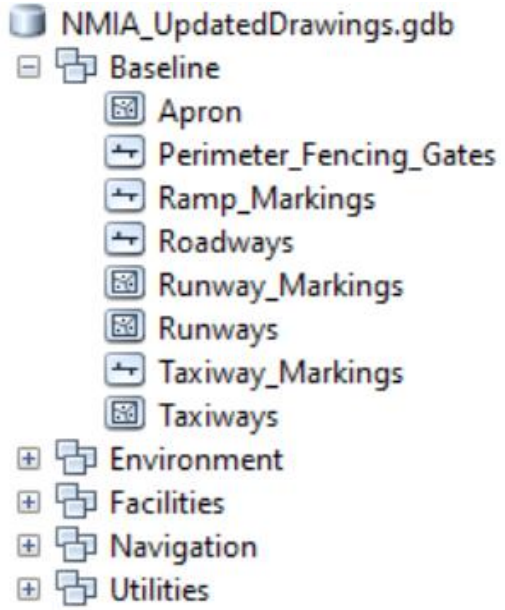


Diagram showing the shapefiles stored within the Baseline Feature Dataset of the GIS Database System

Environment Feature Dataset

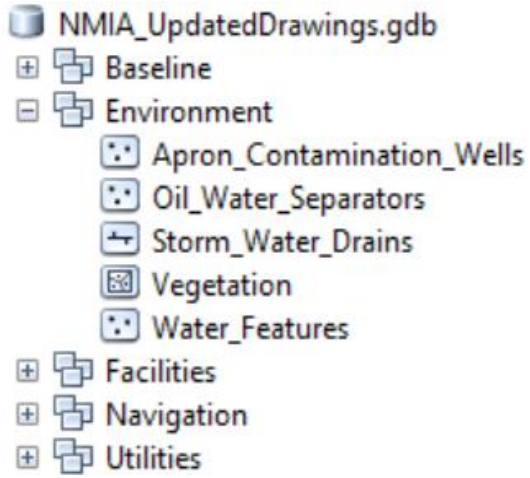


Diagram showing the shapefiles stored within the Environment Feature Dataset of the GIS Database System

Facilities Feature Dataset

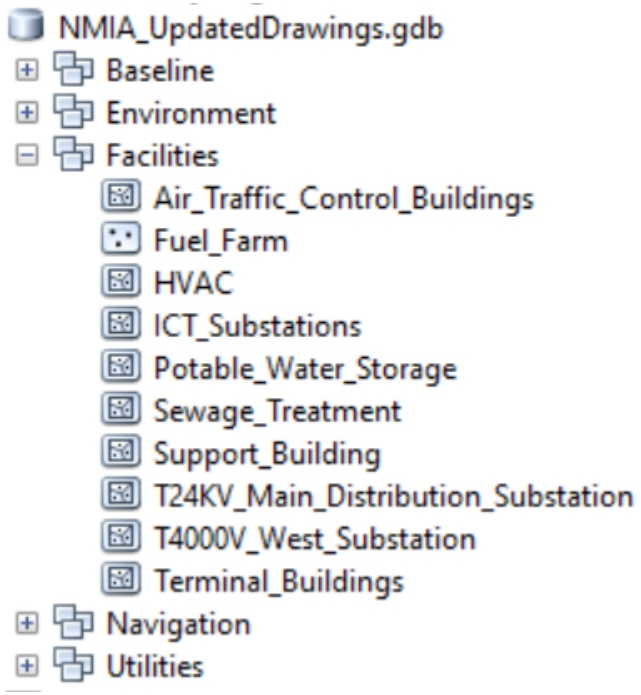


Diagram showing the shapefiles stored within the Facilities Feature Dataset of the GIS Database System

