# Environmental Baseline: Gladstone Road Improvement Project (GRIP) Rev. 2

New Providence, The Bahamas

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# 1 Executive Summary

This Environmental Baseline pertains to the Gladstone Road Improvement Project (GRIP) on the island New Providence, The Bahamas. An Environmental Baseline documents existing site conditions and outlines environmental management techniques to manage construction practices. An Environmental Baseline shall not be considered an Environmental Impact Assessment.

The Government of The Bahamas (GOB) through the Ministry of Public Works (MOPW) seeks to undertake the widening of Gladstone Road from a single lane to a dual carriageway (4 lanes). In addition to increased vehicle capacity, the improvements will include junction improvements, installation of medians, drainage facilities, street lighting, traffic signs, and road markings. These improvements to Gladstone Road are collectively referred to as the Gladstone Road Improvement Project (GRIP).

Gladstone Road is a main arterial road connecting John F. Kenney Drive to Carmichael Road along a predominantly north/south axis. It is a 2.93 mile (15,486 ft.) long, single carriageway within a 100ft wide road reservation. Gladstone Road provides access to commercial entities, education institutions, places of workshop and religious organizations, an entertainment complex, and residential areas. As a primary route to the center of the island of New Providence, it is subject to long delays and high traffic volumes daily. This congestion is anticipated to worsen with population growth and new development.

**Biological Baseline**

The perimeter of the GRIP Corridor, where undeveloped, is predominantly interior upland with the exception of wetland on the periphery of Lake Cunningham at the Gladstone Road and JFK Roundabout. Realignment of the JFK roundabout to north and west may necessitate up to one (1) acre reclamation of Lake Cunningham with an unavoidable loss of the wetland periphery including individuals of *Rhizophora mangle* (red mangrove). Elsewhere wetlands exist as part of the Lake Killarney floodplain in close proximity and west of the Gladstone Road 100 ft right-of-away. Three (3) vegetation type classes were encountered within the Gladstone Road survey area – Human Altered, Pine Woodland and Dry broadleaf evergreen formation (DBEF).

Sixteen (16) invasive species were observed almost exclusively in previously cleared areas. Five (5) protected tree species were recorded including *Guapira discolor* (Narrow leaf Blolly), *Swietenia mahagoni* (Mahogany), *Pinus caribaea var. bahamensis* (Caribbean Pine), *Caesalpinia vesicaria* (Brasiletto) and *Ceiba pentandra* (Silk Cotton).

A combined twenty-one (21) avian species were observed during field investigations at Gladstone Road and Lake Cunningham. Along the Gladstone Road corridor, traffic noise, and windy conditions contributed to the low count of observed individuals with exception of the urban adapted Eurasian collard-dove *Streptopelia decaocto* and Northern Mockingbird *Mimus polyglottos.* At Lake Cunningham, four (4) avian species observed are known waterfowl and forage at lake for food.

**Traffic Assessment**

Parsons prepared a Traffic Review and Analysis Report for the Gladstone Road Corridor (GRC) to inform the number, locations, and geometric design of intersections to be implemented during the GRC expansion to 4 lanes over a 2040 planning horizon. Capacity analyses confirmed operational issues at the Gladstone/JFK roundabout and at the Gladstone Road/Fire Trail and Gladstone Road/Carmichael Road intersections. The lack of deflection for the westbound approach to the JFK roundabout creates issues for other approaches. Recommendations include but are not limited to the following: 3 Primary Roundabouts (JFK, Firetrail, & Carmichael) and 3 Secondary Roundabouts (Munnings Drive, Aquinas College, & Farmer's Market). This scenario provides for the greatest Level of Service with the reorientation of the JFK Roundabout.

**Socio-Economic**

According to the 2010 Census, 246,329 persons reside on New Providence; it is the most populated island of The Bahamas. Similarly, New Providence is the most densely populated island with a population density of 3,079 persons per square mile. This figure represents a 16.9% increase in population density on New Providence since 2000. The population of The Bahamas is projected to increase to 454,060 in 2040.

Gladstone Road provides access to commercial entities, education institutions, places of workshop and religious organizations, an entertainment complex, and residential areas. As a primary route to the center of the island of New Providence, it is subject to long delays and high traffic volumes daily. This congestion is anticipated to worsen with population growth and new development. With expansion to a four (4) lane corridor, traffic management communication to homes and businesses along this corridor is paramount. The Traffic Management Master Plan shall include communication and grievance redress protocols for the public. Advanced notification will be provided to homes and businesses to be affected by trenching and utility installation activities.

**Recommended Best Management Practices for GRIP:**

- **Environmental Management Plan.** An Environmental Management Plan (EMP) will be prepared for use by the workforce prior to construction. An EMP provides the monitoring protocol to enforce best management practices during construction.
- **Sediment and Erosion Controls**. BMPs reduce the potential for sediment transport during storm events and entry into subsurface caverns and marine environment. Potential best management practices to consider include a drainage plan, silt fencing and dewatering away from wetland features. Drainage has been designed to avoid direct surface drainage into the wetlands and floodplain. To account for climate change, calculated flows were increased by 10% based on present drainage volumes and present sea level rise.
- **Traffic Management Master Plan.** The Contract will prepare a Traffic Management Master Plan (TMMP) to address the reduction of road network capacity during construction. The TMMP will address: safe access to the site, the effects of noise, dust, vibration, and exhaust fumes, communication, and grievance redress.
- **Materials Storage and Fuel Storage**. Materials storage should be kept away from sensitive environmental features. Fuel storage and refueling should adhere to best practices, including raised storage with either 110% containment mechanism or doubled walled tanks in the event of spill.

- **Invasive Species Removal.** Removal of invasive species considered a threat to small island nations will slow the proliferation of unwanted plant species. It is recommended that the developer perform routine removal of saplings to prevent recolonization.
- **Protected Tree Species & Planting with native tree species.** Where feasible, protected trees will be avoided and/or saved for reuse in planting. Permits to Harvest a Protected Tree will be applied for under the Forestry Unit. Additionally, the landscaping program will feature native species and protected tree species planting to encourage visits by native fauna.
- **Reduce Light Pollution.** Install lighting that meets guidelines for the International Dark Sky Association (IDA) to reduce light pollution impacts to residences and to preserve night skies.
- **Mangrove Mitigation.** Reclamation of Lake Cunningham will be mitigated by mangrove planting at a 2:1 ratio. Two (2) mangroves will be planted for each mangrove removed due to reclamation activities.
- **Pedestrian and Bicycle Improvements – Social Benefit Optional.** Improved access to sidewalks with design considerations for a bicycle pathway will provide social benefit to the residents and users of Gladstone Road.

**Conclusion**

The Gladstone Road Improvement Project (GRIP) occurs largely within the right-of-way of an existing arterial road that has incurred increasing vehicle volume due to the expansion of industrial, commercial, and residential uses along the Gladstone Road corridor. This congestion is anticipated to worsen with population growth and new development. Traffic analyses were prepared using leading traffic software to determine new intersection location and design recommendations based on present volumes and 2040 planning horizon. The level of service is expected to increase with the 4 lane expansion and JFK roundabout realignment with additional consideration for long-term service at the JFK intersection.

GRIP will result in an unavoidable loss of vegetation; however, as a previously disturbed site with land use remaining the same, the roadway expansion will result in increased vehicle capacity and installation of drainage controls to address seasonal flooding and weather variations due to climate change. Realignment of the Gladstone Road and JFK Roundabout will result in an unavoidable loss of wetlands to be mitigated by beautification of the southern shoreline of Lake Cunningham and mangrove planting. Additional options to mitigate impacts include the creation of a pedestrian and cycling trail and installation of lighting approved by the International Dark Sky Association.

The Project's Environmental Management Plan (EMP) will include a Traffic Management Master Plan to outline best management practices to ensure the health and safety of the travelling public and local business operators and residents during construction. Additionally, the EMP will contain measures for erosion and sediment control, and practices for prevention of pollution to groundwater as Lake Killarney's floodplain extends east to Gladstone Road.

# 2 Purpose and Scope

An Environmental Baseline Terms of Reference (TOR) is prepared for consultation with the Department of Environmental Planning and Protection (DEPP). This Environmental Baseline: GRIP is written according to the TOR to which DEPP has stated its ‘no objection’.

An Environmental Baseline documents existing site conditions and outlines environmental management techniques to manage construction practices. The document serves as a botanical and physical record prior to site clearing. Its purpose is to record existing conditions, highlight potential issues of environmental concern, and to recommend practices for environmental management during construction. The project area and its area of influence shall be known as the ‘site’. An Environmental Baseline shall not be considered an Environmental Impact Assessment.

# 3 Project Description

Gladstone Road is a main arterial road connecting John F. Kenney Drive to Carmichael Road along a predominantly north/south axis. It is a 2.93 mile (15,486 ft.) long, single carriageway with in a 100ft wide road reservation.

Gladstone Road serves as the primary route to major industrial center on the island of New Providence. As a primary route, it is subject to long delays and high volumes of traffic on a daily basis that are anticipated to worsen with new development.

The Government of The Bahamas (GOB) through the Ministry of Public Works (MOPW) seeks to undertake the widening of the route from a single land to a dual carriageway. In addition to increased vehicle capacity, the improvements will include junction improvements, installation of medians, drainage facilities, street lighting, traffic signs, and road markings. The JFK roundabout redesign and two major intersection upgrades including the JFK and Fire Trail; and Fire Trail and Carmichael Road. The limit of works for these three (3) intersections is three hundred (300) feet on either side of Gladstone Road's centerline.

To facilitate a higher level of service, six (6) roundabout scenarios were reviewed for the GRIP Corridor. Scenario 5 with improvements to six (6) intersections was identified as the optimal design with the level of service at B (minor delays) or D (moderate delays), see Figure 3-2 Scenario 5 Primary Roundabouts.

Intersection Improvements:

- JFK Roundabout Realignment
- Munnings Roundabout
- Aquinas Roundabout
- Firetrail Roundabout
- Farmers Market Roundabout
- Carmichael Roundabout

These improvements to Gladstone Road are collectively referred to as the Gladstone Road Improvement Project (GRIP).

*Figure 3-1 Map of New Providence, The Bahamas*

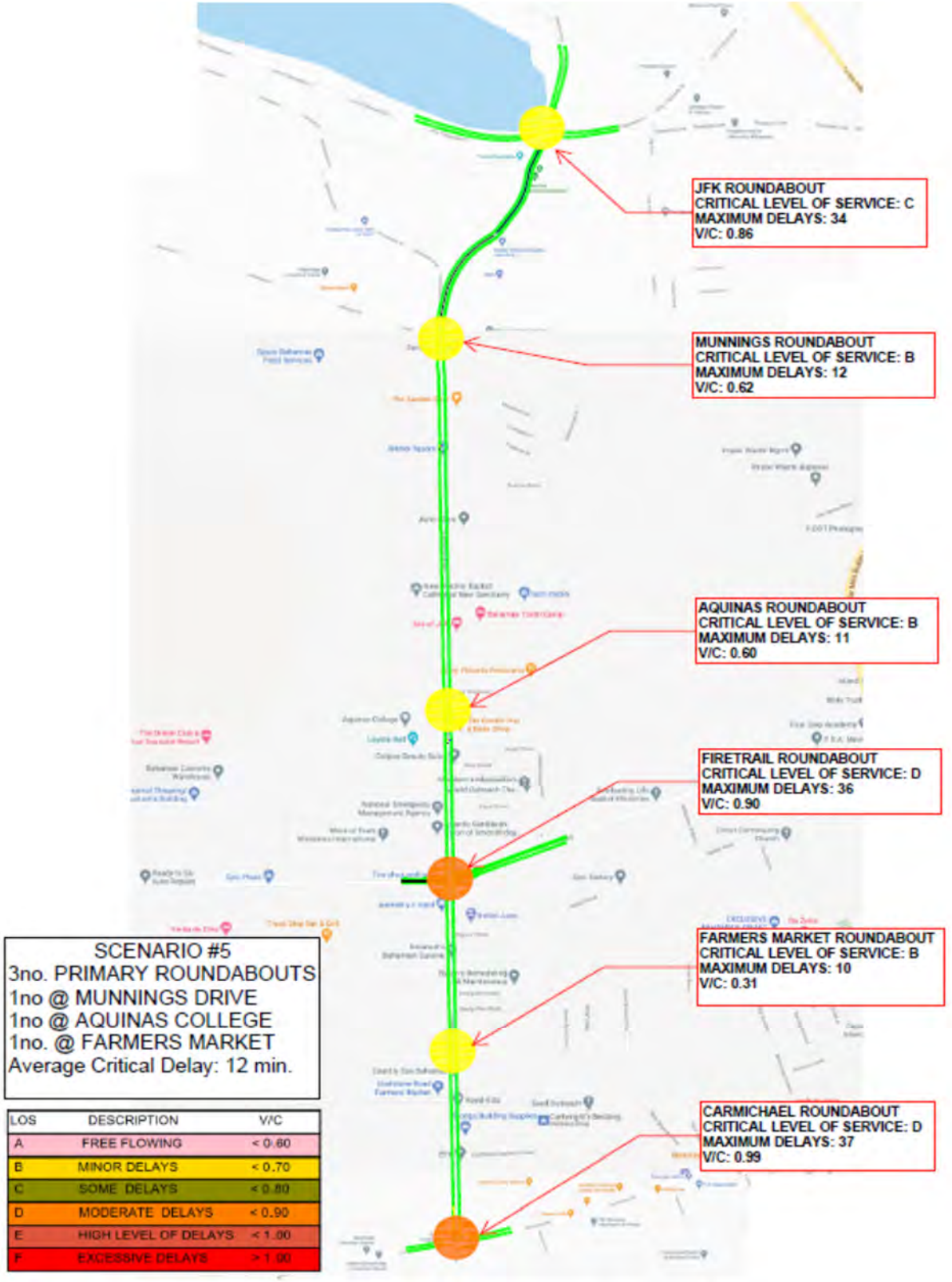


*Figure 3-2 Scenario 5 Primary Roundabouts*

# 4 Physical and Biological Baseline

## 4.1 General Climate of The Bahamas

The climate of The Bahamas is considered sub-tropical; it lies in a transition zone between the temperate and tropical zone. The archipelago spans 450 miles in longitudinal extent from 21°N to 27.5°N. The northern Bahamas experiences cooler winters and higher amounts of rainfall compared to the southern Bahamas where annual temperatures deviate less and the climate is markedly drier. The climate of The Bahamas is influenced by the sea particularly, the Gulf Stream which lies between Florida and the Great Bahama Bank. (Sealey, 2006)

Average High and Low Air Temperature is given in degrees Fahrenheit for Nassau (Sealey, 2006)

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| High | 77.3 | 77.5 | 79.7 | 81.8 | 84.6 | 87.3 | 89.1 | 89.3 | 88.4 | 85.4 | 81.8 | 78.7 |
| Low | 62.1 | 62.5 | 63.8 | 66.2 | 69.8 | 73.3 | 74.7 | 74.8 | 74.4 | 71.9 | 68.0 | 63.8 |

New Providence can expect 57.1 inches and 137 rain days (Sealey, 2006). Rainfall is highest between the months of May and November with peaks during June and October. Generally, prevailing winds are from the northeast with a rotation to the southeast during the summer months, May to September. In winter, wind may shift to the northwest due to cold fronts emanating from North America. According to the Bahamas Department of Meteorology, the average wind speed is eight (8) knots.

## 4.2 Geology

The Bahamas archipelago exists on a partially exposed carbonate platform between the Atlantic Ocean and the North American Plate. The platform surface geology is comprised mostly of *oolitic limestones.* Pleistocene limestones, Holocene sands and marshland sediments extend to a depth over of four (4) miles below the surface. Fourteen marine banks make up the surface plateaus; the largest being the Great Bahama Bank followed by the Little Bahama Bank. New Providence forms part of the Great Bahama Bank.

Carbonate geology is highly porous and subject to atmospheric erosion leading to the formation of karst solution systems including vast networks of subterranean caverns and Blue Holes. Rainfall and surface discharges quickly infiltrate the permeable limestone. Most surface runoff drains into the porous ground or brackish tidal creeks; The Bahamas has no freshwater rivers.

In general, the landscape of The Bahamas is flat with undulating ridges averaging 30 to 45 meters in height. Cat Island has the highest point of elevation, 206 ft., at Mount Alvernia. Given these physical properties, The Bahamas is subject to storm surge and wave action during tropical cyclone events.

It is not anticipated that cutting will be necessary into the ridge in the area of the Fusion Complex and Bayview Cemetery to accommodate the road widening.

## 4.3 Topography

Gladstone Road is predominantly flat with a gradual increase in elevation from south to north with a steep climb to approximately thirty (30) feet at the Fusion complex followed by a rapid descent to the JFK and Gladstone roundabout. With the exception of the Nassau Ridge, the majority of Gladstone Road is less than five (5) feet above ground level.

## 4.4 Hydrological and Hydrogeological Resources

In The Bahamas, groundwater comprises the fresh, brackish, saline and hypersaline waters found in the near and deep subsurface and in the lakes and ponds that intercept the surface. The Bahamas has no fresh surface water and therefore, no freshwater lakes, rivers, or creeks.

Freshwater resources in The Bahamas originate from rainfall only and accumulate in Ghyben-Hertzberg lenses. The Ghyben-Hertzberg lens consists of three (3) lateral zones: 1) freshwater where chloride ranges from 90 to 400 ppm; 2) a transition zone (brackish), approximately 1-2m think where chlorides increase rapidly from 400 to 1200 ppm; and 3) a saline zone where chlorides rise above 1200 ppm. Freshwater is less dense than salt water, thus sits above the saline zone separated by a brief mixing layer of brackish water.

On average, the freshwater lens occurs at a depth of two (2) to five feet (5ft.) below the surface. Ninety percent (90%) of freshwater lens resources in The Bahamas are within five feet (5ft.) of the surface. Given the close proximity of fresh water to the surface and the high porosity of limestone, over-extraction and pollution may lead to depletion, saltwater intrusion, and/or contamination, impairing the fragile layer of freshwater over salt.

Threats to groundwater resources:

- **Saltwater Intrusion**. Saltwater intrusion to groundwater may occur due to 1) storm surge generated by tropical disturbances; 2) sea level rise due to climate change; and 3) over-pumping/extraction of freshwater aquifers.
- **Development/Building Features.** Canals and marinas have the potential to disturb subsurface freshwater lens by allowing the sea to connect at the inland surface.
- **Climate Change.** Based on the IPCC 5$^{th}$ Assessment Report and the Coupled Model Intercomparison Project 5 (CMIP5); climate change will alter existing rainfall patterns in The Bahamas. Climatology data suggest that The Bahamas region will incur a three percent (3%) decrease in monthly rainfall averages with an increase of intensity of rainfall events between October and February. Overall, total rainfall is expected to decrease placing additional pressure on freshwater resources.
- **Contamination.** Groundwater is susceptible to contamination from untreated sewage, industrial wastes, and leaking fuels; this vulnerability is particularly true for New Providence. New Providence is the most populated island and has the highest population density.

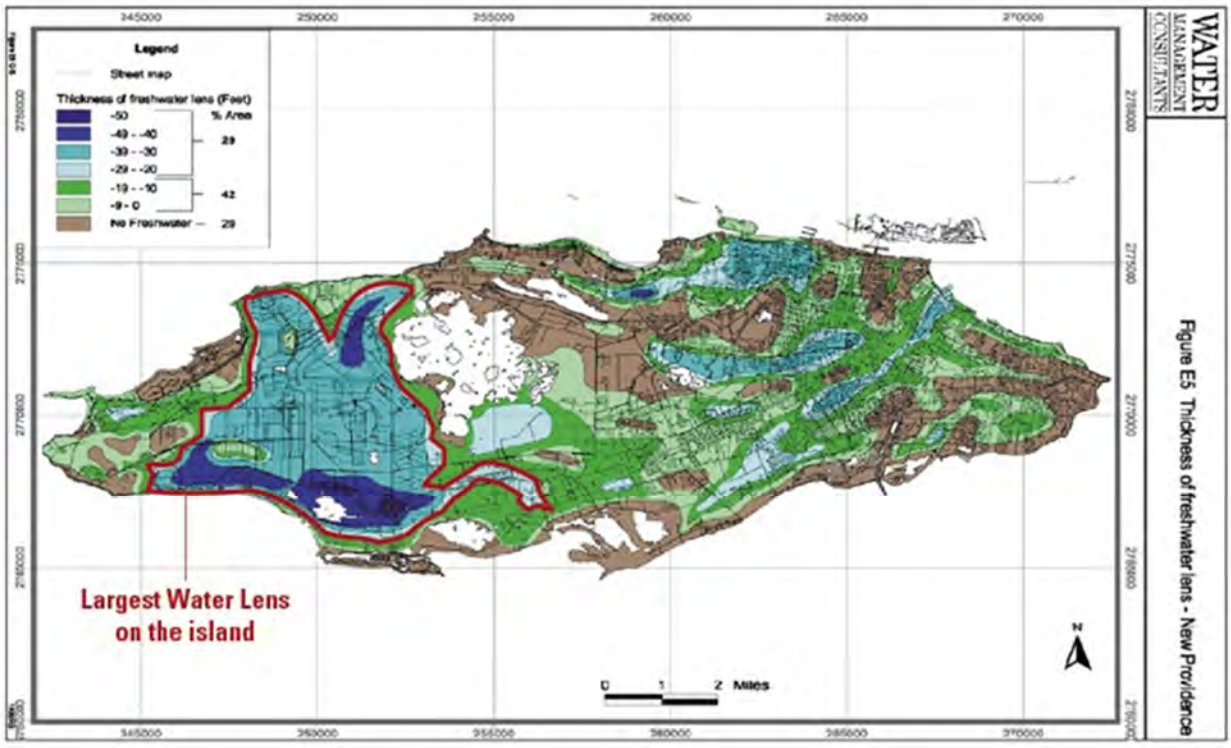


*Figure 4-1Thickness of the Freshwater Lens – New Providence*

### 4.4.1 *Hydrology and Drainage Report – Gladstone Road*

An Hydrology and Drainage Report including Rainfall Analysis, and Recommendations for Drainage was produced in association with the Climate Vulnerability Assessment (CVA) for GRIP. Gladstone Road is predominantly flat with a gradual increase in elevation from south to north with a steep climb to approximately thirty (30) feet at the Fusion complex followed by a rapid descent to the JFK and Gladstone roundabout. With the exception of the Nassau Ridge, the majority of Gladstone Road is less than five (5) feet above ground level. This low relief contributes combined with the western edge of Lake Killarney's floodplain contributes to poor drainage.

#### 4.4.1.1 Flooding – GRIP

Flooding along the Gladstone Road corridor occurs and is exacerbated by several aspects. Lake Killarney and its floodplains abut Gladstone Road to the west. Seasonal fluctuations in rainfall result in the high water table rising during the wet season as rainfall exceeds evapotranspiration. Excessive rain coupled with sea level rise may hamper drainage and result in prolonged internal flooding.

Additionally, there is extensive commercial development and large areas of impervious surface on and immediately south of the Nassau Ridge. These impervious areas increase rainfall run-off volume and velocity into the corridor. The combination of these factors results in flooding along Gladstone Road impeding travel.

#### 4.4.1.2 Rainfall Trend Analysis 2018

Drawing upon the Mott Hydrology and Drainage Report (2000) with updated rainfall totals from the Nassau International Airport over the period 2000-2018, the total annual rainfall increased over the 67 year period ending in 2018 to just above 55 inches per annum with annual totals varying from 35 inches to 75 inches.

Rainfall Patterns Observed:

- Rainy season (June to November) are sequential days of rainfall of varying amounts
- Dry season (December to April), by comparison, has single day events with a trace of rain at the beginning or end of the period
- Distinct winter (January to March) cold front passages which produce rainfall events
- One day events account for only 27% of rain days in the wet season
- The wet season pattern often involves several day (2-9 in length) of rainfall of varying amounts

### 4.4.2 *Stormwater Management – GRIP*

It is expected that engineering controls for stormwater will prevent runoff into wetland areas along the periphery of Lake Killarney and provide adequate drainage to maintain safe passage along an arterial roadway. These same engineering controls will take into consideration storm surge impacts, inclement weather, and sea level rise stemming from climate change.

## 4.5 Climate Change

Climate change will contribute to greater climate variability where changes may occur to precipitation patterns, increase in frequency and intensity of storm events, extreme heat, global sea level rise, and alteration of wave patterns leading to shoreline erosion. Given this climate variability, engineering and building designs should plan for a scenario for future high anthropogenic greenhouse gas emissions.

Based on the IPCC 5$^{th}$ Assessment Report and the Coupled Model Intercomparison Project 5 (CMIP5); climate change will alter existing rainfall patterns in The Bahamas. Climatology data suggest that The Bahamas region will incur a three percent (3%) decrease in monthly rainfall averages with an increase of intensity of rainfall events between October and February. Overall, total rainfall is expected to decrease placing additional pressure on freshwater resources. For impacts to freshwater resources and generally hydrology in The Bahamas refer to Section 4.4 and the Climate Vulnerability Assessment in Section 12.2.

### 4.5.1 *Climate and Transportation*

In 2017, greenhouse gas emissions (GHGs) reached a record 49.2 $GtCO_2$ after remaining relatively stable from 2014 to 2016. Preliminary global $CO_2$ estimates indicate that emissions from fossil fuels, industry and cement for 2017 increased 1.2%. Fossil fuels, industry, and cement dominate total $CO_2$ emissions which have the largest impact on total GHG emissions. Transportation is responsible for 24% of direct $CO_2$ emissions from fuel combustion with road vehicles accounting for nearly three quarters of these emissions.

In order to meet Sustainable Development Scenarios (SDS), measures to increase efficiency and reduce energy demand must expand. However, it is anticipated that emissions will continue to grow due to:

- A continuation in consumer preference for larger, heavier vehicles negating the rise in electric vehicles.
- A rising global GDP and online commerce with rapid delivery leading to increased road freight demand.

Direct (tank-to-wheel) GHG Emissions Reduction (Transport – Chapter 8/Climate Change 2014/IPPC)

- Avoiding journeys where possible.
- Model shift to lower-carbon transport system where investment is made to public transport, walking, and cycling infrastructure. Modifying roads, airports, and ports to become more attractive for users and to minimize travel time and distance.
- Lowering energy intensity by enhancing vehicle and engine performance, using lightweight materials, increasing freight load factors, increasing passenger occupancy rates, and new technologies.
- Reducing carbon intensity of fuels by substituting oil based products with natural gas, bio-methane, biofuels, electricity or hydrogen produced from low GHG sources.

### 4.5.2 *Climate Vulnerability Assessment (CVA)*

A Climate and Vulnerability Assessment accompanied the Hydrology and Drainage Report; the report in full is provided in the Appendix.

#### 4.5.2.1 Prioritized Hazards 2050 Horizon

Below is a Table identifying prioritized hazards based on possible impacts over time horizon to 2050.

| Climate Aspect | Description | Impact | Recommended Best Practice |
|---|---|---|---|
| Coastal Flooding | On New Providence, coastal flooding occurs during extreme low-pressure troughs (i.e. Hurricanes) create conditions that raise sea levels. | Hazard maps and SLOSH models indicate the southern end of Gladstone Road could be impacted by severe hurricane (Category 3+) surge approach from the south. | Residents and emergency officials in the area south of Gladstone Road would need to use the Corridor for evacuation and access to impacted areas. |
| Inland Flooding | Southern New Providence has historically experienced inundation from storm surges, flooding from heavy rainfall from hurricanes resulting in an accumulation of water, poor drainage, saturated soils or | While flood prone area maps do not identify Gladstone Road as a vulnerable area, these maps fail to consider inland lakes merging with flood waters. Should the Lake Killarney floodplain overflow east to Gladstone Road, access | Raise Gladstone Road to allow safe passage during high rainfall events. |

| | | | |
|---|---|---|---|
| | blocked drainage channels resulting in inland flooding. | would be impeded along the low-lying central porting. | |
| Groundwater Saline Intrusion | Salinization of groundwater on New Providence is the result of rising sea levels, saline intrusion, and storm surges. | Freshwater resources are a sensitive resource. The freshwater lens has greatest depth in Western New Providence with portions of freshwater likely in close proximity to GRIP. | Implement BMPs to prevent pollution to groundwater resources including oil & water separators and minimal erosion and sediment impacts. |

#### 4.5.2.2 Summary of Climate Change Projections to 2050

| Climate Aspect | Result | | |
|---|---|---|---|
| Temperature | Maximum daily and mean temperature are expected to increase by 1.97C by 2050. | | |
| Sea Level Rise | 9.0cm (3.6 in) by 2030 | 20cm (7.9 in) by 2050 | 70cm (27.6in) by 2100 |
| Rainfall: *Most Extreme Event Will Change From:* | Decrease from 58 to 42 years | Resulting in a 1 in 100 year increase | With rainfall totals from 560mm (20.5 in) to 622 mm (24.4 in) or a **19% increase** |

#### 4.5.2.3 Recommendations

| Design Challenges for GRIP | Description | Results | Drainage System Design Parameters |
|---|---|---|---|
| Wet Season Expectations (June to November): | • Rainfall volumes will exceed field capacity of porous limestone<br>• Seasonal rise in mean water table elevations during summer months<br>• Impervious surfaces increase runoff<br>• Flooding events may not have distinct dry periods between them | • Ground saturation likely to remain at or near fully saturated for the entire wet season<br>• Exacerbated flooding | • Provide for rapid movement of rainfall from impervious paved surfaces/verges<br>• Accommodate runoff from hills at northern end of the Corridor<br>• Elevated and maintained to function at peak efficiencies<br>• Retention Ponds linked to drainage wells or channels to |

| | | | |
|---|---|---|---|
| Dry Season Expectations (December to May): | • Less frequent flooding<br>• Flooding events based on rain amount and number of days | • Field saturation levels may not be reached or exceeded<br>• Water percolation into relatively dry limestone will result in more rapid drainage | direct water away from the road |

## 4.6 Hurricanes

New Providence is situated in the hurricane zone. Hurricane season begins June 1st and ends November 30th though tropical cyclones may form outside this period. According to the coastal dataset of the Coastal Service Center, National Oceanic and Atmospheric Administration, seventy-two (82) tropical disturbances (tropical storms and hurricanes) have come within 50 nautical miles of Nassau, New Providence between 1859 and 2019. Hurricane history tracker and database can be found at this link: http://coast.noaa.gov/hurricanes/.

In 2016, Hurricane Matthew a dangerous category 4, passed to the west of New Providence sparing it a direct hit; however, western New Providence experienced sustained periods of hurricane force winds and the southern and eastern coastal areas of the island incurred a storm surge which caused coastal flooding. Storm surges up to eight (8) feet inundated the southern coastal area of New Providence and Grand Bahama.

Hurricane Dorian, one of the strongest hurricanes on record made landfall at Elbow Cay, Abaco in September 2019 with sustained winds of 160 knots. Though over ninety nautical miles away, New Providence received high winds and rains over several days.

## 4.7 Botanical Survey

Design Elements was engaged by Waypoint Consulting to conduct a biological investigation along the verges of Gladstone Road on New Providence, The Bahamas. The assessment was conducted along both side of the road verge and extended approximately 100 feet from the edge of the road for approximately three (3) miles. Field studies were conducted on 05 March 2020 for botanical and avian data collection.

The main purpose of the botanical study was to map vegetation types, record protected species abundance and make observations of vegetation quality, floristic diversity, and invasive species.

*Figure 4-2 Survey Area*

### 4.7.1 *Methodology*

Vegetation types were mapped by examining aerial photography and verified by walking along the survey lines and the interior of site at various locations. Vegetation type taxonomy is based on Areces et al. (1999). Vascular plant species occurring in each vegetation type were recorded and used to compile an overall floral list. Plant taxonomy is based on Corell and Corell (1982). The presence, location and abundance of vascular species listed under the Conservation and Protection of the Physical Landscape Act, Protected Trees Order (1997) and the Department of Marine Resources, National Invasive Species Strategy for The Bahamas, 2013 were noted when encountered. Percentage cover were recorded in the abundance categories - Rare (less than 5%), Occasional (5- 20%), Moderate abundance (20-50%), Abundant (50-80%) and Dominant (80-100%).

### 4.7.2 *Vegetation Types*

The entire site was interior upland. There were no coastal or wetland vegetation types present. Three (3) vegetation type classes were encountered within the survey area – Human Altered, Pine Woodland and Dry broadleaf evergreen formation (DBEF). These vegetation types are described in the sections below.

#### 4.7.2.1 Human Altered

The entire verge on both sides of the road is human altered. The Western verge is considerably wider than the Eastern side in the southern section but narrows out in the northern section. The general profile moving from the edge of the road consisted of a strip of manicured vegetation that abuts mature vegetation (either secondary forest or human altered) or buildings.

- **Manicured Areas.** The manicured areas are primarily weeds. The vegetation is maintained as manicured ground cover by periodic mowing. There are several street vendor operations that are set up within the western manicured areas. Electrical and Water utility infrastructure are also located in the manicured areas to the west. Infrastructure on the eastern side of the road include a portion of sidewalk and Bus stop shade structures.
- **Vacant Lot.** Other human altered vegetation includes vacant lots that were previously cleared and revegetated primarily with invasive species.
- **Buildings.** Buildings include homes, businesses, schools and churches facilities.

*Figure 4-3Manicure verge on western side of Gladstone Road*

*Figure 6.7.2-2 Pop-up street vendor selling coconut water*

*Figure 4-4 Semi-fixed food trailer vendor*

*Figure 4-5 Electrical infrastructure in western verge*

*Figure 4-6 Water infrastructure in western verge*

*Figure 4-7 Bus stop shade structure on eastern side of Gladstone Road*

*Figure 4-8 Human altered area dominated by invasive trees and vines*

*Figure 4.7.2-7 Human altered area dominated by invasive trees and vines*

School

Business

Church Facility

House

*Figure 4.7.2-8 Various building uses along Gladstone Road*

#### 4.7.2.2 Pine Woodland

It should be noted that the entire survey area is historically *Pinus caribea var. bahamensis* (Caribbean Pine) Formation. Although heavily disturbed and developed, there are pockets of vegetation with Caribbean Pine in the canopy. The distribution of Pine varies at different locations, from areas with new Pine growth to areas that are at an advanced stage of succession into broadleaf dominated vegetation.

*Figure 4-9 Pine Woodland with new pine growth in an area beyond manicured verge on western side of Gladstone Road*

*Figure 4-10 Pine Woodland with understory species at 10 feet in height in an area beyond manicured verge on western side of Gladstone Road*

#### 4.7.2.3 Dry Broadleaf Evergreen Formation

Dry broadleaf evergreen formation (DBEF) was present in a small section on the eastern side of the road beyond an area of manicured verge. This area is within private property and fenced off. This vegetation type was also present in the north western section of the survey area. In this instance the vegetation was along a ridge near the road with little to no verge present. The vegetation was previously cleared, and regrowth was at the shrubland stage.

*Figure 4-11 DBEF on eastern side of Gladstone Road within private property*

*Figure 4-12 DBEF on western side of Gladstone Road*

### 4.7.3 *Other Observations*

#### 4.7.3.1 Sink holes

Small holes were observed in the human altered areas of the site where the substrate was exposed. These features are common throughout The Bahamas due to the porosity of carbonate geology which allows for rapid infiltration of rainfall and surface runoff that dissolves the rock creating characteristic sinkholes, caves and caverns that can create an extensive underground drainage system.

*Figure 4-13 Sink hole in road verge along Gladstone Road*

#### 4.7.3.2 Wetlands

The South eastern periphery of Lake Killarney is in close proximity to the south western section of the survey area. A small section of vegetation is cleared up to the wetland edge exposing the Red Mangrove (*Rhizophora mangle*) Shrubland.

Additionally, there is a small section on the western side of the road between 60+00 and 75+00 that may be the periphery of a small finger outcropping of the wetland to the west. This area has saturated soils and hydrophilic species such as *Cladium jamaicense* (Saw grass), *Conocarpus erectus* (Buttonwood) and *Acrostichum danaeifolium* (Giant Leather fern).

At or near station 60+00 saturated soils and associated hydrophilic species may also be attributed to a drop in elevation from the road creating a swale like effect and or an undetected water main leak, as water infrastructure was noted in this area.

*Figure 4-14 Red mangrove shrubland west of Gladstone Road verge*

*Figure 4-15 Aerial view of Figure 6.7.3.2-1 showing distance of red mangrove shrubland to Gladstone Road*

*Figure 4-16 Vegetation between station 60+00 and 75+00*

*Figure 4-17 Aerial of section between station 60+00 and 75+00 showing wetland periphery (outlined in red)*

*Figure 4-18 Area along western verge with saturated soils in slight swale depression*

*Figure 4-19 Location reference for area along western verge with saturated soils in slight depression*

### 4.7.4 *Invasive Species*

Fifteen (15) species listed on National Invasive Species Strategy (2013) were recorded during the investigation. Invasive species were observed in properties along the road that were previously cleared, predominantly on the eastern side. These areas revegetated almost exclusively with a variety of invasive species in some instance or form large stands of the same species in the case of *Casuarina equisetifolia* (Australian Pine).

*Figure 4-20 Previously cleared area re-established with invasive species*

*Figure 4-21 Stand of Casuarina equisetifolia (Australian pine) in vegetation along Gladstone Road*

### 4.7.5 *Protected Species*

Five (5) species listed on the Conservation and Protection of the Physical Landscape Act, Protected Trees Order (1997) was recorded during the survey: *Guapira discolor* (Narrow leaf Blolly), *Swietenia mahagoni* (Mahogany), *Pinus caribaea var. bahamensis* (Caribbean Pine), *Caesalpinia vesicaria* (Brasiletto) and *Ceiba pentandra* (Silk Cotton).

Mahogany was the only species observed within the road verge. It was planted as landscape species along the street front of a business establishment. There are approximately seven (7) mature trees in this area. A few individuals of Mahogany was also observed in the DBEF in the north-western section of the survey area.

Only one (1) Silk cotton was observed in Human altered vegetation dominated by invasive species.

A few individuals of Brasiletto and Narrow leaf Blolly were present in human altered vegetation along eastern side of the road. A few individuals of Brasiletto was also observed in the DBEF on the eastern side of the road, in private property that was fenced off from the road verge.

Where feasible, protected trees will be avoided, and/or saved and utilized for replanting. It is anticipated that landscaping will feature native species and will include planting of protected tree species. Permits to harvest a protected tree species will be applied for under the Forestry Unit.

*Figure 4-22 Mature Mahogany trees in road verge*

*Figure 4-23 Silk Cotton tree in vegetation along verge*

### 4.7.6 *Vascular Plant Diversity – Gladstone Road*

A total of ninety-nine (99) vascular plant species was observed during the investigation. The full species listing is Section 12.4. It is highly unlikely that this number represents all of the plants species present within the site but is a fair representation of species present.

The survey area has both human altered vegetation and pockets of intact vegetation. Species diversity is low in the human altered areas due to the presence of invasive species; however, vegetation biodiversity is good for areas of intact vegetation.

## 4.8 Botanical Survey – Lake Cunningham

Design Elements was engaged by Waypoint Consulting to conduct a biological investigation at Lake Cunningham near the intersection of Gladstone Road. The assessment was conducted along both side of Bahamar Blvd. and extended approximately 300 feet from the edge of the road on the western and eastern sides and 300 feet north of the Gladstone Road & JFK roundabout (See Figure 1: Survey Area). Field studies was conducted on 27 May 2020 for botanical and avian data collection. This report serves as an addendum to an assessment conducted on 5 March 2020 along Gladstone Road, however, it is presented as a standalone document. Combined botanical and avian species lists for both assessments are included in the appendices of this document.

*Figure 4-24 Survey Area (Outlined in Red)*

### 4.8.1 *Methodology*

The main purpose of the botanical study was to map vegetation types, record protected species abundance and make observations of vegetation quality, floristic diversity and invasive species. Vegetation types were mapped by examining aerial photography and verified by walking along the road verge. Vegetation type taxonomy is based on Areces et al. (1999). Vascular plant species occurring in each vegetation type were recorded and used to compile an overall floral list. Plant taxonomy is based on Corell & Corell (1982). The presence, location and abundance of vascular species listed under the Conservation and Protection of the Physical Landscape Act, Protected Trees Order (1997) and the National Invasive Species Strategy for The Bahamas, 2013 were noted when encountered. Percentage cover were recorded in the abundance categories Occasional (less than 20%), Moderate abundance (20-50%), Abundant (50-80%) and Dominant (80-100%).

### 4.8.2 *Vegetation Type - Wetland*

The entire survey area is historically wetland. Lake Cunningham is located immediately north of Gladstone road. Bahamar Blvd, which is connected to the northern end of Gladstone road via a roundabout, was constructed through the easternmost section of this inland waterbody.

The profile on the western side of the road transitions as follows:

1. strip of **human altered** vegetation near the road with landscape species that include a ground cover of *Stenotaphrum secundatum* (St. Augustine grass) with a row of trees that included *Cocos nucifera* (Coconut Palm) and *Tabebuia heterophylla* (Pink Poui); existing utility infrastructure also present;
2. small band of rock revetment along the slope;
3. row of **mixed species** vegetation along the water's edge that included invasive species like *Schinus terebinthifolia* (Brazilian Pepper), *Casaurina equisetifolia* (Australian Pine), and *Scaevola tacadda* (White Inkberry); species common in the upland vegetation such as *Coccoloba diversifolia* (Pigeon Plum) *Lysiloma latisiliquum* (Wild Tamarind) and *Metopium toxiferum* (Poisonwood); and wetland species including *Sabal palmetto* (Sabal palm) and *Chrysobalanus icaco* (Coco Plum) with ***Conocarpus erectus*** **(Buttonwood)** more persistent in the western section.
4. a retaining wall;
5. open water with **Red Mangrove (*Rhizophora mangle*)** 10-15 feet in height.

*Figure 4-25 Vegetation Profile along western side of Bahamar Blvd. (view facing North of Gladstone road)*

*Figure 4-26 Showing retaining wall*

7

*Figure 4-27 Red Mangrove vegetation in water*

*Figure 4-28Western edge of survey area with Buttonwood along wetland edge (view facing East)*

*Figure 4-29 Large stand of invasive Brazilian Pepper*

The eastern most end of Lake Cunningham was cut off during the Bahamar Blvd. road construction. There was no culvert installed thus the entire eastern section is not connected to the open waters of Lake Cunningham. The southern section of the fragmented wetland is recharged by rain water and experiences fluctuations in water levels from 0-3 feet. At the time of the inspection, there was only one foot of water present. ***Rhizophora mangle*** **(Red Mangrove) shrubland** less than 10 feet in hight is scattered throughout this area. *Cladium jamaicense* (Saw Grass) is present as an associated species along the southern edge close to JFK drive road verge. Other species present include wetland species such as *Conocarpus erectus* (Buttonwood) and *Eleocharis sp.* (Spikerush Grass).

*Figure 4-30 Wetland East of Bahamar Blvd. (view facing North)*

The Western and Southern margins of the Red Mangrove Shrubland abut road verges which is **human altered** with landscape vegetation that include a ground cover of manicured grass and hedges of landscape species such as *Conocarpus erectus* var. *sericeus* (Silver Buttonwood), *Nerium oleander* (Oleander) and *Clusia guttifera* (Small leaf Clusia). Underground utilities are also located along the southern verge and above ground infrastructure along the western verge.

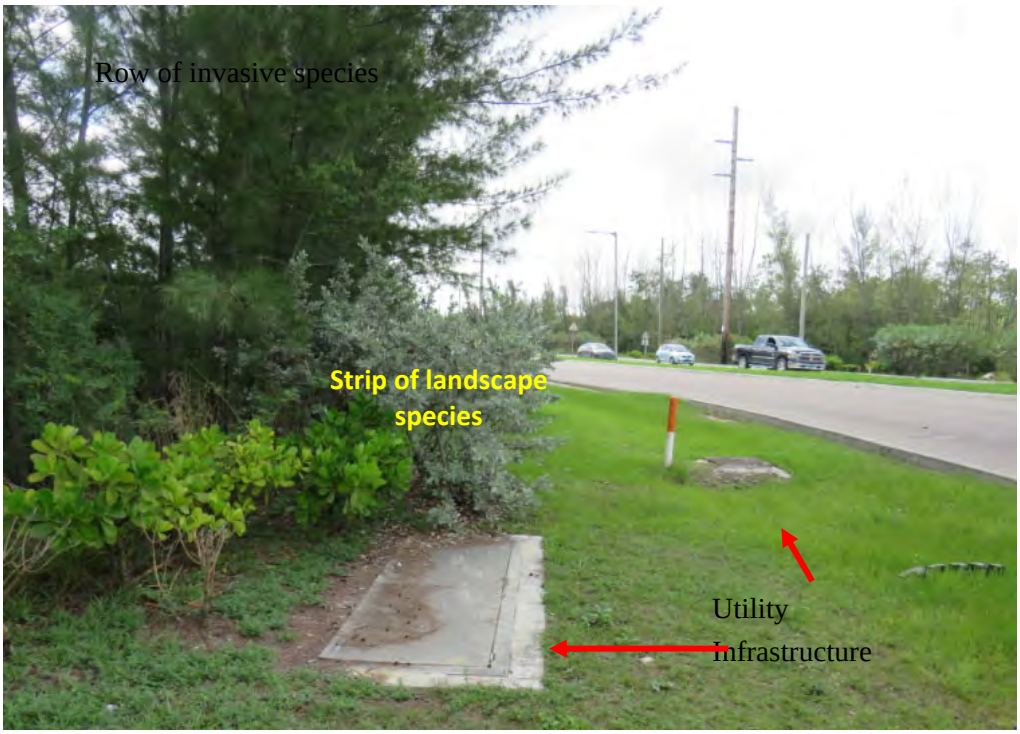


*Figure 4-31Road verge along JFK Drive (View facing East)*

A strip of invasive species is present immediately along the wetland edge and between the landscape verge. There is a causeway running East to West that divides the Eastern fragmented wetland into two sections. The causeway is exclusively ***Casaurina equisetifolia*** **(Australian Pine).**

*Figure 4-32 Causeway dividing the eastern wetland (dominated by Australian Pine)*

To the North of the causeway is a **manmade pond** created from excavation of material. There are signs of poor water quality, evident with the dominance of *Typha domingensi*s (Cattail) and algae build up in the water.

*Figure 4-33 Section of eastern wetland with abundance of Cattail*

### 4.8.3 *Vascular Plant Diversity*

A total of sixty-three (63) vascular plant species was observed during the investigation.

### 4.8.4 *Protected Species*

There were no species listed on the Conservation and Protection of the Physical Landscape Act, Protected Trees Order (1997) was recorded during the survey at Lake Cunningham.

### 4.8.5 *Invasive Species*

Nine (9) species listed on the National Invasive Species Strategy (2013) were recorded during the investigation. Please refer to the Appendix for the full list of invasive species.

### 4.8.6 *Vegetation Map*

*Figure 4-34 Vegetation Map - Lake Cunningham*

## 4.9 Avian Survey – Gladstone Road

The assessment comprised of one (1) day of active avian and ecological observation on March 3, 2020 along the Gladstone Road Corridor. The avifauna of the area was assessed and recorded by walking along the road verge and examining the perimeter of vegetation that abuts verge. Species numbers were recorded in the abundance categories, Single, Few (2-10) and Many (11-100). Species recorded were compiled for final abundance estimates.

Please refer to Section 4.10 for avian and ecological observations taken on May 27, 2020 at Lake Cunningham.

### 4.9.1 *Findings*

#### 4.9.1.1 Species Observed

A total of fourteen (14) species were recorded during the investigation.

(Taxonomic list below based on *The Clements Checklist of Birds of the World*, Sixth edition (2019-update). Status is based on International Union for Conservation of Nature (IUCN).

TABLE KEY:

| RANGE | STATUS |
|---|---|
| **PRB** = Permanent Resident Breeding | **LC =** Least Concern (Conservation- IUCN) |
| **WRN =** Winter Resident Non-breeding | **NT** = Near Threatened (Conservation-IUCN) |
| **e** = Endemic subspecies | |

| SCIENTIFIC NAME | COMMON NAME | MASTER OBSERVATION | STATUS/RANGE/ CONSERVATION STATUS |
|---|---|---|---|
| **Patagioenas leucocephala** | White-crowned pigeon | F | NT/PRB |
| **Streptopelia decaocto** | Eurasian Collared-Dove | M | IRB/LC |
| **Crotophaga ani** | Smooth-billed Ani | F | PRB/LC |
| **Falco sparverius** | American Kestrel | S | PRB/LC |
| **Myiarchus sagrae** | La Sagra's Flycatcher | F | PRB/LC |
| **Plegadis falcinellus** | Glossy Ibis | F | PRB/LC |
| **Dumetella carolinensis** | Gray Catbird | F | WRN/LC |
| **Mimus polyglottos** | Northern Mockingbird | F | PRB/LC |
| **Passer domesticus** | House Sparrow | F | IRB/LC |
| **Mniotilta varia** | Black-and-white Warbler | S | WRN/LC |
| **Setophaga ruticilla** | American Redstart | F | WRN/LC |
| **Setophaga americana** | Northern Parula | F | WRN/LC |
| **Setophaga palmarum** | Palm Warbler | F | WRN/LC |
| **Setophaga discolor** | Prairie Warbler | F | WRN/LC |

*Table 4-1 Avifauna observed on Gladstone Road, New Providence*

#### 4.9.1.2 Species Abundance

With the exception of the urban birds, Eurasian collard-dove *Streptopelia decaocto* and Northern Mockingbird *Mimus polyglottos*, which were present in good numbers, the number of individuals observed for each species recorded was low.

The survey area consisted of verges along a busy road completely disturbed and human altered. Traffic noise and windy conditions were the main factors affecting the outcome of the avian survey and the low number of individuals recorded.

The large areas of grasses that would typically support resident seed eating species e.g. Black-faced grassquit *Melanospiza bicolor;* Common ground dove *Columbina passerina;* Mourning Dove *Zenaida macroura* and migrant species such as Indigo Bunting, *Passerina cyanea* were not conducive to birdlife due to the proximity to the road and associated noise.

The greatest abundance of species was recorded in the pockets of vegetation that provided shelter for the resident and migrant bird species.

### 4.9.2 *Conclusion*

The majority of the survey area was human altered. While avifauna were recorded in the fragment habitat present along Gladstone Road, there were no significant habitat utilization or species of concern recorded during the investigation. Vegetation beyond the road verge was discussed, however, it is unlikely that these areas will be impacted by habitat loss from clearing due the proposed project, based on the design details reviewed.

## 4.10 Avian Survey – Lake Cunningham

### 4.10.1 *Methodology*

The assessment comprised of one (1) day of active avian and ecological observation. The avifauna of the area was assessed and recorded by walking along the road verge and examining the perimeter of vegetation that abuts verge. Species numbers were recorded in the abundance categories, Single, Few (2-10) and Many (11-100). Species recorded were compiled for final abundance estimates.

### 4.10.2 *Findings*

A total of nine (9) species were recorded during the site investigation on May 27, 2020. The number of species recorded is low which can be attributed to the time of year the survey was conducted. The non-breeding fall/winter migrants which account for a significant number of species recorded in The Bahamas have left for their breeding grounds in North America. And the summer breeding species have just starting arriving.

Previous investigations in this area have recorded a diversity of water birds not observed during this investigation using the open water lake/shoreline (west side) and the shallower wetland/mangrove areas at the eastern end throughout the year. Some previously recorded species include ducks such as White cheeked Pintail (*Anas bahamensis*) and Blue winged Teal (*Spatula discors*); waterfowl including Green Heron (*Butorides virescens bahamensis*), Tricolored Heron (*Egretta tricolor*) and Great Egret (*Ardea alba*); and shorebird species like Lesser Yellowlegs (*Tringa flavipes*), Willet (*Tringa semipalmata*) and Clapper rail (*Rallus crepitans coryi*). Land birds have also been recorded utilize the vegetation surrounding the edges of the wetlands and the nearby coppice throughout the year.

During April/May each year, Laughing Gulls (*Leucophaeus atricilla*) congregate in large numbers, by the thousands, along the western shoreline of the lake to select mates for the upcoming summer breeding season. When they have completed this ritual, they leave for the offshore cays to nest. This congregation is not within the survey area and it is unlikely that the event will be impacted by any works in the survey area.

| TABLE KEY: | |
|---|---|
| RANGE | STATUS |
| **PRB** = Permanent Resident Breeding | **LC =** Least Concern (Conservation- IUCN) |
| **SRB =** Summer Resident Breeding | **NT** = Near Threatened (Conservation-IUCN) |

| SCIENTIFIC NAME | COMMON NAME | MASTER OBSERVATION | STATUS/RANGE/ CONSERVATION STATUS |
|---|---|---|---|
| **Patagioenas leucocephala** | White-crowned pigeon | F | NT/PRB |
| **Mimus polyglottos** | Northern Mockingbird | F | PRB/LC |
| **Tachybaptus dominicus** | Least Grebe | F | PRB/LC |
| **Gallinula galeata** | Common Gallinule | S | PRB/LC |
| **Aramus guarauna** | Limpkin | S | PRB/LC |
| **Leucophaeus atricilla** | Laughing Gull | M | PRB/LC |
| **Sternula antillarum** | Least Tern | F | SRB/LC |
| **Tyrannus dominicensis** | Gray Kingbird | F | SRB/LC |
| **Tiaris bicolor** | Black-faced Grassquit | F | PRB /LC |

*Table 4-2 Avifauna observed at Lake Cunningham near Gladstone Road, New Providence, The Bahamas*

### 4.10.3 *Species Abundance*

With the exception of the Laughing Gull (*Leucophaeus atricilla*) which were present in good numbers, the number of individuals observed for each species recorded was low.

### 4.10.4 *Habitat Utilization*

Four (4) of the species recorded were water birds which included a pair of Least Terns (*Sternula antillarum*) that were diving for food in the lake (which is a good indication that they are breeding nearby). Several Laughing Gulls (*Leucophaeus atricilla*) were observed flying over the Lake and resting along the Lake shore. These are likely immatures that are not ready to breed or late breeders that haven't left for breeding sites following the annual congregation ritual. Two (2) waterfowls Least Grebe (*Tachybaptus dominicus*) and Common Gallinule (*Gallinula galeata*) were observed swimming in deeper waters of the lake.

*Figure 4-35 Least Tern diving for food in Lake Killarney*

Several land birds were recorded moving between the nearby upland vegetation to the Northeast and the wetland edge that has upland plant species.

*Figure 4-36 Gray Kingbird perched on branch in vegetation along Lake*

### 4.10.5 *Conclusion and Recommendations*

The western section of the survey area has a healthy stand of Red Mangrove along the perimeter of the northern limits of the survey area. Impacts to these mangroves can be minimized or avoided with careful design considerations and construction impact minimizing techniques.

While the Eastern section of the survey area is fragmented it is still functioning as a habitat for a number of avian species. The fluctuation in water levels during dry and rainy seasons and the overall low water levels attract different species than those that would utilize the deeper waters of the open Lake Cunningham to the West. However, installation of culverts can slow the habitat degradation noted since the fragmentation and improve the quality of the system.

In the event that it is determined that a mitigation project is need the following are recommended for consideration:

1. Installation of culverts to connect Lake Cunningham and the Red Mangrove Shrubland to the East
2. Construction of an observation deck in Lake Cunningham to facilitate bird surveys.

# 5 Socio-Economic Overview

## 5.1 Population

The Bahamas is an archipelagic nation comprising 700 islands and cays situated over 100,000 square miles of the Atlantic Ocean. Located east of Florida and north of Cuba, The Bahamas has a population of 351,461 persons of which 70% reside on New Providence. Collectively New Providence, Grand Bahama, and Abaco represent 90% of the population.

New Providence is located east of Andros, southeast of the Berry Islands, southwest of Abaco, west of Eleuthera and northwest of the Exuma island chain. According to the 2010 Census, 246,329 persons reside on New Providence; it is the most populated island of The Bahamas. Similarly, New Providence is the most densely populated island with a population density of 3,079 persons per square mile. This figure represents a 16.9% increase in population density on New Providence since 2000. The population of The Bahamas is projected to increase to 454,060 in 2040. The Bahamas has a life expectancy of 74 years.

## 5.2 Economic Activities

Tourism plays an important role in The Bahamas; gross tourism expenditure in 2018 amounted to $3.35 billion, directly contributing to 27% of GDP, $12.45 billion. In 2019, overall arrivals increased by 9.41% to 7.24 million visitors with cruise arrivals representing the largest visitor category at 75%. Air and sea arrivals rose by 4.11% to 1.81 million visitors.

While in Fiscal Year 2018/2019, the accommodations and food services industries and wholesale and retail trade sectors expanded by 12.49% ($1.05 billion) and by 7.87% ($1.45 billion), the agriculture, forestry, and fishing industry contracted by 14% to $98.1 million, manufacturing weakened by 16% and construction slowed by 16%.

The Bahamas' country debt to GDP continues to rise and as of September 2019, the national debt stood at $8.317 billion or 66.95% of GDP. It is anticipated that the Government's overall deficit widened following Hurricane Dorian.

The preliminary results of the December 2019 Labour Force Survey note a labor force of 170,835 persons with 78.2% participation rate in the economy. Unemployment stands at 10.7% up from 9.4% in May on New Providence. Of note, the Labour Force Survey December 2019 was only conducted in New Providence due to Hurricane Dorian's impact on Grand Bahama and Abaco. The community, social, and personal services (which includes civil service, police service, and domestic service) accounts for 39% of the overall workforce and constitutes the country's largest employer. Hotels and restaurants follow with nearly 20% of the overall workforce with wholesale and retail at 7%. The Bahamas has a high per capita income of $30,520.

## 5.3 Economic Disruption 2019-2020

The Bahamas has incurred two (2) significant disruptions to economic activity over the past twelve (12) months: Hurricane Dorian and COVID-19. The International Monetary Fund (IMF) estimates 2020 Project Real GDP to decline by -8.3% before rebounding in 2021.

Hurricane Dorian, a Category 5 hurricane, made landfall on Elbow Cay, Abaco in September 2019 and moved slowly east over Grand Bahamas before turning north. It is estimated to have caused $3.4 billion in damages representing 27% of 2018 nominal GDP. New Providence experienced inclement weather but was outside tropical storm conditions.

The second disruption and on-going, is the worldwide COVID-19 pandemic. Given COVID-19 and the curfews imposed by the Emergency Powers Order No. 1, No. 2 and No. 3, economic activity has been severely curtailed and tourism non-existent. The Central Bank notes the near-term economic outlook for The Bahamas has become uncertain and contractionary.

## 5.4 Existing Land Use and Ownership

Gladstone Road is an existing two land road within a 100 ft. right of way. Land acquisition may be required at locations where existing junctions are improved, a new junction is introduced, or utility diversions are required.

Gladstone Road provides access to commercial entities, education institutions, places of workshop and religious organizations, a cemetery, and residential areas. Commercial entities include food and liquor distribution centers, waste management headquarters, warehouses, gas suppliers, petrol stations, plant nursery, and smaller retail units.

A large portion of land abutting Gladstone Road to the west is under the care of the Ministry of Agriculture and Marine Resources which operates the Bahamas Agricultural and Industrial Corporation (BAIC).

Refer to the table below for identified land uses along the GRIP corridor:

| Name | Land Use Type |
|---|---|
| Aquinas College | Education |
| National Emergency Management Authority (NEMA) | Government |
| Nassau Port Facilities Bonded Services | Government |
| Bahamas Waste Management Company | Industrial Distribution |
| Excellence Estates | Residential |
| Victoria Gardens | Residential |
| Jubilee Subdivision | Residential |
| Fusion Superplex | Recreation/Entertainment |
| Sysco Bahamas (Formerly Bahamas Food Services & Tropic Seafood) | Wholesale Distribution |
| Bristol Liquors/1er Cru | Wholesale/Retail Distribution |

| | |
|---|---|
| Lakeview Memorial Gardens & Mausoleum | Cemetery |
| Bahamas Wholesale Agencies | Wholesale Distribution |
| Rubis Gas Station (Under Construction) | Petroleum Product |
| Bahamas Youth Camp | Recreational/Education |
| South Haven Christian Academy | Education |
| National Training Agency | Government |
| Nassau Block Company | Industrial |
| Central Gas | Petroleum Product |
| Munroe's Landscaping | Landscaping |
| Brady Linen Service | Dry Cleaning |
| 360 Waste Management | Industrial |
| Bahamas Foam | Industrial |
| G & G Scrap Service | Automotive |
| Honda Plus | Commercial |
| Easy Car Auto Sales | Commercial |
| Nassau Gas & Tanks | Petroleum Product |
| Phil's Food Services (Building unoccupied) | Vacant Building |
| E. Charles Moss Gas Company | Petroleum Product |
| Meera's Car & Scooter Rentals Plus Tours | Commercial |
| Stuart Auto House & Tires | Automotive |
| New Destiny Baptist Church (Under construction) | Religion |
| Caribbean Gas & Storage Terminal | Petroleum Product |
| Jubilee Mission Baptist Ministries | Religion |
| Farrington House | Community |
| Loyola Hall | Community |
| Carib Construction & Project Management | Religion |
| Mt. Thees Union Baptist Church | Religion |
| Osterbelle Wash & Laundromat Services & Cornerstone Assembly | Dry Cleaning |
| Seventh Day Adventist Regional Headquarters | Religion |

| | |
|---|---|
| BPL Substation | Utility |
| Brandon's Tire Repair and Carwash | Automotive |
| Roots Landscaping | Landscaping |
| Good Earth Farm | Farming |
| Beltek Auto Repair | Automotive |
| 4 Horseman Bar & Lounge | Bar/Restaurant/Lounge |
| Ministry of Agriculture & Marine Resources | Government |
| Country Gas | Petroleum Product |
| The Market at Gladstone Road (BAIC) | Government |
| Royal Kids Academy | Education |
| Polar Ice | Industrial |
| Wong's Home Center/Wong's Print Shop & Copy Center | Commercial |
| BTC & Cash N Go | Retail |
| O.H. Brooks Auto Repair | Automotive |
| Gladstone Road Wholesale Liquors | Wholesale Distribution |
| Paris Beauty Place | Retail |
| St. Ambrose Parish | Religion |
| Carmichael Bible Church | Religion |
| Gladstone Gardens | Residential |
| Ritchville Subdivision | Residential |

## 5.5 Transportation

Gladstone Road is a main arterial road connecting John F. Kenney Drive to Carmichael Road along a predominantly north/south axis. It is a 2.93 mile (15,486 ft.) long, single carriageway with in a 100ft wide road reservation.

Parsons prepared a Traffic Review and Analysis Report for the Gladstone Road Corridor (GRC) to inform the number, locations, and geometric design of intersections to be implemented during the GRC expansion to 4 lanes over a 2040 planning horizon, please refer to the Appendix for the full report. Traffic data collection was completed in February 2020 and used Miovision, a global leader in smart traffic technology.

#### 5.5.1.1 Traffic Review and Analysis – Summary

According to Parsons, average daily traffic within the GRC ranges from 16,000 and 20,000 vehicles with a noticeable imbalance of northbound versus southbound volumes near JFK and Fire Trail whereas Carmichael directional volumes are more balanced. Capacity analyses confirmed operational issues at the Gladstone/JFK roundabout and at the Gladstone Road/Fire Trail and Gladstone Road/Carmichael Road intersections. The lack of deflection for the westbound approach to the JFK roundabout creates issues for other approaches.

#### 5.5.1.2 Traffic Review and Analysis – Recommendations

Parsons Traffic Review and Analysis Report includes but it not limited to the following recommendations:

- Three (3) new full-movement intersections to be provided within the GRC, in addition to the existing intersections and JFK, Fire Trail, and Carmichael. New intersections are suggested near Tranquil, Aquinas College, and near Rocky Pines with exact locations to be identified during final drawings.
- A centre median, prohibiting right-turn movements from/to Gladstone Road except at the designated intersections to maximize safety.
- At JFK, the exiting roundabout control requires refinement to address the existing issue within westbound approach that is recognized to adversely impact the northbound approach. The level of service is expected to increase with realignment and southbound road widening. However, in the long-term, population projections at the low-growth and high-growth scenarios reveal a decline in the level of service provided by the JFK roundabout.

## 5.6 Air Quality and Ambient Noise

Gladstone Road is an existing arterial road. GRIP will widen the existing two (2) lanes to a four (4) lane corridor with safety improvements. No air testing was performed or is anticipated.

Sound collection methodology followed the Florida Department of Transportation (FDOT) Project Development and Environmental Manual: Highway Traffic Noise, July 1, 2020. To note, the FDOT “defines that a substantial noise increase occurs when the existing noise level is predicted to be exceeded by 15 decibels or more as a result of the transportation improvement project. When this occurs, the requirement for abatement consideration will follow.”

Sound recordings were performed by ETS on October 16, 2020 and October 19, 2020 at three time periods (morning, mid-day, late afternoon) at three (3) locations: Aquinas College, JFK Roundabout, and Hall Close. These locations were chosen to capture specific land uses being a school, cemetery & entertainment facility, and a residential community along the entirety of Gladstone Road. With the exception of JFK Roundabout these land uses fall under Activity C with exterior sound level-decibels valued at 66 Leq(h) by FDOT. JFK Roundabout may also be considered Activity E & F due to its proximity to industry, restaurants, and other developed lands where the Activity Leq (h) is at 71 or nonexistent for consideration for noise abatement. Existing sound level data captured for these areas is below the Activity Leq (h) considered by FDOT. It is anticipated that sound levels will not substantially increase along Gladstone Road. The roadway speed limit is anticipated to be 40 mile per hour.

*Figure 5-1 Sound Level Recording Locations*

Results

| Location | Max. Reading (dB) | Min. Reading (dB) | Average (dB) | Activity Leq(h) |
|---|---|---|---|---|
| Aquinas College | 91.3 | 30.8 | 60.6 | 66 |
| JFK Roundabout | 95.4 | 31.6 | 65.6 | 71 + |
| Hall Close | 90.2 | 31.6 | 63.2 | 66 |

*Table 5-1 Sound Level Recording Results*

During construction, there will be an unavoidable increase in noise due to activity of heavy machinery. This will result in a short-term deterioration of sound quality. Best management practices for noise attenuation will be outlined in the Environmental Management Plan. Worker safety will follow NIOSH Recommended Exposure Limits. The NIOSH Recommended Exposure Limit (REL) for occupation noise exposure is 85 decibels, a-weighted, as an 8-hour time weighted average (85 dBA as an 8-hr TWA) using a 3-dB exchange rate. Exposures at or above this level are considered hazardous.

## 5.7 Historic Resources

There are no known historic resources within the Gladstone Road right of way.

## 5.8 Utility Provisions

### 5.8.1 *Sewer& Potable Water*

The Water & Sewerage Corporation (WSC) maintains several potable force mains and sewerage force mains that run parallel to Gladstone Road. These mains are shown on the Master Plan. Agency consultation is on-going to identify and plan works to avoid and/or limit disruption to residents and users of the Gladstone Road Corridor.

### 5.8.2 *Electricity*

The Bahamas Power and Light Company (BPL) maintains a major east-west overhead power transmission system supplying electricity from Clifton Pier to Blue Hills, adjacent to Carmichael Road. The system branches onto a north-south powerline reserve into the Gladstone Road corridor; electrical lines provide power to transformers at the junction of Fire Trail Road and northward to the Cable Beach strip.

BPL also transfers automotive diesel fuel along Carmichael Road to the Blue Hills Power Station. The buried fuel transmission line crosses beneath the Gladstone Road and Carmichael Road intersections.

*Figure 5-2 BPL Pipeline location (red line) Gladstone Road & Carmichael Road Intersection*

# 6 Environmental Laws, National Environmental Policies and International Conventions

The Gladstone Road Corridor comprises several constituencies being Southern Shores represented by The Hon. Frankie A. Campbell, M.P., Golden Isles represented by Vaughn Miller, M.P., and Tall Pines represented by Donald L. Saunders, M.P..

## 6.1 Environmental Laws of The Bahamas

| Environmental Law, Regulation, Policy | Subject | Summary |
|---|---|---|
| Antiquities, Monuments, and Museum Corporation Act 1998, Chapter 51 | To protect antiquities | An Act to provide for the preservation, conservation, restoration, documentation, study and presentation of sites and objects of historical, anthropological, archaeological and paleontological interest, to establish a National Museum, and for matters ancillary thereto or connected therewith. |
| Antiquities, Monuments, and Museum Regulations, 1999 | To establish the National Register of Historic Places and provide application for permits and licences | Regulations to establish the National Register of Historic Places, and provide procedures for application for a permit, application for a licence, fees for permits and renewal application. |
| Bahamas National Trust Act, 1959<br>Bahamas National Trust Amendment, 2013<br>Bahamas National Trust Amendment, 2019 | Designation and management responsibility for National Parks | This Act and Amendment founded the Bahamas National Trust and grant it authority for the provision and oversight of National Parks in The Bahamas.<br>The 2019 Amendment expands the duties of the Bahamas National Trust; to revise the constitution of the council; and to expand its authorized capital investments; and for connected purposes. |
| Conservation and Protection of the Physical Landscape of The Bahamas, 1997 Chapter 260 | Excavation, Landfill, Quarrying, Mining, Protected Trees Listing | This Act makes provisions for the regulation of activities including excavation, landfill, quarrying, mining, and harvesting of protected trees in The Bahamas for the purpose of conservation of maintenance of the environment. The Regulations include a list of protected tree species in The Bahamas. |
| Environmental Health Services (Collection and Disposal of Wastes) Regulations 2004 | To administer and outline waste collection and management facilities | Environmental Health Services (Collection and Disposal of Wastes) Regulations 2004 establish the collection and control of waste including waste facilities and other matters relating to wastes. |
| Environmental Health Services (Fees and Services) Regulations 2000 | To establish fees and services performed by the Department of Environmental Health Services | The Fees and Services regulations outline services and associated fee rates performed by the Department of Environmental Health Services. The Department may provide testing for air quality, water quality, and radioactive materials. |
| Environmental Health Services Act 1987 | To promote and protect the public health and to provide for the conservation and maintenance of the environment | An Act to promote the conservation and maintenance of the environment in the interest of health for proper sanitation in matters of food and drinks, and generally for the provision and control of services, activities, and other matters connected therewith or incidental thereto. |
| Environmental Planning and Protection Act 2019 | To establish the Department of Environmental Planning and Protection | An Act to establish the Department of Environmental Planning and Protection; and to provide for the prevention or control of pollution, the regulation of activities, and the administration, conservation and sustainable use of the environment and for connected purposes. The Act defines procedures for environmental impact assessments and environmental reporting requirements for protection of natural resources. |

| | | |
|---|---|---|
| Environmental Impact Assessment Regulations, 2020 | To provide procedures for a Certificate of Environmental Clearance (CEC). | The Regulations provide procedures for the review proposed projects inclusive of monitoring and compliance requirements. The Regulations dictate the requirements for a Certificate of Environmental Compliance (CEC). |
| Forestry Act of 2010 | To protect the forests and make declarations to use | The Act provides for utilization of forest products and non-timber forest products from the forest estate. It sets forth the management and conservation of the Forest estate and associated industries. |
| Health and Safety at Work Act 2002<br>Health and Safety at Work Amendment, 2015 | To protect human health and safety at work | The purpose of the Act is to secure the health, safety and welfare of persons at work- protect persons other than persons at work against risks to health or safety arising out of or in connection with the activities of persons at work- control the storage and use of explosive or highly flammable or otherwise dangerous substances, and generally preventing the unlawful acquisition, possession and use of such substances. |
| Planning and Subdivision Act, 2010<br>Planning and Subdivision Regulations (Application Requirements), 2011 | To regulate the built environment | This Act regulates the development of the built environment though physical planning protocols across the archipelago of The Bahamas. The Act stipulates the process for subdivision approval subject to specific conditions with respect to the features of the proposed development or project including the preparation of an Environmental Impact Assessment/Statement. |
| Plant Protection Act 2016 | To protect and promote plant health | An Act to protect and promote plant health; to prevent the introduction and spread of plant diseases and pests and to provide for appropriate phytosanitary measures for their control; to facilitate trade in plants and plant products; and to regulate other matters connected thereto. |
| Public Works Act 1963 | To provide for the physical development of The Bahamas | An Act to provide for the construction, management and development of public works, buildings, and road. |
| Water and Sewerage Act 1976 | To establish the Water and Sewerage Corporation and to control water resources | An Act to establish a Water and Sewerage Corporation for the grant and control of water rights, the protection of water resources, regulating the extraction, use and supply of water, the disposal of sewage and for connected purposes |
| Wild Animals Protection Act 1968 | To protect wild animals of The Bahamas | The Act provides a listing of protected animal species in The Bahamas |
| Wild Birds Protection Act 1987<br>Wild Bird Protection Act (Reserves) | To protect wild birds of The Bahamas | The Act protects the wild birds of The Bahamas and makes provision for the dedication of time periods for the hunting of specific species. |

## 6.2 National Environmental Policies

| Relevant National Policies | Subject | Summary |
|---|---|---|
| National Policy for the Adaptation to Climate Change 2005 | Climate change assessment for the immediate and project adaptation techniques for The Bahamas | The National Policy for the Adaptation to Climate Change outlines a national framework to meet the goals and objectives of the United Nations Framework Convention on Climate Change (UNFCC). The Bahamas is committed to reduce greenhouse gases and address climate change impacts. |
| National Invasive Species Strategy for The Bahamas, 2013 | Identifies and recommends a management framework for the control and eradication of invasive species. | The National Invasive Species Strategy for The Bahamas originally published in 2003, was updated in 2013 as part of the Global Environment Facility funded project, Mitigating the Threats of Invasive Alien Species in the Insular Caribbean (MITIASIC). It sets forth a management framework for the control and eradication of invasive species. |
| National Biodiversity Strategy and Action Plan, 1999 | A plan to maintain biodiversity through sustainable development for a small island developing nation. | The Bahamas Government is committed to conserve biodiversity and to pursue sustainable development. This document highlights the role of biodiversity in the Bahamian social and environmental context and recommends measures to ensure its compatibility with future development. |

## 6.3 International Conventions of Relevance

| International Convention/Organization | Subject | Summary |
|---|---|---|
| Cartagena Convention Ratified: June 24, 2010 | An agreement for the protection and development of the marine environment in the wider-Caribbean region | The Convention provides a legal framework for cooperation in the wider Caribbean region. Three technical agreements support the Convention which include:<br>- Protocol for Co-Operation in Combating Oil Spills<br>- Protocol for Specially Protected Areas and Wildlife (SPAW)<br>- Protocol Concerning Pollution from Land-based Sources and Activities (LBS) |
| Convention on Biological Diversity Signed: June 12, 1992 | To preserve species diversity | The Bahamas is a signatory to the Convention on Biological Diversity which came into force December 1993. It has three main goals: a) The conservation of biological diversityb) The sustainable use of components of biological diversityc) The fair and equitable sharing of the benefits arising out of the utilization of genetic resources |
| Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar Convention) Signed: June 7, 1997 | This convention provides a framework for the international protection of wetlands as contributors for human resources and moreover, for avifauna which do not adhere to international boundaries. | The Bahamas is a signatory to the Convention on Wetlands of International Importance, also known as the Ramsar Convention. This convention provides a framework for the international protection of wetlands as contributors for human resources and moreover, for avifauna which do not adhere to international boundaries. Ramsar defines wetlands as ‘areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters’. |

| | | |
|---|---|---|
| Convention to Combat Desertification & Drought<br>Signed: Nov. 10, 2000 | To combat desertification and to mitigate the effects of drought | The Convention is a proponent for sustainable development by addressing social and economic issues that directly impact land degradation. |
| United Nations Framework on Climate Change<br>Signed: June 1992<br><br>Kyoto Protocol<br>Signed: April 9, 1999<br><br>Paris Agreement<br>Ratified: August 22, 2016 | To stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with climate systems | The Bahamas is a signatory to UNFCC which entered into force in March 1994. The UNFCC was the culmination of climate negotiation at the Rio Earth Summit in 1992. This summit established a framework with an aim to stabilize atmospheric greenhouse gas. The Kyoto Protocol was developed under the UNFCC to provide emissions targets and timetables for developed countries. The Paris Agreement as put forth at the Conference of the Parties (COP21) in December 2015. The agreement has not yet come into force as it requires at least 55 parties to have ratified the agreement. |

## 6.4 Government Departments and Local Non-Governmental Organizations

- Ministry of Public Works
- Ministry of the Environment and Housing
- Ministry of Agriculture and Marine Resources
- Department of Forestry
- Department of Environmental Planning and Protection
- Department of Physical Planning
- Department of Environmental Health
- Water and Sewerage Corporation
- Bahamas Power & Light

# 7 Register of Environmental Issues

| Register of Environmental Issues: Gladstone Road Improvement Project (GRIP)<br><br>Project Objective: The Government of The Bahamas (GOB) through the Ministry of Public Works (MOPW) seeks to undertake the widening of the route from a single land to a dual carriageway (4 lanes). In addition to increased vehicle capacity, the improvements will include junction improvements, installation of medians, drainage facilities, street lighting, traffic signs, and road markings. | | | |
|---|---|---|---|
| Aspect | Ecological/Social Value | Impacts | Recommendations for Mitigation & Management |
| Botanical | Vegetation at the site consists of interior upland. Previously cleared areas have revegetated predominantly with invasive species. Elsewhere verges are either manicured with frequent mowing, vacant lots, or with buildings. Historically, prior to clearing the site was predominantly pine woodland. Botanical and avian surveys were performed at Gladstone Road and Lake Cunningham.<br><br>Sixteen (16) invasive species were observed in previously cleared areas occurring mostly to the east of the road. These areas revegetated almost exclusively with a variety of invasive species in some instance or form large stands of the same species in the case of *Casuarina equisetifolia* (Australian Pine).<br><br>Five (5) protected tree species were recorded including *Guapira discolor* (Narrow leaf Blolly), *Swietenia mahagoni* (Mahogany), *Pinus caribaea var. bahamensis* (Caribbean Pine), | Given the site's previous disturbance, the quantity of invasive species types, the presence of the protected tree species as ornamental in landscaping, GRIP will not have a significant impact on botanical species. Lake Killarney and its floodplains abut Gladstone Road. Excessive rain coupled with sea level rise may hamper drainage and result in prolonged internal flooding. It is expected that engineering controls for stormwater will prevent runoff into wetland areas along the periphery of Lake Killarney and provide adequate drainage to maintain safe passage along an arterial roadway.<br><br>Realignment of the JFK roundabout will result in the loss of wetland vegetation. It is recommendation that red mangrove is removed by individual to prevent unnecessary clearing.<br><br>These same engineering controls will take into consideration storm surge impacts, inclement weather, and sea level rise stemming from climate change. | 1. Engineering controls for stormwater<br>2. Mangrove Mitigation 2:1<br>3. Removal of Invasive Species<br>4. Landscaping with Native Species<br>5. Erosion and Sediment BMPs<br>6. Air Quality & Dust Mitigation BMPs<br>7. Waste Management Program<br>8. Site Safety & Health (PPE) |

| | | | |
|---|---|---|---|
| | *Caesalpinia vesicaria* (Brasiletto) and *Ceiba pentandra* (Silk Cotton). | Land clearing and site preparation activities should focus on the avoidance and minimization of sediment and erosion, pollution prevention, waste management, materials storage, refueling, and BMPs included herein. | |
| Avian | Fourteen (14) avian species were observed during field investigations at Gladstone Road. With the exception of the urban birds, Eurasian collard-dove *Streptopelia decaocto* and Northern Mockingbird *Mimus polyglottos*, which were present in good numbers, the number of individuals observed for each species recorded was low.<br><br>At Lake Cunningham, four (4) waterfowl were observed foraging in the water. A total of nine (9) avifauna species were observed here. | Traffic noise and windy conditions were the main factors affecting the outcome of the avian survey and the low number of individuals recorded. While avifauna were recorded in the fragment habitat present along Gladstone Road, there were no significant habitat utilization or species of concern recorded during the investigation. | 1. Landscaping with Native Species<br>2. Air Quality & Dust Mitigation BMPs<br>3. Noise attenuation BMPs<br>4. Dark Sky Association approved Lighting |
| Socio-Economic | GRIP will widen roads to accommodate increasing vehicle use driven by increased commercial, residential, and industry development along and accessed by Gladstone Road. Gladstone Road is an arterial road for travel to Nassau for commerce and employment.<br><br>Congested with idling vehicles and no safety measures for pedestrians, the present condition of Gladstone Road hampers safe and efficient travel. | The Traffic Management Master Plan will address community health and safety during construction. Traffic noise can be a significant nuisance leading to interference with conversation, stress, and raised blood pressure and heart rates.<br><br>Air emissions typically relate to dust during construction and exhaust from vehicles. The road expansion may result in visual intrusion to nearby properties.<br><br>A 4-lane roadway with median will require a change in behavior with backtracking necessary to access properties on the opposite side. | 1. Traffic Management Master Plan<br>2. Site Safety & Health (PPE)<br>2. Air Quality & Dust Mitigation BMPs<br>3. Noise attenuation BMPs<br>4. Grievance Redress<br>5. Public Notification<br>6. Landscaping<br>7. Dark Sky Association Approved Lighting |

| | | | |
|---|---|---|---|
| | | Community stakeholders will be kept informed by a minimum of three (3) formal town hall meetings. Grievance redress will provide a method for community members to participate with effective response by the Contractor. | |

# 8 Environmental Management

Environmental management is a systematic approach that integrates environmental policy and planning with continuous monitoring of implementation techniques to improve environmental compliance in order to achieve the goals of sustainable development. Hazards to human health and safety and the environment can be managed through careful planning, vigilance and strong communication during works, and continual improvement to the overall environmental management program.

The preferred management approach is to avoid, minimize, and control adverse impacts to human health, safety, and the environment. Where adverse impacts cannot be avoided, best management practices should be employed to mitigate human and environmental harm.

The EMP is a dynamic document with revisions anticipated throughout the various stages of the Project. A copy of the EMP will be kept on site at all times.

## 8.1 BMPs Road Construction

Best management practices for road construction and operation pertain primarily to physical hazards such moving vehicles and equipment operation. Additional focus areas for road construction BMPs include:

- Traffic Management Master Plan to ensure work zone safety for construction workers and the travelling public.
- Chemical hazards associated with dust exposure and paving activities, exhaust from heavy equipment and motor vehicles and managed through the use of PPE.
- Noise hazards associated with operation of heavy equipment and working in close proximity to vehicular traffic and managed through the use of PPE.
- Community health and safety measures to manage pedestrian safety, traffic safety, and community awareness of works.
- Emergency preparedness to address on site accidents, vehicle accidents, inclement weather, and release of oil or hazardous materials.

## 8.2 Good Housekeeping Practices

Good housekeeping practices help to maintain a safe and healthy workplaces by eliminating hazards. While seemingly simple, a well-kept site improves productivity and worker health thereby aiding in accident and fire prevention. A tidy work site, free of clutter and organized, allows for more effective use of the site.

General guidelines for good housekeeping practices include but are not limited to the following:

- Identification and marking of physical hazards, such as open trenches
- A designated materials storage area with adequate space and organization for supplies
- Preventive maintenance on tools and machinery to reduce the threat of spills and accidents

- A waste management program that provides and frequently empties bins for litter, dumpsters, and a designated area for construction debris
- Daily street cleaning to prevent elevation of dust particles and mud during rainfall events

## 8.3 Site Safety and Health

Personnel on site will have access to sanitary conveniences, potable water, and personal protective equipment (PPE). PPE protects the body from safety and health risks at work. Additional PPE will be available for work sites near water or open trenches with standing water and will include ladders, safety harnesses, and training.

PPE will include but is not limited to the following:

- Steel toed boots
- Safety Vests
- Hard hats
- Gloves
- Eye Protection

All personnel will undergo an initial site safety and health training followed by periodic tool-box talks. Employees should receive training on how to use PPE properly and effectively. PPE shall be inspected and maintained in good condition. If PPE becomes worn or broken, new PPE shall be distributed and used.

Potable drinking water will be available on site at all times. Sanitary conveniences will be available for use on site and regularly emptied.

Adequate lighting will be provided should works continue during nighttime hours.

A first aid kit and emergency contact list will be available at all times. Hazards such as open trenches and utilities, will be marked by caution tape. Security and signage will identify hazards to public safety.

## 8.4 Materials Storage

Materials stored according to best management practices prevent spills through hazard avoidance.

Materials shall be stored in a designated and secured area. Every material requires specific handling procedures as materials differ by composition, size, and weight. Materials shall be handled and stored according to specifications found in the Material Safety Data Sheet (MSDS). MSDS shall be kept on site at all times.

Flammable materials will be stored away from ignition sources to prevent fire. The Contractor shall have fire extinguishing equipment on site at all times.

## 8.5 Traffic Management Master Plan

The Contract will prepare a Traffic Management Master Plan (TMMP) to address the reduction of road network capacity during construction. The TMMP will address: safe access to the site, the effects of noise, dust, vibration, and exhaust fumes. According to the Employer’s Requirement, the TMMP shall include but is not limited to the following:

- A description of the plan and the basis on which it has been developed clearly stating how the contractor intends to sequence the Works while minimizing the impact on the road network capacity.
- A description of the proposed plan for lane closures and detours on each section of the Work
- A schedule showing roads corridors with no traffic management in place (new), corridors with no traffic management in place (existing), corridors with traffic management in place (under construction) and corridors open to traffic (construction substantially complete) on a month-by-month basis
- An outline describing how the contractor intends to satisfy any constraints
- A statement describing how the contractor intends to seek specific and general approvals from the relevant statutory bodies
- A statement describing whether he intends to undertake night work at key locations to minimize traffic congestion
- A description of how the contractor intends to liaise with affected residents, local businesses, public utilities, emergency services, and the media on affected roads
- An outline describing how the contractor intends to manage complaints relating to traffic management
- An outline describing how the contractor intends to communicate and coordinate the opening of new sections of Work
- A description of how the contractor intends to enforce and maintain Traffic Management

## 8.6 Waste Management

Waste management identifies a project's waste streams, makes provision for timely and effective removal, and allocates responsibility for waste disposal. General housekeeping should keep the work areas free of litter and ad-hoc construction debris.

All solid waste materials will be placed in a designated dumpster or bin to be emptied on a fixed schedule and disposed of at a facility as directed by the Department of Environmental Health Services (DEHS). Sanitary conveniences will be emptied at regular intervals by an approved sewage disposal company. Hazardous materials, if any, will be identified, appropriately stored, and disposed of in coordination with DEHS.

## 8.7 Protection and Preservation of Natural Resources/Sensitive Environmental Features

Employment of best management practices will minimize adverse impacts to natural resources and ensure viability of sensitive environmental features such as caves, wetlands and nearshore habitats.

- A walkover survey is performed to identify affected protected tree species and to apply for a permit to harvest a protected tree under the purview of the Department of Forestry under the Forestry Act 2010.
- Fencing of particularly sensitive areas is required to prevent disturbance to wildlife and encroachment. Temporary fencing shall be placed around broadleaf coppice, woodland edges to protect from encroachment, illegal dumping and damage from machinery.
- Erosion and sediment control measures will minimize sedimentation impacts and constitute a form of pollution control.

- Spill prevention practices include designated refueling and fuel storage areas with adequate containment measures, preventive heavy vehicle and machinery maintenance, and spill clean-up kits on site, and waste management.

## 8.8 Stormwater

Construction or widening of roads increases the amount of impervious surface areas which increases the rate of surface water runoff. These high stromwater flow rates can lead to erosion and flooding. Stormwater may be contaminated with oil and grease, metals, particulate matter, and other pollutants released by vehicles. Stormwater may also contain nutrients and herbicides used for the management of vegetation in the right of way.

Stormwater management practices slow peak runoff flow, reduce sediment load, and increase infiltration. Infiltration is increased via vegetated swales, filter strips, terracing, detention ponds or basins, infiltration trenches/basins, and constructed wetlands.

General stormwater management practices:

- Methods to reduce/slow peak runoff flow
- Installation of oil/water separators
- Regular maintenance of erosion and runoff control measures

## 8.9 Erosion and Sediment Control

Sediment impacts may occur during heavy storm events where flash flooding may erode surfaces and transfer suspended sediments to another location. Turbid conditions may adversely affect light penetration through the water column impairing photosynthesis for marine species.

BMPs for erosion and sediment control include but are not limited to the following:

- Dewatering hoses will be placed away from sensitive environmental features and allow time for suspended sediment to fall out.
- Installation and on-going maintenance for sediment and erosion control devices such as silt fencing and/or turbidity curtains
- Revegetation and/or sodding of a cleared area

## 8.10 Prevention of Pollution of Groundwater Resources

Employment of best management practices will minimize adverse impacts to natural resources and ensure viability of sensitive environmental features such as wetlands and nearshore habitats. Erosion and sediment control measures will minimize sedimentation impacts and constitute a form of pollution control.

Spill prevention practices include

- A designated refueling and fuel storage area; with adequate containment measures (110% of capacity);
- Preventive heavy vehicle and machinery maintenance;

- A designated wash-down area away from surface waters and sensitive environmental features
- A waste management program, and;
- Spill clean-up kits on site.

## 8.11 Air Quality and Noise

Air

The Contractor shall implement measures to maintain ambient air quality. Fine sediment may become airborne during the dry season which typically begins in November and ends in late May. Dust mitigation strategies include periodic dampening and street cleaning of the public roadway, Gladstone Road.

Additional practices for management of air quality include but are not limited:

- Tarpaulins used on dump trucks
- Vehicle speed restrictions
- Frequent site watering during the dry season
- Daily road cleaning and sweeping

Noise

Noise prevention and mitigation begins at the source of noise. Noise reduction at the source prevents extraneous noise output. Noise reduction option include but are not limited to the following:

- Selecting equipment with lower sound power levels
- Installing suitable mufflers on engine exhaust and compressor components
- Installing acoustic enclosures for equipment casing radiating noise
- Installing vibration isolation for mechanical equipment
- Limiting hours of operation for specific pieces of equipment or operations, especially mobile sources operating through community areas

Noise impacts should not exceed the following:

| Construction Noise Standards | | | |
|---|---|---|---|
| Time | Noise levels in dBA | | |
| | L10 | L95 | Lmax |
| 0530-0730 | 60 | 45 | 70 |
| 0730-2000 | 70 | 55 | 85 |
| 2000-0530 | 55 | 40 | 75 |

*Table 8-1 Noise Level Guidelines MOW Employer's Requirements – Specification*

| Noise from Construction Equipment | | |
|---|---|---|
| Equipment | Typical noise (dBA) | Range (dBA) |
| Portable air compressor | 81 | 74-87 |

| | | |
|---|---|---|
| Concrete Mixer | 85 | 81-89 |
| Jackhammer | 88 | 81-89 |
| Pneumatic Tools | 85 | 82-89 |
| Generator | 76 | 71-82 |
| Pile Driver | 101 | 95-106 |

*Figure 8-1 Noise from Construction Equipment MOW Employer's Requirements - Specification*

## 8.12 Fire and Hurricane Risks

The North Atlantic tropical cyclone season begins June 1st and ends November 30th. However, tropical disturbances may form prior to the start and after the close of this time period. As The Bahamas lies within the hurricane zone, it is expected that tropical disturbances, tropical depressions through Category 5 Hurricane, may periodically make landfall. Risks associated with tropical cyclones include storm surge, high winds, and heavy rainfall. Given the low elevation of the site and the surrounding areas, the drainage system must be able to effectively dispose runoff during heavy storm events.

Fire-fighting equipment such as a fire extinguisher must be available on site at all times. The inventory of materials shall dictate any substances requiring additional specialty fire-fighting equipment. A list emergency numbers should be available on site at all times.

## 8.13 Environmental Monitoring

Environmental compliance is achieved through frequent and consistent site inspection and strong communication with the Contractor. Construction monitoring documents Contractor compliance to the EMP with respect to but not limited to: site safety and health, protection of ground water, general housekeeping, hazardous waste disposal, noise and air quality control, and protection of natural resources. The monitoring checklist is the mechanism within the environmental management system to document onsite practices, provide recommendations, and note when corrective action is required.

Environmental monitoring will be performed daily with reports provided to DEPP electronically daily. These daily reports will be compiled and recorded in monthly reports to the DEPP.

Monitoring for GRIP shall include but not be limited to:

- Erosion along highway segments and borrow sites during and after construction
- Silting and increased sediment loads to water bodies in the vicinity of the roads
- Investigating drainage wells to ensure no inadvertent pollution of the underlying freshwater lens
- Noise impacts and air pollution and dust impacts
- Installation of erosion control and drainage works (including silt traps)
- Extraction and restoration works at borrow areas
- Vegetation and wildlife protection measures
- Prevention of damage to undiscovered significant archaeological or historical finds
- Verification that appropriate waste management and disposal operations at construction sites are employed

- Assurance that construction sites are cleaned up and restored after construction activities cease
- Inspection of vegetative cover (removal and regrowth) on the basis of field examination

## 8.14 Grievance Redress

Grievance redress is a management tool to identify, assess, and provide resolution of complaints during a project cycle. Implementing a system of grievance redress early in a project's cycle allows for resolution of minor issues before escalation to high-profile and expensive disputes at the local and national level. Support is garnered from local communities which have access to a system for complaint filing and resolution. Grievance redress mechanisms (GRMs) are a core component of managing project operational risk.

Given the high traffic volume and use of Gladstone Road, it is highly recommended that GRMs are incorporated to the overall project. system to receive, catalogue, and respond to community concerns will be paramount.

According to the *World Bank's Approach to Grievance Redress in Projects* the following steps should be taken:

Step 1 Assessment of Risks and Potential Grievances and Disputes
Step 1 is the identification of potential issues, stakeholders, and existing institutional capacity for dispute resolution.

Step 2 Capacity Assessment
Step 2 reviews the capacity for local and national institutions to address and resolve project concerns. Institutions will be reviewed through a credibility assessment with the following criteria: legitimacy, accessibility, predictability, fairness, rights compatibility, transparency, and capability.

Step 3 Action Plan
Step 3, the Action Plan, creates tangible steps to be implemented during project planning and execution to enable effective grievance management for dispute resolution. Successful grievance management systems contain the following components:

- Access Point(s) for Complaints, i.e. Help Desk
- Grievance Log Database
- Assessment, Acknowledgement, and Response to Complaint(s)
- Appeals Process
- Resolve and Follow-Up

## 8.15 Draft EMP TOR - GRIP

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Environmental Management Plan
Gladstone Road Improvement Project
New Providence, The Bahamas


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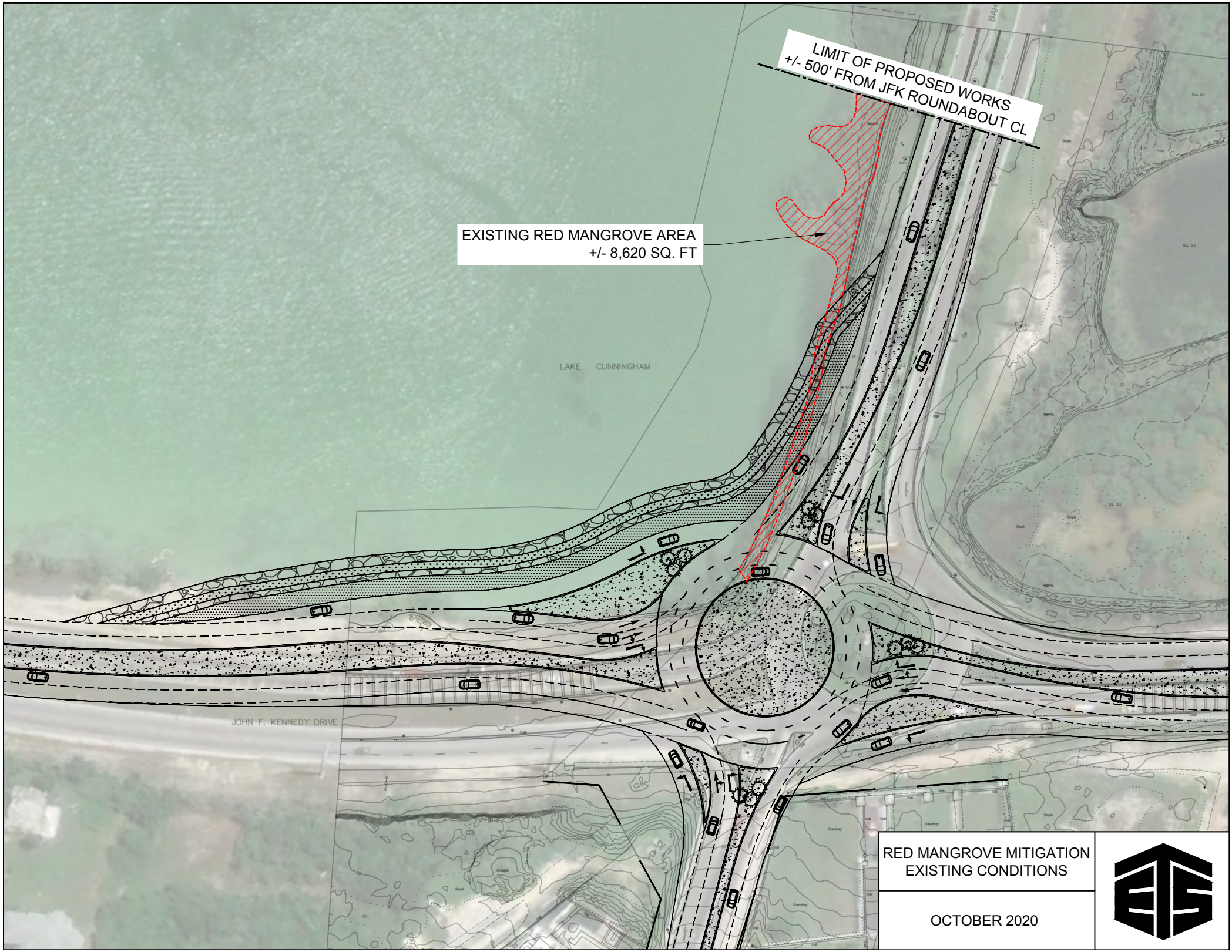
13.1. Oil Spill Plan
13.2. Hurricane Preparedness Plan
13.3. Hazardous Materials Management & Response

14. Appendix
14.1. Stormwater Management Plan
14.2. Traffic Management Master Plan

# 9 Recommendations and Mitigation Strategies

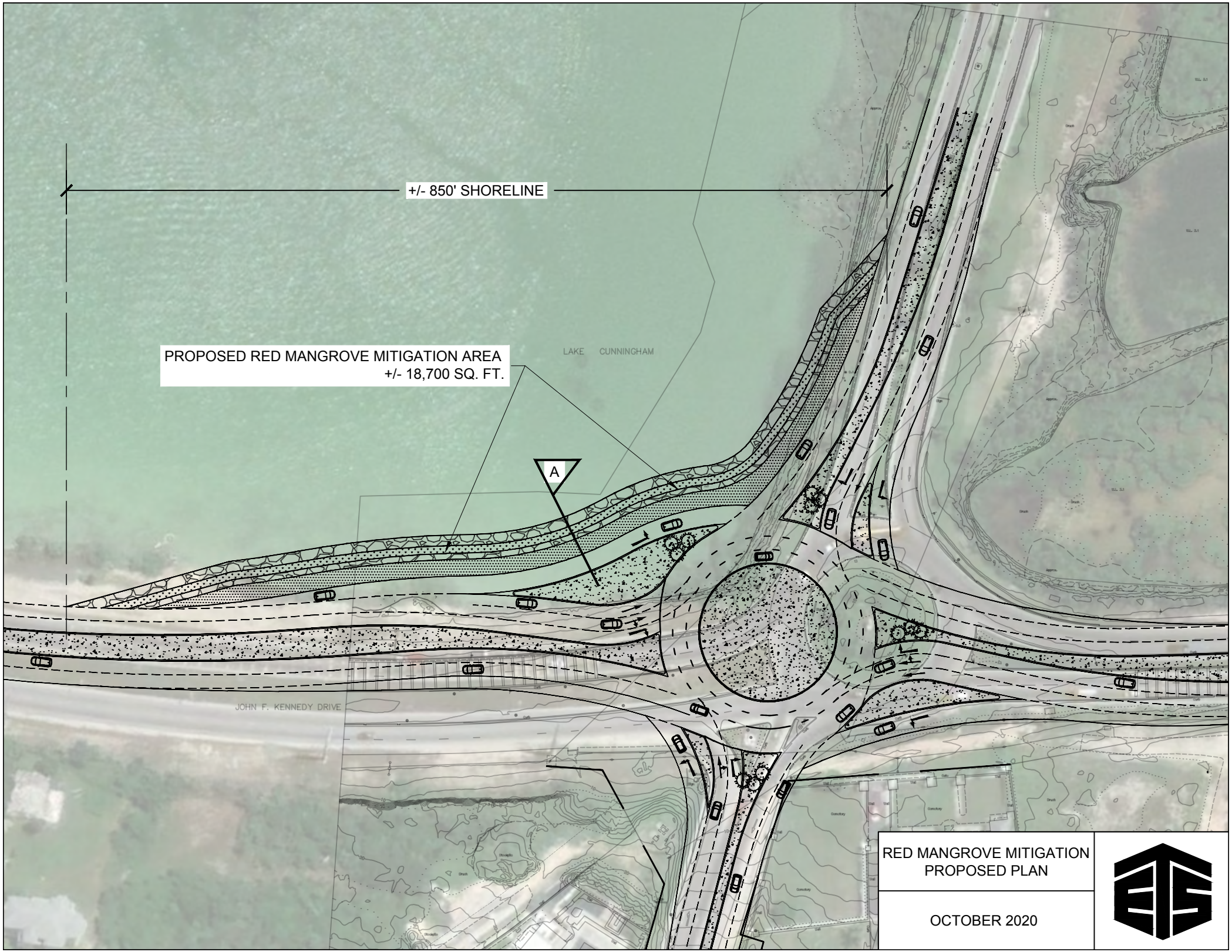
## 9.1 JFK Roundabout Reorientation

The Gladstone Road and JFK Roundabout will be reoriented to enhance driver safety and increase the Level of Service. This reorientation will result in a direct loss of red mangrove shrubs on the eastern perimeter of Lake Cunningham abutting Baha Mar Boulevard. It is estimated that up 8,620 sq ft of existing mangrove area may be impacted by the construction works. To mitigate this loss of mangroves, the road design will incorporate 18,700 sq ft of mangrove planting area. Please refer to the next pages for drawings.



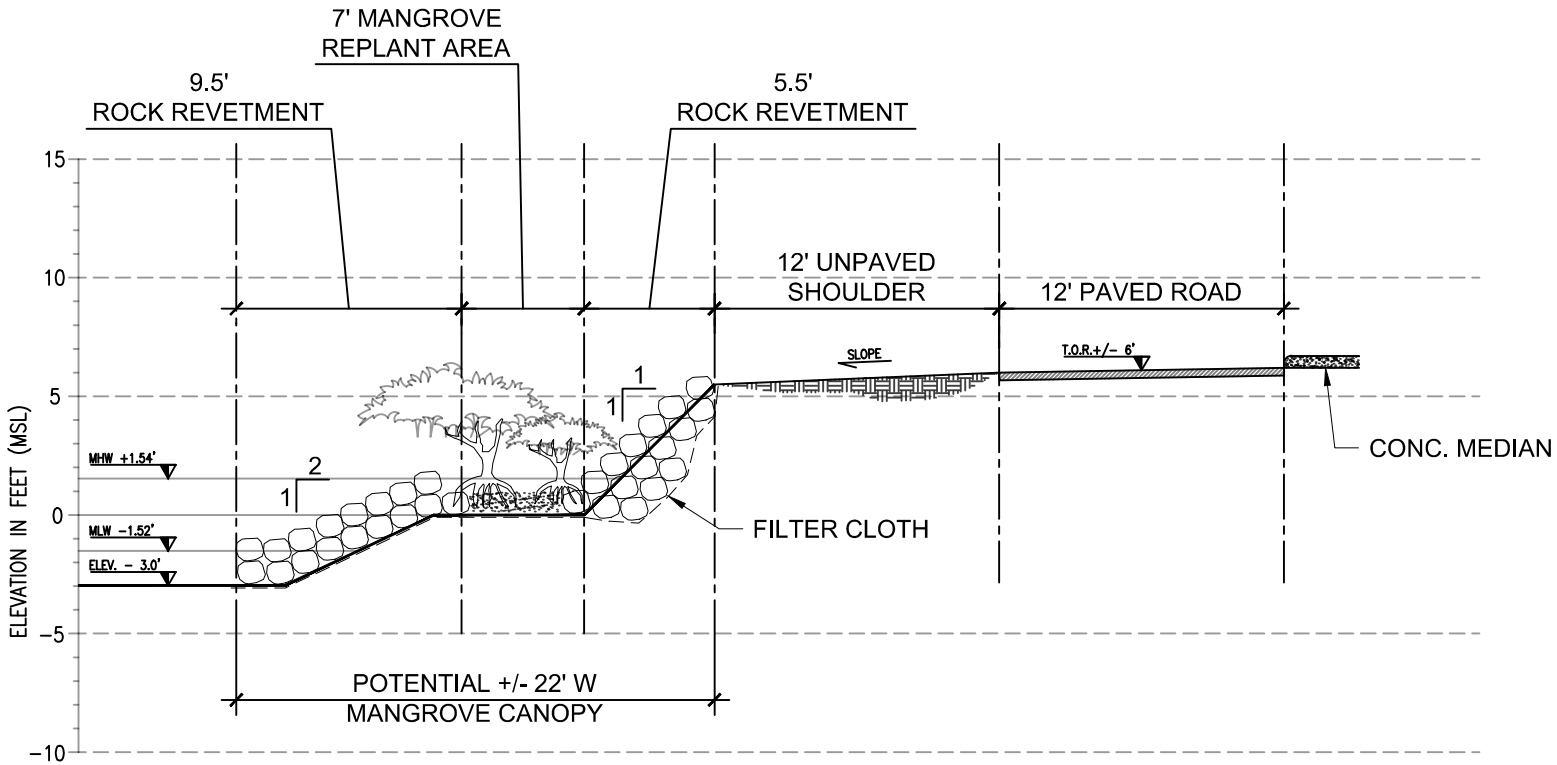

RED MANGROVE MITIGATION
EXISTING CONDITIONS

OCTOBER 2020




RED MANGROVE MITIGATION
PROPOSED PLAN

OCTOBER 2020




# SECTION A - TYP. ENBANKMENT DETAIL

SCALE: 1/8" = 1'-0"

| |
|---|
| RED MANGROVE MITIGATION<br>PROPOSED TYP. SECTION |
| OCTOBER 2020 |

### 9.1.1 *Botanical Baseline Condition*

*Figure 9-4 Baha Mar Bldv., JFK, & Gladstone Road Roundabout Vegetation Map*

The proposed reorientation of the roundabout will impact the southern portion of the mangrove fringe, mixed species, and human altered areas along the Airport Gateway dual carriageway. Existing species within the proposed area for reclamation include native flora *Rhizophora mangle* (Red Mangrove) *Conocarpus erectus* var. *sericeus* (Silver Buttonwood), and *Clusia guttifera* (Small leaf Clusia) and invasive species, notably a large stand of Brazilian pepper, and Casuarina equisetifolia (Australian pine).

*Figure 9-5 Western edge of survey area with Buttonwood along wetland edge (view facing East)*

*Figure 9-6 Large stand of invasive Brazilian Pepper*

*Figure 9-7 Baha Mar Boulevard Verge Transition to Wetland at Lake Cunningham*

It is anticipated that hydrologic conditions will be conducive to mangrove planting success given the existing presence along Lake Cunningham's eastern shoreline. The southwest portion of the reclamation may transition to wetland species that exist in more ephemeral wetland conditions such as buttonwood.

The total number of mangrove shrubs to be removed will be determined upon construction. Mangrove shrubs will be moved with the intention for reuse in combination with locally available mangrove seedlings. Again, given the presence of red mangroves within the existing wetland community, hydrologic conditions with some physical assistance along the area of reclamation should allow for continued natural revegetation of Lake Cunningham's shoreline.

## 9.2 Reduce Light Pollution – IDA Approved Lighting

- Reduce light pollution by the installation of IDA approved lighting
- IDA approved lighting minimizes glare and reduces light trespass

The International Dark Sky Association (IDA) educates lighting stakeholders including the public about light pollution to preserve dark night skies. The association developed a Fixture Seal of Approval to provide objective, third-party certification for lighting that minimizes glare, reduces light trespass, and doesn't pollute the night sky.

Light pollution affects wildlife and ecosystems including avian species. Additionally, human health can be impacted by unnecessary lighting that disrupts sleeping patterns and causes irritation. The installation of lighting systems draws energy and should be placed only where deemed necessary.

GRIP anticipates installing CREE XSP Series street lamps which are IDA approved when ordered with 27K7 or 30K7 CCTS.

## 9.3 Pedestrian and Bicycle Shared Pathway – Optional Social Benefit

- Improved fitness and physical activity
- Access to the outdoors
- Reduced use of motor vehicles for short-trips
- Integrates with the IDB Emerging and Sustainable Cities Initiative – Sustainable Nassau Action Plan (2016)

With an existing right-of-way utility corridor, installation of a pedestrian & bicycle pathway will positively benefit residents and users of Gladstone Road. The 2016 Final Draft release of Study 3 – Urban Growth Study within the Sustainable Nassau Action Plan, recognized the need for and the ability to implement an island wide bicycle system (See Figure below).

Pedestrian and bicycle pathways can co-exist with utilities and high traffic roadways. Electric and magnetic fields exist wherever electric current flows (powerlines, electrical appliances, etc.). Design criteria are presently being reviewed to consider feasibility of a bicycle pathway.

*Figure 9-8* Proposed network of bicycle and recreation paths for New Providence

*Figure 9-9 Washington & Old Dominion Trail in Falls Church, Virginia, USA*

## 9.4 Planting with Native Tree Species and Removal of Invasive Species

GRIP provides an opportunity to beautify the Gladstone Corridor through native tree planting and creation of natural drainage areas such as swales or retention ponds.

**Invasive Species Removal.** Removal of invasive species considered a threat to small island nations will slow the proliferation of unwanted plant species. It is recommended that the Ministry of Works or relevant Department perform routine removal of saplings to prevent recolonization.

**Planting with native tree species.** A landscaping program that uses a palate of native trees will encourage visits by native fauna.

# 10 Contributors

Melissa Alexiou, Environmental Specialist, Waypoint Consulting

Lambert Knowles, Engineer, ETS

Tanya Ferguson, Botanist

Predensa Moore, Avian Expert

Philip Weech, Climate Vulnerability Assessment

Parsons, Traffic Review and Analysis Report

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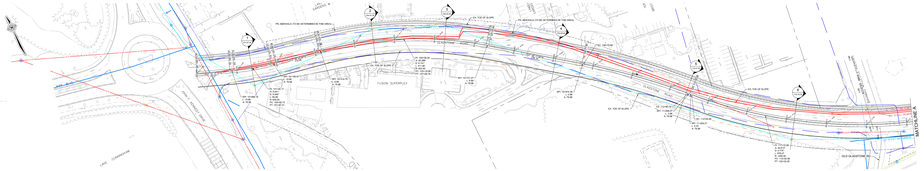
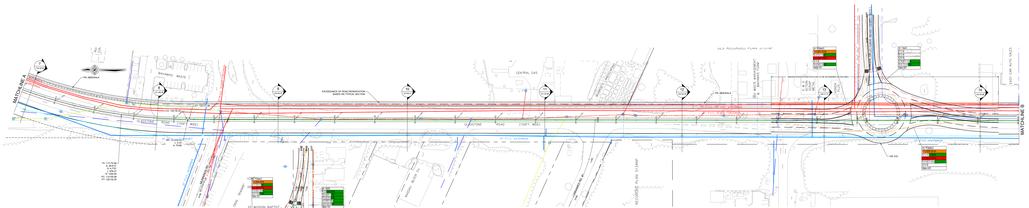
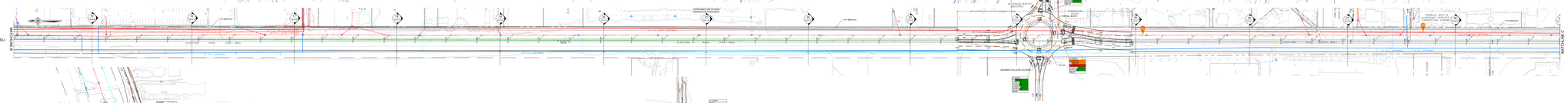
# 12 Appendix

## 12.1 Master Plan



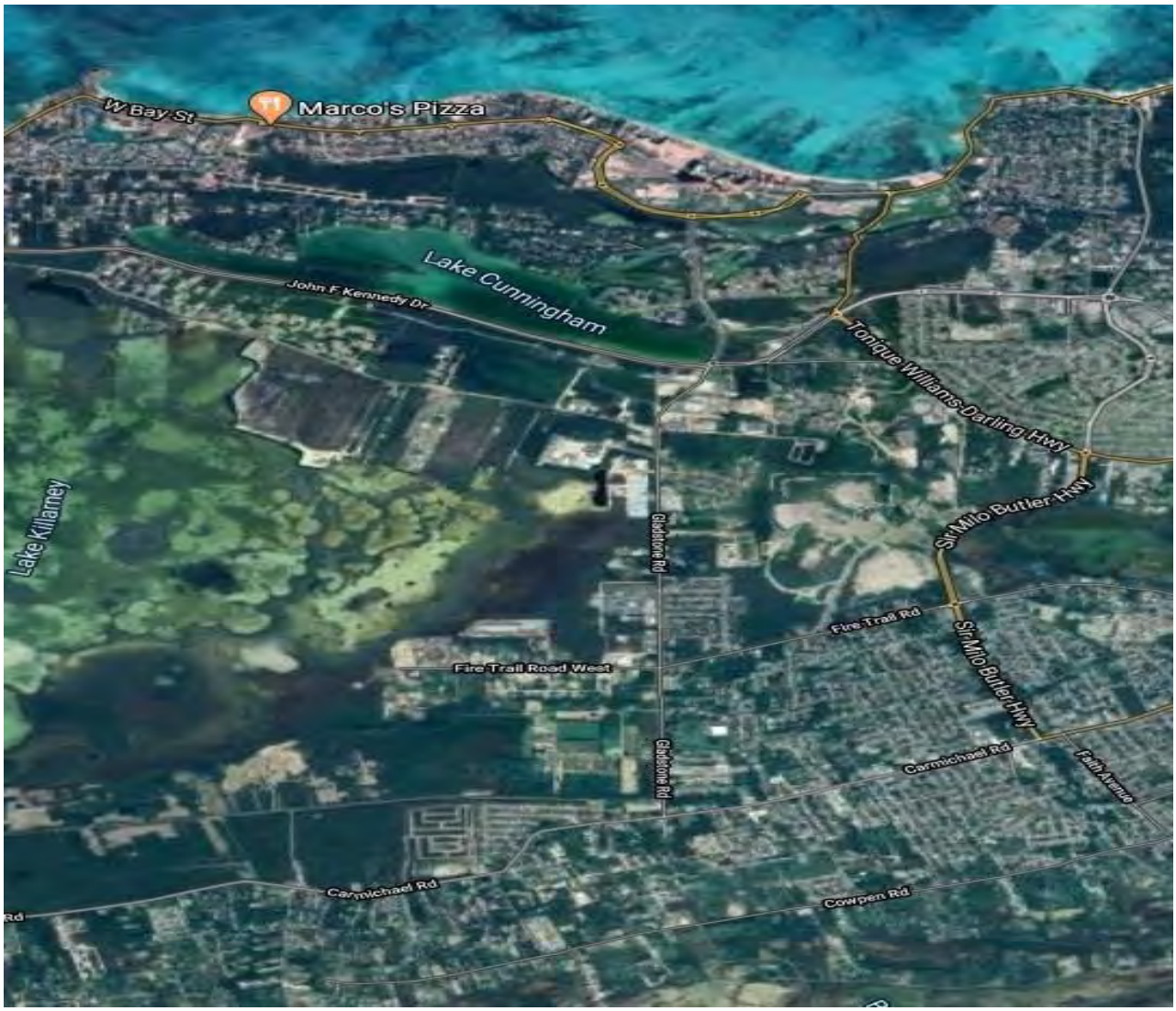





GLADSTONE ROAD (CUPT. WDC)
NORTH LANE
SOUTH LANE
ADJACENT TO EXISTING RETAINING WALL
ADJACENT TO EXISTING RETAINING WALL
ADJACENT TO EXISTING RETAINING WALL

## 12.2 Climate Vulnerability Assessment

# Gladstone Road Improvement Project (GRIP), New Providence.

## Hydrology and Drainage Report, Rainfall Analysis, Recommendations for Road Drainage and Climate Vulnerability Assessment (CVA)



# Hydrology and Drainage Report[1], Rainfall Analysis, Recommendations for Road Drainage and Climate Vulnerability Assessment (CVA)

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[1] February 2000 issued to Bidders for the New Providence Road Improvement Project, Nassau N.P. The Bahamas

# Introduction

Gladstone Road is a three-mile-long, single carriageway with a one-hundred-foot-wide road reservation, aligned in a north/south direction linked by a west/east junction to Milo Butler Highway, via Fire Trail Road. It extends south to Carmichael Road and north to John F. Kennedy Drive serving as the primary route to the industrial centre. Gladstone Road is subject to high volumes of traffic resulting in long traffic delays which will worsen as the area continues to develop and grow.

The Ministry of Public Works (MOPW) seeks to widen the route from a single to a dual carriageway, improve junctions, drainage facilities, street lighting, traffic signs, road markings and install medians.

# Purpose

In preparing this report, it is important to note that Gladstone Road, as an arterial corridor, is critical to the safe movement of people, goods and services for New Providence and The Bahamas' Family Islands. Its environs include businesses, schools, the Nassau Port Facilities Bonded services, The Bahamas Nassau Emergency Management Authority (NEMA), Aquinas College, Bahamas Waste Management Company and other businesses located in the Gladstone Road "Corridor".

The road and its corridor also serve as a vital north-south vehicle and travel system for residents in the south west of the City of Nassau. The use of the corridor by essential services (police, fire department and ambulances) is critical in providing service and emergency response to residents on New Providence. East of Gladstone Road, at its northern section, on John F. Kennedy Drive is the New Providence Landfill and its related facilities.