Navigation Feature Dataset

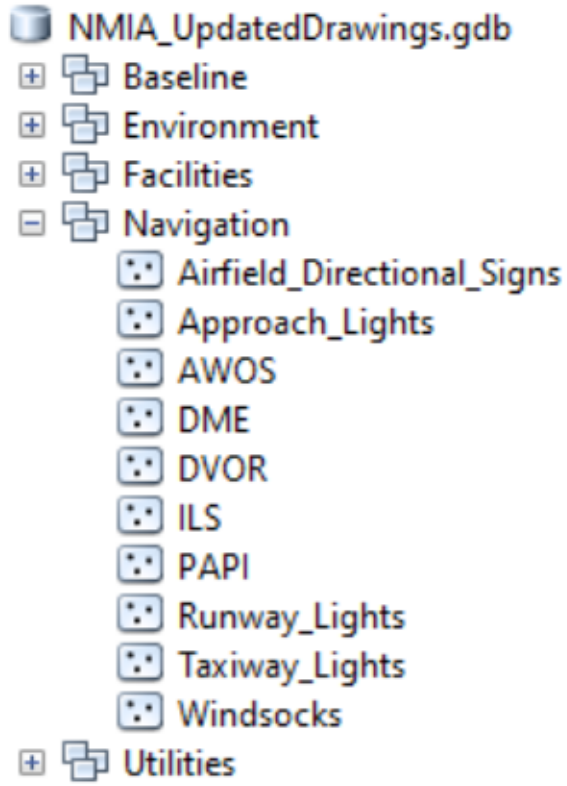


Diagram showing the shapefiles stored within the Navigation Feature Dataset of the GIS Database System

Utilities Feature Dataset

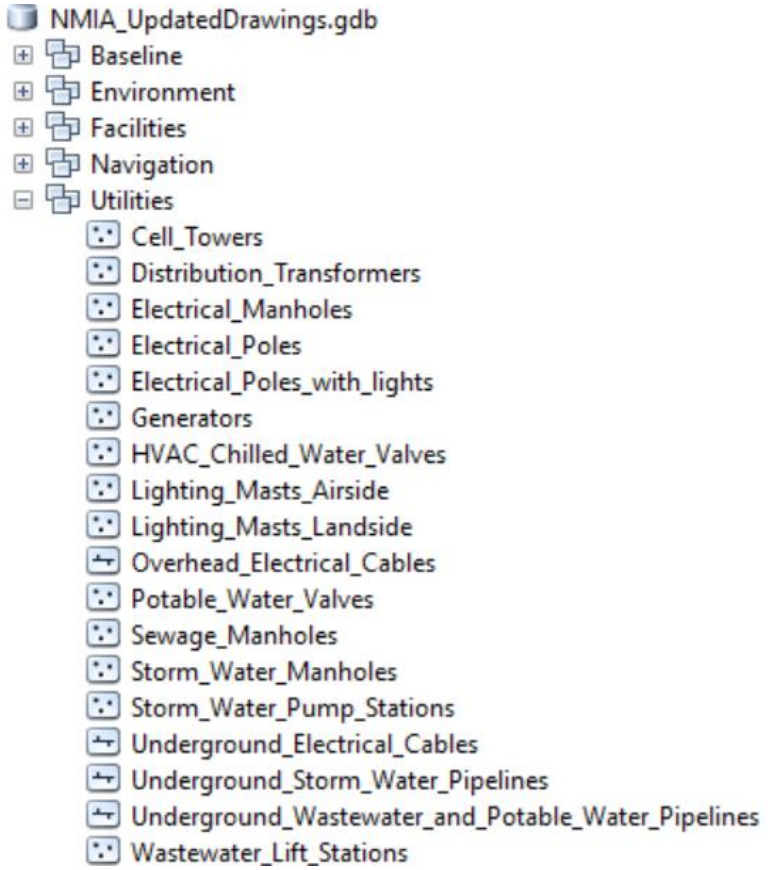


Diagram showing the shapefiles stored within the Utilities Feature Dataset of the GIS Database System

Examples of Unresolved Data Gaps

Table 2 showing the unresolved data gaps within the Mechanical Category

Mechanical Feature	Nature of Unresolved Gaps
Underground Storm Water Pipelines	Cross-sectional area, product and dimensions details have not been recovered
Storm Water Manholes	No invert level and crown level data has been collected
HVAC Chilled Water Valves	Unable to retrieve product and/ manufacturer details
Underground Wastewater and Potable Water Pipes	Unable to ascertain condition and product details

Table 3 showing the unresolved data gaps within the Electrical Category

Electrical Feature	Nature of Unresolved Gaps
Underground Electrical Cables	Area, product and electrical details still to be added; Only coordinate data obtained thus far

Summary

Of the fifty-one (51) assets mapped, forty-three (84%) of these features can be deemed to be spatially complete. This means that all previously identified spatial and attribute gaps within the Gap Analysis phase have been filled.