This report is submitted, in accordance with the Terms of Reference[2], for the consultancy services – Gladstone Road Improvement Project (GRIP) and prepared by the Key Expert under section 9, subitem (d) Environmental Specialist.

The report responds to Section 3 Scope of Services activities and to the Terms of Reference:

- (v) consideration given to climate change and hydrological modeling, climate change vulnerability assessment (CVA)
- (vi) input to the environmental impact assessment (EIA) and,
- Section 5 Description of Services (ii) Phase I subsection (c ) Storm water runoff, and, the TOR,
- Section 3 Scope of Services activities; (v) consideration given to climate change and Hydrological modeling

A review of Mott MacDonald's (Mott's) Report also serves as a basis, after examining the data from 2000 to 2018, to:

- make recommendations for addressing rainfall runoff on the corridor
- update analysis performed by Mott using current rainfall data
- confirm if Mott's findings and recommendations remain valid, considering time passage, and in accordance with the TOR:

[2] Section 7. Terms of reference Bid documents pages 40 to 86.

- provides recommendations to guide a drainage plan using drainage wells to accommodate a one in five-year design storm for arterial roads with a 5-year peak value of or exceeding 3.13 in/hr.

This report includes a Climate Vulnerability Assessment (CVA), based on climate change scenarios and modeling results, which considers the potential impacts of climate change on New Providence, and, on any changes in the hydrological regime over the design life of the road.

## Background

Mott MacDonald's (Mott's) Report, "Hydrology and Drainage Report, February 2000", formed part of the documents issued to bidders for the New Providence Road Improvement Project, Nassau, New Providence, The Bahamas. Mott's Report is based on rainfall data collated by the Bahamas Department of Meteorology (DOM), at Nassau International Airport (NIA), from November 1957 to September 1999. The report draws upon DOM's publication, "Rainfall of New Providence", dated 1977.

Mott's report, for New Providence, sought to;

- collect and analyze the rainfall data
- review drainage options
- derive a "design rainfalls" for flooding calculations and drainage design
- provide a preliminary assessment of runoff and drainage options

Mott recognized the DOM, Nassau International Airport, data would not necessarily be representative of conditions across the island but serve as the most reliable record available which, based on the Terms of Reference could be used, to develop a 10-year storm and determine runoff. In doing so, Mott determined the standard set for a 10-year storm might be too severe. Instead, they produced rainfall magnitudes for return periods of 2, 5 and 10 years. Mott recommended adoption of the 2-year event as the design standard.

## Site Conditions, Gladstone Road Corridor 2020

Mott's report noted that of the overall project covering 19 road corridors, one required a detailed design and the remaining 18 required study/outline designs before the appointment of design/ build contractors.

The Gladstone Road Corridor is to be expanded to accommodate increased traffic flows,

- North, towards Cable Beach, and at the junction west to Nassau International Airport
- South, three quarters along its length into Firetrail Road, which feeds traffic eastward and westward to and from the Milo Butler Highway system, and,
- Carmichael Road feeds, at its terminus, into east to west road traffic flow, along Carmichael road.

Traffic flow data for these areas, from February 11th to 13th, 2020, over a twelve-hour period (06:00 to 18:00 hrs.) had 60,535 movements with 22,718 (38%) southbound, 20,106 northbound (33%), 13,568 eastbound on Firetrail road and 4,143 westbound on Firetrail road.

Light vehicles comprised 82.4% to 95.4 % of all vehicular movements, medium sized vehicles 4.2% to 14.9%, and articulated trucks 0.2% to 2.7 %.

Along Firetrail Road, eastbound articulated trucks had its highest percentage at 2.7%, mediums represented 14.9% and lights 82.4%, its lowest of vehicular flows compared to the north to south vehicular movements. Refer to Annex 1 - Table 1, appended.

*Photo 1 Gladstone Road Hill view to NW*

Improvements at the junction of Gladstone Road with Carmichael Road would facilitate traffic, traveling east and west, into the Corridor. Traffic movement comprises light, medium, articulated trucks and large trailers from the port at Arawak Cay to the customs handling facility off Gladstone Road. The roadway will be expanded to four lanes with a total width of 60 feet, including its shoulders.

Most of Gladstone Road is flat, its profile rises in the north, from near sea level at the junction of the JFK roundabout to approximately 30 feet in a quarter mile long section, excavated into a portion of the Nassau Ridge.

Gladstone Road then rises gradually to approximately 3-5 feet, as it approaches the junction with Firetrail Road and extends to about 7-10 feet above ground level to Carmichael Road. Over most of its length the corridor is flat, approximately 2-4 feet above ground level, over its length of approximately 4 miles.

*Photo 2 GRIP Low area view to west across road reservation*

It was observed that in several sections along the roadway, the road was the lowest point in the corridor, inwardly draining rainfall onto its surface. The existing two-lane roadway is heavily trafficked with a width not exceeding 30 feet as its rises over the ridge to the North.

*Photo 3 GRIP west of Bahamas Youth Camp*

Recent excavations, along its west side, revealed the flat terrain comprises oolitic limestone caprock with a significant inland lake, immediately west, making up the extended floodplain of Lake Killarney. Vegetation in the area is mixed coppice and pineland, interspersed with mangroves and buttonwood species which floods extensively in the rainy season.

*Photo 4 GRIP Wetland on west side of Bahamas Youth Camp*

Flooding is the result of the water table rising in the wet season as rainfall exceed evapotranspiration and runoff from the Nassau Ridge to the north. Rainwater flows off the ridge southward impacting flat areas where the road appears to be internally draining. Rainwater flows off Nassau Ridge also affects the John F Kennedy Drive and Gladstone Road roundabouts at its northern extremity. Commercial development, on both sides of Gladstone Road, is made of large paved and covered surfaces also increasing rainfall runoff year-round into the corridor.

Travel along Gladstone Road, during the rainy season, is frequently affected by rainfall events and the resulting flooding due to poor drainage.

The Bahamas Power and Light Company (BPL) maintains a major east–west overhead power transmission system supplying electricity from Clifton Pier to Blue Hills, adjacent to Carmichael Road. The system branches onto a north-south powerline reserve into the Gladstone Road corridor; electrical lines provide power to transformers at the junction of Firetrail Road and northward to the Cable Beach strip. BPL also transfers automotive diesel fuel along Carmichael Road to the Blue Hills Power station. The buried fuel transmission line crosses beneath the Gladstone Road and Carmichael Road intersection.

*Photo 5 GRIP BPL reservation north of BPL east west junction*

The overhead transmission corridor is maintained as a controlled right-of-way, providing access to BPL transformers at the Firetrail Road Junction and the overhead transmission lines system, on both sides of the corridor.

*Photo 6 BPL Firetrail Road Transformers junction view to north west from Firetrail Road*

## Constraints in data source, analysis and review

This review is challenged by the lack of data on rainfall intensities or intensity measurements, by event, over the 2000 to 2010-time frame.

It draws extensively on rainfall data which reflects a 24-hour period determined at 7:00 am the following day. The Department of Meteorology's (DOM) procedures and equipment, used for collecting 24-hour rainfall totals, meets World Meteorological Organization's (WMO) standards and DMO employed appropriate measures to verify data produced.

The DOM's annual published reports, which compiles daily rainfall totals in inches and number of rain days, form the basis of this report. (Annex 2)

### Rainfall

#### Mott's data source

Monthly rainfall characteristics for Nassau International Airport (NIA), based on data for 1957 to 1999, was extracted from Mott's Report and presented in Table 1 below:

*Table 1 Mott McDonald Table 1. Monthly Rainfall Characteristics, Nassau Airport.*

| | Rainfall Depth (inches) | | | Average Raindays | Maximum Daily |
|---|---|---|---|---|---|
| | Minimum | Mean | Maximum | | |
| January | 0.04 | 1.99 | 11.67 | 8 | 4.62 |
| February | 0.09 | 1.67 | 9.53 | 6 | 5.86 |
| March | 0.08 | 1.99 | 7.62 | 6 | 3.48 |
| April | 0.00 | 2.43 | 16.93 | 6 | 11.23 |
| May | 0.05 | 4.75 | 12.71 | 10 | 3.50 |
| June | 2.00 | 8.97 | 21.85 | 15 | 6.55 |
| July | 0.78 | 6.14 | 14.49 | 17 | 5.01 |
| August | 3.12 | 8.25 | 20.92 | 18 | 6.23 |
| September | 2.21 | 6.98 | 16.69 | 17 | 5.31 |
| October | 1.23 | 6.60 | 19.97 | 15 | 9.59 |
| November | 0.19 | 2.94 | 7.67 | 9 | 3.59 |
| December | 0.08 | 1.96 | 8.80 | 8 | 4.64 |
| Year | 37.35 | 54.81 | 76.28 | 136 | 11.23 |

Note: Data for 1957-99, from Meteorological Department, Government of The Bahamas

The DOM "Rainfall of New Providence, Meteorological Department, January 1977", sections 30 and 31, determined rates for 1966 to 1975 rainfall duration and provide observations of rainfall duration and intensities at NIA.

The DOM report observed for:

*Duration*

> *"rain lasts on average about ten minutes each day in the "dry" season, and between half an hour and an hour during the "wet" season.*

*Average rates*

> *"average rates of rainfall, mainly between one quarter and one half an inch per hour correspond with the fact that rain is normally in the form of moderate or heavy showers."*

DOM, using the rain recorder tabulations of rain for each clock hour for the 12-year period 1965 to 1976, constructed a rate of rainfall (mm/hour or ins/hour) vs duration in hours table. To do this, they defined "periods" or days with more than a set accumulation of rainfall in mm/ day and rainfall of 1 to hour duration. DOM then generated plots with return periods of 1, 2, 4 hour and an extreme (>4hrs) hour table.

Based on DOM's methodology, Mott extracted the annual maximum daily rainfall in inches for each year, between 1958 to 1999. This data set was used to statistically model the "best" fit for NIA using a generalized Extreme Value Distribution Analysis (Gumbel Type I and 2) for extreme daily rainfall. Mott's report is reproduced below as Table 2.

*Table 2 Mott McDonald Table 3. Monthly Rainfall Characteristics, Nassau Airport*

**Maximum Daily Rainfalls for a Range of Return Periods (inches)**

| Return Period (years) | Assumed Distribution | | Adopted Value |
|---|---|---|---|
| | GEV Type 1 | GEV Type 2 | |
| 2 | 3.96 | 3.74 | 3.9 |
| 5 | 5.66 | 5.22 | 5.6 |
| 10 | 6.79 | 6.42 | 6.7 |
| 50 | 9.26 | 9.88 | 9.8 |
| 100 | 10.31 | 11.75 | 11.7 |

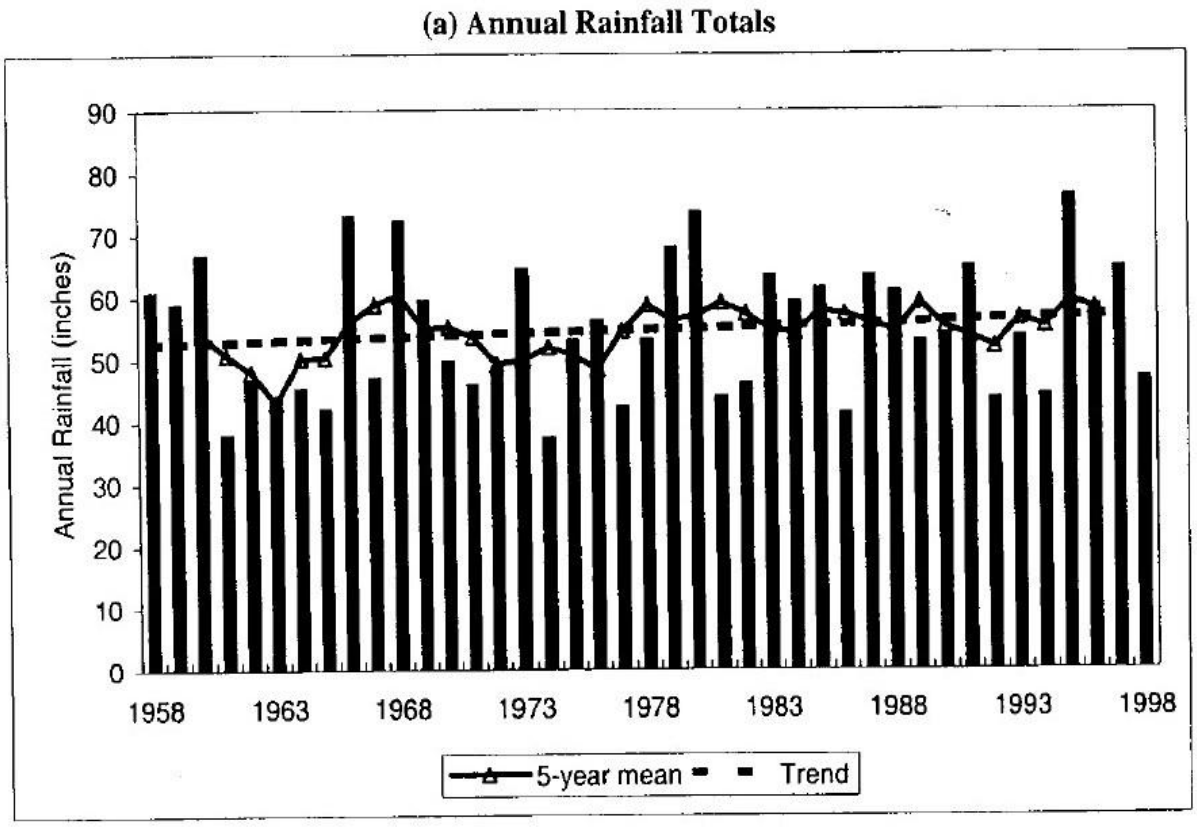
Mott concluded GEV type 2 (Gumbel Distribution, Type 2) as the best fit for the maximum daily rainfalls and determined the return period in years (2, 5, 10, 50 and 100 years) associated with the adopted value.

Mott recognized the data from Nassau International Airport (NIA) would not necessarily be representative of conditions across the island, but the most reliable record available, based on their Terms of Reference to develop a 10-year storm for the determination of runoff. In doing so, Mott determined, based on their work, the standard 10-year storm might be too severe. Instead, they produced rainfall magnitudes for return periods of 2, 5 and 10 years. Mott recommended the 2-year event for the design standard.

## Trend analysis rainfall at NIA (MOTT)

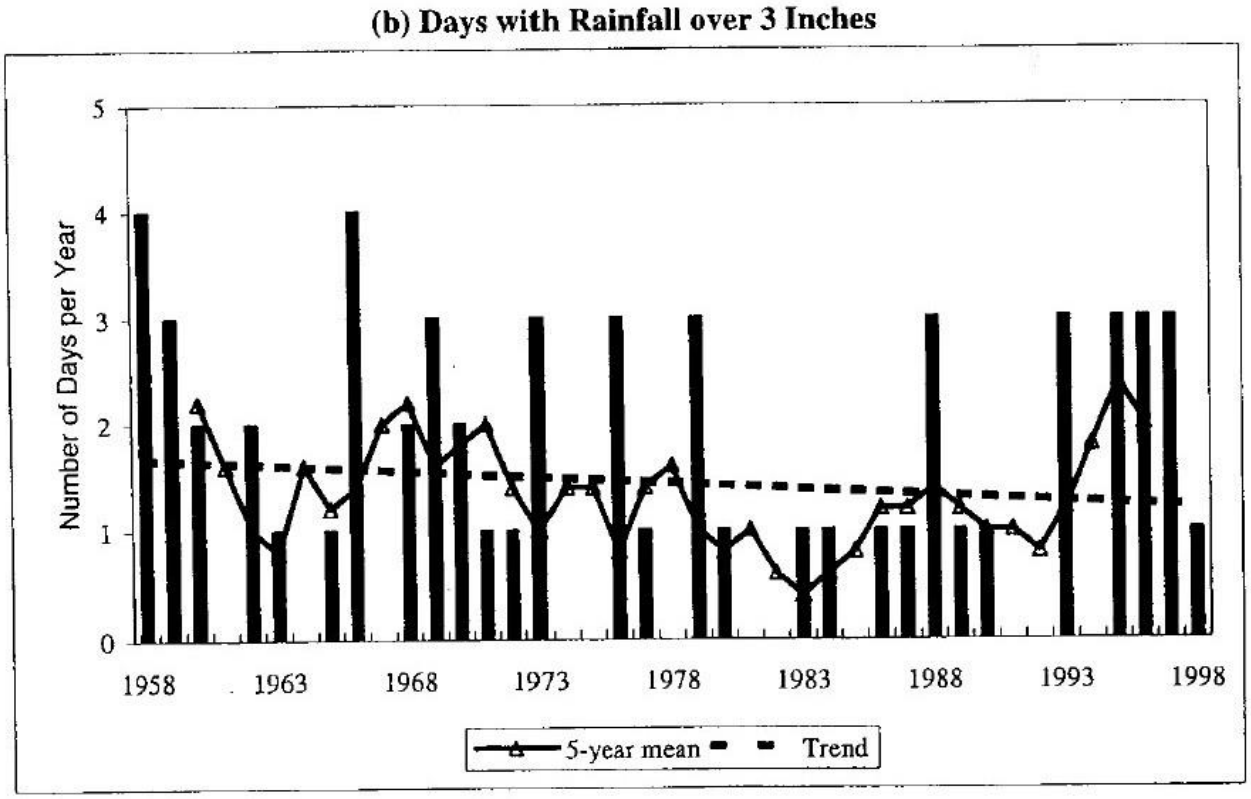
Mott also sought to determine a trend analysis of annual rainfall totals at NIA and presented their analysis in Figure 1, extracted below, which suggest a slight upward trend in annual rainfall totals of 0.1 inches per year, over the 40-year period.

*Figure 1, Mott McDonald Annual Rainfall Totals (inches) Monthly Rainfall Characteristics, Nassau Airport.*




In examining the data using rainfall over 3 inches a downward trend could be observed, as presented in Figure 2 below.

*Figure 2 Days with Rainfall over 3 Inches Mott McDonald, Monthly Rainfall Characteristics, Nassau Airport.*




## Mott's observations and conclusions

Employing a factor of 1.13,which was considered appropriate for The Bahamas, Mott proposed the 1 in 2-year 24-hour rainfall would total 4.4 inches for a 24-hour rainfall period.

## Short Duration rainfall analysis

Based on published analysis (1965-76), 1-6-hour rainfalls occur on average 0.5 days per year or approximately 1 in 2-year return period.

The daily data gives a value of 4.38 inches, equivalent to the maximum daily rainfall, derived from the Gumbel distribution analysis for a 2-year return period (Figure 2 / Type 2 distribution).

Based on the analysis of published short duration rainfall events for 1965-1976, Mott concluded the following:

For maximum hourly rainfall:

- Gumbel Type 2 distribution for return period of 2 to 10 years provided annual maximum daily rainfall totals of 3.9 inches and 6.7 inches, for the respective periods.

- Higher rainfall results from longer duration events and higher intensity.
- The maximum hourly rainfall, as a percentage of daily totals, has a substantial range which reflects variability and storm duration.
- Rainfall intensities at the start and end of a storm event are very low and for practical purposes it should be sufficient to consider storm length on not more than 6-8 hours.

Mott observes that the Bahamas' Building Code requires allowance for half an inch per 5 minutes or an intensity of 6 inches per hour based on an extrapolation of equations of 5 minutes at best tenuous. Mott derived, using their methodology, values of 2.9 to 4.5 inches per hour for 2 and 10-year return period. Mott, noted from the analysis, that the frequency of major storms is one of the factors affecting flooding.

The underlying assumption is rainfall runoff causes flooding at Nassau International Airport and occurs as extreme rainfall events, in amounts referenced in Table 2 of page 11 as "adopted value".

# Hydrology and Drainage Report, Rainfall Analysis, Recommendations for Road Drainage

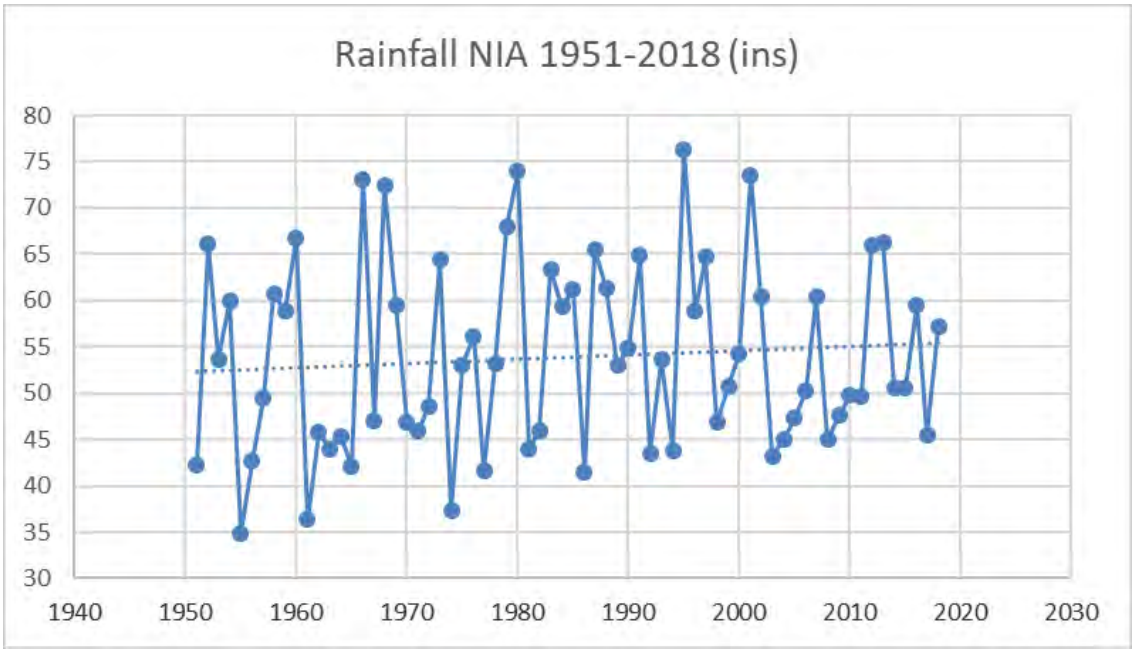
Drawing upon the Mott Hydrology and Drainage Report[3], this section further examines the rainfall record of Nassau International Airport (NIA) to provide recommendations for the design of a drainage system for Gladstone Road. The review of the Mott report serves as a basis, after examining the years from 2000 to 2018, and makes recommendations to address rainfall runoff from the Gladstone Road corridor.

## Rainfall Trend Analysis 1951 to 2018

Chart 1, presented below, reflects the trend in annual total rainfall at Nassau International Airport for a longer timeframe from 1951 to 2018. Total Annual rainfall increased over the 67-year period ending in 2018 to just above 55 inches per annum. Annual totals varied from 35 inches in the 1950s to 75 inches in 1995.

As discussed earlier, variability is as a result of tropical depressions, storms, hurricanes and, in the winter months, the effect of cold from off the United States to the north and northwest of New Providence.

*Chart 1 Rainfall Trend 1951-2018 in inches*




The shorter duration rainfall trend above, shows an increase in total rainfall and the annual total averaging 55 inches per annum.

[3] February 2000 issued to Bidders for the New Providence Road Improvement Project, Nassau N.P. The Bahamas

## Monthly rainfall 2000 to 2010

Table 3, below, provides a longer-term comparison of rainfall data, by month over the 1951-2010 period, which includes the period covered by Mott McDonald's report for 1957-1999.

*Table 3 Rainfall by month, 1951-2010, Summary*

| Rainfall 1951-2010 | | | |
|---|---|---|---|
| **Month** | **Min** | **Avg** | **Max** |
| **JAN** | **0.07** | **1.72** | **11.67** |
| **FEB** | **0.17** | **1.62** | **5.71** |
| **MAR** | **0.01** | **1.20** | **7.62** |
| **APR** | **0.00** | **2.16** | **16.93** |
| **MAY** | **0.61** | **4.57** | **12.71** |
| **JUN** | **3.03** | **8.83** | **20.35** |
| **JUL** | **0.78** | **6.34** | **14.49** |
| **AUG** | **3.12** | **7.36** | **20.92** |
| **SEP** | **2.44** | **6.91** | **15.18** |
| **OCT** | **1.33** | **8.13** | **20.61** |
| **NOV** | **0.19** | **2.59** | **7.67** |
| **DEC** | **0.10** | **1.59** | **6.74** |
| **TOTAL** | **11.85** | **53.01** | **160.60** |

*Table 4 Rainfall comparison – NIA 1951 to 2018 and 2000 to 2018*

| **1951-2018** | | | | **2000-2018** | | |
|---|---|---|---|---|---|---|
| **Avg** | **Min** | **Max** | **Month** | **Avg** | **Min** | **Max** |
| **1.92** | 0.04 | 10.96 | Jan | **1.72** | 0.07 | 11.67 |
| **1.95** | 0.06 | 9.53 | Feb | **1.62** | 0.17 | 5.71 |
| **2.55** | 0.21 | 6.58 | Mar | **1.20** | 0.01 | 7.62 |
| **2.46** | 0.25 | 5.89 | Ap | **2.16** | 0.00 | 16.93 |
| **4.55** | 0.05 | 13.66 | May | **4.57** | 0.61 | 12.71 |
| **8.77** | 2.00 | 21.85 | Jun | **8.83** | 3.03 | 20.35 |
| **5.88** | 1.91 | 13.56 | Jul | **6.34** | 0.78 | 14.49 |
| **8.54** | 3.29 | 17.15 | Aug | **7.36** | 3.12 | 20.92 |
| **7.18** | 2.21 | 16.69 | Sep | **6.91** | 2.44 | 15.18 |
| **5.42** | 0.64 | 14.54 | Oct | **8.13** | 1.33 | 20.61 |
| **3.11** | 0.14 | 13.27 | Nov | **2.59** | 0.19 | 7.67 |
| **2.03** | 0.08 | 8.80 | Dec | **1.59** | 0.10 | 6.74 |
| **54.34** | **10.88** | **152.48** | **TOTAL** | **53.01** | **11.85** | **160.60** |

Rainfall statistics covering both periods are generally comparable with the average, minimum, maximum and totals, by category, and do not differ significantly.

## Methodology used

Sections 30 and 31 of the New Providence Rainfall Report January 1977 extracted “periods” or days from the rainfall records, with more than a set accumulation of rainfall in mm/ day and rainfall of 1 to 4 hour duration. Plots were generated with return periods of 1, 2, 4 hour and an extreme (>4hrs) table. The rain gauge charts were the underlying dataset used to record rainfall volume, duration and time of occurrence. There is no rain gauge data or compilations available of rainfall volume in inches, duration in minutes and time of occurrence in clock hours for 2000 to 2010.

The existing record 2000 to 2010, cannot be similarly used as daily rainfall total is recorded in the range from trace (less than 0.01 inches) and in increments of 0.01 inches to the maximum volume collected in a 24- hour period ending at 7 am, the following day. As such, the DOM’s monthly and annual rainfall compilations of daily accumulated total rainfall in inches, over 24 hours (reported at 7 am on the following day) are the primary data source available and used in this analysis.

On examination, total number of rain days (events) with a trace of rain recorded between 2000 to 2010 was 503 days, greater than a trace recorded for 1532 rain days (events).

The start and stop time for rainfall events are not collected by the observers at NIA but are reported at 7 am on the following day in DOM records.

The “patterns” observed are:

- Rainy season (June to November) are sequential days of rainfall of varying amounts including days with a trace at the beginning and end of a sequence of rain days
- Dry season (December to April), by comparison, has single day events with a trace of rain at the beginning or end of the period
- Distinct winter (January to March); cold front passages produce rainfall events
- One day events account for only 27 % of rain days in the wet season, and,
- The wet season pattern often involves several days (2-9 in length) of rainfall of varying amounts.

## Results of Analysis

*Table 5 (a) Number of rainfall events in consecutive duration (days) by month for 2000 to 2010 NIA*

#Rain Events 2000-10

| Month | 2D | 3D | 4D | 5D | 6D | 7D | 8D | 9D | 10D | 11D | 12D | total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan | 12 | 4 | | | | | | | | | | 16 |
| Feb | 4 | | 1 | | | | | | | | | 5 |
| Mar | 14 | 3 | 2 | 1 | | | | | | | | 20 |
| Apr | 14 | 2 | | | | | | | | | | 16 |
| May | 7 | 12 | 6 | 1 | | | | | | | | 26 |
| Jun | 10 | 8 | 7 | 2 | 2 | 1 | | | 1 | | | 31 |
| Jul | 1 | 6 | 4 | 1 | | 6 | 1 | 1 | 1 | | 1 | 22 |
| Aug | 10 | 16 | 6 | 6 | 1 | 2 | 3 | | | | | 44 |
| Sep | 7 | 8 | 9 | 2 | 2 | 2 | 2 | | | | | 32 |
| Oct | 2 | 4 | 6 | 4 | | | 2 | | 1 | 1 | | 20 |
| Nov | | 2 | 1 | | 1 | | | | | | | 4 |
| Dec | 3 | 3 | | | | | | | | | | 6 |

*Table 5 (b) Rainfall event total rainfall volume (inches) by month in consecutive day total.*

Rain Volume 2000-10

| Month | 2Day | 3Day | 4Day | 5Day | 6Day | 7Day | 8day | 9day | 10day | 11day | 12day | total | Median |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan | 10.02 | 2.29 | | | | | | | | | | 12.31 | 6.16 |
| Feb | 4.65 | | 1.64 | | | | | | | | | 6.29 | 3.15 |
| Mar | 9.83 | 6.55 | 0.31 | 1.51 | | | | | | | | 18.2 | 4.03 |
| Apr | 8.02 | 6.12 | | | | | | | | | | 14.14 | 7.07 |
| May | | | 11.71 | 11.31 | | | | | | | | 23.02 | 11.51 |
| Jun | 20.6 | 10.97 | 18.78 | 7.97 | 6.16 | 2.95 | | | 9.7 | | | 77.13 | 9.47 |
| Jul | 0.24 | 7.43 | 6.44 | 1.23 | | 13.46 | 7.4 | 10.61 | | | 4.51 | 51.32 | 7.40 |
| Aug | 13.7 | 14.09 | 7.38 | 22.1 | 0.95 | 6.54 | 11.84 | | | | | 76.6 | 11.84 |
| Sep | 5.94 | 11.92 | 24.8 | 6.14 | 4.21 | 9.05 | 11.52 | | | | | 73.58 | 9.05 |
| Oct | 2.38 | 5.41 | 12.1 | 10.33 | | | 8.08 | | 6.83 | 3.08 | | 48.21 | 8.08 |
| Nov | 2.77 | | 12.85 | | 2.24 | | | | | | | 17.86 | 2.77 |
| Dec | 3.44 | 3.14 | | | | | | | | | | 6.58 | 3.29 |

The number of rainfall events in consecutive days of rain (rain days) shows a distinct wet (highlighted) and dry season pattern over the period by month for 2000 to 2010.

## Comparison between rainfall events and rainfall volume per event for 2000 to 2010 NIA

When the number of events and volume per event are compared (refer to tables above), rainfall in the:

- Wet (June to November) season median rain day ranged from 2.77 to 11.84 inches per rainfall event (for 2 to 9-day rainfall event), account for 63% of the wet season rain days representing 81% of total annual volume in inches

- Dry (January to March) season median 3.15 to 11.51 inches per rainfall event (for 2 to 5-day rainfall events) account for 37% of the dry season rain days representing 19% of total annual volume in inches
- Longer duration rainfall events (> than 3 days) occur in the wet season and the dry season on average have shorter consecutive rain days (between 2-5 days); the longer periods coincide with the passage of winter "cold fronts" (January to March), and,
- Rainfall events can produce "flooding" in any month of the year, not only in extreme rainfall events (>than 3.00 inches in a 24-hour period), as demonstrated by Mott's analysis, but also as a result of 2 to 5 sequential days of rainfall in the dry (January to March) season and 2-12 days in the wet (June to November) season.

## Climate Vulnerability Assessment (CVA)

A Climate Vulnerability Assessment (CVA) for the Gladstone Road corridor is a project deliverable, confined to the limits of the project's road corridor[4] and its immediate environs.

This section responds to

### Terms of Reference

- (v) consideration given to climate change and hydrological modeling, climate change vulnerability assessment (CVA),
- (vi) input to the environmental impact assessment (EIA)

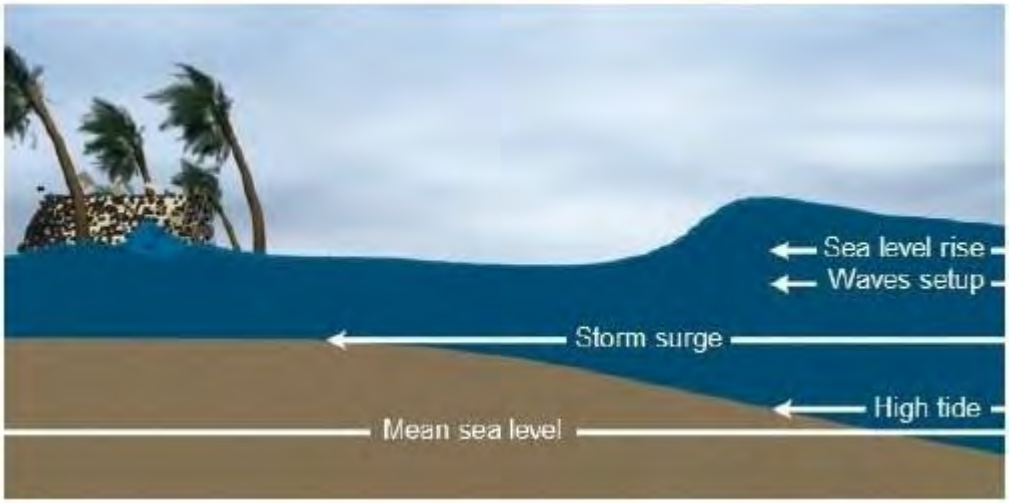
The CVA also draws on submissions made to the United Nations Framework Convention on Climate Change (UNFCCC) in the Bahamas' initial and Second National Communications to the Convention and the Bahamas Journal of Science and other relevant publications.

Although global climate models identify hazards for New Providence, due to downscaling and resolution errors, the Gladstone Road corridor cannot be distinguished.

The Figure (below) produced by the United States National Oceanographic and Atmospheric Administration (NOAA) provides a context for the CVA discussion for hazards resulting from hurricanes.

[4] Gladstone road corridor is described in section XX on page VV

*Figure 3 NOAA Hurricane Hazard*




## Prioritized hazards based on possible impacts overtime, up to a 2050-time horizon

### Coastal Flooding:

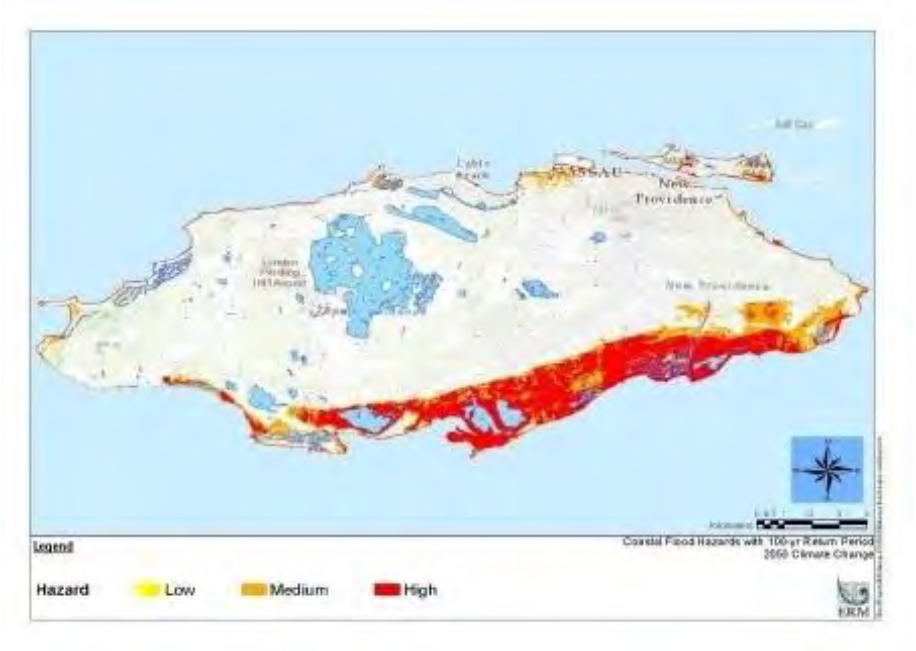
This occurs when sea level rises during tropical storms and hurricanes and has the potential to severely impact low-lying coastal development and infrastructure. On New Providence, coastal flooding usually occurs during the hurricane season but extreme low-pressure troughs, passing the offshore, create conditions that can also impact coastal systems, create flooding and exacerbate coastal erosion.

The sea lakes and overland surges from hurricanes or "SLOSH[5]" model and its Atlas, produced by the DOM, is the main reference point for coastal flooding as a result of hurricanes. The analysis indicates that the southern end of Gladstone Road could be impacted by a severe hurricane (category 3 and above) and storm surge approach from the south of New Providence. Figure 4 extracted below from a soon to be published IDB[6] Hazard and Risk Study, Sustainable Action Plan, Environmental Resources Management (ERM), Emerging and Sustainable Cities Initiative, Final Draft, June 2016, provides a Coastal Flooding Hazard Map for a 100-year return period event under a climate change projection for 2050.

[5] A storm surge Atlas for the Northern and Central Bahamas (New Providence and Vicinity), Arthur W. Rolle DOM and Storm Surge Group of NOAA

[6] Hazard and Risk Study, Sustainable Action Plan, Environmental Resources Management (ERM), Emerging and Sustainable Cities Initiative, Final Draft, June 2016.

*Figure Figure 4 Coastal flooding hazard Map for a 100-year Return Period under Climate Change for 2050 - Horizon Hazard and Risk Study, Sustainable Action Plan, Environmental Resources Management (ERM), Emerging and Sustainable Cities Initiative, Final Draft, June 2016.*




The Hazard Map, Figure 4, shows coastal flooding limited to the areas south of Carmichael Road and outside of the Gladstone Road Corridor. Should an event of the magnitude portrayed happen, residents in the area and recovery efforts would need access to the Gladstone Road corridor to evacuate.

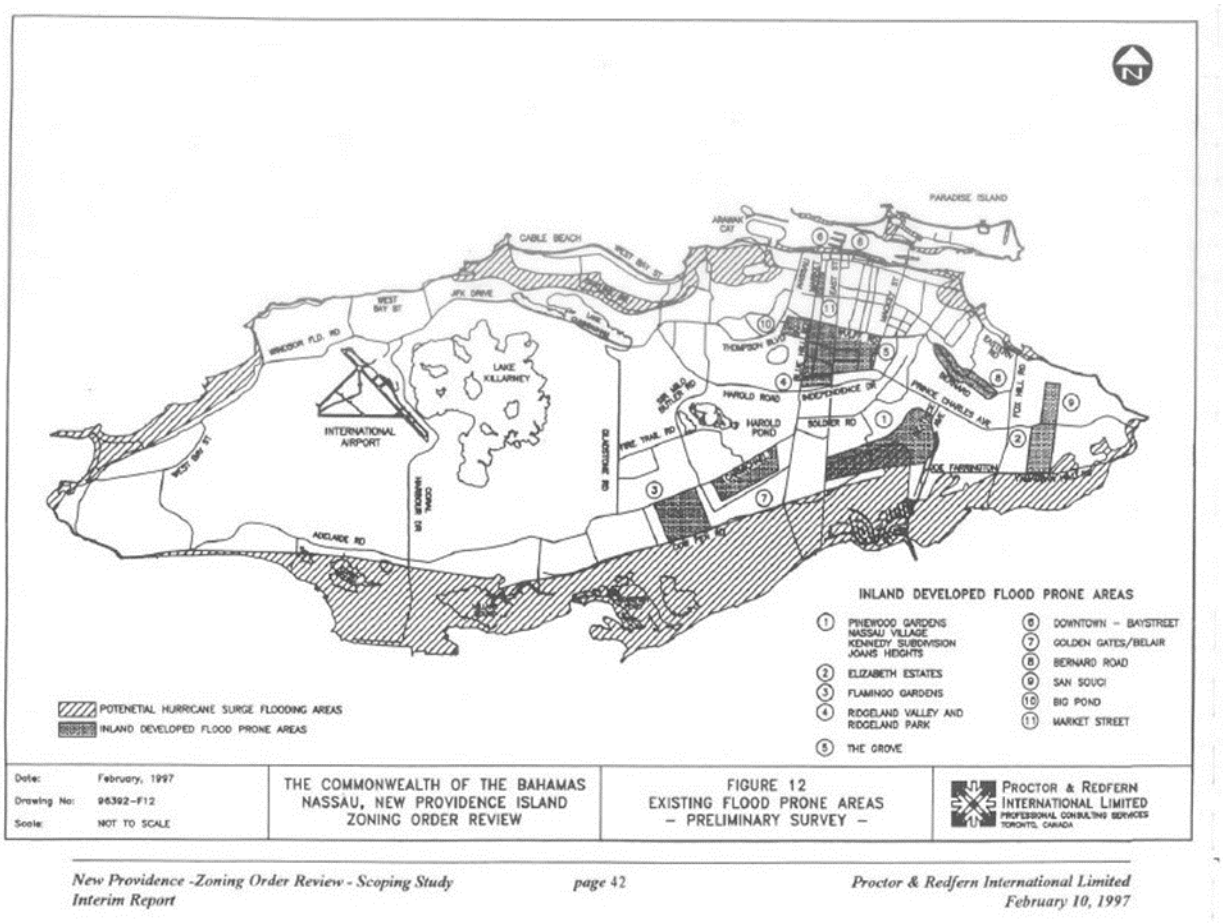
## Inland Flooding:

Using Figure 4 as a reference point, The Commonwealth of The Bahamas has eighty percent of its landmass having mean elevations less than six (6) feet or two (2) meters above sea level.

The shallow southern side of New Providence has historically experienced inundation from storm surges, flooding from heavy rainfall and extreme rainfall associated with passing hurricanes. Storm surges or rainfall-induced accumulation of water, poor drainage, saturated soil or blocked drainage channels result in inland flooding.

The New Providence – Zoning Order Review Scoping Study Interim Report of February 1977 provided a map showing vulnerable areas on New Providence. The Gladstone Road Corridor was not highlighted as a flood prone area (refer to Figure 5 below).

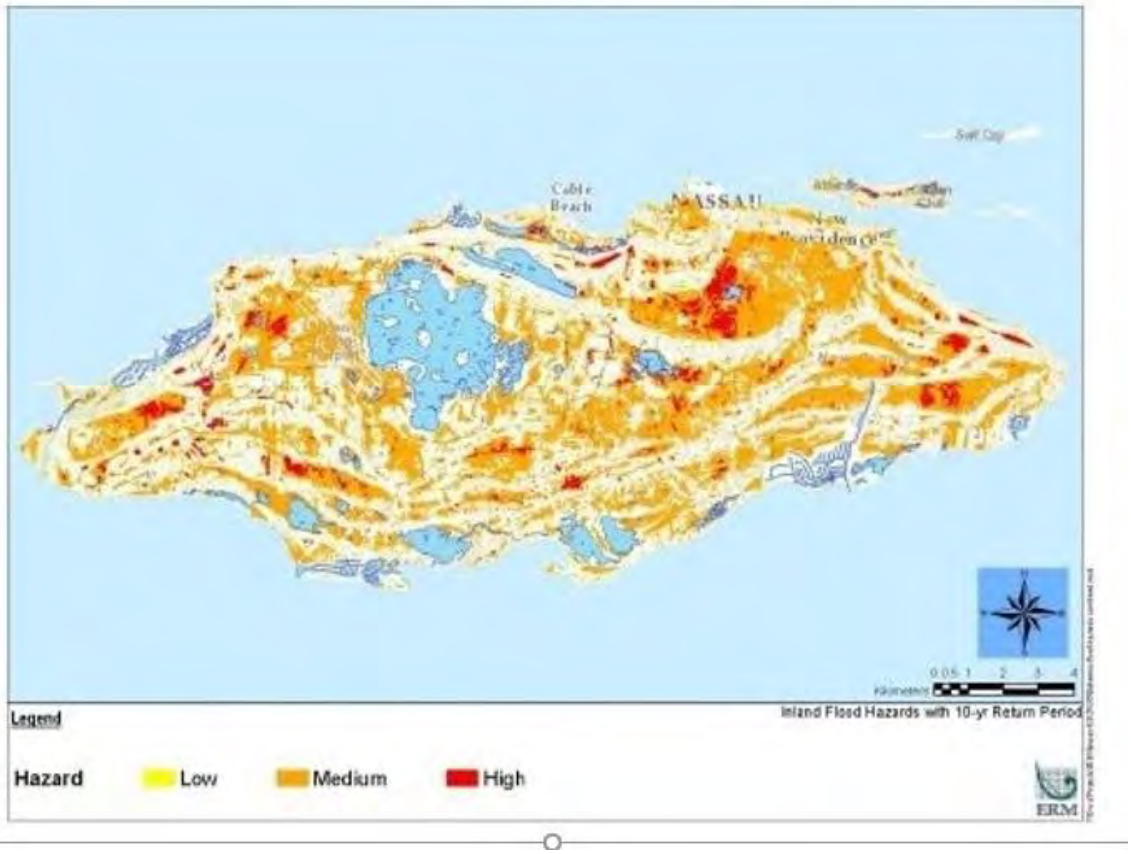
*Figure 5 Flood prone areas NP The New Providence – Zoning Order Review Scoping Study Interim Report of February 1977*




*New Providence -Zoning Order Review - Scoping Study Interim Report* *page 42* *Proctor & Redfern International Limited February 10, 1997*

Flooding from extreme rainfall events, often associated with hurricanes, is the primary natural disaster that has caused death and destruction in The Bahamas.

*Figure 6 Flood intensity 2004 NP Hazard and Risk Study, Sustainable Action Plan, Environmental Resources Management (ERM), Emerging and Sustainable Cities Initiative, Final Draft, June 2016. Table 8 and related figure*




A flood intensity 2-dimensional model (refer to Figure 6) was utilized to determine flood intensity, maximum depth and velocity, and a hazard level for New Providence. While the model used is questionable, with respect to the use of velocity, it does reflect the inland flood hazard for New Providence.

What it fails to show, however, are the inland lakes merging with flood water and overflowing their banks. Should this scenario occur, access to Gladstone Road would be restricted, and, as in an extreme event floodwater could extend west to east, flooding the low-lying central portion of the Corridor.

## Groundwater Saline Intrusion:

Groundwater resources are already affected by salinization as a result of rising sea levels, saline intrusion, storm surges and the inundation of freshwater by seawater as a result of severe hurricanes. In New Providence, the combined effects have resulted in existing groundwater resources being unable to meet potable water demand. Potable water supply for the islands relies on Reverse Osmosis (RO) treatment techniques for desalinization. Saline intrusion of seawater into fresh groundwater aquifers will increase and be aggravated by sea level rise from climate change

## Climate Change Projections

The climate change projections referenced in this CVA are extracted from The BahamasSimCLIM[7] system outputs and reported in The Second National Communication Report of The Commonwealth of The Bahamas (SNC, 2014).

The SNC (2014) report used the A1FI emission scenario as it represented the most pessimistic, and conservative, estimate of global greenhouse gases (ghg) projections for the Bahamas, based on outputs for the 2050-time horizon.

For the hazard and risk assessment studies, the following projected variables were used:

### Temperature

According to The BahamasSimCLIM system's projections using a group of 21 GCM's and considering the A1FI emission scenario, the maximum daily temperatures for the 2050 horizon are expected to increase by 1.97 C for The Bahamas.

Average daily maximum temperature increases for winter months will be less than two degrees centigrade (2C) while summer months will be over two degrees centigrade (2C).

### Precipitation

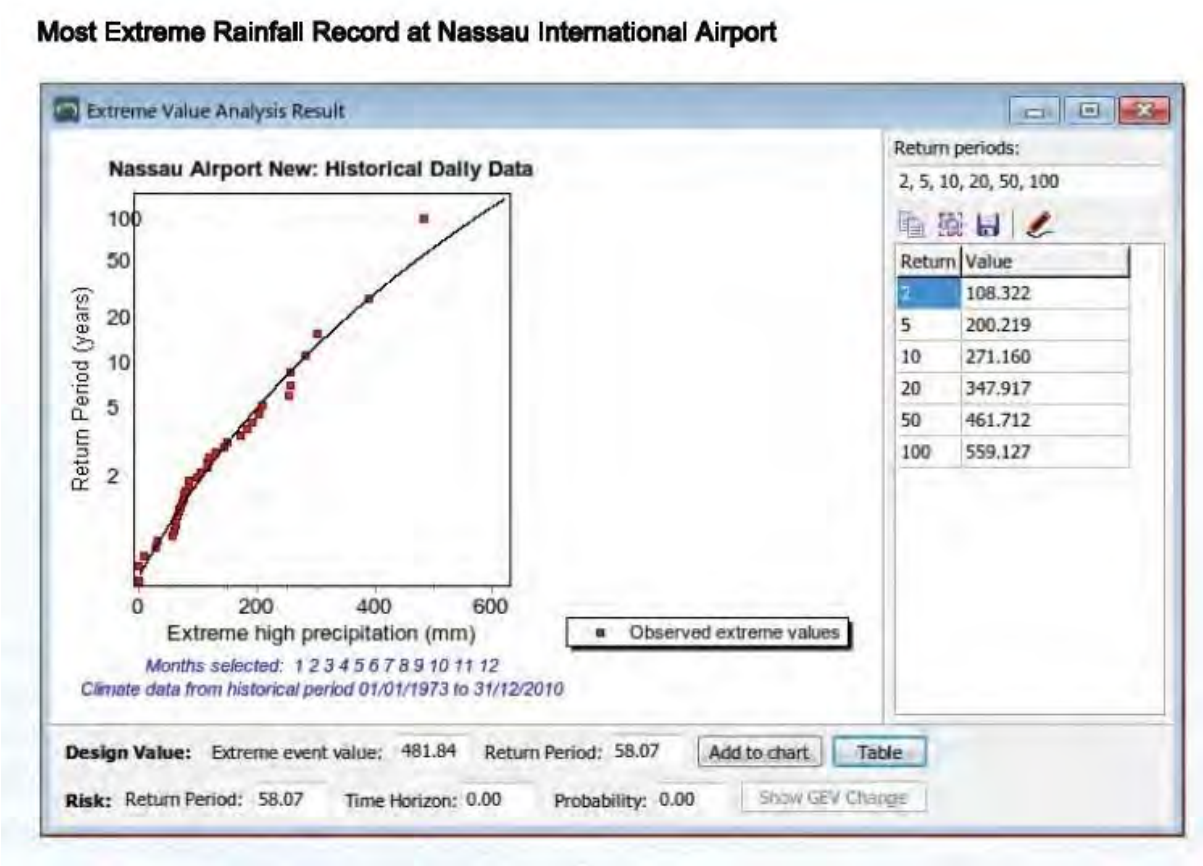
The percentage of change in precipitation from The BahamasSimCLIM for the entire Bahamas, projected for the 2050 horizon, suggests an average decrease in annual precipitation of 10% and 20% during some months, for most of the islands.

It is projected precipitation on New Providence would decrease by up to 20% during the dry and wet seasons, March to August, while extreme precipitation events are expected to increase between 6% and 11%.

Extreme events were evaluated by using an extreme value analysis and historical precipitation data collected at the Nassau International Airport, which has the most complete and long-term climatological records for New Providence. Figure 8, below, presents the results of the analysis.

[7] The BahamasSimCLIM is a tool used to generate climate change and sea level rise (SLR) projections based on the use of different Special Report on Emissions Scenarios (SRES). This tool uses 21 Global Climate Model (GCM) patterns for generating climate change and SLR projections for the Bahamas. The Climate Change projections assumed an A1FI emissions scenario which was defined by IPCC. The A1FI assumes a future world of very rapid economic growth with fossil fuel intensive technological emphasis.

*Figure 8 The BahamasSimCLIM Figure 25 Extreme Rainfall Event at Nassau International Airport for return periods 2, 5, 10, 20, 50 and 100 years*




The BahamasSimCLIM projection for rainfall to 2050, represented by the extreme event analysis, projects a decrease in rainfall across the entire Bahamas suggesting extreme high events to be less severe.

New Providence, in the north central Bahamas, however, may not fit into this generalization as the rainfall totals in the northern Bahamas are, on average, higher than that of the south and south-central Bahamas and is influenced by cold fronts in the winter months which move through the north and north central Bahamas from the United States.

The rainfall results, when considering the 12 Global Circulation models output, are the most pessimistic greenhouse gas projections and paints a different picture for the 2050-time horizon. The return period for the present most extreme event is expected to fall from 58 years to 42 years, with a 1 in 100 event increasing from 560 mm (20.5 inches) to 622 mm (24.4 inches). More frequent and severe extreme events are projected.

Extremely low rainfall was also considered for New Providence, the current one in a 10-year period has a three-month total of less than 24 mm or one inch.

Decreased rainfall of 17% is projected for the driest period, December to February, due to extreme drought conditions. The implication being that droughts will be even more severe in the 2050-time horizon.

## Sea Level Rise

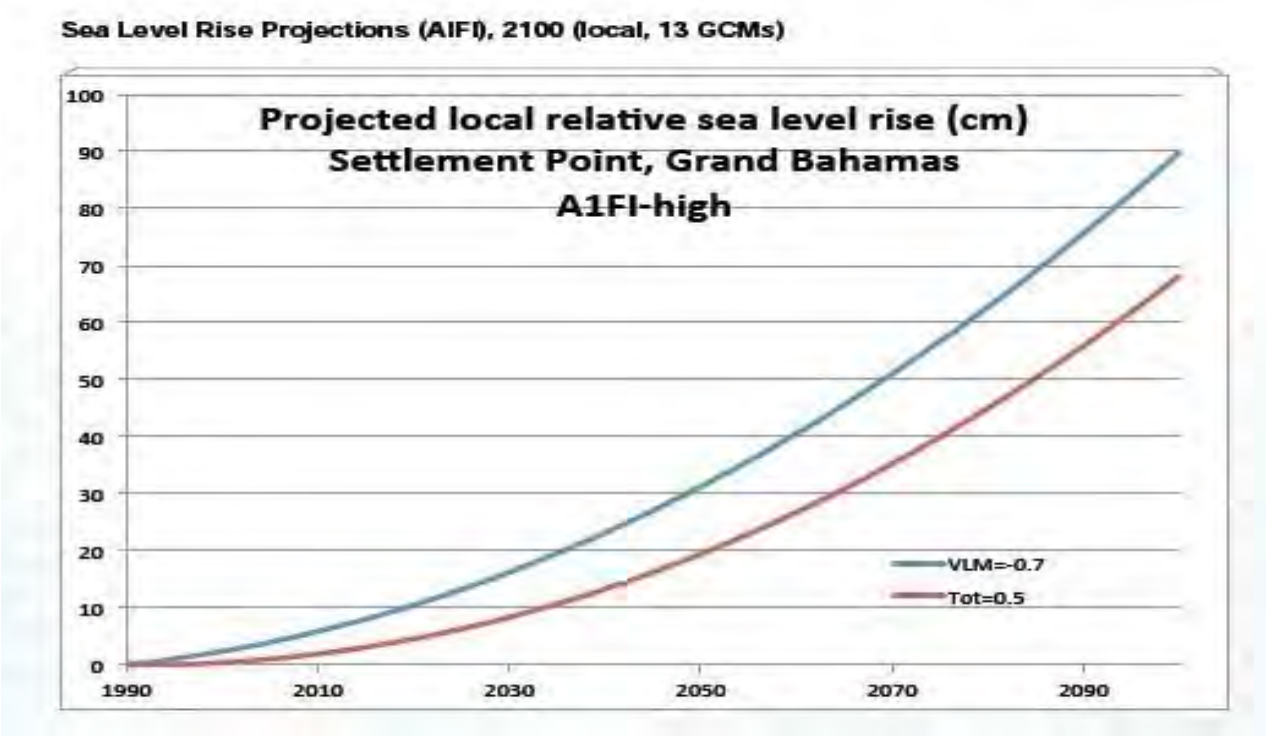
As reported by the Bahamas Second National Communications (SNC (2014)) and CCCCC (2015), the IPCC climate change estimation for sea level rise for 2050 in the Bahamas is 20 mm. The Settlement Point, Grand Bahama, is the reference used in by BahamasSimCLIM Figure 9 below shows projections considering vertical land movement (VLM) and total sea level rise (Tot). A net Sea Level Rise (SLR) of one foot, for The Bahamas, is evident in the analysis of the Shattuck datum established in Nassau in 1905.

The SLR Projections for A1FI emission scenario generated from the system indicate that sea level will rise 9.0 cm (or 3.6 inches), 20 cm (or 7.9 inches), and near 70 cm (or 27.6 inches) by 2030, 2050 and 2100, respectively. The blue line shows vertical land movement (VLM) and the red line total sea level rise (Tot) on the y axis in millimeters to the 2100. The Bahamas as a stable oolitic platform has over geological timescales little vertical land movement.

The projected SLR from The BahamasSimCLIM is consistent with the global SLR trend.

Figure 9 shows the SLR projections generated from The BahamasSimCLIM for Bahamas.

*Figure 9 BahamasSimCLIM Seal Level Rise Projection (A1F1) to 2100 (local, 13 GCM results)*



In considering the Gladstone Road corridor and its environs, the Climate Vulnerability Assessment identifies the following concerns over the design time frame of the road improvements:

*Sea level rise*

Sea level has risen over the last century by approximately one foot (12 inches) (SNC)

Ghyben-hertberg freshwater response dynamics equate:

- The depth from ground surface to freshwater inland rising closer to the surface
- Inland lakes and seasonal water bodies occupy a larger area causing flooding over a wider area and the water persist longer in the dry and wet seasons
- Water quality would change due to increased evapo-transpiration rates, resulting in water becoming more brackish

*Increasing temperatures*

The Mean Daily Maximum and Mean Temperature for July has risen from 88F (31.1C) to 90F (32.2C) between 1945 and 2000[8]

- Temperatures are expected to increase for both the air temperatures and surface temperatures of road surfaces
- Heat builds up at the New Providence Landfill possibly increasing the fire risk over time
- Asphalt surface mean temperature in the summer months could result in:
    - Increasing the volatility of lighter hydrocarbons in the tar
        - shortening the life of the asphalt, and,
        - making it more mobile and reducing tire traction

*Increased rainfall*

- Flooding, due to short more intense rainfall events and a change in the number of rain days and, over time, an increase in the number of 24hour rainfall events
- Seasonally heavier rainfall and down pours, reduced visibility
- More debris from road surfaces blocking drainage systems, increased accidents in the rainy season
- Increased traffic and resulting fatalities

*Increase in the frequency and intensity of Hurricanes and extreme events:*

- Damage to BPL transmission lines to Cable Beach, downed transmission lines causing traffic disruptions along the Gladstone Road
- Flooding, caused by intense rainfalls, associated with the passage of hurricanes and storms in both the wet and dry seasons
- Storm surges resulting in the inland penetration of seawater from south to north into the Gladstone Road Corridor, over time
- Debris carried by the wind or inland surge of seawater blocking the drainage system.