Consequently, these features are found to be spatially correct and have been tagged with all the necessary attributes as per the Terms of Reference. Conversely, though all of the fieldwork has been completed (100%), the collection of all the stipulated attribute data was not at all possible for all the assets identified.

Recommendations

1. The NMIA can expect significant benefits because of implementing an Airport Geographic Information Systems Database
2. Using the Standard ArcGIS Desktop software alongside proposed handheld GPS/ mobile devices
3. Capacity planning can be facilitated for different scenarios, and for the different airport zones
4. Utilizing the ArcMap Sound Tools, real-time sensors would feed information into the system as Coordinates
5. Using the Standard ArcMap Desktop or ArcMap Pro software, the future and existing weather and hydrometeorological information

Limitations / Difficulties Encountered

Five (5) main hinderances or challenges were encountered in the process of completing the GIS/GPS Asset Mapping component of the project. These included:

1. **Data received (drawings/shapefiles) from NMIA was not concise or well organized** and in most cases contained significant overlaps with other data layers. For example, the drawing for the sewage treatment plant also contained information related to roadways, toilets, walls driveways and topographical information.

2. **Data received from NMIA was in many cases mislabeled** which made it difficult to discern what the feature layer was actually referring to. In many cases there were several layers with layer attributes which had numerical layer tags. For example, a layer would be labeled “0” within the attribute table, however on closer inspection; the layer represented a road or tree. This level of detailed investigation was unable to be completed at this stage of the project and so in many cases it has been left up to onsite inspection to confirm these cases.

Limitations / Difficulties Encountered

3. **Data conversion was not as smooth a process as intended based on poor-resolution specifications** of the input data/drawings. In many cases, the input drawing contained illegible elements at fine scale which could not accurately be converted. This indiscernible data had to be removed from consideration as it was unclear what was actually being illustrated.

4. **The field verification and collection of attribute data for several underground several features was not at all possible due to the inaccessibility of the airport assets** – thus resulting in gaps as the required attribute data could not be collected.

5. **Lack of available skilled personnel** – particularly, with regards to the electrical and mechanical assets, the asset mapping team was not equipped with the requisite knowledge to capture all the required product and/ manufacturer details. Consequently, as disclosed in table 2, a few features were left with unresolved attribute gaps.