[8] Bahamas Journal of Science (ISSN 1022-2189) Volume 8 Number 2, May 2001. “Climate Change in The Bahamas? Evidence in the Meteorological Records”.

# Summary

Mott McDonald extracted the Maximum Daily Rainfall by year (1958 to 1999) in inches from the DOM dataset. Also, using a Gumbel Type 2 probability distribution, Mott produced a rainfall Intensity (inches/hour) vs duration (minutes) return period analysis. The results of their analysis are presented below, along with the extrapolation of the Bahamas Building Code "allowance for New Providence".

*Table 6 Summary of Return period of extreme daily annual rainfall total for one day from Mott Mcdonald*

| | Return Period (years) | Rainfall rate (ins/hour) |
|---|---|---|
| Mott McDonald's Report | 2 | 3.9 |
| | 5 | 6.7 |
| Bahamas Building Code[9] | 2 | 2.9 |
| | 5 | 4.5 |

*Table 7 Summary of DOM rainfall records 2000 – 2019 flooding conditions*

| | Dry Season Dec-May | Wet Season June- Nov |
|---|---|---|
| Flooding occurs when condition met; rainfall total exceed | >3 ins/24hr period | >3 ins/24hr period |
| Duration of rainfall event in days | 2 - 9 days | 2 - 5 days |
| Volume of rainfall Mean, Low and High over 24 hr. period | 2.77 - 11.84 | 3.15 - 11.51 |

[9] Motts translation of the Bahamas Building Code allowance for one half an inch per 5 minutes (6 ins/hr.)

*Table 8 Summary Climate Change projections to 2050*

| | | | |
|---|---|---|---|
| **Temperature** | Maximum daily and mean temperature | Increase by 1.97C | |
| | | Winter increase less than 2C | Summer increase over 2 C |
| **Sea level rise** | 9.0 cm (3.6 ins) by 2030 | 20 cm (7.9 ins) by 2050 | 70 cm (27.6 ins) by 2100 |
| **Rainfall**<br>***Most extreme event will change from:*** | Decrease from 58 to 42 years | 1 in 100-year event increase | from 560 mm (20.5 ins) to 622 mm (24.4 ins)<br>**19% increase** |

The observed rainfall patterns for New Providence from the DOM, Nassau International Airport, presents the following challenges for the design of flood control systems for the Gladstone Road corridor.

In the wet (June to November) season, it is expected that:

- rainfall volumes will frequently exceed the field capacity of the porous limestones
- the seasonal rise in mean water table elevations during the summer months will further exacerbate flooding
- the impervious road surface and the surfaces on adjacent properties will increase runoff into and adjacent to the roadway and its verges
- flooding events may not have distinct dry periods between them, therefore, ground saturation is likely to remain at or near fully saturated for the entire wet season.

In the dry (January to March) season:

- less frequent flooding events can be expected
- the passage of winter (January to March) cold spells can and will create flooding events based on the amount and duration of rain days
- water table elevations will be lower
- field saturation levels may not be reached or exceeded and
- water percolation into the relatively dry limestone will result in more rapid drainage from adjacent impervious surfaces onto the roadway and verges

In both seasons, the drainage system must be designed:

- to provide for the rapid movement of rainfall from the impervious paved surface and verges
- accommodate runoff from the hills at the northern end of the corridor
- be elevated and maintained so that drainage systems work at their peak design efficiencies
- provide for retention ponds linked to drainage wells or channels to direct water away from the raised road base

The use of drainage wells combined with retention pond(s) and directed runoff into the verges, would represent one of the options to address runoff from the road from rainfall both in the short and longer terms. The design of the drainage wells must take into consideration long term and seasonal water table

fluctuations. The “head” or difference from the top of the casing to the water level in a borehole, required to quickly and efficiently drive freshwater into the saline zone will increase over time as sea level rises.

The following should be considered in determining the specifications of any drainage well:

The wells will have to penetrate to greater than ninety (90) feet), be cased in the lower soil horizon (-90 feet below ground level) with an open borehole into the bottom marine unit below -70 feet. The total depth will depend on the wells capacity to exceed 1,000 US Gallons per Minute per foot (USGm/ft) of drawdown.

The following conditions regarding the hydrogeology of the Gladstone Road corridor would have to be considered in determining the location, number(s) and elevations of wells relative to the airport centerline:

a. Any drainage well cased into the saline zone will have to overcome the density difference between fresh and sea water, the Ghyben-Hertzberg ration of 1:40 would apply
b. The effects of tide would be evident in all boreholes, as well as a time lag between the open ocean and well; the deeper the well the shorter lag time would be evident between the north (Atlantic Ocean) and south
c. The efficiency of drainage will be related directly to the difference in elevation of water surface in the well and the height of water above mean sea level in the well
d. Drainage flows into the well, will be highest at mean-low water level (relative to sea level) in the well when compared to mean-high water level; seasonal variations effected by rainfall will be evident, and finally,
e. Any drainage well, if not maintained, will have a declining efficiency over time as the pores of the drainage zone becomes clogged by the ingress of debris in discharging water into the saline aquifer.

Drainage wells must be maintained and regularly cleared of debris, particularly in the summer months, between rainfall events to reduce water accumulation around the wells and flooding.

## Annex 1 Table 1 GRIP Traffic Flow Study 11th to 13th February 2020

Table 1 Gladstone Road 11 – 13 February 2020 traffic flows

| hour | Southbound | Northbound | total |
|---|---|---|---|
| 6 | 224 | 541 | 1059 |
| 7 | 447 | 657 | 1511 |
| 8 | 516 | 532 | 1564 |
| 9 | 453 | 512 | 1434 |
| 10 | 414 | 462 | 1321 |
| 11 | 435 | 440 | 1360 |
| 12 | 480 | 499 | 1493 |
| 13 | 572 | 457 | 1500 |
| 14 | 554 | 534 | 1582 |
| 15 | 730 | 565 | 1819 |
| 16 | 766 | 487 | 1786 |
| 17 | 958 | 512 | 1912 |
| 18 | 831 | 461 | 1692 |
| 6 | 212 | 567 | 1126 |
| 7 | 431 | 703 | 1559 |
| 8 | 528 | 505 | 1425 |
| 9 | 386 | 525 | 1368 |
| 10 | 405 | 460 | 1334 |
| 11 | 435 | 517 | 1400 |
| 12 | 551 | 496 | 1538 |
| 13 | 543 | 472 | 1509 |
| 14 | 588 | 504 | 1532 |
| 15 | 824 | 544 | 1912 |
| 16 | 941 | 498 | 2013 |
| 17 | 990 | 549 | 1990 |
| 18 | 837 | 478 | 1739 |
| 6 | 220 | 570 | 1119 |
| 7 | 449 | 660 | 1520 |
| 8 | 457 | 523 | 1364 |
| 9 | 432 | 498 | 1393 |
| 10 | 426 | 446 | 1274 |
| 11 | 460 | 482 | 1404 |
| 12 | 534 | 482 | 1538 |
| 13 | 528 | 437 | 1474 |
| 14 | 614 | 549 | 1616 |
| 15 | 843 | 580 | 1971 |
| 16 | 904 | 484 | 1906 |
| 17 | 991 | 499 | 904 |
| 18 | 809 | 419 | 1572 |
| Grand Total | 22,718.00 | 20,106.00 | 60,535.00 |
| % | 38% | 33% | |
| Firetrail West | 4143 | 7% | |
| Firetrail East | 13568 | 22% | |

**ANNEX 2 Department of Meteorology (DOM) Rainfall record 2010**

Bahmet 30/1

# DEPARTMENT OF METEOROLOGY

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## RAINFALL RECORD

STATION: LYNDEN PINDLING INTERNATIONAL AIRPORT NUMBER: 78073 YEAR: 2010

ISLAND: NEW PROVIDENCE Latitude: 25° 03' N Longitude: 77° 28' W Altitude: 22FT.

Totals of rainfall for 24 hours commencing at 7:00 AM on the date shown, in inches, tenths and hundredths.

| Date | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Trace | Trace | | | | 0.58 | 0.16 | Trace | 0.05 | | | 0.58 |
| 2 | | | | | | 0.11 | 0.08 | | 0.24 | 0.87 | | |
| 3 | 0.17 | | | | | 0.20 | | 0.66 | 0.10 | 0.41 | 0.02 | |
| 4 | 0.05 | | | | | 0.87 | 0.05 | | 0.06 | 1.06 | 0.60 | |
| 5 | | 0.02 | | | | | 0.24 | 0.02 | 0.08 | 2.44 | | |
| 6 | | 0.04 | | | | Trace | 0.07 | | 0.06 | 0.06 | | |
| 7 | | | Trace | | | | 0.50 | 1.68 | 0.12 | | | |
| 8 | | | Trace | | | Trace | 0.57 | 0.66 | 1.07 | | | |
| 9 | 0.18 | 0.06 | | | | 0.01 | 0.02 | 0.91 | 0.52 | | | 0.08 |
| 10 | | | | | 0.06 | | 0.14 | | 0.09 | | | 0.09 |
| 11 | | | | 0.10 | | 0.01 | 1.58 | 0.01 | 0.71 | | Trace | |
| 12 | | 0.14 | | 0.12 | | 0.18 | 0.90 | 0.06 | | 1.14 | | 0.15 |
| 13 | | | 0.18 | | 0.01 | | 0.38 | 0.51 | | 0.12 | | |
| 14 | | | | | | 0.14 | 0.10 | 0.80 | 0.08 | 0.42 | | |
| 15 | | 0.01 | | | | 0.25 | 0.01 | Trace | 0.25 | Trace | Trace | |
| 16 | | 0.07 | | 0.07 | | 0.01 | | | | | 0.08 | |
| 17 | Trace | | 0.04 | | | | Trace | | | | 0.88 | 0.01 |
| 18 | | | | 1.97 | | 0.29 | 0.85 | | | Trace | 0.02 | 1.26 |
| 19 | | 0.01 | | 0.01 | 2.68 | 0.04 | | 0.09 | | 0.02 | | Trace |
| 20 | | | | 0.07 | 0.15 | Trace | 0.10 | | | 0.48 | | |
| 21 | Trace | 0.14 | | | 0.06 | 0.09 | 0.01 | 0.24 | | 0.04 | | |
| 22 | 0.06 | 0.62 | 1.11 | | 0.01 | 0.18 | 0.95 | 0.08 | | 0.41 | | |
| 23 | 0.05 | | | | | 0.02 | 0.04 | 0.02 | 0.09 | Trace | | |
| 24 | Trace | 1.98 | | | | 0.88 | Trace | 0.01 | 0.06 | | | |
| 25 | | | | Trace | | 0.06 | 0.01 | | | Trace | | |
| 26 | | | | 0.92 | | | | | Trace | 0.14 | | 0.10 |
| 27 | | 0.54 | | | | | | 1.55 | 0.10 | | | |
| 28 | | | | | | 0.01 | | 0.06 | 0.90 | | | |
| 29 | | | 0.11 | 0.06 | | | 0.01 | 0.80 | 3.00 | Trace | 0.86 | |
| 30 | | | | 0.04 | | 0.07 | | 0.01 | Trace | 0.08 | Trace | |
| 31 | 0.02 | | | | | | 1.48 | 0.85 | | | | |
| Total | 0.53 | 3.63 | 1.39 | 3.36 | 2.97 | 2.85 | 7.70 | 8.02 | 7.53 | 7.64 | 1.86 | 2.27 |
| Cumulative | 0.53 | 4.16 | 5.55 | 8.91 | 11.88 | 14.73 | 22.43 | 30.45 | 37.98 | 45.62 | 47.48 | 49.75 |
| Days | 6 | 11 | 4 | 9 | 6 | 19 | 22 | 19 | 18 | 14 | 6 | 7 |
| Long Term(1971-2000) | | | | | | | | | | | | |
| Total | 1.86 | 1.93 | 2.14 | 2.73 | 4.13 | 8.62 | 6.33 | 9.27 | 6.42 | 6.42 | 3.17 | 1.97 |
| Cumulative | 1.86 | 3.79 | 5.93 | 8.66 | 12.79 | 21.41 | 27.74 | 37.01 | 43.43 | 49.85 | 53.02 | 54.99 |
| Days | 8 | 6 | 7 | 6 | 10 | 15 | 17 | 19 | 17 | 15 | 10 | 8 |

## 12.3 Traffic Review and Analysis

# Gladstone Road Corridor

## Traffic Review and Analysis Report

13 May 2020

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# TRAFFIC REVIEW AND ANALYSIS REPORT

## 1.0 Introduction

The ensuing Traffic Review and Analysis Report represents a key deliverable for the Gladstone Road Corridor (GRC) Project. The primary basis for the analysis of existing conditions within the Corridor are traffic data gathered as part of a comprehensive data collection effort in February 2020 using MIOVISION technology at major intersections and traditional tube counters at strategic mid-block locations. Using this baseline information, combined with available input from the Ministry of Works (MOW) regarding plans for other transportation infrastructure and nearby development potential, traffic projections for the year 2040 time-horizon were used to better inform certain design aspects of the Gladstone Road Corridor, including road geometry and type of traffic control. It should be noted that there is already a commitment by the MOW to widen the existing Gladstone Road to a 4-lane divided facility.

The following topics will be addressed within this study:

- Summary of the traffic data collection program;
- Existing transportation conditions within the study area, with a specific focus on determining peak hour conditions at key intersections within the GRC;
- Future traffic forecasts in support of the development of this area (residential and/or major industry); and
- Analysis of planned roadway modifications necessary to support future traffic conditions.

### 1.1 Objectives

The primary objective of this report is to determine forecasted turning movement volumes at key intersections within the subject Corridor to help inform the number, location and geometric design of intersections. Specifically, the design volumes will influence an appropriate geometric layout of the Corridor in terms of safety, access and performance of all users.

### 1.2 General Approach

Existing turning movement counts at key intersections will be gathered using MIOVISION technology and supplemented with traditional tube counts recorded at strategic locations within the Corridor.

For the future time horizon, it is proposed that the forecasts within the subject Corridor will be derived using first principles that reflect historical growth rates and known development projects within the study area. Existing turning movement counts at the major intersections will be factored to represent this forecasted growth, and new intersections introduced where future major development adjacent to the Corridor is recognized. Forecasts will be developed for the weekday morning and afternoon peak hours.

Projected vehicle turn-movement counts at key locations within the Corridor will be used to inform the design of Gladstone Road, including the type of control (and length of any auxiliary turn lanes if appropriate) at five major intersections (according to the ToR). These include the existing intersections at John F. Kennedy Drive (roundabout), Fire Trail Road, and Carmichael Road, as well as two new intersections located between JFK and Fire Trail Road, and between Fire Tail Road and Carmichael Road. Consideration will also be given to the need for additional intersections or median breaks at any other strategic locations within the GRC.

Intersection capacity analyses at major intersection will be completed using the SIDRA software, which is an Australian-based package (left-hand drive compatible) conducive to modelling roundabouts and traffic signals.

It will provide an assessment of existing and forecasted intersection performance, based on delay and/or volume-to-capacity ratio, for various design alternatives.

## 1.3 Study Area Context

The subject Gladstone Road Corridor extends approximately 3 miles between Carmichael Road in the south to John F Kennedy (JFK) Drive in the north. There is no parallel road situated to the east given Lake Killarney (and Lynden Pindling Airport further east), and Sir Milo Butler Highway (a divided 4-lane facility) is situated roughly 1 mile to the east. See Figure 1.

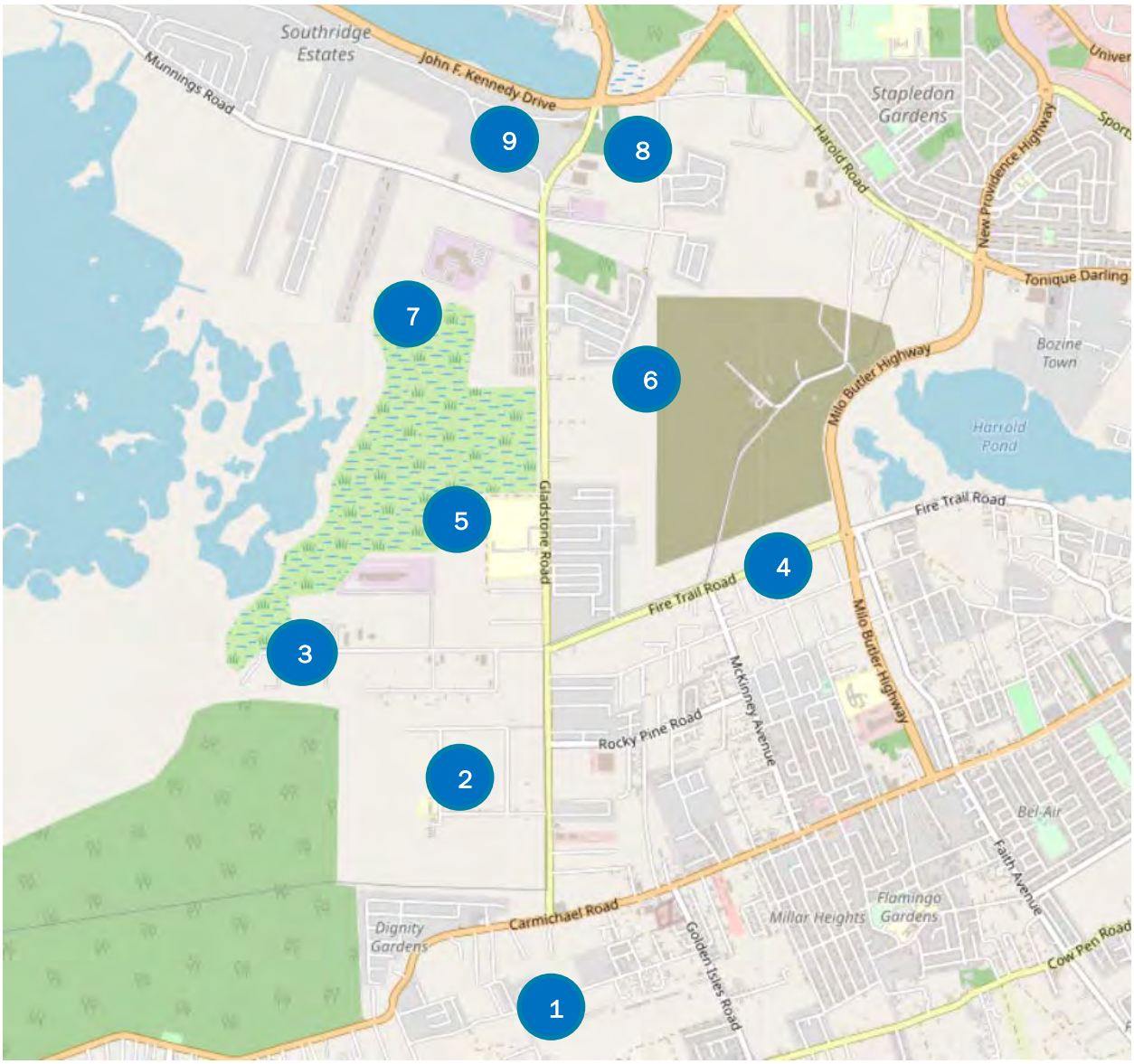
Carmichael Road provides a valued continuous east-west facility for much of the southern part of the Island of Nassau, whereas JFK Drive serves a similar role further north. The one notable intersecting road within the Corridor is Fire Trail Road that links Gladstone Road to Sir Milo Butler Highway.

### 1.3.1 Notable Existing Developments

There are a number of developments/institutions in close proximity to the Corridor:

1. Excellence Estates – a notable residential/mixed use area located south of Carmichael Road (towards the southern shore) within the catchment area of Gladstone Road;
2. Gladstone Road Farmers Market – located on the west side of Gladstone Road between Carmichael and Fire Trail; open on Saturday only
3. Fire Trail Road West – predominantly a light industrial area;
4. Fire Trail Road East – provides a direct road connection to Sir Milo Butler Highway and collects traffic from the adjacent residential community east of Gladstone Road;
5. Aquinas College – Roman Catholic School (serving students of high school age) located on the east side of Gladstone Road north of Fire Trail;
6. Victoria Gardens – small residential community on the east side of Gladstone Road south of Munnings;
7. Sysco Bahamas/Bristol Liquors – light industrial complexes on the west side of Gladstone Road south of Munnings;
8. Lakeview Memorial Gardens – memorial grounds/cemetery located in the southeast quadrant of the JFK/Gladstone intersection; services are intermittent;
9. Fusion Superplex – landmark IMAX theatre complex (100,000 $ft^2$) located in the southwest quadrant of the JFK/Gladstone intersection;

Figure 1: Study Area Context




*Source: OpenStreetMaps*

## 2.0 Traffic Data Collection

An extensive traffic data collection program for the GRC was developed in collaboration with the MOW consisting of MIOVISION technology and supplemented with traditional tube counts recorded at strategic locations within the Corridor. A data collection guide was developed by Parsons in preparation for the deployment of the data collection equipment, and this more detailed document is included as Appendix A.

The traffic data collection program was completed in February 2020.

## 2.1 Miovision

Miovision, a global leader in smart traffic technology. Miovision specializes in traffic AI software that processes traffic data from video sources. They also provide portable video collection units that are designed for reliable recording of turning movement counts. The Ministry has invested into Miovision Scout cameras, of which five (5) were made available to assist with this assignment.

To ensure a comprehensive assessment of the GRC, intersections that connect to other major roads or lead to sizeable developments (e.g. large subdivisions or industrial sites) were included in the data collection program. The intersection included in the data collection program using Miovision are identified in Figure 2. Data were gathered over three days at the three (3) major intersections within the Corridor, namely JFK, Fire Trail and Carmichael, and a single day at the other eleven (11) intersections. Coverage spanned from 13 hours between 6:00am and 7:00pm. The source Miovision data is included as Appendix B.

## 2.2 Conventional Tube Counts

The MOW provided tube counters to assist with the collection of 24h traffic volume data at strategic mid-block locations within the GRC. Tube counter were positioned over at least a 7-day period near JFK, Fire Trail and Carmichael as shown in Figure 2. The tube counters were RoadPod VT5900 Plus units from MetroCount. The source tube count data is included as Appendix C.

Figure 2: GRC Study Area Intersections and Mid-Block Locations

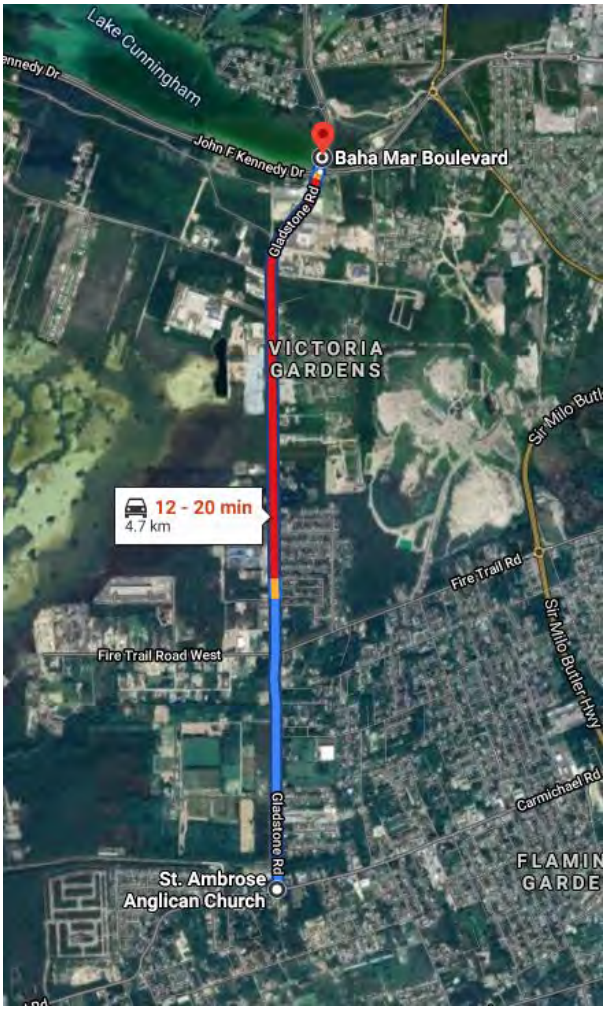
## 2.3 Field Observations

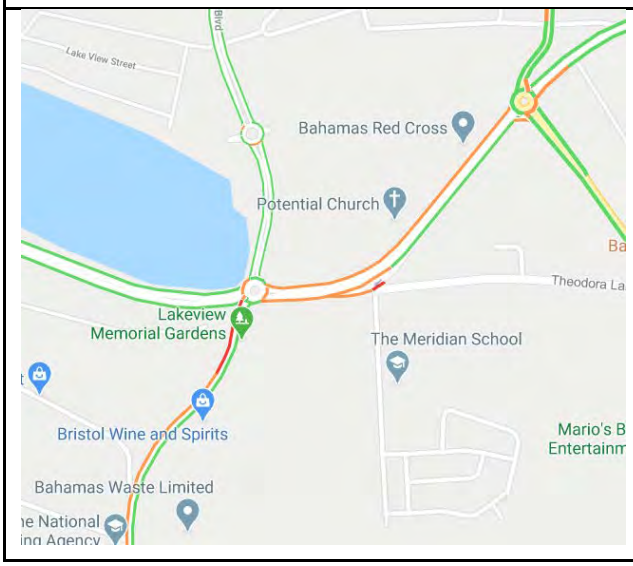
Existing travel times within the GRC were determined using a combination of estimates provided by Google Traffic and limited field observation:

- free-flow travel times for the entire GRC are is approximately 7 minutes, resulting in an average speed of just under 30 mph (50 km/h)
- during the morning commuter peak period, typical northbound travel times range between 10 and 20 minutes, and southbound travel times range between 6 and 9 minutes;
- during the afternoon commuter peak period, typical northbound travel times range between 6 and 9 minutes, and southbound travel times range between 8 and 14 minutes; and
- travel times are highest on a Friday, with the extent of queuing indicated in Figure 3
- on Saturdays, delays do not exceed 3 minutes compared to free-flow conditions;
- the majority of congestion within the Corridor is observed approaching the JFK roundabout, and any funeral service at the Lakeview Memorial Gardens exacerbates congestion south of the roundabout as vehicles park on the shoulder (see Figure 4); and
- other occasional traffic hot spots include near Aquinas College/Jubilee subdivision and near Fire Trail (see Figure 5 - Figure 8).

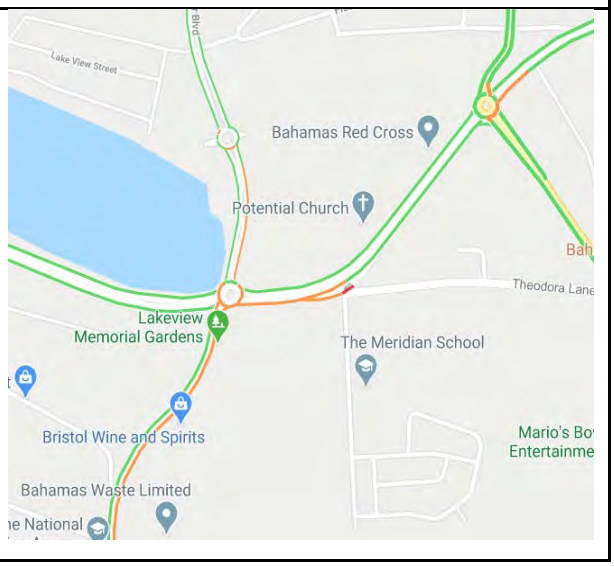
Figure 3: GRC Peak Direction Travel Times and Queuing on a Typical Day

*Northbound (AM peak)*




*Southbound (PM peak)*




*Source: Google Traffic*

Figure 4: Street View - GRC/JFK/Lakeview Memorial Gardens

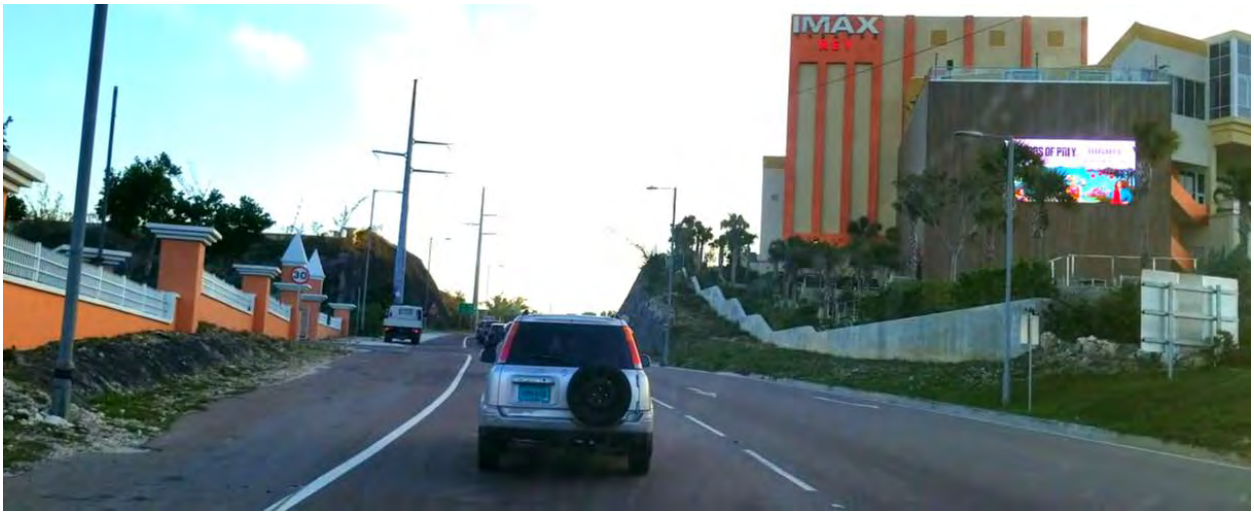


Figure 5: Street View - GRC/Munnings

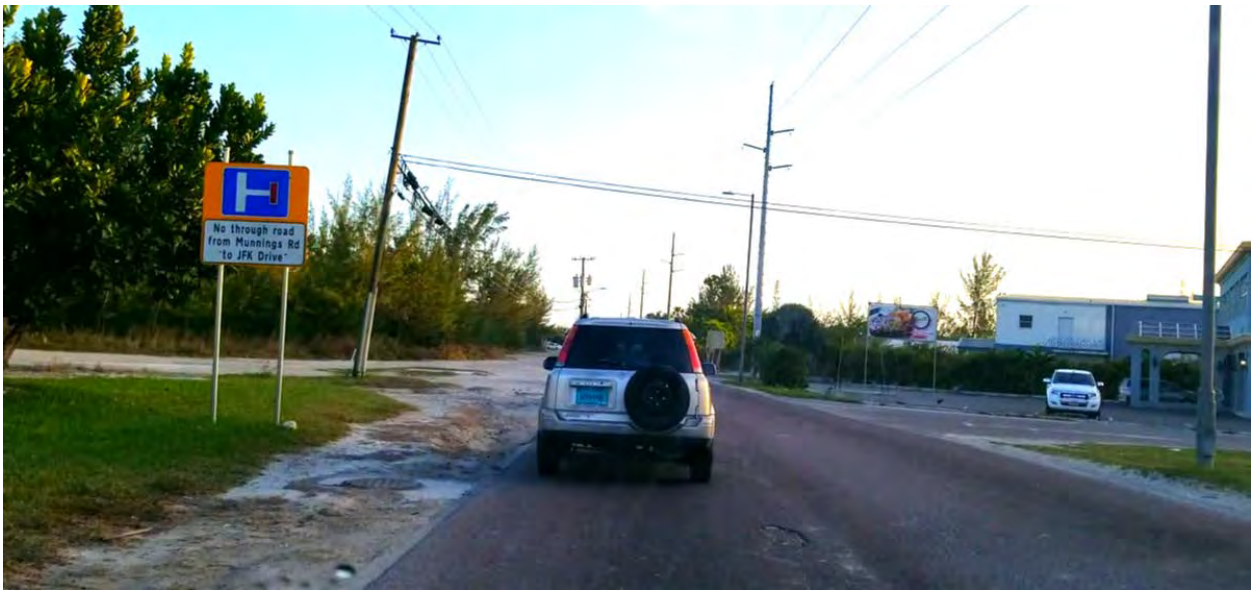



Figure 6: Street View - GRC/Aquinas College

Figure 7: Street View - GRC/Fire Trail

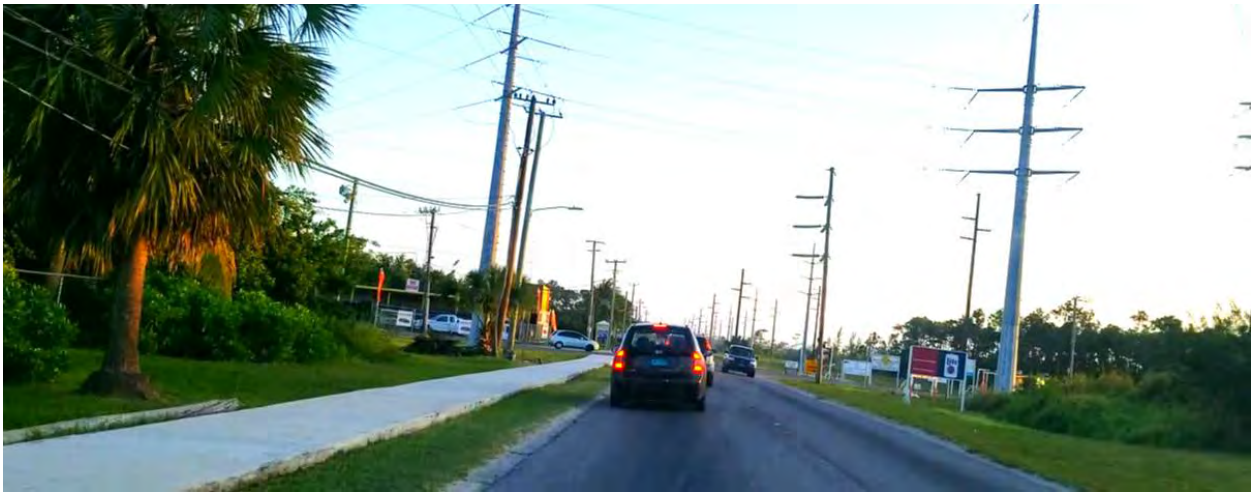


Figure 8: Street View - GRC/Carmichael

## 2.4 Collision History

A summary of the collision history for the GRC was provided by the Royal Bahamian Police Force at the onset of the study. Although details were not provided, the following statistics were provided for year 2019:

- Gladstone/JFK intersection – 53 collisions;
- Gladstone/Fire Trail intersection – 47 collisions
- Gladstone/Carmichael intersection – 48 collisions

# 3.0 Existing Transportation Conditions

The purpose of the ensuing section of the report is to document the existing transportation conditions in terms of current infrastructure (by mode) and characterize the existing traffic volume data gathered as part of the previously described data collection program.

## 3.1 Active Mode and Transit Networks

The pedestrian facilities within the GRC are limited to section of continuous sidewalk, on the east side, south of Virgil Boulevard to Carmichael Road (1.3 miles; see Figure 7 above). There are other short segments of existing sidewalk on Gladstone Road, including the west side near Carmichael Road, as well as on the west side south of JFK. There are no dedicated cycling facilities within the Corridor.

There are two routes that provide transit service within the study area.:

- Route 12: Coral Harbour, Lyford Cay and Airport provides service within the study area by passing through Carmichael/Gladstone intersection on Carmichael Road (on Carmichael from Coral Harbour to Baillou Hill);
- Route 14A: Jubillee Gardens provides service on Gladstone Road between Carmichael Road and Fire Trail Road.

It is understood that there are no particular bus stops, rather, transit riders flag the bus to board, and request a specific location to disembark.

## 3.2 Road Network

Gladstone Road is currently a 2-lane undivided roadway with no posted speed limit. The assumed speed limit is 35 mph based on a review of the appropriate *Motor Vehicle and Speed Limit Regulations* for The Bahamas. There is typically no paved shoulder, except near JFK. Utility poles/streetlights line both sides of the Corridor for much of its length (see Figure 4 through Figure 8).

Existing traffic control impacting travel along the Corridor is limited to the roundabout at JFK, roundabout at Fusion, and STOP control on the southbound approach to Carmichael.

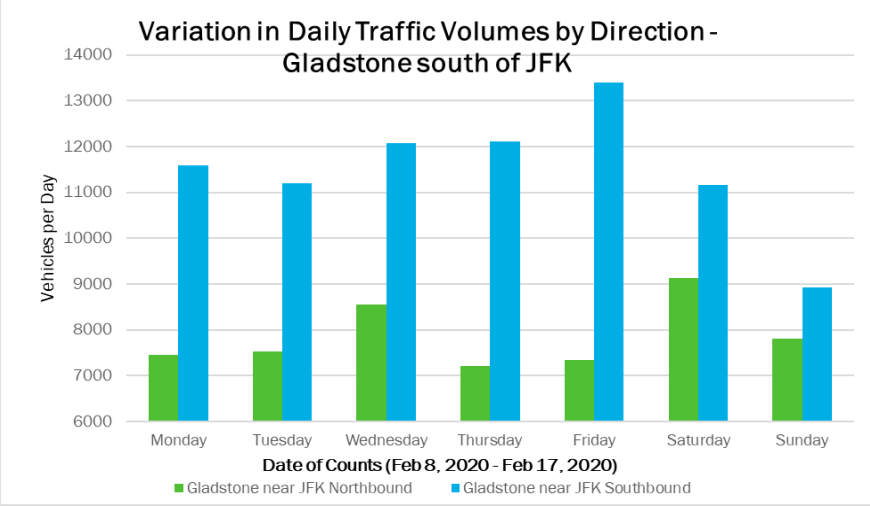
## 3.3 Daily Variation in Traffic Volumes

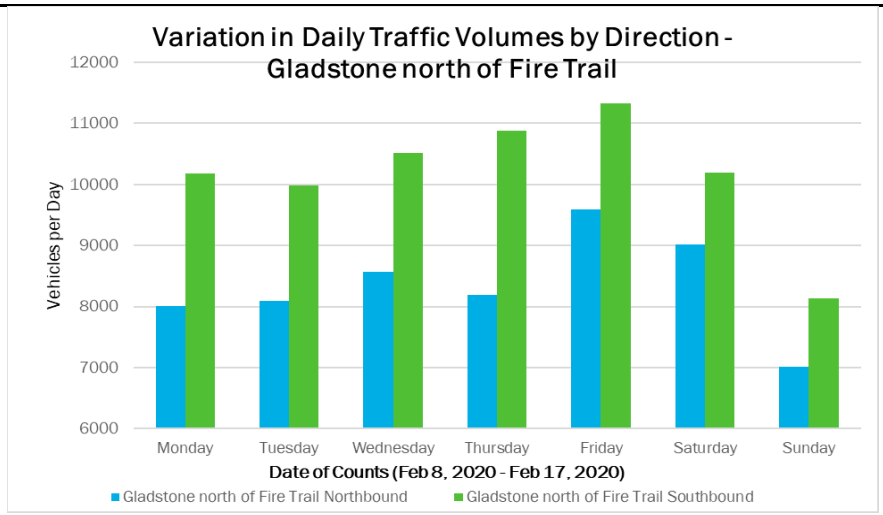
The use of 7-day tube count data at the three strategic mid-block locations enabled an evaluation of how daily and peak hour traffic volumes varied by day-of-week.

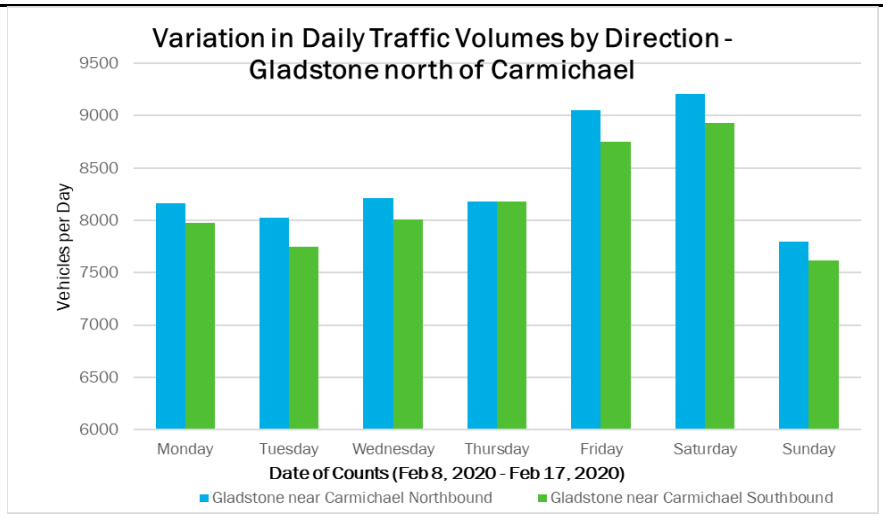
Figure 9 represents a series of plots showing total daily traffic, by direction, for each day of the week near JFK, Fire Trail and Carmichael. Total daily volumes are considered consistent Monday through Thursday, with slightly higher volumes on Friday and Saturday. Volumes are lowest on a Sunday.

Of particular note is the imbalance of northbound versus southbound total daily volumes near JFK and Fire Trail, with southbound volumes considerably higher than northbound. The imbalance is not present near Carmichael. This trend would seem to suggest that the GRC is considered more attractive as a southbound travel route, and that northbound motorists choose to use alternative routes such as Sir Milo Butler Highway.

Figure 9: GRC Daily Variation in Total Daily Traffic Volumes



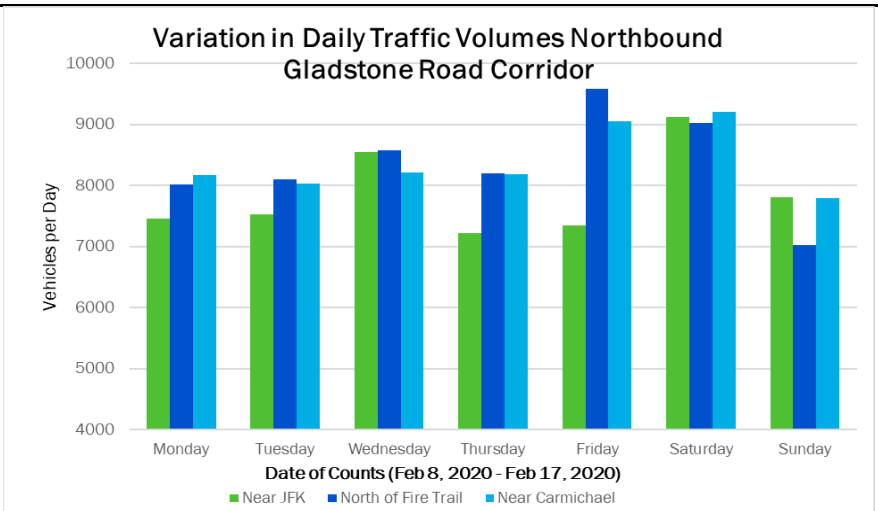


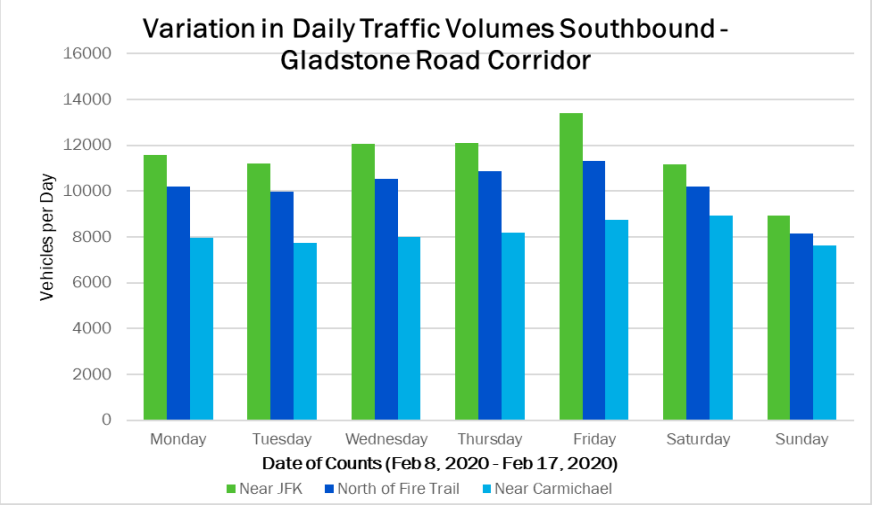




*Source: Tube Counts (Feb 8, 2020 to Feb 17, 2020)*

When the same data at each location are presented together as in Figure 10, total daily volumes in the northbound direction, on weekdays, were found to be generally diminishing as one progresses north towards JFK, and volumes in the southbound direction were found to be generally diminishing as one progresses south towards Carmichael.

Figure 10: GRC Daily Variation in Total Daily Traffic Volumes (all locations)



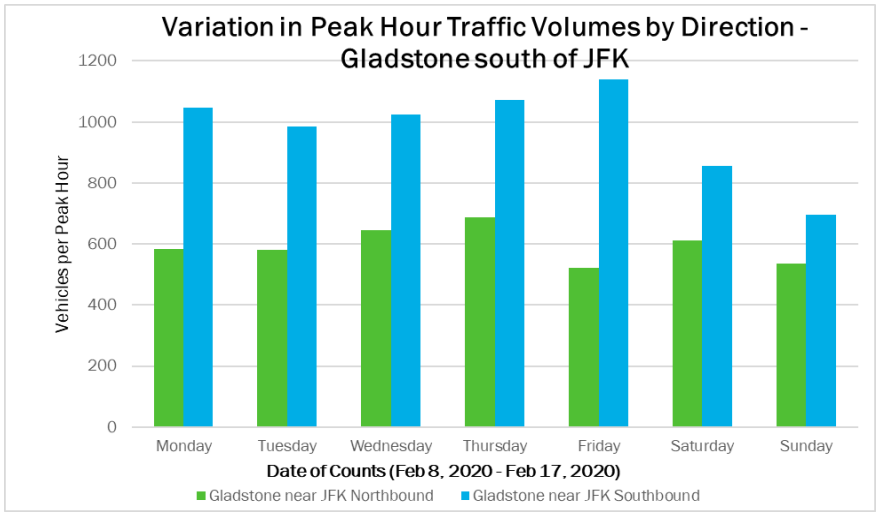

*Source: Tube Counts (Feb 8, 2020 to Feb 17, 2020)*

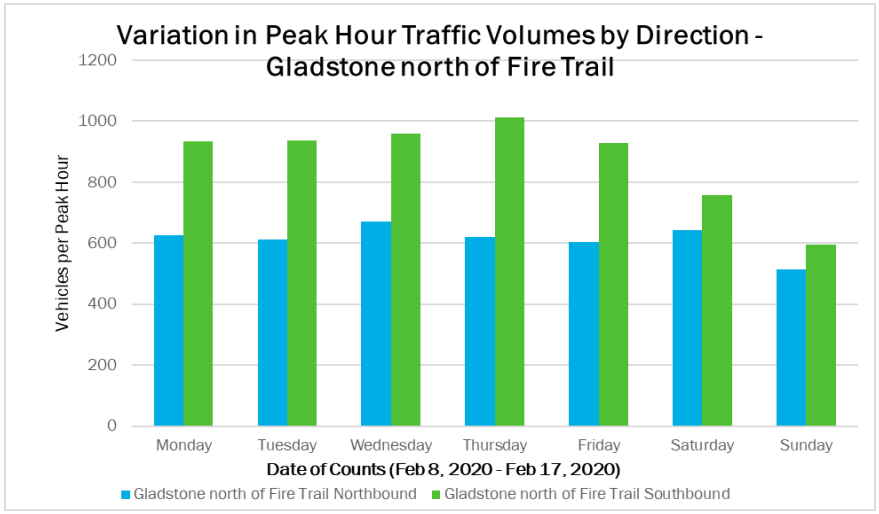
Figure 11 represents a series of plots showing peak hour traffic, by direction, for each day of the week near JFK, Fire Trail and Carmichael. Similar trends noted above of the total daily volumes are also exhibited in the peak hour volumes. The imbalance of northbound versus southbound volumes near JFK and Fire Trail remains evident, whereas directional peak hour volumes are much more balanced near Carmichael.

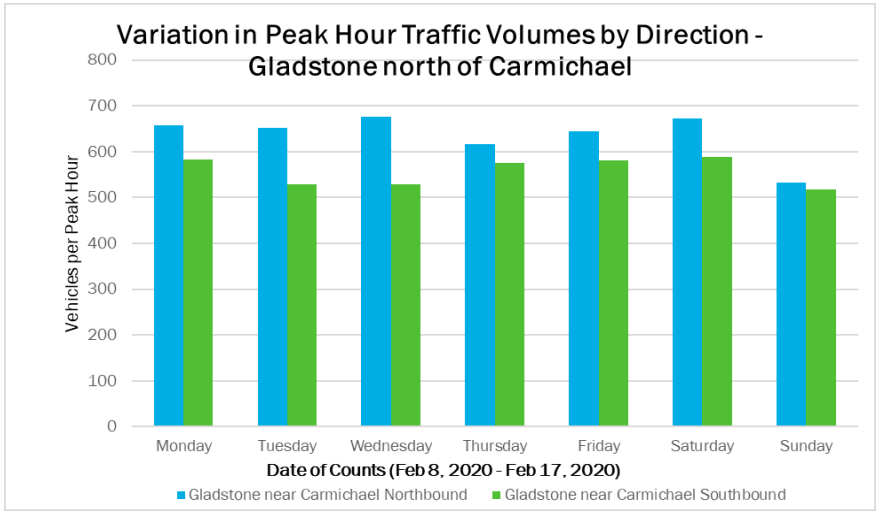
In comparing the weekday peak hour volumes near JFK with other recent transportation studies:

- 600 to 650 veh/h northbound compared to 540 to 720 veh/h identified in the Baha Mar Phase 2 TIS (IBI, 2019) and 360 to 450 veh/h identified in the IMAX TIS (PARSONS, 2018)
- 1,000 to 1,100 veh/h southbound compared to 730 to 920 veh/h identified in the Baha Mar Phase 2 TIS (IBI, 2019) and 470 to 600 veh/h identified in the IMAX TIS (PARSONS, 2018)

Figure 11: GRC Daily Variation in Peak Hour Traffic Volumes




*Source: Tube Counts (Feb 8, 2020 to Feb 17, 2020)*

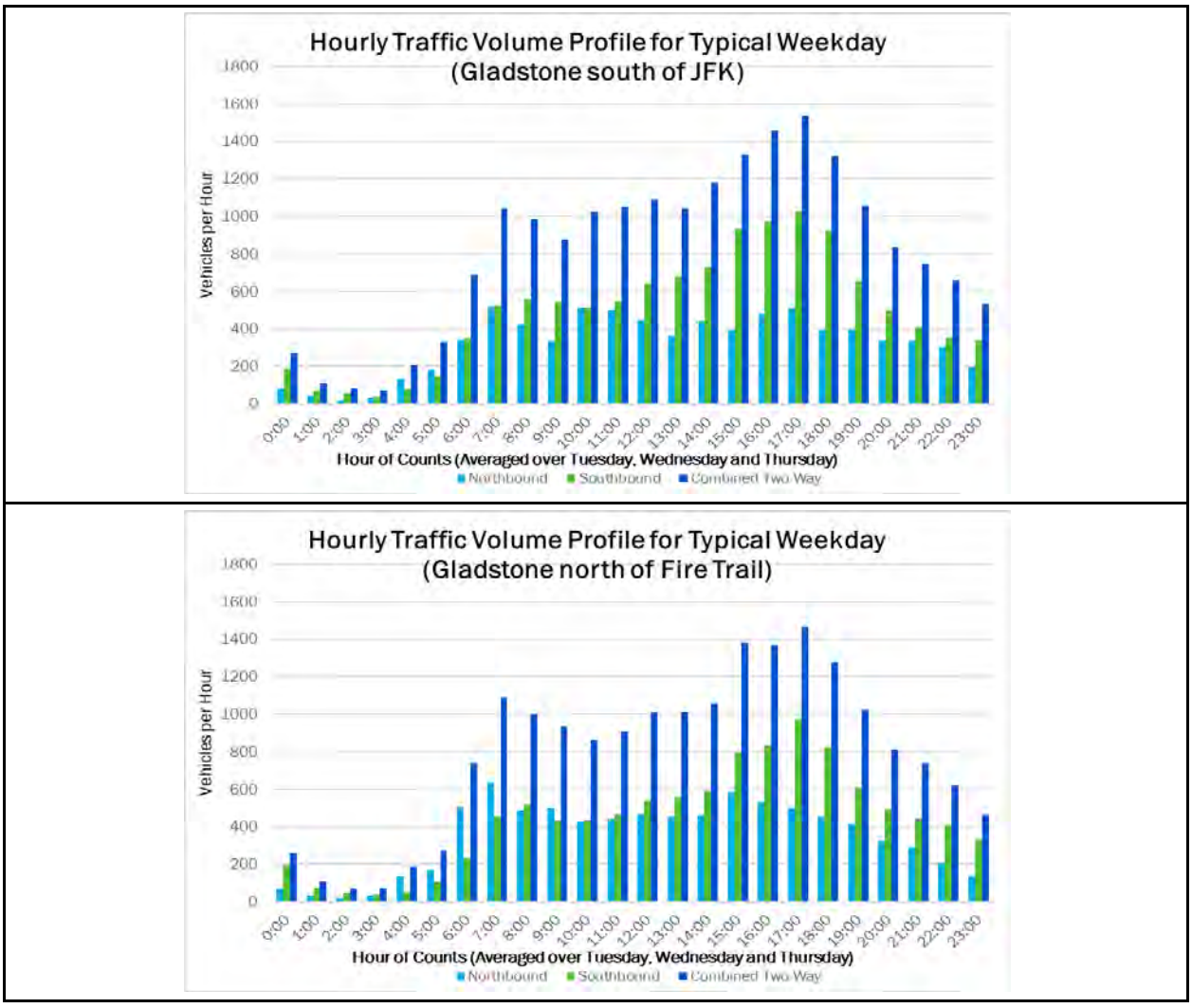
Based on the foregoing, the peak hour volume as a percentage of the total daily volume was found to range between 7% and 10%, with the average weekday value being 8%.

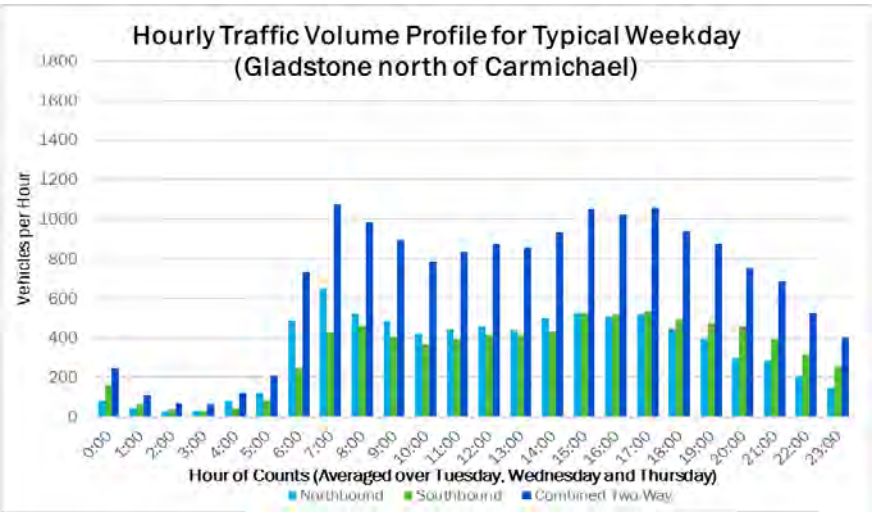
## 3.4 Hourly Variation in Weekday Traffic Volumes

The use of 7-day tube count data at the three strategic mid-block locations also enabled an evaluation of how hourly volumes varied by time of day. Consideration was given to data for weekdays only - Tuesday, Wednesday and Thursday.

Figure 12 represents a series of plots showing total hourly traffic, by direction and two-way, for a typical weekday near JFK, Fire Trail and Carmichael. In the morning, two-way volumes begin to increase starting at 4:00am and reach a peak between 7:00 and 8:00am. Volumes are noted to remain steady throughout the day, and begin to increase again around 2:00pm to signify the more pronounced afternoon peak period. Afternoon volumes peak between 4:00 and 5:00pm. Note that near JFK and near Fire Trail, northbound volumes remain quite stable throughout the day, whereas southbound volumes peak throughout the afternoon peak period. Near Carmichael, the hourly northbound and southbound volumes are more balanced throughout the day.

Figure 12: GRC Hourly Variation in Peak Hour Traffic Volumes






*Source: Tube Counts (Feb 8, 2020 to Feb 17, 2020)*

## 3.5 Validation of Tube Count and Miovision Data Sets

For each of the three major intersections where both tube count data and Miovision data sets were available, an assessment was made using the average hourly volumes over a three-day period, namely Feb 11-13, 2020. These results for each location are shown in Figure 13.

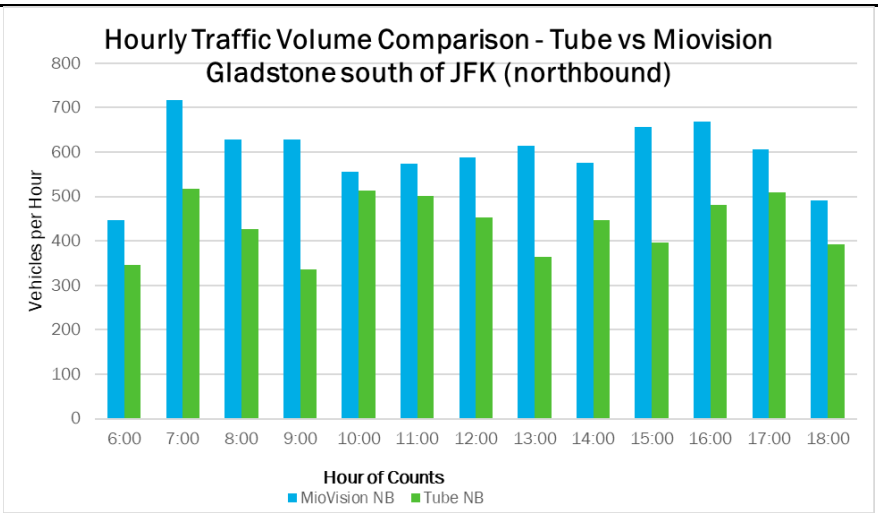
At the location just south of JFK, the data indicate a notable discrepancy in the northbound direction where the hourly volumes from the tube counters are consistently lower than volumes from Miovision by up to 300 veh/h. In the southbound direction, the data are more comparable except in the afternoon peak period when the tube count volume data is consistently greater than the Miovision volume data.