CCA TAG, COC and Stakeholder Consultations

Overview

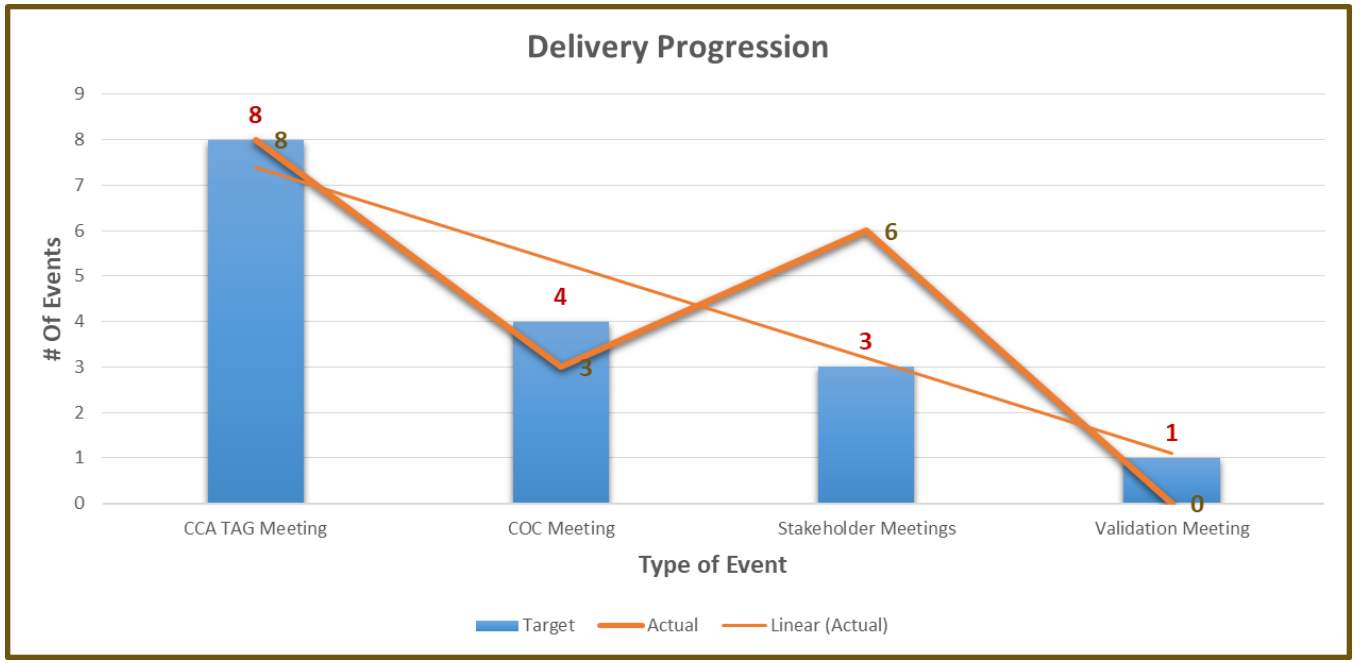
Structured approach to soliciting inputs through a multi-stakeholder engagement process as part of inclusivity thrust and risk management process.

Aims and Objectives

1. Establishment of COC
2. Establishment of CCA TAG and working consultations:
   - All TAG correspondence
   - List of confirmed TAG members
   - TAG meeting Minutes, agenda and related materials
   - Working consultation materials, notices, attendee list, meeting agenda, Minutes, presentation materials.