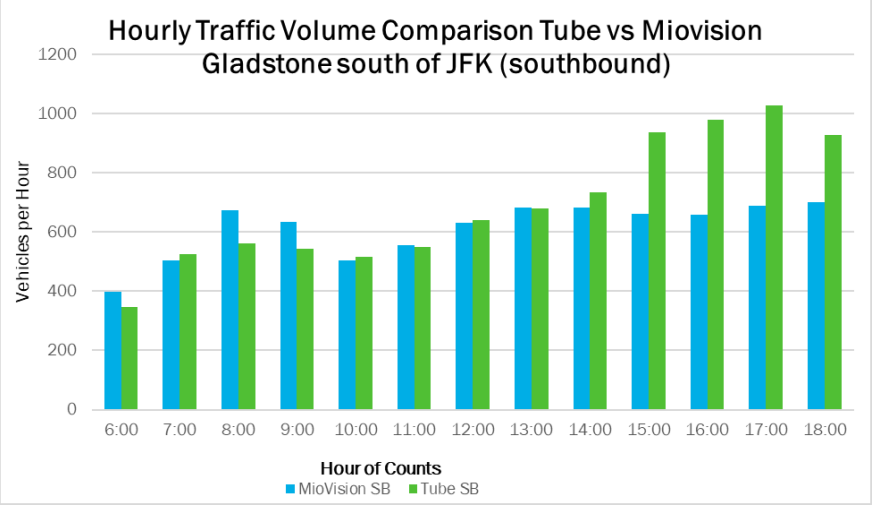
At the Fire Trail and Carmichael locations, there are very small discrepancies between the two data sets.

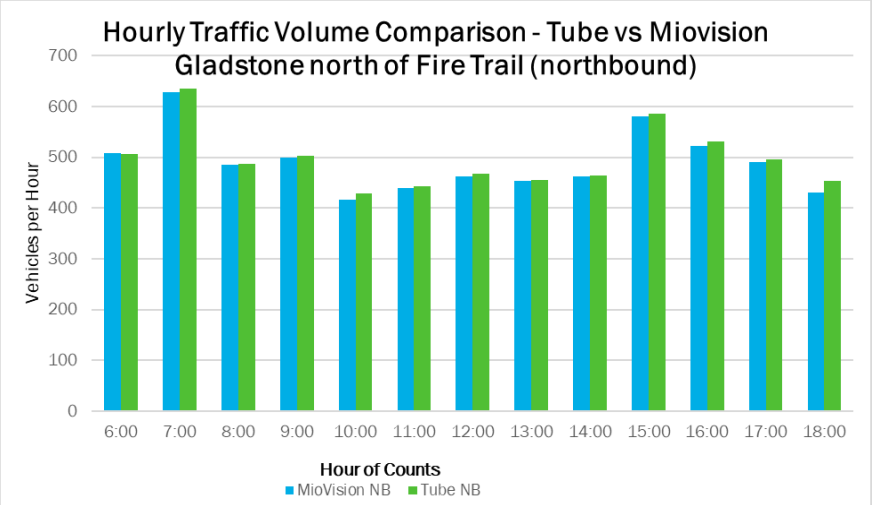
The basic question becomes for the location near JFK, *which source of data is correct and most importantly, which should be used to inform the design?* Recall previously that these same tube count data near JFK were compared to volume data identified in other studies, and although not definitive, there was some evidence that tube counts underestimated northbound volumes and underestimated southbound volumes. Also, given that the Miovision technology is more contemporary and the Miovision data output endured a quality assurance check by technicians at Miovision[1], coupled with the general observation that some of the deployed tube counters were not in good condition, **it is recommended that the baseline data be reflective of the Miovision counts.**

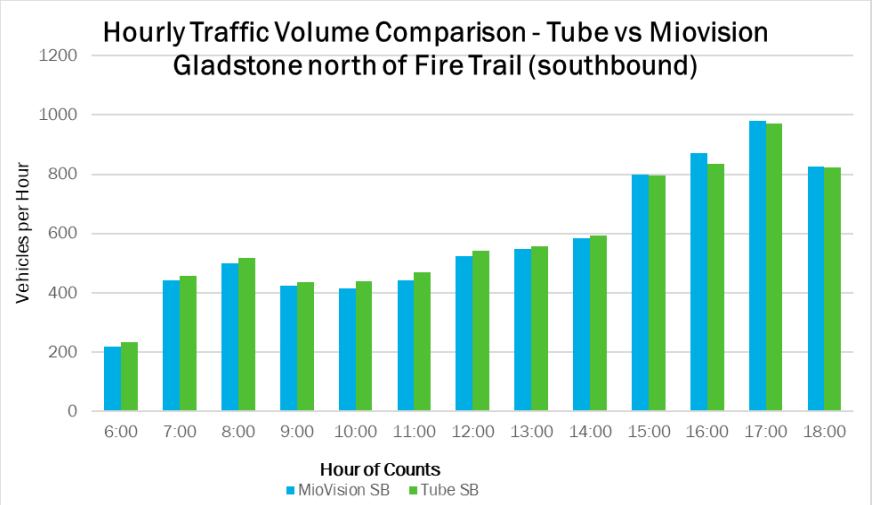
[1] The three camera setups at the Gladstone/JFK intersection each received a rating of 4 out of a possible 5 by Miovision technicians, indicating an accuracy of at least 95%. It is understood that given the roundabout is large and required consolidation from four cameras, a higher rating would not be attainable.

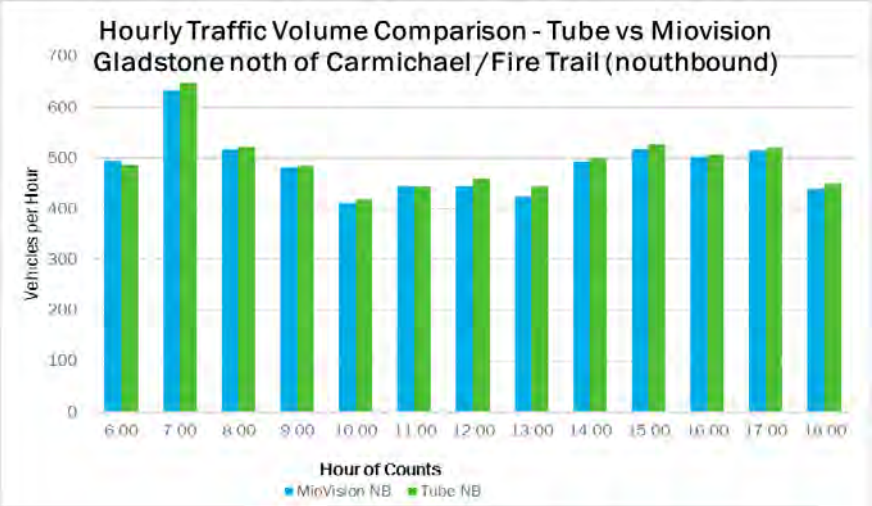
Figure 13: GRC Comparison of Hourly Volumes from Tube Counters and Miovision (averaged over 3-days)

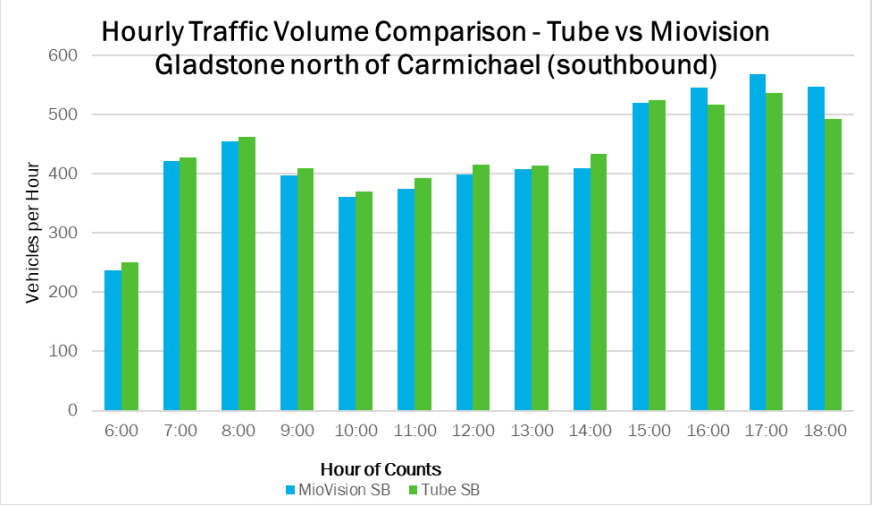





*Source: Tube Counts and Miovision Counts (Feb 11-13, 2020)*

## 3.6 Average Daily Traffic (ADT)

Based on the previous assessment of the mid-block data using both tube count data and Miovision data, the following Table 1 provides a summary of the estimated average daily traffic (ADT) within the GRC. The estimates are based on the daily traffic volumes averaged over a three-day period (Feb 11-13, 2020).

Without additional data to reflect any seasonal variations, it is not feasible to estimate annual average daily traffic (AADT).

Table 1: Summary of Existing Average Daily Traffic within the GRC

| Location | 24-h Northbound Volumes | 24-h Southbound Volumes | 24-h Total Volumes (ADT) | Notes |
|---|---|---|---|---|
| South of JFK | 9,100 | 11,700 | 19,800 | Derived using Miovision data |
| North of Fire Trail | 8,300 | 10,500 | 18,800 | Tube count / Miovision |
| North of Carmichael | 8,100 | 8,000 | 16,100 | Tube count / Miovision |

*Source: Estimate based on three-day average (Feb 11-13, 2020)*

An estimate of existing ADT approaching each of the three major intersections was also derived using the turning movement data from Miovision. Two methods were considered:

- **Method 1**: Daily totals derived based on the assumption that the peak hour volumes represent 7 to 10% of the daily value as indicated in Section 3.4. It is important to note, however, that this method reflects the relationship between the peak hour and daily total traffic volumes within the GRC, but does not necessary reflect conditions on the other legs of the Gladstone/JFK roundabout. For example, at the Gladstone/JFK intersection, the method yields a range of approach ADT between 43,500 vehicles (10%) and 62,000 vehicles (7%).
- **Method 2**: Daily totals derived based on the relationship between the busiest 12-h and 24-h total daily volume. This method is also constrained by the assumption that the volume relationship within the GRC is similar to other legs of the Gladstone/JFK roundabout, however uses the known 12-h total from the Miovision data as a starting reference point. The data indicate that the busiest 12-h data represent 70% of the daily total, and the approach 12-h data from Miovision at JKF, Fire Trail and Carmichael is 44,500, 19,100 and 19,000 vehicles, respectively.

The ADT estimates based on **Method 2** are summarized in Table 2 for each intersection.

Table 2: Summary of Existing Average Daily Traffic Approaching Major GRC Intersections

| Location | AM Peak Hour Approach Volume | PM Peak Hour Approach Volume | Estimated 24-h Total Volumes (ADT) | Notes |
|---|---|---|---|---|
| Gladstone/JFK | 4,350 | 4,300 | 63,700 | Derived using Miovision data |
| Gladstone/Fire Trail | 1,580 | 1,990 | 26,900 | Derived using Miovision data |
| Gladstone/ Carmichael | 1,890 | 1,910 | 27,200 | Derived using Miovision data |

*Source: Estimate based on three-day average (Feb 11-13, 2020)*

## 3.7 Percentage of Heavy Vehicles

Based on the Miovision data, the percentage of heavy vehicles within the GRC is currently in the range of 3-4%, with heavy vehicles including a combination of 'medium' (i.e., buses, single-unit trucks) and 'heavy' (articulated trucks) subcategories. It is noted that some turning movements to/from individual site driveways serving a

commercial venture exhibited a higher percentage of heavy vehicles, for example Fire Trail west of GRC (+15%). The percentage of heavy vehicles was slightly lower on JFK (2-3%), and slightly higher on Carmichael (5-6%).

## 3.8 Weekday Peak Hour Traffic Volumes

Peak hour traffic volumes are typically used as the basis to assess intersection performance during the busiest times of day, and also to inform the geometric requirements. Morning and afternoon peak hour turning movement counts at the study area intersections were determined by mining the Miovision data set to determine the busiest 1h period during each commuter peak period. At the three major intersections, three data sets were available with the average taken, whereas at the balance of the study area intersections only a single data set was available.

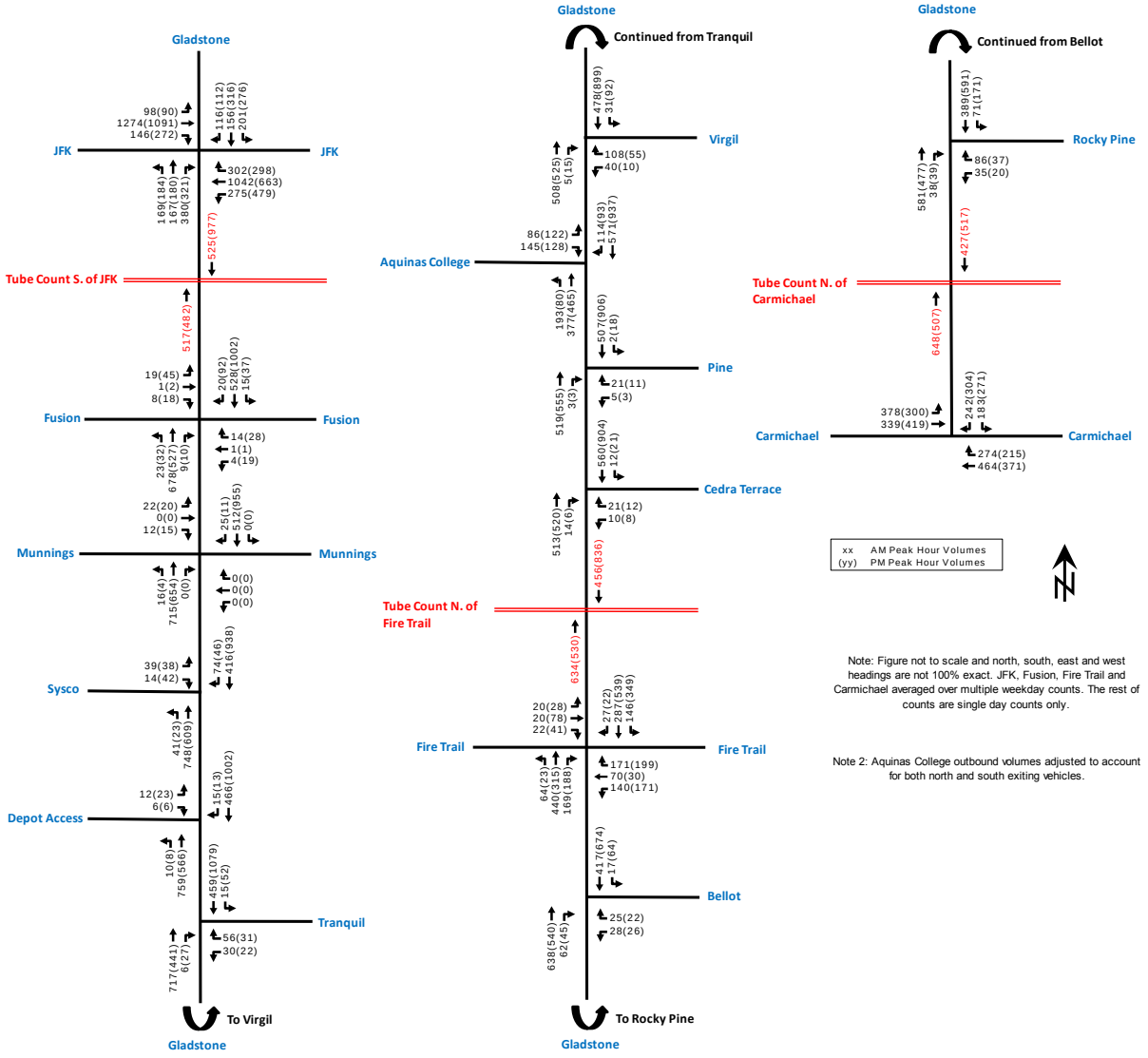
Note that each intersection within the GRC may experience its busiest hour over a slightly different 1h period depending on the nature of the side street traffic demand. In general terms, however, the data indicate the following:

- morning peak period extends between 7:00am and 9:15am, with the peak hour typically at 7:15am to 8:15am
- afternoon peak period extends between 3:15pm and 6:30pm, with the peak hour typically at 4:00pm to 5:00pm

Figure 14 provides a summary of the existing peak hour turning movement volumes at each study area intersection. Checks of volume imbalances (between consecutive intersections) were completed to ensure overall consistency within the Corridor. Aquinas College was the only location where a notable imbalance of more than 100 veh/h was found, suggesting that peak hour activity near the school site may warrant special investigation:

- the site is served by two driveways: the north driveway access is used only for outbound trips and is gated closed after 4:30pm; and the south driveway access is used predominantly for inbound trips, although some outbound traffic does use the southern driveway (especially after 4:30pm when it serves as the only access to the site;
- Miovision data was recorded at the southern driveway access only, and therefore outbound traffic at the northern driveway access was estimated assuming three-quarters of the peak hour inbound traffic at the southern driveway access would drop-off students and immediately exit the site to the north; and
- for the purposes of this report, vehicle activity at the two driveways serving Aquinas College was consolidated into a single access.

Figure 14: GRC Existing Peak Hour Turning Movement Volumes




## 3.9 Intersection Capacity Analysis

An assessment of existing peak hour performance was completed at four intersections within the GRC using the SIDRA software package. SIDRA uses various level-of-service definition for vehicles, including delay or degree of saturation (i.e., volume to capacity (v/c) ratio). For the purpose of this assessment the software's internal delay-based criteria was assumed, as shown in Table 3 for various methods of control.

These model results are summarized in Table 4, which includes detailed notes outlining if/how the default model parameters were adjusted to reflect local driving behavior. SIDRA output of existing conditions is included within Appendix D.

Table 3: SIDRA Delay-based Level of Service Criteria

| Level of Service | Roundabout | Traffic Signal | STOP/Yield Sign |
|---|---|---|---|
| A | ≤10 | ≤10 | ≤10 |
| B | >10 and ≤20 | >10 and ≤20 | >10 and ≤15 |
| C | >20 and ≤35 | >20 and ≤35 | >15 and ≤25 |
| D | >35 and ≤50 | >35 and ≤55 | >25 and ≤35 |
| E | >50 and ≤70 | >55 and ≤80 | >35 and ≤50 |
| F | >70 | >80 | >50 |

*Source: SIDRA User's Guide*

Based on field observations at the Gladstone/JFK roundabout, the westbound through movement experiences minimal deflection on the approach to the roundabout and drivers are not required to significantly reduce their speed as they enter. The consequence is inconsistent vehicle gaps within the roundabout resulting in poor performance: northbound vehicles have difficulty finding gaps; triggering more gaps available for eastbound traffic; triggering fewer gaps available for southbound vehicles. Also of note at the Gladstone/JFK roundabout is presence of traffic congestion in the afternoon peak on southbound Gladstone leaving the roundabout (upgrade along the frontage of Lakeview Memorial Gardens), which introduces spillback through the roundabout impacting the westbound left-turn movement.

At the STOP-controlled intersections, including Fire Trail and Carmichael, only modest delays were observed on the minor approach as drivers tended to enter the traffic stream aggressively and the majority of drivers on the major approach would oblige and leave an appropriate gap.

Table 4 GRC Existing Peak Hour Performance at Key Intersections

| Intersection | Weekday AM Peak (PM Peak) | | | | | |
|---|---|---|---|---|---|---|
| | Critical Movement | | | Intersection 'as a whole' | | |
| | LoS[1] | Max. Delay (s) | Movement | Delay (s) | LoS | Max v/c |
| **Roundabouts** | | | | | | |
| Gladstone/JFK[2] | F(F) | 260(117) | NB(NB) | 55(46) | E(D) | 1.25(1.07) |
| Gladstone/Fusion | B(C) | 13(21) | WB(WB) | 3(4) | A(A) | 0.41(0.58) |
| **Stop-Control on Minor[3]** | | | | | | |
| Gladstone/Fire Trail | D(F) | 26(250) | WB(WB) | 9(56) | A(F) | 0.76(1.23) |
| Gladstone/Carmichael | D(F) | 32(56) | SB(SB) | 16(21) | C(C) | 0.87(0.99) |

Notes:
1.) Intersection performance (LoS) is based on SIDRA delay estimates
2.) Introduced 'exiting flow effect' of 45% for the westbound left approach to reflect observed back-up of southbound receiving lane on Gladstone. Also reduced critical gap for eastbound movements by 1.25s (4.0 to 2.75s) to account for added ease to enter roundabout in response to delayed departure of northbound movement due to uncertainty of possible conflicting vehicles coming from the east who are either turning left or continuing through
3.) Modified critical gap parameters by reducing by 1.0s for through movements (6.5 to 5.5s), by 1.25s for right-turn movements (7.0 to 5.75 s), and by reducing follow up headway by 1.0s (4.0 to 3.0s)

As shown in Table 4, several of the major intersections within the GRC operate poorly during peak hours according to the model:

- Gladstone/JFK (roundabout): the intersection operates with overall delays of 46 to 55 seconds, which results in an overall level of service (LoS) 'E' and 'D' during the morning and afternoon peak hours,

respectively. However, certain movements do exhibit failing performance during the peak hours, including the critical northbound movement with delays of 2-4 minutes and 95th percentile queues of just over 2,000 ft (north of Munnings). More modest delays (< 60 seconds) and queuing occur on all other approaches during peak hours;
- Gladstone/Fusion (roundabout); this newly constructed intersection operates well at LoS 'A' during both peak hours;
- Gladstone/Fire Trail (STOP control on Fire Trail): operates poorly at LoS 'F' during the afternoon peak hour as vehicles turning from Fire Trail onto Gladstone experience long delays;
- Gladstone/Carmichael (STOP control Gladstone): operates reasonably well at LoS 'C' during both peak hours, although vehicles turning from Gladstone onto Carmichael experience modest delays.

It is noteworthy that the SIDRA analysis assumes a standard geometry for the roundabout. Changing the entry deflection angle or turn radius has minimal impact on the results of the analysis within this particular software package.

# 4.0 Future Traffic Projections

The stated horizon year for the study is 2040, which is 20 years from the collection date (February 2020) of the baseline traffic data used to establish existing conditions. Forecasting future traffic volumes within a specific corridor would normally give consideration to future demographic growth (population, employment, etc.) over a broader area, known development adjacent to the corridor, and changes to the transportation infrastructure that may influence travel patterns within the subject corridor.

## 4.1 Travel Demand Models

The CONTRAM model was identified in the Study ToR. CONTRAM is a UK-based computer model of time-varying traffic model based on microscopic simulation principles. The software, developed originally by the Transport Research Laboratory (TRL), is no longer marketed and will not be used to support the GRC Project.

Travel demand models are normally used to as part of strategic level planning for larger municipalities/small countries to help inform the transportation infrastructure needs. Common platforms include EMME, VISUM, CUBE, TRANSCAD, etc. Given that the need for the GRC widening has already been established by the MOW, a travel demand model is not considered essential for this project and instead future volume projections within the Corridor will be derived using first principals.

## 4.2 Historical Growth in Traffic Volumes

If available, a time series of traffic volume data at the same location within a corridor can be used to determine an historical growth rate, which could help to serve as an indicator of future growth. Given the lack of a regular traffic count program within the GRC, this method is not considered feasible and other data sources must be explored.

### 4.2.1 Other Transportation Studies

Below is a summary of known transportation studies with an identified traffic volume/and or historical growth rate for traffic volumes within the GRC. These studies may be useful in determining an appropriate growth rate for the 2040 planning horizon.

*Transport Development Plan for New Providence Island, Bahamas. Preliminary Roadway Design Report Corridor D – Gladstone Road/ West Bay Street Connection (Dillon, 1995)*

- at the time of report (1995), the Gladstone/JFK intersection was a T-intersection; proposal included re-alignment of Gladstone Road to its current alignment;
- peak hour traffic volumes on Gladstone Road were in the order of 200-300 veh/h in the peak direction south of JFK; and
- the projections for traffic volumes on Gladstone Road in the horizon year 2003 were approximately 250 veh/h in the peak hour.

*Baha Mar Resort Project. Environmental Impact Assessment – Traffic Analysis (Ove Arup & Partners California Ltd, 2007)*

- at the time of report (2007), the Gladstone/JFK intersection was a T-intersection; proposal included a roundabout intersection and new north leg consistent with its current configuration;
- peak hour traffic volumes on Gladstone Road were in the order of 600-750 veh/h in the peak direction south of JFK;
- annual growth rate of 3% was applied to baseline traffic counts (i.e., estimate of no-build traffic volume); and
- the projections for traffic volumes on Gladstone Road in the horizon year 2012 were approximately 1,000 veh/h in the peak hour (peak direction).

*Baha Mar Waterpark (Phase 2) – Transportation Impact Study (IBI, 2019)*

- within this study, a linear growth rate of 1.5% was determined to be appropriate for projecting regional growth in travel demand (horizon to year 2026, or 5-years beyond build-out)

### 4.2.2 Population Growth

Another reasonable proxy for traffic growth can be population growth. According to information provided by the website *World Population Review* (https://worldpopulationreview.com/countries/bahamas-population/), the nation-wide historical population growth rate experienced since 2015 is approximately 1% as shown in Figure 15. Over the previous 20-year window, the total population growth within the country was approximately 32% (i.e., 393,244 / 298,051), which equates to 1.4% per annum.

Figure 15: Historical Population Growth Rates (Bahamas)

| Year | Population | % Male | % Female | Density (km$^2$) | Population Rank | Growth Rate |
|---|---|---|---|---|---|---|
| 2020 | 393,244 | 48.59% | 51.41% | 28.20 | 178 | 0.97% |
| 2019 | 389,482 | 48.59% | 51.42% | 27.93 | 178 | 1.00% |
| 2018 | 385,637 | 48.57% | 51.42% | 27.66 | 177 | 1.02% |
| 2017 | 381,755 | 48.56% | 51.44% | 27.38 | 177 | 1.01% |
| 2016 | 377,930 | 48.55% | 51.45% | 27.11 | 177 | 1.00% |
| 2015 | 374,206 | 48.53% | 51.47% | 26.84 | 178 | 1.06% |
| 2010 | 354,942 | 48.46% | 51.54% | 25.46 | 178 | 1.79% |
| 2005 | 324,859 | 48.57% | 51.43% | 23.30 | 177 | 1.74% |
| 2000 | 298,051 | 48.71% | 51.29% | 21.38 | 177 | 1.24% |
| 1995 | 280,184 | 49.41% | 50.59% | 20.09 | 176 | 1.80% |
| 1990 | 256,223 | 49.62% | 50.38% | 18.38 | 177 | 1.78% |
| 1985 | 234,578 | 49.63% | 50.37% | 16.82 | 177 | 2.18% |
| 1980 | 210,591 | 49.65% | 50.35% | 15.10 | 177 | 2.20% |
| 1975 | 188,896 | 49.05% | 50.95% | 13.55 | 176 | 2.21% |
| 1970 | 169,377 | 49.54% | 50.46% | 12.15 | 174 | 3.87% |
| 1965 | 140,059 | 48.88% | 51.12% | 10.05 | 174 | 5.04% |

*Source: worldpopulationreview.com*

Based on the same source, as shown in Figure 16, the projected population growth in the Bahamas through year 2040 is approximately 15% (i.e., 450,4530 / 393,244), which equates to 0.7% per annum.

Similar information from the Bahamian *Department of Statistics: Population Projections 2010-2040* was also reviewed. This data source provided three different growth scenarios for the country, as well as New Providence specifically.

Figure 16: Projected Population Growth Rates (Bahamas)

| Year | Population | % Male | % Female | Density (km$^2$) | Population Rank | Growth Rate |
|---|---|---|---|---|---|---|
| 2020 | 393,244 | 48.59% | 51.41% | 28.20 | 178 | 0.00% |
| 2025 | 410,932 | 48.63% | 51.37% | 29.47 | 177 | 0.88% |
| 2030 | 426,813 | 48.65% | 51.35% | 30.61 | 177 | 0.76% |
| 2035 | 440,087 | 48.66% | 51.34% | 31.56 | 177 | 0.61% |
| 2040 | 450,453 | 48.68% | 51.33% | 32.31 | 178 | 0.47% |
| 2045 | 458,141 | 48.71% | 51.28% | 32.86 | 178 | 0.34% |
| 2050 | 463,333 | 48.78% | 51.22% | 33.23 | 179 | 0.23% |
| 2055 | 466,426 | 48.87% | 51.13% | 33.45 | 179 | 0.13% |

*Source: worldpopulationreview.com*

Table 5: Projected Population Growth Rates (New Providence)

| Growth Scenario | 2010 | 2020 | 2040 | Annual Growth Rate |
|---|---|---|---|---|
| A – high growth | 246,300 | 285,000 | 356,400 | 1.12 |
| B – medium growth | 246,300 | 279,400 | 332,900 | 0.88 |
| C – low growth | 246,300 | 275,700 | 322.200 | 0.78 |

*Source: Population Projections 2010-2014; Department of Statistics Ministry of Finance (2015)*

Based on the foregoing, a reasonable range in traffic growth to apply over a 20-year planning horizon is considered to be between 0.75 % and 1.25%. Larger values, such as the 3% annual growth rate used in the Baha Mar Resort Study, are only considered sustainable over shorter periods of aggressive development.

As a result, existing traffic volumes within the GRC were increased by 15% to reflect a low/modest growth scenario, and by 30% to reflect a high growth scenario at the year 2040 planning horizon.

## 4.3 Known Development Potential

Based on information provided by the MOW during a meeting with Parsons staff on February 07, 2020, there is limited known development potential for parcels of land directly adjacent to the GRC. A gas station is currently under construction on the east side of the GRC north of Munnings, however details are not known at this time. It is noted that a gas station would have a very high pass-by component, and therefore would not be expected to generate a significant number of "new" trips within the Corridor. MOW staff also made reference to the potential for a new church within the Corridor, which would likely generate trips outside of the peak commuting times.

MOW staff also indicated the potential for a residential subdivision off Carmichael Road to the west of Gladstone Road, but no details were provided.

## 4.4 Future Road Network Changes

Based on available information, the following road improvements projects have been identified and were accounted for in the forecasting of future traffic volumes within the GRC at the 2040 planning horizon:

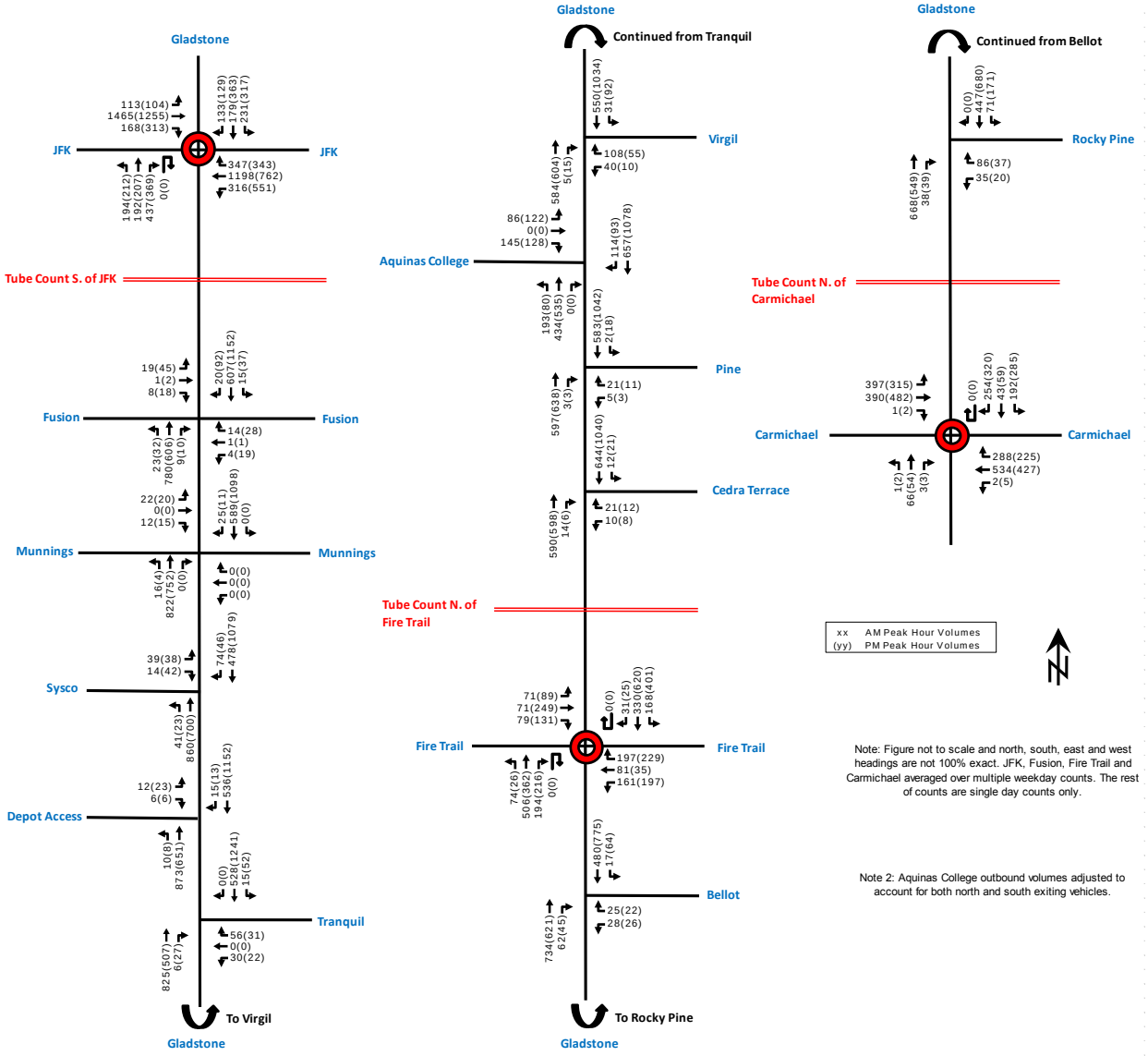
- westerly extension of Fire Trail Road linking Gladstone Road to Coral Harbour Drive; the alignment would be south of Lake Kelarney and provide an alternative route to the Airport; timing unknown; forecasted peak hour traffic of up to 300 veh/h in the peak direction;
- southerly extension of Gladstone Road linking Carmichael Road to Cow Pen Road, the extension would result in a local re-assignment of traffic from Carmichael, but not result in a notable increase in traffic through the intersection given the community to the south is already well-established.

## 4.5 Projected Peak Hour Traffic Volumes

Peak hour traffic volumes at year 2040 were projected for both a low growth and high growth scenario, shown in Figure 17 and Figure 18, respectively. Note that for the purposes of the exhibits, full movements were assumed at all locations (although this will be visited in a subsequent section of the report).

Southbound peak hour volumes within the GRC are forecasted to range between 500 and 1,300 veh/h, and northbound volumes between 700 and 900 veh/h.

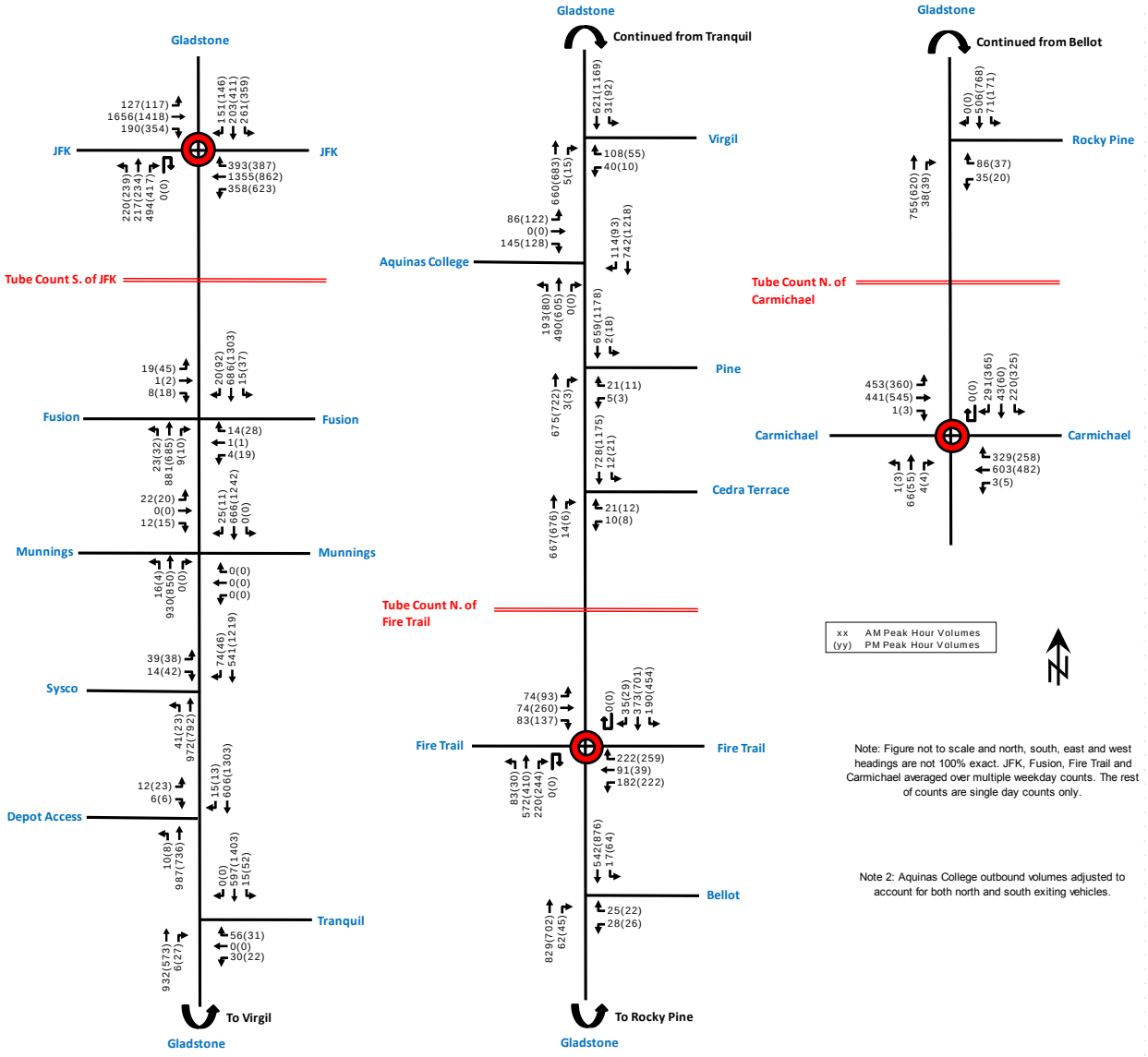
Figure 17: Year 2040 Projected Peak Hour Volumes – Low Growth Scenario




Note: Figure not to scale and north, south, east and west headings are not 100% exact. JFK, Fusion, Fire Trail and Carmichael averaged over multiple weekday counts. The rest of counts are single day counts only.

Note 2: Aquinas College outbound volumes adjusted to account for both north and south exiting vehicles.

Figure 18: Year 2040 Projected Peak Hour Volumes – High Growth Scenario




## 4.6 Projected ADT

Table 6 provides a summary of the projected ADT within the GRC at the 2040 planning horizon, whereas Table 7 provides the same information approaching the three major intersections. The estimates reflect both the low and high growth scenarios.

Table 6: Summary of Projected ADT (year 2040) within the GRC

| Location | Existing (2020) | Projected (2040) Low Growth | Projected (2040) High Growth | Notes |
|---|---|---|---|---|
| South of JFK | 19,800 | 22,800 | 25.700 | Growth 15% to 30% |
| North of Fire Trail | 18,800 | 21,600 | 24,400 | Growth 15% to 30% |
| North of Carmichael | 16,100 | 18,500 | 20,900 | Growth 15% to 30% |

Table 7: Summary of Projected ADT (year 2040) Approaching Major GRC Intersections

| Location | Existing (2020) | Projected (2040) Low Growth | Projected (2040) High Growth | Notes |
|---|---|---|---|---|
| Gladstone/JFK | 63,700 | 73,200 | 82,800 | Growth 15% to 30% |
| Gladstone/Fire Trail | 26,900 | 30,900 | 35,000 | Growth 15% to 30% |
| Gladstone/ Carmichael | 27,200 | 31,300 | 35,400 | Growth 15% to 30% |

*Source: Estimate based on three-day average (Feb 11-13, 2020)*

# 5.0 Design Considerations

The ensuing section of the report will identify various design considerations related to impact to traffic operations, including corridor access management, type of intersection control, and projected performance.

## 5.1 Corridor Access Management Guidelines

The introduction of a centre median with the GRC will impact the ability of drivers to complete inbound and outbound right-turns across the road centerline. These turning movements will therefore be consolidated at those locations where a median break will be provided – either in the form of a full movement intersection or simple median break to permit only certain movements.

The issue of access management within road corridors is well documented with many national, state/provincial and local agencies developing their own guidelines. Common to all of the guidelines is the ultimate goal of balancing mobility and safe access to adjacent development/land. According to the USDOT Federal Highway Administration, *corridor access management preserves the flow of people and freight, and enables safe access to businesses and neighborhoods using a combination of policies and strategies, such as closing, consolidating, or improving driveways, median openings, and intersections; adding or redesigning medians; and planned spacing of intersections, median openings, and driveways*.

A review of the literature was completed to determine if a common set of guidelines existed that would help inform on appropriate spacing of full movement intersections and directional openings within a median divided GRC. Without prior judgement on the type of control at major intersections (i.e., roundabout or traffic signal control), the literature (see Figure 19) indicates that a spacing for full-movement intersections of approximately 0.5 mile (800m) provides a reasonable balance of mobility and access within an arterial road context (Class 3). The introduction of directional openings within the median could be considered at more frequent spacing of 0.25 mile (400m).

Figure 19: Design Guidelines for Arterial Access

**Table 201.3.2 Rule 14-97 - Arterial Access Classifications & Standards**

| Access Class | Median Type | Connection Spacing (feet) | | Median Opening Spacing (feet) | | Signal Spacing (feet) |
|---|---|---|---|---|---|---|
| | | >45 mph | ≤45 mph | Directional | Full | |
| 2 | Restrictive with Service Roads | 1320 | 660 | 1320 | 2640 | 2640 |
| 3 | Restrictive | 660 | 440 | 1320 | 2640 | 2640 |
| 4 | Non-Restrictive | 660 | 440 | | | 2640 |
| 5 | Restrictive | 440 | 245 | 660 | 2640 >45 mph<br>1320 ≤ 45 mph | |
| 6 | Non-Restrictive | 440 | 245 | | | 1320 |
| 7 | Both Median Types | 125 | | 330 | 660 | 1320 |

**Notes:**

1. "Restrictive" physically prevent vehicle crossing.
2. "Non-Restrictive" allow turns across at any point.
3. Speeds shown in this table are posted speeds.

**Connection Spacing Near Interchange Ramps:**

Connections and median openings located within 1,320 feet of interchange ramps require the following spacing (measured from the ramp furthest from the interchange):

- 440 feet ≤ 45 mph
- 660 feet > 45 mph
- 1,320 feet on Access Class 2 Facilities > 45 mph

*Source: Florida Department of Transportation – Design Guide (2019)*

## 5.2 Analysis of GRC Median Breaks

In addition to the foregoing guidelines, the decision of where turning opportunities will be provided within the GRC will give consideration to the following local context:

- location of major intersections, including those existing ones at JFK, Fire Trail and Carmichael;
- location of planned intersections as outlined the study ToR, including one between JFK and Fire Trail and another between Fire Trail and Carmichael;
- locations of side-streets and driveways with notable right-turning volumes, including for example Aquinas College; and
- locations of driveways with a notable commercial/truck activity, recognizing the geometric constraints of completing U-turns at simple median break, including for example Bahama Food Services (BFS).

A preliminary assessment for the majority of the major driveways is included in Table 8, which tabulates turning movements at each driveway, as well as critical right-turn movements from/to the GRC. Note that turning movement data are not available at every driveway, and simply denoted as "low". The purpose of the exercise is to identify those locations within the Corridor where turning movements are highest, and the therefore the potential need for a median break greatest within the context of the distance to adjacent intersections (0.5 mile increments).

Table 8: Preliminary Assessment of Turning Movements at Driveways within the GRC

| GRC Intersection/Driveway | Sum of All Turns (veh/h) | Critical right turns from GRC (veh/h) | Critical right turns to GRC (veh/h) | Notes |
|---|---|---|---|---|
| | | *AM Peak Hour (PM Peak Hour)* | | |
| **JFK** (0.0 miles) | | | | Existing full movement intersection |
| Fusion/LMG/Bristol Wine and Spirits | 190 (420) | 25 (130) SBR | 10 (55) EBR<br>2 (25) WBR | Turns highest during evening; consider LMG access during large gathering; candidate for median break to permit heavy SBR/NBR |
| BWA Grocery Store | Low | Low | Low | - |
| Oak Ridge (Old Gladstone) | Low | Low | Low | - |
| Bahamas Waste Limited | Low | Low | Low | Larger vehicles |
| Munnings | 80 (70) | 30 (15) SBR | 20 (25) EBR | Low volumes since cul-de-sac treatment |
| (0.5 mile) | | | | |
| Sysco/BFS | 180 (150) | 45 (15) SBR | 35 (55) EBR | Larger vehicles |
| Depot Access | 90 (50) | 20 (10) SBR | 15 (10) EBR | Larger vehicles |
| Victoria (Tranquil) | 140 (130) | 10 (25) NBR | 70 (30) WBR | Single road access to a residential neighborhood with approximately 150 homes; possible expansion? |
| Easy Car Sales | Low | Low | Low | - |
| Phil's Food Service | Low | Low | Low | - |
| (1.0 mile) | | | | |
| Youth Camp | Low | Low | Low | - |
| Virgil Blvd | 195 (180) | 5 (15) NBR | 120 (60) WBR | 1st of 4 accesses for Jubilee subdivision located east of GRC; busiest |
| (1.5 mile) | | | | |
| Aquinas College | 540 (425) | 135 (95) SBR | 140 (170) EBR | Educational Institution, large number of turns occurring before and after classes; north (exit only) and south driveways combined for this assessment |
| Virgil Close | Low | Low | Low | 2nd of 4 accesses Jubilee subdivision |
| Pine | 45 (55) | 5 (5) NBR | 25 (10) WBR | 3rd of 4 accesses for Jubilee subdivision |
| Cedar Terrace | 55 (45) | 10 (10) NBR | 20 (5) WBR | 4th of 4 accesses for Jubilee subdivision |
| NEMA | Low | Low | Low | - |
| World of Truth | Low | Low | Low | - |
| **FireTrail** (1.9 miles) | | | | Existing full movement intersection |
| (2.0 mile) | | | | |
| Bellot | 140 (160) | 65 (45) NBR | 35 (20) WBR | Access to neighborhoods located east of GRC |
| Edgars Close | Low | Low | Low | - |
| Evergreen Close | Low | Low | Low | - |
| Rocky Pine | 230 (290) | 40 (40) NBR | 85 (50) WBR | Access to neighborhoods located east of GRC; note 170 veh/h SBL turn in PM |
| (2.5 mile) | | | | |
| Farmers Market | Low | Low | Low | - |
| Wongs Building Supplies | Low | Low | Low | - |
| Caribbean Gardens | Low | Low | Low | - |
| Halls | Low | Low | Low | - |
| **Carmichael** (2-9 miles) | | | | Existing full movement intersection |

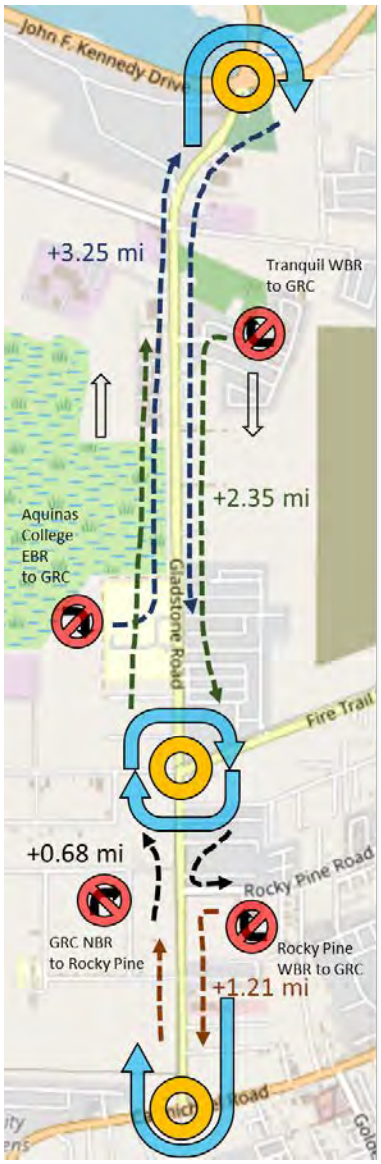
*Text in red refers to critical turning movements which exceeds 1 turning movement per minute on average*

### 5.2.1 Option 1 - Full Movement Intersections at JFK, Fire Trail and Carmichael Only

The first option considered was to provide full movement intersections at three major intersections only, namely JFK, Fire Trail and Carmichael.

The spacing between JFK and Fire Trail is approximately 1.9 miles. Assuming no mid-block median breaks, analyses indicates the following:

- estimated 270 veh/h would be diverted northbound to the JFK intersection in the critical peak hour, which includes any right-turning vehicle onto GRC from a driveway on the west side and right-turning vehicle from GRC accessing a driveway on the east side;
- for example, the 170 vehicles leaving Aquinas College and destined south would be forced to travel over 3.25 miles, which is approximately 6 minutes of travel time assuming an average speed of 35 mph;
- estimated 470 veh/h would be diverted southbound to the Fire Trail intersection in the critical peak hour, which includes any right-turning vehicle onto GRG from a driveway on the east side and right-turning vehicle from GRB accessing a driveway on the west side;
- for example, the 70 vehicles leaving Tranquil Road and destined north would be forced to travel over 2.35 miles, which is approximately 4 minutes of travel time assuming an average speed of 35 mph.




The spacing between Fire Trail and Carmichael is approximately 1.0 miles. Assuming no mid-block median breaks, analyses indicates the following:

- estimated 100 veh/h would be diverted northbound to the Fire Trail intersection in the critical peak hour, which includes any right-turning vehicle onto GRG from a driveway on the west side and right-turning vehicle from GRB accessing a driveway on the east side;
- estimated 110 veh/h would be diverted southbound to the Carmichael intersection in the critical peak hour, which includes any right-turning vehicle onto GRG from a driveway on the east side and right-turning vehicle from GRB accessing a driveway on the west side;
- for example, the 85 vehicles leaving Rocky Pine Road and destined north would be forced to travel over 1.2 miles, which is approximately 2 minutes of travel time assuming an average speed of 35 mph.

The weighted average distance deviated for the approximate 1,700 AM and PM peak vehicles is **3.05** miles per vehicle. Northbound deviated traffic has to travel on average 2.9 extra miles while southbound deviated traffic has to travel on average 3.2 extra miles.

### 5.2.2 Option 2 - Full Movement Intersections at JFK, Fire Trail and Carmichael (Plus 2)

The second option considered was to provide full movement intersections at three major intersections, namely JFK, Fire Trail and Carmichael, plus one additional intersection between each. For illustrative purposes, the new intersections were introduced at Tranquil in the north and Rocky Pine in the south.

The spacing between JFK and Tranquil is approximately 0.7 miles and from Tranquil to Fire Trail is approximately 1.2 miles. Assuming no additional mid-block median breaks, analyses indicates the following:

- estimated 90 veh/h would be diverted northbound to the JFK intersection and 170 veh/h to the Tranquil intersection in the critical peak hour. Vehicles diverted northbound would include any right-turning vehicle onto GRC from a driveway on the west side and right-turning vehicle from GRC accessing a driveway on the east side;
- for example, the 170 vehicles leaving Aquinas College and destined south would be forced to travel over 1.7 miles, which is approximately 3 minutes of travel time assuming an average speed of 35 mph;
- estimated 190 veh/h would be diverted southbound to the Tranquil intersection and 260 veh/h to the Fire Trail intersection in the critical peak hour. Vehicles diverted southbound would include any right-turning vehicle onto GRC from a driveway on the east side and right-turning vehicle from GRC accessing a driveway on the west side.

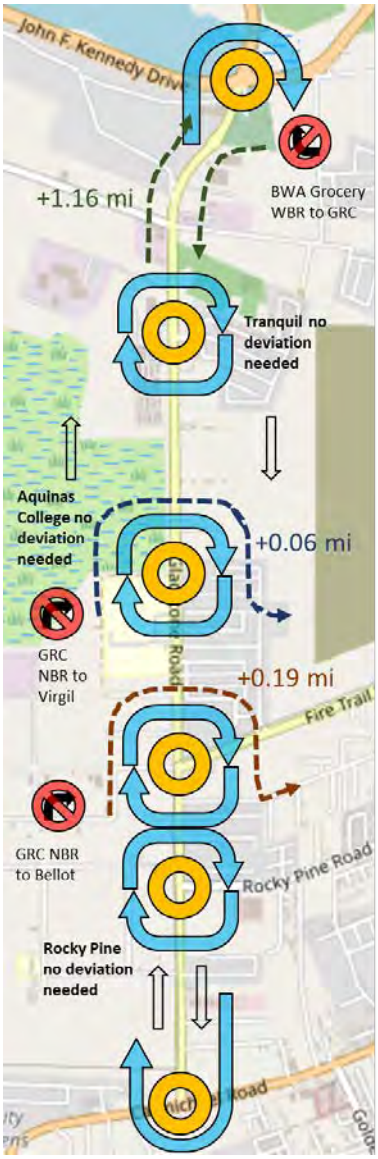
The spacing between Fire Trail and Rocky Pine is approximately 0.3 miles and from Rocky Pine to Carmichael is approximately 0.6 miles. Assuming no additional mid-block median breaks, analyses indicates the following:

- estimated 60 veh/h would be diverted northbound to the Fire Trail intersection in the critical peak hour, which includes any right-turning vehicle onto GRC from a driveway on the west side and right-turning vehicle from GRC accessing a driveway on the east side. All turning movements from Rocky Pine would be accommodated at the Rocky Pine intersection without diversion;
- estimated 30 veh/h would be diverted southbound to the Rocky Pine intersection in the critical peak hour, which includes any right-turning vehicle onto GRC from a driveway on the east side and right-turning vehicle from GRC accessing a driveway on the west side. All turning movements from Rocky Pine would be accommodated at the Rocky Pine intersection without diversion.

The weighted average distance deviated for the approximate 1,700 AM and PM peak vehicles is **1.11** miles per vehicle. Northbound deviated traffic has to travel on average 1.5 extra miles while southbound deviated traffic has to travel on average 0.7 extra miles.

### 5.2.3 Option 3 - Full Movement Intersections at JFK, Fire Trail and Carmichael (Plus 3)

The third option considered was to provide full movement intersections at three major intersections, namely JFK, Fire Trail and Carmichael, plus two additional intersections between JFK and Fire Trail and one additional intersection between Fire Trail and Carmichael. For illustrative purposes, the new intersections were introduced at Tranquil and Aquinas College in the north and Rocky Pine in the south.




The spacing between JFK and Tranquil is approximately 0.7 miles, from Tranquil to Aquinas College approximately 0.7 miles, and from Aquinas College to Fire Trail approximately 0.5 miles. Assuming no additional mid-block median breaks, analyses indicates the following:

- estimated 90 veh/h would be diverted northbound to the JFK intersection, less than 50 veh/h to the Tranquil intersection and less than 50 veh/h to the Aquinas College intersection in the critical peak hour. Vehicles diverted northbound would include any right-turning vehicle onto GRC from a driveway on the west side and right-turning vehicle from GRC accessing a driveway on the east side;
- estimated 190 veh/h would be diverted southbound to the Tranquil intersection, 110 veh/h to the Aquinas College intersection and 50 veh/h to the Fire Trail intersection in the critical peak hour. Vehicles diverted southbound would include any right-turning vehicle onto GRC from a driveway on the east side and right-turning vehicle from GRC accessing a driveway on the west side;
- most turning volumes are accommodated within the new intersections or are accessible within a small diversion.

The spacing between Fire Trail and Rocky Pine is approximately 0.3 miles and from Rocky Pine to Carmichael is approximately 0.6 miles. Assuming no additional mid-block median breaks, analyses is identical for that of Option 2 for the same segment.

The weighted average distance deviated for the approximate 1,700 AM and PM peak vehicles is **0.44** miles per vehicle. Northbound deviated traffic has to travel on average 0.4 extra miles while southbound deviated traffic has to travel on average 0.4 extra miles.

Based on the foregoing, **it is recommended that consideration be given to implementing Option 3** that would maintain existing full movement intersections at JFK, Fire Trail and Carmichael, plus introduce three new full-movement intersections within the GRC, namely two between JFK and Fire Trail and one between Fire Trail and Carmichael. The exact location of the new full movement intersections will be defined as part of the overall design exercise. A centre median, prohibiting right-turn movements from/to the Corridor except at the aforementioned intersections, would be maintained throughout.

## 5.3 Intersection Control Options

### 5.3.1 Traffic Signal Control

A detailed study of the traffic conditions and the physical characteristics are key components to assess whether or not a traffic signal is justified. The assessment to determine whether or not a traffic signal is justified is often made using the following criteria:

- Minimum Vehicle Volumes
- Delay to Cross Traffic
- Collision Experience
- Pedestrian Experience

A traffic signal would be considered warranted if any ONE of the justifications are met, including combinations of minimum volumes and delay to cross traffic. Based on the existing and projected volume of traffic within the GRC, traffic signal control would be considered warranted at the major intersections being contemplated for control.

Regarding auxiliary turn lanes, conventional warrant procedures would indicate that right-turn lanes with appropriate storage and taper would be recommended at most major intersections given the combination of advancing and opposing volumes in combination with the 45 mph design speed. Auxiliary left-turn lanes would be considered where their absence would introduce undue hazard.

### 5.3.2 Roundabout Feasibility

Table 9 is a typical screening tool used to assess the feasibility of a roundabout at a particular intersection, giving due consideration to both positive and contra-indicators, relative to other forms of traffic control or road modifications including all-way STOP control, traffic signal control, auxiliary turn lanes, etc. If a 'yes' is indicated for two or more of the suitability factors then a roundabout should be technically feasible, whereas if a 'yes' is indicated for one or more of the contra-indicators then a roundabout may be problematic.

Table 9: GRC Roundabout Initial Feasibility Screening

| Number | Suitability Factor | Outcome |
|---|---|---|
| 1 | Does the intersection currently experience an average collision frequency of more than 1.5 injury crashes per year, or a collision rate in excess of 1 injury crash per 1 million entering vehicles (MEV) | Yes |
| 2 | Has there been a fatal crash at the intersection in the last 10 years? | Unknown |
| 3 | Are capacity problems currently being experienced, or expected in the future? | Yes |
| 4 | Are traffic signals warranted, or expected to be warranted in the future? | Yes |
| 5 | Does the intersection have more than 4 legs, or unusual geometry? | No |
| 6 | Will planned modifications to the intersection require that nearby structures be widened (i.e. to accommodate left-turn lanes)? | Unknown |
| 7 | Is the intersection located at a transition between rural and urban environments (i.e. an urban boundary) such that a roundabout could act as a means of speed transition? | No<br>*Similar context throughout* |
| **Number** | **Contra-Indication** | **Outcome** |
| 1 | Is there insufficient property at the intersection (i.e. less than 44 m [145 ft] diameter if considering a single-lane roundabout, and less than 60 m [200 ft] if considering a two-lane roundabout) or property constraints that would require demolition of adjacent structures? | Unknown |

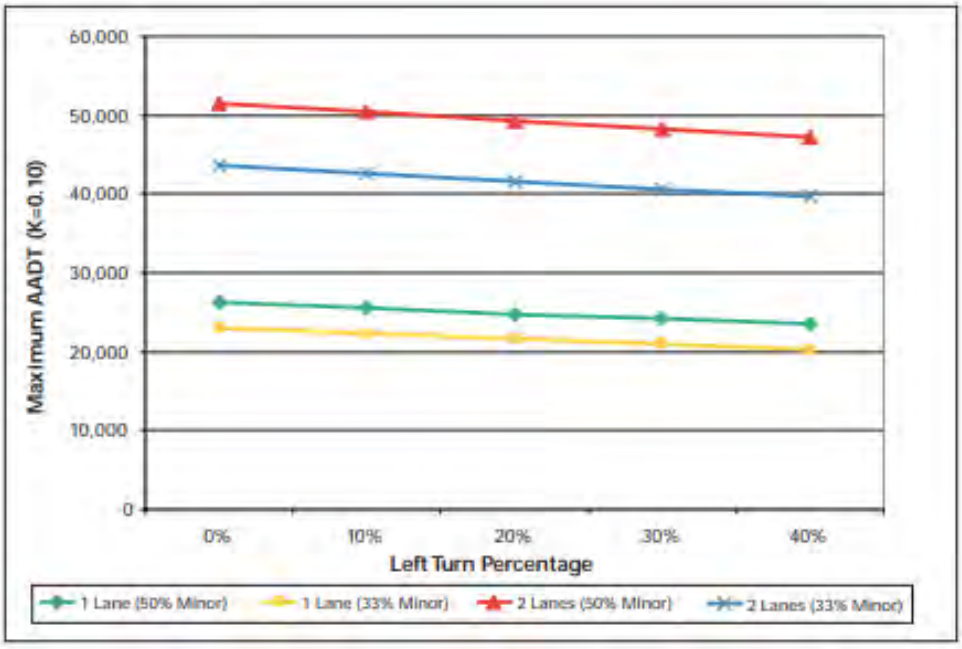
| | | |
|---|---|---|
| 2 | Are there any instances where stopping sight distance (SSD) of a roundabout yield line may not be attainable (i.e. the intersection is on a crest vertical curve)? | No |
| 3 | Is there an existing uncontrolled approach with a grade in excess of 4 percent? | No<br>*Note that existing south approach at JFK has a grade of 6% (along frontage of Fusion) followed by vertical curve reducing grade to 2% near the roundabout* |
| 4 | Is the intersection located within a coordinated signal system? | No |
| 5 | Is there a closely-spaced traffic signal or railway crossing that could not be controlled with a nearby roundabout? | No |
| 6 | Are significant differences in directional flows or any situations of sudden high demand expected? | No |
| 7 | Are there known visually-impaired pedestrians that cross this intersection? | No |

*Source: City of Ottawa: Roundabout Implementation Policy*

Based on the screening tool, roundabouts are considered technically feasible at the major intersections being contemplated for traffic control, with no obvious indicators suggesting that a roundabout should be avoided (subject to a more thorough review of property requirements). Roundabouts will therefore be assumed to be the preferred type of control at all major intersections.

According to the literature (*Roundabouts: An Information Guide* by FHWA), the theoretical capacity of a multi-lane roundabout typically ranges between 40,000 and 50,000 AADT depending on approach volumes and percentage of turning traffic (see Figure 20). Given the projected ADT of less than 40,000 vehicles at all major intersections except Gladstone/JFK (see Table 7 in Section 4.6), a two-lane roundabout is expected to provide ample capacity and offer a very good level of performance at all major intersections (except JFK).

Figure 20: Theoretical Roundabout Capacity




*Source - FHWA Roundabouts: An Informational Guide, p57*

### 5.3.3 Grade Separation at Gladstone/JFK

The Gladstone/JFK intersection is currently controlled by a multilane roundabout with known operational issues during peak times of the day that result from a combination of high approach volumes and poor design. During peak times, police are often deployed at the roundabout to help control traffic.

Recommended measures to refine the roundabout were identified as part of the Transportation Impact Study (TIS) for the IMAX theatre completed in 2018 (Parsons), including changes to the westbound approach angle and widening of Gladstone Road. Furthermore, the TIS for the Baha Mar Phase 2 completed in 2019 (IBI) recommended a number of modifications, including widening of Gladstone Road and westbound left-turn slip lane to provide additional capacity.

According to ITE *Traffic Engineering Handbook*, which references the AASHTO *Policy on Geometric Design of Highways and Streets,* there are six warrants that may provide useful guidance when deciding if a grade separated or interchange is appropriate where two roadways intersect. These are outlined next.

*Warrant 1 - Design Designation*

*The decision to develop a roadway with full control of access becomes the warrant to design grade separation at all intersecting highways. In this situation, continuous flow of traffic on the freeway is provided.*

TBD - The Ministry has not made a definitive decision to grade separate this location.

*Warrant 2 - Reduction in Bottlenecks or Spot Congestion*

*Insufficient capacity on heavily-traveled routes may result in intolerable congestion on one or more approaches.*

SATISFIED - There is observed congestion during peak times at the existing JFK/Gladstone roundabout. However, previously identified mitigation measures should be considered and may help alleviate congestion in the near-term.

*Warrant 3 - Improve Safety*

*A grade separation may be warranted if less expensive methods of alleviating or eliminating the hazardous condition(s) at at-grade intersections with high crash rates are not possible.*

TBD – A detailed safety assessment has not been completed for the existing configuration. The available collision data at the JFK/Gladstone intersection indicates a total of 53 collisions in 2019.

*Warrant 4 - Site Topography*

*At some locations, grade separations are the only economically-feasible alternative. The site topography may be such that an at-grade intersection would be extremely expensive.*

NOT SATISFIED – The current topography accommodates an at-grade configuration. There are notable property constraints that may pose a challenge to implement a grade separated solution.

### *Warrant 5 - Road-user Benefits*

*Grade separation can reduce user costs due to delays at congested intersections.*

SATISFIED – There are existing delays at the JFK/Gladstone intersection, however, the potential road-user benefit has not been quantified.

### *Warrant 6 - Traffic Volume Warrant*

*A specific volume warrant cannot be calculated for an interchange, however, volumes greater than capacity at an at-grade intersection may justify an interchange.*

NOT DEFINITIVE - Based on the most recent traffic count from February 2020, the existing multi-lane roundabout at JFK/Gladstone has approach volumes of approximately 4,300 veh/h in the commuter peak hours and accommodates average daily traffic of an estimated 63,700 vehicles,

As noted previously, the theoretical capacity of a multi-lane roundabout typically ranges between 40,000 and 50,000 AADT depending on approach volumes and percentage of turning traffic, which is considerably less than the estimate of existing daily traffic at Gladstone/JFK of over 60,000 vehicles. The turning movement data suggests that JFK is the major approach accommodating roughly two-thirds of the approach volume (i.e., minor 33%), and the percentage of right-turning traffic through the roundabout is approximately 25%. On this basis, the JFK/Gladstone roundabout is currently operating near its operational capacity (see Figure 1). Note that should the approach volumes become more balanced (i.e., 50/50 JFK/Gladstone), the percentage of right-turning vehicle change (where right-turns driving on the left are the equivalent to left-turns when driving on the right), or auxiliary slip lanes provided, then additional capacity could be realized (theoretically).

Intersection capacity analyses has also been completed at the Gladstone/JFK roundabout using SIDRA, and while the intersection as a whole operates close to capacity at LoS 'E during peak hours, there are individual movements that perform very poorly. As part of earlier work, various mitigation measures were recommended to increase the roundabout's capacity during peak hours, including widening of Gladstone Road, realignment of the westbound approach, and introduction of left-turn slip lanes.

Based on the foregoing assessment, there is insufficient basis to completely eliminate the possibility of a grade separated solution at the intersection of JFK and Gladstone. From a traffic operational perspective, field observation and analysis completed as part of previous work confirm that there are existing congestion issues at this location, however, recommended mitigation measures have been identified in recent studies that should improve traffic operations in the near-term. Longer-term, it is likely that traffic volumes will eventually exceed the capacity of the multi-lane roundabout, although investment in other transportation infrastructure may provide capacity elsewhere in the network that could divert vehicular traffic and avoid the need for grade separation.

Other considerations not discussed herein include property implications, environmental constraints, capital costs, etc., which extend beyond the scope of this preliminary assessment.

## 5.4 Projected Intersection Performance

### 5.4.1 Existing Traffic Volumes

As indicated earlier, the lack of deflection for the westbound movement at the Gladstone/JFK roundabout is contributing to poor traffic operations during peak times. The impact of introducing more appropriate westbound deflection to slow approaching vehicles and create better gaps within the circulating traffic, as well as adding a second southbound lane of Gladstone associated with the widening, was evaluated assuming no change to approach traffic volumes (i.e., existing 2020 volumes). The findings, shown in Table 10, indicate a notable improvement in roundabout performance when comparing the Existing Geometry to the Refined Geometry. Note that adjustments made to the "exiting flow effect" and critical gap parameters for the existing geometry were removed and default parameters were assumed.

Table 10 Performance at Gladstone/JFK Roundabout (existing peak hour traffic volumes)

| Intersection | Weekday AM Peak (PM Peak) | | | | | |
|---|---|---|---|---|---|---|
| | Critical Movement | | | Intersection 'as a whole' | | |
| | $LoS_1$ | Max. Delay (s) | Movement | Delay (s) | $LoS_1$ | Max v/c |
| **Existing Roundabout Geometry** | | | | | | |
| Gladstone/$JFK_2$ (R0) | F(F) | 260(117) | NB(NB) | 55(46) | E(D) | 1.25(1.07) |
| **Refined Roundabout Geometry** | | | | | | |
| Gladstone/$JFK_3$ (R1) | E(D) | 52(38) | EB(SB) | 21(16) | C(B) | 1.00(0.91) |

Notes:

1.) Intersection performance (LoS) is based on SIDRA delay estimates
2.) Introduced 'exiting flow effect' of 45% for the westbound left approach to reflect observed back-up of southbound receiving lane on Gladstone. Also reduced critical gap for eastbound movements by 1.25s (4.0 to 2.75s) to account for added ease to enter roundabout in response to delayed departure of northbound movement due to uncertainty of possible conflicting vehicles coming from the east who are either turning left or continuing through.
3.) Introduced westbound deflection, an additional northbound lane and a second southbound receiving lane on Gladstone. 'Exiting flow effect' was returned to default of zero for westbound left approach and default critical gap parameters assumed for all approaches.

| Existing Geometry (R0) | Refined Geometry (R1) |
|---|---|
| | |

The key findings are summarized as follows:

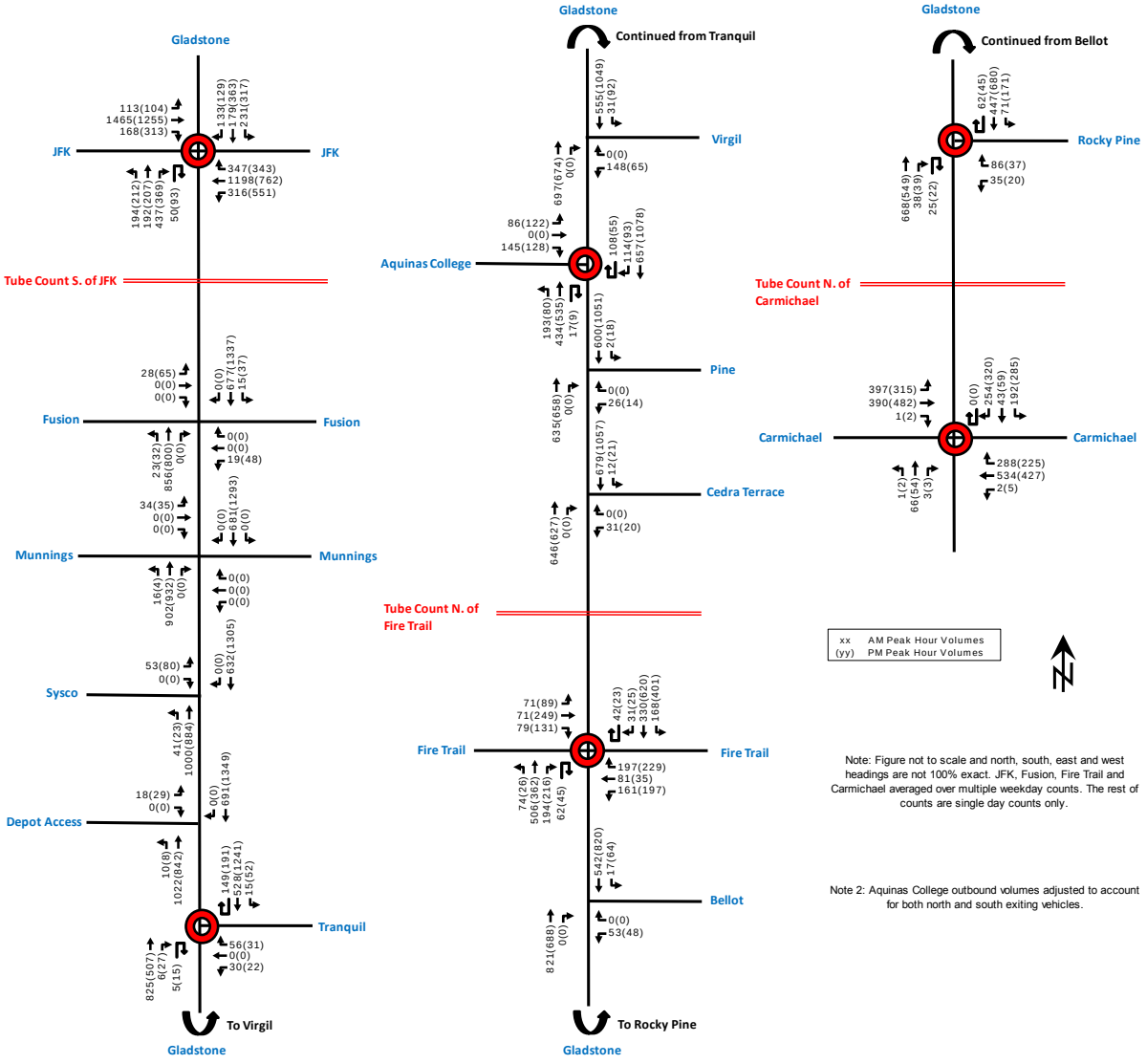
- The refined geometry results in a forecasted improvement in roundabout performance with an overall LoS "C' during the critical morning peak hour, and the critical movement now the eastbound approach operating at LoS "E';
- In the afternoon peak hour, the refined geometry results in a forecasted improvement with an overall LoS 'B', and the critical movement now the southbound approach operating at LoS 'D';

- However, the aforementioned level-of-service is based on delay, and the volume-to-capacity ratio for the critical movement is forecasted close to 1,0 indicating conditions very near capacity;
- It is also noteworthy that traffic signal control was found to operate at a reasonable overall LoS 'D' during both peak hours with an assumed geometry for each approach consisting of two through lanes, dual right-turn lanes, and channelized left-turn lanes.

### 5.4.2 Low Growth Scenario

The low growth scenario assumes a 15% increase in existing traffic volumes for key movements within the Corridor (see Figure 17). The ensuing analysis reflects existing intersections at JFK, Fire Trail and Carmichael plus three new full movement intersections – two between JFK and Fire Trail and one between Fire Trail and Carmichael, including a center median to prohibit right-turn movement at mid-block locations. Both roundabout and traffic signal control was assumed. Note that exact location of the three new intersections can be refined, but for the purpose of the assessment they were located at Tranquil, Aquinas and Rocky Pine as shown in Figure 21.

Figure 21: Year 2040 Projected Peak Hour Volumes – Low Growth Scenario (adjusted for centre median)



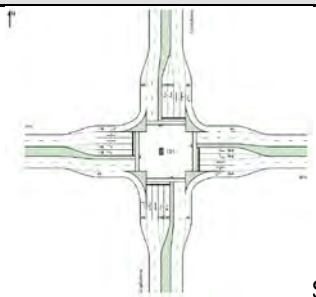
The corresponding SIDRA results are summarized in Table 11, followed by the associated geometry for both roundabout and signal control. Note that the geometry shown is conceptual in nature and not necessarily indicative of the proposed design (i.e., slip lanes could be placed closer to circulating traffic).

Table 11 GRC Projected Peak Hour Performance at Key intersections (low growth)

| Intersection | Weekday AM Peak (PM Peak) | | | | | |
|---|---|---|---|---|---|---|
| | Critical Movement | | | Intersection 'as a whole' | | |
| | LoS | Max. Delay (s) | Movement | Delay (s) | LoS | Max v/c |
| **As Roundabouts[1]** | | | | | | |
| Gladstone/JFK[2] (R1) | F(F) | 351(262) | EB(EB) | 130(117) | F(F) | 1.37(1.28) |
| Gladstone/JFK[6] (R2) | E(E) | 59(57) | EB(WB) | 26(28) | C(C) | 1.00(1.02) |
| Gladstone/Tranquil | B(B) | 10(12) | NB(WB) | 4(4) | A(A) | 0.36(0.53) |
| Gladstone/Aquinas | B(B) | 10(10) | NB(NB) | 5(5) | A(A) | 0.37(0.51) |
| Gladstone/Fire Trail | B(C) | 13(21) | EB(WB) | 7(13) | A(B) | 0.58(0.82) |
| Gladstone/Rocky Pine | A(B) | 9(10) | WB(WB) | 4(4) | A(A) | 0.30(0.33) |
| Gladstone/Carmichael (3-legged)[3] | B(B) | 14(13) | WB(WB) | 10(8) | B(A) | 0.84(0.78) |
| Gladstone/Carmichael (4-legged)[3] | C(B) | 21(18) | NB(NB) | 12(10) | B(B) | 0.86(0.80) |
| **As Signalized Intersections** | | | | | | |
| Gladstone/JFK (S1) | F(F) | 123(86) | NBU(NBU) | 65(49) | E(D) | 1.00(0.93) |
| Gladstone/Tranquil | B(D) | 18(48) | EBR(EBR) | 7(10) | A(A) | 0.44(0.65) |
| Gladstone/Aquinas | C(D) | 23(30) | EBR(EBR) | 12(12) | B(B) | 0.66(0.75) |
| Gladstone/Fire Trail[4] | B(C) | 19(23) | NBU(NBU) | 12(12) | B(B) | 0.74(0.88) |
| Gladstone/Rocky Pine | B(B) | 15(18) | WBR(WBR) | 8(6) | A(A) | 0.42(0.41) |
| Gladstone/Carmichael (3-legged) | C(C) | 33(32) | SBU(WBR) | 16(14) | B(B) | 0.84(0.87) |
| Gladstone/Carmichael (4-legged)[5] | D(C) | 42(26) | SBU(WBR) | 18(13) | B(B) | 0.91(0.87) |

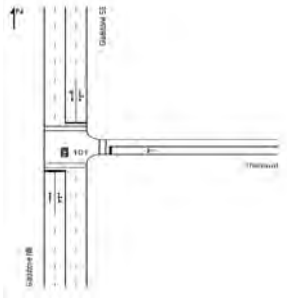
Notes:

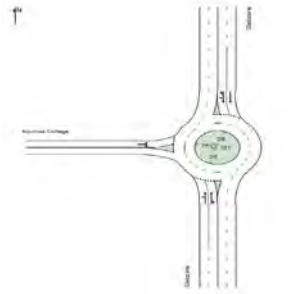
1.) Roundabout assumed symmetrical with default SIDRA angles and radius, with LoS based on delays
2.) Gladstone/JFK westbound approach modelled with adjusted deflection angle and entry radius plus a twinned approach and egress on Gladstone
3.) Gladstone/Carmichael modeled as a single lane roundabout with: (a) an eastbound slip lane that functions as secondary lane added to GRC north of Carmichael; and (b) southbound left slip lane emerging from the shoulder lane on GRC north of Carmichael
4.) Gladstone/Fire Trail modelled with right turn storage lanes at all approaches and a southbound left storage lane due to high volumes
5.) A protected WBR phase was added during the AM peak
6.) Left-turn slip lanes were added to the EB and SB approaches. A WB slip should also be considered if left-turn volumes approach 500 veh/h as indicated in data from 2019 TIS for Baha Mar Water Park. Note #2 above is still valid for this model

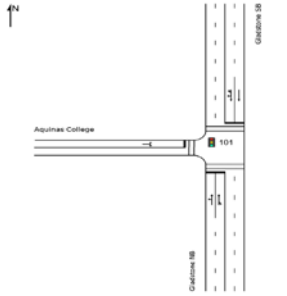
| Roundabout Geometry | Traffic Signal Control Geometry |
|---|---|
| R1 |  S1 |

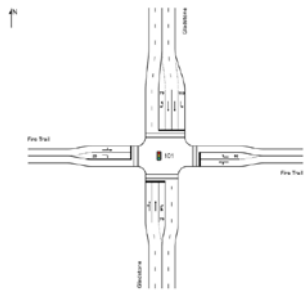
R2

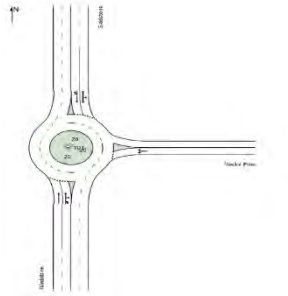
*Note that a WBL slip is also recommended for R2 should left-turn volumes approach 500 veh/h as per count from 2019 included in Bah Mar Water Park (Phase 2) TIS (IBI).*

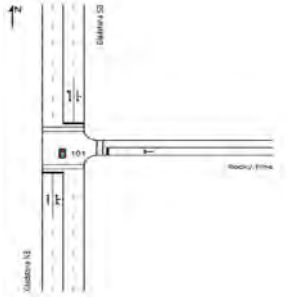






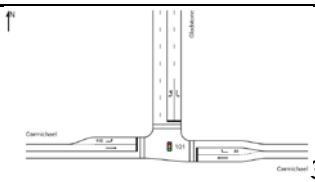




3-Legged

4-Legged



3-Legged

4-Legged

The key findings are summarized as follows:

- At JFK, for roundabout control, new left-turn slip lanes are recommended for the eastbound and southbound approaches; the resulting configuration (R2) is forecasted to result in overall LoS "C" and an acceptable critical movement LoS "E" or better during peak hours; this configuration provides limited spare capacity to accommodate additional northbound traffic; need for a westbound left-turn slip should also be considered should higher left-turn volumes materialize; without the additional slip lanes (R1), LoS 'F' conditions are forecasted;
- At JFK, for traffic signal control, the standard approach configuration (S1) of two through lanes, dual right-turn lanes, and channelized left-turn lanes is forecasted to result in acceptable overall LoS "E" or better; however, critical movements of LoS 'F' are anticipated during peak hours;
- At Tranquil, Aquinas, Fire Trail and Rocky Pine, for roundabout control, a basic configuration with no special treatments is considered effective; the resulting configuration is forecasted to result in overall LoS 'B' or better during peak hours;
- At Tranquil, Aquinas, Fire Trail and Rocky Pine, for traffic signal control, auxiliary turn lanes are generally not required with the notable exception being Fire Trail where auxiliary right-turn lanes are recommended for all approaches, as well as an auxiliary southbound left-turn lane; the resulting configuration is forecasted to result in an overall LoS 'B' or better at each intersection;
- At Carmichael, both 3-legged (existing) and 4-legged (potential extension of Gladstone southerly) configuration were considered;
- At Carmichael, for roundabout control, left-turn slip lanes are recommended for the southbound and eastbound approaches and the resulting configuration is forecasted to result in an overall LoS "B" or better during peak hours;
- At Carmichael, for traffic signal control, auxiliary turn lanes are recommended for the eastbound left-turn, westbound right-turn, and southbound right and left-turns; the resulting configuration is forecasted to result in an overall LoS 'B" during peak hours.

### 5.4.3 High Growth Scenario

The high growth scenario assumes a 30% increase in existing traffic volumes for key movements within the Corridor (see Figure 18) and assumes the same six intersections outlined for the low growth scenario as seen in Figure 22. The SIDRA results are summarized in Table 12, followed by the associated geometry for both roundabout and signal control. Note that the geometry shown is conceptual in nature and not necessarily indicative of the proposed design (i.e., slip lanes could be placed closer to circulating traffic).

Figure 22: Year 2040 Projected Peak Hour Volumes – High Growth Scenario (adjusted for centre median)

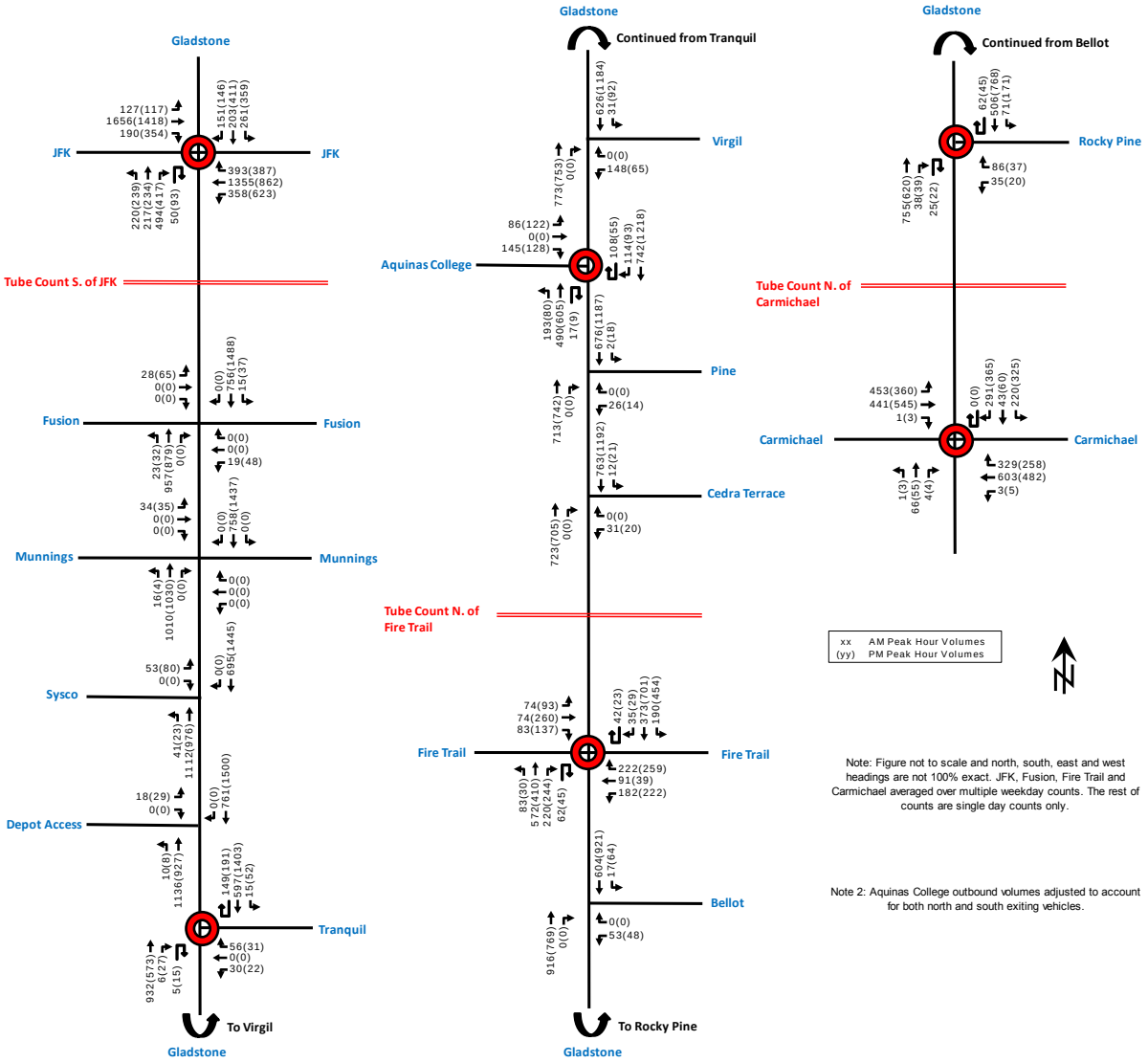
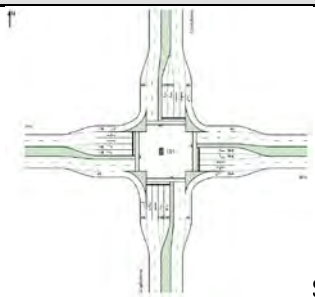
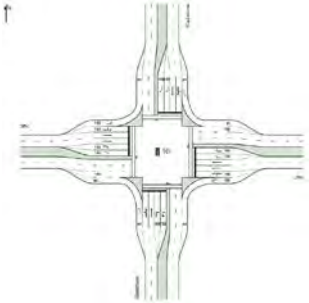
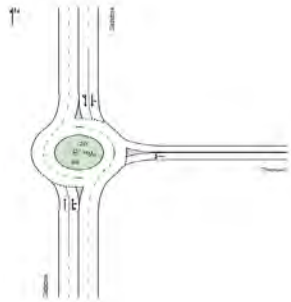
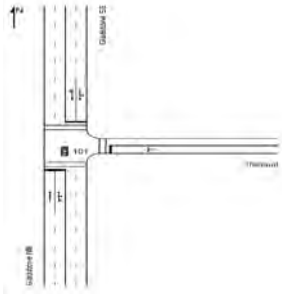
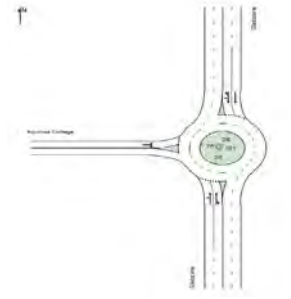
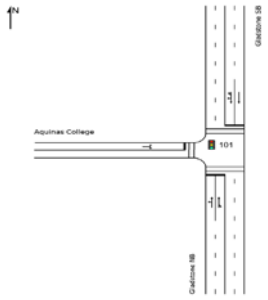


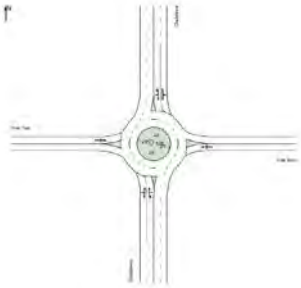
Table 12 GRC Projected Peak Hour Performance at Key intersections (high growth)

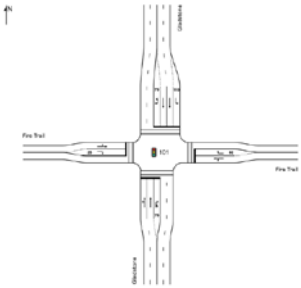
| Intersection | Weekday AM Peak (PM Peak) | | | | | |
|---|---|---|---|---|---|---|
| | Critical Movement | | | Intersection 'as a whole' | | |
| | LoS | Max. Delay (s) | Movement | Delay (s) | LoS | Max v/c |
| **As Roundabouts[1]** | | | | | | |
| Gladstone/JFK[2] (R1) | F(F) | 420(514) | EB(EB) | 173(241) | F(F) | 1.44(1.55) |
| Gladstone/JFK[6] (R3) | *F(F)* | *123(161)* | *EB(EB)* | *42(54)* | *D(E)* | *1.10(1.15)* |
| Gladstone/JFK[7] (R4) | *C(C)* | *26(31)* | *NB(SB)* | *9(11)* | *A(B)* | *0.89(0.83)* |
| Gladstone/JFK[8] (R5) | *TBD* | | | | | |
| Gladstone/Tranquil | B(B) | 10(13) | NB(WB) | 4(4) | A(A) | 0.41(0.58) |
| Gladstone/Aquinas | B(B) | 10(11) | NB(EB) | 5(5) | A(A) | 0.41(0.56) |
| Gladstone/Fire Trail | B(E) | 15(68) | EB(WB) | 8(27) | A(C) | 0.68(1.02) |
| Gladstone/Rocky Pine | B(B) | 10(10) | NB(WB) | 4(4) | A(A) | 0.34(0.37) |
| Gladstone/Carmichael (3-legged)[3] | D(C) | 37(20) | EB(WB) | 26(14) | C(B) | 0.99(0.92) |
| Gladstone/Carmichael (4-legged)[3] | E(C) | 62(27) | EB(EB) | 37(20) | D(C) | 1.02(0.95) |
| **As Signalized Intersections** | | | | | | |
| Gladstone/JFK (S1) | F(F) | 198(117) | NBR(WBR) | 99(66) | F(E) | 1.11(1.01) |
| Gladstone/JFK[9] (S2) | F(E) | 97(75) | NBU(WBR) | 52(45) | D(D) | 0.95(0.93) |
| Gladstone/Tranquil | B(D) | 18(49) | EBR(EBR) | 7(8) | A(A) | 0.49(0.70) |
| Gladstone/Aquinas | C(C) | 23(34) | EBR(EBR) | 13(14) | B(B) | 0.72(0.76) |
| Gladstone/Fire Trail[4] | C(D) | 21(39) | NBU(NBU) | 13(15) | B(B) | 0.83(1.00) |
| Gladstone/Rocky Pine | B(B) | 16(18) | WBL(WBR) | 7(6) | A(A) | 0.45(0.45) |
| Gladstone/Carmichael (3-legged)[5] | D(D) | 39(46) | SBU(SBU) | 19(25) | B(C) | 0.87(0.93) |
| Gladstone/Carmichael (4-legged)[5] | D(D) | 52(53) | SBU(WBR) | 25(21) | C(C) | 0.89(1.00) |

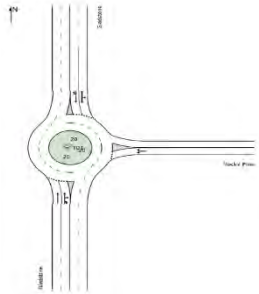
Note:

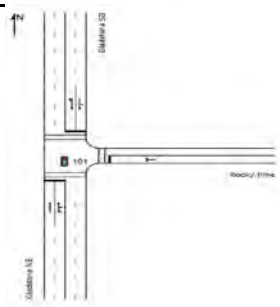
1.) Roundabout assumed symmetrical with default SIDRA angles and radius, with LoS based on delays
2.) Gladstone/JFK westbound approach modelled with adjusted deflection angle and entry radius plus a twinned approach and egress on the south approach
3.) Gladstone/Carmichael modeled as a single lane roundabout with: (a) an eastbound slip lane that functions as secondary lane added to GRC north of Carmichael; and (b) southbound left slip lane emerging from the shoulder lane on GRC north of Carmichael
4.) Gladstone/Fire Trail modelled with right turn storage lanes at all approaches and a southbound left storage lane due to high volumes
5.) A protected WBR phase was added during the AM peak
6.) Slip lanes were added to all approaches to improve intersection performance. Note #2 above is still valid for this model
7.) Three circulating lanes throughout
8.) Refinements, including possible turbo roundabout or other treatments to reduce the footprint, still being evaluated
9.) Localized widening of JFK to three lanes approaching Gladstone

| Roundabout Geometry | Traffic Signal Control Geometry |
|---|---|
| R1 |  S1 |
| R3 |  S2 |
| R4 | |
|  |  |
|  |  |



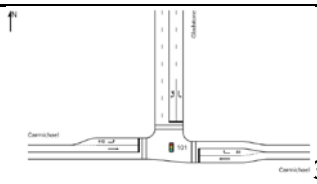




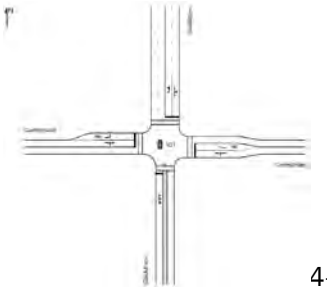


3-Legged

4-Legged



3-Legged



4-Legged

The key findings are summarized as follows:

- At JFK, for roundabout control, the configuration with left-turn slip lanes on all approaches (R3) is forecasted to result in acceptable overall LoS "E" or better during peak hours (average delays < 1 minute); however the eastbound approach is projected to be operating poorly at LoS 'F' with delays for this movement approaching 3 minutes (and volume-to-capacity ratio of 1.15); without the additional slip lanes (R1), overall LoS 'F' conditions are forecasted;
- At JFK, for roundabout control, an additional through lane and receiving lane for the eastbound-westbound approaches on JFK plus a triple circulating lane (R4) is forecasted to result in good overall LoS "B" or better during peak hours (average delays < 1 minute) with critical movements LoS 'C" and delays of less than half a minute; refinements to the this configuration, including a possible turbo roundabout or other treatments to reduce the footprint, are still being evaluated;

- At JFK, for traffic signal control, the standard approach configuration (S1) of two through lanes, dual right-turn lanes, and channelized left-turn lanes is forecasted to result in overall LoS 'F' conditions during peak hours; average delays are forecasted to be in the order of 1-2 minutes; the northbound approach in the AM and westbound approach in PM have the highest forecasted delays of approximately 2-3 minutes;
- At JFK, for signal control, an additional through lane and receiving lane for the eastbound-westbound approaches on JFK (S2) is forecasted to result in acceptable overall LoS "D" or better during peak hours (average delays < 1 minute); however the northbound U-turn and westbound right movements in AM peak are projected to be operating poorly at LoS 'F' with delays for this movement approaching 1 and a half minutes (and volume-to-capacity ratio of 0.95);
- At Tranquil, Aquinas, Fire Trail and Rocky Pine, for roundabout control, a basic configuration with no special treatments is considered effective; the resulting configuration is forecasted to result in overall LoS 'C' or better during peak hours;
- At Tranquil, Aquinas, Fire Trail and Rocky Pine, for traffic signal control, auxiliary turn lanes are generally not required with the notable exception being Fire Trail where auxiliary right-turn lanes are recommended for all approaches, as well as an auxiliary southbound left-turn lane; the resulting configuration is forecasted to result in an overall LoS 'B' or better at each intersection;
- At Carmichael, both 3-legged (existing) and 4-legged (potential extension of Gladstone southerly) configuration were considered;
- At Carmichael, for roundabout control, left-turn slip lanes are recommended for the southbound and eastbound approaches and the resulting configuration is forecasted to result in an acceptable overall LoS "D" or better during peak hours;
- At Carmichael, for traffic signal control, auxiliary turn lanes are recommended for the eastbound left-turn, westbound right-turn, and southbound right and left-turns; the resulting configuration is forecasted to result in an overall LoS 'C" during peak hours

# 6.0 Summary and Recommendations

Based on the above, the following are the main findings and recommendations of this report:

### *Traffic Data Collection*

- A robust traffic data collection program, consisting of both traditional tube counters and more contemporary video-based software tools (namely MIOVIION), was completed at key locations within the GRC to establish baseline conditions. At the three major intersections of JKF, Fire Trail and Carmichael, turning movement data was gathered over three days, whereas as single day counts were completed at selective driveway locations. Tube counters were installed at mid-block locations to help understand daily and hourly variations in traffic volumes.
- A comparison of the two data sources indicated general compatibility, although where any discrepancy existed, it has been recommended that the MIOVSION data source be used to establish the baseline traffic condition.

### *Existing Conditions*

- Average daily traffic within the GRC currently ranges between 16,000 and 20,000 vehicles. There is a notable imbalance of northbound versus southbound volumes within the GRC near JFK and Fire Trail, whereas directional volumes are more balanced near Carmichael. Approaching the three major intersections, the ADT is estimated to be close to 27,000 at Fire Trail and Carmichael, and 63,000 at JFK.

- In the morning, two-way volumes begin to increase starting at 4:00am and reach a peak between 7:00 and 8:00am. Volumes are noted to remain steady throughout the day, and begin to increase again around 2:00pm to signify the more pronounced afternoon peak period. Afternoon volumes peak between 4:00 and 5:00pm.
- Peak hour volume within the CRC currently ranges between 500 and 1,000 veh/in each direction. Turning movements are highest at the three major intersections (JFK, Fire Trail and Carmichael), with critical turning movements to/from minor streets and driveways considered modest and typically range between 20 and 60 veh/h with a few notable exceptions including, for example, Aquinas College and Rocky Pine.
- The available data suggest that free-flow travel times within the GRC are approximately 7 minutes, which correspond to an average speed of just under 30 mph. During peak times, travel times within the GRC can range between 10 and 20 minutes depending on direction. Most of the northbound congestion occurs approaching the existing JKF roundabout, with other notable "hotspots" near Fire Trail Road and Aquinas College.
- Capacity analyses of the existing major intersections during peak hours, using SIDRA software, confirmed current operational issues at the Gladstone/JFK roundabout, as well as for certain movements at the Gladstone/Fire Trail and Gladstone/Carmichael intersections. Of note is the lack of deflection for the westbound approach to the JFK roundabout, thereby creating issues for other approaches to the intersection. It is recommended that this design deficiency be addressed.

### *Future Traffic Projections*

- The stated horizon year for the study is 2040, which is 20 years from the collection date (February 2020) of the baseline traffic data used to establish existing conditions.
- Based on the available data, a reasonable range in traffic growth to apply over a 20-year planning horizon is considered to be between 0.75 % and 1.25% per annum.
- The existing traffic volumes within the GRC were increased by 15% to reflect a low/modest growth scenario, and by 30% to reflect a high growth scenario at the year 2040 planning horizon. Through movements within the Corridor, as well as turning movement at major intersections, were increased by this factor. Turing movements from minor driveways were not factored.
- The projected ADT within the GRC is forecasted to range between 18,000 and 26,000 vehicles at year 2040. Approaching the three major intersections, the ADT is forecasted up to 35,000 at Fire Trail and Carmichael, and exceed 80,000 at JFK.
- The projected peak hour volumes of up to 1,300 veh (peak direction) are forecasted within the Corridor.

### *Design Considerations*

- The preliminary design proposes introduction of a centre median with the GRC to maximize safety. The median will impact the ability of drivers to complete inbound and outbound right-turns across the road centerline.
- A review of the literature revealed that for divided roads, a spacing for full-movement intersections of approximately 0.5 mile (800m) provides a reasonable balance of mobility and access within an arterial road context. The introduction of directional openings within the median could be considered at more frequent spacing of 0.25 mile (400m).
- It is recommended that three new full-movement intersections be provided within the GRC, in addition to the existing intersections and JFK, Fire Trail and Carmichael. A new intersection is suggested near Tranquil and near Aquinas College resulting is intersection spacing of between 0.5 and 0.7 miles, and near Rocky Pine resulting in intersection spacing of between 0.3 and 0.6 miles. The exact location of the new full movement intersections will be defined as part of the overall design exercise.

- A centre median, prohibiting right-turn movements from/to the Corridor except at the aforementioned intersections, should be maintained throughout to maximize safety.
- Both traffic signal control and roundabout control are considered technically feasible (subject to a review of property requirements), although roundabout control is preferred given roundabouts are more amenable to accommodating U-turn movements for all vehicle types that would be imposed as a result of the proposed centre median.
- Regarding roundabout control at the major intersections (except Carmichael and JFK), a standard two-lane configuration, with no auxiliary slip lanes, is considered adequate to accommodate the forecasted traffic volumes at most locations within the GRC. The projected performance assuming a high growth scenario is LoS 'C' or better at these locations. Traffic signal control would offer similar performance.
- At Carmichael, the intersection design will need to provide an appropriate transition from two lanes on Gladstone to a single lane on the intersecting street. Also, both a 3-legged and 4-legged configuration have been proposed depending on the decision to extend Gladstone southerly. The projected performance assuming a high growth scenario is LoS 'C/D' at the intersection for both roundabout and traffic signal control.
- At JFK, the existing roundabout control requires refinement to address the existing issue with the westbound approach that is recognized to adversely impact the northbound approach. This refinement, combined with a widening of the Gladstone to the south of JFK, results in a projected performance of LoS 'C' compared to the current LoS 'E' assuming existing traffic volumes.
- At JFK, for the low growth scenario, the geometry outlined above plus additional left-turn slip lanes is recommended in the two north quadrants of the intersection. The projected performance is LoS 'C'. Consideration should also be given to providing a left-turn slip lane for the westbound left-turn (should there be sufficient property available) on the basis that there is evidence that the volume for this movement fluctuates between 300 to over 500 veh/h during peak times. Traffic signal control is projected to operate at LoS 'E' assuming dual right-turn lanes and channelized left-turn lanes.
- At JFK, for the high growth scenario, turning volumes between Gladstone and JFK are such that a conventional two-lane roundabout (with auxiliary slip lanes) is unable to reasonably accommodate the forecasted demands. A third circulating lane is recommended resulting in a projected performance of LoS 'B'. Additional refinement to the roundabout is suggested during the ensuing design process to assess if specific treatments, including a turbo roundabout that theoretically can increase capacity by approximately 25% (by disallowing lane changing within the roundabout) will result in a reduced geometric footprint. It will also be important to identify the residual capacity of this configuration to accommodate additional northbound demand on Gladstone approaching JFK. Traffic signal control is projected to operate at LoS 'D', however a third through lane is required on JFK through the intersection.
- Microsimulation, using for example VISSIM or AIMSUN, could be considered to more fully examine forecasted traffic operations associated with the ultimate design for the Gladstone/JFK intersection. This optional task is not considered within the current project scope.
- Grade separation of the Gladstone/JFK intersection should not be completely dismissed at this time given the operational challenges identified herein with both roundabout and traffic signal control. The six standard warrants gauging its appropriateness do not provide definitive guidance either way. Additional factors to consider include property implications, environmental constraints, capital costs, etc.

*Appendix A:*

GRC Traffic Data Collection Guidelines

*Appendix B*

Miovision Data (February 2020)

*Appendix C*

Tube Count Data (February 2020)

*Appendix D*

SIDRA Output (existing conditions)

*Appendix E*

Conceptual SIDRA Intersection Layouts (for Appendix F & G)

*Appendix F*

SIDRA Output (forecasted 2040 - LOW growth scenario)

*Appendix G*

SIDRA Output (forecasted 2040 - HIGH growth scenario)

## 12.4 Botanical Table of Observed Species

A combined total of one hundred and twenty-four (124) vascular plant species was recorded during the Gladstone Road and Lake Cunningham surveys. (See Table 4).

*List of vascular plant species recorded during Gladstone Road and Lake Cunningham Surveys, New Providence, The Bahamas*

**Table Key: DBEF** = Dry Broadleaf Evergreen Formation, **PW** = Pine Woodland, **HA** = Human Altered**, MS** = Mixed Species, **RM** = Red Mangrove

| Botanical Name | Common Name | Gladstone Road | | | Lake Killarney | | |
|---|---|---|---|---|---|---|---|
| | | DBEF | PW | HA | MS | RM | HA |
| Acacia choriophylla | Cinnecord | ✓ | | | | | |
| Acrostichum danaeifolium | Giant Leather Fern | ✓ | | | ✓ | | |
| Albizia lebbek | Woman's Tongue | | ✓ | ✓ | | | |
| Alvaradoa amorphoides | Alvaradoa | | ✓ | | | | |
| Andropogon glomeratus | Bushy beard grass | | | ✓ | | | |
| Archontophoenix alexandrae | Alexander Palm | | | ✓ | | | |
| Argemone mexicana | Mexican poppy | | | | | | ✓ |
| Asparagus densiflorus | Asparagus fern | | | ✓ | | | |
| Baccharis angustifolia | Salt bush | | ✓ | ✓ | ✓ | | |
| Bacopa monnieri | Pond Mat | | | ✓ | | | |
| Bidens alba | Shepherd's needle | | | ✓ | | | ✓ |
| *Bletia purpurea* | Pineland Orchid | | ✓ | | | | |
| Borrichia arborescens | Bay marigold | | | | | ✓ | |
| Bourreria ovata | Strongback | ✓ | ✓ | | ✓ | | |
| Bursera simaruba | Gum elemi | ✓ | ✓ | ✓ | ✓ | | |
| *Caesalpinia vesicaria* | Brasiletto | | ✓ | | | | |
| *Canavalia rosea* | Beach Pea | | | | | | ✓ |
| Carica papaya | Papaya | | | ✓ | | | |
| Cassia biflora | Bushy senna | | ✓ | | | | |
| Cassia sp. | Stinking Pea | | ✓ | ✓ | ✓ | | ✓ |
| Cassytha filiformis | Love Vine | ✓ | ✓ | ✓ | | | |
| Casuarina equisetifolia | Australian Pine | ✓ | | ✓ | ✓ | | ✓ |
| Casuarina glauca | Suckering Australian Pine | | | | ✓ | | |
| Ceiba pentandra | Silk Cotton | | | ✓ | | | |
| Centrosema angustifolium | Butterfly pea | | | | | | ✓ |
| Cestrum diurnum | Day Jasmine | | | ✓ | | | |
| Chiococca alba | Snowberry | ✓ | ✓ | | ✓ | | |
| Chiococca parivifolia | Pineland Snowberry | | | | ✓ | | |
| Chrysobalanus icaco | Coco plum | | | | ✓ | ✓ | |
| *Chrysophyllum* oliviforme | Saffron | ✓ | | | | | |

| Botanical Name | Common Name | Gladstone Road | | | Lake Killarney | | |
|---|---|---|---|---|---|---|---|
| | | DBEF | PW | HA | MS | RM | HA |
| Cladium jamaicense | Saw grass | ✓ | | | | ✓ | |
| Clusia guttifera | Small leaf Clusia | | | | | | ✓ |
| Coccoloba diversifolia | Pigeon Plum | | | ✓ | ✓ | | |
| Coccoloba sp. | Pigeon Plum | ✓ | | | | | |
| Coccothrinax argentata | Silver thatch palm | ✓ | ✓ | ✓ | | | |
| Cocolobba uvifera | Sea grape | | | | ✓ | ✓ | |
| Cocos nucifera | Coconut | | | ✓ | | | ✓ |
| Conocarpus erectus | Buttonwood | ✓ | | | ✓ | ✓ | |
| Conocarpus erectus var. sericeus | Silver Buttonwood | | | | | | ✓ |
| Corchorus hirsutus | Wholly booger | | | | | | ✓ |
| Cordia bahamensis | Cocobey | | ✓ | | | | |
| Delonix sp. | Poinciana | | | ✓ | | | |
| Dracena sp. | Dracena | | ✓ | ✓ | | | |
| Drypetes sp. | White wood | ✓ | ✓ | | | | |
| Duranta repens | Golden Dew drop | ✓ | ✓ | | | | |
| Eleocharis sp. | Spikerush Grass | | | | | ✓ | |
| Erithalis fruticosa | Black torch | | ✓ | | | | |
| Erythroxylum areolatum | Pigeon Berry | | ✓ | | | | |
| Eupatorium odoratum | Bitter Bushy | | | ✓ | ✓ | | |
| Euphoria mesembrianthemifolia | Coast spurge | | | | ✓ | | |
| *Eustoma* exaltatum | Marsh gentian | | | ✓ | ✓ | | |
| Exostema caribaeum | Princewood | | ✓ | | | | |
| Exothea paniculata | Inkwood | ✓ | ✓ | | | | |
| Ficus aurea | Strangler Fig | | | ✓ | ✓ | | |
| Ficus benjamina | Weeping Fig | | | ✓ | | | |
| Ficus sp. | Fig | | | ✓ | ✓ | | |
| Fimbristylis cymosa | Spike rush | | | | | | ✓ |
| Guapira discolor | Beefwood | | | ✓ | | | |
| Guapira obtusa | Broadleaf blolly | ✓ | | | | | |
| Guettarda elliptica | Smooth velvet leaf | ✓ | | | | | |
| Gymnanthes lucida | Crabwood | ✓ | | | | | |
| Hamelia patens | Fire Bush | | | ✓ | | | |
| Heliconia sp. | Lobster claw | | | ✓ | | | |
| Heliotropium angiospermum | Rooster comb | | | ✓ | | | |
| Ipomoea purpurea | Morning Glory | | | ✓ | | | ✓ |
| Jasminum fluminense | Jasmine vine | | | ✓ | ✓ | | ✓ |
| Lantana involucrata | Wild Sage | | | ✓ | ✓ | | |
| Leucaena leucocephala | Jumbay | | | ✓ | ✓ | | ✓ |
| Lysiloma latisiliquum | Wild Tamarind | | ✓ | | ✓ | | |
| Mangifera indica | Mango | | | ✓ | | | |
| Merremia dissecta | Noyau Vine | | | ✓ | | | ✓ |

| Botanical Name | Common Name | Gladstone Road | | | Lake Killarney | | |
|---|---|---|---|---|---|---|---|
| | | DBEF | PW | HA | MS | RM | HA |
| Metopium toxiferum | Poison wood | ✓ | ✓ | | ✓ | | |
| Morinda citrifolia | Noni | | | ✓ | | | |
| Mucuna pruriens | Monkey Tamarind | | | ✓ | ✓ | | |
| Nectandra coriacea | Lancewood | ✓ | | | | | |
| Oceoclades maculata | Oceoclades orchid | | | | ✓ | | |
| Pandanas sp. | Pandanas | | | ✓ | | | |
| Passiflora pectinata | Pectinate Passion flower | | | ✓ | | | |
| Passiflora sp. | Passion fruit | | | ✓ | ✓ | | |
| Pennisetum setaceum | Fountain Grass | | | ✓ | | | |
| *Petitia domingensis* | Fowl Berry | ✓ | ✓ | ✓ | | | ✓ |
| Phyllanthus epiphyllanthus | Rock bush | ✓ | | | | | |
| Pinus caribaea var. bahamensis | Caribbean pine | ✓ | ✓ | ✓ | | | |
| Pisonia aculeata | Wild Bougainvillea | | | ✓ | | | |
| Pithecellobium keyense | Ram's horn | ✓ | | | | | |
| Pithecellobium sp. | Cat's claw | ✓ | | | | | |
| Pluchea odorata | Marsh fleabane | | | ✓ | | | ✓ |
| Psilotum nudum | Whisk Fern | | | | | | ✓ |
| Pteridium aquilinum | Bracken Fern | | ✓ | ✓ | | | |
| Randia aculeata | Randia | ✓ | ✓ | | | | |
| Rhabdadenia biflora | Mangrove rubber vine | | | | ✓ | | |
| Rhizophora mangle | Red Mangrove | | | | | ✓ | |
| *Ricinus communis* | Castor bean | | | ✓ | | | |
| Sabal palmetto | Sabal Palm | | | ✓ | ✓ | | |
| Scaevola tacadda | White Inkberry | | | ✓ | ✓ | | |
| Schefflera actinophylla | Umbrella tree | | | ✓ | | | |
| Schinus terebinthifolia | Brazilian Pepper | | | ✓ | ✓ | | |
| Scleria lithosperma | Scleria | | ✓ | | | | |
| Sida acuta | Wire weed | | | ✓ | | | |
| Sideroxylon americanum | Milk Berry | | | ✓ | | | |
| Sideroxylon salicifolia | Willow Bustic | | | ✓ | | | |
| Simarouba glauca | Paradise Tree | | | | | | ✓ |
| Solanum erianthum | Salve Bush | | | | | | ✓ |
| Sorghum halepense | Johnson Grass | | | ✓ | | | ✓ |
| Spathodea campanulata | African Tulip tree | | | ✓ | | | |
| Spermacoce tenuior | Buttonweed | | | ✓ | | | ✓ |
| Sphagneticola trilobata | Carpet Daisy | | | ✓ | | | ✓ |
| Stachytarpheta jamaicensis | Blue flower | | | | | | ✓ |
| Stemodia maritima | Obeah bush | | | ✓ | | | ✓ |
| Stenotaphrum secundatum | St. Augustine Grass | | | ✓ | | | ✓ |
| Swietenia mahagoni | Mahogany | ✓ | | ✓ | | | |

| Botanical Name | Common Name | Gladstone Road | | | Lake Killarney | | |
|---|---|---|---|---|---|---|---|
| | | DBEF | PW | HA | MS | RM | HA |
| Tabebuia bahamensis | Five finger | ✓ | | ✓ | | | |
| Tabebuia heterophylla | Pink Poui | | | ✓ | | | ✓ |
| Tabebuia serratifolia | Yellow Poui | | | ✓ | | | |
| Terminalia catappa | West Indian Almond | | | | ✓ | | |
| Tillandsia usneoides | Spanish Moss | | | ✓ | | | |
| Tradescantia spathacea | Moses in basket | ✓ | | ✓ | | | |
| Trema lamarckiana | Pain in back | ✓ | ✓ | ✓ | | | |
| Trema lamarckianum | Trema | | | | | | ✓ |
| Turnera ulmifolia | Buttercup | ✓ | | ✓ | ✓ | | |
| Typha domingensis | Cattail | | | | | ✓ | |
| Vitis sp. | Wild grape | | | ✓ | | | |
| Waltheria indica | Sleeping Morning | | | | | | ✓ |
| Zamia pumila | Coontie | ✓ | | | | | |

*Figure 12-1 Table of Vascular Plants recorded during Gladstone Road and Lake Cunningham Surveys, New Providence, The Bahamas*

## 12.5 Invasive Species Listing

Sixteen (16) species listed on National Invasive Species Strategy (2013) were recorded during the investigation.

| Botanical Name | Common Name |
|---|---|
| Albizia lebbek | Woman's Tongue |
| Asparagus densiflorus | Asparagus fern |
| Casuarina equisetifolia | Australian Pine |
| Casuarina glauca | Suckering Australian Pine* |
| Cestrum diurnum | Day Jasmine |
| Delonix sp. | Poinciana |
| Ipomoea purpurea | Morning Glory |
| Jasminum fluminense | Jasmine Vine |
| Leucaena *leucocephala* | *Jumbay* |
| Mucuna pruriens | Monkey Tamarind |
| Pteridium aquilinum | Bracken Fern |
| Scaevola taccada | White Inkberry |
| Schefflera actinophylla | Umbrella tree |
| Schinus terebinthifolia | Brazilian Pepper |
| Spathodea campanulata | African Tulip tree |
| Sphagneticola trilobata | Carpet Daisy |

*Observed at Lake Cunningham

*Figure 12-2 Table of Invasive Species – Gladstone Road & Lake Cunningham, New Providence, The Bahamas*

## 12.6 Combined Avian List for Gladstone Road and Lake Cunningham

A combined total of twenty-one (21) avian species was recorded during the Gladstone Road and Lake Cunningham surveys.

| TABLE KEY: | |
|---|---|
| RANGE | STATUS |
| **PRB** = Permanent Resident Breeding | **LC =** Least Concern (Conservation- IUCN) |
| **WRN =** Winter Resident Non-breeding | **NT** = Near Threatened (Conservation-IUCN) |
| **SRB =** Summer Resident Breeding | **e** = Endemic subspecies |

| SCIENTIFIC NAME | COMMON NAME | MASTER OBSERVATION | STATUS/RANGE/ CONSERVATION STATUS | Gladstone Road | Lake Cunningham |
|---|---|---|---|---|---|
| **Patagioenas leucocephala** | White-crowned pigeon | F | NT/PRB | ✓ | ✓ |
| **Streptopelia decaocto** | Eurasian Collared-Dove | M | IRB/LC | ✓ | |
| **Crotophaga ani** | Smooth-billed Ani | F | PRB/LC | ✓ | |
| **Falco sparverius** | American Kestrel | S | PRB/LC | ✓ | |
| **Myiarchus sagrae** | La Sagra's Flycatcher | F | PRB/LC | ✓ | |
| **Plegadis falcinellus** | Glossy Ibis | F | PRB/LC | ✓ | |
| **Dumetella carolinensis** | Gray Catbird | F | WRN/LC | ✓ | |
| **Mimus polyglottos** | Northern Mockingbird | F | PRB/LC | ✓ | ✓ |
| **Passer domesticus** | House Sparrow | F | IRB/LC | ✓ | |
| **Mniotilta varia** | Black-and-white Warbler | S | WRN/LC | ✓ | |
| **Setophaga ruticilla** | American Redstart | F | WRN/LC | ✓ | |
| **Setophaga americana** | Northern Parula | F | WRN/LC | ✓ | |
| **Setophaga palmarum** | Palm Warbler | F | WRN/LC | ✓ | |
| **Setophaga discolor** | Prairie Warbler | F | WRN/LC | ✓ | |
| **Tachybaptus dominicus** | Least Grebe | F | PRB/LC | | ✓ |
| **Gallinula galeata** | Common Gallinule | S | PRB/LC | | ✓ |
| **Aramus guarauna** | Limpkin | S | PRB/LC | | ✓ |
| **Leucophaeus atricilla** | Laughing Gull | M | PRB/LC | | ✓ |
| **Sternula antillarum** | Least Tern | F | SRB/LC | | ✓ |
| **Tyrannus dominicensis** | Gray Kingbird | F | SRB/LC | | ✓ |

| SCIENTIFIC NAME | COMMON NAME | MASTER OBSERVATION | STATUS/RANGE/ CONSERVATION STATUS | Gladstone Road | Lake Cunningham |
|---|---|---|---|---|---|
| **Tiaris bicolor** | Black-faced Grassquit | F | PRB /LC | | ✓ |