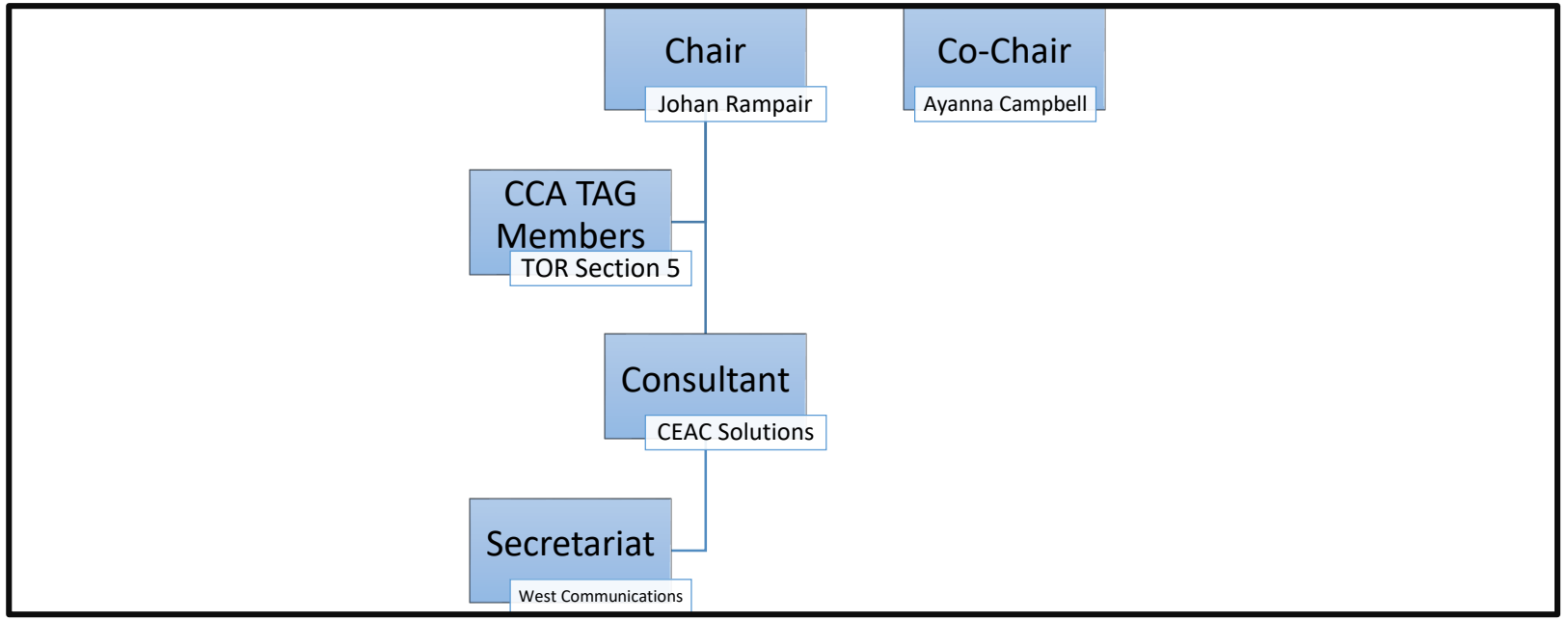
Overall Outputs/Outcomes

- COC and CCA TAG convened; collectively, 11 meetings held
- Six stakeholder meetings held
- 125 institutions from 10 stakeholder groups identified
- 245 unique individuals participated
- The suggested validation meeting cancelled



Specific Outputs/Outcomes – CCA TAG

- Committee convened in January filled by 14 organisations and 20 (permanent + alternate) representatives
- All eight scheduled meetings held



Specific Outputs/Outcomes - COC

1. Committee convened in March filled by 16 organisations and 28 (permanent + alternate) representatives
2. Three of four planned meetings held

Specific Outputs/Outcomes – Stakeholder Meetings

1. Six instead of three parish-based planned meetings held due to outbreak of SARS-CoV-2
2. 257 persons participated; 72% more than the planned 150

Stakeholder Meetings - Key Findings

1. Noise impact has significantly reduced over past 20 years
2. Aviation accident instead of noise was the top concern of the respondents
3. The elderly are mostly affected by intermittent noise (early morning)
4. No objections were raised about the runway expansion plans

Conclusions

1. The impact of noise has significantly reduced over the past twenty (20) years
2. Aviation accident and not noise was at the top of contentious issues
3. Most of the noise experienced are from non-NMIA operational sources such as JDF helicopters and motor vehicles as substantiated by the noise study (Campbell, C. et. al., 2020)
4. The elderly (males + females) are mostly affected by noise followed by women; children at study
5. There are high levels of myths surrounding how the NMIA operations impacts the general public
6. Residents did not object to the runway expansion

Recommendations

1. TCPA/NEPA to improve zoning designation in Development Orders
2. Stringent monitoring by NEPA to minimize zoning violations
3. JCAA to impose penalties for breaches
4. AAJ to continue multi-stakeholder consultations and expand corporate-social outreach
5. Consider compensation for communities (Port Royal, Edgewater, Passage Fort, Garvey Meade, etc.) that continue to be most affected by intermittent noise exceedance, for e.g.:
   - Reserve budget line from normal corporate social responsibility budget
   - Set quotas on scholarships, sponsorships to include most affected communities

Key Messages For Communication

1. Noise levels are within national and international levels
2. Some amount of intermittent noise exceedance is expected but has no adverse health impacts
3. No greater noise that currently experienced is expected from expansion

Limitations / Difficulties Encountered

1. Outbreak of SAR-CoV-2 restricted movements and required modified methodology which reduced quality and quantity of data capture
2. Protracted project delays caused internal administrative and capacity deficits resulting in scheduling and initial quality issues
3. Requirements of the TOR were 100% fulfilled; though some deadlines missed

Lessons Learned

1. Richer stakeholder participation can be achieved by prior circulation of background information and relevant content for review
2. Recognition, validation and management of stakeholder requirements and expectations reduces chances of conflict