*Table 12-1 Avifauna Observed during Gladstone Road and Lake Cunningham Surveys, New Providence, The Bahamas*

## 12.7 Sound Level Readings (ETS)

# AQUINAS COLLEGE - SOUND RECORDINGS

*Data Record*

| OCTOBER 16, 2020 - MIDDAY | | | OCTOBER 16, 2020 - EVENING | | | OCTOBER 19, 2020 - MORNING | | |
|---|---|---|---|---|---|---|---|---|
| Record | Time | Noise(dB) | Record | Time | Noise(dB) | Record | Time | Noise(dB) |
| 1 | 16/10/20 12:56:17 | 69 | 1 | 16/10/20 16:34:00 | 67.4 | 1 | 19/10/20 09:50:40 | 91.3 |
| 2 | 16/10/20 12:56:22 | 65 | 2 | 16/10/20 16:34:05 | 69.4 | 2 | 19/10/20 09:50:45 | 91.3 |
| 3 | 16/10/20 12:56:27 | 64.6 | 3 | 16/10/20 16:34:10 | 55.9 | 3 | 19/10/20 09:50:50 | 91.3 |
| 4 | 16/10/20 12:56:32 | 58 | 4 | 16/10/20 16:34:15 | 65.7 | 4 | 19/10/20 09:50:55 | 34.6 |
| 5 | 16/10/20 12:56:37 | 59.8 | 5 | 16/10/20 16:34:20 | 61.3 | 5 | 19/10/20 09:51:00 | 35.5 |
| 6 | 16/10/20 12:56:42 | 62.5 | 6 | 16/10/20 16:34:25 | 46.8 | 6 | 19/10/20 09:51:05 | 49.4 |
| 7 | 16/10/20 12:56:47 | 62 | 7 | 16/10/20 16:34:30 | 65.5 | 7 | 19/10/20 09:51:10 | 49 |
| 8 | 16/10/20 12:56:52 | 62.8 | 8 | 16/10/20 16:34:35 | 66 | 8 | 19/10/20 09:51:15 | 51.4 |
| 9 | 16/10/20 12:56:57 | 61.4 | 9 | 16/10/20 16:34:40 | 67.4 | 9 | 19/10/20 09:51:20 | 44.2 |
| 10 | 16/10/20 12:57:02 | 66.7 | 10 | 16/10/20 16:34:45 | 67.3 | 10 | 19/10/20 09:51:25 | 76.8 |
| 11 | 16/10/20 12:57:07 | 55.3 | 11 | 16/10/20 16:34:50 | 64.5 | 11 | 19/10/20 09:51:30 | 34.1 |
| 12 | 16/10/20 12:57:12 | 51.4 | 12 | 16/10/20 16:34:55 | 59.8 | 12 | 19/10/20 09:51:35 | 34.6 |
| 13 | 16/10/20 12:57:17 | 68.3 | 13 | 16/10/20 16:35:00 | 67.2 | 13 | 19/10/20 09:51:40 | 31.6 |
| 14 | 16/10/20 12:57:22 | 65.3 | 14 | 16/10/20 16:35:05 | 66.4 | 14 | 19/10/20 09:51:45 | 54.8 |
| 15 | 16/10/20 12:57:27 | 53.4 | 15 | 16/10/20 16:35:10 | 65.5 | 15 | 19/10/20 09:51:50 | 68.9 |
| 16 | 16/10/20 12:57:32 | 56.9 | 16 | 16/10/20 16:35:15 | 67.4 | 16 | 19/10/20 09:51:55 | 47.2 |
| 17 | 16/10/20 12:57:37 | 68 | 17 | 16/10/20 16:35:20 | 61.2 | 17 | 19/10/20 09:52:00 | 51.3 |
| 18 | 16/10/20 12:57:42 | 50.9 | 18 | 16/10/20 16:35:25 | 66.8 | 18 | 19/10/20 09:52:05 | 71.2 |
| 19 | 16/10/20 12:57:47 | 58.2 | 19 | 16/10/20 16:35:30 | 68.6 | 19 | 19/10/20 09:52:10 | 78.8 |
| 20 | 16/10/20 12:57:52 | 68.1 | 20 | 16/10/20 16:35:35 | 68.2 | 20 | 19/10/20 09:52:15 | 53.2 |
| 21 | 16/10/20 12:57:57 | 73.6 | 21 | 16/10/20 16:35:40 | 63.9 | 21 | 19/10/20 09:52:20 | 53.2 |
| 22 | 16/10/20 12:58:02 | 67 | 22 | 16/10/20 16:35:45 | 65.6 | 22 | 19/10/20 09:52:25 | 71 |
| 23 | 16/10/20 12:58:07 | 77.3 | 23 | 16/10/20 16:35:50 | 61.2 | 23 | 19/10/20 09:52:30 | 49 |
| 24 | 16/10/20 12:58:12 | 61.4 | 24 | 16/10/20 16:35:55 | 68 | 24 | 19/10/20 09:52:35 | 69.1 |
| 25 | 16/10/20 12:58:17 | 72.6 | 25 | 16/10/20 16:36:00 | 64.4 | 25 | 19/10/20 09:52:40 | 44.2 |
| 26 | 16/10/20 12:58:22 | 66.9 | 26 | 16/10/20 16:36:05 | 66.5 | 26 | 19/10/20 09:52:45 | 44.2 |
| 27 | 16/10/20 12:58:27 | 66.3 | 27 | 16/10/20 16:36:10 | 65.6 | 27 | 19/10/20 09:52:50 | 45 |
| 28 | 16/10/20 12:58:32 | 59.6 | 28 | 16/10/20 16:36:15 | 65.7 | 28 | 19/10/20 09:52:55 | 72.5 |
| 29 | 16/10/20 12:58:37 | 70 | 29 | 16/10/20 16:36:20 | 62.4 | 29 | 19/10/20 09:53:00 | 56.8 |
| 30 | 16/10/20 12:58:42 | 69.4 | 30 | 16/10/20 16:36:25 | 62.1 | 30 | 19/10/20 09:53:05 | 67 |
| 31 | 16/10/20 12:58:47 | 66 | 31 | 16/10/20 16:36:30 | 62.9 | 31 | 19/10/20 09:53:10 | 50.3 |
| 32 | 16/10/20 12:58:52 | 69.9 | 32 | 16/10/20 16:36:35 | 62.6 | 32 | 19/10/20 09:53:15 | 63.6 |
| 33 | 16/10/20 12:58:57 | 59.2 | 33 | 16/10/20 16:36:40 | 57.4 | 33 | 19/10/20 09:53:20 | 53.1 |
| 34 | 16/10/20 12:59:02 | 68.4 | 34 | 16/10/20 16:36:45 | 67 | 34 | 19/10/20 09:53:25 | 55.2 |
| 35 | 16/10/20 12:59:07 | 75.3 | 35 | 16/10/20 16:36:50 | 47.4 | 35 | 19/10/20 09:53:30 | 48.5 |
| 36 | 16/10/20 12:59:12 | 69.7 | 36 | 16/10/20 16:36:55 | 47.7 | 36 | 19/10/20 09:53:35 | 66.2 |
| 37 | 16/10/20 12:59:17 | 69.8 | 37 | 16/10/20 16:37:00 | 49.5 | 37 | 19/10/20 09:53:40 | 55.9 |
| 38 | 16/10/20 12:59:22 | 72.4 | 38 | 16/10/20 16:37:05 | 68.8 | 38 | 19/10/20 09:53:45 | 43.2 |
| 39 | 16/10/20 12:59:27 | 62.3 | 39 | 16/10/20 16:37:10 | 66.1 | 39 | 19/10/20 09:53:50 | 55.9 |
| 40 | 16/10/20 12:59:32 | 61.1 | 40 | 16/10/20 16:37:15 | 53.9 | 40 | 19/10/20 09:53:55 | 46 |
| 41 | 16/10/20 12:59:37 | 68.4 | 41 | 16/10/20 16:37:20 | 52.9 | 41 | 19/10/20 09:54:00 | 64.5 |
| 42 | 16/10/20 12:59:42 | 64 | 42 | 16/10/20 16:37:25 | 66.7 | 42 | 19/10/20 09:54:05 | 42.5 |
| 43 | 16/10/20 12:59:47 | 65.2 | 43 | 16/10/20 16:37:30 | 68.6 | 43 | 19/10/20 09:54:10 | 46.6 |
| 44 | 16/10/20 12:59:52 | 67.7 | 44 | 16/10/20 16:37:35 | 65.3 | 44 | 19/10/20 09:54:15 | 46.6 |
| 45 | 16/10/20 12:59:57 | 57.3 | 45 | 16/10/20 16:37:40 | 58.3 | 45 | 19/10/20 09:54:20 | 42.1 |
| 46 | 16/10/20 13:00:02 | 65.2 | 46 | 16/10/20 16:37:45 | 65.9 | 46 | 19/10/20 09:54:25 | 42.1 |
| 47 | 16/10/20 13:00:07 | 68.5 | 47 | 16/10/20 16:37:50 | 64.9 | 47 | 19/10/20 09:54:30 | 44.1 |
| 48 | 16/10/20 13:00:12 | 69 | 48 | 16/10/20 16:37:55 | 67.9 | 48 | 19/10/20 09:54:35 | 40.6 |
| 49 | 16/10/20 13:00:17 | 66.7 | 49 | 16/10/20 16:38:00 | 66.9 | 49 | 19/10/20 09:54:40 | 34.6 |
| 50 | 16/10/20 13:00:22 | 63.4 | 50 | 16/10/20 16:38:05 | 66.1 | 50 | 19/10/20 09:54:45 | 61.8 |
| 51 | 16/10/20 13:00:27 | 58 | 51 | 16/10/20 16:38:10 | 66.3 | 51 | 19/10/20 09:54:50 | 53 |
| 52 | 16/10/20 13:00:32 | 59.6 | 52 | 16/10/20 16:38:15 | 66.8 | 52 | 19/10/20 09:54:55 | 50.1 |
| 53 | 16/10/20 13:00:37 | 77.2 | 53 | 16/10/20 16:38:20 | 62.5 | 53 | 19/10/20 09:55:00 | 50.1 |
| 54 | 16/10/20 13:00:42 | 66.5 | 54 | 16/10/20 16:38:25 | 64.1 | 54 | 19/10/20 09:55:05 | 69.1 |
| 55 | 16/10/20 13:00:47 | 67.3 | 55 | 16/10/20 16:38:30 | 68 | 55 | 19/10/20 09:55:10 | 69.1 |
| 56 | 16/10/20 13:00:52 | 62.3 | 56 | 16/10/20 16:38:35 | 61 | 56 | 19/10/20 09:55:15 | 64.5 |
| 57 | 16/10/20 13:00:57 | 67.2 | 57 | 16/10/20 16:38:40 | 66.4 | 57 | 19/10/20 09:55:20 | 50.1 |
| 58 | 16/10/20 13:01:02 | 60.4 | 58 | 16/10/20 16:38:45 | 60.9 | 58 | 19/10/20 09:55:25 | 47.6 |
| 59 | 16/10/20 13:01:07 | 68.6 | 59 | 16/10/20 16:38:50 | 67.5 | 59 | 19/10/20 09:55:30 | 53.3 |
| 60 | 16/10/20 13:01:12 | 72 | 60 | 16/10/20 16:38:55 | 65.8 | 60 | 19/10/20 09:55:35 | 37.7 |
| 61 | 16/10/20 13:01:17 | 57.5 | 61 | 16/10/20 16:39:00 | 66.5 | 61 | 19/10/20 09:55:40 | 34.1 |
| 62 | 16/10/20 13:01:22 | 64.4 | 62 | 16/10/20 16:39:05 | 65.8 | 62 | 19/10/20 09:55:45 | 34.6 |
| 63 | 16/10/20 13:01:27 | 69.7 | 63 | 16/10/20 16:39:10 | 65.7 | 63 | 19/10/20 09:55:50 | 50.3 |

# AQUINAS COLLEGE - SOUND RECORDINGS

*Data Record*

| OCTOBER 16, 2020 - MIDDAY | | | OCTOBER 16, 2020 - EVENING | | | OCTOBER 19, 2020 - MORNING | | |
|---|---|---|---|---|---|---|---|---|
| Record | Time | Noise(dB) | Record | Time | Noise(dB) | Record | Time | Noise(dB) |
| 64 | 16/10/20 13:01:32 | 68.8 | 64 | 16/10/20 16:39:15 | 67.9 | 64 | 19/10/20 09:55:55 | 53.9 |
| 65 | 16/10/20 13:01:37 | 71.9 | 65 | 16/10/20 16:39:20 | 66.8 | 65 | 19/10/20 09:56:00 | 53.9 |
| 66 | 16/10/20 13:01:42 | 69.6 | 66 | 16/10/20 16:39:25 | 63.6 | 66 | 19/10/20 09:56:05 | 64.9 |
| 67 | 16/10/20 13:01:47 | 59.7 | 67 | 16/10/20 16:39:30 | 58.1 | 67 | 19/10/20 09:56:10 | 54.4 |
| 68 | 16/10/20 13:01:52 | 68.4 | 68 | 16/10/20 16:39:35 | 61.5 | 68 | 19/10/20 09:56:15 | 69.6 |
| 69 | 16/10/20 13:01:57 | 73.4 | 69 | 16/10/20 16:39:40 | 67.7 | 69 | 19/10/20 09:56:20 | 62 |
| 70 | 16/10/20 13:02:02 | 69.5 | 70 | 16/10/20 16:39:45 | 63.3 | 70 | 19/10/20 09:56:25 | 47.3 |
| 71 | 16/10/20 13:02:07 | 55.7 | 71 | 16/10/20 16:39:50 | 73.7 | 71 | 19/10/20 09:56:30 | 47.3 |
| 72 | 16/10/20 13:02:12 | 60.6 | 72 | 16/10/20 16:39:55 | 64.1 | 72 | 19/10/20 09:56:35 | 49.7 |
| 73 | 16/10/20 13:02:17 | 68.7 | 73 | 16/10/20 16:40:00 | 58.6 | 73 | 19/10/20 09:56:40 | 67.9 |
| 74 | 16/10/20 13:02:22 | 63.1 | 74 | 16/10/20 16:40:05 | 64.7 | 74 | 19/10/20 09:56:45 | 80.2 |
| 75 | 16/10/20 13:02:27 | 66.6 | 75 | 16/10/20 16:40:10 | 63.9 | 75 | 19/10/20 09:56:50 | 39 |
| 76 | 16/10/20 13:02:32 | 68.2 | 76 | 16/10/20 16:40:15 | 66.8 | 76 | 19/10/20 09:56:55 | 44 |
| 77 | 16/10/20 13:02:37 | 75.3 | 77 | 16/10/20 16:40:20 | 64.3 | 77 | 19/10/20 09:57:00 | 57.5 |
| 78 | 16/10/20 13:02:42 | 66.8 | 78 | 16/10/20 16:40:25 | 69.7 | 78 | 19/10/20 09:57:05 | 63 |
| 79 | 16/10/20 13:02:47 | 64.2 | 79 | 16/10/20 16:40:30 | 69 | 79 | 19/10/20 09:57:10 | 60.3 |
| 80 | 16/10/20 13:02:52 | 54.4 | 80 | 16/10/20 16:40:35 | 64 | 80 | 19/10/20 09:57:15 | 50.1 |
| 81 | 16/10/20 13:02:57 | 62.5 | 81 | 16/10/20 16:40:40 | 68.8 | 81 | 19/10/20 09:57:20 | 58.9 |
| 82 | 16/10/20 13:03:02 | 74.7 | 82 | 16/10/20 16:40:45 | 62.7 | 82 | 19/10/20 09:57:25 | 37.1 |
| 83 | 16/10/20 13:03:07 | 61.4 | 83 | 16/10/20 16:40:50 | 66.4 | 83 | 19/10/20 09:57:30 | 36.9 |
| 84 | 16/10/20 13:03:12 | 67.1 | 84 | 16/10/20 16:40:55 | 69.8 | 84 | 19/10/20 09:57:35 | 37.2 |
| 85 | 16/10/20 13:03:17 | 51.5 | 85 | 16/10/20 16:41:00 | 68.5 | 85 | 19/10/20 09:57:40 | 35.5 |
| 86 | 16/10/20 13:03:22 | 62.9 | 86 | 16/10/20 16:41:05 | 63.8 | 86 | 19/10/20 09:57:45 | 40.2 |
| 87 | 16/10/20 13:03:27 | 67 | 87 | 16/10/20 16:41:10 | 64.7 | 87 | 19/10/20 09:57:50 | 64 |
| 88 | 16/10/20 13:03:32 | 70.7 | 88 | 16/10/20 16:41:15 | 67.2 | 88 | 19/10/20 09:57:55 | 66.5 |
| 89 | 16/10/20 13:03:37 | 68.5 | 89 | 16/10/20 16:41:20 | 64 | 89 | 19/10/20 09:58:00 | 35.5 |
| 90 | 16/10/20 13:03:42 | 72.3 | 90 | 16/10/20 16:41:25 | 67.1 | 90 | 19/10/20 09:58:05 | 51 |
| 91 | 16/10/20 13:03:47 | 68.6 | 91 | 16/10/20 16:41:30 | 61.9 | 91 | 19/10/20 09:58:10 | 41.5 |
| 92 | 16/10/20 13:03:52 | 68.8 | 92 | 16/10/20 16:41:35 | 61.1 | 92 | 19/10/20 09:58:15 | 37.7 |
| 93 | 16/10/20 13:03:57 | 65.9 | 93 | 16/10/20 16:41:40 | 66.3 | 93 | 19/10/20 09:58:20 | 34.3 |
| 94 | 16/10/20 13:04:02 | 74.7 | 94 | 16/10/20 16:41:45 | 69.1 | 94 | 19/10/20 09:58:25 | 60.6 |
| 95 | 16/10/20 13:04:07 | 60.7 | 95 | 16/10/20 16:41:50 | 69.7 | 95 | 19/10/20 09:58:30 | 35.1 |
| 96 | 16/10/20 13:04:12 | 54.6 | 96 | 16/10/20 16:41:55 | 60.3 | 96 | 19/10/20 09:58:35 | 44.7 |
| 97 | 16/10/20 13:04:17 | 67.1 | 97 | 16/10/20 16:42:00 | 64.8 | 97 | 19/10/20 09:58:40 | 69.8 |
| 98 | 16/10/20 13:04:22 | 58.7 | 98 | 16/10/20 16:42:05 | 62.8 | 98 | 19/10/20 09:58:45 | 42 |
| 99 | 16/10/20 13:04:27 | 68.4 | 99 | 16/10/20 16:42:10 | 66.2 | 99 | 19/10/20 09:58:50 | 42 |
| 100 | 16/10/20 13:04:32 | 69.6 | 100 | 16/10/20 16:42:15 | 65.9 | 100 | 19/10/20 09:58:55 | 49.1 |
| 101 | 16/10/20 13:04:37 | 59.3 | 101 | 16/10/20 16:42:20 | 73.4 | 101 | 19/10/20 09:59:00 | 56.7 |
| 102 | 16/10/20 13:04:42 | 61.3 | 102 | 16/10/20 16:42:25 | 64.6 | 102 | 19/10/20 09:59:05 | 50.5 |
| 103 | 16/10/20 13:04:47 | 66.1 | 103 | 16/10/20 16:42:30 | 68.3 | 103 | 19/10/20 09:59:10 | 32.7 |
| 104 | 16/10/20 13:04:52 | 65.4 | 104 | 16/10/20 16:42:35 | 61.4 | 104 | 19/10/20 09:59:15 | 30.8 |
| 105 | 16/10/20 13:04:57 | 69.1 | 105 | 16/10/20 16:42:40 | 65.5 | 105 | 19/10/20 09:59:20 | 34.3 |
| 106 | 16/10/20 13:05:02 | 59.4 | 106 | 16/10/20 16:42:45 | 66.8 | 106 | 19/10/20 09:59:25 | 31.6 |
| 107 | 16/10/20 13:05:07 | 67 | 107 | 16/10/20 16:42:50 | 64.6 | 107 | 19/10/20 09:59:30 | 32.7 |
| 108 | 16/10/20 13:05:12 | 62.1 | 108 | 16/10/20 16:42:55 | 69.2 | 108 | 19/10/20 09:59:35 | 49.3 |
| 109 | 16/10/20 13:05:17 | 57.2 | 109 | 16/10/20 16:43:00 | 58.9 | 109 | 19/10/20 09:59:40 | 49.3 |
| 110 | 16/10/20 13:05:22 | 64 | 110 | 16/10/20 16:43:05 | 67.9 | 110 | 19/10/20 09:59:45 | 68.9 |
| 111 | 16/10/20 13:05:27 | 72.9 | 111 | 16/10/20 16:43:10 | 62.5 | 111 | 19/10/20 09:59:50 | 51.8 |
| 112 | 16/10/20 13:05:32 | 66.5 | 112 | 16/10/20 16:43:15 | 65 | 112 | 19/10/20 09:59:55 | 50.6 |
| 113 | 16/10/20 13:05:37 | 69.9 | 113 | 16/10/20 16:43:20 | 60.7 | 113 | 19/10/20 10:00:00 | 50.6 |
| 114 | 16/10/20 13:05:42 | 62.8 | 114 | 16/10/20 16:43:25 | 63.3 | 114 | 19/10/20 10:00:05 | 50.6 |
| 115 | 16/10/20 13:05:47 | 66.7 | 115 | 16/10/20 16:43:30 | 64.8 | 115 | 19/10/20 10:00:10 | 50.9 |
| 116 | 16/10/20 13:05:52 | 59.9 | 116 | 16/10/20 16:43:35 | 64.7 | 116 | 19/10/20 10:00:15 | 65.4 |
| 117 | 16/10/20 13:05:57 | 69.4 | 117 | 16/10/20 16:43:40 | 63.8 | 117 | 19/10/20 10:00:20 | 62.3 |
| 118 | 16/10/20 13:06:02 | 68.7 | 118 | 16/10/20 16:43:45 | 65 | 118 | 19/10/20 10:00:25 | 35.1 |
| 119 | 16/10/20 13:06:07 | 66 | 119 | 16/10/20 16:43:50 | 67.8 | 119 | 19/10/20 10:00:30 | 34.6 |
| 120 | 16/10/20 13:06:12 | 62.3 | 120 | 16/10/20 16:43:55 | 78.7 | 120 | 19/10/20 10:00:35 | 41.4 |
| 121 | 16/10/20 13:06:17 | 59.2 | 121 | 16/10/20 16:44:00 | 61.3 | 121 | 19/10/20 10:00:40 | 59.8 |
| 122 | 16/10/20 13:06:22 | 83.6 | 122 | 16/10/20 16:44:05 | 64.9 | 122 | 19/10/20 10:00:45 | 52.1 |
| 123 | 16/10/20 13:06:27 | 74.4 | 123 | 16/10/20 16:44:10 | 61.6 | 123 | 19/10/20 10:00:50 | 52.1 |
| 124 | 16/10/20 13:06:32 | 70.2 | 124 | 16/10/20 16:44:15 | 58.3 | 124 | 19/10/20 10:00:55 | 52.1 |
| 125 | 16/10/20 13:06:37 | 72.5 | 125 | 16/10/20 16:44:20 | 65.1 | 125 | 19/10/20 10:01:00 | 52.1 |
| 126 | 16/10/20 13:06:42 | 67.6 | 126 | 16/10/20 16:44:25 | 57.8 | 126 | 19/10/20 10:01:05 | 52.1 |

# AQUINAS COLLEGE - SOUND RECORDINGS

*Data Record*

| OCTOBER 16, 2020 - MIDDAY | | | OCTOBER 16, 2020 - EVENING | | | OCTOBER 19, 2020 - MORNING | | |
|---|---|---|---|---|---|---|---|---|
| Record | Time | Noise(dB) | Record | Time | Noise(dB) | Record | Time | Noise(dB) |
| 127 | 16/10/20 13:06:47 | 65.3 | 127 | 16/10/20 16:44:30 | 56.3 | 127 | 19/10/20 10:01:10 | 46.6 |
| 128 | 16/10/20 13:06:52 | 66.9 | 128 | 16/10/20 16:44:35 | 60.3 | 128 | 19/10/20 10:01:15 | 46.6 |
| 129 | 16/10/20 13:06:57 | 69.3 | 129 | 16/10/20 16:44:40 | 55.2 | 129 | 19/10/20 10:01:20 | 35.9 |
| 130 | 16/10/20 13:07:02 | 66.4 | 130 | 16/10/20 16:44:45 | 68.1 | 130 | 19/10/20 10:01:25 | 37.2 |
| 131 | 16/10/20 13:07:07 | 72.5 | 131 | 16/10/20 16:44:50 | 64.5 | 131 | 19/10/20 10:01:30 | 51.7 |
| 132 | 16/10/20 13:07:12 | 69.7 | 132 | 16/10/20 16:44:55 | 67 | 132 | 19/10/20 10:01:35 | 64.5 |
| 133 | 16/10/20 13:07:17 | 66.3 | 133 | 16/10/20 16:45:00 | 63.8 | 133 | 19/10/20 10:01:40 | 48.7 |
| 134 | 16/10/20 13:07:22 | 64.9 | 134 | 16/10/20 16:45:05 | 69.3 | 134 | 19/10/20 10:01:45 | 53.5 |
| 135 | 16/10/20 13:07:27 | 62.6 | 135 | 16/10/20 16:45:10 | 64.8 | 135 | 19/10/20 10:01:50 | 58.2 |
| 136 | 16/10/20 13:07:32 | 64.8 | 136 | 16/10/20 16:45:15 | 62.6 | 136 | 19/10/20 10:01:55 | 58.4 |
| 137 | 16/10/20 13:07:37 | 73.7 | 137 | 16/10/20 16:45:20 | 69.3 | 137 | 19/10/20 10:02:00 | 57.6 |
| 138 | 16/10/20 13:07:42 | 66.9 | 138 | 16/10/20 16:45:25 | 65.6 | 138 | 19/10/20 10:02:05 | 68.3 |
| 139 | 16/10/20 13:07:47 | 67.2 | 139 | 16/10/20 16:45:30 | 62.2 | 139 | 19/10/20 10:02:10 | 70.4 |
| 140 | 16/10/20 13:07:52 | 76.9 | 140 | 16/10/20 16:45:35 | 67.1 | 140 | 19/10/20 10:02:15 | 35.8 |
| 141 | 16/10/20 13:07:57 | 67.6 | 141 | 16/10/20 16:45:40 | 66.8 | 141 | 19/10/20 10:02:20 | 60.6 |
| 142 | 16/10/20 13:08:02 | 67.5 | 142 | 16/10/20 16:45:45 | 69.5 | 142 | 19/10/20 10:02:25 | 56.6 |
| 143 | 16/10/20 13:08:07 | 65.1 | 143 | 16/10/20 16:45:50 | 69 | 143 | 19/10/20 10:02:30 | 56.2 |
| 144 | 16/10/20 13:08:12 | 83.8 | 144 | 16/10/20 16:45:55 | 66.1 | 144 | 19/10/20 10:02:35 | 48.2 |
| 145 | 16/10/20 13:08:17 | 67.7 | 145 | 16/10/20 16:46:00 | 60.4 | 145 | 19/10/20 10:02:40 | 47.2 |
| 146 | 16/10/20 13:08:22 | 65.7 | 146 | 16/10/20 16:46:05 | 67 | 146 | 19/10/20 10:02:45 | 60.7 |
| 147 | 16/10/20 13:08:27 | 56.3 | 147 | 16/10/20 16:46:10 | 58.3 | 147 | 19/10/20 10:02:50 | 41 |
| 148 | 16/10/20 13:08:32 | 68.4 | 148 | 16/10/20 16:46:15 | 58.8 | 148 | 19/10/20 10:02:55 | 63.2 |
| 149 | 16/10/20 13:08:37 | 67.2 | 149 | 16/10/20 16:46:20 | 66 | 149 | 19/10/20 10:03:00 | 43.4 |
| 150 | 16/10/20 13:08:42 | 63.4 | 150 | 16/10/20 16:46:25 | 66.4 | 150 | 19/10/20 10:03:05 | 47.3 |
| 151 | 16/10/20 13:08:47 | 57.9 | 151 | 16/10/20 16:46:30 | 64 | 151 | 19/10/20 10:03:10 | 35.7 |
| 152 | 16/10/20 13:08:52 | 60.8 | 152 | 16/10/20 16:46:35 | 52.8 | 152 | 19/10/20 10:03:15 | 65.3 |
| 153 | 16/10/20 13:08:57 | 65.2 | 153 | 16/10/20 16:46:40 | 63.2 | 153 | 19/10/20 10:03:20 | 35.1 |
| 154 | 16/10/20 13:09:02 | 62.3 | 154 | 16/10/20 16:46:45 | 75.8 | 154 | 19/10/20 10:03:25 | 47.5 |
| 155 | 16/10/20 13:09:07 | 69.4 | 155 | 16/10/20 16:46:50 | 62.6 | 155 | 19/10/20 10:03:30 | 50.2 |
| 156 | 16/10/20 13:09:12 | 66.6 | 156 | 16/10/20 16:46:55 | 62.9 | 156 | 19/10/20 10:03:35 | 60.6 |
| 157 | 16/10/20 13:09:17 | 69.3 | 157 | 16/10/20 16:47:00 | 63.7 | 157 | 19/10/20 10:03:40 | 69.9 |
| 158 | 16/10/20 13:09:22 | 59.4 | 158 | 16/10/20 16:47:05 | 66 | 158 | 19/10/20 10:03:45 | 50.2 |
| 159 | 16/10/20 13:09:27 | 67.8 | 159 | 16/10/20 16:47:10 | 61.6 | 159 | 19/10/20 10:03:50 | 55 |
| 160 | 16/10/20 13:09:32 | 68.8 | 160 | 16/10/20 16:47:15 | 60.3 | 160 | 19/10/20 10:03:55 | 55 |
| 161 | 16/10/20 13:09:37 | 69.8 | 161 | 16/10/20 16:47:20 | 62 | 161 | 19/10/20 10:04:00 | 67.3 |
| 162 | 16/10/20 13:09:42 | 66.4 | 162 | 16/10/20 16:47:25 | 58.5 | 162 | 19/10/20 10:04:05 | 57.5 |
| 163 | 16/10/20 13:09:47 | 59.5 | 163 | 16/10/20 16:47:30 | 58 | 163 | 19/10/20 10:04:10 | 68.1 |
| 164 | 16/10/20 13:09:52 | 62.5 | 164 | 16/10/20 16:47:35 | 69.1 | 164 | 19/10/20 10:04:15 | 35.1 |
| 165 | 16/10/20 13:09:57 | 68.6 | 165 | 16/10/20 16:47:40 | 63.5 | 165 | 19/10/20 10:04:20 | 64.7 |
| 166 | 16/10/20 13:10:02 | 66.6 | 166 | 16/10/20 16:47:45 | 64.7 | 166 | 19/10/20 10:04:25 | 61 |
| 167 | 16/10/20 13:10:07 | 66.8 | 167 | 16/10/20 16:47:50 | 65.6 | 167 | 19/10/20 10:04:30 | 41.4 |
| 168 | 16/10/20 13:10:12 | 66.7 | 168 | 16/10/20 16:47:55 | 59.8 | 168 | 19/10/20 10:04:35 | 41.4 |
| 169 | 16/10/20 13:10:17 | 63.7 | 169 | 16/10/20 16:48:00 | 64.4 | 169 | 19/10/20 10:04:40 | 60.1 |
| 170 | 16/10/20 13:10:22 | 64.6 | 170 | 16/10/20 16:48:05 | 64.9 | 170 | 19/10/20 10:04:45 | 47.5 |
| 171 | 16/10/20 13:10:27 | 69.6 | 171 | 16/10/20 16:48:10 | 61.9 | 171 | 19/10/20 10:04:50 | 47.5 |
| 172 | 16/10/20 13:10:32 | 68.7 | 172 | 16/10/20 16:48:15 | 63.8 | 172 | 19/10/20 10:04:55 | 64.6 |
| 173 | 16/10/20 13:10:37 | 62.8 | 173 | 16/10/20 16:48:20 | 62.7 | 173 | 19/10/20 10:05:00 | 67.6 |
| 174 | 16/10/20 13:10:42 | 61.4 | 174 | 16/10/20 16:48:25 | 65.9 | 174 | 19/10/20 10:05:05 | 47.5 |
| 175 | 16/10/20 13:10:47 | 64.3 | 175 | 16/10/20 16:48:30 | 69.5 | 175 | 19/10/20 10:05:10 | 71.9 |
| 176 | 16/10/20 13:10:52 | 65 | 176 | 16/10/20 16:48:35 | 58.9 | 176 | 19/10/20 10:05:15 | 63.2 |
| 177 | 16/10/20 13:10:57 | 61.5 | 177 | 16/10/20 16:48:40 | 62.1 | 177 | 19/10/20 10:05:20 | 43.4 |
| 178 | 16/10/20 13:11:02 | 64.9 | 178 | 16/10/20 16:48:45 | 53.8 | 178 | 19/10/20 10:05:25 | 54.6 |
| 179 | 16/10/20 13:11:07 | 67.2 | 179 | 16/10/20 16:48:50 | 64.1 | 179 | 19/10/20 10:05:30 | 42.7 |
| 180 | 16/10/20 13:11:12 | 64.8 | 180 | 16/10/20 16:48:55 | 64 | 180 | 19/10/20 10:05:35 | 51.8 |
| 181 | 16/10/20 13:11:17 | 68.8 | 181 | 16/10/20 16:49:00 | 61.4 | 181 | 19/10/20 10:05:40 | 51.8 |
| 182 | 16/10/20 13:11:22 | 64.1 | 182 | 16/10/20 16:49:05 | 60.4 | 182 | 19/10/20 10:05:45 | 66 |
| 183 | 16/10/20 13:11:27 | 51.1 | 183 | 16/10/20 16:49:10 | 63.8 | 183 | 19/10/20 10:05:50 | 47.5 |
| 184 | 16/10/20 13:11:32 | 54.4 | 184 | 16/10/20 16:49:15 | 62 | 184 | 19/10/20 10:05:55 | 53.5 |
| 185 | 16/10/20 13:11:37 | 69.4 | 185 | 16/10/20 16:49:20 | 64.7 | 185 | 19/10/20 10:06:00 | 50 |
| 186 | 16/10/20 13:11:42 | 67.1 | 186 | 16/10/20 16:49:25 | 65.9 | 186 | 19/10/20 10:06:05 | 50 |
| 187 | 16/10/20 13:11:47 | 74.9 | 187 | 16/10/20 16:49:30 | 66.7 | 187 | 19/10/20 10:06:10 | 56 |
| 188 | 16/10/20 13:11:52 | 65.6 | 188 | 16/10/20 16:49:35 | 63.3 | 188 | 19/10/20 10:06:15 | 49.2 |
| 189 | 16/10/20 13:11:57 | 62.7 | 189 | 16/10/20 16:49:40 | 64.9 | 189 | 19/10/20 10:06:20 | 64.5 |

# AQUINAS COLLEGE - SOUND RECORDINGS

*Data Record*

| OCTOBER 16, 2020 - MIDDAY | | | OCTOBER 16, 2020 - EVENING | | | OCTOBER 19, 2020 - MORNING | | |
|---|---|---|---|---|---|---|---|---|
| **Record** | **Time** | **Noise(dB)** | **Record** | **Time** | **Noise(dB)** | **Record** | **Time** | **Noise(dB)** |
| 190 | 16/10/20 13:12:02 | 55.7 | 190 | 16/10/20 16:49:45 | 65.4 | 190 | 19/10/20 10:06:25 | 59.6 |
| 191 | 16/10/20 13:12:07 | 54.2 | 191 | 16/10/20 16:49:50 | 69.1 | 191 | 19/10/20 10:06:30 | 57.1 |
| 192 | 16/10/20 13:12:12 | 68.2 | 192 | 16/10/20 16:49:55 | 65.4 | 192 | 19/10/20 10:06:35 | 35.8 |
| 193 | 16/10/20 13:12:17 | 72.9 | 193 | 16/10/20 16:50:00 | 64.7 | 193 | 19/10/20 10:06:40 | 35.7 |
| 194 | 16/10/20 13:12:22 | 69.4 | 194 | 16/10/20 16:50:05 | 64.2 | 194 | 19/10/20 10:06:45 | 48.4 |
| 195 | 16/10/20 13:12:27 | 65.3 | 195 | 16/10/20 16:50:10 | 57.8 | 195 | 19/10/20 10:06:50 | 60 |
| 196 | 16/10/20 13:12:32 | 66.1 | 196 | 16/10/20 16:50:15 | 56.3 | 196 | 19/10/20 10:06:55 | 69.3 |
| 197 | 16/10/20 13:12:37 | 62.1 | 197 | 16/10/20 16:50:20 | 55.4 | 197 | 19/10/20 10:07:00 | 59.2 |
| 198 | 16/10/20 13:12:42 | 69.1 | 198 | 16/10/20 16:50:25 | 63.6 | 198 | 19/10/20 10:07:05 | 35.9 |
| 199 | 16/10/20 13:12:47 | 67.5 | 199 | 16/10/20 16:50:30 | 64.5 | 199 | 19/10/20 10:07:10 | 35.5 |
| 200 | 16/10/20 13:12:52 | 62.7 | 200 | 16/10/20 16:50:35 | 67.1 | 200 | 19/10/20 10:07:15 | 36.4 |

| | | | |
|---|---|---|---|
| **MAXIMUM READING** | **91.3** | **at** | **October 19, 2020 at 9:50:44 am** |
| **MINIMUM READING** | **30.8** | **at** | **October 19, 2020 at 9:59:15 am** |
| **AVERAGE** | **60.6** | | |

***Paramaters***

| Record Parameters | Content |
|---|---|
| Address | 1 |
| Serial Number | 202016991 |
| Test Name | RECORD TEST2 |
| Setting Time | 16/10/2020 12:56:10 |
| Total Records | 200 |
| Record Interval | 5 sec |
| Immediately/Manual | Manual |
| Noise Alarm | L:30 H:130 dB |
| Sample Level | FAST |
| Noise Level | A |
| Start Time | 16/10/2020 12:56:17 |
| Test Records | 200 |
| Is Noise Alarm | |

| Record Parameters | Content |
|---|---|
| Address | 1 |
| Serial Number | 202016991 |
| Test Name | RECORD TEST2 |
| Setting Time | 16/10/2020 16:33:53 |
| Total Records | 200 |
| Record Interval | 5 sec |
| Immediately/Manual | Manual |
| Noise Alarm | L:30 H:130 dB |
| Sample Level | FAST |
| Noise Level | A |
| Start Time | 16/10/2020 16:34:00 |
| Test Records | 200 |
| Is Noise Alarm | |

| Record Parameters | Content |
|---|---|
| Address | 1 |
| Serial Number | 202016991 |
| Test Name | RECORD TEST2 |
| Setting Time | 19/10/2020 09:50:33 |
| Total Records | 200 |
| Record Interval | 5 sec |
| Immediately/Manual | Manual |
| Noise Alarm | L:30 H:130 dB |
| Sample Level | FAST |
| Noise Level | A |
| Start Time | 19/10/2020 09:50:40 |
| Test Records | 200 |
| Is Noise Alarm | |

# JFK ROUNDABOUT - SOUND RECORDINGS

*Data Record*

| OCTOBER 16, 2020 - MIDDAY | | | OCTOBER 16, 2020 - EVENING | | | OCTOBER 19, 2020 - MORNING | | |
|---|---|---|---|---|---|---|---|---|
| Record | Time | Noise(dB) | Record | Time | Noise(dB) | Record | Time | Noise(dB) |
| 1 | 16/10/20 12:25:36 | 74.8 | 1 | 16/10/20 15:59:27 | 63.3 | 1 | 19/10/20 09:24:19 | 51.3 |
| 2 | 16/10/20 12:25:41 | 61.3 | 2 | 16/10/20 15:59:32 | 62.7 | 2 | 19/10/20 09:24:24 | 51.3 |
| 3 | 16/10/20 12:25:46 | 69.3 | 3 | 16/10/20 15:59:37 | 66.3 | 3 | 19/10/20 09:24:29 | 67.4 |
| 4 | 16/10/20 12:25:51 | 61 | 4 | 16/10/20 15:59:42 | 63.9 | 4 | 19/10/20 09:24:34 | 69 |
| 5 | 16/10/20 12:25:56 | 66.2 | 5 | 16/10/20 15:59:47 | 62.1 | 5 | 19/10/20 09:24:39 | 64.1 |
| 6 | 16/10/20 12:26:01 | 71.8 | 6 | 16/10/20 15:59:52 | 64.7 | 6 | 19/10/20 09:24:44 | 71.7 |
| 7 | 16/10/20 12:26:06 | 78.2 | 7 | 16/10/20 15:59:57 | 67.9 | 7 | 19/10/20 09:24:49 | 70.5 |
| 8 | 16/10/20 12:26:11 | 65.9 | 8 | 16/10/20 16:00:02 | 66.3 | 8 | 19/10/20 09:24:54 | 65.1 |
| 9 | 16/10/20 12:26:16 | 75.7 | 9 | 16/10/20 16:00:07 | 63.5 | 9 | 19/10/20 09:24:59 | 49.2 |
| 10 | 16/10/20 12:26:21 | 81.8 | 10 | 16/10/20 16:00:12 | 67 | 10 | 19/10/20 09:25:04 | 73.4 |
| 11 | 16/10/20 12:26:26 | 70.4 | 11 | 16/10/20 16:00:17 | 65.5 | 11 | 19/10/20 09:25:09 | 79.3 |
| 12 | 16/10/20 12:26:31 | 69.4 | 12 | 16/10/20 16:00:22 | 80.9 | 12 | 19/10/20 09:25:14 | 65.5 |
| 13 | 16/10/20 12:26:36 | 69.8 | 13 | 16/10/20 16:00:27 | 63.1 | 13 | 19/10/20 09:25:19 | 67.6 |
| 14 | 16/10/20 12:26:41 | 75.5 | 14 | 16/10/20 16:00:32 | 64.4 | 14 | 19/10/20 09:25:24 | 76.3 |
| 15 | 16/10/20 12:26:46 | 68.5 | 15 | 16/10/20 16:00:37 | 61.6 | 15 | 19/10/20 09:25:29 | 79.9 |
| 16 | 16/10/20 12:26:51 | 72.3 | 16 | 16/10/20 16:00:42 | 63.4 | 16 | 19/10/20 09:25:34 | 83.6 |
| 17 | 16/10/20 12:26:56 | 80.1 | 17 | 16/10/20 16:00:47 | 69.2 | 17 | 19/10/20 09:25:39 | 68.7 |
| 18 | 16/10/20 12:27:01 | 69 | 18 | 16/10/20 16:00:52 | 62.3 | 18 | 19/10/20 09:25:44 | 80.2 |
| 19 | 16/10/20 12:27:06 | 75 | 19 | 16/10/20 16:00:57 | 60.6 | 19 | 19/10/20 09:25:49 | 72.4 |
| 20 | 16/10/20 12:27:11 | 75.4 | 20 | 16/10/20 16:01:02 | 62.7 | 20 | 19/10/20 09:25:54 | 83 |
| 21 | 16/10/20 12:27:16 | 69.2 | 21 | 16/10/20 16:01:07 | 62 | 21 | 19/10/20 09:25:59 | 71.8 |
| 22 | 16/10/20 12:27:21 | 66.1 | 22 | 16/10/20 16:01:12 | 55.7 | 22 | 19/10/20 09:26:04 | 60.7 |
| 23 | 16/10/20 12:27:26 | 68.3 | 23 | 16/10/20 16:01:17 | 58.2 | 23 | 19/10/20 09:26:09 | 35.5 |
| 24 | 16/10/20 12:27:31 | 64.5 | 24 | 16/10/20 16:01:22 | 60.6 | 24 | 19/10/20 09:26:14 | 32.7 |
| 25 | 16/10/20 12:27:36 | 66.9 | 25 | 16/10/20 16:01:27 | 60.5 | 25 | 19/10/20 09:26:19 | 54.4 |
| 26 | 16/10/20 12:27:41 | 66 | 26 | 16/10/20 16:01:32 | 71.4 | 26 | 19/10/20 09:26:24 | 75.9 |
| 27 | 16/10/20 12:27:46 | 69.3 | 27 | 16/10/20 16:01:37 | 60.6 | 27 | 19/10/20 09:26:29 | 74.4 |
| 28 | 16/10/20 12:27:51 | 84.3 | 28 | 16/10/20 16:01:42 | 69.4 | 28 | 19/10/20 09:26:34 | 68.8 |
| 29 | 16/10/20 12:27:56 | 67.5 | 29 | 16/10/20 16:01:47 | 68.7 | 29 | 19/10/20 09:26:39 | 71.9 |
| 30 | 16/10/20 12:28:01 | 72.1 | 30 | 16/10/20 16:01:52 | 65.6 | 30 | 19/10/20 09:26:44 | 72.9 |
| 31 | 16/10/20 12:28:06 | 67 | 31 | 16/10/20 16:01:57 | 62.1 | 31 | 19/10/20 09:26:49 | 59.4 |
| 32 | 16/10/20 12:28:11 | 69 | 32 | 16/10/20 16:02:02 | 67.2 | 32 | 19/10/20 09:26:54 | 63.4 |
| 33 | 16/10/20 12:28:16 | 73.7 | 33 | 16/10/20 16:02:07 | 66.4 | 33 | 19/10/20 09:26:59 | 82.1 |
| 34 | 16/10/20 12:28:21 | 56.4 | 34 | 16/10/20 16:02:12 | 69 | 34 | 19/10/20 09:27:04 | 68.2 |
| 35 | 16/10/20 12:28:26 | 66.9 | 35 | 16/10/20 16:02:17 | 65.3 | 35 | 19/10/20 09:27:09 | 71.7 |
| 36 | 16/10/20 12:28:31 | 63.7 | 36 | 16/10/20 16:02:22 | 65 | 36 | 19/10/20 09:27:14 | 55.1 |
| 37 | 16/10/20 12:28:36 | 69.4 | 37 | 16/10/20 16:02:27 | 66.3 | 37 | 19/10/20 09:27:19 | 77.5 |
| 38 | 16/10/20 12:28:41 | 69.6 | 38 | 16/10/20 16:02:32 | 65.9 | 38 | 19/10/20 09:27:24 | 50 |
| 39 | 16/10/20 12:28:46 | 68.6 | 39 | 16/10/20 16:02:37 | 58.7 | 39 | 19/10/20 09:27:29 | 64.7 |
| 40 | 16/10/20 12:28:51 | 67.7 | 40 | 16/10/20 16:02:42 | 61.6 | 40 | 19/10/20 09:27:34 | 88.6 |
| 41 | 16/10/20 12:28:56 | 61.6 | 41 | 16/10/20 16:02:47 | 65.3 | 41 | 19/10/20 09:27:39 | 80.2 |
| 42 | 16/10/20 12:29:01 | 64.9 | 42 | 16/10/20 16:02:52 | 67.1 | 42 | 19/10/20 09:27:44 | 56.9 |
| 43 | 16/10/20 12:29:06 | 67.1 | 43 | 16/10/20 16:02:57 | 65.7 | 43 | 19/10/20 09:27:49 | 59.7 |
| 44 | 16/10/20 12:29:11 | 69.6 | 44 | 16/10/20 16:03:02 | 72.7 | 44 | 19/10/20 09:27:54 | 76.6 |
| 45 | 16/10/20 12:29:16 | 68.6 | 45 | 16/10/20 16:03:07 | 66.1 | 45 | 19/10/20 09:27:59 | 63.8 |
| 46 | 16/10/20 12:29:21 | 73.5 | 46 | 16/10/20 16:03:12 | 64.8 | 46 | 19/10/20 09:28:04 | 74 |
| 47 | 16/10/20 12:29:26 | 69.9 | 47 | 16/10/20 16:03:17 | 64.5 | 47 | 19/10/20 09:28:09 | 82.2 |
| 48 | 16/10/20 12:29:31 | 68.5 | 48 | 16/10/20 16:03:22 | 66.9 | 48 | 19/10/20 09:28:14 | 72.9 |
| 49 | 16/10/20 12:29:36 | 68.8 | 49 | 16/10/20 16:03:27 | 64.6 | 49 | 19/10/20 09:28:19 | 56.6 |
| 50 | 16/10/20 12:29:41 | 66.6 | 50 | 16/10/20 16:03:32 | 70.4 | 50 | 19/10/20 09:28:24 | 55.1 |
| 51 | 16/10/20 12:29:46 | 69.2 | 51 | 16/10/20 16:03:37 | 77.8 | 51 | 19/10/20 09:28:29 | 75.5 |
| 52 | 16/10/20 12:29:51 | 62.9 | 52 | 16/10/20 16:03:42 | 71.4 | 52 | 19/10/20 09:28:34 | 71.4 |
| 53 | 16/10/20 12:29:56 | 64.9 | 53 | 16/10/20 16:03:47 | 68.4 | 53 | 19/10/20 09:28:39 | 70.3 |
| 54 | 16/10/20 12:30:01 | 66.3 | 54 | 16/10/20 16:03:52 | 68.4 | 54 | 19/10/20 09:28:44 | 73.3 |
| 55 | 16/10/20 12:30:06 | 67.3 | 55 | 16/10/20 16:03:57 | 75.2 | 55 | 19/10/20 09:28:49 | 84.2 |
| 56 | 16/10/20 12:30:11 | 69.9 | 56 | 16/10/20 16:04:02 | 69.4 | 56 | 19/10/20 09:28:54 | 75.4 |
| 57 | 16/10/20 12:30:16 | 66.5 | 57 | 16/10/20 16:04:07 | 76.2 | 57 | 19/10/20 09:28:59 | 59 |
| 58 | 16/10/20 12:30:21 | 69.9 | 58 | 16/10/20 16:04:12 | 86.1 | 58 | 19/10/20 09:29:04 | 42.1 |
| 59 | 16/10/20 12:30:26 | 68.4 | 59 | 16/10/20 16:04:17 | 69.4 | 59 | 19/10/20 09:29:09 | 44.3 |
| 60 | 16/10/20 12:30:31 | 65 | 60 | 16/10/20 16:04:22 | 68.5 | 60 | 19/10/20 09:29:14 | 67.9 |
| 61 | 16/10/20 12:30:36 | 69.6 | 61 | 16/10/20 16:04:27 | 65.8 | 61 | 19/10/20 09:29:19 | 75.3 |
| 62 | 16/10/20 12:30:41 | 66.9 | 62 | 16/10/20 16:04:32 | 67.9 | 62 | 19/10/20 09:29:24 | 67 |
| 63 | 16/10/20 12:30:46 | 65.3 | 63 | 16/10/20 16:04:37 | 65.9 | 63 | 19/10/20 09:29:29 | 63.7 |
| 64 | 16/10/20 12:30:51 | 62.6 | 64 | 16/10/20 16:04:42 | 67 | 64 | 19/10/20 09:29:34 | 73.8 |
| 65 | 16/10/20 12:30:56 | 67.2 | 65 | 16/10/20 16:04:47 | 69.5 | 65 | 19/10/20 09:29:39 | 74.5 |
| 66 | 16/10/20 12:31:01 | 68.9 | 66 | 16/10/20 16:04:52 | 70.8 | 66 | 19/10/20 09:29:44 | 63.3 |
| 67 | 16/10/20 12:31:06 | 60.6 | 67 | 16/10/20 16:04:57 | 78.5 | 67 | 19/10/20 09:29:49 | 68.2 |
| 68 | 16/10/20 12:31:11 | 66 | 68 | 16/10/20 16:05:02 | 68.7 | 68 | 19/10/20 09:29:54 | 43.8 |
| 69 | 16/10/20 12:31:16 | 58.7 | 69 | 16/10/20 16:05:07 | 67.4 | 69 | 19/10/20 09:29:59 | 43.8 |
| 70 | 16/10/20 12:31:21 | 64.3 | 70 | 16/10/20 16:05:12 | 61.8 | 70 | 19/10/20 09:30:04 | 80.9 |
| 71 | 16/10/20 12:31:26 | 73.4 | 71 | 16/10/20 16:05:17 | 60.8 | 71 | 19/10/20 09:30:09 | 69.9 |
| 72 | 16/10/20 12:31:31 | 65.4 | 72 | 16/10/20 16:05:22 | 58.6 | 72 | 19/10/20 09:30:14 | 71.1 |
| 73 | 16/10/20 12:31:36 | 68.8 | 73 | 16/10/20 16:05:27 | 59.1 | 73 | 19/10/20 09:30:19 | 61.8 |
| 74 | 16/10/20 12:31:41 | 67.8 | 74 | 16/10/20 16:05:32 | 58.9 | 74 | 19/10/20 09:30:24 | 73.1 |
| 75 | 16/10/20 12:31:46 | 76.5 | 75 | 16/10/20 16:05:37 | 60.2 | 75 | 19/10/20 09:30:29 | 45.9 |

# JFK ROUNDABOUT - SOUND RECORDINGS

*Data Record*

| OCTOBER 16, 2020 - MIDDAY | | | OCTOBER 16, 2020 - EVENING | | | OCTOBER 19, 2020 - MORNING | | |
|---|---|---|---|---|---|---|---|---|
| Record | Time | Noise(dB) | Record | Time | Noise(dB) | Record | Time | Noise(dB) |
| 76 | 16/10/20 12:31:51 | 74.9 | 76 | 16/10/20 16:05:42 | 61.8 | 76 | 19/10/20 09:30:34 | 45.9 |
| 77 | 16/10/20 12:31:56 | 72.2 | 77 | 16/10/20 16:05:47 | 65.3 | 77 | 19/10/20 09:30:39 | 59.7 |
| 78 | 16/10/20 12:32:01 | 78.7 | 78 | 16/10/20 16:05:52 | 64.4 | 78 | 19/10/20 09:30:44 | 95.4 |
| 79 | 16/10/20 12:32:06 | 69 | 79 | 16/10/20 16:05:57 | 62.2 | 79 | 19/10/20 09:30:49 | 75.6 |
| 80 | 16/10/20 12:32:11 | 67.5 | 80 | 16/10/20 16:06:02 | 65.1 | 80 | 19/10/20 09:30:54 | 72.9 |
| 81 | 16/10/20 12:32:16 | 62.5 | 81 | 16/10/20 16:06:07 | 64.9 | 81 | 19/10/20 09:30:59 | 68.5 |
| 82 | 16/10/20 12:32:21 | 67.4 | 82 | 16/10/20 16:06:12 | 66.3 | 82 | 19/10/20 09:31:04 | 75 |
| 83 | 16/10/20 12:32:26 | 63.9 | 83 | 16/10/20 16:06:17 | 63.4 | 83 | 19/10/20 09:31:09 | 67.2 |
| 84 | 16/10/20 12:32:31 | 75.7 | 84 | 16/10/20 16:06:22 | 67.1 | 84 | 19/10/20 09:31:14 | 77.1 |
| 85 | 16/10/20 12:32:36 | 82.2 | 85 | 16/10/20 16:06:27 | 62 | 85 | 19/10/20 09:31:19 | 55.5 |
| 86 | 16/10/20 12:32:41 | 79.8 | 86 | 16/10/20 16:06:32 | 64.6 | 86 | 19/10/20 09:31:24 | 35.9 |
| 87 | 16/10/20 12:32:46 | 66.3 | 87 | 16/10/20 16:06:37 | 69.8 | 87 | 19/10/20 09:31:29 | 74.4 |
| 88 | 16/10/20 12:32:51 | 66.6 | 88 | 16/10/20 16:06:42 | 71.1 | 88 | 19/10/20 09:31:34 | 31.6 |
| 89 | 16/10/20 12:32:56 | 65.6 | 89 | 16/10/20 16:06:47 | 75.8 | 89 | 19/10/20 09:31:39 | 52.9 |
| 90 | 16/10/20 12:33:01 | 67 | 90 | 16/10/20 16:06:52 | 81 | 90 | 19/10/20 09:31:44 | 51.2 |
| 91 | 16/10/20 12:33:06 | 61 | 91 | 16/10/20 16:06:57 | 82.6 | 91 | 19/10/20 09:31:49 | 69.5 |
| 92 | 16/10/20 12:33:11 | 64.5 | 92 | 16/10/20 16:07:02 | 72.9 | 92 | 19/10/20 09:31:54 | 66.5 |
| 93 | 16/10/20 12:33:16 | 76 | 93 | 16/10/20 16:07:07 | 67.4 | 93 | 19/10/20 09:31:59 | 70.6 |
| 94 | 16/10/20 12:33:21 | 73.1 | 94 | 16/10/20 16:07:12 | 66 | 94 | 19/10/20 09:32:04 | 75.4 |
| 95 | 16/10/20 12:33:26 | 64.1 | 95 | 16/10/20 16:07:17 | 81 | 95 | 19/10/20 09:32:09 | 73.1 |
| 96 | 16/10/20 12:33:31 | 68.2 | 96 | 16/10/20 16:07:22 | 61.9 | 96 | 19/10/20 09:32:14 | 69.8 |
| 97 | 16/10/20 12:33:36 | 67.3 | 97 | 16/10/20 16:07:27 | 69.9 | 97 | 19/10/20 09:32:19 | 65.3 |
| 98 | 16/10/20 12:33:41 | 66.9 | 98 | 16/10/20 16:07:32 | 64.8 | 98 | 19/10/20 09:32:24 | 79.5 |
| 99 | 16/10/20 12:33:46 | 61.6 | 99 | 16/10/20 16:07:37 | 64.3 | 99 | 19/10/20 09:32:29 | 70.8 |
| 100 | 16/10/20 12:33:51 | 68.5 | 100 | 16/10/20 16:07:42 | 63.6 | 100 | 19/10/20 09:32:34 | 82.7 |
| 101 | 16/10/20 12:33:56 | 66.5 | 101 | 16/10/20 16:07:47 | 63.3 | 101 | 19/10/20 09:32:39 | 68.3 |
| 102 | 16/10/20 12:34:01 | 79.7 | 102 | 16/10/20 16:07:52 | 69.6 | 102 | 19/10/20 09:32:44 | 36.9 |
| 103 | 16/10/20 12:34:06 | 66.2 | 103 | 16/10/20 16:07:57 | 67.5 | 103 | 19/10/20 09:32:49 | 37.2 |
| 104 | 16/10/20 12:34:11 | 67.3 | 104 | 16/10/20 16:08:02 | 62.6 | 104 | 19/10/20 09:32:54 | 35.5 |
| 105 | 16/10/20 12:34:16 | 69.1 | 105 | 16/10/20 16:08:07 | 57.7 | 105 | 19/10/20 09:32:59 | 62.8 |
| 106 | 16/10/20 12:34:21 | 66.9 | 106 | 16/10/20 16:08:12 | 61.5 | 106 | 19/10/20 09:33:04 | 77.6 |
| 107 | 16/10/20 12:34:26 | 67.1 | 107 | 16/10/20 16:08:17 | 67.4 | 107 | 19/10/20 09:33:09 | 63.8 |
| 108 | 16/10/20 12:34:31 | 72.2 | 108 | 16/10/20 16:08:22 | 58.4 | 108 | 19/10/20 09:33:14 | 62.4 |
| 109 | 16/10/20 12:34:36 | 79.8 | 109 | 16/10/20 16:08:27 | 61 | 109 | 19/10/20 09:33:19 | 78.5 |
| 110 | 16/10/20 12:34:41 | 62 | 110 | 16/10/20 16:08:32 | 63.4 | 110 | 19/10/20 09:33:24 | 46.7 |
| 111 | 16/10/20 12:34:46 | 69 | 111 | 16/10/20 16:08:37 | 65.8 | 111 | 19/10/20 09:33:29 | 35.9 |
| 112 | 16/10/20 12:34:51 | 60 | 112 | 16/10/20 16:08:42 | 69.9 | 112 | 19/10/20 09:33:34 | 66.7 |
| 113 | 16/10/20 12:34:56 | 62.1 | 113 | 16/10/20 16:08:47 | 61.8 | 113 | 19/10/20 09:33:39 | 63.2 |
| 114 | 16/10/20 12:35:01 | 79.3 | 114 | 16/10/20 16:08:52 | 63.9 | 114 | 19/10/20 09:33:44 | 31.6 |
| 115 | 16/10/20 12:35:06 | 60.8 | 115 | 16/10/20 16:08:57 | 61.7 | 115 | 19/10/20 09:33:49 | 66.7 |
| 116 | 16/10/20 12:35:11 | 68.8 | 116 | 16/10/20 16:09:02 | 62 | 116 | 19/10/20 09:33:54 | 79.6 |
| 117 | 16/10/20 12:35:16 | 64.3 | 117 | 16/10/20 16:09:07 | 61.7 | 117 | 19/10/20 09:33:59 | 72.4 |
| 118 | 16/10/20 12:35:21 | 61.6 | 118 | 16/10/20 16:09:12 | 58 | 118 | 19/10/20 09:34:04 | 70.9 |
| 119 | 16/10/20 12:35:26 | 69.5 | 119 | 16/10/20 16:09:17 | 58.4 | 119 | 19/10/20 09:34:09 | 64.6 |
| 120 | 16/10/20 12:35:31 | 79.9 | 120 | 16/10/20 16:09:22 | 65.8 | 120 | 19/10/20 09:34:14 | 70.7 |
| 121 | 16/10/20 12:35:36 | 77.9 | 121 | 16/10/20 16:09:27 | 60.7 | 121 | 19/10/20 09:34:19 | 48.5 |
| 122 | 16/10/20 12:35:41 | 66.9 | 122 | 16/10/20 16:09:32 | 61.8 | 122 | 19/10/20 09:34:24 | 64.8 |
| 123 | 16/10/20 12:35:46 | 66.1 | 123 | 16/10/20 16:09:37 | 62.2 | 123 | 19/10/20 09:34:29 | 68.6 |
| 124 | 16/10/20 12:35:51 | 69.1 | 124 | 16/10/20 16:09:42 | 62 | 124 | 19/10/20 09:34:34 | 60.1 |
| 125 | 16/10/20 12:35:56 | 59.2 | 125 | 16/10/20 16:09:47 | 62.8 | 125 | 19/10/20 09:34:39 | 49.4 |
| 126 | 16/10/20 12:36:01 | 67.8 | 126 | 16/10/20 16:09:52 | 64.2 | 126 | 19/10/20 09:34:44 | 61.7 |
| 127 | 16/10/20 12:36:06 | 64.4 | 127 | 16/10/20 16:09:57 | 63.9 | 127 | 19/10/20 09:34:49 | 83.1 |
| 128 | 16/10/20 12:36:11 | 66.2 | 128 | 16/10/20 16:10:02 | 66.6 | 128 | 19/10/20 09:34:54 | 60.4 |
| 129 | 16/10/20 12:36:16 | 62.2 | 129 | 16/10/20 16:10:07 | 64.1 | 129 | 19/10/20 09:34:59 | 85.3 |
| 130 | 16/10/20 12:36:21 | 79.3 | 130 | 16/10/20 16:10:12 | 65.2 | 130 | 19/10/20 09:35:04 | 69.6 |
| 131 | 16/10/20 12:36:26 | 64.5 | 131 | 16/10/20 16:10:17 | 65.5 | 131 | 19/10/20 09:35:09 | 87.9 |
| 132 | 16/10/20 12:36:31 | 68.5 | 132 | 16/10/20 16:10:22 | 62.6 | 132 | 19/10/20 09:35:14 | 76.9 |
| 133 | 16/10/20 12:36:36 | 68.3 | 133 | 16/10/20 16:10:27 | 64.2 | 133 | 19/10/20 09:35:19 | 66.4 |
| 134 | 16/10/20 12:36:41 | 64.1 | 134 | 16/10/20 16:10:32 | 61.8 | 134 | 19/10/20 09:35:24 | 70.4 |
| 135 | 16/10/20 12:36:46 | 66.2 | 135 | 16/10/20 16:10:37 | 65.8 | 135 | 19/10/20 09:35:29 | 71.5 |
| 136 | 16/10/20 12:36:51 | 68.1 | 136 | 16/10/20 16:10:42 | 60.6 | 136 | 19/10/20 09:35:34 | 69.6 |
| 137 | 16/10/20 12:36:56 | 59.9 | 137 | 16/10/20 16:10:47 | 62.3 | 137 | 19/10/20 09:35:39 | 62.2 |
| 138 | 16/10/20 12:37:01 | 60.5 | 138 | 16/10/20 16:10:52 | 58.7 | 138 | 19/10/20 09:35:44 | 60.6 |
| 139 | 16/10/20 12:37:06 | 60.4 | 139 | 16/10/20 16:10:57 | 60.5 | 139 | 19/10/20 09:35:49 | 43.2 |
| 140 | 16/10/20 12:37:11 | 64.4 | 140 | 16/10/20 16:11:02 | 65.4 | 140 | 19/10/20 09:35:54 | 69 |
| 141 | 16/10/20 12:37:16 | 68.2 | 141 | 16/10/20 16:11:07 | 62 | 141 | 19/10/20 09:35:59 | 49.6 |
| 142 | 16/10/20 12:37:21 | 77.8 | 142 | 16/10/20 16:11:12 | 64.1 | 142 | 19/10/20 09:36:04 | 49.6 |
| 143 | 16/10/20 12:37:26 | 68.2 | 143 | 16/10/20 16:11:17 | 62.1 | 143 | 19/10/20 09:36:09 | 49.6 |
| 144 | 16/10/20 12:37:31 | 61 | 144 | 16/10/20 16:11:22 | 61.1 | 144 | 19/10/20 09:36:14 | 66.7 |
| 145 | 16/10/20 12:37:36 | 69.5 | 145 | 16/10/20 16:11:27 | 66.3 | 145 | 19/10/20 09:36:19 | 69.9 |
| 146 | 16/10/20 12:37:41 | 58.5 | 146 | 16/10/20 16:11:32 | 62.5 | 146 | 19/10/20 09:36:24 | 62.4 |
| 147 | 16/10/20 12:37:46 | 79.2 | 147 | 16/10/20 16:11:37 | 64.7 | 147 | 19/10/20 09:36:29 | 50.6 |
| 148 | 16/10/20 12:37:51 | 64.1 | 148 | 16/10/20 16:11:42 | 62.3 | 148 | 19/10/20 09:36:34 | 50.6 |
| 149 | 16/10/20 12:37:56 | 67.8 | 149 | 16/10/20 16:11:47 | 66.2 | 149 | 19/10/20 09:36:39 | 80.3 |
| 150 | 16/10/20 12:38:01 | 67.2 | 150 | 16/10/20 16:11:52 | 67.5 | 150 | 19/10/20 09:36:44 | 35.8 |

# JFK ROUNDABOUT - SOUND RECORDINGS

*Data Record*

| OCTOBER 16, 2020 - MIDDAY | | | OCTOBER 16, 2020 - EVENING | | | OCTOBER 19, 2020 - MORNING | | |
|---|---|---|---|---|---|---|---|---|
| Record | Time | Noise(dB) | Record | Time | Noise(dB) | Record | Time | Noise(dB) |
| 151 | 16/10/20 12:38:06 | 61.3 | 151 | 16/10/20 16:11:57 | 66.9 | 151 | 19/10/20 09:36:49 | 40.6 |
| 152 | 16/10/20 12:38:11 | 69.6 | 152 | 16/10/20 16:12:02 | 66.5 | 152 | 19/10/20 09:36:54 | 54.6 |
| 153 | 16/10/20 12:38:16 | 65.2 | 153 | 16/10/20 16:12:07 | 61.9 | 153 | 19/10/20 09:36:59 | 64.2 |
| 154 | 16/10/20 12:38:21 | 61 | 154 | 16/10/20 16:12:12 | 60.3 | 154 | 19/10/20 09:37:04 | 73.8 |
| 155 | 16/10/20 12:38:26 | 54.8 | 155 | 16/10/20 16:12:17 | 60.5 | 155 | 19/10/20 09:37:09 | 66.5 |
| 156 | 16/10/20 12:38:31 | 53.4 | 156 | 16/10/20 16:12:22 | 61.3 | 156 | 19/10/20 09:37:14 | 59.7 |
| 157 | 16/10/20 12:38:36 | 57 | 157 | 16/10/20 16:12:27 | 61.9 | 157 | 19/10/20 09:37:19 | 35.7 |
| 158 | 16/10/20 12:38:41 | 69.2 | 158 | 16/10/20 16:12:32 | 61.7 | 158 | 19/10/20 09:37:24 | 34.1 |
| 159 | 16/10/20 12:38:46 | 71.8 | 159 | 16/10/20 16:12:37 | 63.7 | 159 | 19/10/20 09:37:29 | 34.6 |
| 160 | 16/10/20 12:38:51 | 71.2 | 160 | 16/10/20 16:12:42 | 59.1 | 160 | 19/10/20 09:37:34 | 31.6 |
| 161 | 16/10/20 12:38:56 | 63.1 | 161 | 16/10/20 16:12:47 | 62.3 | 161 | 19/10/20 09:37:39 | 75.4 |
| 162 | 16/10/20 12:39:01 | 63.6 | 162 | 16/10/20 16:12:52 | 70.3 | 162 | 19/10/20 09:37:44 | 70.2 |
| 163 | 16/10/20 12:39:06 | 68.6 | 163 | 16/10/20 16:12:57 | 64.3 | 163 | 19/10/20 09:37:49 | 75.1 |
| 164 | 16/10/20 12:39:11 | 62.9 | 164 | 16/10/20 16:13:02 | 58.1 | 164 | 19/10/20 09:37:54 | 69.3 |
| 165 | 16/10/20 12:39:16 | 68.2 | 165 | 16/10/20 16:13:07 | 58 | 165 | 19/10/20 09:37:59 | 77.3 |
| 166 | 16/10/20 12:39:21 | 71.5 | 166 | 16/10/20 16:13:12 | 59.2 | 166 | 19/10/20 09:38:04 | 45.4 |
| 167 | 16/10/20 12:39:26 | 64.2 | 167 | 16/10/20 16:13:17 | 63.3 | 167 | 19/10/20 09:38:09 | 47.1 |
| 168 | 16/10/20 12:39:31 | 65.1 | 168 | 16/10/20 16:13:22 | 60.4 | 168 | 19/10/20 09:38:14 | 79.6 |
| 169 | 16/10/20 12:39:36 | 65.9 | 169 | 16/10/20 16:13:27 | 58.5 | 169 | 19/10/20 09:38:19 | 59.8 |
| 170 | 16/10/20 12:39:41 | 79.2 | 170 | 16/10/20 16:13:32 | 58.5 | 170 | 19/10/20 09:38:24 | 66.3 |
| 171 | 16/10/20 12:39:46 | 64.1 | 171 | 16/10/20 16:13:37 | 60.2 | 171 | 19/10/20 09:38:29 | 57.1 |
| 172 | 16/10/20 12:39:51 | 67.7 | 172 | 16/10/20 16:13:42 | 59.9 | 172 | 19/10/20 09:38:34 | 67 |
| 173 | 16/10/20 12:39:56 | 68.7 | 173 | 16/10/20 16:13:47 | 61.1 | 173 | 19/10/20 09:38:39 | 71.7 |
| 174 | 16/10/20 12:40:01 | 69.5 | 174 | 16/10/20 16:13:52 | 64.4 | 174 | 19/10/20 09:38:44 | 50.6 |
| 175 | 16/10/20 12:40:06 | 65.5 | 175 | 16/10/20 16:13:57 | 67 | 175 | 19/10/20 09:38:49 | 50.6 |
| 176 | 16/10/20 12:40:11 | 65.8 | 176 | 16/10/20 16:14:02 | 62.1 | 176 | 19/10/20 09:38:54 | 50.6 |
| 177 | 16/10/20 12:40:16 | 66.3 | 177 | 16/10/20 16:14:07 | 63.7 | 177 | 19/10/20 09:38:59 | 64.4 |
| 178 | 16/10/20 12:40:21 | 67.8 | 178 | 16/10/20 16:14:12 | 66.8 | 178 | 19/10/20 09:39:04 | 71.4 |
| 179 | 16/10/20 12:40:26 | 84.1 | 179 | 16/10/20 16:14:17 | 72.3 | 179 | 19/10/20 09:39:09 | 61.3 |
| 180 | 16/10/20 12:40:31 | 63.5 | 180 | 16/10/20 16:14:22 | 68.6 | 180 | 19/10/20 09:39:14 | 64.6 |
| 181 | 16/10/20 12:40:36 | 63.6 | 181 | 16/10/20 16:14:27 | 65.2 | 181 | 19/10/20 09:39:19 | 63.1 |
| 182 | 16/10/20 12:40:41 | 63.9 | 182 | 16/10/20 16:14:32 | 62.8 | 182 | 19/10/20 09:39:24 | 70.7 |
| 183 | 16/10/20 12:40:46 | 63.9 | 183 | 16/10/20 16:14:37 | 63.2 | 183 | 19/10/20 09:39:29 | 69.6 |
| 184 | 16/10/20 12:40:51 | 69 | 184 | 16/10/20 16:14:42 | 61.5 | 184 | 19/10/20 09:39:34 | 51.5 |
| 185 | 16/10/20 12:40:56 | 71.8 | 185 | 16/10/20 16:14:47 | 66.1 | 185 | 19/10/20 09:39:39 | 70.4 |
| 186 | 16/10/20 12:41:01 | 65.2 | 186 | 16/10/20 16:14:52 | 62.2 | 186 | 19/10/20 09:39:44 | 50.9 |
| 187 | 16/10/20 12:41:06 | 62.3 | 187 | 16/10/20 16:14:57 | 65.4 | 187 | 19/10/20 09:39:49 | 49 |
| 188 | 16/10/20 12:41:11 | 62.8 | 188 | 16/10/20 16:15:02 | 62.3 | 188 | 19/10/20 09:39:54 | 55.9 |
| 189 | 16/10/20 12:41:16 | 64.5 | 189 | 16/10/20 16:15:07 | 63.7 | 189 | 19/10/20 09:39:59 | 63.3 |
| 190 | 16/10/20 12:41:21 | 62.7 | 190 | 16/10/20 16:15:12 | 65.9 | 190 | 19/10/20 09:40:04 | 65.4 |
| 191 | 16/10/20 12:41:26 | 64.1 | 191 | 16/10/20 16:15:17 | 77.8 | 191 | 19/10/20 09:40:09 | 77.3 |
| 192 | 16/10/20 12:41:31 | 63.9 | 192 | 16/10/20 16:15:22 | 68.2 | 192 | 19/10/20 09:40:14 | 61.3 |
| 193 | 16/10/20 12:41:36 | 81.5 | 193 | 16/10/20 16:15:27 | 65.3 | 193 | 19/10/20 09:40:19 | 73.9 |
| 194 | 16/10/20 12:41:41 | 64.6 | 194 | 16/10/20 16:15:32 | 66.2 | 194 | 19/10/20 09:40:24 | 63.9 |
| 195 | 16/10/20 12:41:46 | 66 | 195 | 16/10/20 16:15:37 | 64.9 | 195 | 19/10/20 09:40:29 | 73.8 |
| 196 | 16/10/20 12:41:51 | 66.4 | 196 | 16/10/20 16:15:42 | 63.6 | 196 | 19/10/20 09:40:34 | 64.9 |
| 197 | 16/10/20 12:41:56 | 63.5 | 197 | 16/10/20 16:15:47 | 64.5 | 197 | 19/10/20 09:40:39 | 66 |
| 198 | 16/10/20 12:42:01 | 63 | 198 | 16/10/20 16:15:52 | 65.6 | 198 | 19/10/20 09:40:44 | 77.9 |
| 199 | 16/10/20 12:42:06 | 62.4 | 199 | 16/10/20 16:15:57 | 63.9 | 199 | 19/10/20 09:40:49 | 56.5 |
| 200 | 16/10/20 12:42:11 | 61.2 | 200 | 16/10/20 16:16:02 | 69.9 | 200 | 19/10/20 09:40:54 | 58.1 |

| | | | |
|---|---|---|---|
| **MAXIMUM READING** | **95.4** | **at** | **October 19, 2020 at 9:30:44 am** |
| **MINIMUM READING** | **31.6** | **at** | **October 19, 2020 at 9:31:39 am** |
| **AVERAGE** | **65.6** | | |

***Paramaters***

| Record Parameters | Content |
|---|---|
| Address | 1 |
| Serial Number | 202016991 |
| Test Name | RECORD TEST2 |
| Setting Time | 16/10/2020 12:25:31 |
| Total Records | 200 |
| Record Interval | 5 sec |
| Immediately/Manual | Manual |
| Noise Alarm | L:30 H:130 dB |
| Sample Level | FAST |
| Noise Level | A |
| Start Time | 16/10/2020 12:25:36 |
| Test Records | 200 |
| Is Noise Alarm | |

| Record Parameters | Content |
|---|---|
| Address | 1 |
| Serial Number | 202016991 |
| Test Name | RECORD TEST2 |
| Setting Time | 16/10/2020 15:58:49 |
| Total Records | 200 |
| Record Interval | 5 sec |
| Immediately/Manual | Manual |
| Noise Alarm | L:30 H:130 dB |
| Sample Level | FAST |
| Noise Level | A |
| Start Time | 16/10/2020 15:59:27 |
| Test Records | 200 |
| Is Noise Alarm | |

| Record Parameters | Content |
|---|---|
| Address | 1 |
| Serial Number | 202016991 |
| Test Name | RECORD TEST2 |
| Setting Time | 19/10/2020 09:24:08 |
| Total Records | 200 |
| Record Interval | 5 sec |
| Immediately/Manual | Manual |
| Noise Alarm | L:30 H:130 dB |
| Sample Level | FAST |
| Noise Level | A |
| Start Time | 19/10/2020 09:24:19 |
| Test Records | 200 |
| Is Noise Alarm | |

# HALL CLOSE - SOUND RECORDINGS

*Data Record*

| OCTOBER 16, 2020 - MIDDAY | | |
|---|---|---|
| Record | Time | Noise(dB) |
| 1 | 16/10/20 13:25:31 | 81 |
| 2 | 16/10/20 13:25:36 | 60.1 |
| 3 | 16/10/20 13:25:41 | 68.8 |
| 4 | 16/10/20 13:25:46 | 67.9 |
| 5 | 16/10/20 13:25:51 | 64.4 |
| 6 | 16/10/20 13:25:56 | 67 |
| 7 | 16/10/20 13:26:01 | 69.3 |
| 8 | 16/10/20 13:26:06 | 69.9 |
| 9 | 16/10/20 13:26:11 | 69.8 |
| 10 | 16/10/20 13:26:16 | 61.7 |
| 11 | 16/10/20 13:26:21 | 63.7 |
| 12 | 16/10/20 13:26:26 | 59.7 |
| 13 | 16/10/20 13:26:31 | 61.6 |
| 14 | 16/10/20 13:26:36 | 61.7 |
| 15 | 16/10/20 13:26:41 | 66.7 |
| 16 | 16/10/20 13:26:46 | 57.4 |
| 17 | 16/10/20 13:26:51 | 68.3 |
| 18 | 16/10/20 13:26:56 | 63 |
| 19 | 16/10/20 13:27:01 | 70.1 |
| 20 | 16/10/20 13:27:06 | 65.4 |
| 21 | 16/10/20 13:27:11 | 74.6 |
| 22 | 16/10/20 13:27:16 | 59.7 |
| 23 | 16/10/20 13:27:21 | 68.8 |
| 24 | 16/10/20 13:27:26 | 75 |
| 25 | 16/10/20 13:27:31 | 63 |
| 26 | 16/10/20 13:27:36 | 68.3 |
| 27 | 16/10/20 13:27:41 | 68 |
| 28 | 16/10/20 13:27:46 | 82.6 |
| 29 | 16/10/20 13:27:51 | 64 |
| 30 | 16/10/20 13:27:56 | 67.8 |
| 31 | 16/10/20 13:28:01 | 68.4 |
| 32 | 16/10/20 13:28:06 | 58.3 |
| 33 | 16/10/20 13:28:11 | 65.3 |
| 34 | 16/10/20 13:28:16 | 66 |
| 35 | 16/10/20 13:28:21 | 68.7 |
| 36 | 16/10/20 13:28:26 | 66.2 |
| 37 | 16/10/20 13:28:31 | 57.7 |
| 38 | 16/10/20 13:28:36 | 61.2 |
| 39 | 16/10/20 13:28:41 | 62.5 |
| 40 | 16/10/20 13:28:46 | 72.5 |
| 41 | 16/10/20 13:28:51 | 69.4 |
| 42 | 16/10/20 13:28:56 | 69.1 |
| 43 | 16/10/20 13:29:01 | 79.1 |
| 44 | 16/10/20 13:29:06 | 76.8 |
| 45 | 16/10/20 13:29:11 | 72.9 |
| 46 | 16/10/20 13:29:16 | 69.3 |
| 47 | 16/10/20 13:29:21 | 80.7 |
| 48 | 16/10/20 13:29:26 | 64.1 |
| 49 | 16/10/20 13:29:31 | 69.9 |
| 50 | 16/10/20 13:29:36 | 68.8 |
| 51 | 16/10/20 13:29:41 | 67.9 |
| 52 | 16/10/20 13:29:46 | 63.9 |
| 53 | 16/10/20 13:29:51 | 66.7 |
| 54 | 16/10/20 13:29:56 | 69.8 |
| 55 | 16/10/20 13:30:01 | 81.2 |
| 56 | 16/10/20 13:30:06 | 71.6 |
| 57 | 16/10/20 13:30:11 | 63.2 |
| 58 | 16/10/20 13:30:16 | 76.1 |
| 59 | 16/10/20 13:30:21 | 68.8 |
| 60 | 16/10/20 13:30:26 | 68.2 |
| 61 | 16/10/20 13:30:31 | 66.5 |
| 62 | 16/10/20 13:30:36 | 66.3 |
| 63 | 16/10/20 13:30:41 | 90.2 |
| 64 | 16/10/20 13:30:46 | 75.3 |
| 65 | 16/10/20 13:30:51 | 69.1 |
| 66 | 16/10/20 13:30:56 | 64.5 |
| 67 | 16/10/20 13:31:01 | 69.4 |
| 68 | 16/10/20 13:31:06 | 65.7 |
| 69 | 16/10/20 13:31:11 | 56.5 |
| 70 | 16/10/20 13:31:16 | 73.1 |
| 71 | 16/10/20 13:31:21 | 59.3 |
| 72 | 16/10/20 13:31:26 | 64.5 |
| 73 | 16/10/20 13:31:31 | 69.8 |
| 74 | 16/10/20 13:31:36 | 63.8 |
| 75 | 16/10/20 13:31:41 | 66.2 |
| 76 | 16/10/20 13:31:46 | 60.3 |
| 77 | 16/10/20 13:31:51 | 69.6 |
| 78 | 16/10/20 13:31:56 | 68.1 |
| 79 | 16/10/20 13:32:01 | 67.5 |
| 80 | 16/10/20 13:32:06 | 63.1 |
| 81 | 16/10/20 13:32:11 | 70.6 |
| 82 | 16/10/20 13:32:16 | 66.3 |
| 83 | 16/10/20 13:32:21 | 46.6 |

| OCTOBER 16, 2020 - EVENING | | |
|---|---|---|
| Record | Time | Noise(dB) |
| 1 | 16/10/20 17:03:25 | 59 |
| 2 | 16/10/20 17:03:30 | 57.3 |
| 3 | 16/10/20 17:03:35 | 58.6 |
| 4 | 16/10/20 17:03:40 | 59.8 |
| 5 | 16/10/20 17:03:45 | 57.6 |
| 6 | 16/10/20 17:03:50 | 55.7 |
| 7 | 16/10/20 17:03:55 | 57.6 |
| 8 | 16/10/20 17:04:00 | 54 |
| 9 | 16/10/20 17:04:05 | 62.3 |
| 10 | 16/10/20 17:04:10 | 57.7 |
| 11 | 16/10/20 17:04:15 | 58.2 |
| 12 | 16/10/20 17:04:20 | 54.2 |
| 13 | 16/10/20 17:04:25 | 59.8 |
| 14 | 16/10/20 17:04:30 | 58.8 |
| 15 | 16/10/20 17:04:35 | 54.6 |
| 16 | 16/10/20 17:04:40 | 63.1 |
| 17 | 16/10/20 17:04:45 | 57.7 |
| 18 | 16/10/20 17:04:50 | 59.2 |
| 19 | 16/10/20 17:04:55 | 60.5 |
| 20 | 16/10/20 17:05:00 | 65.6 |
| 21 | 16/10/20 17:05:05 | 62.9 |
| 22 | 16/10/20 17:05:10 | 60.7 |
| 23 | 16/10/20 17:05:15 | 53.4 |
| 24 | 16/10/20 17:05:20 | 56.1 |
| 25 | 16/10/20 17:05:25 | 57.4 |
| 26 | 16/10/20 17:05:30 | 62.9 |
| 27 | 16/10/20 17:05:35 | 61.2 |
| 28 | 16/10/20 17:05:40 | 57.1 |
| 29 | 16/10/20 17:05:45 | 69.5 |
| 30 | 16/10/20 17:05:50 | 70.3 |
| 31 | 16/10/20 17:05:55 | 66.6 |
| 32 | 16/10/20 17:06:00 | 68.1 |
| 33 | 16/10/20 17:06:05 | 75 |
| 34 | 16/10/20 17:06:10 | 57.6 |
| 35 | 16/10/20 17:06:15 | 59.7 |
| 36 | 16/10/20 17:06:20 | 61.1 |
| 37 | 16/10/20 17:06:25 | 62.4 |
| 38 | 16/10/20 17:06:30 | 67.9 |
| 39 | 16/10/20 17:06:35 | 69.3 |
| 40 | 16/10/20 17:06:40 | 69.3 |
| 41 | 16/10/20 17:06:45 | 63.1 |
| 42 | 16/10/20 17:06:50 | 69.3 |
| 43 | 16/10/20 17:06:55 | 61.8 |
| 44 | 16/10/20 17:07:00 | 62.4 |
| 45 | 16/10/20 17:07:05 | 69.1 |
| 46 | 16/10/20 17:07:10 | 66.3 |
| 47 | 16/10/20 17:07:15 | 63.6 |
| 48 | 16/10/20 17:07:20 | 60.3 |
| 49 | 16/10/20 17:07:25 | 62 |
| 50 | 16/10/20 17:07:30 | 61.5 |
| 51 | 16/10/20 17:07:35 | 62.6 |
| 52 | 16/10/20 17:07:40 | 60.1 |
| 53 | 16/10/20 17:07:45 | 61.3 |
| 54 | 16/10/20 17:07:50 | 60 |
| 55 | 16/10/20 17:07:55 | 58 |
| 56 | 16/10/20 17:08:00 | 67 |
| 57 | 16/10/20 17:08:05 | 64 |
| 58 | 16/10/20 17:08:10 | 64.7 |
| 59 | 16/10/20 17:08:15 | 59.6 |
| 60 | 16/10/20 17:08:20 | 60.8 |
| 61 | 16/10/20 17:08:25 | 69 |
| 62 | 16/10/20 17:08:30 | 64.7 |
| 63 | 16/10/20 17:08:35 | 59.8 |
| 64 | 16/10/20 17:08:40 | 55.9 |
| 65 | 16/10/20 17:08:45 | 61.5 |
| 66 | 16/10/20 17:08:50 | 57.1 |
| 67 | 16/10/20 17:08:55 | 55.1 |
| 68 | 16/10/20 17:09:00 | 56.2 |
| 69 | 16/10/20 17:09:05 | 55.3 |
| 70 | 16/10/20 17:09:10 | 57 |
| 71 | 16/10/20 17:09:15 | 53.4 |
| 72 | 16/10/20 17:09:20 | 59 |
| 73 | 16/10/20 17:09:25 | 67.1 |
| 74 | 16/10/20 17:09:30 | 56.3 |
| 75 | 16/10/20 17:09:35 | 66.7 |
| 76 | 16/10/20 17:09:40 | 63.7 |
| 77 | 16/10/20 17:09:45 | 57.5 |
| 78 | 16/10/20 17:09:50 | 55.2 |
| 79 | 16/10/20 17:09:55 | 57.6 |
| 80 | 16/10/20 17:10:00 | 65.8 |
| 81 | 16/10/20 17:10:05 | 62.6 |
| 82 | 16/10/20 17:10:10 | 67.2 |
| 83 | 16/10/20 17:10:15 | 62.5 |

| OCTOBER 19, 2020 - MORNING | | |
|---|---|---|
| Record | Time | Noise(dB) |
| 1 | 19/10/20 10:15:29 | 45.6 |
| 2 | 19/10/20 10:15:34 | 59 |
| 3 | 19/10/20 10:15:39 | 70.7 |
| 4 | 19/10/20 10:15:44 | 35.5 |
| 5 | 19/10/20 10:15:49 | 55.3 |
| 6 | 19/10/20 10:15:54 | 58.7 |
| 7 | 19/10/20 10:15:59 | 71 |
| 8 | 19/10/20 10:16:04 | 57.9 |
| 9 | 19/10/20 10:16:09 | 63 |
| 10 | 19/10/20 10:16:14 | 55.4 |
| 11 | 19/10/20 10:16:19 | 63.1 |
| 12 | 19/10/20 10:16:24 | 58.9 |
| 13 | 19/10/20 10:16:29 | 52.8 |
| 14 | 19/10/20 10:16:34 | 70.5 |
| 15 | 19/10/20 10:16:39 | 67.8 |
| 16 | 19/10/20 10:16:44 | 62.2 |
| 17 | 19/10/20 10:16:49 | 62.1 |
| 18 | 19/10/20 10:16:54 | 77.2 |
| 19 | 19/10/20 10:16:59 | 60.3 |
| 20 | 19/10/20 10:17:04 | 65.2 |
| 21 | 19/10/20 10:17:09 | 78.2 |
| 22 | 19/10/20 10:17:14 | 73.5 |
| 23 | 19/10/20 10:17:19 | 52.1 |
| 24 | 19/10/20 10:17:24 | 67.8 |
| 25 | 19/10/20 10:17:29 | 59.3 |
| 26 | 19/10/20 10:17:34 | 68.4 |
| 27 | 19/10/20 10:17:39 | 52.3 |
| 28 | 19/10/20 10:17:44 | 52.3 |
| 29 | 19/10/20 10:17:49 | 60.5 |
| 30 | 19/10/20 10:17:54 | 66.3 |
| 31 | 19/10/20 10:17:59 | 46 |
| 32 | 19/10/20 10:18:04 | 79.4 |
| 33 | 19/10/20 10:18:09 | 88.6 |
| 34 | 19/10/20 10:18:14 | 71 |
| 35 | 19/10/20 10:18:19 | 71.2 |
| 36 | 19/10/20 10:18:24 | 60.1 |
| 37 | 19/10/20 10:18:29 | 64.9 |
| 38 | 19/10/20 10:18:34 | 80 |
| 39 | 19/10/20 10:18:39 | 67.6 |
| 40 | 19/10/20 10:18:44 | 61.2 |
| 41 | 19/10/20 10:18:49 | 57.1 |
| 42 | 19/10/20 10:18:54 | 72 |
| 43 | 19/10/20 10:18:59 | 72.3 |
| 44 | 19/10/20 10:19:04 | 37.2 |
| 45 | 19/10/20 10:19:09 | 71.2 |
| 46 | 19/10/20 10:19:14 | 62.3 |
| 47 | 19/10/20 10:19:19 | 62.3 |
| 48 | 19/10/20 10:19:24 | 62.3 |
| 49 | 19/10/20 10:19:29 | 66.5 |
| 50 | 19/10/20 10:19:34 | 39.1 |
| 51 | 19/10/20 10:19:39 | 61.2 |
| 52 | 19/10/20 10:19:44 | 75.7 |
| 53 | 19/10/20 10:19:49 | 70.8 |
| 54 | 19/10/20 10:19:54 | 65.6 |
| 55 | 19/10/20 10:19:59 | 58.3 |
| 56 | 19/10/20 10:20:04 | 75 |
| 57 | 19/10/20 10:20:09 | 38.9 |
| 58 | 19/10/20 10:20:14 | 38.9 |
| 59 | 19/10/20 10:20:19 | 38.9 |
| 60 | 19/10/20 10:20:24 | 38.9 |
| 61 | 19/10/20 10:20:29 | 38.9 |
| 62 | 19/10/20 10:20:34 | 49.4 |
| 63 | 19/10/20 10:20:39 | 49.4 |
| 64 | 19/10/20 10:20:44 | 73.8 |
| 65 | 19/10/20 10:20:49 | 65.1 |
| 66 | 19/10/20 10:20:54 | 69.3 |
| 67 | 19/10/20 10:20:59 | 61.9 |
| 68 | 19/10/20 10:21:04 | 41.2 |
| 69 | 19/10/20 10:21:09 | 72 |
| 70 | 19/10/20 10:21:14 | 54.2 |
| 71 | 19/10/20 10:21:19 | 77 |
| 72 | 19/10/20 10:21:24 | 59.5 |
| 73 | 19/10/20 10:21:29 | 70.8 |
| 74 | 19/10/20 10:21:34 | 70.8 |
| 75 | 19/10/20 10:21:39 | 80.4 |
| 76 | 19/10/20 10:21:44 | 51.6 |
| 77 | 19/10/20 10:21:49 | 44.6 |
| 78 | 19/10/20 10:21:54 | 43.7 |
| 79 | 19/10/20 10:21:59 | 43.7 |
| 80 | 19/10/20 10:22:04 | 63.8 |
| 81 | 19/10/20 10:22:09 | 67.8 |
| 82 | 19/10/20 10:22:14 | 53.6 |
| 83 | 19/10/20 10:22:19 | 75 |

# HALL CLOSE - SOUND RECORDINGS

*Data Record*

| OCTOBER 16, 2020 - MIDDAY | | | OCTOBER 16, 2020 - EVENING | | | OCTOBER 19, 2020 - MORNING | | |
|---|---|---|---|---|---|---|---|---|
| Record | Time | Noise(dB) | Record | Time | Noise(dB) | Record | Time | Noise(dB) |
| 84 | 16/10/20 13:32:26 | 47.5 | 84 | 16/10/20 17:10:20 | 63.8 | 84 | 19/10/20 10:22:24 | 67.9 |
| 85 | 16/10/20 13:32:31 | 66.8 | 85 | 16/10/20 17:10:25 | 57.8 | 85 | 19/10/20 10:22:29 | 50.9 |
| 86 | 16/10/20 13:32:36 | 66.8 | 86 | 16/10/20 17:10:30 | 61.5 | 86 | 19/10/20 10:22:34 | 41.4 |
| 87 | 16/10/20 13:32:41 | 64.7 | 87 | 16/10/20 17:10:35 | 62.3 | 87 | 19/10/20 10:22:39 | 41.4 |
| 88 | 16/10/20 13:32:46 | 67.6 | 88 | 16/10/20 17:10:40 | 63.7 | 88 | 19/10/20 10:22:44 | 63.9 |
| 89 | 16/10/20 13:32:51 | 72.4 | 89 | 16/10/20 17:10:45 | 66.3 | 89 | 19/10/20 10:22:49 | 45.4 |
| 90 | 16/10/20 13:32:56 | 51.9 | 90 | 16/10/20 17:10:50 | 64.6 | 90 | 19/10/20 10:22:54 | 45.4 |
| 91 | 16/10/20 13:33:01 | 67 | 91 | 16/10/20 17:10:55 | 62.8 | 91 | 19/10/20 10:22:59 | 45.4 |
| 92 | 16/10/20 13:33:06 | 85.9 | 92 | 16/10/20 17:11:00 | 64.1 | 92 | 19/10/20 10:23:04 | 61.9 |
| 93 | 16/10/20 13:33:11 | 62.6 | 93 | 16/10/20 17:11:05 | 60.2 | 93 | 19/10/20 10:23:09 | 45.2 |
| 94 | 16/10/20 13:33:16 | 62 | 94 | 16/10/20 17:11:10 | 63.3 | 94 | 19/10/20 10:23:14 | 72.1 |
| 95 | 16/10/20 13:33:21 | 71.9 | 95 | 16/10/20 17:11:15 | 65.1 | 95 | 19/10/20 10:23:19 | 49.9 |
| 96 | 16/10/20 13:33:26 | 69.8 | 96 | 16/10/20 17:11:20 | 60.9 | 96 | 19/10/20 10:23:24 | 60.3 |
| 97 | 16/10/20 13:33:31 | 62.7 | 97 | 16/10/20 17:11:25 | 58.9 | 97 | 19/10/20 10:23:29 | 48.7 |
| 98 | 16/10/20 13:33:36 | 63.8 | 98 | 16/10/20 17:11:30 | 57.6 | 98 | 19/10/20 10:23:34 | 72.7 |
| 99 | 16/10/20 13:33:41 | 67.6 | 99 | 16/10/20 17:11:35 | 62.2 | 99 | 19/10/20 10:23:39 | 69.3 |
| 100 | 16/10/20 13:33:46 | 73 | 100 | 16/10/20 17:11:40 | 61.4 | 100 | 19/10/20 10:23:44 | 72.3 |
| 101 | 16/10/20 13:33:51 | 71.8 | 101 | 16/10/20 17:11:45 | 57.9 | 101 | 19/10/20 10:23:49 | 67.7 |
| 102 | 16/10/20 13:33:56 | 67.8 | 102 | 16/10/20 17:11:50 | 57.9 | 102 | 19/10/20 10:23:54 | 66.5 |
| 103 | 16/10/20 13:34:01 | 68.5 | 103 | 16/10/20 17:11:55 | 64 | 103 | 19/10/20 10:23:59 | 50.2 |
| 104 | 16/10/20 13:34:06 | 63 | 104 | 16/10/20 17:12:00 | 60.5 | 104 | 19/10/20 10:24:04 | 63.4 |
| 105 | 16/10/20 13:34:11 | 61 | 105 | 16/10/20 17:12:05 | 62.3 | 105 | 19/10/20 10:24:09 | 88.2 |
| 106 | 16/10/20 13:34:16 | 69.6 | 106 | 16/10/20 17:12:10 | 58.9 | 106 | 19/10/20 10:24:14 | 52.1 |
| 107 | 16/10/20 13:34:21 | 68.4 | 107 | 16/10/20 17:12:15 | 56.6 | 107 | 19/10/20 10:24:19 | 52.1 |
| 108 | 16/10/20 13:34:26 | 58.7 | 108 | 16/10/20 17:12:20 | 53.9 | 108 | 19/10/20 10:24:24 | 52.1 |
| 109 | 16/10/20 13:34:31 | 57.6 | 109 | 16/10/20 17:12:25 | 63.1 | 109 | 19/10/20 10:24:29 | 69 |
| 110 | 16/10/20 13:34:36 | 66.4 | 110 | 16/10/20 17:12:30 | 56.3 | 110 | 19/10/20 10:24:34 | 41.8 |
| 111 | 16/10/20 13:34:41 | 52.2 | 111 | 16/10/20 17:12:35 | 53.9 | 111 | 19/10/20 10:24:39 | 64.9 |
| 112 | 16/10/20 13:34:46 | 54.3 | 112 | 16/10/20 17:12:40 | 54.5 | 112 | 19/10/20 10:24:44 | 76.9 |
| 113 | 16/10/20 13:34:51 | 69.4 | 113 | 16/10/20 17:12:45 | 52.5 | 113 | 19/10/20 10:24:49 | 44.4 |
| 114 | 16/10/20 13:34:56 | 65.9 | 114 | 16/10/20 17:12:50 | 53.9 | 114 | 19/10/20 10:24:54 | 57.6 |
| 115 | 16/10/20 13:35:01 | 66 | 115 | 16/10/20 17:12:55 | 58.7 | 115 | 19/10/20 10:24:59 | 59.4 |
| 116 | 16/10/20 13:35:06 | 62.4 | 116 | 16/10/20 17:13:00 | 61.7 | 116 | 19/10/20 10:25:04 | 61.5 |
| 117 | 16/10/20 13:35:11 | 62.8 | 117 | 16/10/20 17:13:05 | 54.2 | 117 | 19/10/20 10:25:09 | 54.3 |
| 118 | 16/10/20 13:35:16 | 65.4 | 118 | 16/10/20 17:13:10 | 62.6 | 118 | 19/10/20 10:25:14 | 63.5 |
| 119 | 16/10/20 13:35:21 | 60 | 119 | 16/10/20 17:13:15 | 51.9 | 119 | 19/10/20 10:25:19 | 38.7 |
| 120 | 16/10/20 13:35:26 | 58.9 | 120 | 16/10/20 17:13:20 | 53.5 | 120 | 19/10/20 10:25:24 | 81.8 |
| 121 | 16/10/20 13:35:31 | 67.8 | 121 | 16/10/20 17:13:25 | 55.8 | 121 | 19/10/20 10:25:29 | 62 |
| 122 | 16/10/20 13:35:36 | 73.3 | 122 | 16/10/20 17:13:30 | 52.6 | 122 | 19/10/20 10:25:34 | 71.9 |
| 123 | 16/10/20 13:35:41 | 65.9 | 123 | 16/10/20 17:13:35 | 60.9 | 123 | 19/10/20 10:25:39 | 45.9 |
| 124 | 16/10/20 13:35:46 | 63.5 | 124 | 16/10/20 17:13:40 | 54.3 | 124 | 19/10/20 10:25:44 | 57.3 |
| 125 | 16/10/20 13:35:51 | 73.9 | 125 | 16/10/20 17:13:45 | 53.9 | 125 | 19/10/20 10:25:49 | 66.7 |
| 126 | 16/10/20 13:35:56 | 74 | 126 | 16/10/20 17:13:50 | 54.8 | 126 | 19/10/20 10:25:54 | 74.8 |
| 127 | 16/10/20 13:36:01 | 66.2 | 127 | 16/10/20 17:13:55 | 57.9 | 127 | 19/10/20 10:25:59 | 72.2 |
| 128 | 16/10/20 13:36:06 | 71.9 | 128 | 16/10/20 17:14:00 | 65 | 128 | 19/10/20 10:26:04 | 71.9 |
| 129 | 16/10/20 13:36:11 | 73.7 | 129 | 16/10/20 17:14:05 | 65.5 | 129 | 19/10/20 10:26:09 | 63.6 |
| 130 | 16/10/20 13:36:16 | 69.4 | 130 | 16/10/20 17:14:10 | 63.9 | 130 | 19/10/20 10:26:14 | 35.5 |
| 131 | 16/10/20 13:36:21 | 53.9 | 131 | 16/10/20 17:14:15 | 57.7 | 131 | 19/10/20 10:26:19 | 76.3 |
| 132 | 16/10/20 13:36:26 | 69.6 | 132 | 16/10/20 17:14:20 | 64.2 | 132 | 19/10/20 10:26:24 | 34.3 |
| 133 | 16/10/20 13:36:31 | 81.4 | 133 | 16/10/20 17:14:25 | 62.4 | 133 | 19/10/20 10:26:29 | 51.7 |
| 134 | 16/10/20 13:36:36 | 69.1 | 134 | 16/10/20 17:14:30 | 62.3 | 134 | 19/10/20 10:26:34 | 61.2 |
| 135 | 16/10/20 13:36:41 | 69 | 135 | 16/10/20 17:14:35 | 61.9 | 135 | 19/10/20 10:26:39 | 50.6 |
| 136 | 16/10/20 13:36:46 | 67 | 136 | 16/10/20 17:14:40 | 67.5 | 136 | 19/10/20 10:26:44 | 50.6 |
| 137 | 16/10/20 13:36:51 | 70.5 | 137 | 16/10/20 17:14:45 | 50.9 | 137 | 19/10/20 10:26:49 | 68.4 |
| 138 | 16/10/20 13:36:56 | 66.7 | 138 | 16/10/20 17:14:50 | 56.3 | 138 | 19/10/20 10:26:54 | 68.6 |
| 139 | 16/10/20 13:37:01 | 67.3 | 139 | 16/10/20 17:14:55 | 60.2 | 139 | 19/10/20 10:26:59 | 36.9 |
| 140 | 16/10/20 13:37:06 | 55.1 | 140 | 16/10/20 17:15:00 | 62.7 | 140 | 19/10/20 10:27:04 | 36.4 |
| 141 | 16/10/20 13:37:11 | 66.8 | 141 | 16/10/20 17:15:05 | 61.4 | 141 | 19/10/20 10:27:09 | 31.6 |
| 142 | 16/10/20 13:37:16 | 69.8 | 142 | 16/10/20 17:15:10 | 53.9 | 142 | 19/10/20 10:27:14 | 68.1 |
| 143 | 16/10/20 13:37:21 | 69.1 | 143 | 16/10/20 17:15:15 | 61.8 | 143 | 19/10/20 10:27:19 | 64.3 |
| 144 | 16/10/20 13:37:26 | 69.6 | 144 | 16/10/20 17:15:20 | 67.7 | 144 | 19/10/20 10:27:24 | 65.4 |
| 145 | 16/10/20 13:37:31 | 69.5 | 145 | 16/10/20 17:15:25 | 54.9 | 145 | 19/10/20 10:27:29 | 75 |
| 146 | 16/10/20 13:37:36 | 69.9 | 146 | 16/10/20 17:15:30 | 59.7 | 146 | 19/10/20 10:27:34 | 54.2 |
| 147 | 16/10/20 13:37:41 | 75.6 | 147 | 16/10/20 17:15:35 | 74.8 | 147 | 19/10/20 10:27:39 | 79.1 |
| 148 | 16/10/20 13:37:46 | 68.4 | 148 | 16/10/20 17:15:40 | 65.7 | 148 | 19/10/20 10:27:44 | 61.5 |
| 149 | 16/10/20 13:37:51 | 67.7 | 149 | 16/10/20 17:15:45 | 61.7 | 149 | 19/10/20 10:27:49 | 65.4 |
| 150 | 16/10/20 13:37:56 | 61.2 | 150 | 16/10/20 17:15:50 | 65.5 | 150 | 19/10/20 10:27:54 | 65.2 |
| 151 | 16/10/20 13:38:01 | 63.1 | 151 | 16/10/20 17:15:55 | 69.3 | 151 | 19/10/20 10:27:59 | 72.4 |
| 152 | 16/10/20 13:38:06 | 75.9 | 152 | 16/10/20 17:16:00 | 74.8 | 152 | 19/10/20 10:28:04 | 65.9 |
| 153 | 16/10/20 13:38:11 | 69.5 | 153 | 16/10/20 17:16:05 | 69.9 | 153 | 19/10/20 10:28:09 | 69.6 |
| 154 | 16/10/20 13:38:16 | 71.2 | 154 | 16/10/20 17:16:10 | 65.8 | 154 | 19/10/20 10:28:14 | 43.1 |
| 155 | 16/10/20 13:38:21 | 74.7 | 155 | 16/10/20 17:16:15 | 61.2 | 155 | 19/10/20 10:28:19 | 54.2 |
| 156 | 16/10/20 13:38:26 | 64.9 | 156 | 16/10/20 17:16:20 | 57 | 156 | 19/10/20 10:28:24 | 58.6 |
| 157 | 16/10/20 13:38:31 | 64.2 | 157 | 16/10/20 17:16:25 | 60.8 | 157 | 19/10/20 10:28:29 | 64 |
| 158 | 16/10/20 13:38:36 | 68.8 | 158 | 16/10/20 17:16:30 | 62.2 | 158 | 19/10/20 10:28:34 | 67.6 |
| 159 | 16/10/20 13:38:41 | 69.1 | 159 | 16/10/20 17:16:35 | 57.5 | 159 | 19/10/20 10:28:39 | 63.4 |
| 160 | 16/10/20 13:38:46 | 68.1 | 160 | 16/10/20 17:16:40 | 63.8 | 160 | 19/10/20 10:28:44 | 60.5 |
| 161 | 16/10/20 13:38:51 | 58.3 | 161 | 16/10/20 17:16:45 | 65.9 | 161 | 19/10/20 10:28:49 | 62.4 |
| 162 | 16/10/20 13:38:56 | 60.3 | 162 | 16/10/20 17:16:50 | 64.6 | 162 | 19/10/20 10:28:54 | 57.3 |
| 163 | 16/10/20 13:39:01 | 66.1 | 163 | 16/10/20 17:16:55 | 70.8 | 163 | 19/10/20 10:28:59 | 71.4 |
| 164 | 16/10/20 13:39:06 | 69.9 | 164 | 16/10/20 17:17:00 | 57.2 | 164 | 19/10/20 10:29:04 | 59.9 |
| 165 | 16/10/20 13:39:11 | 57.7 | 165 | 16/10/20 17:17:05 | 63.3 | 165 | 19/10/20 10:29:09 | 73.3 |
| 166 | 16/10/20 13:39:16 | 65.7 | 166 | 16/10/20 17:17:10 | 53.4 | 166 | 19/10/20 10:29:14 | 71.2 |

# HALL CLOSE - SOUND RECORDINGS

***Data Record***

| OCTOBER 16, 2020 - MIDDAY | | |
|---|---|---|
| **Record** | **Time** | **Noise(dB)** |
| 167 | 16/10/20 13:39:21 | 70.1 |
| 168 | 16/10/20 13:39:26 | 68.6 |
| 169 | 16/10/20 13:39:31 | 70.1 |
| 170 | 16/10/20 13:39:36 | 65.7 |
| 171 | 16/10/20 13:39:41 | 64.1 |
| 172 | 16/10/20 13:39:46 | 61.2 |
| 173 | 16/10/20 13:39:51 | 71.5 |
| 174 | 16/10/20 13:39:56 | 79.6 |
| 175 | 16/10/20 13:40:01 | 69.2 |
| 176 | 16/10/20 13:40:06 | 76 |
| 177 | 16/10/20 13:40:11 | 67.6 |
| 178 | 16/10/20 13:40:16 | 70.5 |
| 179 | 16/10/20 13:40:21 | 67.1 |
| 180 | 16/10/20 13:40:26 | 62.3 |
| 181 | 16/10/20 13:40:31 | 61.1 |
| 182 | 16/10/20 13:40:36 | 64.4 |
| 183 | 16/10/20 13:40:41 | 66.1 |
| 184 | 16/10/20 13:40:46 | 66.5 |
| 185 | 16/10/20 13:40:51 | 70.3 |
| 186 | 16/10/20 13:40:56 | 70.6 |
| 187 | 16/10/20 13:41:01 | 73.9 |
| 188 | 16/10/20 13:41:06 | 69.7 |
| 189 | 16/10/20 13:41:11 | 72.4 |
| 190 | 16/10/20 13:41:16 | 68.8 |
| 191 | 16/10/20 13:41:21 | 72.6 |
| 192 | 16/10/20 13:41:26 | 66.6 |
| 193 | 16/10/20 13:41:31 | 61.9 |
| 194 | 16/10/20 13:41:36 | 82.5 |
| 195 | 16/10/20 13:41:41 | 69.6 |
| 196 | 16/10/20 13:41:46 | 68.4 |
| 197 | 16/10/20 13:41:51 | 71 |
| 198 | 16/10/20 13:41:56 | 69.6 |
| 199 | 16/10/20 13:42:01 | 60.3 |
| 200 | 16/10/20 13:42:06 | 67.7 |

| OCTOBER 16, 2020 - EVENING | | |
|---|---|---|
| **Record** | **Time** | **Noise(dB)** |
| 167 | 16/10/20 17:17:15 | 54.3 |
| 168 | 16/10/20 17:17:20 | 62.9 |
| 169 | 16/10/20 17:17:25 | 61.6 |
| 170 | 16/10/20 17:17:30 | 54.1 |
| 171 | 16/10/20 17:17:35 | 56.6 |
| 172 | 16/10/20 17:17:40 | 59.9 |
| 173 | 16/10/20 17:17:45 | 64.6 |
| 174 | 16/10/20 17:17:50 | 64.3 |
| 175 | 16/10/20 17:17:55 | 56.1 |
| 176 | 16/10/20 17:18:00 | 55.8 |
| 177 | 16/10/20 17:18:05 | 54.9 |
| 178 | 16/10/20 17:18:10 | 64 |
| 179 | 16/10/20 17:18:15 | 56.8 |
| 180 | 16/10/20 17:18:20 | 58.8 |
| 181 | 16/10/20 17:18:25 | 63.7 |
| 182 | 16/10/20 17:18:30 | 78 |
| 183 | 16/10/20 17:18:35 | 73.1 |
| 184 | 16/10/20 17:18:40 | 61.4 |
| 185 | 16/10/20 17:18:45 | 62.3 |
| 186 | 16/10/20 17:18:50 | 66.1 |
| 187 | 16/10/20 17:18:55 | 68.8 |
| 188 | 16/10/20 17:19:00 | 62.1 |
| 189 | 16/10/20 17:19:05 | 63.8 |
| 190 | 16/10/20 17:19:10 | 62 |
| 191 | 16/10/20 17:19:15 | 59.6 |
| 192 | 16/10/20 17:19:20 | 66 |
| 193 | 16/10/20 17:19:25 | 60.8 |
| 194 | 16/10/20 17:19:30 | 66.3 |
| 195 | 16/10/20 17:19:35 | 67.4 |
| 196 | 16/10/20 17:19:40 | 65.4 |
| 197 | 16/10/20 17:19:45 | 63.7 |
| 198 | 16/10/20 17:19:50 | 60.8 |
| 199 | 16/10/20 17:19:55 | 57.3 |
| 200 | 16/10/20 17:20:00 | 58.7 |

| OCTOBER 19, 2020 - MORNING | | |
|---|---|---|
| **Record** | **Time** | **Noise(dB)** |
| 167 | 19/10/20 10:29:19 | 81.5 |
| 168 | 19/10/20 10:29:24 | 89.1 |
| 169 | 19/10/20 10:29:29 | 78.6 |
| 170 | 19/10/20 10:29:34 | 62.7 |
| 171 | 19/10/20 10:29:39 | 69.4 |
| 172 | 19/10/20 10:29:44 | 66.6 |
| 173 | 19/10/20 10:29:49 | 72.9 |
| 174 | 19/10/20 10:29:54 | 64 |
| 175 | 19/10/20 10:29:59 | 60.8 |
| 176 | 19/10/20 10:30:04 | 44.1 |
| 177 | 19/10/20 10:30:09 | 60.6 |
| 178 | 19/10/20 10:30:14 | 69.5 |
| 179 | 19/10/20 10:30:19 | 51.6 |
| 180 | 19/10/20 10:30:24 | 47.3 |
| 181 | 19/10/20 10:30:29 | 69.2 |
| 182 | 19/10/20 10:30:34 | 70.3 |
| 183 | 19/10/20 10:30:39 | 64 |
| 184 | 19/10/20 10:30:44 | 47.3 |
| 185 | 19/10/20 10:30:49 | 54.1 |
| 186 | 19/10/20 10:30:54 | 73.7 |
| 187 | 19/10/20 10:30:59 | 70.5 |
| 188 | 19/10/20 10:31:04 | 45.9 |
| 189 | 19/10/20 10:31:09 | 56.5 |
| 190 | 19/10/20 10:31:14 | 83.5 |
| 191 | 19/10/20 10:31:19 | 66.3 |
| 192 | 19/10/20 10:31:24 | 56 |
| 193 | 19/10/20 10:31:29 | 72.9 |
| 194 | 19/10/20 10:31:34 | 68 |
| 195 | 19/10/20 10:31:39 | 70.4 |
| 196 | 19/10/20 10:31:44 | 73 |
| 197 | 19/10/20 10:31:49 | 75.7 |
| 198 | 19/10/20 10:31:54 | 68.9 |
| 199 | 19/10/20 10:31:59 | 50.2 |
| 200 | 19/10/20 10:32:04 | 48.9 |

| | | | |
|---|---|---|---|
| **MAXIMUM READING** | **90.2** | **at** | **October 16, 2020 at 1:30:41 pm** |
| **MINIMUM READING** | **31.6** | **at** | **October 19, 2020 at 10:27:39 am** |
| **AVERAGE** | **63.2** | | |

***Paramaters***

| Record Parameters | Content |
|---|---|
| Address | 1 |
| Serial Number | 202016991 |
| Test Name | RECORD TEST2 |
| Setting Time | 16/10/2020 13:25:24 |
| Total Records | 200 |
| Record Interval | 5 sec |
| Immediately/Manual | Manual |
| Noise Alarm | L:30 H:130 dB |
| Sample Level | FAST |
| Noise Level | A |
| Start Time | 16/10/2020 13:25:31 |
| Test Records | 200 |
| Is Noise Alarm | |

| Record Parameters | Content |
|---|---|
| Address | 1 |
| Serial Number | 202016991 |
| Test Name | RECORD TEST2 |
| Setting Time | 16/10/2020 17:03:19 |
| Total Records | 200 |
| Record Interval | 5 sec |
| Immediately/Manual | Manual |
| Noise Alarm | L:30 H:130 dB |
| Sample Level | FAST |
| Noise Level | A |
| Start Time | 16/10/2020 17:03:25 |
| Test Records | 200 |
| Is Noise Alarm | |

| Record Parameters | Content |
|---|---|
| Address | 1 |
| Serial Number | 202016991 |
| Test Name | RECORD TEST2 |
| Setting Time | 19/10/2020 10:15:21 |
| Total Records | 200 |
| Record Interval | 5 sec |
| Immediately/Manual | Manual |
| Noise Alarm | L:30 H:130 dB |
| Sample Level | FAST |
| Noise Level | A |
| Start Time | 19/10/2020 10:15:29 |
| Test Records | 200 |
| Is Noise Alarm | |